DEPARTMENT OF THE INTERIOR

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1 OF 2

PROPOSED
1977 OUTER CONTINENTAL SHELF
OIL AND GAS LEASE SALE
SOUTH ATLANTIC
OCS SALE NO. 43

PREPARED BY THE BUREAU OF LAND MANAGEMENT

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

PROPOSED 1977 OCS OIL AND GAS LEASE SALE

UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

BLM

DIRECTOR

Summary: Proposed OCS Lease Sale No. 43

(X) Draft ( ) Final Environmental Statement Department of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, Louisiana

1. Proposed Oil and Gas Lease Sale, South Atlantic Outer Continental Shelf

(X) Administrative ( ) Legislative Action

2. This proposed oil and gas lease sale is an initial sale for the South Atlantic OCS Frontier Region (see Figure A-1).

Two hundred twenty five tracts (518,400 hectares—1,280,966 acres) of OCS lands are proposed for leasing action. The tracts are located offshore of South Carolina, Georgia, and Florida with distance to shore ranging from approximately 48 to 120 kilometers (30 to 75 mi). The tracts are situated in water depths that range from approximately 13 to 165 meters (43 to 540 ft). If implemented, this sale is tentatively scheduled to be held in late 1977.

Development at the following level is expected: 10-25 platforms, 255-720 wells, 80-320 miles of pipeline, 1-2 terminals, storage areas, and processing plants.

3. An oil risk analysis was made for 19 resource categories. Each proposed lease tract has received a proximity evaluation using a matrix technique to identify significant environmental impacts should leasing and subsequent oil and gas exploration and production ensue.

All tracts offered pose some degree of risk to the environment. Accidental or chronic oil spillage is the chief potential cause of impact. Other sources of impact include platform and pipeline installation.

The principal adverse impacts that will occur include: some effects on recreational beaches from Daytona Beach, Fla. to Cape Fear, N.C., localized effect on recreational and commercial fishing grounds particularly scallops, crabs and oysters, benthos organisms at the localized sites of development, some potential danger to marine mammal habitat of manatees, some small loss of waterfowl, and unknown but potential effects on archaeological sites.

Existing air and water quality onshore will be adversely impacted by operations of gas processing plants, and any additional refineries, should they be constructed.

Beneficial economic impact is anticipated in employment and income with some adverse effect from induced development growth patterns in local areas.

4. Alternatives to the Proposed Action:

A. Hold the Proposed Sale in Modified Form
B. Delay the Proposed Sale
C. Withdraw the Proposed Sale

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III. ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

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Visual Graphic for Proposed OCS Lease Sale No. 43

The visuals prepared for the proposed South Atlantic OCS Lease Sale No. 43 consist of three sets:

Section I

Description of Proposal

A. Proposed Lease Sale

1. Location and Resources

The proposed Federal action under consideration is the leasing of 225 tracts (each tract consists of 2304 hectares; 5,693.18 acres; or approximately 9 square miles in area) on the South Atlantic Outer Continental Shelf (OCS), in an area known as the Southeast Georgia Embayment Figure A-1 and Visual No. 1S). These tracts comprise an area of 518,400 hectares (1,280,966 acres). They are located from approximately 48 to 120 kilometers (30 to 75 miles) offshore South Carolina, Georgia, and Florida; and in water depths of approximately 13 to 165 meters (43 to 540 feet). The tracts are summarized by water depth and distance from shore in Appendix A. They are being proposed to be leased for exploration, development and production of potential oil and gas resources in accordance with Section 8 of the Outer Continental Shelf (OCS) Lands Act (76 Stat. 462; 43 U.S.C.; Sec. 1337) and regulations issued under that Act.

The proposed action constitutes a first proposed sale in a frontier area, and does not represent proposed development of all of the potential resources of the Southeast Georgia Embayment region.

Undiscovered resources are defined as those quantities which are reasonably expected to exist in favorable geologic settings, but which have not yet been identified by drilling. If exploration confirms the existence of recoverable hydrocarbons, such resources would be reclassified as "reserves".

The U.S. Geological Survey (USGS) estimated in July 1976 (Appendix B) that, based on proprietary geophysical data, the 225 tracts proposed to be leased may contain undiscovered recoverable resources ranging from 0.28 to 1.0 billion barrels of oil and 1.9 to 6.8 trillion cubic feet of gas. Based on these estimates, the proposed action may result in peak daily production of between 56 to 170 thousand barrels of oil and 0.47 to 1.4 billion cubic feet of gas, peaking approximately 14 years after production has commenced. The estimated production life of this proposed oil and gas project is 25 years.

B. Tract Selection Process

1. Procedure and Nominations

As a first step in the tract selection process, the Department identified a large potential leasing area within the Southeast Georgia Embayment to be opened to nominations. The broadest east-west extent of this area is approximately 239 kilometers (approximately 148 miles) and the longest north-south extent of this area is approximately 608 kilometers (approximately 378 miles). The area contains approximately 8.4 million hectares (approximately 20.7 million acres) and lies between 28 degrees and 34 degrees north latitude off the coasts of Florida, Georgia, South Carolina and North Carolina. Blocks within the area lie approximately 4.8 to 212 kilometers (approximately 3 to 132 miles) from shore (See Figure A-1).

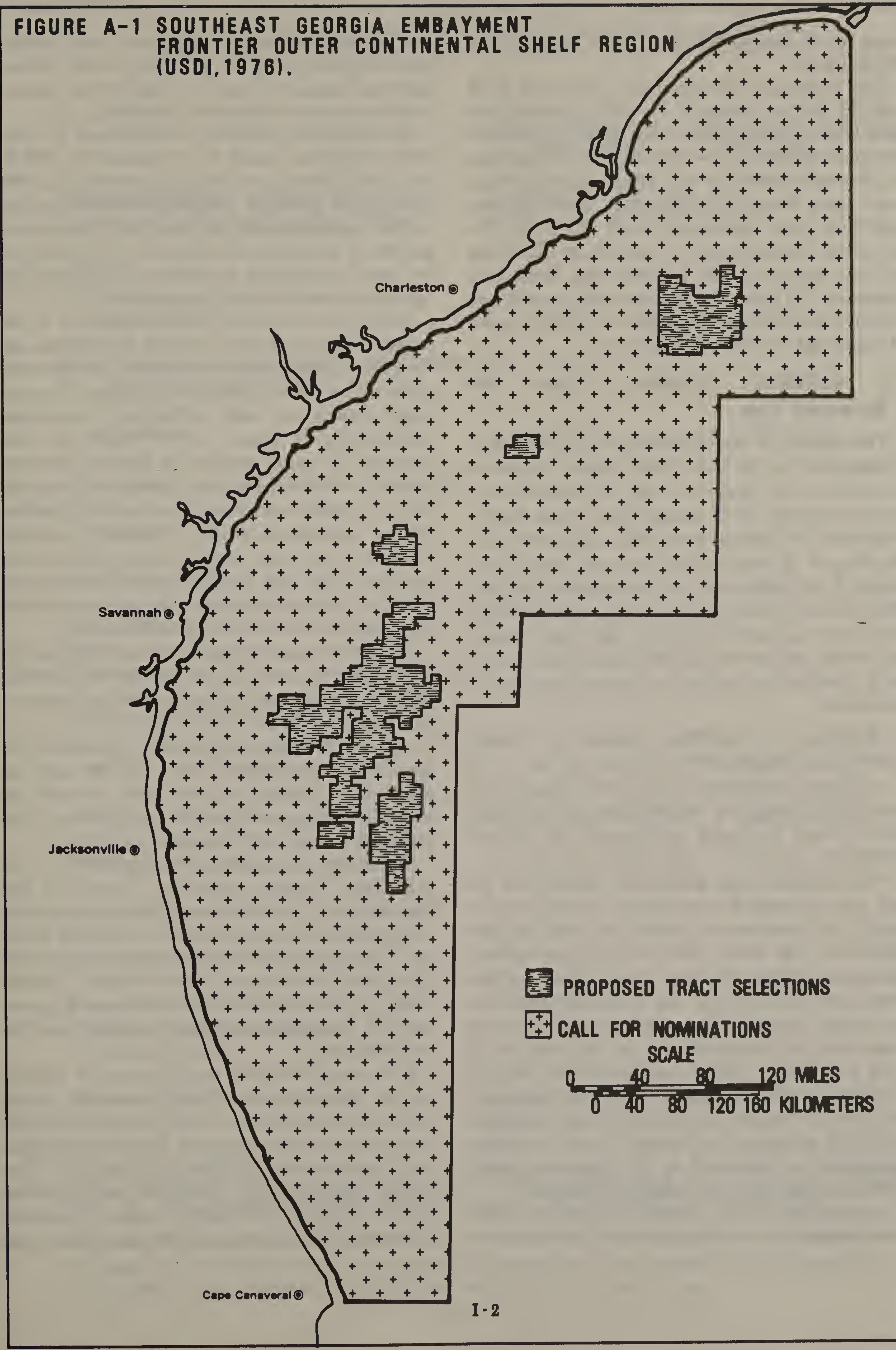
The Bureau of Land Management (BLM) requested resource reports on this area from other Federal agencies in May 1975. In September 1975, a Call for Nominations and Comments was issued (Appendix A). The call invited the oil and gas industry to nominate from within this area the blocks (each full block contains 2,304 hectares (5,693,184 acres), which it wished to be offered for lease. Interested parties, including state governments, were also invited by this call to identify blocks or areas which they felt should be withheld from leasing for environmental or other reasons.

The Call for Nominations and Comments for this South Atlantic proposal resulted in 778 tracts, with total area of approximately 1.8 million hectares (approximately 4.4 million acres) from the call area being nominated by nine companies.

The nominations and comments were evaluated by the New Orleans OCS Office, BLM and the Eastern Region Conservation Division of the U.S. Geological Survey (USGS).

Meetings at the field level were held in Atlanta in November and December 1975 to present and discuss the environmental and competitive aspects of the nominations. Participants in these meetings included Bureau of Land Management; Department of the Interior officials; Fish and Wildlife Service; Geological Survey; National Marine Fisheries Service; National Park Service; and representatives of the Governors and staff specialists from the states of North and South Carolina, Georgia and Florida. All participants were given an opportunity to make recommenda-

FIGURE A-1 SOUTHEAST GEORGIA EMBAYMENT FRONTIER OUTER CONTINENTAL SHELF REGION (USDI, 1976).



tions for or against offering blocks nominated in the call area.

The Washington headquarters' offices of BLM and GS met on February 17, 1976 to review the field level recommendation and develop the tentative tract selection to be approved by the Secretary. Representatives of the South Atlantic States were again invited to participate. Tentative tract selections were announced April 27, 1976. The 778 tracts nominated were reduced to 225 tracts for this proposed sale by removing from consideration 372 tracts that did not receive sufficient industry interest and 181 tracts that fell in areas of expressed environmental concern.

C. Activities Resulting from the Proposed Sale

The amount of commercial activity which may be generated in the U.S. South Atlantic region as a result of this proposed sale is dependent on many variables. Chief among them would be the availability of capital, manpower, equipment, and the amount of recoverable resources found as a result of the exploratory and development drilling. Distribution of recoverable resources, the ratio of oil to gas, geologic, economic, and other factors will affect the number of platforms, wells, and so forth needed to extract a given amount of resources.

1. Summary of Activities Expected to Result from the Proposed Sale

A detailed description of activities expected to result from proposed South Atlantic OCS Sale No. 43 may be found in Appendix B (USGS, 1976).

It is expected that exploratory drilling for oil and gas, conducted from mobile drilling rigs or ships, will commence within one year of the proposed sale date. Most of the exploratory drilling would probably take place in the first five years after the proposed sale date, and exploratory drilling could be completed within 14 to 16 years after the proposed sale. As set forth in 43 CFR Part 3302.2: "All oil and gas leases shall be issued for a term of 5 years and so long thereafter as oil or gas may be produced from the leasehold in paying quantities, or drilling or well reworking operations, as approved by the Secretary under 3305a.1 of this part, are conducted thereon."

Development well drilling, conducted from fixed platforms, could begin within five years of the commencement of exploratory well drilling, and continue for 8 to 12 years. Some service facilities onshore would be required to support exploration and development activities.

Production is expected to commence in 1982. Most platforms would be producing by 1988-91 and peak production may be attained in 1990. Since water depths of less than 200 meters are involved, conventional platforms are anticipated; gravity or concrete structures are not expected to be used. A detailed description of oil and gas operations may be found in Appendix C.

Due to the dispersion of tract locations in the proposed sale area, their distance from shore, and the modest production rates forecast, initial transportation of oil would be via tankers. Furthermore, unless or until strategically convenient deliverability of about 7×10^4 BOPD the construction of an oil pipeline to shore is doubtful because of the low resources anticipated, it is difficult to predict that more than two oil pipelines will be constructed. While a proposed stipulation (Section IV.E.) may reduce transportation of oil by barge from this proposed sale, initial dependence on tanker transport is foreseen for three to five years after production is commenced.

Using the empirical rule that a gas pipeline will be installed for each 7×10^5 MCFPD of deliverability, it is estimated that one to two gas pipelines may be installed.

If logistics and environmental conditions permit, it is conceivable that both oil and gas pipelines will utilize the same route to shore. As to the positioning and land fall for pipelines, it appears too conjectual to predict at this time.

No refinery is expected to be constructed in the U.S. South Atlantic region as a result of this proposed sale. Crude oil brought ashore in tankers or pipelines would be processed at existing facilities. The intercoastal tanker linkage of the U.S. South and Mid-Atlantic region could be utilized. Table C-1 indicates the area and range of activities and requirements expected to result from this proposed sale.

It is possible that this initial activity, if exploration is successful in finding resources, could result in future activities in this Southeast Georgia Embayment area that could extend exploration and development activities beyond the time frames discussed here. However, any additional lease sale proposals would be subject to separate environmental analyses at a later time, to consider

Table C-1 Area, Facilities and Activities Expected to be Required to Develop Hydrocarbon Resources Within the Proposed Sale Area based on USGS Estimates for this Proposed Sale. 1/

	Low Resource Estimate	High Resource Estimate
a. Acres proposed to be offered	1,280,966 (518,400 ha)	
Acres anticipated to be leased	740,114 (299,524 ha)	
b. Wells		
--exploratory	95	220
--development (includes unsuccessful development wells)	160	500
Total Wells	255	720
c. Rigs (maximum working at one time)		
--exploratory	5	12
--development	8	15
Total Rigs	13	27
d. Platforms	10	25
e. Offshore Pipelines		
--oil	80 mi (129 km)	160 mi (257 km)
--gas	80 mi (129 km)	160 mi (257 km)
Total Pipelines	160 mi (257 km)	320 mi (515 km)
f. Terminal/Storage Facilities 2/	1	2
g. Onshore Operations Bases	1	2
h. Gas Processing Plants (Units with capacity of 300 to 500 mmcf/d)	1	2
i. Tankers (16,000 to 25,000 dwt)	3	6

1/ 0.282 to 1.009 billion barrels of oil and 1.890 to 6.810 trillion cubic feet of gas, based on USGS June 20, 1976 sale-specific estimates.

2/ Numbers of anticipated facilities are not necessarily proportional to the amount of estimated recoverable resources, because of differences in assumed development strategies and other assumptions.

Table C-1 (continued)

Estimated Total Weight (Tons) of Drill Cuttings (Average Well Depth 10,000 Feet)

	Low Resource Estimate	High Resource Estimate
Exploratory wells	64,790	150,040 tons
Development wells	109,120	341,000 tons
Total	173,910	491,040 tons

Estimated Total Weight (Tons) of Drilling Muds Retained in Well Bore, Adhering to Cuttings, or Entering Marine Environment (Unrecycled) 1/

Exploratory wells	21,850	220,000 tons
Development wells	36,800	500,000 tons
Total	58,650	720,000 tons

Estimated Total Volume of Formation Water Discharged (Assumes a 1:1 ratio over field life)

	0.3	1.0 billion barrels

Estimated Maximum Amount of Marine Sediment Disturbed by Pipeline Burial

	1,280,000	2,560,000 yd^3

Estimated Land Use Requirements for Directly-Related Onshore Facilities 2/ (Excludes pipeline right-of-way)

	hectares (acres) number	
Onshore operation bases	20(50)1	60(150)3
Onshore oil terminals	16(40)1	32(80)2
Onshore gas processing plants	8(20)1	16(40)2
Total	44(110)	108(270)

1/ While it is not possible to estimate the relative amounts of drilling muds retained in the wellbore and amounts entering the marine environment, the bulk of unrecycled drillings muds is retained in the wellbore.

2/ Other land use requirements are discussed in Section III.E.2.

the impacts of further commitment to this U.S. South Atlantic area to oil and gas development.

2. Scope and Nature of Development Anticipated

The analysis of environmental impact undertaken by this EIS assumes the following scope and nature of the major action causing events to be associated with the sale: (1) an approximate 25 year period of development and production, (2) development based upon the high resource estimate (maximum case), (3) shore operation bases at Charleston, S.C. and Jacksonville, Fla., (4) tanker transportation up to 70,000 bbls/day of oil production and two oil pipelines after that level is exceeded, (5) product export from Jacksonville and Charleston to refineries in the Mid-Atlantic, Gulf of Mexico, or other areas by tankers.

The above assumed scenario could vary when it becomes more clear what resource potential exists and where it is located. Therefore, various possible scenarios to the above are examined further in Section III.E1. It should be recognized that they are assumptions about development possibilities and not alternatives plans of action just as the above is not a proposed plan of action. The above scenario of what development may entail should be regarded only as a judgement of what seems reasonably possible from what we know and can estimate today, projected into the future. Any specific plan of action cannot be formulated until a lease has been granted. Individual companies will have individual plans at that time which may differ or may approach the above scenario differently depending on who becomes the successful lessee, should the proposed sale be held.

3. Environmental Studies Program

The Bureau of Land Management has established broad objectives for environmental studies programs in order to satisfy various legislative requirements, including those of the Outer Continental Shelf Lands Act, the Submerged Lands Act, and the National Environmental Policy Act. These objectives are:

(1) The acquisition of information about the Outer Continental Shelf environment that will enable the Department and the BLM to make better management decisions regarding the development of mineral resources on the Federal OCS.

(2) The acquisition of information about the OCS environment which will enable the Department and the BLM to detect the impacts of OCS oil and gas exploration and development on the marine environment, and information which will enable the detection of environmental changes which may occur as a result of oil and gas operations.

(3) The establishment of a basis for prediction of impact of OCS oil and gas activities in frontier areas.

(4) The identification of sensitive habitats, potential geological hazards, and other factors of concern in the marine environment.

(5) The acquisition of impact data that may result in the modification of leasing stipulations, OCS Operating Orders, Notices to Lessees, and guidelines permitting efficient resource recovery while also insuring the protection of the marine environment.

The environmental studies program for the South Atlantic OCS is designed to acquire three distinct types of data: benchmark, descriptive and predictive. Benchmark data are both qualitative and quantitative data, for which an acceptable statistical significance can be established. These types of data are collected prior to oil and gas production so that any environmental impacts can be detected by monitoring the same parameters during the production stage. Descriptive data fall into two categories. The first is non-quantitative, or semi-quantitative descriptions of the morphological aspects of the environment which identify unique or special cases; the second is non-quantitative biological or chemical data for which statistical significance cannot be feasibly established. These data are primarily used in support of the analyses of effects which are observed through the benchmark and/or predictive data studied. They may also serve as indicators of environmental stress which could lead to the initiation of special studies designed to determine the sources and effects of the stress. Predictive information is primarily composed of physical processes data which can be used to determine the fate of pollutants, and biological effects data which can be used to predict and determine stress levels imposed by oil and gas development.

In order to fulfill its requirements under the marine minerals management goals of the Department of the Interior, the Bureau of Land Management has developed a comprehensive multi-year environmental study plan for the South Atlantic OCS area. This plan, which is entitled "Marine Environmental Study Plan for the South Atlantic

Outer Continental Shelf Area; Georgia Embayment and Blake Plateau Regions'', was jointly prepared by the staffs of the New Orleans OCS Office and the Branch of Environmental Studies of the Washington BLM Office, and was released January 23, 1976. This document outlines the studies to be conducted in the South Atlantic OCS area; the data generated by these studies will represent an important addition to the existing data base and will enhance the Department's ability to make management decisions that will ensure environmental integrity during oil and gas exploration, development, and production in the area.

The studies program, as described in the study plan, is envisioned as a long-term study which will be in effect for a minimum of three to five years, and most likely will continue for the duration of exploratory and development drilling, establishment of production platforms, the laying of pipelines, and other related activities in the South Atlantic OCS area. Planning and budgeting have been based on an initial three-year period of intensive study, a slow decline in funding and effort over the succeeding two years; and a maintenance, or sustaining level of effort and funding for an indefinite number of years to monitor the effects of OCS oil and gas exploration and development over the long-term. Present estimates indicate that this monitoring period could range from five to fifteen years, but these estimates will continue to be revised depending upon the level of oil and gas activities that may occur in the region.

The studies program for the South Atlantic OCS area was formally initiated in the fall of 1975, with a conference/workshop conducted by the Research Triangle Institute, Inc., in Atlanta, Georgia, on October 14-17. The purpose of this workshop was to solicit recommendations from the scientific community, from conservationists, and from other interested parties, for the planning of studies to be conducted in the area. The results of this meeting are compiled and presented in the ''Conference/Workshop Proceedings, Bureau of Land Management's Environmental Studies Program for the South Atlantic Outer Continental Shelf Area'', released February, 1976.

Based upon the recommendations of this conference, and upon the recognized information needs of the BLM, the previously mentioned multi-year study plan and first-year statements of work were prepared which detail the studies to be conducted in the area; these planned studies are synoptically described below. The statements of work have been, or are being, converted to requests for proposals (RFP's), and have been, or will be, advertised in the Commerce Business Daily. Copies of the RFP's are available from the U.S. Department of the Interior, Bureau of Land Management, Branch of Contract Operations, Mail Stop 551, Interior Building, 18th and C Streets, N.W. Washington, D.C. 20240. Five RFP's are anticipated.

(1) Biological and Chemical Benchmark Studies (RFP No. AA550-RP6-20, issued June 11, 1976; proposals due July 30, 1976; contract AA550-CT7-2, issued November 15, 1976, to Texas Instrument, Inc.). Comprehensive benchmark studies designed to document the biological and chemical characteristics of the study area, and including elements of hydrocarbon and trace metal chemistry, benthic and water column biology, histology, microbiology, and program management.

(2) Geological Oceanography (RFP No. AA550-RP6-18, issued June 14, 1976, on a non-competitive basis to the U.S. Geological Survey, proposals due June 30, 1976; memorandum of understanding AA550-MU6-56, issued October 27, 1976). Detailed geological studies, including: sediment mobility; seston flux; vertical distribution of trace metals in sediments; sediment texture and composition studies; sea floor stability; and identification of outcrops and reefal structures.

(3) Physical Oceanography Field Studies (RFP No. AA550-RP7-1, issued November 1, 1976; proposals due December 10, 1976; anticipated contract issuance in January 1977). A major field study designed to describe the current circulation, surface movement, and mixing processes of the Georgia embayment.

(4) Physical Oceanography Literature Survey and Data Synthesis (RFP No. AA550-RP6-29, issued July 8, 1976; reissued November 2, 1976 as RFP AA550-RP7-7; proposals due December 3, 1976, anticipated contract issuance in January, 1977). A proposal requiring a comprehensive review of available published and unpublished data on the physical oceanography of the study area, including data processing so as to maximize the effective use of extant data.

(5) The Virginia Institute of Marine Science (VIMS) report update (RFP not issued at time of writing; anticipated contract issuance in early 1977). In 1973-1974 the Virginia Institute of

Marine Science (VIMS) prepared a comprehensive "Socioeconomic Environmental Baseline Summary for the South Atlantic Region, between Cape Hatteras, North Carolina and Cape Canaveral, Florida" for the BLM, under contract to the Council on Environmental Quality (CEQ contract EQ4AC007). That report consists of five volumes, dealing with physical oceanography, climatology, chemical and biological oceanography, geological oceanography, and a socioeconomic inventory. The present contract study will update the chemical, biological and geological oceanography section of the VIMS report.

It should be noted that the levels of funding and effort, the desired data products, and the timing of future studies may be modified in accordance with experience gained during the first year's study effort; this permits flexibility in selecting the parameters to be measured, the location of sampling stations, the evaluation of the contractors' performance, the evaluation of the data, the initiation of special studies, and other factors. Additionally, it must be emphasized that all funds are obligated on a year-to-year basis even though programs may be planned for longer periods of time.

A. SYNOPSIS OF SAMPLING AND ANALYSIS PROGRAMS

(1) Benthic, Biological and Chemical Program—(Contract AA550-CT7-2)—biological and chemical data, and supporting geologic data, will be collected by the contractor (Texas Instrument, Inc.) during the four biological seasons in the area. Samples will be collected from a total of fifty stations situated along seven transects. Samples will be collected and subsamples for the following analyses:

Geological and chemical analyses: Samples will be collected for trace metal, hydrocarbon and total organic carbon from each station; samples will be collected for granulometric (grain size) analysis from each box core sample taken, whatever the intended analysis.

Biological analyses: Samples will be collected for analysis of microfauna/meiofauna, microbiology, and macroinfauna. The micro-, meio-, and macrofauna samples are collected for taxonomic analysis, the microbial samples are collected for determination of the ratio of heterotrophic to hydrocarbon oclastic bacteria present, and for laboratory studies designed to assess the microbial hydrocarbon degradation "potential"

Biological and chemical analyses: Samples (macrobenthos including resident demersal fishes) will be collected from a maximum of twenty-five stations, using a trawl, dredge, or similar sampling gear. These samples will be used for taxonomic analysis, community characterization, chemical analyses (trace metal and hydrocarbon), and histopathological studies.

Photographic studies: Bottom photographs will be taken of the sites samples by the box corer, to supply additional information on the benthic environment, and to evaluate the representativeness of the site actually being sampled.

(2) Water Column Biological and Chemical Program (Contract AA550-CT7-2)—biological and chemical data, and supporting hydrographic data will be collected by the contractor (Texas Instrument, Inc.) during the four biological seasons in the area. Samples will be collected from a total of twelve stations located on the same seven transects as the benthic samples program. Samples will be collected using the most appropriate sampling gear, viz., plankton nets, niskin or nansen bottles, etc.

Hydrographic, water chemistry, and suspended sediment analyses: Samples will be taken for analysis of salinity, temperature, and dissolved oxygen with depth; dissolved micronutrients (nitrate, phosphate, silicate); chlorophyll *a*; particulate hydrocarbons; dissolved and surface film high molecular weight hydrocarbons; particulate and dissolved organic carbon; particulate trace metals; total (i.e., particulate plus dissolved) trace metals; suspended sediment granulometry; suspended sediment mineralogy; and transmissivity/nephelometry.

Biological analyses: Samples will be collected for analysis of water column microbes and of zooplankton. The effects of crude oil on microbial cultures and the microbial degradation of hydrocarbons will be studied; zooplankton samples will be analyzed taxonomically, and for hydrocarbon and trace metal levels.

(3) Geological Oceanography Program (Memorandum of Understanding AA550-MU6-56, effective October 27, 1976)—the following studies will be performed by the U.S. Geological Survey:

Sediment mobility study: Rates of sediment mobility will be determined in situ by deployment of three bottom-moored tripods seasonally; each tripod will be instrumented for detection of pressure, currents, transmissivity/nephelometry; and inclination. The tripods will also be equipped so as to photograph the changes in surface bed forms and movements of bottom sediments with time, and to collected samples of sediment moving over the sea bed.

Seston flux study: Transmissivity/nephelometry studies will be conducted to determine the movements of suspended sediments in the study area.

Sediment sampling and analyses: Twenty Vibracores and ten hydrostatically damped gravity cores will be collected; these will be analyzed to determine the vertical distribution of trace metals in the sediments; also, granulometry, carbonate and organic carbon content, mineralogy, and paleontologic analysis of down-core sub-samples. Each of the cores will be x-radiographed and analyzed stratigraphically; age-dating will be performed on sediments from twelve of the Vibracores.

Sea floor stability studies: Geophysical surveys will be conducted using seismic reflection techniques to determine the locations of shallow and intermediate depth faults and locations of potential surficial sediment instability in the study area. Identification of outcrop and reefal structures: Surveys will be conducted using side scan sonar, precision depth recorder, and manned submersible dives to locate and define areas of outcrop and reefal structures.

(4) Physical Oceanography Field Studies—the physical oceanography study is expected to provide an understanding of the physical processes involved in the transport and dispersal of suspended or dissolved materials in Georgia Embayment waters sufficiently to parameterize these processes in descriptive models. Such models will permit a rational prediction of the probability of the paths along which potential contaminants associated with oil drilling may reach population centers or areas of biological importance, and the intensity of any environmental impacts arising from that. In conjunction with concurrent biological studies, the physical model aids in estimating the probability of contaminant effect on biological productivity of the continental shelf. It is expected that a period of three years, plus about one year for the production of a final report, will be required to achieve the program objectives. The following first year field study efforts are identified in light of existing knowledge, and with due regard to the limitation of resources available to support research:

Surface currents study: Using floating Lagrangian tracers and two anchored reference markers, drift patterns will be determined via synoptic aerial photography. This study will help define the surface transport across and/or along the turbid-clear water interface of the Georgia Embayment during both wet and dry seasons.

Subsurface currents study: Current measurements will be recorded over a three month period at several depths in the water column near the seaward end of one of the benchmark study transects. These data will be used to describe the short term variations in current profiles caused by Gulf Stream intrusions onto the shelf.

Hydrographic studies: Hydrographic data collected during the benchmark cruises (salinity, temperature, dissolved oxygen, nutrients, chlorophyll *a*) and geological cruises (transmissivity and suspended particulate material), and additional data from other sources (tides, river discharges, sea-level changes, satellite remote sensing, etc.) will be analyzed to characterize the physical system of the study area.

Meteorological and sea state data analysis: Analyses shall be conducted of all meteorological and sea state data collected by BLM supported cruises in the area; these data will be correlated with available meteorological and marine water/sea state data and predictions.

Shelf water and Gulf Stream variability study: Both hydrographic data and remote sensing imagery will be examined with respect to the interrelationship of the Gulf Stream and Georgia Embayment shelf waters.

Long-term current patterns study: One string of three or more continuously recording current meters will be moored near the shelf edge at about 32° 35' N latitude for one year. The data collected will be processed and interpreted to establish a mean and a range of variability of currents in the northern Georgia Embayment.

D. Relationship of This Proposed Sale to Development of Proposed OCS Planning Schedules for Possible OCS Oil and Gas Leasing and the Department's Program to Accelerate OCS Oil and Gas Leasing Nationwide

Proposed OCS Planning Schedules are developed in order to project the timing, size and location of specific lease sales for an OCS leasing program. General sale areas are identified and, at a later date, tentative acreage figures are set through the tract selection process for each proposed sale on the basis of broad resource knowledge and environmental evaluation. The goal of the proposed schedule is to provide for orderly development of OCS oil and gas resources and to maintain an adequate contribution of OCS production to the national supply.

In developing a proposed OCS planning schedule the Department considers the three leasing objectives that have been set for the Departmental OCS program. These objectives are: (1) orderly and timely resource development; (2) protection of the environment; and (3) receipt of a fair return for leased mineral resources. One factor in planning for OCS leasing is to contribute to the domestic supply of oil and natural gas, consistent with the protection of environmental values. This is the basis for the existence of any OCS leasing program. Acreage is tentatively selected in sufficient amount to engender industry interest and promote a fair return.

The proposed OCS planning schedule is essential as a program planning document to enable the Department to proceed in an orderly and timely fashion with its process of considering the several proposed and possible lease sales identified in that document. The proposed OCS planning schedule aids the Department of the Interior in establishing the order in which areas will be examined and in planning the work assignments of personnel and the allocation of resources of the environmental and other studies enumerated. The proposed OCS planning schedule also serves to apprise Federal, State and local agencies, industry, and interested members of the public of the time frame for consideration of potential leasing in the identified areas of the OCS. The proposed OCS planning schedule is a flexible document that is subject to review and revision at any time. More particularly, the consideration of any proposed or possible sale is subject to being advanced, deferred, modified or terminated.

In May 1974, the Department announced that it would prepare a draft environmental impact statement on the proposed program to accelerate OCS oil and gas leasing from 1.2 to 4 million hectares (3 to 10 million acres) in 1975. This proposal considered the entire United States OCS. A draft environmental impact statement on this proposed program was published in October 1974, submitted to CEQ and made available to the public for review and comment. Public hearings were held in February 1975 on this draft statement in Anchorage, AK; Beverly Hills, CA and Trenton, NJ.

In November 1974, the Department modified the goal of its proposed accelerated OCS oil and gas leasing program nationwide from leasing four million hectares (1×10^7 acres) in 1975, to holding six proposed lease sales (a proposed sale refers to a tentative sale where tract selections have been made for the purpose of preparing a site-specific environmental impact statement) in 1975 and six possible lease sales (a possible sale, refers to a tentative sale which has been listed as a proposed planning schedule but has not reached the tract selection stage of the consideration process) per year for the period 1976 through 1978, offering prospects in each frontier area (a frontier area refers to any of the 17 recognized OCS areas in which there has been no prior Federal oil and gas leasing) by the end of 1978. Accelerated leasing remained an integral part of the proposal, but the specific acreage figure had been eliminated.

The Department revised the content of the Draft OCS Programmatic environmental impact statement in light of the written comments received on that statement and oral comments submitted at the public hearings held in February 1975. A Final OCS Programmatic EIS was submitted to CEQ and made available to Federal, State and local agencies, and interested members of the public on July 7, 1975.

In September, 1975, the Department approved a program to accelerate oil and gas leasing on the Outer Continental Shelf. The Department's decision was made only after conducting in-depth studies based on the best information available considering environmental, technical and economic aspects of the proposal to accelerate OCS leasing.

On November 14, 1974, a proposed OCS planning schedule was announced by the Department of the Interior at a conference with coastal States' Governors. This schedule reflected the proposed accelerated leasing program. The November 1974 proposed schedule was revised in June 1975 to indicate changes in timeframes concerning possible or potential sales. Most recently, in January 1977, the Department of the Interior released a modified new Proposed OCS Planning Schedule (Figure D-1) which: (1) reflects changes

Figure D-1

PROPOSED OCS PLANNING SCHEDULE

January 1977
(Revises June 1975 Schedule)

SALE AREA	1976						1977											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
44 Gulf of Mexico		F		N	S													
CI Cook Inlet		P			F		N	S										
47 Gulf of Mexico					E	P		F	N	S								
42 North Atlantic				E		P			F		N	S						
43 South Atlantic								E		P		F		N	S			
46 Kodiak									E		P			F		N	S	
45 Gulf of Mexico							T			E		P			F		N	S
48 Southern California	C		D				T						E		P			F
49 Mid-Atlantic					C		D			T						E		P
Beaufort Sea (near shore)									State - Federal Sale									
51 Gulf of Mexico							C		D			T						E
53 General Pacific							C		D					T				
54 S. Atlantic Blake Plateau											C		D			T		
50 Beaufort Sea 2/													C		D			T
55 Northern Gulf of Alaska																C		D
52 North Atlantic																	C	
56 South Atlantic																		
58 Gulf of Mexico																		
57 Bering - Norton																		
59 Mid-Atlantic																		
60 Bering Sea St George																		
61 Cook Inlet																		
62 Gulf of Mexico																		
63 General Pacific																		
64 Kodiak - Aleutian																		

SALE AREA	1978												1979												1980											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
44 Gulf of Mexico																																				
CI Cook Inlet																																				
47 Gulf of Mexico																																				
42 North Atlantic																																				
43 South Atlantic																																				
46 Kodiak																																				
45 Gulf of Mexico																																				
48 Southern California		N	S																																	
49 Mid-Atlantic			F		N	S																														
Beaufort Sea (near shore)		1/																																		
51 Gulf of Mexico		P			F		N	S																												
53 General Pacific		E		P			F		N	S																										
54 S. Atlantic Blake Plateau				E		P			F		N	S																								
50 Beaufort Sea 2/						E		P			F		N	S																						
55 Northern Gulf of Alaska			T						E		P			F		N	S																			
52 North Atlantic	D			T						E		P			F		N	S																		
56 South Atlantic		C		D			T						E		P			F		N	S															
58 Gulf of Mexico			C		D			T						E		P			F		N	S														
57 Bering - Norton					C		D			T						E		P			F		N	S												
59 Mid-Atlantic								C		D			T						E		P			F		N	S									
60 Bering Sea St George										C		D			T						E		P			F		N	S							
61 Cook Inlet													C		D			T						E		P			F		N	S				
62 Gulf of Mexico														C		D			T						E		P			F		N	S			
63 General Pacific																C		D			T						E		P			F		N	S	
64 Kodiak - Aleutian																	C		D			T						E		P			F		N	S

BUREAU OF LAND MANAGEMENT

U.S. DEPARTMENT OF THE INTERIOR, March 3, 1849

Director, Bureau of Land Management

C - Call for Nominations
D - Nominations Due
T - Announcement of Tracts
E - Draft Environmental statement
1/ State May Conduct Sale

P - Public Hearing
F - Final Environmental Statement
N - Notice of Sale
S - Sale
2/ Within 50 Foot Isobath or Technology Capability

Sales are contingent upon technology being available for exploration and development. A decision whether to hold any of the lease sales listed will not be made until completion of all necessary studies of the environmental impact and the holding of public hearings; as a result of the environmental, technical, and economic studies employed in the decision making process, a decision may, in fact, be made not to hold any sale on this schedule.

INT: 1392-77

in the timetables for consideration of certain possible sales; (2) adds new possible sales for consideration, including one in the South Atlantic region (No. 56); and (3) deletes from consideration during the period covered (through 1980) certain possible sales previously shown in the June 1975 version. This new January 1977 proposed OCS planning schedule is based upon review and comments by coastal States, together with environmental values, demand for petroleum resources, resources potential and industry interest to develop the resources.

This proposed OCS planning schedule does not represent a decision to lease in any of these particular areas. It represents the Department's intent to consider leasing in such areas and to proceed with the leasing and development of such areas if it should be determined that leasing and development would be environmentally, technically, and economically acceptable.

As in the case of the proposed South Atlantic OCS oil and gas lease sale No. 43, the Department has committed itself to preparing site-specific draft environmental impact statements on each oil and gas lease sale that may be proposed. This is in addition to the Final OCS Programmatic EIS and the approval of the accelerated OCS oil and gas leasing program.

The approved accelerated leasing program that includes proposed sales in the South Atlantic does not constitute a decision on this proposed lease sale. This site-specific proposal will be considered on an individual basis after the waiting period for the final site-specific EIS has expired, and only after the Department has considered the environmental, technical and economic aspects of this particular lease sale proposal.

In the planning for the accelerated leasing program, a request for comments from all concerned parties on potential OCS oil and gas leasing appeared in the Federal Register in February 1974. The Bureau of Land Management and the U.S. Geological Survey reviewed all the responses received, and on the basis of these responses, determined several rankings of the 17 OCS areas, including the South Atlantic, which were delineated in the request. The South Atlantic was ranked thirteenth among the 17 areas in a composite ranking according to its resource potential and preference. Four petroleum companies also ranked the 17 areas on the basis of environmental hazard. From least to greatest hazard, on a scale of one to ten (ten being greatest hazard), the South Atlantic was given a ranking of five (USDI-BLM, 1974a). Detailed analyses of the factors affecting this environmental ranking were not provided. This request for comments and ranking procedures was the first tier in the two-tier nomination system for OCS leasing, the second procedure being the tract selection process.

The Council on Environmental Quality (1974a) ranked the Atlantic and Gulf of Alaska OCS areas for environmental hazard. From the least to greatest hazard, CEQ placed the southeast Georgia Embayment as the most hazardous of six generalized areas in the Atlantic, just ahead of the Gulf of Alaska in environmental hazard.

E. Relationship to Other Governmental Programs

1. Federal

a. Administrative and regulatory responsibilities

As indicated in Section I.B., pre-leasing evaluations and analyses and leasing procedures are the responsibility of the Department of the Interior—primarily the Bureau of Land Management and the U.S. Geological Survey. The U.S. Fish and Wildlife Service helps design environmental studies and acts in an advisory capacity through much of the leasing process.

Several agencies, including Interior agencies, are involved in regulatory aspects of offshore oil and gas operations which involve their program areas. Offshore structures require permits to assure that navigation is unobstructed (permits are issued by the Department of Defense, Secretary of the Army, Corps of Engineers), and to ascertain that structures are properly marked to protect navigation (permits are issued by the Department of Transportation, U.S. Coast Guard). Establishment and enforcement of navigational safety is also a responsibility of the U.S. Coast Guard. Pipeline safety is regulated by the Materials Transportation Bureau (MTB) in the Department of Transportation. In May 1976, the Secretary of the Interior and the Secretary of Transportation signed a Memorandum of Understanding (MOU) regarding pipeline safety regulations on the OCS. This MOU specifies each agency's individual responsibilities for pipeline safety supervision and their joint responsibilities for inspection, enforcement, and coordination. The U.S. Geological Survey considers safety features of design specifications in approving applications (Appendix D), and regulates other aspects of oil and gas development through the OCS operating orders (Appendix G) and notices to lessees and operators. BLM grants the rights-of-way for pipelines through the Federal OCS region.

The Federal Power Commission (FPC) and Interstate Commerce Commission (ICC) regulate pipelines linked to interstate commerce, and the FPC sets the wellhead price of OCS-produced gas.

Permits for and regulation of oil discharges are under the jurisdiction of the Environmental Protection Agency (EPA), by the authority of the Federal Water Pollution Control Act (FWPCA), as amended in 1972 (33 U.S.C. 466; 86 Stat. 816). The FWPCA established a National Pollutant Discharge Elimination System (40 CFR 125, 38 F.R. 13528). This system applies to discharges from any point source and requires a permit from EPA for the discharge of any pollutant as defined by the Act. Interim standards limit discharges to 32 mg/l not to exceed 50 mg/l on any one day. Discharges of pollutants without the necessary permit from EPA are unlawful. In accordance with the same Act, the U.S. Coast Guard approves the procedures followed and the equipment used for the transfer of oil from vessel to vessel and between onshore and offshore facilities and vessels. Both the Coast Guard and the Geological Survey perform surveillances for oil spills and discharges along pipeline routes from offshore to onshore facilities. The FWPCA also provides for a National Oil and Hazardous Substances Pollution Contingency Plan for which EPA and the Departments of Interior, Transportation, and Defense will share responsibility.

In addition, an OCS Advisory Board has been established pursuant to the provisions of the Federal Advisory Committee Act and under the authority of the OCS Lands Act of 1953. The objective of the Board is to advise the Department of the Interior in the performance of discretionary functions under the OCS Lands Act. These functions include all aspects of exploration and development of OCS resources, for example, resource evaluation, environmental assessment, leasing, mitigating of adverse impacts, and development plans. In formulating recommendations the Advisory Board shall, as applicable, request advice from the OCS Environmental Studies Committee.

The Advisory Board is chaired by the Secretary of the Interior or his designee and membership consists of one representative from the following: Department of State, Environmental Protection Agency, Federal Energy Administration, Council on Environmental Quality, and the U.S. Departments of Commerce, Defense, and Transportation. In addition, one representative from each of the 22 coastal States plus Pennsylvania are members of the Advisory Board.

The OCS Environmental Studies Advisory Committee was created pursuant to the provisions of the Federal Advisory Committee Act and under the authority of the OCS Lands Act. This Committee advises the Department of the Interior on the design and implementation of studies related to oil and gas exploration and development on the OCS. These studies include baseline or benchmark data collection, evaluation, monitoring and special studies. The committee will serve as the scientific counterpart of the OCS Advisory Board.

The Committee is chaired by a Department of the Interior scientist, designated by the Assistant Secretary, Land and Water Resources, and membership consists of one representative each from the Environmental Protection Agency, National Oceanic and Atmospheric Administration, National Science Foundation, the U.S. Coast Guard, U.S. Geological Survey, U.S. Fish and Wildlife Service, and the Bureau of Land Management. In addition, each of the 22 coastal states, plus Pennsylvania, similar to the Advisory Board, will have one appointed member on the committee. To achieve a balance of views the Secretary of the Interior can appoint not more than six scientists from the private sector to the committee.

The Fishery Conservation and Management Act of 1976 (P.L. 94-265) established a 200-mile fisheries conservation zone off the coasts of the U.S. and its possessions, effective March 1, 1977. The Act provides for creation of Regional Councils to be composed of individuals representative of State and Federal interest responsible and concerned for commercial and recreational fisheries in the marine environment. Administered under the Department of Commerce, the National Marine Fisheries Service will assist the Regional Councils in developing fishery management plans inclusive of the outer continental shelf in the South Atlantic. The South Atlantic Fishery Management Council will develop the fisheries plan for the marine environment corresponding to the offshore area under study for proposed OCS Sale 43. This plan will serve as a basis for policy and management decisions relating to fisheries in the South Atlantic.

b. Other Federal activities on the South Atlantic OCS

Principal military uses of the South Atlantic OCS are by the Navy and Air Force. Operations are conducted for training and support of national defense interests. Exercises include surface and aerial gunnery, bombing, torpedo firing; air-to-air, air-to-surface, and surface-to-surface missile firings; air combat maneuvering; aircraft carrier operations; and surface ship and submarine training.

Launching of space and test vehicles from Cape Kennedy Space Center by the National Aeronautics and Space Adminstration creates a major hazard zone during these activities.

2. State

While the Department of the Interior has diverse leasing, regulatory and other responsibilities with regard to OCS oil and gas development activities, and while these activities influence onshore development, onshore OCS-related development would be guided and controlled by State and local regulations and legislation. Following is a discussion of State programs and legislation which may be affected by or will affect onshore OCS-related activities.

a. Coastal Zone Management

The Coastal Zone Management (CZM) Act of 1972 (16 U.S.C. 1451-1464) as amended, administered by the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, provides grants-in-aid to States for the development and implementation of management programs to control land and water uses in the coastal zone. In order to qualify for implementation monies, a State must develop its management program within four years. The policy which the Act established is aimed at balancing protection of the coastal environment with development and economic interests.

Amendments to the CZM Act were adopted in July 1976 providing that states which are preparing a management program under Sec. 305 of the Act may receive supplementary grants and loans to deal with coastal zone impacts of OCS and other energy developments.

The CZM Act requires that Federal action within the coastal zone must generally be consistent with a state's CZM program once that program has been approved by the Secretary of Commerce. Conversely, state CZM plans must consider the national interest in facility siting. Local governments in turn must consider state and regional interests in the exercise of their coastal regulatory powers.

Under the consistency provision of the Act, exploration and development plans of OCS oil and gas lessees will receive consistency review by affected coastal states with approved management plans.

While the Act allows individual States much leeway in devising management plans and allocating responsibilities, both among State agencies and to regions and localities, the States themselves must approve the management plans. Therefore, the types of development permitted in the coastal zone, including any that might be associated with offshore oil and gas operations in the event this proposed sale is held can ultimately be broadly influenced or controlled by the State programs.

No State adjacent to the proposed sale area has completed or received Secretary of Commerce approval for its Coastal Zone Management Plan. Expected completion dates are discussed for each state in the following pages. The final approved CZM plans of North Carolina, South Carolina, Georgia, and Florida are not expected to prohibit OCS related developments in the coastal zone. These States have expressed support for OCS energy development if sufficient safeguards for the environmental, social, and economic wellbeing of the adjacent coastal region is provided. However, State CZM plans may restrict the placement of pipelines, refineries or other support facilities in areas of particular environmental concern and set standards for their placement elsewhere, however, some provision for their appropriate location is required by the CZM Act as amended.

b. State legislation and regulation

At the present time the siting, construction and operation of OCS-related facilities onshore would be subject to a variety of state and local regulations for each state in the proposed sale area, the following describes the status of Coastal Zone Management planning and briefly identifies existing state and local legislation most pertinent to OCS developments.

North Carolina

North Carolina's Coastal Area Management Act was passed in 1975 and provides the authority to place into effect the Coastal Area Management Plan. The development of this plan is under the direction of the North Carolina Resources Commission and it is expected to be submitted to the Secretary of Commerce for approval in mid-1977 with possible approval by January 1978. Additional statutes and regulations relating to OCS activities which are either in effect or presently under consideration are listed below:

(1) Local Land Use Plans—completed for all participating coastal communities and counties except one.
(2) State Energy Policy Act—in effect.
(3) Area of Environmental Concern Plans and Regulations—under study.
(4) Areawide Waste Treatment Management Plans—under study.
(5) Air and Water Pollution Regulations—in effect.
(6) Geophysical Exploration Act and Regulations—in effect.
(7) Oil and Gas Conservation Act and Regulations—in effect.
(8) Disposition of Mineral Deposits on State Lands Under Water—Act and regulations in effect.

South Carolina

South Carolina has not yet enacted legislation to implement a coastal zone management plan although the Governor has appointed a Coastal Zone Planning and Management Council to draft such legislation. The planning effort under Section 305 of the CZM Act was recently extended by the Governor to September 1977 to allow for development of the plan and the establishment of the legislative base.

At present all development control below the mean high water line in South Carolina is Federal in the form of U.S. Army Corps of Engineers permits. In addition to comments solicited from other Federal agencies, the Corps request state comments from the South Carolina Water Resources Commission. The Commission gathers comments from concerned state agencies and the response to the Corps is coordinated through the South Carolina Budget and Control Board.

Within the Coastal Zone, Horry, Georgetown, and Charleston Counties have adopted land use zoning ordinances, and Georgetown, Charleston and Beaufort have adopted Subdivision Regulations.

The South Carolina Wildlife and Marine Resources Department is making a study of present state laws affecting the coastal zone to support the coastal zone management plan.

Georgia

The Governor's Office of Planning and Budget is responsible for coordinating the Coastal Zone Management Program in Georgia. It is expected that this program will be adopted by January 1979.

At present at least nine state laws regulate activities in Georgia's coastal zone. These laws include the: (a) Oil, Gas, and Other Minerals Drilling Act. (b) Coastal Marshlands Protection Act, as amended. (c) Water Quality Control Act, as amended. (d) Air Quality Control Act, as amended. (e) Groundwater Use Act, as amended. (f) Georgia Health Code (including Rules and Regulations for Water Supply Quality Control and Rules and Regulations for Individual Sewage Disposal Systems). (g) Solid Waste Management Act, as amended. (h) Surface Mining Act, as amended. (i) Erosion and Sedimentation Control Act.

The Coastal Marshlands Protection Act is particularly important with regard to state control of potential OCS related facilities. The act provides that "no person shall remove, fill, dredge, or drain or otherwise alter any marshlands in this State within the estuarine area thereof without first obtaining a permit from the Department of Natural Resources" (Georgia Laws 1970, p. 939 and as amended).

Georgia coastal counties have established a number of land use regulations which are relevant to potential OCS developments. Zoning regulations exist in Chatham, Bryan, Liberty and Camden Counties. Subdivision regulations are in effect in Chatham, Bryan, Liberty and Camden Counties and are pending in Glynn County. Building permits are required by Chatham, Bryan, Liberty and Glynn Counties. A sand dune ordinance is in effect in Glynn County and is pending in Chatham, Bryan and Liberty Counties. (Georgia Department of Natural Resources, Handbook: Building in the Coastal Environment, June 1975.)

Florida

Under the new CZM Act Amendments, Florida expects to receive Secretary of Commerce approval of their CZM plan by September 1978. The plan is under development by the Bureau of Coastal Zone Management within the Florida Department of Natural Resources. The State already has extensive authority to regulate activities within its coastal zone although these powers are contained in a number of legislative acts and are administered by several state agencies.

The Florida Department of Natural Resources, Bureau of Coastal Zone Planning has identified 24 laws which bear in some degree upon activities and developments within the State's coastal zone (Suggested State Policy and Criteria for Coastal Management in Florida, Preliminary Draft October 1, 1976).

Two of these may have particular significance to OCS development.

Local Government Comprehensive Planning Act of 1975, Chapter 163.3161-163.3211 F.S.

Requires mandatory comprehensive planning by cities and counties by 1979. This act is particularly significant to OCS impact planning because it provides that counties, municipalities, and certain other units of local government are required by July 1, 1979, to prepare and adopt comprehensive plans for guiding future development. Among the act's required planning elements are: future land use (Section 7(6)(a)), conservation (Section (6)(d)), recreation and open space (Section 7(6)(c)), intergovernmental coordination (Section 7(6)(h)), and where appropriate, coastal protection (Section 7(6)(g)). Local plans adopted in accordance with provisions of the act have the force of law and are binding upon future actions of local government.

The Florida Environmental Land and Water Management Act of 1972, Chapter 380, F.S.

Provides for the accomplishment of proper state land and water management policies through the coordination of local decision-making and actions relating to growth and development. Plans for developments which will have regional impact must be reviewed and approved by the affected Regional Planning Council.

F. Legal and Administrative Background

In 1953, the Outer Continental Shelf Lands Act (67 Stat. 462) established Federal jurisdiction over the submerged lands of the Continental Shelf seaward of the state boundaries (usually the three-mile limit of the territorial seas). Federal jurisdiction of the OCS beyond the three-mile limit on the Atlantic coast was upheld in March 1975, in the Supreme Court decision U.S. vs. Maine, 420 U.S. 515 (43 L.ED.2nd 363). The OCS Lands Act charged the Secretary of the Interior with the responsibility for administration of mineral exploration and development on the OCS. It also empowered the Secretary to formulate regulations so that provisions of the Act might be met.

Subsequent to the passage of the OCS Lands Act of 1953, the Secretary of the Interior designated the Bureau of Land Management (BLM) as the administrative agency for leasing submerged Federal lands, and the Geological Survey for supervising operations. The Department formulated three major goals for the comprehensive management program of marine minerals. These are:

(1) The orderly development of marine mineral resources to meet the energy demands of the nation.
(2) The protection of the marine and coastal environment.
(3) The receipt of a fair return for the leased mineral resources.

These leasing objectives are based on legislative mandates as explained below.

(1) Orderly resource development is based on the OCS Lands Act which gives the Secretary the authority, in order to meet the demand for oil and gas, to grant leases to the highest qualified bidder(s) on the basis of sealed competitive bids.

(2) The policy of protection of the marine and coastal environment is a direct outgrowth of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.). This Act requires that all Federal agencies shall utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences in any planning and decision-making which may have an impact upon the environment. Responses to these requirements by BLM include the formation of Environmental Assessment Teams, development of Environmental Impact Statements (EIS's), and sponsorship of contract studies. These studies include environmental benchmark studies, monitoring, and special studies designed to provide information for assessing the effects of oil and gas operations.

(3) Receipt of a fair return has its basis in two separate mandates. United States Code 31, Sec. 483(a) obligates the Federal Government to obtain a fair return for public lands that are sold or leased. This is further implemented within the Executive Branch by the Office of Management and Budget Circular A-25.

Section II

Description of the Environment

A. Geologic Framework

1. Introduction

The region under consideration will cover the coastal portions of the states of North Carolina, South Carolina, Georgia and Florida and encompasses the coastal plain, continental shelf, Blake Plateau and portions of the Blake-Bahama Basin of the Atlantic Ocean. Visual No. 2 N-S shows geologic and geomorphic information for this region.

The major feature of interest here is the Southeast Georgia Embayment which is bounded on the north by the Cape Fear Arch, on the south by the Florida Peninsular Arch and opens seaward toward the Blake Plateau. The origin of these features is complex; however, this description is simplified by using the concepts of continental drift and sea floor spreading. Contributions by Wilson (1966), Bullard et al. (1965) and Olson and Leyden (1973), contend that the Atlantic Ocean became closed in late Paleozoic time (Table A-1) and by the late Triassic period had formed a new rift zone which joined a series of salt basins from the Gulf of Mexico (Louann Basin) to the Proto-Mediterranean Sea. The brine in the sea is proposed to have been ten times the present salinity of sea water.

Plate boundaries, crustal blocks and magma bodies emplaced along linear features have caused prominent gravity and magnetic anomalies in the area. Some of the gravity and magnetic anomalies may be traced to post-Triassic magma emplacements; however, the most prominent features, the East Coast Magnetic Anomaly, about 100-200 gammas, (Drake et al., 1963 and Taylor et al., 1968) correlates with the edge of the continental margin north of Cape Hatteras, divides south of Hatteras with one positive limb trending under the Blake Plateau, and the prominent positive-negative anomaly extends westward crossing the coast at Brunswick, Ga. and continues inland. The positive free-air gravity anomaly also trends along the shelf slope boundary dividing at 31° N. latitude (Rabinowitz, 1973). One branch follows the magnetic anomaly across Georgia and the other branch continues along the edge of the shelf off Florida (Figure A-2). Long (1974) infers that the anomalies across Georgia may be old plate boundaries reflecting collision or separation between the plates. Suggestions have been made that the southern Georgia-Florida and Blake-Bahama blocks were added to the paleocontinent to the north in pre-Paleozoic time.

Sea floor spreading which commenced in the Mesozoic era opened the Atlantic Ocean (Figure A-3). Heavy loads of sediment began to cover the crusted blocks between the continental and Blake Escarpment blocks (Figure A-4). Upper Cretaceous and Tertiary sediments have spilled over the Blake Escarpment Block into the Blake Bahama Basin. Details of this sedimentation are shown by Emery and Zarudzki (1967). They constructed a structural profile from seismic reflection data which consisted of six JOIDES (Joint Oceanographic Institutions Deep Earth Sampling) holes drilled to the Eocene and two coastal plain holes with hole B drilled as deep as the Cretaceous period (nearly 1 km in depth). The location of JOIDES holes J1 through J6 are shown on Visual No. 2S. The USGS has just begun a core hole drilling program along the Atlantic OCS. Four holes are planned for this area and are plotted on Visual No. 2 N-S. Recently the U.S. Geological Survey has collected a series of Common Depth Point (CDP) seismic profiles across the Georgia Embayment and Blake Plateau.

2. Physiography of the Continental Shelf and Slope

The continental shelf ranges from 33 km in width at Cape Hatteras to a maximum width of 135 km between Charleston, S.C. and Jacksonville, Fla. at the Florida Escarpment. The depth of the shelf break between Cape Romain and Cape Canaveral is between 50 and 70 m (Uchupi, 1967). The shelf surface is irregular, and sand ridges are aligned at right angles to the shoreline (Figure A-5). As many as seven terraces or submerged shores have been recognized from echo sounding data on the shelf between Miami and Cape Hatteras; one of these terraces is as deep as 120 m, well below the shelf break (Dillon et al., 1975).

Numerous patch reefs dot the shelf, particularly in Onslow Bay (MacIntyre, 1970, Figure A-6). Some are considered projections of a Miocene marl overlain by a great variety of encrusting calcareous organisms (Dillon et al., 1975). Other reefs, such as Gray's Reef (Hunt, 1974), are dated as Pliocene. More extensive areas of hardbanks, known as the inner, middle and outer banks, are shown on Visual No. 2 N-S. The inner banks are the least extensive and are found near Jackson-

Table A-1. Geologic Time Chart. From Data in Braziunas, T. 1975. A geological duration chart, Geology, 3(6): 342-343.

AGE DIVISIONS: ERA	PERIOD	EPOCH	TIME: DURATION IN MILLIONS OF YEARS — ERA	PERIOD	EPOCH	BEGINNING MILLIONS OF YEARS AGO
CENOZOIC	QUATERNARY	RECENT	70.011	1.011	0.011	0.011
		PLEISTOCENE			1	1
	TERTIARY	PLIOCENE		69	9	10
		MIOCENE			15	25
		OLIGOCENE			15	40
		EOCENE			20	60
		PALEOCENE			10	70
MESOZOIC	CRETACEOUS		160	60		130
	JURASSIC			50		180
	TRIASSIC			50		230
PALEOZOIC	PERMIAN		370	40		270
	PENNSYLVANIAN			64		334
	MISSISSIPPIAN			16		350
	DEVONIAN			50		400
	SILURIAN			40		440
	ORDOVICIAN			60		500
	CAMBRIAN			100		600
PRE-CAMBRIAN	GRENVILLE OROGENY		4000			1000
	OLDEST KNOWN ROCKS IN NORTH AMERICA					3200
	OLDEST KNOWN ROCKS (MURMANSK AREA)					3400
	PROBABLE AGE OF EARTH					4600

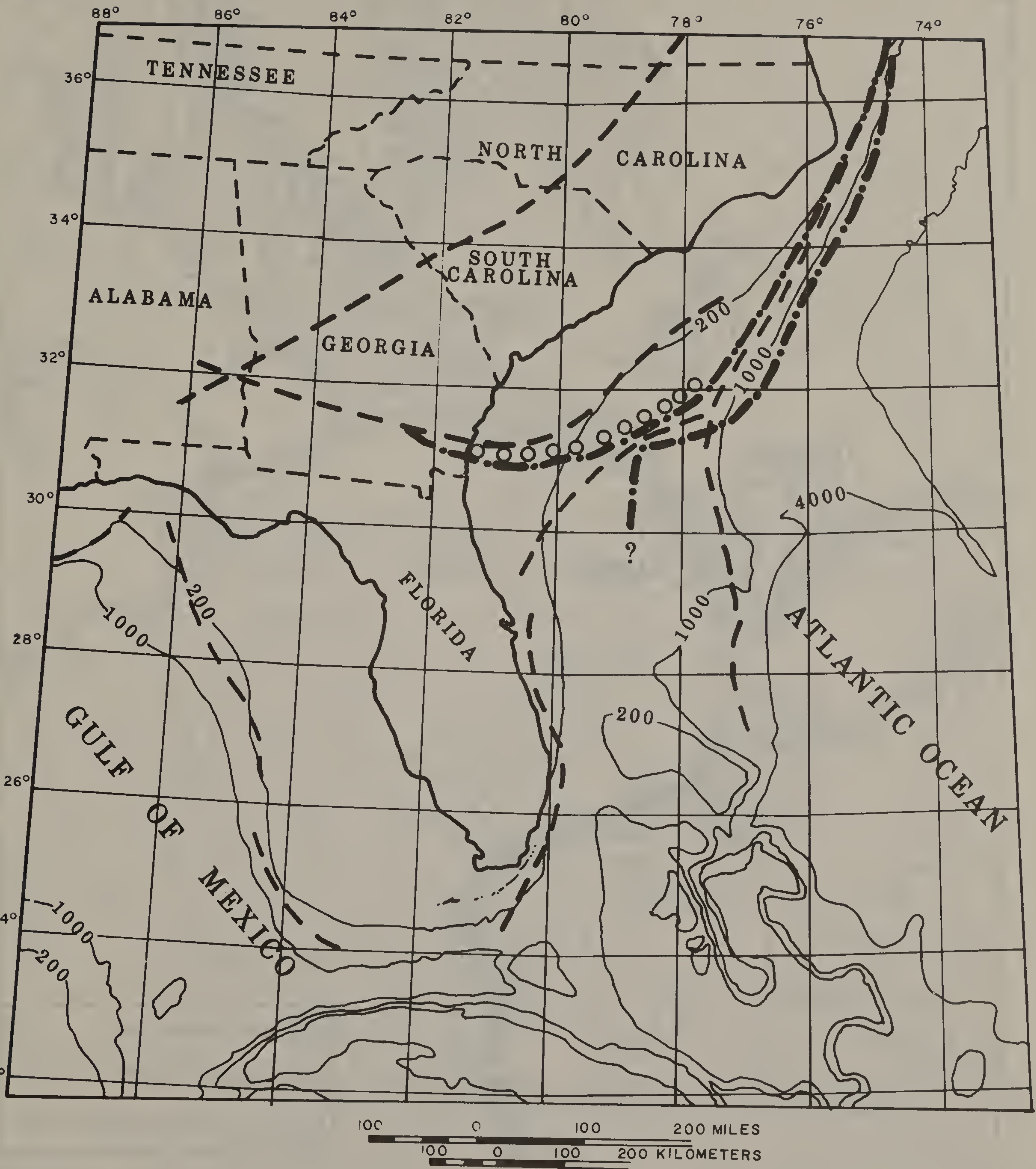


Figure A-2 Major gravity and magnetic anomaly trends in the area. Dashed line is the positive free-air gravity greater than 20 mgal. Dot-dashed line is the positive total intensity magnetic anomaly, 150-250 gammas, running along the shelf edge and along the Appalachians. The line of the circles maps the prominent negative magnetic anomaly swinging into Georgia. Source: Dillon et al., 1971.

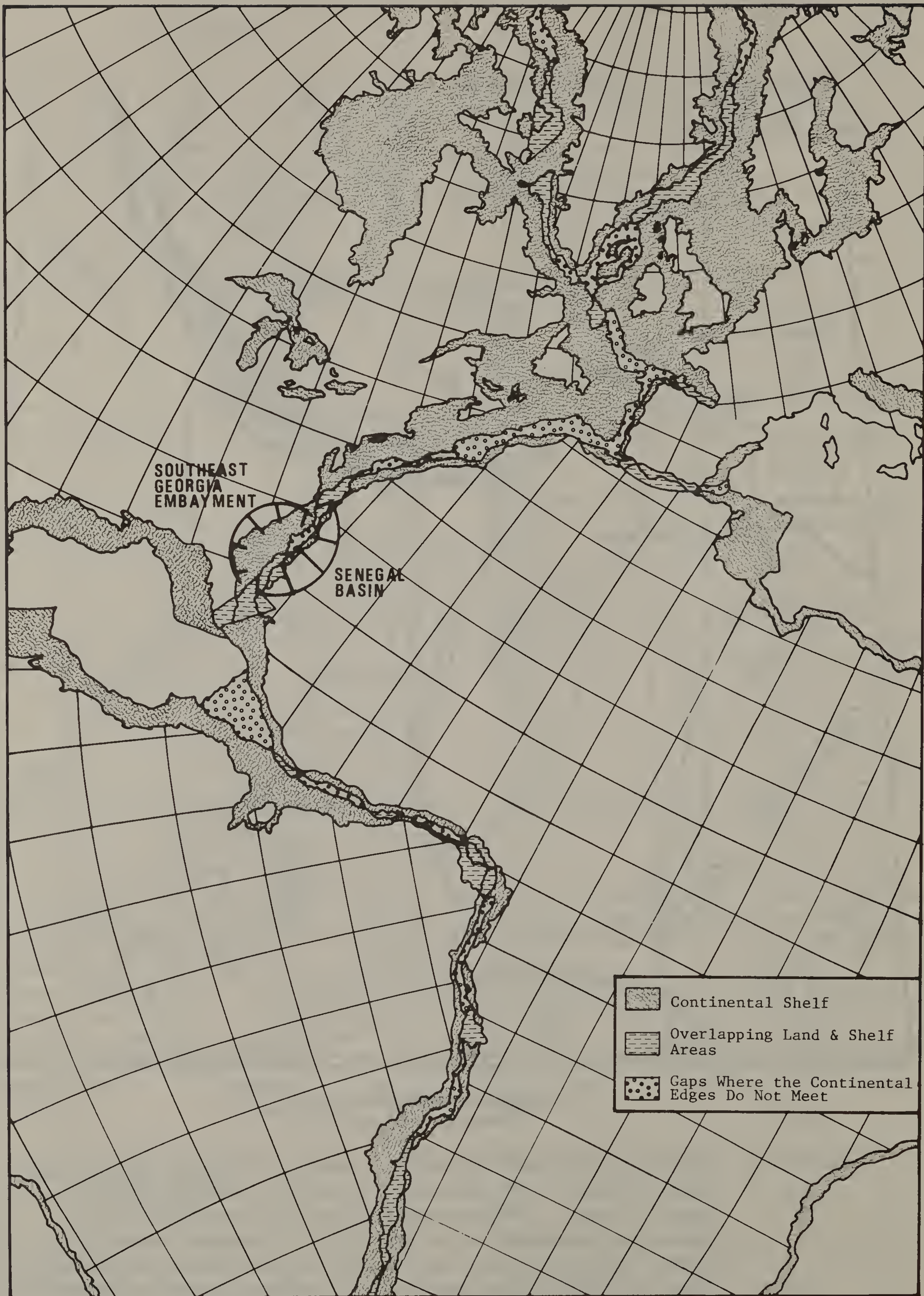
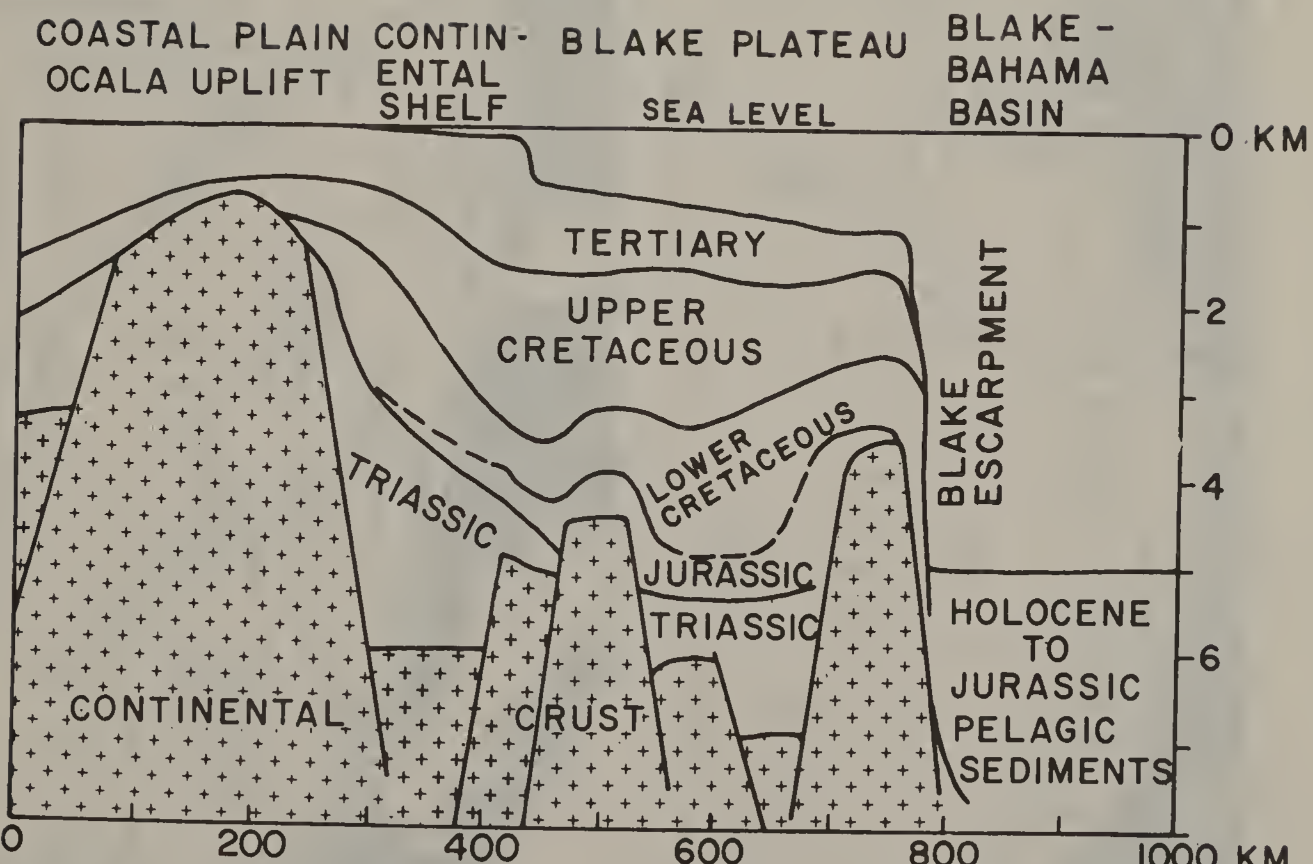


Figure A-3 Position of continents during Jurassic Time. 170 million years before present. (After Briden, Drewry, and Smith, 1974).



FIGA-4 Schematic east-west section across Florida coastal plain and Blake plateau in latitude of Jacksonville showing hypothetical deep structures. (OLSON, 1974)

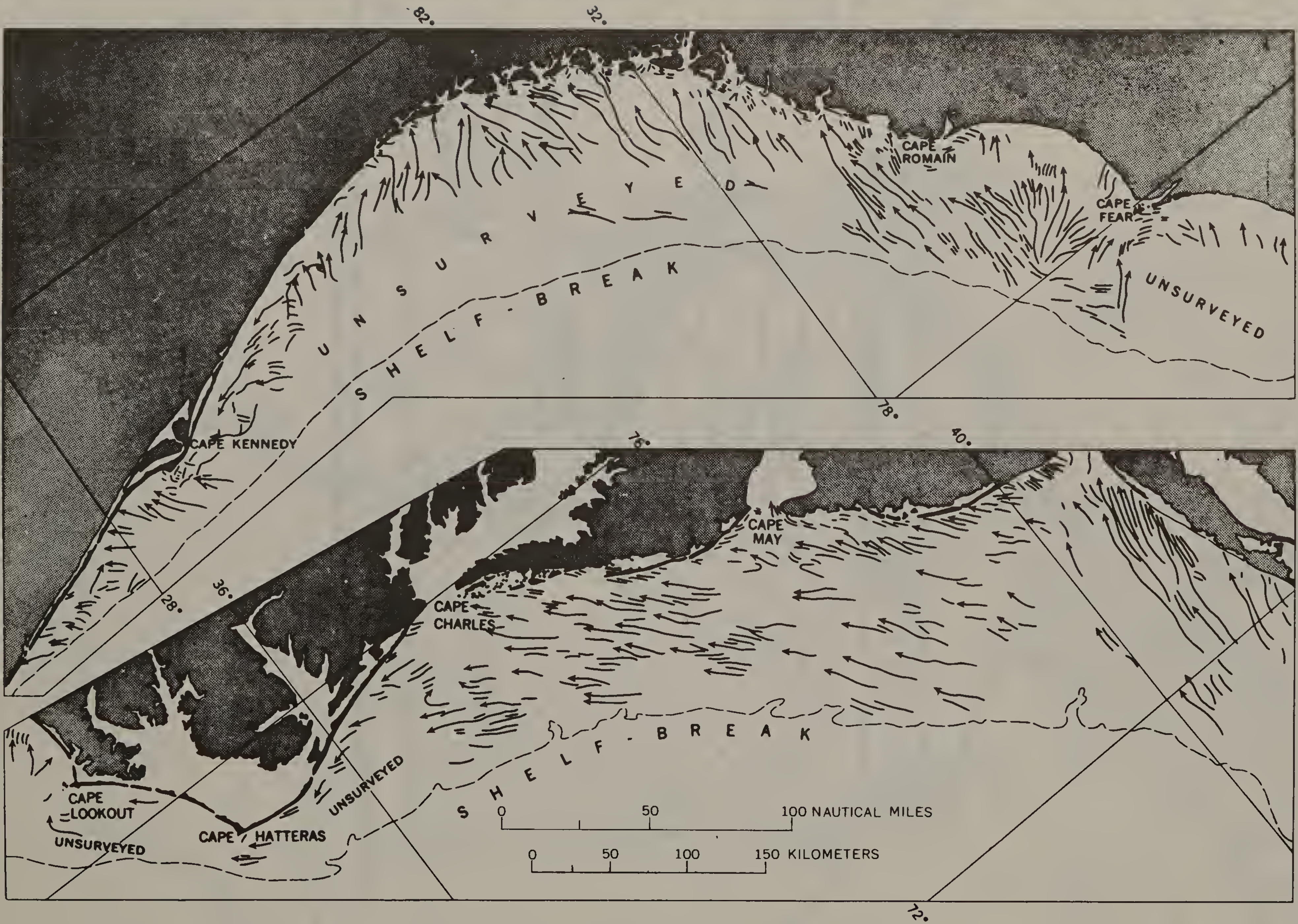


FIGURE A-5 Sand-swell crests on the continental shelf from New Jersey to southern Florida. Arrows placed on the inshore end of the sand-swell crests mapped by Uchupi (1969) resemble residual bottom drift directions determined by Bumpus (1965, 1969) and Norcross and Stanley (1967). This correlation suggests that the sand swells are alined parallel to the bottom current. The transport of bottom sediment may follow these drift directions. (HOLLISTER, 1973).

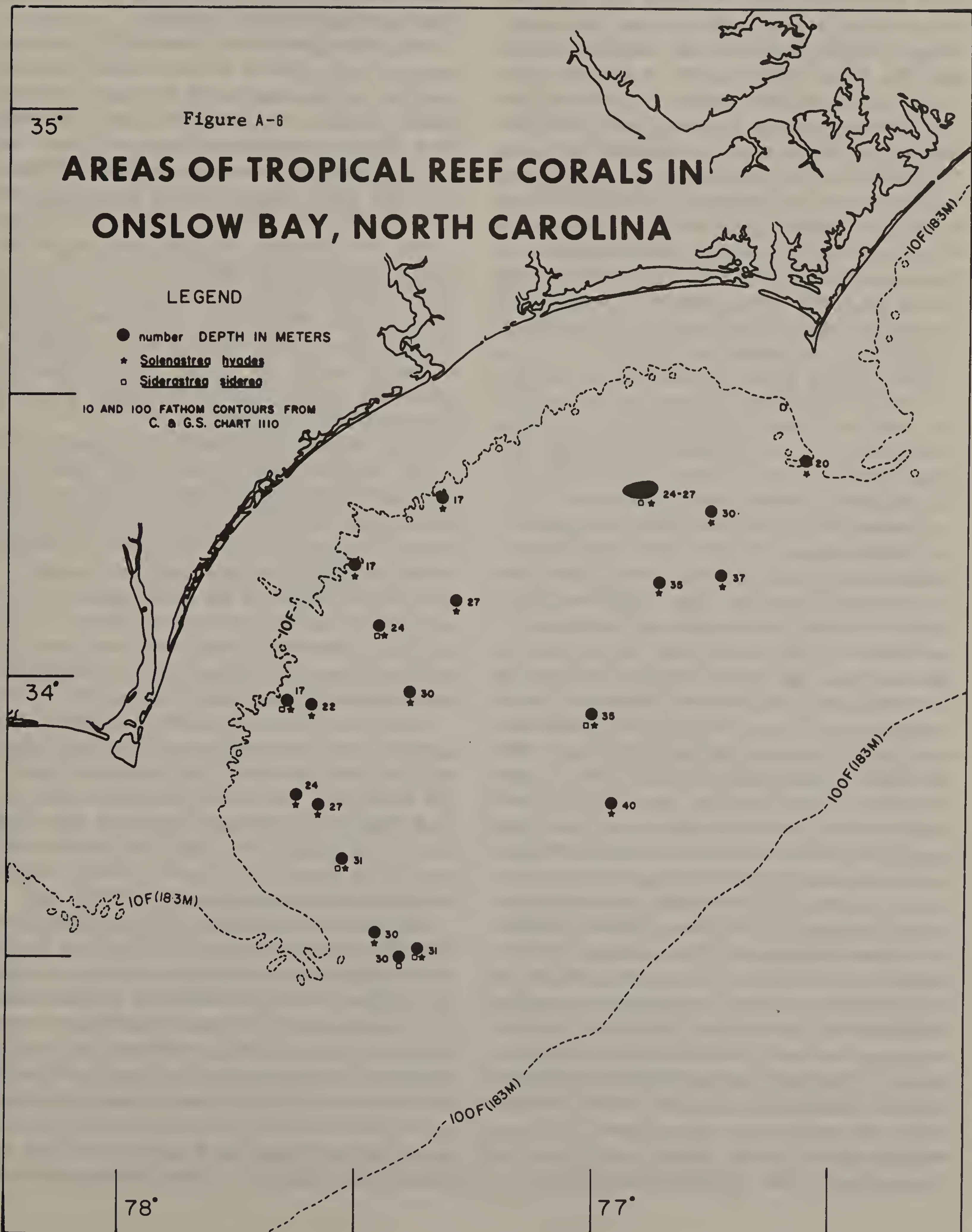


Figure A-6
AREAS OF TROPICAL REEF CORALS IN ONSLOW BAY, NORTH CAROLINA
LEGEND
number DEPTH IN METERS
Solenastrea hyades
Siderastrea siderea
10 AND 100 FATHOM CONTOURS FROM C. & G.S. CHART 1110
35°
34°
78°
77°
10F(18.3M)
10F
100F(183M)
17
17
17
22
24
24
27
27
30
31
30
30
31
35
35
37
40
24-27
30
20

ville Beach, Fla. to offshore Charleston, S.C. The best known portion of the inner banks is Gray's Reef (Lat. 31°24′, Long. 80°53′) about 32 km east of Sapelo Island. Hunt (1974), Henry (1975) and other researchers from Skidaway Institute, Ga., have studied the area with side-scan sonar, sub-bottom profiling, bottom towed cameras and diving. The inner banks appear to be low relief 'rocky' outcrops which support a growth of sessile biota, surrounded by loose sandy and silty material. These areas are commonly known as 'hard-banks' or 'live-bottom' areas and are areas used for sports and head-boat fishing. Growth on these banks appears sparse when the outcrops are covered with a thin layer of sediment and growth becomes concentrated on the rocky outcrop portion of the banks. The continuity of exposure of the outcrops or the relief (presumed to be approximately 3 to 5 m) is unknown at this time.

Less is known about the continuity of the middle banks than the inner or outer banks. The middle banks are shown to extend from offshore Jacksonville, Fla. to beyond the Frying Pan Shoals into the area of outer Onslow Bay and may be similar in nature to the inner banks.

A notable study for the Onslow Bay region is the Oceanographic Atlas of the Carolina Continental Marian (Newton et al., 1971). A study for the outer banks and the shelf break from Cape Hatteras to Fort Lauderdale was developed by MacIntyre and Milliman (1970). Major features that were surveyed include ridges in depths of 80 to 110 m near the shelf break off North Carolina (interpreted as Pleistocene algal reefs by Menzies et al., 1966). Terraces (Uchupi and Tagg, 1966) and ridges of algal origin (Uchupi, 1967; Uchupi and Emery, 1968; Zarudzki and Uchupi, 1968) which extend discontinuously along the shelf break from Cape Hatteras to southern Florida have been identified as relict features formed during low stands of sea level during the Pleistocene period (Fairbridge, 1960). Rona (1970) identified four ridges with sediment filled troughs off Cape Hatteras and interpreted these as algal ridges, or barrier beaches with algal coatings. Surveys are continuing on the shelf by MARMAP (Marine Resources Monitoring, Assessment and Prediction Project by the South Carolina Wildlife and Marine Resource Department) (Burrell, 1975). Various sources of published and unpublished data were reviewed and an outline of the major extent of the outer banks from offshore Cape Canaveral to Cape Hatteras is shown on Visual No. 2 N-S. Restricted outcrops of the outer banks probably exists southward along the Florida Escarpment.

The following information was presented by MacIntyre and Milliman (1970) for the shelf edge from Cape Fear to Cape Kennedy.

Topography: From Cape Fear (33°25′ N.) to an area just north of Cape Kennedy (29°15′ N.), the sea floor at the outer shelf and upper slope is mainly smooth and undulating, and the shelf break generally indistinct. Whenever there is no marked change in slope between depths of 60 to 80 m, the minor change in slope between depths of 40 to 50 m is taken to be the shelf break. Ledges, small terraces and slight rises are present near the shelf break in depths of 50 to 110 m, but no depth correlation was established between these features. The terraces occur at depths of 70 to 110 m, whereas the ledges (6 to 10 m relief) are in depths of 50 to 70 m. Rises commonly established on the edge of the ledges generally have relief of less than 5 m.

Bottom Photography: Bottom photographs from around the shelf break show mainly gravel and shell hash scattered in or partly covered by sand-mud matrix. Small rock fragments are present in a few photographs, and rough rock ledges covered by rich epifaunal growths are exposed locally; large clusters of the coral *Oculina* sp. are common off the coast of northern Florida. As in the area off North Carolina, the abundance of burrows, mounds and trails indicates considerable infaunal activity in this area of the sea floor.

Rock-Dredge Samples: Rock-dredge samples are generally similar to those taken between Cape Hatteras and Cape Fear; algal limestone, quartz-rich calcarenite, calcareous quartz sandstone and shell hash were collected from ledges and small rises at the shelf break. The noncarbonate fraction of the sandstones, however, is significantly higher than in the sandstones north of this area.

Sandstone and limestones nearly identical to those from the Cape Hatteras to Cape Fear region were received from small ledges or terraces, and small ridges associated with these features, near the characteristically indistinct shelf break in this area. The wide distribution of these rock types strengthens the hypothesis that they constitute a thin blanket of mainly Holocene sediments covering a pre-Holocene surface. Sparker profiles across the shelf edge just south of Cape Fear indicate thick sequences of steeply dipping prograding beds (Pilkey and MacIntyre, in prep). Although these data were obtained from only the northern part of this area, they suggest that the generally smooth and gently dipping sea floor of the outer shelf and upper slope is related to rapid deposition of pre-Holocene sediments, probably terrigenous sediments derived mainly from the Piedmont rivers of South Carolina and Georgia. The thick cover (49 m) of post-Miocene "shelly quartzose sand and sandstone" noted in a drill hole near the shelf break off Jacksonville, Fla. (JOIDES, 1965) further supports this suggestion.

3. Structure of the Southeast Georgia Embayment

The Southeast Georgia Embayment lies in a transitional zone between a predominantly classic depositional province north of Cape Hatteras and a carbonate province which includes Florida and the Bahamas. More than 400 wells have been drilled in Georgia and Florida (Visual No. 9), some drilling reached basement rock, and a few wells have been drilled in the Bahamas area. In the offshore area, in addition to taking short cores, a few test holes have been drilled several hundred feet during the JOIDES program into the Southeast Georgia Embayment (Figure A-7), but no well has been drilled offshore which penetrated pre-Tertiary strata. There are at least 2,800 m of sediments and possibly as much as 5,500 m of sedimentary rocks in the offshore basin beneath the Blake Plateau out to the 600 m water depth. It is likely that up to 4,000 m of Lower Cretaceous and Jurassic sedimentary rocks are present beneath the embayment.

The Blake Plateau has an average depth of 850 m. Uchupi (1967) describes the area north of latitude 32°s as relatively smooth, dipping seaward with a gradient greater than 0°30′ (9 m/km), and forming a transitional zone between the continental slope to the north and the broad and flat plateau proper to the south. The plateau is widest south of latitude 30°. This segment of the plateau is relatively smooth, except for a rough zone near the base of the Florida-Hatteras Slope. This irregular zone extends from the Straits of Florida to Cape Romain. Between latitudes 30° and 32° the jagged topography extends across the plateau. Within the area of rough topography there are large, broad and generally flat-bottomed hollows with reliefs in excess of 40 m. Around the margins of these lows and occasionally within them are innumerable conical hills that add to the relief of the depressions and accentuate the roughness of the topography. Bottom samples and bottom photographs indicate that the conical hills are coral mounds.

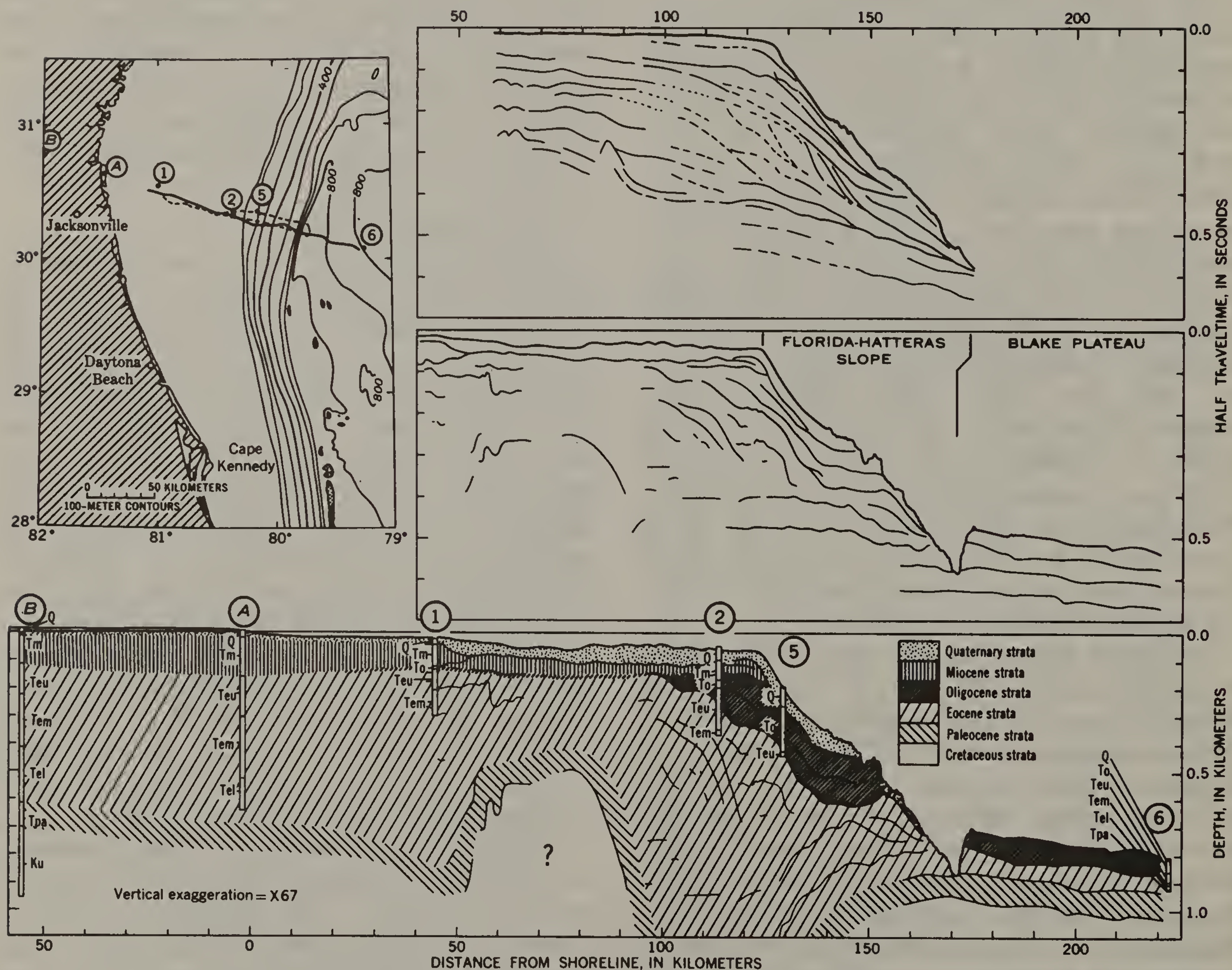
Pratt and Heezen (1964) have shown depressions in the floor of the western Blake Plateau that are thought to be erosional, possibly resulting from the deep currents associated with Gulf Stream flow. MacIntyre (1970) reported the existence of low relief mounds which were thought to be corraline in nature on the floor of the Blake Plateau. Studies involving the modern techniques of seismic reflection profiling (Markl et al., 1970) have covered the continental shelf and Blake Plateau with a series of tracklines (Figure A-8). Submersible work reported by Hawkins (1969) showed visual sightings of beds of manganese and phosphate concretions concentrated at the crests of sand waves on gentle slopes grading in size from nodules to solid pavement (Figure A-9).

4. Marine Surficial Sediments

Holister (1973) studied more than 800 bottom-sediment samples (Figure A-10 and Visual No. 9) which were collected from the continental margin between New Jersey and Florida and show that sand covers almost the entire continental shelf. The sand is mainly unimodal, is well sorted, and has a symmetrical grain-size distribution curve. Mean grain size generally increases toward the shelf break. Shelf sands containing an appreciable amount of calcium carbonate on the continental shelf south of Cape Hatteras are texturally similar to the sands consisting mainly of quartz and feldspar north of Cape Hatteras, and thus it appears that composition does not influence grain-size distribution. The continental slope off the Carolinas is covered by sand; north of this area, the slope is covered by clayey and sandy silt. The upper continental rise is veneered by silty clay.

Certain distinctive patterns of textural parameters appears to correlate with patterns of ocean-bottom circulation. The continental slope off Florida is covered by poorly sorted clay and silt deposited beneath the Gulf Stream Counter Current. Most fine-grained sediment is removed directly beneath the Gulf Stream. The silty sand near the southern margin of the Blake Plateau may be winnowed pelagic ooze transported from the eastern Blake Plateau by the westward-flowing Antilles Current. These two major current

FIGURE A-7 DRILLING ON THE CONTINENTAL MARGIN OFF FLORIDA, USGS PROFESSIONAL PAPER 581-A, BY K. O. EMERY AND E. F. ZARUDZKI, 1967.



Continuous seismic reflection profiles near JOIDES drill holes 1, 2, 5, and 6. The top right panel is a composite profile made by E. T. Bunce and S. T. Knott (in Joint Oceanographic Institutions' Deep Earth Sampling Program, 1965) just prior to drilling and along the route marked by a dashed line on the insert map. The middle panel is a profile made by Elazar Uchupi and A. R. Tagg (Uchupi and Emery, 1967) after the drilling and along the route marked by a solid line on the insert map. The bottom panel was constructed by adjusting the depths of the reflecting horizons in the middle panel for measured and estimated sound velocities (fig. 4) and correlating them with stratigraphic information from JOIDES drill holes and from wells on land (A, B) that were described by Herrick and Wait (1965) and Leve (1961).

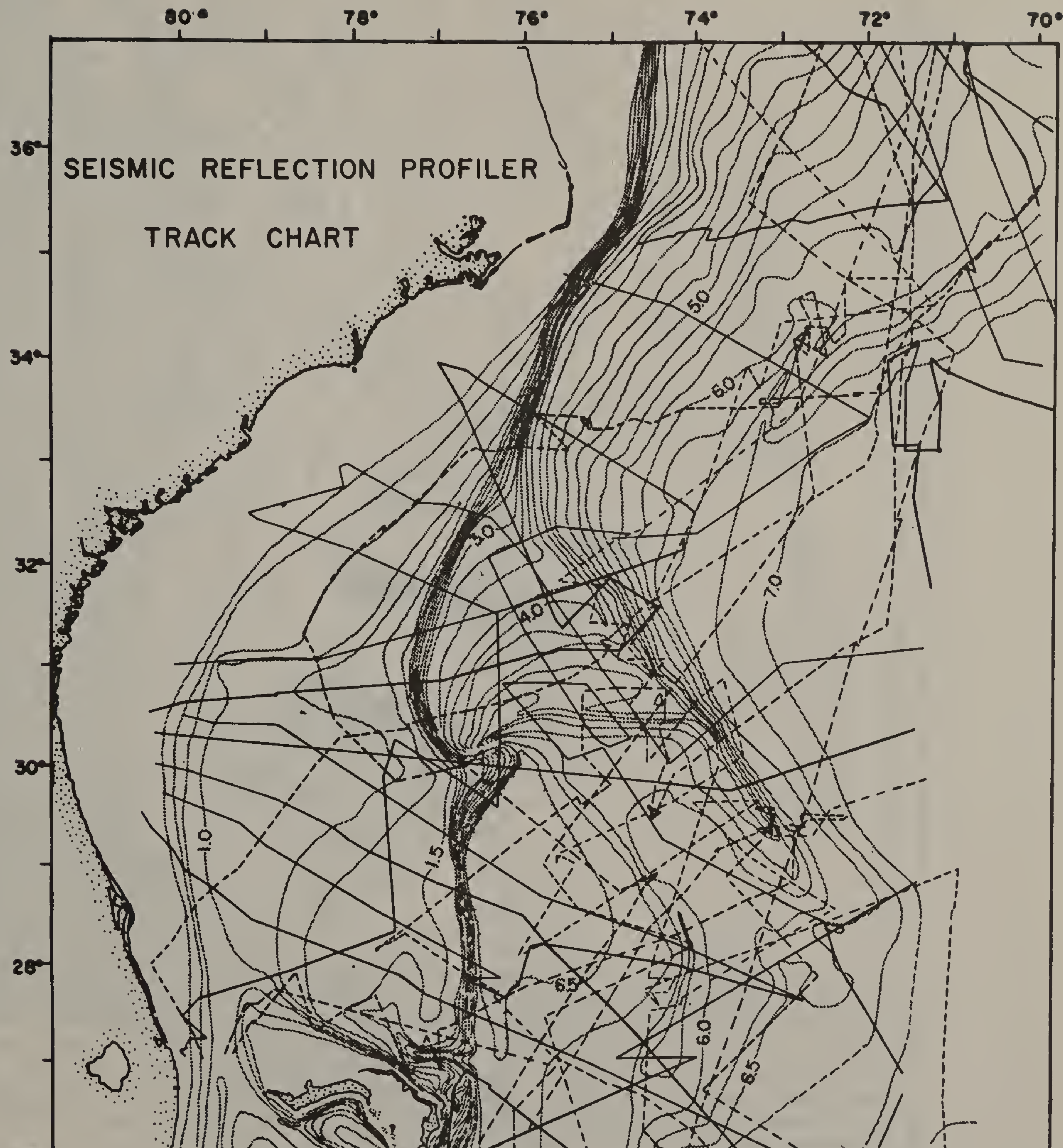


Fig.A-8 Bathymetric map and seismic profiler track chart of the area studied; contours are in seconds of reflection time (¼ sec = 100 nominal fathoms or 183 meters). Dashed tracks indicate the use of a pneumatic sound source; solid tracks indicate that explosives were used. (MARKL ET AL., 1970)

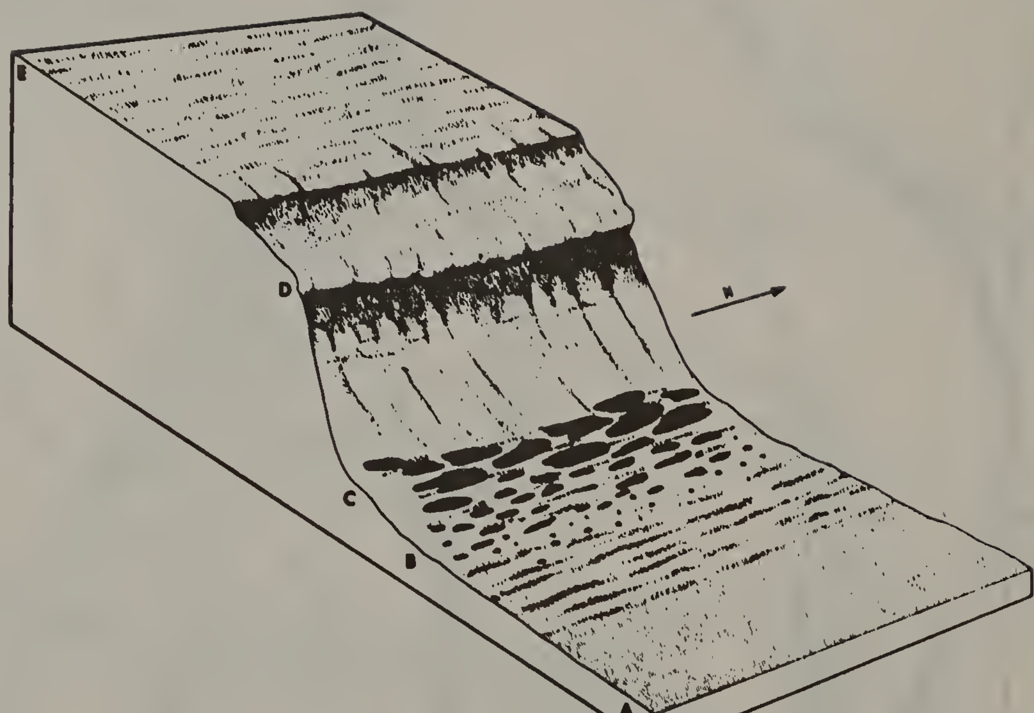
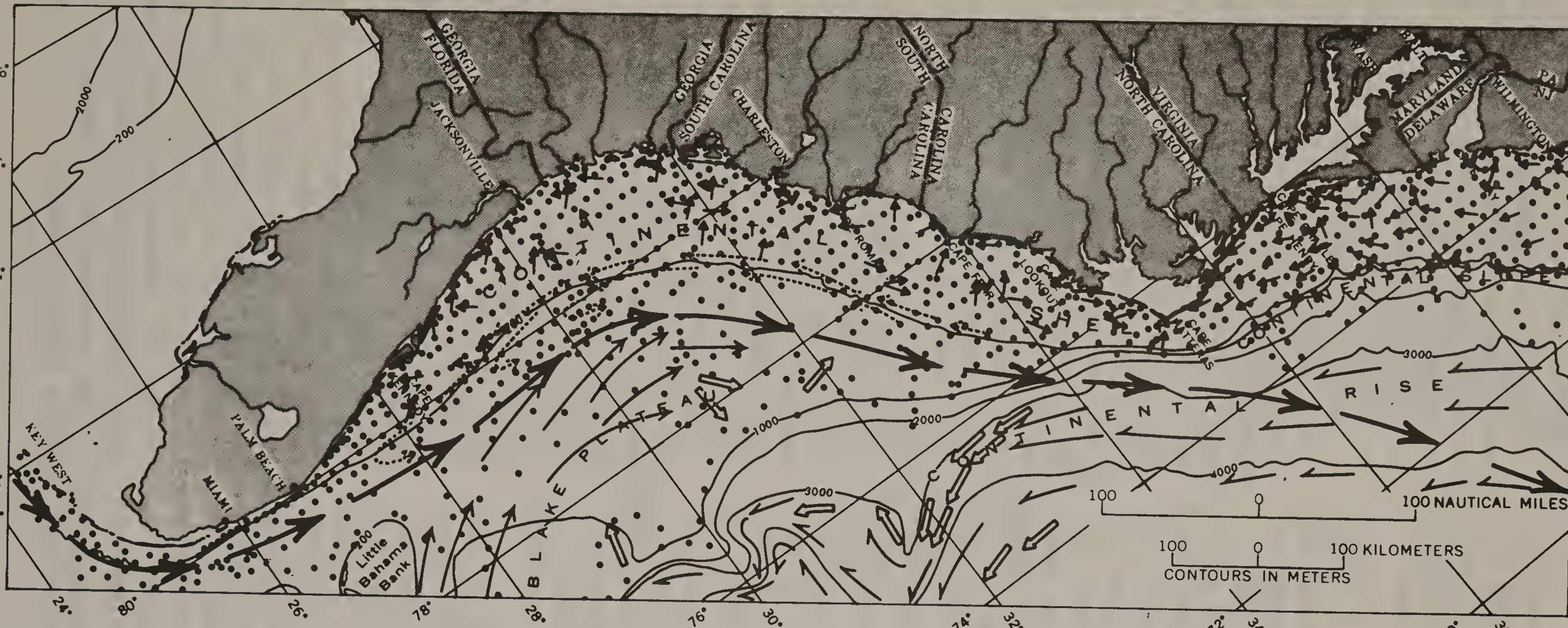


Fig.A–9 Diagrammatic view of area observed during dive 2. Vehicle bottomed at 1130 meters on a slightly undulating plain at A. A thin carbonate crust sparsely covers a manganese nodule and sand suite. Nodule exposures are intermittent with sand in N–S oriented windrows to B. From B to C the slope inclines 10° to 20°, and nodules grade to a larger size and finally to a fractured pavement at the base of the scarp. A talus slope of 45° terminates at the oxidized rock outcrop and overhang at D. From D to E a smaller talus slope and outcrop terminate the vertical feature, and the bottom resumes the appearance of nodules and interspersed sand. (HAWKINS, 1969)



EXPLANATION

Sample location

Gulf Stream Counter Current

Western Boundary Undercurrent

Gulf Stream *(Bottom axis)*

Antilles Current

Residual bottom drift *From Bumpus (1965) and Norcross and Stanley (1967)*

Photographic current measurement *From Pratt (1963) and Heezen, Hollister, and Ruddiman (1966)*

FIGURE A-10

Continental margin from New Jersey to southern Florida showing sample localities and bottom currents. The area is south of the region of glaciation. Textures of surface samples taken north of the area shown in this figure are given by Schlee (1973). (HOLLISTER, 1973).

systems appear to control sediment texture on the Blake Plateau.

One of the most detailed offshore bottom sediment and shallow structure studies is being conducted under the direction of the U.S. Corps of Engineers, Coastal Engineering Research Center in Fort Belvoir, Virginia, by Edward P. Meisburger.

In 1964, a program was initiated to survey offshore regions of the Atlantic, Pacific, Gulf and Great Lakes coastal areas to delineate the character of sand deposits. Formerly called the Sand Inventory Program, it was initiated with a survey of the New Jersey Coast. Subsequent surveys have included the inner Continental Shelf off Florida, New England, New York, Maryland and part of North Carolina, Delaware, Virginia and California. The program is now referred to as the Inner Continental Shelf Sediment and Structure Program (ICONS). The ICONS program is directed towards mapping of sand deposits suitable for beach restoration and delineation of shelf structural characteristics.

As shown in Figure A-11, four surveys within the southeastern Georgia embayment have been studied and reports have been written. They are: TM No. 29, Long Key to Palm Beach; TM No. 34 Delray Beach to Cape Canaveral; TM No. 42 Melbourne to north of Titusville; TM No. 54 Cape Canaveral to St. Augustine. Data has been collected off the North Carolina Coast between Cape Lookout and the South Carolina border but no report has been written. Survey tract line grids have a one mile line spacing and reconnaissance lines were run in a zig-zag pattern.

Visual No. 9 bottom sediment portion is taken entirely from Newton, Pilkey and Blanton, (1971). This sediment distribution map is a textural classification with no particle size analysis. Fig. A-12 is a map showing the abundance of heavy minerals on the Onslow Bay portion of the Carolina Shelf. Heavy minerals represent a potential economic resource on the Continental Shelf. Figure A-13 is a map of the distribution of fine sand-sized phosphorite grains. The area of highest phosphorite concentration near Cape Fear has been examined by several phosphate mining companies as a potential deposit of commercial grade phosphate.

5. Coastal and Onshore Geology

a. General geology and physiography

Capes, shoals and barrier islands which encompass the lagoons, marshes and coastal waterways, are the prominent features along this portion of the Atlantic Coast. Hoyt and Henry (1971) conclude that the concurrence of capes and rivers is too prevalent to be fortuitous. Cape Fear, N.C., is postulated to correspond to a shoal area seaward of the Pleistocene mouth of the Neuse River prior to its capture by the Pamlico River. Development of the Cape Hatteras complex has been augumented by sediments from the Roanoke and Pamlico Rivers and from the Susquehanna River-Chesapeake Bay system.

These capes are not deltas under present conditions; however, at the beginning of a glacial stage, the river gradients were markedly increased by sea-level lowering and deltas developed. As the sea retreated, the deltas formed farther seaward on the continental shelf, resulting in the deposition of deltaic ridges of sediment perpendicular to the coast.

During the subsequent submergence which accompanied glacial melting, the deltas became the loci of barrier islands and prominent capes. Submergence was accompanied by erosion and retreat of the barrier capes resulting in the present capes, shoals, and embayments (Figure A-14). Swift (1970) explains that the genesis of most barriers is that they have retreated in from the position of their immediate predecessors. Barrier genesis, in the classic sense of large-scale, refers to coastwise spit progradation or mainland-beach detachment depending on coastal relief and slope, with steep, rugged coasts favoring spit progradation at the expense of mainland-beach detachment. Since most major barrier systems form on flat coastal plains, it would appear that mainland-beach detachment is the more important mode of barrier formation.

During stillstands or periods of reduction in the rate of sea level rise, coasts can more nearly approach their climax configuration in which the shoreline is relatively straight, and the shoreface is well developed and of maximum possible slope.

Research on barrier islands and coastal terraces by Skidaway Institute particularly, explain the geomorphology of Coastal Georgia and Northern Florida. According to Oertell (1974), barrier islands along the Georgia coast are separated by

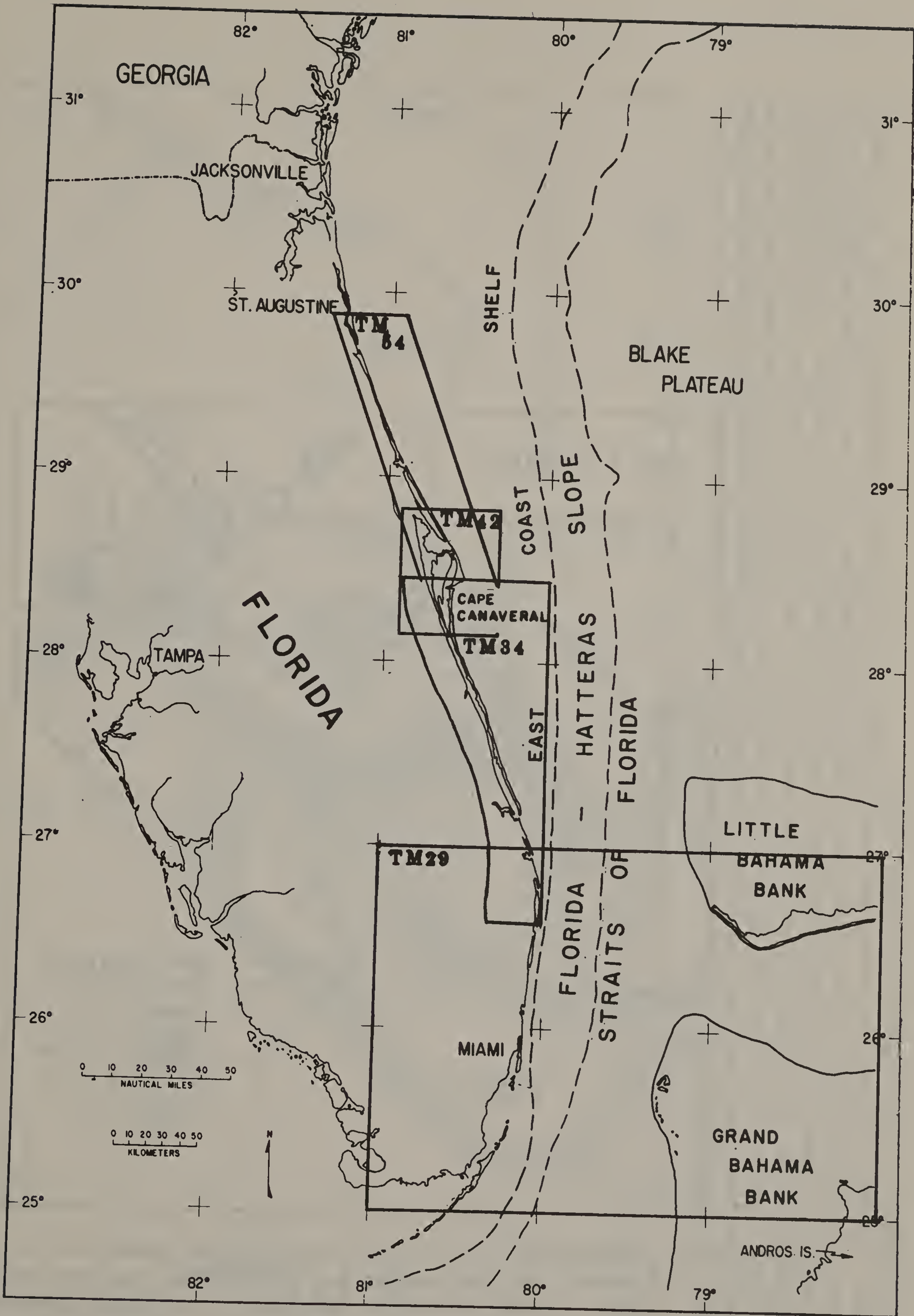


Figure A-11 Map of the Major Physiographic Provinces of the Florida Continental Margin. The survey areas are outlined. Source: U.S. Army Corp of Engineers, 1975.

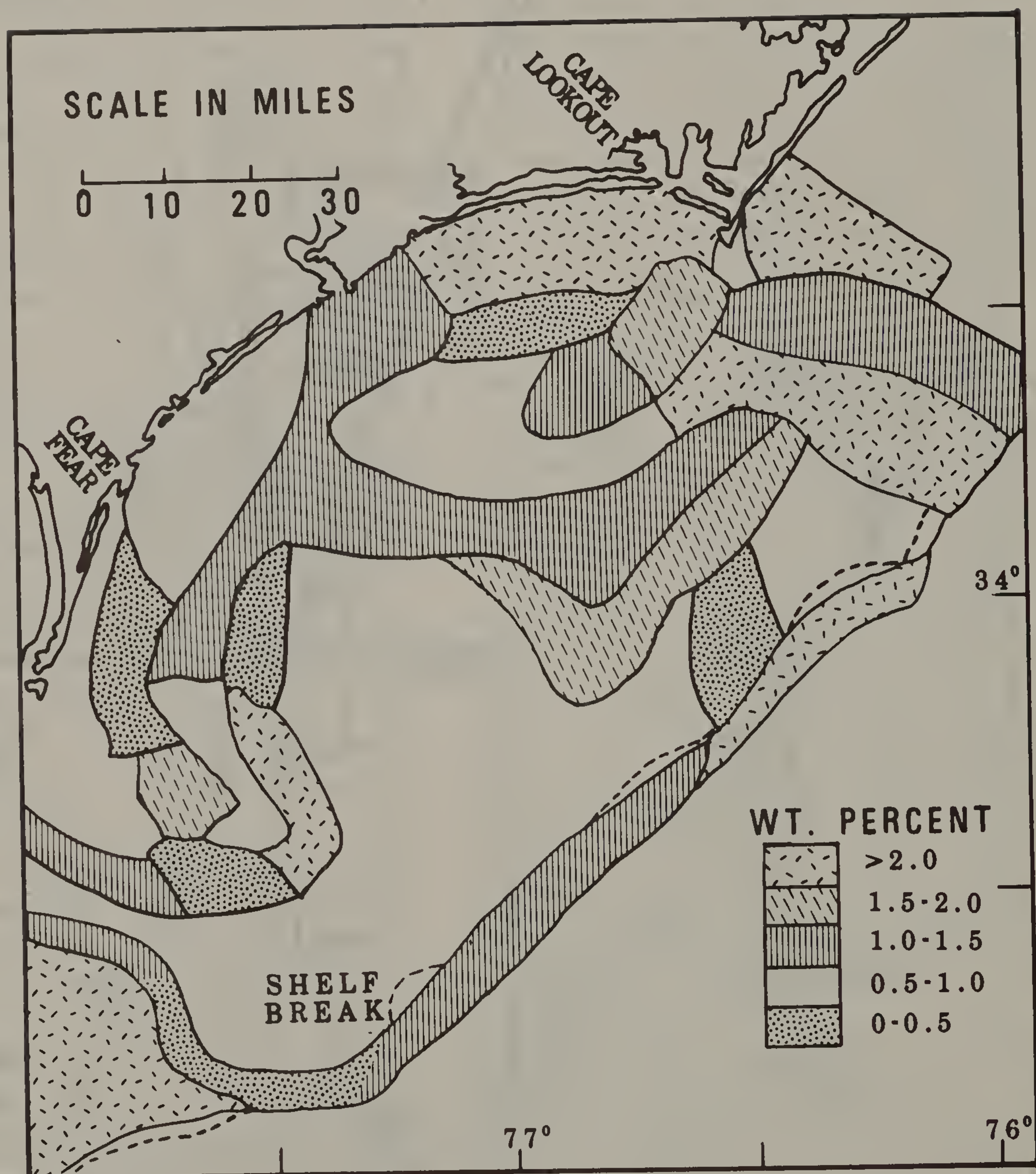


Figure A-12 Map showing the distribution of the abundance of heavy minerals on the Onslow Bay portion of the Carolina shelf. Heavy minerals represent a potential economic resource on the continental shelf. Source: Newton, et al., 1971.

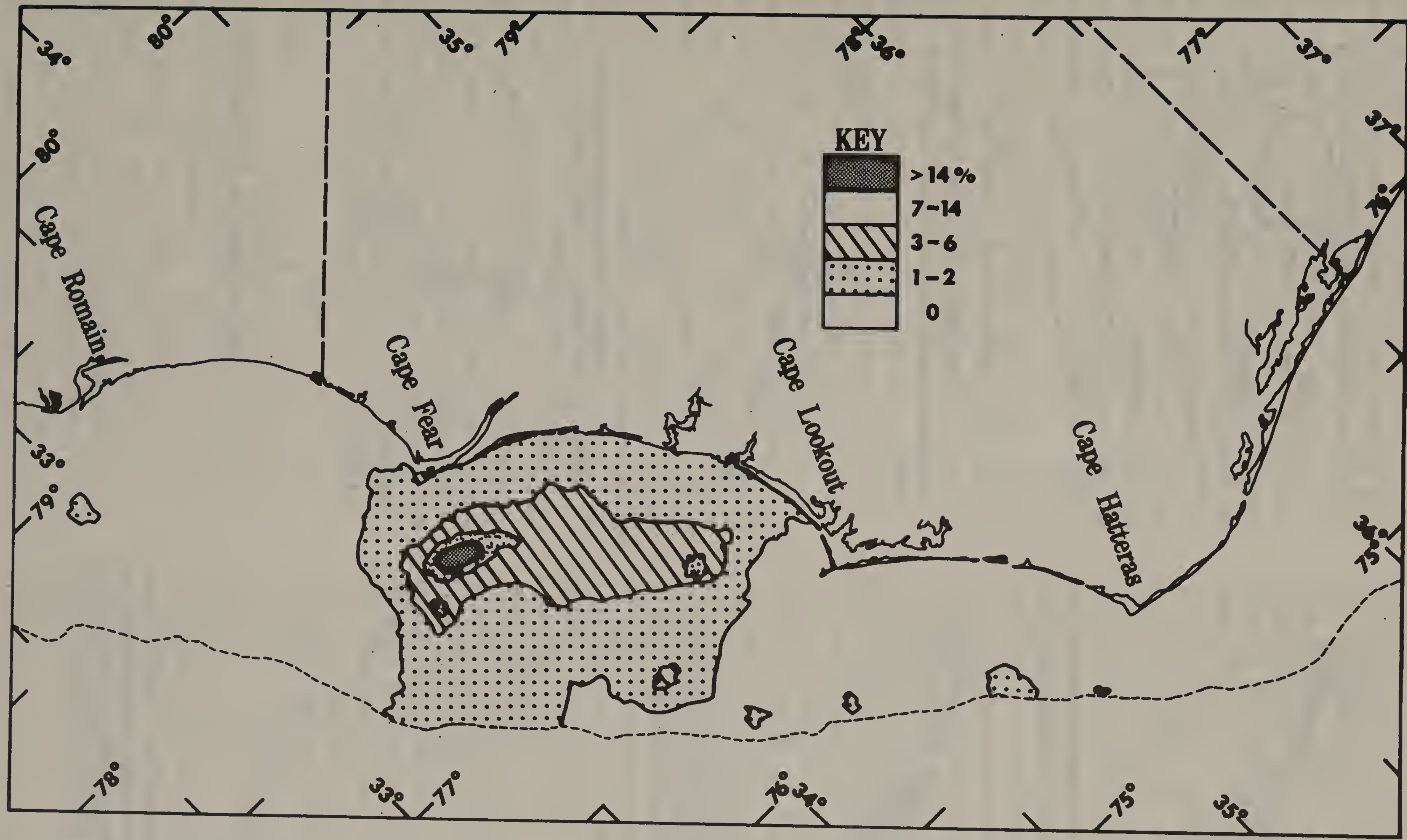
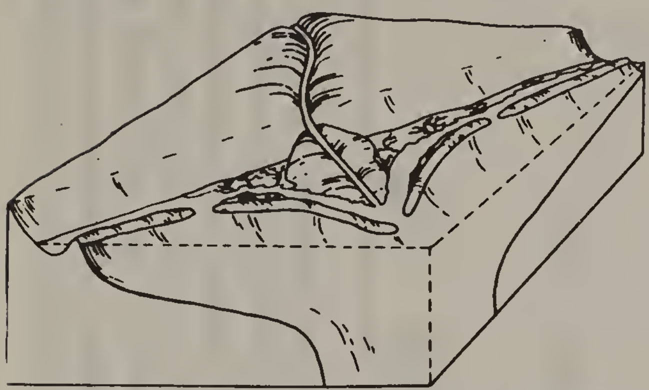
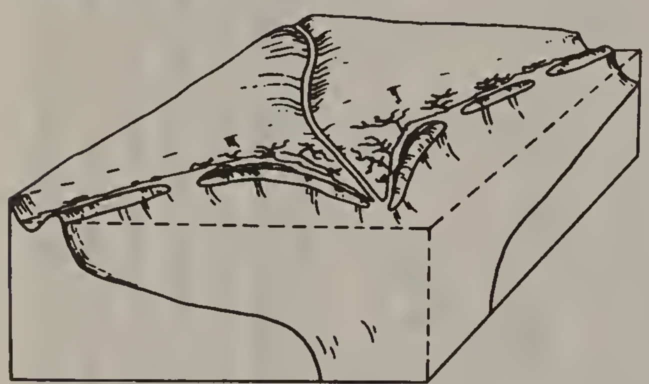


Figure A-13 Distribution of small sand-sized phosphorite grains recognizable by their shiny surface texture and black to dark brown color. The phosphorite distribution is one line of evidence indicating that sediment is being transported from the shelf to the shoreline. Present-day Carolina rivers carry only small amounts of phosphorite grains, but estuarine and beach sediments are often highly phosphatic. Close examination of the distribution reveals that when the adjacent continental shelf sediment contains phosphorite grains, beaches and estuarine sands are phosphatic. When shelf sands are devoid of phosphorite grains, nearby beaches and estuaries are not phosphatic. The area of highest phosphorite concentration near Cape Fear has been examined by several phosphate mining companies as a potential deposit of commercial grade phosphate. (From Luternauer and Pilkey, 1967).

Origin of Capes and Shoals along the Southeastern Coast of the United States



Idealized diagram showing formation of barrier islands along deltaic ridges by submergence of sand dunes.



Idealized diagram showing results of continued slow submergence and barrier islands retreat which resulted in present cape morphology.

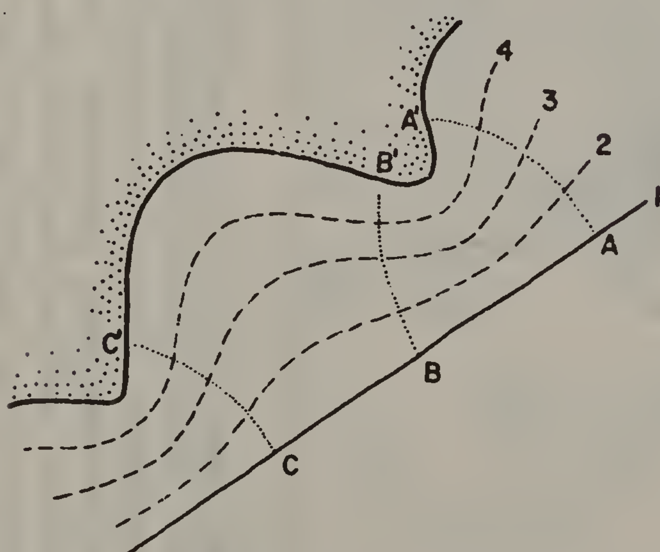


Diagram of wave refraction showing concentration of wave energy on headlands. Wave front A to B impinges on headlands from A′ to B′, whereas wave from B to C is spread along embayment from B′ to C′.

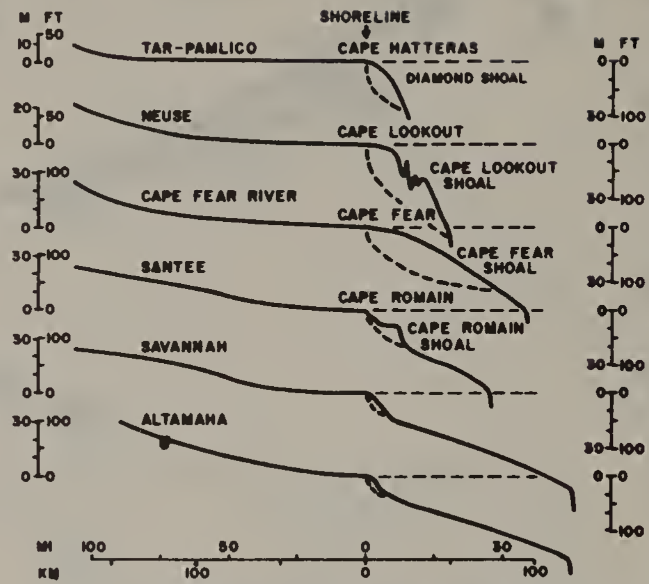
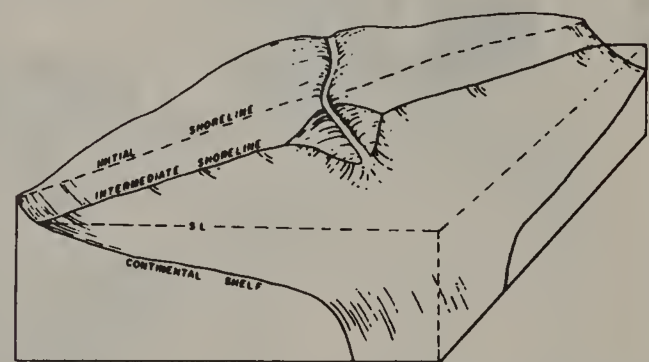
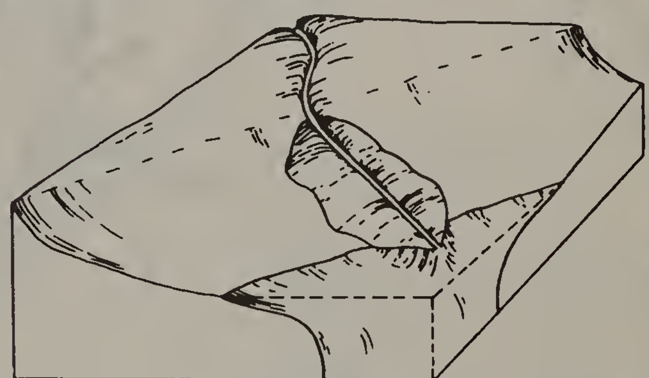


Diagram showing river and shelf profiles. Dashed profiles are from embayments adjacent to capes.



Idealized diagram showing deposition of sediment at river mouth as a result of lower sea level. Vertical scale greatly exaggerated.



Idealized diagram showing deltaic ridge

Figure A-14 MAP SHOWING MORPHOLOGY OF CAROLINA CAPES AND SHOALS

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relatively deep inlet channels. These channels are generally deepest at the estuary entrance (inlet trough) and become shallower in a seawall direction—over a ramp to the sea, and in a landward direction—over a ramp to the sound (Figure A-15). Seaward of the inlet, the ramp to the sea is bordered by a peripheral-shoal complex.

On intertidal parts of ram-margin shoals, clean fine sands are deposited in a variety of low-amplitude bedforms. Mud and shell fragments are generally not abundant on these parts of the shoals. Heavy mineral concentrations are generally higher here than in the surrounding less turbulent areas. Flood-oriented bedforms may be present in certain areas on the seaward side of shoals.

The relict barrier islands also occur inland. Details of the coastal plan of Georgia are shown by Hails and Hoyt (1969) (Figure A-16) and are also shown on Visual No. 2S. Henry et al. (1973) relates that these geomorphic features extend inland about 60 miles from the Atlantic Ocean, on the eastern boundary of Georgia, and about 175 miles along the Florida state line. Sands and sandy loams make up most of their "terraces", except in the swamps, where the sands are covered by muck or peat. Seven eustatic shorelines—six Pleistocene and one Holocene—composed of segmented barrier islands, have been identified on the lower coastal plain. A cross section of these "terraces" is shown in Figure A-17.

Each barrier sequence can be related to the highest level of the sea during several Pleistocene glacial episodes, and can be further subdivided into barrier island and lagoon/salt marsh facies. The barrier island facies include dune, littoral and shallow neritic deposits, and the lagoon/salt marsh facies include salt marsh and tidal channel deposits.

b. Soils

The soils areas illustrated in Visual Nos. 3N and 3S were prepared from general soil maps of the U.S. Department of Agriculture (Florida, 1962; Georgia, 1968; South Carolina, 1966; North Carolina, 1974). The U.S. Department of Agriculture (1938) provided a complete description of the soil types occurring in the southeastern states.

(1) Tidal swamp and marsh soils, and sand dunes: swamp and marsh soils occur in scattered areas in tidal channels at the mouths of rivers which empty into the ocean, in the quiet waters of lagoons, and behind barrier islands which fringe the coast. Generally the surface materials consist of brown, coarse, fibrous and matted peat. This surface peat material is porous and permeable, and gradually built up over black clay mud flats or gray loose sand by an accumulation of plant remains. Gradations from saltwater to brackish and fresh-water types are frequently encountered.

The shoreline consists of sand dunes and coastal beaches that border the Atlantic Ocean. The dunes, which are formed by wind, are mounded areas of dry, loose, very pale brown to yellow sand. Between the dunes are areas of nearly level fine sand, some of which are flooded twice daily by ocean tides.

(2) Atlantic Coast flatwood soils: consisting of unconsolidated sands, sandy clays and clays of recent geological origin. Practically all of the soils are characterized by matted subsoils which indicate poor aeration and drainage.

Most of the soils are light-colored and contain a small amount of organic matter, although there are large areas of black soils that are highly charged with organic matter.

(3) Poorly drained coastal soils: are similar in parent material and general characteristics to the Atlantic Coast flatwood soils except that they are located in poorly drained areas.

(4) Riverine alluvial and swamp soils: consist of recently deposited water laid materials which have been little changed by the environment. They normally consist of layers of sand, silt or clay with a fairly high organic content, especially in swampy areas.

(5) Southern Florida flatwood soils: ranges from sea level to 15 m in elevation. It is characterized by a dominantly flat to undulating surface, numerous low sand ridges and hummocks, water and grass ponds, swamp and tidal marshes. Natural surface drainage is poor except for the sand ridges. A hardpan layer in some areas prevents the free movement of rain water downward and the capillary rise of the water table water upward.

Surface layers range from light gray fine sands to brown heavy clays. Subsoils consist of heavy, fine sandy clay or heavy plastic clay, and, in hardpan areas, fine sand cemented by organic matter.

(6) Everglades and associated area soils: consist of muck and peat. "Muck", is developed from

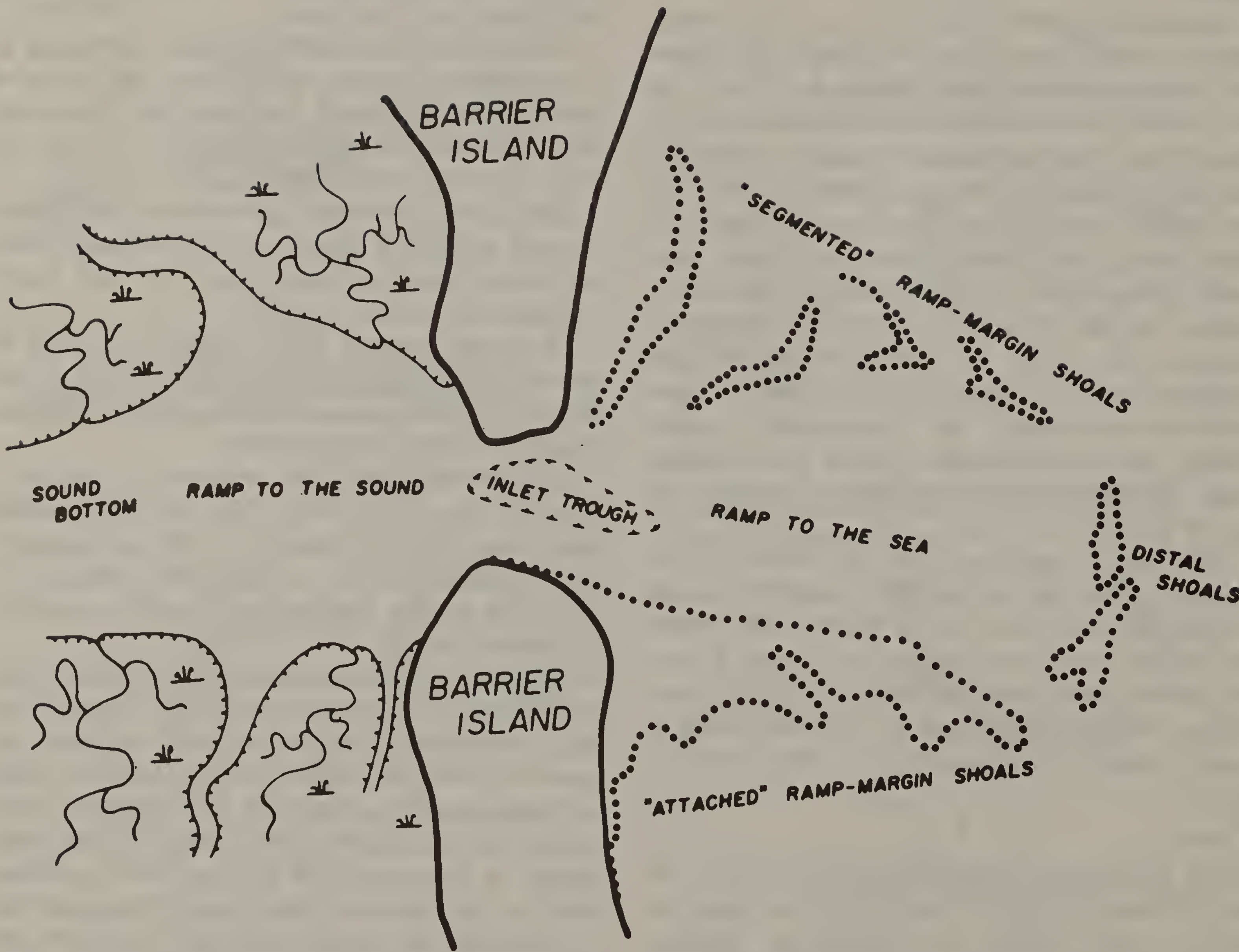


Fig. A-15 Generalized map of a Georgia tidal inlet, indicating the terminology of topographic forms (OERTELL, 1974).

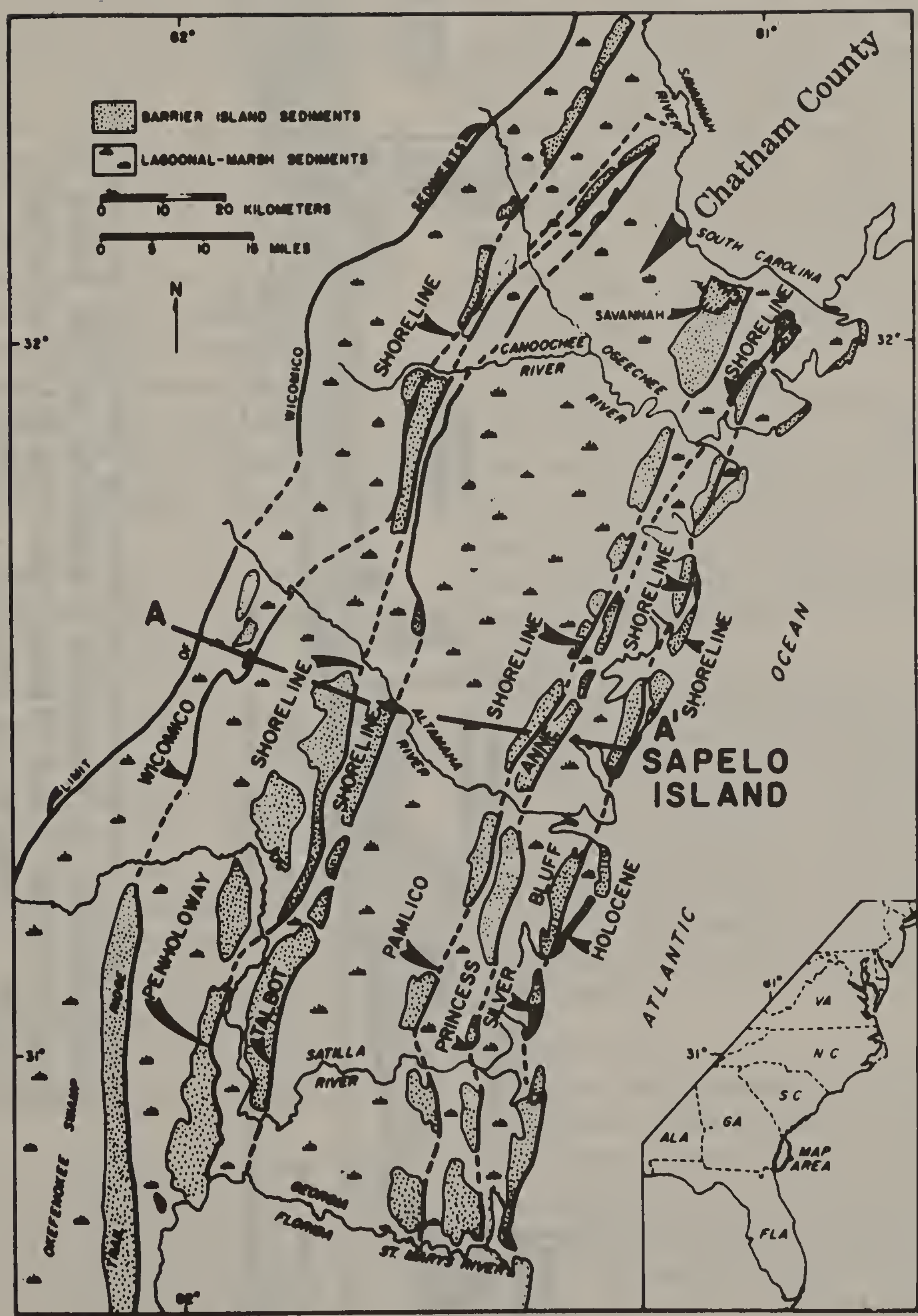


Fig. A-16 Lower Coastal Plain of Georgia, showing location of Chatham County and distribution of Quaternary barrier island/saltmarsh sequences. Line A-A' = location of cross section shown in Figure A-17 (After Hails and Hoyt, 1969.)

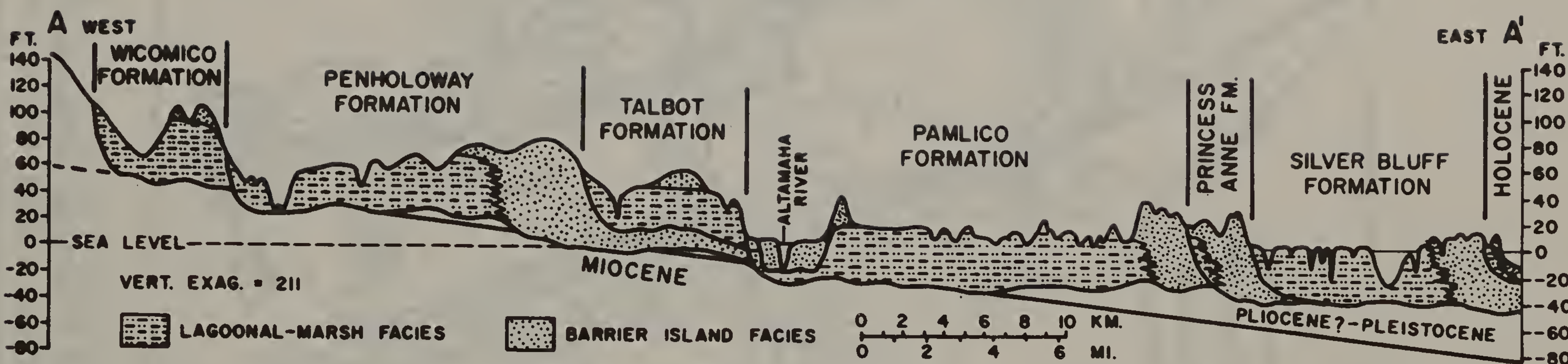


Fig. A-17 Diagrammatic cross section showing possible subsurface relationships of Quaternary deposits of the lower Coastal Plain. See Figure A-16 for location of cross section. (From Hails and Hoyt, 1969.)

black organic sediments originating from aquatic vegetation, occurs within a narrow belt bordering the southern shore of Lake Okeechobee. The soil contains some silt and clay, is dense when wet, and shrinks and becomes quite hard when dry. Practically all of it is underlain by brown fibrous peat resting on bedrock.

Brown or dark brown partly decomposed fibrous peat occupies most of the remaining area. It consists of fine roots and flattened coarse underground stems of dominantly sawgrass underlain by brown or dark brown fibrous sedge peat that rests on bedrock.

(7) Southern coastal plains soils: occupy a broad belt of land comprising the larger part of the Atlantic Coastal Plains above the flatwoods section, and ranges from 23 to 152 m above sea level. The surface of the land over much of this area ranges from nearly flat to undulating and is cut by many large rivers and small streams.

The soils are derived from unconsolidated beds of sands, sandy clays and clays. The soils tend to be light-colored, dominantly sandy in the surface portion, ranging from coarse sands to fine sandy loams.

(8) Freshwater marsh and swamp soils: developed from the vegetation of marshes, bogs and swamps. Each has contributed plant remains which have been accumulated either in basins of standing water or on land with a rising water level. Extensive areas of woody and fibrous peat and muck occur in the flat seaward portion of the southeastern Atlantic Coastal Plain. They occupy level upland terraces and border practically all lakes, ponds and streams near sea level.

The woody peat is generally dark brown in color, moderately decomposed and contains buried logs and stumps. Fibrous peat is derived from underground stems and roots of dense stands of cane, sedges, rushes and grasses accumulated in water basins.

(9) Sand hill soils: presents a rather conspicuous landscape, as the country rises higher than either the Piedmont or the typical Coastal Plain. Topography is quite variable, ranging from almost level to steeply sloping and hilly topography. Both surface and internal drainage ranges from good to excessive.

Parent material for these soils consist of beds of sand, probably old marine beaches, which are underlain by light-red, yellow, gray or white sandy clay material. Soils are mainly coarse sands with smaller areas of sandy loams and they are inherently low in mineral plant nutrients and organic matter.

(10) Southern piedmont soils: this soil area ranges from an elevation of 122 m bordering the coastal plains soils area, to much higher elevations westward. The topography varies from undulating or gently rolling to rolling, steep, and broken. The entire area is thoroughly dissected by streams and the natural surface drainage is good.

Parent materials for these soils are granites, gneisses and schists which underly most of the area. The soils are medium to strongly acid in reaction, low in organic matter, but contain much potash, particularly the subsoils. Scattered over the surface locally are fragments of quartz and occasionally outcrops of granite. Soils range in texture from coarse sandy loams to clays. Small scales of mica are common throughout the soil and subsoil.

(11) Central Florida ridge soils: this land area is dominantely undulating to gently rolling with some almost level areas and some that are hilly. Cypress swamps and thousands of lakes dot the region. Drainage is good to excessive over the area except in flatter depressions. There are few perennial streams and most of the drainage is subterranean.

Beds of marine-deposited fine sands overlying fine sandy clay are the parent materials for these soils. The soils have an extremely sandy texture, loose open consistency, very low content of mineral plant nutrients, a small amount of organic matter, and a strongly acid reaction. The dominant soil of the region consists of a light-gray or yellowish gray fine sand underlain by a fine loose yellow sand.

c. Hydrology

Improper well completion or trenching practices could cause contamination of artesian aquifers. Many municipalities along the coast depend on wells entirely, or in part, for their freshwater supplies, including Savannah and Brunswick, Ga. and Jacksonville, Daytona Beach, Cape Kennedy and Orlando, Fla. (Counts and Donsky, 1963; Klein, 1971).

The Floridan aquifer is artesian due both to the geometry of the dipping strata of the coastal plain and their varying permeability, Figure A-18. This aquifer consists of Eocene, Oligocene and Miocene limestone which contain beds of

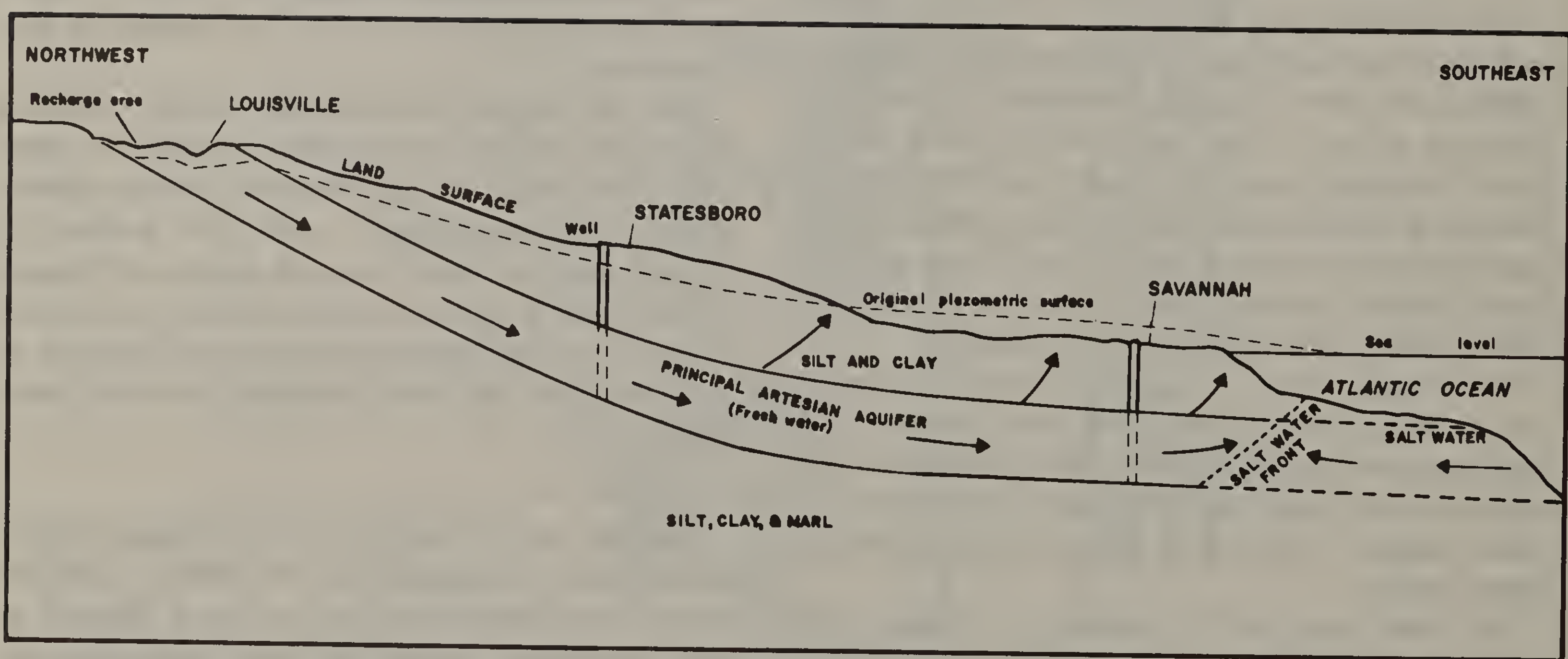


Figure A-18 Diagrammatic section of principal artesian aquifer, showing theoretical fresh water-salt water interface.

From Counts and Donsky (1963).

dolomite, sand, silt, clay and marl (Callahan, 1964). Limestone of the Ocala Group (late Eocene age) occur as part of the aquifer in Florida, Georgia and South Carolina; the Eocene Castle Hayne limestone is apparently equivalent in North Carolina. Most of the water in the Savannah area is produced from Eocene and Oligocene limestones (Counts and Donsky, 1963). In Florida, the lower part of the aquifer consists of highly cavernous dolomitic limestone, ranging in age from early Eocene to Paleocene. The unit has been named the ''Boulder Zone'' because of its drilling characteristics, although no boulders exist. The Boulder Zone probably contains nonpotable water throughout the state (Klein, 1971). Potable water is generally produced from permeable zones in the limestone and from solution cavities in the upper part of the aquifer in Florida.

Principal artesian aquifers extend offshore beneath the continental shelf. Freshwater from these aquifers flowed from the drill pipe at JOIDES hole J-1 (Visual No. 9) on the inner shelf 40 km off Jacksonville, and slightly saline water was obtained at hole J-2 on the outer shelf 120 km from the coast (Manheim, 1967). Brackish water was obtained from the deepest sample of hole J-5 on the Florida-Hatteras slope from upper Eocene deposits. In the Savannah area, the present fresh water-salt water contact in the aquifer is thought to be farther seaward than would be predicted from a static balance based on position of sea-level and the head of water in the aquifer (Counts and Donsky, 1963). This is considered to be due to a flushing of salt water from the aquifer during Pleistocene sea-level lowering and a lag in landward movement of the salt-fresh interface after sea-level rise. Freshwater apparently persists in the offshore part of the aquifer as far as Cape Lookout, N.C., where it is believed to extend a few miles offshore, whereas north of Cape Lookout all offshore beds contain salty water. Offshore springs also provide evidence for offshore extension of the aquifer (Callahan, 1964; Stringfield, 1966; Manheim, 1967). Submarine springs are formed by breaches in the confining bed of the aquifer, and represent locations where ocean water can enter the aquifer if head is not maintained. Such saltwater intrusion apparently is happening in the Savannah area (Counts and Donsky, 1963). The deeper parts of the principal artesian (Floridan) aquifer beneath much of the Florida platform are considered to be open to slow circulation of ocean water driven by geothermal heating (Kohout, 1965). This probably has caused accelerated solution of rocks to form caves and sinkholes.

In the Brunswick, Georgia area native ground water in the principal artesian aquifer is of the calcium bicarbonate type, very hard, alkaline, and low in chloride. In a roughly triangular area of downtown Brunswick, brackish water in the zone confined by dolomites is rising through a locally porous part of the upper dolomite and is spreading northward in both permeable zones of the principal artesian aquifer at rates up to 213 m/yr.

Any increase in pumpage which would enlarge present cones of depression would accelerate this rate. Elsewhere, the quality of water in wells that had been contaminated has returned to that of ''native'' water after the parts of the wells which penetrate the chloride-bearing zone had been plugged. None of the high-chloride water comes from lateral sea-water encroachment, nor is any likely to do so in the future (Wait & Gregg, 1973).

6. Potential Geologic Hazards

a. Seismic

Although minor earthquakes and microseisms occur yearly in South Carolina (Bollinger, 1972) (Figure A-19), only one earthquake is known to have occurred offshore. In 1960, an earthquake occurred near Charleston at 33° N. latitude and 80° W. longitude (Figure A-20) and was a magnitude of V (Coffman and von Hake, 1973). The only earthquake in this region large enough to have been a serious hazard was the Charleston earthquake of 1886. The magnitude of this quake was IX-X (Modified Mercalli Scale of 1931) and affected an area of over 1,287 km in radius. Earth waves were estimated to be over 0.6 m in height. The quake was followed by 10 severe aftershocks and numerous light aftershocks. More than 400 quakes have occurred in Charleston area since 1754 (Bollinger, 1972).

Present projects to monitor earthquakes in the area being undertaken by Arthur Tarr and others of USGS and Paradeep Talwani, University of South Carolina under ERDA contracts. Stewart (1975) stated that indications of pre-earthquake conditions occur at Cape Fear near Wilmington and Southport, N.C., about 113 km north of the area of high nominations interest.

The Charleston quake of 1886 occurred about 113 km west of the area of high nominations in-

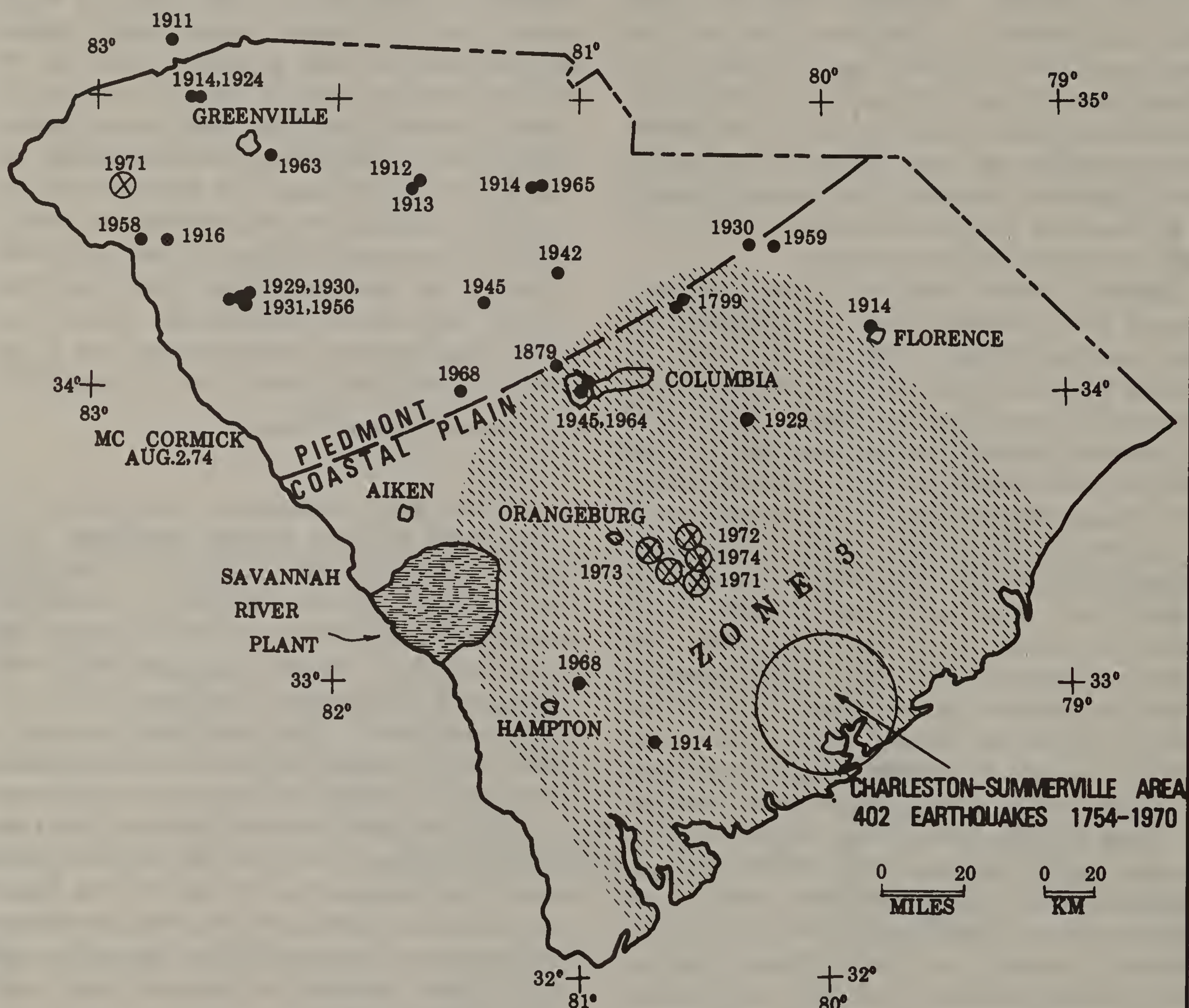


Figure A-19 Seismicity map for South Carolina. Year is given by each epicenter (from Bollinger). Map is updated to include 1972 and 1973 earthquakes. Map also includes seismic risk zone 3 (Algermissen, 1969), and the McCormick earthquake.

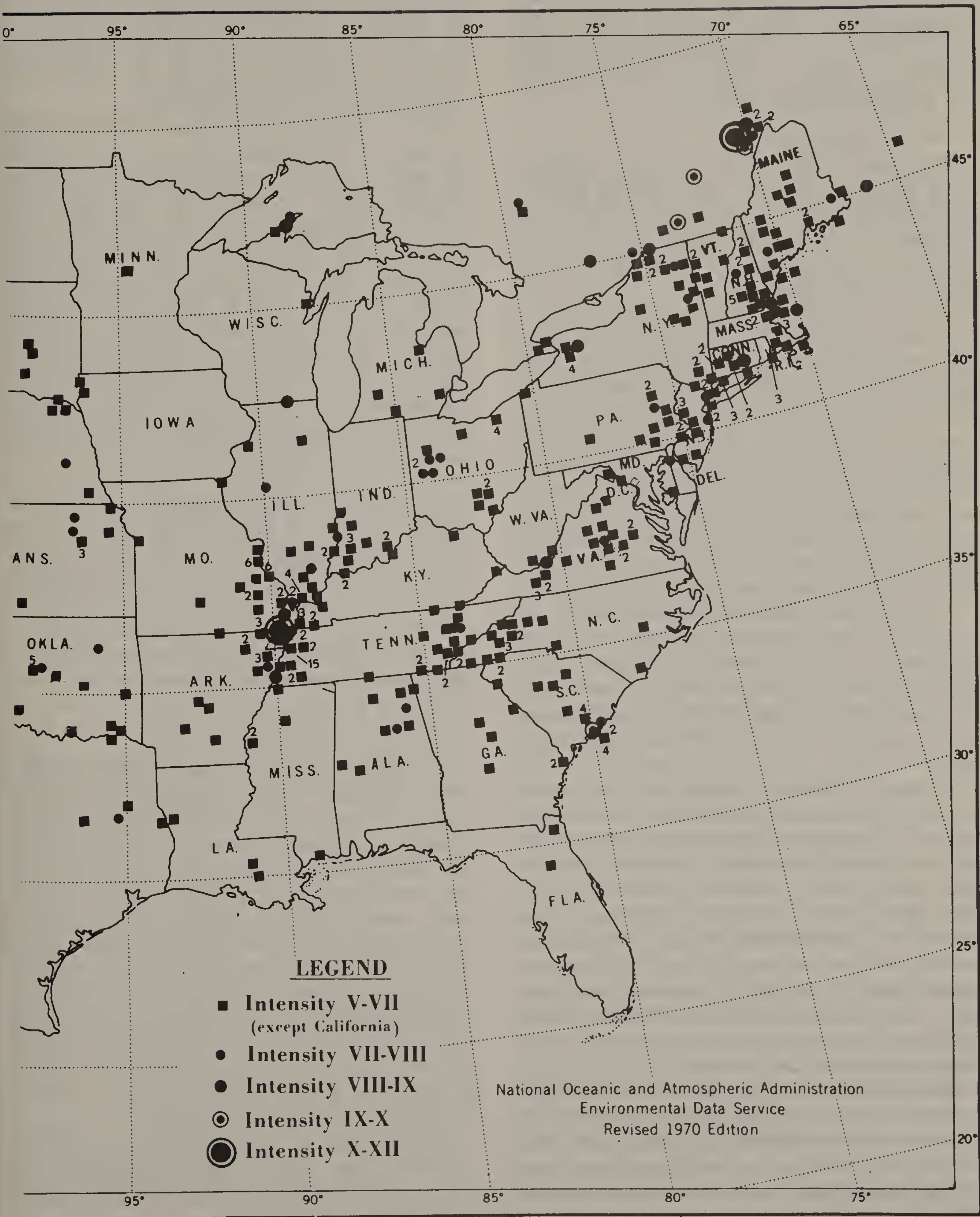


Figure A-20 From Earthquakes History of the United States, Coffman and Von Hake, 1970.

terest, and the causes of the quake are still an enigma. The incidence or probability of a damaging earthquake is rather low, however, the risk is still high and the Charleston area is rated as Zone 3 (Algermissen, 1969 and Perkins, 1974). In Zone 3 a major destructive earthquake may occur which corresponds to intensity VIII or higher on the Modified Mercalli Scale of 1931.

b. Bottom conditions

Platforms constructed on the outer continental shelf could be damaged by movement of their supporting material. This movement can occur by sediment transport either by scour or by mass movement and by collapse of sea floor rocks related to solution cavities.

(1) Sediment transport by scour: As noted in the section on marine surficial sediments (II.A.4.), the mid and outer shelf sediments are sands which appear to be in textural equilibrium on this shallow shelf. The presence of primary structures such as cross bedding, ripple marks, and graded bedding indicate active deposition or redeposition. In the high energy zones near the capes, mud and sand are carried seaward by current and wave action across the shelf and deposited on the slope. Between the capes, a shoreward migration of grains from the central and outer shelf occurs.

The dynamic sedimentary environment of this shallow shelf indicates the possibility that bottom structures would be affected by scour around their supports. This would also be a problem on the inner Blake Plateau where erosional features are common and produced by the Gulf Stream flow.

(2) Mass movement of sediments: The medium to coarse sand which predominates on the shelf would be relatively dense as a result of reworking by ocean currents and thus should offer good support characteristics. However, dense sands typically provide great resistance to pile penetration. Patches of lagoonal muds and peats which occur on the shelf would result in scattered areas in which support capabilities could be very poor, since static bearing capacity and stability against sliding can be drastically reduced by the presence of even a very thin layer of clay.

Slumping occurs on the slope where fine sediments are being deposited. Clays being deposited here are semi-consolidated at best. Slope sediments have had no subaerial exposure and, lacking desiccation, retain their mobile plasticity (Dillon et al., 1975).

(3) Karst topography: Submerged karst topography (irregular surfaces and caverns created by the solution of limestone rock by surface and ground waters) extends offshore from Florida and the Bahamas. The Ocala Limestone (Eocene) is one of the principal aquifers of southeastern Georgia and Florida and is known to be cavernous throughout most of this area.

The cavernous porosity encountered during the drilling of the Bahamas Oil No. 1 Andros Island has been well documented (Maher, 1971: Meyerhoff and Hatten, 1974). Caverns were penetrated at 15 different depths and at the total depth 4,448 m; 2,430 m of drill pipe was lost in the hole (see Visual No. 9 for well location). Circulation of drilling mud was lost at nearly all cavernous zones listed above, indicating that they extended laterally for considerable distances. Cavernous porosity was also encountered in Lower Cretaceous carbonates in the Esso No. 1 Hatteras Light between depths of 2,550-2,575 m (Maher, 1971). Such porosity may exist throughout the southeast Georgia Embayment area.

In areas where Karst topography is present, loading of the shelf surface above a cavern by a bottom mounted platform could result in collapse with damage to structures and possible leakage of water or oil. Modern geophysical hazards surveys can be designed to detect cavernous limestones and Karst features near the surface; however, deep caves causing loss of circulation are nearly impossible to detect prior to drilling.

c. Other near surface hazards

Trenching or burying of pipelines which is common in the Gulf of Mexico can protect pipelines from many near surface hazard forces; however, trenching or jetting of pipes in the South Atlantic OCS will be difficult due to the hardbank outcrop and compacted surface sediments which exist in many areas. Trenching into the zones of groundwater aquifers can release artesian flow and cause loss of head and subsequent salt water intrusion. Trenching of pipes may offer a poor solution to the hazard problem in many parts of the Atlantic OCS, and sandbagging or bridging of pipes across outcrops may also be an unmanageable. Serious study of this problem will be necessary before a workable solution can be presented.

Hazards such as creep, slumping, gasification, subsidence and near surface faulting are of a lower order of concern in this area in comparison to the Gulf of Mexico.

D. GEOPRESSURES

It is speculative at this time to state that hazardous geopressures can be anticipated in the Southeast Georgia Embayment or Cape Fear Arch. Proper mudweight will compensate for geopressure and as in the case of aquifer protection much of the responsibility is left to the experienced and alert procedures used by the drillers.

Many wells penetrating Mesozoic rocks in the State of Mississippi have encountered geopressures well above the 0.65 psi/ft. gradient which is considered the lower limit of the over-pressured section in the Tertiary strata of the Gulf coast. Wells in up-dip locations encountered hydrostatic geopressures while those in down-dip or seaward locations encountered geopressures. Whether these geopressures extend to offshore Georgia and South Carolina is not known at this time, but the Jay field (in the Florida panhandle) which produces from the Jurassic Smackover (Figure A-21) formation, does not encounter these geopressures (Visual No. 9).

In addition to geopressures, hydrogen sulfide (H_2S), which does extend into Alabama and Florida, is hazardous to those people which work on the rig.

E. GEOLOGICAL HAZARDS SUMMARY

It is difficult to rate hazards in an offshore area which has no previous drilling history. We can however, compare this area to what is already known for the Gulf of Mexico and make the following assumptions. Earthquakes, although very unlikely, would cause considerable damage if a quake the magnitude of the Charleston 1886 quake occurred in the area. Platforms constructed in the OCS could be damaged by movement of their supporting material. This movement can occur by sediment transport either by scour or by mass movement and by collapse of sea floor rocks related to solution cavities. Trenching or drilling into the zones of groundwater aquifers can release artesian flow and cause loss of head and subsequent salt water intrusion. Hazards such as creep, slumping gasification, subsidence and near surface faulting all of a lower order of concern in this area in comparison to the Gulf of Mexico. It is speculative at this time to state that hazardous geopressures can be expected. However many wells penetrating the Mesozoic rocks in the State of Mississippi have encountered geopressures.

7. U.S. South Atlantic Overview of Geologic Resources

The following information has largely been taken from the USGS open file report No. 75-411 Dillon et al. 1975; because of the excellent drilling summary on the continental margin and complete discussion of the hydrocarbon potential for the U.S. South Atlantic Outer Continental Shelf.

A. DRILLING ON THE ATLANTIC MARGIN

Except for shallow core holes, there have been no wells drilled on the U.S. South Atlantic Continental Shelf. If, however, we consider the Atlantic Continental margin of the U.S., numerous deep wells have been drilled. These include about 50 wells in North Carolina (Richards, 1967) including a 3,064 m deep well drilled on Cape Hatteras only 35 km west of the Continental Slope; 11 wells in South Carolina (Olson, 1973); 148 wells in Georgia (Pickering, 1974); and many wells on the Atlantic and Gulf coasts of Florida.

Hydrocarbon shows have been reported in wells in southern Georgia along with a few oil seeps in central Georgia. The J. R. Sealy No. 3 Spindle Top in Seminole County reported oil and gas shows and the Sealy No. 1 Fee in Decatur tested a small amount of gas. A Carpenter Oil Company well in Coffee County and the Parsons and Hoke No. 1 Spurlin reported in the vicinity of Scotland in Telfair County where 30 API gravity oil and gas escape from surface sands and clays of probable Oligocene age (Maher, 1971). In northern Florida, the St. Mary's River Oil No. 1 Hilliard Turpentine in Nassau County was reported to have questionable asphaltic staining in the Cedar Keys Limestone (Paleocene), and the Taylor-age limestone and Atkinson Formation (Upper Cretaceous) (Figure A-21). On the Gulf coastal province of Florida, eight small fields have been discovered in the South Florida Embayment and large hydrocarbon discoveries have been made in the Jurassic strata at Jay Field in northwest Florida with reserves estimated in excess of 345 million bbls (McNabb, 1975).

In summary, although discoveries have been made on the Gulf coast of Florida, in the immediate vicinity of the Southeast Georgia Embayment, no commercial production of oil and gas has been established. The lack of production in the South Atlantic coastal province has been explained by many reasons. For coastal North Carolina and Georgia, the sedimentary section is

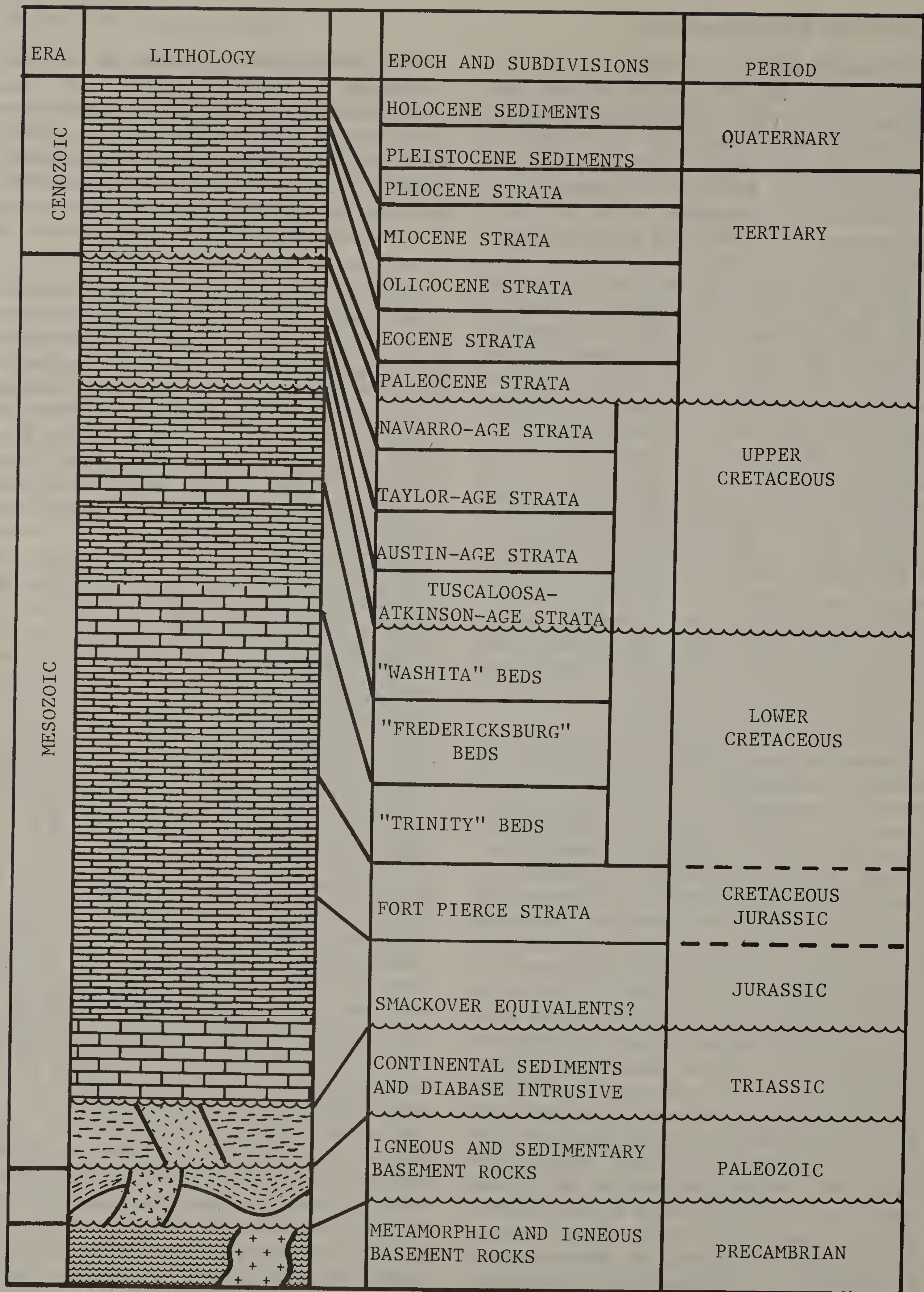


FIGURE A-21 SUMMARY GEOLOGIC COLUMNAR SECTION mostly non-marine. For South Carolina, the basement rock is at a relatively shallow depth. The reasons for the poor production history for the Atlantic Coast of Florida could include a lack of effective porosity and permeability, lack of source beds, lack of sufficient subsurface temperature needed to transform organic molecules into petroleum and even the difficulty of seismic exploration (Reel and Griffin, 1971).

b. Potential hydrocarbon traps (areas of accumulation)

The depositional environment and tectonic history of the South Florida Embayment appear to be similar to the southeast Georgia Embayment; the hydrocarbon potential of the Southeast Georgia Embayment and the South Florida Embayment may be similar.

(1) Stratigraphic traps: The facies change between downdip marine carbonate and updip marine clastics may provide potential stratigraphic traps. This type of trap could occur along a depositional strike as the predominantly carbonate section in the Bahamas grades northward into predominantly clastic section of the Carolinas.

Signification lateral variations in porosity and permeability may occur within the thick marine carbonates of Jurassic and Cretaceous age.

Updip pinch-outs of Jurassic and Cretaceous clastic units, especially in near-shore off the coasts of South and North Carolina, offer possibilities for stratigraphic traps.

Carbonate banks and reef traps may be developed on the Florida-Hatteras slope and on basement highs, such as the Cape Romain anomaly.

Unconformities have been suggested as possible hydrocarbon traps in the southeast Georgia Embayment (Maher, 1971, Spivak and Shelburne, 1971, and Olson, 1973).

(2) Structural traps: Significant petroleum traps could be located on structural highs associated with draping and differential compaction over basement blocks. Early Jurassic sediments in this embayment were deposited on a highly block faulted basement surface. Such structures would have provided timely traps for hydrocarbons generated in Jurassic or Lower Cretaceous age rocks. Drape structures over basement blocks have provided substantial petroleum traps in other parts of the U.S. such as the giant panhandle—Hugoton field of Texas, Oklahoma and Kansas (Pippin, 1970).

Low relief anticlines should not be overlooked as potential traps in the southeast Georgia Embayment. Although difficult to locate without detailed seismic coverage, this type of trap could be significant. In the Sunniland Field of Florida, petroleum is presently being produced from low relief anticlines with as little as 11 m of closure (Myerhoff & Hatten, 1974).

Continued movement of basement blocks during Jurassic and possibly during lower Cretaceous time may have resulted in fault traps. If such traps exist, they are in the lower part of the sedimentry section.

c. Potential source and reservoir rocks

(1) Paleozoic: Pre-Cretaceous rocks have few characteristics of petroleum producing beds. Paleozoic rocks in pre-mesozoic basement are highly metamorphosed except in southwestern Georgia and Central Florida where they are so highly indurated and folded as to have doubtful reservoir characteristics (Maher and Applin, 1971).

(2) Mesozoic: Triassic rocks exhibit many continental aspects, such as red beds and conglomerates, and numerous igneous intrusions; such rocks may contain good reservoirs, but they are not generally regarded as good source rocks (Maher and Applin, 1971).

(3) Mesozoic: Upper Jurassic—Lower Cretaceous sediments in excess of 4000 m are expected on the continental shelf of the Southeast Georgia Embayment. These beds offer the most promising prospects for oil and gas production in the Atlantic Coastal Region (Maher and Applin, 1971).

The Jurassic section is a prolific producer in the Gulf Coast and in the Jay Field in northwest Florida. Maher (1971) believes that porous dolomitic and oolitic limestone beds of Jurassic age may occur at depth offshore. The ESSO-Hatteras Light No. 1 well penetrated 280 m of Late Jurassic rocks which Brown et al. (1972) has described as predominant coarse sand and shale. Three deep wells in the Bahamas penetrated Late Jurassic (Portlandian or Early Cretaceous (Neocomian) rocks. Although not many thick shale beds have been drilled in the sequence as yet, adequate sealing beds may be provided by dense limestone and anhydrite beds. The "black marine Jurassic shale" reported from the Great Isaac No. 1 well may furnish source beds for the above mentioned reservoir rocks.

With the exception of the recent Jurassic discoveries in northwest Florida-southwest Alabama, the Lower Cretaceous section contains the only producing strata in the immediate area and is expected to offer the best possibility for hydrocarbon entrapment in the offshore Southeast Georgia Embayment. There are three main reasons for this: (1) availability of seals to prevent the vertical migration and possible loss of hydrocarbon to the surface, (2) good reservoir rocks, and (3) possible hydrocarbon source rocks.

The warm shallow waters of the Early Cretaceous seas were conducive to anhydrite deposition on the stable southeast Atlantic continental shelf from Cape Hatteras to Cuba. Minor amounts of Lower Cretaceous anhydrite have been reported in the Esso No. 2 North Carolina well (Spangler, 1950) and the Hatteras Light No. 1 well (Brown et al., 1972), and alternate beds of Lower Cretaceous limestone, dolomite and anhydrite have reported in the Chevron Great Issaco No. 1 well (Meyerhoff and Hatten, 1974). Seaward from the Georgia coast and between these two wells, there is a good chance of encountering Lower Cretaceous anhydrite which would make an excellent hydrocarbon seal. Thin layers of shale would also make adequate seals. Although great thicknesses of Lower Cretaceous shale are not expected, not much is needed. It is worth noting that only 30 m of shale over the crest of Burgan field, Kuwait, seals 62 billion bbls of oil (Kamen-Kaye, 1970).

The downdip Lower Cretaceous carbonates are expected to have adequate porosity and permeability. Thirty-seven porosity and permeability measurments were made for Lower Cretaceous rocks from the Hatteras Light No. 1 well (Spangler, 1950; Maher 1971). The average porosity and permeability based on these measurements are 26.1% and 487 md, respectively. Within Sunniland field, the porosity of the producing zone ranges from 15 to 24.5% and permeability average 312 md parallel to the bedding and 84 md perpendicular to the bedding (Pressler, 1947). Within the Lower Cretaceous Sunniland Limestone near Miami, porosity ranges from 6.5 to 23.3% and permeability between 0 and 2.3 darcys (Meyerhoff and Hatten, 1974). Cavernous porosity has been reported in a well drilled on Andros Island, Bahamas (Meyerhoff and Hatten, 1974) and the Esso No. 1 Hatteras Light (Maher, 1971).

If it extends beneath the shelf in the Southeast Georgia Embayment area, the thick, black marine Jurassic Lower Cretaceous shale penetrated in the Great Isaac well and DSDP Holes 101 and 105 might provide an excellent source rock for overlying permeable Lower Cretaceous dolomites and limestones.

The largest geographic separation (over 1,000 km) between DSDP Hole 101 and 105 suggest broad areal distribution of these Albian through Cenomanian organic-rich clays in the western North Atlantic. Whether these beds exist beneath the shelf can only be answered by deep-drilling. Even if these beds do not extend under the shelf of the Southeast Georgia Embayment they could still be a potential source of petroleum for shelf reservoirs because of long distance migration. It should be added that the quantity of organic-carbon content of a rock by itself does not assure its source rock properties (Fuloria, 1967) the convertibility of the organic matter to petroleum and the efficiency of oil explusion are also important. The authors are not aware of evidence that indicates that these Lower Cretaceous deepwater clay deposits of the Western North Atlantic are associated with any commercial assumulations of hydrocarbons. Other potential Lower Cretaceous source rocks include organic rich carbonate muds which were not oxidized before burial. Winston (1971) has stated that the Lower Cretaceous Sunniland Limestone has good carbonate source rocks. According to Rona (1970), the sedimentation rate during the Lower Cretaceous was relatively fast on the southeastern continental margin of North America and northwestern Africa; hence hydrocarbon precursors may not have been exposed to oxidizing conditions for extended periods of time Preliminary work by Fischer and Arthur (1975) suggests that on a world-wide basis, the Lower Cretaceous may not have been a period of extensive marine sediment oxidation. In their discussion at the 1975 AAPG-SEPM annual meetings, Fischer and Arthur presented data which indicate that the Albian, and to a lesser degree, the Aptian, was a time of deposition of extremely non-oxidized sediments. It may have been a time of reduced oceanic circulation or a time when high rates of organic productivity overwhelmed the available oxygen. In connection with the latter point, flourishing marine organisms could have created their own bottom-reducing conditions, (Hedberg, 1964). In general, the data of Fischer and Arthur suggests that this was a time of warmer temperatures, high faunal diversity, and heavy carbonate carbon isotopes.

Mattick (1974) has speculated on the possiblity of Lower Cretaceous reef reservoirs occurring along the shelf edge in the Baltimore Canyon trough. Seismic evidence indicates that reefs could occur along the shelf edge in the Southeast Georgia Embayment area also. The importance of reefs in petroleum accumulation apparently is due to the fact that they furnished timely, high porosity reservoirs near favorable source areas (Hedberg, 1964). In this case, shelf edge reefs might be potential reservoirs, not only for petroleum generated on the shelf, but also, if we appeal to the concept of long distance migration, for petroleum generated on the slope. In this connection, the suggestion of Emery (1963) that sediment which slided to the foot of the slope might create rich source material should be considered. Conversely, however, Meyerhoff and Hatten (1974) are not impressed with the reservoir potential of shelf edge reefs off Florida. According to these authors, the Atlantic Ocean has been able to flush the exposed reefs of the Bahamas area since its early history. Whether Lower Cretaceous reefs could or could not have generated petroleum is open for debate.

During Late Cretaceous time, silts and clays could have been transported to the continental slope by currents through the Suwannee Channel and could have sealed the Lower Cretaceous reefs. In addition, alternating marine regression and transgression during lower Upper Cretaceous time (Rona, 1970) could have provided a favorable environment for deposition of clay and silt over the reefs.

Lower Cretaceous fore-reef deep-water shales and/or limestones of the U. S. Atlantic coast might have been capable of generating hydrocarbons, similar to conditions Meyerhoff and Hatten (1974) have suggested for the Golden Land Fields of Mexico. Deep-water Early to Middle Cretaceous Tamabra Limestone and Tamaulipas Limestone of the Tampico Embayment of Mexico (Coogan, 1972) possibly contained the original materials that were transformed into petroleum for the giant reserves in the Golden Land Fields which produce from the shallow water reef limestone of the El Abra Formation (Meyerhoff and Hatten, 1974).

(4) Upper Cretaceous: Very stable shallow-water shelf conditions persisted throughout most of Upper Cretaceous time. Sedimentation rates were much slower than during Lower Cretaceous time. These two factors are not conducive to hydrocarbon generation. Organic matter that may have been deposited, either land derived or marine, was probably oxidized before it could be preserved. Ernst (1974) stated that sediments (carbonates, orthoquartzites, etc.) on continental shelves of the Atlantic type accumulate in an environment that promotes exidation and solution of unstable lithic, biogenic and mineral grains and the formation of secondary quartz and carbonates. Meyerhoff and Hatten (1974) take a negative view regarding the hydrocarbon potential of Late Cretaceous rocks, at least in the Bahamas sediment, because ''there are no seals in evidence to protect a reservoir, once formed''. They did indicate, however, that this may not be true in the Little Bahama Bank area where they believe terrigenous clastic rocks may extend upward into the Tertiary.

Rainwater (1971) summarized the petroleum potential of the Upper Cretaceous by stating that the tectonic and sedimentary history of peninsular Florida and adjacent continental shelves during the Late Cretaceous time was not favorable for oil and gas generation. Though many porous carbonate rocks and sandstones are present, they are not likely to contain petroleum accumulations.

Maher (1971) is more optimistic in his assessment of Upper Cretaceous rocks. He believes that thick marine source rocks may be expected beneath the shelf and writes that the Upper Cretaceous rocks have good possibilities for oil and gas production beneath the continental shelf.

(5) Tertiary: the Tertiary strata of this embayment offers little hope for commercial quantities of petroleum. There is a lack of sealing beds within the Tertiary strata (Meyerhoff and Hatten, 1974; Cramer, 1974). The section is less than 1,000 m thick (Scott and Cole, 1974), contains fresh-to-brackish water, and crops out in part along the continental shelf and Blake Plateau. Any indigenous oil that may have formed has probably been flushed out by fresh waters.

Reported shows of oil or gas in the Tertiary strata of Florida are rare (Winston, 1971). In three JOIDES holes drilled offshore Jacksonville, ''oil odors and asphalt specks'' have been reported (Schlee and Gerard, 1965, Emery and Zarudzki, 1967). Hollister et al. (1972) reported "a substantial amount of gas, consisting primarily of methane with a trace of ethane" for DSDP Hole 103 drilled on the southwest flank of the Blake-Bahama Outer Ridge.

d. Ocean mining

Studies of coastal processes and morphology have uncovered considerable (although not completely evaluated) indications presently subeconomic mineral resources. Phosphates, sand, gravels and ceramic muds (Manheim, 1972) may be the most likely to incur future economic development. Table A-2 lists these surface or near surface resources of the coastal zone. Sand and gravel are the most likely deposits economic extractions on a large scale. Dillion et al. (1975) reported that U.S. Atlantic OCS estimated reserves of 450 to 4,500 billion tons of dry sand and 1.4 to 50 billion tons of gravel. Phosphate mines are in operation in the coastal zone in Florida and North Carolina, however, the future of phosphate mining in the Atlantic OCS is presently uncertain.

8. Geologic and Bathymetric Mapping Status

Geologic and topographic mapping is coordinated between the state geologists and the U. S. Geological Survey (USGS) with geologic mapping normally performed by the states and topographic maps printed by the USGS. The geologic information for those areas above sea level was taken from the American Association of Petroleum Geologists (AAPG) Geological Hishway Map series. These maps were compiled by Renfro Feray (1975) for the South Carolina, North Carolina and Virginia areas and Bennison et al. (1975) for the Georgia and Florida areas, with the cooperation of the U. S. Geological Survey. The AAPG maps were compiled from the latest state and federal information available as noted in their sections "Principal Sources of Map Information" (Table A-3) Other principal sources are also listed in Table A-3. Mapping of the upland Geology is adequate for the scale used (i.e., 1:1,000,000). All of the states have programs whose goal is to update existing geologic maps. Geologic mapping in the offshore areas is inadequate. Maps that are available, such as the map by Uchupi (1965) (Figure A-22) are usually quite generalized. The most detailed information is the JOIDES prolife by Emery and Zarudzki (1967); therefore, Visual No. 2 N-S is very generalized for the offshore area. The U.S. Geological Survey is at present, preparing an offshore geologic map for this region.

Bathymetric mapping for the offshore regions of the proposed sale is also inadequate. Generalized maps by Uchupi (1966) and by Holland (1970) are now dated and are difficult to use in detailed investigations at the 1:1,000,000 scale. Of the 27 proposed bathymetric maps adjacent to the coasts of North and South Carolina, Georgia and Florida, only one 1:250,000 map, Figure A-23, has been printed by National Ocean Survey (NOS). This map is the Beaufort, N. C. sheet and is detailed from modern data. Three other sheets (Savannah, Brunswick and Jacksonville) are scheduled for printing in 1976.

9. Geological Data Requirements

As part of the BLM environmental studies program, the U.S. Geological Survey Office of Marine Geology over the last year has been conducting geological and geophysical research. This research is designed to obtain up-to-date information on potential shallow hazards, sediment transport, trace metal and hydrocarbon content of surficial sediments, and to learn more about the history of the U.S. South Atlantic Continental Shelf.

In order to evaluate potential shallow hazards, uniboom, minisparker, and 3.5 KHz echo sounder systems profiles have been obtained across the U.S. South Atlantic shelf.

a. Bathymetric maps

Requirements for accurate bathymetric maps used in managing offshore oil and gas operations are as follows:

(1) Determination of slope gradients in mudslide areas for geologic hazards.
(2) Base maps for plotting individually reported geologic hazards, as mud lumps, gas seeps, and faulting.
(3) Determination of bathymetric features such as high and low relief areas, fishing banks, coral reefs, and other features.
(4) Determination of high probability areas for shipwrecks and submerged aboriginal (Indian) living sites.
(5) Determination of the upper and lower limits of practical use of geophysical instrumentation for archaeological and biological survey stipulations.
(6) Depth requirements on shunting of drill cuttings.
(7) Location of favorable areas for recreational uses (such as diving and underwater parks).
(8) Base map for almost all offshore environmental information such as shoaling areas for tornadoes, cable and pipeline information for EIS and Sale Matrix.
(9) Location of favorable areas for other uses of the seafloor and subbottom.

As stated in the status of mapping for offshore U.S. South Atlantic region, the available bathymetric maps are inadequate. Figure A-24 de-

TABLE A-2

Data sources for resources other than oil and gas for the South Atlantic OCS

Material	Selected Data Sources
Phosphorite	Stanley et al. (1967); McKelvey and Wang (1969) Manheim (1972); Milliman (1972); McKelvey et al. (1969)
Anhydrite	McKelvey and Wang (1969)
Manganese nodules - including trace elements: Ni, Cu, Co, Sn, Fe, Zn, Ag, Ba, Al, B, Ti, V, Ar, and many others	McKelvey and Wang (1969); Horn and Delach (1973); Mero (1965); Horn (1972); Manheim (1972)
Ilmenite, monzaite, zircon, staurolite, kyanite, sillimanite, and garnet	Trumbull et al. (1958); McKelvey and Wang (1969); Emery and Noakers (1968); Hathaway (1971); Manheim (1972); Ross (1970); McKelvey (1969); McKelvey (1969); Manheim (1972)
Copper and zinc (chal-copyrite and sphalerite minerals)	Manheim (1972)
Sand, gravel and mud	Manheim (1972); Schlee (1974, 1968); Schlee and Pratt (1970); Emery (1965); Duane (1968); Davenport (1971); Taney (1971); Economic Associates Inc. (1968); Milliman (1972); Ross (1970); McKelvey and Wang (1969); Nossaman (1969); Doumani (1973); Rexworthy (1968)
Glauconite	McKelvey et al. (1969)
Carbonate	Hillsemann (1967); Milliman (1972)

Source: Dillion et al., 1975.

Table A-3 Sources of Map Information for the AAPG Geological Highway Map Series

Agency	Publication or Map
U.S. Geological Survey	Geologic Map of North America, 1965 Tectonic Map of North America, 1969 Tectonic Map of United States, 1962 Basement Rock Map of U.S., 1968 Geologic Map of Appalachian Region, 1968 Professional Papers of the Geological Survey
Virginia Division of Mineral Resources	Geologic Map of Virginia, 1963
North Carolina, Div. of Mineral Resources	Map of North Carolina, 1958
South Carolina	Geologic Map of the Crystalline Rocks USGS Misc. Geol. Investigations, I-413, 1965
South Carolina Division of Geology	Geologic Map of South Carolina, 1965
Florida Division of Geology	Geologic Map of Florida, 1964
Georgia Division of Geology	Geologic Map of Georgia, 1975
Princeton University Press	The Quaternary of U.S., 1965
Utah State University Press	Post-Miocene Stratigraphy of Central and Southern Atlantic Coastal Plain, 1974
U.S. Geological Survey	Bulletins, circulars and maps (CQ, I, OC, POC, POM series)

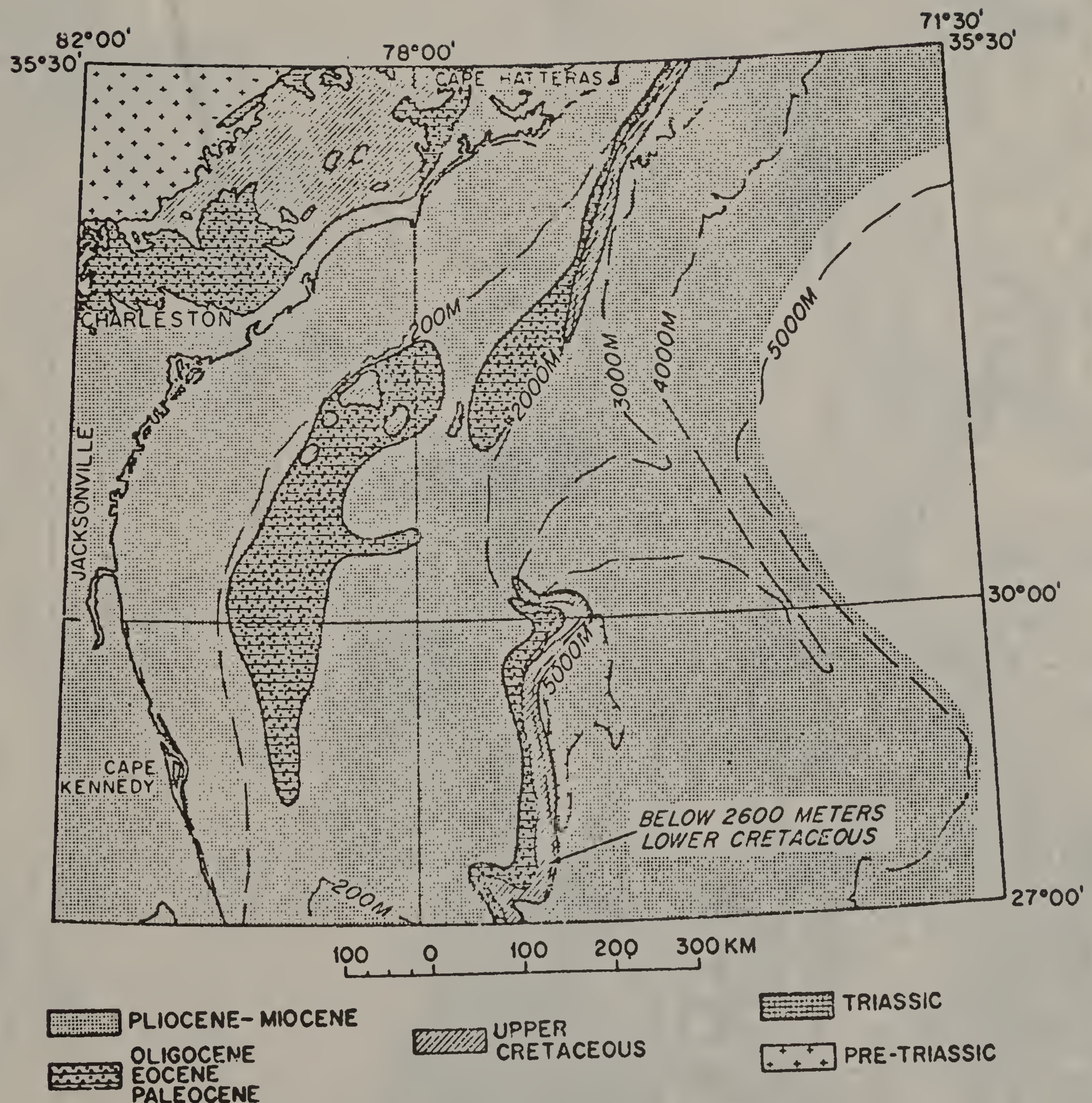
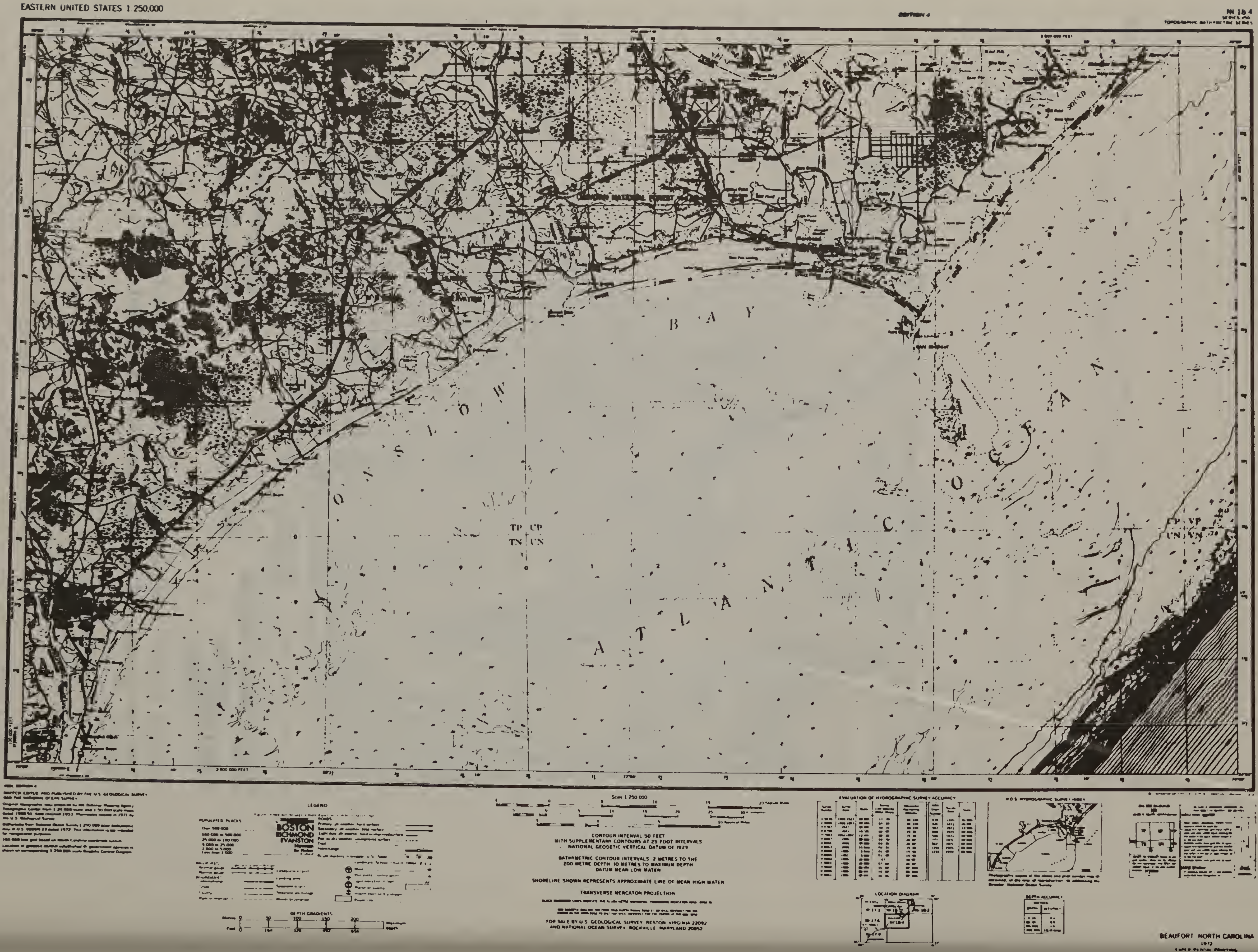
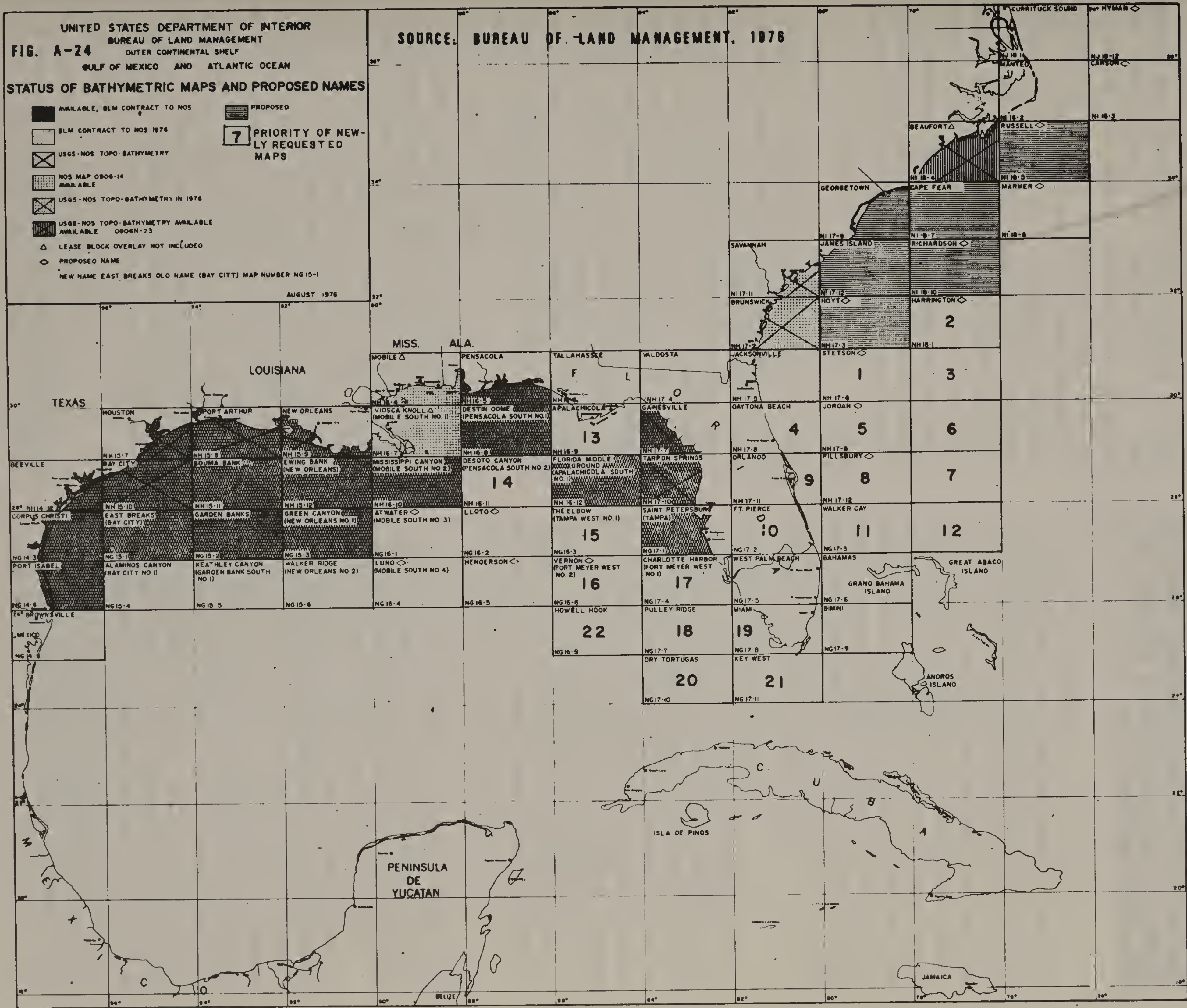


Figure A-22. Geologic map of the continental margin south of Cape Hatteras, if the Quarternary sediments were removed, Uchupi (1967).

Figure A-23 BEAUFORT, N.C. - BATHYMETRIC MAP.





UNITED STATES DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
FIG. A-24
OUTER CONTINENTAL SHELF
GULF OF MEXICO AND ATLANTIC OCEAN
STATUS OF BATHYMETRIC MAPS AND PROPOSED NAMES
AVAILABLE, BLM CONTRACT TO NOS
BLM CONTRACT TO NOS 1976
USGS-NOS TOPO-BATHYMETRY
NOS MAP 0806-14 AVAILABLE
USGS-NOS TOPO-BATHYMETRY IN 1976
USGS-NOS TOPO-BATHYMETRY AVAILABLE 0806N-23
LEASE BLOCK OVERLAY NOT INCLUDED
PROPOSED NAME
NEW NAME EAST BREAKS OLD NAME (BAY CITY) MAP NUMBER NG 15-1
PROPOSED
PRIORITY OF NEWLY REQUESTED MAPS
AUGUST 1976
SOURCE: BUREAU OF LAND MANAGEMENT, 1976
TEXAS
LOUISIANA
MISS.
ALA.
HOUSTON
PORT ARTHUR
NEW ORLEANS
BEEVILLE
BAY CITY
BOUMA BANK
EWING BANK (NEW ORLEANS)
CORPUS CHRISTI
EAST BREAKS (BAY CITY)
GARDEN BANKS
GREEN CANYON (NEW ORLEANS NO 1)
PORT ISABEL
ALAMINOS CANYON (BAY CITY NO 1)
KEATHLEY CANYON (GARDEN BANK SOUTH NO 1)
WALKER RIDGE (NEW ORLEANS NO 2)
BROWNSVILLE
MEXICO
MOBILE
PENSACOLA
VIOSCA KNOLL (MOBILE SOUTH NO 1)
DESTIN DOME (PENSACOLA SOUTH NO 1)
MISSISSIPPI CANYON (MOBILE SOUTH NO 2)
DESOTO CANYON (PENSACOLA SOUTH NO 2)
ATWATER (MOBILE SOUTH NO 3)
LLOYD
LUND (MOBILE SOUTH NO 4)
HENDERSON
TALLAHASSEE
VALDOSTA
F L O R
APALACHICOLA
GAINESVILLE
FLORIDA MIDDLE GROUND (APALACHICOLA SOUTH NO 1)
TARPON SPRINGS
THE ELBOW (TAMPA WEST NO 1)
SAINT PETERSBURG (TAMPA)
VERNON (FORT MEYER WEST NO 2)
CHARLOTTE HARBOR (FORT MEYER WEST NO 1)
HOWELL HOOK
PULLEY RIDGE
DRY TORTUGAS
KEY WEST
MIAMI
WEST PALM BEACH
FT. PIERCE
ORLANDO
DAYTONA BEACH
JACKSONVILLE
BRUNSWICK
SAVANNAH
GEORGETOWN
JAMES ISLAND
HOYT
STETSON
JORDAN
PILLSBURY
WALKER CAY
BAHAMAS
BIMINI
GRAND BAHAMA ISLAND
GREAT ABACO ISLAND
ANDROS ISLAND
CAPE FEAR
RICHARDSON
HARRINGTON
BEAUFORT
RUSSELL
MARMER
MANTEO
CURRITUCK SOUND
NYMAN
CARSON
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
C U B A
ISLA DE PINOS
PENINSULA DE YUCATAN
BELIZE
JAMAICA
M E X I C O

picts the current mapping status. Additional areas which bathymetric maps have been requested for are designated by a priority number.

B. MARINE GEOLOGIC MAPS

As noted in the section on Physiography—Continental Shelf and Slope, there is an acute need for a marine geologic map. Especially needed is an accurate depiction of the inner, middle and outer hard banks areas.

B. Physical Oceanography

1. Estuaries

The area of the South Atlantic Coastal region from Cape Hatteras, N.C., to Cape Canaveral, Fla. is marked by both open and semi-enclosed embayments. Barrier islands with associated lagoons are typical from Cape Hatteras to Cape Fear and again from Jacksonville to Cape Canaveral. The region between Cape Fear and Jacksonville is characterized by mud flats, salt marshes and an abundance of small islands. In general, the entire area is marked by drowned river valleys, barrier islands, tidal marshes, backed by large wetlands. Fresh water run-off is fairly constant along the length of the coast but is less abundant than coastal regions to the north. Figure B-1 shows major drainage areas flowing into the Atlantic Ocean in the region of interest.

a. Characteristics of estuaries and classification

Pritchard (1955) defines an estuary as a semi-enclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with fresh water derived from land drainage. He has developed a system for classifying estuaries on the basis of salinity stratification. Several physical parameters directly influence stratification; freshwater run-off, wind, tide, and dimensions of the estuary. The following is a brief description of how estuaries are classified in the coastal region from Cape Hatteras to Cape Canaveral.

(1) Salt-wedge estuaries

The salt-wedge estuary forms when the volume of freshwater runoff is high in relation to the tidal volume (Figure B-2). This occurs usually at the mouths of large tidally influenced river systems, such as, the Neuse River in North Carolina (Visual No. 2N) and the Cooper River in South Carolina (Visual No. 2S). The main characteristic of these estuaries is the fact that vertical mixing between salt and fresh water can only occur upward. The salinity increases constantly with distance downstream. It is possible for salt water to become entrained in the upper layer as it moves seaward thus increasing the salinity of the river water.

(2) Partially mixed estuaries

A partially mixed estuary results when tidal inflow is increased and river runoff is decreased. This type of estuary is no longer river dominated and vertical mixing occurs both upward and downward. The addition of seawater to the upper layer outflow results in an increase of upstream flow of the bottom layer. Freshwater, free of any salt, is found only at the head of the estuary. Examples include the Winyah Bay-Pee Dee River in South Carolina, the Savannah River in Georgia and the Altamaha River in Georgia (Visual No. 2S).

(3) Vertically homogeneous estuaries

The vertically homogeneous estuary is usually a broad embayment with insignificant river input. In this type of embayment the salinity variance is much greater laterally and longitudinally than vertically. The Coriolis Effect causes lower salinity seaward flow to be found on the right and higher salinity tidal inflow to be found on the left. This type of estuary exhibits vertical mixing both upward and downward. The best example of this type of embayment is the Pamlico River in North Carolina (Visual 2N) (VIMS, 1974).

b. Major harbor estuaries

Data on major harbor estuaries were taken largely from information compiled by John P. Jacobson of the Virginia Institute of Marine Science in A Socio-economic Baseline Summary for the South Atlantic Region Between Cape Hatteras, North Carolina and Cape Canaveral, Florida (VIMS, 1974). Jacobson has compiled and summarized available information and provided a description of some major harbor estuaries located within the area of interest.

(1) Pamlico Sound

Pamlico Sound, North Carolina is 129 km (80 miles) long and from 24 to 48 km (15 to 30 mi) wide and covers approximately 4.33 x 10^5 hectares (1,670 mi^2) with a mean depth of 4.9 m (16 ft.).

The sound extends from Oregon Inlet to Ocracoke Inlet with additional ocean communication at Hatteras Inlet. The sound is separated from the ocean by the Outer Banks, a barrier island chain. Fresh water inflows come primarily from the Neuse-Trent River (drainage area—1.45 x 10^6 ha) (5600 mi^2) and the Tar-Pamlico River (drainage area—1.1 x 10^6 ha) (4200 mi^2). The total drainage area of Pamlico Sound is 2.9 x 10^6 ha (11,100 mi^2) with an average freshwater inflow of 510 m^3/sec (18,000 cfs). Evaporation is about 1 m (40 in) per year and precipitation average 1.3 m (50 in) each year.

FIG. B-1 Average annual runoff to ocean in terms of km³/linear km of coast. From data of Bue (1970) and Wilson and Iseri (1969).

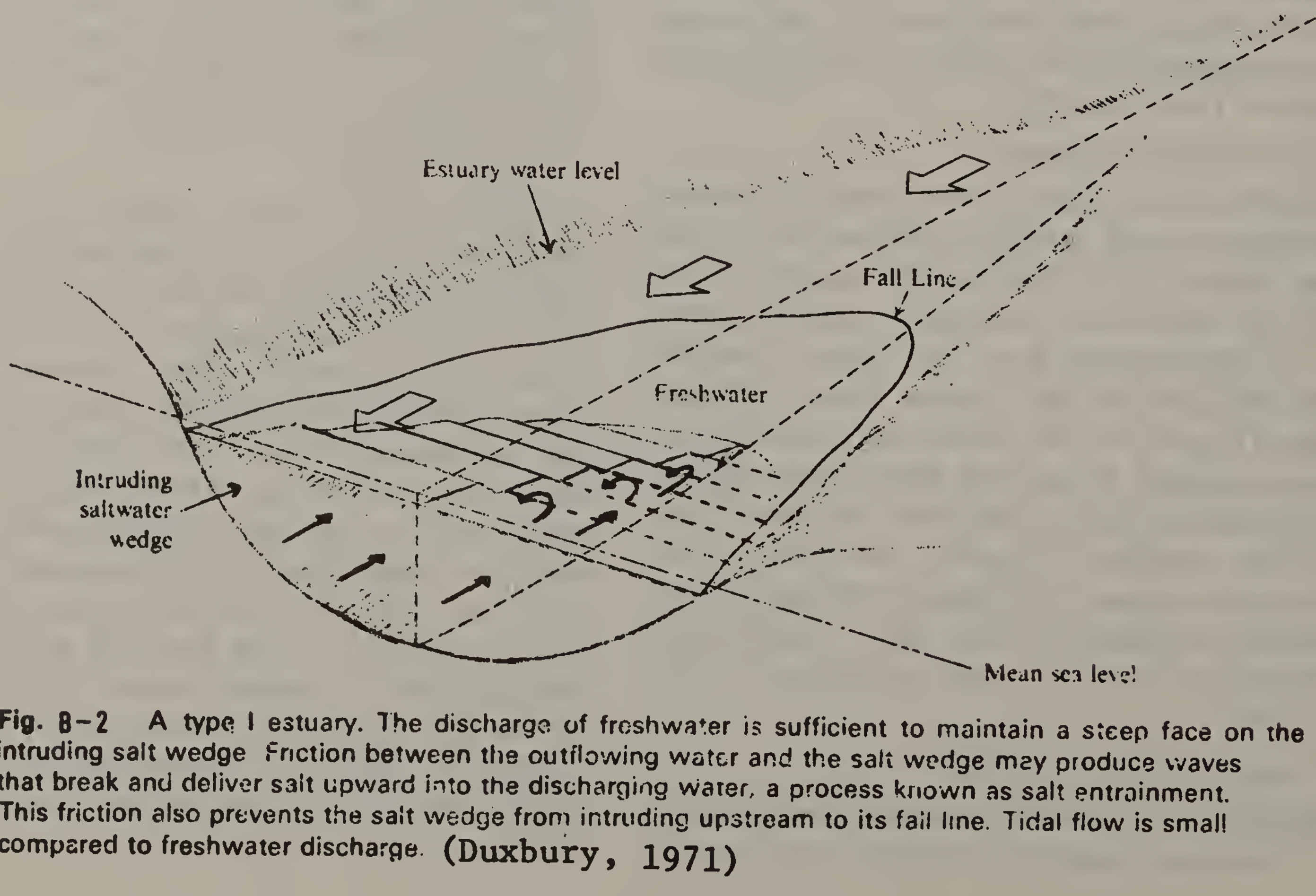


Fig. B-2 A type I estuary. The discharge of freshwater is sufficient to maintain a steep face on the intruding salt wedge. Friction between the outflowing water and the salt wedge may produce waves that break and deliver salt upward into the discharging water, a process known as salt entrainment. This friction also prevents the salt wedge from intruding upstream to its fall line. Tidal flow is small compared to freshwater discharge. (Duxbury, 1971)

The sound is highly saline (average 20 ppt) with little vertical stratification (vertically homogeneous) due to its shallow depth and wind mixing. Horizontal salinity stratification is evident throughout the year with the stronger gradients in the western part of the sound due to dilution highly saline tidal inflow from the ocean. Monthly temperature and salinity distributions in Pamlico Sound have been presented by Williams et al. (1973).

There are weak currents and a negligible tidal range in the sound. The astronomical tides only average 15 cm (6 in.) but wind often will cause a change in the level of the water surface greatly exceeding this value. Roelofs and Bumpus (1953) report that the tidal exchange through the inlets is approximately eight times the average river inflow. The flushing time is approximately three months.

(2) Wilmington, North Carolina

The harbor of Wilmington, N.C. is located in the southeastern part of the state, 39 km (24 mi.) from the coast on the Cape Fear River. The harbor is 280 km (151 nautical miles) northeast of Charleston and 284 km (154 naut. mi.) southwest of Morehead City, N.C. A dredged ship channel extends from the ocean to the mouth of the Northeast (Cape Fear) River at Wilmington, and then 5 km (3 mi.) up that river. The mean low water depth over the Cape Fear bar is 12.2 m (40 ft.) and of the channel at Wilmington, 11.6 m (38 ft.). The Cape Fear River is the only major river in North Carolina which flows directly into the ocean.

The Cape Fear River is a tidal estuary extending approximately 108 km (67 mi.). The estuary at Wilmington fluctuates between partially mixed and vertically homogeneous. The average freshwater inflow is 396.5 m^3/sec (14,000 cfs). Current velocities at Wilmington are approximately 1 m/sec (3 ft/sec) at strength of flood and 0.8 m/sec (2½ ft/sec) at strength of ebb. The spring tide range at Wilmington is 1.2 m (4 ft.). The mean salinity at Southport, near the mouth, for the years 1946-54 was 22.8 ppt with a mean range between 17.4 ppt in March and 26.4 ppt in October. The annual mean surface water temperature is 18.7°C (65.6°F) with a mean range from 10.9°C (51.6°F) in January and February to 29.7°C (85.5°F) in July and August.

(3) Charleston, South Carolina

Charleston, S.C., is located on a peninsula at the confluence of the Cooper River, on the east, and the Ashley River on the west. The inflows of the Cooper, Ashley and the Wando rivers form the harbor, with the predominant inflow coming from the Cooper. The entrance to Charleston Harbor is between converging jetties which extend nearly 5 km (3 mi.) seaward. The channel to Charleston is dredged to a depth of 10.7 m (35 ft.). Charleston Harbor is 148 km (80 naut. mi.) northeast of the mouth of the Savannah River and closer to the sea than any other South Atlantic Coast port (7 mi.).

In 1942, the Santee River was diverted into the Cooper through Lake Marion and Lake Moultrie with drastic changes in the flow (170 m^3/sec. average to 510 m^3/sec.). This changed the estuary from a vertically homogeneous state to that of a highly stratified salt-wedge, with sediment particles becoming entrapped in the wedge. The result has been such an increase in the rate of sedimentation that rediversion is being considered.

The mean salinity at Charleston Customhouse Wharf for the years 1942-1958 was 17.6 ppt. The mean range was between 14.00 ppt in April and 21.0 ppt in October. The annual mean surface temperature of the water is 19.9°C (67.8°F) and the range is between 10.7°C (51.3°F) in January and 28.6°C (83.4°F) in July and August. The mean tidal range in the harbor is 1.58 m (5.2 ft.), spring 1.83 m (6 ft.), neap 1.28 m (4.2 ft.). The average freshwater inflow ranges from 510 to 566 m^3/sec. (18,000 to 20,000 cfs) and the mean discharge during ebb is 1.0 x 10^8 m^3 (3.6 x 10^9 ft^3). The water velocity is 122 to 152 cm/sec (4 to 5 ft/sec) at the surface and slightly less at the bottom at midtide.

(4) Savannah, Georgia

Savannah, the chief port of Georgia, is located 105 km (65 mi.) south of Charleston and 169 km (105 mi.) north of Jacksonville, Fla. on the south bank of the Savannah. The deep water entrance from the ocean to the Savannah River is by way of a dredged channel approximately 26 km (16 mi.) long, 11.6 m (38 ft.) deep across the bar through Tybee Roads. The harbor, which is regulated by two upstream reservoirs, consists of the lower 30.6 km (19 mi.) of the river. The fresh water inflow averages 198 m^3 /sec (7000 cfs.).

The tides are semi-diurnal with spring tides averaging 2.74 m (9 ft.) and neap tides 1.52 m (5 ft.). The mean tidal range is 2.1 m (6.8 ft.) at the entrance to the river and 2.3 m (7.4 ft.) at the city of Savannah. The harbor carries large amounts of fresh water during spring freshets and floods. There are maximum current velocities in the navigation channels on the order of 1.52 m/sec (5 ft/sec) during ebb and 1.22 m/sec (4 ft/sec) during flood. Salinity varies from essentially fresh water in the upper portion of the harbor to coastal water at the mouth. At Fort Pulaski, near the mouth of the Savannah River, the mean salinity for the year is 17 ppt with a mean range between 12 ppt in April and 20 ppt in both August and October. At Fort Pulaski the annual mean surface water temperature was 20.3°C (68.5°F) for 1940-1966 with a mean range between 10.9°C (51.6°F) in January and 28.9°C (84.0°F) in August. The harbor estuary may be classified as partially mixed according to Pritchard's classification.

(5) Jacksonville, Florida

The port of Jacksonville is located in northeastern Florida on the St. Johns River, 169 km (105 miles) south of Savannah, Ga. The deep water entrance to the river is located between east-west jetties across the ocean bar from the river mouth. A dredge channel of 9.14 m (30 ft.) extends from the entrance to the St. Johns to Jacksonville. The waterfront facilities are located on both banks of the lower 39 km (24 mi.) stretch of St. Johns.

The river at Jacksonville may be classified as vertically homogeneous. There is almost complete vertical mixing during the entire tidal cycle. The salinity at Jacksonville varies from 0 to 15 ppt, with salinities generally higher in May and June and lowest in October and November on the average. Salt-water intrusion is 62.8 km (39 mi.) above the river entrance. Mean flow of fresh water is 374 m^3/sec (13,200 cfs).

The average river water temperature over a 20 year period at Jacksonville was 22.8°C (73°F) (Bostwick et al. 1948), with a general decrease in temperature progressively downstream. The mean range of surface water temperature between 1955 and 1959 was between 14.1°C (57.4°F) in January and 30.6°C (87.3°F) in July.

Tides in the harbor are semi-diurnal. The mean tidal range is 1.5 m (4.9 ft.) on the bar and 1.5 m (1.2 ft.) at Jacksonville. Strong winds greatly affect tide levels. Tidal currents are strong in St. Johns River upstream to Jacksonville. Channel velocities at the strength of the current are approximately 0.4 m/sec (4.8 ft/sec) at the mouth and approximately 1.2 m/sec (3.8 m/sec) at Jacksonville. The ebb tide velocity is increased and the flood velocity decreased or interrupted by strong southeast winds.

2. Water Temperature

The surface water temperatures of the western North Atlantic, south of Cape Hatteras, are directly dependent upon seasonal air temperature. During winter, surface water temperatures decrease from the relatively warm Gulf Stream toward the coast. During spring this gradient weakens until summer, when temperatures are essentially isothermal across the shelf. The sequence of seasonal surface water temperature variation and the average annual range can be seen in Figures B-3 through B-6 (Schroeder, 1966).

The bottom temperature contours for the Continental Shelf waters generally parallel the coast (Figures B-7 through B-10). Bottom water temperatures near the coast are almost isothermal throughout the year due to wind mixing (Newton et al., 1971). They also show a large annual range, near the coast, because of the effect of seasonal air temperatures. At the shelf break, bottom water temperatures can be warmed by Gulf Stream intrusion or chilled by cooler nearshore water sinking and sliding down the shelf. In general, bottom water at the shelf break shows a much smaller temperature range than surface water for two reasons. The water at this depth is not directly affected by changing air temperatures and lies below water that is mixed by surface winds.

Newton et al. (1971) reported that minimum horizontal gradients and maximum vertical gradients of temperature occur during summer along the U.S. south Atlantic Coast. During the winter the situation is reversed with minimum vertical gradients and maximum horizontal gradients of temperature. Figures B-11 through B-17 illustrate the horizontal and vertical temperature gradients as they vary seasonally on the shelf between Cape Lookout, N.C. to Cape Canaveral, Fla. These T. N. Gill Data are the most complete temperature information published in the proposed sale area (VIMS, 1974).

3. Circulation

a. Water masses

Kuroda and Marland (1973) using data from the T. N. Gill cruises identified four different water

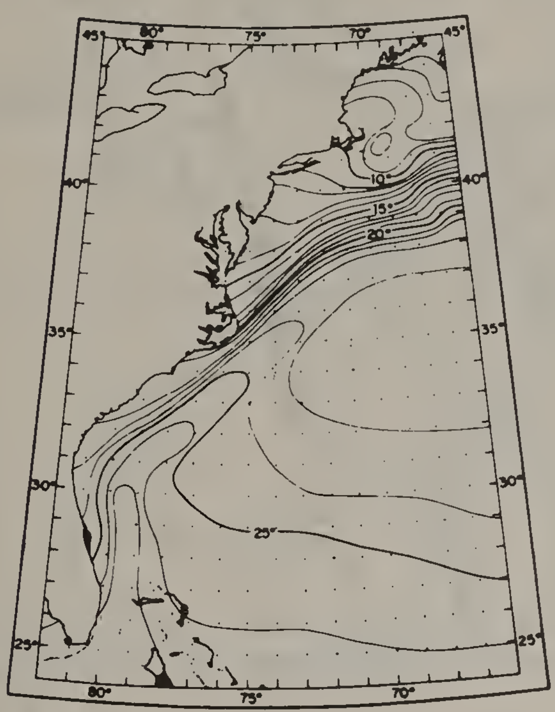


Figure B-3 Average spring surface temperature (^{o}C), 61,787 observations (Schroeder 1966).

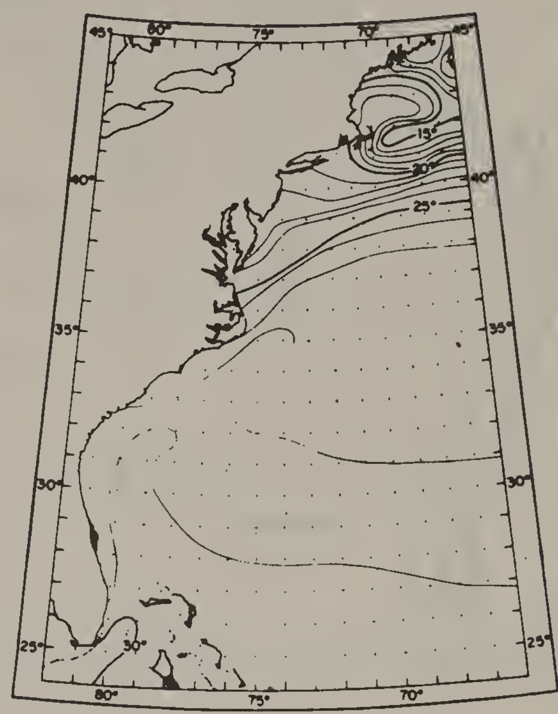


Figure B-4 Average summer surface temperature (^{o}C), 50,668 observations (Schroeder 1966).

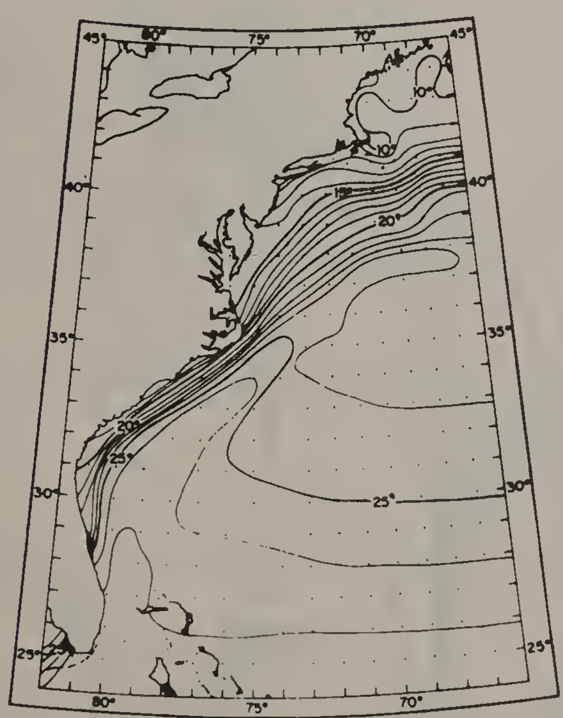


Figure B-5 Average fall surface temperature (^{o}C), 39,123 observations (Schroeder 1966).

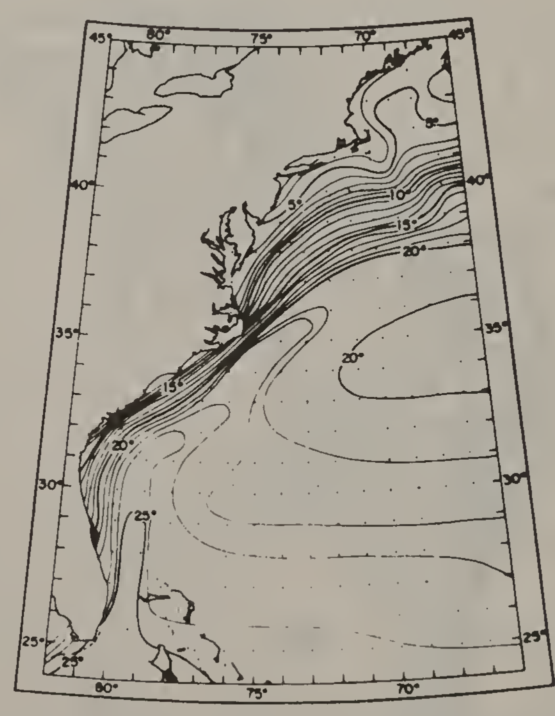


Figure B-6 Average winter surface temperature (^{o}C), 40,052 observations (Schroeder 1966).

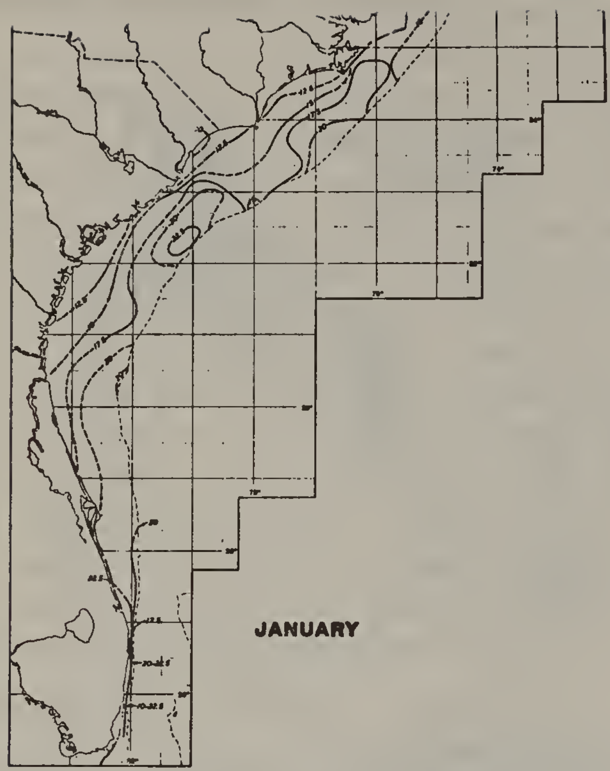


Figure B-7 Bottom temperatures (°C) on the Continental Shelf, January (Walford and Wicklund, 1968).

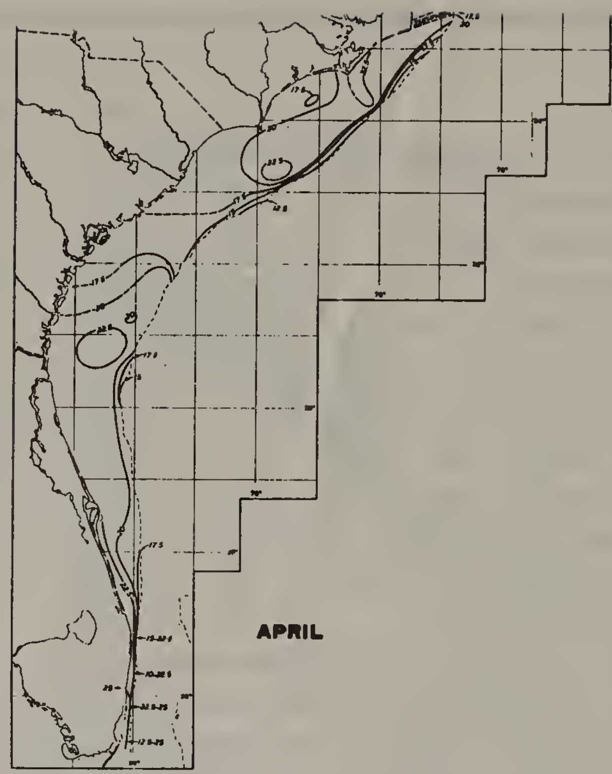


Figure B-8 Bottom temperatures (°C) on the Continental Shelf, April (Walford and Wicklund, 1968).

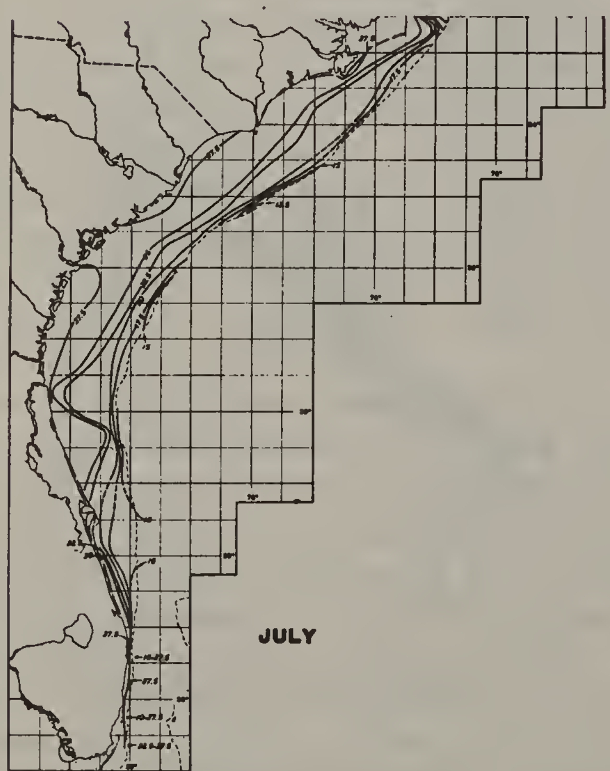


Figure B-9 Bottom temperatures (°C) on the Continental Shelf, July (Walford and Wicklund, 1968).

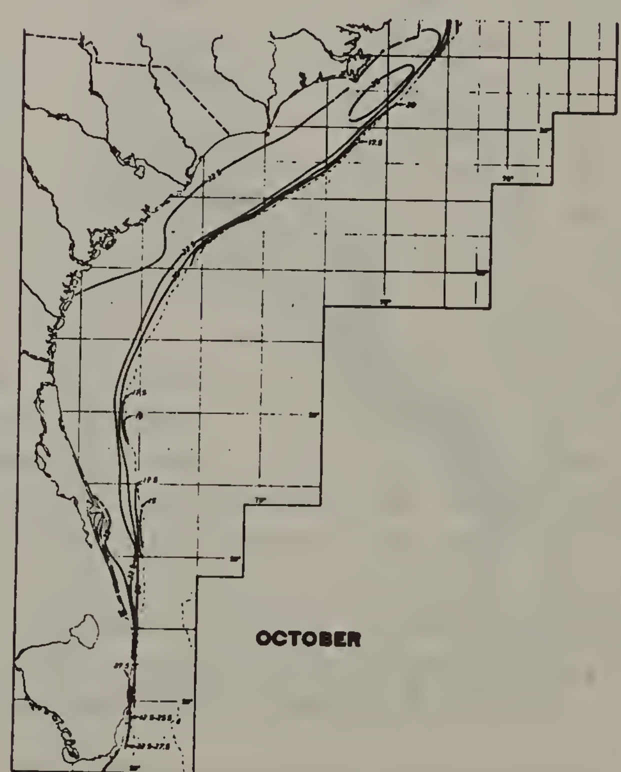


Figure B-10 Bottom temperatures (°C) on the Continental Shelf, October (Walford and Wicklund, 1968).

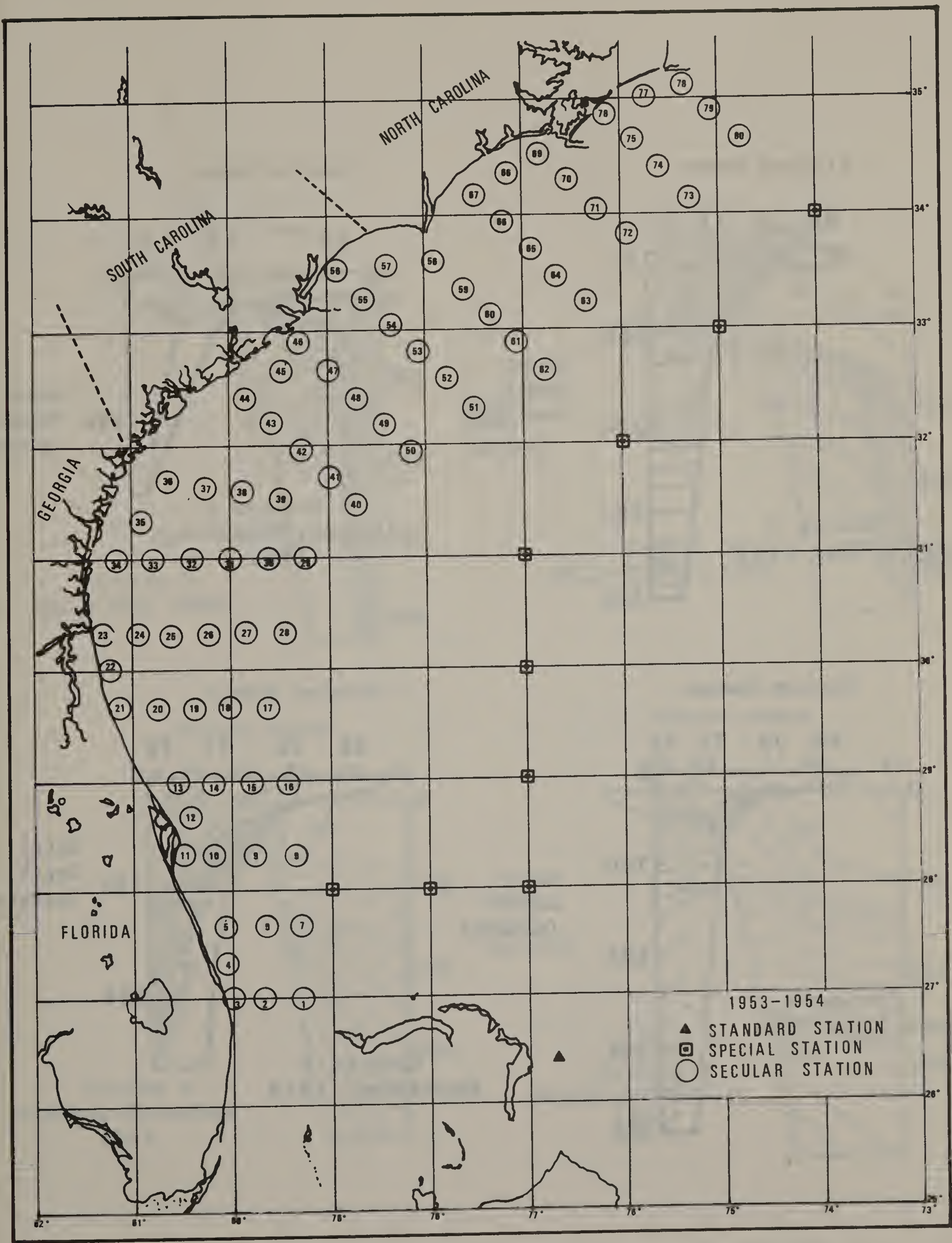


FIGURE B-11 STATIONS OF T.N. GILL CRUISES FOR FIGURES B-12 THROUGH B-17 (VIMS,1974).

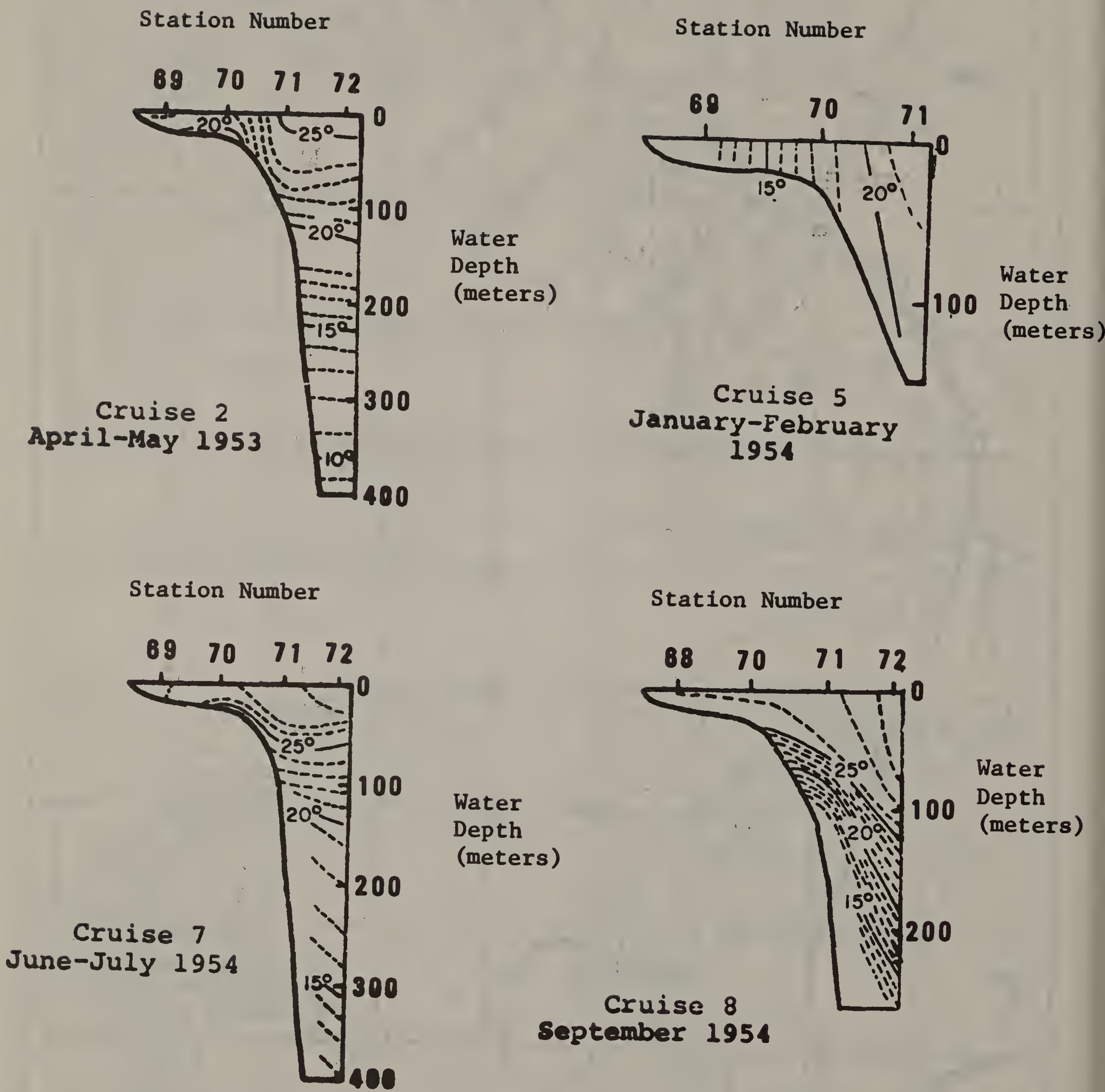


Figure B-12 Seasonal vertical temperature cross-sections (C^{o}), Cape Lookout, N.C. Station Number vs. Depth (meters), see Figure B-11 for station locations. T.N. Gill Cruises (VIMS, 1974).

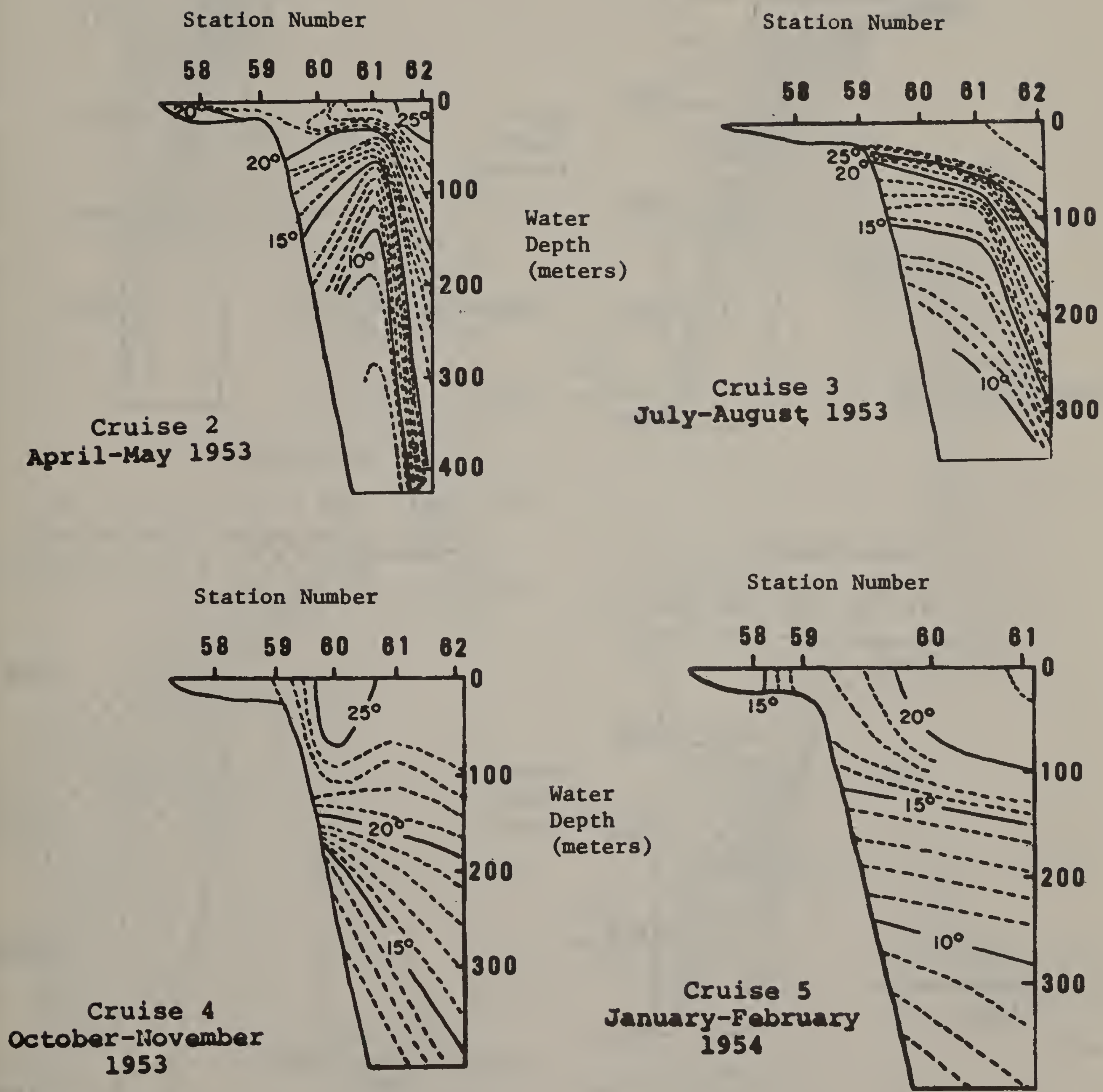


Figure B-13 Seasonal vertical temperature cross-sections (C°), Cape Fear, N.C. Station Number vs. Depth (meters), see Figure B-11 for station locations. T.N. Gill Cruises (VIMS, 1974).

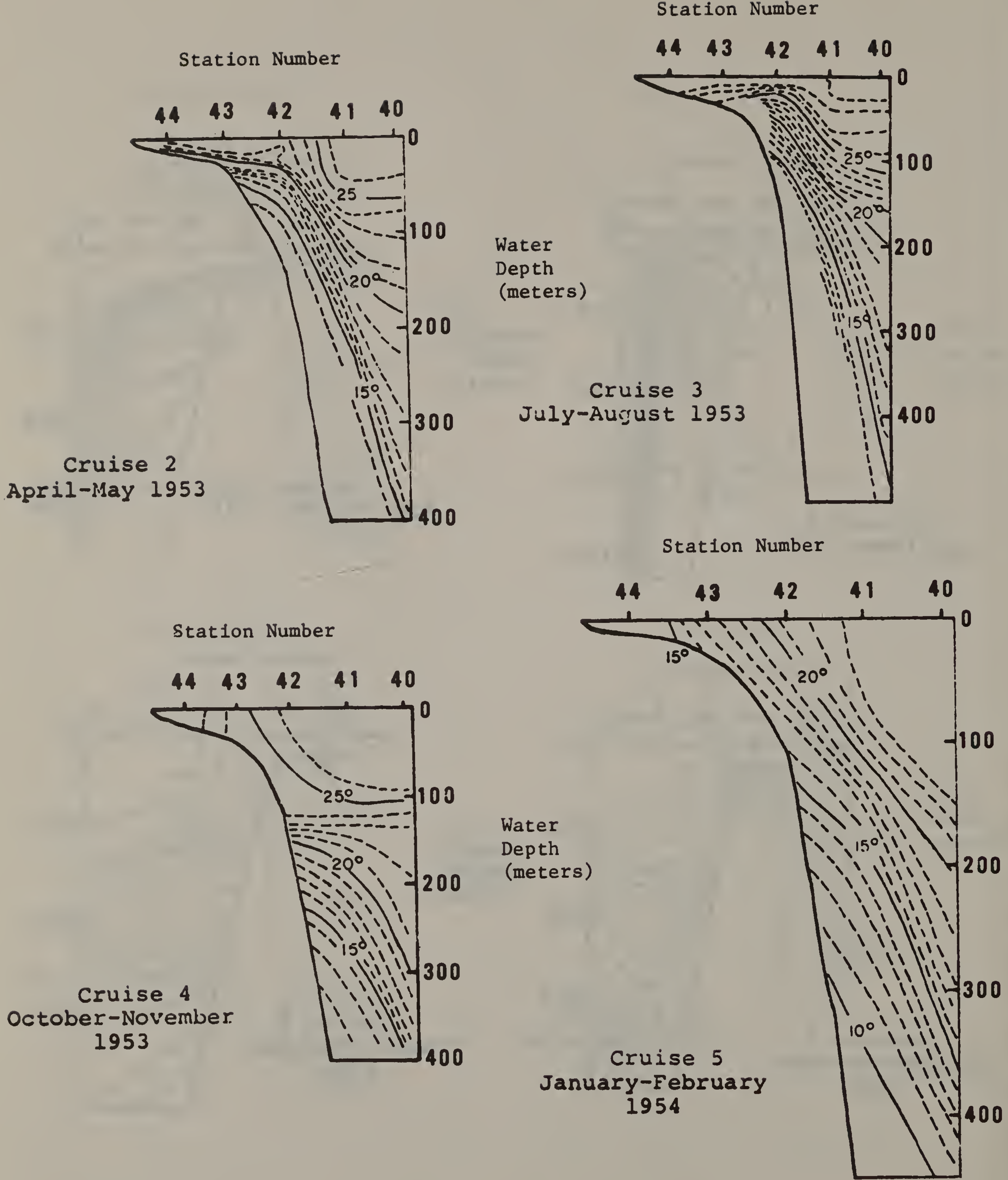


Figure B-14 Seasonal vertical temperature cross-sections, (C^{o}), Charleston S.C., Station Number vs. Depth (meters), see Figure B-11 for station locations. T.N. Gill Cruises, (VIMS, 1974).

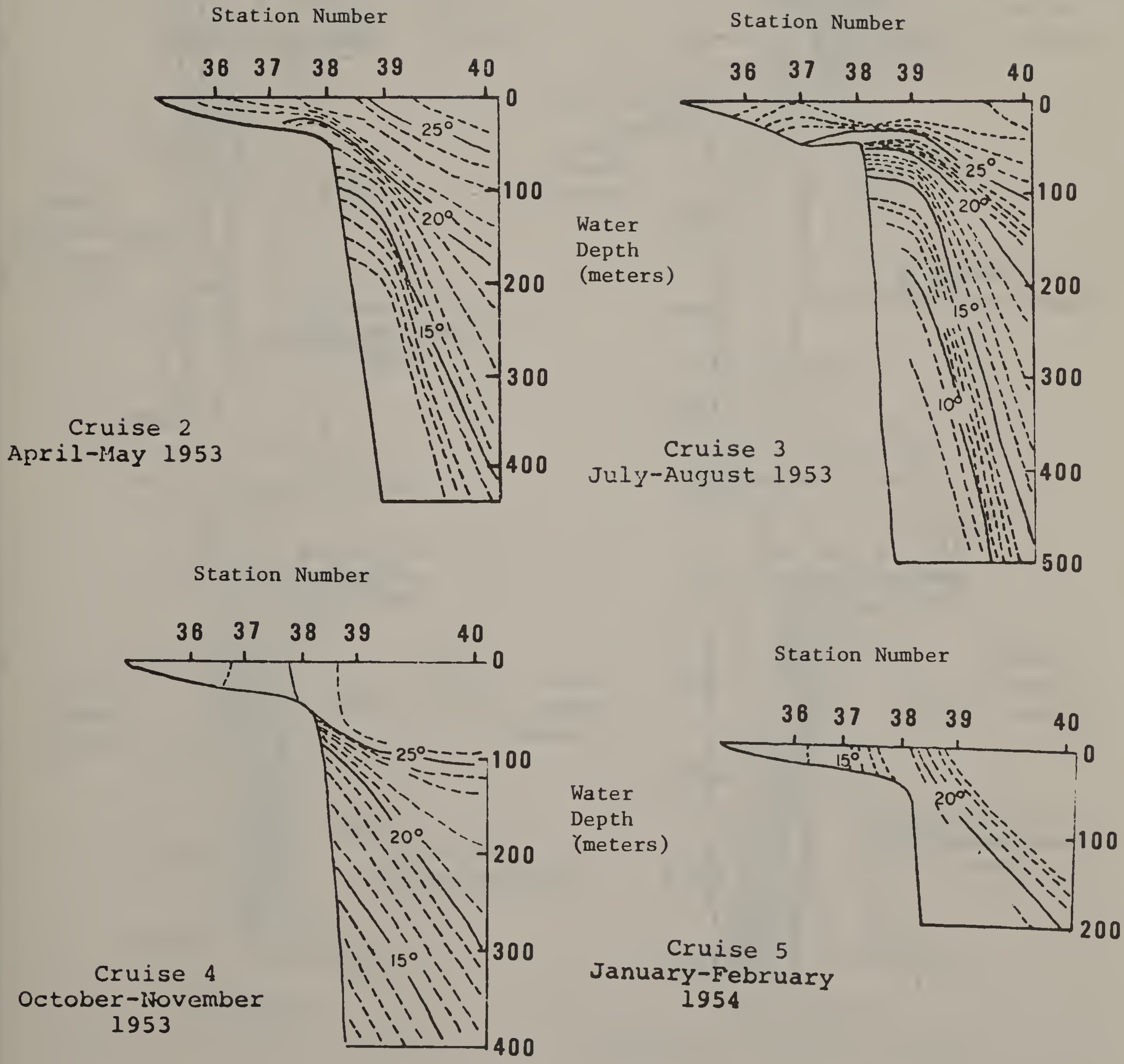


Figure B-15 Seasonal vertical temperature cross-sections, (C°), Savannah, Ga. Station Number vs. Depth (meters), see Figure B-11 for station locations, T.N. Gill Cruises (VIMS, 1974).

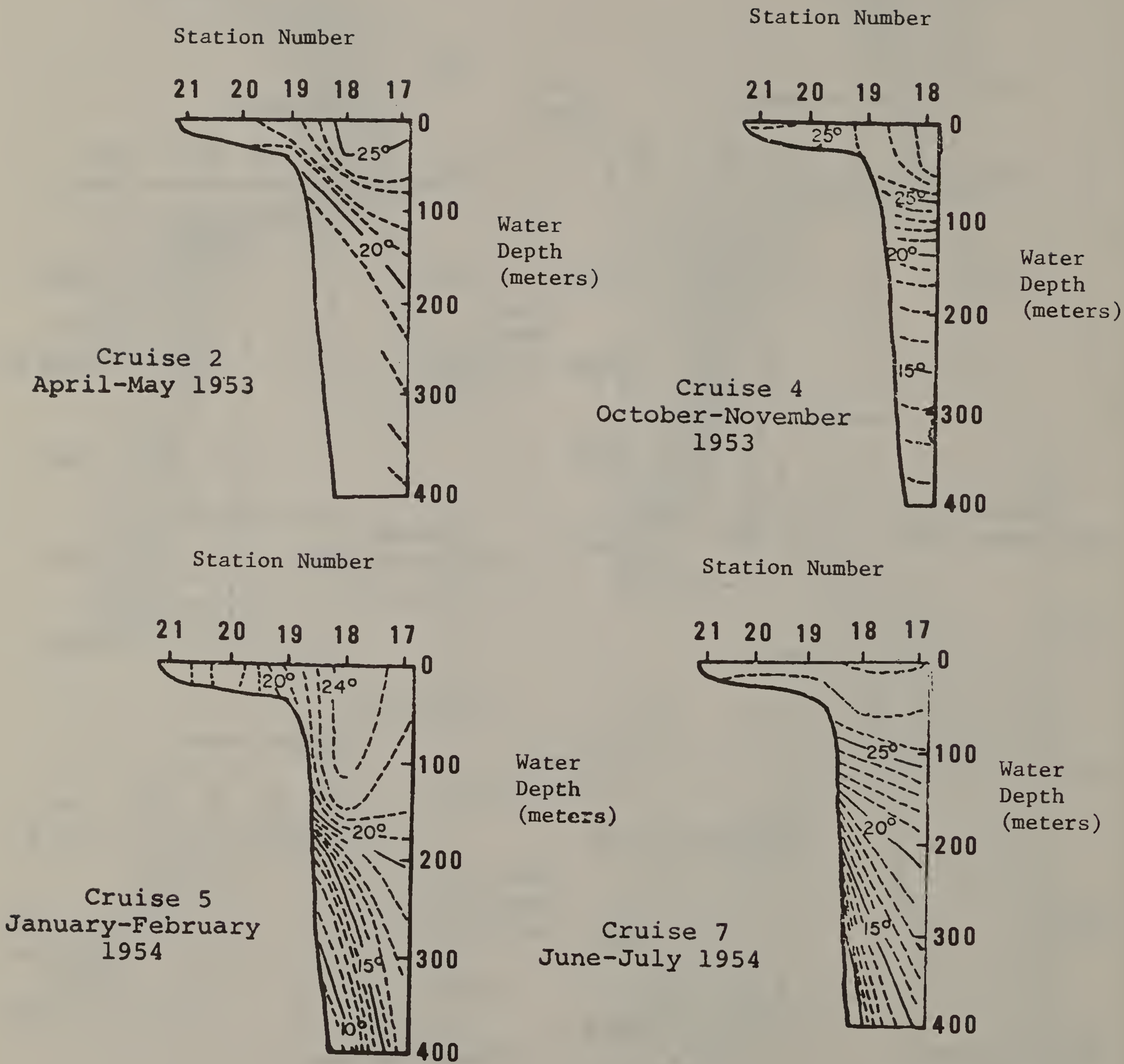


Figure B-16 Seasonal vertical temperature cross-sections (C°), Matanzas Inlet, Fl. Station Number vs. Depth (meters), see Figure B-11 for station locations, T.N. Gill Cruises, (VIMS, 1974).

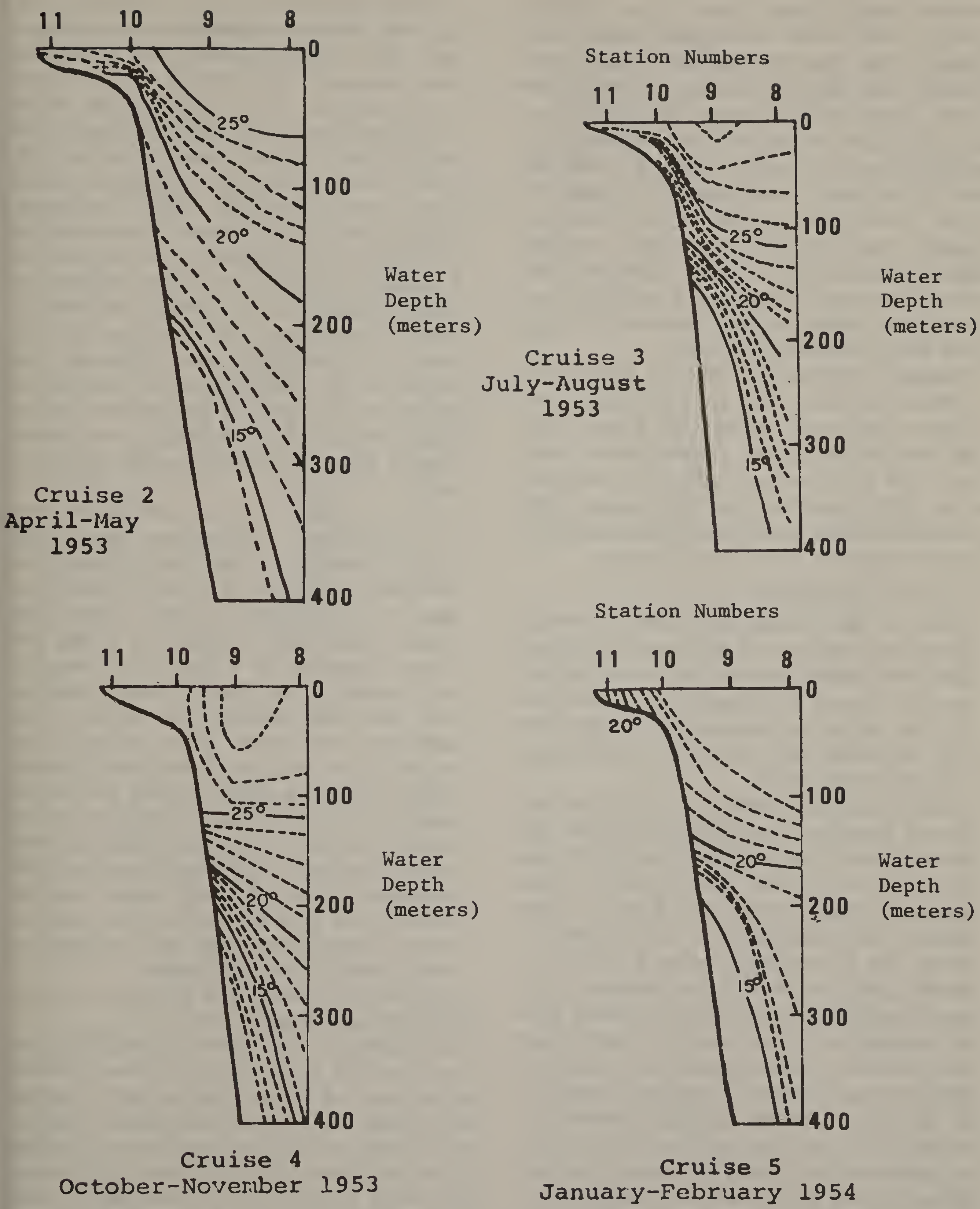


Figure B-17 Seasonal vertical temperature cross-sections (C°), Cape Canaveral, Fl. Station Number vs. Depth (meters), see Figyre B-11 for station locations, T.N. Gill Cruises (VIMS, 1974).

masses; North Atlantic Central Water (NACW), mixing water, shelf water and coastal water (Figure B-18). The North Atlantic Central Water exhibits large seasonal variation in temperature above 200 m (656 ft.) (Section II.B.2). Temperature of NACW remains fairly constant below 200 m. Mixing water is similar to NACW except during fall and winter when temperatures range 5°C lower. Shelf water exhibits more temperature variation than mixing water and has a salinity limit of 34.5-36 pppt. Coastal water has large seasonal variation of temperature and salinity and show lower values of both characteristics than shelf water except during summer.

Bumpus and Pierce (1955) showed coastal water of North Carolina to be composed of Carolina coastal water (warm, saline Gulf Stream water and river effluents) and Virginia coastal water (cold shelf water and river effluents). Stefansson et al. (1971) found that the Gulf Stream is the characteristic water mass over the outer shelf and beyond the shelf break off North Carolina.

b. Surface circulation

Much of the following information on surface circulation in the area of the proposed sale was taken from interpretation of draft bottle data obtained by Bumpus (1973) during the period 1960-1970. The bottles are ballasted to be affected by water movement just below the water surface rather than surface wind.

The data suggest a northerly component of drift from off Georgia to Cape Hatteras in January and February, with a southerly flow along the Florida coast to where the shelf narrows south of Cape Canaveral (Figures B-19 and B-20). A weak southerly drift appears close to the shore in Raleigh and Onslow Bays during February, expanding during March with the addition of Virginia Coastal Water (Figure B-21). During April the southerly drifts near shore are discontinuous and as northerly currents prevail over most of the shelf from Cape Canaveral northward (Figure B-22). By May, a strong southerly current segmented by indrafts from the Florida Current exists southward from Frying Pan Shoals. The shelf currents in June are northerly and nearshore currents are southerly (Figure B-24). Virginia coastal water in addition to Gulf Stream water flows past Cape Hatteras into Raleigh Bay.

According to Bumpus:

"With the recovery rate still modest in July, the drift off North Carolina is now northeasterly. The Virginian coastal water indraft has been pinched off. The drift off Cape Canaveral is still northerly, but a southerly drift begins over the mid-part of the shelf off Georgia. This southerly drift expands during August and continues during September, involving the whole shelf from Frying Pan Shoals southward. Florida Current water becomes entrained in the shelf drift, which commonly reaches speeds of 9 nautical miles/day. Off North Carolina the direction of drift is intermittent, northerly at times, southerly on other occasions. By October and continuing into November and December, the southerly drift is restricted to off Georgia and Florida; the remainder of the shelf exhibits a very poor recovery rate, insufficient to determine the direction and velocity of drift.

It would appear that two conflicting systems are at play here, a geostrophic current interrupted by invasions of the Florida Current. The geostrophic current tends to flow southerly and does so successfully in May, during late summer, and early autumn from Frying Pan Shoals southward. It is interrupted frequently by invasions of the Florida Current riding up over the shelf carrying the surface water northward. On those occasions when the recovery rate is poor in the South Atlantic Bight, one can generally assume the surface water has been forced out by a meander of the Florida Current, and the drift bottles have been carried north past Cape Hatteras and out of the immediate system. It would appear that the meanders are more frequent and more successful in accomplishing this total exchange of water north of Frying Pan Shoals."

Figures B-25 through B-30 illustrate the above interpretation by Bumpus (1973).

In conclusion, the southerly coastal current found north of Cape Hatteras becomes transient on the shelf off North Carolina, South Carolina and Georgia. Major factors influencing circulation in the proposed sale area are density gradients caused by temperature and salinity differences, the nearby Gulf Stream, and prevailing winds. The Gulf Stream exerts a northward frictional drag on those waters lying on the continental shelf. Both Gray and Cerame-Vivas (1963) and Bumpus and Lauzier (1965) indicate that there is

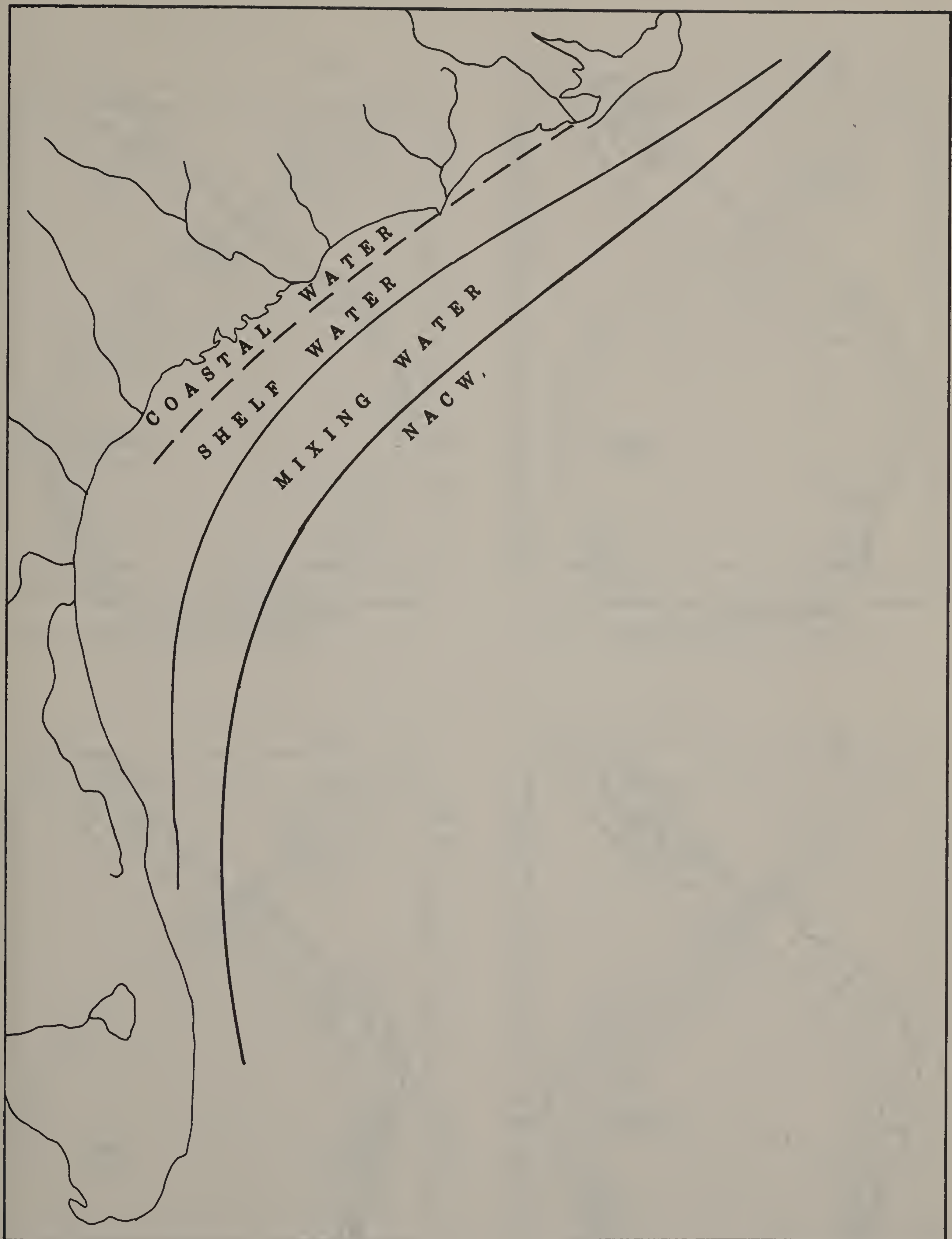


Figure B-18-Location of water masses on the South Atlantic Bight according to Kuroda and Marland (1973).

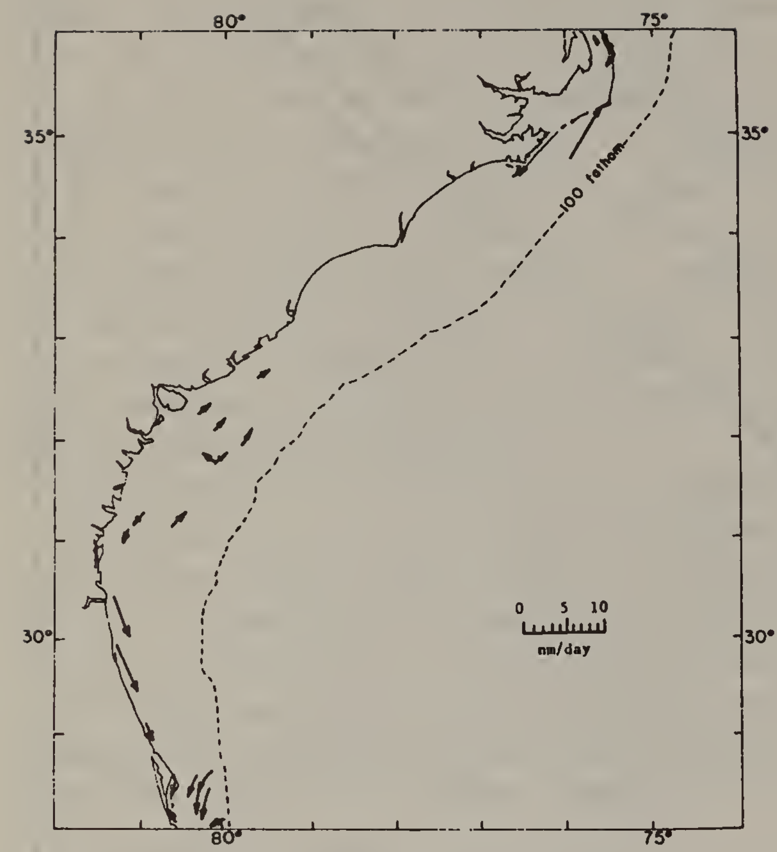


Figure B-19. Inferred surface drift, Jan. 1960-1970 (after Bumpus, 1973).

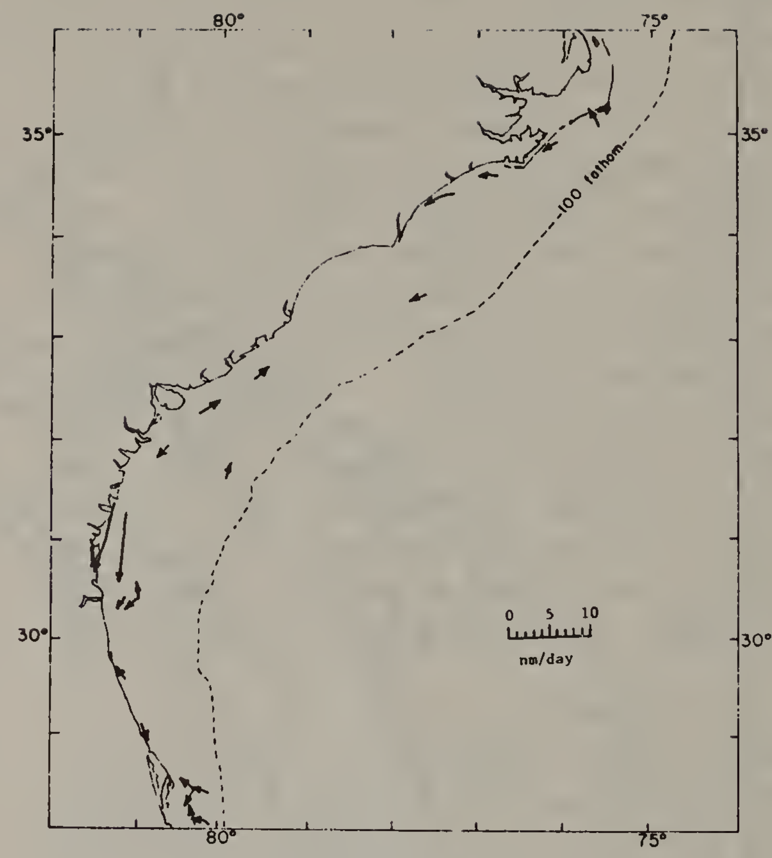


Figure B-20. Inferred surface drift, Feb. 1960-1970 (after Bumpus, 1973).

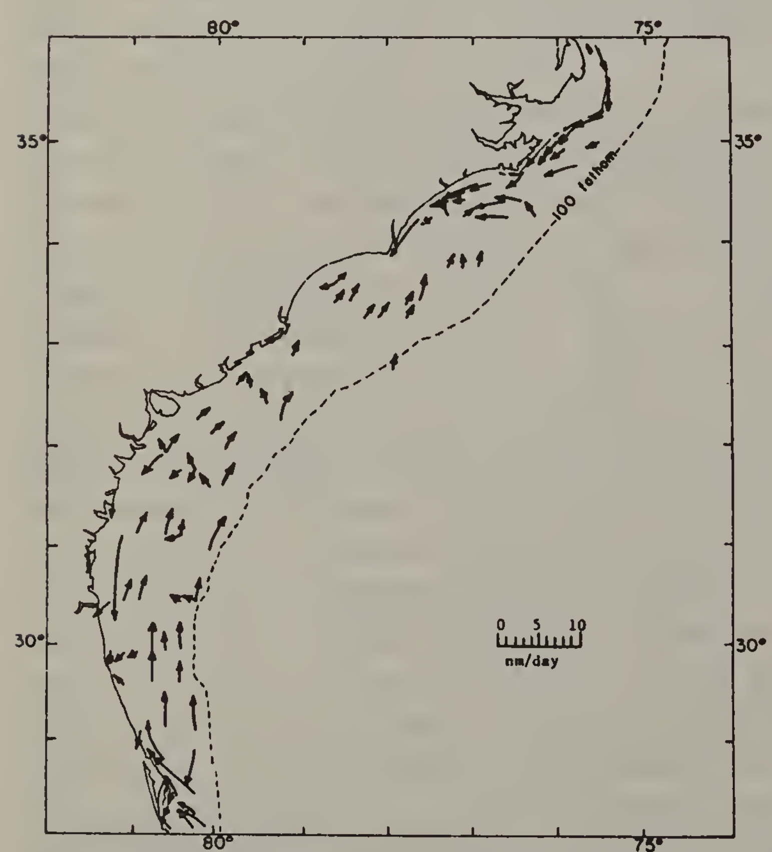


Figure B-21. Inferred surface drift, Mar. 1960-1970 (after Bumpus, 1973).

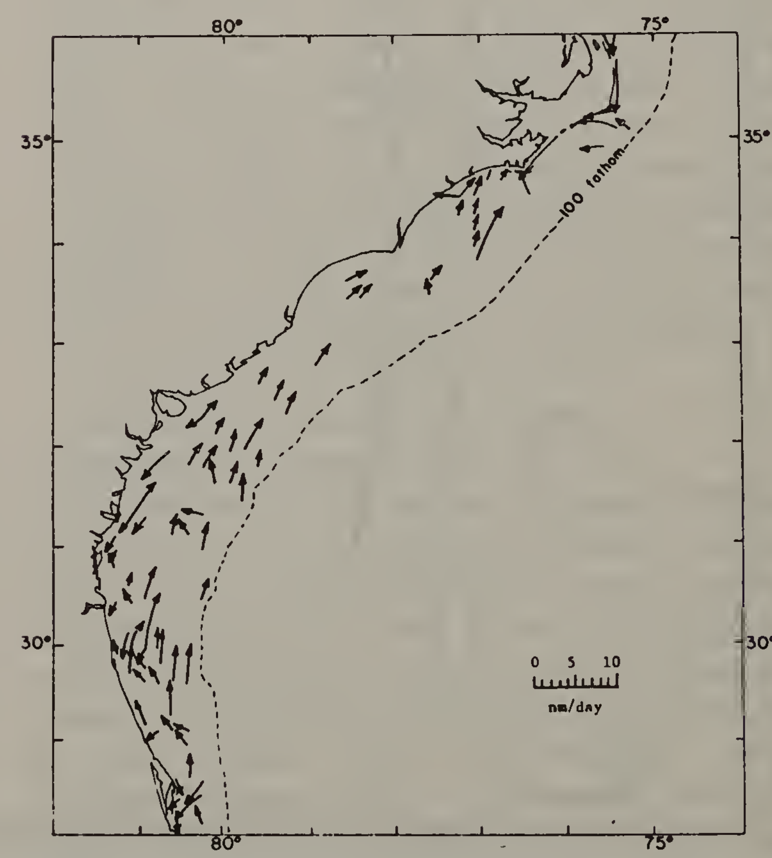


Figure B-22. Inferred surface drift, Apr. 1960-1970 (after Bumpus, 1973).

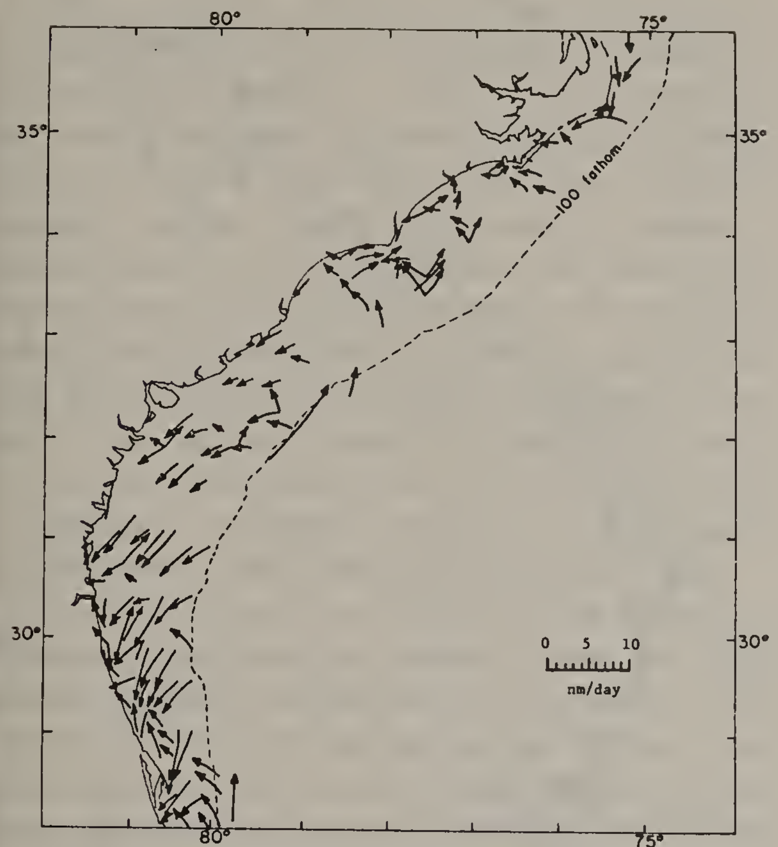


Figure B-23. Inferred surface drift, May 1960-1970 (after Bumpus, 1973).

Figure B-24. Inferred surface drift, Jun. 1960-1970 (after Bumpus, 1973).

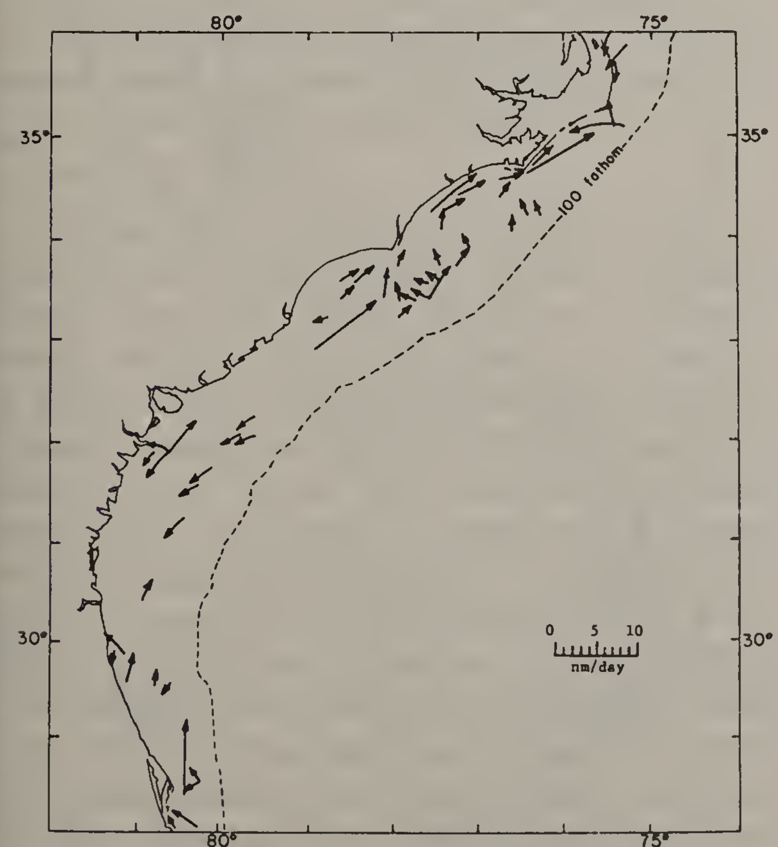


Figure B-25. Inferred surface drift, Jul. 1960-1970 (after Bumpus, 1973).

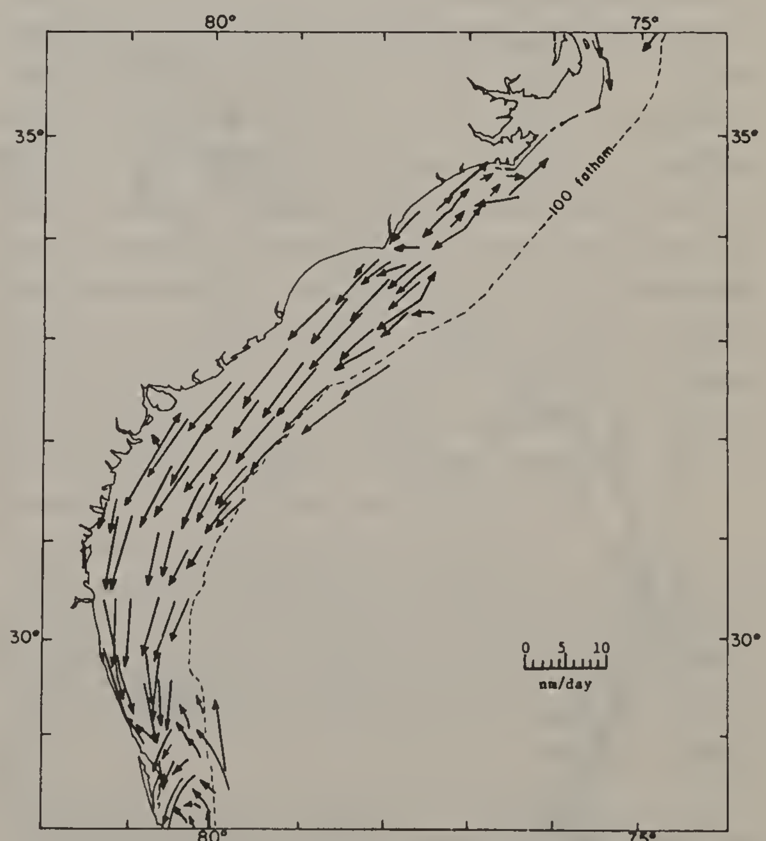


Figure B-26 Inferred surface drift, Aug. 1960-1970 (after Bumpus, 1973).

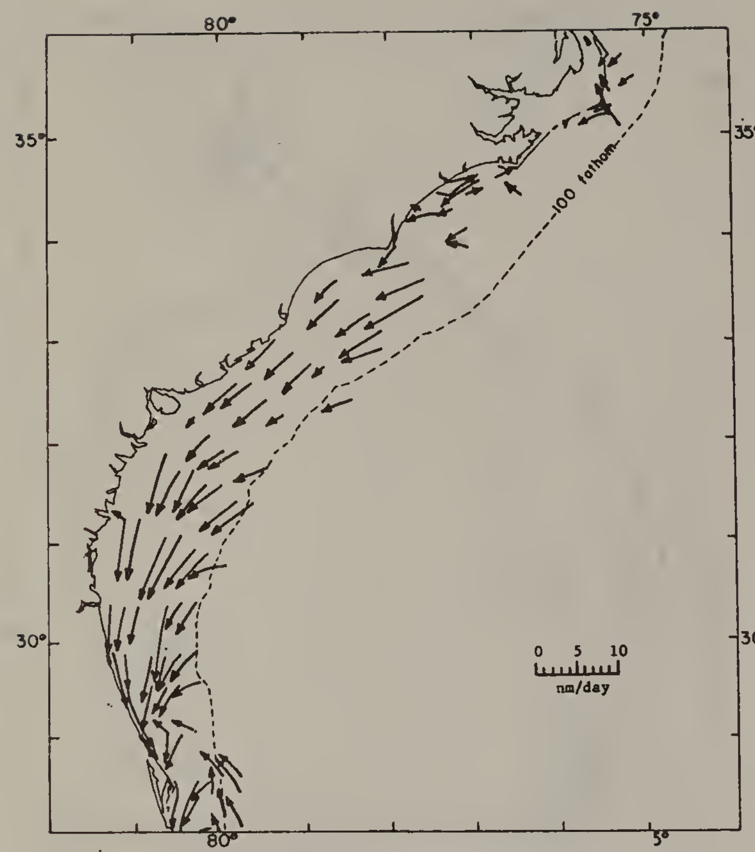


Figure B-27. Inferred surface drift, Sept. 1960-1970 (after Bumpus, 1973).

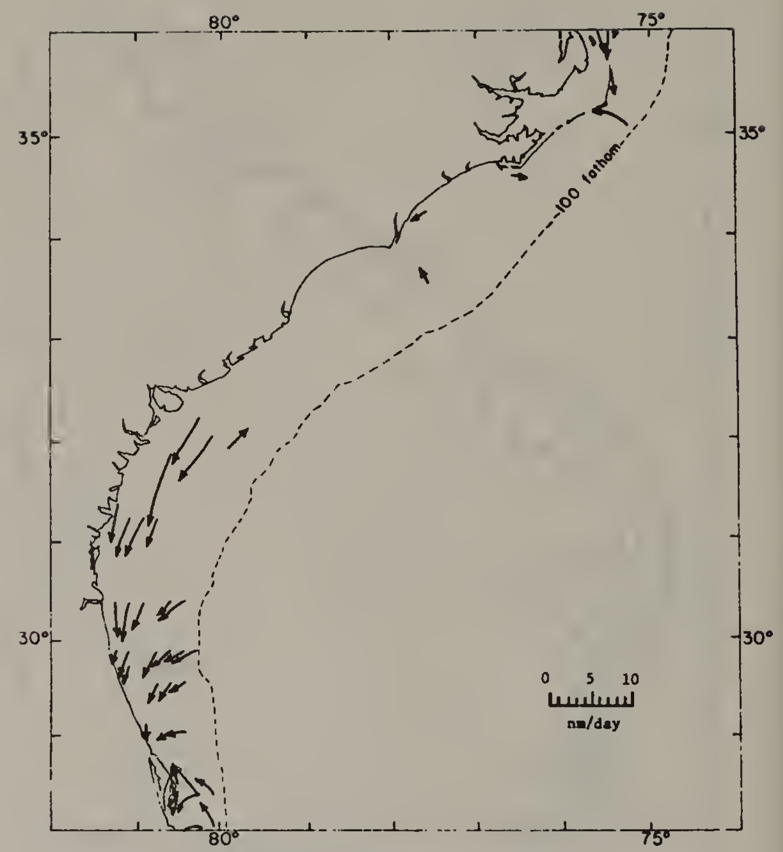


Figure B-28. Inferred surface drift, Oct. 1960-1970 (after Bumpus, 1973).

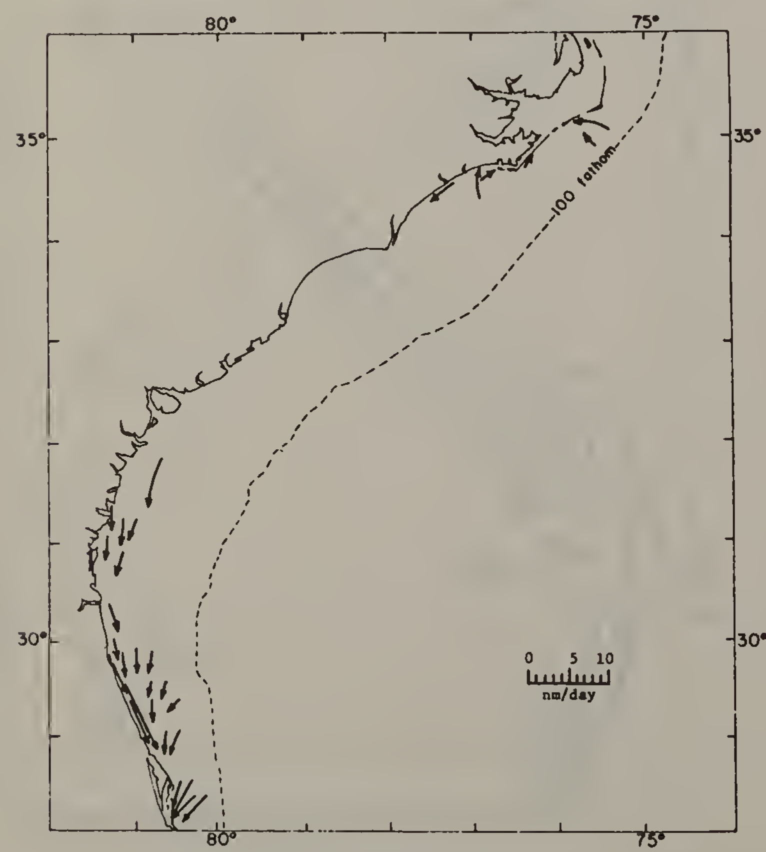


Figure B-29. Inferred surface drift, Nov. 1960-1970 (after Bumpus, 1973).

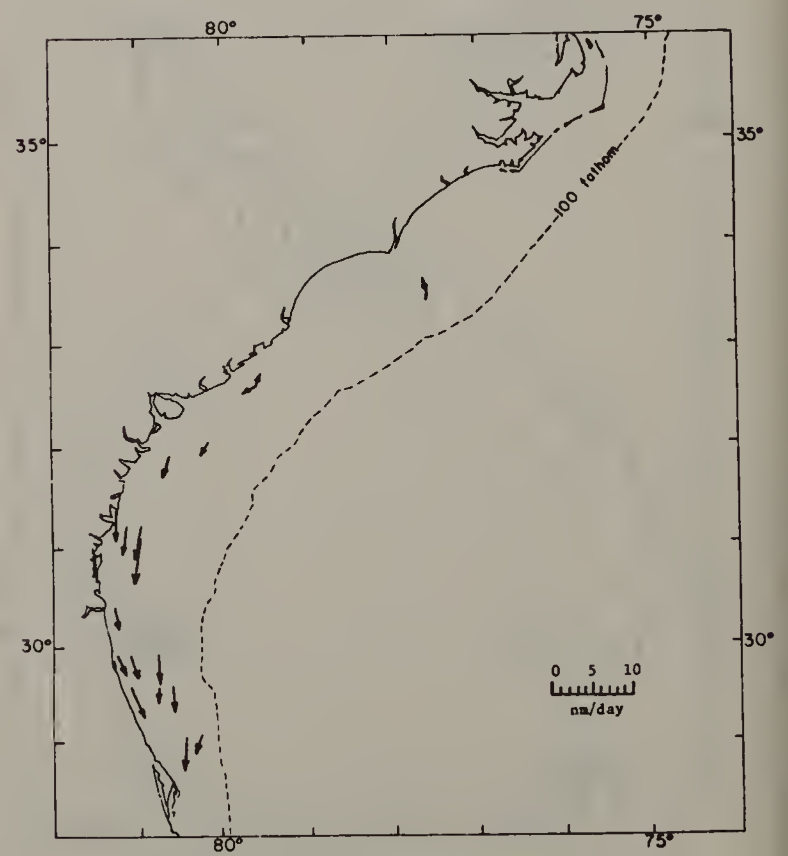


Figure B-30. Inferred surface drift, Dec. 1960-1970 (after Bumpus, 1973).

a tendency towards a southerly flowing coastal current inshore of the predominant northeasterly flowing current much of the time.

c. Subsurface and bottom circulation

Bottom current data presented by Bumpus (1973), obtained form sea bed drifters indicated a convergence towards capes, i.e. Hatteras, Lookout, Fear and Canaveral. Off the Carolina Bays the bottom drift is northerly (less than 2.3 cm/sec.) on the outer shelf with a tendency toward shore or southerly near the coast. Off South Carolina and Georgia bottom drift measurements show no consistent pattern. It is speculated that these currents are directly influenced by indrafts from the Gulf Stream with periods of about two weeks. Off Florida that drift is northerly with a confused, sometimes north, sometimes south, drift between Cape Canaveral and Jacksonville.

Water on the continental shelf of the Southeast Georgia Embayment is renewed from the Gulf Stream by two mechanisms. In summer, when shelf water becomes warmed and less dense water intrudes along the bottom. This movement has been inferred from oxygen anomalies and nutrient distributions (Stefansson et al., 1971). As water moves up the shelf and mixes upward, nearshore surface water is flushed offshore. During winter, cooler nearshore water cascades down the shelf allowing Gulf Stream water to intrude on the surface as mentioned in Section B.2. (Stefansson et al., 1971). Upwelling of cool water in July and August along the central Florida coast has also been reported by Taylor and Stewart (1959).

d. The Gulf Stream

The Gulf Stream is one of the major currents that form a clockwise gyral in the North Atlantic Ocean (Jacobson, 1974). It flows northward through the Straits of Florida along the continental slope north to Cape Hatteras. Total transport of water through the Straits of Florida is approximately 32 x 10^6 m^3/sec and increases to approximately 63 x 10^6 m^3/sec by the time the Gulf Stream reaches Cape Hatteras. Figure B-31 depicts the velocity of the Gulf Stream at four locations within the area of interest. Figures B-32 to B-34 illustrate the current speed variation with depth off Cape Canaveral, Jacksonville, and Cape Fear. Measurements taken of bottom current on the Blake Plateau (Pratt, 1963) during June and July 1961 show speeds averaging 25 cm/sec.

4. Waves

Wind waves are formed by a transfer of energy from turbulent air flowing over water. The wind velocity, the distance over which the wind blows (fetch), and the length of time that the wind blows (duration) all have a direct effect upon wave propagation and size. In general, any increase in these three factors will result in larger waves. Where waves are irregular and actively being generated by wind is called sea. Sea waves that are no longer under wind influence will become more uniform as the faster waves move through the slower ones. These well-sorted, uniform waves, far from the generating influence are called swell. It is possible for sea and swell to occur in the same area resulting in a "confused" sea.

a. The offshore wave climate

The offshore wave climate for the southeast Atlantic coast of the United States, generally, reflects the predominant wind conditions that prevail during a particular season. The wave conditions throughout the area of interest are more severe during the fall and winter when waves are larger and move in from the north and west (Table B-1). The majority of waves along this coast during spring and summer are small and from the south and east.

Figures B-35 thru B-38 have been prepared by VIMS (1974) from U. S. Naval weather service command data. These data were obtained from a comprehensive collection of marine surface weather observations that were taken aboard vessels of varying registry. These data are somewhat biased towards good weather since ships tend to avoid inclement weather whenever possible. The data presented in the roses are visual estimates and are of sea waves only (Jacobson, 1974). Charts of isolines of percent frequency are based on tabulations by two degree squares of data at the National Climatic Center and the U. S. Oceanographic Office prior to 1958.

(1) Area 17—Cape Hatteras (Fig. B-35)

Wave heights in this area are observed to be less than 1.2 m (4 ft.) 58% of the time during the year. Waves were observed to be greater than 3.7 m (12 ft.) for two percent of the year.

(2) Area 19—Charleston (Fig. B-35)

Seas were observed to be less than 1.2 m (4 ft.) 57% and greater than 3.7 m (12 ft.) two percent of the time during the year.

(3) Area 20—Jacksonville (Fig. B-35)

Seas of less than 1.2 m (4 ft.) occur 62% and greater than 3.7 m (12 ft.) less than one percent of the time during the year.

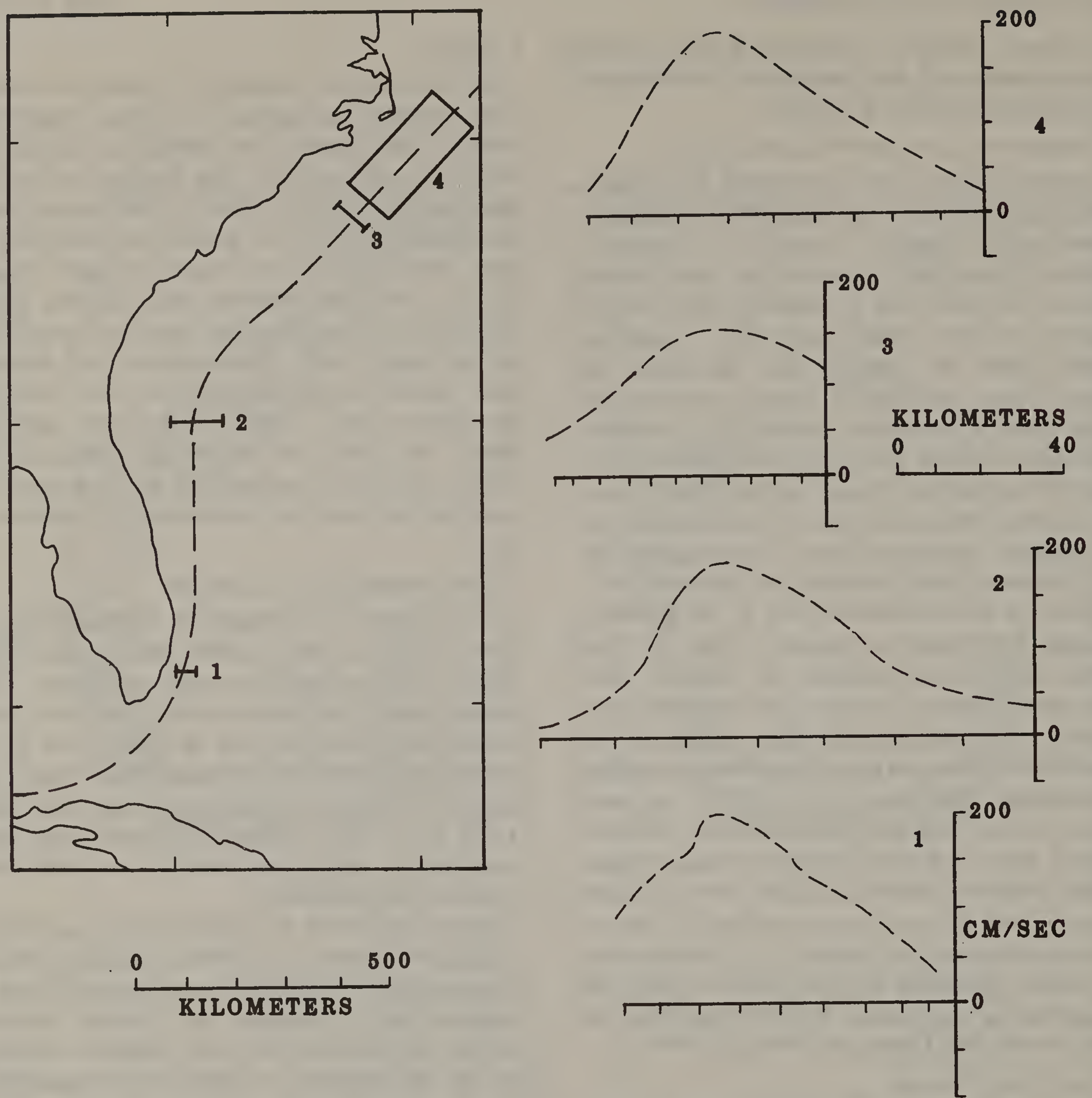


Figure B-31-Observed downstream velocity in cm/sec at four locations along the Gulf Stream (Webster, 1961).

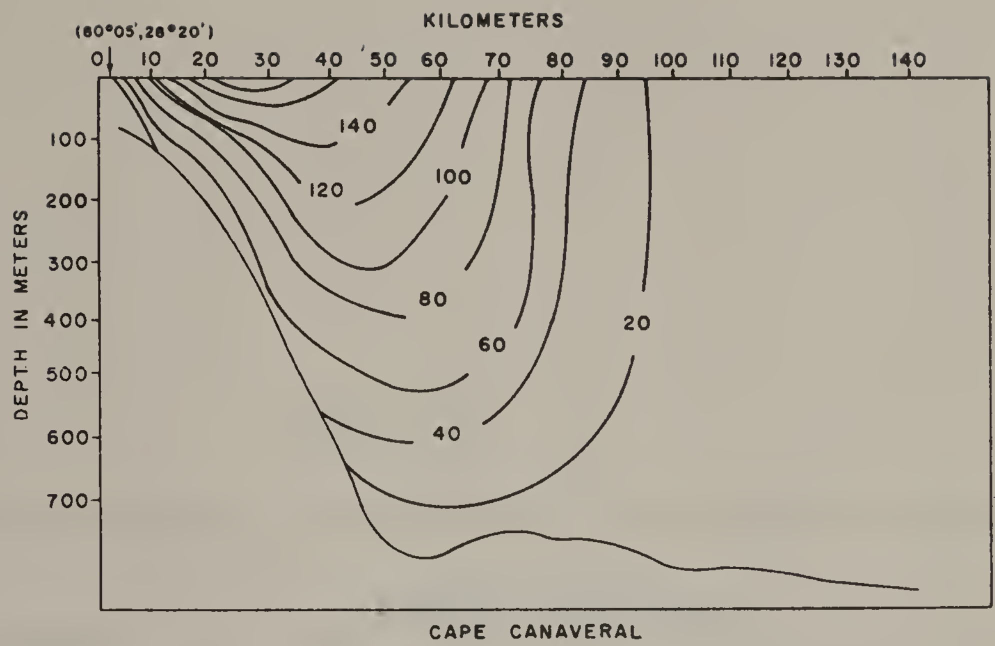


Figure B-32 Downstream velocity of Gulf Stream off Cape Canaveral in cm/sec (Richardson et al. 1969).

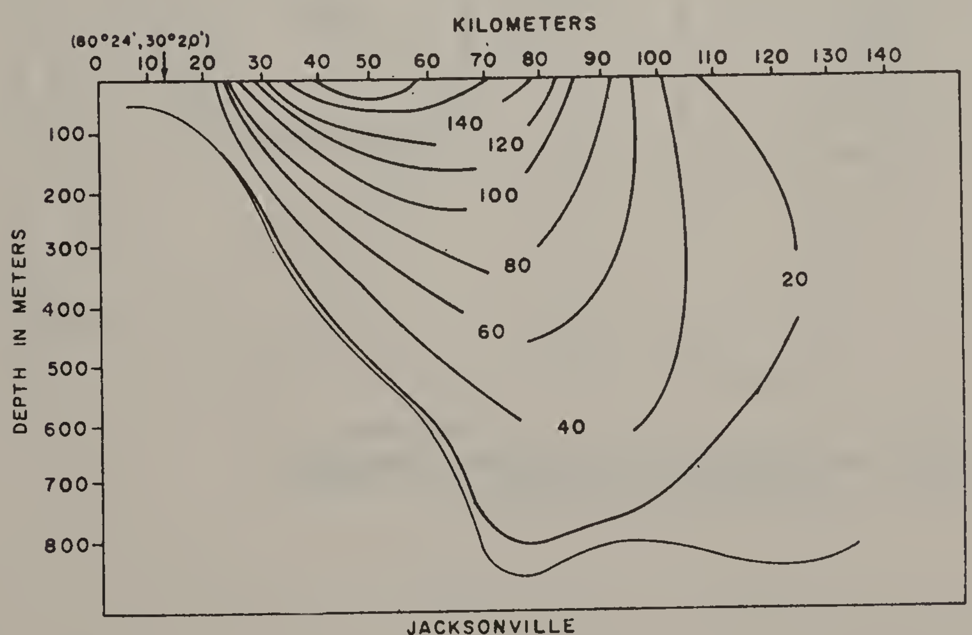


Figure B-33 Downstream velocity of Gulf Stream off Jacksonville in cm/sec (Richardson et al. 1969).

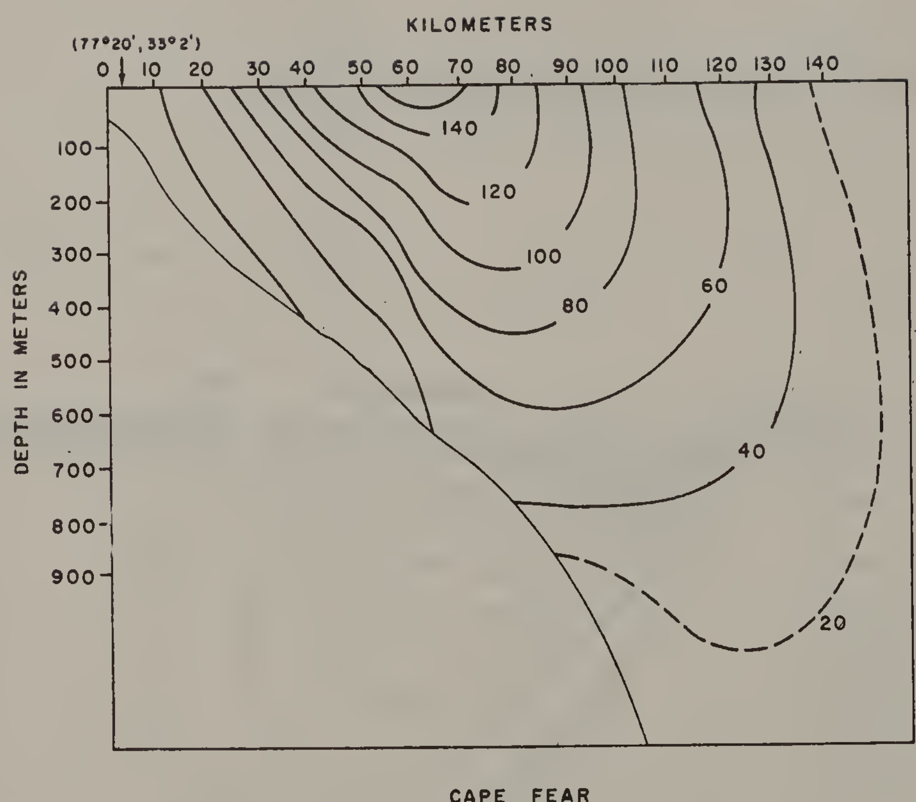


Figure B-34 Downstream velocity of Gulf Stream off Cape Fear in cm/sec (Richardson et al. 1969).

Table B-1

Offshore Wave Climate, Southeastern U.S. Offshore Region

SSMO AREA	Height (meters)	Percent Frequency Feb.	May	Aug.	Nov.	Annual
AREA 17	1.22	40	66	74	52	58
	3.66	5	2	1	2	2.5
AREA 19	1.22	40	66	74	48	57
	3.66	5	2	1	1.5	2.4
AREA 20	1.22	40	76	83	49	52
	3.66	5	1	1	1	2

Source: Helle, 1953.

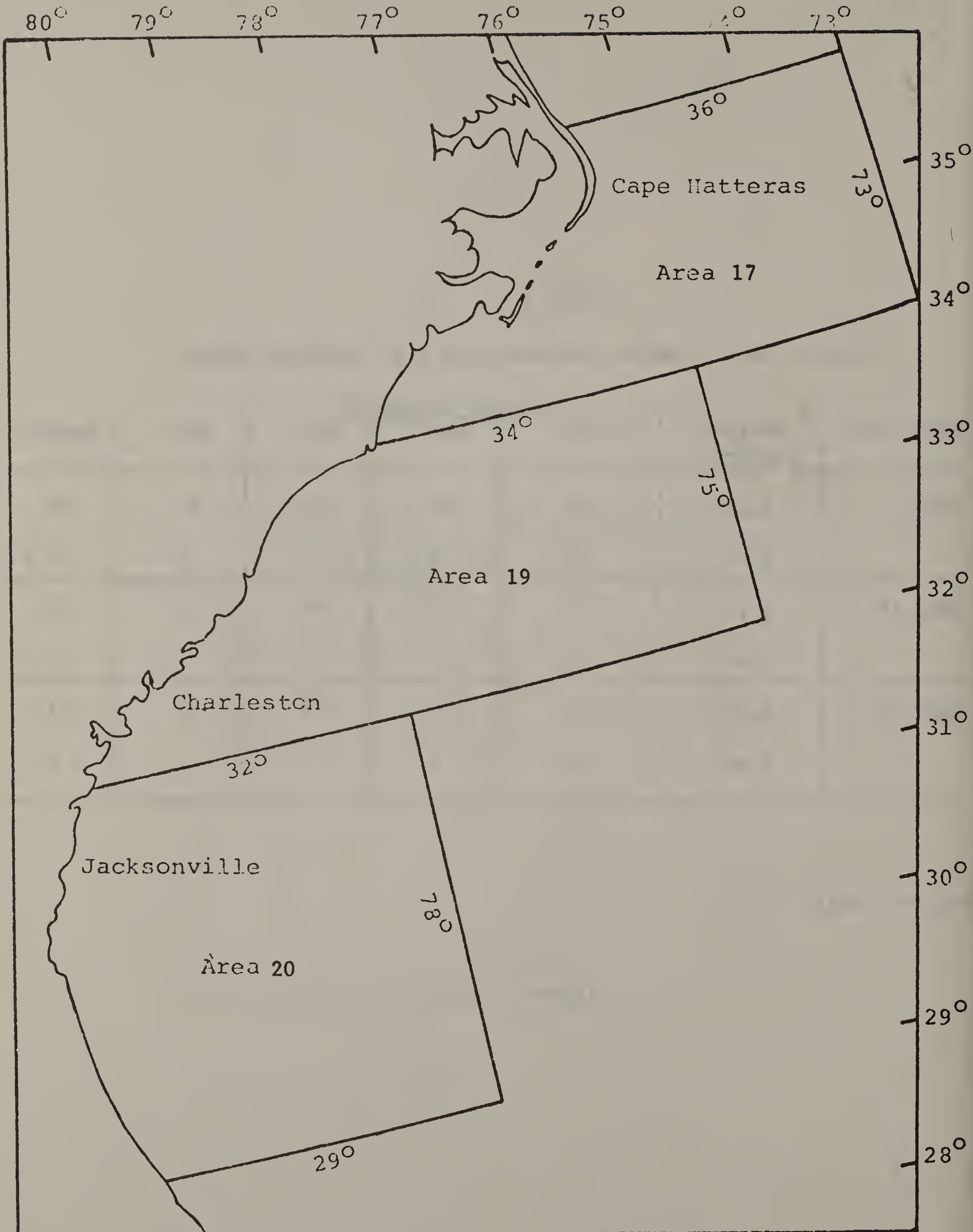


Figure B-35 Areas of SSMO Data (adopted from VIMS, 1974).

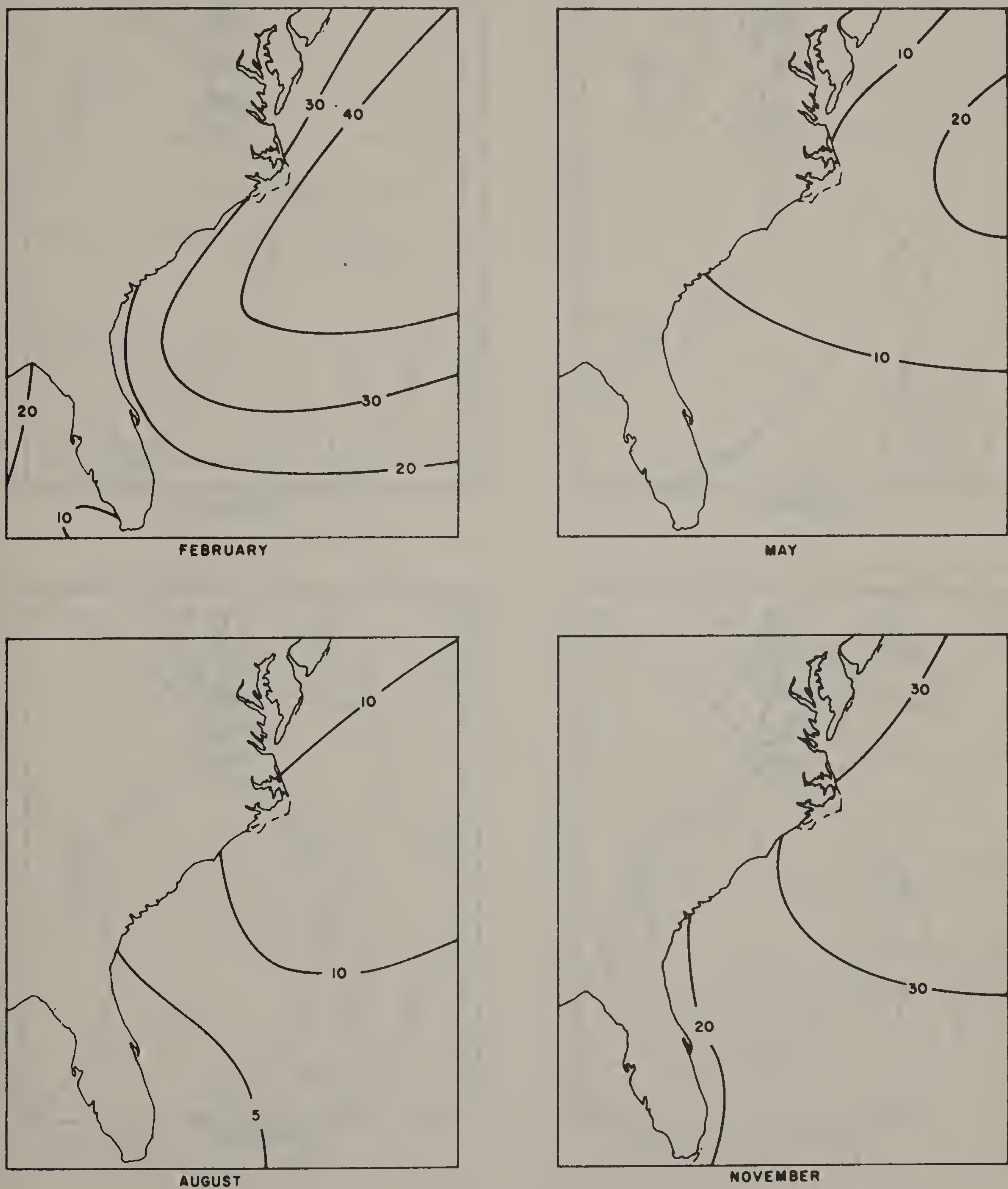


Figure B-36 Percent frequency of seas greater than 1.5 meters (5 ft.) (NOAA, 1973).

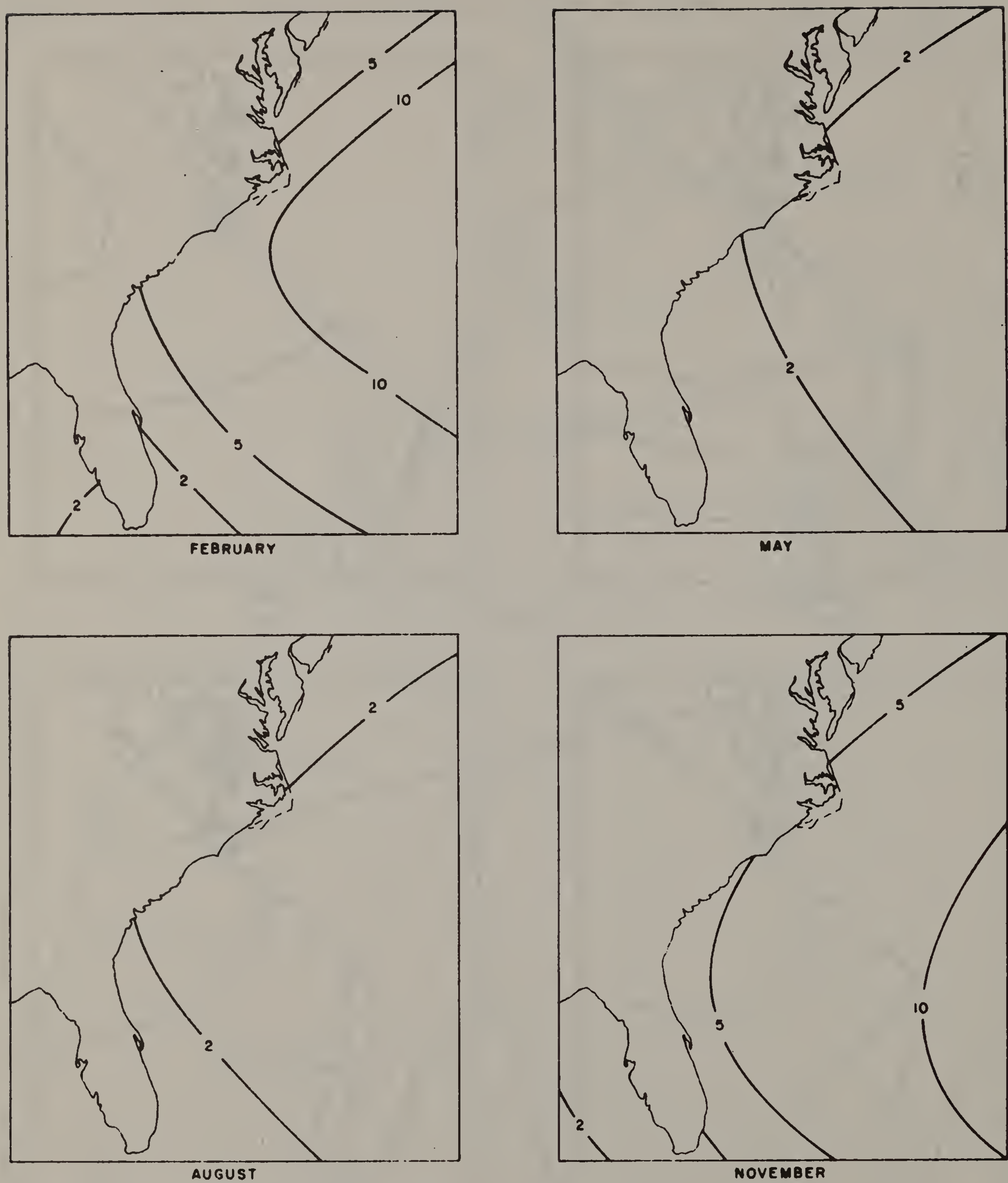


Figure B-37 Percent frequency of swell greater than 3.6 meters (12 ft.) (NOAA, 1973).

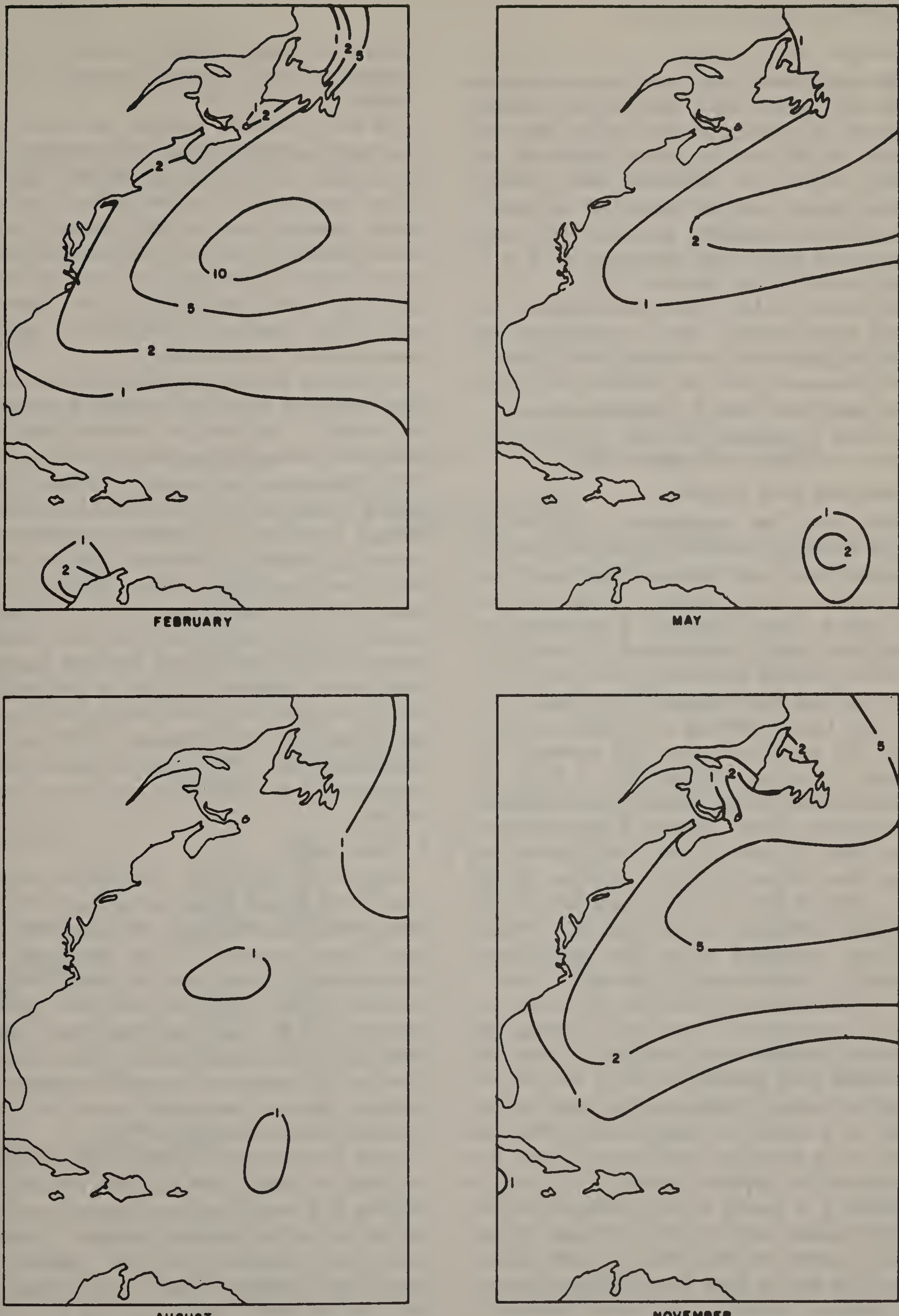


Figure B-38 Percent frequency of seas greater than 6 meters (20 ft.), (NOAA, 1973).

b. Coastal wave climate

The typical deep water ocean waves discussed in the last section have long and low profiles. However, as waves pass into shallow area they steepen and decrease in velocity. Eventually, the orbital velocity of individual water particles becomes greater than the velocity of the wave itself. In general, depending upon the wave period, waves break when water depths reach 1.3 to 1.7 times the wave height (Shepart, 1973).

Surf records at four Coast Guard stations for a period from October 1954 to December 1956 (Table B-2) show that the onshore wave climate is greatly decreased from the offshore observations at the same time. Table B-2 illustrates that surf in these areas is generally less than 1.3 m (4 ft.) and hardly ever exceeds three meters (9 ft.).

5. Tides and Tidal Currents

Tides along the southeastern coast of the United States are semi-diurnal and thus have two complete cycles every lunar day. The tide at Cape Hatteras occurs approximately one hour later than the tide at Cape Canaveral. The spring tidal ranges vary from a maximum of 2.4 m (8 ft.) at Savannah, Georgia decreasing to the north, 0.9 m (3 ft.) at Cape Hatteras and to the south, 1.2 m (4 ft.) at Cape Canaveral (U.S. Dept. of Navy, 1959). The spring tidal range also decreases with distance from shore (Visual Nos. 6 N-S). The maximum range of tidal height on the continental shelf is approximately 0.6 m (2 ft.) with tidal currents up to 25 cm/sec (VIMS, 1974). In the open ocean, tidal currents are rotary in nature so that in a tidal cycle of 12.5 hrs., the direction of flow will have precessed to the right all compass directions. According to the 1976 Tidal Current Tables (U.S. Department of Commerce, 1976d):

> "A characteristic feature of the rotary current is the absence of slack water. Although the current generally varies from hour to hour, this variation from greatest current to least current and back again to greatest current does not give rise to a period of slack water. When the velocity of the rotary tidal current is least, it is known as the minimum current, and when it is greatest it is known as the maximum current. The minimum and maximum velocities of the rotary current are thus related to each other in the same way as slack and strength of current, a minimum velocity of the current following a maximum velocity by an interval of about three hours and being followed in turn by another maximum after a further interval of three hours."

The above reference provides the time of slack water and maximum current and speed for various estuaries and locations on the shelf. Tide prediction tables are also available giving an estimate (within one-half hour) of high and low tide for coastal stations. Figure B-39 illustrates the precession of tidal current directions. The ellipses indicate the relative magnitude of the currents as well as the variation of direction for different coastal stations, simultaneously.

The tides in estuaries lag behind those along the coast due to the travel time required in moving up the estuary. Tidal range in estuaries may vary from the coast depending upon local configuration of the embayment and weather conditions. Information on tidal currents in estuaries has been provided in Section II. 1. b. Above the upper limit of an estuary (defined by Pritchard (1967) to be the short transitional region where chlorinity drops from 0.06—0.01 ppt). There is a stretch of the freshwater river that is still subject to tidal influence. This tidal section of the river has sufficient flow to counteract the flow of the flood tide but still is subject to tidal variation in water elevation (Pritchard, 1967). Pritchard (1967) has also determined that the tidal elevation effect frequently ceases where the river bed rises above sea level.

6. Storm Surge

Storm surge along the southeastern Atlantic coast of the United States can be caused by hurricanes or strong northeasters (Figure B-40). Principal factors involved in the generation and modification of storm surge are wind stress, inverted barometer effect, and bathymetry and configuration of the local shoreline. Other factors which may have an effect on the storm surge are wave set up, rotation of the earth, second order coupling between astronomic tides and storm surge and rainfall (Jacobson, 1974).

When a component of wind blows normal to the coast, it causes a net transport toward shore resulting in a water level rise. The rise in sea level due to the fall in barometric pressure is approximately one centimeter for every millibar fall, under ideal conditions (Harris, 1963) (Figure B-41). The flat, wide continental shelf of the east coast of the United States often amplifies the ef-

Table B-2

Coastal Wave Climate, Southeastern U.S. Coastal Region (1955).

Location	Height (meters)	Percent Frequency February	May	August	November
Cape Lookout	0 - .61	13	15	NO DATA	40
	.61 - 1.22	73	85		45
	1.22 - 1.83	14			10
	1.83 - 3.05				
Cape Fear	0 - .61	70	80	65	80
	.61 - 1.22	30	20	20	15
	1.22 - 1.83			10	
	1.83 - 3.05			5	
Brunswick	0 - .61	95	98	85	90
	.61 - 1.22	5	2	10	10
	1.22 - 1.83			5	
	1.83 - 3.05				
New Smyrna Beach	0 - .61	6	25	20	55
	.61 - 1.22	80	75	75	45
	1.22 - 1.83	6		5	
	1.83 - 3.05	2			

Source: Helle, 1953.

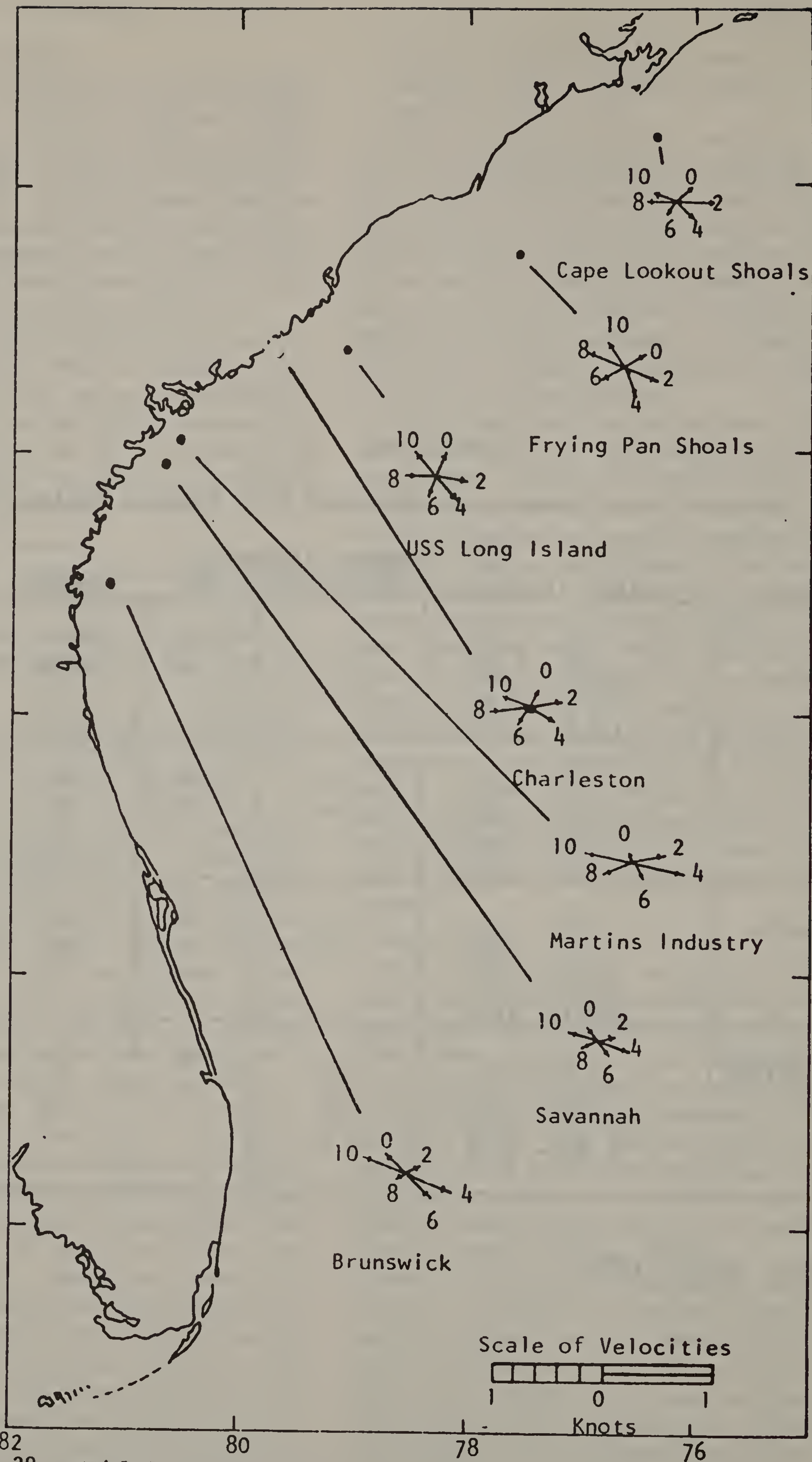


Figure B-39 Tidal ellipses on the shelf showing speed and direction of the tidal current for hours after the Greenwich Transit of the moon (Haight,1942).

FIGURE B-40—OBSERVED STORM SURGE M(FT) ALONG THE SOUTHEASTERN UNITED STATES COAST. (DATA FROM PERDIKIS, 1967).

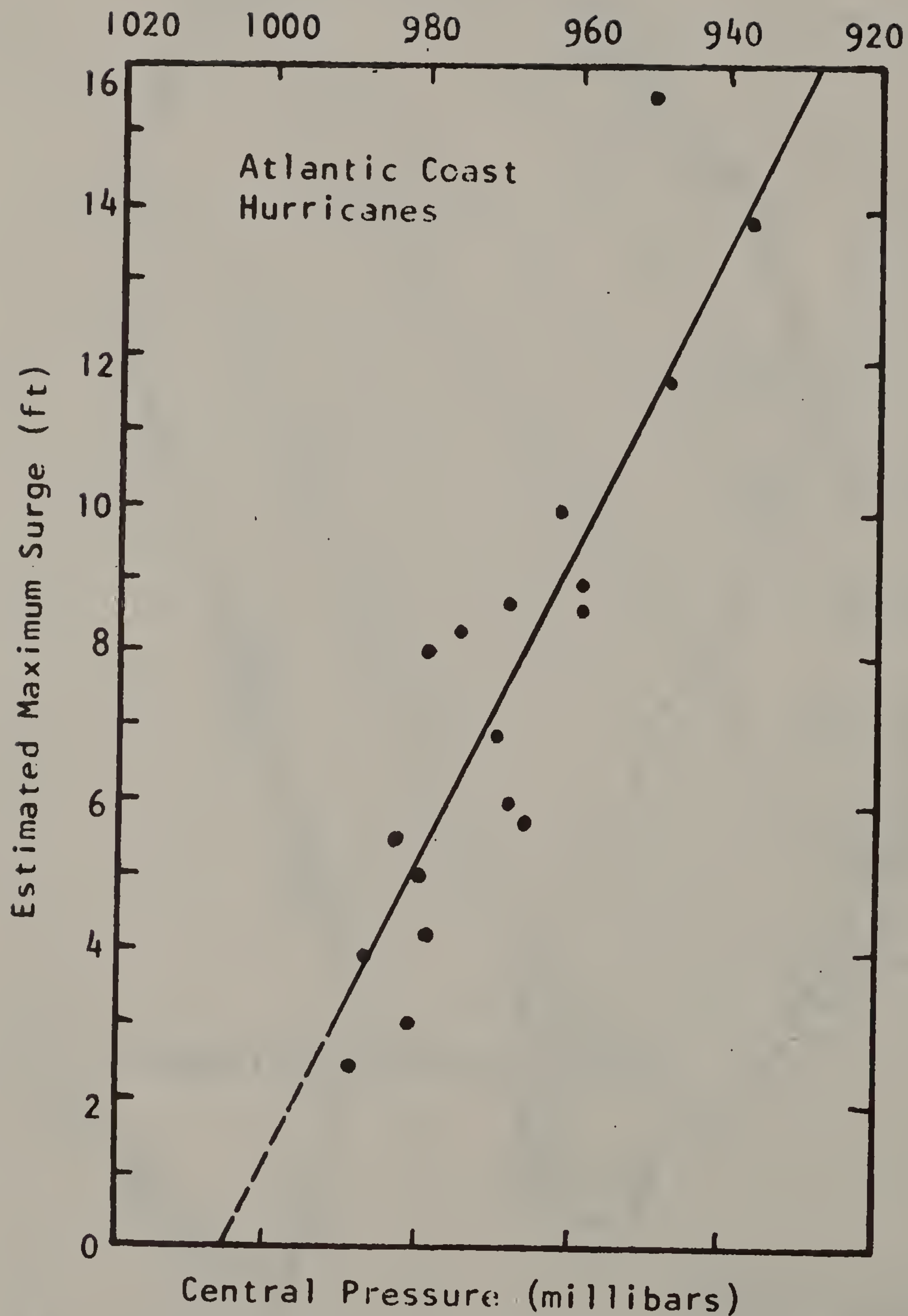


Figure B-41 Regression of maximum surge height on central pressure for Atlantic Coast hurricanes (Hoover 1957).

fect of storm surge. If storm waves approach perpendicular to the coast, this may trap the water being transported onshore inside the breaker line thus rising the water level. The water is unable to return through the surf zone and may amount to a 1.8 m (6 ft.) wave step up. Hurricanes can produce as much as 30.5 cm (12 in.) of rain during 24 hours resulting in a significant rise of sea level. Surge profiles for the coast of south of Cape Hatteras may be 4.3 m (14 ft.) (Dunn and Miller, 1960) (Figure B-42).

7. Sea Level Variation

The yearly mean sea level is determined by averaging the hourly sea level heights over one calendar year. The yearly variability is caused by variations in the meteorological and oceanographic parameters of wind, direct atmospheric pressure, river discharge, currents, salinity and water temperature (Hicks and Crosby, 1972).

As the yearly mean sea level is determined for a year, it is compared with data for previous years. From the data of previous years it is possible to postulate the trend of sea level. These trends result from tectonic, glacial-eustatic, or other climatological and oceanographic effects. The problem encountered in formulating such a hypothesis is that it can not be determined if variations are periodic or just segments of large oscillations. Figure B-43 shows a comparison of sea level variation for several tide gauge stations along the Atlantic coast of the United States.

8. Oceanographic Data Requirements

Section I.D.2. describes the environmental studies program of BLM. Further work is needed in a number of subject areas. The use of properly designed current meters placed at various depths as well as concurrent passive drift studies can be used to gain a better understanding of water circulation across the shelf and at the shelf slope boundary. Current meter surveys using shelf recording current meters have not been carried out and therefore there is a lack of knowledge about currents as they vary with time and depth over the entire shelf (VIMS, 1974). Although some information is available on salinity and temperature for selected portions of the shelf, more intensive sampling programs should be undertaken to clarify the physical oceanographic picture. The Gulf Stream has been studied more closely than other portions of the proposed sale area but parameters such as salinity and current velocity could be studied more closely to gain understanding of shelf circulation.

In the past estuaries have received more attention than the shelf water but information to determine classification and distance of tidal influence is needed. Coastal and offshore wave information must be obtained to facilitate the design and placement of offshore structures. Another area that deserves intensive study is the effect of weather on the physical processes of the shelf.

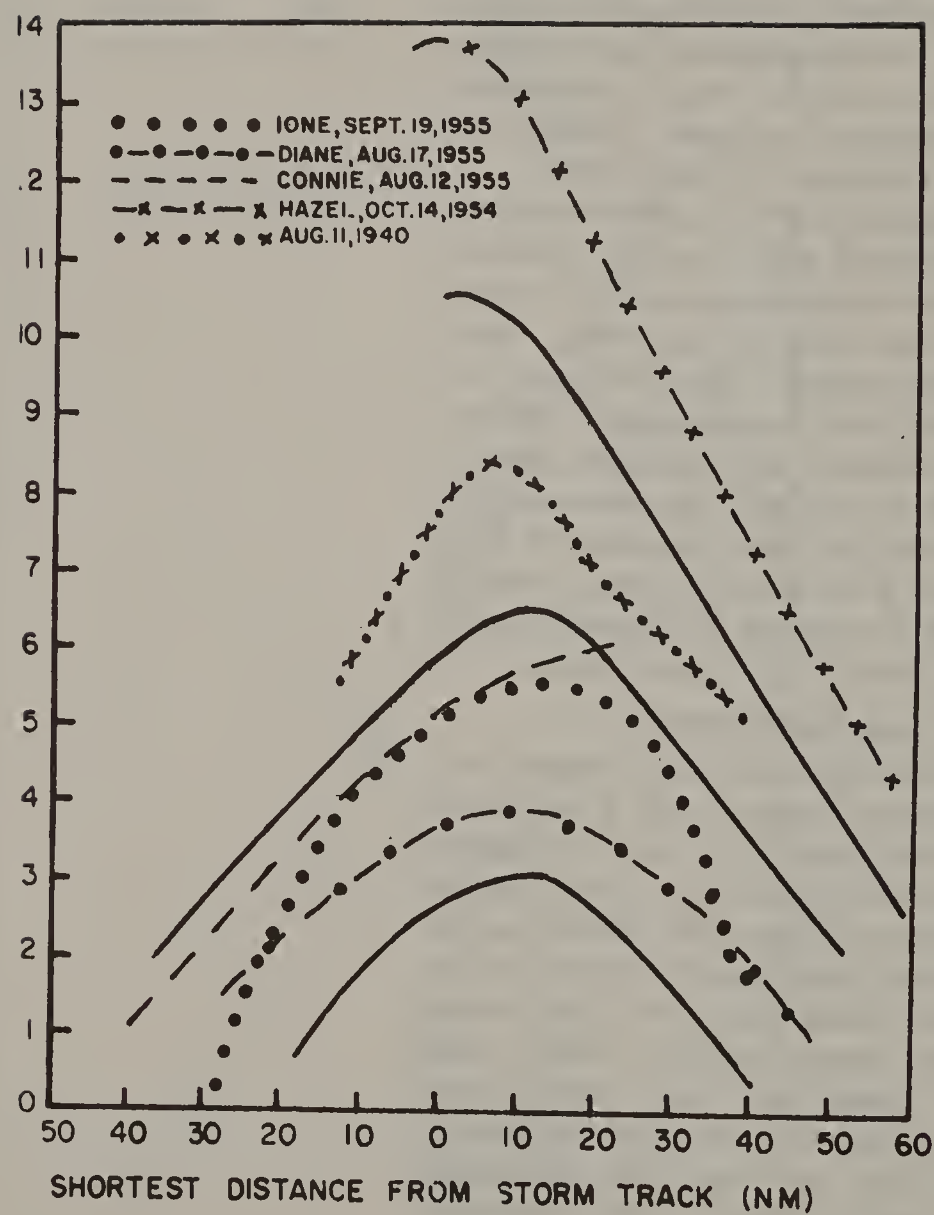


Figure B-42 Surge profiles of hurricanes which have entered the coasts of North Carolina, South Carolina, and Georgia (Dunn and Miller 1960).

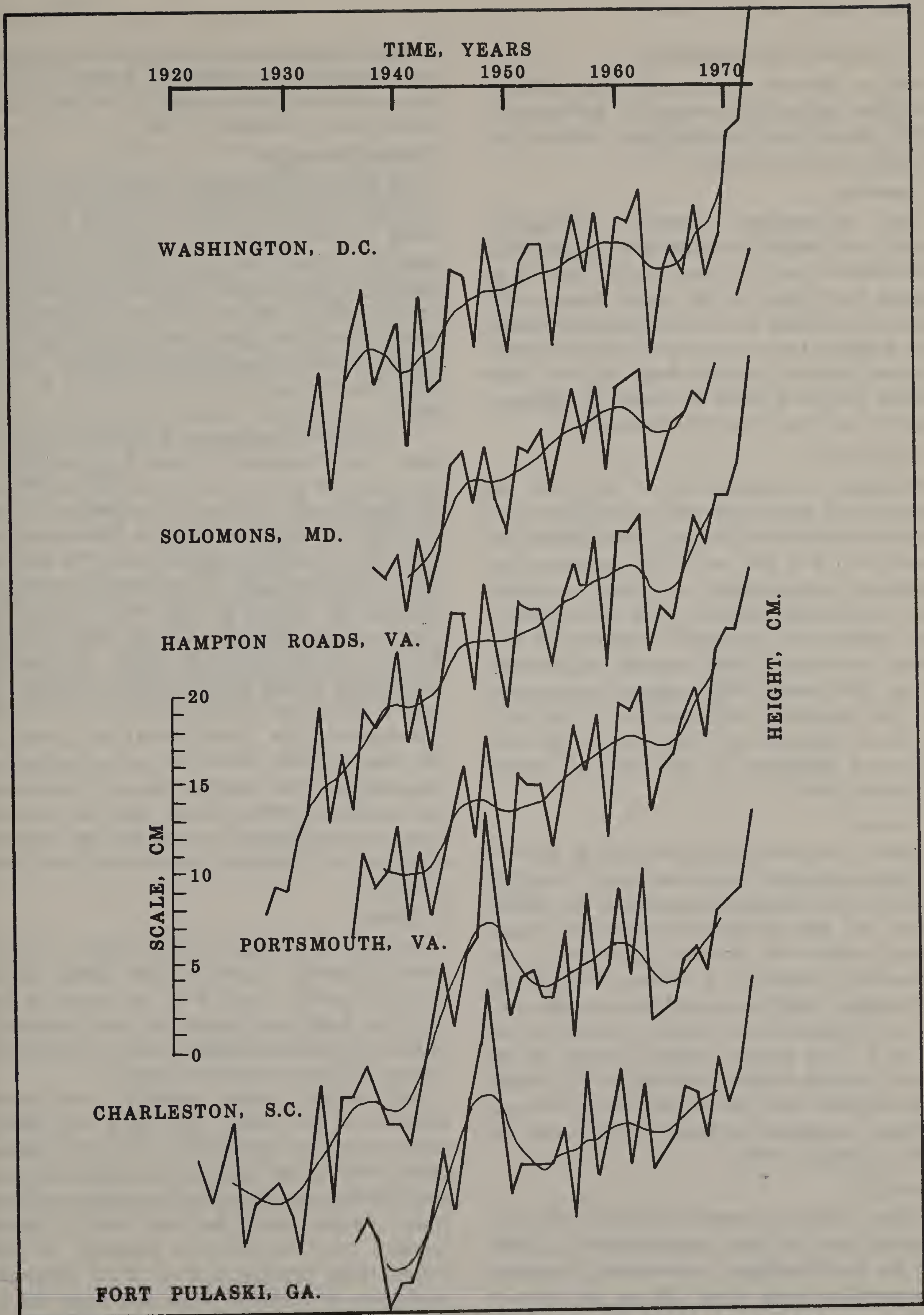


Figure B-43-Change in sea level with respect to adjacent land for stations from the District of Columbia to Georgia (Hicks and Crosby, n.d.).

C. Chemical Oceanography

Data on chemical oceanography were taken largely from information compiled by Roberts et al. (1974). More recent information on nutrients has been provided by Atkinson (1976).

1. Nutrients

The phytoplankton nutrients, phosphate, nitrate, and silicate are essential to the growth of phytoplankton and, therefore, are the base of the marine food chain. In the South Atlantic OCS nitrate in particular is in short supply and often is the limiting factor in phytoplankton growth. Nutrient data are available from all areas in the subject area as a result of cruises by Skidaway Institute and Duke University Marine Lab.

a. Phosphate

Phosphate concentrations in the OCS are generally less than 0.2 um (0.2 x 10^{-6} Molar or 0.2 u gram-atoms/liter) and surface concentrations are usually less than 0.05 um. In the nearshore area phosphate concentrations are higher, especially near river mouths where 1.0 um is not unusual. In the offshore area subsurface intrusions of Gulf Stream water supply large amounts of phosphate to the shelf waters. While surface concentrations are zero, phosphate may reach 1.0—1.5 um at 50 m. These intrusions are thought to be the main source of phosphate to the area of interest (Atkinson, 1976).

b. Nitrate

Nitrate concentrations are very low in the shelf surface waters with values less than 0.1 um typical. Near river mouths concentrations are slightly higher but high biological consumption usually quickly reduces the amounts to less than 1 um. Subsurface intrusions of deeper Gulf Stream water supply large amounts of nitrate to the shelf waters. Concentrations typically reach 10-20 um at 50 m. This process supplies 20-50% of the nitrate required for phytoplankton growth. Nitrate is an excellent tracer of the intrusion process and provides quantitative estimates of their input and effect (Atkinson, 1976).

c. Silicate

Surface silicate is always higher near the coast resulting from the high concentrations in runoff and the small biological consumption. Nearshore concentrations range from 1-20 um and offshore surface concentrations are usually less than 2 um. As with phosphate and nitrate, silicate is advected onto the shelf by intrusions. Because of this process silicate often is above 10 um in the subsurface waters (Atkinson, 1976).

2. Dissolved Oxygen

The surface concentration of dissolved oxygen over the southeast Atlantic coast shelf and slope during fall ranges from 4.17 to 5.01 ml/l. The concentration remains the same during winter except near shore where values increase to greater than five ml/l. During the rest of the year distributions remain about the same except for changes in pockets of low concentration nearshore. These data were obtained from the 1954 T. N. Gill cruise.

The vertical distribution of dissolved oxygen from Cape Hatteras to Cape Fear exhibits a decrease from greater than 4.5 ml/l at the surface to a minimum of 3 to 4 ml/l at a depth of 150-400 m during the winter and spring at both capes and the summer season at Cape Hatteras. The concentration increases again at 700 to 800 m at Cape Hatteras and 400 m at Cape Fear. During the other seasons, dissolved oxygen concentrations decrease monotonically with depth. The increase in dissolved oxygen is characteristic of North Atlantic Deep Water (Sverdrup et al., 1942). The data from the R.V. EASTWARD for a transect off Cape Lookout show the same distribution characteristics for dissolved oxygen. Stefansson and Atkinson (1967) showed that the oxygen minimum at mid-depths is a result of the intrusion of subsurface Caribbean water during some time periods.

3. Salinity

The shelf water south of Cape Hatteras is fairly saline compared to coastal water further north. This high salinity results from, as mentioned before, low fresh water runoff and close proximity to the Gulf Stream. Isohalines tend to parallel the coast with largest gradients nearshore.

Shelf salinity varies seasonally with lower salinities in late winter and spring and higher values during summer and fall. The high salinities during summer and fall can be attributed to low runoff during that period and prevailing southeast winds. Another factor that may result in higher salinities over the shelf is intrusion of Gulf Stream water (Stefansson et al., 1971). Prolonged occurrence of northeast winds may cause the intrusion of Virginia coastal waters, southward around Cape Hatteras thus significantly decreasing salinities in Raleigh Bay and to a smaller extent Onslow Bay. River runoff is the primary cause of low salinities in the area.

Surface salinities and bottom salinities may show a large variance at certain times. This vertical salinity variance depends largely upon meanders of the Gulf Stream, mixing and wind velocity (direction and speed).

Recent data from Skidaway Institute shows that surface salinities in the Gulf Stream are occasionally much lower than normal due to entrainment of Mississippi River water. Northward extensions of the Loop Current entrain Mississippi River water and it is then transported to the Gulf Stream, through the Straits of Florida, and then along the southeast coast (Atkinson, 1976).

4. Heavy Metals

The distribution of Cd, Ni, Zn, and Hg for shelf and slope surface waters off the southeast Atlantic coast is depicted in Table C-1. The concentration of heavy metals show a decrease from north (off South Carolina) to south (off Georgia-Florida) where levels approximate those of the Gulf Stream. There were no variations in heavy metal concentrations as samples moved offshore except for Zn and Hg (high near river mouths).

Table C-1 Concentration of heavy metals off the southeastern United States coast (from Windom and Smith 1972 and Windom 1973).

	Concentration (ug/l)				
	North		South		
Cadmium	0.11	(39)*	0.06	(18)	
Cobalt	0.17	(20)	0.06	(10)	
Nickel	1.0	(35)	0.3	(17)	
Zinc	7.4	(50)	2.2	(19)	
Mercury	0.17	(5)	0.02	(17)	summer
	0.08	(9)	0.04	(23)	winter

*Number of determinations.

D. Climatology of the U.S. South Atlantic Coastal Region

The description of meteorology was taken mainly from two sources which give the region very good coverage: The U.S. Department of Commerce (1975) and Ruzeki (1974).

1. Barometric Pressure

The Azores or Atlantic High is the center of the surface circulation system in this area. During the year it migrates a limited distance to the north or south and to the east or west, but is persistent throughout the year. The circulation over the eastern seaboard is controlled largely by the proximity of the Azores High.

During the winter the mean position of the Azores High is far out to sea. Major frontal systems developing over the continent and the Gulf of Mexico sweep over the Middle Atlantic states until the mountain ranges to the west partly obstruct their progress and cause considerable modification. Usually only the strongest polar outbreaks penetrate the southernmost points in the area. The rapidly changing air masses in the northern part of the area may be observed in variable temperatures from day to day and in the alternation between brief stormy periods followed by crisp, clear days. The contact between polar air masses of continental and maritime origin and tropical maritime air is greatest at this time. Consequently, winter storms are generally severe and are accompanied by strong, gusty winds.

During the spring the Azores High begins to move westward and northward. It affects the southern Atlantic coast where frequency of passing cyclonic storms decreases and the weather becomes more uniformly warm and humid. The northern part of the area, still at the outer edge of High, is subject to frontal activity and changing air masses. Warm spring rains usually alternate with mild weather. It is not uncommon, however, for the Azores High to dominate the entire area in this season, bringing summer heat and enervating humidities.

In summer, the center of the Azores High has moved to its northern limit and extends over the entire eastern seaboard. The intensity is moderate but persistent, blocking the eastward movement of the continental pressure systems. For weeks at a time the weather on the coast may not change significantly. This season is characterized by frequent instability, showers and thunderstorms, high temperatures and humidities, and relatively low wind velocities.

During the fall the Azores High retreats southward and eastward, leaving the Atlantic coast under the influence of a weak continental high-pressure zone. The weakening of the pressure system indicates the gradual transition to the winter pattern accompanied by increased frontal activity, particularly in the northern part. The weather is usually cool and fine, interrupted by brief rainy periods associated with the passage of fronts.

The pressure pattern changes considerably over the area from winter to summer. At individual stations, however, the seasonal variation in mean pressure is only 3.04 to 4.33 mm (0.77 to 1.1 in.) through the year. Extremes vary considerably more than this. During the summer the mean pressure remains low and steady, but begins to rise again in September and continues to rise through the remainder of the year.

2. Surface Winds

In winter, over the northern part of the sea area (north of latitude 30°) predominant winds are from the northwest quadrant. Southwest winds are also frequent (Figure D-1). Along the coast north of latitude 35°, wind directions are variable, though predominantly from the northern quadrant. Along the middle coast, directions are mostly from the western quadrant. Along the Florida coast, south of latitude 30°, easterly winds are prominent throughout the year.

Winter storms over the entire area are modified by the Appalachian Mountain range. However, even the extreme southern portion occasionally experiences northwesterly winds when the severest of the winter storms penetrate this far south.

In spring, over the northern part of the sea area (north of latitude 30°), winds from the southwest, south and northeast are equal in frequency. Along the caost (north of latitude 35°) southwest winds predominate. North and south winds are also frequent. Along the middle coast, south and southwest winds predominate.

In summer, the persistence and dominance of the Azores High is shown in the increasing frequency of southwesterly winds over the northern part of the sea area (Figure D-2). Along the coast (north of latitude 35°) southerly winds predominate. Along the middle coast southwest winds predominate.

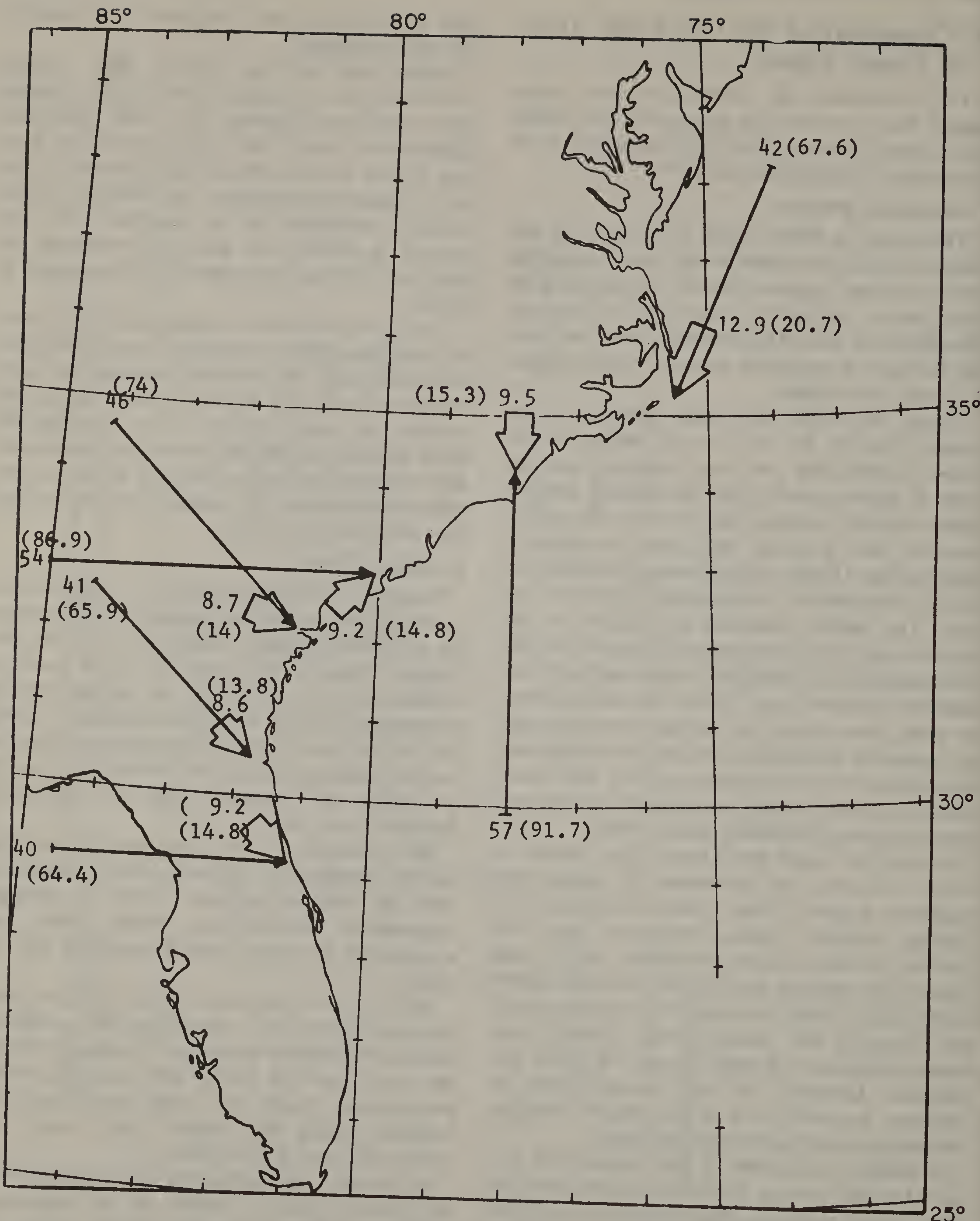


Figure D-1 Surface Winds at Shore Stations for January. Broad arrows indicate mean wind direction. Thin arrows indicate highest recorded wind direction. Arrow lengths are proportional to velocity. Wind speeds are indicated at the base of each arrow in mph (figures in parenthesis are kph.) (Ruzeki, 1974)

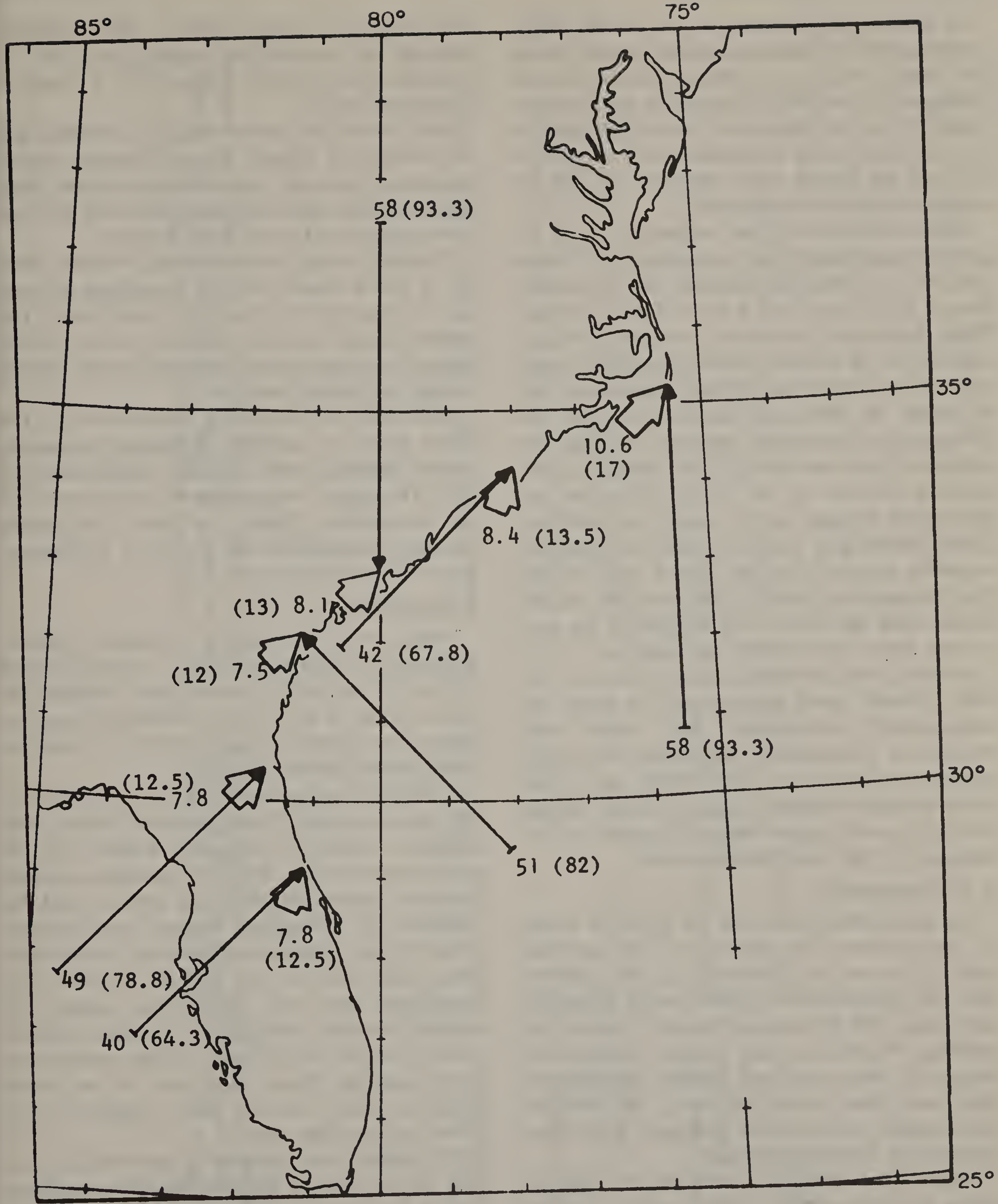


Figure D-2 Surface Winds at Shore Stations for July. Broad arrows indicate mean wind direction. Thin arrows indicate highest recorded wind direction. Arrow lengths are proportional to velocity. Wind speeds are indicated at the base of each arrow in mph (figures in parenthesis are kph.) (Ruzeki, 1974) II-81

In autumn the recession of the Azores High, accompanied by changing pressure systems along the coast, results in a sharp increase in the frequency of northerly winds which are recorded about 50% of the time over the northern part of the sea area. Along the coast (north of latitude 25°) and the middle coast (between 30° and 35° latitude) northerly winds prevail.

Wind velocities along the southeastern coast are generally moderately light, averaging 8 to 12 knots over the year. Monthly averages vary in summer from 6 to 10 knots, and 8 to 15 knots in winter. Wide departures from these averages should be expected in all seasons. In the immediate coastal area, the windward side of the promontories may be lashed by gales and heavy seas, while the leeward side is relatively protected. Averages do not show these variations. Cape Hatteras is particularly exposed to the winds, with open sea from north through east to southwest. South of Cape Hatteras gale winds are much less frequent, occurring generally on less than 15 days a year. The frequency of calms is less than one percent in the north and from 15 to 20% during the year at most places in the middle and south.

Extreme wind velocities are a hazard at any time. Though winds greater than 34 knots are comparatively infrequent, they have been recorded at all stations in this stretch of coast at almost any time of the year (Table D-1). Gale winds usually accompany sharply defined frontal systems, severe cyclone storms, hurricanes or occasionally severe local thunderstorms.

3. Air Temperature

The temperature regime of the southern Atlantic coast varies from temperate in the northern part of the area to subtropical in the southern part. The gradation from north to south is regular, increasing with decreasing latitude. Another interesting variation is the general modification process of the ocean and coastal temperatures upon each other. Along the coast, the sheltered land stations have warmer summers and cooler winters than do exposed points.

Temperature along the southeastern seaboard region are conducive to a long period of small-craft operation.

The southern Atlantic coast minimum monthly air temperatures range from 9°C at Cape Hatteras, North Carolina (Figure D-3) to 19°C at Miami, Florida (Figure D-4) in January. July is the warmest month at most stations with maximum monthly air temperatures ranging from 29°C at Cape Hatteras to 28°C at Miami (U. S. Dept. of Commerce, 1972).

Over water, the coldest month is February and the warmest is August. Exposed coastal stations experience mean air temperatures more like those over the water than those over land, and have annual extremes in February and August.

The daily range in temperatures averages from 6°C to 8°C at coastal stations throughout the year and is likely to be less over the water. The greatest daily variation occurs at most stations during the winter and early spring and the lowest during late summer and fall.

Very little data on extreme temperatures for the ocean areas are available. Although uncommon, coastal stations have recorded temperatures of 38°C. The highest temperature on record was 41°C at Jacksonville, Florida, in July. The lowest recorded temperature was -12.8°C at Charleston, South Carolina, in January.

4. Precipitation

Along the southeastern seaboard region, precipitation is moderately heavy, averaging about 121 to 142 cm (48 to 56 in.) a year. Monthly departures may be large in any individual year, but over a long period of record, 50 to 75 years, a fairly uniform pattern prevails.

In the northern part of the area, maximum rainfall occurs normally during July and August, and minimum rainfall in November (Figure D-5). In the southern section, however, maximum rainfall occurs in August, September or October, and the minimum in December, January or February (Figure D-6). Average monthly totals at most stations range from 51 to 152 mm (2 to 6 in.) throughout the year. During the months of greatest hurricane frequency, excessive rains of 23 to 38 cm (9 to 15 in.) in a 24-hour period have been recorded. These may occur at any point along the coast, but are most common in the southern part of the area.

The monthly mean number of days with 2.5 mm (0.01 in.) or more of precipitation in the northern part of the area ranges from about 8 to 10 days a month in the fall to 10 to 12 days a month in the summer and winter. In the central part of the area the most rainy days are in summer, 11 to 16 days a month, and the least in the spring and fall, six to nine days a month. The most rainy days

Table D-1 Percent of the time winds are greater than or equal to 34 knots (39 mph, 62 kmph), the wind speed at which damage begins to occur. Data is based on ships traveling near the coast, biasing the figures toward good weather as they avoid the worst storms. (Dept. of Commerce, 1975)

COASTAL STRETCH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cape Hatteras Area	8.8	7.5	4.7	2.1	1.9	1.4	0.2	0.2	2.5	3.9	3.7	2.7
Cape Fear to Savannah	5.6	5.9	4.5	1.0	1.6	1.0	0.5	0.2	1.8	6.7	3.4	3.1
Savannah to Ponce de Leon Inlet, Florida	2.4	4.5	1.7	0.6	0.7	1.4	0.4	0.1	2.7	2.9	1.9	2.0
Ponce de Leon Inlet to Florida Keys	0.8	1.6	0.5	0.1	0.2	0.4	0.1	0.2	1.9	2.0	0.7	0.8

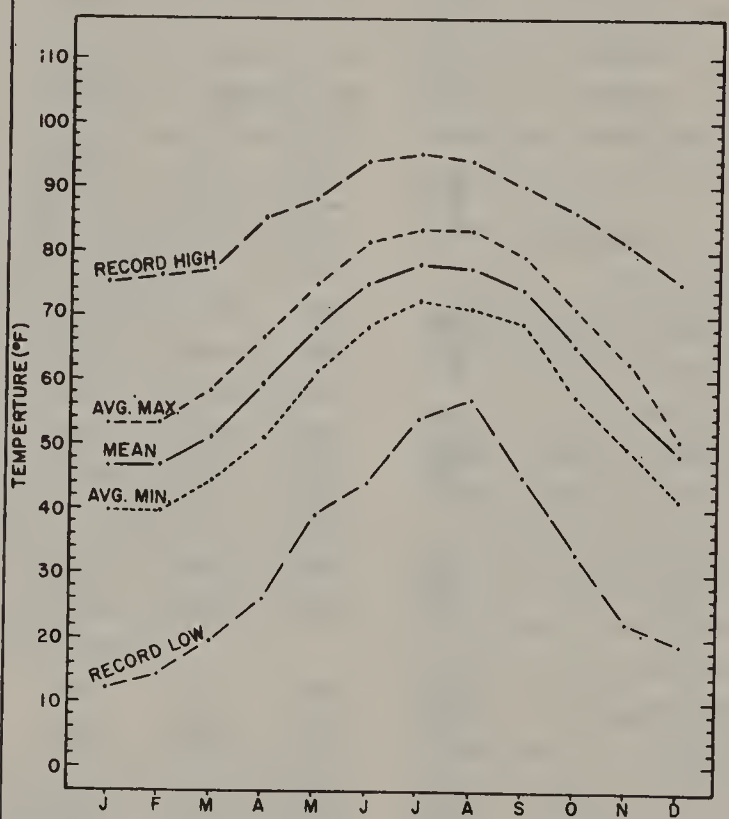


Figure D-3 Monthly air temperatures (°F) for Cape Hatteras, N. C. showing (top to bottom) record highest, average daily maximum, daily mean, average daily minimum, and record lowest temperatures for each month. (Ruzeki, 1974)

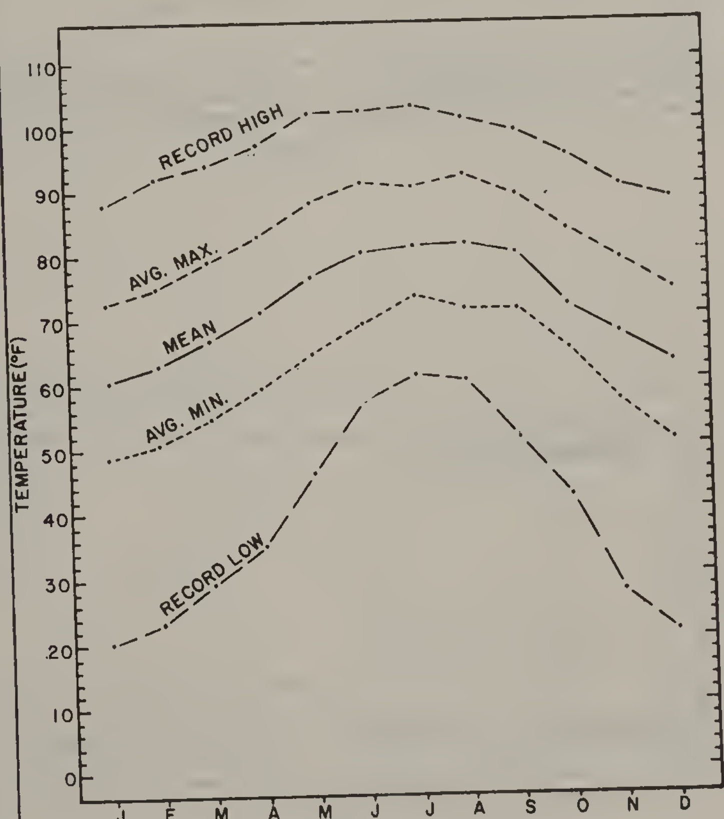
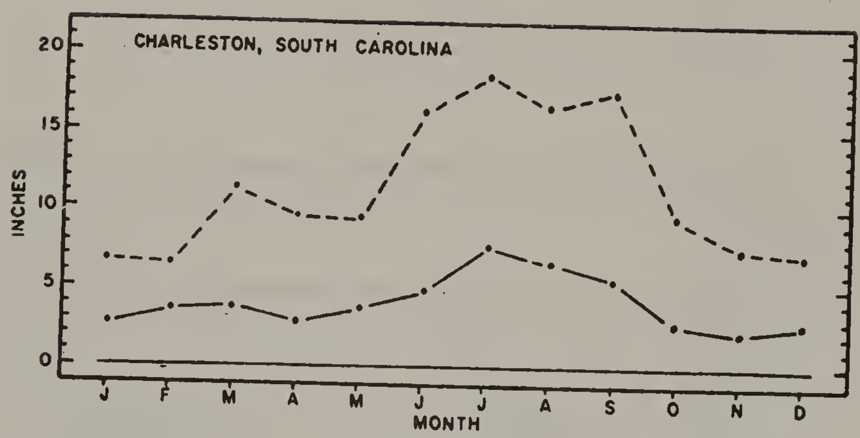


Figure D-4 Monthly air temperatures (°F) for Titusville, Fla. showing (top to bottom) record highest, average daily maximum, daily mean, average daily minimum, and record lowest temperatures for each month. (Ruzeki, 1974)



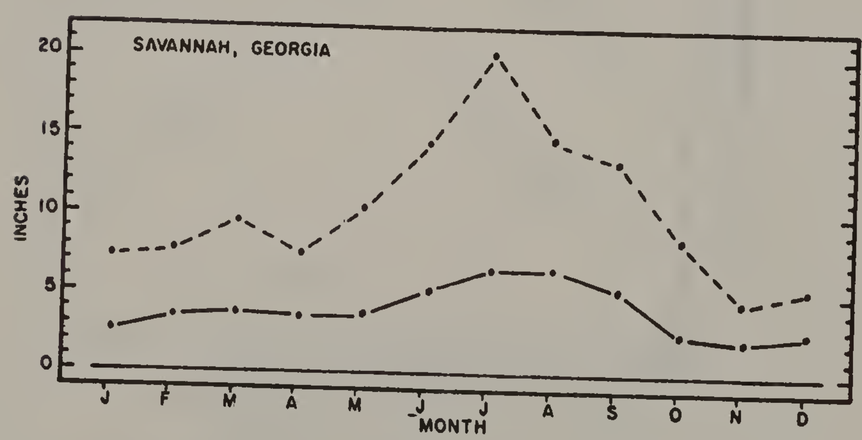
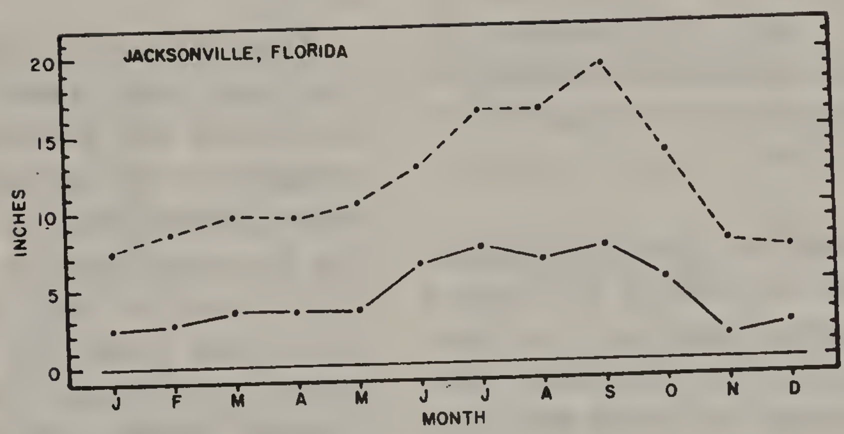


Figure D-5 Normal total monthly precipitation (lower line) and Maximum monthly precipitation (upper line.) (Ruzeki, 1974)



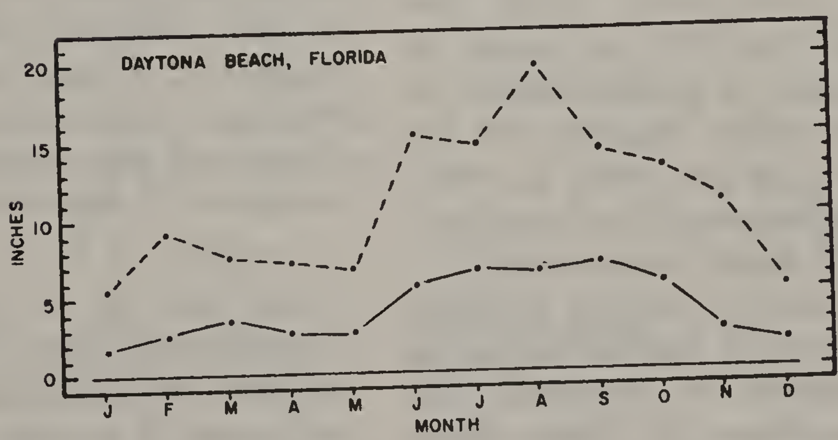


Figure D-6 Normal total monthly precipitation (lower line) and Maximum monthly precipitation (upper line.) (Ruzeki, 1974) along the Florida coast, 14 to 18 days a month, generally occur in late summer and early fall, and the minimum number, five to eight days a month, from February through April.

Much of the precipitation is associated with cyclonic activity throughout the year. During the winter, precipitation is usually general, but may come with occasional thunderstorms associated with fronts. During the summer, when the area is dominated by the Azores High and cumulus clouds predominate, precipitation is localized and is showery in nature.

Thunderstorms along the coast occur on an average from 40 days a year in the north to 80 days a year in the south. Maximum occurrence is from June through August, and an average of 7 to 19 thunderstorms a month occur during this season.

Snow falls from December through March in the northern part of the area one or two days a month. As far as coastal operations are concerned, snow precipitation is not significant since most of the area is entirely free from snow the year round.

5. Relative Humidity

Mean relative humidity is highest from July through September and lowest in April and May. Relative humidities over water areas are uniformly high ranging from 72% in January to 81% in July. The presence of minute particles of salt in the air over the ocean, together with the high moisture content in the air, results in a very corrosive effect upon equipment and supplies, both on the water and at nearby shore points.

The general daily trend in relative humidity shows a decrease as the air is warmed during the day. With the exception of Savannah and Jacksonville, winter humidities are highest during the early morning hours before warming has begun, whereas summer humidites are highest at night. The smallest daily range in relative humidity occurs at Cape Hatteras where average January humidities range through 12 percentage points and those in July through 20 percentage points. Largest ranges are at Jacksonville with 28 percentage points in April and 30 in September. Average humidities range from evening values of 46 percentage points at Savannah in March to 1:00 a.m. values of 92 percentage points at Charleston and Daytona Beach in August.

6. Visibility and Sky Cover

Visibility is generally good throughout the year over the entire area. Fog is the principal restriction to visibility. In general, fog decreases from north to south, and the worst fog conditions occur during the winter when air masses change frequently. Visibility is usually poorest during the night and early morning.

In addition to fog, precipitation occasionally reduces visibility over both land and water, and haze and smoke sometimes restrict visibility over land.

a. Fog

Along the coast, radiation fog is frequent, forming shortly after sunset. These fogs generally do not extend any great distance seaward, but may seriously restrict harbor activities. Sea fogs sometimes drift onshore on hot summer days, persisting for many hours in a shallow layer along the coast. Over the land, dispersal usually begins at the surface giving the effect of lifting. Over the water, fog generally persists at the surface and restricts visibility until the last vestige of the formation disappears.

The occurrence of heavy fog at land stations between Cape Hatteras and Cape Canaveral varies from an average of six days during January at Daytona Beach to less than one day a month at Cape Hatteras during July and September (Figures D-7 and D-8). Heavy fog is most frequent at Savannah with an average of 44 days a year and least frequent at Wilmington with an average of 25 days a year.

b. Sunshine

The area as a whole experiences monthly averages from 52% to 80% of possible hours of sunshine during the year. In the north, the largest percentage of possible sunshine occurs in spring and fall and the smallest percentage in winter. In the overall picture, the extreme south and a narrow belt in the north-central part of the area shows a greater percentage of possible sunshine than the northern and south-central sections.

c. Cloudiness

Cloudiness over the area is moderate to moderately high throughout the year, averaging from 35% to 65% sky cover. In general, however, the cloudiest month is January in the northern sections and over most of the water areas, and may be any month from June through September

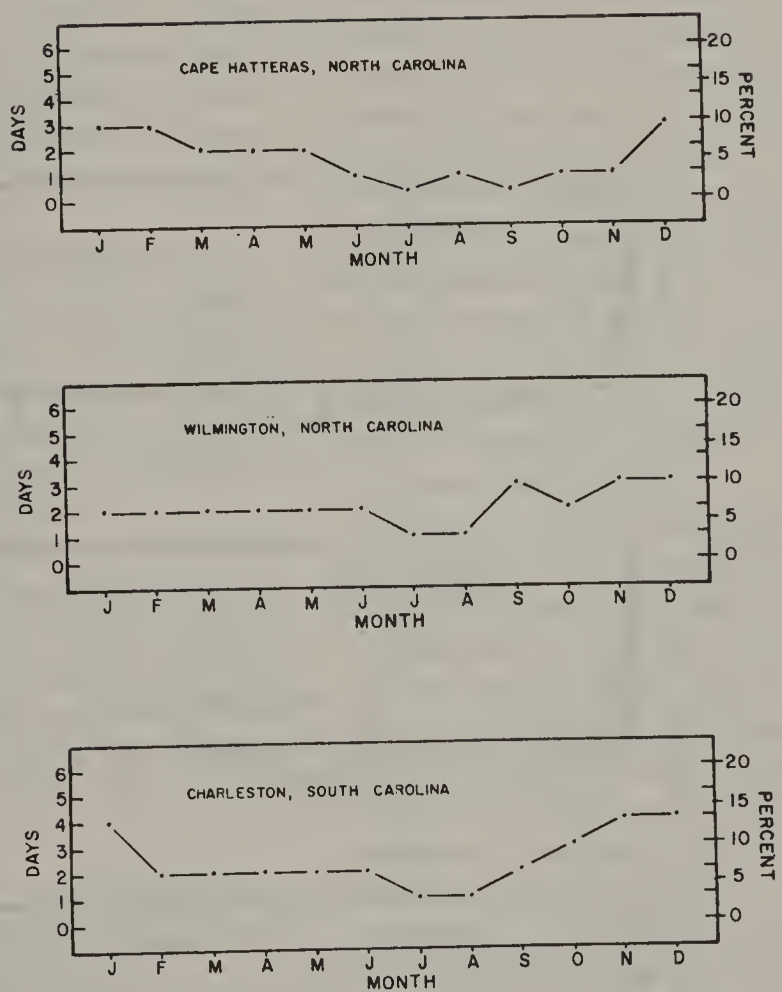
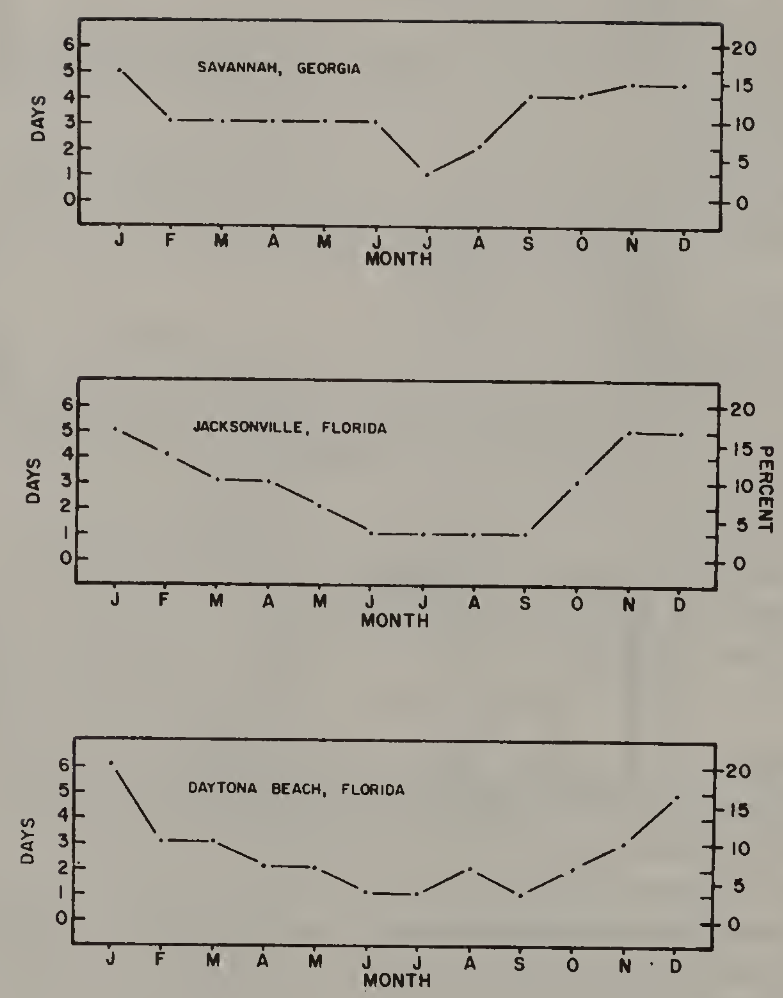


Figure D-7 Mean Number of Days with Heavy Fog. (Ruzeki, 1974)



FigureD-8 Mean Number of Days with Heavy Fog. (Ruzeki, 1974) in the southern section. At most of the individual stations in the northern part of the area, the least average cloudiness occurs in October and in the extreme southern part, the least cloudiness occurs in February or March.

Since the air usually contains moisture, only a small decrease in temperature is necessary to cause condensation and cloud formation. At the edge of the warm northward-moving Gulf Stream and the cool southward-moving countercurrent which skirts the shore from Cape Hatteras, N.C., to Jacksonville, Fla., sharp contrasts in temperature result in the formation of heavy stratus clouds which may appear very much as a cold front. These clouds may persist for days at a time if the wind is light and they may be carried inland by northeasterly winds. Such cloudiness is common during the spring when the gradient between shore water and Gulf Stream temperatures is steepest.

The fact that the maximum cloudiness for the year occurs during the winter at northern coastal stations may be explained by the maximum frequency of cyclonic storms passing northward or north-eastward from the central or south-central section during that season. These rarely affect the extreme southern part of the area.

Much of the cloudiness over the entire area is of the cumulus type, resulting from either the unstable conditions that accompany cyclonic activity in all seasons, or the general air mass instability during the summer. Such clouds frequently form over land during the day and drift seaward at night.

7. Tornadoes and Waterspouts

Funnel clouds, tornadoes and waterspouts are different types of the same phenomenon; the latter two being funnel clouds which have extended downward to the ground or water surface respectively. A total of 208 of these meteorological features have been reported in the coastal area between 1960 and 1972.

Tornadoes are usually associated with cyclones, both tropical and extratropical. Movement of over 60% of tornadoes reported in the U.S. is generally from southeast to northwest (Figure D-9). Although highly destructive, tornadoes are the smallest of severe weather distrubances, and are limited in duration as well as in length and width of path. These paths vary from a few meters to several hundred meters in width and can extend from a few hundred meters to over 482 km. The average width and length of tornado paths in the U.S. are 366 m and 26 km.

Tornadoes generally travel at speeds of about 64 kmph, however, these forward speeds range from 0 to 109 kmph. Wind speeds within tornadoes have not been measured but are estimated to be in excess of 804 kmph.

8. Tropical Cyclones, Tropical Storms, Hurricanes and Great Hurricanes

Tropical cyclones differ from extratropical cyclones in that extratropical cyclones obtain their energy from the variances of temperature and moisture in air masses within the circulation; whereas tropical cyclones obtain energy from the latent heat of condensation of water vapor. The average diameter of a tropical cyclone is between 96 and 965 km at maturity.

Tropical cyclones are classified by stages according to the sustained surface wind speeds. The most intense stage, called a great hurricane, has winds in excess of 201 kmph. The hurricane has sustained surface winds from 119 to 199 kmph. Tropical storms have sustained winds 62 to 117 kmph. Tropical depressions have sustained winds not exceeding 61 kmph.

Location and environment determine the development and dissipation of tropical cyclones. They form in ocean areas having a high surface temperature 25°C to 27°C with the greatest number occurring in the late summer and early fall in the Northern Hemisphere. After formation, the pull of the Easterlies causes a tropical cyclone to make a curved path from east to west. In some instances, tropical cyclones will reverse their direction of travel, a phenomenon called "recurving". If the storm's tract crosses over land, the storm rapidly dissipates as a result of the removal of the oceanic energy source.

The coastal region has generally experienced tropical cyclones of one type or another as early as May 28 and as late as December 2 (Figure D-10). The portion of the region near Miami is the most likely to experience a hurricane in any one year (16% probability). Probability drops to less than two percent northward along the coast in the Jacksonville area, rises back up to eight percent in the Charleston area, and stays uniformly high, peaking again at 11% probability at Cape Hatteras.

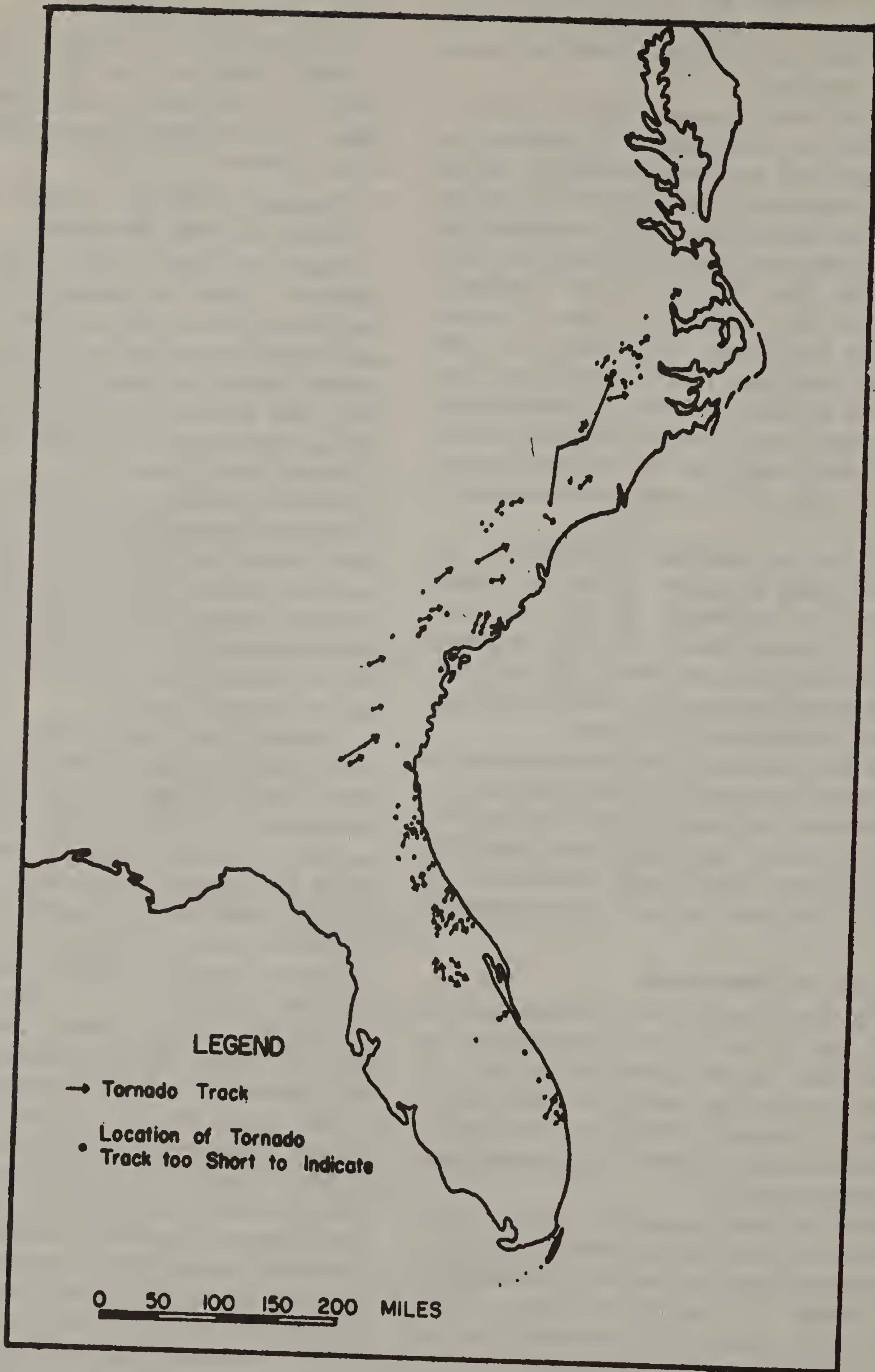


Figure D-9 Tracks of all tornadoes for the period 1916-1950 (from Weather Bureau Technical Paper No. 20, 1952).

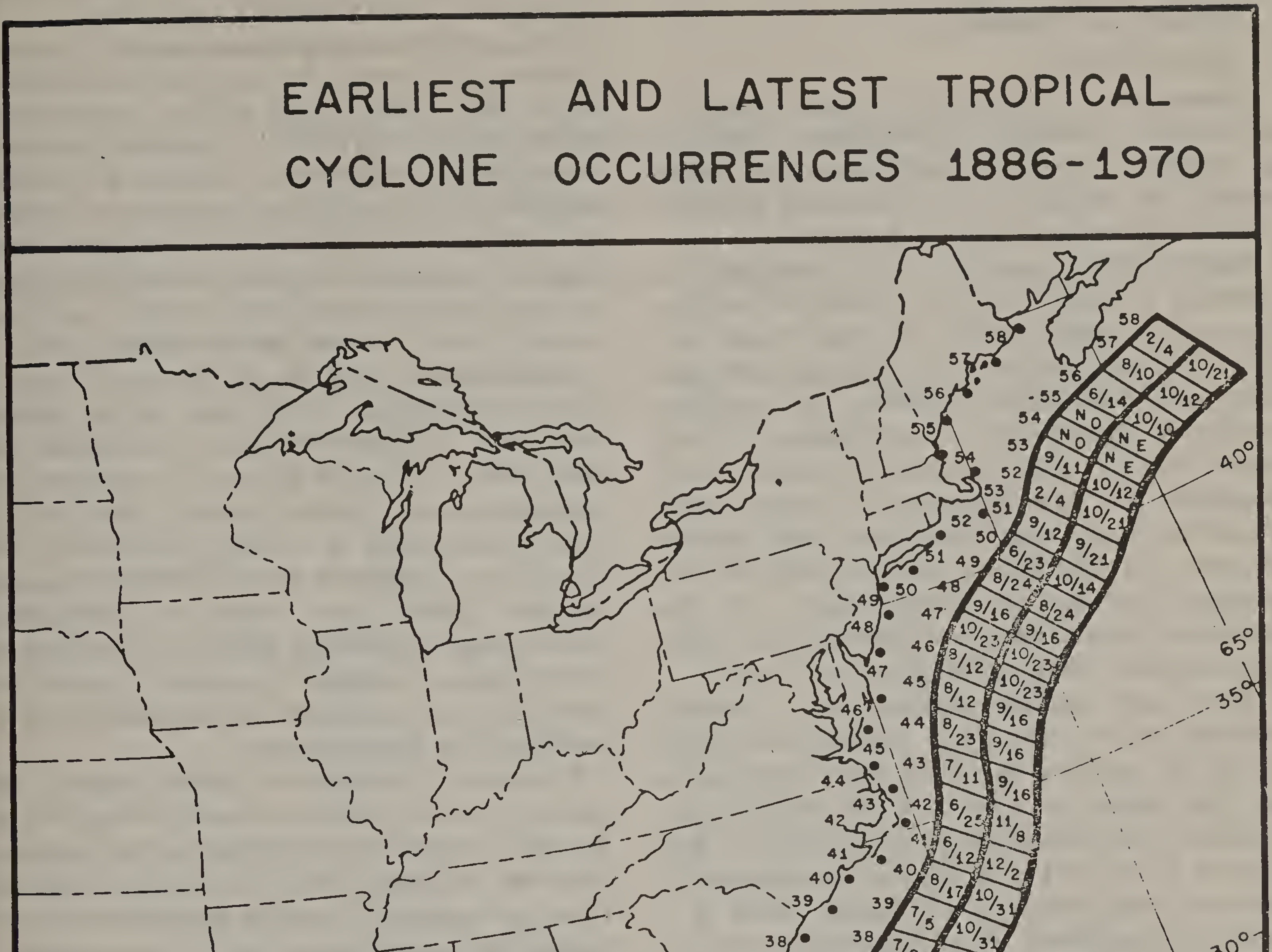


Figure D-10 Numerals indicate coastal strips approximately 50 nautical miles in length. (U.S. Dept. of Commerce, 1972)

E. Biological Communities

1. Offshore and Nearshore

a. Phytoplankton

Roberts (1974) summarized several sources of information concerning phytoplankton occurring in southeast United States' continental shelf waters. The majority of the following narrative has been taken from Roberts' discussion.

Hulbert (1967) reported on the phytoplankton collected in April, 1965, at a series of stations (four on the shelf, four in the Gulf Stream and five in the Sargasso Sea) on a transect nearly due east from Jacksonville, Florida. The dominant species of phytoplankters were diatoms in shelf waters and coccoliths in the Gulf Stream. These organisms are most important in deep waters where attached vegetation and land derived nutrients are diminished Table E-1 indicates the abundant species of phytoplankters of the southeast United States shelf waters, all of which may be found within the proposed lease area.

Total cell numbers decline in a seaward direction in the shelf waters ranging from 18,390 to 305,100 cells/liter nearshore while the range in the Gulf Stream is 4,530 to 8,030 cells/l. These variations can be accounted for by the fact that there is a distribution of salinity and nutrients in different areas of the shelf waters. There is a higher concentration of phytoplankton close to shore at 18 m (60 ft) depths due to an abundance of nitrate and phosphate. Beyond the 183 m (600 ft) contour line from Cape Hatteras to Florida where the nitrate and phosphate levels were negligible, a lower phytoplankton concentration was observed (Hulbert and MacKenzie, 1971). However, all of the proposed lease areas are in waters of less than 200 m and are all essentially west of the Gulf Stream. In areas where the shelf is wide, cell counts ranged from 75,000 to 75,000/l in shallow coastal stations, but were only 8,000 to 43,000/l in deeper stations.

Diatoms dominate the flora of the shelf waters. Marshall (1971) reported 100 diatom species throughout the study area with 86 species occurring during fall, winter and spring. Diatom cell numbers reached a maximum of 67,920/l over the shelf declining to 0 to 10 cells/l (36 species) in the Sargasso Sea. The dominant species of diatoms in shelf waters are: *Skeltonema costatum*, *Leptocylindrus danicus* and *Nitzschia seriata*. Other diatom species present include: *Chaetoceros decipiens*, *Navicula* sp., *Rhizosolenia alata*, *Thalassionema nitzschioides*, and *Rhizosolenia stolterfothii*.

The number of coccoliths increase in a seaward direction. *Coccolithys huxleyi* dominate the coccolith flora; other types include *Syracospheara mediterranea* and *S. pulchra*. *Coccolithys huxleyi* is absent close to shore from Virginia to Georgia, while the other species of phytoplankton compose the abundant populations in the shallow areas. Figure E-1 compares the locations and density for the total phytoplankton cell numbers and *Coccolithys Huxleyi* (Hulbert and MacKenzie, 1971).

Dinoflagellates were present during all seasons. They are important in the open sea in tropical water and in summer this group dominated the shelf flora. The major species for this area are *Amphidinum* sp., *Ceratium furea*, *C. fusus*, and *C. tripos*. *Gymnodinum* sp. is also present but is not present year round nor is it a dominant species. Marshall (1969) also found an unidentified dinoflagellate at nearly all depths to 300 m (984 ft) in the summer months. It reached a density of 3680/l and was a part of the dominant flora in shelf and Gulf Stream waters.

Productivity studies in coastal waters are limited. Thomas (1966) measured productivity in the shelf waters up to 25 km (15 mi) offshore from the Altamaha River and Sapelo Sound in Georgia using the C^{14} method. He observed an extremely high production of 547 g $C/m^3/yr$. Production was highest in August and lowest during the cooler months. Despite differences in run-off from the two estuaries, offshore productivity was equal for the two areas on an annual basis, but differed significantly during some months. In nearshore waters (less than 17 km (10 mi) offshore), productivity on a volume basis was maximal. However, on an areal basis, production was lower than further offshore. This results from the higher turbidity and shallower compensation depth of the nearshore waters. New productivity was positive at all stations since the critical depth exceeded the depth of the water column. Thus a trend toward increasing net production on an areal basis can be observed from just offshore (Ragotzkie, 1959) to further offshore waters (Thomas, 1966).

Thomas (1966) suggested that the seasonal differences in offshore productivity can be explained by the phosphate-poor river water pushing phosphate-rich estuarine water to an offshore location where increased transparency leads to high

Table E-1 - Abundant phytoplankton of the southeast United States shelf waters in January, 1968 (from Hulber and MacKenzie, 1971).

Species	Area
Diatoms	
Nitzschia seriata	inshore
Bacteriastrum comosum	inshore
Asterionella japonica	inshore
Chaetoceros affinis	inshore
Skeletonema costatum	inshore
Chaetoceros decipiens	inshore
Leptocylindrus danicus	inshore
Rhizosolenia stolerfothii	inshore
Nitzschia closterium	inshore
Nitzschia delicatissim	inshore
Thalassionema nitzschioides	inshore
Coccolithopores	
Coccolithys huxleyi	widely dist.
Umbilicosphaera mirabilis	widely dist.
Calyptrospeaera oblonga	widely dist.
Chrytophyte	
Rhodomonas amphioxeia	inshore

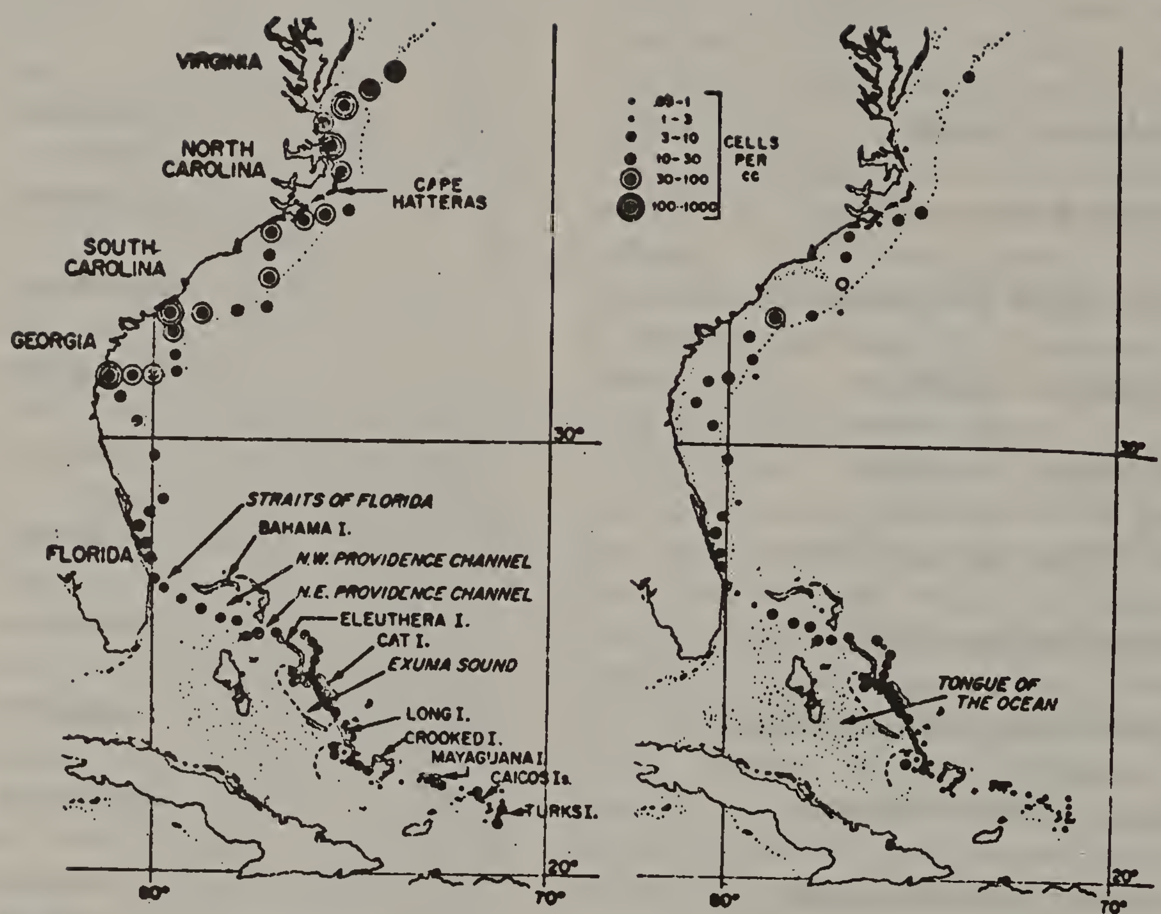


FIGURE E-1 Surface distribution of: left, total cell number; right *Coccolithus huxleyi.*

Source: Hulburt, Edward M. and R. S. Mackenzie. 1971. Distribution of Phytoplankton Species at the Western Margin of the North Atlantic Ocean. Bulletin of Marine Science. Vol. 21:603-612.

production even though the phytoplankton standing crop (measured as chlorophyll *a*) is low. Maximum productivity is limited to the summer months when river discharge is not so great to dilute the estuarine phosphate levels below stimulatory levels. High spring run-off dilutes the estuarines phosphate concentration, preventing the occurrence of a spring bloom.

A second study of productivity was reported for shelf waters (Thomas, 1971). Thomas studied a series of 21 stations during September ranging from Cape Fear to Cape Canaveral. Particulate organic matter (POM) and dissolved organic matter (DOM) ranged from 0.4 to 18.5 mg C/m^3/hr and 0.00 to 0.57 mg C/m^3/hr respectively. Released DOM was highly variable, ranging from 0 to 27%, but was usually less than 12.5%. An additional series of stations was studied in the Gulf Stream and Sargasso Sea of North Carolina in November. Release rates for DOM were generally higher in this region, reaching nearly 44%. Thus the release rate of DOM increases markedly in a seaward direction but is extremely variable in all zones.

Thomas (1971) also demonstrated that DOM release rates increase with depth. This must be considered in calculating integrated productivity rates even in coastal waters. This data cannot be converted to an annual basis from the information given, and hence cannot be directly compared to his earlier work (Thomas 1966). Information on coastal productivity throughout the region is inadequate and in need of further study.

b. Zooplankton

The zooplankton community of the southeastern U.S. continental shelf has not been extensively studied; however, Roberts (1974) summarized the available information for this area, the bulk of which comes from cruise reports and resultant papers based on collections conducted from the T. N. GILL, 1953-1954.

Bowman (1971) reported in detail on the copepods collected during the first four cruises of the T. N. GILL. He reported 100 species of copepods from these samples and compiled detailed distribution/abundance maps for each species collected.

There was a marked inshore-offshore zonation by species related to the water masses sampled (shelf water, Gulf Stream, and Sargasso Sea). The diversity of copepods increased in an offshore direction (10 species/sample near shore to 25 species/sample offshore), whereas copepod numbers decreased. There were no north-south trends observed.

Bowman (1971) computed affinity indices for the 13 species consistently present in significant numbers. From this data, he recognized three species associations related to inshore-offshore relationships (Table E-2). It should be noted that the proposed lease tracts are located in the ''Shelf Water Mass''. Of the remaining 81 species collected, most were oceanic. Despite the close affinity of copepod species with water masses, the degree of admixture of species from other masses is considerable, which is to be expected from the circulation patterns of these waters.

A few stations were dominated by coastal species, especially near the mouth of the St. Johns and Indian rivers (at Cape Canaveral), *Acartia tonsa* is dominant near Beaufort Inlet, St. Johns River and Cape Canaveral. *Labidocera aestiva* is more widely distributed in coastal and shelf waters.

The absence of a north-south variation in the copepod fauna results from the relative uniformity in temperature-salinity conditions along this axis. North of Cape Hatteras, the fauna is similar during warmer months when tropical species carried northward can find suitable conditions, but is clearly different during the cooler months. Species such as *Acartia tonsa* do occur in Virginia coastal water, but are increasingly limited to warmer months in northern areas and are replaced by *A. clausi* in colder months.

Pierce and Wass (1962) described in detail the chaetognath fauna from the T. N. GILL collections. They observed 12 species in three genera which is in agreement with the results of previous studies limited to the North Carolina coast (Bumpus and Pierce, 1955). The average density for the area was 8.7m^3 with individual species having average abundances ranging from 0.1 to 3.1/m . The dominant species based on abundance were different from those based on percent occurrence (Table E-3).

The abundance of chaetognaths in inshore areas was two to five times that of offshore areas, but species diversity increased. Table E-4 lists the 12 species and specifies the water masses with which they were associated. *Saggita hispida* was considered the best indicator of shelf waters, while *S. hexaptera*, *S. lyra*, *Krohnitta pacifica* and

Table E-2 Copepod species associated by water mass (from Bowman, 1971)

Water Mass	Species
Coastal	*Acartia tonsa* *Labidocera aestiva*
Shelf	*Paracalanus parvus* *Centropages furcatus* *Eucalanus pileatus* *Temora turbinata*
Oceanic	*Lucicutia flavicornis* *Temora stylifera* *Paracalanus aculeatus* *Clausocalanus furcatus* *Calanus minor* *Undinula vulgaris* *Euchaeta marina*

Table E-3 Dominant species of chaetognaths based on abundance and based on percent occurrence (from Pierce and Wass, 1962)

Species	Percent Abundance[1/]	Percent Occurrence[2/]
<u>Sagitta enflata</u>	36.1	88.5
<u>Sagitta tenuis</u>	19.2	____
<u>Sagitta helenae</u>	15.4	50.5
<u>Sagitta serratodentata</u>	11.7	65.2
<u>Krohnitta pacifica</u>	____	60.2
<u>Pterosagitta draco</u>	____	54.4

1/ Percent of total individuals; species accounting for more than 10%.

2/ Percent of samples; species accounting for more than 50%.

Table E-4 Chaetognath species observed, and water mass(es) where each occurred (from Pierce and Wass, 1962).

Species	Water Mass
Sagitta enflata	Wide-spread
S. tenuis	Coastal
S. helenae	Shelf
S. serratodentata	Oceanic
S. hispida	Coastal
S. minima	Oceanic
S. pipunctata	Oceanic
S. hexaptera	Oceanic (deep water)
S. lyra	Oceanic (deep water)
Krohnitta pacifica	Wide-spread (but declined markedly in Sargasso Sea)
K. subtilis	Gulf Stream (rare)
Pterosagitta draco	Outer shelf and Gulf Stream

Pterosagitta draco were the best indicators of Gulf Stream water. There was neither any north-south changes in distribution nor clear differences in seasonal distribution of these species, abundance changes were observed but could not be correlated with season.

The distribution of two pelagic decapods observed in the T. N. GILL collections (Bowman and McCain 1967), *Lucifer faxoni* and *L. typus*, has been described in detail. *L. faxoni* occurred over most of the sampled area, but were absent from the furthest offshore stations (Sargasso Sea). During the winter and spring months, *L. faxoni* was also absent from coastal stations. *L. typus* was found well offshore, usually seaward of the 200 m (656 ft.) contour. This species was closely associated with the Gulf Stream.

The pteropods have been identified from a collection that was limited to North Carolina waters (Chen and Hillman 1970). Nineteen species were found and can be grouped as subarctic (1 species), subtropical species, *Limacina retroversa* was found in cold slope waters (mainly north of Cape Hatteras) where it was dominant (97% of pteropods). The average abundance in this water mass was 15/m^3. The subtropical group represented 10% of the pteropods in surface waters of the Gulf Stream (20-30% of the pteropods in the upper 200 m). The tropical species domintated the Gulf Stream waters with *L. trochiformis* representing 60% of the surface pteropod fauna (40% of the upper 200 m) and *Creceis virgula conica*, 21-36%. Pteropods were four times more abundant in slope water and seven times more abundant in the Sargasso Sea than in the Gulf Stream.

The only meroplanktonic group in the T. N. GILL collections which has been reported to date in a separate detailed publication is *Callinectes* larvae (not differentiated to species) (Nichols and Keney 1963). All eight zoeal stages and the megalopa were observed. They were most abundant in certain sections of the coast (Matanzas, Jacksonville, Savannah, Charleston and Cape Fear) which correlate with major sources of freshwater inflow. The largest numbers of early zoeal stages were found near the shore, with later stages found progressively further offshore. In Florida and Georgia waters, larvae were caught in every month (late stage larvae from April to October only) whereas in North and South Carolina waters early zoeae were observed from May to December, late zoeae from May to September, and megalopae year round. This correlates with the longer breeding season for *Callinectes* in southern waters, and suggests that these southern waters may be an important source of larvae for more northern waters. Other decapod larvae observed were listed (when identifiable) but no quantiative data were given.

Sutcliffe (1950) gives the percent occurrence for various zooplankters in North Carolinian waters (Table E-5). However, with the exception of copepods, chaetognaths and cladocerans, he did not distinguish between species. These data are somewhat misleading since seasonal differences in plankton composition are not considered. More meroplankters tend to be present in greater abundance during the warmer months and during these periods represent a larger fraction of the total zooplankton.

The zooplankton composition in cross categorizations was presented for each station sampled during the T. N. GILL cruises in the preliminary data reports, (Anderson et al. 1956a, 1956b and 1957; Anderson and Gehringer 1957, 1958a, 1958b, 1959a and 1959b). Data for cruises 5, 2, 7, and 8 have been selected to represent the situation during winter, spring, summer and fall, respectively.

The total concentration of surface zooplankton (numbers/m^3) tends to decrease with distance offshore. Relatively low concentrations observed were 3317/m^3 off Cape Canaveral in the spring, 3499/m^3 off Cape Romain in the summer and 3277/m^3 off St. Augustine in the fall. During the winter the concentration was usually less than 1000/m^3 except for three scattered stations.

In order to assess the zooplankton composition, raw data (numbers/m^3) for stations on four transects (Cape Hatteras, Cape Fear, Savannah and Cape Canaveral) were converted to percentages. The zooplankton was dominated in general by copepods and offshore, by larvaceans, both holoplankters. The degree of dominance at inshore stations was low during the spring, summer and fall when large numbers of meroplankton enter the fauna. Other holoplankters present include coelenterates (in part) and miscellaneous organisms (in part). Coelenterates and chaetognaths were increasingly important in the offshore plankton reaching eight percent. On rare occasions, high densities were also observed inshore. Euphausids were rare or absent on the

Table E-5 Composition of the zooplankton off North Carolina (Sutcliffe, 1950)

Organisms	% Total Zooplankton
Copepodids	44.3
Copepod nauplii	41.2
Tunicate larvae, larvacea	5.1
Pelecypod larvae	3.6
Annelid larvae	2.3
Gastropod larvae	1.6
Chaetognaths	0.8
Medusae	0.2
Barnacle larvae	0.2
Echinoderm larvae	0.2
Pteropods	0.2
Cladocera	0.1
Pelagic tunicates	0.1

inner shelf (1%) and usually one to three percent over the outer shelf and slope. Pteropods were slightly more abundant offshore, but nowhere exceeded two percent of the zooplankton. Miscellaneous crustaceans and the miscellaneous organisms category presumably contained some holoplankton (Lucifer sp., cladocera and rotifers), but their individual contribution to the total zooplankton has not been evaluated.

The meroplankton included coelentrates (in part), miscellaneous worms, shrimp, crabs, miscellaneous crustacea, molluscs, tunicates, lepticardii and other organisms. Miscellaneous worms were only a minor component of the zooplankton (1%) with no obvious seasonal or geographic trends. Shrimp were seasonally abundant (maximum of 15.79%) with greatest abundance on the inner shelf. Crabs (mostly larvae) were present during the spring, summer, and/or fall at different stations. Relative abundance over the outer shelf and slope was low (2%) and relatively uniform over the seasons. The maximum concentration (44%) occurred during the spring at the nearshore station on the Cape Fear Transect. On the Cape Hatteras transect, crabs were never more than 0.81% of the zooplankton even at the nearshore station. Miscellaneous molluscs (larvae) were seasonally abundant with a maximum of 11.3% during the fall at the nearshore station of the Savannah transect. This group was present year round, but generally less than two percent of the total zooplankton. Miscellaneous tunicates and lepticardii were minor components of the zooplankton with seasonal abundance peaks (summer or fall). Miscellaneous organisms sometimes dominated the nearshore (inner shelf) zooplankton (e.g. 59%, Cape Hatteras, nearshore station, spring; 34%, Cape Fear, inner shelf, fall; 77%, Cape Canaveral, nearshore station, fall).

Ichthyoplankton (fish eggs and larvae) were also enumerated. Eggs and larvae were present at all stations during all seasons with only a few exceptions. Fish eggs generally declined in abundance in an offshore direction. A maximum of 13% occurred over the outer shelf on the Cape Fear transect in the spring, and 10.9% nearshore on the outer shelf on the Cape Canaveral transect in the spring. Abundance of fish eggs seemed to increase slightly from north to south (not shown by the maxima), again suggesting that southern waters are a source of eggs and larvae for more northern waters. Seasonal abundance peaks occurred during the spring, summer, and/or fall, depending on the station. Fish larvae were always less than two percent, usually less than one percent of the total zooplankton, with no obvious seasonal or geographic trends.

St. John (1958) reported the zooplankton volumes for eight transects in North Carolina coastal shelf waters from Albemarle Sound to Cape Fear. The chaetognaths constituted 9 to 12% of the plankton volume in these samples. Maximum zooplankton volumes (m/m^3) occurred at stations located over the outer continental shelf, usually near the 40 m (131 ft.) depth contour (32 to 54 m). The average zooplankton volume in each transect ranged from 0.14 to 0.27 ml/m^3. The volume of plankton was relatively uniform regardless of season which supports the conclusion from enumerative data for the copepod and chaetognath species cited above.

Plankton volumes were also determined during the T. N. GILL cruises. Sampling sites for the plankton do not correspond to the standard stations and vary in number and location among the several cruises. The mean values of plankton for the inner shelf, outer shelf, and slope ranged from 0.045 to 0.431 ml/m^3. During each season, plankton volume was low over the inner shelf, increased over the outer shelf, and decreased over the slope. Closer examination of the data revealed a maximum plankton volume at stations located approximately between th 20 and 40 m (66-131 ft) depth contour, comparable to the results of St. John (1958). No north-south trend was evident except over the outer shelf during the winter cruise of 1954. In this case, the mean plankton volume was 0.210 ml/m^3 north of 33°, 0.652 ml/m^3 south of 33°.

The mean plankton volumes from the T. N. GILL cruises of 1954 and those of St. John (1958) for transects off the North Carolina coast are essentially the same, indicating that over the time span considered, plankton volumes were consistent.

Certain conclusions can be deduced from the available data. There is no major seasonal change in zooplankton community structure or abundance. The entire section of the coast is quite uniform from north to south with regard to species occurrence. In an onshore-offshore direction, there is a general increase in diversity but a decrease in standing crop (expressed as numbers per liter and ml plankton per liter) with several water masses discernibly based on species composition: coastal water (strong admixture of estuarine water), shelf water, (possibly divisible into inner and outer shelf), Gulf Stream and Sargasso Sea.

c. Benthos

The dominant benthic species on the southeastern U.S. continental shelf region include cephalochordate amphioxus (*Branchiostoma caribaeum;*) polychaetes (*Spiophanes bombyx* and *Magelona* spp.); crustaceans (*Oxyurostylis smithi*, *Pinnixa chaetopterana* and *Callianassa* spp.); pelecypod (*Tellina* sp.) and ophiuroid (*Hemipholis elongata*).

Two major factors regulate benthic distribution on the continental shelf, sediment conditions and temperature. There is a relationship between the discontinuity of temperature and the distribution of chaetognaths and other benthic organisms.

Three subtidal sand bottom assemblages or zones were identified by Dat et al. (1971): The turbulent zone, the outer continental shelf zone and the upper continental slope zone. The turbulent zone (from the surf zone to a depth of 20 m) is affected by a rippling wave action. The major species of this area include the sand dollar (*Mellita quinquiesperforata*), crabs (*Dissodactylus mellitae*), *the archiannelid* (*Polygordius*), the polychaete (*Maeroelymene zonalis*), the surf clam (*Spisula raveneli*) and the gastropod (*Olivella mutica*). These are all detritus feeders; however, a few filter-feeders (*Spisula* and *Branchiostoma*) also occur in this area (Table E-6). While none of the tracts of this proposed lease area are located shoreward of the 20 m isobath, the effects of oil and gas operations may be felt in this zone.

The outer continental shelf zone (40—120 m depth) is mainly affected by the Gulf Stream. Polychaetes represent the major taxonomic group in this area (Table E-7). The upper continental slope zone (160—205 m depth) is composed of the dead shells of pteropods and is the third assemblage. This zone is also dominated by polychaetes (Table E-8). All of the tracts of this proposed lease are within these two zones.

Off Beaufort Inlet, North Carolina, Bird (1970) studied the molluscan fauna. He identified some of the major species which include *Spisula raveneli, Lucina multilineata, Acteocina canaliculata, Crepidula convexa* and *Olivella mutica*. The South Carolina coast has a species composition similar to North Carolina.

Investigations have been carried out by Smith (1973) off Sapelo Island, Georgia. He found this area is dominated by polychaetes, molluscs and crustaceans. The dominant species in this area include *Notomatus* sp., *Spiophanes bombyx*, *Abra aequalis*, *Tellina texana*, *Oxyurostylis smithi*, *Callianassa* sp., and *Pinnixa caetopterana*. The echinoderms that dominate this area are *Hemipholis elongata*, *Micropholis atra* and *Mellita quinquiesperforta*.

Total community respiration ranged from 53.7 to 92.7 ml $0_2/m^2/hr$ (annual oxygen consumption was estimated at 676.6 l $0_2/m^2$. The contribution of the macrofauna respiration ranged from 5 to 26% of the total (based on the sum of individual measurements for each species in the community). Annual macrofaunal respiration equaled 82 $0_2/m^2$ which is equivalent to 397 $kcal/m^2/yr$. Bacterial respiration accounted for 30 to 60% of the total community respiration. In contrast, meiomicrofauna and micorflora were estimated to be responsible for 25 to 58% of the total community respiration. Total community respiration and bacterial respiration were closely correlated with temperature and dissolved oxygen concentration, but respiration of the other components of the total community were not closely correlated.

The species were ranked by their contribution to total community respiration by season. The first five species for each season are listed in Table E-9. In general, these species also ranked high in numerical abundance and/or biomass for the same season. The exceptions to this general rule and the lack of exact correspondence in ranking, point out the potential danger of equating numerical or biomass dominance with functional studies (energy and material flow) and they are paramount to a complete understanding of communities and ultimate evaluation of the effect of man's activities on these communities.

Leiper (1973) analyzed the benthic fauna according to feeding types present. The proportion of detritus feeders in the faunal assemblages declines with distance offshore, while the proportion of suspension feeders increases. The differences are related to the availability of detritus derived from estuarine salt marshes. The sand bottom fauna is dominated by polychaetes, pelecypods, crustaceans (especially amphipods) and echinoderms. The seasonal variation of the benthos was also noted by Leiper.

Table E-6 - Major Benthic Species of the Turbulent Zone (0-20 m) off North Carolina 100/sample

Species	Total Number of Organisms/Sample
Archiannelida	
Polygordius sp.	382
Polychaeta	
Palanotus heteroseta	116
Magelona papillicornis	229
Macroclymene zonalis	541
Amphipoda	
Platyischnopos n. sp.	102
Maera sp.	197
Echinodermata	
Mellita quinquiesperforata	1044
Gastropoda	
Olivella mutica	101

Source: Day, J. H. et al., 1971.

Table E-7 - Major Benthic Species of the Outer Continental Shelf (40-120 m) off North Carolina 100/Sample

Species	Total Number
Polychaeta	
Onuphius nebulosa	136
Chaetozone setosa	300
Amphipoda	
Siphonoecetes maculicornis	175

Source: Day et al., 1971.

Table E-8 - Major Benthic Species of the Upper Continental Shelf of North Carolina 100/Sample

Species	Total Number
Polychaeta	
Lumbrineris cruzensis	210
Scolaricia capensis	135
Chaetozone setosa	278
Notomastus latericeus	170
Amphipoda	
Unciola irrorata	187
Celecypoda	
Nucula delphinodonta	234

Source: Day et al., 1971.

Table E-9. Functionally dominant benthic species based on respiration by season of a sand bottom community off Sapelo Island, Georgia (from Smith, 1973).

Summer

Notomastus sp.
Mellita quinquiesperforata
Glycera dibranchiata
Haliactus n. sp.
Nephtys picta

Fall

Callianassa n. sp.
Pinnixa chaetopterana
Abra aequalis
Micropholis atra
Magelona sp.

Winter

Abra aequalis
Notomastus sp.
Callianassa n. sp.
Micropholis atra
Pinnixa chaetopterana

Spring

Abra aequalis
Sabellides oculata
Solen viridis
Micropholis atra
Tellina texana

Source: Smith, K. L., Sr., 1973.

Besides the sand bottom fauna, there are four other benthic assemblages in this area: calico scallop beds, coral outcroppings, a reef formed by ancient Lithothamnion deposits and ''black rock reefs''.

There are two calico scallop beds along the southeast Atlantic coast, one in Raleigh Bay, N.C., and another off Cape Canaveral (Cummins et al., 1962a). The dominant species are: *Arcopectin gibbus* (calico scallops); *Balanus amphitrite* and *B. calidus* (barnacles); *Pomatoceros americanus, Sabellaria floridensis* and *Polydora websteri* (polychaetes (Table E-10). This assemblage is primarily dependent on plankton for its energy base.

Coral reefs are unknown in this area of assessment; however, outcropping of coral heads, sea fans and associated fauna have been reported from Onslow Bay, North Carolina, (Huntsman and Macintyre, 1971) and probably occur southward to Cape Canaveral. The reef-forming species that are dominant in this area include *Solenastrea hyades, Sidastrea siderea;* the non-reefing forming species are *Oculina arbuseula, Astrangia astreiformis, Phyllangia americana* and *Balanophyllia floriana* (Table E-10). This community is very important to commerical fishes and is known as the ''live bottom area''. McCloskey (1970) pointed out that this assemblage has an extremely high diversity when compared to assemblages from adjacent habitats. This is a result of the physical diversity of the coral heads.

Lithothamnion reefs have been identified seaward of the shelf break at the 80-110 m (262-361 ft) contour, approximately 76 km (47 mi) offshore from Onslow Bay, N.C. (Menzies et al., 1966). The reef fauna consists mainly of species associated with hard substances and/or epifaunal species, (Cerame-Vivas and Gray, 1966), and contains about 91% tropical species in composition. The upper sandy portion of this reef is dominated by the pelecypod, *Glycymeris* and an epifauna consisting of echinoids, gorgonians, hydroids and bryozoans. The low reef mud-sand assemblage is dominated by the gastropod, *Ploystira* and the brochyuran, *Acanthocarpus* (Table E-10). The food chain of this area is based on plankton and detritus.

The "Black Rock" reefs occur off North Carolina and are dominated by fossil pelecypods (*Venus gardneri*). The major species of this area are sessile snails, *Vermicularia spirata* and various tubicolous polychaetes. Corals are present but not in any significant amount. Other species present include boring clams (*Saxicava rugosa* and *Lithophaga bisulcata*) and sessil clams. Most species have a southern affinity.

d. Nekton

Nekton are organisms which remain suspended in the water and whose power of locomotion are great enough to resist the set and drift of current, being subject only to large-scale physical forces. They are represented for offshore waters by five major taxonomic categories—marine mammals and reptiles, fishes, cephalopod molluscs (octopuses and squid) and certain crustaceans (shrimp and swimming crabs). Individuals of this group commonly but not always range over broad areas, thus they participate in several biotic communities. For example, shrimp have pelagic planktonic larvae, estuarine juvenile and pelagic or benthic adult stages. However, most nekton are limited in geographic and vertical ranges by the same environmental conditions as less mobile organisms; i.e., temperature, salinity, available food and types of bottom.

The following descriptions were taken mainly from Roberts (1974) and TRIGOM (1974).

The waters over the continental shelf of the South Atlantic region vary in their physical nature and resource potential (Struhsaker, 1969). The area inshore of approximately the 20 m (66 ft) depth is the area of the traditional fisheries for shrimp, crabs and the sciaenids. The bottom is generally smooth and sandy and the area undergoes large seasonal temperature fluctuations. Over most of the outer shelf (20 to 200 m (66-656 ft) the bottom is smooth and sandy to muddy. This area is directly influenced by the Gulf Stream, and bottom temperatures are often higher and more uniform seasonally than those inshore. This accounts for the occurrence of tropical fishes such as the snappers, groupers and porgies. Interspersed over the open shelf are areas of live-bottom habitat. These consist of rock outcroppings and reef formations that are heavily encrusted with sessile invertibrates such as sponges and sea fans. These usually occur at depths greater than 30 m (98 ft) but off the North Carolina coast they occur at depths as shallow as 18 m (59 ft). These are productive areas and support a handline fishery for snappers and groupers and a pot fishery for sea bass. On the lower shelf,

Table E-10. Special Benthic Assemblages with Associated Major Species

Calico Scallop Area (Wells et al., 1964)	Scleratinian Coral Area (McCloskey, 1970)	Lithothamnion Reef Area (Menzies et al., 1966)
Balanus amphitrite	Coelenterata	Porifera
	Aiptasia eruptaurantia	
B. calidus		Coelenterata
	Nemertea	
Pomatoceros coerdus	*Nemertean sp. A*	Nemertea
Sabellaria floridensis	Annelida	Ectoprocta
	Polychaeta	
Websterinerus tridentata	*Autolytus prolifer*	Sipunculida
	Brania sp.	
Pinnotheres maculatus	*Eupomatus dianthus*	Echiuroidia
	Exogene sp	
Pontonia marginata	*Heteromastus filiformis*	Annelida
	Nereis occidentalis	
Odostomia seminuda	*N. succinea*	Mollusca
	Ophiodromus obscurus	
	Ploydora sp.	Arthropoda
	Sabellaria floridensis	
	Syllis cornuta	Echinodermata
	S. gracilis	
	Terebella rubra	Chordata
	Pelecypoda	
	Diplothyra smithi	
	Lithophaga aristata	
	L. bisulcata	
	Arthropoda	
	Copepoda	
	Parateutha n. sp.	
	Cirripedia	
	Balanus trigonus	
	Kochlorine floridana	
	Tanaidacea	
	Tanaid sp. A	
	T. sp. B	
	Isopoda	
	Jaeropsis coralicola	
	Erichthonius n. sp.	
	Gammaropsis maculatus	
	Lembos websteri	
	L. sp.	
	Leucothoe spinicarpa	
	Photis pugnator	
	Decapoda	
	Ophiothrix angulata	
	Echnidermata	
	Synalpheus frtizmuelleri	

below 120 m (394 ft), the substrate is predominantly smooth mud with relatively stable temperatures and a cold water-high-latitudinal fauna of hakes, flatfishes and butterfishes (Visuals Nos. 4N-S and 5N-S).

Nekton are generally categorized according to their principal mode of existence into the following categories:

(a) Pelagic—range widely throughout the water column, feeding on plankton and other fish such as squid, schooling fishes, marine mammals and cartilaginous fish.

(b) Demersal—associated with the bottom, feeding on bottom invertebrates and fishes and more restricted in their movements than pelagic species; for example, flounders, black sea bass, shrimp and swimming crabs.

Life history data for selected species of commercial and recreational finfish and shellfish for the South Atlantic were compiled by Roberts (1974). Additionally, Opresko et al. (1973) compiled life history data for lobsters and lobster-like animals and Voss et al. (1973) compiled data on octopus and squid. The total number of species considered in these data were: finfish 31, shellfish 12 and octopus and squid 7.

For additional information on nektic communities, please see Section II.E.1.e., Marine Mammals; II.E.2.c., Endangered Species; II.G.5., Commercial Fishery Resources; and II.G.6.d., Sport Fishing, and Visual Nos. 4N-S and 5N-S.

e. MARINE MAMMALS

The marine mammal fauna of the southeast Atlantic coast of the United States between Cape Hatteras, N.C. and Cape Canaveral, Fla., consists almost entirely of cetaceans (whales, dolphins and porpoises). However, two other groups, the pinnipeds (seals and sea lions) and sirenians (manatees) are also represented.

Caldwell and Caldwell (1974) summarized the data available on marine mammals in this region. Various checklists of North American mammals that include records of marine mammals from the study area include those of Caldwell and Golley (1965), Golley (1966), Caldwell et al. (1971), Moore (1953) and Layne (1965). A listing of these species, their population, migration, distribution and primary food source are included in Table E-11.

In general, two species of dolphin of any commercial significance inhabit this region. The Atlantic bottle-nosed dolphin (*Tursiops truncatus*), and the Atlantic spotted dolphin, (*Stenella plagiodon*). Both species are captured within the study area for commercial display and/or for research. Even though there is little, if any, commercial pressure on the other species, they all have an aesthetic significance that has been widely publicized. Because of this public interest, the U.S. Marine Mammal Protection Act of 1972 was established. This law provides for the protection of all marine mammals in the territorial waters of the United States (including marine mammal products imported into the United States). Although there is no commercial pressure on the pinnipeds and sirenians of the study area, they too are protected by the Act to the same degree as the cetaceans.

No species of marine mammal is restricted to this region, but a range extreme for some species does occur within the area. While not an absolute barrier, Cape Hatteras and/or Cape Canaveral tend to delineate ranges of a number of animal species, including some mobile marine mammals. The range limits are probably set more by oceanographic conditions than by the capes themselves. Most marine mammals are wide ranging and some are even world-wide in distribution, especially within a zoogeographic belt such as the tropics or temperate seas. The overall range of each marine mammal species is summarized by Rice and Scheffer (1968).

The population status of marine mammals in the western North Atlantic is relatively stable with a few exceptions such as the Sei Whale. There is a continual fluctuation in the numbers from time to time, but this could be due to less sighting of the animal rather than a decrease in population. There is no evidence to suggest that the fluctuations in food stock have affected the cetaceans, and weather plays a minor role in their population dynamics.

Within the study area, only three species of marine mammals can be said to utilize estuaries in a regular manner. These include the Atlantic bottlenosed dolphin, the Florida manatee, and the harbor seal. The California sea lion, is also found in estuaries in the study area, but it is a feral introduced species not known to breed in the western North Atlantic. The Atlantic bottlenose dolphin and the Florida manatee may also enter freshwater rivers, creeks and springs. These species are probably the most vulnerable of all marine mammals to man's activities such as shoreline development, bottom disturbances of various kinds (dredging) and water sports.

Some of the larger whales that occur in the study area are considered endangered (U.S. Dept.

Table E-11 Species of Marine Mammals Known to Occur in the Region Between Cape Hatteras, N.C. and Cape Canaveral, Florida

Common Name	Scientific Name	Population	Migration	Distribution	Primary Food Source
* Black Right Whale	* Eugalena glacialis	Increasing	Inshore movement-January-March	N. Carolina-Florida	Zooplankton-copepods
* Humpback Whale	* Megaptera novaeangliae	Increasing	Southward-winter	N. Carolina-Florida	Krill & schooling fish
* Sei Whale	* Balaeoptera acutorostrata	Declining	No data		Krill, schooling fish, and copepods
Bryde Whale	B. edeni	Stable	No data	N. Carolina-Florida	Schooling fish and pelagic crustaceans
* Fin Whale	* B. physalus	No data	No data	N. Carolina-Florida	Krill,squid,small fish
False killer whale	Pseudora crassidens	Stable	No data	N. Carolina-Florida	Squid and large fish
Killer Whale	Orcinus orca	Stable	No data	N. Atlantic-Florida	Squid, fish, sea turtles, sea birds, & other marine mammals
Short-finned Pilot Whale	Globicephala macrorhyncha	Stable	No strong seasonal movement	N. Carolina-Florida	Squid and fish
* Sperm Whale	* Physeter catodon	Above maximum sub-stanance levels	Northward-spring & summer Southward-fall	N. Carolina-Florida	Squid and fish
Pygmy Killer Whale	Feresa attenuata	Stable	None	Florida	Squid
Pygmy Sperm Whale	Kogia breviceps	Stable	None	N. Carolina-Florida	Squid
Dwarf Sperm Whale	K. simus	Stable	No data	N. Carolina-Florida	Squid
Antillean Beaked Whale	Mesoplodon europaeus	Stable	No data	N. Carolina-Florida	Squid

* Endangered Species

Source: Roberts, 1974. Dept. of Commerce, 1976.

TABLE E-11 (continued)

Common Name	Scientific Name	Population	Migration	Distribution	Primary Food Source
True's Beaked Whale	Mosoplodom mirus	Stable	No data	N. Carolina-Florida	No data
Dense Beaked Whale	M. densirostris	Stable	No data	N. Carolina-Florida	Squid
Goose Beaked Whale	Ziphus cavirostris	Stable	No data	N. Carolina-Florida	Squid
Rough-toothed Whale	Steno bredanensis	Stable	No data	N. Carolina-Florida	Squid
Risso's Dolphin	Grampus griseus	Stable	No data	S. Carolina-Florida	Fish and squid
Saddleback Dolphin	Delphinus delphis	Stable	No data	No data	No data
Bottlenose Dolphin	Tursiops truncatus	Stable	Northward-summer Southward-winter	Inshore N. Carolina-Florida	Fish, squid, and crustaceans
Spinner Dolphin	Stenella longirostris	Stable	No data	N. Carolina-Florida	Squid
Bridled Dolphin	S. frontalis	Stable	No data	N. Carolina-Florida	Squid and small fish
Spotted Dolphin	S. plagiodon	Stable	Continental shelf-moves inshore-spring; close to shore-spring and summer	N. Carolina-Florida	Squid
Harbor Porpoise	Phocoena phocoena	Stable	No data	Pamlico South-N. Carolina	Bottom fish,mollusks and crustaceans
Manatee West Indian (Florida)	Trichechus manatus	Stable & Increasing	Northward in summer into shallow waters and warmer springs and rivers	S. Carolina-Florida	Aquatic vegetation
California Sea Lion	Zalophus califorianus	feral species few	No data	S. Carolina-Florida	Squid and small fish
Harbor Seal	Phoca vitulina concolor	feral species few	No data	N. Carolina-NE Florida	Fish,mollusks, and crustaceans
Hooded Seal	Cystophora cristata	feral species few	No data	N. Carolina-Florida	Fish,mollusks, and crustaceans

of Interior, 1975d). These whales are the black right whale and the humpback whale are considered endangered and the fin whale is considered vulnerable by an international group (IUCN, 1972). No dolphins, pinnipeds or odontocetes known to occur in this region (other than the sperm whale) are considered endangered. The Florida manatee is considered endangered (USDI, 1975d), and the species which includes this subspecies is listed as endangered by the international group (IUCN, 1972).

Many cetaceans found in the study area are considered rare, not only in this region, but also world-wide. Some of them are probably not rare but rather only infrequently encountered by man. The pygmy sperm whale and the goosebeaked whale, for example, have long been termed as rare species, but recent evidence (namely greater observational effort) suggests that they are, in fact, rather common.

The Florida manatee population is increasing in Florida and its range has extended to South Carolina. The major area where these animals congregate are in warm waters. It is definite that manatees migrate offshore and avoid the extremely shallow flats and waterways near coastal inlets. They seek open water and travel long established corridors through the complex of sand bars, oyster reefs and limestone shelves (Hartman, 1969). The primary food source of the Florida manatee is aquatic vegetation.

The majority of the population now survives in isolated pockets in Florida. The main enemy of the Florida manatee is man's activities. Many animals are lost each year as a result of increased use of waterways by commercial ships and pleasure boats. Their slow rate of reproduction, one calf per adult female every three years, has severly handicapped the population. Those that survive are left with scarred backs from wounds inflicted by the propellers on boats.

Further work is being conducted regarding population densities and habitat of manatees by Reynolds at the University of Miami.

f. Pelagic birds

Wass (1974) summarized available data pertaining to pelagic birds species in the southeast and north Atlantic (Table E-12). The general order of abundance of pelagic birds along the southeast U.S. coast is as follows: petrells, shearwaters, gannets, phalaropes, jaegers and terns. Many of these species migrate annually through the area. However, a significant number are located offshore and also use the southeast Atlantic states for nesting purposes (Visual Nos. 5N-S). Pelagic bird rookeries are found in Pamlico Sound and Cape Fear, North Carolina; the entire Georgia coast; and in the vicinity of Cape Canaveral, Florida. Brown pelican rookeries have been observed in Pamlico Sound, North Carolina; Bulls Bay and Seabrook Island, Georgia; near Daytona Beach, Vero Beach, and Ft. Pierce, Florida. Stragglers from the north include the skua, alcids and northern gulls, terns, boobies, tropicbirds and frigatebirds migrate from the south.

Two groups of migratory pelagic birds are identifiable, based on definite patterns of movement. The first group exhibits a southward movement in fall and a return movement the next spring. The bird most often seen in this group is the gannet, which winters north to Massachusetts, but is often seen in greatest numbers in the Carolinas, and less often in Florida. Juveniles of this species move further south. Gannets usually stay well offshore, except when strong "northeasters" occur.

Two shorebirds which exhibit this migratory pattern are the northern and red phalaropes. However, they move south earlier, continuing into the tropics, and return from April to June inclusive. They also tend to stray offshore. Red phalaropes appear off North Carolina in mid-August. Northern phalaropes appear about a month later off North Carolina, and off Florida during October. Although the northern phalarope is said in general to be the more abundant of the two, it occurs in smaller concentrations off the southeastern U.S. coast.

The pelagic group also includes the skuas and three species of jaegers. The largest movement of these birds along the southeastern U.S. coast was reported by Buckley (1973). He recorded 47 jaegers during seven hours of counting from May 30 to June 1, 1972. These included 11 pomarine, 26 parasitic, and 10 long-tailed jaegers and 2 skuas.

The sooty shearwater usually migrates somewhat earlier than the other shearwaters. Shearwaters, especially the greater, have occasionally suffered mass die-offs in the last decade. In Britain, die-offs have been attributed to PCB's. However, along Virginia, North Carolina, and Georgia the cause of the die-offs have not been

Table E-12. Pelagic Birds Occurring in the Southeastern North Atlantic Region.

Stercorarius pomorinus	Pomarine Jaeger
S. parasiticus	Parasitic Jaeger
S. longicaudus	Long-tailed Jaeger
Larus hyperboreus	Glaucus Gull
L. glaucoides	Iceland Gull
L. marinus	Great Black-backed Gull
L. fuscus	Lesser Black-backed Gull
L. argentatus	Herring Gull
L. delawarensis	Ring-billed Gull
L. ridibundus	Black-headed Gull
L. atricilla	Laughing Gull
L. philadelphia	Bonaparte's Gull
L. minutus	Little Gull
Rissa tridcatyla	Black-legged Kittiwake
Xema sabini	Sabine's Gull
Gelochelidon nilotica	Gull-billed Tern
Sterna forsteri	Forster's Tern
S. hirundo	Common Tern
S. paradisaea	Arctic Tern
S. dougallii	Roseate Tern
S. anaethetus	Bridled Tern
S. fuscata	Sooty Tern
S. albifrons	Least Tern
Aiious stolidus	Noddy Tern
Thalasseus maximum	Royal Tern
T. sandvicensis	Sandwich Tern
Hydroprogne caspia	Caspian Tern
Chlidonias niger	Black Tern
C. leucopterus	White-winged Black Tern
Rynchops nigra	Black Skimmer
Alca Torda	Razorbill
Uria lomvia	Thick-billed Murre
Plautus alle	Dovekie
Cepphus grylle	Black Guillemot
Fratercula arctica	Common Puffin

Source: Wass, 1974.

studied. Nevertheless, shearwaters are perhaps one of the most abundant pelagic birds.

The second group of migratory pelagic birds is more truly oceanic in that most of the group breed on islands in the south Atlantic and migrate annually in a great circle around the north Atlantic. Because of its wide-spread dispersal, the Wilson's storm petrel, whose numbers typically exceed those of all other pelagic species combined for most of May to September off the southeastern U.S. coast, is most notable. This "sea swallow" nests on islands of the Antarctic Ocean and even in Antarctic. It moves up the Atlantic coast during March through August, crosses the ocean on the North Atlantic Drift, turns south along Europe, reaches the equator by mid-October and its breeding grounds about mid-November.

Wilson's storm petrel is the best known pelagic bird, and its concentrations are exceeded by those of migrating shearwaters. Such large flocks pass Cape Hatteras that in six hours of observation (during two evenings) Buckley (1973) estimated 10,000 shearwaters (half being Cory's, one-fourth greater and one-fourth sooty). In addition, Manx shearwaters were seen, a record for the coast south of Long Island. The latter species nests mainly in the eastern Atlantic, but has recently nested off Massachusetts. The shearwaters seen in the southeastern U.S. coastal region mostly nest in the South Atlantic. Four species of terns occur offshore, the Arctic tern being the most frequent. The bridled, sooty, and noody tern are tropical and occasionally straggle north over the Gulf stream.

g. Biologically sensitive areas

The southeastern continental shelf of the U.S. contains areas commonly referred to as "live bottoms". These areas are defined as containing biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans and hard corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and whose lithotope favors accumulation of turtles, pelagic and demersal fish, (Visuals No. 4N and 4S). Other names given to these areas are hard bottoms, coral patches, fishing banks, snapper banks, block rocks and limestone or "lithothamnion" reefs. These areas support a major finfish fisheries (commercial and recreational) on the South Atlantic OCS in addition to artificial reefs. Those type bottom-fisheries associated with these areas include porgies (*Calamus* and *Pagrus*), groupers (*Epinephelus* and *Mycteroperca*), snappers (*Lutjanus* and *Rhomboplites*), and grunts (*Haemulon*) (Huntsman, 1976).

Except for "Sapelo Live Bottom" or Gray's Reef and the Onslow Bay coral patches, little is known about the location, size and ecology of these live bottom areas. Underwater television of certain live bottoms indicate that they are very "patchy" or localized in character which makes accurate areal description, based on existing data, impossible.

Huntsman (1976) described two types of headboats in North and South Carolina that fish along the live bottom areas. (1) those that fish near inshore rocks and coral patches from 27 to 46 m (15 to 25 fath) (inshore boats) and (2) those that fish the shelf break zone and the extreme outer shelf from 46 m to 73 m (25 to 80 fath) (offshore boats). Roller trawling has recently been introduced in these areas and is known to cause some damage to the live bottom habitat. However, the temporal and spatial extent of the damage is not well known at present and is the subject of some controversey (National Fisherman, 1976).

In Georgia, live bottom areas are likely to be found in the following areas: 16 m to 24 m (9 to 13 fath) depth contour; the 31 m to 39 m (17 to 21 fath) depth contour; and the 110 m to 165 m (60 to 90 fath) depth contour. The shelf break off Georgia occurs at 150 m (82 fath) (Harding, 1976).

Lastly, Moe (1963, 1970) delineated certain areas off the east coast of Florida as containing live bottom areas but he did not limit areas according to depth contours.

Specific locations and descriptions of live bottom ("hard bottom") areas or where concentrations of porgies, groupers, and snapper were caught have been reported by Bearden and McKenzie (1973), Bullis and Thompson (1965), Ogren (1975), Harrington and Rivers (1975), Huntsman and Macintyre (1971), Radcliffe (1914), Struhsaker (1969), Scott and Huntsman (1976), Jacksonville Offshore Sport Fishing Club (1973), Smith (1975), Hutsman (1976), Barans (1975), Newton, Pilkey, and Blanton (1971), North Carolina Department of Conservation and Development (1969), Macintyre (1969), Harding (1976) and Macintyre and Pilkey (1969). While only 5% of the proposed lease tracts have specifically reported live bottoms in them, it is clear from Visual No. 4S that these areas lie in a general North-South trend just shoreward of the 200 m isobath, and that the proposed lease tracts lie more or less astride this trend. Thus it is likely that more of these important fishing areas will be discovered during the exploratory phase of oil and gas development, and measures to protect them will have to be taken.

Relief for these areas varies significantly with the shelf break having probably the greatest vertical relief in the proposed lease area. Topography for the shelf break consists primarily of undulating sand and sand ridges broken by ridges, troughs, ledges, and terraces varying from minimal (less than 1 m) to 15 + m for certain ridges (Macintyre and Milliman, 1970). "Rufus Reef" at 155 m (85 fath.) off Savannah, Ga. has a relief of 11 m (6 fath.) (Harding, 1976). The same type of minimal relief can also be expected for the inner and intermediate shelf areas with the greatest vertical relief being approximately 7 m (6.6 m was reported by Hunt (1974) for Gray's Reef).

The following narration describes those areas in which scientific investigations have been conducted.

(1) Shelf break

The shelf break from Cape Hatteras to Cape Canaveral is probably the most significant undersea feature in the study area. The following description was taken from Macintyre and Milliman (1970):

> The topography near the shelf break of the continental margin off the southeastern U.S. is highly variable, but for summary purposes may be divided into four distinct areas, each having characteristic morphologies and lithologies: (a) Cape Hatteras to Cape Fear, (b) Cape Fear to Cape Kennedy, (c) Cape Kennedy to Palm Beach, and (d) Palm Beach to Fort Lauderdale. Each area is subdivided into topographic zones, and plots of representative profiles within each zone are shown in Figures E-2, E-3 and E-4.

Cape Hatteras to Cape Fear: For a distance of about 300 km off North Carolina between Cape Hatteras and Cape Fear (zones A to J, Fig. E-2), ridges, troughs and terraces (depths of 50 to 150 m) parallel the shelf break (50 to 80 m), but here and there give way to a smooth, undulating sea floor (zones C and I). Although there is a little depth correlation between features throughout this area, terraces and ridge bases between Cape Lookout and Cape Fear occur in a depth range of 90 to 110 m (zones F to J). These ridges do not have relief of more than 15 m above the trough directly shoreward of them, and they do not rise above the general over-all slope of the sea floor, except possibly in zones A and E.

Bottom photographs of the outer shelf edge and upper slope in this area show the sea floor to be composed mainly of rock fragments (<64 mm), gravel (2 to 64 mm), and shell hash, all in a sand matrix. Knobby rock surfaces or poorly defined rock ledges commonly protrude through the sediment cover on the upper slopes above the ridges, troughs, and terraces.

Algal limestone, sandstone, and shell hash constitute the material collected in rock dredges from the Cape Hatteras to Cape Fear area, and although all three components were present both above and below the shelf break, more algal limestone was recovered from the ridges and terraces, whereas sandstone was more abundant on the slope above the ridges or terraces, and on the outer shelf edge.

Sediments on the outer shelf off North Carolina are rich in carbonate (generally greater than 50%) and are dominated by coralline algae, barnacles, and mollusk fragments, corresponding in composition to the coralline algal and barnacle assemblage described by Milliamn et al., (1968). In the immediate vicinity of the ridges, algal fragments tend to be crustose; leeward the fregments become increasingly branching. Oolite sediments are found locally. Seaward of the ridges, the slope sediments are characterized by increasing amounts of planktonic foraminifera.

Cape Fear to Cape Kennedy (Cape Canaveral): From Cape Fear (33°25′N) to an area just north of Cape Kennedy (29°15′N), the sea floor at the outer shelf and upper slope is mainly smooth and undulating, and the shelf break generally indistinct. Wherever there is no marked change in slope between depths of 60 to 80 m, the minor change in slope between depths of 40 to 50 m is taken to be the shelf break. The K profiles (Figs E-2 and E-3) illustrate typical bathymetric transects of this area. Ledges, small terraces, and slight rises are present here and there near the shelf break in depths of 50 to 110 m, but no depth correlation was established between these fea-

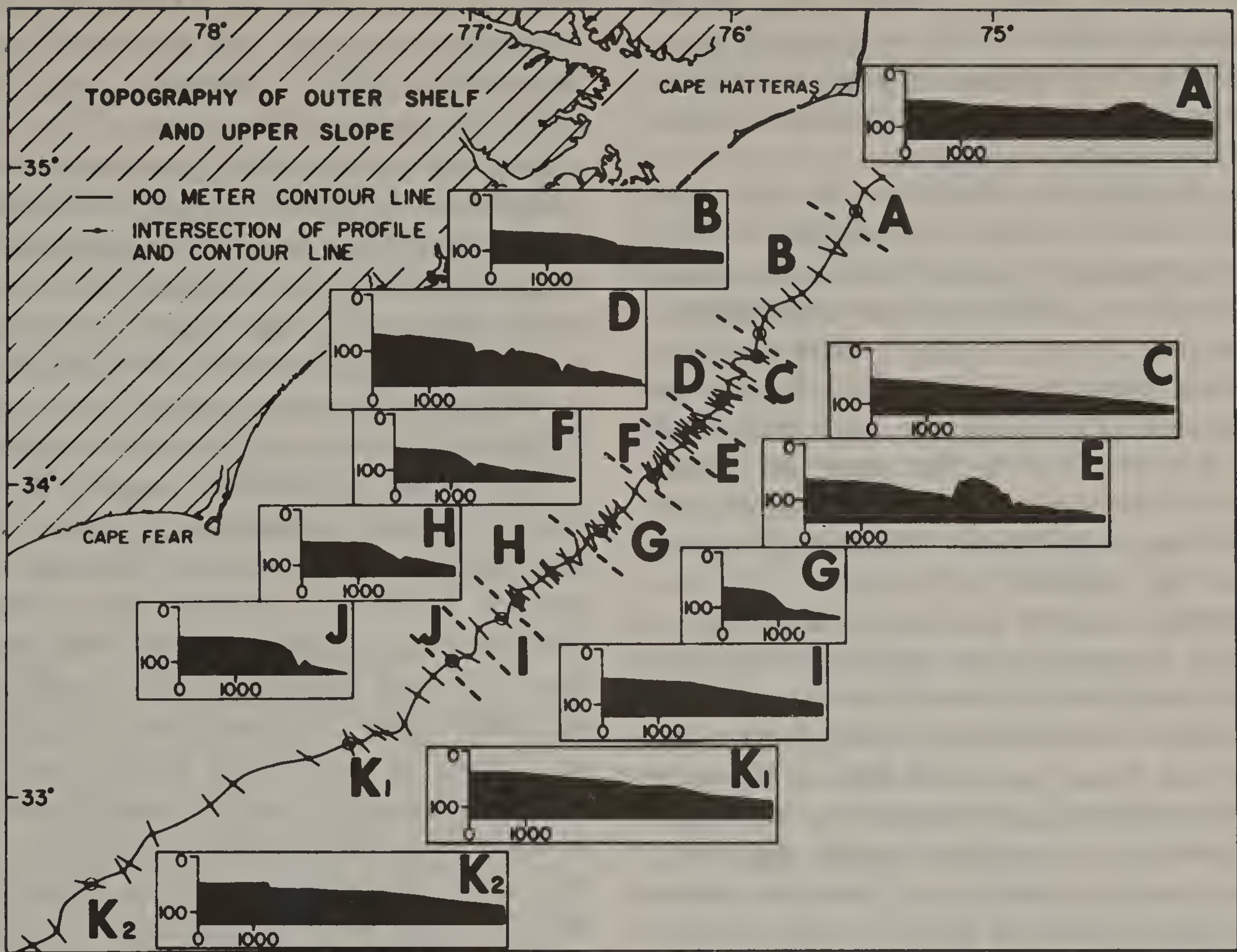
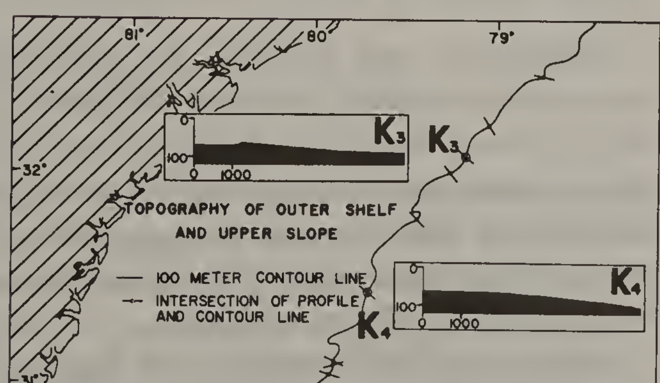


FIGURE E-2



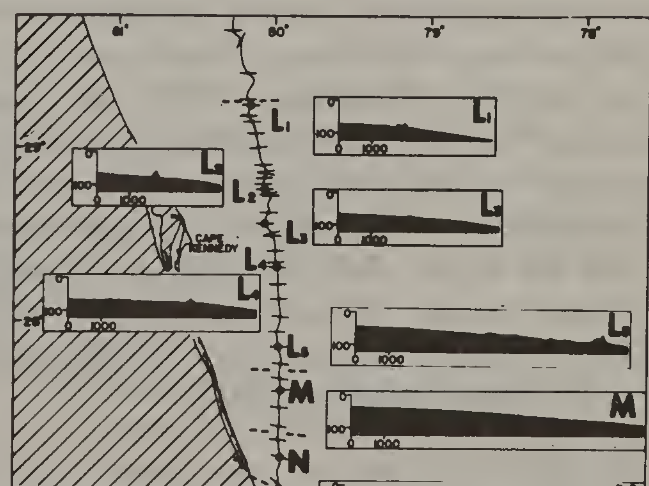


FIGURE E-4

FIGURE E-3

Source: Macintyre and Milliman, 1970.

tures. The terraces occur at depths of 70 to 110 m, whereas the ledges (6 to 10 m relief) are in depths of 50 to 70 m. Rises commonly established on the edge of the ledges generally have relief of less than five meters.

Bottom photographs from around the shelf break show mainly gravel and shell has scattered in or partly covered by a sand mud matrix. Small rock fragments are evident in a few photographs, and rough rock ledges covered by rich epifaunal growths are exposed locally (Fig. E-4); large clusters of the coral *Oculina* sp. are common off northern Florida. As in the area off North Carolina, the abundance of burrows, mounds, and trails indicates considerable infaunal activity in this area of the sea floor.

Rock-dredge samples generally are similar to those taken between Cape Hatteras and Cape Fear: algal limestone, quartz-rich calcarenite, calcareous quartz sandstone, and shell hash were collected from ledges and small rises at the shelf break. The noncarbonate fraction of the sandstones, however, is significantly higher than in the sandstones north of this area, averaging about 50% and ranging from 24 to 72% in the samples studied. The carbonate mineralogy is very similar to that of rock from the area north; both the algal limestone (average 73% MgCl) and the sandstones (average 64% MgCl) are rich in magnesium calcite and have lessor amounts of aragonite and calcite).

Sediments from this area are relatively rich in terrigenous material derived from Piedmont rivers in the neighboring coastal areas; carbonate values rarely exceed 40% (Milliman, 1972). Off South Carolina and Georgia, the carbonate components are dominated by coralline algae and barnacles in similar proportions to the sediments found farther north. On the outer shelf off southern Georgia and northern Florida, oolite becomes a dominant component, and algal fragments are less important (Pilkey et al., 1966; Milliman, 1972).

(2) *Coral patches*

Coral reefs are unknown from the study area but rock outcrops supporting epifaunal communities of coral heads, sea fans and associated fauna have been reported from Onslow Bay, N.C. (Macintyre and Pilkey, 1969; Huntsman and Macintyre, 1971) and probably occur southward to Cape Canaveral out to 40 m. The coral consist of reef-forming species, *Solenastrea hyades* and *Sidastrea siderea*, and the non-reef forming species, *Oculina arbuscula*, *Astrangia astreiformis*, *Phyllangia americana*, and *Balanophyllia floridana* (Macintyre, 1970), Huntsman and Macintyre (1971) list various fish species collected near the coral outcroppings. This community is very important to commercial fishes and motile invertebrates as a food source. This is known as ''live bottom habitat'' by fisheries scientists as are many other areas. The tropical reef corals have not been reported in water depths of less than 20 m off North Carolina however, non-reefbuilding species are common in these colder turbid waters.

The faunal assemblage associated with the coral, *Oculina arbuscula*, at four sites was described by McCloskey (1970). He examined samples from three shallow water sites, Cape Lookout jetty, Sharkshoal jetty (both near Beaufort, N.C.) and Charleston, S.C., north jetty, and one deep water site, the Cape Lookout outcrop (ca. 10 m). A total of 309 species was reported. Although basically similar, assemblages differed in detail between various sampling sites. The shallow water assemblages showed higher diversity than the deep water assemblage, contrary to expectation based on the greater variability of obvious physical factors (salinity, temperature, etc.) in shallow water which generally result in low diversity. McCloskey (1970) suggested that sand scouring is the dominant physical parameter on Cape Lookout outcrop, which explains the distribution of diversity. Increased scouring or sediment loads can be expected to adversely affect this community.

Polychaetes and molluscs are represented by the greatest number of species (89 and 74 respectively). From these lists it can be seen that many species occurred as dominants at several stations, but the fact that their relative ranking in the samples differed is not shown, implying differences in the structure of the assemblages.

McCloskey (1970) pointed out that this assemblage in the broad sense has an extremely high diversity compared to assemblages from adjacent habitats. He believes that the high diversity results from physical diversity of the coral heads.

The vast majority of the dominant species are deposit feeders, with a number of filter feeders and carnivores also dominant. Detritus may well be significant in the diet of the filter feeders as well as the deposit feeders.

(3) Black rock reefs

Pearse and Williams (1951) described the fauna associated with the so-called "black rock" reefs off the Carolinas. These rock out-crops consist of a base of Trent marl dominated by a fossil pelecypoda (*Venus gardneri*). Some 300 species are listed (including associated fish fauna). The chief species contributing to building of the reefs are the sessile snail, *Vernicularia spirata*, and various tubicolous polychaetes. Corals are present but do not contribute significantly to the relief of these structures, according to Pearse. Boring clams (*Saxicava rugosa* and *Lithophaga bisulcata*) and sessile clams are conspicuous members of the assemblage. Most species have a southern affinity.

(4) Gray's Reef—("Sapelo Live Bottom").

Hunt (1974) described the geology and origin of Gray.s Reef which is also known as Sapelo Live Bottom. It is located in about 19.8 m of water approximately 33 km due east of Sapelo Island, Ga. The reef substrate is a layer of rock composed of a moderately to strongly dolomitized, sandy biomicrite which occurs as an outcropping layer. The reef itself is heavily encrusted by sessile benthos (sea fans, sea whips, hydroids, anenones, ascidians, sponges, bryozoans, and hard corals) and serves as a valuable habitat for snappers, groupers, porgies, tropical fish, and other associated motile reefal species (Hunt, 1974 and Smith, 1975). The total vertical relief in the area is 6.6 m. This reef is not in the proposed lease area.

2. Coastal and Onshore

a. Vegetation

The upland vegetation biome characteristic of the entire southeastern United States, exclusive of the southern portion of the Florida peninsula, is classified as Southeastern Evergreen Forest. This biome begins in southeastern Virginia, south of the James River, and is restricted to the coastal plain throughout its range.

Numerous major river systems dissect the southeast. Low, broad floodplains are particularly characteristic of the rivers in the southeastern evergreen forest. The largest bottomlands occur along the major rivers and represent some of the most natural country remaining in the southeast due to their general inaccessibility.

The southeastern evergreen forest contains several community types which are treated by several authors. Waggoner (1975), Roberts et al. (1974), U.S. Dept. of the Army (173a, 1973b), USDA (1969), Hedlund and Janssen (1963), and Braun (1950) have detailed the vegetative profile for the southeastern region of the country. Mapped vegetative data are depicted from available sources on Visual Nos. 4N-s.

The following discussion on the community types characteristic of the southeastern evergreen forests is a brief summary of a more detailed treatment of Waggoner (1975).

Coastal plain upland hardwood forests: are primarily climax communities that exist in three phases (dry, intermediate and rich) depending on the soil conditions. The dominant species are comprised mostly of oaks (*Quercus* spp.) with other common hardwoods (beech, gum, hickory, etc.) becoming increasingly prevalent in the rich phase of this forest type.

Upland pine forests: these communities are successional in nature and are dominated by an overstory of pines with the understory comprised of oak species. Three phases also occur in this type that are determined by edaphic conditions.

The Florida scrub phase is restricted to Florida and is totally dominated by sand pine (*Pinus clausa*). The sandhills phase occurs wherever there are areas of moderate, deep sand deposits. Dominant vegetative composition consists of an overstory of longleaf pine with a scrubby inventory usually consisting of turkey oak (*Quercus laevis*). The loblolly pine—shortleaf pine phase occurs on disturbed upland habitats. As the name implies, loblolly pine (*Pinus taeda*) and shortleaf pine (*Pinus echinata*) dominate the various areas of this type. Several species of hardwoods may comprise the understory.

(*Pine flatwoods:* are the dominant vegetation type over this southeastern U.S. coastal region. The vast expanse of primarily longleaf pine (*Pinus palustris*) forest over the relatively level coastal plain are largely responsible for the name "southeastern evergreen forest" region. Depending on the particular habitat within this type, longleaf pine dominates the drier soils, slash pine (*Pinus ellcitti*) dominates the wetter flatwoods and pond pine (*Pinus serotina*) is predominate in the wet flatwoods which have a pH < 4.5.

Cypress-gum swamp forests: are one of the most characteristic communities of the southeastern evergreen forest and occur along many of the major rivers. In the deeper swamps, baldcypress (*Taxodium distichum*) and/or water tupelo (*Nyssa aquatica*) exist without associates. This community represents the least disturbed area in the southeast.

Bottomland hardwood forests: are one of the most diverse in vegetative types in the southwest and occupy the floodplains on the major rivers. Several species comprise this community. Depending on the location, species of maple, cottonwood, hickory oak, beech, elm and many others comprise the vegetative composition. The cypress-gum swamplands and bottomland hardwood forest together comprise the freshwater forested wetland system.

Evergreen shrub bog: this community type occurs in the lower coastal plain in areas of low water energy. It is usually characterized by an open canopy of pond pine or loblolly bay. The dominant understory species include sweet, red and loblolly bay. Other shrubby species include fetter bush, sweet galfberry, zenobia, leatherleaf and other species with tropical affinities.

Maritime forest: this community type occurs on the outer fringe of the coastal plain adjacent to the ocean. It occurs on the mainland and/or offshore islands and banks. Live oak (*Quercus virginiana*) is the most characteristic species of this community, and typical species associated with this type include red cedar (*Juniperus virginiana*), ironwood (*Carponus caroliniana*), red mulberry (*Morus rubra*) and wild olive (*Osmanthus americana*).

Savanna: this community type has on the most diverse floras of any community in this region. These areas result from continuing annual burning of pine flatwoods. Longleaf pine and/or slash pine occur in very open strands or they may be entirely absent. Species of bald cypress are present in the innundated areas. An unparalleled variety of forbs and grasses comprise the majority of the vegetation.

b. Wildlife

(1) Birds

There are approximately 400 different species of birds found between Cape Hatteras, N.C. and Cape Canaveral, Fla. Approximately 60% of the birds which occur along the coast are dependent on various aquatic habitat during parts of the year.

Most oceanic species dive into the water to catch their prey, (gannets and pelicans) while some species feed on surface plankton, (petrels and phalaropes). All these birds require water which is clear enough to see their prey.

Isolated islands, spoil banks and remote or protected beaches are especially valuable habitats for ground nesting sea birds. Other ground nesting species utilize dunes, marshes and washovers.

There are several sources for abundance data, the U.S. Fish and Wildlife Service surveys and the Christmas Bird Counts (CBC's) made by the Audubon Society. The most common birds found during CBC's made in the coastal counties of South Atlantic States are found in Table E-13. Florida is responsible for most of the high totals, while North Carolina is second indicates the presence of excellent habitats as well as better coverage in those states. Only the Ringbilled Gull, Mourning Dove and Fish Crow are somewhat evenly distributed among the four states. Since the 1930's a greater interest in preserving the bird species of a particular area became evident. Early conservation methods were headed by the Audubon Society and resulted in saving egrets, pelicans and some other birds until refuges, laws and enforcement were adequate. Coastal refuges such as Cedar Isle Wildlife Refuge and Pung Wildlife Refuge, North Carolina have been acquired and sportsmen have aided this effort by purchasing Duck Stamps. Banding and winter censuses were also expanded by the Fish and Wildlife Service.

Diving Birds

This group includes loons, grebes, pelicans and cormorants. The Brown pelican is the most important of this group. This species is considered endangered and nests in large colonies. It is rarely found north of Ocracoke, North Carolina. Their primary food source is fish for which they dive.

Pelagic Birds

The general abundance of pelagic birds along the southeast coast is petrels, shearwaters, gannets, phalaropes, jaegers and terns. These species migrate through the area annually. There are two groups of pelagic birds that are identified by their patterns of movement. The first group exhibits a southward movement in the fall and returns in the spring, it is represented by the gannet and phalaropes. The second group is oceanic in that they breed on islands in the South Atlantic and migrate in great circles around the North Atlantic

Table E-13. Most common winter birds (area 10). Based on Christmas bird counts for the coastal counties of the four southeastern states, 1972-1973.

Species	North Carolina Total Count	North Carolina Rank	South Carolina Total Count	South Carolina Rank	Georgia Total Count	Georgia Rank	Florida Total Count	Florida Rank	Total Area Total Count	Total Area Rank
Snow Goose	6,000	4	---		---		1		6,000	
Pintail	3,920	6	30		10		2,400		6,360	
Green-winged Teal	3,100	10	210		5		640		3,955	
Wigeon	340		1040	7	215		3,130		4,725	
Wood Duck	80		70		355		10		515	
Lesser Scaup	90		1090	5	100		65,770	2	67,050	4
Red-breasted Merganser	3,450	8	30		55		256		3,790	
American Coot	1,200		820	9	250		84,120	1	86,390	1
Dunlin	3,580	7	1210	3	500	9	900		6,190	10
Herring Gull	14,200	1	580		890	5	3,880	10	19,550	6
Ring-billed Gull	12,380	2	765		2250	1	8,770	6	24,165	5
Black Skimmer	170		3		1090	3	4,150	9	5,415	
Mourning Dove	300		775		445	10	530		2,050	
Tree Swallow	165		15		125		11,455	5	11,760	8
Blue Jay	200		1385	2	640	7	835		3,065	
Fish Crow	530		380		205		5,500	8	6,615	9
Robin	5,600	5	1100	4	605	8	63,575	3	70,875	3
Yellow-rumped Warbler	8,500	3	1000	8	2145	2	63,100	4	74,745	2
Red-winged Blackbird	3,240	9	3660	1	870	6	5,910	7	13,680	7
Boat-tailed Grackle	800		1060	6	910	4	2,140		4,910	
Common Grackle	70		985	8	290		1,480		2,825	
Dark-eyed Junco	320		770	10	10		4		1,100	

Source: Audubon Society, 1974.

annually. Two species which are representative of this group are migrating shearwaters and Wilson's storm petrel. The shearwaters migrate in such masses that Buckley (1973) estimated over 10,000 during a six hour observation period at Cape Hatteras, N.C.

Waterfowl

This group includes swans, geese and ducks. They spend a considerable portion of their life on various water bodies on which they depend for much of their food supply.

The Whistling Swan has been known to winter in Pamlico Sound, North Carolina. These species feed on aquatic and marsh plants; any disruption or loss of this habitat could be detrimental to the population. The Canadian Goose has also increased its population by establishing new breeding grounds. The development of wildlife refuges and its ability to feed on agricultural crops has allowed the population to remain stable.

The common species of ducks include dabbling ducks, pochards and sea ducks. The dabbling ducks are represented by the Mallard and Black Duck. These species are the most common hunted species as a result the population has been decreasing (Ferguson and Smith, 1974). The pochards include four common diving ducks in the study area, Canvasback, Redhead, Lesser Scaups and Ringed-Necked Duck. The Lesser Scaups winter in Florida and probably outnumber all other ducks in the area. The Canvasback and redhead also winter along the east coast. A large number of Redheads are found at Merritt Island, Fla. These birds usually breed in the northern regions in the summer and migrate to the warmer climates in the winter.

Sea ducks include species such as the Common scoter which is the most common species south of Cape Hatteras. Only six to seven percent of the Atlantic Flyway is inhabited by sea ducks.

Wading Birds

This group includes herons, bitterns, ibises and egrets whose habitat is freshwater areas and saltwater bays. These birds, particularly the larger ones, are quite euryphagous. In areas where they occupy large heronries, they recycle considerable amounts of organic matter and associated nutrients from the water to swamps and lands. The population of species such as the Night Heron, Green Heron and White Ibis have decreased in this area, while the egrets and Great Blue Heron have increased.

Shorebirds

Of the 44 species that occur in the study area only three are confined to nesting mainly in the eastern U.S., the American Oystercatcher, American Woodcock and Wilson's Plover. The habitat range for these species is marsh lands (American Woodcock), dunes and high beaches in Beaufort, N.C. (Wilson's & Piping Plover). Both are suffering a decline in population that can be attributed to man's encroachment.

Birds of Prey

The three predatory species which formerly impacted most heavily on coastal ecology are the Bald Eagle, Osprey and Peregrine Falcon all of which hunt mainly over saline water in estuaries and nearshore. At present the Bald Eagle has only been found to nest in South Carolina and Florida. The reduction of the Bald Eagle in Florida seems mainly due to development which has destroyed most of the tall longleaf pines. The Osprey is also found nesting in North and South Carolina where there is a substantial number of sites (Table E-14).

The Peregrine Falcon has not nested in the wild in the eastern limited states for over a decade. The reduction of this species is basically due to their poisoning by pesticides.

Vultures, kites and owls are the other predators that nest along the South Atlantic coast. Two species of vultures occur in the study area, the Turkey Vulture which occurs along the coast and the Black Vulture which feeds on fish and young birds from heronries. These species have been on the decline because of better animal husbandry and fewer animal carrion.

Three species of kites occur in the study area, Shallow-tailed, Mississippi and White-tailed Kites. The first two breed in South Carolina, Georgia and Florida. Of these birds only the Mississippi Kite which breeds along the Gulf Coast is increasing in population.

Owls constitute the largest group of terrestrial predators. The only common species in the study area are the Screech, Great-Horned and Barred Owl. Their numbers have been declining in the last decade.

Upland Game Birds

There are six species in this category found on the coastal plains. The Bobwhite, the only eastern quail, is the most intensely hunted bird in North America. It is among the most common species in Georgia. The turkey is found throughout the area

Table E-14. Representative species of the Southeast Atlantic Bird Populations

Common Name	Scientific Name	Habitat	Primary Food	Population Trend
Birds of Prey				
* Bald eagle	*Haliacetus levcocephalus	freshwater areas	ducks, rodents, rabbits	declining
Osprey	Pandion haliaetus	coastal bays and estuaries	fish	declining
* Peregrine falcon	*Falco peregrinus	coastal and mountainous areas	small birds	breeding pop. existent
Limpkin	Aramus guaraua	freshwater marshes	mullusks & crustaceans	decreasing
American Coot	Fulicia americana	estuaries and bays	omnivorous	decreasing
Shorebirds				
American oyster catcher	Haematopus ralliatus	mafine coasts, tidal zones and beaches	oyster	increasing
Piping plover	Charadrius melodus	lake shores and sandy marine beaches	crustaceans & marine animals	decreasing
Wilson's plover	Charadrius wilsonia	beaches, sand bars, mud flats & inlets	small mollusks and shrimp	decreasing
Seabirds				
Great black-beaked gull	Larus marinus	beaches, harbors and garbage dumps	fish	increasing
Ring-billed gull	Larus delawarensis	lakes, seacoasts, and estuaries	insects, rodents, eggs	decreasing
Gull-billed tern	Gelochelidon nilotica	seacoasts and marshes	insectivorous	decreasing
Forster's tern	Sterna forsteri	fresh & saltwater marshes	fish & aquatic organisms	stable
Least tern	Sterna albifrons	mud, sand & gravel beaches of estuaries and oceans	small fish	increasing
Black Skimmer	Rhynchops nigra	ocean coasta, lagoons and barren sands	fish & crustaceans	decreasing

Table E-14 (continued)

Common Name	Scientific Name	Habitat	Primary Food	Population Trend
Belted kingfisher	Megaceryle alcyon	fresh water and salt-water shores	fish	stable
*Dusky seaside sparrow	*Ammospiza nigrescens	salt marshes	insects	decreasing
Open Water Birds				
Common loon	Gavia immer	saltwater-winter, freshwater-summer	fish	stable
*Brown pelican	*Pelecannus occidentalis	inshore saltwater bays, sandy beaches	menhaden	stable
Water Turkey	Anhinga anhing	swamp and slow moving fresh & saltwater	fish & aquatic veg.	decreasing
Wading Birds				
Great blue heron	Ardea herodias	tree tops(nest) feed salt & freshwater	fish	stable
Green heron	Butorides virescens	fresh and saltwater	small fish	decreasing
Little blue heron	Florida caerulea	fresh and salt marshes, meadows	small fish and crustaceans	increasing
Cattle egret	Bubulcus ibis	nest in brachish areas	orthopterous insects	increasing
Wood Stock	Mycteria americana	fresh & brackish water	small fish	decreasing
Glossy ibis	Plegadis falcinellus	marshes - saltwater & fresh	crayfish & insects	increasing
White ibis	Eudocimus albus	brackish & freshwater marshes	crustaceans	stable
Waterfowl				
Wood duck	Aix sponsa	ponds, swamps & rivers	oak, hickory & duckweed	decreasing
Redhead	Myroca americana	freshwater & estuaries	aquatic roots & bulbs	increasing
Canvasback	Aythya valisineria	prairie potholes & freshwater	aquatic vegetation	decreasing
Lesser Scaup	Aythya affinis	saltwater bays and estuaries	plants	decreasing
Red-breasted merganser	Mergus serrator	freshwater-summer & saltwater-winter	fish	decreasing

* Endangered
Source: Roberts, 1974.

and especially on Jekyll Island, Georgia where it is protected. The Chachalaca was introduced to Georgia barrier islands and still exists on Sapelo Island. The Mourning Dove is also intensely hunted in the south. Development probably has benefited this species especially in Florida where large areas have been off limits to hunting. The Rock Dove or "pigeon" is the most urban bird and is found in metropolitan areas.

Cranes, Lumpkins, Rails and Coots

The Florida Sandhill Crane is a subspecies that is found to breed in considerable numbers in Florida and Georgia. The Lumpkin is another species that is known only to breed in the Florida swamps. These populations are presently surviving due to the establishment of refuge areas.

The Clapper Rail is another species that inhabits salt marshes along the southeastern coast. Coastal development has posed a problem for the clapper since it migrates at night and becomes confused by the city and highway lights.

One of the most abundant Florida wintering birds is the American Coot. This species depends on marsh habitat.

Gulls, Terns and Skimmers

Gulls are primarily cold water birds while terns prefer warmer climes. There are five gulls found within the study area, The Laughing, Herring, Black-beaked, Ringbilled and Bonaparte's Gull. The Ringbilled is the most common along the east coast. Fourteen terns have been recorded along the southeast coast but only two were found to nest in great abundance the Least and Gull-billed Terns. The Gull-billed Tern has been found to nest in abundance at Cape Romain, however, as a result of severe storms much of their nesting sites have been destroyed. Foster's Tern are abundant during the winter in Florida and North Carolina. The Black Skimmer is another species that nests along the southeast coast using tern nests for their broods. These species are also decreasing due to the severe storms.

The Belted Kingfisher nests along the east coast on stable banks in which it tunnels a hole for its nest and requires open water for feeding.

Cuckoo's are also represented along the east coast by the Yellow-billed and Black-billed cuckoo which nest in deciduous forests. These are valuable birds because they consume catepillars. Goatsuckers are another group of birds which Chuck's-will-widow is a common species throughout coniferous forest, including maritime forest and salt marshes (Frenduburg and De Poe, 1958).

The Ruby-throated Hummingbird is the only species that breeds along the east coast. The Red-cockaded Woodpecker which is on the endangered list occurs over most of the southeast in pine forests.

(2) Other wildlife

Wildlife species in the southeastern U.S. coastal region are as diversified as the numerous habitat types that occur in this region. Many of these species are ubiquitous, while others are more selective in their habitat preferences, and others still may be endemic to a particular region. Several data sources are available concerning specific vertebrate fauna of the region. Conant (1958) lists 113 species or subspecies of herptofauna that occur in this region; mammals are treated by Burt and Grossenheider (1964), and fifty-one species or subspecies of mammals are recorded as occurring in this region. Parnell and Adams (1970) detailed the upland faunal components of a typical island off the coast of North Carolina. This island appears to be representative of islands existing offshore from the southeastern U.S. states. Neuhauser and Baker (1974) and Hillestad (1974) provide accounts of species representative of habitat types in the southeastern states. The purpose of this section will be to briefly identify some of the more common species which characterize some of the habitat types found in this region. Freshwater fish species are also discussed in this section. Endangered species are discussed in Section II.E.2.c. and approximate habitats are illustrated on Visuals Nos. 5N and 5S.

The Department of the Army (1973a and 1973b) discusses various species typical of the habitat types in North and South Carolina. Much of the following discussion on upland habitats was taken from these sources.

The upland hardwood of the oak-hickory type provide food cover and a good, wide-ranging habitat for wildlife, particularly the gray squirrel, southern flying squirrel, black bear, and white-tailed deer. Mast from oak, hickory, walnut, beech, gum, wildgrape, dogwood, persimmon and other trees and shrubs provide ample food. Hardwood forests also provide tree dens for squirrels and raccoons and trunk dens for big animals, like the black bear. Extremely dense, mature hardwood stands are not particularly well suited to deer populations because the growth of understory vegetation which provides browse is restricted by overstory shading.

In comparison to hardwood forests, mature pine stands furnish a smaller variety and quantity of food, and tree dens are less frequent and adequate. Animals of the coniferous forests are usually more food specific and also more tolerant of the dense cover conditions than those animals associated with hardwood forests.

Characteristic species of this community are dominated by rodents, small carnivores and various reptiles and amphibians. White-tailed deer are common in upland forests, though not as abundant as in the more open forested areas.

Small game animals and fur animals are in general abundance, being represented by marsh rabbits, squirrels, opossums, raccoons, foxes, muskrats, minks and otters. Beaver colonies are established in some river sections. Larger animals include deer and bobcat. Alligators, an endangered species, are an important inhabitant of the riverine ecosystem. Although this narrative focuses on the high density riverine areas, it should be recognized that these animals are found in all wetland habitats.

Considerable fishery data are available from stream surveys for the southeastern U.S. region. For the purpose of this statement, these surveys are considered to be representative transects which adequately depict the fish fauna of this region.

Several reports are available from North Carolina. Smith and Bayless (1964) surveyed and classified the Tar River and its tributaries. The total fish population of this watershed included 20 families and 75 species with the sunfishes (centrarchidae) as the dominant family. Eleven species of game fish were prevalent in this survey. These included the redfin and chain pickerel, largemouth, striped and Roanoke bass, flier, warmouth, redbreast sunfish, pumpkinseed, bluegill and black crappie.

Louder (1962) surveyed the Lumber and Shallotte rivers and found similar results. However, species diversity was less evident with only 46 species being accounted for. Typical non-game fishes observed in this survey included the golden and ironcolor shiner, lake chubsucker, yellow bullhead and the American eel. Ratledge, et al. (1966) also compiled a checklist of fishes for the lotic waters of North Carolina.

Curtis (1970 and 1971) conducted anadromous fish surveys of the Combahee, Santee and Cooper rivers of South Carolina. In the Combahee watershed, sunfishes were dominant representing a total of 15 species out of the total of 67 species recorded. Numerous species of shiners, catfishes and darters were also evident. Species in the Santee River did not deviate significantly from the species recorded in the Combahee. However, several marine species were collected in the Cooper in addition to the freshwater species. An unpublished checklist lists species collected in a Savannah River survey. Sixteen species of minnow and carp and 14 species of sunfish accounted for about 41% of the composition of 72 species.

Dahlberg et al. (1971) summarized data and provided an annotated checklist of the freshwater fishes of Georgia. A total of 209 species and 22 families comprised the freshwater fish fauna that was dominated by 67 species of minnow and carp. In addition, there were 25 species of sunfish and 39 species from the perch families. However, only 38 species are restricted to the coastal plain of Georgia.

An unpublished checklist from the Florida Game and Freshwater Fish Commission lists fish fauna occurring in freshwater sources in the Atlantic coastal plain of Florida. The species listed were comparable to those previously discussed states.

c. Endangered species

Several federally designated endangered species occur, either on a permanent or on a transitional basis, within the geographic area being assessed for this proposed sale. With many of these no definitive range is identified, thus it is difficult to portray the species accurately for environmental assessment purposes.

Table E-15 lists the federally endangered species that occur in this analysis area. In lieu of attempting to depict all of these on Visual Nos. 5N-S, a brief description of the habitat and range of all the species will follow.

Short-nosed sturgeon: This species is confined to the lower sections of larger rivers and in coastal marine habitats primarily from southern New Brunswick to extreme northeastern Florida, however, it rarely occurs south of central South Carolina and its occurrence in Florida is based on a single account from the St. Johns River. However, it has been reported in the Altamaha River,

Table E-15. Endangered Species Occurring in the U.S. South Atlantic Region.

Common Name	Scientific Name
Short-nosed sturgeon	*Acipenser brevirostrum*
Leatherback turtle	*Dermochelys coriacea*
Hawksbill turtle	*Eretmochelys imbricata*
Atlantic ridley	*Lepidochelys kempii*
American alligator	*Alligator mississipiensis*
*Brown pelican	*Pelacanus occidentalis*
*Southern bald eagle	*Haliaeetus levcocephalus*
*Everglades kite	*Rostuhamus sociabilis plumbeus*
Peregrine falcon	*Falco peregrinus*
*Red-cockaded woodpecker	*Dendrocopus borealis*
*Dusky seaside sparrow	*Ammospiza maritima nigrescens*
Bachman's warbler	*Vermivora bachmanii*
Florida panther	*Felis concolor coryi*
Eastern cougar	*Felis concolor cougar*
Humpback whale	*Megaptera novaeangliae*
Right whale	*Eubalaena spp.*
Sei whale	*Balaenoptera borealis*
Sperm Whale	*Physeter catodon*
West Indian manatee	*Trichechus manatus*

*Depicted on Visual 5N-S.

Georgia, as well. Also, shad fishermen have reported catching this species.

Brown pelican: This species breeds and lives on the Atlantic coast from North Carolina to Florida, Visual Nos. 5N-S. This species nests in large colonies on sandy beaches and in trees and shrubs along the southeastern United States. They feed mainly on menhaden and other fish. Since the establishment of refuges and law enforcement and the decreased use of DDT, this species appears now to have a chance to increase its population.

Southern bald eagle: The primary breeding population of eagles for this analysis area is located in Florida and South Carolina (Visual Nos. 5N-S). The other south Atlantic states report transitional eagles. Reduction of the bald eagle in Florida is mainly due to heavy use of pesticides and to development which has destroyed the longleaf pine which are used as nesting sites. The bald eagle is primarily riparian, associated with the coast or with lake and river shores, and feeds on rodents, ducks, coots, rabbits, and fish.

Dusky seaside sparrow: This species is restricted to Brevard County, Florida (Visual No. 5S). Primary habitat is cordgrass (*Spartina bakerii*) marses and wet savannahs on the slightly brackish St. Johns floodplain.

Alligator: The alligator in this geographic area occurs from North Carolina to the southern tip of Florida. It occurs primarily in the fresh water environment (rivers, swamps, bogs, etc.) from the coastal area inland.

Arctic Peregrine falcon: The occurrence of this species in the assessment area results mainly from migrating individuals. However, Florida serves as an important wintering habitat. The primary migration routes are located along the high energy beaches of the south Atlantic states. This species formerly bred south to north Georgia, but although the breeding sites remain along the east coast, the birds do not utilize them. However, it is very likely that breeding the Peregrine falcon will again be established if a population increase can be effected. Sites such as Tallulah, George, among others, still exhibit all the criteria for falcon nesting sites.

Everglade kite: This subspecies of kite occurring in the United States is confined strictly to Florida (Visual No. 5N). Kites require freshwater marshes with a distant horizon and low vegetative profiles. Almost permanent flooding of the marsh is needed to sustain an adequate food supply which is exclusively the freshwater Apple Snail.

Bachman's warbler: The species in this area is known only from recent observations near Charleston and Francis Marion National Forest in South Carolina. However, its habitat of river swamp forests does not preclude it from occurring in other areas within the assessment region.

Red-cockaded woodpecker: The geographic distribution of this woodpecker is primarily coastal plain pinewoods in the southeastern United States. Presently, South Carolina, Georgia and Florida are believed to have the highest populations. This species is associated exclusively with mature to overmature southern pines. Historically, longleaf pine has been the most utilized with loblolly, shortleaf, slash and pond pine used with varying degrees of frequency.

Eastern cougar: There does not appear to be a definite range reported for the cougar in this area of assessment. Several credible observations from the Carolinas indicate that it does occur in this region through the population is probably small and widely dispersed.

Florida panther: The Florida panther is primarily restricted to Florida though recent sightings suggest that the species may occur in parts of Georgia. Large, unmolested habitats that support abundant deer populations favor the panther.

Sea turtles: These species are inclusive of those listed in Table E-15 plus the loggerhead and green sea turtles which are currently proposed for a classification of "threatened" under the U.S. Fish and Wildlife Service criteria. The areas of concern in the analysis area are the high energy beaches occurring along the south Atlantic which the turtles utilize for nesting (Visual Nos. 5N-S).

Humpback whale: This species is considered stable in the study area. During winter they migrate southward to Bermuda, the Bahamas and the West Indies to mate and calve. The primary food source is krill and shoaling fish.

Right whale: The population status of this species is stable to increasing in the southeast Atlantic. The appearance of the right whale is seasonal. These animals migrate northward from January to March moving close to shore, and their southward movement is believed to occur offshore in the fall. The primary food sources is zooplankton—copepods.

Sei whale: The records for southeast Atlantic sightings are too sparse to make a judgement concerning population. However, in other areas this mammal is near the level of a viable population size and therefore potentially on the verge of decline. The migration pattern of the sei whale is southward during colder months and northward during warmer months.

Sperm whale: The population of this species is considered stable. The migrate route is northward during the spring and summer and southward during the fall. Their primary food source is squid.

West Indian manatee: This species is presently on the increase in Florida and its range has extended to South Carolina. These animals congregate in warm waters and they seek open water to travel along well established corridors through the complex of sand bars, oyster reefs, and limestone shelves (Hartman, 1969). The majority of the population now survive in isolated pockets in Florida. Their primary food source is aquatic vegetation.

F. Biological Environments of the Coastal Zone

1. High Energy Beaches

A. INTERTIDAL

High energy beach is the predominant front shoreline type in the South Atlantic planning area and is quartz dominated south to Cape Canaveral where it becomes calcareous in nature. The inventoried ocean shoreline in this reach consists of 1,918 km of which 1,575 km are considered high energy beach (U.S. Army, 1971b). The sand grain sizes are self-organizing in dependence on the energy of the waves. Surging waters are received, filtered and returned to the sea. Characteristic beach fauna participate within the massive sand medium in the process of filtering organic matter. The beach line provides organization to passing water masses and supports many reproductive cycles in which eggs are deposited at the beach. The characteristic longshore current supports many migrations.

This special ecosystem, with its shifting sands and pounding waves, includes a very specialized biota, the sand dwellers or psammon. Some of the sand fauna are found entirely below the water line, some high on the beach, and some at the drift line where organic rubbish accumulates. The epipsammon (shore-birds, fishes, certain beetles, etc.) live on the sand surface; the endopsammon (snails, bivalves, crustacea, etc.) burrow beneath the surface; and the mesopsammon (diatoms, ciliates, tardigrades, turbellarians, gastrotrichs, gnathostomulids, copepods, etc.) live between the sand grains. The beach with its sand fauna forms an extensive food filtering system which takes nutrients from the inrushing water in the form of detritus, possibly dissolved materials, and planktonic or larger organisms.

Some of the macrofauna of Southeastern U.S. sand beaches are shown in Figure F-1. Interstitial fauna are shown in Figures F-2 and F-3. Special locomotory, respiratory and morphological adaptations permit the psammon to inhabit a shifting environment that may be alternately flooded and exposed to desiccation, where oxygen tension may be low, and where waves beat ceaselessly.

Especially characteristic of high energy beaches in the South Atlantic area are the pelecypod, *Donax variabilis*, and the mole crab, (*Emerita talpoida*). Both are adapted for rapid burrowing in the loose sands at the tide line. They have been shown to migrate up and down the beach in response to wave action (Pearse et al., 1942; Turner and Belding, 1957). Both species are filter-feeders. Several species with permanent burrows also occur in the lower intertidal or subtidal area, including several crustaceans (*Callianassa major* and *Lepidopa websteri* and polychaetes (especially *Scolelepis squamata*). These forms are also filter-feeders. Numerically dominant are various haustoriid amphipods which are interstitial filter-feeding species. In the upper portion of the intertidal zone, amphipods of the genus *Talorchestia* (beach hoppers) are frequently dominant, feeding on organic detritus (algal and grass fragments) cast up by the waves (Reid and McMahan, 1974).

Carnivores are typically more mobile and include marine animals that follow the rising tide (silversides, killifish, flounders, lizard fish, crabs and creeping starfish) and terrestrial predators that feed on the exposed beach at low tide (Pearse et al., 1942).

Among those birds which feed on mollusks, crustaceans, and other invertebrates at low tide are the American oyster-catcher, semipalmated plover, pipping plover, Wilson's plover, black-bellied plover, ruddy turnstone, willet, American knot, least sandpiper, semipalmated sandpiper, western sandpiper, and sanderling. Several species feed below and in the intertidal zone on small fish. These include common terns, least terns, royal terns and black skimmers. Herring gulls, ring-billed gulls, black vultures, and fish crows are common scavengers of the beach and dune areas. Formerly, the bald eagle was a commonly observed scavenger along the beach (Johnson et al., 1974).

In the spring and early summer, horseshoe crabs (*Limulus polyphemus*) appear on the beaches in large numbers to breed and lay their eggs. Late in the summer tiny crabs may be seen on the beach sand at low tide. The breeding and reproductive stage of the life cycle is the only time horseshoe crabs come ashore. Both the young and adult crabs normally feed in the bottom habitat of shallow waters. Some of the largest individuals of the species have been reported from the Georgia coast (Shuster, 1955 and Johnson et al., 1974).

B. UPPER BEACH AND DUNES

The area of the beach above the high-tide mark is inhabited or frequented primarily by organisms

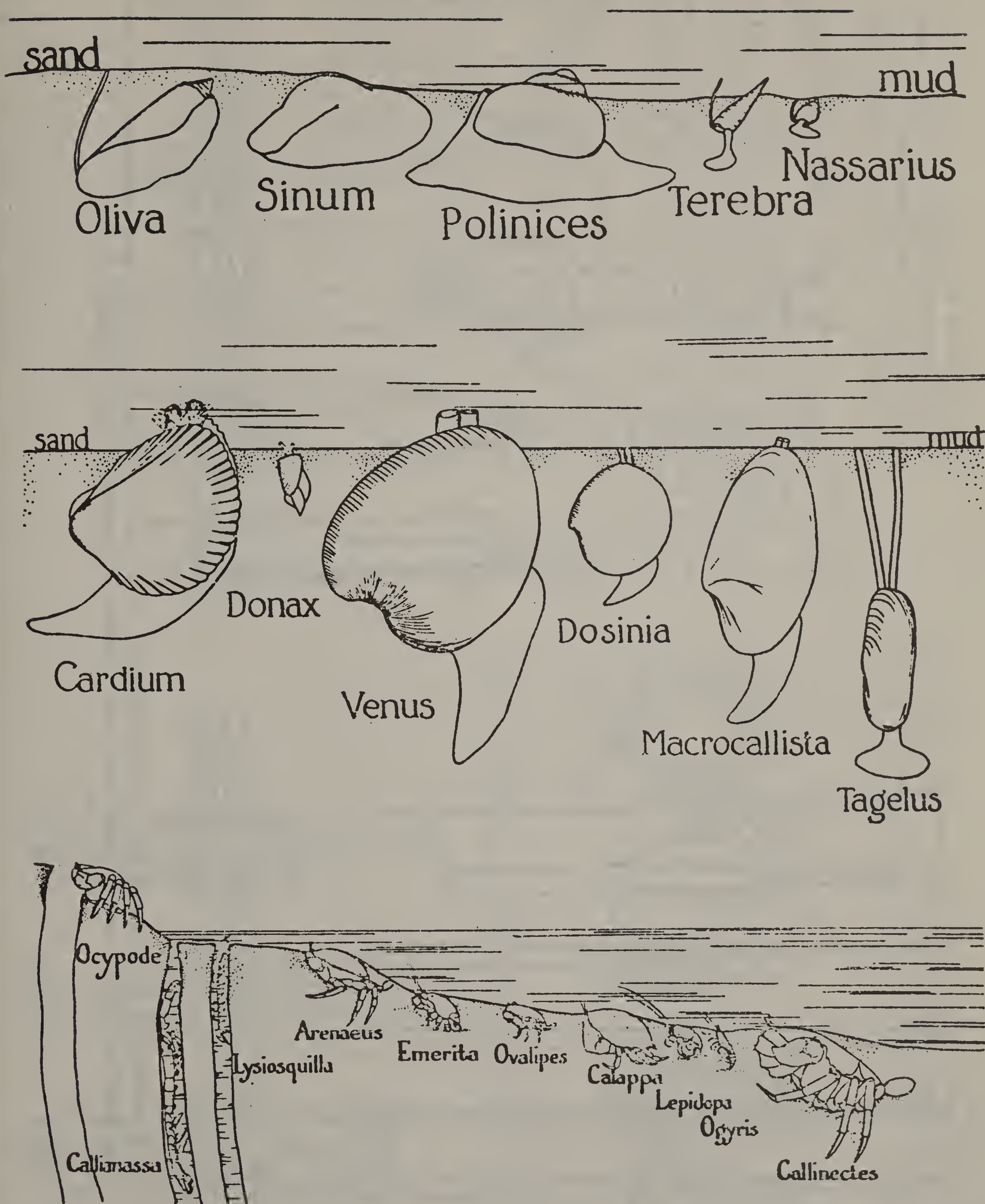
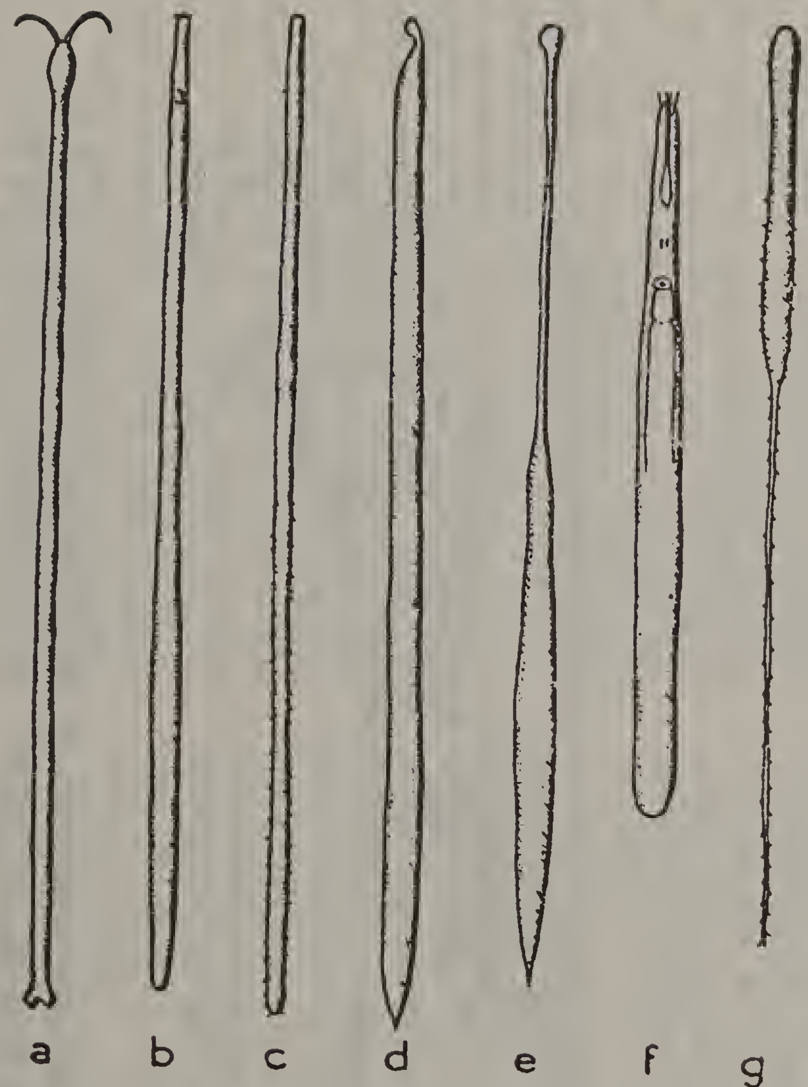
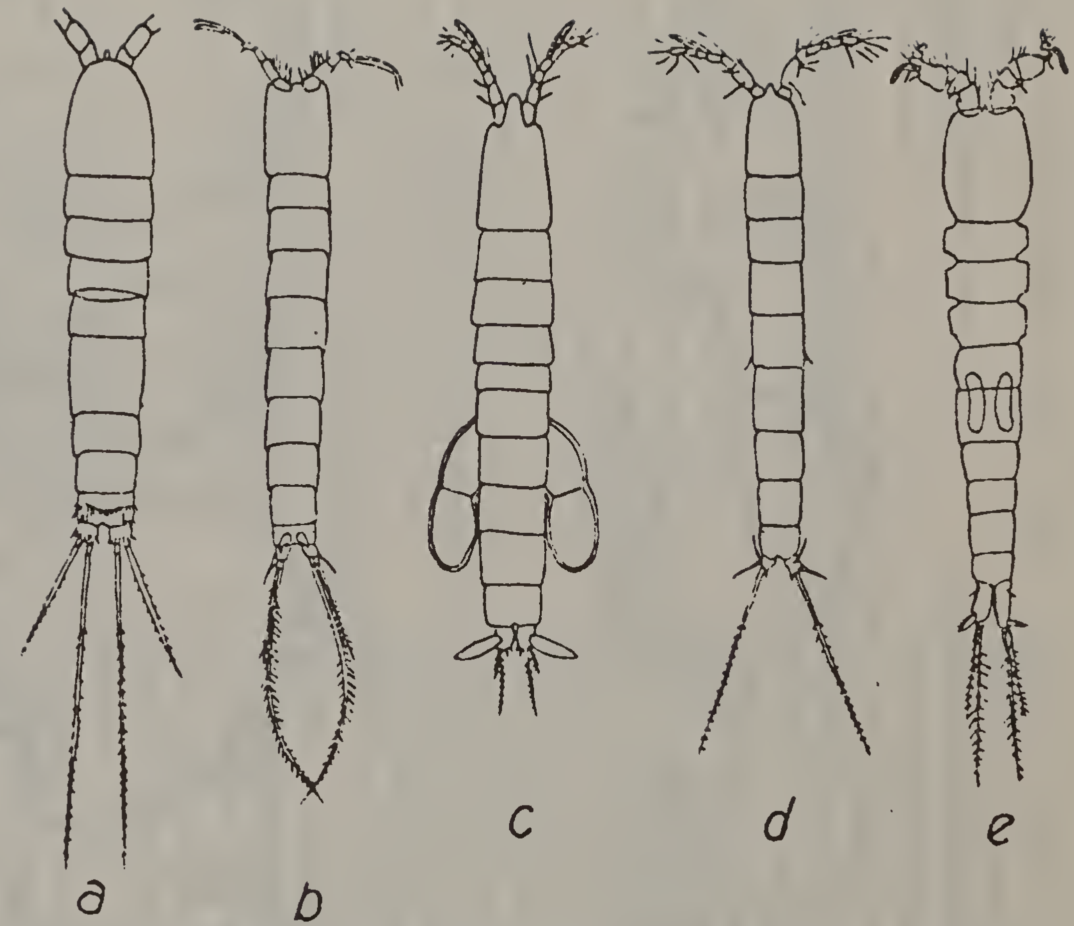


FIGURE F-1 Macrofauna (endopsammon) of sand beaches at Beaufort, N.C. Burrowing snails, bivalves and crustacea. (From Pearse, Humm and Wharton, 1942)

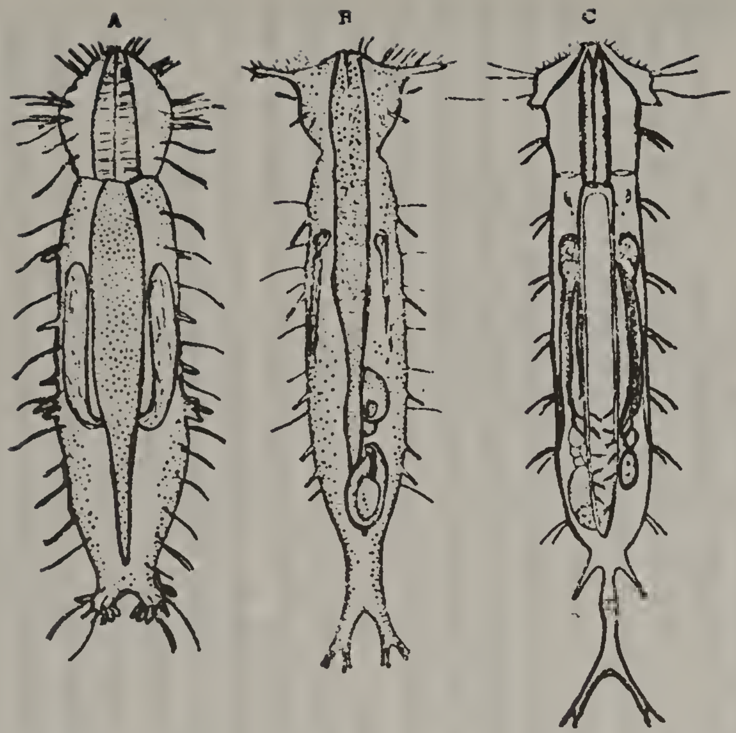


– Convergence chez divers groupes interstitiels. — *a*, *Protodrilus chaetifer* (Archiannélide). — *b*, *Coelogynopora* sp. (Turbellarié). — *c*, *Michaelsena* (Oligochète). — *d*, Cilié. — *e*, *Trachelocerca* (Cilié). — *f*, *Proschizorhynchus oculatus* (Turbellarié Rhabdocoele). — *g*, *Urodasys mirabilis* (Gastrotriche) (d'après REMANE, 1953).

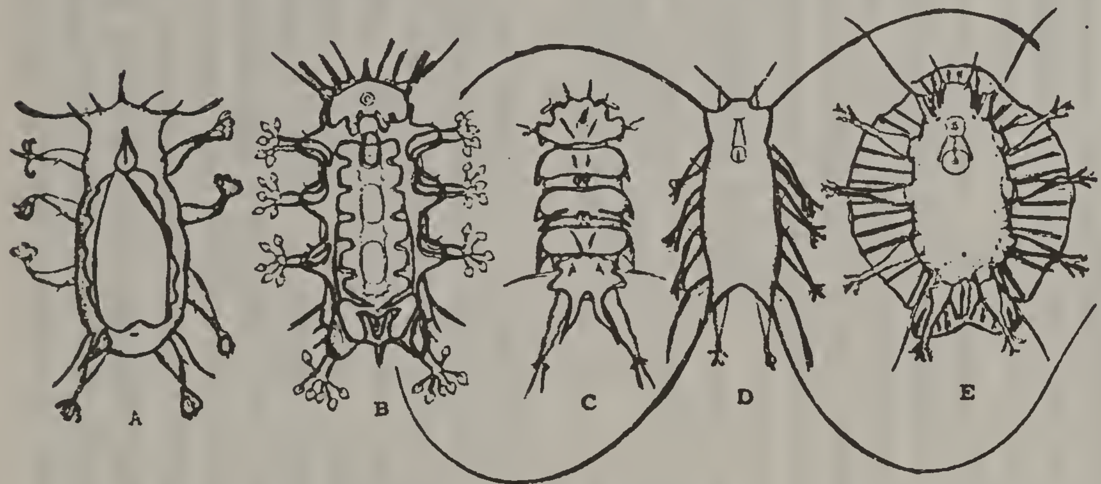


– *Copépodes psammiques marins* (d'après WILSON). — *a*, *Nitocra chelifer*, femelle, vue dorsale. — b, *Arenosetelia spinicauda*, mâle. — c, *Goffinella stylifer*, montrant les ovicacs appliqués et les œufs de grande taille. — d, *Paraleptastacus brevicaudatus*, femelle. — e, *Emertonia gracilis*, mâle.

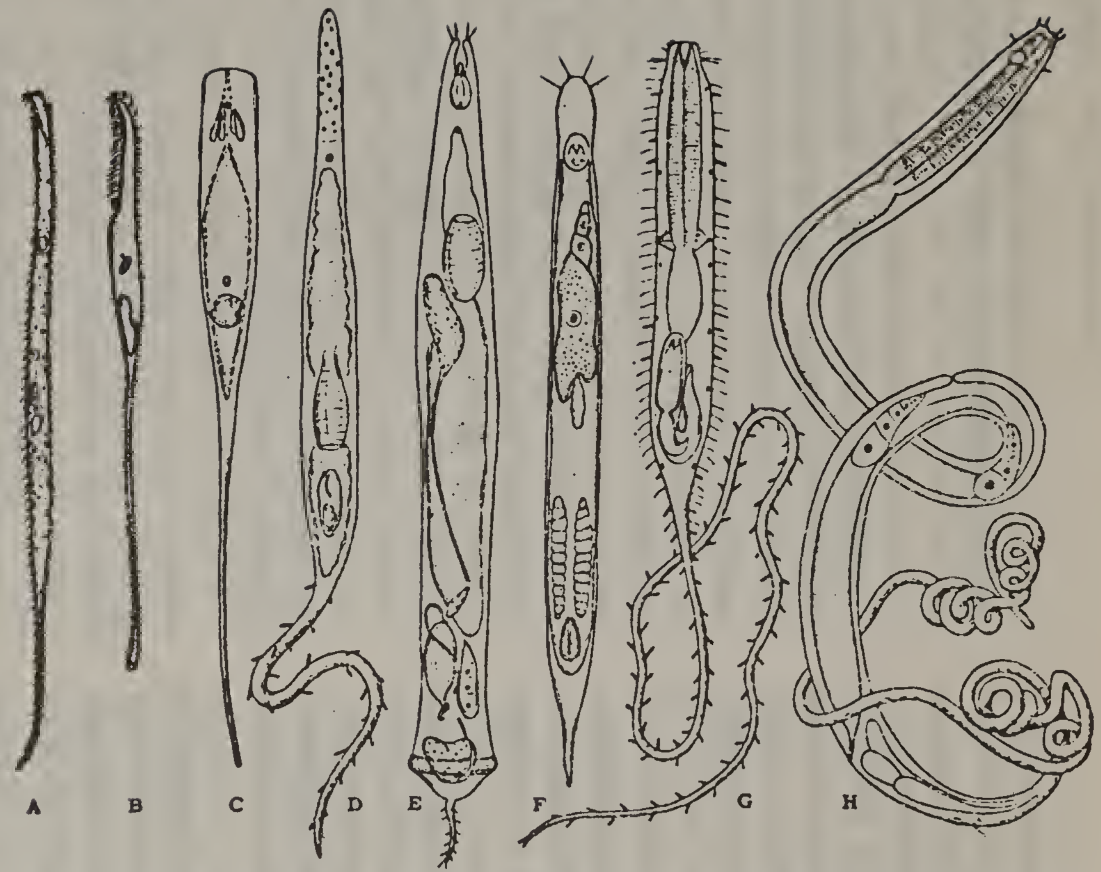
FIGURE F-2 Mesopsammon (archiannelids, turbellarians, oligochaetes, gastrotrichs, and copepods), minute organisms which live between the sand grains on beaches (From Delamare 1960)



Gastrotrichen der Ordnung Macrodasyoidea. Differenzierung eines Gabelschwanzes in der Familie Dactylopodaliidae. A) *Dactylopodalia baltica* Remane, B) *Dactylopodalia cornuta* Swedmark, C) *Dendrodasys gracilis* Wilke (aus Ax 1963).



Mesopsammale Tardigraden der Ordnung Arthrotardigrada. A) *Halechiniscus subterraneus* Renaud-Debyser, B) *Batillipes mirus* Richters, C) *Stygarctus bradypus* Schulz, D) *Tanarctus tauricus* Renaud-Debyser, E) *Actinarctus doryphorus* Schulz (nach Renaud-Debyser, 1949b, Marcus 1936, Schulz 1951, Grell 1937).



Differenzierung eines Schwanzfadens in der interstitiellen Sandfauna. A) *Remanella caudata* Dragesco (Ciliata), B) *Spirostomum filum* (Ehrbg.) Pénard (Ciliata), C) *Mecynostomum filiferum* Ax (Turbellaria Acoela), D) *Boreocelis urodasyoides* Ax (Turbellaria Proseriata), E) *Cheliplanilla caudata* Meixner (Turbellaria Kalyptorhynchia), F) *Gnathostomula paradoxa* Ax (Gnathostomulida), G) *Urodasys viviparus* Wilke (Gastrotricha Macrodasyoidea), H) *Trefusia longicauda* (de Man) (Nematodes). — (nach verschiedenen Autoren aus Ax 1963).

FIGURE F-3 Mesopsammon or interstitial sand fauna (Gastrotrichs, tardigrades, ciliates, turbellarians, gnathostomulids, nematodes) (From Ax 1966) with terrestrial affinities, but some marine types inhabit or use the area.

Most conspicuous among the invertebrates of this zone is the ghost crab or sand crab (*Ocypode quadrata*). Although of marine origin, the adult ghost crab lives in burrows along the upper beach and well back into the dunes. Primarily nocturnal, the ghost crab forages as a scavenger and predator (Johnson, et al., 1974).

The upper beach also serves as a nesting area for certain species. Loggerhead turtles, with ancient evolutionary ties to the terrestrial environment, instinctively return to the beach to lay eggs (Visual No. 5).

Several species of birds nest on the upper beaches. These include the royal tern, least tern, American oyster-catcher, Wilson's plover, and willet (Johnson et al., 1974). The nesting rookeries of these and other species are depicted on Visual No. 5.

Except for the loggerhead turtle and the ghost crab, animals using the dunes are terrestrial. Data on food habits of animals from dune areas are lacking, but it is evident that many species forage in the dunes.

Sea oats, in addition to their important role in dune formation and stabilization, also form an integral part of the food web involving important animals characteristic of the habitat. Tippins and Beshear (1968) reported scale insects (*Duplasionaspis*) infesting sea oats, and Circulapis and Odonapis seriously affecting other dune grasses (*Spartina* and *Panicum*). Wagner (1964) reported 15 species of beetles and three species of sucking bugs associated with sea oats panicles during flowering. *Collops nigriceps* and *Isomira* sp. were especially common. He examined the stomach contents of seven individuals of each of these species and found that all contained pollen grains of sea oats.

Both the old field mouse and the cotton mouse occur on some, but not all of the Georgia islands. On Cumberland Island, cotton mice commonly forage in the dunes. On the mainland, the cotton mouse is usually found in relatively moist habitats, and the old field mouse is more common in drier habitats (Golley, 1962). Few data exist on the food habits of either species on the islands.

The marsh rabbit is a common animal frequenting the dune area. Droppings are frequently observed in the sheltered area behind the dunes. Exact food habits of marsh rabbits are not known, but cut stems on Sapelo and Blackbeard islands indicated that they were feeding on sea oats.

Songbirds, especially song sparrows and other fringillids, and red-winged blackbirds are the major consumers of the sea oats seeds. Sea beach panic grass, which produces a panicle of large seed, is no doubt a very important source of food for seed-eating birds and mammals. Beach hogwort and beach primrose probably also contribute to the diet of these birds (Johnson, et al., 1974).

Trees and shrubs that grow in the lee of the rear dunes produce large quantities of fruit and seed that are heavily utilized by a variety of animals including such larger, important species as wild turkeys, raccoons, deer, and hogs. Notable among these plants are live oak, wax myrtle, saw palmetto, yaupon, and dahoon (*Ilex cassine*) (Johnson, et al., 1974).

Feral hogs visit the dunes to forage on beach pennywort. Cattle graze on sea oats and other grasses and forbs on the dunes. (Johnson et al., 1974).

2. Sea Grasses

Considerable data have been written concerning sea grass ecosystems. Phillips (1974) provides a good summary on the distribution and ecology of eelgrass (*Zostera* spp.) in the temperate regions and Roberts (1974) described the sea grasses of the South Atlantic region.

The dominant submerged grass in high salinity areas in the South Atlantic coastal region is eelgrass (*Zostera marina*) a northern species. It forms extensive beds in Pamlico, Core and Bogue sounds of North Carolina during the spring and summer months (Dillon, 1966, 1971). The southern limit of *Zostera* is given as Beaufort, N.C. by den Hartog (1970) but probably extends south of Bogue Sound where it was reported by Dillon (1966, 1971). It is reputedly absent from South Carolina and Georgia. Distribution maps are not reproduced here because the limits of these beds are not clearly defined and vary through time.

During the winter months, *Zostera* is replaced by *Halodule beaudettei* (Dillon, 1966, 1971). *Halodule* is a southern species which occurs discontinuously from North Carolina to the Caribbean and Gulf of Mexico. Roberts (1974) reports that it does not occur in South Carolina and Georgia probably because of the water turbidity and tidal amplitude of the area.

In North Carolina, *Halodule* becomes dominant after the decline of *Zostera* in September. Active growth begins in May, before *Zostera* reaches its peak. *Halodule* reaches maximum biomass (105-200 g/m^2) in October to December, although it is present throughout the year. A significant portion of this biomass peak is due to the epiphyte, *Ectocarpus* sp., rather than *Halodule* itself (Dillon, 1971).

Turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*) are common sea grasses on the south Florida coast, but are not reported from the northeastern Florida coast. *Thalassia* is reported to reach its northern limit at Cape Canaveral; Syringodium apparently does not reach Cape Canaveral (Moore, 1963).

Throughout the region, widgeon grass (*Ruppia marina*) is found in low salinity waters. Several freshwater species tolerant of brackish water, such as *Potamogeton* spp., are often associated with it.

In the southern portion of its range, Halodule is subordinate to *Thalassia*, *Syringodium* and other sea grasses, achieving dominance only when these genera are absent or in a period of decline.

Sea grasses form an important habitat for many faunal and floral species. Allee (1923a, 1923b) reported 138 faunal species associated with eelgrass beds in Woods Hole, Mass. Stauffer (1937) organized the microhabitats of these animals into four categories: those growing on the plants; those swimming among the plants; those living on the mud surface; and burrowing forms.

In category one, most animals existed as epiphytes or clung to the leaves. These included anemones, encrusting bryozoa, hydroids, isopods, protozoa (ciliates and flagellates) and small crabs.

In category two, numerous species of fish and crustaceans such as the amphipods, copepods and cladocerans occur.

A great number of organisms lived on the mud surface in and near the eelgrass system. These included the entire list of detritus feeders, i.e., crabs, many different molluscs, worms, some fish, small and larger commercial shrimps, amphipods, rotifers, myriads of nematodes, sea cucumbers, brittle-stars, starfish, sea urchins, and occasionally sea-pends. Many flatfish live on the substrate surface in eelgrass. The bay scallop (*Argopecten irradians*) and the soft clam (*Mya arenaria*) are two commercially important species that utilize the grass beds for setting of the larvae.

Among the burrowing forms in category four, representative species include worms, some molluscs, brittle stars and some crustaceans such as the blue mud shrimp or mud pawn (*Upogebia*).

Sizable literature exists pertaining to the use of eelgrass by waterfowl in North America and Europe. Cottam (1934) established that eelgrass constituted 80% of the winter food of the sea brant goose and was an important food to several other species. McRoy (1966) estimated that Black brant and Canada geese consumed about 17% of the standing stock of eelgrass in Iżembek Bay, Ak., during the summer and autumn feeding period. Winter waterfowl surveys by the U.S. Department of the Interior (1973 and 1974) indicate significant concentrations of waterfowl utilizing the sounds of North Carolina and thus probably depend on the seagrasses to some extent.

Phillips (1974) believes that the eelgrass system is one of the richest in terms of variety and abundance of life in the sea. Eelgrass plays several roles: as a substrate for organisms which could not otherwise live on a soft substrate; it is used as food for a small number of animals; products resulting from eelgrass breakdown support a large diversified community of animals; and the physical presence of the plant on an unconsolidated muddy bottom provides protection and cover for organisms requiring quiet or silt-free water. Thus, the association with eelgrass is direct and indirect. It appears that a very large number of animal forms have adapted in interrelated ways to the various types of microhabits that an eelgrass system presents.

3. Mesohaline Systems

Odum et al. (1974) have described the mesohaline system and the following is taken from their publication.

The image most people see when one says "estuary" is the medium salinity, moderate depth bay which has much fishing but not much visible evidence of anything else. The bay draws support from food webs of invisible microscopic plankton supporting the characteristic populations of crabs, fish and commercial shrimp. Many of our largest estuaries are predominantly of this type although they are often fringed and bordered by smaller subsystems of other types. High nutrient levels and good stirring mechanisms generally produce high photosynthetic rates wherever clarity of water is maintained although the rates are less than those found in systems like the marshes which have less water to absorb light.

In winter, with low light and well stirred waters due to tidal shifting and some turbidity from rivers, the plant cells spend too much time in the shade and stop making much food. In the spring as light conditions increase, the critical condition at which the plant cells can make a net gain is reached and there is a sudden bloom of some of the diatoms that sets off the seasonal production sequence. During the winter there is organic particulate food remaining from the previous season, from marshes, from rivers, and other storages that allows some of the animal life to persist. With the rising burst of plankton growth there are some releases of larvae from clams, oysters and barnacles, and little water-flea-sized copepods develop. *Acartia* predominates this system throughout the east coast. Reproductions and migrations of shrimp and fishes that eat the zooplankton are timed to coincide with the increased yields of these small components so that the rise in stocks and consumption takes the rising production, most of which is entirely invisible to the man in the boat above unless he measures the phytoplankton, some index of its activity such as oxygen production, pulls a zooplankton net, or has some way to estimate the rising stocks of fishes and shrimp. The middle salinity estuary has species with some ability in their kidney systems to deal with salinity fluctuation, some ability to switch food intake from organic matter to phytoplankton base, and an effective temporal program for migration and reproduction so as to hook the need for more food to the timing of appearance of more food.

Whereas the bottom clams and the special subsystems of the bay margins are contributors, the main system is one of plankton and plankton eaters. As the sunlight begins to decline after July, the population growth and reproduction declines and soon many populations migrate out again decreasing their load on the system.

Because the source of energy of this system is from microscopic phytoplankton, from invisible organic contributions from the rivers that support bacteria as intermediates, and from energetic services of tidal currents, rarely do persons not trained in marine science understand the basis for this system and its management. The food web is out of sight and thus out of mind.

The medium salinity estuaries often have partial stratification with wedges of dense salt water underneath. In systems allocated to this type, mixing is adequate to prevent anaerobic conditions from developing at the bottom even though oxygen is less there since respiration is higher at the bottom of the estuary than at the surface. Estuaries tend to be deeper as one goes north, but also the amount of tidal energy available for currents and mixing and eddy diffusion coefficients increase.

Mesohaline systems which occur within the area under consideration include the Cumberland River, St. Catherines Sound and Ossabaw Sound in Georgia; Port Royal Sound, St. Helena Sound and Winyah Bay in South Carolina; Cape Fear River, New River and the Pamlico Sound complex in North Carolina.

Bellis (1974) has summarized the geographical variation in southeastern U.S. estuaries as follows:

> The markedly different oceanic biotas north and south of Cape Hatteras are not reflected in coastal systems behind the barrier islands. Shape and depth constitute the primary difference between Chesapeake Bay and the North Carolina Sounds. Shallow depth and dampened tidal effects promote good mixing. Water masses tend to be relatively turbid and move about in broad gentle swirls rather than as part of a current. Patterns of water movement depend in large measure on wind direction and velocity. In reality, the sounds are shallow basins into which the estuaries empty. Lower levels of the food web in these sounds have been incompletely studied. In general, production is accomplished by diatoms and dinoflagellates. This energy moves up to the nekton level via copepods. Dominant nekton are of the characteristic "southern" types (e.g. bluefish, striped bass, flounder, mullet, and shad). Bluecrab (*Callinectes*) and menhaden (*Brevoortia*) are abundant and of considerable economic importance.

North Carolina's sounds constitute the largest estuarine system along the Atlantic coast. Most of this vast system is of the medium salinity, (5-18 ppt), plankton-based type and as such functions as a nursery or a temporary home for migrating nekton of commercial importance. Shrimp, striped bass, and menhaden do most of their "growing" during periods spent in the sounds or near shore coastal waters where they become the beneficiaries of a high level of phytoplankton production.

In estuarine systems such as this, efficiency of energy transfer between plant and animal is greater than in most land environments. This is so because the producer components of the food web are primarily diatoms. Diatoms convert some of their carbon intake to energy-rich (high calorie) fats and oils while most green plants store carbon as less rich carbohydrates.

South of Cape Fear, rivers such as the Pee Dee in South Carolina and the Savannah in Georgia empty into the sea via low marshland. Extension barrier islands, of the type responsible for formation of the North Carolina sounds, are absent or much reduced in importance. Consequently, estuaries along this portion of the Atlantic Coast have been described as a ''muddy river mouth'' type. Here the ''middle-salinity-plankton-based'' system consists of tidal channels through the salt marsh, major portions of the Charleston and Georgetown harbors, and a 16 to 19 km wide strip of ''estuarine'' water which remains trapped between higher salinity ocean water and the beach. Sport fisheries, dependent at least in part on the middle estuary plankton, are similar to those of the North Carolina sounds. Commercial fisheries involve primarily oysters and blue crabs, both of which are directly dependent upon the plankton during one or more stages of their life cycle. Shrimp become of increasing commercial importance southward along the Georgia coast.

One general characteristic of plankton organisms of the middle estuary is that, while they may be volumetrically abundant, they tend to be limited with respect to species variety (Riley 1967).

In terms of actual numbers, as well as number of species, the great majority of estuarine plankton organisms belong to just four major groups. Calanoid copepods are the largest in size and adults may be just visible without magnification. Photosynthetic dinoflagellates and elongate diatoms are next in order of size and usually require magnification to be seen. Various algae, frequently flagellates, comprise the smallest members of the plankton (nanoplankton) which in many situations form a very significant fraction of the photosynthetic biomass.

Diatoms and dinoflagellates are of comparable size and are usually collected and studied together. Essentially, these organisms constitute the ''net phytoplankton''. Riley (1967) reported a total phytoplankton flora of 150 species for Long Island Sound. Weighting for consistency and relative dominance, he suggested that perhaps 13 species could be considered ''native'. to the estuary. Of these 13 species, nine were diatoms and four were dinoflagellates. Phytoplankton community structure is similar to that of the zooplankton in that a single species, the diatom *Skeletonema costatum*, is characteristically dominant. Concentrations of this diatom reaching 35 x 10^6 cells per liter were observed by Riley and Conover (1967) in Long Island Sound. The fact that the percentage composition of *S. costatum* is similar in several estuaries (Narragansett Bay, 81.2%, Smayda (1957); Block Island Sound, 83.5%, Riley (1952); and James River, 83% Marshall (1967)) suggests that a ''characteristic'' estuarine phytoplankton structure is a real entity.

The diatom flora of the middle estuary is diverse and varies seasonally as well as geographically. Even so, *Skeletonema costatum* is frequently overwhelmingly dominant and important associate species, while variable, represent relatively few genera. Many estuarine diatoms may be strays which achieve success only on rare occasions. By considering only species that were well enough suited to the environment to be significant in normal patterns of seasonal periodicity, Riley (1967) reduced the important diatoms of Long Island Sound to six genera including nine species: *Skeletonema costatum*, *Thalassionema nitzschioides*, *Paralia* (*Melosira*) *sulcata*, *Schroderella delicatula*, *Thalassiosira decipiens T. gravida*, *T. nordenskioldii*, *Rhizosolena sertigera*, and *R. delicatula*.

Various dinoflagellates, though seldom as numerically important as the diatoms, are characteristic components of the net plankton. In St. Andrew Bay, Fla., diatoms clearly dominated the phytoplankton (Hopkins, 1966). Although little quantitative data were given concerning non-diatom groups, armored dinoflagellates were sparse. Ceratium spp. occurred rarely and silicoflagellates, mainly *Dichtoyoca*, were sparse.

Perhaps typical of the taxonomic analysis of estuarine phytoplankton is the distribution given by Marshall (1967) of 74 phytoplankters identified from Willoughby Bay and Hampton Roads, Va., 52 were diatoms, 19 were pyrrophytes (dinoflagellates), one chlorophyte, one euglenophyte, one cyanophyte, and two crytophytes. *Skeletonema costatum*, *Asterionella japonica* and *Nitzschia pungens* var. *atlantica*, were abundant in colder weather while phytoflagellates were present throughout the year but reached peak abundance during the warmer months. A generally similar taxonomic distribution was reported by Kawamura (1966). Of 104 phytoplankton species in Sandy Hook Bay, New Jersey, 60% were diatoms, 22% were dinoflagellates, and 2% cyanophytes.

Yentsch and Ryther (1959) suggested that the micro-flagellate population might comprise a significant proportion of the bulk of organic production in marine plankton systems. The basis for this suggestion came from their comparative studies of whole water samples and net samples in which it was shown that many small diatoms (*Nitzschia*, *Thalassiosira*, the "summer" form of *Skeletonema costatum*) and several other species exhibited only about 10% retention in a standard No. 25 mesh phytoplankton net. Many nanoflagellates (*Carteria*, *Dunaliella* and *Gymnodinium*) exhibited only 2% retention. Patten et al. (1963) got two very different pictures of the annual phytoplankton cycle in the lower Chesapeake Bay depending upon whether net concentrated water samples or whole water samples were used in the taxonomic analyses. In terms of dominance and fidelity, it may well be that certain nanoplankton such as *Chilomonas* spp. (Patten et al. 1963; Marshall 1967; Fournier, 1966) or *Nannochloris* and *Stichococcus* (Patten 1962, Ryther 1954) are at least as indicative of a distinctive estuarine plankton community structure as are *Acartia* and *Skeletonema*.

If there is a system-wide pattern of estuarine phytoplankton periodicity, it would seem to consist of repeating seasonal variations in the relative abundance of its three principal components: diatoms, dinoflagellates and nanoplankton (often nanoflagellates). In general, diatoms dominate the winter flora, but share or yield dominance to dinoflagellates during the summer. Nanoflagellates are usually present throughout the year, but may exhibit spring or fall blooms (Marshal, 1967).

Patten (1963) has pointed out that seasonal alterations in the structure of a phytoplankton community may occur as a result of: (1) differential reproduction and selective elimination of component species, and (2) water mass transfer and consequent dispersal or concentration. The resultant diversity changes, usually cyclic over many years, give in a single year, the appearance of ecological succession. The significance of diversity can be illustrated by conclusions drawn by Patten (1962) with respect to his study of species diversity in Raritan Bay. Higher diversity levels prevailed in the lower estuary, signifying higher biotope quality (greater variety in ecological niches) toward lower bay.

The calanoid copepod *Acartia tonsa* appears to be the most persistent and abundant zooplankter in the middle estuary. *Acartia tonsa* occurs from the Gulf of St. Lawrence to the Gulf of Mexico (Riley, 1967) and is perhaps the most characteristic biotic component of the middle estuary plankton.

Other important zooplankters associated with Acartia dominance are variable. Cronin et al. (1962) reported that in Delaware Bay *Eurytemora hirundoides*, *E. affinis*, *Pseudodiaptomus coronatus*, and *Neomysis americana*, together with *Acartia tonsa* were resident species which made the estuarine zooplankton in the mesohaline region distinctly different from the ocean or the river. *Oithona* spp. were among the more important zooplankton in St. Andrew Bay (Hopkins, 1966) or were among the principal grazers in Narragansett Bay (Martin, 1965) in portions of these estuaries dominated by *Acartia*.

Relatively few fish lead an entirely estuarine existence. Killifish (*Fundulus majalis*) appears to be the most abundant truly estuarine species in the Chesapeake region (McHugh, 1967). Other plankton-feeding herring-like fish move into the middle estuary only during a part of the year. The striped anchovy (*Anchoa hepsetus*) is abundant in Chesapeake Bay in the summer during which time its eggs are a common constituent of the plankton. Anchovies leave the bay during winter, and their position in the food web is occupied by the spotted hake (*Urophycis regius*). A similar seasonal pattern in hake (*Urophycis floridanus*) abundance has been reported from the Gulf Coast by Gunter (1945).

A variety of fish, several of considerable commercial value, use the middle estuary as a spawning ground or nursery. The hogchoker (*Trinectes maculatus*), bay anchovy (*Anchoa mitchilli*) and silver perch (*Bairdiella chrysura*) are important inshore fish which spawn in Chesapeake Bay (McHugh, 1967). Other fish, spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogon undulatus*), and Atlantic menhaden (*Brevoortia tyrannus*) spawn offshore during colder months. Upon hatching, the young move rapidly into the estuary where they exhibit little growth until the return of warmer weather. Rapid growth occurs in summer as the young fish gradually move down the estuary and into more saline water.

The great majority of numerically or commercially important estuarine fish thus appear to be only summer residents of the middle estuary. Most explanations of fish migration involve correlations with seasonal ''climate'' patterns such as temperature, day length, breeding behavior, etc. However, the relationship of migration patterns to quantity and quality of food sources may be an equally important aspect of estuarine dynamics.

Plankton organisms form the dominant biomass of the middle estuary and thus constitute the base of its food web. Photosynthetic production by the phytoplankton serves as a direct source of biotrophic energy inflow. Invisible diatoms and phytoflagellates are the primary food of just visible copepods which in turn are eaten by relatively small herring-like fish. Figure F-4 represents the sort of complex web that can develop when food chains are integrated at the genus level.

A less obvious, but under some conditions equally significant, energy input is derived from import into the system of dissolved and particulate organic matter. At least in some estuaries, estimates of production capacity based on phytoplankton studies may be conservative because of failure to consider the availability of organic energy sources.

Moving water constitutes a force capable of doing work. Currents and the water masses which comprise them carry suspended organic and inorganic substances. Dissolved substances may become colloidal particles as they progress along a density-alkalinity gradient. This suspended load is important as a potential source of nutrients, in providing both a substrate and surface area for bacterial and fungal growth, as a direct source of food for filter feeders, and because its density affects water turbidity and thus the capacity for photosynthetic conversion of light energy.

Suspended organic matter may arise from: (1) detritus derived from normal biotic components of the water column, (2) import from upstream or the edge, (3) resuspension from the bottom resulting from upwellings and eddys or, (4) formation and aggregation of colloidal particles. Quantitative information concerning the relative importance of the various sources is lacking although the magnitude of non-living particulate material, relative to the phytoplankton concentration, is such that it constitutes a resource of potentially major significance in the trophic economy of inshore waters (Patten et al., 1966).

Moving water masses interact with the bottom in such a way that sediments are frequently picked up and redeposited elsewhere. Interaction between these sediments and their medium during transport results in mineral and nutrient exchanges. Large pieces of organic matter settle to the bottom and there become reduced to a smaller, more soluble, or colloidal state. Resuspension of this material would result in dispersal and increased surface contact with water. Since the organic components settle more slowly than the inorganics, water movement has performed work in bringing about a sorting process and the water phase becomes richer in dissolved and particulate organics. This change in chemical status may be further complicated in some environment or at certain seasons by the transfer of materials from a reducing environment on the bottom to an oxidizing one above.

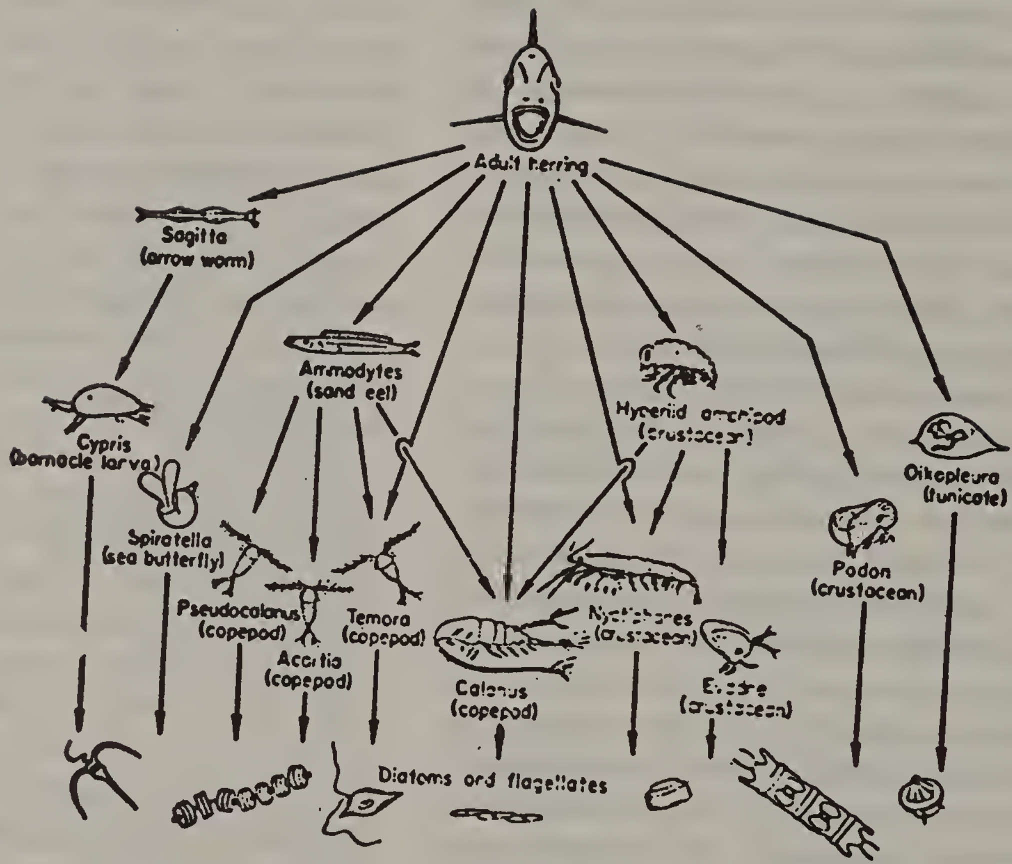
4. Oligohaline Systems

Copeland et al. (1974) have described the oligohaline system and much of the following is taken directly from their publication.

The distinctive system existing at the river mouth-estuarine area of most temperate estuaries is unique in many ways. The unidirectional flow of the river changes to the slowly mixing circulation of a wide shallow body of water, representing a change in energy from flow to circulation. The water is characteristically turbid and contains large amounts of silt materials coming in from the river. The bottoms are dominated by grass and filtering clams (*Rangia cuneata* in the southern temperate zone and *Mya arenaria* in the northern temperate zone, with some overlap in the intermediate zones).

The species diversity of the flooding system is relatively low. Because these rivers flow strongly at times, there are sudden fluctuations in salinity. It is this sudden change in salinity which eliminates many species. Those species that survive apparently possess adaptive abilities to divert part of their energies to salinity and turbidity adaptations.

Nutrients and organic detritus transported into the system are dependent on the source and



The feeding relationships of adult herring. (Based on HARDY, 1924 and 1959; courtesy of Collins.)

Fig. F-4 Food chains of herring-like fishes. This example is from Europe and involves some feeding outside of the middle salinity zones (ODUM AND COPELAND, 1974).

volume of flood waters via the contributing streams. After extensive flooding, for example, the river water is relatively poor in nutrients and organic matter.

These systems manage to consume and produce at high levels in spite of the heavy import-export flux, light-absorbing turbidity and salinity shocks. According to Odum (1967) populations of *Rangia* may exceed $12/ft^2$ in some areas. With a large filtering rate, imported organics are captured, minerals are released from the imports and waters are cleared by aiding flocculation, all of which provide a regenerative feedback of minerals to the phytoplankton.

Systems of this type which occur within the planning area include the mouths of: St. Lucie Canal, Indian and St. John's rivers in Florida; Satilla, Altamaha, Canoochia and the Savannah rivers in Georgia; Broad, Combahee, Edisto, Cooper and Pee Dee rivers in South Carolina; Cape Fear, New, White Oak, Neuse, Pamlico, Champan and North Landing rivers in North Carolina.

Probably the best understood of these is the Pamlico River estuary, the major part of which constitutes a typical oligohaline system in which salinity is normally less than 10 ppt.

The estuary is characterized by low salinity, high turbidity and shallow water. Some of the important energy transfers have been deduced and are shown in simplified diagram in Figure F-5. The more abundant and characteristic organisms in the system are named rather than using a broad general classification. For example, dinoflagellates and *Acartia tonsa* dominate the phytoplankton and zooplankton, respectively.

Because the estuary is shallow and the deeper waters are frequently low in dissolved oxygen during the summer, most of the benthis invertebrate species occupy the sandy, nearshore sediments. These shallow waters of low salinity have dense stands of *Ruppia* with attached periphytic algae and associated animals, particularly rotifers, polychaetes, nematodes, gammarid amphipods and grass shrimp (*Paleomonetes* sp.). Of the two dominant species, *Macoma balthica* appears ubiquitous, whereas *Rangia cuneata* is restricted to the oligohaline portion of the estuary. In a recent study, Tenore et al. (1968) demonstrated that *Rangia* receive a major part of their nutrition from organic matter in the substrate, which may be a function of input from the river.

The estuary is protected by Pamlico Sound and the outer banks so that the diurnal tidal amplitude averages less than 20 cm. The flushing rate is correspondingly low and entrained particles tend to remain in the estuary for long periods of time. Salinity is low in the spring and increases to maximum values in the fall or winter. Changes in salinity seasonally seem to be associated with variation in fresh water runoff as suggested by Roelofs and Bumpus (1953). Williams and Deubler (1968) indicated that this general salinity cycle is characteristic of North Carolina estuaries. The plankton based system of Pamlico Sound replaces most of the oligohaline system of Pamlico River during the fall and winter months. However, during the more productive time of the year, the system is essentially oligohaline, particularly in the shallow water where most of the species exist. Typically, a zone of reduced dissolved oxygen develops in the bottom one meter of the water column during periods of the summer. This zone is brought about by a combination of thermohaline vertical stratification, a high surface turbidity and reduced wind stress. If these conditions persist for a period of time, dissolved oxygen concentration falls, often below 1 mg/l. This characteristic of Pamlico River may be responsible for the virtual absence of macro-benthic invertebrates from the deeper water sediments (Tenore et al. 1968). *Macoma balthica* does occur, but may suffer severe mortalities in years when dissolved oxygen concentrations drop to particularly low values or persist for relatively long periods of time.

The euphotic zone is generally restricted to the upper two meters of the water column. This feature, coupled with the shallow nature of the estuary, may be responsible for the relative scarcity of diatoms in the phytoplankton. The phytoplankton is dominated by motile dinoflagellates which would seem to have an advantage over the heavier diatoms in their ability to remain in the surface euphotic zone. *In situ* phytoplankton C^{14} assimilation experiments during 1967 yielded average values which compare favorable with data collected by Williams (1966) for a nearby, but more saline environment, in North Carolina. However, there was no apparent seasonal cycle, and average values fluctuated considerably from one sampling period to the next, although there was better agreement among stations at any one time. Peak assimilation values in

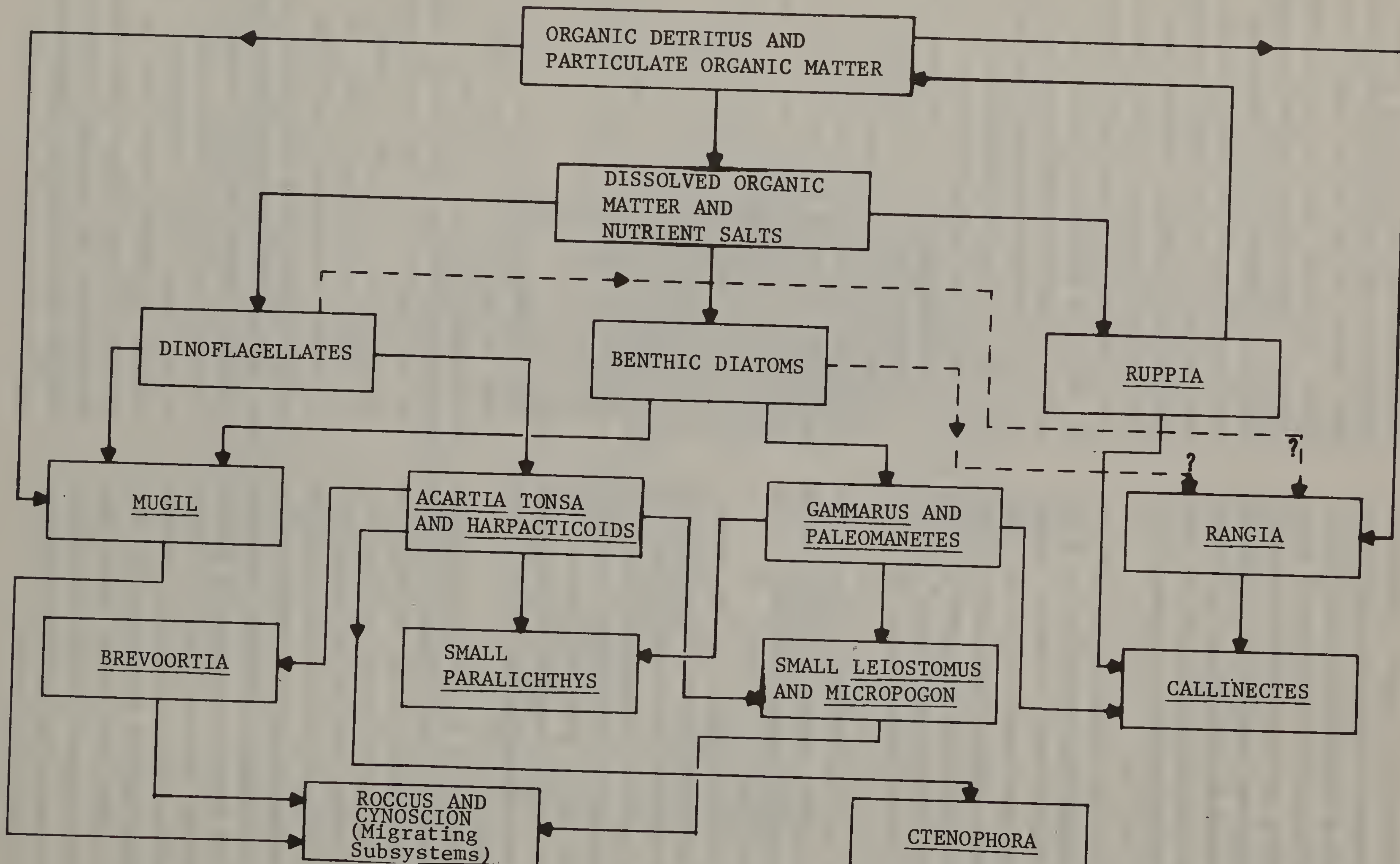


Figure F-5 Simplified diagrammatic representation of major food web components in the Oligohaline System, Pamlico River Estuary, N.C. (Odum and Copeland, 1974).

excess of 200 mg C/m²/day were estimated for dates in November, January, February and June. Perhaps stormy weather, including wind mixing and accompanied by nutrient-rich rainwater (Reimold and Daiber, 1967), creates conditions allowing brief bursts of phytoplankton activity. The standing crop of phytoplankton did not reflect the fluctuations in C^{14} assimilation. Biomass estimates by direct count and cell size calculations averaged less than 7 mg/l except during the period between mid-January and mid-March when peak concentrations averaged greater than 30 mg/l. This early spring bloom was attributed to a single species of dinoflagellate, *Peridinium triquetrum* and was studied intensively by Miller and Hobbie during the 1967-68 flowering. They suggest that the dinoflagellate bloom, which is atypical in Atlantic coast estuaries where diatoms are usually dominant during the spring flowering, is related to low salinity, high metabolite concentrations, low nutrients, shallow water or the shallow euphotic zone of the estuary. Peters (1968) showed that the seasonal cycle of particulate carbon in Pamlico River followed the same trend as did chlorophyll *a* concentrations. This may indicate a rapid turnover of both phytoplankton and oxidizable organic matter.

In the shallow inshore waters less than two meters in depth, dense stands of rooted macrophytes are present. *Ruppia maritima* dominates this community in the typically oligohaline portions of the estuary where salinity ranges between 3 to 10 ppt, but *Potamogeton* sp. is also common. The blades of both species accumulate a rich epiphytic and animal biota during the growing season.

Peters (1968) studied the distribution of zooplankton in the Pamlico estuary. He found *Acartia tonsa* to be the most abundant copepod species present as did Herman et al. (1968) in a similar oligohaline environment. Harpacticoid copepods were very common in his samples at night, but were in extremely variable numbers; they were virtually absent from samples taken during daylight hours. In one instance the average concentration (samples were taken vertically at one meter intervals) was over 18,000 individuals/m³ or about twice the maximum holoplanktonic concentration observed. He found that some of the variability could be explained by wind speed. Harpacticoid abundance in the water column was positively associated with surface wind velocity. Peters suggests that the harpacticoid copepods are positively rheotactic and respond to the wind induced turbulence, although light appears to be the main factor for the entrance and exit from the plankton community.

Ctenophores are also abundant and dominate the plankton at times. There is an apparent seasonal bimodal cycle of abundance of ctenophores with peaks during the spring and fall. In a study of ctenophore feeding rates in the Patuxent River estuary, Bishop (1967) estimated that approximately 31% of the standing crop of *Acartia tonsa* was cropped by the ctenophores each day. Although ctenophores are apparently efficient and important carnivores, the fate of this consumed energy is unknown. Herman et al. (1968) cite two fishes, *Peprilus alepidotus* (harvestfish) and *Poronotus tricanthus* (butterfish) which feed on adult ctenophores, but neither species is abundant in Pamlico River.

Keup and Bayless (1964) described the fish fauna in a similar estuary (Neuse River) in North Carolina. They collected fish by rotenone from 18 stations with a salinity range from 0 to 12 ppt, although only six of their stations were more saline than 4 ppt. They found 42 primarily freshwater species and 20 salt-water or brackish-water forms. They did find a broad overlap of fresh and salt-water fish distributions with respect to salinity, however. This supports the view that there is no sharp demarcation between oligohaline and mesohaline estuarine systems and that freshwater fish can and frequently do enter water with a salinity of 10 ppt or greater (approaching isosmotic conditions) and salt-water fish are commonly found in very low salinity water during the summer. In the Pamlico River, fish were sampled by otter trawl at several stations at monthly intervals during the spring, summer and winter of 1965. Samples taken in water of salinity between 3 and 10 ppt were composed substantially of salt-water species although the method of sampling was probably responsible for the virtual absence of freshwater species in the collections. Twenty species in addition to the salt and brackish-water forms mentioned by Keup and Bayless (1964) were collected. Most of these were species which only stray into the estuaries during the summer months.

Copeland et al. (1974) reported that the dominant fish inhabiting the major oligohaline portion of Pamlico River are primarily salt-water species. The permanent and semi-permanent species are given in Table F-1.

Table F-1. Permanent and semi-permanent salt-water species inhabiting the oligohaline system (5-10 ppt) of Pamlico River, N. C. (Copeland et al. 1974)

Common Name	Scientific Name
Permanent Residents	
Common mummichog	*Fundulus heteroclitus*
Rainwater killifish	*Lucania parva*
Naked goby	*Gobiosoma bosci*
White perch	*Roccus americanus*
Striped anchovy	*Anchoa hepcetus*
American eel	*Anguilla rostrata*
Hogchoker	*Trinectes maculatus*
Present Year-round Except During Winter	
Tidewater silverside	*Menidia beryllina*
Rough silverside	*Membras vagrans*
Common silverside	*Menidia menidia*
Spot	*Leiostomus xanthurus*
Atlantic croaker	*Micropogon undulatus*
Pinfish	*Lagodon rhombides*
Atlantic menhaden	*Brevoortia tyrannus*
Summer flounder	*Paralichthys dentatus*
Northern pipefish	*Sygnathus fuscus*
Migrating through September	
Hickory shad	*Alosa mediocris*
Alewife	*Alosa pseudoharengus*
Glut herring	*Alosa aestivalis*
American shad	*Alosa sapidissima*
Gizzard shad	*Dorosoma cepedianum*
Stripe bass	*Roccus saxatilis*
Common sturgeon	*Acipenser oxyrhynchus*

The overwhelming characteristic of the oligohaline systems is the low salinity and great shocks of freshwater floods. Organisms capable of surviving the rigors of the system are few, but those that do, manage to flourish during certain seasons of the year. Important adaptations include attachment to avoid being swept away during high flow rates and the ability to withstand salinity variations.

Plants in the oligohaline regime include such freshwater forms as *Najas* and *Potamogeton* and the brackish water plant *Ruppia maritima*. Benthic diatoms are common on the oligohaline mud flats and dinoflagellates dominate the phytoplankton.

Fauna include certain molluscan species that have special filtering ability to utilize the tremendous organic content of the muddy river water. *Macoma balthica*, for example, seems to be a common inhabitant of southern oligohaline zones, but is normally replaced by other clams in more northern areas. *Nereis succinea*, a polychaeta, is common in the zoobenthos of all oligohaline systems within the study area.

Migrating subsystems are important constituents of the oligohaline system and channel much of the energy harvested by man. Common among these migrating forms are the herring-like plankton-feeding fishes represented by shad (*Alosa sapidissiums*) and menhaden (*Brevoortia tyrannus*) on the Atlantic coast. Other migrating forms include the carnivorous striped bass (*Roccus saxatillis*).

In spite of the low diversity and biomass of organisms in the oligohaline systems, they are relatively highly productive due to the constant influx of organic matter via rivers from the land.

5. Mangroves

The mangrove ecosystem occurs sparsely along the U.S. southeast coast. Shaw and Fredine (1971) indicate a northern extremity in Florida of approximately 10,117 hectares (25,000 acres) in the Cape Canaveral area. The remaining mangrove in this region is restricted to the southern extremity of Florida as depicted in Figure F-6 (Tabb, 1963).

Humm (1973) has summarized available literature on the mangrove ecosystem of Florida. Three species of mangrove trees, red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*) dominate the mangrove communities; buttonwood (*Conocarpus erecta*), although not a true mangrove, is important in the transition zone between the swamp and upland vegetation.

The different species of mangrove trees sometimes grow in randomly mixed associations, but usually different species dominate certain bands or zones which are clearly delimited from the others. This characteristic zonation pattern results from differences in rooting and growth of seedlings and from various competitive advantages which each species has in the several gradients present from below the low water to above the high water lines. Red mangrove seedlings sprout in marl soil below the low tide level; these form the most seaward band. This species may be easily recognized by its arching prop roots and by the long slender seeds which germinate before dropping from the tree. The prop roots are the most important attachment surfaces for sessile organisms in the intertidal region. The mature red mangrove is found inland, on slightly higher intertidal peat soil; the prop roots of these trees are inundated by almost every high tide. The zone inland is composed of black mangrove trees which grow on flat areas flooded by the higher tides. Black mangrove has characteristic pneumatophores. Large numbers of these slender appendages grow up from the main roots until they emerge from the mud. Still further inland, buttonwood swamps and blackrush (*Juncus roemerianus*) marshes form the transition band between the mangroves and either the tropical forest trees or the sawgrass (*Mariscus jamaicensis*), plants that are unable to survive significant amounts of salt. White mangrove is found in all zones but is usually not the dominant species; it is often most abundant near the brackish marshes between the black mangrove and buttonwood swamps.

The mangrove trees are the dominant producers in the swamps, but algae are also important, especially because their production may be much more quickly consumed by the mangrove fauna than the woody materials produced by the trees. In Florida, open shoal areas below mean low water are often covered by tropical species such as *Caulerpa*, *Acetabularia*, *Penicillus*, *Gracilaria*, *Halimeda*, *Sargassum*, and *Batophora* (Davis, 1940 and Taylor, 1954). Above this region, on the intertidal muds, one may find a thick growth of *Vaucheria* or *Cladophoropsis* (Taylor, 1954). There is also a subterranean algal flora composed of unicellular and filamentous blue-green and green

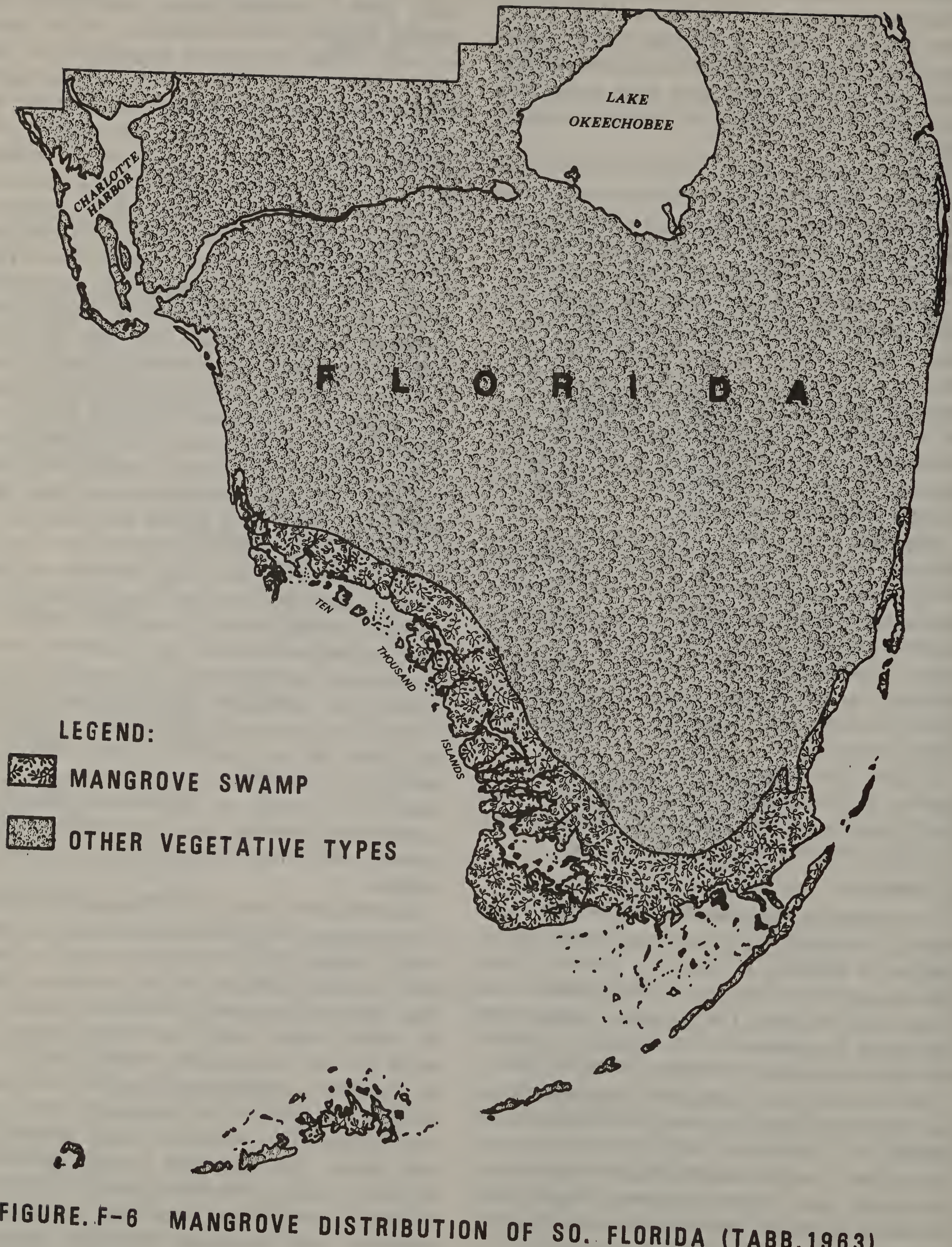


FIGURE. F-6 MANGROVE DISTRIBUTION OF SO. FLORIDA (TABB, 1963).

algae (Marath, 1965). Many species of animals are found in mangrove swamps, in sharp contrast to the low diversity of plant species. The most important benthic marine animals are probably crustaceans and mollusks and most of these can be classified as either deposit or filter feeders. Fiddler crabs (Uca spp.) are frequently dominant in terms of biomass (Golley et al., 1962). The crabs on intertidal flats of mangrove islands in Florida bay include *Uca pugilator*, *U. speciosa*, *U. thayeri* and *Eurytium limosum*; other species, *Aratus pisonii*, *Sesarma curacaoense*, and *S. reticulatum* are abundant in mangroves above high water (Tabb et al., 1962). Barnacles such as *Balanus eburneus* attach to roots and stems where they can filter their food from the water at high tide. Coon oysters (*Ostrea frons*), also important filter feeders, are abundant on mangrove roots in Florida and the weight of their shells may eventually cause the root to break off. The dead shells and undigested food of these barnacles and oysters contribute to the sediments of the swamp. Several kinds of snails (*Cerithium*, *Melogena*, *Cypraea*, and *Littorina angulifera*) feed on material deposited on the roots or on the mud surface (Davis, 1940 and Tabb et al., 1962). Some vertebrates of the Florida swamps include turtles, crocodiles, alligators, bears, wildcats, puma and rats (Davis, 1940). Birds are discussed below. Other important consumers in Florida swamps are amphipods, isopods, the crab *Rhithropanopeus harrissii*, and fishes, especially *Cyprinodon variegatus*, *Mollinesia latipinna* and *Floridichtys carpio*.

Birds are abundant, conspicuous, and probably important in mangrove swamps. Approximately half of the species utilize the swamps for nesting activities and the others feed there or congregate there in large communal roosts. The food resources of the birds are varied. Many (egrets, herons, ibis, ducks, kingfishers, crab hawks, stilts, and pelicans) feed on estuarine fishes and invertebrates, and others (fly-catchers, woodpeckers, wrens, and blackbirds) feed on seeds outside the swamps but return for roosting or nesting. The mangroves and their fruits, however, do not directly supply nutriment to birds, and their food supply, like that of the other animals, comes predominantly from marine life in the channels or on the mud flats. The dense nesting colonies in some areas may physically harm the trees, but the excreta is probably of some benefit.

Florida mangrove swamps also serve as nursery grounds for many animal species of economic importance—menhaden, black mullet, spotted sea trout, snook, tarpon, red drum, mangrove snapper, pompano, and pink shrimp. Edible oysters growing on the bottoms of shallow bays or on the mangrove prop roots are also harvested in some areas.

6. Salt Marsh

Salt marshes are typically intertidal beds of rooted vegetation extending from somewhat above the low tide level to supratidal levels inundated only by extreme tides on low energy beaches. They occur along the margins of estuaries, gradually intergrading into freshwater marshes at upstream locations.

The salt marshes of the U.S. southeastern states have been the subject of considerable study, and in general represent the best development of salt marshes in the United States. Spinner (1969) has summarized the acreage of the salt marshes of the coast from North Carolina to Florida (Table F-2). Visual Nos. 4N-4S indicates salt marsh distribution for this region.

A voluminous amount of data is available on the floral components of the salt marshes of this area. Representative studies include those of Reed (1947), Bourdeau and Adams (1956), Adams (1963) and Cooper and Waits (1973). Cooper (1974) provided a detailed account of the typical species composition of salt marshes from which much of the following information is taken.

Behind the outer banks of the southeastern states, fringing the inner shores of the brackish sounds, irregularly flooded marshes occur. Here tidal amplitudes are very limited and often there are rather great changes in salinity of the ground and flooding water. In these marshes, the tidal amplitudes are usually less than a 0.3m (1 ft.) and higher tides are wind-driven and are associated with storms and rapid changes of wind direction and velocity. In these marshes smooth cordgrass (*Spartina alterniflora*) seldom occurs in extensive stands and is generally found fringing the edge of rather straight tidal creeks.

There are two major community types in these marshes (Waits, 1967). Black needlerush occurs in vast, pure stands lying at an elevation just above the mean high water level. There are almost 40,469 ha (100,000 acres) of this type of marsh in the counties fringing Pamlico Sound, North

Table F-2 Coastal Salt Marshes of the Southeastern States

	North Carolina	South Carolina	Georgia	Florida
Juncus roemerianus	100,450 ac (40,651 ha)	91,000 ac (36,826 ha)	74,850 ac (30,291 ha)	76,500 ac (30,959 ha)
Spartina alterniflora	58,400 ac (23,634 ha)	345,000 ac (139,617 ha)	285,650 ac (115,599 ha)	41,200 ac (16,673 ha)
Est. destroyed (1954-1968)	14,700 ac (5,949 ha)	2,000 ac (809 ha)	2,700 ac (1,093 ha)	25,500 ac (10,320 ha)

Source: Spinner, 1969.

Carolina, and the vast majority of this is *Juncus roemerianus* marsh. Few other species occur in this marsh type. On slightly higher ground, along the edge of creeks or at the heads of creeks where sand may accumulate, *Baccharis halimifolia*, *Borrichia frutescens*, and *Spartina cynosuroides* may occur. The other community type is dominated by *Spartina patens*, and resembles the salt meadows of New England marshes. Here, *Spartina patens* forms extensive stands overlying several inches of raw, brownish peat. *Distichlis spicata*, *Scirpus robustus* and *Pluchea purpurascens* are scattered throughout, but these rarely become dominant. Locally, wet openings and ponds occur in these meadows. These form favorite feeding sites for over-wintering waterfowl and, during the summer, for wading and shore birds.

Variations in habitat factors in these marshes are less clearly associated with community types than in some other salt marshes (Waits, 1967). Although there is little apparent difference in elevation, the species maintain the same general spatial relationships found in the low marsh. *Spartina alterniflora* is confined to the intertidal creek banks with *Juncus roemerianus* occurring slightly higher just above mean high water. *Spartina patens*, in general, is slightly higher than *Juncus roemerianus*. The ponds, occurring in the *Spartina patens* zone, are often lower than the surrounding vegetation which permits water to accumulate. Usually the standing water is fresh to brackish. Occasionally, salt water may penetrate into a pond. When penetration occurs, stands of *Spartina alterniflora* and *Salicornia* sp. develop, with much initial establishment of *Spartina alterniflora* from seed. The consequent vegetation is greatly different from that of the brackish ponds. The substratum appears to be a uniform, unsorted sand and the elevational differences in the surface communities reflect elevational differences in the original surface of the sand. With the exception of the salt ponds, where salinities often greatly exceed sea strength, the highest salinities are in the *Juncus roemerianus* zone. Salinity is considerably less in the *Spartina patens* areas. Standing water is present in the *Juncus roemerianus* areas only as a result of wind-driven tides. Drainage is otherwise good. In *Spartina patens*, on the other hand, rainwater may accumulate at any time, but particularly in late fall-winter and in mid-summer. This zone often becomes completely dry in early summer or autumn.

From Cape Lookout, N. C., south to the Jacksonville, Fla. area, the optimum development of salt marsh in the United States is found (Linton, 1968). These marshes, often called low marshes, form behind narrow barrier islands in areas influenced by heavy silt deposition from large rivers. There is a relatively small amount of open water behind the barrier islands. Tidal amplitudes are variable, ranging from 0.6-1.5 m (2-5 ft.) in North Carolina and northern Florida, to as much as 2.4 m (8 ft.) in Georgia and South Carolina. Although marshes throughout this entire region are similar, those from Cape Lookout to Myrtle Beach, S. C., are somewhat less extensive and well-developed than those from Myrtle Beach to Jacksonville. This latter area includes the famous Sea Islands of South Carolina and Georgia.

The characteristic feature of these marshes is the vast expanse of smooth cordgrass (*Spartina alterniflora*) which covers the soft, grey sediments between mean sea level and approximately mean high water. These broad, nearly level expanses of grass and soft sediment develop under the influence of high tidal amplitudes, dendritic creeks and deep tidal channels in vast number, giving the marshes a characteristic dissection pattern when viewed from the air. The slow, gentle subsidence of these South Atlantic marshes also contributes to formation of these intricate creek patterns.

Several distinct community types may be recognized within the South Atlantic salt marshes (Reed, 1947; Kurz and Wagner, 1957; Teal, 1962; Adams, 1963). Although these are reasonably well-defined and characterized by a clear combination of physiographic and biotic features, they actually grade into one another so that the marsh is in reality a series of communities which change gradually from the tidal creeks to higher ground.

Few data are available on the general proportions of the different communities in a given area of marsh. At Sapelo Island, Georgia (Teal, 1962), 20% of the marsh was creek-bank and tall *Spartina alterniflora*, 35% medium *Spartina* and 45% short *Spartina* and *Salicornia*. In Brunswick County, N. C., 6% of the area was tall *Spartina alterniflora*, 11% medium, and 47% short. *Juncus roemerianus* occupied 9% of the area and creeks 27%. No estimate of creek banks was made. Despite the differences in methods and communities recognized, these data do demonstrate that any given large area of marsh is almost half short

Spartina alterniflora and that the creek bank and tall *Spartina alterniflora* zone is less than 20% of the total area. Further, they suggest that farther northward the proportion of short *Spartina alterniflora* increases relative to the other *Spartina* community types.

Despite the complexity of zonation patterns in salt marshes, they are real and definable in specific cases. The overwhelming dominance of one or a few species within zones simplifies the problem of measuring net productivity (Roberts, 1974). Basically two kinds of information are necessary to calculate productivity: the real extent of each marsh zone, and an estimate of the net production of the dominant species/unit area for each marsh zone.

Complementing the data available on salt marsh zonation, several authors reported on the net productivity of the marsh ecosystem. Net productivity, expressed as kcal/m²/yr, can be derived from the g/m²/yr form if the caloric content of the grass is known. Stroud and Cooper (1968) reported the caloric content (gcal/g) for selected salt marsh plants in North Carolina (Table F-3).

Roberts (1974) summarized estimates of productivity for various marsh grasses in Table F-4. Where necessary, values were converted from the original units to kcal/m²/yr to facilitate comparison. Table F-5 shows the total marsh net productivity as a function of location (latitude). The values for productivity are underestimates in that root production is ignored. Since it is the above-ground portion of the plants which enters the food web (at least predominantly), this is not a serious criticism.

Schelske and Odum (1961) estimated that in salt marshes adjacent to Sapelo Island, Georgia, the marsh grass productivity represented 66-75% of the total productivity of the estuary. Phytoplankton contribute little or nothing in this ecosystem on an annual basis, although they may be a significant source of energy during certain seasons Teal (1962) estimated that 55% of net production is utilized within the marsh, the remaining 45% being exported to the open water portion of the estuary.

A considerable amount of data on salt marsh faunal species has been documented by several authors. However, data summarized by Lynch (1968), Sprunt (1968), Cooper (1974) and Johnson et al. (1974) provide a good overview of the salt marsh faunal components.

Although the common larger animals of these marshes are well known, the distribution and populations of lesser animals, particularly invertebrates, are poorly understood. The most thorough study is that of Teal (1962) which summarizes work done by a number of investigators on Sapelo Island, Georgia. Davis and Gray (1966) give data for insect populations in marshes in the vicinity of Beaufort, North Carolina. The salt marsh grasshopper (*Orchelimum fidicinium*) and the salt marsh plant hopper (*Prokelisia marginata*) are the two major herbivores. *Orchelimum* consumes smooth cordgrass tissues and *Prokelisia* sucks cordgrass juices. These and other less numerous insects support spiders, wrens and sparrows. Relatively speaking, a low proportion of the total energy flow of the marsh moves through the grazing, herbivore-based food chain. A much larger group of organisms lives at or near the mud surface feeding on organic detritus, formed by bacterial decomposition of *Spartina alterniflora*, and on algae. *Spartina alterniflora* stems are broken down by bacteria. These reduce the total amount of organic matter present but increase its food value (de la Cruz, 1965). The most conspicuous algae-detritus feeders are fiddler crabs (genera *Uca* and *Sesarma*), horse mussels (*Modiolus demissus*), and the salt marsh periwinkle (*Littorina irrorata*), in addition to a variety of annelid worms, oligochaetes and insect larvae. These, in turn, may be eaten by mud crabs (*Eurytium limosum*), clapper rails (*Rallus longirostris*) and raccoons (*Procyon lotor*). These relationships are evident in smooth cordgrass-dominated areas. Little is known of the animal populations and feeding relationships in the *Juncus roemerianus* marsh except that insect populations are much more meager than in *Spartina alterniflora* areas (Davis and Gray, 1966).

In addition to the animals of the marsh proper, a great variety of immature and mature fish and shellfish are found in the tidal creeks and shallow waters associated with the marsh. Mature oysters (*Crassostrea virginica*), clams (*Mercenaria mercenaria*), blue crabs, larval and mature shrimp of several species, and the juvenile and mature forms of many fish such as flounder, bluefish, menhaden, croaker and tarpon are commonly found in the creeks. De la Cruz (1965) showed that a number of these species, plus other estuarine fish such as *Fundulus* spp. *Gambusia affinis*, *Mugil* spp., had particulate detritus of salt marsh origin in their guts.

Table F-3 Caloric Content (gcal/g)for Selected Salt Marsh Plants

	Spartina alterniflora Low	Spartina alterniflora Medium	Spartina alterniflora High	Juncus roemerianus	Scripus robustus	Spartina patens	Distichlis spicata
Aug.	4127.0	3931.8	4017.7	4590.7	-----	-----	------
	4057.4	4006.2	4196.1	4411.2	-----	-----	------
June	3843.4	3944.0	4048.1	4352.2	-----	-----	------
	3809.4	3942.0	3977.1	4432.4	-----	-----	------
Sept.	4128.7	4184.0	4764.0	4340.5	-----	-----	------
	4054.9	4080.9	4674.0	4397.4	-----	-----	------
March	3760.0	3809.4	3616.4	4354.4	-----	-----	------
	3805.0	3620.2	3787.3	4297.3	-----	-----	------
$\overline{X}$	3947.5	3939.8	4135.1	4397.1	-----	-----	------
May	------	------	------	4252	3991	4574	4467
	------	------	------	4578	3931	4516	4464
early	------	------	------	4569	4343	4621	4506
June	------	------	------	4561	4306	4527	4474
late	------	------	------	4533	4250	4583	4511
June	------	------	------	4509	4287	4495	4458
July	------	------	------	4571	4488	4576	4460
	------	------	------	4637	4394	4604	4621
Sept.	------	------	------	4644	4348	4596	4446
	------	------	------	4644	4365	4597	4526
Oct.	------	------	------	5166	4157	4613	4548
	------	------	------	5115	4158	4522	4554
$\overline{X}$	------	------	------	4648	4252	4569	4503

Source: Stroud and Cooper, 1968.

Table F-4 Net Productivity by Vegetation Type (kcal/m^2/yr).

Location	Method	Spartina alterniflora Short	Spartina alterniflora Medium	Spartina alterniflora High	Juncus roemerianus	Spartina patens	Mixed marginal	Mixed marginal	Source
Oak Island	1	881	1635	4848	2878	----			Stroud and Cooper 1969
	2	1300	1816	5365	3502	----			
	3	951	1856	4769	2103				
	4	1106	1856	6471	5324				
Carteret Co., N.C. North River	5	----	----	----	3410				Williams and Murdoch 1972
Bodie Island, N.C.	1	----	----	----	3814	2374*	3193*	1713*	Waits 1967
	2	----	----	----	5018	6539	6651	4608	(1965)
		----	----	----	7227	5130	5130	2795	(1966)
	3	----	----	----	2314	1942	2512	1394	(1965)
	4	----	----	----	4028	6152	4428	1797	(1965)
Sapelo	2	2618	----	9117	----	----	----	----	Smalley 1959

*Three species included (S. patens, Scirpus robustus, Distichlis spicata).

Source: Roberts, 1974.

Table F-5 . Total Marsh Net Productivity vs. Latitude (location).

Location	Methods	Net Prod (kcal/m^2/yr)	Source
Oak Island Brunswick County, N.C. (mouth of Cape Fear River)	1	1084	Stroud and Cooper 1969
	2	1370	
	3	1067	
Duplin River Sapelo Island	2	802 g/m^2/yr	Reimold, et al. 1972
Bodie Island, N.C.	1 3 yr Avg.	2465	Waits 1967
	2 1965	5916	
	1966	4783	
	3 1965	----	
	4 1965	4324	
Sapelo Island	2		

Source: Roberts, 1974.

The harshness of the salt marsh habitat restricts the number of resident mammals to a few species. Raccoons are one of the most abundant mammals, and marsh rabbits are common along the edges of the marsh adjacent to high ground. Mink and otter occur in the marsh, but both of these carnivores are seen infrequently. The rice rat is common along the levees of tidal creeks.

The mammals occurring in the salt marshes are primarily carnivorous with the exception of the marsh rabbit. Raccoons are known to feed heavily upon fiddler and squareback crabs (*Uca* spp. and *Sessarma* spp.) two of the most abundant animals in the marshes. Teal and Teal (1969) stated that clams and crabs comprise the principal food organisms of the marsh mink in the fall. The rice rat also feeds primarily on fiddler and squareback crabs and larvae of the rice borer with other insects occurring as incidental food items (Sharp, 1962).

Kale (1965) stated that three species of birds were intimately associated with the salt marsh community in coastal Georgia. These included the long-billed marsh wren, the clapper rail and the seaside sparrow. Sprunt (1968) discussed several other species of birds associated with the marsh. This list was comprised of egrets, herons, rails, shorebirds and passerine species. Several bird rookeries are located in the salt marsh ecosystem (Visual Nos. 4N-S).

The salt marshes (not including potholes and tidal streams) have limited appeal as feeding areas for most species of waterfowl. Lynch (1968) stated that the "true worth of the southern tidal marsh lies not so much in its direct appeal to waterfowl, but rather in its subtle contributions to waterfowl in salt marshes are mainly animal forms. In tidal creeks and potholes, widgeongrass, a submerged aquatic, is the most important duck food. Most dabbling and diving ducks utilize this plant. The black duck, the most common duck using the salt marsh, feeds primarily on snails. Many species of waterfowl use areas within the salt marsh as resting and loafing areas (Teal and Teal, 1969).

The open waters of the tidal creeks are especially attractive to diving ducks and other birds preferring animal foods. Pied-billed grebes, red-breasted and hooded mergansers, and large numbers of scaup commonly feed in the tidal creeks.

At low tide the exposed mud flats of the tidal creeks and marshes are preferred feeding areas for many species of shorebirds such as willets and greater yellowlegs.

7. Freshwater Marsh

Freshwater marshes occur primarily near the mouths of larger mainland streams and they may extend for some distance up the rivers before being replaced by cypress-gum or hardwood swamps. Much of the area in the southeastern coastal plain now covered by freshwater marsh was cypress swamp before it was cleared and diked for rice culture. Shallow freshwater marshes contain a variety of species including cattails, several bulrushes, smartweeds, aneilema, arrowhead, arrow arum, and others. The deeper freshwater marshes are more extensive. In many areas this marsh type is comprised almost exclusively of giant cutgrass. Stands of sawgrass occur intermittently. Around the deeper margins of the marsh, stands of cattail are common and wild rice occurs in sporadic stands. In the deeper creeks and potholes, submersed and floating-leaved plants are dominant.

As salinities increase to brackish conditions (about 0.5-2 ppt), giant cutgrass is replaced primarily by big cordgrass and, to a lesser extent, by salt marsh bulrush (Johnson, et al., 1974).

Freshwater marshes basically consist of tidal fresh water and non-tidal fresh water. Tidal fresh water marshes are divided into two types based on shallow and deep water depths. The principal type of deep fresh water marsh in the coastal areas is the giant cutgrass marsh, which occurs along the larger streams that are subject to daily tidal effects. These marshes extend inland from the coast up the rivers for several miles in some instances. In general, vegetative species consists primarily of cattails, wildrice, pickerelweed, giant cutgrass and spatterdocks, often accompanied by pondweeds and other submerged growths in marsh openings. This marsh type is limited to South Carolina and Georgia in the south Atlantic region.

The shallow fresh water marshes are generally located along the larger streams in those portions which are also subject to daily tidal effects. Shallow fresh water marshes are distinguished from the deep fresh water marshes on the basis of their shallow water and vegetative composition (bid cordgrass, maidencane, sedges, rushes, etc.). These marshes occur predominantly in North Carolina in this analysis area.

Two accounts consider this ecosystem as a unit in this area of interest. Shaw and Fredine (1971) indicate that approximately 160,000 acres (64,750 ha) of shallow and deep fresh water marshes occur in the southeast coastal zone of which 45,000 acres (18,211 ha) are in North Carolina, 80,000 acres (32,375 ha) in South Carolina, 30,000 acres (12,141 ha) in Georgia and 5,000 (2,023 ha) in Florida.

These coastal wetlands and associated bodies of open water are very important to numerous species of waterfowl. Of particular importance are the freshwater marshes, where most developments for the management of ducks are found. Undeveloped cutgrass marshes are used primarily during peak flights in the fall months. While the tidal rivers associated with the fresh water marshes offer little in the way of food organisms, they are nevertheless valuable in attracting waterfowl which utilize the adjacent freshwater ecosystem. The ecosystem is used most by the puddle ducks (mallards, teals, pintails, widgeons, etc.) (U.S. Dept. of Interior, 1973).

Other representative wildlife species include passerine birds, raccoons, rabbits and small predators. In addition, several freshwater fish as well as some marine fish species utilize the freshwater marsh ecosystem.

G. Human Utilization

1. Transportation

a. Port facilities

There are seven commercial ports within the U.S. South Atlantic Region, of which the four largest are located within the major cities of Wilmington, N.C.; Charleston, S.C.; Savannah, Ga. and Jacksonville, Fla. All of these have oil storage facilities in excess of five million barrels. Smaller ports are located at Morehead City, N.C.; Georgetown, S.C.; Brunswick, Ga. and Canaveral, Palm Beach, Port Everglades and Miami, Fla. The larger ports are served by 11.6-12 m depth (38-40 ft.) channels and the smaller ports by channels of 10.6 m (35 ft.) or less. Table G-1 summarizes the key elements of each port.

The port of Morehead City, North Carolina is on a peninsula extending easterly from the mainland between Bogue Sound and Calico Creek. The port is 247.8 km (154 nautical miles) northeast of Wilmington, North Carolina, and 400 km (249 nautical miles) south of Norfolk, Virginia (U.S. Dept. of the Army, 1971).

The deepwater approach from the Atlantic Ocean to the port is via a dredged channel across the bar and through Beaufort Isles. The channel extends to a Y-shaped turning basin. Beaufort Inlet, about midway between Cape Hatteras and Cape Fear, is approximately 35.4 km (15 mi.) westward along the coast from Beaufort Inlet to Bogue Inlet. It is separated from the ocean by Bogue Banks.

The route of the Atlantic Intracoastal Waterway passes through Morehead City harbor. The Corps maintains a bar channel of 10.6 m (35 ft.) deep and 121.9 m (400 ft.) wide through Beaufort Inlet, increased to 182.8 m (600 ft.) wide at the bend; thence an inner channel 10.6 m (35 ft.) deep and 91 m (300 ft.) wide.

Twenty-four piers, wharves and docks comprise the port of Morehead City. Five of these facilities are for deep-draft vessels and are located on the turning basin; the remaining 19 waterfront facilities are for use of fishing boats, barges and other types of small vessels.

Three of the waterfront facilities are equipped to receive and/or ship petroleum products and asphalt; one of the facilities provides bunkering service to vessels. Table G-2 gives information on the facilities equipped to handle petroleum products.

The Port of Wilmington, North Carolina: is in the southeastern part of the State, 242 km (154 naut. mi.) southwest of Morehead City, N.C. The port's principal waterfront facilities are along the city's waterfront on the east banks of the Cape Fear and Northeast Cape Fear rivers; the junction of the two rivers is at Wilmington, about 45 km (28 stat. mi.) above the mouth of the Cape Fear River (U.S. Dept. of Army, 1971a).

The mouth of the Cape Fear River is about 8 km (5 mi.) west of Cape Fear, between Smiths Island on the east and Oak Island on the west. The deep-water approach from the Atlantic Ocean to the port is via a dredged channel across the bar and upstream to Wilmington.

The Corps maintains a 12 m (40 ft.) channel from the ocean to Southport, and 11.5 m (39 ft.) from Southport to Wilmington harbor. Above Wilmington there is a 7.6 m (25 ft.) channel for 48 km (2.9 mi.) to Navassa and 3.6 m (12 ft.) from there for 18 km (30 mi.) to Acme.

Forty-one piers, wharves and docks are located in the port of Wilmington. Nine of the waterfront facilities are equipped to receive and/or ship petroleum products, petrochemicals and asphalt. One of the facilities provides bunkering services to vessels; one oil company can bunker tankers while berthed at its facility; and four facilities are equipped to fuel towboats and other types of small vessels. Table G-3 gives information on the facilities equipped to handle petroleum products.

The Port of Georgetown, South Carolina is located along the north bank at the mouth of the Sampit River, which empties into the head of Winyah Bay from the northwest. The port is about 22 km (14 naut. mi.) from the Atlantic Ocean, 127 km (79 naut. mi.) northeast of Charleston, S.C., and 173 km (108 naut. mi.) southwest of Wilmington, N.C. (U.S. Dept. of the Army, 1970).

Winyah Bay extends about 25.7 km (16 mi.) from the ocean to the confluence of the Pee Dee and Waccamaw rivers at its head near Georgetown, S.C. The deepwater approach to the port is via a dredged 8.2 m (27 ft.) channel leading from the ocean through Winyah Bay and Sampit River to a turning basis at the western end of the harbor.

Waterfront facilities exist for deep-draft vessels and the principal waterborne commodities handled at the port are pulpwood, paper, steel and petroleum products. The route of the Atlantic Intracoastal Waterway passes through Winyah Bay.

Table G-1. Port and Harbor Facilities in the U.S. South Atlantic Coastal States.

	Morehead City, N.C.	Wilmington, N.C.	Gerogetown, S.C.	Charleston, S.C.	Savannah, Ga.	Brunswick, Ga.	Jacksonville, Fla.
Channel Depth Meters (ft.)	10.6 (35)	11.5 (38)	8.2 (27)	10.6 (35)	12 (40)	9.7 (32)	11.5 (38)
Number of Piers, Wharves and Docks	24	41	16	54	51	19	82
Number of Oil Handling Facilities	3	9	1	8	13	4	18
Oil Storage Tank Capacity (000 bbls.)	1191	5262	188	6043	5430	480	6630
Waterborne Commerce 1972 (short tons)	1423	7590	1524	7477	8037	1263	14,886

Source: Virginia Institute of Marine Science (VIMS), 1974. A Socio-Economic Environmental Baseline Summary for the South Atlantic Region Between Cape Hatteras, N.C. and Cape Canaveral, Fla. Volume V, Socio-Economic Inventory.

Table G-2. Oil-Handling and Oil-Bunkering Facilities, Morehead City, N. C.

Operator and/or User	Storage Tanks Number	Capacity (Barrels)
Turning Basin		
Aviation Fuel Terminals, Inc.	10 (1)	600,000
Blue Ride Fuel Company	8	172,000 (2)
Humble Oil and Refining Co.	8 (3)	243,400 (3)
Trumbull Asphalt Co.	8 (5)	150,000 (4)
North Carolina State Ports Authority	3 (3)	26,200
TOTAL	37	1,191,000

(1) Three additional tanks are at terminal for storing liquid fertilizer, total capacity 6,600,000 gallons.
(2) Bunkering vessels.
(3) Tanks were not in use at time of survey.
(4) Asphalt and fuel oil for plant consumption.
(5) Pipelines extend from tanks to 6, steel, asphalt emulsion storage tanks at Central Oil & Asphalt Corp.'s plant, total capacity 240,000 gallons.

Source: VIMS, 1974.

Table G-3. Oil-Handling and Oil-Bunkering Facilities, Wilmington, N.C.

Operator and/or User	Storage Tanks Number	Storage Tanks Capacity (Barrels)
Left Bank, Cape Fear River		
Humble Oil and Refining Co.	29	1,377,487 (1) (2)(3)
Mobile Oil Corp.	5	256,000
American Oil Co.	43	333,300 (4)
Shell Oil Co.	13	399,000 (5)(2)
Atlantic Richfield Co.	7	248,610
Sun Oil Co.	7	336,066
Texaco, Inc.	9	332,000 (2)
Phillips Petroleum Co.	5	247,114
Chevron Asphalt Co., Inc.	5	122,105 (6)
Hess Oil & Chemical Division Amerada Hess Corp.	14	580,000 (5) (7)(3)
Union Oil of California	29	910,800 (5) (2)(8)
Left Bank, Northeast Cape Fear River		
Seaboard Coast Line Railroad Co.	2	120,000 (9)
TOTAL	168	5,262,482

(1) Bunkering vessels.
(2) Fueling towboats and other types of small vessels.
(3) Loading barges for bunkering vessels at berth in harbor.
(4) Includes storage for asphalt.
(5) Includes storage for petrochemicals.
(6) Asphalt.
(7) Bunkering tankers berthed at wharf.
(8) In addition to Union Oil Co. of California, the following use the facilities of this terminal: Gulf Oil Co.-U. S., Division of Gulf Oil Corp.; BP Oil Corp.; Marathon Oil Co.; Wright Chemical Co.; and American Mineral Spirits Co.
(9) Diesel fuel for own consumption.

Source: VIMS, 1974.

The port consists of 16 piers, wharves and docks. Only one of the waterfront facilities receives petroleum products, and in an emergency or by special arrangement, bunkering service for large ocean-going vessels can be provided. The Hess Oil and Chemical Division, Amerada Hess Corporation, operates an offshore-type wharf owned by the South Carolina State Ports Authority. Two pipelines, one 30 cm (12 in.) and one 25 cm (10 in.), extend from the wharf to four steel storage tanks in rear; these tanks have a total capacity of 188,000 barrels.

The Port of Charleston, South Carolina: is on a peninsula at the confluence of Cooper River on the east and the Ashley River on the west. The rivers flow into the bay known as Charleston Harbor. The port is 127 km (79 naut. mi.) southwest of Georgetown, S.C., and 164 km (102 naut. mi.) northeast of Savannah, Ga. (U.S. Dept. of the Army, 1970).

The deepwater entrance from the ocean to the port is via a 10 m (35 ft.) dredged channel between two stone jetties lying outside Sullivans Island on the northeast and Morris Island on the southwest.

The United States Navy dredged a 10 m (35 ft.) channel with varying widths between the mouth of Goose Creek and a point about 7.7 km (4.8 mi.) upstream. Charleston Harbor forms part of the route of the Atlantic Intracoastal Waterway.

Fifty-four piers, wharves and docks make up the port facilities of Charleston. Eight of the waterfront facilities are equipped to receive and/or ship petroleum products, petrochemicals, asphalt, or to load a tank barge at the port for bunkering vessels at berth; seven are along the right bank of the Cooper River, and one is on the right bank of the Shipyard River (Table G-4).

The Port of Savannah, Georgia is located on the right bank of the Savannah River; about 24 km (15 mi.) from the Atlantic Ocean. Savannah is the second largest city and chief port of the State. The port is 164 km (102 naut. mi.) south of Charleston, S.C. and 233 km (145 naut. mi.) north of Jacksonville, Fla. (U.S. Dept. of the Army, 1972).

The deepwater entrance from the ocean to the mouth of the river is via a 15.4 km (9.5 mi.) long, dredged channel across the bar through Tybee Roads. The Port's principal waterfront facilities are located along the right bank of the river.

The route of the Atlantic Intracoastal Waterway crosses the Savannah River. Fifty-one piers, wharves and docks are described in this report for the port of Savannah. Thirteen of the waterfront facilities described above this are equipped to receive and/or ship petroleum products; 12 are along the right bank and one is on the left bank of the Savannah River on Hutchinson Island. Two of the wharves provide bunkering service to vessels (Table G-5).

The Port of Brunswick, Georgia is 131.9 km (82 naut. mi.) north of Jacksonville, Fla. and 167 km (104 naut. mi.) south of Savannah, Ga. The harbor includes a 9.7 m (32 ft.) dredged channel across the ocean bar to the entrance of St. Simon Sound (U.S. Dept. of the Army, 1972). Nineteen piers, wharves and docks are listed for the port of Brunswick, Ga. Four of the waterfront facilities described are equipped to receive and/or ship petroleum products. The Eastern Seaboard Petroleum Company, Inc. provides bunkering service for large ocean-going vessels berthed at the Brunswick Port Authority Lanier Dock and the Georgia Ports Authority, Brunswick State Docks. This company owns and operates five tank barges. These barges are based at the port of Jacksonville, Fla., with cargo-carrying capacities ranging from 4,200 to 11,000 barrels (Table G-6).

The Port of Jacksonville, Florida is on the St. Johns River 233 km (145 naut. mi.) south of Savannah, Ga. and 555 km (345 naut. mi.) north of Miami, Fla. The deepwater entrance from the ocean to St. Johns River is between jetties which extend in an east-west direction across the ocean bar from the river's mouth. Eighty-two piers, wharves and docks are provided in the port of Jacksonville. Eighteen waterfront facilities are equipped to receive and/or ship petroleum products; to provide bunkering service to vessels. Large, ocean-going vessels are usually bunkered at berth by tank barges.

Table G-7 gives information on facilities equipped to handle petroleum products. Table G-8 provides a summary of the water movement of freight traffic for selected ports along the southeastern coast of the U.S. during 1973. The data are shown for total freight tonnages, and tonnages of crude petroleum and petroleum products (SIC 13 and 29). The data were compiled from U.S. Department of the Army, 1973b.

Table G-9 summarizes traffic volumes for waterborne commerce, and petroleum and products shipping at selected ports and waterways.

Table G-4. Oil-Handling and Oil Bunkering Facilities, Charleston, S.C.

Operator and/or User	Storage Tanks Number	Storage Tanks Capacity (Barrels)
Right bank - Cooper River		
Humble Oil & Refining Co.	169	2,909,200 (1)
Hess Oil & Chemical Division, Amerada Hess Corp.	19	462,000 (2)
BP Oil Corp.	9	296,000 (2)
Shell Oil Co.	5	282,800 (1)
Texaco, Inc.	25	373,800 (1)
Phillips Petroleum Co.	5	245,000
Hess Oil & Chemical Division Amerada Hess Corp.	9	530,000 (3)
Cities Service Oil Co.	4	240,000
Right bank - Shipyard River		
Gulf Oil Co. - U.S., Division of Gulf Oil Corp.	46	705,000 (1)
TOTAL	291	6,043,000

(1) Bunkering vessels.
(2) Includes petrochemicals.
(3) Bunkering tank vessels berthed at wharf.

Source: VIMS, 1974.

Table G-5. Oil-Handling and Oil Bunkering Facilities, Savannah, Ga.

Operator and/or User	Storage Tanks Number		Capacity (Barrels)	
Belcher Oil Company			160,000	
Standard Oil Company of Kentucky	13		351,000	
Union Oil Company of California	14		290,000	
Atlantic Richfield Company	4		109,890	
Charter International Oil Company, Houston Division	20		509,480	
Savannah Electric & Power Company	2		15,000	(3)
Colonial Oil Industries, Inc.	21	(5)	945,800	(5)
do	12	(6)	195,100	(6)
Union Camp Corp.	1		80,000	(3)
American Oil Co.	16		941,900	
The Ruberoid Division, GAF Corp.	2		40,580	(7)
Southland Oil Corp.	18		1,062,300	(5)
do	10			
Shell Oil Company	5		130,350	
Savannah Terminal, Inc.	4		122,500	(7)
Shelter Industries, Certain-Teed Products Corp .	1		32,000	(7)
Chevron Asphalt Co.	24		245,000	(7)
Savannah Sugar Refinery Division of Savannah Foods & Industries, Inc.	3		35,800	(3)
Savannah Electric & Power Co.	2		50,000	(3)
Continental Can Co., Inc.	2		42,000	(3)
TOTAL	174		5,430,000	

(1) Fueling various types of small vessels.
(2) Bunkering vessels.
(3) Fuel oil for plant consumption.
(4) Loading barges for bunkering vessels at berth in harbor.
(5) Petroleum products.
(6) Petrochemicals.
(7) Asphalt.

Source: VIMS, 1974.

Table G-6. Oil-Handling and Oil-Bunkering Facilities, Brunswick, Ga.

Operator and/or User	Storage Tanks Number	Storage Tanks Capacity (Barrels)
Left bank, East River		
Eastern Seaboard Petroleum Co., Inc.	1 (1)	150,000 (2)
Left bank, Turtle River		
Brunswick Pulp & Paper Co.	1	20,000 (3)
Allied Chemical Corp.	4	9,520 (3)
Georgia Power Company	4	300,970 (3)
TOTAL	10	480,490

(1) Constructed after field survey.
(2) Bunker C fuel oil.
(3) Fuel oil for plant consumption.

Source: VIMS, 1974.

Table G-7. Oil-Handling and Oil-Bunkering Facilities, Jacksonville, Florida.

Operator and/or User	Storage Tanks Number	Capacity (Barrels)
Left bank - St. Johns River		
Department of Electric & Water Utilities	2	218,000 (1)
Hess Oil and Chemical Co.	1	150,000
Gulf Oil Corp.	17	900,000
American Oil Co.	4	218,750
Eastern Seaboard Petroleum Co., Inc.	9	600,000
Phillips Petroleum Co.	5	243,000
Shell Oil Co.	10	448,500
Alton Box Board Co., Paperboard Division	3	105,000 (1)
Department of Electric & Water Utilities	4	298,000 (1)
Texaco, Inc.	32	312,000
Standard Oil Co. of Kentucky	38	789,844
Sun Oil Co.	6	166,121
Atlantic-Richfield Co.	4	170,000
Southern States Oil Co.	9	596,000
Pure Oil Co.	5	119,000
Trumbull Asphalt Co.	44	321,650 (5)
Colonial Oil Co.	7	128,000
Sinclair Refining Co.	6	350,000
Right bank - St. Johns River		
Department of Electric & Water Utilities	4	306,000 (1)
Southern States Oil Co.	3	190,000
TOTAL	213	6,629,865

(1) Fuel oil for plant consumption.
(5) Asphalt.

Source: VIMS, 1974.

Table G-8. Water Movement of Freight Traffic for Selected Ports Along the Southeastern Coast of the U.S., 1973. (thousands of short tons)

Harbor	Total	Foreign		Coastwise		Internal		Local
		Imports	Exports	Receipts	Shipments	Receipts	Shipments	
1. Morehead City, N.C.								
Total	1,161	307	386	290	2	66	110	0
(SIC 13,29)	521	175	0	212	0	64	70	0
2. Wilmington, N.C.								
Total	9,301	4,083	216	2,942	86	132	1,776	66
(SIC 13,29)	5,917	2,657	0	2,249	22	11	913	65
3. Georgetown, S.C.								
Total	1,486	339	152	29	7	944	13	0
(SIC 13,29)	356	317	0	29	0	10	0	0
4. Charleston, S.C.								
Total	9,380	3,781	1,071	3,281	307	141	686	113
(SIC 13,29)	6,269	2,391	1	3,040	9	78	644	106
5. Savannah, Ga.								
Total	8,980	4,052	1,766	2,144	223	100	207	487
(SIC 13,29)	4,247	2,012	7	1,493	220	3	29	484
6. Brunswick, Ga.								
Total	1,394	721	47	2	6	312	202	104
(SIC 13,29)	530	129	0	0	0	296	1	104
7. Jacksonville, Fla.								
Total	15,514	6,206	1,864	4,511	877	117	1,829	110
(SIC 13,29)	10,166	4,113	2	4,120	30	0	1,796	107

Table G-8 (continued)

Water Movement of Freight Traffic for Selected Ports Along the Southeastern Coast of the U.S., 1973. (thousands of short tons)

Harbor	Total	Foreign		Coastwise		Internal		Local
		Imports	Exports	Receipts	Shipments	Receipts	Shipments	
8. Canaveral, Fla.								
Total	2,363	1,461	4	205	0	4	688	0
(SIC 13,29)	1,943	1,058	0	201	0	0	684	0
9. Palm Beach, Fla.								
Total	1,284	957	204	77	39	5	2	0
(SIC 13,29)	815	808	3	0	0	2	1	0
10. Port Everglades, Fla.								
Total	12,542	4,763	225	6,430	967	129	29	0
(SIC 13,29)	10,443	3,024	11	6,308	945	127	28	0
11. Miami, Fla.								
Total	5,569	1,700	494	474	171	59	1,366	1,305
(SIC 13,29)	4,244	1,185	5	338	19	28	1,364	1,305

Source: U.S. Department of Army, U.S. Corps of Engineers, 1973.

Table G-9. Petroleum and Petroleum Products Freight Traffic - 1972. Selected Other Harbors & Waterways (in thousands of short tons).

PORT/WATERWAY	Total Volume All Shipping	Residual Fuel Oil	Gasoline	Jet Fuel	Kerosene	Distilled Fuel Oil	Coke Petroleum Coke
Pamlico & Tar Rivers, N.C. domestic	559	33	-	-	-	-	
Neuse River, N.C. domestic	476	78	32	12	6	12	
Atlantic Intracoastal Waterway (Wilmington District) domestic	2,796	429	124	120	29	66	32
Cape Fear River above Wilmington, N.C. domestic	728	499	2	-	12	-	-
Northeast (Cape Fear) River, N.C.	386	56	-	-	-	-	-
Beaufort Harbor N.C.	64	22	-	-	-	-	-
Mantec (Shallowbag) Bay, N.C.	25	-	13	-	2	4	-
Perquimans River N.C.	2	-	1		0.5	0.4	-
Rollinson Channel, N.C.	32	-	2	-	-	1	-
Silver Lake Harbor, N.C.	4	-	0.6	-	-	-	-

Table G-9 (continued)

PORT/WATERWAY	Total Volume All Shipping	Residual Fuel Oil	Gasoline	Jet Fuel	Kerosene	Distilled Fuel Oil	Coke Petroleum Coke
Waterway, Norfolk, Va., to Sounds of N.C.	45	-	10	-	2	-	-
Atlantic Intracoastal Waterway (Charleston District) domestic	1,445	.5	10	111	12	2	32
Atlantic Intracoastal Waterway (Savannah District) domestic	1,353	555		97	12	3	
Atlantic Intracoastal Waterway (Jacksonville District) domestic	1,241	861		97		3	
Rice Cree, Fla.	272	272					
St. John's River, Fla., Jacksonville to Lake Harvey	1,133	945	2	160	1	5	
Intracoastal Waterway Jacksonville to Miami, Fla., Oceangoing	246	125	-	-	-	2	-
Internal	592	525					

Source: VIMS, 1974.

b. TRANSPORTATION SYSTEMS

(1) Ocean Shipping

In order to prevent conflicts between ocean shipping and oil and gas operations a traffic separation scheme has been adopted in certain ocean areas around the United States. In the Gulf of Mexico well defined navigational "fairways" have been established wherein no oil or gas operations may take place. No navigational "fairways" have been established for the U.S. South Atlantic OCS region, (USCG, 1976).

(2) The Intracoastal Waterway

This canal system is a toll free waterway which affords continuing passage behind the Atlantic Coast and the Florida Keys for more than 2029 km (1,243 stat. mi.) between Norfolk, Va. and Key West, Fla. It is used by light draft vessels and tows unable to navigate long stretches in the open ocean (U.S. Dept. of Commerce, 1975).

According to the Department of the Army (1973) a total of 3,877,819 tons of commodities moved along the waterway between Norfolk, Va. and the St. Johns River, Fla. Of this total 1,666,168 tons consisted of petroleum and kindred products.

(3) Pipelines

In the southeastern U.S. coastal region, the only major pipelines are for natural gas. The lack of oil fields in the region, until those to be developed offshore have become operative, and the proximity of port facilities have rendered the transport of crude oil through pipelines unnecessary. The system of pipelines serving and traversing the region is depicted on the accompanying map (Figure G-1).

The pattern of natural gas lines is, for the most part, one of branch lines tapping the Transcontinental Gas Pipeline Corporation's main line in the Piedmont Region, and traversing the Coastal Plains Region in a southeasterly, or easterly, direction toward the coast. Natural gas lines terminate at Brunswick, Savannah, Beaufort, Charleston, Georgetown, Myrtle Beach, Wilmington, New Bern, and Washington. All densely populated and industrial areas are served by natural gas lines. Exclusive of local distributors, six natural gas pipeline companies operate in the Coastal Plains Region; North Carolina Natural Gas Corporation; Piedmont Natural Gas Company; Public Service Company of North Carolina; Carolina Pipeline Company; South Carolina Electric and Gas Company; and Southern Natural Gas Company. These firms transport and/or distribute natural gas originating in Texas, Louisiana, and Oklahoma. Some of these firms both transport and distribute gas. Others transport and turn it over to local companies or local public authorities for local distribution.

Product pipelines are not as extensive in the area. The U.S. Department of the Interior, Bureau of Mines (1974b) provides the following data.

	1971	1974
Florida 15.2 cm to 25.4 cm (6" to 10")	140 km (87 miles)	373 km (232 miles)
Georgia 10.1 cm to 60.9 cm (4" to 24")	2,780 km (1,728 mi)	3,035 km (1,886 mi)
North Carolina 10.1 cm to 60.9 cm (4" to 24")	1,342 km (834 miles)	1,448 km (900 miles)
South Carolina 15.2 cm to 24 cm (6" to 24")	1,021 km (635 miles)	1,076 km (669 miles)

(4) Railroads

The two major rail systems serving the southeastern U.S. coastal region are the Southern Railway and the Seaboard Coast Line. Although its main north-south lines are west of the region, the Southern Railway operates several east-west lines which extend to the coast. The Seaboard Coast Line serves the region intensively with both north-south and east-west lines. Passenger service in the region is very limited and continues to decline. However, there is sufficient capacity for freight service on the existing rail network to allow expansion of services which will be required for accelerated economic development related to possible oil and gas production on the OCS.

The Southern Railway owns 10,224 km (6,274 mi.) of track and has its headquarters in Washington, D.C. Although its main lines are west of the Coastal Region, the Southern operates east-west lines from its main lines which extent to Charleston, Savannah, New Bern, and Morehead City.

The Seaboard Coast Line owns over 14,646 km (9,000 mi.) of tract and has its executive headquarters in Jacksonville, Fla. This system serves the Region intensively with lines extending to all parts of the Region running both north-south and east-west. The Seaboard also provides service to all major points in Florida, and it extends as far north as Richmond, Va., thereby offering a vital connection to the Northeast. Several small lines are important to the communities

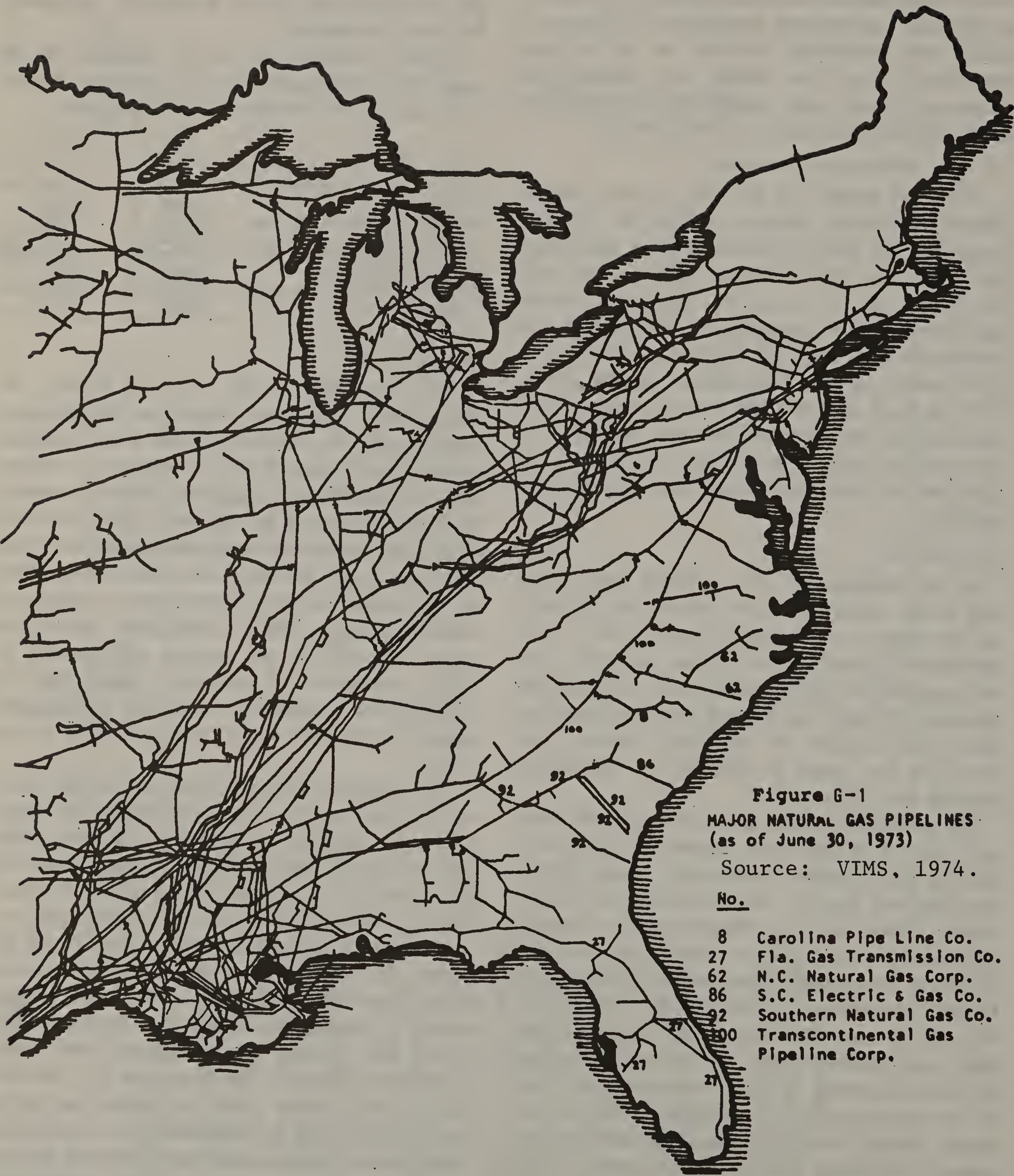


Figure G-1
MAJOR NATURAL GAS PIPELINES
(as of June 30, 1973)

Source: VIMS, 1974.

No.	
8	Carolina Pipe Line Co.
27	Fla. Gas Transmission Co.
62	N.C. Natural Gas Corp.
86	S.C. Electric & Gas Co.
92	Southern Natural Gas Co.
100	Transcontinental Gas Pipeline Corp.

which they serve. A complete list of rail lines serving the coastal area is presented in Table G-10.

(5) *Highways*

Less than five percent of the highways, other than Interstate, on the State Primary Systems within the region are four-lane (only 97 km (60 mi.) would qualify as freeway). A very large percentage is two-lane, narrow, with poor alignment. Many urban areas are not bypassed by through traffic, and cause delays which increase travel time from point to point. The accident rates for North and South Carolina and Georgia are among the highest in the nation.

An indication of traffic flow in the coastal area is given on the map of "Traffic Flow in Interstate and United States Highways, 1967" prepared by Wilbur Smith for the Coastal Plains Regional Transportation Study (Fig. G-2). Although not up to date, this map probably presents a fairly accurate representation of traffic flows in the Coastal Zone with the important exception of Route I-95 for which sections have been completed since 1967, and state highways which provide important connections not shown on the map.

Most significant for the coastal zone is the lack of any interstate route in the area above Charleston. From Savannah northward, I-95 moves inland requiring driving distances of 119 to 145 km (73 to 89 mi.) from Wilmington and 189 km (116 mi.) from Morehead City to reach the interstate route. Charleston has a good connection to I-95 via I-26, and all but 42 km (26 mi.) of Route 70 from Morehead City to I-95 is developed as a four-lane highway. This, and the generally sparse system of improved highways in the coastal zone, constitute serious limits to its accessibility for much of its area (Planners, Inc., 1974).

(6) *Airports*

Most passenger traffic in the coastal area is by air, bus or passenger cars. No data on bus or private car travel are available. Air travel plays an increasingly important role in passenger traffic, particularly for longer trips. The air freight services offered are also an important factor in economic development.

There are 69 airports in the coastal zone of which eight provide scheduled airline service. Of these, five can be classified as major airports. A listing of these by county is in Table G-11.

2. Dredging

The marine transport of huge tonnages of materials has led to the development of ports and navigable waterways that could accommodate vessels with greater drafts. The development and maintenance of these ports and waterways requires extensive dredging of large volumes of sediments each year. The principal responsibility for dredging operations is vested with the Army Corps of Engineers.

Dredging entails the excavation of bottom material. The types of dredging devices fall into two classifications—hydraulic and mechanical. Mechanical dredges pick up material by various types of buckets. Hydraulic (or suction) dredges utilize a centrifugal pump which moves a slurry of water and material through a pipeline either into the hold of hoppers or to a distant discharge point.

The mechanical dredges discharge either alongside the place of excavation, or into barges. This type of dredge is used extensively around breakwaters, docks and piers in maintenance dredging. It is mostly applied to excavating soft and cohesive subaqueous materials as silts and stiff muds.

The hydraulic dredges all have a suction line through which the excavated material is diluted with water and pumped to the disposal site either on shore, alongside the barge or into the hold of the dredge. The hopper dredge is an example of this type and is suitable for all but very hard materials. This type is generally used for maintenance and improvement of harbors, rivers and bays where near-by dumping grounds are not available. The cutter dredge is another example of the hydraulic type. This type is used in excavation and maintenance, and is used to dredge rock-like formations such as limestone, without blasting, and rock after blasting.

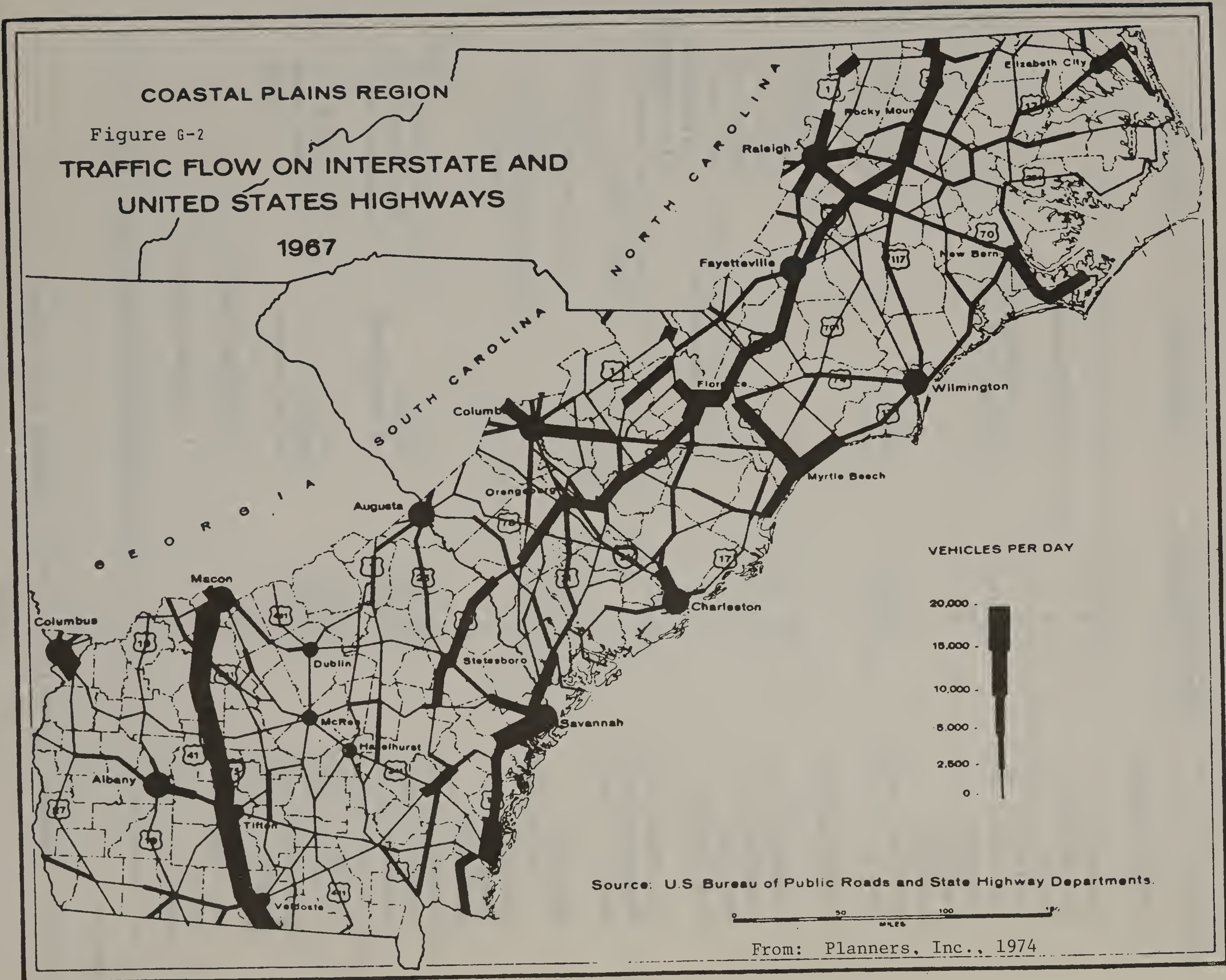
Each year dredging operations are carried out in major harbors and along the intercoastal waterways. The disposal of the dredged material varies from open ocean dumping sites, diked areas near shore and onshore dumping sites. Following is a brief summary of some of the major dredging operations that occur along the southeast Atlantic coast. Table G-12 summarizes the dredging location, frequency, yardage and disposal areas for each South Atlantic State.

Table G-10. Railways Serving the Southeastern U.S. Coastal Region.

Railroad Name	Home Office	Mileage of Rail	Services Offered 1/ P	F	RE	TOFC	States Served
Atlantic & East Carolina	New Bern, N.C.	94		X		X	N.C.
Beaufort & Morehead City	Beaufort, N.C.	3		X	X		N.C.
Central of Georgia	Savannah, Ga.	1,743	X	X	X	X	Ala., Ga., Tenn.
Cape Fear	Fort Bragg, N.C.	42	X	X		X	N.C.
Camp Lejeune	New Bern, N.C.	30		X		X	N.C.
Savannah & Atlanta	Savannah, Ga.	168		X	X		Ga.
Seaboard Coast Line	Jacksonville, Fla.	9,632	X	X	X	X	Ala., Fla., Ga.
Southern	Washington, D.C.	6,274	X	X	X	X	Ala., D.C., Fla., Ga., Ill., Ind., Ky., Miss., N.C., S.C., Tenn., Va.

1/ P - Passenger, F - Freight, RE - Railway Express, TOFC - Trailer on Flat Car.

Source: Rand McNally, 1967. Handy Railroad Atlas of the United States. National Railway Publication Company, 1968. The Official Guide of the Railways.



COASTAL PLAINS REGION

Figure G-2

TRAFFIC FLOW ON INTERSTATE AND UNITED STATES HIGHWAYS

1967

From: Planners, Inc., 1974

Table G-11. Airports in the Southeastern U.S. Coastal Zone.

Location	Non-Commercial	Scheduled	Military
1. NORTH CAROLINA			
Brunswick	1	-	-
New Hanover	1	1 Wilmington*	-
Pender	2	-	-
Onslow	2	1 Jacksonville*	1
Craven		1 New Bern*	1
Carteret	3	-	1
Pamlico	-	-	-
Beaufort	1	-	-
Hyde	2	-	-
Dare	2	-	-
2. SOUTH CAROLINA			
Jasper	1	-	-
Beaufort	3	-	1
Berkley	1	-	-
Charleston	5	1 Charleston*	1 (same as city airport)
Colleton	1	-	-
Georgetown	-	-	-
Horry	2	-	-
3. GEORGIA			
Camden	2	-	-
Glynn	3	1	-
McIntosh	4	-	-
Liberty	2	-	1
Bryan	-	-	-
Chatham	1	1 Savannah*	1
4. FLORIDA			
Brevard	3	1 Melbourne	2
Flagler	2	-	-
Volusia	2	1 Daytona Beach	-
St. Johns	1	-	-
Duval	2	1 Jacksonville*	2
Nassau	1	-	-

*Major

Source: Planners Incorporated, 1974. Coastal Zone Atlas.

Table G-12. Major Dredging Sites in the Southeastern Atlantic Coastal Region

State	Frequency	Yardage	Disposal Location
N. Carolina			
Morehead City	annual	800,000	ocean dump
Wilmington	annual	1 million	ocean dump
S. Carolina			
Georgetown	annual	2.5 million	
Port Royal	"	0.5 "	ocean dumps
Charleston	"	8.5 "	& diked areas
Intercoastal Waterway	"	2 "	
Georgia			
Savannah harbor entrance		1 million	ocean dump
" inner harbor	continuous	6 "	harbor disposal area
Brunswick	6 month		diked
outer portion		700,000	
inner "		800,000	
Atlantic Intercoastal		1 million	open marsh
Waterway	continuous		
Florida			
Jacksonville Harbor	2 yrs.	500,000	ocean & dike dump
St. Augustine "	annual	100,000	ocean dump
Cape Canaveral "	"	600,000	beach nurishment
			ocean & dike dump
Ft. Pierce "	5 yrs.	150,000	dike
Palm Beach "	annual	100,000	dike & ocean dump
Miami "	12 yrs.	unknown	beach nurishment
			dike

Source: U.S. Army Corps of Engineers, 1976.

a. North Carolina

There are two dredging operations in North Carolina, at Morehead City and Wilmington that maintain shipping channels to these harbors. At Wilmington approximately one million yards of dredged material, consisting of sand and shell is disposed of in ocean dumping sites. This operation is conducted at approximately five miles offshore to the entrance of the Cape Fear River at the 12 m (40 ft.) contour. The Morehead City dredging operation is about two miles offshore at the 12 m (40 ft.) contour to maintain a shipping channel. Approximately 800,000 yard of sand and shell is dredged and disposed of at ocean dumping sites.

b. South Carolina

There are four major dredging sites in South Carolina. The dredged material from these areas is disposed of either in ocean dumps or in diked areas. Maintenance dredging occurs in three ports, Georgetown, Port Royal and Charleston. In Georgetown approximately 2.5 million yards per year are dredged; Port Royal has approximately 0.5 million yards per year and Charleston has approximately 8.5 million yards per year of dredged material. There are several dredging sites along the Intercoastal Waterway where approximately two million yards per year are dredged.

c. Georgia

There are four major dredging areas along the Georgia coast. The Savannah Barge Channel which consists of the ocean portion of the Savannah harbor is dredged periodically. The dredge material is disposed of in ocean dumping sites at an estimated one million yards per year. A continuous dredging operation occurs on the inner harbor for pipeline dredging. The dredge material from this operation is disposed of in five major disposal areas in the Savannah Harbor. These areas range from 40-124 hectares (100-3000 acres) and approximately six million yards per year of dredged material is deposited in these areas.

Brunswick harbor is another site where maintenance dredging operations work twice a year. There are two sites where dredged material from the harbor are disposed. The outer portion disposes approximately 700,000 yards per year in ocean dumping sites and the inner portion disposed approximately 800,000 yards per year on Andrews Island in a diked area.

The Atlantic Intracoastal Waterway has six major dredging sites that excavates approximately 1,000,000 yards per year of dredged material. This material is disposed of in open marsh areas that have been designated by EPA. This material consists of 80% silt and 20% sand.

Another area that is dredged once a year at alternating locations is between Savannah and Augusta, Georgia. Approximately 100,000 to 200,000 yards per year of sand material is dredged from this area.

d. Florida

There are many dredging operations along the southeast coast of Florida. Some of the major operations are at Jacksonville, St. Augustine, Cape Canaveral, Ft. Pierce, and Palm Beach. These are shown on Table G-13. The types of disposal areas for these operations vary from beach nourishment, diked areas to ocean dumping sites. The main beach nourishment dredging operations occur at Cape Canaveral, here dredged material consists mainly of sand.

3. Ocean Dumping

Ocean dumping under the 1972 Marine Protection Research and Sanctuaries Act is regulated by permits issued by the Environmental Protection Agency. An interim list of approved dumping sites was published in the Federal Register (May, 1973). Table G-13 lists 17 of the approved interim sites located in the South Atlantic coastal region south of 37° N. The approved dumping sites are all within 32 km (20 mi.) of shore. The proposed lease tracts are 48 km (30 mi.) or more from shore. All of the proposed lease tracts are greater than 35 km (22 mi.) from the nearest approved dumping site.

Explosives have been dumped in the South Atlantic OCS in two dumping sites, both presently inactive. These sites are located over 170 km (106 mi.) from shore and approximately 64 km (40 mi.) from the nearest proposed lease tract (Figure G-3).

EPA has issued a permit for dumping chemical industrial wastes to APM Manufacturing Company, Augusta, Georgia. No dumping has as yet taken place on the permit area which is indicated in Figure G-3.

4. Military Use of the Continental Shelf

Figure G-3 (Section II.G.3.) indicates the Fleet Operating Areas. These areas provide controlled

Table G-13 Approved Interim Dumping Sites - EPA Region IV

Location	Size Square Kilometers (mi^2)	Depth Meters (ft)	Primary Use
Wilmington Harbor 33°48', 78°02'	9.0 (3.5)	14 (45)	Sand and silt (hopper dredge)
Morehead City 34°39', 76°42'	30.0 (11.6)	15 (50)	Do. 1/
Georgetown Harbor 33°11', 79°08'	2.6 (1.0)	8 (28)	Mostly sand and shell
Port Royal Harbor 32°09', 80°36'	3.6 (1.4)	6 (20)	Do.
Port Royal Harbor 32°05', 80°36'	2.6 (1.0)	6 (21)	Do.
Brunswick Bay 31°02', 81°17'	5.2 (2.0)	9-11 (29-36)	Sand with some shell silt
Savannah Bar 31°57', 80°46'	5.2 (2.0)	6-11 (20-36)	Do.
Canaveral Harbor 28°23', 80°34'	4.1 (1.6)	9 (31)	Sand silt
Fernandina Harbor 30°42', 81°22'	0.2 (0.1)	11 (37)	Sand, shell, and mud

(continued)

1/ Ditto

Table G-13 (continued) Approved Interim Dumping Sites - EPA Region IV

Location	Size Square Kilometers (mi^2)	Depth Meters (ft)	Primary Use
Fernandina Harbor 30°42', 81°24'	0.2 (0.1)	10 (33)	Do.
Fort Pierce Harbor 27°27', 80°15'	0.8 (0.3)	12 (39)	Do.
Jacksonville Harbor 30°21', 81°18'	0.8 (0.3)	9 (31)	Sand and shell
Miami Harbor 25°45', 80°05'	0.3 (0.13)	12-21 (41-68)	Do.
Palm Beach Harbor 26°46', 80°01'	13.4 (5.2)	8-17 (26-57)	Do.
Port Everglades Harbor 20°06', 80°06'	0.2 (0.1)	7 (24)	Do.
St. Augustine Harbor 29°54', 81°15'	0.8 (0.31)	11 (36)	Fine sand
St. Lucie Inlet 27°10', 80°09'	0.2 (0.1)	3 (11)	Sand and shell

Source: Federal Register, May 1973.

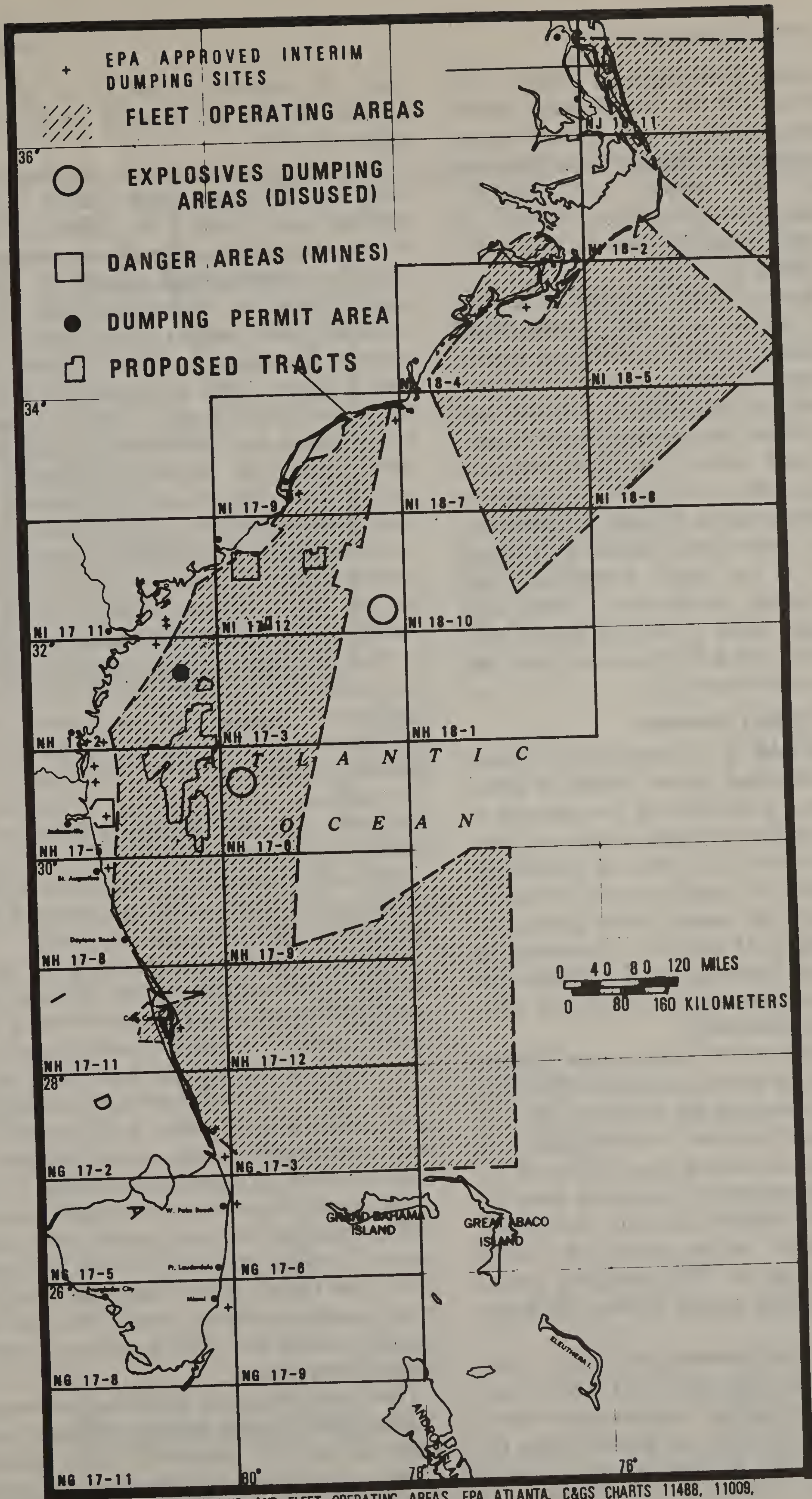


FIGURE G-3 OCEAN DUMPING AND FLEET OPERATING AREAS. EPA ATLANTA, C&GS CHARTS 11488, 11009, COMEASTSEAFRON INSTRUCTION 3120, S.C. JUNE 1972.

territory for testing and training of surface, submarine and air units of the United States Armed Forces. Detailed charts on the Fleet Operating Areas can be found in "Atlantic Fleet Operating Areas Within the Eastern Sea Frontier", COMEASTSEAFRON Instruction 3120.5C of June 28, 1972 Area coverage of the detailed charts are shown on Figure G-4.

Within the South Atlantic OCS region, sea and air space are utilized by Defense Department agencies for military exercises including surface and aerial gunnery, bombing, torpedo firing, air-to-air, air-to-surface, and surface-to-surface missile firing; air combat maneuvering; aircraft carrier operations; and surface ship and submarine training. Additionally the National Aeronautics and Space Administration through its operations at the Kennedy Space Center utilizes the Atlantic Ocean seaward of the missile launch sites and south of the thirtieth parallel for a buffer area subject to booster cases or aborted launch vehicles. No tracts offered in this proposed lease sale lie south of the thirtieth parallel.

5. Commercial Fishery Resources

In 1975, the total U.S. commercial fisheries landings were 4.8 billion pounds valued at $970.8 million. This was a decrease of two percent in volume but an increase of eight percent in value compared with 1974 (U.S. Dept. of Commerce, 1976). The decline in quantity could be due to decreased catch of low priced finfish, particularly menhaden. Tables G-14 and G-15 summarize the breakdown of total landings for the southeastern Atlantic states and the total for finfish and shellfish for the area, respectively.

Landings in 1975 for the southeastern Atlantic States accounted for seven percent or 300 million pounds and six percent or $61 million of the U.S. catch. The greatest volume of commercial fish landings were finfish, ranging from 74-81% of the total catch, with menhaden comprising from 38-65% of the total volume (Chestnut and Davis, 1975). North Carolina led the states with a catch of 200 million pounds in 1975. Menhaden ranked first and thread herring second in catch for North Carolina.

The shellfish catch increased in volume; however, it decreased in value from 1973. This is partially due to the increase of calico scallops which sold at approximately $0.55 per pound (Table G-16). North Carolina led in total landings for 1975 with 238 million pounds, 73% of the total landings. It also led in value for 1975 with $20 million or 33%.

Menhaden ranked first in volume and total catch for the species landed in the southeastern Atlantic states (Table G-16). Table G-17 indicates the leading species according to price/lb. is the pompano which is landed mostly in Florida but also appears in North Carolina and South Carolina. Roller trawling for red snapper has been recently introduced in South Carolina with six ships currently utilizing this method to trawl the live bottom areas offshore. Since red snapper is a highly priced fish and roller trawling has been shown to be a very productive method of harvest, the usage of roller trawling will probably become more common offshore of the southeastern U.S.

The distribution of Atlantic menhaden in the southeast Atlantic states varies with season. During the warmer months, the fish congregate in schools which are found in greater concentrations in water depths of less than 36 m (120 ft.). Throughout the summer months, the young are confined to estuaries. In late autumn, juveniles and adults are found only off the coast of North Carolina (Roithmayr, 1973). The greatest volume of landings occur during November and December when the menhaden fishery is at its peak (Chestnut and Davis, 1975).

Tables G-18 through G-20 represent a summary of commercial fisheries for the southeast Atlantic states (U.S. Dept. of Commerce, 1976).

The major shellfish caught along the southeast Atlantic coast are crabs, shrimp, oysters, scallops and spiny lobsters. In 1974, there was a total of approximately 74 million pounds caught which was valued at $31 million (U.S. Dept. of Commerce, 1976). The 1973 figures were approximately 65 million pounds valued at $39 million. There was approximately a nine percent increase in the total catch and a 15% decrease in value.

Shrimp constitute the most valuable commercial fishery resources for this area. In 1975, approximately 25 million pounds or 7% and $30 million or 13% of the United States shrimp catch was landed in the southeast Atlantic states. This area ranked second in value and third in volume of the total United States catch.

There are five species of shrimp that are caught commercially: brown shrimp (*Penaeus aztecus*); white shrimp (*P. fluviatiles*); pink shrimp (*P. duorarum*); rock shrimp (*Hymenopeneaus robustus*)

Figure G-4 Atlantic Fleet Operating Areas Within the Eastern Sea Frontier (U.S. Department of the Navy, 1972).

Table G-14

Southeastern U.S. Commercial Fisheries Landings by State, 1973-1974

State	Thousand lbs.	Rank	%	Thousand $	Rank	%
1974						
N. Carolina	206,683	7	68.9	17,544	13	36.8
S. Carolina	18,402	19	6.1	6,861	19	14.4
Georgia	18,157	20	6.1	7,094	18	14.9
Florida (east coast)	56,695	8	18.9	16,211	5	33.9
Total	299,937			47,710		
Southeastern U.S. Total	299,937		6.1	47,710		5.3
Total U.S.	4,939,600			898,500		
1975						
N. Carolina	238,296	7	73	20,003	14	33
S. Carolina	20,078	19	6	13,116	17	22
Georgia	17,751	20	5	11,943	18	20
Florida (east coast)	51,276	8	16	15,603	6	25
Total	327,401			60,664		
Southeastern U.S. Total	327,401		7	60,664		6
Total U.S.	4,841,800			970,800		

Source: U.S. Dept. of Commerce, 1976. Fisheries of the United States, 1975.

Table G-15

Southeastern U.S. Finfish and Shellfish Landings by State, 1972 - 1974

	1972				1973				1974			
Finfish by State	Thousand lbs.	%	Thousand $	%	Thousand lbs.	%	Thousand $	%	Thousand lbs.	%	Thousand $	%
N. Carolina	146,847	75	5,761	50	111,867	69	8,516	55	173,240	82	10,347	60
S. Carolina	5,216	3	718	6	3,886	2	663	4	2,770	1	490	3
Georgia	1,075	1	279	2	7,984	5	241	2	728	1	246	2
Florida (east coast)	42,583	21	4,800	42	38,875	24	6,021	39	33,898	16	6,058	35
Total	195,721		11,558		162,612		15,441		210,636		17,141	
Shellfish by State												
N. Carolina	21,055	29	6,038	19	18,586	29	7,439	19	22,809	31	6,978	23
S. Carolina	16,840	23	7,107	23	17,187	26	10,603	27	16,225	22	6,627	22
Georgia	14,469	23	6,527	21	16,344	25	10,382	27	17,426	24	6,849	22
Florida (east coast)	17,487	25	11,288	37	12,974	20	10,215	27	17,052	23	10,180	33
Total	71,904		30,966		65,091		38,639		73,512		30,634	

Source: U. S. Department of Commerce, 1976.

Table G-16

Major Species of Finfish Caught, Southeastern U.S., 1974

Species	Total Pounds Thousands	Weight Ranking	Total Prices Thousands
Menhaden	133,836,125	1	3,287,481
Flounder	12,143,813	2	2,927,916
Spot	7,729,450	3	926,094
Alewives	6,331,009	4	253,923
Mullet	6,327,045	5	616,124
Sea Trout, Grey	6,187,070	6	657,322
Croaker	6,185,558	7	618,269
Herring, Thread	4,448,184	8	121,975
King Mackerel	4,317,946	9	1,706,029
Bluefish	3,455,693	10	401,109
Catfish (sea)	2,422,148	11	527,802
Spanish Mackerel	1,580,935	12	468,870
Sea Bass	1,476,693	13	616,391
King Whiting	1,353,146	14	263,782
Sea Trout, Spotted	1,016,191	15	482,692
Striped Bass		16	393,187

Source: U.S. Department of Commerce, 1976.

Table G-17

Price/Pound Ranking of Finfish, Southeastern U.S.

Species	Price Per Lb.	Ranking
Pompano	$ 1.14	1
Red Snapper	.72	2
Snapper (unclassified)	.71	3
Hogfish	.45	4
Groupers	.42	5
King Mackerel	.40	6
Sea Bass	.39	7
Striped Bass	.39	8
Tilefish	.36	9
		10

Source: U.S. Department of Commerce, 1976.

Table G-18

Location and Number of Factories
Producing Canned Fishery Products,
Fish Fillets and Steaks,
Southeastern U.S.

State	Canned Fishery Products		Industry Fishery Products		Fish Fillets And Steaks		Total	
	1974	1975	1974	1975	1974	1975	1974	1975
N. Carolina	4	4	11	12	9	7	22	22
S. Carolina	2	2	-	-	3	3	5	5
Georgia	-	-	2	2	1	1	4	3
Florida	2	2	3	4	20	20	18	26

Source: U.S. Department of Commerce, 1976.

Table G-19

Seafood Processing and Wholesale Establishments and Employment, Southeastern U.S., 1973

Area and State	Processing			Wholesale			Total		
		Employment Average			Employment Average			Employment Average	
	Plants	Season	Year	Plants	Season	Year	Plants	Season	Year
Southeastern U.S.:									
North Carolina . . .	81	2,095	1,371	103	403	287	184	2,498	1,650
South Carolina . . .	22	787	619	62	367	213	84	1,154	832
Georgia	14	2,056	1,595	41	295	202	55	2,351	1,797
Florida, East Coast.	42	1,396	1,197	68	191	179	110	1,587	1,376
Total	159	6,334	4,782	274	1,256	881	433	7,590	5,663

Source: U.S. Department of Commerce, 1976.

Table G-20

Number of Full-Time and Part-Time Commercial Fishermen, Southeastern U.S., 1974

State	Full-Time	Part-Time	Total
N. Carolina	2,455	1,850	4,305
S. Carolina	760	860	1,620
Georgia	759	835	1,594
Florida	9,700	1,950	11,650

Source: U.S. Department of Commerce, 1976.

and royal red shrimp (*Sicyonia brevirostris*). The shrimp fishery is based primarily upon exploitation of brown and white shrimp which comprise about 95% of the catch (Table G-15). In the past six years the catch of species have varied from year to year (Table G-21-22). It is noted that the royal red shrimp catch has been on a constant decline from 1970 to 1975, in 1976 there was an increase in landings. The pink shrimp catch has increased in landings, while the brown and white catch has fluctuated from year to year.

Shrimp are caught primarily between May and December in coastal waters. The major shrimp fishing areas along the coast are: North Carolina—Pamlico Sound (50% of annual catch), Core, Bogue, White Oak, New, Cape Fear sounds and the mouths of the Neuse and Newport rivers. South Carolina—St. Helena, Port Royal, Calibougue and Bulls Bay sounds. Georgia—Wassaw, Ossabow, Sapelo, St. Simons, St. Andrew and Cumberland sounds. Florida—Fernandina and the mouth of the St. John's River, St. Augustine, New Smyrna and Cape Canaveral sounds. There areas are most productive from the 15 m contour (50 ft.) or about 9.7-11.3 km (6-7 miles) from the shoreline (see Visual Nos. 5N and 5S). There is less extensive trawling south of Fort Pierce due to coral bottoms. Recreational shrimping occurs between May-December and is concentrated in bays and sounds. About 10-15% of the total shrimp catch in the region may be taken by recreational fishermen (Eldridge and Goldstein, 1975).

Royal red shrimp are a deep water species and are found off Florida between Cape Canaveral and St. Augustine. Their commercial importance has been very limited due to the depths (366-502 m) at which they are trawled (Bullis, 1959).

Blue crabs (*Callinectes sapidus*) are the basis for one of the most stable commercial fisheries of the southeast Atlantic. Crab trawling is conducted primarily in sheltered bays and sounds along the coast of Georgia in areas not exceeding 15 m (50 ft.) (Cummins and Rivers, 1962b).

There have been massive mortalities and a decline in abundance of the blue crab along the South Atlantic coast from 1960 through 1968. First mortalities occurred in June 1966 from Holden Beach, North Carolina to Ossabow Sound, Georgia and continued sporadically throughout the summer. Further mortalities occurred in June 1967, beginning in Georgia and spreading up the coast as far as the Santee River in South Carolina during the summer. Mortalities beginning in April of 1968 were confined to the Georgia coast. These declines affected the economic stability of the crab industry and commercial fishermen witnessed a drop in production from 40.2 million pounds in 1964 to 24.4 million pounds in 1968 (Manhood et al., 1970). Since then, blue crab landings have increased and in 1974 the total catch for the South Atlantic was 38 million pounds. North Carolina leads in amount of catch—13 million pounds at $1.4 million; Georgia ranked second—10 million pounds at $1.2 million; South Carolina and Florida ranked third and fourth respectively bringing 16 million pounds valued at $2 million. In 1974, the total blue crabs caught in the United States was 143 million pounds at $18 million and for the U.S. South Atlantic region, 38 million pounds at $4.5 million. This indicated that the U.S. South Atlantic States produce approximately 27% of the blue crabs caught in the United States. The individual crab fishermen in 1974 received an average ex-vessel price of $0.16/lb.

The calico scallop (*Angopecten gibbus*) is found off the coast of North Carolina and Florida on continental and insular shelves. Off North Carolina, south of Cape Hatteras, they are found from depths of approximately 13 m (43 ft.) to at least 94 m (310 ft.) (Cummins and Rivers, 1962). Off the Florida east coast, their depth has been reported to be from 9-74 m (29-243 ft.) by Drummond (1969). The calico scallop inhabits open marine water and usually does not occur in estuarine areas (Bullis, 1965).

Currents are considered of primary importance in controlling the distribution of scallop larvae and the location of the scallop beds. The beds are generally located along the flow lines of currents running parallel to the coastline and are associated with beds of turtle grass. Off Cape Canaveral they are distributed irregularly in long narrow bands. The greatest concentration occurs offshore from Cape Canaveral, Florida and Cape Lookout, N.C. (Allen and Costello, 1972).

The commercial production of calico scallops remains low (Table G-23). As indicated, there has not been any catch off the North Carolina coast during the past year. However, this industry looks promising as a result of discovery of large concentrated beds off the Florida east coast and the improvement or processing machines used for harvesting.

Table G-21

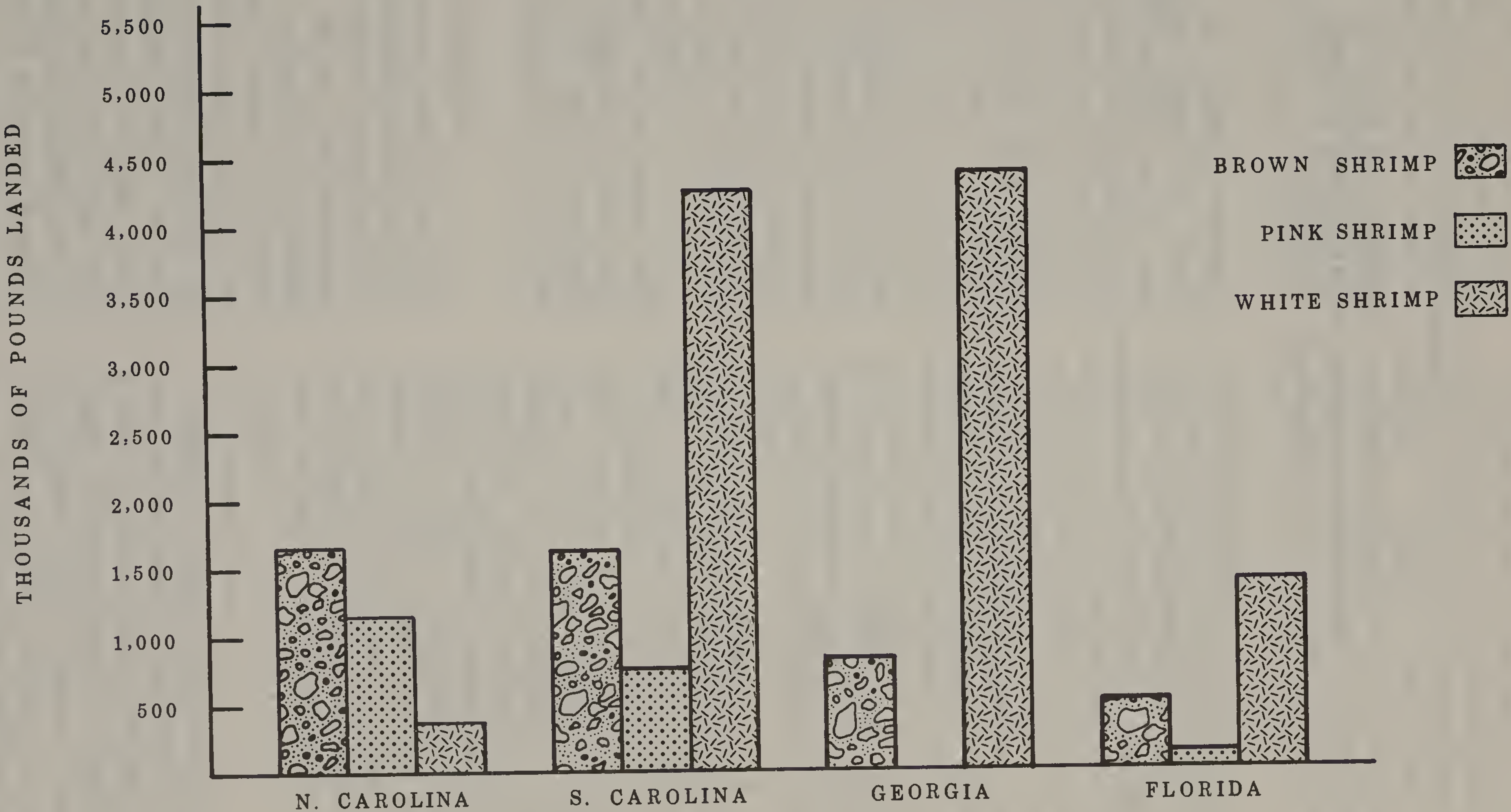
Shrimp Catch for the Southeast Atlantic Region, 1970-1975
(pounds)

	North Carolina	South Carolina	Georgia	Florida (East Coast)
<u>1970</u>				
brown	2,379,976 lbs.	1,160,420 lbs	633,802 lbs	256,314 lbs
pink	534,235	-	775	2,855
white	238,844	2,001,730	3,230,176	2,640,380
royal red	-	-	-	68,323
<u>1971</u>				
brown	3,175,038	1,710,094	716,047	463,702
pink	1,196,660	-	-	-
white	381,994	5,194,397	5,006,227	1,631,865
royal red	-	-	-	87,285
<u>1972</u>				
brown	1,989,967	1,395,522	1,058,507	354,403
pink	492,673	-	-	-
white	1,020,220	3,790,630	3,606,302	2,373,359
royal red	-	-	-	15,408
<u>1973</u>				
brown	1,053,826	1,067,868	377,737	297,401
pink	947,410	-	-	4,423
white	1,166,497	4,244,717	4,960,773	1,473,138
royal red	-	-	-	5,906
<u>1974</u>				
brown	3,809,000	1,291,000	897,000	909,000
pink	1,320,000	-	-	4,000
white	127,000	3,475,000	3,774,000	1,309,000
royal red	-		-	575
<u>1975</u>				
brown	1,601,266	1,478,843	804,964	284,709
pink	1,223,385	7,161	5,520	29,375
white	407,900	4,203,717	4,380,028	1,340,167
royal red	-	-	20,225	6,182

Source: U.S. Department of Commerce, 1976.

TABLE G-22

SHRIMP LANDINGS FOR THE SOUTHEAST REGION, 1975



SOURCE: U.S. DEPARTMENT OF COMMERCE. 1976.

Table G-23

Calico Scallop Landings for the Southeast Atlantic Region 1962 - 1974 (Thousands of lbs.)

Year	N. Carolina	Fla. East Coast
1962	-	-
1963	-	-
1964	-	-
1965	871	-
1966	1,857	-
1967	1,389	21
1968	-	30
1969	-	181
1970	1,574	196
1971	-	-
1972	1,050	302
1973	556	2
1974	-	-

Source: U.S. Department of Commerce, 1976.

Oysters (*Crassostrea virginica*) are found around the mouths of rivers where they enter the sea (Ingle and Smith, 1956). In Georgia, there are approximately 4120 ha (10,180 ac.) of oyster beds that are located intertidally and landward of the barrier islands. The soft mud bottom of the South Atlantic is only marginally suitable for oysters. The beds are better developed in the northern portion of the state where they occur in bands 11-13 km (7-8 mi.) wide. However, all of these beds are located on privately held areas (Johnson, et al., 1974).

Oyster production in the southeast Atlantic states has sharply decreased since 1960. South Carolina leads in oyster production for this area but has had a 33% decrease in the amount of oysters caught. In 1960, a total of 4.1 million lbs. of oysters were landed at a value of $1.6 million for the southeast Atlantic states. In 1974, a drastic decrease to 1.8 million lbs. valued at $1.2 million occurred.

Spiny lobsters (*Panulirus argus*) are caught off the southern tip of the Florida coast. It is an important fishery industry in Dade County, Florida and ranks as the fifth most valuable commercial fishery in the State (Robinson and Dimitriau, 1963). This industry has increased since 1971. In 1974 approximately 3.9 million pounds at $4.8 million were landed in Dade County.

The spiny lobster fishery for the southeastern United States is primarily limited to areas south of Fort Pierce, Florida where there is undulating seafloor topography and/or coral reefs (Little, 1975).

6. Recreation and Allied Resources

The South Atlantic coastal region is noted for its many and varied outdoor recreation resources. Visuals No. 1N and S attempt to geographically identify the major state and nationally recognized public interest areas. Included are publically owned areas like parks, beaches and wildlife lands as well as nationally designated sites and cultural resources, such as natural landmarks and historic register properties. Many nationally designated sites are in private ownership and are not always accessible to the public. The beach areas noted on the visuals were derived from the Corps of Engineers National Shoreline Study and therefore include private as well as public beach areas. A general discussion of the different categories of areas which can provide recreation opportunities are included in the following descriptions.

A. OUTDOOR RECREATION AREAS

Included in this subsection is a discussion of the traditional resources which attract the general public as recreation destination areas. The areas generally described below are specifically identified on Visuals No. 1N and S which also depicts a geographic relationship between proposed sale tracts and individual recreation resource areas.

(1) National Parks:

From the North Carolina-Virginia border to the Florida Keys the National Park Service administers 16 areas under the National Park System. Areas in the National Park System were set aside by the National Congress specifically to preserve recreational, natural and cultural resources of national significance and to systematically devise management schemes which will maximize public appreciation without endangering the resources. Included are four National Seashores, one National Park (Everglades), six National Monuments, two National Historic Sites, two National Memorials and one National Military Park.

In 1975 the most heavily visited National Park areas along the South Atlantic coast were Cape Hatteras National Seashore which received over 1.5 million visitors and Everglades National Park which 866,000 people chose to visit. Included within the 16 areas along the South Atlantic seaboard are three recently authorized areas which are currently undergoing acquisition and development phases. Included in this category are Canaveral and Cumberland Island National Seashores and Biscayne National Monument. All three areas should attract a large percentage of the recreating public seeking water oriented and water enhanced recreation activities in the years to come.

(2) National Forests:

Within the coastal region of the South Atlantic there are the three National Forests encompassing a total of 759,244 acres (307,256 hectares). The Croatan National Forest in North Carolina and the Francis Marion National Forest in South Carolina are located within a few minutes drive from the Atlantic coast whereas the Ocala National Forest is approximately an hour's drive inland from the east coast of Florida.

All national forests present a forest based recreation environment managed by the U.S. Forest Service under the multiple use principle for wood, water, forage, wildlife and recreation. The three national forests found in the South Atlantic coastal region have specifically designated recreation sites accommodating the recreation needs of campers and picnickers, however the greatest public use stems from dispersed recreation use throughout the forest environment. Opportunities for hunting, freshwater fishing, hiking and sightseeing attract most visitors to national forest in the coastal zone.

(3) *National Wildlife Refuges:*

Twenty national wildlife refuges are located along the South Atlantic coast. Most tend to be oriented towards the protection of waterfowl and other wetland wildlife, however all encourage public visitation and accommodate those recreational activities that are compatible with the primary wildlife mission of the refuges.

Most refuges like Pungo National Wildlife Refuge in North Carolina which is primarily a Canada Goose wintering area encourage activities such as nature study, photography and wildlife observation. Other refuges like Merritt Island, Blackbeard Island and Cape Romain have areas specifically designated for public hunting and fishing.

(4) *State Parks:*

Over 30 state parks dot the coastal area. These are rather well distributed along the coast with a slight concentration in Florida. These recreational areas vary in size and function from multi-activity recreation areas to sites managed specifically for historical interpretation. Similar to the National Park System some states have established classification systems for their state parks which distinguish between recreation areas, historical areas, preservation or natural areas, demonstration areas, etc.

Examples of state parks would include Hammocks Beach State Park, an 890 acre (360 hectare) facility on the seashore of North Carolina. The park offers facilities for picnicking, camping, boating, swimming and fishing. In contrast to this is Old Dorchester State Park in South Carolina. This is the site of a Revolutionary War fort. It is only 8.9 hectares (22 acres) in size and offers few activities other than visiting the fort. John Penneycamp State Park on the southeastern coast of Florida is a unique type state park focusing visitor use and appreciation of submarine resources such as coral reefs and shipwrecks. Another underwater park on black rock reefs off Topsail Beach, North Carolina is currently under consideration. Here again, delicate reefal flora and fauna will be the focus of submarine users attracted to this natural resource.

(5) *State Forests:*

State forests are managed primarily for timber resources but like national forests they provide an environment suitable for forest recreation activities. Cary State Forest in northern Florida is the only state forest located in a coastal county along the South Atlantic seaboard. State forests generally are considerably smaller than national forests found within the South Atlantic region but provide similar type recreational activities compatible with a forest environment.

(6) *State Wildlife Refuges and Management Areas:*

Although management goals may differ somewhat from state to state, these areas serve primarily to maintain habitat and breeding space for wildlife, and to provide wildlife-oriented recreation under closely controlled conditions.

There are 25 such areas along the coast extending from Northwest River Marsh State Game Land in northeastern North Carolina to Everglades State Wildlife Management Area north of Everglades National Park.

(7) *Local Outdoor Recreation Areas and Facilities:*

In addition to Federal and State recreation areas, there are numerous city and county parks and recreation areas in the coastal zone. These facilities are generally found in and around the major population centers where the demand is greatest. In addition, private and commercial recreational facilities exist in great numbers along the South Atlantic coast. The list could include resorts, marinas, tennis clubs, amusement and theme parks, water access sites and many others. Due to their large number, small size, and difficulty in obtaining comparable data for the entire area a complete mapping or listing of these facilities and areas was not attempted.

(8) *Specifically Designated Areas:*

This subsection was included to describe those classification systems which designate certain natural resources of state and national significance. Such areas are usually so identified in order to proclaim the value of their innate natural qualities and to foster the preservation of these same qualities for educational, aesthetic and scientific purposes. These same areas either by design or happenstance accommodate a selected range of recreation activities.

The National Natural Landmark Program administered through the National Park Service has as its primary objective to encourage the preservation of sites illustrating the geological and ecological character of the United States. Publicly or privately owned, a Registered Natural Landmark is a selected portion of America's land and waters.

Because of the rapidly growing nature of the natural landmarks program, both actual sites and sites being considered for inclusion into the register by the National Park Service are included on Visuals 1N and S. There are 56 such sites identified along the South Atlantic coastal area, many of which are included as part of outdoor recreation areas such as state parks or national wildlife refuges.

The State of Florida as well as the Federal Government have established marine preserve systems.

Florida owns about 25,806 sq. km (10,000 sq. miles) of submerged tidal lands. Much of this submerged land supports biological, aesthetic and other natural features important ecologically and for outdoor recreation. To set aside certain exceptionally valuable and representative areas for perpetual public enjoyment and to preserve important natural systems, a statewide system of aquatic preserves was established in 1969. Eleven aquatic preserves are distributed along the coast, most being located in lagoons behind the barrier islands which extend along much of the eastern coast of the state.

Title III of the Marine Protection Research and Sanctuaries Act of 1972 gave the Secretary of Commerce (NOAA) the authority to designate national marine or estuarine sanctuaries in coastal marine waters. Within the geographic jurisdiction of this statement the John Penneycamp Marine Sanctuary off the southeast coast of Florida and the Monitor Marine Sanctuary seaward of North Carolina's Cape Hatteras National Seashore have thus far been designated.

There are no nationally designated wild and scenic rivers in the coastal area of the four states influenced by this proposed sale. The Ogeechee River in Georgia is the only waterway thus far identified as a potential study river for national classification. All states however have enacted enabling legislation and are progressing towards selection of specific rivers for recognition, protection and management in state administered systems.

The Department of Natural Resources in the State of Florida has developed a canoe trail system. Rivers identified with stretches denoted as pleasant for canoeing along the east coast include: St. Mary's, Econlockhatches, and Loxahatchee Rivers and Bulow and Spruce Creeks.

(9) *Recreation Beaches and Barrier Islands:*

Wherever they are accessible for recreational use the sandy beaches and barrier islands along the South Atlantic coast are of major recreational importance. From Cape Hatteras, North Carolina to Key West, Florida, an ocean shoreline distances of 1917 km (1,192 miles), a wide variety of recreational opportunities, numerous unique environmental areas, and panoramas of scenic beauty can be found. Included in this extensive expanse of shoreline is 1575 km (979 miles) of ocean beach in addition to 12,956 km (8,052 miles) of bay/estuary shoreline. As a matter of law most states recognize that portion of beach property between the mean high and mean low water lines as public trust land dedicated to citizen use and enjoyment. Furthermore, some states, Florida for example, have shown through litigation that the privately held dry sand beaches above the mean high water line are subject to the interest and rights of the public to customary recreational uses (Fla. 1974).

The predominance of barrier islands is another characteristic of the South Atlantic coast. Examination of coastal charts as well as Visuals 1N and S will show that barrier islands align almost the entire South Atlantic seaboard. These islands vary considerably in size, shape, length, width, height, vegetational characteristics and development. They are generally backed by shallow, narrow lagoons, bays or sounds usually with extensive marsh systems.

The 1575 km of sandy beach along the South Atlantic coast are generally composed of quartz type sand with shell content varying widely. The beach at Hunting Island, South Carolina for example, is composed of very fine gray sand almost devoid of any shell fragments, whereas near Flagler Beach, Florida, the content of reddish shell fragments in sand is high enough to give a rusty appearance to the beach. Whatever the type, all the natural beaches along the South Atlantic states unspoiled by incompatible human activities are very attractive recreational resources.

Table G-24, a summary of South Atlantic shoreline resources, as well as much of the resource data in this subsection comes from the Corps of Engineers National Shoreline Study Report (1973). As is indicated in the table a large percentage of the beaches and islands along the South Atlantic coastline are in public ownership. Many of the national and state parks and wildlife areas noted earlier in this section comprise a large percentage of this shoreline resource. Recent national and state acquisition programs are dedicating additional shoreline acreages to park and wildlife programs. The beaches of Cape Canaveral and the uplands of Cumberland Island are two examples where the National Park Service is currently devising use schemes which will encourage public appreciation of the inherent natural values of these lands. Suitable portions of the Federal recreation estate are also being considered and included in the national wilderness system.

Much of the privately controlled beach frontage and coastal islands also serve as recreation attractions in the form of resorts, country clubs, marinas, private residences, and tourist accommodations. Examples would include South Carolina's 80.4 km (50 mile) seashore vacation land and residential area known as the Grand Strand and the Sea Pines Resort on Hilton Head Island.

In summary, shoreline recreation resources such as beaches and barrier islands serve as a first line of defense or natural buffer between ocean waters and inland areas. Likewise this buffer area and transition zone is also potentially vulnerable to offshore oil spills and to direct visual impact from any nearshore structures or lease generated traffic.

b. Coastal recreation activities

The diverse environments found in areas where water and land converge presents an interesting setting for leisure pursuits. In the more than 1900 km (1,200 miles) of ocean shoreline from North Carolina to Southern Florida one finds barrier islands, coastal beaches, estuarine bays and sounds, the tidal marshes contributing to an atmosphere supportive of water dependent and water enhanced outdoor recreation activities.

Traditionally, the shoreline of the Atlantic Ocean has provided residents of Coastal States and tourists with an opportunity to enjoy and participate in a wide range of activities. A precise assessment of the scope of this public use is difficult. No comparable use figures regarding user activities in the immediate coastal area are available for the four states adjacent to this proposed lease sale. All states, however, show swimming, fishing, picknicking and boating as some of the most popular forms of outdoor recreation statewide. Likewise, State Comprehensive Outdoor Recreation Plans (N.C., S.C., Ga., and Fla. SCORPS, 1971, 1972, 1975 and 1976) for the four South Atlantic Coastal States show beach activities, fishing, nature appreciation, camping and hunting as forms of outdoor recreation sought by residents and out-of-state visitors. Hunting, fishing, nature appreciation, camping and beach appreciation are forms of recreation especially popular along the undeveloped islands inaccessible to automobiles along the coasts of North Carolina, South Carolina and Georgia.

Other coastal recreation activities occurring on the immediate shoreline potentially affected by this proposed sale are resource dependent with very little published materials on the nature and scope of public use. Examples would include clamming, crabbing, oyster gathering, cast netting, etc.

The area most directly affectable by the proposed oil and gas lease sale would be the offshore marine environment or the Atlantic Coastal waters (neritic zone). These waters serve as a basic resource for the two major outdoor recreation activities common to the four states-recreational boating and fishing.

c. Recreational boating

The third most popular recreational activity within this entire region is boating. Ridgeley (1975) estimated that the South Atlantic Region (excluding Florida, which was included in the Gulf Region) had 751,000 recreational boats of all sizes and that approximately 157,000 of those fished in salt water at some time. With the inclusion of the eastern coast of Florida in the region,

Table G-24. SOUTH ATLANTIC - Selected Shoreline Information (kilometers)

	OCEAN		OWNERSHIP		
State	Shoreline	Federal	Non. Fed. Public	Private	Uncertain
No. Carolina	515	225	21	269	0
So. Carolina	300	40	24	224	13
Georgia	148	26	18	105	0
Florida (West Coast	954	76	92	719	67
Total	1,917	367	155	1,318	80

	BAY/ESTUARY		OWNERSHIP		
State	Shoreline	Federal	Non. Fed. Public	Private	Uncertain
No. Carolina	5,367	890	74	1,408	3,204
So. Carolina	4,627	660	2,312	1,115	541
Georgia	180	21	18	142	0
Florida (West Coast)	2,772	180	48	2,544	0
Total	12,955	1,551	2,452	5,209	3.744

Source: Extracted from Corps of Engineers National Shoreline Study, 1973.

this part of the nation would rank high in its use of coastal waters for recreational boating activities of all kinds.

North Carolina's coast with its outlying banks is particularly well suited to recreational boating. Recreational development on the mainland along the coast reflects this in the construction of 80 marinas, 50 fishing piers and 75 boat ramps.

Approximately 14% of all North Carolina households own a boat. Considering all households in the state together, about 2.5 days per year per household are spent in some kind of boating activity (North Carolina Department of Natural and Economic Resources 1972).

In 1968, figures indicated that 10 million participation days were spent fishing and 3.4 million for boating. Boating has shown an increase in the state of nearly five times the population growth. To support the fishing and boating activity, there were 106,000 outboard motors of 10 horsepower or more, and 10,000 inboard motors. Deep sea fishing is supported by 154 charter boats, 14 "head or party boats" and a large portion of the inboard motor boats registered in the state (Planners, Inc. 1974).

In South Carolina, the Department of Parks, Recreation and Tourism has collected data for the entire state by subregions, a system which allows a study of only the coastal subregion. The study reveals 70 boat ramps along the coast with berthing for 1,228 boats in marinas. In addition, rental boats of various sizes provide seating for a total of 897 persons (Planners, Inc. 1974). A total of 28,319 power boats were registered in coastal counties during 1973 (South Carolina Division of Research and Statistical Services, 1974).

A study by the State of Georgia (1975) indicated that there were about 70 points along the coast where boats have access to water. This includes some 20 boat ramps, 26 fish camps and 17 marinas. The study also indicated that the lack of public access to many coastal islands hampers their potential use as recreational boat launching points. Throughout the state, boating is the eighth most popular recreational activity with 5.05% of the adult population participating (State of Georgia, 1972).

Florida's climate and her status as a recreational mecca for out of staters helps boost the importance of boating in the state. Figures from "Outdoor Recreation in Florida", are given based on state planning regions. In order to concentrate mostly on the coastal areas, figures for salt water are used here; however, it must be recognized that fresh water boating activities extend from the inland into the coastal areas. In 1971, the Florida coast north of Palm Beach provided 114 salt water oriented boat ramps, 43 marinas and 21 boat lifts. These structures can economically provide for the peak demand needs of 54,315 persons per day (State of Florida, 1971).

Finally, the Intracoastal Waterway plays a part in recreational boating in all of the states by providing a safe, well marked channel for coastwide navigation for short distance travel, but also for the very long distance movement of pleasure craft.

d. Sport fishing

A salt water angling survey conducted by the National Marine Fisheries Service (NMFS) in 1970 provides the most recent comprehensive sport fishing statistics for the South Atlantic (Deuel, 1973, Table G-25). However, Deuel (1975) has in progress a survey on recreational fishing in the South Atlantic for calendar year 1975 which will be published by the Division of Statistics and Market News—NMFS at a later date.

Geographic boundaries for the South Atlantic angling survey of 1970 are from Cape Hatteras, N.C. to southern Florida including the Florida Keys.

It was estimated that 1,808,000 salt water anglers were active in the South Atlantic in 1970. The estimated number of fish landed was 184,177,000 with a weight of 403,913,000 pounds. The principal method of fishing was by private or rented boat with bridge, pier or jetty ranking second, party or charter boat third, and beach or bank fishing ranking fourth. The principal area of fishing was the ocean, with sounds, rivers and bays second. Table G-26 gives a breakdown of these statistics.

The offshore charter boats fish from 8-121 km (5-75 mi) off the coast for big gamefish. These boats specialize in offshore trolling for fish ranging from Spanish and King mackerel to sailfish and blue marlin. These boats operate under a fixed fee depending on the species of fish sought. Usually four to six fishermen are accommodated on these trips.

Inshore charter boats generally carry three to six anglers for a fixed fee per trip. These boats fish the rivers and sounds specializing in sea trout, channel bass, flounder and cobia.

Table G-25 Estimated number of salt-water anglers and their catches in the United States in 1960, 1965, and 1970, by survey region

Region	Number of anglers			Number of fish caught			Weight of fish caught		
	1960	1965	1970	1960	1965	1970	1960	1965	1970
	- - - - - - - - - Thousands - - - - - - - - -						- - - Thousand pounds - - -		
I. North Atlantic (New England and New York)	1,160	1,530	1,666	97,383	172,660	117,014	183,740	316,360	267,451
II. Middle Atlantic (New Jersey to Cape Hatteras)	1,344	1,375	1,767	114,502	92,126	168,209	178,000	128,288	246,267
III. South Atlantic (Cape Hatteras to Florida Keys)	1,024	1,720	1,808	156,942	190,802	184,177	370,112	391,833	403,913
Gulf of Mexico 1/ (Florida West Coast to Texas)	1,412	--	--	184,582	--	--	411,110	--	--
IV. East Gulf of Mexico (Florida West Coast to Mississippi River)	--	1,234	1,478	--	104,551	188,888	--	187,957	334,120
V. West Gulf of Mexico (Mississippi River to Texas)	--	738	872	--	89,550	97,708	--	187,618	151,608
VI. South Pacific (Pt. Conception South)	687	978	894	50,064	48,542	37,221	154,120	176,828	94,234
VII. North Pacific (Pt. Conception North)	714	999	1,311	23,399	38,508	24,100	83,219	85,469	79,230
ALL REGIONS	6,198 2/	8,236 2/	9,392 2/	632,872	736,739	817,317	1,380,301	1,474,353	1,576,823

1/ The Gulf of Mexico was not separated into East and West sampling regions for the 1960 Angling Survey.
2/ These figures are less than the sum of anglers for the individual regions because some anglers fished in more than one region.

Source: (Deuel, 1973)

Table G-26 Salt-Water Fishermen and Their Catches by Principal Area and Method of Fishing - 1970

Region	Principal area of Fishing		Principal methods of fishing			
	Ocean	Sounds, rivers, and bays	Private or rented boats	Party or chartered boats	Bridge, pier, or jetty	Beach or bank
	Thousands					
South Atlantic:						
Number of fishermen...	1,127	773	505	450	565	483
Number of fish caught.	112,203	71,974	74,214	19,545	47,555	42,863
Total weight (000 lbs.)	287,385	116,528	224,476	56,417	69,363	53,657

Source: (Deuel, 1973)

Offshore head boats fish bottom areas which lie 8-80 km (5-50 mi) off the coast, depending on whether black sea bass or larger snapper and grouper are being sought. A wide variety of trips are offered by these boats depending on what type of fishing the angler desires and how much time he has to spend. Fees are charged per angler, usually with discounts to large groups.

Freeman and Walford (in press) will present a geographical study of marine recreational fishing for the South Atlantic in a series of publications entitled "Angler's Guide to the United States Atlantic Coast". The purpose of this publication will be two-fold. First, it will serve as an atlas dealing with the location of the fishing grounds, the various boating and fishing facilities, local conditions and characteristics of fishing, as well as the diagnostic features, life habitats and environmental requirements of fishes that are of particular interest to anglers. Secondly, it will serve as an assessment of knowledge about marine fishes which anglers catch, including their life conditions, and the status of those fishes in the 1970's.

Salt water sportfishing as previously stated includes an inshore and offshore fisheries, with approximately 400 species of fish found in these waters. Bearden and McKenzie (1973) listed three major ecological groupings being prominent:

Inshore species: both resident and migratory fishes are found close to shore and in the coastal estuaries including: drum, croaker, spot, flounder, sheepshead, shad, striped bass, sea trout, cobia and channel bass.

Offshore migratory species: seldom found inshore except when young: tunas, mackerels, jacks, bluefish, dolphin and billfish.

Offshore bottom species: found on reefs, rough bottom areas and old wrecks: black sea bass, snappers, porgies, groupers and grunts.

Discussions and locations on reefs, rough bottom areas ("live bottom") and artificial reefs may be found in Section II.E.l.g. and Visual Nos. 4N and 4S.

(1) North Carolina

North Carolina coastal salt water fishermen are faced with the problem that most close to shore ocean bottoms are barren sand and silt surface. Fish are usually rather sparse in these areas. For a good catch, fishermen usually go to capes or shoals to try for the schooling fish. Stone jetties near inlets also attract fish. Other good fishing sites include offshore wrecks, which are usually not too accessible to the fisherman with a smaller boat. Recently, however, another alternative, artificial reefs, has been added. The reefs are located close to shore so therefore, most fishermen that have a boat of moderate size can safely reach them as well as the live bottom areas so popular with coastal fishermen. Like live bottoms, artificial reefs provide habitat for bottom dwelling fish and attract ocean ranging fish.

Robertson (n.d.) gives a complete description of salt water fishing in North Carolina in an atlas entitled "Salt Water Sport Fishing and Boating in North Carolina" which indicates a fishery similar in species and seasons to those for the other South Atlantic States.

(2) South Carolina

The following discussion was taken from Bearden and McKenzie (1973).

The inshore group of fishes is the most important and is sought by pier, surf and small boat anglers. The most frequently caught inshore species in South Carolina waters are as follows: spotted sea trout (winter trout), channel bass (red drum), spot, flounder, king whitings, Spanish mackerel, black sea bass, croaker, bluefish and black drum.

The major types of fishing in the State are shore, pier and bridge, small boat, charter boat and head boat fishing. Small boat fishing in the tidal rivers, sounds and near-shore ocean waters is the most popular form of saltwater angling activity. Recently, the offshore fishing grounds on the continental shelf areas were recognized as almost virgin territory with an unlimited potential for big game fishing. The addition of man-made fishing reefs in certain less productive areas of the ocean had led to excellent near-shore bottom fishing and trolling opportunities.

Aside from excellent hook and line fishing, the Palmetto State offers other saltwater recreational fishing activities such as crabbing, shrimping, clam digging and oyster picking in almost any unspoiled area along the coast.

(3) Georgia

While the best salt water fishing is found in Georgia during the fall and winter months, many fishermen are sucessful almost year round (Georgia Department of Natural Resources, n.d.).

Because of the vast stretches of estuaries and sounds, a major portion of Georgia's salt water fishing activity takes place in inshore waters.

Coastal anglers fish from piers, bridges, banks and small boats. Common fish caught include seatrout, striped bass, black sea bass, sheepshead, shad and tarpon.

Offshore species found in Georgia waters include Spanish mackerel, bluefish, cobia, red snapper, flounder, crevalle jack, greater amberjack, little tuna, king mackerel, great barracuda, Atlantic bonita and even sailfish. The warm Gulf Stream waters pass by Georgia on the way from Florida to North Carolina, and species that are taken either north or south may be caught in Georgia waters.

In July and August, huge schools of Spanish mackerel and bluefish move with the Gulf Stream northward from the Bahamas. They are caught by trolling 8-10 km (5-6 mi) from shore and at the mouths of the large sounds between the offshore islands.

(4) Florida

Salt water sport fishing is very important in Florida. According to Taylor et al. (1973) the sport fishing "industry" earned $350 million in 1971 and had been growing at an annual rate of $25 million per year. Man-days spent in salt-water sport fishing in 1971 were estimated at 8,800,000. No breakdown in the statistics was made between the Atlantic and Gulf coasts of Florida, but the Florida Department of Natural Resources estimated in 1972 that approximately 50% of the salt water sport fishing in Florida can be attributed to the Atlantic coast.

The Florida Department of Natural Resources, and the Florida Marine Patrol (1975), Tallahassee, Florida give weekly, quarterly and annual salt water sport fish forecasts by areas for the entire coastline. Areas VII and VIII represent the area of concern for the South Atlantic BLM planning unit (Table G-28).

The annual report for 1974 (Tables G-27 and G-28) presented a diversity of sport fishing opportunities for the two areas. Common fishing locations included canals, inlets, surf, rivers, pier and jetties, bridges, beaches and offshore. Offshore areas include wrecks, reefs, holes and artificial reefs. Many species were abundant all year while some species were only seasonal.

e. Cultural resources

(1) Procedures used to identify cultural resources

In the OCS area covered by this description cultural resources data offshore is uneven in its coverage and level of detail. The data acquired was limited solely to information on the locations of shipwrecks. The locations for onshore cultural resources were obtained from national and state lists as there has been no cultural resource inventory work carried out by the BLM in the study area.

Information on cultural resources on the sea bottom was obtained from three sources containing the locations of shipwrecks. The most complete as far as area coverage is the Unclassified Non-Submarine Contracts List (1976) produced by the U. S. Navy Oceanographic Office. The list is concerned mostly with post-1900 shipwrecks; however, older shipwrecks are also included but not identified. Another source is An Oceanographic Atlas of the Carolina Continental Margin (Newton et al., 1971) which contained a detailed map and descriptive list of shipwrecks of all ages in the Cape Fear-Cape Hatteras Region. The third source is a map entitled Shipwrecks and Submerged Archaeological Sites in Florida Coastal Waters (Florida Department of State, 1973). Shipwrecks are represented on Visuals Nos. 4N and 4S.

Coastal cultural resource information was obtained from two basic sources. The Federal Register of February 10, 1976, updated to May 4, 1976 provided a list of sites on, or eligible for inclusion, on the National Register of Historic Places. These sites are represented on Visual Nos. 1N and 1S. Further data was obtained in contacts with the State Historic Preservation Offices of the various states. These are in the form of maps or lists of sites of historic or archaeologic nature which are considered important.

(1) North Carolina, 1975. North Carolina Historical Commission list of National Register Sites, National Historic Landmarks and G. S. Chapter 121 properties.

(2) South Carolina, 1975. List by county of National Register Sites, state historic sites, and archaeological sites.

(3) Georgia, 1975. "Resources for Preservation". Maps by County from; Coastal Resources Maps prepared by Resource Planning Section, Department of Natural Resources.

(4) Florida, 1973. Shipwrecks and Submerged Archaeological Sites in Florida Coastal Waters, map by Division of Archives, History and Records Management.

(2) Cultural context

Shipping, and hence shipwrecks, in the waters of the Southeast cover a five hundred year span of time. Probably the greatest early concentration of shipping and shipwrecks is along the Florida coast related to the movement of Spanish treasure

Table G-27 Florida Annual Salt Water Sport Fishing Forecast

Area VII - Volusia, Brevard and Indian Counties (1974)

Fish Available	Most Abundant	Location
Shad	January-March	St. Johns River
Trout	All Year	Deep holes, flats in summer and canals in winter
Flounder	January-September	Inlets and surf
Pompano	All Year	Surf, inlets and rivers
King & Spanish Mackerel	All Year	Offshore, piers and jetties
Redfish	All Year	Inlets, rivers and surf
Tarpon	October-December	Beaches and inlets
Bluefish	October-March	Inlets and surf
Drum	All Year	Piers, bridges and inlets
Red Snapper, Grouper	April-December	Offshore

Source: Florida Department of Natural Resources
Florida Marine Patrol, 1975

Table G-28 Florida Annual Salt Water Sport Fishing Forecast

Area VIII - Duval, Flagler, Nassau and St. Johns Counties
(1974)

Fish Available	Most Abundant	Location
Speckled Trout	All Year	Inlets and rivers
Redfish	All Year	Inlets and rivers
Flounder	October-June	Inlets and rivers
Drum	January-March	Inlets and rivers
Sheepshead	October-March	Jetties
Bluefish	January-October	Piers and inlets
Whiting	All Year	Surf
Sailfish	July-September	Offshore
Tarpon	July-September	Inlets and sounds
Grouper and Red Snapper	July-September	Offshore
Spanish & King Mackerel	July-December	Offshore
Pompano	April	Surf and piers

Source: Florida Department of Natural Resources
Florida Marine Patrol, 1975

fleets (Florida Dept. of State, 1973). While taking advantage of northeasterly winds and the currents of the Gulf Stream, Spanish fleets traveled northward along the Florida coast before striking out across the Atlantic, storms wrecked a large number of these vessels in shallow waters along the southern part of this region.

Later shipping associated with the settlement and economic development of the coastal area by the English concentrated itself further towards the north, especially off the coast of the Carolinas.

Here vessels engaged in coastal trading frequently came to grief along the coast. A particularly heavy toll of vessels was extracted by the rough, shallow waters around Cape Fear and Cape Hatteras (Newton, et al., 1971).

As settlement and economic development progressed during the nineteenth century shipping increased considerably and the waters of the region contained numerous ships plying the coastal trade business, international trading ships, and some fishing vessels. During the age of sail, when ships were more at the mercy of the elements than the powered ships of today, wrecks along the coast were frequent, again with heavy concentrations in the Cape Fear and Cape Hatteras areas.

The Civil War increased the number of wrecks throughout the offshore area due to naval operations associated with the blockade of Confederate ports, and from losses due to increased traffic. Finally World War I and II added numerous wrecks from natural and combat (mostly submarine) related activities.

The entire ocean area covered by this statement has the potential for holding shipwrecks, however the number of known wrecks decreases very rapidly with distance from shore. The entire coastline and its associated shallow waters has a high potential for containing shipwrecks but the largest concentrations appear to be in the Florida area (Spanish treasure ships) and the Cape Fear-Cape Hatteras area (ships of all ages).

It is difficult to determine the time span during which man has occupied the southeast coast of North America. Evidence varies widely in occupation dates for most parts of the continent, but 12,000 (Before Present) is generally accepted as a date at which many parts of the continent became occupied by Paleo-Indians (Coastal Environments Inc. n.d.). Evidence of such occupation is scattered and difficult to locate but numerous sites have been found in the southwest. During this period of time the last of the continental ice sheets was in the process of melting, and sea level was rising from its estimated lowest level of over 100 m (328 ft.) below present sea level. At the appearance of the Paleo-Indians sea level is estimated to have been approximately 40 m (131 ft.) below present. Thus, Paleo-Indian living sites could be found in areas presently covered by the Atlantic Ocean.

Indian occupation of the coastal area is documented both by archaeological techniques and by the observations of early European explorers and settlers. The Indian population of the area at the time of early European settlement was unknown but estimated to be over 50,000, most of whom lived within one day's travel from the coast. Villages varied in size from 50 to 200 inhabitants, were surrounded by considerable agricultural clearings, and were apparently frequently moved (Brown, 1948). The Indians hunted, fished, gathered wild foods and practiced farming. Evidence of their occupation of the areas can be found in the form of mounds and shell middens, pottery sherds and stone tools (Hoag, 1956). Sites with evidences of Indian occupation are most frequently found along stream courses, high dry areas along bays and on coastal islands (Martin, 1962).

European settlement of the region began with the Spanish in the St. Augustine area in the mid-1500's (Brown, 1948). The English arrived later, failing to establish colonies at first, but finally succeeding in the late seventeenth and early eighteenth centuries. Expansion along the coastal area of the Carolinas progressed rapidly and by the late eighteenth century the area was essentially completely European (Clay et al., 1975). Settlement of the coast as far south as St. Augustine was completed by 1820, and as far south as Cape Canaveral by the end of the nineteenth century (Dept. of the Interior, 1970). Cities like Wilmington, Charleston, Savannah and St. Augustine were all fairly well developed urban centers by the early nineteenth century.

As a result of the early development of the region in American history, there are innumerable roads, trails, structures and sites of historic importance. This is reinforced by the additions of sites associated with the Civil War.

The most recently developed area is southern Florida, where settlement and development is to a large extent a product of the twentieth century, and where in places such as the NASA space center at Cape Kennedy important historic sites date back only a few years.

(3) Summary of known cultural resources

There is at present only one known National Register or Eligible Site in the OCS Area covered by this study. The wreck of the ironclad warship "U.S.S. Monitor" is located in a NOAA administered marine sanctuary about 26 km south-southeast of Cape Hatteras Light. Table G-29 contains a list of National Register Sites, National Register Eligible Sites (as of May 4, 1976) and other sites on state registers or of state interest which are, as much as it is possible to determine from maps, directly on the coastline, or in state waters within the region. Many of these are represented on Visuals 1N and 1S.

(4) Summary of the unknown cultural resources

Except for a small percentage of the shipwrecks probably in this OCS area, very little is known of the location and numbers of vessels sunk along the South Atlantic coast. Earlier vessels, lacking communications equipment must have sunk without word ever being sent as to the location of the wreck. Vessels are often abandoned before sinking, leaving the ship to finally go down, after drifting, in an unknown location. A knowledge of the location of a sinking is frequently not the location of the wreck, which may float beneath the surface for some time, or which may slide along the bottom due to the effects of storms or currents.

Even less is known about living sites beneath Atlantic waters. That sea level was lower than at present in various stages of glaciation during the Pleistocene has been fairly well documented by various sources from different parts of the world. The exact amount of sea level depression is still limited to estimates. Assigning a date 12,000 B.P. for the arrival of Paleo-Indians in the coastal area would mean sea level was approximately 40 m below the present level (Coastal Environments, Inc., n.d.). Simply put this would mean that areas presently under 40 m (131 ft.) of water or less would have been dry land surface. Certain things complicate the picture, however. Geologic changes in the level of the surface are important. A particular part of the sea bed may have risen 20 m while sea level rose 40 m (131 ft.), leaving the area now under only 20 m (66 ft.) of water. Likewise, if an area has been geologically depressed, say 20 m (66 ft.) the once dry land surface will now be 40 m (131 ft.) plus 20 or 60 m beneath present sea level. Using the simplest assumption, that sea level was depressed about 40 m and therefore all sea floor covered by 40 m or less was exposed, a broad plain roughly 80 km (50 miles) wide could be added to the present coastline (Coastal Environments, Inc. n.d.). Since we find a high concentration of Indian living sites near the coast today, we might assume that Paleo-Indians likewise tended to live along the coastline. This would put possible Paleo-Indian living sites out as far as the present 40 m (131 ft.) depth line, about 80 km (50 miles) into the Atlantic near Georgetown, S.C., 95 km (59 miles) out at Savannah, Ga., and 106 km (66 miles) out at Brunswick. No sites are known at present, rather geologic and archaeological evidence points to the possibility of underwater sites. A detailed study should be carried out along the South Atlantic OCS region to determine geologic trends, in order that a more accurate estimation of the approximate extent of dry land during Paleo-Indian and later times. Under such a time as the study is completed and a more authoritative depth than the 40 m postulated herein determined, all tracts proposed for leasing will have to be considered capable of containing prehistoric living sites.

On land far more is known about historic and archaeological sites, however more is constantly being discovered. As man explores the coastal area more throughly more and more sites will come to light. The National Register list is constantly expanding and any OCS related operation on shore will have the potential of unearthing archaeological sites.

7. Solid Waste

Solid waste management is considered a state and local problem. The Federal government has no jurisdiction over disposal practices at other than Federal installations. It does provide grants for research and the development of new methods of collection and disposal and purchases recycled materials. It has, in the past, funded demonstration projects for new technologies and has tried to eliminate discriminatory interstate transportation rates.

Most states require regional or county management plans specifying conditions and future alternatives. Regions and counties are urged to

Table G-29

National Register Sites, Sites Eligible for the National Register, and Other State Sites

North Carolina

Currituck Beach Lighthouse
Wright Brothers National Memorial
Nags Head Woods
Fort Macon
Gibbs House
Jacob Henry House
Cape Lookout Light Station
Fort Fisher
Bold Head Light House
Fort Caswell

South Carolina

Chapin Company
The Hermitage
Cedar Hill
Sunnyside
Atalaya
LaBruce-Lemon House
Pawley's Island Historic District
E. C. Boyle House
Bartol-Calhoun House
Winyah Bay Jetties
Bull's Island Fort
Crow Island
Sullivan's Island Historical Area
U. S. Coast Guard Historic District
Old Army Historic Area
Ft. Moultrieville
Moultrienlb Historic District
Mt. Pleasant Historic District
Castle Pinckney
Battery Thomson
Ft. Sumter
Battery Gasden
Ft. Johnson
Stiles - Hinson - Thompson House
Seabrooks Beach Battery
Presbyterian Manse
Nell S. Graydon House
Edisto Beach Battery
Coffin House
Ft. Gilmore

Table G-29 (continued)

Fort Walker
Easterbrook Battery Braddock Point
Bloody Point Lighthouse

<u>Georgia</u>

Fort Pulaski National Monument
Eugene O'Neill House
St. Simons Lighthouse Keepers Building
Strachan-Stuckey House

<u>Florida</u>

Fort Clinch
Spanish Coquina Quarries
Turtle Mound
Ponce de Leon Inlet Lighthouse
Spanish Fleet Survivors and Salvors Camp Site
House of Refuge at Gilbert's Bar
Bingham-Blossom House
Mar-a-Lago National Historic Site
Cape Florida Lighthouse

In addition to the sites listed for Florida, numerous historic shipwrecks have been exactly or approximately located in state waters along the Florida coast. The are illustrated very generally in Figure G-5.

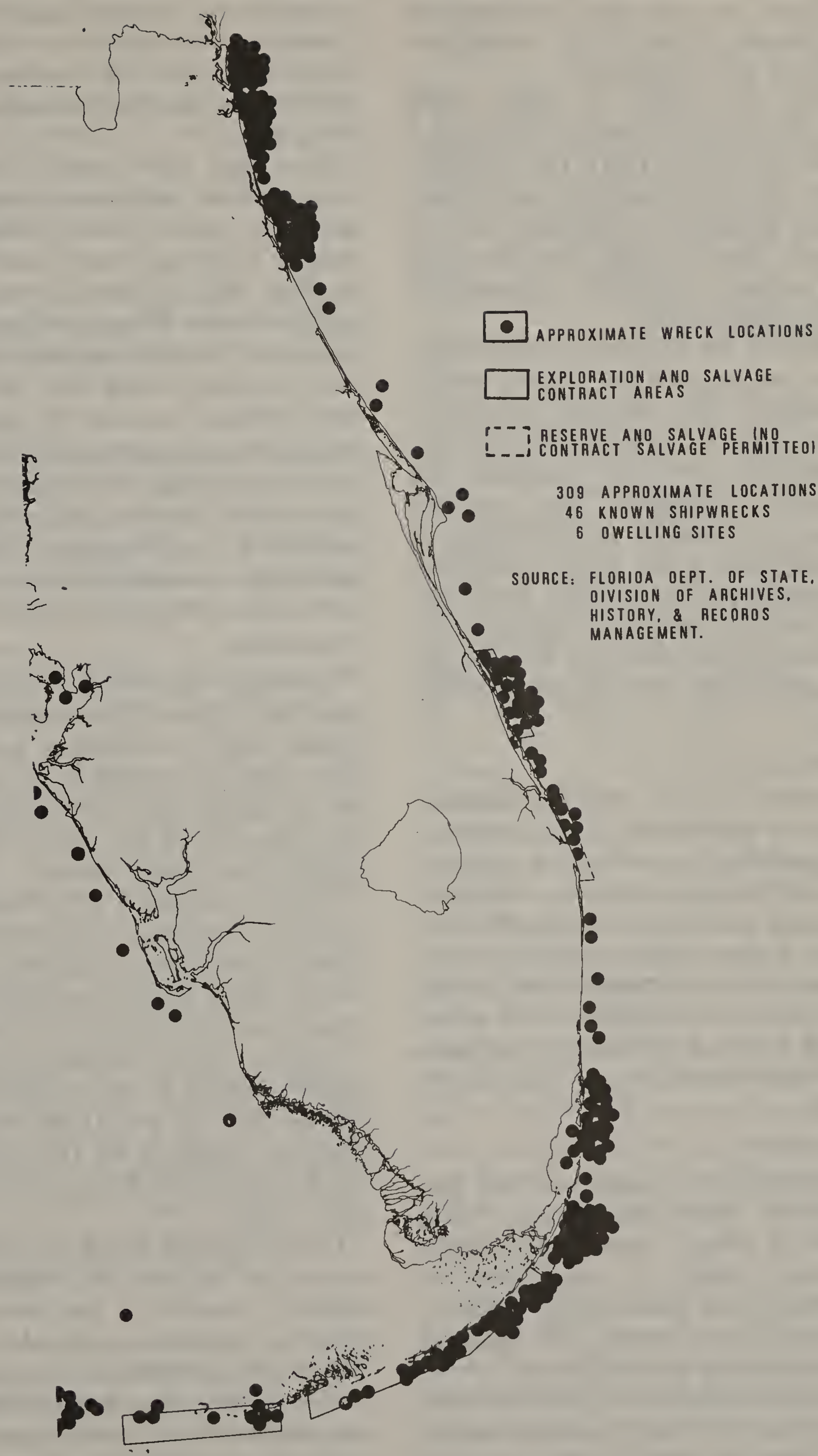


FIGURE G-5 SHIPWRECKS IN FLORIDA COASTAL WATERS cooperate so as to share the financial burden and maximize the use and efficiency of disposal facilities. The problems are most acute in population centers where density is high, waste volumes are large, and disposal sites are scarce.

Estimates of the amount of solid waste generated per person range from 3.3 lb/day to 6 lb/day (Snyder, 1974; CEQ, 1974). The 3.3 lb/day figure includes wastes generated in households, commercial and business establishments and institutions. Higher figures include those generated by industrial processes, agricultural, construction, demolition and sewage wastes.

More than 90% of the solid wastes are directly disposed of on land, in open and burning dumps, or sanitary landfills. Other methods of disposal are incineration, use of materials to build such things as artificial reefs and collection and recovery. Sanitary landfilling, the preferred method involves the disposal of solid waste on land by spreading them in thin layers, compacting them to the smallest practical volume, and covering them with soil. This method is employed by a majority of communities. Following is a description of the methods employed by the southeast Atlantic states.

a. North Carolina

In North Carolina the state provides standards for the disposal of solid wastes. The counties assume the responsibility for solid waste collection and disposal for small communities while the larger cities handle solid waste disposal for their area. Landfill is the most common method disposal although some communities have collection of certain types of solids wastes. The annual tonnage of solid wastes is calculated according to population and is estimated at approximately one ton/person/year.

b. South Carolina

South Carolina has state regulations that provides standards for solid waste disposal. These regulations have six parts, 1) design and construction for sanitary landfill, 2) regulations for shredder operations and finally daily cover, 3) collector systems, 4) pesticides, 5) industrial wastes, and 6) the closing of open dumps.

Solids wastes are disposed of by two methods along the east coast of South Carolina, landfill, shredding and milling operations. There are four landfill operations north of Georgetown County and four shredder and milling operations in Charleston, Beaufort, Georgetown and Williamsburg counties.

The largest shredder operation is located in Charleston where solid waste disposal in this area ranges from 700-1,100 tons/day. The material in this area and Beaufort is weighed as it is brought to the site.

There are three acute problems that have resulted from solid waste disposal. In landfill operations ground waste pollution has resulted because of the high water table. This is caused by leaching material entering the ground water aquifer. In the Charleston area there is a large volume of (500,000-600,000) tires. These tires were previously being used to develop artificial reefs offshore, however, this operation has sinced ceased. Another problem in this area is the availability of a shredder site, the presently existing site has reached capacity and another site must be established. In Charleston County the present landfill site is nearing its capacity and another site is presently under consideration.

c. Georgia

The major type of solid waste disposal in Georgia is land disposal. The most serious problem for landfill areas is the disposal problems associated with a high water table. Each county is responsible for setting up solid waste disposal plans, a brief summary of the disposal methods and tonnage for each county follows.

Bryan County has a FY 1976 grant for the purpose of establishing a central sanitary landfill and a bulk container rural collection system. The site for the landfill has not yet been selected. The projected tonnage for 1976 is 4,766 tons.

Camden County presently has one permitted sanitary landfill in the southeast. The estimated tonnage for 1975 was 11,660 tons. A solid waste grant was issued for FY 1977 to upgrade the sanitary landfill and establish a rural collection system in the county.

Chatham County has three sanitary landfills and some areas that take only non-putrescible wastes. Resource recovery is also being considered for this area. The estimated solid waste tonnage for 1974 was 125,309 tons.

Glynn County has two landfills operating for non-putrescribles and two sanitary landfills. Both the sanitary landfills require pumping to keep the trenches above the water table. The landfill on St. Simon's Island is being used as a land reclamation site. Jekyll Island has a separate authority and operates its own disposal facilities—a landfill and incinerator. The estimated tonnage for 1975 was 13,122 tons.

Liberty County presently has several "dumps", and an application has been submitted to establish a rural collection system. The estimated solid waste tonnage for 1975 was 9,366 tons. A solid waste grant to construct a sanitary landfill was issued for FY 1977.

McIntosh County presently operates several dumps. A grant was issued in FY 1976 to establish a central sanitary landfill and a bulk container rural collection system. The estimated solid tonnage for 1974 was 20,185 tons.

d. Florida

Florida has enacted state regulations that pertain to solid waste disposal. These regulations are in two parts: Part I pertains to sanitary landfills and was enacted in October, 1974; it states that all counties must comply with state regulations for sanitary landfill by July 1, 1977. Part II of the regulations was enacted on June 30, 1976 and sets forth guidelines for state solid waste management plans to be constructed. These plans are to include standards for storage, collection and resource recovery of various types of solid wastes. All counties and municipalities must develop the solid waste management plans by July, 1978. Also, the regulations require 22 designated counties to incorporate into their plans a resource recovery section. There are seven of the southeastern coastal counties that have been so designated, Brevard, Broward, Dade, Duval, Indian River, Palm Beach, and St. Lucie.

The majority of the solid wastes are disposed of in sanitary landfills. There are some sanitary landfills and approximately six municiple incinerators along the east coast. There are two incinerators each which are located in Broward, Dade and Plam Beach counties. The tonnage of solid wastes is calculated according to population and is estimated at approximately one ton/person/year.

8. Land Use

The Virginia Institute of Marine Science (VIMS) study prepared for BLM in 1974 groups the coastal counties between Cape Hatteras and Cape Kennedy into ten sectors for more convenient discussion. The following discussion is based upon the VIMS data with additional information adapted from the USDA Soil and Water Conservation Needs Inventories for each state and from the U.S. Census of Agriculture.

a. North Carolina

Sector 1: This section of the North Carolina coast is comprised of Dare, Hyde, Beaufort, Pamlico, Craven and Carteret counties (Figure G-6). These six counties are outside of the mainstream of coastal plain development, and, with soils unsuited for intensive farming they are in general heavily forested. Sixty-nine percent of the land in Sector 1 is in commercial forest, and in addition much of this forest is on wetlands which in turn comprise more than 50% of the 0.9 million hectare area.

At least 26% of the wetlands, forest and barrier islands in both public and private ownership are dedicated to recreation or conservation purposes. Table G-30 summarizes the major areas devoted to these uses (see Visual No. 1N).

Federal ownership of non-cropland in these six counties is estimated to be 9.8% of the total area. The urban and built-up land use category covers approximately 1.6% of the total area. Estimates of Federal non-cropland ownership and areas of urban and built-up lands are derived from: USDA, SCS, Land & Water Conservation Needs Inventory for each South Atlantic State, published in 1971.

Nineteen percent of all land was in 1969, as opposed to 21% in 1964, representing a decline in farmland in all counties except Hyde.

The Pamlico Sound area is largely rural, with Dare, Hyde and Pamlico counties having no urban population. Craven County, the most populous of the six counties had a 1970 population of 62,554 of which 55.2% was urban; New Bern is the only urban center. Beaufort County had a 1970 population of 35,980, of which 24.9% was considered urban. The town of Washington in Pamlico County is its only urbanized area. Morehead City is the only urban center in Carteret County. The population of the county is 31,603, of which only 27% is urbanized.

Sector 2: Onslow and Pender are largely rural counties, with as much as 50% of their land in wetlands and 79% in commercial forest areas. The entire coastline of these two counties is protected by a series of narrow barrier islands. The hinterlands of these islands are for the most part marshes which are separated from the drier mainland shore by the intra-coastal waterway.

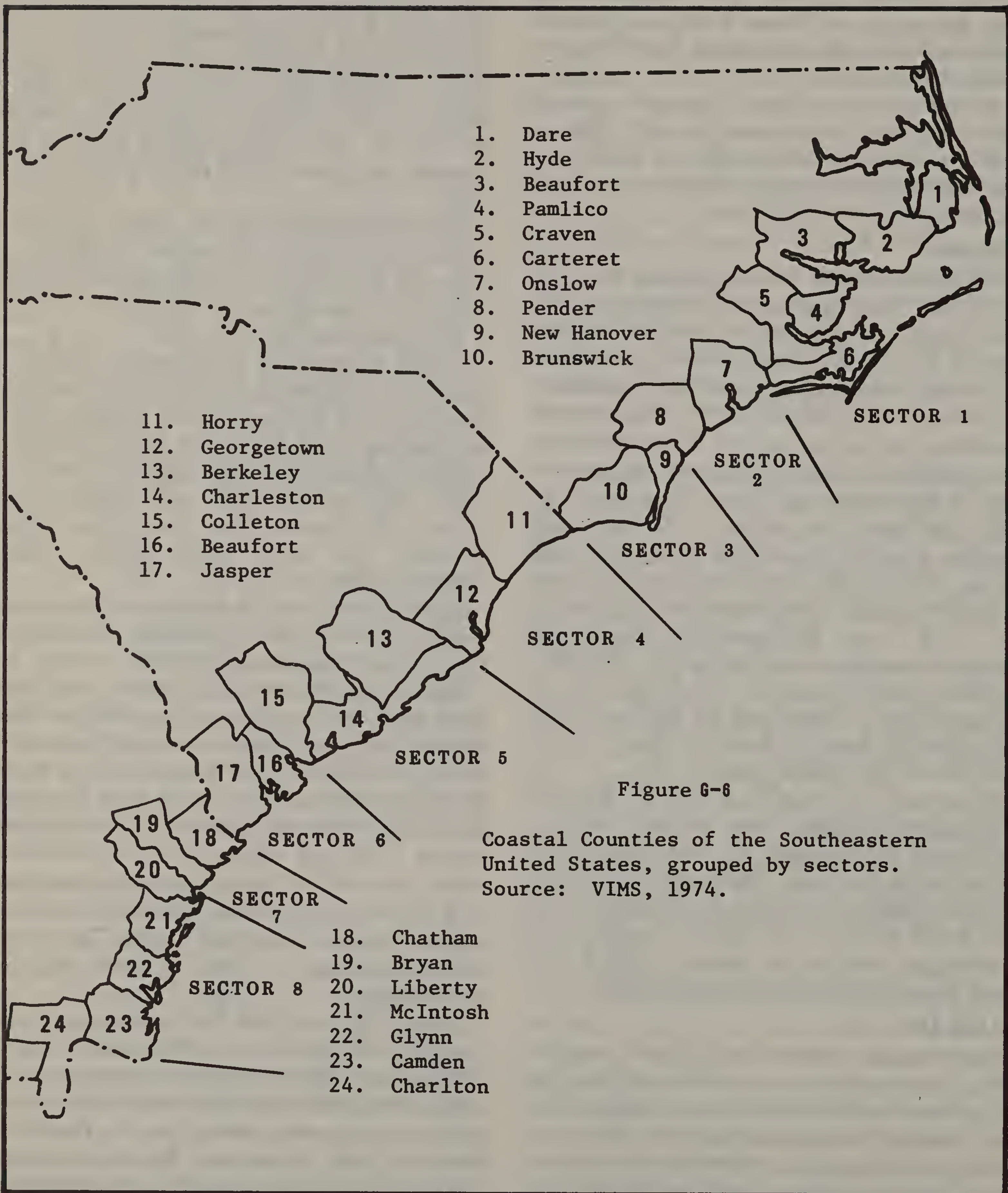


Figure G-6

Coastal Counties of the Southeastern United States, grouped by sectors. Source: VIMS, 1974.

Table G-30 Selected Recreation or Conservation Areas in North Carolina

Cape Hatteras Nat. Seashore	13,153	hectares
Cape Lookout Nat. Seashore (proposed)	10,117	"
		23,270
Matamuskeet N.W.R.	20,307	
Pea Island N.W.R.	12,780	
Swan Quarter	16,163	
Cedar Island	5,069	
		54,319
Croatan National Forest		61,656
Gull Rock State Wildlife Mgr. Area		7,631
Fort Macon State Park		157
Goose Creek Game Land	2,873	
Dare Game Land	62,783	
Big Pocosin Game Lane	9,759	
		83,046

Approximately 20% of Onslow County is taken up by Camp Lejeune U.S. Marine Reservation, which is located around the large natural bay created by the New River. Hammocks Beach State Park occupies 361 hectares in Onslow County. Pender County is best known for its Holly Shelter State Game Land and Angola Game Land which together occupy 30,757 ha of predominantly wetland areas.

Federally owned non-cropland for this sector is approximately 8.3% of the area, nearly all in Onslow County, and the urban and built-up area is approximately 1.7%.

Between 1964 and 1969 land in farms declined 13.8% although there was a slight increase in total cropland (0.4%).

Onslow County, although largely rural, owes its relatively high population of 103,125 to Camp Lejeune. Jacksonville is located near the military reservation and is the county's only urban center. Pender County, like Onslow County, is rural and contains vast forest and wetland areas.

Sector 3: New Hanover and Brunswick counties continue the characteristic pattern of swampy, forested coastal flatlands. Soils are generally of poor quality for farming. Approximately 78.6% and 46.2% of all land in Brunswick and New Hanover county, respectively, is in commercial forest. Here, as in other coastal counties, forests provide the raw materials for an extensive pulp, paper and wood products industry. New Hanover County has proportionately less forest area because it is more highly urbanized than the adjoining coastal counties. Wilmington, the primary city, owes its growth largely to its strategic port location 32 km north of the mouth of the Cape Fear River. The river has an 11 m (36 ft) navigation channel which is maintained by regular dredging.

The amount of land in farms increased slightly from 12.8% to 15.2% in New Hanover County between 1964 and 1969 and decreased from 17.9% to 15.9% in Brunswick County. For this sector, the net change in farmland was a 9.5% decline and an 8.5% drop in cropland.

Lands under environmental protection or management are the Masonboro State Park (178 ha) on Masonboro Island in New Hanover County and the Eagle Island Game Land (809 ha) in Brunswick County. The excellent beaches along the coast of both counties have been experiencing a growth in the construction of second homes and low profile hotel and motel facilities in recent years.

Federally owned non-cropland makes up 2.2% of Sector 3 with the urban and build-up category accounting for 6.3% of the area.

New Hanover County is the most highly urbanized of the North Carolina coastal counties. Sixty-nine percent of its 83,000 population is urban and is located in the rapidly growing port city of Wilmington, the only North Carolina city along the coast which is classified as a regional center. Urban and suburban growth has spread over most of the northern half of the Cape Fear peninsula as far as Route 17. The river front, from the northern city limit of Wilmington southward for about ten kilometers is largely taken up by port facilities, warehousing and oil storage terminals. Large new industries have been expanding north towards Castle Hayne and northwest between the Northeast Cape Fear and Cape Fear rivers into Brunswick County. Resort and second home development is occurring in the Wrightsville Beach and Caroline Beach areas, as well as along the Intracoastal Waterway and the lower Cape Fear River. Smith Island, at the southern tip of the peninsula, is currently being proposed as an exclusive private resort community, but this is vigorously opposed by conservation groups.

Brunswick County is largely rural, its only urban center being Southport at the mouth of the Cape Fear River. It is the site of a new nuclear power plant constructed in 1972 and a proposed Pfizer chemical plant.

New Hanover County has nearly 100 manufacturing firms of which all but six are located in Wilmington. Forest products, cement and cement products, asphalt, textiles, processed foods, packaging, chemicals and fertilizers are the most commonly produced items. In Brunswick County, eight manufacturing firms produce textiles, cement, fish products, building materials, wood products, chemicals and machine parts.

b. South Carolina

Sector 4: Although large land areas in Horry and Georgetown counties are wetlands, they are well defined along the rivers which drain them (Fig. G-7). The Little Pee Dee, Pee Dee, Black and Sampit rivers are tributaries of the Waccamaw River. The latter flows south-southwest from Lake Waccamaw, its source in Brunswick

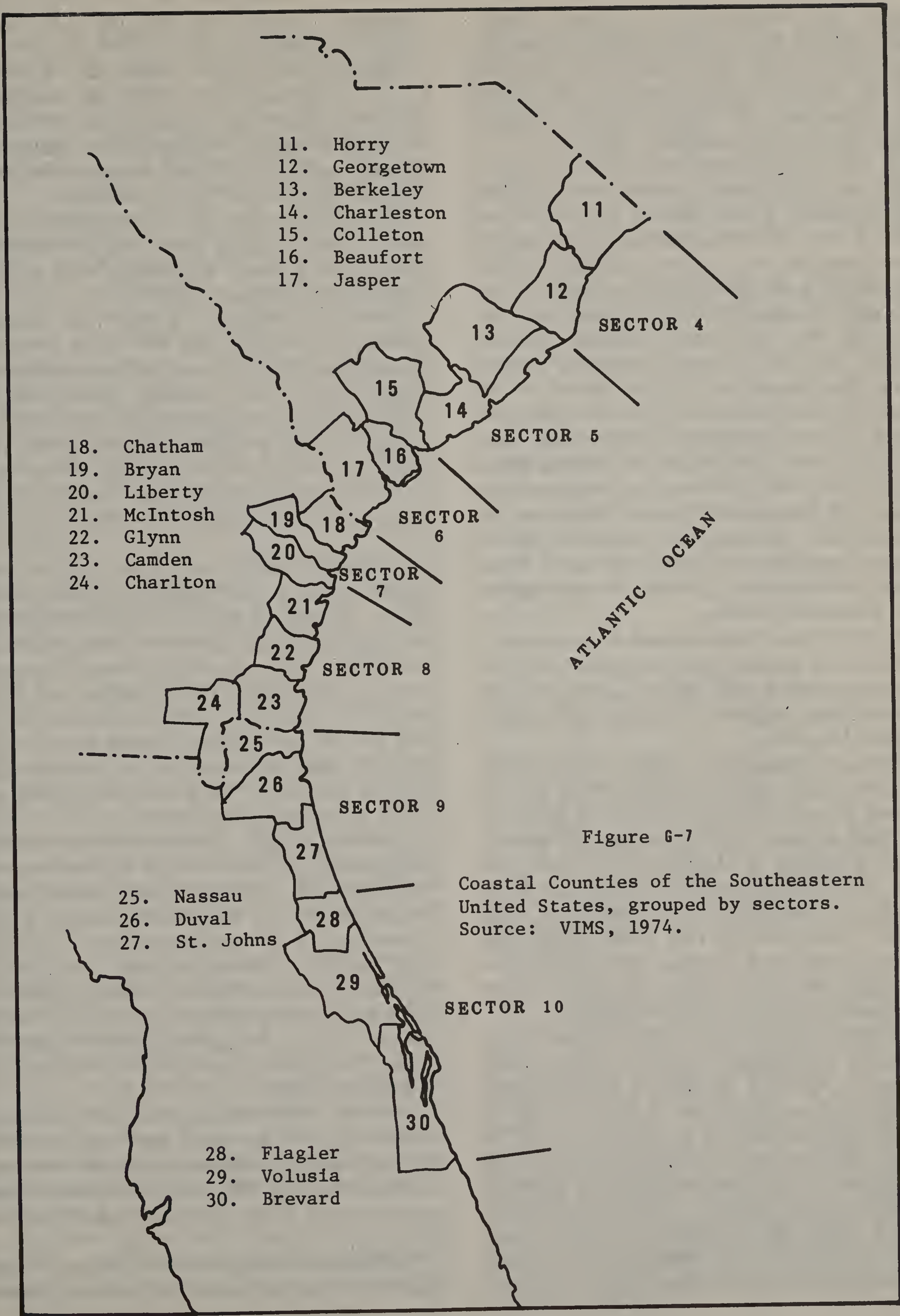


Figure G-7

Coastal Counties of the Southeastern United States, grouped by sectors. Source: VIMS, 1974.

County, into Winyah Bay, Georgetown County. Below Winyah Bay, another major river, the Santee, forms a marshy delta where it flows eastward into the Atlantic. This two-county sector is sparsely developed with 70% of the land in forest, 69% is classified as commercial forest.

In 1969, 36.7%, respectively, of this land in Horry and Georgetown counties, was in farms. This represents a sharp decline from 43.7% and 24.3% in 1964. Environmental use or management areas along the coast include Huntington Beach and Myrtle Beach State parks, totaling 1,138 ha. Five game management areas, Gapway Bay, Kilsock, Pee Dee, Biust, and Waccamaw comprise another 19,979 ha. Of these, all but the Pee Dee Game Management are (516 ha, owned by the South Carolina Wildl. and Mar. Res. Dept.) are owned by paper companies. Another large area, Hobcaw Barony (7,082 ha) on the Winyah Bay in Georgetown County, is owned by a private foundation and operated by Clemson University for research and education in forest and marine resource management. Another 232 ha at Myrtle Beach are devoted to the South Carolina Agricultural Experiment Station.

Federally owned non-cropland in this sector is only 0.3% of the total area and urban and built-up land comprises 4.9%. Between 1964 and 1969, land in farms declined 24.7% and total cropland decreased by 1.9%.

Horry and Georgetown counties are best known for their resort areas of Myrtle Beach and the "Grand Strand". Horry County has a population of 70,000 of which 29.5% is urban. Georgetown, with a population of 33,500 is 39.6% urban. Conway, North Myrtle and Myrtle Beach in Horry County and Georgetown and Andrews in Georgetown County are the only urban centers considered by the South Carolina State Planning and Grants Division to be primary (as opposed to regional) growth areas in these two counties.

Industrial development in this section, as in other coastal counties with major urban concentrations, is scattered. Because of excellent sandy beaches with a total extent of 75,639 m and an area of approximately 27 ha, promises to be the biggest industry here. Between 1962 and 1972, employment in the service industries increased substantially, an average of 12.03% and 6.05% per year in Horry and Georgetown counties respectively. In Horry County, employment in services increased faster than any other sector and the rate compares favorably with that of employment growth as a whole which was 8.0% per year. In Georgetown County, the average rate of growth for all employment was 4.26% per year, also lower than the rate of increase in the service sector of the economy. Employment in construction increased as well, but less spectacularly: only 5.54% in Horry and 8.09% in Georgetown.

The two-county area has 13,714 hotel and motel rooms, 7,844 camping sites, eight commercial marinas with a total of 423 berths, 54,000 acres of hunting area, and 26 golf courses.

Sector 5: Berkeley County is sparsely developed, with more than 83% of its land area forested and 14% in farms. Although it has no coastline of its own, Berkeley County was included in the coastal area analysis because it is part of the Charleston SMSA and for much of its length is no more than 16 km from the ocean. It has two outlets to the sea, the Cooper and the Wando Rivers, which flow into Charleston Harbor.

Charleston County has large wetland and coastal marsh areas. Unlike Horry and Georgetown counties, whose beach hinterlands are wide and largely dry, Charleston County has wide marsh areas and an extensive system of marshes, estuaries and inlets. This condition has been created by a number of rivers which drain the inland swamps and meander toward the sea. The marsh is most pronounced at the northern and southern portions of the county, and makes access to many beaches difficult.

Charleston County, which has substantial urban development, has only 50% of its land covered with forest and 11.7% of its land in farms. Large sections of Sector 5 have been designated as environmental use or management areas. These include the Francis Marion National Forest (99,642 ha, Charleston and Berkeley counties), which is also a game management area; the Cape Romain National Wildlife Refuge (22,285 ha, Charleston County) and Edisto Beach State Park (508 ha, Charleston County).

Federally owned non-cropland rises to an impressive 23.1% in this sector and urban and built-up areas cover a substantial 5.7% of the area. Between 1964 and 1969, the land in farms in this sector declined 30.6% and total cropland declined 11%.

Charleston County, with 82% of its 247,650 population living in the city of Charleston, Mount

Pleasant and James Island, is the most populous and urban of South Carolina's coastal counties. Berkeley County has less than one-fourth of the population of Charleston County and its population density is substantially lower: 20 persons/km² compared to 102 persons/km² in Charleston County. Berkeley County's population is only 45.1% urban and it has two urban centers, Monck's Corner and Goose Creek.

Firms in Charleston County include metal and machinery manufacturing, printing, food and seafood processing and packing, textile, wood products, petro-chemical, fertilizer and building component industries. Shipping, trade and warehousing are important port-related activities.

Tourism is important in this area, with beaches and historic Charleston which attract vacationers. There are two historical parks in the area, Charles Towne and Old Dorchester, with another part, Hampton Plantation, under construction.

Charleston County has 32 km of beach and 75 ha of beach area. There are 3,075 hotel and motel rooms, 1,087 camping sites, 11 golf courses, 590 marina berths and 49,245 ha for hunting. In 1972, 2.4 million vacation and/or weekend person-trips were made to the area, of which 78.5% were made by non-South Carolina residents.

Sector 6: This sector characterized by its vast system of coastal rivers, marshes, waterways and islands, most of which is undeveloped and inaccessible except by boat. Beaufort is an exception lying at the center of a large group of marshy islands which include St. Helena, Ladies, Port Royal and Parris. The area includes two military reservations. The northeastern end of Helena Island contains the 2,023 ha Hunting Island State Park.

The South Edisto, Combahee Bull, Coosaw, Beaufort, Broad, Chechesse, Colleton and May rivers converge in this area, along with countless other streams and creeks.

Approximately 50% to 60% of the counties in Sector 6 are in wetlands. Sixty-four percent is forested and 30% is in farms. Between 1964 and 1969, land in farms declined 19.9% and cropland decreased by 5.6%. Federal non-cropland makes up 1.4% of this sector, and urban and built-up lands cover 3.8%.

The Savannah National Wildlife Refuge (2,925 ha) is a notable environmental management area located on the Savannah River about 24 km from its mouth.

Colleton, Beaufort, and Jasper counties are largely rural. Beaufort County, with a density of 15 persons per square kilometer, owes its population of 51,136 largely to the Marine Corps bases near Port Royal and Beaufort, which are the only urban settlements in the county. Twenty-three percent of Colleton's 27,622 population is located in Walterboro, the county's only urban center. Jasper County, where the population is just under 12,000, is rural.

Tourism plays a smaller role in Sector 6, with only 619,727 vacation/weekend person trips recorded for 1972. Of these, less than 50% were generated by out-of-state tourists. Beach length has been measured at 29 km, with 154 ha of beach area. In 1972, there were 885 hotel and motel rooms available to tourists, as well as 371 camping sites. Six marinas provide 215 berths. In addition, there are 13 golf courses and 14,974 ha of land available for hunting. A large part of Hilton Head Island, located at the mouth of the Broad River on Port Royal Sound, has been developed as an attractive and exclusive resort community.

c. Georgia

Sector 7: Chatham and Bryan counties are similar to Beaufort and Jasper counties to the north. Broad expanses of marsh, waterways and sounds characterize the coast. The Savannah, Wilmington, Ogeechee and Medway rivers empty into the tidal marshlands along the coast. The city of Savannah is approximately 24 km inland from the sea separated from it by Wilmington and Tybee Islands. Originally built on the dry hammocks which dot parts of this flat and watery terrain, Savannah has had to expand by draining and filling wetlands.

About 62% of both counties is covered by forest. In Chatham County, 8.8% of the land was in farms in 1969, down from 16.7% in 1964. In Bryan County, 11.0% was in farms, down from 12.5% in 1964. Outside metropolitan Savànnah, development in both counties is exceedingly sparse. A large part of Bryan County (and adjacent Liberty County Sector 8) is occupied by Fort Stewart Military Reservation and therefore excluded from private development. An expansion of the number of military personnel at this base is presently contributing to some deficiencies in housing and other population related facilities in the surrounding area.

Environmental management areas include Fort Pulaski National Monument (2,233 ha), Savannah National Wildlife Refuge (2,702 ha), and Tybee National Wildlife Refuge (40 ha). The latter two areas are located at the mouth of the Savannah river. In addition Skidaway Island State Park covers 194 ha.

Federal non-cropland ownership in 1969 was 22.4% of the area, with 6.6% in urban and built-up lands. For the sector, land in farms declined 33% between 1964 and 1969 although the total acreage of cropland increased by 16.2%.

Chatham County is the most highly urbanized of the Georgia coastal counties, with 89.3% of its population of 187,767 located in Savannah, three other surrounding municipalities and various unincorporated urban areas. The city of Savannah is located in the extreme north central part of Chatham County, immediately adjacent to the south bank of the Savannah River. The city comprises 37 of the 1,093 km^2 in the county. Most of the older developed portions south of the river are on hammocks of well-drained soils. Some of the later development areas are characterized by poor natural soil fertility and poor drainage.

The relative flatness of the county and the existence of numerous stream channels render it highly susceptible to flooding, especially when extreme rainfall coincides with high tides. East and south of Savannah, Chatham County consists largely of marshland. Additional development constraints are imposed by flat or depressed areas in the western part of the county which have slow surface run-off, heavy clayey sub-soil and/or poor internal drainage. Throughout most of the city and county, site-engineering modifications such as recontouring, muck excavation and backfilling, and drainage canal construction are usually necessary prior to construction.

Savannah is currently experiencing a decrease in population caused by out-migration of many middle and upper income families into the suburban fringes which offer a higher level of amenities and services.

The 1975 Land Use Plan for Savannah proposes what appear to be a system of infilling as a means of accommodating future urban growth.

The Port of Savannah has been a vital factor in the stimulation of industrial growth and economic progress in the Savannah area and the State of Georgia. Although it ranks only third in tonnage of shipping among the ports of the coast between Hatteras and Canaveral, Savannah leads the South Atlantic coast ports in general cargo and foreign commerce.

Primary industries are wood products, textiles, chemical, asphalt, metal products, machines, building materials, oil refining, food processing and printing. Extensive tourism development is found at Savannah Beach.

Bryan County, south of Savannah, is rural, with large areas of marsh and swampland. More than 30% of the county is occupied by the Fort Stewart military reservation.

Sector 8: Eighty percent of the land in these counties is forested. Only some 8% of the land area is in farms. Brunswick in Glynn County is the only city of appreciable size, with the remaining counties sparsely populated.

Four state parks are located in the area: Crooked River (202 ha, Camden County), Jekyll Island (4,452 ha, Glynn County), Santa Maria (26 ha, Camden County) and Stephen C. Foster (32 ha, Charlton County). Other environmental management areas include the Altamaha Waterfowl Public Hunting Area (12,141 ha, McIntosh County), Fort Frederica National Monument (82 ha, McIntosh County), R. J. Reynold State Wildlife Refuge (7,285 ha, McIntosh County), Harris Neck National Wildlife Refuge (1,087 ha, Liberty and McIntosh Counties), Okefenokee National Wildlife Refuge (138,003 ha, Charlton County), and the Wolf Island National Wildlife Refuge (218 ha, McIntosh County). Cumberland Island, one of the largest barrier islands, is located opposite the Camden County mainland and is a National Seashore.

Federally owned non-cropland accounted for 15.5% of the area in 1969, with urban and build-up acreage totaling 1.8%. During the census period 1964 and 1969, land in farms dropped a total of 42.4% although total cropland declined only 4%.

The combined population of Sector 8 (Liberty, McIntosh, Glynn, Camden and Charlton counties) is less than 100,000. Glynn County, with a 1970 population of 50,373, houses the city of Brunswick, the most important urban center on the Georgia coast outside of Savannah.

Approximately 30% of Liberty County is occupied by the Fort Stewart military reservation in the northwest, effectively precluding civilian development of the area. It accounts for a large share of the population of 17,569. Hinesville is the only urban area. Only 4.35% of the total county land is developed.

McIntosh County is rural, with a population of 7,371 persons. The largest town is Darien, a fishing town on Cathead Creek. Of the total county land area, 8.2% is developed.

Glynn County occupies 6,838 ha, of which 5,103 ha are marsh and water. Other settlements in the Brunswick area are Saint Simons Island, Sea Island and Jekyll Island, which recently have developed or redeveloped as year-round recreational communities. Of the county's total area, 7.35% is developed. The Blythe Island Naval Reservation occupies 4,059 ha of land to the west of Brunswick.

Glynn County has experienced a relatively high rate of growth within the past ten years. The primary growth areas are Saint Simons Island, Blythe Island on the Turtle River, and the urban fringe areas of Brunswick. Most of the commercial establishments in the county are located along U.S. Highway 17, U.S. Highway 341 and in the village of Saint Simons Island. Concentrated areas of commercial strip or spot type development are found along Highways 17 and 841. Only 60 ha are currently used for industrial purposes, primarily along the Turtle River and Southern Railroad; 7,067 ha are zoned for industrial uses. Of these 4,488 ha are marsh and low lying land not suitable for industrial use. Of the remaining 2,578 ha, 1,619 ha are available for industrial uses.

Camden County's population is 11,334. A single urban center, St. Marys, is located on the St. Marys River which forms the boundary between Georgia and Florida. The only other settlement having a population greater than 1,000 is Kingsland, which is located further inland on Route 17 and the Seaboard Coast Line Railroad. Only 7.35% of the total area of the county is developed.

Cumberland Island, a large barrier island stretching from St. Andrews Sound to the mouth of the St. Marys River, is a National Seashore. On the island itself only minimal development, such as camping areas for backpackers and facilities for daytime use of the beaches, will be permitted. However, substantial tourism development is expected to occur on the adjacent mainland.

Charlton County is rural, with a population of less than 6,000. Folkston, the best known of its communities, is the starting point for visits to the Great Okefenokee National Wildlife Refuge. It is being promoted as the west leg of "Georgia's Golden Triangle", the other legs of which are Waycross, the gateway to Okefenokee's Swamp Park, Brunswick and the Golden Isles.

The State of Georgia has only recently begun participating significantly in the growing nationwide tourism industry. While studies have shown that Route 17 is a major tourist route along the eastern seaboard and over five million people per year travel this highway, the majority of vacation and recreational traffic passes through the area. Only the Savannah, Brunswick, Jekyll and Saint Simons areas gain any major advantage as a destination point. The completion of I-95 has drawn traffic from Highway Route 17 in sufficient numbers to cause some significant localized economic problems. Efforts are being made by state and regional planning agencies to better utilize the tourism potential of Georgia's natural and historical resources.

d. Florida

Sector 9: Eighty-three percent of Nassau County is covered by forests which provide the basis for its primary industry, pulp and paper. Of its total land area, 15.7% was in farms in 1969. Similar statistics for Duval and St. Johns counties are 60% and 75% forest area and 15.2% and 17% in farming, respectively. The topography, soils, and other natural characteristics are similar for all three counties. Development is sparse except for the concentration in the heavily populated Jacksonville area and the resort-oriented urban centers of St. Augustine, Jacksonville Beach and Fernandina Beach.

The terrain is level with the sandy soils characteristic of the dry areas of the coastal counties interspersed with swamp. Tidal marshes, islands and estuaries are found extensively between the barrier islands and the mainland north of the mouth of the St. Johns River. Here, the marshes extend inland 16 to 24 km along the St. Marys, Nassau and St. Johns river, which drain the swampy forests to the west.

The western third of Nassau County, bounded by the Little St. Marys River to the north-northwest, Boggy Creek and the Nassau River to the south, and Route 17 to the east-northeast, is in forestry and game management areas. The estuarine northeastern portion of the county is within the hurricane flood zone and is unsuitable for development. The St. Marys and St. Johns rivers, their tributaries, coastal marshlands, and the ocean three miles offshore above the St. Johns River have been established as Florida Aquatic Preserves which prohibit development which will harm the natural environment of the aquatic system. Large areas between Lofton Creek and the coastal marshes and smaller areas to the west have been established by the Florida Coastal Plains Coordinating Council as suitable for future intensive development.

South and east of the St. Johns River, where there are no west/east flowing rivers, the coastline changes markedly. For some 29 km there are no barrier islands, except those artifically formed by the digging of the Intracoastal Waterway some 3 km inland. It is not until Lake Ponte Vedra, the Tolomota River and the Matanzas River, that the barrier island coastal configuration is reestablished. The salt marshes backing these islands are few. However, the inland portion of this area, composed of St. Johns and Duval counties, which may be termed a peninsula of sorts, is primarily swampland and sparsely developed.

Of the presently undeveloped land remaining in Duval County, about 20% is deemed suitable for intensive development with corrections. The remainder is earmarked for conservation and preservation, with compatible development permitted in some areas. Approximately 80% of St. Johns County is designated as marginal land. Limited areas near Route I-95 and Route 16, east of Tocoi Creek, along Routes 206 and 305, and west of the Matanzas River, have been designated as suitable for intensive development with corrective action.

Two state parks in Sector 9 are Fort Clinch on the northern end of the Amelia Island and Little Talbot Island State Park on the island of that name.

Federally owned non-cropland in this sector is 2.1% of the total area, and urban and built-up lands comprise 5.8% of the total. Land in farms declined 22.3% between 1964 and 1969, although total cropland actually increased by two percent.

Nassau County, with its population of 60,626, is only 33.7% urban. It is largely composed of forest interspersed with swamp areas. Its only urban center is Fernandina Beach, located at the northern end of Amelia Island. The island, which is approximately 24 km long, is accessible by car for most of its length and is well known for its fine ocean beaches. One of the most recent developments there is the Amelia Island Plantation resort community, which, in concept, resembles the low profile, exclusive resort communities built recently on the larger barrier islands in Georgia and South Carolina.

Duval County is by far the most populous of the coastal counties between Hatteras and Canaveral. Its population is 528,865, of which 97.9% is urban. Jacksonville is a regional urban center and a major port whose shipping tonnage exceeds 11 million short tons per year. The city is situated at a bend in the St. Johns River where it turns south. Although Jacksonville's industrial growth was uneven in the 1960's, manufacturing as a source of employment has grown in importance and diversity. Nearly 13% of all employment is in manufacturing of durable goods and food products, paper, printing/publishing, chemicals, and allied products and other non-durable goods. Motor freight and warehousing, as well as wholesaling and distribution are important employment sources.

Industrial sites are located primarily along the northern and western shores of the St. Johns River, along the Seaboard Coast Line Railroad and the Southern and the Atlantic Coast Line Railroad, within the limits of the Jacksonville Beltline. Future industrial development is being encouraged to expand to the south along I-95, Phillips Highway and Florida East Coast Railway as well as along the above-mentioned corridors, but beyond the Beltline.

Other urban development has occurred along the coast at Jacksonville Beach. The beaches in Duval County are all accessible by road and have been built up with resort hotels, motels and private homes. Little Talbot Island State Park offers daytime visitor facilities and picnic areas.

St. Johns County has a population of 30,727, of which 40.2% is urban. St. Augustine, located on the Mantanzas River and the Intracoastal Waterway is the largest city. Much of the area behind the coastal beachfront is wooded and swampy. The coast and parts of the St. Johns River are readily accessible; recreation and tourism are an important sector of the economy, encouraged by the historic attractions of St. Augustine.

Sector 10: Flagler, Volusia, and Brevard counties are 84%, 68% and 19% covered by forests, respectively. The corresponding figures for the proportion of land in farms are 29.4%, 32.8% and 35.3%. Intensive development in these counties in the past has occurred only in the ocean resorts and in Deland to the west. For the sector, land in farms declined by 16% between 1964 and 1969, and total cropland fell by 32.4%. Federal ownership of non-cropland totals 8.1% of the area, and 5.8% of the area is urban or built-up.

Large portions of the counties are considered marginal lands unsuitable for development. Along the coast are areas which are within hurricane floodplain zones. Beginning in central Volusia County, broad coastal marsh areas begin to reappear between the barrier islands and the mainland. In Brevard County, the greater part of Merritt Island has been designated as a wildlife refuge, but this does not preclude its use for aerospace installations at the John F. Kennedy Space Center. The Indian River to the north of the island and east of the Intracoastal Waterway has been designated as a Florida Aquatic Preserve.

In the three-county sector, vacant land deemed suitable for future development is generally limited to narrow strips adjacent to existing developed areas.

Flagler County, which contains large areas of swamp land, is sparsely populated. Its density is only 9 persons per square mile and its total population was below 5,000 in 1970. Its beaches are still sparsely developed, except for Flagler Beach in the southeastern corner of the county, which adjoins Ormond Beach, a part of the Daytona Beach complex.

Volusia County is well known for its extensive tourism development and beaches; Daytona Beach, Ormond Beach, and New Smyrna Beach form a continuous belt of tourist and second home developments along the coast. The highest point of concentration is at Daytona Beach. Another important urban center is De Land in the western section of the county.

Future development of an 80,000 acre tract along the coast between Daytona Beach and St. Augustine is expected to change the character of Flagler and Volusia counties by introducing a population increase of up to 750,000 by 1980.

Brevard County is noted for the John F. Kennedy Space Center and related industries at Cape Canaveral. The only urban center in Brevard County north of Cape Canaveral is Titusville.

Immediately to the south of Cape Canaveral are the large resorts centering on Cocoa Beach, which serve as the residential and services areas for the huge aerospace complex.

H. Water Quality

1. Introduction

The southeast Atlantic states—North Carolina, South Carolina, Georgia and Florida are presently developing Water Quality Management Plans pursuant to Section 303e of the 1972 Amendments of the Federal Water Pollution Control Act (P.L. 92-500). The purpose of these plans are twofold: to provide an analysis and assessment of the present environmental conditions and stresses within basins; and to provide a qualification of the waste waters. The basin plans may affect local water pollution control activities by identifying polluted waters, establishing maximum pollution loads which may be discharged into waters, identifying waste water treatment plants which are discharging more BOD (Biological Oxygen Demand) than the waters can safely accept, and suggesting measures which would correct local water pollution problems. The 1972 amendments to the Federal Water Pollution Control Act also require that every "point source" discharge of pollutants to obtain a permit which specifies the allowable constituents and amounts of its effluent (CEQ, 1974). Those with ocean outfalls are required to comply with criteria set out in the Marine Protection Research and Sanctuaries Act of 1972. This permit program is administered by EPA or by authorized states that have met certain requirements.

Each state is divided into hydrological units (basin) (Figure H-1). These are further divided into segments or sub-basins. The segments of each basin have been analyzed in detail for water quality, and the existing state standards and classification of surface water and segment categorization are evaluated for each segment.

The sub-basins are classified as either water quality or effluent limited. The water quality segments require a significant point source or non-point source to be controlled beyond the best practical treatment or secondary treatment to achieve standards. The effluent limited segment is and will continue to meet water quality standards by the "best practicable control technology" or secondary treatment for publicly owned facilities. Figures H-2 thru H-5 indicate the segment classifications for each state. However, Georgia has not adopted this method. Instead, it classifies each discharge rather than the segment as a whole, and has identified and numbered all of the remaining stream segments in the state. This designation does not mean that every discharger has the same classification.

In contrast to effluent standards, the 1972 amendments to the Federal Water Pollution Control Act (P.L. 92-500) establish water quality standards. The primary difference is that water quality standards involve a calculation of the maximum amount of wastes which can be safely discharged into water.

There are also two principal types of non-point sources: urban and agricultural practices and construction. Some of the types of pollutants that enter the water from non-point sources include soil particles, nutrients, organic matter, microscopic organisms, inorganic matter, heavy metals, chemicals and pesticides. The erosion of soil particles is the major single source of pollutant. The majority of non-point pollution can be attributed to erosion areas, intense agricultural areas and highly populated areas.

In implementing the plan for waste load allocation, effluent discharge parameters for individual point source discharges have been established. These effluent limitations are quantities, rates and concentrations of chemical, physical, biological, and other constituents that are discharged into navigable waters, waters of the contiguous zone, or the ocean. In determining the maximum allowable wasteloads of BOD an analysis of the assimilation capacity of the receiving stream is calculated. The reasonable background values are defined as: DO (Dissolved Oxygen) 85% saturation, TKN (Total All Killed Nitrogen) 1.3 mg/l maximum; BOD 4 mg/l. Significant point source discharges are any discharges that have effluent of 100,000 gallons per day or more and/or discharges that are associated with a significant water quality violation problem. Since each state presents the water quality data differently they are considered separately. The preceding information was largely taken from the water quality basin plans for the coastal region of each South Atlantic state. These plans were submitted in accordance with the 1972 Federal Water Pollution Control Amendments (P.L. 92-500, Sec. 303e).

2. North Carolina Basins

There are four coastal basins in North Carolina (Figures H-1 and H-2), Tar-Pamlico, White Oak, Cape Fear, and Yadkin, each of which is divided into sub-basins. A brief description of the water

Figure H-1

Water Quality Control Basins of the Southeastern U.S. coastal counties.

01 Chowan
03 Tar-Pamilco
04 Neuse
05 White Oak
06 Cape Fear
07 Yadkin-PeeDee
08 Santee-Cooper
09 Edisto-Combahee
13 Savannah
14 Ogeechee
17 Altamaha
18 Satilla
19 St. Mary's-Nassau
20 St. Johns
27 Florida East Coast
28 Lower Florida

Source: Environmental Protection Agency, 1972.

Figure H-2 Water Quality Classification by Sub-basins for North Carolina

Effluent Limited		Water Quality Limited
54	04	55
50	05	03
52	01	02
53	17	24
51	59	
07		
10		

Source: State of North Carolina. Water Quality Management Plans. Dept. of Natural and Economic Res. Div. of Environ. Mgmt. Environ. Mgmt. Comm. Raleigh, N.C. 1975.

quality problems for each sub-basin follows. Table H-1 indicates a summary of major discharges in these areas. There is a special state regulation 2-79 (1975) that prohibits future discharge into coastal waters that have ''SA'' (shellfishing area) designation. Publicly owned facilities that have been discharging prior to this regulation must comply with the regulation except by special decision of the Environmental Management Commission.

The major eastern rivers are effected by dischargers that are further upstream than will be considered in this discussion. There are some eutrophication problems being experienced in the coastal sub-basins that have resulted from these upstream dischargers.

a. Chowan Basin

Sub-basin 03-01-50: There is one major discharger in this sub-basin with a design capacity of 2.5 mgd and an actual flow of 2.2 mgd. The treatment plant is adequate, but severe infiltration problems require correction.

Sub-basin 03-01-51: This sub-basin has one major point source discharger with a design flow of 0.25 mgd and actual flow of 0.15 mgd. This discharger presently has secondary treatment.

Sub-basin 03-01-52: There is one major point source discharger with a design flow of 0.3 mgd and an actual flow of 0.21 mdg. This discharger is using secondary treatment facilities and adequately treated effluent is being discharged.

Sub-basin 03-01-53: There is one major point source discharger with a design flow of 0.15 mgd and an actual flow of 0.09 mgd. Facilities are marginally adequate to handle this flow.

Sub-basins 03-01-54 and 03-01-55: There are no major point source dischargers in this area. The water quality of these areas is presently adequate. This area is a resort area in which development is continually increasing. If development continues at an accelerated rate, water quality problems could result unless adequate controls are met.

b. Tar-Pamlico Basin

Sub-basin 03-03-07: There are no large population centers in this sub-basin. Water quality degradation occurs mainly in small streams below points of effluent discharges. There are four major dischargers with a design flow of 4.37 mgd and an actual flow of 2.9 mgd. These discharges have the most significant effect on water quality. Generally the water quality of the Pamlico River is good, with occasional low values being noted for dissolved oxygen concentrations that occur naturally.

c. Neuse Basin

Sub-basin 03-04-10: There are nine major point source dischargers in this sub-basin with a design flow of 10.29 mgd and an actual flow of 6.90 mgd.

Although some of these dischargers dispose effluent into water quality limited tributaries the over all sub-basin is effluent limited. For proper discharge from these plants tertiary treatment is necessary.

d. White Oak Basin

Sub-basin 03-05-01: There is one major discharger with a design flow of 0.3 mgd and an actual flow of 0.1 mgd. This discharger is presently in compliance with federal and state regulations, however, to provide adequate treatment by July '77 a new secondary facility will soon be under construction.

Sub-basin 03-05-02: This is the most heavily populated area in the basin because of Camp Lejeune Marine Base and the town of Jacksonville. Water quality data indicates that approximately 13% of this segment is degraded to some degree and the condition has been described as having ''serious degradation'' conditions. There are 14 major point sources with a design flow of 16.6 mgd and an actual flow of 10.6 mgd. There are three major point source dischargers that must be upgraded to furnish better BOD removal. These dischargers are presently at their design capacity flow and development to relieve the present problems. This sub-basin is therefore classified as ''water quality limited''.

Sub-basin 03-05-03: There are two major population centers in this sub-basin, Morehead City and Beaufort. The water quality data indicates that approximately 0.05% of the segments are degraded to some degree and the condition has been described as ''serious degradation''. There are 39 major point source dischargers with a design flow of 2.7 mgd and an actual flow of 1.7 mgd. Analysis of this area indicates a ''water quality limited'' classification and secondary treatment would not be adequate to protect water quality standards. The town of Newport will be upgraded to advanced treatment.

Sub-basins 03-05-04 and 03-05-05: Both are designated as ''effluent limited'' areas because neither area has any major point source dischar-

TABLE H-1

Point Source Dischargers for North Carolina

Sub-basins	Number of Major Discharges	Design Flow mgd 1/	Actual Flow mgd
Chowan			
50	1	2.5	2.2
51	1	0.25	0.15
52	1	0.3	0.21
53	1	0.15	0.09
54	0	0	0
55	0	0	0
Tar-Pamlico			
07	4	4.37	2.9
Neuces			
10	3		
White Oak			
01	1	0.3	0.1
02	4	16.6	10.6
03	4	2.7	1.7
04	0	0	0
05	0	0	0
Cape Fear			
17	16	77	56.7
24	2	0.8	0.6
Yadkin			
59	1	0.3	0.01

1/ Million gallons per day (1 gal = 3.785 liters).

Source: State of North Carolina, 1975c.

gers. There is a non-point source problem in 03-05-03 from a large farming operation which is causing run-off into waters that are classified for shellfish harvest.

e. Cape Fear Basin

Sub-basin 03-06-24: This area is a major recreation area; the largest year-round population is at Wrightville Beach. There are two point source dischargers in the area, four of which are major dischargers. Two of these are discharging inadequately and do not meet water quality standards.

Sub-basin 03-06-17: Wilmington is the major population center in this area, there are 16 major point sources with a design flow of 77 mgd and an actual flow of 56.7 mgd., of which three do not discharge adequately to meet water quality standards. The inadequacy is due to the discharge of large amounts of nitrogen. The Carolina beach area has a seasonal increase in population during the summer months. This sub-basin analysis has been given an ''effluent limited'' classification.

f. Yadkin Basin

Sub-basin 03-07-59: This area does not have any large population centers. There is one major point source discharger in the area with a design flow of 0.3 mgd and an actual flow of 0.01 mgd. This facility is providing adequate treatment for the small volume of wastewater being received. This area has been designated as ''effluent limited'' since secondary treatment would provide adequate treatment. The analysis indicates that a maximum of 0.3 mld (0.085 mgd) of secondary waste could be safely assimilated and the present design capacity of discharge is 0.05 mld (0.012 mgd).

3. South Carolina Basins

South Carolina has four basins and eleven coastal sub-basins as shown in Figures H-1 and H-3. Basin study plans have been designed for two basins. South Carolina law for water quality standards requires that all waste, prior to discharge into state waters, be treated in a manner which will result in a minimum of 85% reduction of biodegradable matter or an equivalent to maintain conditions under existing water standards.

Of the four major river basins in South Carolina, the Santee-Cooper River Basin was found to have the highest priority value.

a. Edisto-Combahee River Basin

There are no significant dischargers into the north or south Edisto River (segments 03-09-02 and 03-09-04). Segment 03-09-20 (the Combahee, Coosaw and Morgan rivers) shows severe contraventions of the South Carolina water quality standards. One of the most severely effected areas is the Beaufort River above the City of Beaufort, due to the discharge of raw municipal sewage.

b. Santee-Cooper River Basin

In segments 03-08-02 and 03-08-06 there are no significant point source discharges. The major problems in this area are due to a large number of non-point source discharges such as livestock and poultry operations. Segment 03-08-14 has approximately three significant discharges. The water quality problem is primarily due to the City of Charleston.

There are 16 existing facilities in the coastal sub-basin of the basin, four have secondary treatment and four are currently meeting December 31, 1975 standards found in the Water Quality Control Act. Of these facilities that do meet December 31, 1975 secondary standards few meet the water quality standards. Presently 63% of the facilities do not meet water quality standards.

4. Georgia Basins

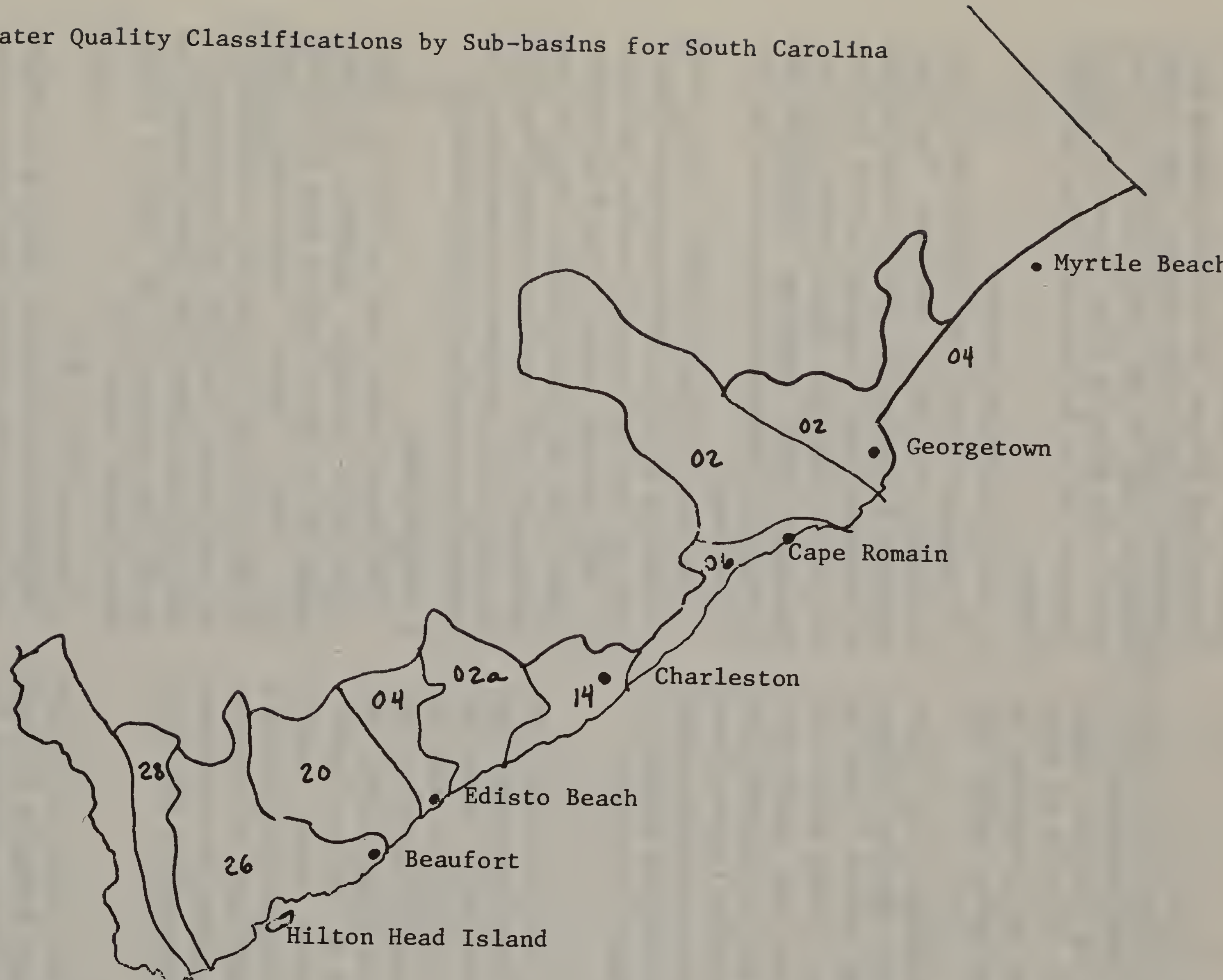
The Georgia coastal area has five river basins (Figure H-1): Savannah, Ogeechee, Altamaha, Satilla and St. Marys. Each of these are divided into Water Quality Management Units (WQMU's). Table H-2 indicates a summary of the point source discharges and design flow for each unit. The current water quality standards of Georgia are contained in the Rules of Georgia Water Quality Control, 1973.

a. Savannah River Basin

WQMU 0115: the City of Savannah is a highly populated and industrialized area. Discharges into the Savannah River come from 29 waste water facilities, five of which are considered major.

Analysis indicates that the biological assessment of water quality in most streams is healthy. However, there are some major water quality problems. Below the Augusta area the Savannah River recovers and is once again of good quality until it reaches the Savannah estuary, where it is degraded by individual and municipal waste water discharges The Savannah River downstream from

Figure H-3 Water Quality Classifications by Sub-basins for South Carolina



Effluent Limited	Water Quality Limited
02a	02
04	06
20	14
28	26

Source: State of South Carolina. River Basin Water Quality Management Plans. South Carolina Dept. of Health. 1975.

Table H-2 Point Source Dischargers for Georgia

WQMU	Number of Dischargers	Number of Major Dischargers	Number of Dischargers into Mainstream	Design Flow mgd[1]
Savannah River Basin				
0115	25	5		12.1
0192			14	115
Ogeechee River Basin				
0211	10	3		1.92
0212	4	0		0.1
0213	5	2		10.6
0292			1	0.15
Altamah River Basin				
0610	2	0		0.075
0611	1	0		0.034
0691			1	70.00
Satilla River Basin				
0710	1	0		0.35
0711	0	0		0
0712	25	10		249.9
St. Mary's River Basin				
0803	5	3		42.7

1/ Million gallons per day

Source: State of Georgia, 1974.

Hawks Gully and the King and Sibley Mills canals carries domestic and textile wastewaters and oils that altered the benthic community due to organic and toxic wastes. From U.S. Highway 17 to the mouth of the river depressed dissolved oxygen levels exist during the warm weather months.

b. Ogeechee River Basin

WQMU 0211: this area has 10 discharges three of which are considered major. They all are in compliance with discharge regulations. The median water quality characteristics show complete conformance with the applicable "recreational" water quality standards. Examination of the quality on flow data characterization reveals dissolved oxygen and fecal coliform violations; these are probably due to natural causes. In general, the water quality characteristics at this point are excellent and present little indication of man's influence on the environment.

WQMU 0212: this area contains the lowest population density in the management area. It has four point source discharges, none of which are considered major. Analysis indicates that the water quality in this area show excellent flow characteristics.

WQMU 0213: this is the largest WQMU in the basin. There are five discharges in this unit, two which are major. The median water quality characteristics show a slight violation of the single dissolved oxygen standards.

In general the water quality in the North Newport River estuarine sampling stations is excellent.

c. Altamaha River Basin

WQMU 0610: this unit has two discharges none of which are considered major. Non-point source water pollution information is not available for this basin.

WQMU 0611: this area has one point source discharge but it is not considered major. There has not been any analysis on the non-point sources.

The general water quality in both these management units is considered good.

d. Satilla River Basin

WQMU 0710: there is one point source discharge of minor importance in this unit. The major cause of pollution in this area is non-point sources. Significant man induced non-point water pollution sources occur in the Woodbine area. This is basically due to failing septic tanks and inadequate disposal of solid wastes.

The general description of water quality in the area is in violation of fishing standards. There is a high coliform count and phosphorus level in this area.

WQMU 0711: this area does not have any non-point or point source discharges.

WQMU 0712: the most significant non-point water pollution problem in the WQMU is the contamination of the areas of ground water reserves by salt water intrusion. The other non-point sources that result in problems are solid waste disposal, and storm runoff in the Brunswick area.

The Brunswick area is highly populated and industrialized. There are 25 point source discharges in the area, 10 of which are major. The general water quality for this unit has a high fecal coliform content. The dissolved oxygen violations present are probably due to natural causes rather than man-induced.

e. St. Marys River Basin

WQMU 0803: the non-point pollution in this area is mainly due to natural causes. The amount of agricultural land in the WQMU is small in comparison to vast amounts of existing forest levels, causing little day to day non-point pollution from agricultural sources. Storm water runoff may add to non-point problems.

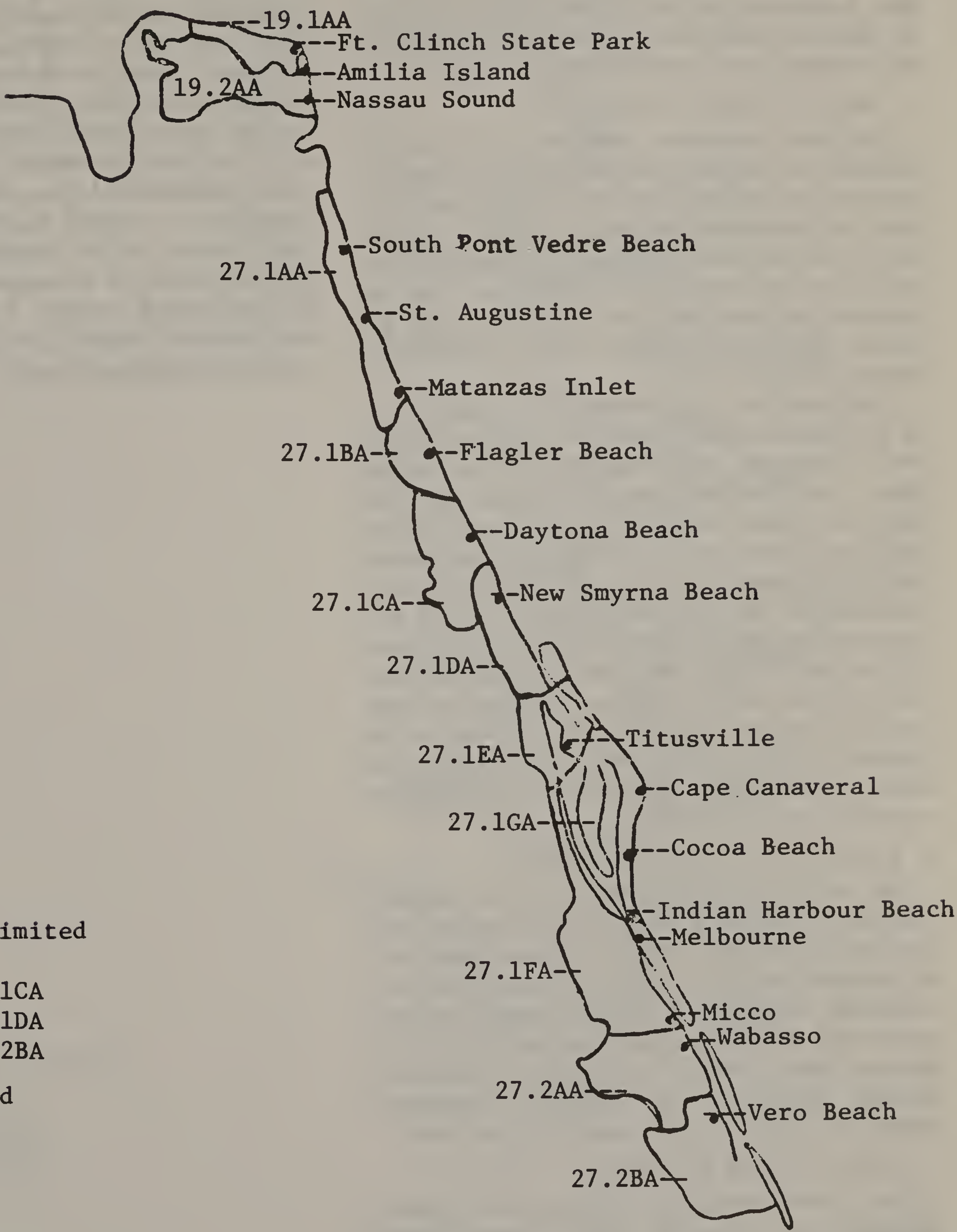
There are five discharges in this area and three are considered major. Of the total waste source in this basin 84% is from WQMU 0803.

In general it can be concluded that the water quality of St. Marys watershed violates stream standards. Violations are most consistent in terms of pH, but occasional contraventions in terms of dissolved oxygen are also likely. This is obviously due to the release of swamp water by natural drainage and runoff into the receiving streams. These swamp waters are supersaturated with CO_2 (H_2CO_3 acid) as they are released into the receiving stream.

5. Florida Basins

There are three coastal basin plans for the east coast of Florida: Nassau-St. Marys, East Coast Florida, and Lower Florida. Each of the basins are divided into segments. The Nassau-St. Marys basin has two coastal segments; Upper Florida east coast (Figure H-4) has nine coastal segments and Lower Florida has eight coastal segments. The segments are analyzed separately with a ranking according to pollution severity and population, and then classified as either water quality

Figure H-4 Water Quality Classification by Segments for Upper Florida East Coast



Water Quality Limited

19.2AA	27.1CA
27.1AA	27.1DA
27.1BA	27.2BA

Effluent Limited

27.2AA

Unclassified

27.1EA
27.1GA
27.1FA

Source: State of Florida. Water Quality Management plans. East coast Florida River Basin and Nassau-St. Mary's River Basin. Dept. of Pollution Control. 1975.

limited or effluent limited. Table H-3 gives a summary of the segments in regards to: segment ranking; number of point sources and major point sources within the segment; total design flow; total actual flow for each segment; and classification. A summary of water quality analysisis found in Table H-4. This gives an indication of some of the problem areas on the Florida East coast.

a. Nassau-St. Marys River Basin

The most frequently observed water quality problems in the Nassau-St. Marys River Basin are high nutrient and low dissolved oxygen concentrations and unacceptable fecal coliform bacteria levels. Natural swamp drainage, diffuse-source runoff from agricultural and urban areas, and the discharge of domestic and industrial waste effluents seem to be the likely causes of the water quality problems.

There are three significant industrial dischargers in the coastal basin located in segment 19.1AA which discharge their effluents into the Amelia River. Low dissolved oxygen problems and fish kills have been observed in the Amelia River which may have been caused by these companies discharging large amounts of BOD into the river. According to the EPA (1972), the dissolved oxygen concentration is not expected to be above 5.9 mg/l even if there were no discharge into the river. In view of this, effluent standards were set for each company and these can be found in the Nassau-St. Marys River Basin Plan. In general this is a small basin with good water conditions except for the Amelia River.

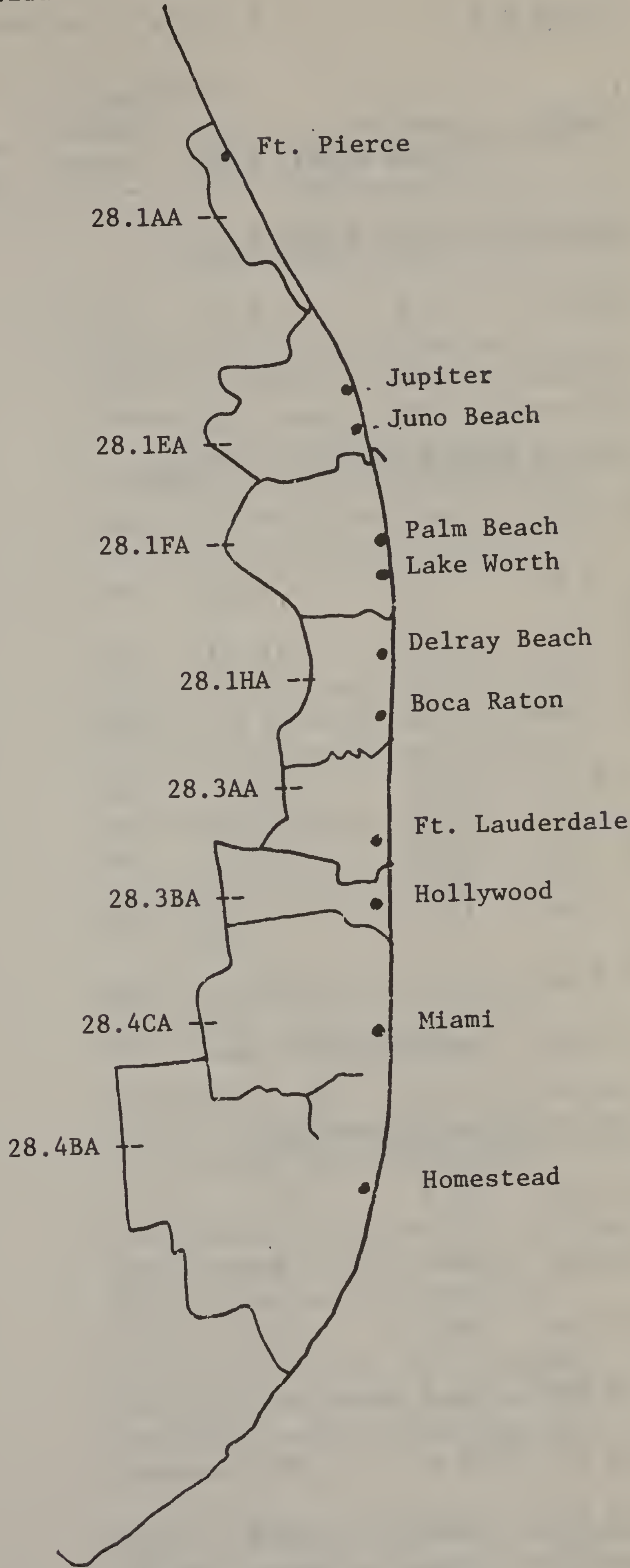
b. Florida East Coast River Basin

The most frequently observed water quality problems in this river basin are high nutrient and low dissolved oxygen levels. High concentrations of phytoplankton and coliform bacteria occur occasionally. Discharge of treated domestic wastes and runoff from developed areas seem to be the primary sources of the water quality problems indicated. There are no significant industrial dischargers in the coastal segments of this basin.

c. Lower Florida River Basin

The Lower Florida River Basin water quality problems are generally high nitrogen, high nitrogen-phosphorous and low dissolved oxygen concentrations. Unacceptable fecal coliform bacteria levels are indicated less frequently. The only significant industrial discharger in this basin is in segment 28.1 AA. However, it is the most severely affected basin of the coastal region as indicated in Table H-3. Segment 28.3 AA is ranked first both in the basin and the state for poor water quality. This segment has the greatest amount of dischargers for the coastal area, 95 point sources with 79 of these considered major. The design flow for the area is 6510 mld (1719.9 mgd). According to the Water Quality Management Plan for the lower Florida River Basin (Palm Beach area) the point wastewater dischargers were the major contributing factors degrading water quality conditions in several freshwater canals and in Lake Worth. In the summary of water quality analysis, Table H-4 indicates that this segment has widespread nutrient, fecal coliform bacteria and dissolved oxygen (DO) problems as well as excessive chlorophyll levels.

Figure H-5 Water Quality Classification by Segments for Lower Florida East Coast



Water Quality Limited

28.1EA 28.3BA
28.1FA 28.4CA
28.1HA 28.4BA
28.1AA

Effluent Limited

28.1AA

Source: State of Florida. Water Quality Management Plans. Lower Florida River Basin. 1975.

Table H-3 Florida River Basin Summary

Segment	Design Flow (mgd)	Flow mgd	Number of Point Sources	Number of Major Point Sources	Ranking in State	Classification
Nassau-St. Marys River Basin						
19.1 AA	1.5	1.5	7	1	62	EL
19.2 AA	6.1	0.6	17		81	WQ
Florida East Coast River Basin						
27.1 AA	5.3	3.2	45	6	100	WQ
27.1 BA	0.3	0.01	19	1	102	WQ
27.1 CA	20.3	15.53	60	9	59	WQ
27.1 DA	1.8	2	20	3	82	WQ
27.1 EA	1251.6	197.4	16	6	72	UK
27.1 FA	14.5	11.3	26	11	67	UK
27.1 GA	12.2	9.2	14	12	87	UK
27.2 AA	0	0	16	0	110	EL
27.2 BA	insufficient data		68	---	90	WQ
Lower Florida River Basin						
28.1 AA	5.5	UK	36	4	97	E
28.1 EA	6	4.6	38	11	13	WQ
28.1 FA	48.3	27.7	54	20	9	WQ
28.1 HA	38.3	11.1	43	13	14	WQ
28.3 AA	1719.9	UK	95	79	1	WQ
28.3 BA	48.3	25.3	36	19	12	WQ
28.4 CA	UK	UK	UK	UK	5	WQ
28.4 BA	UK	UK	UK	UK	8	WQ

UK - UNKNOWN WQ - WATER QUALITY LIMITED E - EFFLUENT LIMITED

Source: State of Florida, 1975b.

Table H-4 Water Quality Analysis for Florida

Segment	Number of Dischargers Not Meeting Standards	Water Quality Analysis
<u>Nassau - St. Mary's Basin</u>		
19.1 AA	2	Nutrient, coliform bacteria and low DO problems; domestic and industrial wastes are responsible.
19.2 AA	UK	Nutrient and low DO problems; source of problem is one point source and non-point sources.
<u>Florida East Coast Basin</u>		
27.1 AA	4	Nutrient and low DO problems; source of problem is one point source and non-point sources.
27.1 BA	0	No serious water quality problem.
27.1 CA	UK	Nutrient, coliform and low DO problems.
27.1 DA	2	High phosphorous and low DO (problems are not serious).
27.1 EA	UK	Phosphorous and low DO problems; urban runoff and domestic waste discharges are responsible.
7.1 GA	UK	Phosphorous and low DO problems; urban runoff and domestic waste discharges are responsible.
27.1 FA	UK	Nutrient and low DO problems; non-point sources and several domestic waste discharges are responsible.
27.2	0	High concentrations of nutrients low DO; domestic wastes and urban runoff can cause problems.

Table H-4 (continued)

Segment	Number of Dischargers Not Meeting Standards	Water Quality Analysis
<u>Lower Florida Basin</u>		
28.1 AA	0	Nitrogen problems and low DO levels.
28.1 EA	UK	High nutrient levels.
28.1 FA	UK	High nutrient levels.
28.3 HA	UK	High nutrient levels.
28.3 AA	UK	Widespread nutrient, coliform bacteria and low DO problems; excessive chlorophyll levels.
28.3 BA	UK	Frequent nutrient, coliform bacteria and low DO problems (this area is highly populated).
28.4 BA	UK	High nutrient levels and low DO problems; point source dischargers were major cause of water degradation.

DO - dissolved oxygen

UK - Unknown

Source: State of Florida, 1975b.

I. Air Quality

The purpose of atmospheric pollution control is to limit the allowed maxima of pollutant concentrations in the atmosphere of an urban or rural area. These maxima are determined by State and Federal agencies in regard to the characteristics of principal pollutants and the degree of inconvenience and damage that can be tolerated.

In 1971 pursuant the Clean Air Act as amended (42 USC 1857c, *et seq.*) the Environmental Protection Agency promulgated national primary and secondary ambient air quality standards for six pollutants. Within 9 months after promulgation of these standards each state was required to adopt a plan which provided for the implementation, maintenance and enforcement of the national air quality standards within each air quality control region (AQCR). Table I-1 lists the Federal Ambient Air Standards which are as stringent or more stringent than the Federal standards.

Some of the state air quality standards are more stringent than the Federal air quality standards, these are identified in Table I-2. It is noted that Florida has special air quality standards for Dade, Broward and Palm Beach counties, this is evident in the requirements of particulate and SO_2 standards. These counties presently have good air pollution ratings, but violations of both suspended particulate and ozone standards do occur. It has also been indicated that the population of these counties has an increased number of elderly persons with respiratory ailments. Therefore, the air quality standards have been made more stringent so as to minimize the potential adverse effect of lowered air quality on this group of elderly persons.

South Carolina has a regulation that requires the control of hydrogen flouride (HF) emissions. This is the result of HF etching windows in areas where this emission occurs. It was also found that hydrogen fluoride in high concentrations can cause damage to flora and fauna and can build up in the food chain causing fluorosis in high order animals. Currently, the stainless steel and fiberglass industries in this state contribute to these emissions. However, the locations of these facilities are inland and do not effect the coastal area.

Pursuant to the Clean Air Act as amended, the Environmental Protection Agency has divided the country into Air Quality Control Regions (AQCR's). There are eight coastal AQCR's within the Southeast Atlantic States. Figure I-1 illustrates these regions.

Estimates of air pollution emissions for each AQCR and for coastal counties have been compiled by EPA Region IV in Atlanta, Ga. These data are compiled in Tables I-3 thru I-7.

The emissions data give quantities of pollutants being emitted into the air, and the air pollution potential gives some indication of the likelihood that the emissions will not be satisfactorily dispersed. However, the data that is presented is not a true picture of the air quality of a given AQCR or county. Most of the data available are from urban centers. This might seem to indicate a region wide problem where in fact it is only an urban problem. Measurements are being initiated in non-urban areas but data has not yet been obtained from these areas.

Figure I-2 gives a general indication of the areas which exceed the national ambient air quality standards.

The influence of particulate and sulfate concentrations on increased mortality has been demonstrated. Over the past 30 years, there has been an increase in death rates due to respiratory and cardiovascular ailments that have been strongly correlated with increased particulate and sulfate air pollution levels (Gottlieb, 1975).

The pollutant produced in the largest volume is carbon monoxide. In 1975 the total carbon monoxide reading for the southeastern coastal AQCR's was 5,824,308 tons/yr. Over 90% of these emissions are due to automobiles.

Table I-8 indicates the counties and the point sources responsible for the highest emissions for particulates, SO_x, NO_x, hydrocarbons and carbon monoxide. It is generally noted that: 1) particulate emissions result from industrial processes such as mineral and wood products, area burning, fugitive dust and paved roads; 2) the SO_x and NO_x result from fuel combustion of coal, oil or natural gas; 3) the use of gasoline for transportation is responsible for carbon monoxide emissions; 4) and hydrocarbons have varied sources for each particular area.

The general air quality in the study area is good. However, the counties with major urban areas indicates high pollution concentrations. It therefore indicates that an increase in pollutants directly correlates with the increase in population of an area. These urban areas seem to be isolated problems.

Table I-1 Federal Ambient Air Quality Standards

Parameter	Standard Primary	Standard Secondary
Particulate Matter:		
Annual geometric mean	75 ug/m^3 1/	60 ug/m^3
24-hour maximum	260 ug/m^3	150 ug/m^3
Sulfur Oxides:		
Annual arithmetric mean	80 ug/m^3	
24-hour maximum	365 ug/m^3	
3-hour maximum	--	1300 ug/m^3 (not to be exceed more than once per year)
Carbon Monoxide:		
8-hour maximum	10 mg/m^3 2/	10 mg/m^3
1-hour maximum	40 mg/m^3	40 mg/m^3
Photochemical Oxidants:		
1-hour maximum	160 ug/m^3	160 ug/m^3
Hydrocarbons:		
3-hour maximum	160 ug/m^3	160 ug/m^3
Nitrogen Dioxide:		
Annual arithmetic mean	100 ug/m^3	100 ug/m^3

1/ ug/m^3 = micrograms per cubic meter

2/ mg/m^3 = milligrams per cubic meter

Source: EPA, 1971.

Table I-2 States that have more stringent air quality standards than federal air quality standards for particualr pollutants.

State	Parameter	Federal Secondary Standards ug/m^3	State Standards ug/m^3	County Standards ug/m^3
North Carolina				
NO_2	annual arithimatic mean	160	same	
	24 hours 1/	none	250	
South Carolina				
photochemical oxidant	1 hour	160	100	
non-methane hydrocarbons	3 hours	160	130	
Georgia				
SO_2	annual arithimatic mean	60	43	
	24 hours	260	229	
	1 hour	none	715	
total oxidant	1 hour	160	98	
non-methane hydrocarbons	3 hours	160	98	
Florida				
SO_2	annual arithimatic mean	80	60	8.6 2/
	24 hours	265	260	28.6
	3 hours1/	1300	same	57.2
	1 hour	none	same	286
Particulate	annual arithimatic mean	60	same	50
	24 hours	150	same	180

1/ not to be exceeded more than once per year

2/ Dade, Broward & Palm Beach counties, Florida

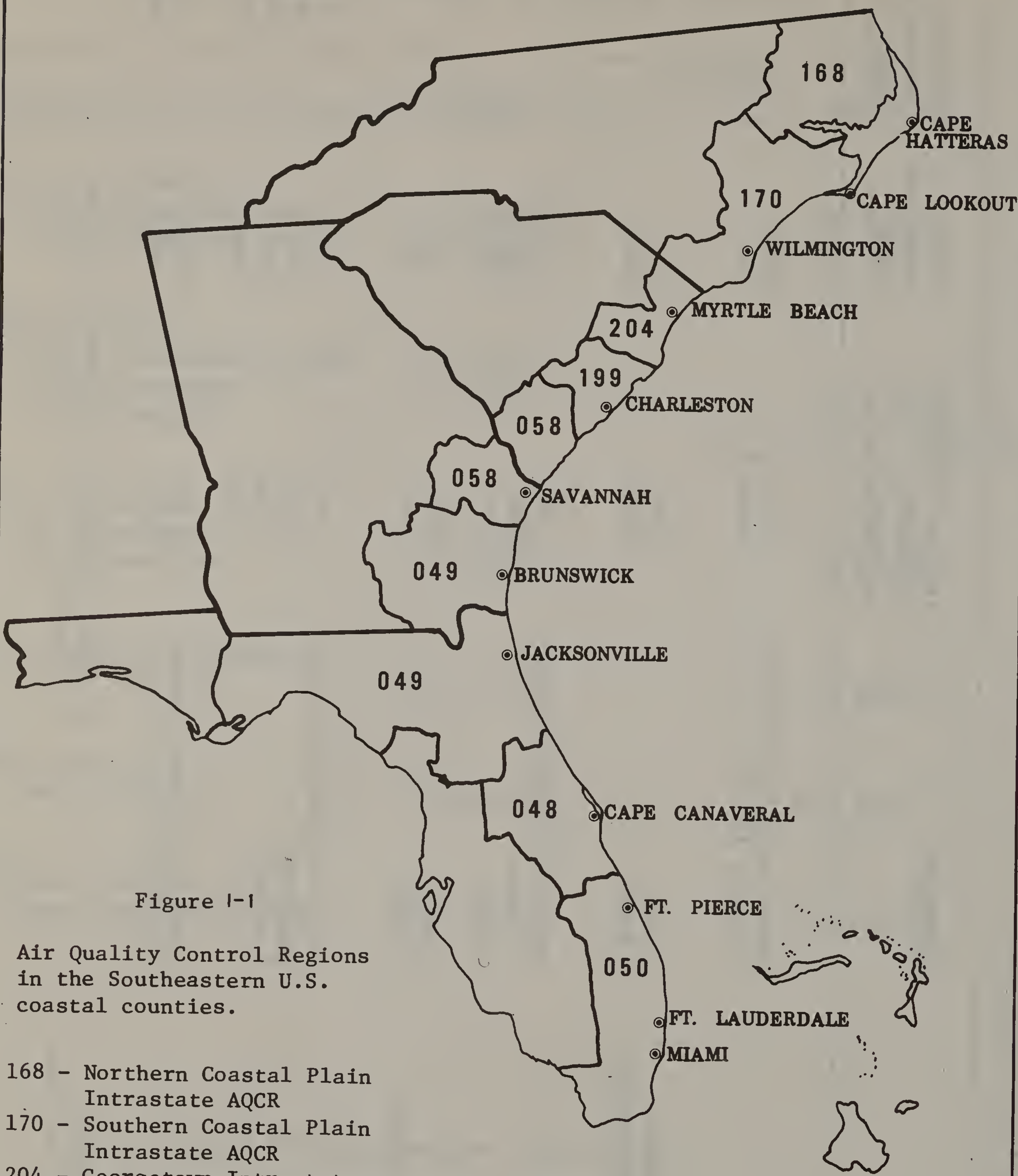


Figure I-1

Air Quality Control Regions in the Southeastern U.S. coastal counties.

168 - Northern Coastal Plain Intrastate AQCR
170 - Southern Coastal Plain Intrastate AQCR
204 - Georgetown Intrastate
199 - Charleston Intrastate
058 - Savannah (Ga.) - Beaufort (S.C.) Intrastate AQCR
049 - Jacksonville (Fla.) - Brunswick (Ga.) Intrastate AQCR
048 - Central Florida Intrastate AQCR
050 - Southeast Florida Intrastate AQCR

Source: Environmental Protection Agency, 1972.

Table I-3 Air Pollution Emissions Estimates for the AQCR of the Southeast Atlantic Coastal Region

	Emissions in Tons/yr				
AQCR	Particulates	Sulfur Oxides	Nitrogen Oxides	Hydrocarbons	Carbon Monoxide
168	42,549	26,059	32,897	42,243	*4,576,171
170	84,626	70,165	69.077	66,588	324,756
204	12,016	23,725	17,429	24,843	122,858
199	39,450	96,411	47,832	52,164	158,351
058	68,720	52,383	54,120	62,061	247,160
049	*93,987	*212,157	*126,734	*77,914	307,619
048	14,529	49,977	69,614	29,018	87,393

* Highest recording

Source: EPA Region IV Data Bank, 1974.

Table I-4 Air Pollution Emissions Estimates for North Carolina Atlantic Coastal Region

County	Particulates	Sulfur Oxides	Nitrogen Oxides	Hydrocarbons	Carbon Monoxide
	Emissions in Tons/yr				
Beaufort	2,781	9,602	3,417	3,429	15,721
Berte	3,418	268	1,580	2,409	11,511
Brunswick	2,915	2,066	5,320	5,442	20,812
Camden	440	130	927	1,073	4,102
Cartert	1,100	960	3,734	4.586	18,179
Chowan	325	520	589	1,177	5,051
Craven	3.071	5,107	5,720	6.281	34,562
Currituck	490	337	2,434	1,672	5,685
Date	201	249	1,321	2,549	8,922
Hyde	1,010	403	2,982	3,027	9,367
New Hanover	*13,377	25,728	16,033	10,836	27,534
Onslow	5,162	921	6,541	*11,267	55,050
Pamlico	367	325	2,229	1,538	5,208
Pasquotank	5,454	568	1,144	1,682	7,070
Pender	1,220	349	2,628	3,280	13,035
Perquimans	309	102	523	958	4,542
Tyrrell	3,037	*67,157	*44,008	2,097	6,280
Washington	1,807	149	831	1,807	*4,431,329

Source: EPA Region IV Data Bank, 1975.

Table I-5 Air Pollution Emissions Estimates for the South Carolina Atlantic Coastal Region

County	Particulates	Sulfur Oxides	Nitrogen Oxides	Hydrocarbons	Carbon Monoxide
	Emissions in Tons/yr				
Beaufort	1,191	489	2,518	5,515	21,393
Charleston	*11,306	*21,962	*17,531	*39,524	*112,192
Colleton	5,156	15,925	13,984	4,146	18,119
Georgetown	6,365	14,793	4,389	8,644	63,703
Horry	3,865	8,531	10,908	11,409	39,953
Jasper	675	56	734	2,574	7,427

Source: EPA Region IV Data Bank, 1974.

Table I-6 Air Pollution Emissions Estimates for the Georgia Atlantic Coastal Region

County	Particulates	Sulfur Oxides	Nitrogen Oxides	Hydrocarbons	Carbon Monoxide
	Emissions in Tons/yr				
Bryan	132	91	1,086	1,330	5,769
Camden	1,705	14,049	3,804	2,648	24,258
Chatam	*48,444	*32,842	*23,118	12,308	*108,197
Glynn	7,462	19,337	9,504	5,555	34,809
Liberty	11,278	2,263	6,073	*22,608	41,960
McIntosh	139	83	1,129	2,175	8,904

Source: EPA Region IV Data Bank, 1974.

Table I-7 Air Pollution Emissions Estimates for the Florida Atlantic Coastal Region

County	Emissions in Tons/yr				
	Particulates	Sulfur Oxides	Nitrogen Oxides	Hydrocarbons	Carbon Monoxide
Brevard	1,887	13,950	19,882	6,619	18,105
Broward	6,204	38,994	42,473	20,089	36,510
Dade	3,388	10,906	21,705	*34,803	*67,864
Duval	*21,607	*110,593	*58,593	19,097	41,792
Flagler	1,149	36	290	1,215	4,204
Indian River	1,469	9,274	4,818	2,164	6,877
Martin	3,731	19,610	7,891	2,338	6,726
Nassau	4,013	15,546	4,774	2,441	8,299
Palm Beach	6,683	24,706	21,367	9,487	24,390
St. John's	1,150	98	667	2,019	6,699
St. Lucie	1,518	143	959	2,591	8,219
Volusia	4,900	33,562	38,247	6,593	19,385

Source: EPA Region Data Bank, 1974.

Figure I-2 Southeastern United States Regions That Exceed National Ambient Air Quality Standards

Status of oxidant/ozone levels, 1973.

- ANNUAL OR 24-hour STANDARD EXCEEDED
- ALL REPORTED DATA ARE BELOW STANDARDS
- NO DATA

Status of sulfur dioxide levels, 1973.

- 1-hour STANDARD EXCEEDED
- ALL REPORTED DATA BELOW 1-hour STANDARD
- NO DATA

Status of suspended particulate levels, 1973.

- PRIMARY STANDARD EXCEEDED (24-hour OR ANNUAL)
- ALL REPORTED DATA ARE BELOW PRIMARY STANDARD
- NO DATA

Status of carbon monoxide levels, 1973.

- 8-hour STANDARD EXCEEDED
- ALL REPORTED DATA BELOW THE 8-hour STANDARD
- NO DATA

Source: Monitoring and Air Quality Trends Report, 1973. U.S. Environmental Protection Agency. Office of Air and Waste Management. Research Triangle Park, N. Carolina. EPA-450/1-74-007.194

Table I-8. Point Source Emissions for Selected Southeastern U.S. Coastal States and Counties.

State	County	Emission	Source	Point Source
North Carolina	New Hanover (Wilminton) Onslow Tyrell Washington	particulate hydrocarbons SO_x and NO_x CO	industrial proc. miscellanous fuel comb. solid waste disposal	mineral prod. forest fire agri. burning elec. gen. gituminous coal incineration wood ind.
S. Carolina	Charleston (Charleston)	particulate SO_x NO_x and CO HC	industrial proc. fuel comb. transportation industrial prod.	mineral & wood prod. residual oil gasoline evaporation
Georgia	Chatam (Savannah) Liberty	particulate SO_x and NO_x CO HC	industrial proc. fuel comb. (industrial) indus. prod. & trans. transportation	wood prod. residual oil, gas & wood wood & gasoline military aircraft
Florida	Dade	HC & CO	transportation	gasoline
	Duval (Jacksonville)	particulate SO_x and NO_x	industrial proc. fuel combustion	mineral prod. residual oil

Source: EPA Region IV Data Bank, 1975

Table I-9 lists the air quality control regions which have exceeded the national ambient air quality standards. The number of sampling stations in each region is indicated and the number of stations with readings above national standards is indicated. In almost every case, the data are from sampling points located in urban or industrial areas. The trends in Table I-9 are based on limited data.

Table I-9. Summary of Air Quality Control Regions (AQCR) Exceeding National Ambient Air Quality Standards in selected southeastern U.S. Coastal Regions.

Number of Occurrances When Levels Exceeded the Air Quality Standards

	AQCR #168			AQCR #170			AQCR #204			AQCR #199			AQCR #58			AQCR #49			AQCR #48			AQCR #50		
	Northeastern Region Washington Office N. Carolina			Southeastern Region Wilmington Office N. Carolina			Georgetown Intrastate S. Carolina			Charleston Intrastate S. Carolina			Savannah - Beaufort Region S. Carolina And Georgia			Northeastern Region Florida			Central Region Florida			Southeastern Region Florida		
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974
Nitrogen Dioxide Annual #sampling stations	11	11	11	12	13	13	2	2	3	5	6	6	2	6	6	1	1	2						
No. greater than the primary and secondary standards 100 ug/m^3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						

Source: EPA Region IV Data Bank, 1975
State of N Carolina, 1974.
State of S. Carolina, 1974; State of Florida.
State of Georgia, 1973.

Table I-9 (continued)

Number of Occurrances When Levels Exceeded the Air Quality Standards

	AQCR #168			AQCR #170			AQCR #204			AQCR #199			AQCR #58			AQCR #49			AQCR #48			AQCR #50	
	Northeastern Region - Washington Office N. Carolina			Southeastern Region Wilmington Office N. Carolina			Georgetown Intrastate S. Carolina			Charleston Intrastate S. Carolina			Savannah - Beaufort Region S. Carolina And Georgia			Northeastern Region Florida			Central Region Florida			Southeastern Region Florida	
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973
Sulfur Dioxide Annual # sampling stations	11	11	11	12	13	13	2	2	3	5	6	6	2	9	7	1	1	2					
No. greater than the secondary standard 60 ug/m^3 = 0.02 ppm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
No. greater than the primary standard 80 ug/m^3 = 0.03 ppm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					

Table I-9 (continued)

Number of Occurances When Levels Exceeded the Air Quality Standards

	AQCR #168			AQCR #170			AQCR #204			AQCR #199			AQCR #58			AQCR #49			AQCR #48			AQCR #50	
	Northeastern Region Washington Office N. Carolina 11 Sampling Stations			Southeastern Region Willmington Office N. Carolina			Georgetown Intrastate S. Carolina			Charleston Intrastate S. Carolina			Savannah - Beaufort Region S. Carolina And Georgia			Northeastern Region Florida			Central Region Florida			Southeastern Region Florida	
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973
<u>Suspended Particulates</u> <u>Annual geometric mean</u> # sampling stations	11	11	11	13	14	14	3	4	4	4	4	4	8	9	10	1	1	3					
No. greater than the secondary standard 60 ug/m^3	0	0	1	2	3	2	1	3	3	2	1	1	2	4	3	1	1	0					
No. greater than primary standards 75 ug/m^3	0	0	0	1	1	0	1	2	3	1	1	1	1	2	2	0	1	0					

J. Historical and Projected Economic Growth

1. Introduction

The report of the Commission on the Future of the South to the Southern Growth Policies Board (1975) included consideration of the four areas of growth management, land and natural resources, human resources and transportation. As a result of the energy crisis and inflation, the scope of the Commission's work expanded to include these topics.

The report of the Commission included a 15 state region within its area of consideration, extending from Maryland to Texas, and provided some general comments concerning the factors that led to the growth of the South.

During the 1950's the region made its transition from an agricultural and mining economy to a manufacturing economy. During the 1960's the South's own internal markets and urban centers developed sufficiently to provide, for the first time, more jobs for those engaged in making goods, mining, or raising food and fiber. Also, it was during this period that Southern financial institutions achieved the ability to finance growth from the region's own capital resources, a dramatic breakthrough from the previous need to seek development capital outside the region.

The massive outmigration of southern population, particularly Appalachian and black, that occurred during earlier decades is rapidly tapering off, and the South is becoming an area of net inmigration although this trend is highly concentrated and many sections of the South are still exporting large numbers of their people.

The Commission's report noted certain growth related characteristics of the South, including: 1) the South is heavily dependent upon the automobile, 2) the South's pattern of growth is energy intensive, 3) the South has become an urban society, and 4) several Southern cities are becoming major U.S. and world centers.

The report made mention of some of the problems associated with the growth of the South. Among these problems were:

1) Much recent growth has not yielded commensurate benefits to the people of the South.

2) The South has been preoccupied until recently with the quantity of its economic growth rather than its quality.

3) The growth of the South has been very unevenly distributed.

4) Urban areas are growing without regard for the wise use of land or the orderly provision of public services and access.

5) Simultaneously, the more isolated non-urban areas of the South, heavily depopulated by the migration of the past, suffer from depleted tax resources, inadequate public services and housing, and insufficient economic opportunities.

6) Where growth has occurred it has been allowed, in many instances, to erode the region's prized natural assets.

The Report to the Southern Growth Policies Board contained numerous recommendations in many areas of concern; including the need for a growth policy, human resource development, land use and natural resources, human resources, and transportation. The Commission hoped that the report and the extensive research and committee findings generated for the Commission would be widely used. It was hoped that the major portions would furnish subjects for conferences and seminars concerned with the impacts of growth on government, local communities, private enterprise and the Southern people generally.

Figure J-1 reproduced from this report illustrates the major employment trends in a area comprising the 15 Southern states and Missouri.

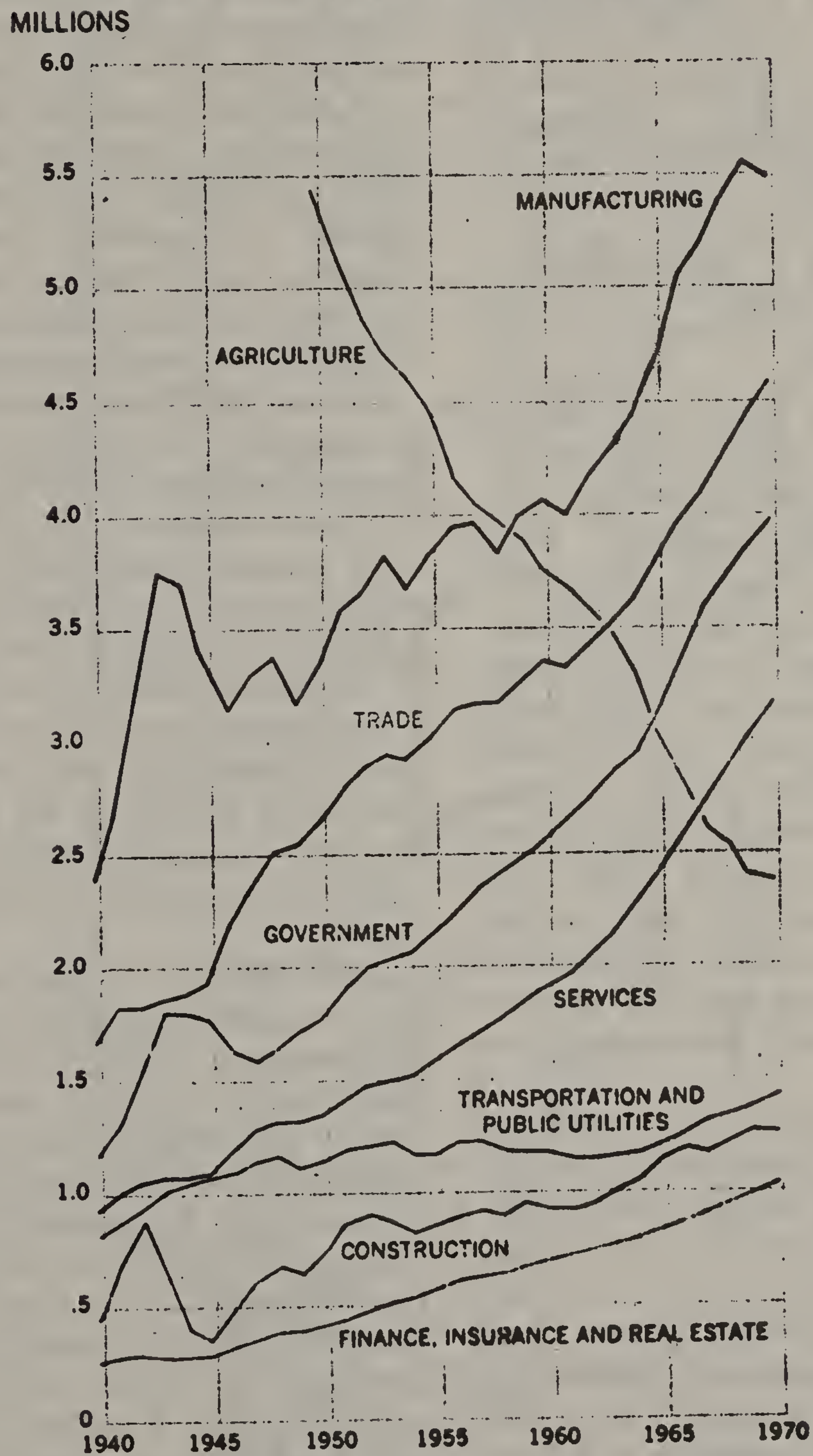
In the following section, comments applicable to individual states and regions have been obtained from other refernece material.

a. North Carolina

The past trends in the North Carolina economy were reviewed in the publication, Economic Development Strategy, Phase 1, North Carolina's Economic Growth Management Study, prepared for the North Carolina Department of Administration and the North Carolina Department of Natural and Economic Resources by the Research Triangle Institute and published during July 1974. The following passages were obtained from this publication:

"Between 1950 and 1960, population grew by 12.2% in spite of a continuing out-migration of large numbers of people. The transition from agriculture to manufacturing, which had begun as early as 1880, was accelerated during the decade; this shift was fueled principally by white males from the agricultural sector. The Employment Security Commission estimates that employment in manufacturing grew by 105,000 and, by 1960, the manufacturing sector represented 31.2% of total employment and the agricultural sector only 13.4%. However, these manufacturing jobs were improvements over alternative forms of employment and permitted the State's per capita personal income growth to keep pace with the growth in the national average, throughout the decade."

FIGURE J-1 EMPLOYMENT TRENDS IN THE 16-STATE SOUTH[1] BY SELECTED MAJOR INDUSTRIES, 1940-1970



1 Includes 15 Southern states and Missouri.

Source: Ross W. Hammond, Economic Development Trends in the 16-State South, Industrial Development Division, Georgia Institute of Technology, March 1972.

"The North Carolina economy made significant gains in the 1960-1970 decade in employing higher percentages of its working age population, in stemming out-migration, and in closing the per capita income gap between North Carolina and the nation. Although the relative standing of manufacturing wages remained 49th among the States, per capital personal income, which rose from 70.4% of the national average in 1960 to 81.6% in 1970, continued up to 84.5% in 1972. There was a substantial increase in the number of workers entering the labor force, particularly white and non-white females. The major share of the manufacturing employment growth continued to be in relatively low wage jobs, for the latter part of the decade showed a trend toward higher wage employment. This trend has continued into 1974."

The report commented on the growth characteristics of the Coastal Plain regional division, incorporating an area larger than the four coastal planning regions, in the following passage:

"Generally, Coastal Plain counties other than those in the northeast began moving into an intermediate stage of development over the decade. They experienced manufacturing employment growth rates that exceeded the State average; however, total employment rates in those counties were below the State average. More recent evidence of Coastal Plains growth after 1970 seems to indicate that this region is completing its movement out of the initial stage of development and into the intermediate stage (with dependence on manufacturing replacing dependence on agriculture)."

The Statewide Development Policy, a publication of the Department of Administration of the State of North Carolina in March 1972, commented on the changes that had taken place in the economy of the state:

"Today, the whole of the rural southeast is in the midst of a remarkable economic transformation, one without historical parallel. This is the unyielding movement from a rural farm to a rural non-farm way of life.

"For the past quarter century, the spotlight has been on the spectacular urban growth of the south-resulting in the emergence of major metropolitan centers.

"Now, agriculture is universally and rapidly declining as a major source of rural job opportunities and farm population along with it. Although economic activity in rural population centers has expanded it has not been sufficient to fully replace agriculture. Population has been flowing into these centers. But their growing importance as a source of non-farm job opportunities has not been recognized, nor has the need for an urban service base to support these centers as an alternative to metropolitan concentration."

The coastal area of North Carolina has been included in four multi-county planning regions designated regions O, P, Q and R (Figure J-2).

The planning agencies for the various regions are identified in the following summation.

Region O (Cape Fear Council of Governments): consists of the four counties of Brunswick, Columbus, New Hanover and Pender. This region is located on the southern portion of the North Carolina coast adjacent to South Carolina.

During 1970, the population of this planning region amounted to 172,305, and the 1970 per capita income amounted to $2,894, compared to the state per capita income of $3,218. Cash receipts from farm marketing amounted to approximately $57 million during 1971. During 1971, approximately 5.4% of the workforce was unemployed, compare to 3.9% unemployed on a statewide basis.

Region P (Neuse River Council of Governments): consists of the nine counties occupying the central portion of the coastal area of North Carolina, including Greens, Wayne, Duplin, Lenoir, Onslow, Jones, Craven, Pamlico and Carteret.

During 1970, the population of this planning region amounted to 410,123 persons, and the per capita income of $3,218. Cash receipts from farm marketing amounted to approximately $225 millions of dollars during 1971. During 1971, approximately 5.1% of the workforce were unemployed, compared to a state unemployment rate of 3.9%.

Region Q (Mid-East Economic Development Commission): this planning region consists of five counties located between the common border with the State of Virginia and Pamlico Sound, and since the region is located inland of planning area R, it is not adjacent to the Atlantic Ocean. During 1970, the population of Planning Region Q amounted to 178,667 persons, and the per capita income was $2,598, compared to a state per capita income of $3,218. Cash receipts from farm marketing amounted to approximately $129 millions of dollars in 1971, and, during that year 5.6% of the workers were unemployed, compared to a state figure of 3.9% unemployed.

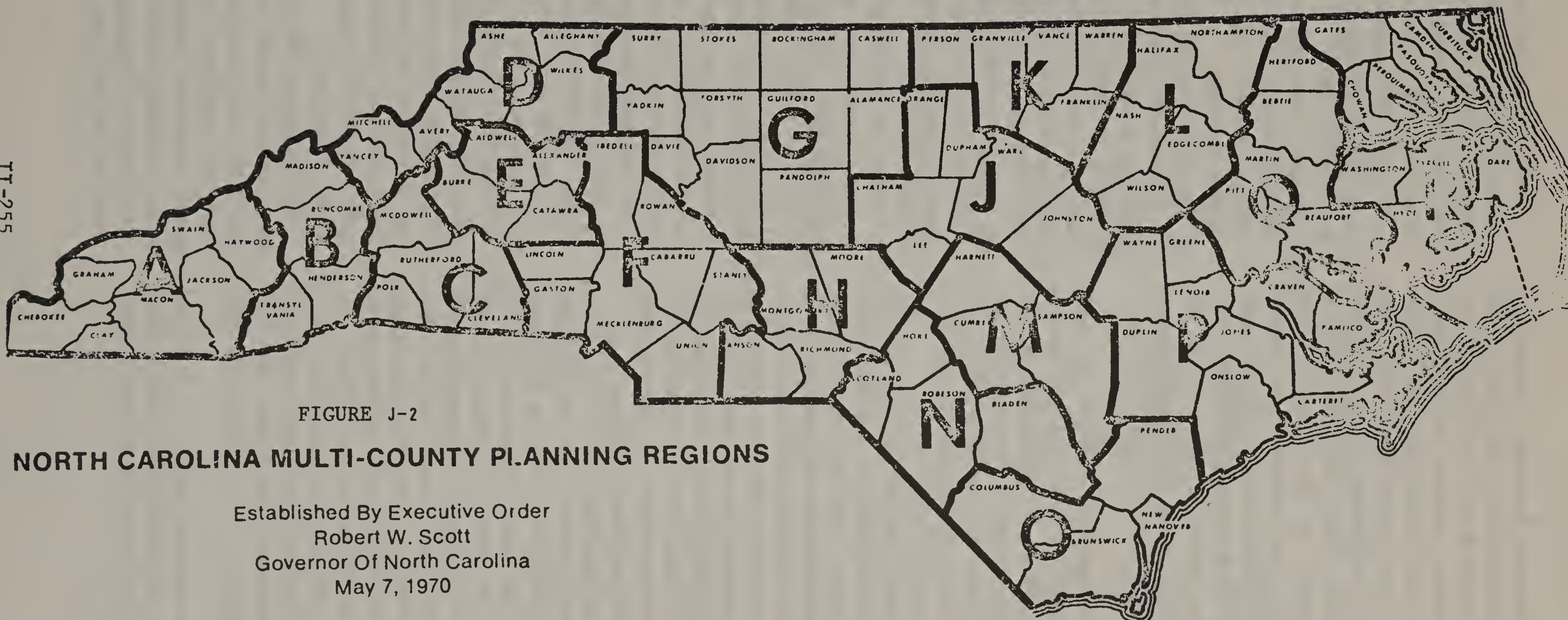


FIGURE J-2

NORTH CAROLINA MULTI-COUNTY PLANNING REGIONS

Established By Executive Order
Robert W. Scott
Governor Of North Carolina
May 7, 1970

Source: State of North Carolina, 1972

Region R (Albemarle Regional Planning and Development Commission): this 10 county planning region is located in the northeastern portion of North Carolina, adjacent to the Atlantic Ocean and the Boundary of the State of Virginia. It is composed of the counties of Currituck, Camden, Pasquotank, Perquimans, Gates, Chowan, Washington, Tyrrell, Dare and Hyde. During 1970, the population of the planning region amounted to 97,302, and the per capita income amounted to $2,305 compared to a state per capita income of $3,218. Cash receipts from farm marketing amounted to approximately 5.7 x 10^7 dollars during 1971, and during 1971, unemployment was 6.3%, compared to a statewide unemployment of 3.9%.

The changes in population between the years 1940 and 1970 (Table J-1) show an overall pattern of growth, with Region P exhibiting a rate of growth greater than the rest of the coastal region, and greater than even the rate of growth in the state population. However, the growth rates have fluctuated as reflected in Table J-2.

The State of North Carolina has been divided into eight crop reporting districts. The districts incorporating the coastal zone are the Northern, Central and Southern Coastal districts. The counties included within these districts include all of the counties included within the four planning regions, and some additional inland counties are included within the crop reporting districts that are included in other planning districts. Therefore, the following statistics incorporate a larger area than statistics relating to the planning regions.

The Coastal Plains comprise about two-thirds of the State's harvested cropland but only an eighth of its pastureland (Table J-3). Thus the flat fields, easily-tilled and loamy soils in the eastern third of the State support the principal acreages of row crops especially corn, tobacco, soybeans, peanuts and cotton while the fertile pastures on the rolling topography of the Piedmont and Mountain regions nurture most of the States' dairy and beef cattle enterprises. (State of North Carolina, 1975d).

The changes in employment that have taken place within the activities of agriculture, forestry, fishing and mining during this decade 1960-1970 have been summarized in The North Carolina Economy (1974).

In the four state planning regions O, P, Q and R the percentage of employment within these categories declined, in spite of an increase in total employment (Table J-4).

Additional tabular data contained within "The North Carolina Economy." (State of North Carolina, 1974) identify the following trends. In the four state planning regions, the total number of commercial farms declined during the decade 1959-1969. The percentage of farms with sales over $20,000 increased, but the percentage of commercial farms with sales below $5,000 decreased very markedly in each of the four planning regions. Cash farm receipts, however, increased in each of the planning areas during the decade 1959-1969.

The percentage of total farm operators included in the category of tenancy declined in each of the planning districts, and the off-farm employment of farm operators was summarized in tables indicating a substantial increase in the percentage of farm operators working 100 or more days off the farm. Comparison of the percentage of operators so engaged in 1959, indicated that a substantially higher percentage of the farm operators were engaged in working 100 or more days off the farm in the latter year.

Within the coastal planning regions during the period 1958-67, the number of manufacturing establishments, number of employees, and amount of payroll generally increased in regions O, R and Q, but declined in region R, adjacent to the Virginia border (Tables 5 and 6).

Similar increases and comparisons were made for the categories of wholesale and retail trade and selected service industries (Table 7).

The following passages were based on some of the data presented in the North Carolina Data File (State of North Carolina 1975b).

During the year 1974, the total volume of export sales exceeded $1.4 billion. During the year 1973 the state's agricultural exports totalled $526 million, leading the southeastern region. Manufactured exports showed an increase from $739 million in 1969 to $930 million in 1972. During 1972, North Carolina exported more than $337 million dollars worth of tobacco and $143 million dollars worth of machinery.

Approximately 64% of the state's exports are manufactured goods and 34% are agricultural products. Major exports include tobacco, tobacco products, machinery, chemicals, soybeans, feed grains, electrical equipment, food products, and paper and allied products.

In order to accommodate increasing trade activity, the North Carolina State Port Authority is

Table J-1. Population Trends in North Carolina from 1940 - 1970.

Region	1940	Population 1970	Change	Percent Change
Region O	128,433	172,305	+43,872	34.15
Region P	245,979	410,123	+164,144	66.73
Region Q	169,339	178,667	+9,328	5.50
Region R	95,902	97,302	+1,400	1.45
Total 4 Regions	639,653	858,397	218,744	34.19
State Total	3,571,623	5,082,059	1,510,436	42.28

Source: State of North Carolina, 1972.

Table J-2. Percent Change in Population for North Carolina from 1940-1970.

Planning Region	Percent Change 1940-50	1950-60	1960-70
Region O	18.0	5.2	8.0
Region P	23.7	27.4	5.8
Region Q	4.4	1.9	-0.8
Region R	1.7	0.1	-0.4

Source: State of North Carolina, 1972.

Table J-3. Land Use in North Carolina.

	North	Central	South	Total Acreage
Total Land in tracts (acres)[1/]	3,845,313	3,197,397	4,514,677	11,557,387
Non-Farm Land	1,218,672	811,055	1,444,856	3,474,583
Farm Land:				
Harvested Cropland	978,953	951,538	967,160	2,897,651
Idle Cropland	81,884	112,501	202,698	397,083
Open Pasture	74,863	66,312	99,994	241,169
All Other[2/]	1,490,941	1,255,991	1,799,969	4,546,901
Total Form Land	2,626,641	2,386,342	3,069,821	8,082,804

Note: Data not complete for some districts.

[1/] Total land in tracts of ten or more acres.

[2/] Other uses include homesites, woods, waste, etc.

Source: State of North Carolina, 1975d.

Table J-4. Employment Trends in North Carolina.

Planning Region	Total Employment 1970	Percentage (1970) Agr. Forest Fishing & Mining	Manufac-turing	Trade	Services	Other
O	63,651	7.9	26.2	19.1	30.1	16.7
P	120,446	11.3	19.9	20.0	35.7	13.1
Q	63,162	14.8	22.7	20.1	30.4	12.0
R	32,776	11.1	23.8	18.9	32.5	13.7

Planning Region	Percentage Change (1960-70) Total Employment 1970	Arg. Forest Fishing & Mining	Manufac-turing	Trade	Services	Other
O	20.6	-51.1	65.3	26.9	38.6	18.2
P	21.3	-45.4	87.3	30.0	44.6	18.5
Q	12.3	-46.7	59.9	28.1	41.1	23.0
R	6.6	-48.3	19.7	21.6	29.8	14.7

Source: State of North Carolina, 1974.

Table J-5. Manufacturing, Employment and Payroll Statistics for North Carolina, 1958-1967.

Manufacturing (1967)

Planning Region	Number of Establishments	Number of Employees	Payroll $ million
O	271	12,500	60.4
P	415	18,400	85.4
Q	271	11,900	49.8
R	149	2,700	11.0
Total	1,106	45,500	$206.6

Source: State of North Carolina

Table J-6. Selected Employment Statistics for North Carolina, 1972.

Labor Force (1972)

Planning Region O	Total	Manufac.	Non-Manufac.	Public Admin.	Agri.	Other
Brunswick	9,830	2,560	5,050	1,280	820	2,060
Columbus	19,290	5,200	4,870	1,930	4,810	2,370
New Hanover	36,740	10,160	19,160	5,010	450	5,590
Pender	6,730	610	1,120	880	1,610	880
Total	72,590	18,530	30,200	9,100	7,690	10,900

Planning Region P	Total	Manufac.	Non-Manufac.	Public Admin.	Agri.	Other
Cartevet	11,880	1,580	4,410	1,370	310	2,380
Craven	19,950	3,440	7,420	7,640	1,810	2,580
Duplin	16,340	4,210	2,990	1,700	4,520	2,360
Greene	6,940	760	560	650	2,180	690
Jones	3,360	210	370	390	1,130	510
Lenior	23,370	7,830	8,360	3,870	3,010	3,220
Onslow	20,090	1,580	8,590	7,300	1,060	2,040
Pamlico	3,250	450	470	350	530	410
Wayne	30,130	6,200	11,760	6,800	3,870	5,110
Total	135,310	26,260	44,930	30,070	18,420	19,300

Table J-6 (continued)

Planning Region Q	Total	Manufac.	Non-Manufac.	Public Admin.	Agri.	Other
Beaufort	15,560	4,310	5,440	1,600	2,230	2,570
Bertie	6,480	1,510	990	980	2,270	940
Hertford	9,490	2,440	3,570	1,130	1,420	1,270
Martin	10,830	4,310	2,870	1,280	2,530	1,620
Pitt	31,560	5,720	9,750	5,930	5,240	4,880
Total	73,920	18,290	22,620	10,920	13,690	11,280

Planning Region R	Total	Manufac.	Non-Manufac.	Public Admin.	Agri.	Other
Camden	1,820	30	130	180	370	210
Chowan	4,090	1,070	1,630	500	750	750
Currituck	2,610	120	370	290	400	250
Dare	3,380	60	1,950	450	20	1,060
Gates	2,270	220	340	380	730	310
Hyde	1,810	140	360	260	500	280
Pasquotank	10,120	1,690	3,690	2,620	670	1,520
Perquimans	2,800	330	550	410	710	480
Tyrrell	1,390	220	270	180	260	160
Washington	4,500	380	940	720	530	530
Total	35,290	4,260	10,230	5,990	4,940	5,550

NOTE: Totals do not add due to adjustment for multiple job holdings and commuters etc.

Source: State of North Carolina, 1974.
Growth and change in some of the economic factors are summarized in Table J-7. (State of North Carolina, 1974).

Table J-7. Business and Employment Statistics for North Carolina, 1958-1967.

Manufacturing Establishments

	Number of Establishments (1967)	Percent Change 1958-67	No. of Employees 1967 (thousands)
Region O	271	16.3	12.5
Region P	415	22.8	18.4
Region Q	271	9.7	11.9
Region R	149	-12.9	2.7
Total 4 Regions	1,106		45.5
State	8,266	13.4	643.8

Wholesale Trade Establishments

	Number of Establishments	Percent Change 1958-67	No of Employees 1967
Region O	256	12.3	2,565
Region P	432	6.4	3,823
Region Q	263	9.1	2,305
Region R	146	0.7	959
Total 4 Regions	1,097		9,652
State	7,010	22.1	76,625

Retail Trade Establishments

	Number of Establishments	Percent Change 1958-67	No. of Employees 1967
Region O	1,822	12.0	6,060
Region P	3,561	13.0	13,599
Region Q	1,994	7.1	6.982
Region R	1,030	-1.3	3,138
Total 4 Regions	8,407		29,779
State	45,447	10.1	196,412

Table J-7 (continued)

	Selected Service Establishments		
	Number of Establishments	Percent Change 1958-67	No. of Employees 1967
Region O	959	34.7	1,950
Region P	1,792	48.6	3,473
Region Q	851	47.0	1,384
Region R	594	43.1	866
Total 4 Regions	4,196		7,673
State	26,827	45.6	65,209

Source: State of North Carolina, 1974.

continuously expanding and improving its facilities. The Port Authority operates two major ports at Wilmington and Morehead City. Capital expenditures for expansion of facilities at Wilmington and Morehead City in 1974 and 1975 totals $15 million.

b. South Carolina

The coastal portion of South Carolina consists of 10 counties included within three regional councils of government (Figure J-3).

The Waccamaw Regional Council of Governments consists of the three northerly counties of Georgetown, Harry and Williamsburg, located adjacent to the North Carolina state boundary.

The Berkeley-Charleston-Dorchester Regional Planning Council incorporates the three counties in the central coastal area of the state centered on the port city of Charleston including Berkeley, Charleston and Dorchester counties.

The third area, including Beaufort, Colleton, Hampton, and Jasper counties, is known as the Lowcounty Regional Planning Council.

South Carolina may be divided into three regions: The Piedmont, Midlands and the Coastal Region. The Piedmont occupying approximately the northwestern third of the state, the Midlands the central third of the state, and the Coastal region the area adjacent to the Atlantic Ocean.

The Piedmont has 38.7% of the state's population and contains 23,722 km^2 (9,159 mi^2), or 30.3% of the state's area.

The Midlands has 38.9% of the state's population, and 32,914 km^2 (12,708 mi^2), or 42% of the area of the state.

The Coastal Region has 22.4% of the state's population and contains 21,647 km^2 (8,358 mi^2).

The South Carolina Development Plan, prepared for fiscal years 1974/1975 (South Carolina, 1975) commented on the changes that have been taking place in the South Carolina economy in the past. The following discussion has been obtained from this publication.

During the last decade, South Carolina has experienced remarkable economic progress. In the 1960's , total personal income increased 142%, from $3.1 billion in 1960. Per capita personal income showed a gain of 105% over the same period, from $1,334 to $2,737. This momentum has carried over into the 1970's. By the third quarter of 1973, total personal income for South Carolina had reached $10.5 billion.

The decline in agricultural employment has been of major importance to South Carolina's economic development. Though agricultural employment has declined, income generated from agriculture has grown steadily and therefore agriculture is, and will remain, an important sector in the state's economic structure. South Carolina had a consistently low unemployment rate in comparison to the national average. This indicates that as agricultural employment has declined, it has been absorbed elsewhere in the economy. Much of this former agricultural employment has shifted into manufacturing and other non-agricultural employment such as contract construction, services, wholesale, and retail trade, etc. This shift has allowed South Carolina to develop a more diversified economic structure. The employment pattern of the 1960's has begun to shift. In 1974, manufacturing was 36.6% of total wage and salary employment as compared with 40.7% in 1960, and 40.4% in 1970. The sectors showing the largest growth in wage and salary employment are contract construction, services, and government, particularly at the state and local levels.

Agriculture in many parts of the state traditionally has not been only an economic endeavor but a way of life. The traditional agricultural products have been tobacco and cotton, and until recently, almost one fourth of the labor force was engaged in agricultural pursuits. This activity was characterized by small inefficient farms and a preponderance of readily available, low-skill labor. Recently introduced products such as soybeans, poultry and livestock products, peaches, watermelons, specialty crops and forest products have required lesser amounts of labor.

Until the 1960's, textile apparel, wood and lumber products were dominant in the state's manufacturing activities. More recently, however, a slow diversification has begun and now paper products, electronic components, transportation equipment, chemical products, synthetics and other more sophisticated products are manufactured in the state. However, the industries which dominate the manufacturing scene are those which rank below average in the areas of employment growth and wage.

Some comments on economic and industrial conditions applicable primarily to the coastal zone were obtained from the South Carolina Development Plan (South Carolina Division of Administration, 1975).

THE STATE OF SOUTH CAROLINA REGIONS AND DISTRICTS

FIGURE J-3

Source:
South Carolina
Division of Administration,
1975

*** Coastal is not the same as the federally-designated Coastal Plains Region which encompasses all of the Coastal and Midlands except Fairfield and Newberry Counties.

1 S. C. Appalachian Council of Governments
2 Upper Savannah Regional Planning & Development Council
3 Catawba Regional Planning Council
4 Central Midlands Regional Planning Council
5 Lower Savannah Regional Planning & Development Council
6 Santee-Wateree Regional Planning Council
7 Pee Dee Regional Planning & Development Council
8 Waccamaw Regional Planning & Development Council
9 Berkeley-Charleston-Dorchester Regional Planning Council
10 Lowcountry Regional Planning Council

The state's principal seaport is Charleston which has the largest containerization handling facilities in the U.S. Georgetown and Port Royal provide the state with two other deep-water ports.

During 1974, a record of 3.17 million tons of cargo was moved across state docks, with 2.3 million tons handled in Charleston alone. The majority of the port users are located in the Piedmont section of the state, and a large proportion of the tonnage coming through South Carolina ports is associated with other states as far away as Tennessee, Ohio, Wisconsin and Illinois. The South Carolina Port Authority was created with the broad purpose of facilitating and increasing the cargo handled at South Carolina's ports for the economic benefit of all the citizens of the State. Because both Georgetown and Port Royal harbors are severely restricted by project depth 8 m, (27 ft.) and 7 m (24 ft.) respectively, and because trade in those ports is closely tied to the local industry, all future expansion in port facilities is planned for the Charleston harbor area.

The military and military-related establishments in the state make a substantial contribution to the economy. It is evident that military establishments are a dominant factor in several sub-areas. Charleston and Beaufort, in particular, rely on civilian-military related employment. A major shift in the allocation of the nation's output from military to civilian uses will have significant effects on these areas which depend heavily on military contracts for high levels of employment unless continuing efforts are made to accommodate the transition.

South Carolina provides a year-round variety of both man-made and natural tourist attractions including beaches, historic cities, flower gardens and fishing. In 1974, there were more than 28 million out-of-state visitors traveling to or through South Carolina. This is an increase of 27% over 1973 figures. The Grand Strand (Myrtle Beach area) receives the largest share of the state's annual volume of non-resident visitors with about 30%. Charleston is next with 17% of the non-resident visitors. The Beaufort (Hilton Head Island) area and the Santee-Cooper area are also rapidly becoming destination areas for tourist and outdoor recreation.

The Coast Region of South Carolina has 301 km (187 mi.) of shoreline 80 km (50 mi.) of which is the "Grand Strand" (dominated by Myrtle Beach) with more than 13,000 hotel and motel rooms and almost 8,000 campsites. By far the state's most significant tourist attraction, South Carolina beaches, are among the best in the world and offer opportunities for nearly every form of saltwater recreation from sailing to swimming. The four coastal state parks; Myrtle Beach, Huntington, Edisto and Hunting Island account for the attendance in the state park system.

The state has 3,074 km (2,876 mi) of tidal shoreline and 182,115 ha (450,000 acres) of tidal streams and sounds available for sport fishing, and over 16,090 km^2 (10,000 mi) of offshore water area is also accessible. It is estimated that at least $15 million is spent each year by anglers on saltwater sport fishing in South Carolina.

c. Georgia

The following description of the economy of the coastal region of Georgia was based primarily on the publication Overall Economic Development Program for Coastal Georgia (First Stage) published in 1970 by the Coastal Area Planning and Development Commission located in Brunswick, Georgia. The areas included within the Coastal Area Planning Commission includes the counties of Camden, Glynn, McIntosh, Long, Liberty and Bryan; and thus includes the entire coastal area of Georgia except for Chatham County, located in the northern portion of Georgia coast adjacent to South Carolina.

During the early 1900's the timber industry, based on the availability of virgin forest, gave way to the paper pulp and naval stores industry, based on reforestation. During this period, Brunswick became established as the distribution and transportation center of the area.

Following World War II, an economic slump resulted from the deactivation of government facilities and the closing of the shipyards in Brunswick. By the 1950's, paper production was the dominant economic factor. Small industries, and tourism became increasingly important.

The economy of the area in the last 50 years has not changed as drastically as the changes that have taken place in other areas of the south. This has been due, in part, to the fact that the area had not been a strong agricultural area for the past 50 years. However, some areas of the economy have experienced a surge causing a need, and the resulting influx, of labor from the more agriculturally oriented areas in the interior. Such industries as tourism, seafood and light industry, and the expansion of pulp and paper, and naval stores have been noted as industries requiring increased amounts of labor.

Agriculture plays a relatively minor role in the area's economy, with crop products assuming moderate significance in only Bryan, Long and Liberty counties. Camden County, while devoid of other agri-enterprise, need be mentioned because of its tobacco production.

Only 590 persons out of an area labor force of over 31,000 were employed in agriculture, and this low employment level may be due to several factors including relatively unproductive agricultural soils and the more productive alternative use of land for timber production. Also, the production of beef is making gains within the area although a basic problem of grain supply is holding back this endeavor.

The importance of the timber industry in the area may be judged by the following statements.

"The coastal area contains approximately 785,563 ha (1,941,100 acres) of land. Of this area 557,029 ha (1,376,400 acres) or 70.9% of the total area is contained in commercial forest land. Longleaf, loblolly and yellow pine are the most prevelant species of trees grown in the area." (Georgia Coastal Area Planning and Development Commission, 1970).

Studies by the Bureau of Business and Economic Research at the University of Georgia show that in 1966 over ten million vacation-recreation trips, involving more than thirty million travelers, were taken by private automobiles on Georgia highways. U.S. 17 traversing the entire length of the coastal area is a major tourist route from the eastern seaboard to Florida. Over five million people a year travel this route, and it has been estimated that with the completion of Interstate 95 this number should almost double. The majority of visitors and pass-through travelers through the area are from the East Coast and other parts of Georgia. Jekyll Island, a state owned park, Brunswick and the St. Simons area are destination points in the region.

The Coastal Area Planning and Development Commission published the Areawide Economic Base and Population Study in April, 1975. The area included in this report was expanded to include all of the Atlantic coastal counties and two counties located inland adjacent to the coastal counties. This study incorporated projections of population and employment as well as brief descriptions of the economy of the individual counties.

The eight county area included an areal expanse of 9,777 km^2 (3,775 mi^2) and was entirely located within the Coastal Plain physiographic region (Figure J-4). The total population amounted to 298,700 in 1973. The region is located between two Standard Metropolitan Statistical Areas (SMSA), Savannah, Ga. and Jacksonville, Fla., and is served by Interstate Highway I-95 which traverses the area. The principal transportation hub is Savannah with rail, air and port facilities.

The South Georgia agriculture and timber economy has an even impact on the entire length of the coastal area. Coastal fisheries exist throughout the area, and the area's undeveloped resources, economic problems and other factors appear to be consistent throughout the area.

The economic base of the city of Savannah may be described as diversified and includes such activities as the production of pulp and paper products, fertilizer manufacturing, tourism, food processing and the port activity.

The second largest city in the area is Brunswick, located in Glynn County. The principal activities in the Brunswick area include forest related industries, pulp and chemical processing, and tourism. Resort activity is based on the presence of ocean beaches, golf and sites of historical interest. The Port of Brunswick, operated by the Georgia Ports Authority, is equipped to handle general cargo. One notable export from this port was gypsum, used in the manufacture of wallboard. Hinesville, in Liberty County, inland from the coast, is experiencing growth related to the activation of Fort Stewart as a training base.

Among the economic problems identified by the Coastal Area Planning and Development Commission as characteristic of the area are a declining agricultural base, highway and barge transportation to the hinterland, declining fisheries, a lack of recreational facilities (other than in the Brunswick area), a lack of employment for unskilled workers, lack of knowledge of, and exploration for mineral resources, and increasing cost of governmental services and rising taxes caused by increased service demands upon local and state governments.

The income distribution in the eight county area was developed from census data and presented as both family median income and per capita income for the year 1970 (Table J-8). The per capita income figures provide a means of comparing the

LOCATION OF PLANNING AREA

FIGURE J-4

State of Georgia
Coastal Area Planning and Development Commission, 1975.

Table J-8. Per Capita Income for Selected Georgia Counties, 1970.

Area	Per Capita Income (1970)
Bryan County	$1,891
Camden County	2,228
Chathem County	2,671
Effingham County	2,163
Glynn County	2,566
Liberty County	2,010
Lang County	1,630
McIntosh County	1,729
Regional	$2,520
Georgia	2,649
National	3,945

Source: Coastal Area Planning and Development Commission, 1975.

region and the state with the national income figure for that year.

Although continued farming is expected to be carried on in the region, it is anticipated that the farms will be of larger size and probably employ fewer workers than in the past.

Forest lands with commercial value make up an estimated 74.1% of the region, and forest management practices have insured that the pulpwood industry will not run out of raw materials.

Textiles play an important role in half of the counties in the region. It is a major Georgia industry, but has not made significant inroads on the coast. Food processing is a major activity in those counties where access to the fishing and shrimping grounds is best. Chemical products produced in the area meet the needs of regional industries and provide supplies to other areas.

Manufacturing in the coastal area accounted for 23.1% of the employment in 1970, and employment in manufacturing was projected to increase from 25,870 in 1975 to 32,490 in the year 1990.

The following brief descriptions of the economies within the individual counties were obtained from Coastal Area Planning and Development Commission (1975). The counties are discussed in order commencing with the northern coastal counties and proceeding southwards.

Chatham County includes the city of Savannah, the regional center for the coastal planning area, with a trade area extending to Brunswick to the south and into South Carolina on the north.

Agricultural activity has declined almost to insignificance while residential, commercial and industrial land uses have become dominant. Employment during 1970 amounted to 65,851 persons.

During 1970, 12,763 persons were employed in manufacturing establishments producing wood, food, chemical and other products.

During 1974, 3.3 million tons of freight passed through the port, and shipping can be classified as a major industry employing 500 persons.

Retail and wholesale commercial establishments employed 16,000 persons during 1972, and the total sales volume amounted to more than a billion dollars.

Tourism is a major business within the county due to the historic interest of Savannah and other locations of scenic beauty.

Effingham County, located northwest, and adjacent to Chatham County, has recently experienced growth as residents move in from Chatham County. The development is anticipated to spread from the southern portion of the county, in response to an anticipated increase in the number of residents commuting into neighboring Chatham County.

The trend of gradual reduction in the amount of acreage in farm land is expected to continue.

Total employment in Effingham County amounted to 4,368 persons in 1970, of which 1,732 were employed in manufacturing wood products, transportation equipment and textiles. Approximately 440 persons were engaged in construction activity.

Bryan County, located south and west of Chatham County, has been changing from a rural, farming oriented community to a suburban community to the expanding Savannah metropolitan area. Fort Stewart divides the county into two parts, and an anticipated build up in the presonnel employed at Fort Stewart may be expected to add to the development pressures within the county.

The major basic business activities such as wood products and tourism can be expected to remain the same, but some relocation will probably result from the growth of Fort Stewart as well as additional highway facilities.

During 1970, 2089 persons were employed at various occupations within the county. Manufacturing, retail sales and construction accounted for more than half of the employment.

Liberty County is the third largest county in the coastal group as measured by population.

Liberty County's 3,770 employed persons were distributed with broad diversity among many industries. There are few manufacturing industries located within the county, the largest of which was a paper company with 355 employees. Textiles was another major activity, in 1974 there were over 400 people employed by two firms, but during early 1975, one was shut down due to the economic situation of the nation. Employment in retail and wholesale trade, and in the service industries, is expected to increase due to the build up in Fort Stewart.

McIntosh County, located approximately in a central position along the Georgia coast, has, in the past, been a rural, farming, fishing, and forest oriented community. Development pressure from Glynn County on the south can be expected to continue. Major business activities have evolved around the fishing and food processing industries, a plant producing foot-wear and other rubber products, and forest products. McIntosh County's 2,363 employed persons were employed predominantly in manufacturing (35.5%), retail trade (14.6%), agricultural (9.7%) and construction (9.2%). During 1970, manufacturing employment was 839, more than half of which commuted to nearby Glenn County. Food processing, especially seafood, is expected to continue to thrive as well as the related fishing industry.

Glynn County, including the port city of Brunswick, has been the second most populus county in the coastal region for many years. Industrial expansion is expected to take place along the waterfront and on Colonel's Island, while commercial establishments are expected to consolidate themselves in Brunswick and along the strip leading to the Brunswick mall. Major business activities in the county consist of pulp and paper, retail and wholesale trade, tourism and food processing. St. Simons and Jekyll Islands will continue their roles as resort residential areas.

Glynn County's 17,841 employed persons were engaged primarily in manufacturing, services and retail sales during 1970, and the employment pattern is expected to remain about the same, although an increase in government employment might result from the location of the Federal Law Enforcement Training Center.

During 1974, Glynn County had 51 manufacturing firms, and during 1970, 4,656 people were employed in manufacturing chemicals, food products, textiles, metals, wood products, and other products. Five of the fifteen largest industrial employers in coastal Georgia are located in Glynn County and are engaged in food processing, paper, chemicals, and fabricated metal (CZM, 1976). Total employment in manufacturing in Glynn County was estimated to increase from 5,150 in 1975 to 6,030 in the year 1990. Other employment results from the tourist activity based on resort areas and marshlands, the increased traffic along I-95, and shipping activity in Brunswick. As Brunswick becomes a central city, the employment in retail and wholesale trade can be expected to increase from the 1972 level of 4,000 workers, and a similar increase may occur in the service industry.

Camden County is the most southerly coastal county in Georgia. During 1970, 4,206 persons were employed, over 70% in manufacturing, retail sales and the service industries. Agricultural employment is expected to remain at close to existing levels until development pressures force the farmer to sell off land.

Camden County has very few manufacturing industries within its borders. In 1970, the majority of the 2,004 workers employed in manufacturing were either involved with the paper industry or the manufacture of chemical goods.

Tourism, although not presently a major business activity, is expected to receive a tremendous boost with the opening of Cumberland Island. With the National Seashore as a destination, tourism should improve.

d. Florida

State Planning District No. 4 is located in the northeastern portion of the State of Florida, adjacent to the Atlantic Ocean and the common state boundary with Georgia. The district includes the counties of Baker, Clay, Duval, Flagler, Nassau, Putnam and Saint Johns (Figure J-5). The principal population center in the region is the city and Standard Metropolitan Statistical Area of Jacksonville.

State Planning District No. 6 is located in the east central portion of the state, adjacent to the Atlantic Ocean, and adjoining District No. 4. District No. 6 includes the counties of Brevard, Lake, Indian River, Orange, Osceola, Seminole, and Volusia (Figure J-5).

The population of the counties within these planning districts was published by the Bureau of Economic and Business Research (1975) in the Florida Statistical Abstract (Table J-9). The projected population figures shown are those published in the Statistical Abstract. The agencies shown are the designated regional planning agencies for the multi-county planning districts (Figure J-5).

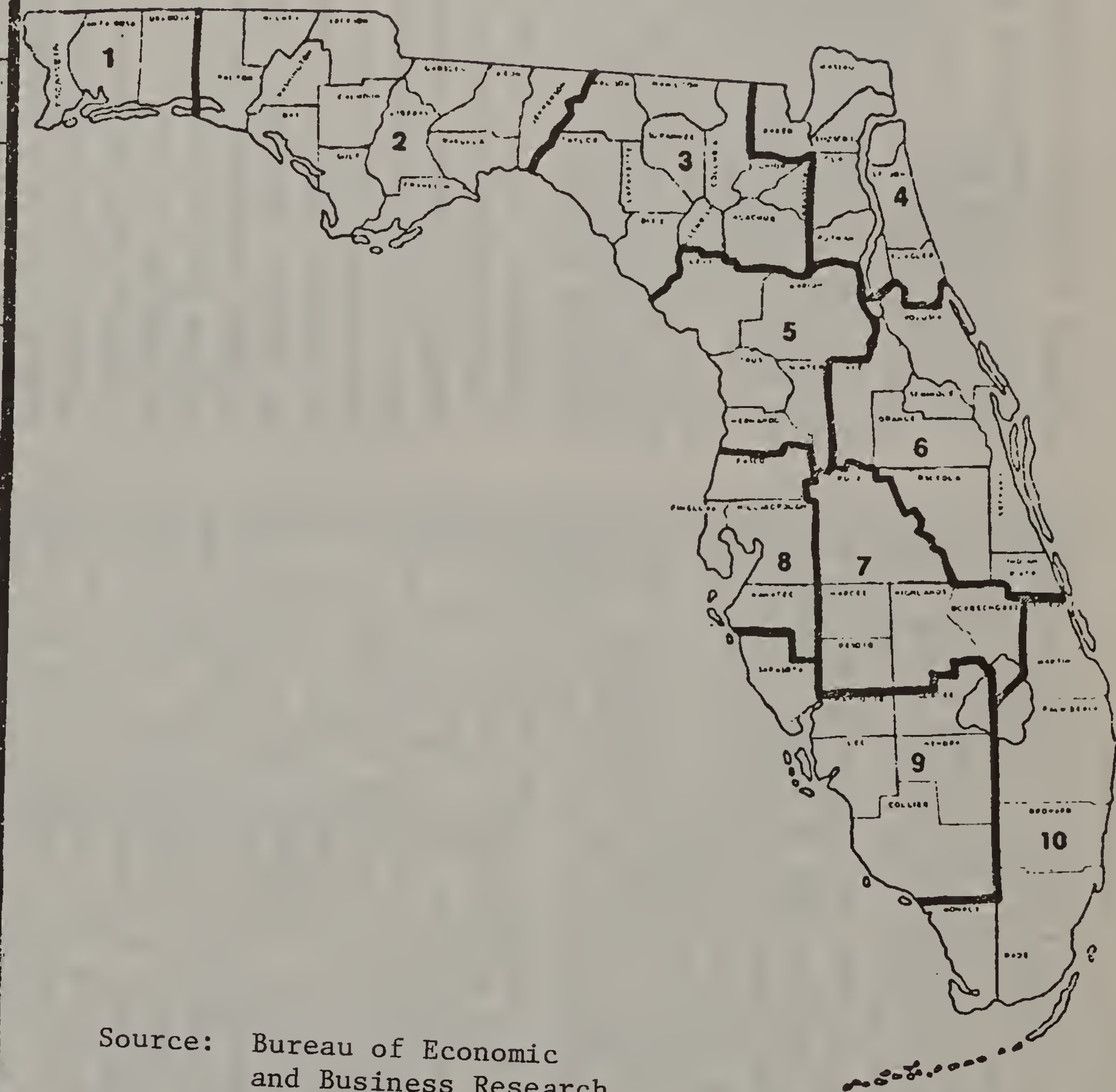
During the years from 1945 to 1969, the number of farms in Florida decreased from 61,159 to 35,586. During the year 1945, approximately 5.3 x 10^6 ha (13.1 million acres) were included in farms. The acres of land in farms increased to 6.2 x 10^6 ha (15.4 million acres) in 1964 and decreased to 5.7 x 10^6 ha (14.0 million acres) in 1969. During 1969, approximately 1.5 x 10^6 ha (3.8 million acres) were classified as cropland, 0.9 x 10^6 ha (2.2 million acres) as harvested cropland, and 0.4 x 10^6 ha (1 million acres) used as pasture. During 1969, approximately 1.5 x 10^6 ha (3 million acres) were classified as woodland, and 2.6 x 10^6 ha (6.4

REGIONAL PLANNING AGENCIES DESIGNATED UNDER CHAPTER 380, FLORIDA STATUTES

(effective date July 1, 1974)

FIGURE J-5

Regional Planning Agency	Multi-County Planning District	Counties		Regional Planning Agency Director Mailing Address & Telephone Number
West Florida Regional Planning Council	1	Escambia Okaloosa Santa Rosa		Mr. Deniel F. Krumel, Exec. Dir. P. O. Box 486, Pensacola 32502 (904) 434-1027
Northwest Florida Planning and Advisory Council	2	Bay Calhoun Franklin Gadsden Gulf Holmes Jackson	Jefferson Leon Liberty Wakulla Walton Washington	Mr. Barry A. Boswell, Exec. Dir. 5321 B - West Highway 98 Panama City 32401 (904) 785-9581
North Central Florida Regional Planning Council	3	Alachua Bradford Columbia Dixie Gilchrist Hamilton	Lafayette Madison Suwannee Taylor Union	Mr. Charles F. Justice, Exec. Dir. No. 5 Southwest Second Place Gainesville 32601 (904) 376-3344
Jacksonville Area Planning Board	4	Baker Clay Duval Flagler	Nassau Putnam St. Johns	Mr. Edward D. Baker, Exec. Dir. Room 401, Courthouse Jacksonville 32202 (904) 633-2690
Withlacoochee Regional Planning Council	5	Citrus Hernando Levy	Marion Sumter	Mr. Jackson E. Sullivan, Exec. Dir. 3500 N. E. Silver Springs Blvd. Ocala, Florida 32670 (904) 629-8921
East Central Florida Regional Planning Council	6	Brevard Indian River Lake Orange	Osceola Seminole Volusia	Mr. Clifford Guillet, Exec. Dir. 1011 Wymore Road Winter Park 32789 (305) 645-3339
Central Florida Regional Planning Council	7	DeSoto Hardee Highlands	Okeechobee Polk	Mr. Jim Duene, Exec. Dir. P. O. Box 2089, Bartow 33830 (813) 533-4146
Tampa Bay Regional Planning Council	8	Hillsborough Manatee Pasco Pinellas		Mr. Scott Wilson, Exec. Dir. 3151 Third Avenue North St. Petersburg 33713 (813) 821-2811
Southwest Florida Regional Planning Council	9	Charlotte Collier Glades	Hendry Lee Sarasota	Mr. Roland Eastwood, Exec. Dir. 2121 W. Ist St., Ft. Myers 33902 (813) 334-7382
South Florida Regional Planning Council	10	Broward Dade Martin	Monroe Palm Bch. St. Lucie	Mr. Barry Peterson, Exec. Dir. Ste. 429, 1515 NW 167 St. Miami 33169 (305) 621-5871



Source: Bureau of Economic and Business Research, 1975

Table J-9. Population Trends in Selected Florida Counties

District 4 - Jacksonville Area Planning Board

County	Population (Thousands) 1970	1985	Change	Percent Change
Baker	9.2	18.0	8.8	95.6
Clay	32.1	72.5	40.4	125.9
Duval	528.9	665.3	136.4	25.8
Flagler	4.5	12.0	7.5	166.7
Nassau	20.6	45.1	24.5	118.9
Putnam	36.4	52.5	16.1	44.2
St. Johns	31.0	51.6	20.6	66.5
District	662.7	917.0	254.3	38.4

District 6 - East Central Florida Regional Planning Council

County	Population (Thousands) 1970	1985	Change	Percent Change
Brevard	230.0	302.7	72.7	31.6
Indian River	36.0	69.0	33.0	91.7
Lake	69.3	111.7	42.4	61.2
Orange	344.3	555.7	211.4	61.4
Osceola	25.3	54.9	29.6	117.0
Seminole	83.7	218.6	134.0	161.2
Volusia	169.5	293.1	123.6	72.9
District	958.1	1,605.7	647.6	67.6

Source: Bureau of Economic and Business Research, 1975.

million acres) as "all other land". During the period 1945-1969, increases have occurred in the amount of harvested cropland, in cropland used for grazing, and in "all other land". The acreage classified as woodland has decreased. During this time, there has been a decrease in the number of farms with less than 81 ha (200 acres) harvested, and an increase in the number of farms with more than 81 ha (200 acres).

During 1969, the number of farms, and the land in farms as a percent of the total land area for the counties included in State Planning Regions 4 and 6, is shown on Table J-10.

Farm marketings in Florida during the year amounted to approximately $1.9 billion, approximately $1.3 billion from crops and approximately $600 million from livestock and products. The principal commodities produced included oranges, cattle, milk and grapefruit. During the 1973-74 crop year, all citrus production in Florida amounted to approximately 228 million boxes. Approximately 77 million boxes were produced in the counties included in Planning District 6. According to statistics published by the research department of the Federal Reserve Bank of Atlanta, farm employment in Florida increased from 105,000 in 1951 to 131,000 in 1958, and declined from that peak to approximately 114,000 in 1972.

During the year 1975, tree farms containing 2.5 x 10^6 ha (6.3 million acres) were located in Florida. The wholesale manufactured value of forest products in Florida amounted to more than $859 million. The most important forest product was pulpwood valued at $695 million, but the value of lumber amounted to approximately $93 million, and other products included naval stores, veneer, poles and pilings, fuel wood, and such miscellaneous items as fence posts, charcoal wood and rustic products.

Table J-11 lists the quantity and value of landings of fish in Florida and adjacent states and was obtained from the Florida Statistical Abstract and incorporates data published by the National Marine Fisheries Service.

During 1974, the principal species of fish, measured by value, landed in Florida included: shrimp, spiny lobster, red snapper, black mullet and king mackerel.

The total number of commercial fishermen employed in Florida during 1974 was 11,950, 9,850 full time and 2,100 part time. The total number of fishery products plants in Florida in 1974 was 18; two produced canned fishery products, three industrial fishery products, and 13 produced fish fillets and steaks.

The Division of Economic Development of the Florida Department of Commerce includes 17 counties in the Northeast Florida region, and therefore, this region includes a larger areal extent than the counties included within the State Planning Region. Florida Trend, a publication of Trend Publications, Inc. of Tampa, Florida reviewed the economy of the northeast region of Florida in the issue dated April, 1975. Marion County was not included in the Northeast Florida region in Florida Trend's article. The following comments have been obtained from this source.

The dominant feature of the Northeast region's population is its slow growth relative to the rest of Florida. A study of the annual growth rate of the Northeast region's counties for the four years 1970 to 1973 clearly shows where the population increases are occurring most rapidly. Duval County grew at a rate of only 1.74% while the state as a whole grew at a rate of 4.78% during the period. However, the remaining four counties in the Jacksonville SMSA had relatively rapid growth, led by Clay with 9.0%.

Nonagricultural employment during March, 1972 is shown on Table J-12 reproduced from Northeast Florida, a publication of the Florida Department of Commerce (July, 1975). In northeast Florida, the retail and wholesale trades are the chief employers. Retail trade employment may be related to the size of the regional population and tourist flow. The volume of wholesale trade employment is unusually high due to the heavy port traffic through Jacksonville. Manufacturing employment in the region is concentrated in the five industries, paper and allied products, food and kindred products, transportation equipment, lumber and wood products, and printing and publishing.

The central Florida region consists of eight counties, as classified by the Florida Department of Commerce, and the central Florida area as defined in the April 1975 issue of Florida Trend also consists of eight counties. However, the regions differ slightly in the area included within the defined regions.

During 1974, the economy of the central Florida region was affected by the energy crisis, inflation and the recession, in that an excess of motel and hotel rooms led to a slowdown in new construction.

Table J-10. Trends in Farm Land for Selected Florida Counties

Region 4

County	Number of Farms	Farm Lands Percent of Total Land
Baker	180	20.9
Clay	189	41.1
Duval	320	15.2
Flagler	79	29.4
Nassau	221	15.7
Putnam	462	55.8
St. Johns	219	17.0
District	1,670	

Region 6

County	Number of Farms	Farm Lands Percent of Total Land
Brevard	473	35.3
Indian River	425	58.5
Lake	1,634	56.3
Orange	1,224	42.4
Osceola	416	104.3
Seminole	510	34.5
Volusia	895	32.8
District	5,577	

Source: Bureau of Economic and Business Research, 1974.

Note: An excess of farm acreage over land area occurs because a farm's entire acreage is counted at its headquarters, and part may lie in another county.

Table J-11. Fish Landed - Quantity and Value of Landings 1974

State	Pounds (1,000)	Value ($1,000)
Florida	171,394	$66,367
Alabama	36,962	17,087
Georgia	18,157	7,094
Louisiana	1,228,906	86,694
Mississippi	304,794	16,355
North Carolina	206,683	17,544
South Carolina	18,402	6,861
Texas	97,203	72,455

Note: Landings for interior waters are estimated.

Source: Bureau of Economic and Business Research, 1974.

Table J-12. Nonagricultural Employment in Northeast Florida, March, 1972

County	Total	Mfg.	Const.	Trans. & Public Utilities	Trade	Finance, Ins. & Real Estate	Services	Govt.	All Others
Alachua	48,280	3,360	3,520	1,300	8,400	1,700	4,180	21,400	4,420
Baker	2,320	140	40	40	240	40	100	1,460	260
Bradford	4,160	460	40	40	600	80	300	2,080	560
Clay	6,340	520	480	380	940	200	1,360	1,800	660
Columbia	10,480	1,940	200	320	1,960	240	1,240	3,060	1,520
Dixie	1,420	440	80	60	180	60	60	340	200
Duval	218,600	24,000	12,500	20,100	52,300	19,600	31,900	34,100	24,100
Gilchrist	1,000	20	20	20	140	20	20	640	120
Hamilton	2,660	380	20	40	320	20	880	600	400
Lafayette	460	80	20	20	60	20	60	180	20
Levy	3,500	720	380	120	560	60	160	760	740
Marion	24,700	3,760	1,380	1,020	6,520	1,020	3,220	4,280	3,500
Nassau	6,940	2,400	140	160	940	80	460	1,840	920
Putnam	10,120	3,320	260	380	1,900	220	760	1,720	1,560
St. Johns	9,400	1,120	580	580	2,120	280	1,920	1,480	1,320
Suwannee	5,320	460	140	380	1,680	180	640	1,000	840
Union	980	220	0	0	80	20	20	520	120
Northeast Florida	356,680	43,340	19,800	24,960	78,940	23,840	47,280	77,260	41,260

Source: Florida Industrial Commission, Research and Statistics Department. Basic Labor Market Information.

Construction layoffs and cutbacks in the national space program resulted in high unemployment rates in the region. Manufacturing jobs fell by 3,800 over the year to 25,800, with most of the loss in durable goods manufacturing industries.

Some concept of distribution of nonagricultural employment during 1972 can be gleaned from Table J-13 reproduced from Central Florida, a publication of the Florida Department of Commerce (1975).

According to Economic Development of Florida, Florida's position as the nation's leading tourist vacation destination is enviable. Tourism is the state's greatest single source of income and is one of the largest industries in the nation. During 1973, tourism boosted the Florida economy by more than $5.5 billion, contributing heavily to tax monies and, therefore, towards defraying the cost of state operations and improvement.

The number of Florida tourists was estimated by the Division of Tourism of the Florida Department of Commerce to have increased from approximately 11 million in 1960 to 25 million in 1973.

One reflection of the growth in tourism is the growth in the number of employees in the service group, which includes employees in hotels, motels, tourist attractions and related industries. This group was the most rapidly growing sector of the Florida economy, with 210,000 jobs added during the period 1963-1972. Another sector of the economy linked to the tourist market is retail trade. During the year 1972 approximately 490,000 persons were employed in the retail trade classification. More than half of the employment in retail trade is concentrated in food stores, eating and drinking establishments and merchandising.

Thompson (1975) reviewed some of the developments in the employment conditions in Florida. In March of 1974, there were 3,331,900 people in the labor force of Florida of whom 3,169;100 were employed and 162,800 were not employed. The unemployment rate was 4.9.

In March of 1975, the number of persons in the labor force had increased by 3.0 to a total of 3,432,100. The number of employed persons declined by 3.2% to 3,066,800. The increase in the number of persons in Florida who wanted to work plus the decrease in the number of persons who were actually employed caused the number of unemployed to more than double. In March, 1975, it stood at 365,300 or 124.4% more than were unemployed twelve months previously.

Thompson provided some comment on the employment in specified geographic areas of the state, and discussed employment in the various industries in the U.S. and Florida.

In comparing 1974 to 1973, Thompson commented that data from the U.S. Department of Labor indicated that more people were employed on the average in the nonagricultural sector in 1974 than in 1973 in both the nation as a whole and Florida.

Mining employment increased in both Florida and the nation, but it accounts for only 0.4% of Florida's employment and 0.8% of the nation's.

Average annual manufacturing employment remained almost unchanged in Florida with a drop of only 100 jobs from 1973 to 1974. However, in the nation there was an average annual loss of 38,000 jobs in manufacturing in 1974.

Average annual employment in 1974 in construction was 43,000 less for the U.S. as a whole and 12,300 less for Florida than in 1973. Thus, one out of every 3.5 construction jobs in the nation were lost in Florida.

More recently, construction employment, which on the average for the year 1974 was down only some 12,300, showed the tremendous decline of 75,000 from March, 1974 to March, 1975. A considerable part of the decline in manufacturing employment in Florida has taken place in industries related to building such as lumber and wood products, furniture and fixtures, stone, clay and glass products and fabricated metal products.

2. Projected Population Growth

The 1972 OBERS projections provide basic economic information in the form of near-term, mid-term and far-term projections of population, economic activity, and land use for the nation as well as geographic subdivisions of the nation. The projections include population, personal income, employment and earnings of persons, by industry.

The projections were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce and the Economic Research Service of the U.S. Department of Agriculture for the U.S. Water Resources Council, an independent executive agency of the U.S. Government.

The areas for which data were prepared include functional economic areas known as BEA areas, water resource regions and sub-areas, the states and the District of Columbia, the Standard Metropolitan Statistical Areas, and the non-SMSA

Table J-13. Nonagricultural Employment in Central Florida, March, 1972

County	Total	Mfg.	Constr.	Trans. & Public Utilities	Trade	Finance Ins. & Real Estate	Services	Govt.	All Others
Brevard	79,100	11,500	2,500	3,200	14,900	2,800	9,700	15,900	8,600
Flagler	1,160	200	40	20	200	20	220	300	160
Lake	23,160	2,500	1,400	1,120	5,840	720	3,620	4,040	3,920
Orange (and Seminole)	191,500	23,600	15,200	9,800	45,000	11,100	38,900	26,000	21,900
Osceola	8,440	980	580	140	1,960	360	1,260	2,040	1,120
Sumter	3,140	460	0	240	740	80	360	840	420
Volusia	57,600	5,400	3,000	2,200	13,400	2,900	11,200	9,200	10,300
Central Florida	364,100	44,640	22,720	16,720	82,040	17,980	75,260	58,320	46,420

Source: Florida Industrial Commission, Research and Statistics Department, Basic Labor Market Information.

1970 Employment by Occupation

Occupation	Central Florida (percent)	United States (percent)
Clerical and kindred workers	17.2	17.9
Professional, technical, and kindred workers	17.1	14.8
Craftsmen, foremen, and kindred workers	14.1	13.9
Service workers, Except private household	11.8	11.3
Managers and administrators, except form	9.7	8.3
Sales workers	8.6	7.1
Operatives, Except transport	7.2	13.7
Laborers, Except farm	4.7	4.5
Transportation equipment operatives	3.6	3.9
Farm laborers and farm foremen	3.1	1.2
Private household workers	2.2	1.5
Farmers and farm managers	0.7	1.9

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population, 1970.

portions of economic and water resource subareas.

The Census Bureau periodically publishes several series of national population projections incorporating currently attained population, current birth rates, assumed future birth and death rates, and levels of international migrations. Projections based on Series C national population and the Series E national population projections have been published. The Series E projection assumes a birth rate which will eventually result in no further population growth except for immigration. These assumptions lead to an estimated national population of approximately 263.8 million for the year 2000, compared to an estimated 306.8 million population in the year 2000 provided by the Series C assumptions.

The OBERS projections are baseline or reference series and do not reflect the current energy problem, recent changes in agricultural exports, and recent changes in conservation and environmental activities.

Table J-14 incorporates the projected population (Series E) for the States of Florida, Georgia, North Carolina and South Carolina for selected years. These projected populations account for approximately 9.4% of the total U.S. population during the year 1970, and increase to approximately 11.16% of the total U.S. population in the year 2000. A large portion of the increased percentage is due to the increase in the projected population for Florida, although the population in each of the states is projected to increase during the thirty year period between 1970 and the year 2000.

The BEA Economic Areas that are located in the coastal region adjacent to the proposed sale include the following:

- BEA Area 022, Norfolk-Portsmouth, Virginia
- BEA Area 023, Raleigh, North Carolina
- BEA Area 024, Wilmington, North Carolina
- BEA Area 030, Florence, South Carolina
- BEA Area 031, Charleston, South Carolina
- BEA Area 033, Savannah, Georgia
- BEA Area 034, Jacksonville, Florida
- BEA Area 035, Orlando, Florida
- BEA Area 036, Miami, Florida

A comparison of the population projections for the States of Florida, Georgia, North Carolina and South Carolina, as published in the Series E and Series C (Table J-15) volumes indicate some areas of similarity and some differences.

The population of the U.S. was projected to increase to approximately 307 million in the year 2000 in the Series C projection, and to approximately 264 million in the Series E projection. The population of the four states was projected to amount to 25.9 million by the Series C projection in the year 1900, and to approximately 26.5 million by the Series E projection for that year.

This relationship suggests that with a smaller national population, an increase in the proportion of that smaller population will be located in the southeastern portion of the nation. A large number of this increased population was projected to be located in Florida, but population increases were projected to occur in each state.

Comparison of the projections of population for the coastal BEA areas reveals a similar relationship in that an increasing percentage of the total U.S. population was anticipated to occur in the nine BEA areas along the southern Atlantic coastline.

A comparison of the earnings projections developed in the Series E and Series C volumes for a sample BEA area (BEA 031 Charleston) is illustrated in Table J-16. For this economic area, projections of earnings are lower in the Series E projections than in the Series C projections.

3. Oil and Gas Industry in the U.S. South Atlantic Region

During the year 1974, approximately 3.6 x 10^7 barrels of crude petroleum were produced in the state of Florida from 136 oil wells. A comparison of the production and number of wells in 1974 and 1973 was published by the Bureau of Mines (USDI, 1975a).

Florida	1974	1973
Number of producing oil wells	136	147
Crude petroleum produced (thousand barrels)	36,351	32,695
Average value per barrel	$9.66	$4.59

During the first six months of 1975, 20,410 thousand barrels were produced in Florida, compared to 17,958 x 10^3 bbls during the same period in 1974.

As of December 31, 1974, the crude oil reserves in the State of Florida were estimated by the American Petroleum Institute (1975) to amount to 302,709 x 10^3 bbls.

There was no recorded crude oil production in the states of North Carolina, South Carolina and Georgia.

Table J-14. Population (thousands) Trends for Southeastern U.S., Series E Projections

State	1970	1980	1990	2000
Florida	6,845.0	8,926.4	10,978.1	12,713.9
Georgia	4,602.0	5,147.3	5,907.4	6,458.1
North Carolina	5,091.0	5,736.3	6,464.7	6,972.9
South Carolina	2,596.0	2,818.5	3,121.9	3,319.4
Total 4 States	19,134.0	22,628.5	26,472.1	29,464.3
Total U.S.	203,857.8	223,532.0	246,039.0	263,830.0
Percent	9.4	10.1	10.8	11.2

BEA Area	1970	1980	1990	2000
022	1,234.1	1,224.4	1,325.7	1,386.6
023	1,624.1	1,788.1	2,009.2	2,159.9
024	482.9	471.5	516.0	544.0
030	401.6	436.9	474.7	491.9
031	431.7	407.9	434.1	447.6
033	418.9	423.4	445.7	452.0
034	1,057.0	1,234.1	1,425.7	1,569.9
035	951.4	1,209.2	1,440.0	1,622.3
036	2,452.8	3,408.4	4,408.0	5,300.6
Total	9,054.5	10,603.9	12,479.1	13,974.8
Total U.S.	203,857.9	223,532.0	246,039.0	263,830.0
Percent	4.4	4.7	5.1	5.3

Source: OBERS Projections (USDC, 1972).

Table J-15. Population (thousands) Trend for Southeastern U.S., Series C Projections

State	1969	1980	1990	2000
Florida	6,683.0	8,197.0	9,913.0	11,767.0
Georgia	4,570.0	5,335.0	6,230.0	7,176.0
North Carolina	5,051.0	5,713.0	6,430.0	7,321.0
South Carolina	2,578.0	2,914.0	3,277.0	3,729.0
Total	18,882.0	22,159.0	25,850.0	29,993.0
Total U.S.	201,877.0	234,208.0	269,759.0	306,782.0
Percent	9.4	9.5	9.6	9.8

BEA Area	1969	1980	1990	2000
022	1,227.3	1,327.9	1,424.2	1,549.1
023	1,611.9	1,733.5	1,904.9	2,109.7
024	480.7	505.9	550.8	601.3
030	402.0	431.1	476.7	530.0
031	425.5	470.7	523.9	575.9
033	420.1	452.3	494.4	540.8
034	1,049.1	1,225.1	1,429.3	1,632.2
035	913.7	1,173.7	1,464.3	1,784.2
036	2,381.2	3,016.6	3,714.5	4,469.8
Total	8,911.4	10,336.8	11,983.0	13,793.0
Total U.S.	201,877.0	234,208.0	269,759.0	306,782.0
Percent	4.4	4.4	4.4	4.5

Source: OBERS Projections (USDC, 1972).

Table J-16. Comparison Between Series C and E Projections for Charleston, S. C. - BEA 031

Series C Projection - Earnings (thousand 1967 dollars)

	1969	1980	1990
AG. F. & F.	23,044	25,200	28,700
Mining	225	(S)	(S)
Cont. Cons.	56,699	85,300	126,100
Manufact.	148,508	238,200	353,500
Transport.	46,256	71,000	104,800
W & R Trade	115,384	189,500	288,100
Fire	29,560	47,400	72,300
Services	97,317	168,600	269,500
Gov't.	440,618	654,900	940,000
Total Earnings	957,609	1,481,000	2,183,900

Note: Columns may not add to exact totals shown.

Series E Projection - Earnings (thousand 1967 dollars)

	1970	1980	1990
AG.F. & F.	25,560	26,200	28,900
Mining	258	(S)	(S)
Cont. Cons.	59,119	74,200	100,300
Manufact.	148,529	207,500	283,700
Transport.	47,084	64,000	89,300
W & R Trade	118,200	157,700	210,300
Fire	29,776	50,700	75,900
Services	102,769	162,700	248,400
Gov't	469,343	556,100	747,700
Total Earnings	1,000,633	1,299,700	1,785,500

Note: Columns may not add to exact totals shown.

Source: OBERS projections (USDC, 1972).

a. Petroleum refining

Petroleum refining activity is very limited in the Atlantic coastal areas of North Carolina, South Carolina, Georgia and Florida.

Pace Oil Company operates a Topping plant at Wilmington, N.C. According to the Bureau of Mines (USDI, 1975a) this plant does not process crude oil.

No refineries processing crude oil were listed for South Carolina.

The Amoco Oil Company operates a refinery located in the Savannah area. This refinery has a crude oil distillation capacity of 1.3×10^4 bbls/day and produces asphalt.

The Seminole Asphalt Refining, Inc. operates a refinery at St. Marks, Florida with a capacity of 6.0×10^3 bbls/day. This refinery is located adjacent to the Gulf of Mexico in the panhandle region of Florida.

Adjacent to the proposed sale area is an operating oil refinery located at Freeport in the Bahamas. This refinery is operated by the Bahamas Oil Refining Company, and the capacity of the refinery was listed at 5.0×10^5 bbls/day of crude oil capacity (Petroleum Publishing 1975).

Additional crude oil refining capacity is located in Puerto Rico and the Virgin Islands, as well as the coastal area of the U.S. in regions north of the boundary between the states of Virginia and North Carolina (Table J-16.1).

The Coastal Plains Regional Commission and eight co-sponsoring oil and petrochemical companies engaged R. R. Nathan Associates and the Coastal Zone Resources Corporation (1975) to investigate the technical, economic and environmental feasibility of developing deepwater terminals for unloading very large crude carriers off the coasts of North Carolina, South Carolina and Georgia. The views and findings expressed in this report were those of the consultants.

The consultants selected three representative sites for refinery complexes which we were chosen on the basis of minimization of environmental conflict that might be anticipated from construction of a deepwater terminal, refineries and related facilities.

The basic refinery module would be a 2.0×10^5 bbl/day unit. To handle projected throughput, therefore, three refineries would be required to be "on-stream" for the first year of deepwater terminal operations, and nine units would be required when crude volumes received by the deepwater terminal reached 1.8×10^6 bbls/day. The consultants also assumed, based in part on the demand analysis, that the growth rate between initial and final levels of throughput would be linear. This means that during the 20-year project analysis period (1980-2000) one new refinery will come on-stream approximately every three years.

The South Carolina Development Plan, Fiscal Years 1974/1975, noted:

> South Carolina has also shown its willingness to acquire an oil refining capacity, to develop a deepwater terminal capable of accommodating the new large supertanker, and to support offshore Outer Continental Shelf (OCS) exploration and drilling. Outer Continental Shelf exploration is still in its planning stages and it will be years before drilling, if any, is begun off the South Carolina shore. The possibility of a deepwater terminal and oil refinery are much closer. Chevron Oil has purchased a potential refinery site along the Savannah River in Jasper County.
>
> The development of an oil refining capacity in South Carolina would require the construction of a deepwater terminal to accommodate supertankers, a pipeline system to transfer the crude oil, an onshore storage capacity, the total investment could range from $1.5 billion to $4.5 billion. The most likely geographical area in the state to locate such a network of facilities is the coastal area from Charleston to the Savannah River. The Coastal Plains Regional Commission, recently completed a study analyzing the environmental and economic feasibility of constructing a deepwater terminal and the accompanying refinery complexes. This study was done in conjunction with the Coastal Plains Regional Commission, North Carolina, South Carolina, Georgia, Ashland Oil, Chevron Oil, Cities Service Oil, Exxon Pipeline, Mobay Chemical, Mobil Oil, Shell Oil and Tenneco Oil.

Georgia has also been mentioned as the possible site of an oil refinery. A study has been conducted by the State's Office of Planning and Budget to develop information regarding the probable impact which the development of a refinery might have on Coastal Georgia. The following discussion has been drawn from the publication, Summary of Petroleum Refinery Feasibility Study of Coastal Georgia, by the Office of Planning and Budget.

Table J-16.1 OPERATING PETROLEUM REFINERIES IN THE WESTERN NORTH ATLANTIC REGION (January 1, 1976)

REFINER	LOCATION	CRUDE OIL CAPACITY BARRELS/CALENDAR DAY
Delaware		
Getty Oil	Delaware City	140,000
Maryland		
Amoco	Baltimore	15,000 (asphalt)
Chevron	Baltimore	13,500 (asphalt)
Virginia		
Amoco	Yorktown	53,000
Puerto Rico		
Caribbean Gulf	Bayamon	37,800
Commonwealth Oil and Refining	Penuelas	141,000
Sun Oil Co.	Yabucoa	68,300

SOURCE: Petroleum Refineries in the United States and Puerto Rico (USDI- BLM, 1976).

Virgin Islands		
Hess Oil Virgin Island	St. Croix	728,000
Bahamas		
Bahamas Oil Refining	Freeport	500,000

SOURCE: International Petroleum Encyclopedia, 1976 Petroleum Publishing, Tulsa, Okla.

Two localities were selected as representative communities of the Coastal area to assess potential impacts of locating a refinery. Savannah was chosen as a representative urban site, and Darien as a representative rural site, but the conclusion drawn was that the Savannah area was the most feasible location for a refinery due to the superior harbor capacity and the fact that its size provides the many amenities necessary for such a huge undertaking.

The hypothetical refinery used in the study was assumed to have a processing capacity of 200,000 barrels per day, approximately 8 million barrels of storage space, and to require between 400 to 1800 acres of land. The construction force required would average 2000 over a period of two and one-half to three years, with a peak labor force of approximately 4,000 persons. Upon completion, permanent employment would likely be in the 500 to 600 range. The major portion of the total social costs of a refinery would result from a spill, with possible consequences of damage to the shrimping industry, commercial fishing and the oyster industry, and potential damage to tourism along Georgia's coastline. The summary also considered the need for additional transportation facilities, both marine and land based; and the social concerns of housing, education, and health, social and cultural services. Other factors that the summary considered were water supply and quality, air quality, noise abatement, and energy supply, and the impacts resulting from pipeline constuction.

Many questions not mentioned in the summary were raised and recommended for study, either immediately, or upon the proposal of a specific site and refining operation, should such a proposal be made at some future time.

The Department of Administration of the State of North Carolina is preparing a study evaluating the possible impact of the construction and operation of a petrocomplex in the coastal area of North Carolina.

Three areas were selected incorporating civilian employment ranges from 14,000 to 85,400 (1995 Projected Baseline), and Low Growth and High Growth scenarios were specified.

Area III was identified as including the counties of Brunswick, New Hanover, and Pender. The example site in Area III was located approximately two miles north of Wilmington on U.S. 421, adjacent to an existing industrial complex along the west bank of the Northeast Cape Fear River. The availability of transportation facilities for petroleum and products was also considered.

Among other considerations being incorporated into the study are the need for electric generating capacity, and the local effects at the time of termination of the project.

b. Natural gas

According to the Bureau of Mines data, during the year 1974 natural gas production in the State of Florida amounted to 38,137 x 10^6 ft3, compared to 33,857 x 10^6 ft^3 produced in 1973. The average wellhead value of this gas was 53.6/mcf, compared to 34.3/mcf in 1973 (USDI, Bureau of Mines, 1975c).

During the year 1974, natural gas was delivered to consumers in all four states (Tables J-17 thru J-19).

Table J-17. Production and Consumption of Natural Gas in Southeastern U.S., 1974. (Million cubic feet)

State	Marketed Production	Net Receipts Interstate	Transmission Loss[1/]	Consumption
Florida	38,137	255,493	710	292,920
Georgia	0	335,472	5,133	330,339
N. Carolina	0	142,934	2,717	140,217
S. Carolina	0	137,102	5,111	131,991
Total	38,137	871,001	13,671	895,467
Total (U.S.)	21,600,522	882,495[2/]	372,394	22,110,623

1/ Includes net change in underground storage
2/ In this table, this figure represents net imports of natural gas into the U.S.

Source: USDI, 1975c.

Table J-18. Consumption of Natural Gas in Southeastern U.S., 1974
(million cubic feet)

State	Total Consumption	Extraction Loss	Lease and Plant Fuel	Pipeline Fuel	Delivered To Consumers
Florida	292,920	3,369	2,700	3,081	283,770
Georgia	330,339	0	0	4,850	325,489
N. Carolina	140,217	0	0	4,496	135,721
S. Carolina	131,991	0	0	2,164	129,827
Total	895,467	3,369	2,700	14,591	874,807
U.S. Total	22,110,623	887,490	1,477,386	668,792	19,076,955

Source: USDI, 1975c.

Table J-19. Quantity of Natural Gas Delivered to Consumers in Southeastern U.S. 1974. (million cubic feet)

State	Total	Residential	Commercial	Industrial	Electric Utilities	Other[1/]
Florida	283,770	14,793	18,619	91,588	154,862	3,908
Georgia	325,489	76,207	41,189	161,879	43,086	3,128
N. Carolina	135,721	26,830	17,183	86,817	1,072	3,819
S. Carolina	129,827	20,383	13,618	73,114	21,510	1,202
Total	874,807	138,213	90,609	413,398	220,530	12,057
Total U.S.	19,076,955	4,786,128	2,262,909	8,305,979	3,429,231	292,708

[1/] Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.

Source: USDI, 1975c.

K. Future Environment Without the Proposal

The population increases forecast for the states of North Carolina, South Carolina, Georgia and Florida are anticipated to take place independently of this specific proposed lease sale. Projections of the growth in population reflect national trends, and projections of the population in specific areas reflect economic opportunities present in these areas, as well as the choices of individuals and families in search of desired living arrangements.

With increased population and economic activity, there will be continued pressure on available land for development. In the region as a whole, undeveloped land suitable for residential, commercial and industrial use exists, but the most intense development pressures would probably occur in proximity to presently developed areas, a reflection of the urban and suburban developments of the past years. Competition for suitable land space between development needs and recreation needs, between new uses as well as traditional uses, and requirements for the transportation of goods and services produced in one area to other areas for consumption will continue.

Legislation concerning the efforts to harmonize and accommodate the necessary activities with the least environmental damage, or impairment of the alternative uses of areas containing several resources, is being developed on the national, state and local levels, and implementation of this legislation has been carried forward in many areas during the past few years.

Demand for recreation facilities can be anticipated to expand along the coastal portions of the southeastern U.S., and increased recreation facilities imply increases in transportation facilities in order to reach the recreation sites. Increased levels of industrial activity imply greater need for land use for industrial sites, residential areas, and public facilities to meet the requirements of larger populations.

In general, the increase in population, and the economic growth that may accompany the increase in population, implies a larger consumption of energy producing substances. ''Energy Alternatives: A Comparative Analyses'' (CEQ, 1975) presents a thorough discussion of various energy sources, both presently available and those which may prove to be of greater importance in the future.

In the event that this proposed sale is not held, no significant decrease in the amount of energy required in the region adjacent to the proposed sale could be attributed to the fact of cancellation. It is assumed that the men and materials, including the energy required, would be employed in other areas.

Energy requirements in the southeastern U.S. would be met from other sources. Altnernative energy forms that would meet requirements during the next decade appear to be nuclear, coal, and oil and gas from other sources. The most probable source appears to be oil products and natural gas imported into the region from other domestic areas or from foreign sources.

Section III

Environmental Impacts of the Proposed action

A. Basic Assumptions Utilized in the Analysis of Environmental Impacts

1. Day to Day Operations

The analysis herein is based on the assumption (USGS, 1976, Section I.C.) that the area leased will contain approximately 0.282 to 1.009 billion barrels of oil and 1.890 to 6.810 trillion cubic feet of natural gas. To develop resources of this magnitude, about 95 to 220 exploration wells and 160 to 200 development wells will be required. These would probably be drilled to an average depth of about 3,048 m. Also there would need to be about 10 to 25 drilling and production platforms, about 257 to 515 km of pipeline, 1 to 2 onshore oil terminals and 1 to 2 onshore gas processing terminals. Peak daily production may reach 56,000 to 170,000 barrels of oil and 466,000 to 1,400,000 million cubic feet of natural gas.

The activities involved in achieving peak production are divided into six stages: geophysical exploration, drilling exploration, development, production, transportation and termination. For a detailed description, see Oil and Gas Operations, Appendix C. The assumption is made that normal operations as described below will be utilized for development likely to take place in the South Atlantic OCS.

a. Geophysical exploration

A number of geological and geophysical techniques have been developed over the years to assist in the prediction of petroleum occurrence. These methods include seismic refraction, seismic reflection, gravity, magnetics, bright spot technology, and stratigraphic correlation. Surface vessels of the 50 to 300 ton class are utilized to perform geophysical surveys. In general seismic surveys record the behavior of shock waves through various rock formations. This information is used to determine the presence of salt domes, folds, faults, sediment thickness and gas pockets. Shallow seismic surveys indicate the presence of potentially hazardous conditions to be avoided when locating a platform (Section II.A.6. Potential Geologic Hazards).

b. Exploratory drilling

Exploratory drilling operations are basically the same regardless of mobile rig type (jack-up drilling rigs, drillships and semi-submersibles). Initially, a drive casing is installed along with a blowout preventer. The casing is either jetted into place or driven into the bottom with a pile driver. Drill mud is circulated through the drill stem and casing to contain subsurface pressures and remove rock cuttings. Cuttings are washed and discharged overboard where they settle to the bottom. Some mud remains attached to the cuttings when they are discharged. As the cuttings cascade down through the water column, the mud is washed free and creates a turbid plume trailing with the prevailing surface current. The volume of drill cuttings generated and drilling muds is listed in Table A-1.

Otteman (1976) has considered the problem of drill cuttings and muds which result from offshore drilling and has presented the following analysis which is based upon experience in the Gulf of Mexico.

"The first 150± feet will be drilled or jetted with seawater. The resulting seawater mud will be returned directly to the sea floor without being pumped to the rig. While drilling the hole to 1,000 feet, typically only seawater will be used as drilling fluid; and it will be discharged overboard. When the formation clays do not make a viscous enough mud, some natural bentonitic clay will be added to the system. The discharged water amounts to approximately 7,000 barrels, (for a typical 10,000 ft well), and it will contain mostly natural mud generated while drilling the hole. Before running the conductor pipe to 1,000 ft, approximately six tons of bentonite clay will be added to the 1,000-barrel saltwater system. When the conductor pipe is cemented, this volume of bentonite clay in seawater will be discharged overboard."

"While drilling the remainder of the hole, the mud is continuously cycled back through the mud system. Some mud is discharged with the drill cuttings; and periodically drilling mud is discharged overboard to make room for natural mud made while drilling the hole. The maximum discharge will not exceed 200 barrels a day while drilling to 5,000 feet and 50 barrels a day from 5,000 to 10,000 feet. During approximately 20 days of drilling to 10,000 feet, some 2,000 barrels of bentonite clay and lignosulfonate treated mud would be discharged overboard. We would possibly begin converting the mud system from a seawater gel mud to a lignosulfonate treated freshwater mud at around 6,000 feet. This decision would be based on the relative economics of hauling freshwater from shore versus the higher

Table A- 1 VOLUME OF DRILL CUTTINGS GENERATED AND DRILLING MUDS

WELL TYPE	HOLE SIZE INCHES 10,000 FT	HOLE SIZE INCHES 18,000 FT	CUTTING VOLUME YD^3 10,000 FT	CUTTING VOLUME YD^3 18,000 FT	WEIGHT OF CUTTINGS REMOVED FROM HOLE TONS 10,000 FT	WEIGHT OF CUTTINGS REMOVED FROM HOLE TONS 18,000 FT	TOTAL MUD VOLUME (INCL. HOLE VOLUME BBLS 10,000 FT	TOTAL MUD VOLUME (INCL. HOLE VOLUME BBLS 18,000 FT	DRILLING MUD TYPE
INTERVAL BELOW MUDLINE (FT)									
0-150	36	36	39	39	72	72	As required		Seawater and natural mud
150-1,000	25	32	108	176	203	332	As required		Seawater-gel natural mud
1,000-4,500	18	20	229	283	448	534	1800	2200	Seawater-gel Lightly treated mud
4,500-10,000	11	-	135	-	272	-	1600	-	Seawater/fresh-water - lignosulfonate mud
4,500-12,000	-	15	-	342	-	690	-	2800	Seawater/fresh-water - lignosulfonate mud
12,000-18,000	-	10	-	121	-	262	-	2000	Freshwater lignosulfonate mud
	TOTAL		511 YD^3	961 YD^3	995 TONS	1890 TONS			

Source: Otteman, 1976.

maintenance cost of saltwater muds. During the additional 70 days operations while drilling from 10,000 to 18,000 feet, the discharge rate will not exceed 50 barrels a day; approximately 4,000 barrels of lignosulfonate drilling mud would be dumped overboard. When the well is completed, the mud remaining in the surface system is discharged overboard; and this can amount to as much as 800 barrels.''

The typical composition of gelled seawater and lignosulfonate treated muds are listed in Table A-2.

c. DEVELOPMENT

Field development drilling creates the same effluents as exploratory drilling only spatially more concentrated since as many as 10 to 20 wells may be drilled from a single platform. Observations in the Gulf of Mexico indicate that these drill cuttings form low mounds on the seafloor with a maximum relief of approximately 20 cm. These cuttings will be worked into the surrounding sediment by bioturbation or colonized by sessile organisms to form a miniature reef.

d. PRODUCTION

The production phase of OCS oil and gas operations consists of those steps necessary to bring the product to the surface and prepare it for transport. Production wastes include formation waters associated with the extracted oil, sand and other solids removed from the formation waters, deck drainage from the platform surface, and sanitary wastes. The sand is disposed of directly unless it contains oil in which case it must be treated before disposal. Formation waters are relict sea water but with anomalous ion ratios. The ranges of constituents found in produced formation water offshore Louisiana are listed in Table A-3. The sanitary wastes from offshore oil and gas facilities are composed of human body waste and domestic waste such as kitchen and general housekeeping wastes. Combustible solids are burned on site and non-combustibles are transferred to shore for disposal.

e. TRANSPORTATION

Transportation of the products which may be produced from the area may require the installation of large diameter (61 to 91 cm) pipelines. Installation of pipelines will require the jetting or cutting of these lines into the sea bottom to a minimum depth of 0.9 m. The suspended sediments fall diffusely along either side of the trench and the pipeline eventually becomes covered by the reworked sediments. Turbidity created by such an operation, although temporary, must be considered as a disturbance. As the pipeline comes ashore, a corridor two to four meters wide will be disturbed. Chronic oil leaks are potential effluents from transportation via pipeline.

An alternative to pipeline transportation would be transportation via oil tanker which would increase the risk of spillage. This alternative is examined further in Section VIII.D. The USGS (1976) has considered the transportation of potential production from the proposed lease sale as follows:

> ''It can be anticipated that, due to the dispersion of tract locations in proposed sale area, their distance from shore, and the anticipated small pool sizes, initially transportation of oil would be via tankers. Tankers would probably be of the 16,000 to 25,000 dead weight tons (dwt) class. Furthermore, unless or until strategically convenient deliverability of about 70,000 barrels of oil per day (BOPD), the construction of an oil pipeline to shore is doubtful. Based on this empirical rule of thumb, no more than two oil pipelines are predicted to result from the subject proposed sale. The initial dependence on tanker transport is foreseen for three to five years after production is commenced. This time frame of course is subject to the timing and quantity of resource discoveries. Therefore, in the period 1982-84, an investment decision can be anticipated on whether or not to construct an oil pipeline to shore.''

f. TERMINATION

According to industry estimates, with proper placement of wells and sufficient pipeline capacity, a gas reservoir could be drained in as little as 10 years. In contrast, some oil reservoirs have been producing for over 20 years. When a reservoir has been depleted to a level at which it cannot be profitably produced, operations are terminated.

OCS Orders (see Appendix G) requires wells to be plugged, the casing severed well below the mudline, the platform removed, and all obstructions cleared from the area. Major trunklines may be used for future production from adjacent areas, but smaller lines would probably be abandoned in place. Abandonment consists of purging

Table A-2 TYPICAL MUD COMPOSITION - SEAWATER GEL MUD

This type mud is typically used to drill from the base of the conductor casing to the surface casing point. Generally, the seawater gel system will be used from less than 1000 feet to a maximum of 4500 feet. The components used to make up and maintain the required characteristics of this mud system are:

Mud Components	Lbs/Bbl of Mud
1. Drilled Solids	48-60
2. Bentonitic Clay	30-40
3. Caustic - Sodium Hydroxide	0.5-1.5
4. Mica Flakes (Lost Circulation Material)	0.0- .5
5. Cellulose Polymer	0.0-.25
6. Seawater	As required - approx. 10#/bbl salt from the seawater

LIGHTLY TREATED LIGNOSULFONATE SEAWATER/FRESHWATER (6,000-8,000 ppm Cl^-) MUD

As the hole is deepened below surface casing it becomes necessary to start adding additional materials to maintain the desired mud characteristics. Slowly fresh water is substituted for sea water as the depth and temperature increase. A typical 10.0-10.5 pound per gallon lightly treated lignosulfonate system used to about 10,000 feet would include:

Mud Components	Lbs/Bbl of Mud
1. Drilled Solids	55-70
2. Bentonitic Clay	20-30
3. Barium Sulfate - Weight Material	45.60
4. Caustic - Sodium Hydroxide	1.0-2.0
5. Lignosulfonate	4-6
6. Lignite	0.0-3.0
7. Cellulose Polymer	0.0-.25
8. Seawater/Freshwater	As required - approx 5#/bbl salt from 50/50 seawater-freshwater

LIGNOSULFONATE FRESHWATER (3,000-4,000 ppm Cl^-) MUD

The deep portion of a typical well (below approximately 10,000 ft.) would require a freshwater lignosulfonate mud system in order to maintain the mud properties as desired for proper hole maintenance. A typical 10.0-11.0 pound per gallon lignosulfonate treated mud system would include:

Mud Components	Lbs/Bbl of Mud
1. Drilled Solids	65-80
2. Bentonitic	20-30
3. Barium Sulfate - Weight Material	55-150
4. Caustic Sodium Hydroxide	1-2
5. Lignosulfonate	4-8
6. Lignite	3-8
7. Defoamer/Detergents	0.5
8. Fresh water	As required

Source: Otteman, 1976

TABLE A-3 MEDIAN CONCENTRATION OF TRACE METALS IN PRODUCED WATERS 1/

Median Concentration (equaled or exceeded by 50% of the samples) in Each Area

	Number of Samples	Total Solids (madian) (g/l)	Co	Cr	Cu	K	Li	Mg	Mn	Ni	Sn	Sr	Ti	V	Zr
Illinois Basin	22	98	ND	2p	10p	300	15	6,000	175p	ND	< 1p	300	<10p	ND	<10p
Louisiana and Texas Gulf Coast	79	69	ND	<1p	<25p	300	ND	250	3.5	<1p	< 1p	85	<10p	ND	<10p
East Texas	88	66	ND 3/	ND	< 1	50	ND	250	3.3	<1p	3p	350	ND 3/	ND 3/	ND
North Texas	24	222	ND	<1p	150p	300	ND	5,000	45	15p	12p	450	7p	ND	<10p
West Texas and New Mexico	148	111	ND	2p	1p	350	15	1,000	1.8	<1p	< 1p	200	<10p	ND	ND
Parmian only	74	143	ND	2p	2p	400	10	1,000	1.7	<1p	< 1p	90	<10p	< 1p	ND
Pennsylvania only	34	115	ND	3p	< 1p	300	10	1,000	2.8	<1p	< 1p	300	<10p	< 1p	ND
Silurian-Devonian only	15	55	ND	2p	4p	300	10	400	300p	<1p	1p	90	<10p	ND	ND
Ordovician-Cambrian only	21	67	ND	<2p	4p	400	15	800	400p	<1p	1p	250	<10p	ND	ND
Anadarko Basin 4/	118	137	ND	10p	10p	250	10	1,550	5.6	6p	2p	300	<10p	< 1p	<10p
Williston Basin, post-Paleozoic	25	59	<5p	<2p	<25p	300	ND	250	300p	<3p	< 1p	100	ND	< 1p	ND
Williston Basin, Paleozoic	55	173	ND	3p	3p	800	35	600	660p	ND	< 1p	95	<10p	< 1p	ND
Powder River Basin	22	5	<5p	<2p	<25p	300	ND	40	450p	<3p	< 1p	25	<10p	< 1p	<10p
Other Wyoming	28	5	ND	ND	ND	300	ND	100	300p	ND	< 1p	20	<10p	< 1p	ND
Colorado	18	5	<5p	ND	<25p	300	ND	30	300p	<3p	<10p	20	<10p	< 1p	<10p
California	116	18	ND	5p	5p	45	ND	90	950p	10p	2.5p	10	<10p	< 1p	ND
Seawater	-	35	0.27p	0.04p-0.07p	1p-15p	380	0.1	1,272	1p-10p	5.4p	3p	13	Present	0.3p	ND
Estimated Detection Limit	-	-	1p	1p	1p	50	2	10	1p	1p	1p	16	10p	1p	10p

1/ Taken from Rittenhouse, Fulton, Grabowski, and Bernard

2/ ND = below detection limits; p = concentration in parts per billion, otherwise parts per million

3/ No data; less sensitive methods of analysis used.

4/ Includes Oklahoma Platform and Ardmore Basin.

Source: "Environmental Aspects of Produced Waters from Oil and Gas Extraction Operations in Offshore Coastal Waters, prepared by OOC, Sept., 1976.

the lines of entrained hydrocarbons by water flushing (the water disposed of onshore) and severing the ends below the mud line. The necessity for removal of pipelines nearshore is usually regulated by the State. Removal of nearshore pipelines has been completed in isolated cases in the Gulf of Mexico.

2. Effects of Potential Geologic Hazards on Offshore Operations

Impacts of potential geologic hazards are discussed under four categories: seismic hazards, bottom conditions, near-surface hazards, and geopressures.

The only major earthquake large enough to have caused an impact on operations in the proposed sale area was the Charleston, S.C. earthquake of 1886. This quake had a magnitude of IX to X (modified Mercalli Scale of 1931) and effected an area within a radius of over 1,287 km (800 mi). More than 400 quakes have occurred in the Charleston area since 1754 (Bollinger, 1972). The potential for seismic effects is therefore presumed to exist, but the probability seems low and the magnitude moderate.

However, only one earthquake is known to have occurred offshore. This one, in 1960, occurred near Charleston at 33° N. latitude and 80° W. longitude and was of magnitude V (Coffman and von Hake, 1973). The Charleston quake occurred some 113 km (70 mi) west of the area of high nominations interest. Although the probability of a damaging earthquake is rather low, the Charleston area is rated as Zone 3 on the Seismic Risk Map of the U.S. (Perkins, 1974; Algermissen, 1969). A Zone 3 is one in which may occur a major destructive earthquake which corresponds to intensity VIII and higher on the Modified Mercalli Scale of 1931.

If a large earthquake did occur, damage, injury, death and oil spills could occur in offshore operations. Pipeline disruption, especially nearshore where quakes are more frequent, could result in spilled oil.

Impacts on offshore operations caused by bottom conditions would result primarily from sediment movement. As stated in Section II.A.6.b., the presence of primary sedimentary structures such as cross-bedding, ripple marks and grading bedding indicate active deposition or redeposition. The damage that could occur in offshore operations as a result of this dynamic sedimentary environment could be caused by scour around the bottom of platform supports.

Good support would be found in the dense, medium- to coarse-grained sands which predominate the sedimentary regime of the South Atlantic OCS. However, standard site selection surveys must be used in final site selection for platforms, as scattered patches of lagoonal muds and peats do occur. These patches would offer poor support capabilities.

The existence of large sandwaves are indicated in Figure A-5 (Section II.A.) on the South Atlantic OCS. Standard geophysical surveys would locate these features prior to site selection. Similar features with foreslope dips up to 5°± and backslope dips of up to 15°± have been reported on the Mid-Atlantic OCS, directly to the north (USGS, personal communication, 1976). Slopes of this magnitude associated with sand waves will probably not be found on the South Atlantic OCS.

Near surface hazards, such as hard-bottom areas will have to be contended with on the South Atlantic OCS. The precise locations of most of these hard-bottom occurrences are not known at the present time, but they are known to occur in "trends". The tracts with reported occurrences of hard-bottom communities are as follows: 3, 10, 12, 13, 16, 33, 40, 41, 43, 45, 46, 49, 69, 116, 117, 118, 130, 131, 132, 143, 144, 145, 203, 223, and 224. There are many more tracts that occur in the trends (see Visual No. 4S). Until a mapping program can be completed, we must assume that these features occur in all tracts. These hard-bottom areas, cemented sedimentary rock outcrops in most cases, would result in difficulties in trenching operations for pipelines. Damage to a platform could result from the placement of supports in one of these areas, since scarps are common in these zones and the rock units tend to be brittle.

Impacts to offshore operations caused by creep, slumping, gasification, subsidence and near-surface faulting are negligible since these features are much less common than in the Gulf of Mexico. The Gulf of Mexico sediments have been deposited very rapidly with a high degree of muddy sediments whereas the sediments of the South Atlantic OCS consist of more carbonate and sandy material. The principal areas where creep or slumping would have to be contended with would be on the continental slope where the clays found there are only semi-consolidated.

Impact on drilling operations by geopressures are entirely speculative at this time. In the Mississippi area a slightly over-pressured section was found in the Tertiary strata. Wells in up-dip locations encountered by hydrostatic pressures while those in down-dip or seaward locations encountered geopressures. Whether these geopressures extend to offshore Georgia and South Carolina is not known, but geopressure is not encountered in the Jay field (in the Florida panhandle) (Visual No. 9).

Hydrogen sulfide (H_2S) in formation gases would be a hazard to crews involved in drilling operations.

In conclusion, the most significant of the potential geologic hazards, and the most likely to impact the offshore operations on the South Atlantic OCS, would be seismic hazards in the form of earthquakes. Although the probability of a significant earthquake is deemed very low, if one did occur it could result in a financial and time loss due to damage or loss of equipment. Injuries, loss of life and possible oil spills could also result from such an earthquake. The impacts of offshore operations resulting from bottom conditions, near-surface hazards and geopressures would be negligible since they would be mitigated through current practices utilized in site selection surveys and drilling procedures. Hard bottoms could impede pipeline burial and would have to be contended with.

3. Effects of Oceanographic and Meteorological Conditions on Offshore Operations

Sections II.V. and C. discussed in detail the existing information on the physical and chemical oceanographic conditions of the U.S. South Atlantic OCS.

The surface water temperatures of the western North Atlantic south of Cape Hatteras, being directly dependent upon seasonal air temperature, seldom fall below 12° C (53.6° F) nearshore in the winter and are even warmer offshore due to the warming effects of the Gulf Stream. These temperatures, although low enough to cause discomfort and minor loss of efficiency in personnel involved in offshore operations, are not as severe as those faced in Alaska, the North Sea or Celtic Sea, where successful operations have taken place. Water temperature, therefore, will probably have little impact on offshore operations.

The surface circulation (Section II.B.3.b) of around 16.5 km/day (9 nautical miles/day), with tidal circulations (Section II.B.5.) of up to 23 km/day (12 nautical miles/day), are considered to be negligible. Current up to 17 km/hr (9 knots) are contended with daily by operations in Cook Inlet, Alaska. Therefore, the lower speed water movements of the U.S. South Atlantic OCS should not present any problems. One possible impact on offshore operations by circulation of water masses would be in the form of scour around the base of jack-up rigs by bottom currents, thereby causing foundation instability.

Sea level variations caused by tides, storm surge and annual average variation would have little, if any, effect on operations on the South Atlantic OCS. Tidal variation on the continental shelf has a maximum range of 1.8 m (6 ft) nearshore and decreasing further offshore (Visual No. 6N and 6S). This range would have no impact on operations

The most important impact of physical oceanographic conditions on offshore operations would be that of waves. Since the vast majority of sea waves are wind-generated, there is a great deal of overlap in the discussion of oceanographic conditions and meteorological conditions. Section II.B.4. and II.D. discuss in detail wave and meteorological conditions, respectively, on the South Atlantic OCS. Comparison between this and other operating regions indicates that petroleum operations have been, and are, carried out in more severe conditions than will be faced as a result of this proposed sale.

Sexton (1976) stated that jack-up rigs can operate with wind speed limitations of approximately 97 km/hr (50 mph), drill ships with wind speeds of 48 km/hr (30 mph) and wave heights of 4 m (12 ft), and semi-submersibles with winds of 80 km/hr (50 mph) and 11 m (35 ft) waves.

We can see from Figures B-36 through B-38 (Section II.B.4.) that the expected frequency for waves higher than 6 m (20 ft) is less than 3% in the month of November in the proposed lease area. Therefore little down time due to weather and seas is expected compared with other areas currently under development. A SEDCO semi-submersible on the Canadian shelf of Vancouver Island recorded sustained winds of 121 km/hr (74 mph) with gusts to 161 km/hr (100 mph) accompanied by waves up to 29 m (95 ft) during a severe storm (Sexton, 1976). Hurricanes passing through the Gulf of Mexico, such as Camille, have generaged winds of 201 km/hr (125 mph) and 22 m (72 ft) waves (Patterson, 1976). Such extreme conditions as these are rarely expected in the South Atlantic OCS.

According to Feder (1975), North Sea wave heights are greater than 2.5 m (8 ft) for 16-18% of winter. In the Celtic Sea, daily maximum wave heights exceed 3 m (10 ft) 40% of the year and 6 m (20 ft) for 5% of the year (Oil and Gas Journal, 1975). Data indicate, therefore, that periods when operations will be suspended due to high seas will be less frequent than occur in the North or Celtic Seas. According to USGS (Conservation Division, Washington, D.C., personal communication, 1976), operations were safely conducted on the COST (Continental Offshore Stratigraphic Test) well drilled off New Jersey from December, 1975, to March, 1976. During that period, operations were suspended for a total of only 24 hours due to weather and seas. Conditions in the South Atlantic are expected to be less severe.

According to VIMS (1974), visibility is reduced to less than 3.7 km (2 nautical miles) on the average of one percent per year primarily in winter, in the proposed leasing area. Visibility reduction due to fog is faced regularly by operators in the Gulf of Mexico and the North Sea. These conditions may briefly limit supply of crew activities by helicopter, and slow down boat movement.

4. Probability of Oil Spills in the U.S. South Atlantic Region

Operational activities in the northern Gulf of Mexico (1964-1976) appear to be the most representative of anticipated offshore oil and gas operations in the U.S. South Atlantic region. It should be noted that the physical environments of these two areas are not exactly alike. More hazardous environmental conditions in the South Atlantic OCS might increase the probability of oil spills over that of the Gulf of Mexico OCS experience. However, statistical data obtained from the North Sea (a more severe operating area than the U.S. South Atlantic) do not support this assumption at this time. Because operating equipment and personnel programs were designed proportional to the harsh conditions expected. No significant pollution accidents have occurred in the North Sea in drilling about 700 wells during a period of about 10 years (USDI-BLM, 1976b). The assumption is made for the South Atlantic that experience there will be similar.

Operational oil spills statistics for the Gulf of Mexico can be used to estimate the probability of oil spills for the proposed sale area. The Gulf of Mexico records represents the most extensive data with respect to all phases of OCS oil field development in the United States.

The most important feature of oil spill statistics as reported by the CEQ (1974) is the size of individual spills. The statistics represent oil spills of all types (exploration, production, collisions, etc.) ranging in size from a few gallons to 150,000 barrels. Most spills are at the low end of this range. For example, in 1972, 96% of the spills were less than 24 barrels (1,000 gallons) and 85% were less than 2.4 barrels (100 gallons). A few very large spills account for most of the oil spilled. The *Torrey Canyon* accident of 1967 (860,000 bbls), for example, spilled twice as much crude oil as was reported spilled in the United States in 1970. In 1970 and 1972, three spills each year accounted for two-thirds of all the oil spilled in the United States navigable waters in those years. Because the total volume spilled per incident can vary by factor of one million, it is difficult to estimate average amounts that might be spilled during the life of any field (Devanney and Stewart, 1974). Data supplied by the U.S. Geological Survey for the total period of 1964-1976 in the Gulf of Mexico indicates a total of 55 significant pollution incidents (50 bbls or more) connected with Federal OCS oil and gas operations.

On December 15, 1976 the Liberian-registered tanker ARGO MERCHANT ran aground on the Nantucket Shoals. The tanker broke apart on December 21, spilling 7.6 million gallons of No. 6 fuel oil. On January 4, the spill was floating 145 km (90 mi) from the coast covering an area 346 km (215 mi) long and 161 km (100 mi) wide. The spill was reported to have been caught up in a Gulf Stream eddy about 241 to 322 km (150 to 200 mi) east-southeast of the original spill site. If the spill was caught in the eddy of warmer Gulf Stream water, then the process of degradation and dispersion would be accelerated.

The estimated total volume of oil spilled during this period as a result of these incidents is over 326,000 barrels (13.7 million gallons). Table A-4 illustrates the distribution of Gulf of Mexico incidents as to type and barrels spilled. For example, pipeline breaks and leaks account for 29.1%

of the 55 incidents but were the cause of 61.4% of oil spilled. Conversely, production equipment malfunctions of all types amounted to 36.4% of incidents and 20% of oil spilled (USDI-GS, 1976e). Table A-4 is discussed further in the following subsections.

It is assumed that tanker or barge transportation will be utilized initially to bring South Atlantic production to shore. As production increases, from two to four oil or gas pipelines may be constructed and used to transport oil and gas to onshore terminals. Onshore terminals will be used to load tankers for distribution to existing treatment facilities outside the area. The following discussion outlines the probabilities estimated from past experiences, of oil spills caused by pipeline accidents, well blowouts, fires, tankers, and natural phenomena.

a. Pipeline accidents

Since the USGS OCS Operating Orders concerning pipelines went into effect in 1970, pipeline breaks and leaks accounted for 29.0% significant pollution incidents and 27.7% of oil spilled. These data refer to the Gulf of Mexico which has the largest Federal OCS record and the most offshore pipeline activity of any area in the United States. Oil spilled by pipeline accidents account for approximately 0.0014% of the total production in the Gulf of Mexico. Assuming the USGS estimates of recoverable resources, between 0.282 and 1.009 billion barrels of oil could be produced from this proposed sale, from 3,948 to 14,126 barrels might be spilled by pipelines during the 25-year expected life of this lease area.

Since 1970, 72.9% of the total volume of oil spilled by pipelines and 37.5% of accidents are believed to be the result of ship anchors dragging across the pipeline causing it to rupture. Other causes of pipeline damage include movement due to wave action during storms, impact of trawl boards of commercial fishing boats, and corrosion of the pipe due to formation water that is produced with the oil. The pipelines are protected cathodically with zinc anodes and an internal corrosion inhibitor is injected with production through the line. But small pits form on the interior walls of the pipeline and as the line gets older these pits develop into pin hole leaks.

Taking the USGS high recovery estimates, there will be a total of 160 miles of oil pipelines constructed during the 25-year life of the field. In the Gulf of Mexico there is currently over 7700 miles of oil and gas pipelines. At least 1000 miles of those 7700 miles are oil pipelines. According to USGS there have been 16 pipeline breaks and leaks of over 50 barrels of oil from 1964 to 1976 (Table A-4). There have been 6 spills of the 16 that were greater than 1000 barrels each. It would be logical to assume there will occur at least one spill greater than 1000 barrels during production from the South Atlantic leasing area.

b. Oil and/or gas well blowouts

It is possible for oil or gas to blow out of control during drilling operations, completion and production. Blowouts may be prevented during drilling by increasing mud weight and activating blowout preventers. When a well is completed, a subsurface safety device is installed to prevent the well from blowing out if surface control is lost. A gas well blowout will cause little or no pollution because it will burn or disperse into the atmosphere. An oil well blowout can release large quantities of drill mud, cuttings, sediment and some oil and gas into the marine environment.

Gulf of Mexico statistics show that during the period of 1956 to November 1, 1976 one blowout occurred for every 231 wells drilled, spilling an average of 1,053 barrels of oil each. Although there have been a total of 60 well blowouts since 1956, only 8 have resulted in significant volumes of oil spillage. In fact a single incident accounts for spillage of 53,000 barrels of the total of 63,193 barrels spilled by blowouts in the last 21 years in the Gulf of Mexico. Most blowouts causing spillage result from producing oil wells, not wells being drilled. Producing oil well blowouts are normally a result of equipment malfunctions, workover procedures, human errors, storms and collisions.

It is estimated that between 255-720 exploratory and development wells will be drilled as a result of the proposed sale. Based upon the above statistics in the Gulf of Mexico, there may be between one to three blowouts resulting in approximately from 1,053 to 3,159 barrels of oil spilled during exploration and production in the U.S. South Atlantic lease area.

c. Oil spills resulting from explosions and fires

Combustible hydrocarbon liquids or vapors making contact with arching electrical or overheated mechanical devices undoubtedly cause

Table A-4. Oil Spills Greater than 50 Barrels in the Gulf of Mexico, 1964-1976

Cause of Spill	Number of Incidents	% of Incidents	Barrels of Oil Spilled	% of Oil Spilled
1. Blowout	5	9.1	5,138	1.6
2. Hurricane Damage	6	10.9	14,357	4.4
3. Pipeline Breaks & Leaks				
a. Unknown Cause	7	12.7	8,209	2.5
b. Corrosion	4	7.3	5,564	1.7
c. Anchor Dragging	5	9.1	186,652	57.2
Subtotal	(16)	(29.1)	(200,425)	(61.4)
4. Fires	1	3.6	30,600	9.4
5. Barge Spills	3	5.5	7,340	2.2
6. Collisions	3	5.5	2,825	0.87
7. Production Equipment Malfunction				
a. Valves	4	7.3	365	0.11
b. Overflow of Vessel or Tank	10	18.2	1,113	0.34
c. Workover	1	1.8	53,000	16.2
d. Well Abandonment	1	1.8	500	0.15
e. Other Equip. Failures	4	7.3	10,500	3.2
Subtotal	(20)	(36.4)	(65,478)	(20.0)
Total	54	100.1	326,163	99.87

Source: USDI-GS, 1976e.

most platform fires. More rarely, they are ignited by lightning or static electricity. Sometimes platform fires involve the accidental ignition of fuel, solvent or heat exchanger fluids.

If producing wells are damaged to the extent that oil flows freely and ignites, they are usually allowed to burn while remote control operations are underway. In this way, most hydrocarbon liquid expelled by the well burns, reducing the fire hazard during relief operations and lowering ocean pollution levels. If a blowing well is releasing mostly natural gas, ocean pollution is minimal. However, personnel and the platform or drilling structure are imperiled in the event of a fire.

From 1956 to November 1, 1976 platform fires of varying species have occurred during OCS production in the Gulf of Mexico. Most were extinguished without causing serious damage or pollution. Of 189 recorded explosions and fires, only 19 resulted in oil spills amounting to a total of 87,132 barrels. Approximately one explosion and/or fire occurs for every 74 wells drilled, spilling an average of 461 barrels of oil. Assuming that a minimum of 255 and a maximum of 720 wells will be drilled as a result of this proposed sale, between 3-10 explosions and/or fires may result during the expected production period.

d. Tanker accidents and operations

Because of the low resource estimates, distance to shore, economic considerations, and the position of the tracts in relation to one another, it is more probable that tankers rather than pipelines will be used to transport any oil found in the South Atlantic from the platforms to existing or future refineries. These tankers would be U.S. vessels, probably in the 16,000 to 25,000 dwt size range. Figure A-1 shows the percentage of total outflow from various polluting sources. Table A-5 shows the budget of petroleum hydrocarbons introduced into the oceans as compiled by the National Academy of Sciences (NAS, 1975). Figure A-2 illustrates the percentage and amount of oil discharged by tanker accidents by type for 1969-1970. However, tanker operations including ballast discharge, tank washing, and bilge bunkering introduce several times as much oil into the oceans that is attributable to actual accidental spills.

To alleviate this problem, both international and internal regulations have been promulgated. The Intergovernmental Maritime Consultative Organization (IMCO), a voluntary membership organization, has proposed the Load-On-Top (LOT) procedure, among many others, as the best method of eliminating the problem of oil discharge, from tanker ballasting and cleaning operations. This procedure can reduce the amount of oil introduced to the oceans by more than 50 percent. They also suggest that no discharges of contaminated water be allowed within 50 miles of a shoreline. Amendments presently proposed are even more stringent and should alleviate most of the problems related to oil pollution from tankers if they are practiced.

The effectiveness of the Load-On-Top system depends upon the length of the voyage and sea conditions enroute. It is possible that distances within the proposed sale are insufficient to allow adequate separation of oil from bilge water. Therefore, LOT may not be of much benefit in this proposal. Several solutions to the problem would be segregated ballast tanks, on board oil water separators, or reinjection of ballast water at the production site.

At the present, there are no methods for computing the estimated volume of oil that might be spilled or released from tankers in this South Atlantic area alone. The only means presently available to calculate such a percentage for tankers from offshore platforms is on the basis of worldwide tanker spills versus volume of oil carried. This method however is not actually valid for the South Atlantic because: 1) relatively small size of ships would be employed 16,000 to 25,000 dead weight tons (dwt) or smaller; 2) only U.S. vessels and personnel will be used; these have better overall performance records than those of most nations; 3) worldwide spill records are compiled for some tanker operations (port-to-port, barging, lightering) that probably would not be employed in the South Atlantic; and 4) 84% of the worldwide spillage is attributed to washing tanks without using the Load-On-Top procedures, whereas new United States Coast Guard regulations will require Load-On-Top procedure. The statistics, however, do represent a worst case projection and are usable until more specific data with respect to size and type of tanker can be obtained (Table A-5.1). (The new CG regulations require segregated ballasts in tankers over 70,000 dwt; however, use of vessels of this size to transport any South Atlantic OCS produced oil is not anticipated due to channel restrictions at existing terminals.)

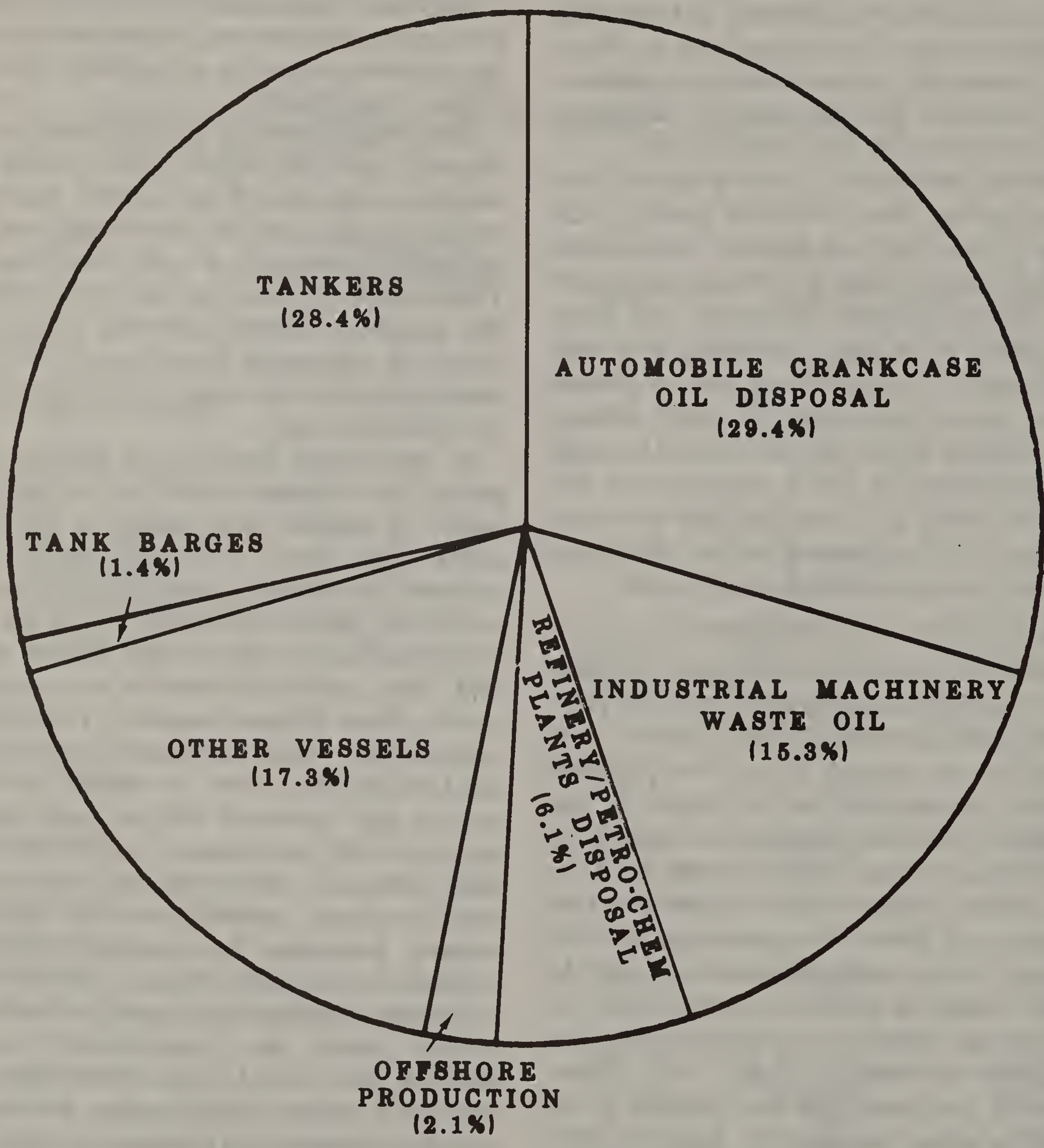


Figure A-1. Sources of Oil Pollution to the Oceans.

Source: Porricelli and Keith, 1973

TABLE A-5 Budget of Petroleum Hydrocarbons Introduced into the Oceans

Source	Input Rate (million metric tons)		Reference
	Best Estimate	Probable Range	
Natural seeps	0.6	0.2-1.0	Wilson et al. (1973)
Offshore production	0.08	0.08-0.15	Wilson et al. (1973)
Transportation			
LOT tankers	0.31	0.15-0.4	Results of workshop panel deliberations
Non-LOT tankers	0.77	0.65-1.0	
Dry docking	0.25	0.2-0.3	
Terminal operations	0.003	0.0015-0.005	
Bilges bunkering	0.5	0.4-0.7	
Tanker accidents	0.2	0.12-0.25	
Nontanker accidents	0.1	0.02-0.15	
Coastal refineries	0.2	0.2-0.3	Brummage (1973a)
Atmosphere	0.6	0.4-0.8	Feuerstein (1973)
Coastal municipal wastes	0.3	-	Storrs (1973)
Coastal, Nonrefining, industrial wastes	0.3	-	Storrs (1973)
Urban runoff	0.3	0.1-0.5	Storrs(1973) Hallhagen
River runoff	1.6	-	Storrs (1973) Hallhagen
TOTAL	6.113		

Adapted from: National Academy of Sciences, 1975.

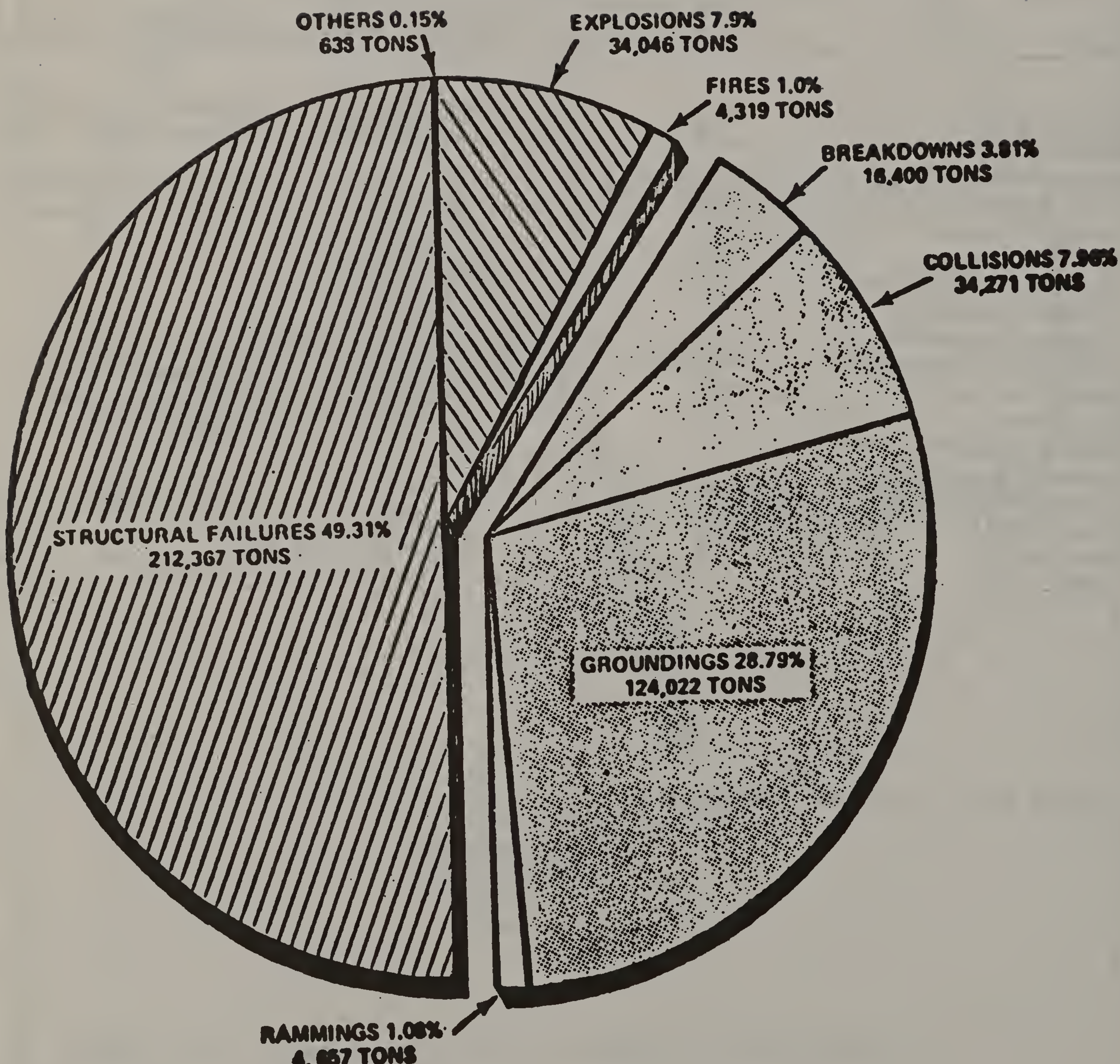


Figure A-2 1969-1970 Tanker Polluting Incidents, Percentage Oil Outflow by Type of Accident from Porricelli and Keith, 1973.

Table A-5.1 Hypothetical Tanker Oil Spillage Summary by Loss Category Over a 25-Year Field Life

Category	Rate = Vol. Spilled / Vol. Carried	Oil Spilled: Low Estimate of Production 2.82×10^8 bbls.	Oil Spilled: High Estimate of Production 1.009×10^9 bbls
Bilges, leaks and Bunkering	0.00005	14,100 bbl.	50,450 bbl.
Casualties	0.00016	45,120	161,440
Casualties Minus Structural Failures	0.00009	25,380	90,810
Terminal Operations	0.0000022	620	2,220
Dry Docking	0.000369	104,058	372,321
Tank Washing (Without Lot)	0.0035	987,000	3,531,500
Tank Washing (With Lot)	0.000352	99,264	355,168
TOTAL		1,275,542 bbl.	4,563,909 bbl.

Using methods and assumptions developed for worldwide tanker spill statistics (the methodology for developing these statistics may be found in the Final EIS for Proposed Lease Sale No. 35 (Southern California), Vol. 2, pp. 50-75. It incorporates the estimated rates published by NAS (1975) as shown in Table A-5.1 the following volumes hypothetically might be spilled by tankers carrying oil from South Atlantic production sites during the 25-year field development. Estimates of oil spilled are based upon the high and low estimates of production provided by the USGS.

e. NATURAL PHENOMENA

The preceeding sections dealt with estimates on the volume of oil that may be spilled annually as a result of human error and/or equipment failure. This section is devoted to oil spill probability estimates due to natural phenomena in the proposed sale area. It is taken, with minor changes, from the CEQ (1974) report which estimates the likelihood of natural phenomena damaging or destroying an offshore structure. Estimates were not based on past experiences in offshore oil operations because the environmental conditions of the U.S. South Atlantic region differ from previous experience so that estimates based on past experience have marginal value. The CEQ, therefore, used an analytical approach considering design criteria, safety specifications of the structures, and likelihood of a particular event.

Major offshore structures are designed to withstand environmental stress specified by the contracted owner or operator. Typically, forces associated with the 100-year storm have been the specified stress. There is always a chance, however that these forces could be exceeded resulting in an oil spill. For example, over a 25-year field life, the probability of at least one storm occurring with forces exceeding the 100-year storm is 26% and with forces exceeding the 200-year storm, 14%.

Based on several assumptions, the CEQ calculated the number of times oil spills can be expected to occur due to natural phenomena. It was assumed that: each severe natural occurrence is independent of the others; the probability of the occurrence is small so that the Poisson distribution applies; the probability that a natural event will occur is adequately described by the recurrence relations given in other sections of the CEQ report; structural designers can develop structures which will withstand the forces of specific natural events, and a specific natural event will occur in the vicinity of an oil field exposing the structures to the full forces associated with the event.

Unprotected wells can blow out if the platform collapses, either from excessive storm forces or earthquakes. The probability of a storm exceeding the design storm has been calculated for design specifications of both 100- and 200-year storms with safety factors of 1.5 and 2.0. It was presumed a design spectrum for earthquakes having Richter magnitudes of 6.6, 7.2, and 8.5 could be developed. The analysis further assumed that the platform would experience the full effects of a storm or earthquake exceeding the design spectrum. If a platform collapses, the conductor pipes will shear. The positive open control lines to the subsurface valve will also shear, however, thus closing the valve and preventing the loss of oil. The valves, however, are not 100% reliable and recent tests only show a 0.96 to 0.97 reliability. The CEQ used 0.96 for their calculations. A valve reliability of 0.99 was also used in order to show how improved reliability would reduce failure rates. Table A-6 summarizes the estimates.

Upon examining Table A-6, several important points are readily observed. First, the likelihood of platform collapse has a linear increase as the age of the field increases and a linear decrease as the design storm criteria is increased. The second important point is that platforms used in the U.S. South Atlantic OCS must be able to withstand the maximum recorded earthquake on the U.S. South Atlantic coast if the likelihood of collapse is to be no greater than that for severe storms during the field life. Table A-7 also lists the likelihood of damage caused by having a tsunami occur during a severe storm. At this point, the likelihood of oil spillage from damaged storage systems due to natural phenomena shall be examined. There are three types of storage facilities: onshore, floating and underwater. It is a logical assumption however, that only onshore storage facilities will be used in the U.S. South Atlantic region. It is now required by government regulations that dikes enclose all onshore storage tanks so that, if the tank fails, the released oil will be unable to escape from the area. It is maintained by the CEQ, therefore, that the chance of an oil spill due to natural phenomena is zero provided the dikes are not damaged. Damage to dikes is very dependent on

TABLE A-6. ESTIMATE OF PLATFORM COLLAPSE AND WELL BLOWOUT (SAFETY VALVE RELIABILITY - 0.96 and 0.99)

	Age of field in years			Remarks
	20	30	40	
Severe Storm Design Standard				
100-year storm				
Margin of Safety - 1.5	.09/.0036/.0009*	.14/.0056/.0014	.19/.0076/.0019	Average number of times severe storms will cause well blowout
Margin of Safety - 2.0	.04/.0016/.0004	.07/.0028/.0007	.08/.0032/.0008	
200-year storm				
Margin of Safety - 1.5	.05/.002/.0005	.07/.0028/.0007	.09/.0036/.0009	
Margin of Safety - 2.0	.02/.0008/.0002	.03/.0012/.0003	.04/.0016/.0004	
Earthquake Design				
M = 6.6				
Atlantic M_s - 1.5	.25/.01/.0025	.38/.015/.0038	.51/.02/.0051	Average number of times earthquakes will cause well blowout
Atlantic M_s - 2.0	.23/.009/.0023	.35/.014/.0035	.46/.018/.0046	
M - 7.2				
Atlantic M_s - 1.5	.10/.004/.0010	.16/.064/.0016	.21/.008/.0021	
Altantic M_s - 2.0	.09/.0036/.0009	.14/.056/.0014	.18/.007/.0018	
Combined Severe Storm and Tsunami				
100-year storm	.001/.00004/.00001	.0015/.00006/.000015	.002/.00008/.00002	
200-year storm	.0005/.00002/.000005	.0007/.000028/.000007	.001/.00004/.00001	

*Platform Collapse/Well Blowout R = 0.96/Well Blowout R - 0.99

(Adapted from CEQ, 1974)

Table A-7. Summary of the Effect of Natural Phenomena on Various Elements of the Oil Production System

	Natural Phenomena				
Element	Severe Storm	Earthquake Vibration	Earthquake Soil Stability	Tsunami	Volume of Oil at Risk Per Event
Platform	Slight	Slight 1/	Slight 2/	None	500 to 1500 bbl/ well/day
Pipeline	None	None	Variable 3/	None	10,000 bbl or more
Onshore Storage	Slight 4/	Slight 5/	Slight 2/	None	Up to 1,000,000 bbl or greater 6/

1/ Provided earthquake resistant design features are used.

2/ Provided careful soil analysis program is followed.

3/ The avoidance of slump, faulted, or poorly consolidated sediments can reduce potential impacts.

4/ Provided tanks are sited away from flood prone areas.

5/ Provided free surface effect is reduced.

6/ Dikes give protection against damaging oil spill.

(Adapted from CEQ, 1974)

the quality of the soil foundation and, therefore, it is extremely important that a thorough geologic investigation of the proposed site be made in order to confirm that the soil properties are satisfactory.

With regard to the likelihood of natural phenomena damage to pipelines, if pipelines are properly designed, constructed, and emplaced, they are relatively insensitive to all natural phenomena except ground faulting and slumping along the pipeline routes. The possibility of soil stability loss will be assessed when a thorough geologic analysis of the possible routes has been made and a valve location program selected. These steps are taken during the late stages of the exploration program and follow the decision that the reservoir contains oil and/or gas in sufficient quantities to warrant pipeline transportation. For this reason, the likelihood of pipeline spills due to natural phenomena are difficult to predict at this time.

5. Oil Spill Trajectories in the U.S. South Atlantic Region

The introduction of offshore petroleum activities to the U.S. South Atlantic Region, as a result of this proposed sale, presents the possibility of a major oil spill occurring at some time. Oil spills on the ocean surface are usually described in terms of spreading, drifting and weathering. A combination of many factors control oil spill movement and composition. A partial list of these factors include: original composition of the oil, age, solubility, volume spilled, concentration, dilution, evaporation, photo oxidation, absorption on suspended particulates, microbial degradation, mechanical or chemical treatment, water salinity and temperature, waves, winds, currents, season and geographical location.

In order to assess the possibility of oil spills from offshore locations in the U.S. South Atlantic OCS reaching shore sites, a variety of computer simulations have been conducted. It should be remembered that two separate and distinct probabilities are involved in this type of analysis. The first is the probability of a spill occurring (which has been discussed in Section III.A.4.), and the second is the probability of a spill impacting on environmentally sensitive areas.

One of the first trajectory studies for the Atlantic OCS areas was made at the Massachusetts Institute of Technology by Stewart et al. (1974) for the Council on Environmental Quality. The study consisted of a computer simulation of the OCS environment (wind and currents) affecting movements of hypothetical oil spills. Trajectories were computed for oil spills occurring at selected locations within the Georgia Embayment. Parameters obtained from the analysis included average time to shore, minimum time to shore, and probability of the spill reaching shore. A more complete description of the M.I.T. model as well as results can be found in Appendix L.

A recently developed oil spill risk analysis model was used by the Department of the Interior to develop an analysis of probable impacts associated with OCS oil and gas development within the proposed U.S. South Atlantic lease sale area.

Utilizing available oceanographic and meteorological data in conjunction with the location of fisheries and wildlife resources, critical habitat and recreation resources specific to the U.S. South Atlantic Region, the model provides a means of (1) analyzing the probabilities of OCS-related oil spills occurring, and (2) evaluating possible drilling sites within the proposed sale area in relationship to potential impacts on the environment of the U.S. South Atlantic Region in case of an OCS oil spill. Additionally, the model determines the average time that it would take for a hypothetical spill to reach an environmentally sensitive area. This analysis could facilitate determination of further significant trade-offs for possible alternative selection of tracts that may be offered for lease. A description of the model, details of methodology, and a summary of probable risks are provided in Appendix M.

Representative spill sites were selected for analysis from within eight subdivisions of the proposed lease area (Figure A-3) based on the mean of estimated petroleum resources for individual prospects within those areas (U.S. Geological Survey, proprietary data). Use of Devanney and Stewart distributions permited separate estimates of platform, pipeline, and tanker spill frequency which could then be combined to compare the two alternative modes of transport of crude to shore. Spill frequency estimates were further categorized for spills between 50 and 100 barrels, and greater than 1000 bbls. in size. The size grouping is somewhat arbitrary but very important in considering the significance of weathering and in reducing the impact of oil spills.

Using available wind and current data, an oil spill trajectory model was constructed and used to analyze movements of hypothetical oil spills on a digital map of the area. The area might be affected was defined as the region between 28° N and 35° N latitude and about 76°20′ W longitude and the southeast Atlantic Coast.

The spatial disposition of the trajectory simulations is shown in Figure A-3. The final location of each trajectory was recorded and the results for each spill site (weighed by the estimated spill frequencies) were averaged. Thus, according to Figure A-4, 44% of the spills trajected ashore on the Florida coast, 3% on the Georgia coast, about 12% on South Carolina, and about 23% on North Carolina.

Oil spill trajectory simulations were conducted keeping track of the frequency with which trajectories intersected the locations of biological and recreational resources. Trajectories were recorded as impacting a resource only in cases where the resource was listed as being vulnerable to oil spills in the month the impact took place. Table A-8 gives the probability of impact of each of the 19 categories of biological resources and recreation areas for a spill originating at the eleven spill sites within the proposed lease area (see Figure A-3). As one would expect, the likelihood that a given spill trajectory would beach at the location of a specific land based resource during critical months is generally smaller than the 84% probability of coming ashore anywhere.

Probabilities of at least one spill greater than 1,000 bbls. occurring during the production life of the field and impacting the various groups are given in Table A-9. The probabilities have been calculated for two assumed transportation methods and two assumed transportation routes. There is a tendency for resources that occupy a large area of the shoreline or continental shelf to exhibit higher probabilities of impact. In reality the impacts of a particular spill may only affect a small portion of that resource population or habitat. Therefore Table A-9 in column 5, provides a means to compare the estimated size of the spill in relation to the exposed resource area.

A comparison of the results of these two models shows major discrepancies that cannot be explained by difference in wind and current data. The M.I.T. model results show very few trajectories impacting the Florida coast and many impacting the Savannah area. Conversely the D.O.I. model predicts impacts on the Florida coast 43% of the time and almost no trajectories hitting the Savannah area.

The D.O.I. model was essentially designed after the M.I.T. model. However much has been added concerning impacts to particular resources, sources of spills, size of spills, and probabilities of each. It should be emphasized again that neither of these models accounts for weathering, dispersion, evaporation, and other degradation factors that are important in assessing oil spill impacts. Most average times to shore in the Interior model exceeded 21 days at sea (70%). It is very doubtful that an oil spill 21 days at sea would still exist, except as very small tar balls.

6. Fate and Effects of Oil in the Marine Environment

The bulk of the following analysis was taken from Petroleum in the Marine Environment (NAS, 1975).

a. Fates

Petroleum introduced to the marine environment from whatever source goes through a variety of transformations involving physical, chemical and biological processes. This section attempts to identify major factors controlling each of these processes, to review the relevant experimental and field evidence for quantitative evaluation of the effect of these various degradation processes on petroleum, and to estimate the amount of petroleum hydrocarbons in the sea at present.

Physical and chemical processes begin to operate immediately when petroleum is spilled at the ocean surface. These include evaporation, spreading, emulsification, solution, sea-air interchange and sedimentation. Involved in all these "physical" processes are chemical factors determined by the composition of the petroleum fraction. In addition, purely chemical oxidation of some of the components of petroleum can be induced by sunlight. The products of these processes include hydrocarbon fractions introduced to the atmosphere, slicks and tar lumps on the surface of the ocean, dissolved and particulate hydrocarbon materials in the water column, and adsorbed or particulate hydrocarbons materials in the sediments.

At the same time physical and chemical separation and degradation processes are occurring, biological processes also act on these various

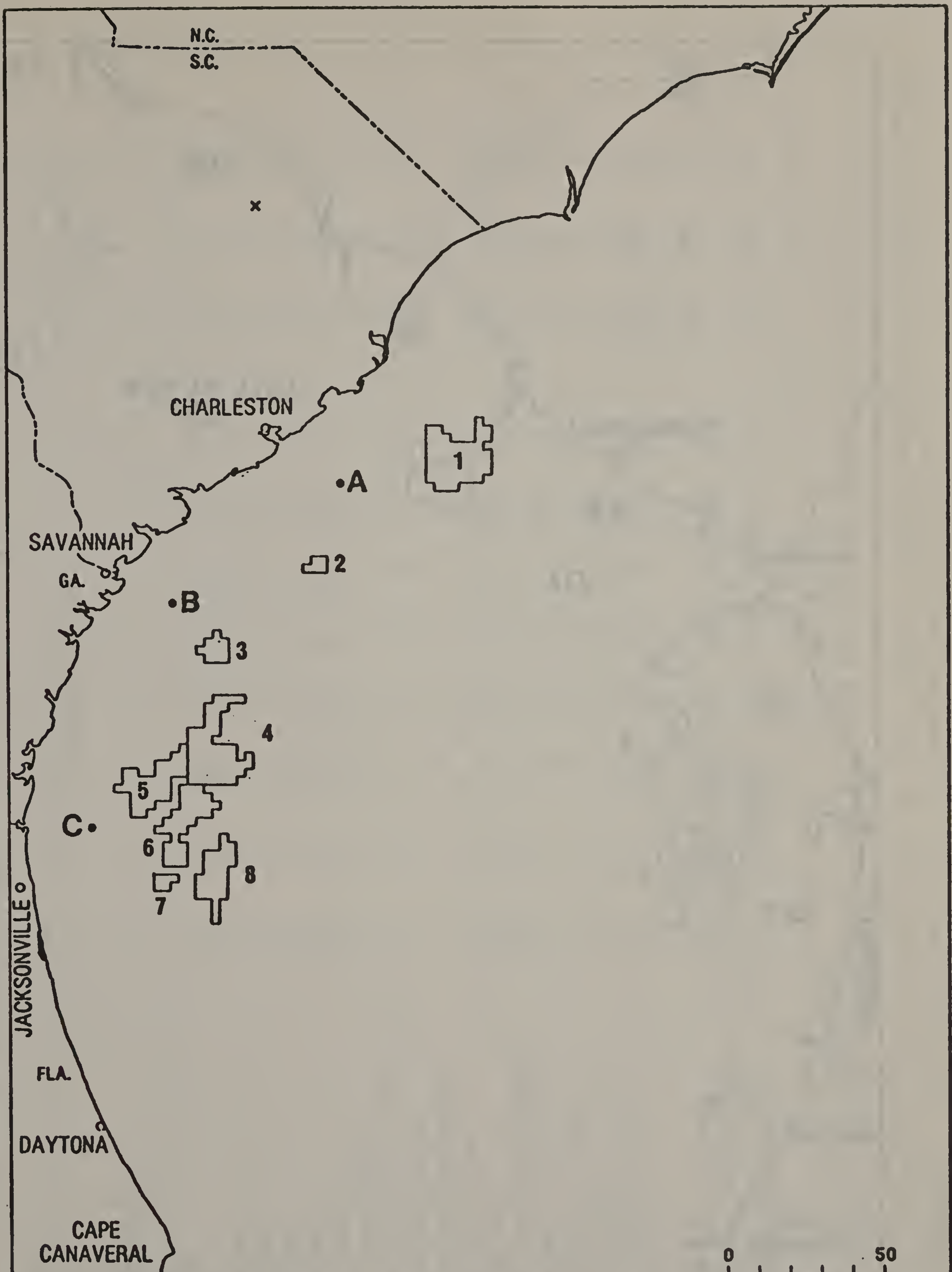


Figure A-3 Map of the South Atlantic Outer Continental Shelf showing subdivision of the proposed lease area and hypothetical transportation routes.

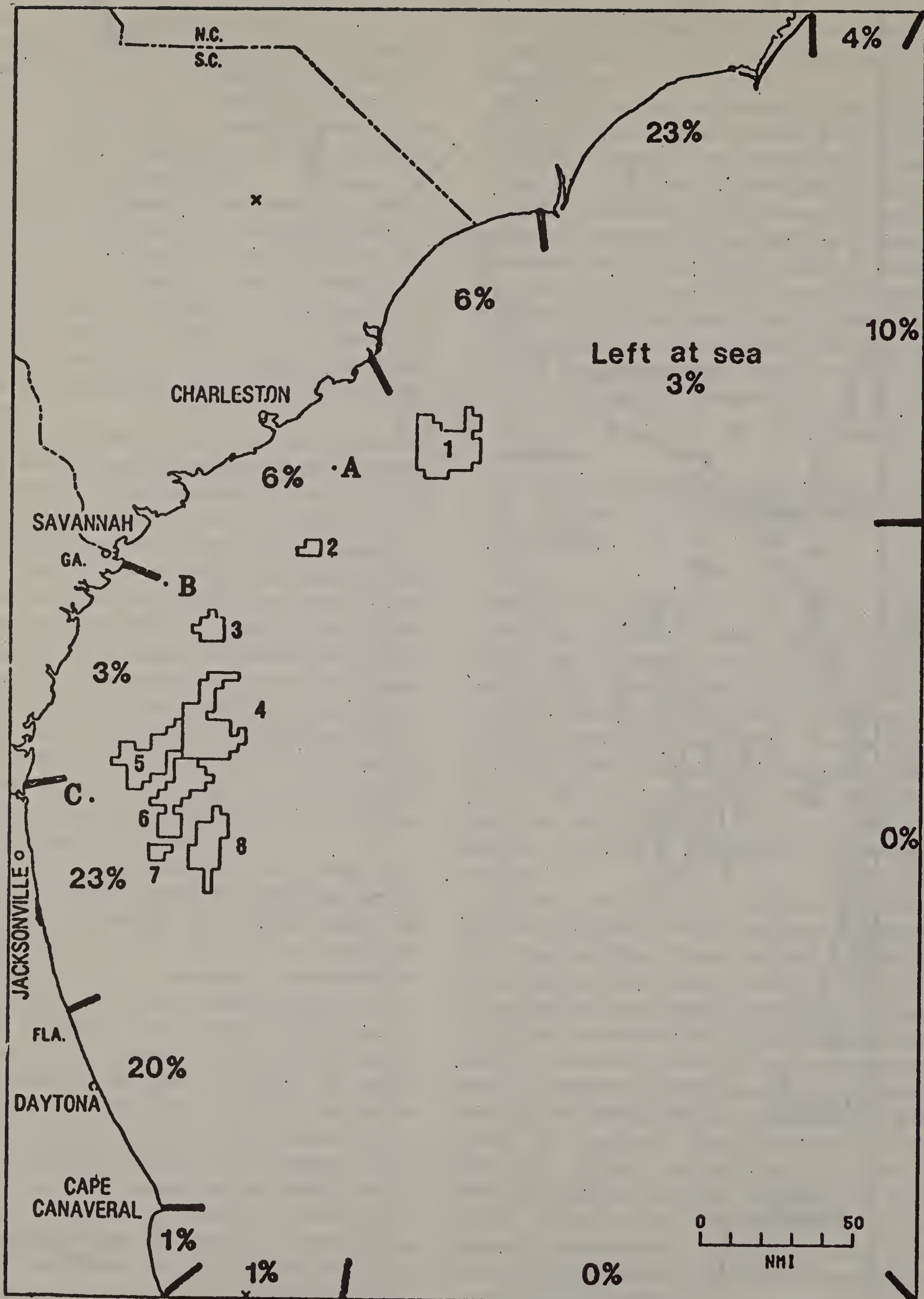


Figure A-4 -- Probability that if an oilspill occurs in the South Atlantic lease area, it will reach a particular geographic location.

Table A-8. Percent probabilities that an oil spill occurring at potential production areas in the South Atlantic lease area would impact important biological resources and recreation areas.

Resources Group	Production Area 1	2	3	4	5	6	7	8	Transportation Route A	B	C
Sandy beaches	69	73	84	84	88	89	93	90	79	86	97
Recreation areas	16	14	15	16	17	16	13	12	12	15	21
Wildlife refuges	1	2	4	2	2	2	2	2	4	4	5
Historical sites	19	17	10	11	10	10	7	7	16	6	4
Marsh and wetlands	6	7	5	4	4	4	3	4	7	8	3
Turbid water zone	19	27	28	23	26	26	27	24	32	31	30
Brown pelican rookeries	*	*	1	1	1	2	2	1	*	1	2
Coastal or pelagic bird rookeries	4	4	3	3	2	2	2	2	3	2	2
Bald eagle nesting sites	*	*	*	*	*	*	*	*	*	*	*
Dusky seaside sparrow habitat	*	*	*	*	*	*	*	*	*	*	*
Arctic peregrine falcon migration routes	57	60	73	75	77	79	83	82	63	71	88
White, brown, and pink shrimp	31	31	34	30	31	27	27	25	31	33	35
Royal red shrimp	*	*	1	1	*	1	1	2	*	*	*
Commercial fishing grounds	g	g	g	94	g	g	g	97	g	g	g
Sport fishing area	2	1	1	2	2	2	1	3	1	1	*
Commercial scallop grounds	32	22	16	19	15	15	11	13	19	8	7
Crabs and oysters	34	37	27	21	21	18	14	16	49	28	10
Bay scallops	4	3	2	2	2	1	*	*	3	1	*
Sea turtle nesting sites	35	38	40	37	39	36	34	34	40	38	37
**Rank ordering-Oil Spill Impact Risk	429	437	443	425	437	430	420	414			
Overall probability ashore	69	73	86	86	90	91	95	93	79	86	97

* Less than 0.5 percent probability

g Greater than 99.5 percent probability - scored as 100% probability for the purposes of rank ordering ($\leq$ % probability)

** Obtained by combining percent probabilities in each resource category (assuming equal weight or value for each resource). The higher the total, the greater the risk anticipated.

TABLE A-9 Probabilities of one or more spills greater than 1,000 bbls occurring and impacting biological resources and recreational areas in the South Atlantic area over the production life of the entire lease area. Also, the size of a major spill in relation to the extent of exposed resource.

	Probability (percent)				
	Based on pipeline transport to Jacksonville and Savannah	Based on pipeline transport to Charleston and Savannah	Based on tanker transport to Jacksonville and Savannah	Based on tanker transport to Charleston and Savannah	Ratio of mean spill size to extent of exposed resources ǂ
Probability of coming ashore	93	92	96	95	.04
Beaches	93	92	95	95	.05
Recreation areas (State and Federal)	40	39	45	43	.24
Wildlife refuges	8	8	9	9	.53
Historical sites	29	32	33	33	1.0
Marsh and wetlands	15	16	17	14	.10
Areas of high sedimentation rate	55	55	61	62	.12
Brown pelican rookeries	3	2	4	3	3.33
Coastal or pelagic bird rookeries	8	8	9	9	.37
Bald eagle nesting sites	*	*	*	*	10.00
Dusky seaside sparrow habitat	*	*	*	*	25.00
Arctic peregrine falcon migration routes	89	89	93	93	.04
White, brown, and pink shrimp	62	62	69	69	.07
Royal red shrimp	2	2	2	2	2.5
Commercial fishing grounds	95	95	97	97	.02
Sport fishing area	4	5	5	5	.71
Commercial scallop grounds	43	44	47	49	.22
Crabs and oysters	53	58	59	65	.06
Bay scallops	6	7	7	7	.53
Sea turtle nesting sites	69	69	75	75	.05

* Less than 0.5 percent.

ǂ Onshore resources compared on the basis of length and offshore resources on the offshore resources on the basis of area (see Appendix M).

fractions of the original petroleum in various ways. The biological processes include degradation by microorganisms to carbon dioxide or organic materials in intermediate oxidation stages, uptake by larger organisms and subsequent metabolism, storage, or discharge. The natural forces acting on oil spilled at sea are shown in Figure A- .5.

(1) Physio-chemical Fate

The NAS workshop concluded the following with regard to the physical and chemical fate of oil in marine systems:

(a) Slicks and tar lumps are transient conditions and do not represent the ultimate fate of petroleum spilled on the sea.

(b) The ultimate fate is one of the following: evaporation and decomposition in the atmosphere, dispersal in the water column, incorporation into sediments, exidation by chemical or geological means to CO_2.

(c) The standing crop of petroleum-like material in the form of slicks and floating lumps is of the order of a year's input. Tar stranded on rocky shores may have a much longer lifetime.

(d) Crude oil and some petroleum products transported by sea can easily form tar. Occurrence of pelagic tar correlates with intensity of tanker traffic in different regions of the ocean.

(2) Biological Fate

The NAS workshop concluded the following with regard to the biological fate of oil in marine systems:

(a) Neither a single rate nor a mathematical model for the rate of petroleum biodegradation in the marine environment can be given at present. On the basis of available information, the most that can be stated is that some microorganisms capable of oxidizing chemicals present in petroleum (under the right conditions) have been found in virtually all parts of the marine environment examined.

(b) Laboratory experiments have demonstrated that the n-alkane fraction of petroleum is most easily degraded. In toxic marine environments, this type of compound is likely to be degraded in a matter of days or months, depending principally on temperature and nutrient supply. Other fractions are more resistant to microbial action, and the time required for substantial decomposition of the most resistant components of petroleum in the marine environment is probably measured in years to decades.

(c) In larger organisms, hydrocarbons are taken up primarily through the gills or by ingestion of particulate matter. Direct uptake from water through the gills is probably the most important pathway in pelagic environments. For benthic organisms, the sediments may be a more important source.

(d) The measured level of petroleum hydrocarbons (after correction for biogenic contributions) in a variety of marine organisms ranges over three orders of magnitude (1 ug/g to 400 ug/g wet weight).

(e) Some organisms (e.g., copepods) can ingest large quantities of petroleum and eliminate it directly as fecal matter without substantial degradation.

(f) Some fish and crustaceans metabolize petroleum hydrocarbons within two weeks; in plankton and benthic invertebrates, however, metabolism is slow and the pathways are poorly understood.

(g) Storage of hydrocarbons, including those from petroleum, occurs in the lipids of many organisms. Biogenic hydrocarbons, particularly di- and triolefins, are often clearly distinguishable from petroleum.

(h) Some organisms (e.g., mussles and oysters) can eliminate most petroleum hydrocarbons (but not all) after absorption if placed in unpolluted water.

(i) Discharge by vertebrates occurs primarily through the gall bladder and kidney. Paths of discharge for invertebrates are not well established.

(j) There is no evidence for food web magnification in the case of petroleum hydrocarbons in the marine environment. On the contrary, evidence is strongest that direct uptake from the water or sediments is more important than from the food chain. A discussion of impacts on food webs is found in Appendix I.

b. Effects

Table A-10 shows that a limited number of documented studies exist that consider the biological, chemical and physical acute and long-term effects of oil in the marine environment. Because most studies have been made in estuaries, little data are available concerning effects on the open ocean. However, certain generalizations about various aspects of oil in the marine environment can be made.

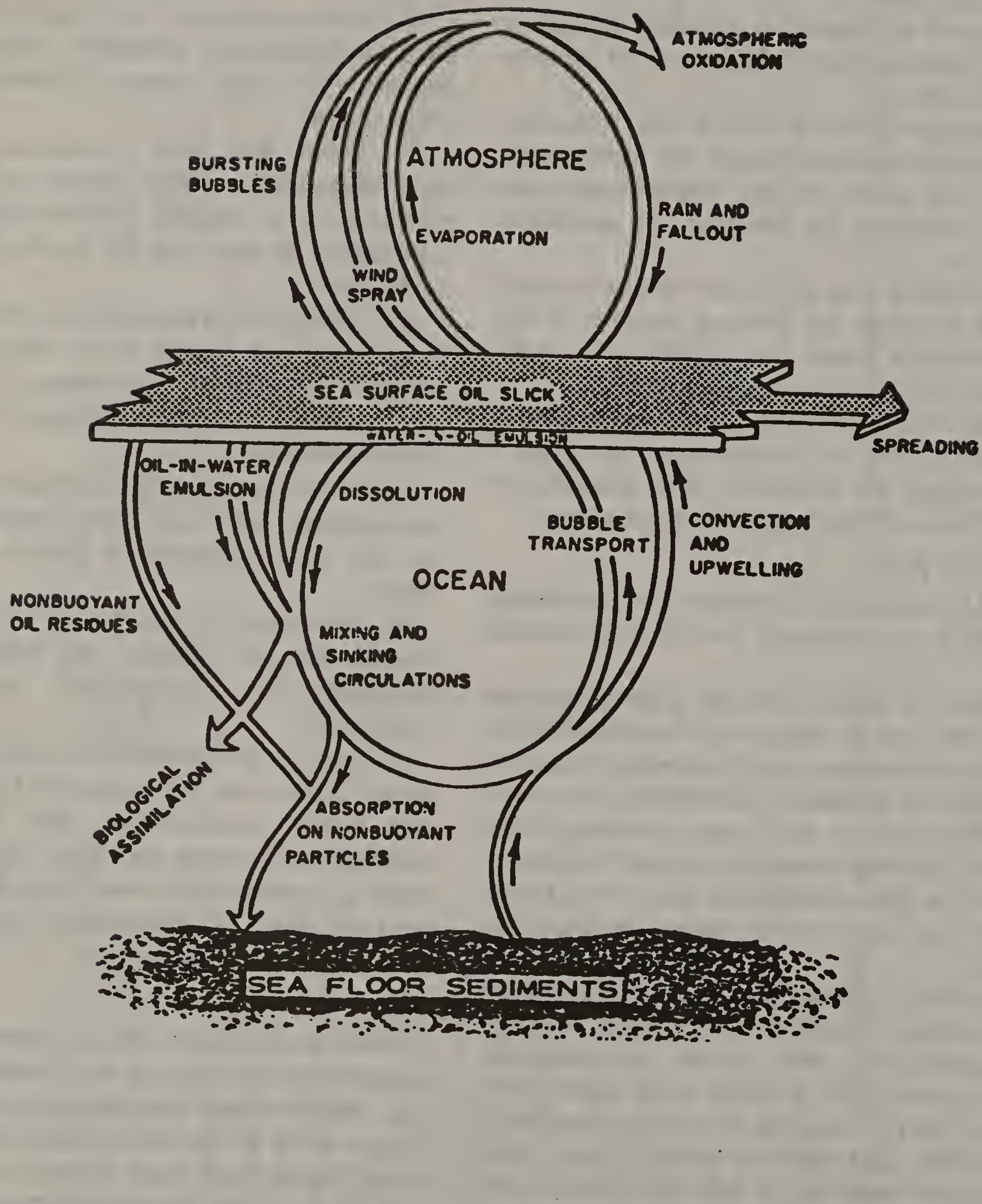


Figure A-5 Natural Forces Which Disperse and Modify Petroleum Slicks on Water (Adapted from Garrett, 1972)

TABLE A-10 A Summary of Several Major Oil Spills Followed by Studies of Their Biological Impact

Date of Spill	Source and Location	Type and Amount of Oil (barrels)	Shoreline Affected (mi)	Localities Studied	Species Identified	Sampling Method	Biological Damage	Reference
March 1957	Tampico Maru, Baja California, Mexico	Diesel oil 60,000	2	Intertidal & subtidal	Larger visible plants and animals	Qualitative, quantitative macrocystis counts	Nearly total devastation immediately, luxuriant growth of seaweed developed within months; biota 90% restored after 3 or 4 years, although relative abundance of certain species still somewhat changed after 12 years	North et al., 1964; Mitchell et al., 1970
July 1962	Argea Prima, Guayanilla Harbor, Puerto Rico	Crude oil 70,000		Mangrove shores; intertidal and subtidal	Blue-green algae	Qualitative	Extensive damage: high mortalities among many shallow water and shore-dwelling organisms, including a wide variety of vertebrates; also extensive damage to intertidal and sublittoral algae and mangrove habitat	Diaz-Piferrer, 1962
Jan. 1967	Chryssi P. Goulandris, Milford Haven England	Crude oil 1,800		Intertidal salt marsh; intertidal rocky shore	Grasses	Semiquantitative rocky shore transect; quantitative studies of grasses	Most damage to intertidal organisms; gastropod molluscs badly affected, also barnacles and sea anemones on a number of shores; no apparent damage to algae	Cowell, 1969; Nelson-Smith, 1968
March 1967	Torrey Canyon, S.W. England	860,000		Intertidal rocky shores and sand beach	Larger visible animals only	Semiquantitative rocky shore transects; qualitative beach and subtidal surveys; quantitative algal counts	Very high mortalities of intertidal shore life, mostly due to use of toxic emulsifiers; many invertebrates and algae killed on shores; fisheries and plankton apparently unaffected; estimated 10,000 birds killed	Bellamy et al., 1967; Smith, 1968
Sept. 1967	R.C. Stoner, Wake Island	Aviation gas, J-P4 jet fuel, A-1 turbine oil, and Bunker C oil 126,000		Intertidal & subtidal	Large visible invertebrates	Qualitative	Many dead fish stranded on shores; also abundant dead molluscs, sea-urchins, and crabs	Gooding, 1968
March 1968	Ocean Eagle, San Juan Harbor, Puerto Rico	Crude oil 83,000		Intertidal rocky shore	15 large sp.	Qualitative	Many subtidal and intertidal organisms killed or damaged by oil or oil and emulsified, including molluscs, crustaceans, and algae, although subsequent recovery good; 10 species of fish found dead or in state of stress	Cerame-Vivas, 1968

TABLE A-10 (continued)

April 1968	Esso Essen, S. Africa	Crude oil 20,000-28,000		Intertidal & subtidal	No species identifications,observations on larger organisms	Qualitative	High mortalities of sandhoppers (amphipods) but otherwise little damage on shores;high bird mortalities	Stander and Ventner, 1968
Dec. 1968	Witwater, Galeta Island, Canal Zone	Diesel and Bunker C oil 20,000		Rocky intertidal coral reef,sandy intertidal mangroves	Uca,mangrove species, four coral species	One quantitative sand sample for meiofauna; otherwise qualitative	On rocky shores,extensive mortality of supralittoral vegetation and tide pool life;on sandy beaches,great population decreases among meiofauna,especially crustaceans;many young mangroves killed in swamp areas, also algae and many invertebrates; coral reefs apparently unharmed	Rutzler and Sterrer, 1970
Jan. 1969	Well A-21, Santa Barbara Channel	Crude oil 33,000	40	Intertidal & subtidal	Subtidally:selected polychaete families, ophiuroids,and molluscs not including smaller polychaetes and amphipods;intertidally:visible rocky shore species and 195 sp. retained by 1.5mm screens in sandy areas	Grab sample,qualitative at species level;quantitative for biomass line transects on rocky shores; 1/100 m^3 samples on beaches	High mortalities of intertidal organisms covered with oil;about 3,600 birds killed;no apparent effects on fish and plankton; no directly attributable damaging effects of oil on large marine mammals or on benthic fauna; area recovering will within a year	Cimberg et al 1973; Fauchald,1971; Foster et al, 1971a,b; Nicholson and Cimberg,1971; Straughan,1972
Sept. 1969	Florida, West Falmouth, Mass.	No. 2 fuel oil 4,500	3	Intertidal mud and sand flats; subtidal to 10 mm	All animals 0.247mm,excluding nematodes,copepods; ostracods and unicellular organisms, including smaller polychaetes and amphipods	Quantitative transects	Severe pollution of sublittoral zone, with 95% kill of all fauna,including many fish,worms,molluscs, crabs,lobsters,and other crustaceans and invertebrates;local shellfish industry severely affected;Wild Harbor still closed to shellfish fishing in May 1974	Blumer and Sass,1972; Blumer et al.,1970a,b
Feb. 1970	Arrow, Chedabucto Bay	Bunker C 108,000	12	Intertidal rocky shore; intertidal lagoon	Common visible species on rocky shore and species 74 mm in lagoon samples	Semiquantitative transects; 2 samples in lagoon	Localized damage to intertidal life, where most mortalities were crabs, limpets,and algae,probably killed by smothering;local fish catches normal;about 2,300 birds killed; 5 months after spill,subtidal flora and fauna healthy;fishing and lobstering normal	Thomas,1973; Navships, 1970
Jan. 1971	Arizona Standard and Oregan Standard, San Francisco Bay	Bunker C 20,000	60	Intertidal & subtidal rocky shore; intertidal sand beach	31 larger sp.	Quantitative transect counts	Some damage to shore life,mainly to acron barnacles,limpets,mussels,and striped shore crabs; 3,600 birds killed;area nearly normal within 1 year	Chan, 1973

TABLE A-10 (continued)

Feb. 1971	Wafra, Cape Aulhas, S.Africa	Crude oil 445,000	10 -	Intertidal rocky shores	Larger intertidal rocky shore species	Qualitative	Little damage to intertidal life; 1,135 black footed penguins found oiled	Day et al., 1971
April 1971	March Point Dock Facility, Anacortes, Washington	No. 2 fuel oil 5,000	20	Intertidal beaches, rocky shores, subtidal	Animals 4mm in subtidal samples, visible fauna identified to major taxa only	Quantitative grabs; quantitative intertidal transects	Some oil on shores, damaging shellfish, limpets, crabs, clams and oysters; about 1,000 birds involved	Watson et al., 1971; Woodin et al., 1973
Jan. 1972	General M.C. Meigs, Wreck Cove, Washington Coast	Navy special oil 3,000	300-500 yd	Intertidal rocky shores	37 sp. algae, sp. animals not including smaller polychaetes and amphipods	Quantitative transects	Urchins affected; plant community showed less of fronds and bleached thalli	Clark et al., 1973

Source: NAS, 1975.

Whereas the concentration of petroleum hydrocarbons dissolved in water is generally low (<10 ppb) it was found to be much higher in sediments, ranging from 1,500 to 5,700 ppm in polluted coastal sediments (natural indigenous hydrocarbons in sediments in nearby unpolluted areas ranged from 26 to 130 ppm). On the outer coastal shelf, concentration in sediments might be as high as 20 ppm, whereas in the deep ocean 1-4 ppm was the usual concentration.

In general, where damage was severe, the oil spill was massive relative to the size of the affected area, and the spill was confined naturally or artificially to a limited area of relatively shallow water (less that 6 m) for a period of several days. Deletrious effects may have been increased by storms or heavy surf water mixed with oil and sediments in the affected area. These effects were also generally localized, ranging from a few miles to tens of miles, depending on ecological and environmental circumstances; however, for a given quantity of oil, the more localized the distribution of the spill, the greater is the mortality.

Different oils were found to have different effects, with toxicity being most pronounced for refined distillates and physical smothering most severe with viscous crude oils or Bunker C crude oil. Refined No. 2 fuel oil was among the oils having the most toxic effect. Variations in physical environment in coastal areas were also considered in determining effects, i.e., a polluted area might experience sudden and unpredictable stresses from synergistic interactions between variable environmental factors and the oil.

The amount of oil and the type of organisms afflicted was also found to be important. For example, a single coating of fresh or weathered crude oil or its derivatives on certain bird species or on seed of plants caused death, whereas marsh plants were killed only after several coatings. In general, emergent plant life was less likely to be affected than marine biota, unless the spill occurred in tropical waters where mangroves were present. Very low concentrations of the soluble fractions of kerosene interfered with searching behavior of a marine snail. Crude oil on the shells of oysters had no effects. The photosynthesis of marine phytoplankton was reported to be reduced by 100 ppb of No. 2 fuel oil. Mortality of some organisms has been found in all major spills for which studies have been published, with the pelagic diving birds being the most obvious casualties. The extent of the mortality depended on local conditions and was greatest when the releases of oil were confined to inshore areas where natural marine resources were abundant. Intertidal organisms tended to be more resistant to stress than subtidal species. In one instance, where the herbivores were reduced, the intertidal plants on which they fed increased markedly. In laboratory studies where organisms were near their limits of tolerance to temperature or salinity, pollution products caused a much greater change in metabolic rates than when the physical conditions were nearer optimum.

The recovery of polluted areas varies greatly, depending on the flushing of the polluted areas, the type of the sediments on the substrata, and the degree of isolation of its ecosystems and the kinds of organisms that form them. The time period for recovery may vary from a few months to several years. In general, the initial stages of recovery are characterized by opportunistic species that are often very productive, with a much longer time required to restore the community to one that supports more long-lived species.

One characteristic of organisms composing an ecological community that may affect its stability and rate of recovery is, for example, a slow rate of reproduction or growth. Such a characteristic increases the vulnerability of a species or ecological community to damage from oil or any other pollution. Marine birds in the planning area may have similar responses.

Some aquatic species that live only in brackish regions of estuaries have planktonic larvae. If these drifted passively in the current, they would be washed out into the open sea and lost; instead, they dive deeper after drifting toward the mouth of the estuary and are carried by the deeper currents back up to where they were spawned in the brackish regions. Thus, if the estuary is an isolated one, almost all the recruitment of these organisms is from the offspring of the resident population. If this population were completely destroyed by pollution, recolonization by chance immigration from a distant estuary would probably take a very long time. The resident population of estuaries provides shelter and food for the young stages of many commercially important marine organisms (shrimp, fish, etc.).

There is very little data on the effect of oil on pelagic species. Without more research, it is clearly premature to conclude anything about the effects of oil on the open ocean.

The information base with regard to the effects of oil in the marine environment on human health is extremely limited. However, certain observations have been made:

1. Compounds with carcinogenic properties are among the hydrocarbon compounds released into the environment.
2. Direct uptake by marine organisms of these compounds can occur.
3. Hydrocarbons are stored in the lipids of marine organisms.
4. Organisms capable of storing hydrocarbon are common human dietary items.
5. Hydrocarbon uptake from marine organisms by man is possible.
6. The quantities accumulated from this source are probably low.
7. The significance of this uptake as related to carcinogenesis is unknown.

Based on this limited information, the National Academy of Sciences (1975) tentatively concluded that modest concern rather than alarm appears to be justified. Although it is known that petroleum contains small amounts of carcinogens and possibly small amounts of other harmful materials, the amounts of carcinogens known to be in petroleum that could be ingested by eating marine organisms is estimated (NAS, 1975) to be no greater than that acquired from eating any other foods.

7. Other Factors Influencing Oil and Gas Operations

This section will discuss the estimated range of facilities and employment anticipated to result from this proposal. The discussion will include those estimates based on the Geological Survey information relative to the estimated recoverable resources on the 225 tracts comprising approximately 518,400 hectares (1,280,966 acres) included in the notice for proposed OCS Sale No. 43 dated April 27, 1976 (Appendix B).

Section III.E. discusses some of the possible onshore impacts of these OCS-related facilities and activities as well as analyze induced activities and their effects on the human and natural environment. Because it is not possible to indicate with any certainty the future locations of facilities which may result from this proposal, a generic approach has been taken for purposes of this analysis.

In order to provide a framework for other subsections, this section will briefly discuss the nature of OCS-related facilities. Factors affecting the timing and distribution will be addressed. In addition, these factors will be applied to indicate general locations that may be affected by OCS development.

a. Resource estimates (oil and gas)

The Geological Survey has provided estimates of recoverable resources that may be found in the tracts offered for lease during proposed OCS Sale No. 43:

	Low	High	Mean
Oil (Billions of barrels)	0.282	1.009	0.65
Gas (Trillions of cubic feet)	1.890	6.810	4.30

The Geological Survey noted that these estimates included several assumptions and also noted that a zero lower limit for resource estimates did exist.

b. Range of facilities

Listed in Table D-1 (Section I) is the estimated range of major facilities anticipated to be required as a result of the proposed sale as provided by the Geological Survey (1976).

c. Refineries

Refineries have not been included as facilities necessitated or stimulated by this proposed sale.

The future demand for domestic refining capacity in the U.S. South Atlantic region cannot be determined with any certainty. There are indications of excess refining capacity nationwide. According to Business Week, January 12, 1976, the two-year decline in demand, coupled with market conditions and high prices, has left U.S. refiners considering how existing capacity should be utilized rather than planning for expansions. Existing capacity has been increasing at an average rate of seven percent in recent years, according to the article. However, most increases were achieved through expansions or improvements of existing facilities. For example, the Oil and Gas Journal, in its annual refining survey (April, 1974), indicated a 6.3% capacity gain in 1973. Practically every case, it reported, was due solely or in large part to debottlenecking.

Another factor to be taken into account when considering links between OCS production and refining is the source of crude oil for a domestic refinery. An article in the New Orleans Times-

Picayune, August 31, 1976, described the new Energy Company of Louisiana (ECOL), Ltd. refinery at Garyville, Louisiana, as a 200,000 barrel-a-day refinery built to produce fuel oil. The article described the refinery as the largest ever built in a single construction phase in the continental United States and is also the largest independent refinery in the U.S. The article appeared on the occasion of the first delivery of imported crude oil to the ECOL refinery.

Within the U.S. Mid-Atlantic region, Mobil cancelled its plans for a new refinery at Paulsboro, New Jersey. The major reasons cited were inflation and a decrease in demand (Oil and Gas Journal, January 11, 1974). Amerada Hess closed down its 65,000 barrel/day refinery at Port Reading, New Jersey, in November, 1974. The refinery could be brought back on stream within about a month if conditions warranted, according to the company (Oil and Gas Journal, October 28, 1974).

Refinery capacity in the U.S. Mid-Atlantic coastal area as of January, 1976, was 1,427,800 barrels per calendar day. Planned expansion to these refineries are expected to add another 110,000 barrels per day by the end of 1976. In addition, new proposed refineries in the Baltimore, Maryland, and Hampton Roads, Virginia, areas could add an additional 384,100 barrels per day capacity (Oil and Gas Journal, April 26, 1974).

Crude oil production as a result of this sale may amount to between 56,000 to 170,000 barrels per day, and this volume of production by itself does not appear to warrant the construction of a refinery.

Operating refining capacity is present in the northern half of the Atlantic seaboard, in the Gulf of Mexico area, and on the islands of the Caribbean Sea, according to Bureau of Mines publications and other data. A selected list of refineries is included in Table J-16.1 (Section II.J).

Although refineries have been proposed for construction in the southeastern United States, information available to the New Orleans OCS Office indicated that no concrete proposals are under consideration at the present time.

For the purpose of developing some concept of the total effect that might result from refinery processing as well as exploration and production activities, some hypothetical scenarios have been included with a refinery located in Chatham County, Georgia. The rationale for this choice was based on the possibility that future increased demand in the four-state area might initiate the construction of a refinery; the area selected was centrally located relative to the sale area, and contained a developed port.

Future developments such as more refined estimates of demand, the location of production (rather than proposed sale area), or the availability of an offshore crude oil facility would be factors that would possibly indicate a site in other areas.

One example that lends some credence to the proposition that crude oil produced in the area does not necessarily lead to the construction of a refinery is contained in the history of the crude oil production in south Florida. Oil produced from fields located in southwest Florida is transported by pipeline to a terminal on the eastern coast of Florida and is shipped to refineries located in other areas.

The principal effect of crude oil production from this proposed sale would probably be to displace a volume of imported crude oil processed in an existing domestic refinery.

d. Factors associated with OCS-related facilities and generalized potential locations

Table A-11 lists primary OCS-related facilities indicated previously plus additional, smaller facilities and approximate employment and investments associated with each.

The timing of investments in OCS-related facilities and resulting employment levels occurring as a result of the proposed sale, depend on the success of initial operations. Exploratory drilling is expected to commence within one year of the proposed sale date and could continue for 14 to 16 years. The peak exploratory activity would occur in the initial five years following the proposed sale. Existing port facilities are expected to be utilized in the early years as staging and supply bases to support these activities.

Information provided by the American Petroleum Institute (API) Production Subcommittee and the Offshore Operators Executive Subcommittee (1976) concerning estimated employment and facility needs for operations on the outer continental shelf indicate that support facilities require inland water dock facilities with access to the Atlantic Ocean, land zoned for industrial uses, facilities for helicopter transportation, access to road and rail transportation, and rental office

INDUSTRY INPUT TO BLM PROPOSED OCS LEASE SALE NO. 43

SOUTH ATLANTIC REGION

TABLE A-11

Support Facilities and Employee Types	Per Rig Operation	Per Platform Operation	Per Unit of Production	Total Number of Employees	Avg. Wages $/Month	Total Wages $/Month	Employees Hired Locally	Employees Maintaining Local Residence	Area Requirements In Acres	Capital Investment 1974 - $	Character of Space	Special Factors	Comments
Exploratory Rig	1 Rig												Exploratory rigs can be either the jack-up, semi-submersible, or floater type. Rig Crews - Pusher, Driller, Derrickman, Motorman, etc. type. Also includes catering. Service Support - Mud Man, Cementing, Logging, etc. type. Air - Pilots, Mechanics. Marine - Standby & Supply Boat Crews
Contract Rig Crew	"			72(7/7)	1,100	79,200	26	49					
Dockside Support	"			6(5/2)	800	4,800	6	6					
Service Support	"			11(7/7)	1,425	15,675	0	9					
Co. Supervision	"			4(7/7)	1,850	7,400	0	3					
Transportation													
Air	"			4(7/7)	1,500	6,000	2	4					
Marine	"			16(7/7)	750	12,000	8	16					
Development Rig	1 Rig												Development rigs are self-contained platform type. Rig Crews - Similar to exploratory, but less in number. Service Support - Similar to exploratory, but includes directional drilling and completion type people.
Contract Rig Crew	"			52(7/7)	1,100	57,200	26	52					
Dockside Support	"			2(5/2)	800	1,600	2	2					
Service Support	"			8(7/7)	1,550	12,400	0	8					
Co. Supervision	"			3(7/7)	1,850	5,550	0	3					
Platform Production Operations		1 Plat.											This operation assumes optimum platform utilization to develop large reserves centrally located. Refer to assumption sheet for production estimates per platform. Remedial Crew - Includes workover rig, wireline, and service technician type.
Co. Employees		"											
Pumper-Operator		"		4(7/7)	1,300	5,200	4	4					
Mechanic		"		2(7/7)	1,400	2,800	2						
Electrician		"		1(7/7)	1,400	1,400	1	1					
Technician		"		1(7/7)	1,300	1,300	1	1					
Roustabout		"		4(7/7)	1,200	4,800	4	4					
Supervisor		"		2(7/7)	1,800	3,600	0	2					
Contract Employees		"											
Welder & Helper		"		1(7/7)	1,000	1,000	1	1					
Paint Crew		"		1(7/7)	800	800	1	1					
Roustabout		"		2(7/7)	650	1,300	2	2					
Remedial Crew		"		2(7/7)	1,200	2,400	2	2					
Caterers		"		2(7/7)	650	1,300	2	2					
Onshore Operations Base			200,000 BOPD						50	2,800,000	Industrial Zoning	Inland water docksite location with Atlantic Ocean Access Atlantic Shoreline not necessary	This type installation is designed to service the offshore drilling and production. Co. Employees - Administrative type. Air - Pilots, Mechanics. 3 - Large helicopters 4 - Small helicopters Marine - Boat Crews 4 - Crew Boats 3 - Cargo 2 - Tugs Development of this region may require 3-5 of these type bases.
Co. Employees			"	8(5/2)	1,400	11,200	4	8					
Contract Employees													
Air			"	27(5/2)	1,525	41,175	20	27					
Marine			"	76(7/7)	800	60,800	62	76					
Service Support			"	25	800	20,000	25	25					
Onshore Office			200,000 BOPD						10,000 Sq. Ft.	Rental	Office Business Zoned	Metropolitan Area	Assumes office space available but may generate new office building construction. May require 3-5 of these type offices and possibly some smaller type in development of this region.
Co. Employees			"										
Supervision			"	8(5/2)	2,200	17,600	0	8					
Technical			"	18(5/2)	1,600	28,800	4	18					
Clerical			"	16(5/2)	900	14,400	12	16					

TABLE A-11 (continued)

Support Facilities and Employee Types	Per Rig Operation	Per Platform Operation	Per Unit of Production	Total Number of Employees	Avg. Wages $/Month	Total Wages $/Month	Employees Hired Locally	Employees Maintaining Local Residence	Area Requirements In Acres	Onshore Capital Investment 1974 - $	Character of Space	Special Factors	Comments
Gas Processing Plant			300,000 MCFD						75	24,000,000	Rural Area Desirable	Highway & Rail Access	Development of this region may require 3-6 of these plants.
Co. Employees			"										
Supervision			"	2(5/2)	1,650	3,300	0	2					
Technician			"	5(5/2)	1,200	6,000	2	5					
Operators			"	8(5/2)	1,200	9,600	5	8					
Maintenance Employees			"	5(5/2)	1,050	5,250	5	5					
Contract Employees			"										
Service			"	1(5/2)	600	600	1	1					
			1,000,000 MCFD	34 Total						$75,000,000			
Pipeline Shore Terminal			200,000 BOPD						40	2,400,000	Rural Area Desirable	Highway Access	This type installation would be constructed if production of oil is transported to refineries thru onshore pipelines. Development of this region may require 3-5 of these type terminals.
Co. Employees			"										
Supervision			"	1(5/2)	1,800	1,800	0	1					
Gauger			"	4(7/7)	1,250	5,000	2	4					
Roustabout			"	6(7/7)	1,050	6,300	6	6					
Technician			"	2(7/7)	1,250	2,500	1	2					
Dispatcher-Clerk			"	4(7/7)	1,150	4,600	4	4					
Pipeline Tanker and Barge Terminal			500,000 BOPD						60	9,800,000	Rural Area Stable Soil Foundation	Water-front, 35' Water Depth Req'd. 2 Berths	This type installation would only be necessary if the decision was made not to use pipelines for oil transportation to refineries. Development of this region should require only one such terminal if found necessary to build.
Co. Employees			"										
Manager			"	1(5/2)	2,500	2,500	0	1					
Supervision			"	4(7/7)	1,800	7,200	0	4					
Gauger			"	8(7/7)	1,250	10,000	6	8					
Roustabouts			"	6(7/7)	1,050	6,300	6	6					
Dispatcher-Clerk			"	4(7/7)	1,150	4,600	4	4					
Technician			"	2(7/7)	1,250	2,500	1	2					
Service Support	10-20 Rigs												
Mud Supplier	"								4	900,000	Industrial Zoning	Inland Water Dockside with access to Atlantic	A minimum of 10 rigs will be necessary to justify establishing this type facility. 10-20 rigs will attract 2-3 suppliers. Full development may attract as many as 5.
Office Employees	"			7(5/2)	1,350	9,450	2	7					
Marine Employees	"			16(7/7)	1,250	20,000	8	16					
Wireline Company Base Employees	10-20 Rigs "			15(5/2)	1,100	16,500	7	15	6	1,200,000	Industrial Zoning	Highway access	Same as above.
Gas Lift Company Employees	10-20 Rigs "			5(5/2)	1,200	6,000	3	5	5	50,000	Industrial Zoning	Highway access	Same as above.
Logging and Perforating Co. Base Employees	10-20 Rigs "			10(5/2)	1,200	12,000	5	10	4	300,000	Industrial Zoning	Highway access	Same as above.
Welding Shop	10-20 Rigs								2	75,000	Industrial Zoning	Highway access	Development of this region may attract as many as 10 of these shops.
Welders & Helpers	"			20(5/2)	1,000	20,000	20	20					
Clerical	"			3(5/2)	600	1,800	3	3					
Rental Tool Co. Employees	10-20 Rigs "			10(5/2)	1,450	14,500	5	10	3.5	400,000	Industrial Zoning	Highway access	Same as above.
Fishing Tool Co. Employees	10-20 Rigs "			9(5/2)	1,400	12,600	4	9	1	200,000	Industrial Zoning	Highway access	Same as above.
Wellhead Equipment Co. Employees	10-20 Rigs "			12(5/2)	1,400	16,800	4	12	1.5	200,000	Industrial Zoning	Highway access	Development of this region may attract 3-5 companies.
Machine Shop Employees	10-20 Rigs "			9(5/2)	1,350	12,150	9	9	1	275,000	Industrial Zoning	Highway access	Development of this region may attract 5 of these shops and utilization of 5 existing shops.
Trucking Firm Employees	10-20 Rigs "			15(5/2)	900	13,500	15	15	5	255,000	Industrial Zoning	Highway access	It is estimated that 2 of these firms will be needed to supplement existing firms.
Cementing Co. Employees	10-20 Rigs "			12(5/2)	1,100	13,200	5	12	5	950,000	Industrial Zoning	Inland water docksite with access to Atlantic. Highway & rail access.	Same as stated for Mud Suppliers.

TABLE A-11 (continued)

Support Facilities and Employee Types	Per Rig Operation	Per Platform Operation	Per Unit of Production	Total Number of Employees	Avg. Wages $/Month	Total Wages $/Month	Employees Hired Locally	Employees Maintaining Local Residence	Area Requirements In Acres	Onshore Capital Investment 1974 - $	Character of Space	Special Factors	Comments
Supply Store Employees	10-20 Rigs "			9(5/2)	1,000	9,000	5	9	2	110,000	Industrial zoning	Highway access	Same as stated for Mud Suppliers.
Downhole Equipment Co. Employees	10-20 Rigs "			11(5/2)	1,250	13,750	4	11	2	130,000	Industrial zoning	Highway access	Development of this region is expected to attract 6 of these companies.
Diving Service Employees	10-20 Rigs "			11(5/2)	1,900	20,900	9	11	.5	150,000	Industrial zoning	Highway access	Development of this region is not expected to attract more than one major company.

NOTE: All company types listed under Service Support require a minimum of 10 rigs operating in order to justify establishing the type of facility shown.

Source: Offshore Operators Committee, 1976 space. In addition to these requirements, living accommodations would be required for the employed personnel.

Several areas provide sites for facilities that meet these requirements. For the purpose of estimating the impacts that may result from this proposed sale, specific points had to be designated as the locations of onshore support bases. In some of the hypothetical cases, an onshore support base was assumed to be established in Chatham County, Georgia. In other cases, support bases were assumed to be located in Glynn County, Georgia; Charleston County, South Carolina; and Duval County, Florida. These locations were chosen to provide a range of areas and degrees of industrial activity and are not firm predictions that support facilities will most probably locate in these areas. Some additional factors that might be considered in the establishment of an operations base include the identity of the successful bidder for particular tracts, the contractor who would drill the exploratory wells, and the availability of suitable space and facilities for sale or rental.

Mr. R. J. Robicheaux of Otis Engineering Corporation provided testimony at a BLM hearing held in Mobile, Alabama on September 23-24, 1975, concerning the onshore impacts that resulted from the exploratory drilling in the eastern portion of the Gulf of Mexico that resulted from the MAFLA (Mississippi, Alabama, and Florida) OCS Sale of December, 1973. The operating points for the oil companies were Port Manatee, Panama City, and Pensacola, Florida, and Dauphin Island, Alabama. The largest amount of land area required was approximately 3.61 ha (9 ac) and the total used in the four areas was approximately 6 ha (15 ac). The total employment presented in this testimony amounted to 83 persons, 39 hired in the local community, and 44 transferred into the communities. An additional factor which should be considered in utilizing this information was the relatively short distance from these bases to existing supply depots established to support operations in the central Gulf of Mexico.

While specific site locational constraints of onshore operations bases, from which rigs and platforms are supplied and serviced, are known, it is not known what the specific transportation and other costs would be. Minimizing the cost of shipping goods and services to where they are needed will be a factor in locating the operations bases. Therefore, the distance between the bases and the operating area (proposed sale area) must be considered. Minimizing transportation costs of obtaining goods and services would also be a factor, so that access to larger metropolitan areas would be a consideration. While other costs (costs of labor, land acquisition, and possibly those stemming from conditions placed upon the project in meeting regulatory standards) could outweigh transportation costs, the latter are considered more important.

Table A-12 indicates industry estimates of expected types of service support facilities which could be required in addition to operations bases. The amount of activity necessary to establish each in the region is also indicated.

The remainder of the onshore facilities which could result from the proposal, gas processing plants and terminal and storage facilities, are constructed to service production operations and are geared to peak levels.

Terminal facilities would be located near the landfall of pipelines, and the oil pipelines could then be built to refineries for processing of the crude oil. Because it is expected that the oil will be processed in existing refineries, tanker transport from onshore terminals to the refining center should be considered as well as pipeline transportation from the onshore pipeline terminal to an existing refinery, or to a refinery that may be built prior to the availability of crude oil from the proposed sale area.

The location of gas processing plants will also be influenced by marine pipeline routes. Therefore, gas processing plants could be located near oil pipeline terminals, if gas pipelines share corridors with oil pipelines. The shortest marine routes for all pipelines with the least environmental impacts would be sought. However, constraints such as bottom conditions (offshore) and appropriate landfalls must also be taken into consideration (offshore pipelaying is discussed in Section III.A., and pipeline approval procedures are discussed in Section IV.D.1.).

Other factors that may be expected to have some influence on the location of gas processing plants would be the identity of the purchaser of the gas, any existing facilities that could transport the gas, and the availability of suitable rights-of-way for pipelines between the gas processing plant and interstate pipeline facilities.

Table A-12. Industry Estimates of Onshore Facility Requirements for OCS Oil and Gas Operators

Stimulus	Number Possibly Required for Full Development of Region	Company Type
Minimum of 10-20 rigs working to establish facility	5	Mud Suppliers Wireline Company Gas Line Company Logging and Perforation Company Cement Company Supply Store
10-20 rigs could attract 2 to 3 facilities		
Minimum of 10-20 rigs working to establish facility	Up to 10	Welding Shops Machine Shops Fishing Tool Company Rental Tool Company Wellhead Equipment Supplier
Minimum of 10-20 rigs working to establish facility	3-5	
Minimum of 10-20 rigs working to establish facility	5 in addition to existing facilities	Machine Shop
Minimum of 10-20 rigs working to establish facility	2 in addition to existing facilities	Trucking Firm
Minimum of 10-20 rigs working to establish facility	Not more than 1	Diving Service

Source: Offshore Operators Committee, 1976

For the purpose of estimating the socioeconomic impact that might result from this proposed sale, the location and capacity of two hypothetical gas processing plants were postulated. For some hypothetical cases, a processing plant employing 25 persons was assumed for Charleston County, S.C. In other hypothetical cases, an additional gas processing plant of larger capacity employing 30 persons was assumed to be built in Duval County, Fla., or Glynn County, Ga.

e. Platform fabrication

Platforms must be constructed for the development and production phase. The U.S. now has platform fabricating yards in Louisiana, Texas and California. Platforms have been constructed in these yards and transported to many other offshore areas including the North Sea. Platforms for the U.S. South Atlantic could be constructed in these existing yards. If additional capacity is needed or other market conditions warrant it, existing yards could be expanded or new yards might be built nearer to production areas. Since traditional shipyards are usually not suitable for platform fabrication, a new site would probably be needed for construction in the frontier area.

The President of J. Ray McDermott and Co., a major fabricating company in Louisiana, presented testimony at the Council on Environmental Quality hearings concerning platform construction for the Atlantic OCS. He indicated that in the early stages of development, platforms would probably be supplied from fabricating yards in the Gulf of Mexico area.

However, Brown & Root, another major platform fabricator, has taken a different approach. It has already purchased a 2,000-acre site for a fabrication facility in Cape Charles, Va., which is on the Delmarva Peninsula and near the major shipbuilding area around Norfolk. Since the site is in a county with no industrial zoning, the construction of the facility is contingent upon a favorable zoning ruling. To date, no final decision has been reached. If the facility is constructed, platforms could be constructed for the Atlantic OCS as well as other offshore areas, depending on where platforms are needed when the company is ready to seek contracts. Since other items can be produced from such a facility including light metal tanks, metal storage bins, LNG tanks, and structual modules, its economic viability would not necessarily be dependent upon platform fabrication.

The July, 1976, issue of Ocean Industry contained a summary of platforms under construction and the locations of the yards in which the construction was being carried out. Platforms for use in Trinidad were being constructed in Texas yards, and a platform for use in Nigeria was being constructed in a Louisiana yard in addition to platforms for use in the Gulf of Mexico.

f. Possible constraining factors

The investments and resulting facilities and employment anticipated to result from this proposed sale depend on availability of investment capital as well as labor and materials.

Funds for capital spending in the petroleum industry come largely from retained earnings, the remainder coming from borrowing and stock offerings. While declining profits and increased taxes caused predictions that exploration and drilling would be cut back in 1975, actual and planned cutbacks in these activities in 1975 were not as extensive as those in refining and marketing. The cutback in refining and marketing reflect regulations which lessen the profitability of these sectors, while strong demand and higher prices were among other factors attributed to the strong drilling and exploration in 1975. Capital can be allotted where the highest return is expected. Allocations can also be shifted between drilling and producing regions as well as between different sectors of the industry.

Recent supply difficulties in the oil industry stemming largely from steel shortages affected tubular goods used in the offshore industry. However, present indications are that this shortage has eased. While spot shortages may persist, they are not expected to pose a serious constraint for this proposed development.

With regard to drilling rigs, a surplus is developing according to an article in Business Week (9/1/75), which reports that there will be more rigs delivered this year than can be absorbed by industry. In two years, the 157 drilling rigs under construction will add to the existing fleet of 300. Lessening activity in the Gulf of Mexico and unfavorable results or conditions in foreign areas could also increase the availability of rigs for use in U.S. frontier areas. A drop in the operating cost of drilling rigs is accompanying the developing surplus.

Dixilyn International, Inc. indicates slightly different statistics (W. N. Plamondon, Jr., Written

Testimony, DES for Proposed OCS Lease Sale No. 40, USDI-BLM, 1976). As of January 1, 1976, world-wide, there were 256 active competitive exploratory mobile rigs. Sixty-six of these units are working in the Gulf of Mexico and two are working offshore California.

Worldwide today there are at least 30 units "stacked" and not working. There are three units stacked in the Gulf of Mexico and at least three additional units which will be available in a short time.

In addition, there are 107 units currently under construction in the world. Sixty-eight of these units do not have contracts. Twenty-nine mobile units are under construction in U.S. shipyards and two units in Canada. A number of these units do not have contracts for employment.

There continues to be a shortage of petroleum engineers and highly skilled rig and platform workers. Petroleum engineers are being supplemented by other types of engineers who are provided training in the petroleum field. Likewise, skilled workers are being developed through on-the-job training. Many skills found in other industries are easily adaptable to the offshore petroleum industry; e.g., welders and mechanics. While skilled specialized labor could present a problem, the nature of the labor force in some portions of the coastal region, unemployment levels, and training programs should be able to alleviate the problem to the degree that it will not pose a major constraint to development in the region as a result of this proposed sale.

8. Cumulative Aspects of the Proposal

a. Additional OCS Oil and Gas Lease Sales

The U.S. Geological Survey, in Open File Report 75-411, provided an estimate of the undiscovered resources of oil and gas that may be present beneath the Atlantic Outer Continental Shelf adjacent to the states of North and South Carolina, Georgia, and Florida. The report cautioned that "These undiscovered recoverable petroleum resources are those quantities of oil and gas that may be reasonably expected to exist in favorable settings, but which have not yet been identified by drilling. Such estimates therefore carry a high degree of uncertainty." (USGS, 1975).

The procedure employed by the Geological Survey in conducting their appraisal was also described in the report. The procedure consisted of a) carefully reviewing the available geological and geophysical data gathered by area specialists, b) individual and collective appraisals of the areas using volumetric-yield procedures, basin analysis, Hendricks potential area categories, and other published techniques, and c) computer fitting of the Resource Appraisal Group's subjectively assigned statistical probabilities for the high, low and modal resource values to a lognormal probability distribution curve for each geologic province.

To provide a range for potential development events, the report also provided estimates of the number of wells, platforms, miles of pipeline, and onshore terminals at two levels of undiscovered resources. These two levels were the statistical mean and the 5% probability values (the higher the resource estimate, the lower the probability of discovering that level).

The area of the Shelf is less than 200 m of water has been generally described as the Southeast Georgia Embayment. In this province the Geological Survey publication estimated that undiscovered recoverable petroleum resources at 5% probability level (1 in 20 chance) would amount to 1.5 billion barrels of oil and 2.8 trillion cubic feet of gas.

Under the higher of these resource volumes, estimates indicate that 20-25 platforms, 440 producing wells, 800 km of pipeline, and 4 onshore terminals may be needed for development and production. The time frames for production, using the highest estimates, were forecast to include 6-7 years after the sale before production commenced, 4-5 years following that to complete significant development, and 12-16 years after the sale until peak production was achieved.

In water depths between 200 m and 2500 m, in the area designated as the Blake Plateau Province, an additional 2.5 billion barrels of oil and 0.4 trillion cubic feet of gas resources (at the 5% probability level) could be present. A possible offering of leases in this area is presently scheduled for the year 1978.

At the present time, no oil or gas has been discovered in the Atlantic offshore areas adjacent to the Southeastern U.S., and, therefore an assumption that oil or gas exists in commercial quantities cannot be made with certainty. The Geological Survey estimated the probability of finding oil and/or gas in commercial quantities was approximately 40% for the South Atlantic and 30% for the Blake Plateau Provinces (corresponding to a 60% and 70% probability of finding no oil or gas in commercial quantities).

It is probable that more than one sale, or offering of acreage, on the OCS, will take place in the area adjacent to the southeastern U.S., and that any commercial discoveries of oil and/or gas on the acreage leased will lead to additional development activities related to drilling, platform and pipeline construction, and logistics support. Similarly, additional or expanded onshore facilities may result from activities undertaken in the course of the proposed and subsequent sales.

Since proposed Sale No. 43, covering leases in only a portion of the Southeast Georgia Embayment, is the first offering of acreage in this frontier area, the results of this proposed sale will undoubtedly have some influence on subsequent leasing, exploration and production activity on the OCS in this general area. The onshore socioeconomic effects of the exploration and production activity of multiple sales, could, of course, be of longer duration than the effects resulting from a single sale. In the event that the exploratory drilling resulting from proposed Sale No. 43 was successful, interest in the general area would be enhanced, and additional drilling would be expected to occur in areas leased subsequent to the leases awarded as a result of proposed Sale No. 43.

If the exploratory drilling resulting from proposed Sale No. 43 is unsuccessful, a lower level of leasing and exploration activity in the adjacent areas would be the most likely result, with the proviso that uniformly discouraging results from the exploratory activity resulting from the initial sale would not necessarily result in the discontinuance of exploratory activity on the entire U.S. South Atlantic Outer Continental Shelf.

In this context, the effects of proposed Sale No. 43 may contain implications of cumulative impacts beyond those associated only with this proposed sale. Generally, discovery of oil and gas in a frontier area can be expected to lead to higher levels of exploratory activity, and if further success accompanies these incremental exploration activities, additional production and construction activities would probably ensue.

The impact of multiple sales could take several forms. One possibility would be the continuation of a given level of activity for a longer period of time, or, in the event that development activities related to more than one sale took place concurrently, the effect would be an impact greater than that due to a single sale. Probably, the results of multiple sales would be a combination of these effects.

In addition to possible lease sales subsequent to proposed Sale No. 43, offerings of OCS acreage are being considered for several adjacent areas. Additional lease offerings are proposed for the Mid-Atlantic (Sale No. 49), and for the North Atlantic (Sale No. 42), and subsequent sales have been included in the Proposed OCS Planning Schedule (USDI, 1976).

Incremental additions to transportation and processing facilities, as well as the relocation of firms supplying equipment required for OCS operations may result from the expansion of oil and gas development to the coastal areas of the Atlantic coastal states.

The estimates provided in Appendix B refer to estimates prepared by the Geological Survey specifically for this proposed sale, and therefore, the frame of reference and the analysis procedure for these estimates is different from the above province-wide estimates.

b. Mid Atlantic OCS Development

The cumulative impact of tentative OCS Lease sales in other regions has been addressed in the Final OCS Programmatic EIS, released by the Bureau of Land Management in July 1975. It is possible that, if the Secretary of the Interior decides to hold this proposed South Atlantic lease sale, cumulative impacts may result from the operations generated by that proposed sale and Sale No. 40 in the Mid-Atlantic.

The Mid-Atlantic Sale No. 40 resulted in the leasing on August 17, 1976, of 93 tracts (214,272 hectares or 529,566 acres) in waters 40 to 185 meters deep. The tracts are located offshore of New Jersey and Delaware with distance to shore ranging from 79 to 147 kilometers (49 to 91 miles). Estimated recoverable resources as a result of proposed Sale No. 40 are 0.4 to 1.4 billion barrels of oil and 2.6 to 9.4 trillion cubic feet of gas. Table A-13 indicates estimated cumulative requirements and effects as a result of both sales.

It is possible that the combination of OCS-produced oil from both the South Atlantic and Mid-Atlantic could contribute to the expansion of existing refining capacity in the Mid-Atlantic. (A decision to expand existing refining capacity in

TABLE A-13

Cumulative Effects

	Sale No. 40		Proposed Sale No. 43		Both Sales	
	Low	High	Low	High	Low	High
Recoverable Resources						
Oil (billions of barrels)	0.40	1.40	0.28	1.01	0.68	2.41
Gas (trillion cubic feet)	2.60	9.40	1.89	6.81	4.49	16.21
Wells						
Exploratory	60	240	95	220	155	460
Development	200	800	160	500	360	1300
Platforms	10	50	10	25	20	75
Pipelines						
Offshore kilometers (miles)	161 (100)	725 (450)	257 (160)	515 (320)	418 (260)	1240 (770)
Onshore kilometers (miles)	56 (35)	193 (120)			56 (35)	193 (120)
Pipeline Terminals and Storage Facilities	1	4	1	2	2	6
Onshore Operating Bases	1	4	1	3	2	7
Gas Processing Plants (300-500 mmcf/d capacity)	3	8	1	2	4	10
Land use						
For pipeline terminals, operating bases, support companies, piepcoating and gas processing plants. In hectares (acres)	65 (160)	261 (645)	44 (109)	108 (267)	109 (269)	369 (912)
For pipelines. In hectares (acres)	170 (420)	583 (1440)	390 (964)	768 (1898)	560 (1384)	1351 (3338)
For possible platform fabrication (in addition to planned 980 acre facility in Cape Charles, Virginia) In hectares (acres)						440 (1100)

the Mid-Atlantic areas would also be based, in part, on demand for refined products). Analysis indicates that a refinery expansion of 200,000 barrels/day could contribute an additional 3300 jobs to the Mid-Atlantic, as well as other incremental economic benefits (Section III.E.3.). Increases in economic activity in the Mid-Atlantic could probably be met with increased productivity and the fuller utilization of existing factors of production.

An increased refinery expansion to which the two sales may contribute could require new land dedicated to refineries. Approximately 400 hectares (1000 acres) are required for 200,000 barrels/day of capacity for a grassroots refinery. However, refinery expansion may also be accomplished on existing refinery sites. An expansion in the Mid-Atlantic of 200,000 barrels/day, about 15%, would add to the existing levels of sulfur oxides (22%), nitrogen oxides (7%), and hydrocarbons (30%), generated during periods of peak production. (SDI-BLM, 1976). These figures would also include the increased air pollution from the commercial and industrial changes that would result from the expansion. Increases of SO_x and NO_x would be serious enough to cause air pollution standards to be exceeded, since these areas often have difficulties meeting the standards at present.

Economic analyses indicate that neither Sale No. 40 or proposed Sale No. 43 would necessarily provide enough incentive to stimulate OCS-related activities which are not essential to a producing area, such as rig construction (support bases, transportation facilities, and in most cases, gas processing plants are facilities which are necessary in a producing area). Just as additional sales in any one region may serve to provide this impetus, so could sales in adjacent regions when proximity to one production area is not required. Platform fabrication is another example. While platform fabrication is related to overall demand at more than one location, a platform fabrication facility could be located in the Mid- or South Atlantic regions. This could occur should transportation costs outweigh the investment cost of a new facility when regional demand is taken into consideration. Other factors include an individual company's market position, and the possible competitive advantage of a Mid-Atlantic site (or a possible additional Mid-Atlantic site, should the 980 acre planned Brown and Root facility be built in Virginia). However, should concrete platforms be utilized for either the Mid-Atlantic or South Atlantic, it is probable that they would be located in the Mid-Atlantic region to provide platforms for both areas.

Areas situated shoreward between the two proposed sale areas could experience increased land use and socio-economic impacts as a result of both sales.

The COST well recently drilled in Georges Bank was serviced out of Davisville, Rhode Island. In addition, Davisville has been chosen as a site for Clean Atlantic Associates oil spill contaminated and cleanup cooperative operations, recently contracted to Haliburnton Services. At present, the site is to service Mid-Atlantic OCS operations. Presumably, a similar location in the South Atlantic area would be selected to service in the initial exploratory drilling resulting from proposed Sale 43.

Should facilities not required spacifically for either sale individually be developed as a consequence (or partial consequence) of both sales, land use dedicated to OCS-related facilities in one or both of the sale regions would increase substantially. The size of a platform fabrication yard, for construction of conventional steel platforms, would require a minimum of 40 to 120 hectares (100 to 300 acres) and could require as much as 400 hectares (1000 acres). A concrete platform construction facility would utilize up to 40 hectares (100 acres).

Facilities proposed to be located in southeastern New England, or elsewhere in the Mid-Atlantic, as a result of both Sale 40 and proposed Sale 43, whether directly required for servicing offshore operations, or stimulated (at least in part) by OCS activities, such as platform fabrication and refinery, will be subject to State and local land use and environmental controls. Land use analysis indicates that sufficient suitable land for industrial development exists in the South Atlantic.

Should any of these facilities be developed, additional environmental effects could be felt. Dredging might be required for platform fabrication facilities. Since all of the above facilities require large sites, construction associated impacts, surface runoff and possible habitat destruction would also result. The extent of these impacts would depend on the location, size and design of such facilities, and have not been quantified at the present time.

Civilian employment in the Mid-Atlantic region as a result of Sale No. 40 is expected to peak at 12,500 in the mid-1980's. Employment in the South Atlantic is estimated to be the greatest around 1988, with up to 7818 persons employed as a result of proposed Sale No. 43. The greatest aggregate employment for the Mid and South Atlantic regions is estimated at approximately 20,000. A noticeable impact anticipated from the two sales is intraregional movement of persons seeking employment.

It is anticipated that much of the onshore activity resulting from proposed Sale No. 43 will take place in the southeastern coastal states. OCS related development could employ some of the currently unemployed in that area. However, unemployment rates, on a county level, are not estimated to be reduced by more than one percent as a result of the proposed sale.

The above employment figures do not consider platform fabrication. Should such a facility locate in the Mid-Atlantic as a result of one or both of the sales (Sale No. 40 and proposed Sale No. 43), significant employment would result (in the order of 1000 primary jobs) and would impact the labor force substantially on a local basis.

Depending upon the size and skills of the existing labor force, and existing jobs, unemployment could be decreased much greater than one percent on a localized basis. It is also possible that persons could be drawn from other jobs.

The peak population increase estimated for the Mid-Atlantic as a result of Sale 40 is about 25,000 persons (previous to peak production). The peak population increase estimated for the South Atlantic as a result of proposed Sale No. 43 is also about 22,000 (occurring at peak production period). The combined effect of both sales is estimated to increase the peak population for the Atlantic coastal region (Mid and South) by about 47,000, occurring around 1988-1990. Should South Atlantic OCS-produced oil be shipped to the Mid-Atlantic, and stimulate refinery expansion it is estimated that a miximum population increase of 6,800 would result in the Mid-Atlantic region.

These population increases could be expected, in the Mid-Atlantic and South Atlantic, to concentrate in existing areas of industrial development and urbanization, where infrastructure such as road and sewer networks are well developed and the increased population would not add significantly to existing demand. An exception may be housing, as vacancy rates in these areas are generally low. In the South Atlantic, a majority of the population increase would be expected to be focused in the southeastern coastal states which have a wide variety of existing infrastructure systems. If development were to concentrate in localities which have experienced declining growth rates and whose road networks, sewer systems, schools, etc., are not currently strained, less impact would be expected than would be in undeveloped areas. Likewise, the metropolitan areas, due to their extensive infrastructure system, would probably not feel a significantly greater demand on services. However, especially if concentrated, this population increase could result in the need for increased governmental expenditures for a combination of physical investment in infrastructure (e.g., roads and sewers) and provision of services (e.g., police protection and increased governmental overhead).

Increases in air and water pollution as a result of population increases would not be expected to be great. However, increased demand for water, if occurring in northern New Jersey as a result of refinery expansion-induced population, would further extend the current shortage of water existing in that area. A population increase of 6800 would increase water demand by 6,800,000 gallons/day.

Whether or not refinery expansion occurs in the Mid-Atlantic, that area should not be subject to greatly increased petroleum-related shipping. (A) Should South Atlantic OCS-produced oil be tankered to existing refineries in the Delaware River Basin, this tankering, along with the chances of Baltimore Canyon platform and pipeline spills reaching the New Jersey coastline, would subject that coastline to increased chances of pollution. (B) Tanker movements from the Southeast Georgia Embayment, in combination with the small chances of Baltimore Canyon platform spills reaching Long Island, could subject Long Island and the Raritan Bay area to increased chances of oil spills. However, over 150 million short tons (1973) of petroleum and petroleum products are currently entering New York harbor. (C) However, as tanker traffic resulting from proposed Sale No. 43 is not expected to exceed one tanker per day, the increases in vulnerability to oil spills as a result of the Southeast Georgia Embayment production should not be greater.

Impacts to biological communities resulting from oil spills, chronic low level oil pollution, and other substances introduced into the environment as a result of the two sales will, for the most part, be additive. Planktonic and benthic species, common to both areas, are probably individual members of different populations. Therefore, effects from oil spills and/or other activities resulting from the proposed Sale No. 43 and Sale No. 40, including mortality, would be localized within the region of the breeding populations.

The impacts to fish populations posed by offshore spills would not be greatly magnified by sales occurring in the two areas. Spills occurring simultaneously in the two areas would not be expected to act in concert, since offshore oil spills are localized events and the probability of exposing the same population to oil spills located over 160 kilometers (100 miles) or more apart, in successive fashion, would be remote.

Cetacean species migrate through both the Mid- and South Atlantic areas. To the extent that they would be subjected to possible effects of oil and other pollution as a result of both sales, greater impacts to marine mammals could result than would occur should only one of the sales be held. However, as knowledge of marine mammal populations is incomplete, it is difficult to predict any population impacts.

Impacts to wildlife resources, such as individual mortalities and habitat destruction, as a result of the proposed South Atlantic Sale and Sale No. 40 in the Mid-Atlantic could be additive in nature, for instance, waterfowl habitat. It is possible that the habitat utilized by the same populations of migrating waterfowl could be affected by spills in both regions. As all wetland habitat on the Atlantic is of importance for migrating waterfowl, oil spills or other impacts to wetlands could affect water, adding more stress to populations.

For example, in the South Atlantic region, the probability of an oil spill contacting a wildlife refuge ranges from 1 to 5%, of contacting marsh and wetlands from 3 to 8%, and of contacting a migration route along the coastline from 57 to 88%. A large oil spill may contact 5% of the beach area in the South Atlantic coastal areas.

An impact on migrating waterfowl could effect this population in both the South, and Mid-Atlantic areas.

While for the most, impacts to biological organisms discussed above would be additive in nature, impacts to those resources along the New Jersey coastline, and Delaware Bay and the southeastern coastal region could be subjected to oil spill related impacts to a greater degree as a result of the two sales. However, tanker traffic resulting from proposed Sale No. 43 (and probably going to the Mid-Atlantic or Gulf of Mexico) is not expected to exceed one vessel per day. This compares, for example, with approximately 12,500 inbound petroleum movements (vessel and barge trips) into New Jersey and New York in 1972. (TRIGOM, 1975.) Effects of oil spills on these resources are also discussed in the Final Environmental Statement for the Proposed OCS Lease Sale No. 40.

c. DREDGING AND OCEAN DUMPING

(1) Dredging

If onshore facilities requiring coastal locations and access to vessels were to be located in areas which cannot presently accommodate required drafts (15 feet), channel dredging would be required. Resuspension of bottom sediments, turbidity and destruction of habitat of marine organisms would occur. Dredging would require a permit from the U.S. Army Corps of Engineers and State authorities. The sites that would most likely be used for servicing the South Atlantic, Charleston, S.C., Savannah, Ga., and Jacksonville, Fla. can already accommodate vessels of the required size, and therefore, no cumulative impacts are expected.

If oil or gas pipelines are required for a South Atlantic find, some dredging would be required in the nearshore areas at which the pipelines come ashore. This would result in disturbance and/or mortalities to the local organisms.

(2) Ocean dumping

The ocean dumping sites that are designated along the South Atlantic coast as mostly used by hopper dredges and for munitions dumping. The materials that are dumped in these areas are sand, shells, and mud. These areas that have been designated by EPA all are close to shore and none are in the immediate vicinity of the proposed lease sale. Since these areas are removed from the proposed action there will not be any cumulative impact.

Drilling mud and drill cuttings will be dumped during the exploration and production of the wells. During approximately 20 days of drilling to 10,000 feet approximately 2,000 barrels of bentonite clay and lignosulfonate treated mud would be discharged overboard. During the additional 70 days operations while drilling from 10,000 to 18,000 feet, the discharge rate will not exceed 50 barrels a day, approximately 4,000 barrels of lignosulfonate. When the well is completed, the mud remaining in the surface system is discharged overboard; and this can amount to as much as 800 barrels. The environmental effects of accumulations of drilling muds is not known, toxicity tests are known being performed on various types of drilling muds.

d. DEEPWATER PORTS

Deepwater ports proposals have been put forth for the offshore area of North Carolina, South Carolina and Georgia in "The Coastal Plains Deepwater Terminal Study" (R. R. Nathan Assoc., 1975) however, the Department of Transportation, the responsible Federal agency, has not received any permit applications for Atlantic Coast deepwater terminals to date.

The extent to which effects of a deepwater port operating concurrently with OCS oil and gas leasing activities in the U.S. South Atlantic region would be cumulative in nature would depend in part on whether such a port is built to accommodate existing crude imports or increased refinery capacity. (To a large extent, the provision of expanded refining capacity and associated deepwater ports will be a function of demand, market location and transportation economics). If deepwater ports on the Atlantic Coast result in a higher volume of crude transported and a higher volume of associated spills, then cumulative oil-related impacts to marine and coastal organisms could be expected. If deepwater ports are associated with new refinery capacity, cumulative economic and socio-economic impacts could accrue to the southeastern U.S. region. The extent and nature of these impacts would depend on the location of the port(s), and new refineries and OCS related facilities.

More information regarding the impacts of deepwater ports may be found in the Department of the Interior's Environmental Impact Statement on Deepwater Ports issued June 1973.

B. Offshore Impacts of Oil and Gas Operations on the Natural Environment

1. Impact on Phytoplankton

Species composition and a description of the habitat are discussed in Section II.E.1.a. Essentially, all the tracts of this proposed lease lie between the 20 m and the 200 m isobaths, and west of the Gulf Stream. Because of currents, winds, and other local influences, including Gulf Stream eddies, which are poorly understood, the distribution of individual species of phytoplankters is patchy and highly variable, and continually changing. As indicated in Section II.E.1.a. above, certain generalizations with regard to seasonality and distance from near shore to off shore; productivity is a maximum in the summer and a minimum in winter; no differences in north-south distribution can be detected; and all of the species may be found throughout the lease area at various times, but with no discernable distributional pattern. Because of the great local variability in distribution, the following discussion of impact on the phytoplankton must be in very general terms.

Exploratory drilling will create turbidity plumes during the disposal of drill muds associated with the cuttings. If we assume that these operations create a plume 20 m wide and 800 m long (plumes of this approximate maximum size have been observed in the Gulf of Mexico) then the euphotic zone will be reduced under a maximum of 16 ha of sea surface for the duration of drilling (approximately 15 days); the disposal of muds is not continuous, and the plume mentioned above is the maximum expected. The residence time for any single phytoplankter within this reduced euphotic zone would depend on the vertical and horizontal transport to which it is subjected. The field development phase will have similar impacts, but with longer duration. Assuming that a maximum of 20 wells will be drilled from each platform approximately 400 drilling days would be necessary and the turbidity plume would be present this period. This would result in a cumulative duration of 10,000 days for 25 platforms throughout the proposed sale area. This turbidity will reduce the photosynthetic assimilation of the total marine system in the proposed sale area by an amount that is dependent on the season, the distance from shore, and the particular organisms present at the drilling site at that particular time. Because the area affected at any one time will be quite small in comparison to the entire South Atlantic OCS, it is estimated that photosynthetic activity due to this turbidity will be reduced by only some small fraction of 1%.

The production phase can impact phytoplankton species through the disposal of formation waters (relict sea water) which contain the soluble fractions of crude oil at an average concentration of 30 mg/l and trace amounts of certain heavy metals such as iron, calcium, magnesium, and sodium (see Table A-3, Section III.2.A). As mentioned above the resultant receiving water concentration of petroleum hydrocarbons is difficult to assess, but if we assume instantaneous mixing into one cubic meter of sea water, the concentration would be approximately 30 mg/l. If excessive concentrations (greater than 30 mg/l) are discharged, a local inhibitory effect can be expected (Mironov, 1970), but these anomalous iron ratios present in formation water should cause minimal disturbance to the phytoplankton due to dilution. In any event, disposal of formation water at concentrations higher than mentioned above is considered very unlikely.

The Gulf Universities Research Consortium (GURC) study (1974) reported on the ecological impact of oil drilling and production on phytoplankton standing crop, primary productivity, nutrients, etc., in the Gulf of Mexico; the same general conclusions can probably be made about these impacts on the proposed lease areas in the South Atlantic:

> Chlorophyll *a* values were consistently higher at all depths sampled (except at the surface) at the Production Platform as compared to the Control Site. At both sampling sites, a marked increase in chlorophyll *a* in the samples collected near the bottom was noted and was indicative of large cell populations of the water column.

Primary Productivity

> Primary Productivity data at both the Platform and Control Sites showed remarkably similar results. Average daily primary production at the Platform is 1.06 g C/M^2 compared to 1.03 g C/M^2 at the Control Site.

Phaeo-Pigments (degradation production of chlorophyll a)

> The distribution of the phaeo-pigments in the OEI (Offshore Ecology Investigations) area

showed a trend similar to that of chlorophyll *a*. Very high values of phaeo-pigment were found at the bottom of the Control Site indicating large cell populations at some prior time.

Photosynthetic Index (P.I.)

The photosynthetic index (or assimilation number) is usually considered as a "measure of the vitality of the phytoplankton organisms". During this study, the P.I. at the Control Site was found to be higher than at the Platform (38.95 and 28.57 mg C/mg Chl*a*, respectively). The values of the P.I. at both sampling sites reflected healthy growth of phytoplankton.

Cell Counts

The total cell counts/liter were found to be much higher at the Platform than at the Control Site.

Number of Species of Phytoplankton

The number of species of diatoms and dinoflagellates were found not to vary appreciably between the Platform and Control Sites.

Seasonal Variations

Seasonal variations in primary production, standing crop of phytoplankton, nutrient salts concentrations, cell counts, and number of species of diatoms and dinoflagellates were observed at both the Platform and the Control Site. As expected from seasonal impact, biological productivity is at its lowest ebb during the November-January period. Maximum phytoplankton density (climaxing in a bloom state) was reached during April, 1973 (flood stage).

Comparison of the Offshore Ecology Investigations (OEI) Data With That of the Overall Gulf of Mexico

When we compare the primary productivity, standing crop and nutrient data collected in the OEI region, with data collected in the Gulf of Mexico during the past nine years, we found that OEI data to be much higher than those collected from both the open Gulf of Mexico and on the continental shelf off Panama City, Florida.

Thus, the production phase is expected to have no significant adverse impact on offshore phytoplankton.

The transportation phase will affect the phytoplankton due to the pulse of turbid euphotic water created by the jetting of pipelines. This pulse will temporarily stress phytoplankton in the immediate vicinity of the operations. If bottom areas high in heavy metals, pesticides, or other pollutants are traversed, the effects will be more severe and possibly of longer duration. In any event, phytoplankton primary productivity will be temporarily altered in a zone of impact probably not exceeding 50 meters wide throughout the length of the pipeline route given water depths which allow the disturbance to reach the euphotic zone.

An oil spill will probably have a severe effect on the phytoplankton floating in the oil or at the oil-water interface. This effect will be relatively short-lived as the oil passes through any given area, and even if only a few cells survive the area will rapidly become repopulated—once the oil passes. The impact from such a spill will be greater in the summer than in the winter, and also greater in near shore areas than in offshore areas. Since there is apparently no north-south differences in distribution and since the oil spill risk analysis of Section III.A.5.b. indicates that most of the oil from a spill within the proposed lease areas will be transported north and south, the impact will be to all species rather than to any one phytoplankter.

In summary, it is believed that the offshore oil and gas operations envisioned by the proposed action will not significantly affect phytoplankton populations, and any reduction that does occur will be over a short time frame and will be temporary. For a more specific discussion of the impact of oil spills on littoral systems, see Section III.F.

2. Impact on Zooplankton

Species composition and a description of the habitat are discussed in Section II.E.1.b. As discussed in that section, zooplankton, like the phytoplankton, show no north-south trends with regard to distribution and show greater numbers in the summer and greater numbers near shore. Local distributions are quite variable and patchy. Thus the following impact on zooplankton must be discussed in general terms.

The turbidity generated during the exploratory and field development phases of OCS oil and gas operations may have an adverse effect on individual zooplankton in the immediate vicinity of the drilling rig. Zingula (1975) has shown that suspended solids concentrations in surface water near drilling discharges are of the order of 300 mg/l and are rapidly diluted to approximately 6 mg/l within 201 m (660 ft) of the discharge. An additional impact may be the temporary resuspension of bottom sediments during platform placement. Given the minimal relative volume of water affected and the duration of the discharge, these potential discharges should not adversely affect the zooplankton component of the marine ecosystem.

The dissolved components of crude oil present in production phase discharges may have an adverse effect on zooplankton in the immediate vicinity of the production platform. If we assume a local concentration of 30 parts per billion (Section III.A.2.), direct lethality should not be a problem. However, Lee (1975) has shown that various zooplankton of the Pacific and the Arctic Oceans can assimilate hydrocarbons from a seawater solution at low concentrations forming the necessary first step in food web concentration. This phenomena is discussed in general in Appendix I. Furthermore, reduction of phytoplankton due to the spill may cause zooplankton mortality due to lack of food. Another potential adverse effect involves the interference by petroleum hydrocarbons with chemically controlled behavior in zooplankton. The magnitude and importance of this potential impact is at present insufficiently known to allow prediction, but experience in the heavily developed area of the Gulf of Mexico indicates no cause for concern (GURC, 1974). The oil spill analysis of Section III.A.5.b. indicates that most of the oil from a spill will be transported north and south; since there is no significant difference in zooplankton distribution from north to south, about all than can be said is that in general, like the phytoplankton, the impact from a spill will be greater in the summer and greater in nearshore areas. All the species found in the area will be affected, except for local, short term aggregations of a species that may sometimes occur.

The possible transportation phase of OCS development in the Southeast Georgia Embayment whether by pipeline or tanker should be little effect on the zooplankton component. Pipelaying will result in the temporary resuspension of bottom sediments and the resultant turbidity will have a local short term effect on the zooplankton.

In nearshore areas, the possibility of the liberation of absorbed toxicants should be taken into consideration in pipeline routing since sufficient concentrations of heavy metals or chlorinated hydrocarbons to stress zooplankton may be present. No such areas have been documented, but it is suspected that OCS areas under the influence of major industrialized rivers, such as the Savannah River, would have relatively high concentrations of such toxicants.

As is the case with phytoplankton, oil and gas operations will not cause any significant nor long term damage to zooplankton populations. A major oil spill will cause the greatest damage, the extent of which will depend upon the season and the location of the spill, coastal waters having a greater sanding crop but shelf waters having a greater diversity of species. For a more detailed discussion of the impact of oil spills on littoral systems, see Section III.F.

3. Impact on Benthos

Species composition and a description of the habitat are discussed in Section II.E.1.c. All the proposed lease areas are located in water depths between 20 m and 200 m and thus the benthic assemblages inspected would be those of the outer continental shelf zone and the upper continental slope zone as described by Day et al. (1971). Also within the proposed lease area are a number of live (hard) bank areas, which are discussed in some detail in Section III.B.1.g. Unfortunately, little is known about specific locations of any given assemblage; baseline biological studies to determine benthic distributions will be made under contract to BLM before any drilling activity takes place, and it is expected that a detailed bathymetric study of each lease block will be made by the leassee prior to any drilling activity in order to determine the possibility of any biologically sensitive areas so that proper protective measures, such as shunting of the drill muds and cuttings, may be taken. The discussion which follows, then, is by necessity general in nature.

The exploratory phase effluents that may be expected to have an effect upon benthic organisms include drill cuttings and drill muds. The sessile benthic organisms upon which the cuttings pile will accummulate will be buried by approximately 2,294 m^3 of cuttings generated by an exploratory well (Section III.A.1.b.). These cuttings usually form a low mound which is later worked into the surrounding sediments. The effect on benthic organisms is dependent upon the nature of the cuttings, nature of the local sediments, depth of disposal, benthic fauna capable of bioturbation and/or encrustation, and the physical factors (such as current) acting upon the cuttings pile. While the immediate effect of such burying is to eliminate those organisms which cannot get out of the way or cannot work their way to the surface of the pile, experience in the Gulf of Mexico has shown that the effects are temporary and that the pile is quickly recolonized.

The drilling fluids (muds), which are associated with the cuttings when they are disposed of overboard, are washed from the cuttings and eventually settle to the bottom after generally a wide dispersal through the water column. Jones and Williams (1973) found sediment barium concentrations to be above normal in areas of the Gulf of Mexico where intensive drilling has taken place. Barium sulfate is the major constituent of drilling fluids and the distribution of barium in the sediments suggest that the above-normal concentrations are due to the disposal of these fluids. Barium sulfate is a highly insoluble, nontoxic salt which is present in seawater at a concentration of approximately 0.05 mg/l and in certain localities concretions and nodules of barium sulphate are found in bottom deposits (Horne, 1969). However, certain chemicals, including bacteriocides, are added to the fluids under specific circumstances (see the Sheen Report, 1976, for a good discussion of the use of fluids and their effects); while it cannot be conclusively stated that these chemicals have no effect on the benthos, observations in the Gulf of Mexico during more than 20 years of operations indicate that such effects, if present at all, are minimal. Research is continuing in this area.

The field development phase will require the placement of platforms and the drilling of up to 20 wells from each of a maximum of 25 platforms. The initial platform placement and anchoring may temporarily disturb the benthic biota in the immediate vicinity. Longer term effects may include a change in the benthic community to reflect the presence of an artificial reef.

The production phase will result in the introduction of the soluble components of crude oil at an average concentration of 30 mg/l. These components may eventually be incorporated into the benthic food web. This will cause a shift in the sediment microflora to a community capable of utilizing petroleum hydrocarbons as an energy source. Those compounds, such as the heavier hydrocarbon fractions, which are not degraded may accumulate in the deeper sediment layers. No investigation that would determine if this is the case has been conducted in areas of offshore petroleum development.

The transportation phase may require the installation of pipelines. If so, certain impacts to the marine benthos will occur: In water depths of less than 61 m, new common carrier pipelines are entrenched by jetting away the sediment beneath the pipe and allowing the pipe to settle into the underlying trench at least 0.9 m (3 ft). Partial burial takes place quite rapidly as the disturbed sediments slide and settle back into the trench. It is recognized that in some areas there is insufficient sediment to permit pipeline burying. This is considered a moot point, however, since, the need for and location of pipelines utilized for production in the area cannot be foreseen at this time.

The jetting process physically disrupts the sediments in its path, and causes resuspension of large quantities of sediment. This process would have the effect of displacing benthic organisms and would result in direct mortality to others through increased vulnerability to predators. Although recoloniaztion would begin immediately, the native fauna could not be fully restored until seasonal reproduction cycles have been completed by representative species from adjacent areas; these would provide a supply of larvae to settle and enter the reworked substrate.

Turbidity resulting from resuspended sediment is capable of producing an adverse impact on filter-feeding molluscan (i.e., clams and oysters) and other benthos populations by clogging the filter-feeding apparatus or blocking respiratory surfaces. This impact is temporary, occurring during burial operations, lasting from several hours to a few days, and would effect those populations adjacent to the pipeline. Currents carry the sediment and redeposit it at a distance depending upon the particle size of the sediment, the strength of the current, and the length of time of the burial operation.

As previously mentioned (Sec. II.A.1.), 257 to 515 km (160 to 320 miles) of pipeline may result from this proposed sale. Locations of these pipelines are unknown. It is expected that the area affected would be localized laterally to within 15 m (50 ft) of the particular operation throughout the water column. However, this distance may be decreased or increased depending upon the following variables: water currents, sea conditions, water depths, natural bottom sediment, and dispersion rate of bottom sediments from jetting operation.

Recovery rates would be dependent upon seasonal reproduction cycles and recolonization by indigenous and other species. Estimates for recolonization range from months (polychaetes) to several years (molluscs, echinoderms).

In summary, structures, drilling, and the disposal of muds and cuttings will have a severe effect on the benthic organisms at the immediate site of these structures, wells, and disposals, but this effect is considered to be minimal, short term, and of no significance to any species or populations. Steps will be taken to avoid such operations on "hard banks", "live banks", or "fishing banks".

Oil spills will have a deleterious effect on benthic areas where the water depth is shallow enough to permit mixing of the oil to the bottom. For a discussion of the impact of spills on hard (live) bottom and other benthic systems, see Section III.F.

4. Impact on nekton

Species composition and a discussion of the habitat are discussed in Section II.E.1.d. The nekton consist of free swimming animals such as fish, marine mammals, and certain crustaceans and molluscs. Thus, unlike benthic and planktonic organisms they are able to avoid structures such as rigs and debris and they can avoid oil resulting from a spill. However, there is no question that animals which might swim in oil contaminated waters, and which feed on phytoplankton or zooplankton that are contaminated, will themselves suffer an adverse impact. Depending on the concentration of the oil in the water, this impact will range from death to reduced health to tainting of the flesh of commercial species. While this impact might be severe in local areas, no species or populations as a whole will suffer any long-term impact. The impact on the commercial fisheries component of the nekton is discussed in more detail in Section III.C.6. (see also Section III.F.). A very minor impact on the nekton will be the exclusion of some portion of the water column to their use. As is pointed out below, however, structures may actually "improve" the habitat with regard to fish.

With the present day use of non-explosive energy sources for seismic survey work the pre-exploratory phase of development should have minimal adverse impact on the marine nekton. Falk and Lawrence (1973) report that while explosive sources killed fish over an area of hundreds of square meters, the non-explosive source tested caused no direct mortality. Weaver and Weinhold (1972) reported no harmful effects from non-explosive sources fired at various depths.

The exploratory phase will have a localized temporary effect on the nekton due to the physical presence of the rig and the disposal of drill cuttings and associated muds during the drilling of exploratory wells. The attraction of nektonic organisms, especially fish, to submerged structures is a widely recognized phenomenon and since drilling rigs are well lighted, this attraction may be enhanced at night. Observations in the Gulf of Mexico indicate that fish are also attracted to the drill cuttings as they cascade down through the water column where they may be sampled as food items and rejected. No definitive bioassays have been conducted with drill muds and species found in the planning area; however, Falk and Lawrence (1973) have found a wide range of lethal concentrations (from less than 1% to 12%) working with fresh water fish. Experience in the heavily developed areas of the Gulf of Mexico indicates that no severe adverse effects upon nektonic populations will result from exploratory drilling.

The field development phase will entail the installation of permanent (20 years average functional design life) platforms from which development wells will be drilled. The cuttings will be disposed of overboard where they will form low mounds on the bottom and subsequently be mixed with the underlying sediment or colonized by benthic organisms (Zingula, 1975). The platforms, like the drilling rigs, will attract the larger organisms immediately; but, due to their permanent nature, they also act as true artificial reefs with the establishment of a community of great diversity.

The production phase of offshore operations can impact the nekton through the disposal of formation waters which contain the soluble components of crude oil (30 mg/l) and trace amounts of certain heavy metals (see Table A-3, Section III.A.). The effects of these low-level chronic discharges are not quantifiable at present

(Appendix I). However, due to the magnitude of dilution and the process of microbial degradation, no adverse effects upon nektonic populations have been noted in areas of intense oil and gas development.

The transportation phase, if by pipeline, will result in temporary, localized increases in suspended sediment which can be easily avoided by the actively swimming nekton. If transportation is by tanker, low-level operational discharges of crude oil will occur. These should have little effect upon the nektonic component of the marine ecosystems in the area of this proposed action.

In summary, routine operations resulting from this proposed sale have little adverse impact on the nekton. Oil spills will severely impact a relatively few individuals for a short period of time, but will have few serious or long-term effects. The most serious impact will most likely be to the commercial fisheries segment of the nekton (discussed in detail in Section III.C.6.), but even than should not be very widespread nor long lasting.

5. Impact on marine mammals

Oil and gas development on the South Atlantic OCS as a result of this proposal may impact marine mammals through potential oil spills. The direct effects of oiling on marine mammals could include the matting of pelage, irritation of skin and eyes, indigestion causing internal disorders, and possible clogging or inflammation of respiratory passages. Secondary impacts may include decrease in or redistribution of food supplies.

Cetaceans (Whales, dolphins and porpoises)

Twenty-two species of cetaceans, including three endangered species (right, fin and humpback whales) have been sighted in recent times (the last 50 years) off the South Atlantic states. There is, however, little information on the life histories of the cetaceans in the area. Lack of frequent sightings may be attributable to the absence of observers. While many cetaceans commonly travel in groups, limited data on regional occurrences may indicate that only individuals would be impacted by oil spills as a result of the proposed sale.

No record is reported of cetacean deaths due to the direct effects of oil polution. There were no reported sightings of dead whales following the Santa Barbara oil spills. Attempts to reroute grey whales which were migrating through the vicinity of the Santa Barbara spill were unsucessful.

A potential danger to cetaceans is absorption through the mucous membrane lining the blow hole distal to the nasal plug. This area remains open near the water surface and may become oiled. The ultimate outcome of oil exposure could be a thin oil film covering of the lungs and respiratory passages which has the same effect as pneumonia including death. There were no reported sightings of dead whales following the Santa Barbara oil spill.

As cetaceans forage for such organisms as copepods, euphausids, and fish, localized decreases or redistributions of these organisms as a result of OCS activities could limit food availability for cetaceans, but because of the large area foraged, this would not be expected to limit overall availability of food supplies for cetaceans. Ingestion of contaminated organisms as a result of an oil spill incident could occur. While young cetaceans might also ingest oil during their period of lactation, other effects of hydrocarbons upon mating, implanation, pregnacy, placentation and parturition are unknown for cetaceans. Chronic contributions of low levels of hydrocarbons and heavy metals as a result of OCS development is expected to be localized and not significantly alter concentrations of these substances in the South Atlantic (Sections III.A. and III.B.1.) in general. Therefore, uptake by cetaceans of substances generated by routine operations would be expected on only a limited basis because of their large forage area. (Appendix I discusses the fate of hydrocarbons and heavy metals in the marine food web in more detail).

Because of the endangered species status of some cetaceans, and their apparent limited distribution or occurrence in the South Atlantic region, any impact to individual cetaceans could have consequences on species populations or distribution. The Sei Whale (*Balaeoptera borealis*) is on the endangered species list and is present on the decline off the Southeast Atlantic States. Any further interference with the life cycle or habitat of this species could result in a further depletion. Other species such as the Humpback Whale (*Megaptera novaeangliae*), Black Right Whale (*Eoglena gacialis*), Fin Whale (*Balaeoptera physulus*) and the Sperm Whale (*Physeter catondon*) are listed as endangered species. The relative abundance of these animals indicates that their populations are increasing.

Besides the species that have been listed as endangered, other more abundant species such as the bottlenosed dolphin, the spotted dolphin and the short finned pilot whale can also become endangered if any structural social patterns were disrupted. This could result from such an occurrence as the destruction of the herd leader.

There are no reported incidents of cetacean fatalities as a result of oil spill incidents. Because of the apparent paucity of cetaceans in the South Atlantic, the probability of an individual being in a specific area at the time of an oil spill appears low. Therefore, while potential for impact exists, cetacean species and populations are unlikely to be impacted as a result of the proposed sale. However, in the case of endangered species of marine mammals, any contamination by oil of an individual and the subsequent harm incurred would be detrimental to the population of that mammal.

Pinnipeds (Seals, walruses, etc.)

There are no breeding sites for pinnipeds in the South Atlantic area. Occasional strays of California sea lions and harbor and hooded seals have been reported. The sea lions and harbor seals are coastal species, while the hooded seal is pelagic. Should oil spills occur as a result of the proposed sale, a few individuals of those species may be affected. Because of their habitat, sea lions and harbor seals would be most impacted by nearshore pipeline or tanker spills. Hooded seals could be impacted by spills in offshore oil-producing areas or offshore tanker spills.

Various impacts to pinnipeds have been reported from previous spills. Brownell (1971) and Le Boeuf (1971) investigated the effect on marine mammals of the Santa Barbara oil spill. Numerous dead animals found after the spill, including grey, sperm and pilot whales, dolphins and elephant seal pups, where examined histologically and chemically for the presence of oil or pathological effects related to oil. No such oil or pathology was found and the deaths were attributed to natural causes. It was also noted that the number of deaths was not abnormally high. However, Connell (1973) analyzed the data of Brownell and Le Boeuf (1971) on the mortality of sea lion pups and showed dead pups had more oil on their bodies than one would expect by chance.

Evidence of eye damage as a result of the oiling of pinnipeds has been shown. Nelson-Smith (1973) reported ". . . after the Arrow spill in Nova Scotia, young grey seals were found blundering about in woods half a mile from shore, unable to find their way back because of oil around the eyes and nostrils . . ." Pearce (1970) reported the rescuing of a blind female during a fuel oil spillage.

Because pinnipeds are only occasional strays to the southeastern U.S. region, there is only a small chance that individuals would be impacted as a result of the proposed sale. None of the species reported sighted in the area are endangered; impact on individuals would not be expected to impact populations.

Sirenians (manatees)

The Florida manatee presently is concentrated in the areas around Florida where the water is warm. Their major food source is aquatic vegetation, therefore, anything that effects the aquatic flora will ultimately effect the manatee. The oil spill trajectory, autumn conditions (Section III., Figure A-8) indicates that the projected route could go towards the Florida coast. The majority of the Florida manatee resides in warm waters in this area. If an oil spill were to occur at this time habitat loss could result which would result in the depletion of the food supply for this species. There has been no investigations performed regarding the results of the manatee ingesting contaminated food.

Due to the mobility of the manatee they would probably avoid any direct contact with an oil spill.

Another threat to the existence of the manatee is increased harbor transportation. Any increase in shipping will have a toll on the existing manatee populations around the harbors. Each year there is a loss of manatees due to wounds inflicted by the propellers of boats. If development on the OCS occurs any increase in shipping traffic could increase the death toll of the manatee.

6. Impact on pelagic birds

The greatest impact on birds will be from accidental discharges of oil during drilling and production, from pipelines, and by intentional discharge from tankers. The probability of one or more spills greater than 1000 bbls. impacting on pelagic bird rookeries in the South Atlantic have been estimated as approximately 8-9%.

Although mass fatalities are often observed after spills of crude and heavy fuel oils, it has been estimated that only 5-15% of those birds actually killed by oil that is washed ashore where the death toll is taken (Nelson-Smith, 1973). Nevertheless, estimates for some spills are 3686 fatalities for the Santa Barbara blowout (Straughan, 1972), and 7000 for the San Francisco spill of Bunker C (Chan, 1972; Boesch et al., 1974). A more recent incident occurred on February 10, 1976, when an oil spill from sunken Stewart Petroleum Company barge was discovered off Smith Point, Va., in the Chesapeake Bay. Seepage from the sunken barge continued for several weeks eventually resulting in a spillage of 250,000 gallons of heavy tar-like oil (Kiernan, 1976). The spill killed an estimated 10,000 birds wintering in the Bay. Approximately 95% of ducks killed were grebes and old squaw. According to F&WS the remainder were loons, canvasbacks, redheads, whistling swans, buffleheads, Canada Geese, ruddy ducks, mallard, and teal. Secondary mortalities included ring-billed gulls and herring gulls which had fed upon the oiled waterfowl. Another 118,000 gallons reported still missing was apparently congealed at the bottom of the Bay.

The immediate effect of oil on birds is the fouling of their feathers. Clark (1969) reports that feathers become matted together and the repellant and insulation properties are lost, as well as their buoyancy. Birds can lose their ability to fly (Erickson, 1963), diving ducks lose their ability to dive for food (Chubb, 1954), or they become so soaked they drown (Tuck, 1960). Hartung (1967) reports that heavily oiled ducks lose more than twice the normal amount of body heat due to the breakdown of the insulating properties of plummage. To compensate for the additional loss, they develop very high metabolic rate which often leads to accelerated starvation. Ingested oil is lethally toxic to birds and often results in inflammation of the digestive tract or disturbs other physiological processes (Boesch et al., 1974). One study showed that seawater-adapted mallard ducklings ingesting 12.5 ppm (lowest level tested) of crude oil demonstrated a diminution of intestinal mucosal transfer rate of NA^+ and water thus diminishing the amount of water available to the organism (Crocker et al., 1974). The study further postulates that dehydration resulting from impairment of mucosal transfer mechanism may be an important factor contributing to the high mortality among oil-contaminated seabirds.

It is thought that some species of sea birds are more prone to oiling than others. Previous reports and observations have shown that diving birds suffer the most direct fatalities whereas others, such as gulls and shearwaters, suffer the least. Reports indicate that the vulnerable species are those that are attracted by slicks and consequently land on them. Bourne (1968) suggests the explanation that oil makes the water calm, or resembles food or tide rips, or shoaling fish associated with the presence of food. He also observed that swimming birds do not notice slicks until they come in contact with them and are consequently trapped. While some species, such as gulls fly away, others such as murres, dive beneath the surface. Surfacing into the slick would be fatal as was observed for alcids killed during the Torrey Canyon spill.

Not all birds are equally vulnerable to oil slicks. Clark (1971) reports that in Western Europe, auks, puffins, razorbills, murres, and other sea ducks suffer the most fatalities as a consequence of spills. Boesch et al. (1974) report that from the Santa Barbara spills, loons and grebes, which account for 7-10% of the total bird population suffered 64% of the mortality. A main concern is that many sea birds are long lived and breed slowly which can make recovery of a population very difficult if populations are reduced to a small size. Along the South Atlantic coast the bird species that are considered most vulnerable are the common loon, canvasback, redhead, whistling swan, mallard and ruddy duck.

The treating of oil contaminated birds had met with only limited success with the survival record being very dismal. According to Boesch et al., (1974), most birds perish soon after capture while others do not survive the cleaning procedures or the following recuperation period. The use of harmful detergents, improper feeding and handling of the treated birds are thought to have been responsible for the failure of early attempts of treating. Boesch et al. (1974) however, reports that established British centers with trained personnel achieve nearly complete survival of treated birds. The pelagic birds believed to be most susceptible to contamination by oil at sea are: gannets, phalaropes, aegus, alcids, boobies, shearwaters, petrels, gulls and terns.

Activities associated with pipeline burials, drilling, and construction of onshore facilities can affect bird populations in both offshore and onshore environments. If pipeline burial and drilling activities should resuspend toxic elements as metals and pesticides, they can enter food chains to affect bird populations (Appendix I). Onshore impacts from onshore activities that can occur are loss of habitats and other environmental disturbances for species that nest in marshes. The extent of the impacts would depend on time of year and where they occurred. If the facilities are constructed in marsh areas the habitat destruction could effect such species as the white ibis and great heron. The change in air and water quality and noise level can also effect these bird species during construction and development.

The time of day, season of the year, and sea conditions all play important roles in the species of foul that occur in a specific area and the probability that they could be impacted by an oil spill. Spills occurring in the migration periods of spring and fall and wintering periods would probably impact the greatest numbers and kinds of birds. The South Atlantic States is the wintering area for many species of pelagic birds. Currituck and Pamlico Sounds in North Carolina are the major wintering areas for such species as the Greater Snow Goose and the Whistling Swan and the east coast of Florida is the wintering area for the Lesser Scaup. If an oil spill were to occur and wash ashore the probability of it reaching Currituck or Pomlica Sound would be about 23%. Since the sea conditions are most severe during the winter months this would be the most susceptible time for a spill to occur. The impact from such an event, if the accident resulted from a platform would be minimal since the expected time before the spill reached shore is greater than 29 days provided no clean-up equipment was used.

There would not be any cumulative impacts on the bird populations as a result of this sale or future sales in the area.

7. Impact on the hard bottom communities

Offshore oil and gas drilling effluents that may be expected to have an effect upon hard bottom communities include drill cuttings and drill muds (Section III.A.1.). Hard bottom areas in the Gulf of Mexico typically occur in banks elevated generally 30 meters or more above the seafloor. This morphology is not necessarily found in the Southeast Georgia Embayment. The hard bottoms of this area, in many instances, occur on relatively smooth seafloor or in depressions and are widely distributed. Therefore, the hard bottom communities of the South Atlantic OCS area are probably more susceptible to impacts resulting from the discharge of drilling effluents than those of the Gulf of Mexico OCS area.

The sessile benthic organisms upon which the cuttings pile will slowly accummulate will be buried by the approximately (391 m³) of cuttings generated by drilling a well (Section III.A.1.). These cuttings, if limestone, may form a low mound or if clays, may be dispersed over the hard bottom area. Their fate is dependent upon the nature of the cuttings, nature of the local sediments, depth of disposal, benthic fauna capable of bioturbation, and/or encrustation, and the physical factors acting upon the cuttings pile.

The drilling fluids (muds), which are associated with the cuttings when they are disposed of overboard, are washed from the cuttings and eventually settle to the bottom after generally a wide dispersal through the water column. Jones and Williams (1973) found sediment barium concentrations to be above normal in areas of the Gulf of Mexico where intensive drilling has taken place. Barium sulfate is the major constituent of drilling fluids and the distribution of barium in the sediments suggest that the above-normal concentrations are due to the disposal of these fluids. Barium sulfate is a highly insoluble, nontoxic salt which is present in seawater at a concentration of approximately 0.05 mg/1 and in certain localities concretions and nodules of barium sulphate are found in bottom deposits (Horne, 1969); therefore, no direct toxic effects on benthic biota are expected from the disposal of drilling fluids during the exploratory phase.

The field development phase will require the placement of platforms and the drilling of up to 20 wells from each of a maximum of 25 platforms. Initial platform placement and anchoring will crush or smother members of the epifaunal community in the immediate vicinity. Longer term effects may include a change in the live bottom community to reflect the presence of an artificial reef.

The drilling of 20 wells will result in the disposal of approximately 7,820 m³ (10,228 yd³) of cuttings which, in this area, are expected to be mainly carbonate in nature. This may result in the establishment of a different benthic community in the immediate vicinity of the cuttings pile.

The production phase will result in the introduction of the soluble components of crude oil at an average concentration of 30 mg/1. Due to mixing energy and the water depths in the proposed sale area, this effluent is expected to have no direct toxic effects on members of the hard bottom community. However, low levels of petroleum hydrocarbons have been shown to impair chemoreception in specific crustaceans (Blume et al., 1973): therefore, if this effluent should result in enhanced hydrocarbon concentrations in bottom water and if the indigenous crustaceans are susceptible to chemoreceptive interference, then an unknown degree of failure may occur in behavioral responses mediated by chemical stimuli. No research has been conducted which would more clearly resolve this issue or determine the magnitude of the problem if a problem exists.

The transportation phase may require the installation of pipelines. If so, certain impacts to the marine benthos will occur.

In water depths of less than 61 m, new common carrier pipelines are entrenched by jetting away the sediment or cutting a trench beneath the pipe and allowing the pipe to settle into the underlying trench at least 0.9 m (3 ft). Partial burial takes place quite rapidly as the disturbed sediments slide and settle back into the trench.

Recolonization rates would be dependent upon seasonal reproduction cycles and recolonization by indigenous or other species. No accurate estimate of the time required for this to occur can be made at present.

The Bureau of Land Management recently published regulations pertaining to the protection of coral on the OCS (Federal Register, September 16, 1976). The regulations state that no person shall engage in any operation which directly causes damage or injury to a viable coral community that is located on the Outer Continental Shelf without having obtained a permit for said operation. Since there are a number of hard bottom communities in the lease area which may contain corals, permits will probably have to be issued for many petroleum development related activities as a result of this sale.

A new law, P. C. 94-265, the Fishery Conservation and Management Act of 1976, will cause the management of coral to fall within the purview of the various Regional Fishery Management Councils established by the law as soon as management plans are developed for coral. In the meantime, the BLM regulations will remain in effect in order to insure the protection of this natural resource.

The aggregate effect upon hard bottom communities from all of the above activities will be:

1. The introduction of an estimated total of 164,220 m^3 of drill cuttings, given the assumption that 420 wells will be drilled in the area to an average depth of 3,048 m. This volume of cuttings could potentially cover an area of 164.22 ha to a depth of 10 cm.
2. Potential impairment of the chemically cued interactions of the biotic components of the hard bottom ecosystem.
3. A potential increase in the barium sulfate content of the sediments immediately surrounding each production platform.
4. A potential temporary disruption of hard bottom communities along pipeline routes in the event pipelines are used for transportation.

8. Impact on Offshore Water Quality

The pre-exploratory phase of operations will have minimal impact on water quality in the planning area. Overboard discharges from the survey vessels are the only potential effluents and these effluents are infrequent and very low in volume.

During exploration and production the discharge of drilling mud and cuttings could result in minor water quality degradation. It is estimated that between 162,000 to 459,000 tons of drilling muds would be discharged over 25 years. These muds are primarily composed of barite, bentonite and other inorganic compounds. It is estimated that between 162,000 to 459,000 tons of drilling muds and 245,000 to 692,000 cubic yards of drill cuttings would be discharged over a 25 year period (this is based on drilling to 18,000 ft). When the mud and cuttings are discharged a turbidity plume is created. The maximum size of a turbidity plume in the Gulf of Mexico was 20 m wide and 800 m long. The exact extent of these plumes will be determined primarily by the prevailing currents. The prevailing currents and winds will allow for mixing and dispersion of the turbidity plume. Zingula (1975) reports a rapid decrease in suspended solids, no appreciable change in pH and undetectable changes in soluble barium and chromium during drilling activities offshore Louisiana. See Table B-1. Ray and Shinn (1975), working in clearer waters confirm these observations. Their samples, however, were taken at 36 m and 75 m while the discharge occurred at 11 m. It is estimated that between 162,000 to 459,000 tons of drilling mud and 245,000 to 692,000 cubic yards of drill cuttings would be discharged over a 25 year period (this is based on drilling to 18,000 ft).

The field development phase will have the same impacts as the exploratory phase only spatially more concentrated. An additional impact may be the potential temporary resuspension of bottom sediments during platform placement.

The production phase results in two pollutants for which the U.S. Environmental Protection Agency has seen fit to establish effluent limitations. These include oil and grease from produced water, deck drainage, muds, cuttings and sand removal; and residual chlorine from sanitary sources. Oil and grease may be discharged at an average concentration of 30 mg/1 and would consist of the soluble components of crude oil. This would be immediately diluted to 30 parts per billion when mixed with 1 m^3 of sea water. The impact of such a receiving water concentration on water quality would be minimal. Support services may generate minor discharges of bilge and sanitary wastes.

Tanker discharge, oil spills, and formation water dischargers would be the major causes of water quality degradation related to oil and gas development in the South Atlantic area. An estimated 4.6 million barrels of crude oil could be lost to the environment during the 25 year expected life of the field. This would be an estimated 1.6-0.5% of the oil that is expected to be produced in this area. The majority of the oil that might be spilled results from tanker operations and accidents. In view of existing tanker pollution in the area the percentage increase of oil spilled would be less than 0.001%.

The use of pipelines as a mode of transporting oil or gas that may be discovered could result in localized water quality degradation due to sediment resuspension during pipeline construction and burial. The jetting away of the substrate from beneath the pipeline will result in the suspension of sediments which may be rich in pollutants, especially in near shore areas adjacent to industrial development. As the width of the trench varies with the compactness and fluidization point of sediment, we can only estimate the volume of disturbed sediments. If the trench is roughly two meters deep by two to four meters wide, and a parabolic cross-section is assumed approximately 1,400 to 3,800 cubic meters per km would be removed, some of which would be resuspended. The turbidity plume will move downcurrent from the operation and can reach proportions of several yards wide and hundreds of yards long if the substrate is exceptionally muddy. The duration of the plume depends on the particular size, shape and density of the material suspended and the water turbulence. This increase in turbidity will create a short-term impact on water quality and may degrade water quality in coastal areas.

In summary the offshore water quality is most likely to be affected by drilling mud and cutting discharge, accidental oil spills and resuspension of bottom sediments during pipeline laying.

As indicated the turbidity plume that results from the discharge of drilling muds and cuttings is localized and short-term. This would therefore not lend itself to any severe water quality degradation problems. Accidental oil spills can also result in water quality degradation, however, over the projected 25 yr. period an estimated 4.6 million barrels of crude oil would be lost to the marine environment, mostly from tanker accidents. Therefore, this sale alone would actually only contribute less than 0.001% of the estimated oil spilled during the 25-year period. The resuspension of sediment in the laying of pipelines is localized and lasts only for a short duration. Other offshore operations such as dishcarges from survey vessels, deck drainage, sanitary wastes from rigs would be so minimal that they would not cause any water quality degradation.

In view of the fact that the offshore impacts on water quality would be localized and short-term there would not be any cumulative impacts if there were future sales in this area or in the Mid-Atlantic region.

9. Impact on Offshore Air Quality

Degradation of offshore air quality will occur in cases of oil spills, oil or gas blowouts, pipeline breaks, and the normal exhaust of platform generators and service vessels. The number of installations which will increase and then decrease over the expected 25-year development period probably will not exceed 31 widely separated installations.

If natural gas is related via a blowout or pipeline break, methane, ethane, propane, hydrogen sulfide, and other toxic gases will be released into the atmosphere. The percentage of each is difficult to predict since the character of the gas is not known at present. If the gas burns when released, carbon dioxide, sulfur oxides, nitrogen oxides, and carbon monoxide are produced. Although the exact quantities introduced during the course of these accidents cannot be predicted, the resulting pollutants will be borne away by the prevailing winds and diluted in a very large air mass.

If a blowout should occur at a gas well and did not burn, the above gases in a comparable ratio would be released into the air. A typical offshore well produces approximately one million cubic feet of gas per day. A blowout could reasonably be expected to release at least this much gas into the atmosphere. However, if the gas well were burning, combustion would be essentially complete and the emissions would consist almost entirely of carbon dioxide (CO_2), water and any sulfurous gases would be oxidized to SO_2. It is difficult to predict the probability of this occurrence. Since essentially all of the components of natural gas are non-reactive, there would be little impact whether or not they are burned. Any impact that could result would be dependent upon how far away the incident is from the receptor and upon meteorological parameters.

If a blowout at an oil well occurred and released crude oil into the water, the resulting impact would be substantially greater. If the oil does not burn, a significant amount of it would evaporate. Almost all of the lighter fractions which have boiling points lower than that of $^{C}12$ (4827° C) evaporates over the life of the spill. Evaporation introduces hydrocarbons and the volatile products of the reaction of sunlight and oil, and of microbial degradation activities into the atmosphere. If the oil burns when released, carbon dioxide, sulfur oxides, nitrogen oxides, carbon monoxide, and other partially oxidized material will be produced. Some of these, sulfur and nitrogen oxides, can cause problems by increasing the acidity of rain in the area. Other partially oxidized materials can cause smoke or haze problems. Although the actual extent of the effects caused by the addition of these pollutants cannot be determined beforehand, air quality will deteriorate in the areas affected by the spill or the associated air mass until the fire is extinguished, the spill dispersed, and the pollutants diluted. Any impact that could result would be dependent upon how far away the incident is from the receptor and upon meteorological parameters.

A reasonable estimate of the range of emission, assuming complete combustion, that an oil well fire could produce per 1,000 bbls burned, might be as follows (Levorsen, 1958, 1958); CO_2, 340,000-347,000 lbs., SO_2: 620-34,000 lbs., and NO: 660-10,000 lbs.

Combustion of oil would be incomplete; however, emissions would contain a smaller amount of the above compounds, and would include such materials as volatilized petroleum, particulate carbon, carbon monoxide, nitrous oxide, sulphur monoxide, along with other altered or partially oxidized matter. There is no reliable way to predict in advance the relative volumes of each of these possible emissions from incomplete combustion because it would depend, among other things, upon moisture content of the air, wind speed, pattern of oil spray from wild wells, number of wells involved, chemical content and physical character of the oil itself, and types of equipment and materials other than oil that might also burn.

The exhaust from the large electric generators on the platforms will contain particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons which would be dispersed by the prevailing winds and rapidly diluted in the South Atlantic offshore air mass.

The air movement in the southeastern U.S. are predominantly northerly winds that move generally seaward (Sec. II.D.2.). The characteristics of these wind patterns indicates that the emissions from offshore facilities would be diluted in the air mass and transported seaward.

In summary offshore air quality will not be degraded as a result of the proposed sale. The largest volume of emissions would result from an oil or gas well blowout. Emissions from electric generators on the platforms would add only a minimal amount of pollutants to the air. Any emissions would be rapidly dispersed by the seaward wind patterns.

There would not be any cumulative effect on offshore air quality as a result of this sale or any future sales in the area.

Table B-1. Analyses of samples collected January 9, 1975, by R.P. Zingula et al., at and around a well being drilled at Exxon's South Timbalier Block 54-E platform (From Zingula, 1975).

Sample No.	Description	Measured pH 1/ on-site	Measured pH 1/ lab	Suspended solids, mg/l	Soluble 2/ Barium	Soluble 2/ Chromium
1	Drilling mud from mud tanks under the shale shaker	8.48	8.5	350,000	0.5 ppm	0.2 ppm
2	Mud at downpipe at water surface	8.42	8.5	278	"	"
3	Water at center of muddy stream at sea surface, 100 yd downstream from downpipe	8.42	8.6	40.7	"	"
4	Surface water at center of muddy stream 1/8 mi downstream from downpipe	8.43	8.6	5.5	"	"
5	30 ft. below sea surface at location of sample 3	8.20	8.4	1.5	"	"
6	30 ft. below sea surface at location of sample 4	8.18	8.4	1.1	"	"
7	"Clean" seawater at sea surface, 100 yd. upstream from downpipe	8.45	8.6	5.2	"	"
	Spersene solution 3/ (lab.)	----	3.1	231	---	11,400 ppm

1/ Samples taken at 8-8:30 a.m., January 9. Onsite pH measurements made at 10-10:30 p.m., January 9. Lab measurements made January 13 & 14.

2/ Measurements of soluble chromium and barium were by atomic absorption, calibrated against a standard. Concentrations were below the limits of measurements of the system, i.e., 0.5 ppm barium and 0.2 ppm chromium.

3/ Spersene solution was made by mixing two aprts water with one part spersene by weight and letting stand for 24 hours.

C. Offshore Impact of Oil and Gas Operations on Human Utilization of the Environment

1. Impact on Ports

During the exploratory phase of sale related operations activities related to servicing offshore facilities can be expected to develop in the ports of Charleston, Brunswick, and Jacksonville. These are all ports within relatively short distances from the major proposed leasing areas, facilitating crewboat, workboat, and helicopter travel to offshore facilities. These ports will receive a positive economic impact by the increased useage of industrial land and structures which may be presently vacant, under-utilized or marginally used. Economic development in the ports will progress due to the establishment of the new industry, and additional business will accrue to industries which are presently located in the ports. Since not all ports will necessarily contain the same set of service facilities, the level of impact may not be determined at this time.

It is anticipated that production from this proposed sale would replace a fairly small percentage of the foreign shipments of crude entering the U.S. There would therefore be an impact on those ports in the U.S. presently importing foreign crude oil. The levels of the impacts on individual ports should be small as the reduction in imports will probably not fall on any single port. Since none of the ports along the South Atlantic coast are crude importers they should not be affected by the increase of foreign crude importation. If, however, a refinery were to be built at one of the South Atlantic ports, and that refinery imported foreign crude, this sale could result in a negative economic impact in that port, if the sale produced petroleum were piped in as there would be a reduction in the need for towing, supply and other tanker servicing facilities.

Should it be decided to use tankers to transport the petroleum produced by this proposed sale, a relatively small number of tankers will be needed and therefore the impact on ports from tanker traffic will be minimal. Using the USGS figures of 56,000 barrels per day production low estimate and 179,000 barrels per day peak production high estimate, using tankers of 25,000 dead weight ton size, approximately one tanker per day would be needed for the high estimate production to be moved to port. In the low estimate situation one tanker would be needed approximately every three days. It is doubtful that such a small increase in tanker use of the ports would have a noticeable economic impact.

2. Impact on Shipping

It is expected that during the first phase of development, resulting from the proposal, there will be a negative impact on ship traffic which will be short term and disruptive in nature. Some conflicts may arise with cargo vessel movements caused by the additional number of vessels performing exploratory activities. In the process of performing seismic and other analysis, exploratory vessels will not be travelling in the customary directions, but will be criss-crossing some areas which could cause vessel collisions. Many of these impacts would still be present during the development well drilling operations. Small craft providing shuttle runs between the coast and offshore sites during supply activities and work crew transport will cause an increase in ship traffic (5 to 10 vessels per day at the low estimate, 10 to 15 at the high) in the harbors and the offshore environment. Also during the development phase, there will be slow moving vessels and barges in the vicinity of laying and trenching operations of pipeline construction.

Pipeline construction operations, which would be disruptive in nature, would terminate once the lines are completed. Trips by service vessels will continue throughout all phases of OCS operations. However, as exploratory and development related activities decline, transport and service trips will subside. The production related trips—workmen transport, supply, and service—will become less frequent. These trips are primarily between onshore operation bases and offshore areas of oil and gas activities.

The overall effect on shipping is expected to be a minor negative one. The increased traffic of small supply and survey vessels, and pipeline barges will increase the number of vessels in the area at any one time. This will increase the hazard of collision and make navigation by large ocean-going vessels slightly more difficult than before development.

3. Impact on Navigation

As a result of the proposed sale, hazards to navigation would result from the presence of offshore structures on the OCS during all phases from exploratory drilling to production. No navigational fairways (such as those in the Gulf of Mexico) are established for the South Atlantic OCS region. Vessels moving along the coast or towards the major ports described in Section II.G.1.a. travel generally to the best navigational and weather advantage to the vessel. Ships are not required to follow any lanes and may travel in any direction. Therefore any rig or platform set up in any of the tracts prepared for leasing could be considered a hazard to navigation.

Northbound traffic along the North American coast tends to follow the Gulf Stream in order to gain the advantage of the northward moving water. This would move these vessels generally seaward of the proposed leasing areas and out of conflict with activities related to the proposed sale.

Southbound vessels either cruise outside of the Gulf Stream or shoreward of it. Those traveling shoreward of the Stream may travel as far inshore as the proposed areas for leasing. For those vessels, the presence of rigs and platforms would constitute a hazard to navigation.

Vessels going into or moving out of any of the ports may travel through any of the tracts proposed for this lease sale. Any rigs or platforms placed in the sale area will therefore constitute a hazard to navigation.

There will be a positive impact, mostly for smaller vessels, as well lit, well identified platforms can be used as navigational landmarks.

At night and during bad weather, fog or heavy seas, ships navigating in the vicinity of structures could collide with them. If rigs and platforms, subsea completion systems of shut-in wells are located in present or future fishing grounds, fishing boats will be inconvenienced by having to detour around them.

Accidentally lost debris from platforms could also constitute a hazard to smaller vessels. Floating objects could foul propellers. The magnitude of the floating trash hazard cannot be determined.

Should collisions between vessels and offshore structures result, the impacts could include loss of human life, spillage of crude oil, or refined products, and the release of debris. Toxic contents of a ship's cargo could pose a threat to onshore and marine ecosystems.

Since there are no OCS-related offshore structures in the South-Atlantic, we must utilize the Gulf of Mexico experience in order to examine the incidence of vessel collisions with these structures. There were eight reported collisions between large vessels and offshore structures in the Gulf of Mexico between July 1, 1962 and June 30, 1973. These collisions include only those vessels over 1000 gross tons. These eight accidents accounted for $87,000 of vessel damage (only four vessels reported damage) and approximately $3.2 million in damage to platforms. No human injuries or deaths were reported. Five of these accidents occurred at night (three within two hours of midnight) and two during daylight. All of the eight major accidents occurred outside established shipping fairways and anchorage areas; only three were less than five miles from these established areas. At least five of the accidents involved foreign flag vessels.

The worst of these eight accidents occurred in 1967 when an 11,600 ton foreign flag cargo vessel collided with a platform during heavy rain, poor visibility, 45 knot winds, and 15 to 20 ft. seas. The vessel escaped with damages estimated at $12,000, but damages to the platform were on the order of $111 million or one-third of the total damages for all eight accidents.

The remaining 22 incidents of collision between vessels of less than 1000 gross tons and platforms caused more damage to the vessels ($426,000) than to the platforms ($102,000 which was relatively insignificant when compared to an average cost of $20 million per installed platform equipped with production machinery). Fifteen accidents including vessels less than 100 gross tons and the remaining seven vessels were between 100 and 650 gross tons. In all cases there was no loss of life involved.

More recently, in August 1975, there was a predawn collision between a British oil tanker and an unmanned platform under construction. The collision resulted in an explosion and the loss of six lives. A six mile long, mile and a half wide oil spill also resulted.

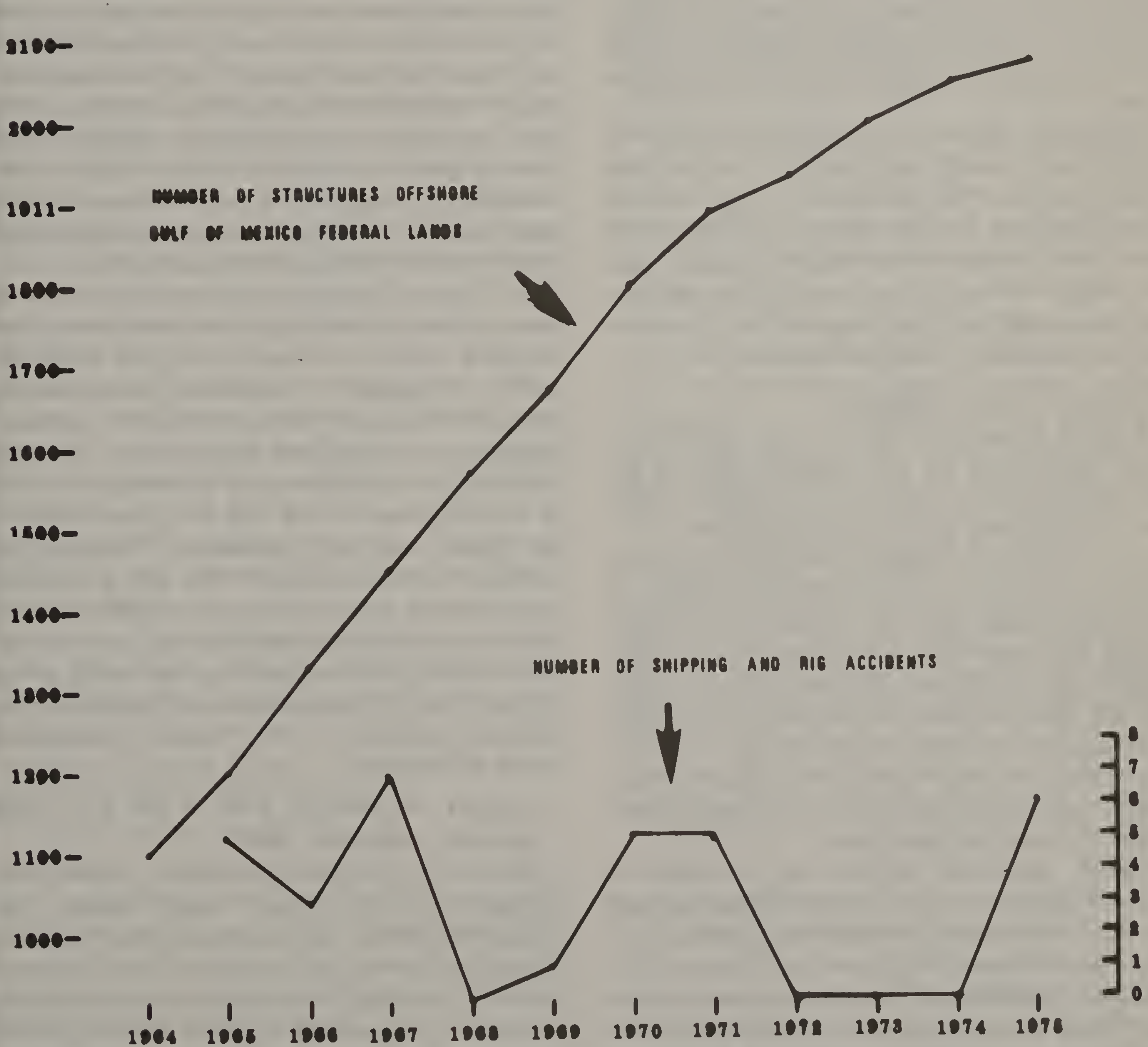
Figure C-1 shows the increase in the number of offshore structures versus the number of accidents involving these platforms in the Gulf of Mexico.

In the South Atlantic OCS area, as in any area, the most serious hazard involving offshore structures resulting from the proposed sale and vessels would be in the case of an oil tanker ramming a platform in such a way as to rupture the tanker and spill oil. The present probability of a tanker-platform accident is zero, but will increase an un-

FIGURE C-1

ACCIDENTS INVOLVING VESSELS AND OFFSHORE STRUCTURES

SOURCES: USGS, USCG



determined amount during the development and production phases if the proposed sale is held.

If oil produced as a result of this proposed sale is transported by tanker to shore, or by tanker away from onshore terminals, it can still be expected to replace shipments of foreign crude on a national basis. As none of the South Atlantic ports are major foreign crude importers the change in traffic caused by tankering South Atlantic OCS oil will be a positive one. Tanker traffic will increase, however, smaller vessels than those used in long haul transport would probably be used due to the small size of the ports. This will be an increase in vessel traffic which will develop fully only at the production stage and it will contribute to a somewhat greater incidence of vessel accidents and vessel-platform accidents within the region.

Because of the lack of navigational fairways in the sale area, vessels are presently free to travel in any direction. The placement of rigs, erection of platforms and possible presence of tankers will inhibit this freedom of movement. A minor negative impact will result upon navigation in the sale area and traffic will no longer be as free from potential hazards as at the present time.

4. Impact on Ocean Dumping

Ocean dumping areas should not be directly impacted as a result of this proposed oil and gas lease sale. Figure G-3 in Section III depicts sensitive dumping areas in relation to lease sites.

The 17 interim dumping sites established by EPA in 1973 are at least 35 km inshore from offered lease tracts. Most all of these sites are intended for deposition of excavation or dredge matter (sand, shell, and silt). One 11 km² dumping site has been permitted for disposal of chemical industrial wastes in the OCS seaward of Savannah. This site is also sufficiently removed from offered lease tracts so as not to be directly impacted by lease site operations.

Wastes generated offshore as a result of offshore operations include spent drilling mud and cuttings, waste paper, plastic, metal, garbage, etc. When not disposed of offshore (drill cuttings, for example, reintroduced into the marine environment when determined to be environmentally acceptable by the Federal Government) wastes are transported back to shore for reclamation or disposal at local incinerators or landfills. Waste generated onshore as a result of industry support needs in the South Atlantic area (construction sites, personal waste of immigrants) is not projected to be dumped in the marine environment.

Pipelines, should hydrocarbon finds require such, may eventually impact with established and former dumping sites. If such a case were to occur there would be a temporary resuspension of waste matter for the duration of the pipe laying.

Two former explosive dumping areas are located sufficiently seaward of the proposed lease tracts so as to be unaffected by any activities associated with oil and gas operations.

The waters seaward of the ports of Jacksonville and Charleston are former mine explosive areas. These areas have been declared safe and available for unrestricted surface use. An adverse impact may occur however should a subsea pipeline be routed through a former mine area. Proper survey and possible decontamination efforts would precede granting a permit for such a right-of-way. Additionally, impacting a former harbor protection mine area with an undersea pipeline would limit its future utility as a live mine area.

In summary, pipelines may indirectly and temporarily have a minor impact on established ocean dumping areas. This impact will not affect the utility or capacity of established ocean dumping areas. This impact will not affect the utility or capacity of established dump sites. Pipelines traversing former mine areas however, run a risk of ordnance hazard and limit the future utility of the mine areas for reactivation. Offshore and onshore waste generated by this sale in conjunction with sale 40 (Mid-Atlantic) will not noticeably affect established ocean dumping sites. Should hydrocarbon finds stimulate further leasing in this region increased construction and population may increase pollution to the marine environment within 10-20 years.

5. Impact on Military Uses of the U.S. South Atlantic Continental Shelf

Figure G-3, Section II provides a graphic relationship between offered lease blocks and designated military fleet operating areas. All lease blocks fall within the Jacksonville or Charleston military operating areas utilized by the Defense Department for training activities such as practice bombings; torpedo and air-to-surface missile firings; aircraft carrier operations; and submarine maneuvers. All activities related to hydrocarbon exploration and development (drilling, production, operations, oil and gas transport) will conflict with the Jacksonville and Charleston operating areas.

Fifty-six tracts fall within the Charleston operations area. Fifty-one of these tracts form a contiguous 60 km^2 lease area which lies between warning areas 132 and 137 and five tracts form a contiguous block less than 35 km^2 within warning area 132 used for surface gunnery and air-to-air firings. The remaining 158 tracts form a large oblong core extending approximately 195 km in a north-south direction and 95 km in an east-west direction in the Jacksonville operations area. These same tracts fall within warning areas 157 and 158 B used for surface-to-air operation and missile firing.

Discussions between the Department of the Interior and the Department of Defense during the tract selection process have resulted in lease stipulations (Section IV.) aimed at avoiding conflicts between military and oil and gas operations. Stipulations recommended are designed to control electromagnetic emissions and boat and aircraft traffic which would interfere with DOD flight, testing or operational activities in specified warning areas.

In summary, exploration, development and attendant shore-to-tract and tract-to-shore operations by sea and air as well as transportation of crude products by sea or undersea which could result from this oil and gas lease sale will effectively remove a large section of the Jacksonville operations area and to a lesser extent portions of the Charleston operations area from military operations. This proposed lease sale in conjunction with Sale No. 40 (Mid-Atlantic) and scheduled future Atlantic hydrocarbon sales will likely restrict the training flexibility of the armed forces by reducing military flexibility and use of existing designated operating areas.

6. Impact on Commercial Fisheries

Offshore oil and gas operations can interfere with commercial fishing activities in three general ways: removal of sea floor and pelagic areas from use, underwater obstructions, and loss of catch due to presence of oil in water and/or flesh (also refer to Section III.B.3. and 4.).

a. Removal of sea floor and pelagic areas from use

The majority of shellfish (such as shrimp) and some finfish species are harvested by bottom trawls. Sites occupied by drilling or production platforms, attendant service boats and tankers would consequently interfere with fishing activities. Only 13 of the 225 tracts being considered for this proposed sale, however, are in waters as shallow as 20 m where some 70% of the trawling operations take place. If the structures employed are jack-up drilling rigs or permanent production platforms, the area of the sea floor removed would amount to approximately 0.8 to 2 ha (2 to 5 ac) for each structure; considering a maximum of 25 structures in the entire lease area, this would affect a maximum of 50 ha (124 ac). In deeper waters over 91 m (300 ft), a seim-submersible drilling rig with its anchoring system occupies up to 66 ha (162 ac) (assuming a 457 m (1500 ft) anchoring radius), giving a maximum of 1650 ha (4070 ac). However, it is estimated that a maximum of 133 to 530 ha (330 to 1310 ac) would be removed from commercial fishing temporarily at any one time, leveling off to a maximum of 101 ha (250 ac); this is based on 0.8 to 2 ha (2 to 5 ac) lost to trawling operations per platform, and 10 to 50 platforms, with 25 platforms considered to be the most likely figure. Actual area removed, will probably be much less (for range of facilities anticipated, refer to Section I.D.1.). Again it is noted that most of the trawling operations take place shoreward of most of the proposed lease tracts. Permanent production platforms may remain in place for 10 to over 20 years.

Seining (for menhaden, mullet, flounder, alewives, croaker, etc.) is also primarily a shallow, nearshore fishery in the U.S. South Atlantic area and platforms should present no interference. Fishermen in the Gulf of Mexico do not complain about oil platforms interfering with their seining operations as they do regarding trawl fishing; this may indicate that there is no problem involved.

Offshore rigs and platforms can also present navigational problems to fishermen. Boats engaged in trawling will have to navigate around fixed structures, and there also exists the possibility of fishing boats colliding with structures. A Coast Guard summary for the Gulf of Mexico for the period July 1, 1962 through June 30, 1973, reported 10 collisions of fishing boats with offshore structures, or approximately one per year on the average. Total damage to boats amounted to $151,000 and damage to platforms $24,000.

b. Underwater obstructions

Underwater stubs, large pieces of debris, and unburied pipelines may, when snagged, cause damage to trawls and nets.

Proposed OCS Operating Order No. 3 requires that all stubs and subsea systems be . . . "removed to that depth below the ocean floor approved by the area Supervisor. . ." when a well is abandoned. If a well is to be temporarily shut down, a stub is left protruding above the ocean floor to facilitate re-opening the well. In this case, Coast Guard regulations require the stub to be marked by a buoy if the water depth is less than 60 m (200 ft) and that the buoy be lighted if the water depth is less than 26 m (85 ft).

Large pieces of debris such as equipment, piping, structural members, tools, and the like, may accidentally be lost off a platform or service barge, the frequency of which cannot be predicted. Losses off a platform may be located easily by divers and retrieved. However, if debris is lost off a boat or barge underway, the location may not be known accurately enough to allow its subsequent recovery. Depending on the size and weight of items lost in this way, varying amounts of damage could be done to trawling nets, but this is expected to be very small during normal operations.

c. Loss of catch due to oil contamination

Offshore oil spills have their most serious environmental effect within the upper few meters of the water column (Laseter, Powers, and Devanney, 1974), although under strong wave turbulence oil has been driven as deeply as 50 meters (Forrester, 1971). The organisms most susceptible to mortality from an offshore oil spill would be those organisms occupying the upper layers and which exhibit little or no directional movement. Actively swimming organisms could be expected to swim away from the slick.

Commercial fishing grounds in the South Atlantic have a 95-97% probability, depending on the development scenario assumed, of being impacted by one or more major oil spills (over 1000 bbls each) sometime during the development of this area. Commercial scallops, crabs, and oysters have a 43-65% probability of impact; white, brown, and pink shrimp have a 62-69% probability; while bay scallops have only a 6-7% probability of impact from such a spill. Fish populations and distribution can become affected from four causes if such impact occurs:

(1) If large amounts of plankton or other assemblages that fish populations are dependent upon for food are destroyed, the food web could be seriously disrupted and result in population declines of organisms directly or indirectly dependent upon them.

(2) Entire year classes of larval or juvenile fish within the contamination area might be destroyed in a given area possibly resulting in reduced yields several years after the spill. For a further discussion of food webs, see Appendix I.

(3) Oil pollution might lower organisms' resistance to disease and other environmental stresses. This could produce an increased mortality rate over a long period of time causing a slow but marked decline in fisheries within an area that had been contaminated. Ketchum (1973) showed that abnormal development occurs following longer periods of exposure to concentrations as low as 0.01 ppm.

(4) Fish may have to be discarded due to tainting of the flesh. One example was given by Connel (1971), who stated that the Australian mullet had a kerosene-like tainting due to the presence of kerosene-like hydrocarbons in the flesh. He found the contaminated compounds to be similar to substances isolated from river sediments. Shipton et al. (1970), through gas chromatography and spectral analysis, reported that the isolated kerosene appeared to be similar to a commercial sample of kerosene. Liver examination by light and electron microscopes revealed higher amounts of free fat than untainted samples (Vale et al. 1970). Sea trout and plaice were found to be tainted as determined by taste tests. These fish were caught after the Torrey Canyon incident involving the spillage of Kuwait crude oil. No chemical analysis by chemical class was reported (Clark, 1973).

Numerous studies on the effects of oil on commercially important shellfish indicate that these invertebrates may both absorb and, to varying degrees, clean themselves of hydrocarbons. These effects are further discussed in detail in the section discussing the impact on the benthos (Section III.B.1.c.) and in Appendix I.

Oil spills can have both short- and long-term impacts on commercial fisheries. Oil spills may physically prevent fishing in contaminated areas. Adult finfish, although they may not be killed outright, may suffer a long-term decline if food webs are interrupted and resistance to disease and environmental stress is lowered. Larval and juvenile fish can also be killed in great numbers which may result in greatly reduced yields several years after the spill, particularly for species which may be overfished. While many fish and shellfish may not be destroyed, they may be tainted with hydrocarbons and be unmarketable. This is very unlikely in offshore or nearshore areas, however, due to the dilution factor. Thus, the various shell fisheries such as that for the surf clam are relatively safe from these effects. However, shellfish in enclosed areas may be more susceptible due to their filter feeding characteristics and their inability to escape. Furthermore, there is some indication that oil contamination may interfere with reproductive behavior in some shellfish. If this is generally true, such contamination may have wide implications not only to the shellfish industry but to other fisheries which depend on shellfish in the food web.

If an oil spill were to occur the impact to the offshore fish populations would be greatest immediately after the incident. It is at this time that the most toxic elements are present. The boundaries of a particular spill are difficult to project; however, the immediate area of the spill would have the greatest impact. Some of the abundant species according to landings that are represented in the proposed leasing area are menhaden, flounder, spot, alewives, mullet, seatrout, croakers, and sea bass. Other species that are not as abundant but have a high market value in this proposed leasing area are pompano, snapper, hogfish, and groupers.

Many species spawn within the marshes and estuaries and spend their juvenile stages there. However, some species spawn offshore and the larvae and juveniles are transported to the estuaries. Some of these are menhaden, flounder, sea bass, and shrimp. The season when spawning occurs varies according to species; menhaden and croaker spawn during the fall and winter while snapper and scup spawn spring and summer. Therefore, the season in which the oil spill occurs would affect different species. Larval stages of marine organisms are generally considered more sensitive to oil pollution than adults (Kuhnhold, 1970). If an oil spill were to occur at the time of spawning, this could result in a death of the larvae in that particular area. However, since the range of these fish is vast, the total impact on the species would be minimal.

The calico scallop is of special interest in the southeast Atlantic because of their value as a commercial fishery and their life cycle. It is believed that the stock of calico scallops that are found off the North Carolina coast are recruited from larvae spawned off the coast of Florida and carried north by the Gulf Stream. Therefore, this larval transport system, which traverses the proposed lease area and connects the Floridian fauna the more northward fauna is likely to be impacted from the proposed sale (Barber, 1976).

The matrix indicates that for offshore structures there are 17 tracts that would have a maximum, 145 moderate, and 63 minimal potential impacts. In regard to the potential impacts on commercial fisheries as a result of oil spills, 5 have been designated maximal, 52 moderate, and 169 minimal. The maximum potential impact by offshore structures on commercial fisheries are tracts: 94-96, 104-106, 119-121, 131, 132, 144, 145, 163, 164, 171.

The tracts which will have a maximum potential impact on commercial fisheries due to oil spills are: 94, 104, 131, 132, 144.

The probability of an impact on commercial calico scallop grounds ranges from 7 to 32 per cent, depending on the production area or transportation write selected as the site of the hypothetical spill.

The bays and estuaries are important spawning and nursery areas for many finfish and shellfish species. The southeast Atlantic coast is rich in shellfish nursery areas. Every bay and estuary along the southeast Atlantic coast has a potential for crab, shrimp, and oyster production. Bay scallops are found in shoal areas of Core and Borgue Sound. The probability of impact on this species is less than four percent depending on the route of the hypothetical oil spill. Albamarle Sound, North Carolina, is a principal spawning area for striped bass and herring. In the spring these anadromous fish enter the estuaries to spawn.

The effect of an oil spill in any confined body of water along a tanker route may be expected to have similar actions upon the fish population, although the species composition may differ among the bodies of water. Thus, all life stages of fish could be seriously affected by an oil spill. Fish eggs and larvae would be killed by exposure to the oil film at or near the surface. Benthic fishes could be exposed to oil-laden particles which settle as a consequence of the high turbidity waters found in estuaries. Spills may have serious effects upon these local populations. However, the effect upon the total population along the Atlantic coast is largely speculative. Most species are distributed along a rather broad geographical range and a serious spill within a single bay may not have any significant effect on the total population.

Authors disagree on the time required for shellfish to cleanse themselves once the source of contamination is removed. Estimates vary from several months for complete depuration to no depuration after six months in clean waters. Conclusive data is lacking for many individual species at this time. However, some cleansing does take place in some species while in others it does not. The probability of an oil spill impacting white, brown and pink shrimp ranges from 25-35 percent depending on the route of the hypothetical spill.

A major impact will occur if a large oil spill reaches shallow water where it would affect benthic organisms (shellfish) or if it reaches the estuaries which, as nursery grounds, constitute a vital habitat at some stage of the life cycle of most commercial species of fish and shellfish. Areas of high sedimentation rate, which include such estuarine areas as well as important shrimping grounds, have a 55-62% probability of impact from a major oil spill, while marshes and wetlands, which also serve as nurseries for commercially important fisheries, have a 14-17% probability of an impact at least once during the life of the field.

Overall, the potential removal of ocean bottom from trawling operations, estimated to be a maximum of 530 ha (1310 ac), the effects of boats and seining operations, and the effects of obstructions do not appear to impose major consequences on commercial fishing operations; effects will be felt locally by individual fishermen if such structures are placed in areas they prefer to fish. Oil spills could both contaminate and destroy some fishery resources periodically. However, it is believed that any such impact will be of short duration and that quantities reaching such areas will not be great.

The cumulative consequences of this potential sale, plus any future sales that might occur in this same area, combined with sales in the Mid-Atlantic areas to the north, would increase the severity of the impact on the commercial fisheries resources described above. However, due to the distance between the Mid-Atlantic lease areas and this one (about 500 miles as presently constituted), the effects of the two areas on commercial fishing are not expected to influence each other. Expanded development in the South Atlantic would increase the risk somewhat. However, fishery resources would be more greatly affected. The probability of impact on scallops, crabs, and oysters, already high, would be increased by additional sales in the area. It must be remembered that the probabilities represent the chances of the oil reaching the resource but do not address the severity nor the duration of the impact. Because of the distances and times involved, it is believed that while such an impact may have severe local effects, the overall impact on the fishery will be temporary and will not contribute to a decline of the resource.

7. Impact on Offshore Cultural Resources

Offshore cultural sites such as known or undiscovered shipwrecks or prehistoric living sites could be impacted by a number of operations carried out in relation to the proposed sale. The placement of drilling rigs (jackup rig legs or mats, drillship or semi-submersible rig anchors, and the actual drilling equipment), pipeline burial operations, and the construction of terminal, storage or pumping facilities all may cause damage or destruction to cultural resources. Operations which place objects on the ocean floor could crush the fragile wood remains of historic ships. Operations which disturb the bottom (drilling holes, setting anchors, burying pipelines) can also destroy or damage all or parts of prehistoric living sites by moving artifacts out of their proper sequence, lifting objects from the protective mud or sand cover and allowing them to be moved by currents, and by actually damaging or destroying artifacts and ecofacts. Unless a magnetometer survey is done of an area prior to the placement of a pipeline or platform, the magnetic signature of a slightly scattered shipwreck could easily be either totally hidden by the much larger anomaly caused by the more modern structure, or the anomaly might be easily interpreted as part of the magnetic signature of the platform or other structure.

Should oil spills occur, and should some of the oil sink to the ocean bottom due either to natural processes or cleanup activities, cultural resources could become coated with oil. The removal of the oil during salvage could destroy or damage the cultural resource, and the presence of oil residue in organic artifacts or ecofacts could negate their being dated by carbon dating procedures. (See section "Mitigating Measures in the Proposed Action" for a special stipulation proposing to precede any operations with a Cultural Resource Survey).

Therefore activities related to this proposed sale could adversely affect some cultural resources such as submerged early Indian sites or sunken historical vessels, on the OCS. However, it is also possible that a beneficial impact could occur if new cultural resources are discovered during pre-operation surveys or during operations.

Shipwrecks: There is only one known shipwreck in the blocks proposed for leasing in this sale. A wreck of presently unknown age or character is located in Brunswick Area, Block 1006. The areas proposed for leasing are generally outside of the highest known concentrations of shipwrecks, however our very incomplete knowledge of the location of shipwrecks, especially older vessels leaves the possibility of there being an unknown wreck in any of the proposed blocks. The Cultural Resource Survey is expected to sample (20% grid) survey the blocks, and shipwrecks located therein should be found. Therefore impacts on historic shipwrecks which might be caused by sale related activities will be minimal.

Pre-historic Living Sites: No pre-historic living sites are presently known on the South Atlantic OCS. Until a study is completed on the possible extent of pre-historic living sites on the OCS all tracts must be assumed capable of containing paleoenvironments suitable as the location of pre-historic man living sites. As such, the Cultural Resource Survey will initially be required on all blocks leased as the result of this proposed sale. The survey is not a complete coverage of the lease block but a 20% sample grid. Should a site be missed by the survey, it could be damaged or even destroyed by sale related activities. Due to the nature of the activities it is unlikely that the destruction of the cultural material would be noticed. The magnitude of the destruction of cultural resources, should any occur, is extremely difficult to determine. Due to the relatively small amount of the Atlantic Ocean floor (up to 105 ha (260 ac)) to be disturbed by petroleum activities resulting from this proposed sale, coupled with the cultural resource survey stipulation, there is little potential for destroying undiscovered cultural resources on the South Atlantic OCS, thus the resulting impact will be minimal. In the future additional impacts can be expected to be added on to those of this sale as further exploration and development takes place in the area. Should pipelines be brought onshore, or oil and gas development occur nearshore (within 3 mi) negative impacts might increase on shipwrecks as the concentration of historic shipwrecks gets heavier closer to the coastline along the Atlantic Coast. The distribution of drowned pre-historic living sites is presently unknown, however it is known that they probably do not extend further out than the maximum exposure of seabottom during the Pleistorene, probably between 40 and 60 meters. Should later development take place further out into the ocean than those depths, there would be no additional impacts on living sites.

The impacts from this sale will combine with those of other sales along the Atlantic Coast (Mid-Atlantic) to increase the total impacts on cultural resources. The impacts expected from the Mid-Atlantic sale are expected to be minor so the total cumulative impact on cultural resources from oil and gas developments off the Atlantic Coast are expected to be minimal.

D. Onshore Impact of Oil and Gas Operations on the Natural Environment

1. Impact on Beaches

The activity which would affect beaches in the planning area, other than a major oil spill, may occur in the transportation phase of development (Section III.A.3.). The importance and location of beaches is discussed in the description of the environment (Section II.F.1.) and the impact of spills on beach recreation is analyzed in Section III.E.6. If pipelines are needed to transport production, then a beach crossing may be necessary. Two-four pipeline landfalls could result from this proposed sale.

As the pipeline approaches the beach, there is a transition from burial by jetting to burial by dredge, either bucket, clamshell, or suction dredge. As this operation crosses the beach, it will disrupt and rework the sand for a width of 10 to 15 m, possibly killing the indigenous beach fauna. A period of at least one year will be required for the disturbed intertidal zone to return to normal.

Above the high-tide line, devegetation will occur along the pipeline right-of-way. Small dunes appear to recover within a few years after the installation of pipelines. Large, primary dunes will surely require much more time. These processes of dune reconstruction can be accelerated by planting of dune vegetation, such that dune communities can be expected to recover within a few years to soil, plant and animal conditions similar to an undisturbed, small dune (Willingham et al., 1975). Therefore, pipelines constructed as a result of this proposed sale should have a minimal impact on beaches.

According to the oil spill risk analysis developed for this area (USGS Open-file Report 76-653), the probability of impact on sandy beaches is high, ranging from 60 to 93%. The effect of oil on the beach biota would depend in large part upon the degree of weathering previously undergone. If the oil arrives on the beach as particles of asphalt-like material with little toxicity, the effects will be minor. Should unweathered oil contact the beaches, then the beach biota will be diminished by the death of those species to which petroleum hydrocarbons are toxic. If cleaning operations are successful in removing the bulk of the oil, then restoration should be rapid and complete within at least two annual cycles. If fresh oil is left on the beach, it will permeate the sand and cause erosion and will continue to leach out of the sand and be a source of chronic pollution for some time. According to the matrix analysis (Section III.F.) oil spills will have a minimal potential impact on these littoral systems. Therefore, the beaches in the planning area, particularly those of Florida, will be affected by oil spills. However, due to the residence time of the oil at sea, the effect will be primarily aesthetic.

2. Wetlands

The transportation phase of development will affect the wetlands in the planning area if the need for pipelines arises and the pipeline right-of-way crosses this ecosystem type. The importance of wetlands and their location is discussed in the description of the environment (Section II.F.6. and 7.).

There are two basic methods of traversing wetlands with a pipeline. The "push" or "shove" technique is possible only where the marsh is firm. In this technique, a narrow, relatively shallow ditch is excavated by a dragline or clamshell digger from the bank. By using a marsh buggy base or by using runners or pads to spread the weight, the damage to the bank is minimized. The ditch may be 1 to 2 m deep by 2 to 3 m wide. The pipe sections are joined together at the point of origin of the ditch, the line given temporary buoyance by strapped floats, and pushed or shoved down the ditch. A section as much as 24 km long can be installed in this fashion. After being floated into place the floats are cut loose and the line allowed to sink to the bottom of the ditch. Typically, there will be approximately 1 m of water above the pipe. The ditch may be left open but is more frequently backfilled. Even with firm marsh, there is generally sufficient subsidence and shrinkage that the spoils will not completely fill the ditch. However, there usually is no canal after completion.

The second method of pipe laying utilizes a flotation canal to provide access for the pipe-laying equipment. Such a canal may be 12 to 15 m wide and two m deep, and may have an additional trench in the bottom to provide 3 to 4 m clearance above the top of the pipeline.

The pipeline is constructed on a series of lay barges and passed over the stern of the train. The pipe is large and heavy, and massive equipment is needed to manipulate it. For example, a standard 12 m section of 1 m diameter pipe weighs approximately 3629 kg. After the addition of a corrosion coating and 76 to 102 mm of concrete to give it negative buoyance, a 12 m section weighs about 15,419 kg. Equipment to handle weights of this magnitude cannot be supported by the marsh.

This type of canal is excavated by a flotation dredge, which normally piles the spoils upon each side to form a low levee. Characteristically, where this type of canaling is carried on, the marshes are soft and unstable, sometimes to the point of being near-floating marshes.

Generally, the spoils are piled back some distance from the canal to leave a 9 to 12 m berm between the canal and the levee. The levees are characteristically low and flat. Depending upon the width and depth of the canal (which determines the quantity of the spoils) and on their stability, a levee may be 1 to 2 m high and possess a base width of 15 to 30 m. The high water content (50-80%) and the organic nature of the excavated muck leads to major shrinkage and subsidence when piled on top of marshland with similar properties. Height reductions of 50% are possible.

Because of these factors, there are never enough spoils from the excavation to backfill a flotation canal. Where canals traverse state-owned land or wildlife refuges, very stringent conditions may be attached to the right-of-way grant with the objective of minimizing impact on the territory, and these may include backfilling a flotation canal. In one recent example, nearly 3 km of flotation canal crossing a wildlife refuge were backfilled. However, as usual there was insufficient spoil material, and additional backfill (nearly 160,000 cubic yards) had to be dredged from a nearby bayou and lake. Backfilling with foreign material on a large scale is probably economically unfeasible, and the environmental impacts of the extensive additional dredging required are unknown but probably not insignificant.

In the course of laying such a line through marshland, numerous bodies of open water will also be traversed. The same equipment may be used, although only a trench will be dredged, or the assembled line can be jetted into place. Hydraulic dredge spoils may be pumped to nearby land, dispersed over the nearby area, or piled up in spoil island, depending on the particular situation.

As with any major engineering effort there are a number of actions and effects from the general pipeline construction operations irrespective of the type of canal constructed. Either type requires surveying and an alignment established and marked. Marsh buggies have normally been used for this operation; these may have a permanent effect on the marshes, especially some softer ones. Even though wide tracks are used, and the unit pressure on the soil is low, the weak marsh structure is compressed and depressed tracts are left. These may not be self-repairing in some cases because of their depth, and may act as erosion foci.

Similarly, when bank-supported draglines are used to dredge push canals, the berm may be damaged, even when pads are used, if the marsh is soft.

In the construction of a flotation canal and laying of a pipeline, there also can be erosion effects upon the canal from the ancillary boat traffic bringing men and materials to the site but this is a short term effect.

Gagliano (1972) has identified several adverse impacts to marshes as a result of pipeline canal dredging. These include primarily the disruption of marsh vegetation, salt-water intrusion, accelerated runoff and increased tidal exchange. Any of these impacts have the potential to reduce a marsh's productivity or alter the floral and faunal components. The duration can be expected to be short-term (less than one year) if the area is rehabilitated upon completion of the pipeline. However, impacts could result for several years if no effort at reclamation is made.

According to the oil spill risk analysis prepared for this area (USGS Open-file Report 76-653), the probability of impact on wetlands is low, ranging from 3 to 7%. Wetlands in the proposed sale area would most likely recover from a single oiling.

Therefore, given the low probability of impact from an oil spill and the minimal number of pipeline traverses envisioned, the impact to wetlands from this proposed sale is expected to be negligible.

3. Vegetation

Upland vegetation will be impacted by construction, both of pipelines and other facilities, and by oil coming ashore from an oil spill. If facilities such as refineries, pipelines, roads, are constructed they would probably be located in already developed areas. Also, any required pipelines will have to be carefully sited in order to minimize adverse impacts due to such construction. The Coastal Zone Management (CZM) program of the South Atlantic states will play a large role in such siting; unfortunately, none of the South Atlantic states presently have an approved CZM program, so this aspect cannot be considered in more detail at this time.

Vegetation at the specific location of pipelines and other facilities will be destroyed, but the areas involved are so small as to be of little significance. Approximately 8 ha would be cleared for operation bases and 20 ha for gas processing facilities. More importantly is the case taken to insure that such construction does not interrupt or change to any degree water flow or drainage. If done, carefully, such construction will allow much of the native flora to return after construction, especially in pipeline areas.

Oil from spills reaching vegetation will have a severe adverse impact if the oil has recently been spilled and is fluid enough to coat the plants and kill them. While the analysis of oil spills from the lease areas shows a probability of 14-17% that oil will reach marshes and wetlands, it is believed that such oil will be weathered and dispersed to the extent of having little effect. More serious is the threat of an oil spill from tankers, dock facilities, or pipelines in close proximity to vegetation so that it is blanketed and killed by recently spilled fluid oil. The probabilities of this occurring at least once during production in this area approaches certainty, so some vegetation will be killed by oil. However, it is believed that such destruction will be limited in area and will recover quickly (within the next growing season), and that no species or populations will be entirely eliminated.

In summary, there will be an adverse impact on coastal vegetation due to oil and gas operations as a result of this proposed lease sale. The impact will be most pronounced in the event of an oil spill in the vicinity of vegetation. Overall, it is believed that the impact on vegetation resulting from this lease sale will be slight and short-term. Similarly, the effects on vegetation in the South Atlantic states from other sales, including potential future sales in the South Atlantic, are considered to be small and temporary.

4. Impact on Wildlife

a. Birds

The bird population of the Atlantic Coast is mainly comprised of migratory species. During the migration period, large populations are concentrated within specific U.S. South Atlantic areas. The most likely birds to be impacted are shorebirds, waterfowl and predatory birds, although other birds may also be impacted. The Arctic peregrine falcon which is on the endangered species list has a migratory route that extends along the entire length of the Eastern Atlantic Coast. It has been estimated that there would be at least a 57% probability that an oil spill occurring within the proposed lease area could affect this species. There would be less than a 2% probability that an oil spill occurring in the potential production area would have an impact on brown pelican rookeries, bald eagle nesting areas or the dusky seaside sparrow habitat.

The migratory waterfowl are probably among the most susceptible due to their flocking habits and the large number of birds using the Atlantic Flyway. Large concentrations of these birds are often found in relatively small areas so that if a spill were to affect an area where the birds are congregated, high mortalities might be expected. Flocks of migratory waterfowl could be impacted during the spring and fall migrations. Also, many waterfowl winter in the U.S. South Atlantic area and therefore would be susceptible during the winter also. If oil should impact these areas, populations can be reduced through loss of habitat or direct fouling. It should be pointed out, however, that most of the refuges and other marshland areas are not liable to direct impacts from spilled oil during drilling or production activities, as most of them are situated within inlets or protected by barrier islands.

Marsh communities of coastal Georgia and to a lesser extent those of coastal North and South Carolina and Florida, might be especially vulnerable to spills from pipelines. Communities adjacent to tanker routes could be vulnerable to spills resulting from tanker accidents.

If a major spill should occur as a result of this proposed sale, habitats utilized by shore birds in the U.S. South Atlantic could be impacted. As Erickson (1963) reports, both habitats and food supply are greatly reduced by oil deposits. Many shore birds rely on intertidal areas which could be affected as a result of a spill. The long-term damage to bird habitats from chronic oil pollution at sea may exceed that caused by irregularly occurring major spills. Murphy (1971) suggests that all hydrocarbons do not degrade readily and carcinogenic ones may persist in the marine environment.

The treating of oil contaminated birds has met with only limited success with the survival record being very dismal. According to Boesch et al. (1974), most birds perish soon after capture while others do not survive the cleaning procedures or the following recuperation period. The use of harmful detergents, improper feeding and handling of the treated birds are thought to have been responsible for the failure of early attempts of treating. Boesch et al. (1974), however, report that established British centers with trained personnel achieve nearly complete survival of treated birds.

Activities associated with pipeline burials, drilling and construction of onshore facilities can affect bird populations in both offshore and onshore environments. If pipeline burial and drilling activities should resuspend toxic elements as metals and pesticides, they can enter food chains to affect bird populations (Appendix I). Onshore impacts from onshore activities that can occur are loss of habitats and other environmental disturbances. The extent of the impacts would depend on time of year and where they occurred. During the migratory or breeding seasons, OCS-related activities could affect bird populations if they should occur nearby. The long-term effects of pipeline burials are not known but are not expected to permanently damage bird habitats. Onshore facilities, depending on the type facility can impact bird populations if they are constructed in sites utilized by birds. If facilities should create changes, as in air and water quality, noise, and so on, they can affect surrounding populations.

In summary, activities associated with pipeline burials and construction of facilities can impact bird populations from disturbances these actions create and through loss of habitat. Disturbances associated with the construction stages are believed to be relatively short-termed and the extent of damage can vary. Loss of habitat due to placement of operation bases (20 ha) and processing plants (8 ha) is expected to be permanent.

The impact of oil on various species of birds is directly related to their behavior patterns and habitats on which they are dependent. Sea birds undeniably receive the greatest impacts, and mortalities can be high as previous cases have shown. Because of the location of proposed tracts for lease, these species would be most likely to receive impacts from an oil spill in the offshore U.S. South Atlantic. In some cases, populations are suppressed for prolonged periods (Uspenskii, 1964). Onshore species can be impacted due to loss of feeding habitat and nesting sites and nests. These species are less likely to be impacted from an onshore spill. They could be impacted by pipeline leaks or breaks or by tanker accidents.

The time of day, season of the year, and sea conditions all play important roles in the species of fowl that occur in a specific area, and the probability that they could be impacted by an oil spill. Spills occurring in the migration periods of spring and fall and wintering period would probably impact the greatest numbers and kinds of birds. The Southeast Atlantic states is the wintering area for many species of birds. Currituck and Pamlico Sound in North Carolina are the major wintering area for such species as the Greater Snow Goose and the Whistling Swan. The east coast of Florida is the wintering area for the Lesser Scaup. If an oil spill were to occur and wash ashore in either of these areas the probability impinging on areas would be about 23%. Since the sea conditions are most severe during the winter months, this would most likely be the most susceptible time for a spill to occur. The impact of an oil spill from a platform, would be minimal since the expected time before the spill would reach shore is greater than 29 days provided no clean up equipment was used.

Some of the species believed to be the most susceptible to contamination by oil at sea that is found in the proposed area are common loons, grebes, scooters, and scaup. Species that are less vulnerable to contamination are the ring billed and great black beak gulls; gull billed, Forster's and Least terns; canvasback redhead and wood duck; Wilson's plover and American oyster catcher.

In summary some of the bird species that would be impacted are the common loons, grebes, scooters and scaup. Other species such as gulls and terns are less vulnerable to oil contamination. Therefore, it is not expected that there would be any serious impact on the bird population of the South Atlantic as a result of this proposed sale or any future sale in the area.

b. OTHER WILDLIFE

The impact on terrestrial wildlife could be direct through habitat encroachment and oil spills and secondary through potential oil spill contamination of food sources.

Direct impacts resulting from construction as a result of the proposed sale would be the greatest on the small mammals, reptiles, and amphibians of the sea (distributions appear in Section II.E.2.b.) at construction sites. It is estimated that a maximum of 122 ha will be required for onshore construction. We have no way of knowing at this time where these new facilities will be constructed, but it likely will be in areas which are already heavily developed and thus will have a minimal impact on wildlife. Pipelines, if constructed, will have an impact on presently undeveloped land and pipeline siting will have to be made with care. The extent of the impact would ultimately depend on habitat recovery (revegetation of the area) but should be limited in magnitude and of short duration. Only those individual animals having home ranges within or overlapping the actual zone of construction could be either destroyed or displaced. This zone could be narrow enough that the initial disturbance should extend little beyond it. There could be, however, a definite alteration of habitat within the construction zone. Whenever vegetation cover of habitat is rendered unsuitable for one animal community, it may be replaced by another community; thus the net change from a food chain viewpoint could be minimal in localized areas.

Any disturbance occurring due to local construction should have only a local and minor impact. This means that there should be little measurable indirect impact on the total system stemming from impact on small animal forms (mammals, reptiles, and amphibians). Much the same can be said for the larger rodents and small predators. There should be little adverse direct or indirect impact on these species. It is possible that a population occupying a very small area could be eliminated, causing greater adverse indirect impact, but no such populations have been identified.

There is potential for direct and indirect impact on both the very small animal forms and larger mammals and predators during any pipeline operation. There could be direct, adverse, short-term impact on small animals (mammals, reptiles, and amphibians) anywhere that an oil spill occurred or reached shore. The impact would depend on the place, the habitat, and the season of the year. It might range from minute to severe depending on the circumstances. There is insufficient information available to evaluate the long-term and indirect effects of oil spills upon small mammals. Shore areas most susceptible to spills would be along pipeline and tanker routes.

Through the beach and marsh vegetation and carrion links in the food web (discussed in Appendix I), it is possible that oil production could affect terrestrial mammals which either constantly or intermittently use habitats subject to oil pollution. Intermittently, deer and other foragers and rodents utilize beach and intertidal zone plants exclusively and would thus be vulnerable to the threat.

Ingestion of oil-covered carrion by foxes, skunks, and shrews would result in petroleum hydrocarbons being assimilated directly at the top of the food chain; however, the relative toxicity of crude oil to these mammals is not known at the present.

The impact on beach-utilizing mammals of oil hydrocarbons that have become entrained in the marine ecosystems from chronic low-level sources is unknown. There is, however, evidence to suggest that chlorinated hydrocarbons which may be resuspended for a time in the water column could cause premature births in California sea lions with a resultant death of pups (Delong et al., 1973). Additional chronic low-level data is presented in Appendix I.

Some mammals could die from ingesting oil from contaminated pelage while grooming (Alaska, 1971). Scavengers such as foxes and skunks could occasionally eat oil-killed animals, and foragers such as deer could eat oil contaminated vegetation thereby ingesting petroleum. It is difficult to estimate possible losses since the effects on animals ingesting hydrocarbons is not well-known at present.

In summary, impact resulting from the burial of pipeline and construction activities will probably be of limited magnitude and of short duration. Species most affected by such construction would be those whose habitat would be destroyed by the construction. Oil spills reaching the shore will also have an impact on wildlife, but this impact is expected to be small because of the time it takes the oil to reach the shore and because the probability of the oil reaching areas of major wildlife habitat such as marsh and wetlands (14-17%) and wildlife refuges (8-9%) is relatively low.

Oil and gas operations in Mid-Atlantic should have little effect on the South Atlantic coastal wildlife due to the distances involved (in excess of 500 miles). However, future South Atlantic sales will increase the risk since more oil will presumably be produced which will increase the risk of a major oil spill. Also, such future sales could increase the number of pipelines that will be built onshore, but the magnitude of such an increase cannot be known at this time. Increased tanker traffic may also result, which would increase the risk of an oil spill near the shore or in harbors, which would greatly increase the risk to wildlife living near such a spill.

5. Endangered Species

The endangered species affected and the characterization of their habitat are discussed in Section II.E.2.e. Those onshore species liable to be impacted are the southern bald eagle, brown pelican, dusky seaside sparrow, Arctic peregrine falcon and Bachman's warbler. Adverse impacts may result to these species in ingesting oil contaminated food. The actual effects resulting from ingesting oil contaminated food are not known at this time, but would certainly not be beneficial. A very remote possibility would be the ingestion of marine forms which incorporated pesticides or metals resuspended during drilling and dredging operations. Also considered remote is a significant reduction of food supply. Additional food chain data is given in Appendix I.

Another possible effect on these birds could be reproductive in nature. In experiments with mallard ducks, Hartung (1965) found that consumption of small amounts of oil disrupted egg laying activities. He also found that eggs smeared with oil had a very low hatching rate. This effect has been noted in osprey on Gardiner's Island, Long Island, but the small sample size and low reproductive success of the remainder of the colony makes it impossible to confidently state that oil was the cause of the failure of the eggs to hatch (Paul Spitger, Cornell University, personal communication, 1976).

Little, if any of the habitat utilized by these species or other endangered species is expected to be lost as a result of the proposed sale. As discussed in previous sections, most of the operations will be restricted to very small areas or corridors. Little habitat is expected to be lost to permanent installations. Possible problems OCS-related facilities may create and possible impacts are discussed in Section III.E.4.

Several colonies of the red-cockaded woodpecker have been identified in the coastal areas of the South Atlantic with the most significant populations occurring in Florida. Since this species is a resident of mature pine forests, it is somewhat removed from offshore leasing. Any primary impact from offshore leasing would result from habitat destruction caused by construction of onshore support facilities and this is not expected to occur in the red-cockaded woodpecker habitat.

The manatee's distribution in the South Atlantic has changed little in recent years and peninsular Florida remains the focus of the species range with appearances in Georgia being relatively uncommon and exceptional in South Carolina. The populations tend to concentrate in select estuarine and river habitats that provide adequate vascular vegetation, recourse to warm water, a source of fresh water, and proximity to channels of at least two meters in depth.

The primary adverse impact to the species that could occur from offshore leasing is that of habitat destruction through water pollution and possible pipeline laying or onshore operations. However, pollution from a lease site is considered remote due to the distance the tracts are from the estuarine areas. Also, it is expected that the currents would considerably dissipate an oil slick before it reached the manatee's habitat.

Increased ship transportation in harbors could also result in injury to the manatee. This would result in a decline in the manatee population.

In summary, the most serious impact on the manatee population would result from increased ship traffic in the harbors. However, in view of the population distributions of the manatee the probability of their habitat locations having an increase in such traffic is slight.

Alligators for all practicable purposes are coastal wide throughout the geographic area of this proposed sale. They are primarily a species of the fresh water environment, but occasionally inhabit brackish marshes. It is not expected that acute or chronic discharges of oil will reach their habitat should this sale proceed. The ingestion of oil-contaminated species is a remote possibility, but if it did occur, it is not expected that this would prove very detrimental for any length of time and would not affect the population as a whole.

The possibility of habitat destruction by allowing salt-water intrusion into the fresh water environment is also possible. However, this would be on a local basis and would not affect the total population to any extent.

Endangered sea turtles in the South Atlantic include the Atlantic ridley, leatherback and hawksbill with the loggerhead and green being classified as threatened. The principal impact that may affect the turtles as a result of offshore leasing is oil washing ashore and possibly contaminating the eggs or hatchlings on onshore installations destroying nesting areas. Individual turtles could be coated with oil if they emerged into an oil slick. But this also would be a remote possibility. This proposed sale should not adversely affect the sea turtle population on a cumulative or immediate basis.

The short-nosed sturgeon could possibly be impacted by habitat destruction through water pollution and possible pipeline laying operations. However, pollution from a lease site is considered remote due to the distance the tracts are from the estuarine areas. Also, it is expected that the currents would considerably dissipate an oil slick before it reached the sturgeon's habitat.

The most destructive impact possible would probably be that of an oil spill reaching the shore or estuaries. As discussed in Sections III.A.4.6., this is not considered very likely. Thus, it is believed that any impacts to endangered species generally as a result of operations proposed by this lease sale would be minor, temporary, and confined to small specific areas, and a few individual animals so that only a small part of the population in question would be affected.

6. Impact on Onshore Water Quality

There are some water quality problems along the South Atlantic coast, especially in the urban centers of Charleston, N.C., Savannah, Ga., and Jacksonville, Fla. These areas also have a great number of discharges. Areas where the population and industrialization is low have good water quality. It is evident that in some of these urban areas the present waste water treatment facilities are being utilized to their fullest extent. Each state is in the process of developing water quality management plans that will identify problem areas and propose a possible solution that will provide adequate treatment.

Changes in the population and industrial sectors as a result of the possible discovery of oil and gas resources in the proposed sale area, would include changes in the water quality of onshore areas in excess of the changes that would occur due to normal growth and development. The largest impact would be on generation of nutrient phosphates and nitrates from municipal sewage, related to projected increases in population. The SEAS model indicates that the nutrient nitrates and phosphates would increase less than six during the peak years of production. This increase was only found in Glynn County, Ga. Maximum increases in population of approximately 5,600 to 10,800 persons, with no one county expected to receive more than 5,000 persons, are indicated.

An estimate of the degree of deterioration of water quality during peak production years due to the increase in population can be made by estimating the increase in sewage loadings. As a "worst" case situation for those areas considered most likely to receive a major portion of the development such as Charleston S.C.; Savannah, Ga.; or Jacksonville, Fla., the maximum increase of 10,800 persons will be used. This population change represents an increase in the BOD loading of 670,140 pounds/year, based on a figure of 0.17 lbs/person/day.

In order to estimate the impact of increased demand on existing water supplies, a figure of 1000 gallons/person/day will be used. This includes municipal, commercial, and industrial needs with municipal and commercial needs representing approximately 20% of the total and industrial needs the remaining 80%. Using the same maximum population increase discussed previously, the increased demand would be approximately 11 million gal/day. This increase would probably not result in the over burdening of local treatment systems since the population increase is expected to be distributed throughout the area.

The effects of increased population could result in an increase in loading for present treatment facilities that are already over loaded. Plans are presently being made by state water quality management boards to comply with the Federal Water Pollution Control Act by increasing present facilities capacities and building new facilities in areas such as Charleston, S.C., Savannah, Ga., and Jacksonville, Fla. New facilities or additions to present facilities should be in operation by July 1, 1977 before any impacts from this proposed sale would be felt.

Increases in most industrial activities would be less than one percent of the present industrial force. The exceptions would be the construction industry and the newly required gas processing industry. Gas processing plants use about 15,000 gallons of water per day and would not seriously affect the water supply of an area. Their contribution of water pollutants would be minimal (CEQ, 1973). With the introduction of natural gas processing plants there would be an increase in auxiliary industry such as industrial organic chemicals and plastics. If this occurs there could be a more serious environmental problem even though these industries employ stringent controls. Any industrial expansion or development would fall under the EPA effluent guidelines for point sources and the water quality standards. These guidelines require the "best practicable" treatment after 1977 and the "best available" after 1983, which should prevent other than incremental deterioration of existing water quality. Pollution from non-point sources may be significant because of increases in construction activity related to the introduction of operation bases (20 ha) and processing plants (8 ha).

An increase in the volume of surface runoff and problems of turbidity and siltation in rivers, streams and estuaries would result from these activities. These impacts are considered most likely to occur in the rivers and near shore areas. Estimate of actual volumes are most possible at this time since the volume is a function of rainfall, slope, erosion control practices, etc. This impact would be short-term, occurring only during the development stage of these facilities.

The SEAS model indicates that if a refinery were constructed in the proposed area there would not be any significant increases in BOD and suspended solids, even if OCS development resulted in increased refinery activity.

Serious water quality degradation could occur within the vicinity of an oil refinery, especially if it were located near an estuary. The oil spill could result in the short-term deterioration and the closing of shell fish harvest areas. This problem would be highly localized near these facilities. Although the problem would be short-term, the results could be severe.

In summary, the water quality would not be severely impacted over the long-term as a result of the proposed sale. The population increases in the area would not result in any major increases needed for sewage facilities. Those facilities that are near or at capacity levels are presently upgraded and will sufficiently handle the minimal population increase. Construction of processing plants and operation facilities would result in only short-term water quality degradation due to runoff.

The development of gas processing plants would result in a minimal effect on the water quality. However, the operations of auxiliary facilities such as industrial inorganic chemicals and plastics plants could result in increased water quality deterioration over a short-term. Refineries would not seriously increase BOD or suspended solids in the water. The most serious problem is accidental oil spills from the refinery and terminal areas. This could severely degrade the water quality for a short-term in the near vicinity.

7. Impact on Onshore Air Quality

The general air quality in the study area is good. The highest pollution concentrations occur in the urban areas of Charleston, S.C.; Savannah and Brunswick, Ga., and Jacksonville, Fla. Most of the monitoring stations in the Air Quality Control Regions (AQCR's) are located in these areas indicating that they are the isolated problems. These urban areas are most likely to be areas for onshore OCS development and activities which further add to the present level of emissions. None of the monitoring stations in the Air Quality Control Regions (AQCR) indicate that the ambient air quality standards for NO_X and SO_X are being exceeded. However, for particulate matter several monitoring stations do indicate that the ambient air quality standards are not being met. This is mostly true of the urban areas around Jacksonville, Fla. and Savannah, Ga., where the levels were 21,607 tons and 48,444 tons per year, respectively. The highest amount of pollutants are being emitted around Jacksonville, Fla. While the greatest amount of carbon monoxide is being discharged in the northern most coastal area of Washington County in North Carolina, which recorded four million tons of CO emissions for 1975.

Changes in population and in the commercial and industrial trial sectors as a result of the possible discovery and development of oil and gas resources in the proposed South Atlantic sale area could induce increases in pollutant levels of particulate matter, SO_X and NO_X. Changes in population have a direct effect on the number of vehicle miles traveled (VMT) and on the volume of residential fuel needed. Changes in economic activity affect the levels of output and fuel use in the commercial and industrial sectors. The major pollutants associated with these sources are indicated in Table D-1. The Harris Model indicates that for the region as a whole, during peak production years in the mid 1980's the increases in population would be less than one percent in most commercial and industrial sectors. The urban areas that would most likely feel an impact are Charleston, S.C., Savannah, Ga., and Jacksonville, Fla.

Transportation also adds pollutants such as NO_X, hydrocarbons, carbon monoxide and particulates into the air. The majority of these emissions result from freight rather than personal vehicles. Small increases of 5% for hydrocarbons and 10% for carbon monoxide emissions was projected during 1988-1996 period. These impacts are brought about due to increased freight transportation activities from construction and other industrial activity related to the operation base. The increase of emissions by personal vehicles would be less than one percent for any given area. Gas processing plants, even with the various advanced treatment devices, add sulfur and nitrogen oxides to the air which cause odor problems and could increase the acidity of rain in the area. Charleston, S.C.; Savannah, and Brunswick, Ga.; and Jacksonville, Fla. The extent of the odor problems, however, could depend on the quantity of sulfur in the natural gas discovered.

The largest impact on air quality would result from a gas processing plant. For the areas where operation bases with terminal facilities are constructed the impacts would be smaller. The potential impacts could result from an increase in NO_X and SO_X. The level of SO_X could result in 5% of the sulfur being emitted into the atmosphere as SO_X. This level would result in non-compliance with environmental standards. However, with further treatment 99.8% of the sulfur can be separated from the natural gas. This would result in less than a 2% increase in SO_X emissions, which would be stringently controlled. The SEAS model projects that the NO_X emissions would increase from 9% in 1988 to 22% in 1996 where a gas processing plant would be in operation. Since their control regulations for NO_X are not stringent, this could result in the deterioration of the air quality.

Another minor impact associated with gas processing plants is acidic rain, however, estimates cannot be made regarding the degree of possible impacts at this time. The results of the environmental study indicated that under worst conditions, high sulfur content of gas and 1971 control levels, rather than most stringent controls, a plant with a capacity of one billion cubic feet per day would emit up to 87,000 tons of sulfur oxides per year. This would be a significant load and would present the potential for increases in acidic rains. However, whether lower pH levels would actually occur would depend upon a complex set of variables, including the constituents of precipitation in the area. Much of the effect would depend upon the amounts of nitric acid in precipitation as well. Therefore, no prediction can be made as to whether a gas processing facility would actually increase the acidity of precipitation, or if it did, the areal extent of effect.

The effects of acid rain are not yet well understood. They may include changes in leaching rates of nutrients, acidification of lakes and rivers, effects on the metabolism of organisms, and corrosion of structures (Likens, 1974).

The exceptions are the anticipated increase in the levels of construction due to the need for onshore support facilities (20 ha), pipelines, access roads, and so on, and the development of gas processing plants (8 ha) where none existed before. Construction activity increases the suspended particulate loadings of the air which increases hazing and soiling. This would be a short-term impact and therefore would not seriously effect the general air quality in the area.

If an oil refinery were built in the South Atlantic, an increase in emissions would result in the vicinity. The estimated typical air emissions for an oil refinery complex are listed in Table D-2. The extent of any environmental impact depends on the different sulfur levels in the oil being refined. There would be an increase of at least 20% of all categories of pollutants with SO_X being the greatest at 10% if there was a refinery. This indicates that the air quality in the vicinity of an oil refinery would be seriously degraded.

In summary, air quality can be effected by population increases, construction of operation bases, and roads, transportation, both personal and freight, gas processing plants and oil refineries.

There is no significant effect on air quality due to population increase, construction activities, and transportation. The overall increase in population throughout the area is less than one percent during the peak years of production. Therefore, this would have little impact on the degradation of air quality. Construction activities would also add only minimal pollutants in the form of particulate matter into the air. This would be short-term and very little deterioration would occur. Transportation would increase in the area and hydrocarbons and carbon monoxide would be emitted. The major contributor would be freight rather than personal vehicles. This should not be considered as serious because of projected stringent controls on automobiles and trucks. Therefore, relative air quality increases over time and small projected increases will not seriously affect the air quality.

The development of a gas processing plant would result in some air quality deterioration. There would be a potential increase of 5% in SO_X emissions. Since further treatment of "sour" gas (gas that has a high sulfur content) is available a minimum increase of less than 2% of SO_X would result. Even if these stringent controls were not applied, there could be some deterioration in air quality due to the introduction of these plants.

The most serious air quality deterioration could result from the introduction of an oil refinery. These could be at least a 20% increase in all types of pollutants with SO_X being the greatest at 80%. This could occur in the vicinity of the refinery and could have a long-term effect on the air quality in that location.

It should be noted that the figures used in calculating the expected rates were on the high side and this would probably not be the case in this region. According to the SEAS model, the projected increases in industrial, commercial, and residential activity related to the hypothetical development of oil and gas resources off the South Atlantic would not create any significant environmental problems.

There would not be any cumulative impact as a result of this or future sales on the general air quality of the region.

Table D-1

Sources of Air Pollutants

SOURCE	MAJOR POLLUTANTS[1]
TRANSPORTATION	
Personal (Automobile and Bus)	SP, SO_x, NO_x, HC, CO
Freight (Trucks)	SP, SO_x, NO_x, HC, CO
RESIDENTIAL FUEL USE	
Natural Gas	SP, SO_x, NO_x, HC, CO
Distillate Oil	SP, SO_x, NO_x, HC, CO
COMMERCIAL FUEL USE	
Distillate Oil	SP, SO_x, NO_x, HC, CO
INDUSTRIAL FUEL USE	
Coal, Gas, Oil	SP, SO_x, NO_x, HC, CO
ELECTRIC UTILITIES	
Oil	SP, SO_x, NO_x, HC, CO
INDUSTRIAL SOURCES	
Gas Processing	SO_x, NO_x, HC
Construction	SP
Petroleum Refining and Storage	HC
Others (Chemicals, Manufacturing)	SP, SO_x, HC
CONSUMER ACTIVITIES	
Dry Cleaning	HC
Painting	HC
Gasoline Service Stations	HC

[1] Suspended Particulates (SP), Sulfur Oxides (SO_x), Nitrogen Oxides (NO_x), Hydrocarbons (HC), and Carbon Monoxide (CO)

Source: EPA. 1975.

TABLE D-2 Estimated Typical Air Emissions (tons/day)

Module	Particulates	SOx	CO	NOx	Hydrocarbons
1000-MBD Low Fuel Oil Refinery Complex	37.9	177.9	10.3	76.5	163.5
1000-MBD High Fuel Refinery Comples	31.9	154.4	10.3	64.9	166.4

Source: Arthur D. Little. New England Regional Commission Energy Program, Tech. Report 75-6 Petroleum Development in New England Vol. Three of Four Volumes.

E. Onshore Impact of Oil and Gas Operations on Human Utilization of the Environment

1. Introduction to the Development Scenarios

Economic development scenarios prepared for this draft environmental impact statement include two base case scenarios without development on the Outer Continental Shelf (OCS) and five scenarios incorporating various hypothetical OCS development schemes. These scenarios are presented in detail in Appendix K, "Economic Study of the Possible Impacts of a Proposed Oil and Gas Lease Sale off the U.S. South Atlantic Coast".

Base I incorporates a projection of economic activity with no additional new refining capacity construction, and no development of oil and gas production on the OCS.

Base II incorporates as projection of economic activity without development of OCS oil and gas production, and with the addition and operation of a general purpose petroleum refinery in Chatham Co., Ga.

The scenarios incorporating the development of oil and gas on the OCS are numbered A, B, C, D, and E. Scenarios A, B, and C incorporate the low resource estimates provided by the Geological Survey (USDI-GS, 1976) and Scenarios D and E incorporate the high resource estimate.

Aside from the level of resource estimates, the principal differences between the scenarios occur in the areas selected as sites for facilities related to OCS operations.

Oil storage and handling facilities, and gas processing plants, were assumed to be located within the counties designated as landing points.

Outline of parameters of development scenarios

a. Scenario A incorporates the following locations for facilities:
   - Operations Base: Chatham Co., Ga.
   - Oil transportation: tankered outside area
   - Gas transportation: none

b. Scenario B includes the following assumptions:
   - Facility locations:
   - Operations Base: Chatham Co., Ga.
   - Oil transportation: by pipeline to Duval Co., Fla., then crude tankered to existing refineries.
   - Gas transportation: by pipeline to Charleston Co., S.C.

c. Scenario C includes the following assumptions:
   - Facility locations:
   - Operations Base: Chatham Co., Ga.
   - Refining location: Chatham Co., Ga.
   - Oil transportation: pipeline to Glynn Co., Ga., overland to hypothetical refinery in Chatham Co., Ga.
   - Gas transportation: pipeline to Charleston Co., S.C.

d. Scenario D includes the following assumed facility locations:
   - Operations Bases: Glynn Co., Ga.; Charleston Co., S.C.; Duval Co., Fla.
   - Oil transportation: by pipeline to Duval Co., Fla., and Charleston, S.C., crude tankered to existing refineries.
   - Gas transportation: by pipeline to Duval Co., Fla., and Charleston Co., S.C.

e. Scenario E includes the following assumed facility locations:
   - Operations Base: Glynn Co., Ga.; Charleston Co., S.C.; Duval Co., Fla.
   - Oil transportation: by pipeline to Chatham Co., Ga.
   - Gas transportation: by pipeline to Glynn Co., Ga. and Charleston, S.C.

Scenario D is deemed to be the most likely scenario, and is used as the basis for impact analysis in Section III.

The other scenarios are analyzed in Section VIII.

2. Land Use Impacts

Table E-3 presents estimated space and locational requirements for facilities which may be required as a result of this sale. Based upon USGS estimates of development needs for the low resource estimate, a total of 44 ha (110 acres) would be required for terminal, storage, and operation bases (Appendix B). The high resource estimate would require 108 ha (270 acres) for these facilities. It is assumed that no refinery construction will be induced in either case. If one each of the remaining facilities listed in Table E-3 were constructed an additional 14 ha (35 acres) would be required. It is expected that unused capacity in some existing facilities would be available (i.e. office space, trucking firms, machine shops) thus a precise estimate of space for new service facilities cannot be made. Even if multiple new facilities are required in some service categories the total area will not be large. Only operations bases, and a few small service companies which require docking facilities, would need to be located in the shore zone itself. While pipeline pumping stations need to be located in coastal areas, the storage facilities do not have to be located in coastal areas, but could be located inland from the pumping stations. Storage facilities are, however, normally located adjacent to the pumping stations.

Scenarios developed for Harris Model analysis, which are based on the highest projected resource discovery, assume that operations bases may be located in Duval County, Fla.; Glynn County,

Table E-3 Estimated Land Use Requirements of Individual OCS Related Facilities[1]

Facility	Acres	Hectares	Locational Requirements
Onshore Operations Base[2] (Includes helicopter pads, warehouse space, small office and dockage)	50.0	20	Inland water docksite with ocean access, Atlantic shoreline not necessary; dockside able to accommodate drafts to 15 feet; industrial zoning.
Pipeline Shore Terminal (including storage facilities)	40.0	16	Rural area desirable; highway access.
Gas Processing Plant	20.0	8	Rural area desirable; highway and rail access.
Onshore Office	--		Rental space; metropolitan area.
Mud Supplier	4.0	1.6	Inland water docksite with ocean access; industrial zoning
Cement Company	5.0	2.0	Inland water docksite with ocean access; highway and rail access; industrial zoning.
Wireline Company	6.0	2.4	Industrial zoning; highway access.
Gas Lift Company	0.5	.2	Industrial zoning; highway access.
Logging and Perforating Company	4.0	1.6	Industrial zoning; highway access.
Rental Tool Company	3.5	1.4	Industrial zoning; highway access.
Wellhead Equipment Company	1.5	.6	Industrial zoning; highway access.
Machine Shop	1.0	.4	Industrial zoning; highway access.
Trucking Firm	5.0	2.0	Industrial zoning; highway access.
Supply Store	2.0	.8	Industrial zoning; highway access.
Downhole Equipment Company	2.0	.8	Industrial zoning; highway access.
Diving Service	0.5	.2	Industrial zoning; highway access.

1 Derived from information from the Offshore Operators Committee, an industry association, with the exception of acreage requirements for gas processing plants, which is from Resource Planning Associates, reported in CEQ's Oil and Gas--An Environmental Assessment.

2 Assumes cooperative ventures between lesses. If this does not occur, additional smaller facilities would be required.

Ga.; and Charleston County, S.C. An oil terminal was assumed to be built in either Charleston County, S.C. or Chatham County, Ga. It was further assumed that a gas processing plant would be located in either Charleston County, S.C.; Glynn County, Ga., or Duval County, Fla. Oil discoveries as a result of this sale are not expected to be sufficient to warrant the construction of an oil refinery in the region. If required onshore bases or oil storage terminals are located in areas where industrial land uses and vacant parcels of suitable industrially-zoned land exist, no adverse land use pattern changes should result. Similarly, if those developments should take place in areas where no industrial bases presently exist, but where developable land is available and such development is considered compatible, impacts would probably be positive. Adverse impacts to land use patterns could occur if such facilities were to be allowed in areas where industrialization or industrial expansion are not compatible.

Gas processing plants do not require coastal locations. They may be near or inland from pipeline terminals if gas and oil pipelines share corridors. Gas processing plants occupy relatively small sites and locational constraints are minimal. They could be placed in existing industrialized areas or in rural areas if local regulations allowed. Siting these plants in industrial areas near population centers could result in the need for incoming gas lines, as well as outgoing lines, to be odorized. The Department of Transportation, Materials Transportation Bureau issued new regulations (Amendment 192-21, Docket No. OPS-241, Federal Register, Vol. 40, No. 91, May 9, 1975) requiring odorization of transmission lines by class location, the class being determined by the population in the area. The expense incurred in this process may account for rural locations desired by industry. Increases are expected in existing areas of petrochemical activity, and incremental increases may result from sale related gas processing. As a consequence, it is not anticipated that gas processing plants will necessarily lead to development of associated petrochemical plants. Therefore, the siting of gas processing plants is not expected to lead directly to other industrial uses. However, to the extent that any industrial facility placed in a previously unindustrialized locality can lead to adjacent industrial land uses, gas processing facilities in such an area could stimulate adjacent industrial uses. In addition, gas processing plants contribute to air quality degradation. Because of the flexibility of their location, they could be placed in either rural or industrial areas, as ample suitable areas of both types exist in the four states.

In an area where no zoning regulations are in force and where no state law specific to coastal facility siting exists, it is possible that industrial or commercial land uses associated with proposed oil and gas operations could develop which would be inconsistent with existing rural land uses in the surrounding area. Where siting and zoning authorities are exercised on a local municipal basis, decisions to site facilities in one municipality could be made which would be adverse to the desires of an adjoining community. For example, a gas processing plant might be allowed to locate in one coastal community in close proximity to a second home and recreation area of another community and be considered undesirable by the second community because of aesthetic reasons, air quality degradation or other reasons. However, siting of a major facility in a coastal area in North Carolina would be subject to state approval and in Florida controversies over land development plans are resolved at the state level. In South Carolina and Georgia, where no coastal area facility siting regulations currently exist at the state level, siting decisions might be made which would adversely affect an adjoining jurisdiction through secondary impacts or because the facility might be inconsistent with neighboring land use. (See Section I.E.2.b.)

Pipeline corridors on land could have adverse impacts if not properly planned for and regulated. If placed across suitable areas, disturbance from burial would be temporary in nature. If placed across wetland areas, areas subject to erosion, with high water tables, poor drainage, or excess slopes, natural processes could be disrupted and/or the pipelines could be exposed. However, these conditions might also constitute engineering problems for the laying of pipeline. These engineering problems could prevent pipeline corridors in such areas, or make alternate routes more attractive economically.

A rough estimate of the width of land disturbed by pipeline would be 15 to 18 meters (50 to 60 feet) disturbed by equipment and a band of perhaps 9 to 12 m (30 to 40 feet) of soil and vegetation removal.

If placed along existing transportation rights-of-way such as highway corridors, used or abandoned railroad rights-of-way or other utility corridors, the long term impact of a pipeline corridor would be minimal—it would be consistent with the existing use of the land. If placed entirely in new corridors, a pipeline would probably traverse many land uses and a swath up to 15 m wide would need to be maintained free of trees or shrubs to permit maintenance vehicle access and to permit surveillance for leakage. Multiple use of the corridor might be made (such as a trail) but disruption and/or removal from other uses could also occur.

No estimates of onshore acreage utilized by pipelines can presently be made. Onshore pipelines for oil (0-2) may be required from landfall sites to a refinery, if one is built in the area. Onshore gas pipelines (1-2) will be required from landfalls, to processing plants, and on to existing transmission systems. Therefore, the amount of pipeline mileage will be dependent, not only on the numbers of pipelines, but landfall locations and location of processing plants relative to landfall and the existing transmission lines. No meaningful estimate can be made at this time. However, maintaining a 15 m (50 foot) swath of land vacant would require about 1.5 ha per km (6 acres per mile) of pipeline.

Secondary Land Use Impacts

In the region there is available acreage to meet cumulative land requirements of increased population and induced development. For example, Resource Planning Associates, for its report to CEQ (in Oil and Gas—An Environmental Assessment) conducted a spatial analysis of the coastal region from eastern South Carolina to northeastern Florida. This analysis included the major urban centers of Charleston, Savannah and Jacksonville, as well as the surrounding rural counties. After removing developed land and land unsuitable for development because of environmental or locational constraints, they concluded that approximately .93 million ha (2.3 million acres) of developable land exists in the roughly triangular area between Georgetown and Orangeburg Counties in South Carolina and Chatham County in Georgia. A five county region around Jacksonville, Florida, was determined to have .73 million ha (1.8 million acres) of developable land remaining. The urbanized and built-up area of the ten coastal sectors discussed in the land use description section (II.G.8) ranged between 1.6 and 6.6% of the sector areas.

While no projection of amounts of required land has been calculated, additional commercial acreage within the region would be needed, as indicated by the growth shown in retail sales. Also required would be additional land for highway or road construction; however, it is not known whether stimulated construction would be in the form of expansion of existing highways or in new highways in new corridors.

Some manufacturing activity may be induced if the proposed sale results in oil discoveries. (Economic Impact subsection b. below.) However, very minimal increases in petrochemical activity would occur; no new facilities are anticipated to be built, but rather expansions of existing plants and higher capacity utilization could occur. Induced increases in industrial activity are anticipated to be stimulated in existing industrialized areas, so that, particularly if adequate land use controls are enforced, siting of these industries should not be a major problem.

It is possible that other rural, somewhat isolated, counties could receive similar induced industrial activity as a result of a combination of several OCS-related activities being located in them. If industries are allowed to locate in areas without existing industry, land use patterns would change. Whether those changes would be adverse would depend on how land use controls are exerted and whether changes are desired by the communities affected.

Induced infrastructure requirements, from a regional perspective, appear to be minimal, as indicated in subsection c. below, with resulting minimal land use implications. The economic analysis indicates that construction in these sectors is not expected to be immediately stimulated by influxes of population, but rather to respond once permanent population levels become apparent.

Within a specific area, however, land use impacts could be substantial if they are not planned for and regulated. If facilities and several thousand people are drawn to one county and tend to concentrate in one or a few locales, accommodation in suitable areas could be a problem.

The Coastal Zone Management Act is designed to be an affirmative program for directing land and water use in the coastal zone. The South-Atlantic states are all scheduled to receive implementation grants in 1977 or 1978, previous to the development of most of the facilities anticipated as a result of this sale. In Chapter VIII, Section B.3. an alternative to delay the proposed sale pending implementation of coastal zone management plans is considered.

Since proposed Sale No. 43 is the initial sale in this area of the OCS, land use impacts that may result from this action may be greater than the impacts associated with a single sale, however additional exploration and production activity will probably mean continued use of land beyond the time estimated for activities resulting from the initial sale, rather than duplication of land requirements for subsequent sales.

In summary, because it is believed that few pipelines and few other onshore facilities will result from this proposed sale, there should be little impact to land use patterns resulting from the sale. States and local governments control facilities and pipeline siting, and such additional construction as is necessary will have to be carefully considered and controlled. If large amounts of oil are discovered, however, which result in refining and pipeline construction becoming economically feasible, such large scale construction could have a significant impact. State siting decisions will have to be carefully made, but as is pointed out above, there is a good deal of land in already industrialized areas so that the ultimate impact on land use patterns will not be unmanageable.

3. Economic Impacts

a. Impact on employment

In order to provide some estimates of the employment and other economic effects that may result from this sale several scenarios incorporating hypothetical locations that might be impacted by OCS related activities were prepared. Dr. Curtis Harris, of the University of Maryland, utilized this input data in the Harris economic model. The output from this model included estimates of the influence of sale related activities upon the population, civilian labor force, earnings, investment, and several other parameters of economic significance. It should be emphasized that the estimates provided below are not predictions that OCS related activity will occur within the political subdivisions identified in the following data presentations or that the degree of economic impact predicted in the various scenarios will be reached, or that the events will occur in accordance with the hypothesized time frames.

The scenarios were chosen to illustrate a range of possible impacts that may result from Sale 43, and although the scenarios are believed to incorporate reasonable assumptions, other scenarios incorporating equally reasonable assumptions could be developed.

The results determined by the various scenarios should be employed with caution, since they are based on rigid assumptions which may not completely reflect the economic changes that the actual operations will produce. Generally speaking, when a choice of data could be made, a selection was made that would tend to produce estimated impacts within the four southeastern states that are probably higher than those which may result from actual operations. Some of these assumptions include:

(1) All employment and the subsequent population estimates, are identified with specified counties within the various scenarios. Other information indicates that offshore workers could reside within a 250 mile radius of the operations point, an area considerably larger than a single county, and the density of population could be less than anticipated.

(2) All investment in facilities has been assigned to specified counties. In the event that expenditures are made in other areas, where specialized facilities for the manufacture of some types of equipment are in existence, the investment, and resulting employment will be less than anticipated.

(3) Allocations of Federal funds have been included as input data into the models. Although the recent Coastal Zone Act amendments establish a link between OCS activity and additional Federal funding, a more precise value would probably differ from the sum included for these estimates.

In considering the coastal region as a whole, the relationship between the number of persons directly employed as a result of sale related activities (input data) and the total increase in the number of employed civilian persons ranged from 1.79 to 4.38. In Scenario B, the relationship ranged from a value of 2.02 in the year 1980, to 4.38 in 1996. In Scenario C, the relationship ranged from 2.00 in 1980 to 3.61 in 1996. In Scenario E, the relationship ranged from 1.79 in 1980 to 3.35 in 1996.

In the South Atlantic Region, which consists of the coastal portions of the four state area, the estimated changes in total civilian employment that are attributed to the sale range from 955 to 7,817, depending on the scenario chosen and the year from which the data are selected.

A summary of the scenarios and the change in civilian employment will be found in Table E-5 and Table E-6.

Tables E-7, E-8 and E-9 include estimates of the changes in the numbers of civilian persons employed as a result of the hypothesized scenarios described previously. The data are provided as estimated employment effects on a county basis. These data represent the lowest employment impact noted in a specific county from any of the postulated scenarios, as well as the highest employment impact from any of the scenarios. The average shown is the average of the employment impacts in a specific county resulting from the five specified scenarios. The sum of the minimum or maximum county employment impacts will not necessarily agree with the estimates relating to the state coastal region totals, since for any given scenario, minimal estimates in one county may be accompanied by moderate increases in an adjacent county; and in another scenario, the situation may be reversed.

These estimates may provide some concept of the range of employment changes that may result on a county level. However, no estimates of the probability of a given scenario being correct could be determined except that the resource estimates provided by the Geological Survey indicate that the low resource estimates used in Scenarios A, B, and C have a higher probability than the high resource estimates incorporated in Scenarios D and E. One possible use of these tables would be to form a tentative concept of the employment impacts in specified areas, given that part of the total impacts may occur in other parts of the coastal region.

The changes in Civilian Employment for these 5 scenarios, as presented on the tables, provide the range in civilian employment impacts on a county level. For example, in the year 1988, the Civilian Employment impact in Charleston County, South Carolina could range from −89 to 4,104 depending on the scenario chosen. The average civilian employment impact from the five runs amounts to 1,228 persons. If each of the scenarios was assigned an equal probability of occurrence, then the average would serve as the expected value. However, this degree of quantification has not been made, nor are the number of scenarios selected sufficient to exhaust all possible points of onshore impact, therefore at the present time, the ranges of effects are the preferred guide to the extent of economic impacts that may result from the sale.

Although the projections of base line conditions are a basic calculation of the Harris Model, selected comparisons have been made to other projections.

The estimated total employment for three specified Standard Metropolitan Statistical Areas have been obtained from Volume 5, 1972 OBERS Projections, based on the Series E population projections.

The minimum and maximum employment impacts anticipated for these areas have been compared to this total estimated employment.

In the event that increases in employment should result in communities smaller than the metropolitan areas identified in Table E-11 employment impact would be greater than indicated.

For example, in Glynn County, Ga., the estimated high change in civilian employment in the year 1988 amounts to 1,614 persons. The 1973 issue of County Business Patterns indicates a total at 16,410 employees within the county during March of that year. In this case, the civilian employment impact would be equal to approximately 10 per cent of the 1973 employment. In the event that employment should increase in Glynn County during the 15 year period 1973-1988, the civilian employment in Glynn County should increase, thus anticipated impact would be a smaller percentage of the total civilian employment.

The impact of this proposed sale in the coastal portions of the South Atlantic states on civilian employment is a small, but positive, increase in employment. The maximum increase in sale induced civilian employment occurred in the year 1988 (Scenario D), with a projected increase of 4,203 in South Carolina, and a total of 7,818 in the entire four state region.

Additional subsequent sales in this area could have a similar impact on employment, but it is more likely that smaller increases in incremental employment would result from these additional sales, due to the use of terminals, pipelines, and operations bases for longer periods of time. No employment effects from the Mid Atlantic and North Atlantic OCS leasing activity are anticipated in the South Atlantic states.

Table E-5 Summary of Sale Induced Civilian Employment (South Atlantic Region)

YEAR	Scenario A	B	C	D	E	Average
1980	955	955	947	2661	2646	1633
1984	2682	1856	1843	3824	3883	2818
1988	1241	1329	1202	7818	5903	3499
1992	1038	1770	1515	3933	3593	2370
1996	1080	1999	1633	4285	3709	2541

Note: Scenarios A, B, and C are based on the low resource estimates, Scenarios D and E are based on the high resource estimates. Rounded to the nearest unit.

Table E-6 Summary of Sale Induced Civilian Employment By States - Selected Years

State & Year	A	B	C	D	E
			Scenario		
N. Carolina					
1980	12	12	12	20	20
1988	14	14	15	57	48
1996	12	21	23	36	50
S. Carolina					
1980	62	62	62	812	813
1988	57	-64*	-62*	4203	2263
1996	52	448	454	1448	1388
Georgia					
1980	850	850	843	894	894
1988	1149	1155	1220	1539	2111
1996	995	1064	1113	1001	1350
Florida					
1980	31	31	31	935	919
1988	22	224	30	2019	1482
1996	21	465	44	1799	921

* Accompanied by decrease in unemployment, indicating migration of labor force.

Table E-7

Summary of Civilian Employment
Range and Average from Five Scenarios

State and County	Year 1980 Low	High	Average (rounded)
North Carolina			
Brunswick	1	1	1
Columbus	2	4	3
New Hanover	7	12	9
Pender	2	3	2
South Carolina			
Beaufort	4	4	4
Berkeley	2	4	3
Charleston	40	777	335
Colleton	1	2	1
Dorchester	3	5	4
Georgetown	3	6	4
Hampton	0	0	0
Horry	~~6~~	10	8
Jasper	1	1	1
Williamsburg	2	3	2
Georgia			
Bryan	0	1	0
Camden	0	0	0
Chatham	109	838	545
Effingham	2	4	3
Glynn	6	775	314
Liberty	3	4	3
Long	0	1	0
McIntosh	0	0	0
Florida			
Baker	1	2	1
Clay	3	5	4
Duval	21	918	377
Flagler	0	0	0
Nassau	1	1	1
Putnam	3	5	4
St. Johns	1	3	2

Table E-8

Summary of Civilian Employment
Range and Average from Five Scenarios

Year 1988

State and County	Low	High	Average (rounded)
North Carolina			
Brunswick	1	3	2
Columbus	2	10	5
New Hanover	8	35	18
Pender	2	8	4
South Carolina			
Beaufort	3	8	5
Berkeley	3	13	6
Charleston	-89	4104	1228
Colleton	1	5	2
Dorchester	3	13	7
Georgetown	3	19	9
Hampton	0	0	0
Horry	7	29	15
Jasper	1	4	2
Williamsburg	2	9	4
Georgia			
Bryan	1	11	4
Camden	-1	0	0
Chatham	180	1193	825
Effingham	3	11	6
Glynn	5	1614	593
Liberty	1	9	4
Long	1	2	1
McIntosh	1	6	2
Florida			
Baker	2	7	4
Clay	3	14	7
Duval	10	1971	730
Flagler	0	1	0
Nassau	1	3	2
Putnam	4	15	8
St. Johns	2	7	4

Table E-9

Summary of Civilian Employment
Range and Average from Five Scenarios

Year 1996

State and County	Low	High	Average (rounded)
North Carolina			
Brunswick	1	5	3
Columbus	2	8	4
New Hanover	8	32	18
Pender	2	5	3
South Carolina			
Beaufort	2	8	5
Berkeley	2	7	5
Charleston	30	1389	712
Colleton	1	4	2
Dorchester	3	12	7
Georgetown	4	10	6
Hampton	0	1	0
Horry	6	21	13
Jasper	1	8	4
Williamsburg	2	5	3
Georgia			
Bryan	0	10	4
Camden	0	1	0
Chatham	139	1088	737
Effingham	2	8	5
Glynn	5	886	350
Liberty	2	6	4
Long	1	4	3
McIntosh	0	4	2
Florida			
Baker	2	4	3
Clay	3	7	5
Duval	10	1765	624
Flagler	0	1	1
Nassau	1	12	6
Putnam	4	14	8
St. Johns	2	7	4

Table E-10

Output Categories
Harris Multiregional Multiindustrial Model

Civilian Labor Force
Net Commuters
Civilian Unemployment
Civilian Unemployment Rate
Population Density
Multijob Holders
Net Population Migration
Population Associated with Labor Force Surplus
Population
Personal Income
Earnings
Property Income
Social Insurance Payments
Transfer Payments
Agricultural Value of Land Per Acre
Federal Government Expenditures (exclude construction)
State and Local Government Expenditures
Federal Government Purchases (exclude construction)
State and Local Government Purchases
Personal Consumption Expenditures
Private Investment
Per Capita Income
Total Supply
Total Demand
Domestic Output
Competing Imports
Non-competitive Industry Imports
Non-competitive Consumer Imports
Gross Foreign Exports
Value Added
Equipment
Construction
Federal Defense Expenditures
Gross Regional Product

Table E-11 Comparison of Future Estimated Employment

SMSA 1/	1990 Total Employment	Minimum	Maximum	Maximum Impact Per Cent
Jacksonville, FL	323,600	10 2/	1971 2/	0.6%
Savannah, GA	84,600	180 3/	1193 3/	1.4%
Charleston, SC	135,500	-89 4/	4104 4/	3.03%

1/ Standard Metropolitan Statistical Area

2/ Duval Co., FL

3/ Chathan Co., GA

4/ Charleston, Co., SC

b. Impact on income

For the purpose of providing an estimate of the economic impacts that may result from OCS Sale 43, additional summary sheets have been prepared on the selected variables: earnings (Tables E-12 and E-13), change in per capita income (Tables E-14 and E-15), residential construction (Tables E-16 and E-17), and private investment (Tables E-18 and E-19). These data are presented for Scenarios B and E as examples of the type and degree of impact that may be expected.

The effect of the sale related activities on earnings, as developed by Scenario E (Table E-13), indicates a maximum increase of earnings amounting to more than 88 million dollars in the year 1988 for the entire South Atlantic region. The major increases in earnings were recorded in Duval County, Florida, Glynn County, Georgia, and Charleston County, South Carolina. For Scenario E Charleston County, South Carolina was assumed as the location for operations base and a gas terminal and gas processing plant; Glynn County, Georgia was assumed as the location of a gas terminal and an operations base; and Duval County, Florida, as an operations base. The base case for this calculation incorporated an operating petroleum refinery in Chatham County, Georgia. Of the total of 88 million dollars increase in earnings in 1988, approximately 90% was attributed to the three counties. The change in civilian persons employed indicates than 89% of the increase in employment can be expected in these three counties. On the basis of a comparison between the earnings and civilian persons employed, the impact on both of these factors appears to be most pronounced at the areas selected for the onshore sites for OCS related activites, and the effects in adjacent counties appears to be minimal. In large part, the distribution of employment effects is controlled by the specification of the input data. Alternative residential locations could have been specified for the work force associated with sale related activities, and presumably, this substitution would have produced different impact patterns.

The relationships discussed above suggest that, prior to additional information to be gained from additional events; such as the actual sale, the exploratory drilling, the production operations (should the exploratory drilling produce encouraging results), the onshore income effects to be anticipated from a sale are highly speculative

Considering Scenarios B (Table E-14) and E (Table E-15), changes in per capita income as a result of the proposed sale were either neutral or positive in all cases with the exception of a negative effect in Williamsburg County, South Carolina, in the year 1996 (Table E-13), and in Chatham County, Georgia in the years 1988, 1992, and 1996. However, the per capita income effects in the states, and for the region, were positive for both scenarios over the years covering the operations.

In summary, the impact of the sale on incomes in the South Atlantic coastal area is forecast to be a moderate increase in per capita income in the region, concentrated in those areas in which onshore facilities are established.

Additional sales in the area, resulting in additional employment, would be expected to also have an incremental positive impact on per capita income. The income effects are foreseen to be mostly limited to local areas.

The impact of additional sales in the Mid Atlantic and South Atlantic areas are not foreseen to have a significant impact on per capita incomes beyond the vicinity of the support and terminal facilities resulting from the proposed sales.

c. Impact on residential construction

Output estimates are available for several construction sectors. The summary table has been prepared for the category residential construction for Scenarios B and E.

In Scenario B (Table E-16), residential construction due to sale related activities is anticipated to increase from $659 (thousand 1972 dollars) in the year 1980 to $2,014 (thous. 1972) in 1986 and to decline to approximately $1,000 (thous. 1972) in the year 1996. These construction impacts are concentrated in Duval County, Florida, Chatham County, Georgia and Charleston County, South Carolina.

In Scenario E (Table E-17) based on the high resource estimates, the sale related increase in residential construction ranges from $1,288 (thous. 1972) in the year 1980 to $5,825 (thous. 1986) in the year 1986, and declines to approximately $1,900 (thous. 1972) in the year 1996.

This estimated increase in sale-related residential construction supports the hypothesis that additional land for the construction of residential facilities will be required.

Table E-12

SCENARIO B-I SUMMARY OF ECONOMIC IMPACTS

Earnings - Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	9	11	9	14	19
Columbus	19	31	21	29	32
New Hanover	55	90	70	102	143
Pender	19	32	21	26	29
S. Carolina					
Beaufort	117	211	136	172	188
Berkeley	18	31	20	24	26
Charleston	491	742	-103	5313	6901
Colleton	7	11	8	13	16
Dorchester	21	34	24	31	38
Georgetown	21	38	26	32	35
Hampton	2	3	3	4	5
Horry	70	118	83	103	116
Jasper	4	7	9	18	34
Williamsburg	12	20	8	21	22
Georgia					
Bryan	4	8	10	24	24
Camden	0	-1	0	1	3
Chatham	11,945	25,327	18,296	17,561	19,316
Effingham	18	34	26	31	51
Glynn	62	101	66	77	83
Liberty	32	49	30	38	41
Long	3	6	6	12	22
McIntosh	4	8	10	15	25
Florida					
Baker	11	17	13	19	21
Clay	30	49	33	37	40
Duval	299	914	3410	5838	7685
Flagler	3	5	4	5	6
Nassau	11	14	12	24	36
Putnam	34	59	44	61	77
St. Johns	19	29	22	29	35

All figures are in thousands of 1972 dollars.

Table E-13 SCENARIO B-I SUMMARY OF ECONOMIC IMPACTS

Change in Per Capita Income Impact Estimates

State & County	1980	1984	1988	1922	1996
N. Carolina					
Brunswick	0	1	0	0	1
Columbus	0	1	1	1	1
New Hanover	1	1	1	1	1
Pender	1	2	1	1	2
S. Carolina					
Beaufort	1	3	2	2	2
Berkeley	0	1	0	1	1
Charleston	1	2	3	7	10
Colleton	0	0	0	0	1
Dorchester	1	1	1	1	1
Georgetown	1	1	1	1	1
Hampton	0	0	0	1	1
Horry	1	1	1	1	1
Jasper	0	1	1	1	2
Williamsburg	0	0	0	0	-3
Georgia					
Bryan	1	1	1	1	7
Camden	0	0	0	0	0
Chatham	22	64	26	19	21
Effingham	1	2	2	2	3
Glynn	1	2	1	1	1
Liberty	1	2	1	1	1
Long	1	1	0	0	1
McIntosh	1	1	0	0	1
Florida					
Baker	1	1	1	1	1
Clay	1	1	1	1	1
Duval	0	1	9	12	13
Flagler	1	1	1	1	1
Nassau	0	0	0	0	0
Putnam	1	1	1	1	1
St. Johns	1	1	1	1	1

All figures are in thousands of 1972 dollars.

Table E-14

SCENARIO B-I SUMMARY OF ECONOMIC IMPACTS
Residential Construction Impact Estimates
(Thousands of 1972 dollars)

State & County	1980	1984	1986	1988	1992	1996
N. Carolina						
Brunswick	0	0		1	1	0
Columbus	0	0		0	1	1
New Hanover	1	1		2	2	3
Pender	1	1		1	0	1
S. Carolina						
Beaufort	5	5	7	5	4	4
Berkeley	0	0		0	0	0
Charleston	18	16	368	150	160	198
Colleton	0	0		0	0	1
Dorchester	1	1		1	1	1
Georgetown	0	0		1	1	0
Hampton	0	-1		0	0	0
Horry	2	3		3	2	3
Jasper	1	0		0	1	1
Williamsburg	1	0		-1	1	0
Georgia						
Bryan	0	0		1	0	1
Camden	0	0		0	0	0
Chatham	617	694	885	748	579	589
Effingham	0	0		1	1	2
Glynn	2	2		2	2	2
Liberty	1	1		1	1	2
Long	0	0		0	0	0
McIntosh	0	0		0	1	1
Florida						
Baker	1	0		0	1	1
Clay	1	1		1	1	0
Duval	6	13	736	60	145	192
Flagler	0	0		1	1	0
Nassau	0	0		0	1	1
Putnam	1	0		2	2	1
St. Johns	1	0		1	1	1
Region	659	741	2014	981	902	1002

Table E-15 SCENARIO B-I SUMMARY OF ECONOMIC IMPACTS
Private Investment Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	0	0	1	2	3
Columbus	0	0	1	3	2
New Hanover	1	0	2	4	9
Pender	1	0	1	1	1
S. Carolina					
Beaufort	5	6	6	6	7
Berkeley	0	0	0	0	1
Charleston	27	28	394	1042	1444
Colleton	0	0	0	1	2
Dorchester	1	0	1	1	2
Georgetown	0	0	1	1	1
Hampton	0	0	0	0	0
Horry	3	3	5	6	9
Jasper	0	0	0	1	2
Williamsburg	0	1	-1	1	2
	36	37	407	1061	1470
Georgia					
Bryan	0	0	0	1	1
Camden	0	0	0	0	0
Chatham	15,975	69,944	8,817	4,075	4,243
Effingham	1	1	1	1	2
Glynn	3	2	3	3	3
Liberty	2	1	1	1	2
Long	0	0	0	1	1
McIntosh	0	1	2	3	4
Florida					
Baker	0	0	1	1	2
Clay	1	1	1	1	1
Duval	8	223	1313	2670	4117
Flagler	0	0	0	0	0
Nassau	0	0	0	1	2
Putnam	1	0	2	3	5
St. Johns	1	0	1	2	3
Region	16,030	70,213	10,556	7,833	9,871

All figures are in thousands of 1972 dollars.

Table E-16

SCENARIO E-II SUMMARY OF ECONOMIC IMPACTS
Earnings Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	13	17	25	34	47
Columbus	31	46	74	60	89
New Hanover	88	133	227	243	366
Pender	33	50	78	59	66
S. Carolina					
Beaufort	201	320	502	342	347
Berkeley	31	47	72	49	53
Charleston	9979	17248	33,288	15,411	21,952
Colleton	9	14	24	31	40
Dorchester	36	53	87	70	88
Georgetown	36	57	92	66	69
Hampton	3	5	7	8	12
Horry	116	117	283	220	256
Jasper	7	11	22	45	96
Williamsburg	18	29	46	40	38
Georgia					
Bryan	7	13	28	64	157
Camden	-2	-3	-2	4	8
Chatham	1514	2274	6917	7,397	7157
Effingham	32	54	89	68	86
Glynn	10,566	17,415	23,684	19,398	17,412
Liberty	50	73	107	86	78
Long	6	9	18	34	64
McIntosh	7	13	25	32	57
Florida					
Baker	18	27	40	36	39
Clay	50	74	116	76	75
Duval	12,213	16,262	22,203	14,602	14,995
Flagler	5	8	13	11	15
Nassau	11	17	32	67	104
Putnam	56	88	143	133	173
St. Johns	31	45	74	67	82
	12,385	16,521	22,622	14,992	15,483
Region	35,165	55,076	88,315	58,752	64,023

All figures shown are in thousands of dollars.

Table E-17

SCENARIO E-II SUMMARY OF ECONOMIC IMPACTS
Change in Per Capita Income Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	1	1	1	1	1
Columbus	1	1	2	1	2
New Hanover	1	1	2	2	3
Pender	2	3	5	3	3
S. Carolina					
Beaufort	3	4	7	4	4
Berkeley	1	1	2	1	1
Charleston	16	24	53	27	38
Colleton	1	1	1	1	1
Dorchester	1	2	2	2	2
Georgetown	1	2	3	2	2
Hampton	0	1	1	1	1
Horry	1	2	3	2	2
Jasper	1	1	2	4	6
Williamsburg	1	4	4	4	3
Georgia					
Bryan	1	2	3	2	12
Camden	0	0	1	1	1
Chatham	6	11	-58	-53	-66
Effingham	2	4	6	4	6
Glynn	76	117	212	221	212
Liberty	2	3	4	3	3
Long	1	2	3	4	6
McIntosh	1	2	3	3	6
Florida					
Baker	1	2	3	2	2
Clay	1	2	3	2	2
Duval	7	9	15	5	5
Flagler	1	2	3	2	2
Nassau	0	1	1	2	2
Putnam	1	2	3	2	3
St. Johns	1	1	2	2	2

Table E-18

SCENARIO E-II SUMMARY OF ECONOMIC IMPACTS
Residential Construction Impact Estimates
(Thousands of 1972 Dollars)

State & County	1980	1984	1986	1988	1990	1992	1996
N. Carolina							
Brunswick	0	0		0		1	1
Columbus	1	0		1		1	2
New Hanover	1	2		4		4	8
Pender	1	1		1		2	1
S. Carolina							
Beaufort	7	8	24	12		9	8
Berkeley	1	0		0		0	0
Charleston	0	549	666	343	1422	438	620
Colleton	0	0		0		1	1
Dorchester	1	1		2		2	2
Georgetown	1	1		1		1	2
Hampton	0	0		0		0	0
Horry	3	4		6		6	6
Jasper	0	0		1		1	2
Williamsburg	0	1		1		0	1
Georgia							
Bryan	0	1		0		1	3
Camden	0	0		0		0	0
Chatham	48	77	2230	297		297	260
Effingham	1	1		2		2	2
Glynn	413	565	2286	795		656	485
Liberty	2	2		2		2	2
Long	1	0		1		1	2
McIntosh	0	0		1		1	2
Florida							
Baker	0	1		1		0	1
Clay	1	2		2		1	2
Duval	407	438	582	647		458	460
Flagler	0	0		0		0	1
Nassau	0	0		1		2	2
Putnam	1	1		2		3	4
St. Johns	0	1		1		1	2
Region	1,288	1,652	5,825	2,385		1,873	1,878

Table E-19

SCENARIO E-II SUMMARY OF ECONOMIC IMPACTS
Private Investment Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	1	2	3	4	5
Columbus	3	5	8	6	8
New Hanover	12	18	30	25	32
Pender	3	4	7	5	5
S. Carolina					
Beaufort	4	6	8	8	8
Berkeley	4	7	10	7	7
Charleston	777	1,284	2,178	970	1,313
Colleton	2	2	4	4	4
Dorchester	5	7	11	9	12
Georgetown	6	9	15	10	10
Hampton	0	0	0	0	1
Horry	10	16	25	18	21
Jasper	1	2	3	4	8
Williamsburg	3	5	7	5	5
Georgia					
Bryan	1	1	3	6	10
Camden	0	0	0	0	1
Chatham	110	193	474	464	430
Effingham	4	6	9	6	430
Glynn	775	1,187	1,614	1,095	886
Liberty	4	6	8	7	6
Long	1	1	2	3	4
McIntosh	0	1	1	2	4
Florida					
Baker	2	4	5	4	4
Clay	5	8	12	7	7
Duval	902	1,096	1,441	900	876
Flagler	0	1	1	1	1
Nassau	1	2	3	7	12
Putnam	5	8	13	11	14
St. Johns	3	4	7	6	7
Region	2,646	3,883	5,903	3,593	[illegible],709

The residential construction requirements for this proposed sale and subsequent possible lease offerings that may occur on the OCS adjacent to the South Atlantic states are forecast to occur in the vicinity of the locations of the support facilities and terminals. The incremental additions resulting from future sales would be less than those attributed to this sale, due to the probable use of facilities established for the initial sale to service activities resulting from subsequent OCS leasing.

The cumulative impact of this proposed sale and the OCS leases issued in the Mid Atlantic region on residential construction in the South Atlantic states would be limited to the areas in the vicinity of support facilities and terminals. No induced residential construction in the South Atlantic area is anticipated to result from operations germane to the Mid Atlantic area, nor would residential construction be induced in the Mid Atlantic states as a result of Sale 43.

d. IMPACT ON PRIVATE INVESTMENT

The impact on private investment (Tables E-18 and E-19) was also either neutral or positive for all counties during the estimated time span of the project, with the exception of a slight decline in Williamsburg County, South Carolina in 1988 (Scenario B, Table E-18). The private investment effects due to proposed sale related activities were positive for each state, as well as for the region as a whole.

The cumulative impacts that are expected to result from this proposed lease offering, as well as future proposed lease offerings in the South Atlantic region, may be greater than those estimated to result from a single sale, but not to increase in direct proportion to the amount of acreage offered in these various sales, but to increase at a rate less than the acreage offerings.

Private investment related to OCS acreage offerings in the Mid Atlantic region would take place primarily in regions adjacent to the sale area, and would have little, or no effect on private investment in the South Atlantic region.

e. SUMMARY OF ECONOMIC IMPACTS

To summarize, the major direct economic impacts of the sale are estimated to consist of increases in civilian employment generally occurring within the coastal portions of the four state area, increases in earnings, generally positive effects on per capita income, increases in residential construction expenditures, and increased private investment. For certain counties, however, exceptions to these general conclusions have been noted in the output provided by the Harris Model calculations.

The impact of the various factors considered within the frame of economic impacts were experienced primarily within the coastal areas of the South Atlantic states, and were concentrated within the counties assumed to be the sites of support facilities and terminals.

Since proposed Sale 43 is the initial offering of OCS leases in the South Atlantic region, future cumulative impacts may be greater than those estimated for a single sale. However, the largest economic impacts would result from the installation and operation of facilities required for the initial sale, and these facilities would probably be employed to service additional acreage and production resulting from future sales.

Therefore, it is probable that the effect of additional sales would be to extend the use of these facilities beyond the time required for servicing the output from the original lease offering.

OCS leases have recently been awarded in the Mid Atlantic region, and consideration is being given to lease offerings in the North Atlantic region of the OCS.

It is not likely that operations in these areas will have an economic impact in the coastal areas of the southeastern U.S., nor that operations in the South Atlantic OCS will have an economic impact in the northern portions of the Atlantic Coastal states.

4. Impact on Population

The changes in population in the coastal regions of the states of North Carolina, South Carolina, Georgia, and Florida that may be attributed to activities resulting from proposed OCS Sale No. 43 have been estimated by Dr. C. Harris of the University of Maryland, based on input data provided by the New Orleans OCS Office of BLM.

The changes in population in the entire four state area range from 2,022 to 22,111, depending on the year chosen and the assumptions incorporated into the hypothetical development schemes, or scenarios (refer to Table E-20).

For the entire Atlantic coast region of the states of North Carolina, South Carolina, Georgia and Florida, the population changes estimated to result from Sale 43 vary depending on the scenario selected (refer to Table E-21).

Table E-20 Increased Population (Sale 43)

State & Year	A	B	C	D	E
			Scenario		
N. Carolina					
1984	-10	-7	-7	57	-16
1988	-3	-2	-1	115	-20
1996	-2	8	9	82	22
S. Carolina					
1984	24	33	-15	3888	3481
1988	4	-346	-386	12462	5441
1996	30	976	922	4370	2334
Georgia					
1984	5321	3438	3186	3883	3709
1988	4484	3033	2913	4459	7327
1996	4187	2783	2358	2861	4731
Florida					
1984	-14	75	-4	2824	2628
1988	-20	-664	-14	5075	2822
1996	-24	-467	-15	4385	2392

Table E-21 Population Impacts (Sale 43)
South Atlantic Region
Scenario

Year	A	B	C	D	E
1980	2272	2272	2222	7,301	6,613
1984	5321	3540	3159	10,652	9,802
1988	4464	2022	2512	22,111	15,570
1992	4010	3154	3380	10,680	9,636
1996	4192	3300	3274	11,698	9,478

Scenarios A, B, and C are based on the low resource estimate provided by the U.S. Geological Survey, and Scenarios D and E are based on the high estimates. The variation in population is large, when all of the scenarios are considered, but the range in estimated impacts narrows when the scenarios are considered as two groups. In runs A, B, and C the population impacts vary from 2,022 to 4,464 and in scenarios D and E the estimates range from 6,613 to 22,111.

Generally speaking, each scenario indicates an increase in population followed by a subsequent decrease. This effect is more pronounced in Scenarios D and E than in the scenarios incorporating the low resource estimates.

Population impacts on a county level have been calculated by Dr. Harris. A summary of these population changes for scenarios B and D have been included in the following Tables, E-22 and E-23.

The distribution of the population is closely related to the regions postulated in the scenarios as potential points for operating bases, gas processing plants, pipeline terminals and other sale related facilities, and, therefore, the population distributions are subject to the assumptions made for the various scenarios. The scenarios, although believed to be reasonable, are not the only reasonable scenarios that could be developed. The population impact projections can be viewed as a range of possible population changes that may result from activities relating to OCS Sale No. 43.

The population impacts developed with the use of Scenario D, which incorporates the high resource estimates, present an impression of small changes in population with the exception of the counties designated as the location of operations bases, oil or gas terminals, or gas processing plants. In these areas, relatively large population increases (more than 1000) occur, particularly in the case of Charleston County, South Carolina, where the population impact was estimated to increase from 2,258 in the year 1980 to 12,216 in the year 1988, diminishing to 3,017 in the year 1992, and increasing again to 4,197 in the year 1996.

The other population impacts are small, either increases of less than 50 persons, or small declines.

The population impacts developed by the use of Scenario B are generally smaller in scope. Chatham County, Georgia was projected as the county with the largest population impact. The population increase amounted to 2,209 in 1980, increased to 3,435 in 1984, and declined to 2,773 in 1996.

A summary of the population changes attributed to activities related to proposed Sale 43 will be found on Tables E-24, E-25, and E-26 for selected years.

The population changes that may result from proposed Sale 43 will occur as an incremental addition to population changes that may be due to other factors. In the following discussion, reference is made to the population projections published in the 1972 OBERS projections, based on the Series E projections.

The details provided in the OBERS projections are summarized for BEA 031 in Table E-27, which includes a six county area, incorporating Charleston, South Carolina. The projections include estimates for the Standard Metropolitan Statistical Area portions and non-SMSA portions of the BEA area.

These figures provide some basis for estimating the anticipated population changes within BEA 031 during the coming years. The population in the non-SMSA portion of the economic area is projected to decline by the year 1980, and to gradually increase through the year 2020, although not reaching the total attained during 1970. The population within the SMSA portion was projected to decline until 1980, and to increase after that year, surpassing the 1970 total between the years 1980 and 1985. The population within the total BEA area declines to a low point during the year 1980, and increases after that year, attaining the 1970 level between the years 1985 and 1990.

There are implications in these projections when an attempt is being made to estimate the effect that a proposed OCS sale may have on land use, demand for public services, availability of labor for OCS operations, and potential availability of facilities no longer required to serve the diminished population.

The population impacts associated with proposed Sale 43 within the six county area are summarized in Table E-28.

Extrapolating the BEA projected figures yields an estimated population of 428,780 persons in BEA 031 in the year 1988. In the event that the high population estimate would prove to be correct, the population impact related to Sale 43 would amount to approximately three per cent of the total population in the BEA 031.

Table E-22 SCENARIO B-I SUMMARY OF POPULATION IMPACTS
Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	0	-1	0	1	2
Columbus	-2	-5	-3	0	0
New Hanover	0	0	2	2	6
Pender	0	-1	-1	-1	-1
S. Carolina					
Beaufort	11	8	7	7	7
Berkeley	-5	-9	-8	-10	-11
Charleston	45	33	-351	872	936
Colleton	-2	-3	-2	-2	-1
Dorchester	-1	-3	-2	-1	1
Georgetown	-2	-3	-2	-3	-3
Hampton	0	-1	-2	-2	-1
Horry	0	-1	-2	-2	-1
Jasper	0	0	0	1	4
Williamsburg	-1	10	7	11	34
Georgia					
Bryan	0	0	2	8	-8
Camden	-1	-1	-1	0	0
Chatham	2209	3435	3019	2811	2773
Effingham	1	1	3	3	5
Glynn	1	-1	-1	-2	-2
Liberty	5	4	3	4	4
Long	0	0	0	1	3
McIntosh	0	0	6	7	9
Florida					
Baker	1	1	1	2	3
Clay	0	-2	-3	-5	-6
Duval	13	79	-662	-561	-469
Flagler	0	-1	0	0	0
Nassau	1	2	4	5	8
Putnam	-2	-3	-3	-2	-2
St. Johns	0	-1	0	0	0

Table E-23 SCENARIO D-I SUMMARY OF POPULATION IMPACTS

Impact Estimates

State & County	1980	1984	1988	1992	1996
N. Carolina					
Brunswick	4	6	10	9	13
Columbus	6	9	20	9	13
New Hanover	21	30	60	30	42
Pender	8	12	24	13	14
S. Carolina					
Beaufort	16	20	21	26	29
Berkeley	14	21	46	17	23
Charleston	2258	3769	12216	3017	4197
Colleton	3	4	9	5	7
Dorchester	14	21	43	22	30
Georgetown	16	23	47	18	20
Hampton	-1	-1	-2	0	1
Horry	25	25	58	23	26
Jasper	3	5	11	8	9
Williamsburg	9	0	13	4	27
Georgia					
Bryan	3	5	11	17	14
Camden	-1	-2	-3	0	1
Chatham	262	302	379	268	222
Effingham	15	24	46	22	32
Glynn	2282	3526	3975	2961	2542
Liberty	17	22	38	23	20
Long	3	4	8	8	16
McIntosh	1	2	5	7	14
Florida					
Baker	9	14	26	12	14
Clay	20	29	55	23	25
Duval	2275	2752	4936	4099	4289
Flagler	1	1	2	1	2
Nassau	0	1	3	10	17
Putnam	12	18	37	20	26
St. Johns	6	9	17	10	13

Table E-24 Estimated Population Impacts

Summary of Five Scenarios (Year 1984)

State & County	High	Low	Average (rounded)
N. Carolina			
Brunswick	6	-2	0
Columbus	9	-8	-3
New Hanover	30	-4	5
Pender			
S. Carolina			
Beaufort	20	7	11
Berkeley	21	-14	4
Charleston	3769	30	1484
Colleton	4	-5	-2
Dorchester	21	-5	1
Georgetown	23	-6	1
Hampton	-1	-3	-2
Horry	25	-1	6
Jasper	5	-1	1
Williamsburg	10	-48	-14
Georgia			
Bryan	5	0	1
Camden	-1	-3	-2
Chatham	5318	191	2486
Effingham	24	1	6
Glynn	3526	-1	1407
Liberty	22	3	7
Long	4	0	1
McIntosh	2	0	0
Florida			
Baker	14	1	4
Clay	29	-4	18
Duval	2752	-8	1093
Flagler	1	-1	-1
Nassau	2	-1	1
Putnam	18	-6	0
St. Johns	9	-2	1

E-25

ESTIMATED POPULATION IMPACTS
Summary of Five Scenarios (Year 1988)

State & County	High	Low	Average (rounded)
N. Carolina			
Brunswick	10	-2	1
Columbus	20	-11	0
New Hanover	60	-4	12
Pender	24	-3	4
S. Carolina			
Beaufort	21	6	10
Berkeley	46	-23	0
Charleston	12,216	-352	3407
Colleton	9	-6	-1
Dorchester	43	-6	6
Georgetown	47	-9	6
Hampton	-1	-5	-2
Horry	58	-2	14
Jasper	11	-1	3
Williamsburg	13	-39	-9
Georgia			
Bryan	20	2	8
Camden	-1	-3	-2
Chatham	4474	379	2947
Effingham	46	2	12
Glynn	3975	-1	1485
Liberty	38	-70	-4
Long	8	0	2
McIntosh	6	-43	-5
Florida			
Baker	26	1	6
Clay	55	-9	7
Duval	4936	-662	1417
Flagler	2	-1	0
Nassau	4	-1	3
Putnam	37	-8	4
St. Johns	17	-2	3

E-26

Estimated Population Impacts
Summary of Five Scenarios (Year 1996)

State & County	High	Low	Average (rounded)
N. Carolina			
Brunswick	13	0	5
Columbus	13	-2	2
New Hanover	42	1	15
Pender	14	-1	2
S. Carolina			
Beaufort	29	-2	12
Berkeley	23	-21	-6
Charleston	4197	1	1681
Colleton	7	-2	0
Dorchester	30	-3	6
Georgetown	20	-6	1
Hampton	1	-3	-1
Horry	25	-1	13
Jasper	11	2	7
Williamsburg	34	-29	15
Georgia			
Bryan	44	-17	9
Camden	1	-1	0
Chatham	4170	222	2634
Effingham	32	2	11
Glynn	2542	-3	735
Liberty	20	-64	-7
Long	16	1	7
McIntosh	14	-64	-5
Florida			
Baker	14	2	5
Clay	25	-13	-1
Duval	4289	-469	1234
Flaglar	2	0	1
Nassau	17	5	10
Putnam	26	-2	3
St. Johns	13	-1	3

Table E-27 Population BEA 031 Charleston, South Carolina

Year	SMSA Portion	Non SMSA Portion	Total BEA Area
1970	304,493	127,180	431,673
1980	297,500	110,400	407,900
1985	308,500	112,400	420,800
1990	319,600	114,400	434,100
2000	332,200	115,400	447,600
2020	365,900	120,900	486,900

Note: Minor discrepancies presumed due to rounding.

Table E-28 Population Impacts 1988

County	High	Low	Average
Beaufort	21	6	10
Berkeley	46	-23	0
Charleston	12,216	-352	3407
Colleton	9	-6	-1
Dorchester	43	-6	6
Hampton	-1	-5	-2
	12,334	-386	3420

Adding the high estimated impact of 12,334 to the estimated total population of 428,780 yields a total of 441,114 persons, approximately 9,441 persons more than 1970 population of the BEA.

In the event that the average population impact figure should turn out to be closer to the actual population increase that may develop as a result of Sale 43, the total population in the BEA would amount to 432,200 persons, approximately 527 persons more than the 1970 total population of the BEA.

The average sale related population increase of 3,420 amounts to slightly less than one per cent of the total projected population of 428,780 within BEA 031, as estimated from the OBERS data.

During the year 1988, the range of population impacts that may be experienced in Duval County, Florida range from a high of 4,936 persons to a low of −662 persons. The average population impact calculated from the five runs amounts to 1,417 persons.

The total high sale-related population impact in the counties of Baker, Clay, Duval, Nassau, and St. Johns amounts to 2,806 in the year 1984, and 5,038 in the year 1988.

The population data projected in the OBERS Series E reports are summarized in Table E-29.

BEA 034 encompasses an extensive geographic area, extending from the Atlantic coast of Florida to the Gulf of Mexico, and extending northward into Georgia. The Jacksonville SMSA includes Duval County, Florida, and probably provides a more realistic basis for estimating population impacts.

The OBERS projections indicate that the population of the Jacksonville SMSA is expected to increase, as shown on the above table. Based on the projections shown, the population in the Jacksonville SMSA in the year 1988 could be expected to number 706,820. In this case, the anticipated high population impact of 5,038 persons would amount to less than 1 per cent of the anticipated population in the Jacksonville SMSA in 1988.

Chatham County, Georgia is included within BEA 033, an area containing a large number of counties centered on the city of Savannah, Georgia. The population projections for this area, as well as the Savannah SMSA as published in the OBERS publications, are contained in Table E-30.

The projected population of the Savannah, Georgia SMSA during the year 1988 would amount to approximately 198,280 based on the above projections. The maximum impact estimated in Bryan, Chatham, and Effingham counties in 1988 amounts to 4,540 persons, approximately two per cent of the estimated population in the SMSA during the year 1988. During the year 1984, the high estimated population impacts in the three Georgia counties amount to 5,347 persons. The high impact estimate amounts to approximately three per cent of the projected 1984 population in the SMSA.

The Economic Development Profile, prepared for Brunswick, Georgia by the Georgia Department of Community Development, noted that the population of Glynn County, Georgia amounted to 50,528 during the year 1970, and if the population in the county should increase in the same proportion as the non-SMSA portion of BEA Economic Area 033, the population of Glynn County is projected to amount to 52,500 in the year 1984, and 53,206 in the year 1988.

The high population impacts due to proposed Sale No. 43 on Glynn County, Georgia as estimated by the scenarios calculated for this impact statement amount to 3,526 in the year 1984 and 3,975 in the year 1988, approximately 7 per cent of the total projected population for these years.

It is difficult to form a concise, and unequivocal estimate of the population changes that can be expected to occur in specific areas, or locations, in the four state area adjacent to the sale area pertaining to proposed OCS Sale No. 43. The primary sources of difficulty are due to uncertainty regarding the extent of exploration and production activities that may result from the sale, and the onshore locations that may be selected as sites for pipelines, support facilities, and terminals, as well as the employed persons choice of areas in which to establish their homes.

Some examples of factors that could be included in plans developed to provide facilities required as a result of activities to proposed Sale 43 have been partially developed in the above discussion.

The employment and population effects of the proposed sale could, in part, replace population migrating away from specific points due to causes having little or no ties to OCS operations. The effects could also take place in an area experiencing increases in population due to causes having little, or no tie to OCS operations.

Table E-29 Population Projections (OBERS - Series E)

Year	BEA 034	Jacksonville, Fla. SMSA
1970	1,057,007	531,592
1980	1,234,100	619,700
1985	1,326,500	672,500
1990	1,425,700	729,700
2000	1,569,900	815,500
2020	1,813,700	964,800

Table E-30 Population

Year	BEA 033	Savannah, Georgia SMSA 207
1970	418,897	188,275
1980	423,400	186,900
1985	434,400	193,900
1990	445,700	201,200
2000	452,000	208,900
2020	463,500	223,000

The scenarios chosen for inclusion in this impact statement represent a small section among many possible alternative development scenarios, and the results of these scenarios incorporate estimates and procedures that may differ from those selected by other entities in order to develop other estimates of economic and population impacts.

The results of these scenarios indicate changes in the population levels which are generally small in scale, amounting to changes of one or two per cent, measured by the maximum estimated population change anticipated in an area. The use of average, or low, estimated population changes would have diminished the anticipated impact.

In the event that additional lease offers are made on the OCS adjacent to the South Atlantic states, and economic quantities of oil and gas are produced as a result of this sale and additional possible sales; higher levels of employment, and related higher levels of population, than those estimated to result from proposed Sale 43 operations could result. The extent of these possible higher levels is difficult to predict due to the uncertainty concerning the time frame in which these events could occur.

For instance, if drilling operations related to proposed Sale 43 coincided with drilling operations related to another subsequent sale, the population impact could be greater than that projected for the initial sale.

For example, with reference to Table E-21, Scenario D indicates a peak population impact of 22,111 during the year 1988. The population was projected to decline to 10,680 in 1992, leading to an estimated decrease of approximately 2,858 persons per year. In the event that a subsequent sale held two years later produced an identical population impact pattern, with a peak in the year 1990 rather than 1988, the effect of these two distinct population estimates would be to produce a stable number of persons during the years 1988, 1989, and 1990, followed by annual declines on the order of 6 thousand persons annually.

The maximum level of population impact in this case would be less than twice the maximum anticipated from a single sale, amounting to approximately 87 per cent at this value, in this example.

The cumulative population impact that would be expected to result from multiple sales in the South Atlantic region would be annual impacts higher than those anticipated from a single sale, but would exhibit more gradual increase and decrease than would be expected from a single offering of leases.

The population impacts associated with sales in the South Atlantic and Mid Atlantic states would be limited to those areas selected as locations for support facilities and terminals for production developed in adjacent OCS areas.

Crude petroleum produced from leases awarded in the South Atlantic states may be transported to refineries located in the Gulf of Mexico region, or possibly, to refineries located in the southerly portions of the Mid-Atlantic states. In this case, activities in the South Atlantic area would have an economic effect outside the area adjacent to the sale, but would mean the substitution of domestic crude oil for imported crude petroleum in existing refineries.

5. Impact on Land and Air Transportation

All of the ports within the region which might become the locations of offshore service centers are connected to the interior and the remainder of the nation by rail and highway networks. Both systems will be able to handle any increase in cargo and passenger traffic generated by all phases of the proposed sale. Many pieces of equipment for drilling and construction of offshore wells and platforms and for the laying of pipelines are commonly moved by land transportation systems. From the low production estimates the most impacted ports will be Charleston, Brunswick and Jacksonville. All of the major ports, Charleston, Savannah, Brunswick and Jacksonville will have service centers in or near their port facilities should the high estimate be the case. During the exploratory and development phases resulting from the proposed sale there would be an increase in rail and highway traffic towards and along the coast between the above mentioned cities as material and equipment is brought into the area and shifted along the coast to meet the demands of the various offshore service facilities. The increase in highway traffic should be well within the main and secondary road system's capabilities. Much of the initial equipment needed during the beginnings of the exploration will likely be carried on board the drilling rigs as they are moved from their former locations. Additional material in large quantities or bulk would probably be barged up the Intracoastal Seaway or be shipped by rail. The increase in barge and rail traffic would probably be the most substantial. The increase should be well within the capacity of the transportation system's abilities.

Air traffic can expect minor impacts from the movement of supplies and personnel into the area. Airports in or near the offshore service facilities mentioned above will receive a moderate increase in the amount of air traffic presently experienced as helicopter traffic develops along with offshore development. Helicopters are a common form of transportation used for the movement of personnel and light equipment. For the lesser development estimates probably three heliports will be established, at Charleston to serve the northernmost set of tracts, and at Brunswick and Jacksonville to serve the larger area of tracts to the south. For the greatest expected development in the OCS up to 15 helicopters may be distributed among the four service bases at Charleston, Savannah, Brunswick, and Jacksonville. For the region as a whole this does not constitute significant increase in air traffic, but for the service bases and surrounding areas this will have an impact on other air traffic by increasing the number of aircraft in the air during the day.

Scheduled airlines can expect a beneficial impact to occur as personnel and air freight traffic increases as a result of the proposed sale. The most heavily impacted airports will probably be those at Savannah and Jacksonville. Flights from other parts of the nation will probably reach them first, then commuter type flights will move onto airports near the service facilities.

The impact on land and air transportation will be minimal, all systems are currently capable of handling any increase brought on by this sale.

The cumulative impact of this and other Atlantic Coast sales will be an increase in the loads on transportation systems. These impacts, though minor, when coupled with possible future sales will increase the demands for surface and air transportation. Once the industry has become established along the coast in response to successful exploration the impacts on air travel should lessen while those on highways, rails and canals will increase.

6. Impact on Recreation Areas and Activities

Stationary marine environments such as specially designated marine preserves and unique shallow water areas noted for water clarity and displaying attractive sedentary undersea features such as coral and historic shipwrecks are very susceptible recreation resources to marine pollution induced by oil and gas activities. Water dependent recreation activities such as swimming, fishing (discussed separately), waterfowl hunting, snorkling, skiing, sailing, etc. are also susceptible to severe impacts from marine pollution induced by oil and gas activities especially in shallow water, near shore areas available for recreation use.

Likewise parks, wildlife refuges and management areas, specially designated areas such as national natural landmarks, National Register sites, beaches and barrier islands and other shoreline recreation resources that front on the Atlantic Ocean or its bays and estuaries can also incur impacts from pipeline construction which comes ashore, from oil spills and from the placement of onshore facilities (such as production terminals or transfer facilities) should they be located in or near a recreational area. Additionally oil and gas activities offshore can visually impact on shoreline resources or contribute non-petroleum floating debris to ocean waters that eventually washes ashore impacting recreation resources and water enhanced recreation activities.

In summary there are six major recreation activities and 74 designated areas under national and state jurisdiction with ocean and sound frontage susceptible to impacts from oil and gas activities in the South Atlantic OCS (see Visuals 1N & S).

By far the most unpredictable negative impact can result from oil released into the marine environment which finds its way into popular recreation waters or reaches shore soiling shoreline recreation resources. Oil spills most likely to affect recreation resources and activities could originate from drill site blowouts, near shore or onshore pipeline breaks or leaks, and crude oil transport vessel accidents, or a non-dramatic combination of all these causes often called chronic pollution.

More predictable and controllable impacts can result from onshore facility requirements such as pipeline alignments, support facility sitings and the aesthetic affects of these type facilities upon people recreating within perceivable distance from these facilities.

It has been assumed, for purposes of this discussion, that if noxious hydrocarbon products find their way into nearshore waters and shoreline areas it will impact recreation areas and consequently recreation use. Such impact can cause additional impacts on outdoor recreation related tourism and ultimately on local economies. As noted in Section II and vividly apparent on Visuals 1S and 1N most of the South Atlantic coastline is used for public and private recreation purposes. The area directly shoreward from the offered lease tracts corresponds generally to the shoreline between Georgetown, South Carolina and Jacksonville, Florida. Within this 500 km coastline is a concentration of wildlife and natural areas, recreation beaches, recognized historic sites, and state parks. Most notably are Georgia's eight major sea islands which vary in recreation use from the highly developed, multi activity Jekyll Island State Park to the heavily forested uncluttered natural setting found on Cumberland Island, a component of the national parks system. Besides the major concentration of historical areas in the Charleston vicinity, Cape Romain National Wildlife Refuge and state parks at Hunting Island and Edisto Beach dominate the coastal recreation setting along the South Carolina seashore south of Georgetown. Little Talbot Island and Fort Clinch State Parks and Aquatic preserves typify the Florida coastline north of Jacksonville. As the closest points between potential production areas and land lies within this arc between Jacksonville and Georgetown it is probable that pipeline landfalls and shoreline support facilities would impact within this area. Industrially zoned land already exists within this same area logically suited for operation bases needed to support this proposed sale. These bases presumably do not presently compete with recreation interests and there are no clearly identifiable factors associated with this proposed sale that would lead us to conclude that onshore facility needs would unduly compete with current or future recreation needs. Pipeline landfalls between offshore production areas and onshore storage and transport areas could also conceivably impact on recreation areas and activities. Such impact should be minimal as a short timeframe is required for pipeline implacement (underground) and should be restricted to a narrow route. According to government regulations rights-of-way are not to exceed 60 m. Two to four oil/gas pipelines are estimated (USGS, 1976) and would be designed to avoid important recreation areas and designed and constructed so as to soften the short term and long term impacts to shoreline resources. Additionally, the pipeline laying operations, and onshore facility construction activities could be undertaken during the time of year when recreation use is least likely, usually during the winter. Consequently, onshore support facilities should have negligible, and in the case of pipelines, short term impacts on recreation opportunities and whatever minimal impacts do occur will be confined to small localized areas.

Oil spills resulting from drill site blowouts, tanker accidents and pipeline failures will have severe impacts on any recreation areas which are directly soiled by the spill. As a floating substance oil slicks are mobile and tend to have the greatest affect on water surface and shoreline areas. Additionally, factors such as wind, wave actions, currents, most notably the Gulf Stream, and speed and effectiveness of containment actions can affect the impact of oil slicks on recreation.

The oil spill risk analysis model in Section III.A.5. indicates that a spill emanating from near the center of the proposed lease area would most likely travel a course parallel to the coastline either to the north or south. Climatic and oceanographic factors affect the rate and direction a spill will travel therefore the model predicts beaching locations and time lags for various sized spills occurring during the four major seasons. The results of the model indicate the beaches and recreation areas lying between Jacksonville and Cape Canaveral to the south and those resources between Wilmington and Nags Head to the north are most vulnerable to potentially damaging oil spills because of predictable spill trajectories. Even though a spill would likely reach shore faster in the autumn and fall than in the summer and winter, lease site spills are predicted to take at least two weeks to reach shore. Natural dissipation in addition to containment efforts should eliminate sufficiently most major spill threats to shoreline recreational resources within that minimum time frame.

The risk analysis indicates however there is a 92% probability that at least one spill greater than 1000 bbls will impact somewhere on shore during the production life of the lease areas (estimated at approximately 25 years). Furthermore, it is very probable such a spill would affect a sandy beach but there is a low probability a designated public recreation area would be affected. Depending on the production area or transportation route selected probability of an oil spill impacting various resources and areas associated with recreation use is predicted to range as follows: sandy beaches, 69-97%; recreation areas, 12-21%; wildlife refuges, 1-5%; historical sites, 4-19%; and sport fishing areas, 1-3%. Table A-12, Section III provides a more detailed analysis on the source specific oil spill impact probabilities.

When considering probabilities of spills coming from pipeline or tanker transport systems some portion of the extensive sandy beaches of the South Atlantic will very likely be affected whereas there is less than a 50% chance a designated recreation area will be impacted. The analysis shows only a slight advantage in protecting recreation resources should specific pipeline transportation systems be utilized instead of a vessel transportation system with the same routing.

The Matrix analysis in Section III.F.4. provides similar conclusions as regards potential impacts on recreation resources from lease site structures and oil spills. Primarily because of distance from the beachfront outdoor recreation areas, shoreline aesthetics show no potential impact from projected structures and only minimal potential impact from possible oil spills.

In general, marine recreation resources such as marine preserves and reefs not associated with a corresponding land base could be only minimally affected as most of the pollutants remain in the top portion of the water column and will tend to move out of the area in a short period of time. Potential users will avoid such areas until the spill and its effects have been removed. Undersea features such as coral, sponges, other biological organisms or even cultural resources should not be greatly affected by such an occurrence. Other sections of this statement discuss impacts on marine biological and cultural resources. Potential exists for oil slicks reaching the established Federal marine preserves and Florida state water preserves, especially those between Cape Canaveral and Jacksonville. A tanker accident away from the lease tracts could more likely affect an established marine preserve. Even then the impact should only be temporary unless the spill is major and climatic conditions hamper effective containment operations.

More susceptible to persistent and damaging impacts are shoreline recreation resources where oil spills have come ashore. Because of the number and extent of public and private recreation resources along the South Atlantic with ocean and bay frontage it is likely that any major spills that eventually come ashore will impact on recreation resources. The greatest number of recreationist would be affected should an oil slick come ashore on a national seashore or a popular recreation beach where the focus of public use is at the water's edge. Of the 1900 km or approximately 1200 miles of beachfront potentially affected by the proposed sale major dedicated ocean front recreation sites are located in areas where spills are most likely to beach. Specifically Cape Hatteras and Cape Lookout National Seashores to the north and Cape Canaveral National Seashore and Anastasia, Frank Butler and Flagler Beach State Recreation Areas to the south are located in high potential beaching sites according to spill trajectory predictions. Likewise state parks and state aquatic preserves along the northeastern shoreline of Florida are most susceptible to damage from spills beaching in the identified probability areas. The areas include Fort Clinch State Park and Aquatic Preserve; Nassau River State Aquatic Preserve, Little Talbot Island State Park; Tomoka State Park and Aquatic Preserve; and Mosquito Lagoon Aquatic Preserve. Water sports such as swimming, wading, skiing, fishing for finfish and shellfish would be directly affected as well as onshore activities such as beach play, camping and picnicking. Cape Hatteras National Seashore for example has 70 miles of ocean frontage and was visited in 1975 by over 1.5 million people. Almost all of these visitors were interested in waterfront enjoyment. Should this use be curtailed because of a major oil beaching, secondary impacts would ensue to the local economy as well. Soiling of wildlife lands, historic sites and natural area shorelines would probably affect fewer recreationists but could be severely detrimental to the resource itself. Not only could the vegetation and wildlife in the localized area be affected to the point of wide spread mortality but small amounts of hydrocarbon ingested by migratory species such as ducks could eventually affect breeding success.

Experience has shown (Santa Barbara Spill, 1969 for example) that although beaching of oil spills can be severly damaging in the short term the effects can be overcome in time. Removal of oil from recreation beaches would probably involve removal of the contaminated sand and replenishment with replacement or cleaned sand. Emergent and submergent vegetation severely damaged will usually revive from the original rootstock during subsequent growing seasons assuming proper cleanup efforts.

Recreation areas and activities also would be affected where chronic low-level discharges have caused a degradation of the environment. The sand beaches, barrier islands and designated shoreline recreation resources of Georgia and South Carolina are less susceptible to dramatic spills as well as chronic small scale spillage (0-1000 bbls, average 3 bbls) resulting during the production life of the proposed lease areas. Figure A-15, Section III shows total quantities of petroleum residues expecting to come ashore over the 25 year production life as ranging from 500 - 1,000 grams per meter of beach along the northeastern Florida coast and places in North Carolina to less than 100 grams per meter near the Georgia-South Carolina border.

Studies by Dennis (1959) and Morris (1973) have documented the occurrence of petroleum residues, commonly referred to as "tar lumps" or "tar balls" as an increasingly chronic problem in the Atlantic Ocean which is affecting Atlantic coastal beaches. A chemical analysis of beached tar lumps by Morris led him to conclude the major source of these pollutants were tanker washings. Quantitative analysis of residues by Dennis led him to conclude that the annual increment of petroleum residues occurring on South Florida beaches was around 600-700 g/m or approximately equivalent to the projected cumulative buildup of residue at the most severely impacted beaches resulting from 25 years of production from the proposed lease sale (Table A-15, Section III).

The Dade County Parks and Recreation Department and the Miami Beach Parks Department have indicated chronic tar ball residues are not a serious problem affecting recreation use of South Florida's public beaches. The U.S. Coast Guard station in Miami indicated they receive complaints from time to time indicating tar balls are a nuisance to recreationist enjoying beach activities in the South Florida area.

Seasonality is another factor which can significantly contribute to the impact of oil spills on recreation. Spoiling a South Carolina vacation beach, the Grand Strand area for example, will have a greater impact on recreationist during the spring or summer as will the spoiling of a bayfront wildlife management area such as Merrit Island National Wildlife Refuge, during the midwinter waterfowl season than would a similar occurrence during the off seasons. Assuming off season shoreline contamination where a successful cleanup is rapidly effectuated, positive publicity could be generated to limit both the scope and duration of potential impacts to recreationist.

The aesthetic character of a given area or resource although difficult to qualify because of value judgment involved is another potential impact resulting from oil and gas activities. Whereas the sight of an offshore platform may bring excitement and anticipation to an offshore fisherman other recreationist would be obviously offended by the sound, sight or smell of offshore energy development. The establishment of an oil or gas related facility for example within apparent perception of the designated wilderness portions of Cape Romain National Wildlife Refuge may be a violent intrusion to the visitor seeking solitude in such a coastal setting.

The major significant potential aesthetic impact resulting from offshore activities as a result of the proposed sale will be oil spill-induced. Drilling and production activities which may take place in the area of the currently selected lease tracts will-not be perceptible from shore because of the distances involved. The beaching of oil, whether from drill sites, pipeline spills or vessel accidents will cause negative visual impacts limited to the areas affected and lasting until clean-up can be completed. The most likely potential for spilled oil which could soil shoreline recreation resources would result from a vessel accident transporting crude between a lease site production area and a shoreline destination point. Final decision on crude transport systems will not be made until discoveries have been made and production quantities are defined.

Aesthetic impacts could result also from placement of oil terminal/storage facilities, gas processing plants and pipelines. The placement of these types of facilities along beaches and shorelines and within wetlands should it be allowed by the states may well create perceptible obtrusive effects to recreationists. Generally, such effects would be localized unless sitings were made on undeveloped shoreline in flat terrain with low vegetation cover where impacts could be more far-reaching.

It should be noted that recreation and tourism are very interrelated. Many of the coastal economies along the South Atlantic are heavily dependent on the quality and attractiveness of ocean and bayfront recreation resources. Should recreation areas be impacted to the point of discouraging public use as a result of this proposed sale, a corresponding impact would be noted in the economies of coastal towns and villages. The extent of economic harm which may result from an oil spill affecting recreation resources would be impossible to predict with any degree of specificity because of the importance of interplay factors previously discussed (spill size, duration, seasonality, locale, etc.). Likewise, the tourism industry is highly dependent on a reasonably priced personal fuel supply. The 1973 energy crisis dramatically demonstrates this relationship. The objective of this proposed sale should reflect on personal energy costs and availability.

Removal of open space, increases in employment and personal income and population expansions resulting from oil and gas development of the Georgia Embayment could cause secondary or indirect impacts to existing or proposed recreation facilities and resources. These same factors could limit public appreciation by increasing competition and straining carrying capacities for those resources currently available. Total land needs directly related to the petroleum industry's onshore support facility requirements were estimated not to exceed 220 acres. Likewise population and earnings are not projected to be significantly affected when considering the South Atlantic region as a whole. Consequently secondary impacts on recreation are projected to be minimal when considering the economic and land modification effects on the broad South Atlantic Seaboard.

Impacts may well be noticed in specific areas where employment, earnings and land use are appreciably affected. (See Section III.E.1., 2., 3. and 4.) By noting which areas receive the greatest economic impacts, one can presume a corresponding indirect impact on recreation. In general, indications are that petroleum development of the Georgia Embayment will be capital intensive as opposed to labor intensive. Assuming encouraging exploration results, increases in employment and population should be gradual in areas affected affording sufficient time to mitigate potential indirect impacts on recreation.

In summary, given the possible oil pollution events the potential exists for: (1) short term loss of water related, near shore recreational activities, (2) oiling of beaches and recreation areas especially between Jacksonville and Cape Canaveral and Wilmington and Nags Head; (3) short term decreases in tourism based on economy; and (4) aesthetic disturbances to a certain segment of the population. Furthermore when considering the recent Baltimore Canyon sale and the pending and scheduled hydrocarbon lease sales planned for the mid and south Atlantic OCS areas the probability, magnitude and frequency of pollution causing events affecting shoreline recreation resources and activities, especially along the outer banks of North Carolina also increases.

7. Impact on Sport Fishing and Recreational Boating

There is an extensive fishing and boating interest which utilizes the sounds and nearshore areas along the South Atlantic seaboard. Most recreational boats other than sailboats are also utilized by sport fishermen. Additionally North Carolina, South Carolina, Georgia and Florida all support charter and party boat fleets which range throughout the Outer Continental Shelf engaging in sport fishing activities.

The most pervasive adverse impacts on boating and fishing stemming from hydrocarbon development in the South Atlantic OCS would probably involve pollution to the marine environment. The most damaging cause of marine pollution would likely result from chronic or dramatic spillage of oil. Boaters and fishermen would not want to soil their boats by entering a contaminated area for the duration of a spill incident. Additionally, a major oil spill could have a longer term impact on sport fishing if the larvae or basic components of the sport fish food chain were diminished as a result of a spill. Sections III.B.1.a.d. and C.4. and Appendix I address the impact of oil spills and hydrocarbon pollutants on the biological communities supportive of saltwater fisheries. Even in the case of major oil spills long term toxic environments would not be maintained and fish populations would be expected to migrate back into affected areas once the oil slick has been removed (by wave action, containment, and cleanup or dispersion). Repopulation of an area could be anticipated to be well underway by the end of the succeeding spawning cycle. In sport species such as mackerel, bluefish, cobia, flounder and seatrout, sport fishing should not be affected for a longer period than one year in any one spill area.

Based on the sensitivity analysis presented in Section III.F.4. known fishing grounds on the Outer Continental Shelf are likely to receive maximum adverse impact from structures which might be erected on 17 offered lease tracts and from oil spills from five offered lease tracts. Recreationists most likely to be affected by these impacts are fishermen who utilize charter or party boats.

Aside from damage caused by oil spills, there is considerable evidence that oil and gas operations have an overall favorable impact on sport fishing activities (Seymour 1975; Shinn, 1974; Gurc, 1974).

One favorable impact is the result of sport fish concentration due to the artificial reef effect of offshore platforms. In the open sea, offshore platforms provide both food and cover in areas that are largely devoid of those essentials. Myriad forms of microorganisms in the water drift by these structures and attach themselves, soon encrusting all exposed surfaces on the platform. Hard substrate is necessary for encrusting organisms: barnacles, hydroids, corals, mussels and other invertebrate organisms which serve as links in the food chain. Randall (1968) has stated that artificial reefs provide protection, food sources, spawning sites and spatial orientation markers for fishes. The same author found that artificial reefs attract available fish from surrounding waters, and increase the size of some populations by providing additional protected areas and food for both the young and adults. The typical platform located in 30 meters of water will have a surface area of about 0.8 hectares (over 8,082 square meters) (Shinn, 1974). Other advantages of these structures is the free movement of water through and around them and their high profile. The high profile provides habitat for a wide variety of fish ranging from the turbid dark bottom zone to the lighter and clearer surface waters. Platforms are easily located by boaters and fishermen and the platforms and their personnel are a source of emergency assistance for all offshore sportsmen.

In offshore Louisiana and Texas where oil and gas operations have been ongoing for approximately 30 years, platforms, which number over 2,000, are the major focus of individual sport fishermen, charter and head boat operations and scuba diving expeditions. Divers are drawn to these stuctures for spear fishing, underwater photography and general pleasure diving. The submerged portion of structures contribute to safety by assuring the diver's orientation to depth and distance (Estopinal, 1975).

The 10 to 25 platforms which are projected for construction as a result of this proposed sale should have a similar positive impact on sport fishing. However, offered tracts in this proposed sale are confined to areas ranging from 50 to 120 km (30-72 miles) from shore. When considering the time and safety factors involved in venturing such distances from shore for pursuit of sport fish it is likely that sportfishing opportunities resulting from the reefal effects of platforms constructed will only be minimally affected. Charter and head boats and those that are currently equipped to travel far distances from shore in pursuit of deep sea fish may find the platforms to be additionally productive sport fishing areas in 5 to 10 years from the proposed sale date.

Results of this proposed sale are projected to have negligible effects on inshore boating and sport fishing. Other than a temporary decline in localized fishing activity from oil slicks in near shore areas the possible construction and use of 160 to 320 miles of pipeline to transport oil and gas finds could have minimum short term effects on inshore fishing and boating areas resulting from temporary disturbance of the bottom sediments, however, no more than three landfalls are projected to result from this proposed sale (USGS, 1976). Stipulations regulating pipeline construction methods require burial of all pipelines out to water depths of 61 meters (200 ft.). Thus it is unlikely that pipelines resulting from this proposed sale would snag lines of sport fishermen or interfere with boat anchors.

In addition to pipeline landfalls, dredging and filling activities and increased runoff resulting from onshore support facilities could have noticeable short-term impacts on larval populations and boating aesthetics, but the overall impacts on sport fishing and boating would be negligible. The size of larval kills and catchable fish out-migrations caused by the turbidity associated with these activities would be influenced by the size of the area affected, as well as the seasonality of occurrence. Assuming there is no permanent turbidity and bottom sediment modifications associated with these onshore and nearshore activities, fish populations and recreational boating would attain almost complete recovery in the recreation season following the temporary disturbance.

Access to recreational waters by boaters and fishermen will not be noticeably affected as a result of this proposed sale.

In summary oil spills and facilities constructed in the marine environment are projected to have minor localized, and temporary adverse effects both offshore and nearshore on boating and sport fishing in the South Atlantic. Although leasing of oil and gas rights in the Mid-Atlantic and additional sales in the South Atlantic may increase these potential pollution causing factors the cumulative effect of widespread platform developments throughout the Atlantic OCS should eventually attract many sport fishermen and stimulate the recreational boating industry.

8. Impact on Onshore Cultural Resources

Onshore development resulting from this proposed sale could negatively affect cultural resources. The building of onshore bases, natural gas processing plants, and trenching for pipelines might destroy or disturb the undiscovered remains or artifacts of early Indian groups and colonial occupations. Oil spills from pipelines onshore could seep through the ground and coat artifacts, adversely affecting their value and usefulness.

The 56 historic sites enumerated in the cultural resource section (II.G.6.e.) some of which are mapped in Visuals 1N and 2S are in a position where they could be affected by oil spills coming ashore in their vicinity, or by the construction of onshore facilities. Those sites which are shown further inland on the Visuals could be affected only by the construction of onshore facilities.

Should an oil spill occur and the oil were to come ashore near a historic or archaeological site, oil on or adjacent to a cultural resource would have a short-term visual impact, assuming clean-up operations could remove the oil within a reasonably short time. Long-term impacts and actual distribution of artifacts could occur if spilled oil was to impregnate dateable organic matter in a prehistoric living site. Oil residue, even after clean-up operations would affect the carbon dating procedures used to analyze the material.

Adverse long-term impacts to the visual environment of a cultural resource may be caused by the construction of onshore facilities adjacent to that site. For inland sites the greatest probability of impacts occurring will be near the port cities of Charleston, Savannah, Brunswick, and Jacksonville, where the probability of siting onshore service and petroleum processing facilities is higher.

Adverse short-term visual impacts could be caused by the burial of a pipeline near a cultural resource. Under normal circumstances the visual effect caused by the trenching and burial operation is quickly modified and eventually hidden by the natural vegetative growth process of the particular environment.

State environmental and regulatory agencies have responsibilities for pipeline siting approval and opportunities to review plans for onshore development related to offshore activities. The State Historic Preservation Officer's (SHPO) staff, in reviewing plans, makes comments pertaining to project related impacts. The SHPO staff makes recommendations as to measures necessary to mitigate the impacts on affected cultural features. This serves to greatly reduce the potential impact of OCS related onshore activities.

We do not foresee that visual impact on any historic sites along the coast would be caused by the visual intrusion of exploratory drilling or other developmental equipment into the line of site. The highest piece of exploratory drilling equipment is a semi-submersible drilling rig, the top of whose derrick stands about 64 m above the water surface during operations. In theory the very tip of the derrick could be seen protruding over the horizon if the rig was 26 km away from a person standing at sea level on the beach. In actual practice, the rig would have to be much closer for it to be visible due to atmospheric interference, wave height, and the resolving ability of the human eye. The most massive and therefore visible part of a rig does not extend more than 36 m above the water surface, and a rig would have to be closer than 20 km from shore to be visible. There are no plans to offer tracts any closer than 48 km from shore. In theory again, a person standing 40 m above the beach could see the top of a rig at that distance, but in practicality, atmospheric conditions and resolution limits of the human eye would mask the image.

The result of offshore operations would therefore be no visual impact on coastline cultural resources due to the intrusion of offshore equipment into the lines of site because of the distance involved. Any site located directly on the coastline has the potential of being impacted by contact with an oil spill, or by being temporarily visually impacted by being within visual distance of a spill.

According to the OCS oil spill risk analysis model two areas along the coast had the highest probabilities of having oil spills come ashore. If a spill were to occur and if it were to behave like one of the trajectories used in the model there would be between a 20% and 23% chance of it coming ashore along a stretch between Cape Canaveral and the Florida, Georgia border, and there would be a 23% chance of a spill coming ashore between Cape Romain and Cape Fear. Historic and archaeological sites along those coastal stretches therefore would have a higher probability of being impacted visually or by contact with an oil spill. The remainder of the coast would have lesser probabilities, the lowest (3%) of which is in the stretch of coastline between Savannah and the Georgia, Florida border.

The location of the origin of the spill also may cause variations in the locations and probability of an impact. According to the model, if a spill originates in one of the southernmost tracts proposed for leasing there is a seven percent probability that a cultural resource along the coast will be impacted. Should the spill originate in one of the northernmost least tracts the probability of cultural impact is higher, up to 19%. These impacts of course are based on the assumption that clean-up activities do not intercept the spill. Thus in reality all percentages should be lower.

The matrix analysis (Appendix J) summarized in Section III-F., which is based on water depth and distance of the tract from shore indicates that there will be minimal impact on onshore cultural resources caused by structures or spills associated with this proposed sale.

Offshore structures will not visually impact coastal sites because of the distance from shore to the proposed lease tracts. The construction of onshore facilities and pipelines will not impact cultural resources because state historical preservation specialists will review all development plans prior to construction. There is a probability that between 7 and 9% oil spills reaching shore could adversely impact pre-historic living sites located within the tidal zone by contaminating them.

9. Solid Waste

a. Offshore

Proposed South Atlantic OCS Order No. 7 requires that no solid waste materials or debris be disposed of in the marine environment, but must be incinerated or transported to shore for disposal according to governmental regulations. Based on 4.5 lbs of solid waste/person/day (estimates range from 3.3 lbs to 6 lbs, Snyder, 1974; CEQ, 1974), the maximum waste generated offshore in the South Atlantic OCS as a result of the proposal during peak production years would be approximately 13 tons/week (662 tons/year). In relation to industrialized areas such as Jacksonville, Savannah and Charleston the amount of solid waste that would be generated offshore would be negligible. For less populated areas such as Flagler County, Fla., and McIntosh County, Ga. the solid waste generated offshore would be less than 13% of the amount generated in these areas. At times other than peak production, the additional increases in annual waste loads would be smaller.

The other source of offshore solid waste resulting from this proposed activity would be that generated during an oil spill cleanup operation. This would include oil impregnated sand, synthetic tapes, foam, straw, chips, etc. The amount of this material would be dependent on individual spills and the particular area involved. Though volumes are not computable at this time, the disposal of this type of waste could create problems for any solid waste management system because of both its volume and characteristics.

b. Onshore

The most prevalent problem resulting from sanitary landfill is leaching. This results because the water table in the South Atlantic coastal states is high. Groundwater or infiltrating surface water moving through the solid waste can produce leachate, a solution containing dissolved and finely suspended solid matter and microbial waste products. This can in turn effect the quality of nearby surface water and ground water. Another problem is the production of decomposition gases such as methane, carbon dioxide and sometimes sulfate which can cause contamination of aquifers.

Impacts on existing solid waste management systems as a result of the proposed sale are predicated on expected population changes and on a figure of six pounds/person/day (1.1

ton/person/year). This figure accounts for the various types of waste generated either directly or indirectly by each individual including residential, commercial, industrial, agricultural and so on. As has been shown in the discussion of population, region wide population increases of less than 0.1% are expected as a result of the proposed action. Since this is a low percent of increase, the solid waste that would be generated would be negligible.

F. Summary of Matrix Analysis

Table F-1 presents a recapitulation of the matrix analysis (see Appendix J) listing the potential impact (possibility of an impact) of offshore structures and oil spills based on the sensitivity scales and, in the case of oil spills, weathering as it applies to potential impact upon the nine selected resources and activities.

Table F-2 presents a summary of Table F-1 listing the number of tracts, the degree of potential impact and types of impact on the nine selected resources and activities. In summary Table F-2 indicates that two resources and one activity may receive maximal potential impacts from offshore oil and gas development.

(1) For hard (live) bottom systems: Offshore structures will have a maximal potential impact for each proposed lease tract in which this bottom type may occur. Oil spills will have a maximal potential impact on five tracts (94,104,131,132 and 244).

(2) For other benthic systems: Oil spills will have a maximal potential impact on five tracts (94,104,131,132 and 144).

(3) For sport and commercial fishing: Offshore structures will have a maximal potential impact on 17 tracts (94-96, 104-107, 119-121, 131, 132, 144, 163, 164 and 171).

Table F-1. Recapitulation of the Matrix Analysis Tables

a. Potential Impact 1/ on Littoral Systems

(1) Offshore structures will not have an adverse impact on littoral systems.

(2) Oil spills will have a minimal potential impact on littoral systems.

b. Potential Impact on Hard (Live) Bottom Systems

(1) Offshore structures will have a maximal potential impact on hard (live) bottom systems for each proposed lease tract in which hard (live) bottom systems may occur.

(2) Oil spills:

Sensitivity Rating	Tract Number	Potential Impact	Total Tracts
3	94,104,131,132 and 144	Maximal	5
2	2,57-63,65,66,86,93,95,96, 98-100,102,105-110,114-117, 119-123,127-130,139-141,145, 159,160,163-168 and 171-173.	Moderate	52
1	1,3-56,64,67-85,87-92,97,101, 103,111-113,118,124-126,133-138, 142,143,146-158,161,162,169,170, 174-225	Minimal	168

c. Potential Impact on Other Benthic Systems

(1) Offshore structures will not have an adverse impact on other benthic systems.

(2) Oil spills:

Sensitivity Rating	Tract Number	Potential Impact	Total Tracts
3	94,104,131,132 and 144	Maximal	5
2	2,57-63,65,66,86,93,95,96,98-100, 102,105-110,114-117,119-123,127-130, 139-141,145,159,160,163-168 & 171-173	Moderate	52
1	1,3-56,64,67-85,87-92,97,101,103, 111-113,118,124-126,133-138,142,143, 146-158,161,162,169,170,174-225	Minimal	168

1/ Potential impact as used in this context, expresses the possibility of an event occurring. Maximal, moderate and minimal expresses the degree of the event.

Table F-1 (continued)

d. Potential Impacts on Endangered Species

(1) Offshore structures will not have a potential impact on endangered species.

(2) Oil spills will have a minimal potential impact on endangered species.

e. Potential Impacts on Sport and Commercial Fishing

(1) Offshore structures:

Sensitivity Rating	Tract Number	Potential Impact	Total Tracts
3	94-96,104-107,119-121,131,132,144, 145,163,164 and 171	Maximal	17
2	1-24,26-28,34-36,42-44,52-55,57-68, 70-72,75,77,79-90,93,97-100,102,103, 108-110,114-118,122,123,127-130, 133-136,139-143,146-148,150-162,165-170,172,182,184-186,189-191,196-198, 206-209 and 213-215	Moderate	145
1	25,29-33,37-41,45-51,56,69,73,74,76, 78,91,92,101,111-113,124-126,137,138, 149,183,187,188,192-195,199-205,210-212 and 216-225.	Minimal	63

(2) Oil spills:

Sensitivity Rating	Tract Number	Potential Impact	Total Tracts
3	94,104,131,132 and 144	Maximal	5
2	2,57-63,65,66,86,93,95,96,98-100, 102,105-110,114-117,119-123,127-130,139-141,145,159,160,163-168 and 171-173	Moderate	52
1	1,3-56,64,67-85,87-92,97,101,103, 111-113,118,124-126,133-138,142, 143,146-158,161,162,169,170 and 174-225	Minimal	168

Table F-1 (continued)

f. Potential Impact on Shipping

(1) Offshore structures will have a minimal potential impact on shipping for each proposed lease tract. Because, at present there are no established shipping lanes, fairways or anchorage areas in the proposed leased sale area.

(2) Oil spills will have no potential impact on shipping.

g. Potential Impact on Aesthetics

(1) Offshore structures will have a minimal potential impact on aesthetics for each proposed lease tract, because the structures will not be visible from shore.

(2) Oil spills will have a minimal potential impact on aesthetics for each proposed lease tract. Because the distance to the nearest coastline (48 km) should allow time for hydrocarbon degradation and clean-up efforts to function.

h. Potential Impact on Outdoor Recreation

(1) Offshore structures will have no potential adverse impact on outdoor recreation.

(2) Oil spills will have a minimal potential impact on outdoor recreation for each proposed lease tract (see g.2.).

i. Potential Impact on Cultural Resources

(1) Offshore structures will have no potential impact on cultural resources.

(2) Oil spills will have a minimal potential impact on cultural resources for each proposed leased tract (see g.2.).

Table F-2. Summary of Potential Impacts on Selected Resources and Activities from Offshore Structures and/or Oil Spills

Selected Resources and Activities	Number of Tracts					
	Maximal Potential Impact 1/		Moderate Potential Impact		Minimal Potential Impact	
	Offshore Struct.	Oil Spills	Offshore Struct.	Oil Spills	Offshore Struct.	Oil Spills
Littoral Systems	NA 2/	0	NA	11	NA	214
Hard (Live) Bottom Systems	215	5	0	52	0	168
Other Benthic Systems	NA	5	NA	52	NA	168
Endangered Species	NA	0	NA	11	NA	214
Sport & Commercial Fishing	17	5	145	52	63	168
Shipping	0	NA	0	NA	215	NA
Aesthetics	0	0	0	0	215	215
Outdoor Recreation	NA	0	NA	0	NA	215
Cultural Resources	NA	0	NA	0	NA	215

1/ Maximal - expresses the degree of an event and potential - expresses the possibility of an event to occur.

2/ NA - Not Applicable

Section IV

Mitigating Measures in the Proposed Action

The following measures will mitigate some of the possible adverse impacts resulting from this proposal. These measures are presented as they relate to the jurisdiction of Federal and State agencies as to oil spills, offshore structures and pipelines, and other impact-producing activities associated with this proposal.

A. Federal Regulations and Enforcement

Although many Federal agencies have responsibilities in energy and environmental affairs policy of the United States, only certain ones have direct OCS regulatory and enforcement authority. These include the Bureau of Land Management, U.S. Geological Survey, Federal Aviation Administration, Materials Transportation Bureau, U.S. Coast Guard, Federal Power Commission, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency and U.S. Navy. Following is a discussion of the mitigating measures that are applied by these Federal agencies to OCS operations.

1. Department of the Interior

a. Bureau of Land Management

The Bureau of Land Management in coordination with other Interior agencies has developed "special stipulations" for this proposed sale which are discussed in Section IV.E. If these proposed stipulations are approved by the Secretary, they will be legally binding on all leases issued as a result of this proposed sale if it is held.

BLM staff at the field level will review operators' actions and reports for compliance with these stipulations, e.g., archaeological and "live bottom" survey data. In addition, the BLM environmental studies program will provide information which may be used to prepare Notices to Lessees or changes in the U.S. South Atlantic Operating Orders issued by the U.S. Geological Survey over the life of a lease. For example, data collected in the Flower Garden Reef area offshore Texas were used for developing restrictions in certain operating practices.

Most of the stipulations proposed in this statement were initially suggested by BLM; under requirements of Secretarial Order 2974 (Appendix E). Meetings and discussions were held at the field level between BLM, EPA, NMFS, USF&WS, USGS, State designees and representatives from the oil industry and academic institutions on the wording and intent of each of the stipulations.

The Bureau of Land Management administers regulations governing the granting of rights-of-way for pipelines on the OCS (43 CFR, Subpart 2883). As part of this role, BLM may propose management studies (if pipelines are required) in an attempt to determine the most technically and environmentally sound pipeline routings to shore. A study of this nature was begun in the Mississippi, Alabama and Florida (MAFLA) OCS region in cooperation with these States but was discontinued because to-date there have been no discoveries of oil and gas over most of this OCS region.

b. U.S. Geological Survey

Regulations governing lease operations on the OCS are administered by the U.S. Geological Survey. These regulations are contained in Title 30, Part 250 of the Code of Federal Regulations (CFR). These regulations will be implemented in the South Atlantic OCS by the proposed South Atlantic OCS Orders. A notice for public comment on draft South Atlantic Orders 1, 2, 3, 4, 5, 7, and 12 will appear in the *Federal Register* in the near future. Public comments on these proposed Orders will be reviewed and changes made where applicable. Appendix G contains the full text of these draft OCS Orders. These seven orders will be issued in a final form prior to proposed OCS Lease Sale No. 43, should it be held. Orders 6, 8, 9, 11, 13, 14, and 15, which are associated with the post-exploration or production phase of offshore operations are still undergoing internal review and will be available for public comment in the future. OCS Order No. 10 concerns marine sulfur extraction and probably will not be issued for the South Atlantic. Additional OCS Orders may be prepared and issued and the existing Orders revised as the need occurs throughout OCS operations in the South Atlantic. In the case of non-compliance lessees are subject to the penalty provided for in the OCS Lands Act of 1953.

A general description of operating requirements under the proposed South Atlantic Orders follows. Proposed Orders 6, 8, 9, 11, 13, 14, and 15, consistent with the established numbering sequences for other OCS areas, are also summarized. Significant public comments on and effected changes to the proposed Orders will also be published in the *Federal Register* with the finalized Orders. The mitigatory aspects of the draft Orders are discussed below.

Proposed South Atlantic OCS Operating Order No. 1

This Order requires all platforms, drilling rigs, drilling ships and wells to have signs of standard specifications for identification of the operator, the specific lease block of operation, and well number.

This Order also requires that all subsea objects resulting from lease operations which could present a hazard to other users of the OCS must be identified by navigational markings, of a design approved by the Supervisor and not inconsistent with applicable U.S. Coast Guard Regulations (Appendix F). Under this provision, the potential for accidents associated with subsea production systems, "stubs," fishing gear, and ship anchors is substantially reduced as is the possibility of an oil spill from such an accident.

This mitigates impacts caused by subsea completions on commercial fishing activities and anchoring, and mitigates impacts caused by the presence of platforms or drilling operations on shipping and navigation.

Proposed South Atlantic OCS Operating Order No. 2

Proposed Order No. 2 concerns procedures in drilling of wells. It requires the operators to file an application for drilling which includes information on the drilling platform or vessel, casing program, mud program, blowout prevention equipment, well control and safety training of operators' personnel, and a list of description of critical drilling operations which are or may be performed. The Order then describes certain procedures or equipment to be used in each phase of the drilling operation.

Due to the technical complexity of the proposed Order, not all details are included in describing its mitigatory impact—the reader may refer to Appendix G to review the entire Order. This proposed Order requires that all drilling platforms and vessels to be used must be capable of withstanding oceanographic and meteorological conditions of the South Atlantic; applications must include all pertinent data on the fitness of the platform or vessel and each such drilling structure must be inspected by the GS for compliance with OCS Orders. The requirement should eliminate most concerns about the impact of South Atlantic weather, waves, sediment scour, and currents on offshore structures. Operators must collect and report oceanographic, meteorological, and performance data of the vessels and platforms during operations in order to assist in developing future or revised operational guidelines for the South Atlantic.

All wells must be cased and cemented in order to support unconsolidated sediments, prevent leakage of fluids between formations or pressure changes in the well. If there are indications of improper cementing, the well must be recemented and logs run to indicate proper sealing of the well hole walls. The casing design and setting depths are to be based on all engineering and geologic factors including the presence or absence of hydrocarbons, potential hazards, and water depths; additional casing strings may be required if abnormal geopressures are encountered in initial wells in an area of the South Atlantic. A pressure test is required of all casing strings, except the drive or structural casing, to determine the presence of leaks or inadequate cementing. The use of casing described in this Order should eliminate potential impacts of fresh water zone contamination, lost production, or the possibility of accidents caused by improper casing.

Blowout preventers and related pressure control equipment must be installed, used and tested in a manner necessary to insure positive well control. A specific number of these preventers must be used in every well and they must include a fail-safe design; dual control systems, and fail-safe valving in critical lines and outlets. These devices provide protection against oil spills resulting from blowouts.

The characteristics, use, and testing of drilling mud, and the conduct of related drilling procedures shall be such as to prevent the blowout of any well. Sufficient quantities of mud are to be maintained and readily accessible for use at all times to insure proper well control. This part of proposed Order No. 2 will provide additional protection against possible blowouts.

Representatives of the operator will provide on-the-site supervision of drilling operations on a 24-hour operation basis. A member of the drilling crew or the toolpusher will maintain surveillance of the rig floor continuously from the time drilling operations commence until the well is either completed or abandoned. All supervisory personnel including drillers must be trained in present day methods of well control, and records of the training are to be kept at the well site. Participation in weekly blowout prevention exercises are required for all rig personnel. These requirements will also substantially reduce the possibility of blowouts in all kinds of weather, and provide additional safety margins for all crew members. Procedures to be followed when drilling operations are undertaken to penetrate reservoirs known or expected to contain hydrogen sulfide gas are now included in U.S. Geological Survey OCS Standard No. 1(GSS-OCS-1), "Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment." This set of standard operating procedures will assure proper testing and safety of the crew as well as the drilling platform or vessel should H_2S be encountered. Hazards of H_2S are substantially reduced by the institution of these procedures.

Since some operations performed in drilling are more critical than others with respect to well control, fire, explosion, oil spills or other accidents, each operator must file with the Supervisor for approval a Critical Operations and Curtailment Plan for the lease.

This Order includes a list and a description of categories of critical operations which are likely to be conducted. Before exceeding the operational limits of an approved plan the operator must notify the Supervisor and curtail operations. This allows the Geological Survey to provide either specific approval in advance of the conduct of the critical operation or to dispatch personnel to the lease site for observation of the operation. This part of proposed OCS Order No. 2 will provide additional governmental control over drilling operations which may be hazardous to the drilling platform, vessel, crew, and the environment.

Proposed South Atlantic OCS Operating Order No. 3

This Order is established to provide control of plugging and abandonment of wells which have been drilled for oil and gas. For permanent abandonment of wells, cement plugs must be placed so as to extend 30 meters (100 ft) above the top and 30 m below the bottom of fresh water, oil and gas zones to prevent those fluids from escaping into other strata. Portions of a well in which abnormal pressures are encountered are also required to be isolated with cement plugs. Plugs are required at the bottom of the deepest casing where an uncased hole exists below. Plugs or cement retainers are required to be placed 30 m above the top and 30 m below any perforation interval of the well hole used for production of oil and gas. A "surface" plug 45 m (150 ft) long shall be placed 45 m or less below the ocean floor. A pressure test must be made on top of the first plug below the surface plug. The spacing between plugs must be filled with drilling muds of sufficient density to exceed the greatest formation pressure encountered in drilling the interval. The casing and piling on the sea floor must be removed to a depth below the ocean floor approved by the Supervisor. For temporary abandonments, all plugs and mud discussed above must be placed in the well with the exception of the surface plug. (The temporary abandoned well would have to be marked in accordance with proposed Order No. 1).

This Order should eliminate concern about contamination of fresh water zones or the possibility of oil and gas leaks from completed wells. The requirement that the sea floor above each final abandonment must be cleared, and that the removal depth of casing and piling must be examined on a case-by-case basis, will provide protection to navigation and fishery interest. The chance that obstructions might become exposed due to sand wave migration is reduced as well.

Proposed South Atlantic OCS Operating Order No. 4

Proposed Order No. 4 provides for extension of a lease beyond its primary term for as long as oil or gas are being produced in paying quantities. If these circumstances should occur, a lease can be extended beyond its initial term, pursuant to Section 8(b)(2) of the OCS Lands Act and Title 30 CFR 250.11 and 250.12 (d) (1).

In addition to a production test for oil, one of similar duration is required for gas. All pertinent engineering, geologic, and economic data is required to support a claim that a well is capable of being produced in commercial quantities. Each test must be witnessed by the Geological Survey, although with prior approval an operator affidavit and third party test results may be acceptable. One primary purpose of this Order is to assure that a lease has been found to be capable of producing oil or gas prior to extending the lease beyond its initial 5-year term.

Proposed South Atlantic OCS Operating Order No. 5

This Order sets forth requirements for the installation, design, testing, operation, and removal of subsurface safety devices.

Proposed Order No. 5 requires that all well tubing installations open to hydrocarbon-bearing zones shall be equipped with a surface controlled, subsurface safety device that is placed 30 m or more below the ocean floor. All wells perforated and completed but not placed on production must be equipped with a subsurface safety device or tubing plug within two days after the well is completed. Subsurface safety devices shall also be placed in injection wells unless they are incapable of flowing. All safety devices must comply with the minimum standards set forth in the "API Spec. 14A, First Edition, October 1973, Subsurface Safety Valves" and recent supplements as approved by the Area Supervisor. Testing of the device must take place monthly for six months after installation and quarterly thereafter; if if does not operate correctly, it must be promptly removed with properly operating device put in place and tested. Additional protective equipment is also required with the use of subsurface protective devices. In a case where tubing installations have been opened to hydrocarbon zones and are not equipped with subsurface safety devices (during workover), the installation must be so identified and such a device or tubing plug must be available at the field location to be emplaced if necessary. Records must be kept of all subsurface safety devices employed at each well with quarterly reports prepared on reasons for any failures of the devices.

This Order provides additional means to prevent blowouts and keep wells under control, thereby reducing risks and impacts from spills.

OCS Operating Order No. 6

This Order will pertain to the development stage of leases and although not yet released, will be available prior to the Federal and State review of development plans. Order No. 6 will set forth requirements for conducting workover operations and will require all completed wells to have casing heads, wellhead fittings, and valves which are designed for handling pressures exerted by the well. It will also require specific testing procedures for the well. Accordingly, this Order will provide for protection of the well during workover and from rupture or loss of oil and/or gas by leakage and thus greatly reduce the possibility of environmental impact from release of oil and gas.

Proposed South Atlantic OCS Operating Order No. 7

Proposed Order No. 7 concerns the prevention of pollution to the marine environment and provides rules for the disposal of waste materials generated as a result of offshore operations.

Proposed OCS Order No. 7 sets forth a means to effectively deal with pollution of the marine environment from offshore petroleum operations. It states that the operator must prevent pollution of the ocean and that the disposal of waste products must not create conditions that can "adversely affect the public health, life or property, aquatic life or wildlife, recreation, navigation or other uses of the ocean." The operator must submit a list of drilling mud constituents, additives, and concentrations expected to be used—this provides a means to prohibit or alter the disposal and use of specific components which might be harmful to the environment. Muds containing free oil shall not be disposed of into the ocean and toxic substances must be neutralized prior to disposal. These requirements in effect eliminate the potential impacts of biological communities, water quality, commercial fisheries, offshore recreation and will mitigate impacts along the coastline which would be caused by the washing of oil, fuel, or chemical residues and toxic substances onshore. Discharges from the rig must meet EPA standards—reducing impacts to marine water quality.

No cuttings, sand or other solids containing free oil are to be disposed of into the ocean unless the oil is removed, thus eliminating potential impacts to water quality and marine organisms caused by such introduction of oil to the marine environment. No solid waste materials or debris can be disposed of in the marine environment but must be incinerated or transported to shore for disposal according to governmental regulations; this requirement eliminates potential impacts to fisheries.

All personnel must be thoroughly instructed in the prevention of pollution from offshore operations. Rigorous inspection schedules are required for all facilities. Pollution reports are necessary for all oil spills with notification of proper authorities. Standby pollution control equipment must be maintained or available to each operator. The equipment must include booms, skimmers, cleanup materials, and chemical agents (though chemical agents can only be used with the express consent of the Supervisor) and it must be inspected monthly with proper maintenance. Results of inspections of this equipment must be recorded. Any application for a drilling permit must include an oil spill contingency plan with provisions for varying degrees of response effort depending on severity of oil spill; identification of containment and cleanup equipment availability; notification procedures of responsible persons and alternates in the eventuality of a spill; and provision for specific actions to be taken after discovery and notification of an oil discharge. Should a spill occur, immediate corrective action must be taken. This portion of the Order provides the maximum protection available for the prevention and cleanup of oil spills. It provides substantial reduction in the potential impact of oil spills.

OCS Operating Order No. 8

Although no draft version of this Order has been released for the South Atlantic, it will be available for State and Federal review prior to the submission of any operator development plans. Order No. 8 will provide approval procedures for the installation and operation of platforms, fixed and mobile structures, and artificial islands to be used for production of offshore oil and gas. Safety procedures and pollution control equipment requirements will also be set forth. This order will provide controls for the prevention of pollution impacts resulting from day-to-day operations, will provide protection against geological hazard impacts on operations, and help prevent impacts on biological communities, water and air quality, and on human use of the OCS.

OCS Operating Order No. 9

This Order will also be available for Federal and State review prior to submission of operator development plans. Order No. 9 will provide approval procedures for pipelines. Information to be submitted for approval will include the purpose of each line, proposed route, water depths, capacity, operating pressures, size and grade of pipe, burial depth, corrosion protection, protective coating, connecting and metering facilities, and pressure control facilities. The methods of welding and laying the pipeline will be monitored, as is the installation of connecting facilities. A hydrostatic test to greater than the designed working pressure of the line will be made upon completion of installation.

Agreements made between the Department of Transportation and the Department of the Interior provide better coordination of these agencies in development of pipeline standards, construction monitoring and inspections.

The effect of this Order will greatly reduce the chance for offshore oil spills or gas leaks. The approval of pipeline routes by the GS as well as BLM and the Department of Transportation (Section IV.A.2.b.) can effectively reduce a variety of impacts to marine and coastal biota and multiple uses of the South Atlantic OCS.

OCS Operating Order No. 11

As in the case of Orders 6, 8, and 9, Order No. 11 will be available before development plans are submitted. It will provide for the prevention of waste, conservation of oil and gas, and protection of correlative rights. Requirements for maximum efficient recovery of oil and gas from a lease and establishment of production rates for oil and gas will be presented. It will also state that each operator shall produce without waste his proper share of oil and gas from a common source of supply. Procedures to be followed in the eventuality of shutins for overproduction or storms will be set forth as will requirements for all tests of well producibility. Requirements concerning the location of all wells will be presented, as will the authority of the Supervisor to decide issues on field unitization.

Therefore, this Order will provide a means to insure a proper production of oil and gas and placement of facilities to maximize production while minimizing environmental impact.

Proposed South Atlantic OCS Order No. 12

This proposed Order sets forth requirements for public availability of data and records concerning offshore petroleum operations. Under the Order, specific types of information, data and records pertaining to production, operations, well tests, sales of lease production, accidents, inspection, and pollution incidents are to be available for public inspection. However, privileged information such as geological and geophysical information would not, at least for a period of time, be made available for public inspection.

OCS Operating Order No. 13

This Order as well as 14 and 15, has not been issued for the South Atlantic OCS. It will be issued before any development plans are submitted for review and approval. Order No. 13 will require the accurate measurement of oil and gas production and set forth conditions under which production from several wells can be commingled. Standards will also be set for meters to be used for measuring production. This Order will offset any possible attempts of fraud and alleviate public concerns that operators are under-estimating royalties due the Federal government.

OCS Operating Order No. 14

Order No. 14 will assure diligence in the development of OCS natural resources by allowing limited suspensions of operations or production while the operator is waiting for installation of equipment or granting of permits necessary for transportation of oil and gas from a lease. Criteria will be set under which suspensions can be granted and will provide a means to determine if production is being withheld for other purposes. A proposed version of this Order for the Gulf of Mexico was issued on December 19, 1975.

OCS Operating Order No. 15

Order No. 15 will detail the required data contents and the review process to be followed before the Area Supervisor can grant approval of a lease development plan(s) pursuant to the November, 1975 changes in regulation 30 CFR 250.34 (Appendix H). The lessee will submit information to the directly affected states concerning the proposed onshore and offshore facilities anticipated for development. This information may be submitted to the affected states prior to the formal submission of development plan(s) to the Supervisor.

Inspection Programs and Approval Requirements

To enforce the Geological Survey Operating Regulations (30 CFR 250) and OCS Orders, a comprehensive inspection system has been developed. OCS operators must receive approval before commencing any work. Operators are required to submit a notice and detailed description of work they desire to perform to the USGS District Supervisor. This requirement is to insure that no operation is conducted without thorough planning for safety, conservation, and protection of the environment, and to determine that all operations meet the standards established by regulations and OCS Orders.

On-Site Inspections

All operations, regardless of the activity, will receive regular on-site inspection for compliance with regulations and OCS Orders. The Geological Survey uses a systematic program including unannounced inspections to assure the achievement of safety objectives.

Floating drilling vessels or drilling units will receive a detailed inspection to insure conformance with regulations and OCS Orders before commencement of drilling operations. These predrilling inspections are comprehensive and often require several days to complete. The Eastern Region of the Geological Survey intends to inspect these rigs daily during the drilling of a well, and all well control, safety, and pollution control equipment will be inspected for proper function.

Permission to either abandon or suspend a well must be granted by the USGS; this includes the setting of all required cement plugs, the cutting of the several casing strings below the sea floor, and the removal of all subsea equipment. The depth below the sea floor at which the casing is removed will be reviewed by the USGS on a case-by-case basis to ensure that sediment migration will not eventually expose the plug (proposed South Atlantic OCS Order 3).

Well workover and well abandonment phases of OCS operations, as with drilling, will receive both scheduled and unscheduled inspections, depending on the progress of a particular operator. Drill stem testing, cement plugs set prior to redrilling a well, cement plugs set to temporarily or permanently abandon a well, and all casing cementing operations must be approved by the GS Supervisor.

OCS pipelines will be installed in accordance with proposed South Atlantic OCS Order No. 9, which will provide for submittal of information such as purpose of each line, proposed route, water depths, capacity, operating pressures, size and grade of pipe, burial depth, corrosion protection, protective coating, connecting and metering facilities, and pressure control facilities. The methods of welding and laying the pipeline are monitored, as in the installation of connecting facilities. A hydrostatic test to greater than the design working pressure of the line is made upon completion of installation.

Inspection Schedule and Enforcement

The inspection program for the South Atlantic OCS area will be maintained by the Geological Survey with the intent that required regulations will be followed to avoid potential hazards to personnel, provide protection for the environment, and preserve the multiple-use concept of the OCS lands. Warnings and operational shut-downs for incidents of non-compliance will be issued and the date of correction of defects will be recorded.

The Geological Survey anticipates that a temporary office will be established to oversee and inspect the initial industry exploratory activities in this South Atlantic area. This office would report to and be supported (technically and administratively) by the Office of the Atlantic Area Oil and Gas Supervisor for Operations in the Conservation Division of the USGS. The location of the office would be contingent upon two primary logistic considerations, i.e., proximity to the concentration of exploratory operations and to the adequate helicopter service areas. The initial staffing of the office would be expanded concurrent with the level of activities in the event the sale is held.

Visual inspections of the water surface over OCS pipelines in other operating areas are currently made by the operator for evidence of failures and leaks. GS and operator personnel in those areas visit production facilities daily and follow a route approximating the pipeline route. Although no specific inspection schedule has been established for this South Atlantic area to-date, the GS will assure that thorough and frequent inspections will be carried out in this proposed sale area. Such a schedule will be developed concurrently with the initial phases of exploration, and will continue through the life of the field.

A routine schedule for external inspection by operators of marine pipelines, for evidence of failures and leaks, including risers to the platforms, will be required for the South Atlantic OCS area.

An approved contingency plan is required from each operator in the area that will include spill control, containment and cleanup, and measures to be taken if there is any likelihood that hydrogen sulfide gas might be encountered during the drilling operation.

Inspection Procedures for Subsea Systems

Subsea systems may possibly be used to produce oil and gas resulting from this proposed sale. Inspections of these systems in the U.S. South Atlantic will be in accordance with the proposed OCS Orders. A new OCS Order especially designed for subsea systems is presently being considered. Proposed Order No. 1 requires the surface marking of all such systems in accordance with guidelines developed by the USGS Supervisor.

The many Federal agencies involved in the review process of subsea systems include in addition to the Geological Survey: EPA, Coast Guard, Corps of Engineers, U.S. Fish and Wildlife Service, and the Bureau of Land Management. Except for proprietary parts, plans for exploration and development utilization are available for general public review.

Operator Reports

A comprehensive reporting system covering all oil spills and any unusual conditions (for example, reporting and investigation of a persistent oil slick from an unknown source, such as a sunken ship or natural oil seep) is to be required by the proposed OCS Orders, and is a key factor in monitoring operations in the U.S. South Atlantic area. Operators are also required to maintain records for inspection by the Geological Survey of required periodic tests of safety equipment. A digest of these operator reports and the various forms that are required can be found in the proposed U.S. South Atlantic OCS Order No. 12 in Appendix G.

Requirements Specific to U.S. South Atlantic Operations

Specifically tailored requirements for the U.S. South Atlantic under the proposed OCS Orders are discussed below.

Proposed Order No. 1 requires all subsea structures (be they temporarily abandoned wells or subsea production systems) shall be marked on the ocean surface in accordance with guidelines developed and approved by the Supervisor and other Federal regulations. This will provide a means to reduce potential damage to fisheries gear or petroleum production equipment as a result of accidents.

Reports on all encountered oceanographic and meteorological conditions encountered by drilling structures and the performance of the structures will be required of all offshore operators in the U.S. South Atlantic OCS.

Proposed Order No. 2 specifies that casing will meet API standards. In addition, cross referenced in proposed Orders Nos. 2 and 7 is approval by the USGS of the mud program before drilling; all substances in the muds to be used must be identified and their use must comply with EPA standards under the Federal Water Pollution Control Act, as amended. No direct ocean disposal of oil-based drilling muds will be allowed in the U.S. South Atlantic, and any request for variance must be reviewed on a case-by-case basis. Although there is no indication of the potential for encountering hydrogen sulfide, safety procedures, equipment, and warning devices will be necessary on offshore drilling rigs and platforms.

As described earlier in this section, casing removal depths will be looked at individually under proposed OCS Order No. 3. To determine whether or not a lease can be extended beyond five years due to discovery of petroleum, an actual production test must be run and all economic, geologic, and engineering data must be supplied to the USGS Supervisor (proposed OCS Order No. 4).

In addition to no direct ocean disposal of oil-based drilling muds, under proposed Order No. 7, no cuttings containing oil can be disposed of at sea; instead, these cuttings must either be washed to remove the oil, with the wash water shipped ashore, or the unwashed cuttings with oil must be shipped ashore. Both methods will be dealt with by applicable State or EPA regulations. All produced formation water must be treated to meet appropriate EPA water quality standards prior to discharge at sea. Copies of all analyses done on produced formation waters must be sent to the USGS Supervisor and EPA. Oil spill containment equipment must be available to the operator; monthly inspections of this equipment will be performed by the USGS.

Under new procedures for State considerations of OCS oil and gas development plans (Federal Register, 40 (179): 42559-42560; 40 (182): 43036; and 40 (213): 51199-51200, see Appendix H), the operator must supply a description of all onshore and offshore facilities and operations which are anticipated; plus other pertinent information regarding these developments, to the Governors of directly affected States 30 days before a formal development plan is submitted to the USGS Supervisor. The states will then have 60 days to review this data to determine its adequacy and comment on it. The Director of the USGS can then further delay development at the States' request until necessary information is provided to the States. In addition, a copy of development plan (minus proprietary data) is also submitted to the Governors of directly affected States at the same time the entire development plan is submitted to the USGS Supervisor. The States have 60 days to review and comment on the submitted plan. This information provided to the States can be used by State agencies to prepare for any environmental and socio-economic impacts which might result from development; they also are afforded, through the Governors, an opportunity to comment or criticize the anticipated development plans.

Enforcement

The USGS policy is intended to eliminate any noncompliance with lease requirements by the operator that may lead to loss of life, loss of property and resources, or damage to the environment. A standardized compilation of items has been prepared by the USGS, entitled "List of Potential Items of Noncompliance and Enforcement Action", the "PING" list, which is used for inspections. During an inspection of drilling and production operations, depending on the hazard presented toward safety or pollution, either a written warning will be given that allows the operator seven days to correct the incident of noncompliance (INC), or a shut-in order will be issued. The shut-in order may be applied only to the equipment affected by the incident of noncompliance (INC), such as a particular piece of production equipment or a producing zone, or to the entire drilling rig, production platform, or onshore facilities, as required.

Additional penalties for noncompliance are specified in Sec. 5(a)(2) of the Outer Continental Shelf Lands Act of 1953, 43 USC Sec. 1334(a)(2).

> Any persons who knowingly and willfully violates any rule or regulation prescribed by the Secretary for the prevention of waste, the conservation of natural resources, or the protection of correlative rights shall be deemed guilty of a misdemeanor and punishment by a fine of not more than $2,000 or by imprisonment, and each day of the violation shall be deemed a separate offense.

Also, Sections 5(b)(1) and 5(b)(2) provide for cancellation by notice of nonproducing leases subject to judicial review or appropriate judicial proceedings.

2. Department of Transportation

a. Federal Aviation Administration

The Federal Aviation Administration is responsible for the monitoring and control of aircraft flights, training of operators, and certification of general operations (Federal Aviation Act of 1958). Flight plans must be filed for all flights which take place in defense warning zones over the OCS (General Operations and Flight Rules, Part 91. Subpart B; Part 121, Subpart U; Part 135, Supplemental Rules). Individual flights through the defense operating areas must be cleared with the Commander, Eastern Sea Frontier (U.S. Navy). The FAA office in charge of certifying of operators, training programs, and aircraft will depend on where the operator is based in the U.S. South Atlantic and the size of the aircraft that will be used.

b. Materials Transportation Bureau

The Office of Pipeline Safety Operations within the Materials Transportation Bureau supervises safety of gas and oil pipelines including the establishment of design criteria for pipeline systems on the OCS. The Department of Transportation is authorized under the Natural Gas Pipeline Safety Act of 1968 (49 U.S.C. Secs. 1671, et seq.) to establish gas pipeline safety standards for transportation of gas and for pipeline facilities. Gathering, transmission or distribution by pipeline or storage in or affecting interstate or foreign commerce is included in the meaning of transportation of gas. The Secretary of Transportation is authorized to advise, assist and cooperate with other federal departments in the planning and development of the standards and in methods for inspecting and testing to determine compliance with the standards. Regulations implementing the Department's authority for gas and oil pipelines are found in 49 CFR Parts 192 and 195. Recent regulations by the MTB more clearly delineate criteria for safety standards for offshore liquid pipelines (including burial depths), (41 Federal Register 34035), and for offshore natural and other gas pipelines (41 Federal Register 34598). New regulations were also issued in 1975 (Federal Register 40, No. 91, May 9, 1975) requiring odorizating of gas transmission lines by class location (class determined by population in the area).

c. U.S. Coast Guard

The OCS Lands Act delegates to the Coast Guard the authority to promulgate and enforce regulations covering warning devices, safety equipment, and other matters related to the promotion of safety of life and property on fixed OCS platforms and drilling vessels. The implementing regulations for this delegation are contained in Title 33 of the Code of Federal Regulations, Part 67 and Subchapter N, Parts 140 to 147. Other Coast Guard regulations cover safety equipment on all types of offshore facilities and vessels, specific personnel licensing procedures, and minimum levels for ships and boats, and prohibit the discharge of pollutants from all vessels.

Lead Coast Guard responsibility resulting from this proposed lease sale will be undertaken by the Seventh Coast Guard District (Miami) since all of the proposed lease tracts are contained in their jurisdiction. Certification of vessels (both boats and rigs) will depend on most recent certification date and operations port. The Coast Guard's responsibility as to oil spill containment and cleanup is discussed under the heading "Contingency Plans" later in this section.

A Memorandum of Understanding between the U.S. Geological Survey and the U.S. Coast Guard is also discussed. No Coast Guard surveillance program for oil spills emanating from rigs, platforms, or pipelines have been developed yet for this U.S. South Atlantic although oil pollution and law enforcement patrols by Coast Guard aircraft cover part of this area. It can be expected that with OCS development and the recent enactment of a 200-mile limit fisheries management law, patrols will be expanded (U.S. Coast Guard, Written Testimony, Public Hearings, DES for Proposed OCS Lease Sale No. 40, 1976, Mid Atlantic).

As standard procedure, the Army Corps of Engineers will request comments from the Coast Guard on the placement of offshore rigs and platforms with respect to interference with navigation. Though no specific regulations are in force, the Corps of Engineers generally does not allow structures to be placed within traffic lanes as identified by the Coast Guard.

3. Federal Power Commission

The Federal Power Commission (FPC) grants certificates of public convenience and safety for gas pipelines. In making a decision regarding the granting of such certificates, if considered necessary, FPC prepares environmental impact statements. Both FPC and the Materials Transportation Bureau must approve these pipeline designs. The FPC also regulates gas prices, purchases, and sales (interstate).

4. United States Army Corps of Engineers

The OCS Lands Act provides that the authority of the Secretary of the Army to prevent obstruction to navigation in the navigable waters of the United States be extended to structures located in the OCS. The Corps of Engineers implements this delegated authority by issuing navigational permits for exploration drilling vessels and fixed and mobile platforms according to 33 CFR 209.120 as amended by the July 25, 1975 Federal Register, pages 31320 et seq. In the event this proposed sale is held permits will be processed by the South Atlantic Engineering Division, Atlanta, Ga. In evaluating the permit application, Corps of Engineers officials will consider the following policies (from 33 CFR 209.120):

> Artificial islands and fixed structures located on the outer continental shelf are subject to the standard permit procedures of this regulation. Where the islands or structures are to be constructed on lands which are under mineral lease from the Bureau of Land Management, Department of the Interior, that agency, in cooperation with other Federal agencies, fully evaluates the potential effect of the leasing program on the total environment. Accordingly, the decision whether to issue a permit on lands which are under mineral lease from the Department of the Interior will be limited to an evaluation of the impact of the proposed work on navigation and national security. The public notice will so identify the criteria.

5. U.S. Environmental Protection Agency

Produced waste water is an unavoidable consequence of producing oil and gas. Presently the Environmenal Protection Agency, the Geological Survey, and offshore operators in other OCS operating areas are in the process of determining the best method from an environmental protection standpoint of treating and disposing of produced waste water. The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-550; 86 Stat. 816, hereinafter the Act), makes the discharge of any pollutant by any person, except in compliance with certain sections of the Act, unlawful. A National Pollutant Discharge Elimination System (hereinafter NPDES) was created by Section 402, and made applicable to discharges into the territorial sea, the waters of the contiguous zone, and the oceans. Permits for discharges will be issued by the Administrator (Environmental Protection Agency) in compliance with guidelines promulgated by him. While the NPDES appears to apply to fixed platforms and structures, it does not apply to 1) addition of any pollutant to the waters of the contiguous zone or the ocean from any vessel or floating craft, or 2) water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil or gas production and disposed of in a well. Regulations governing the NPDES may be found in 40 CFR, Part 125, 38 Federal Register 13528 (1973), and the guidelines issued pursuant to Section 403(c) of the act are found in 40 CFR, Part 227; 38 Federal Register 12872 (1973); 40 CFR, Part 435; 40 Federal Register 42572 and 42543 (1975). Subsurface injection into OCS platform wells is in accordance with Environmental Protection Agency suggested guidelines and is subject to Geological Survey approval and regulation.

The EPA office involved as a result of this proposed sale would be Region IV (Atlanta). No regular program for analysis of platform or rig discharges has been developed for the U.S. South Atlantic to date.

6. United States Navy

Although not involved in OCS petroleum operations and regulation, the Commander, Eastern Sea Frontier (New York, New York) controls military air and sea operations in the area. Because access to air space over much of the U.S. South Atlantic OCS is restricted due to reasons of national defense (and for reasons of safety), helicopter and aircraft operations in support of petroleum activities must be certified by the Commander in order to take place in certain corridors.

B. Oil Spill Containment and Cleanup

At this time, the only Federal regulations applying to oil spill prevention, containment and cleanup between the 12-mile contiguous zone and the 200-mile economic zone, within which BLM is proposing tracts for oil and gas development, are stipulations attached as a condition of leases, and OCS Operating Order No. 7. That Order is discussed below in subsection C.5. Federal pollution plans which would apply within the 12-mile limit are described below. If jurisdiction were to be extended beyond 12 miles, it is assumed that the current Federal pollution plans would be similarly applied beyond the 12-mile limit.

1. National Oil and Hazardous Substances Pollution Contingency Plan

The National Contingency Plan developed in accordance with the Federal Water Pollution Act as amended, P.L. 92-500, provides a pattern for coordinated and integrated responses by Federal agencies to oil spills and promotes the coordination of Federal and state response systems. The National Plan sets up a system for the development of regional plans and includes the resultant regional plans. Primary operational responsibilities are divided between the Coast Guard and EPA. The Coast Guard has responsibility for spills in coastal waters as defined in each regional Oil Pollution Contingency Plan. EPA has responsibility for inland waters.

Within each region, the Coast Guard has designated an On-Scene Coordinator (OSC). Additionally, Regional Response Team (RRT's) have been set up. The RRT is activated in the event of a major spill and serves as a technical advisory board to the local OSC. In the event of a spill, the OSC makes a determination as to whether or not the responsible party is able and willing to adequately combat the spill. Affected States are invited to participate in the deliberation. In the event that the responsible party is deemed to be taking adequate corrective action, the OSC maintains a coordinating function. If it is determined that an adequate response cannot or will not be made by the responsible party, the OSC becomes an On-Scene Commander and cleanup activities are then taken over by the U.S. Coast Guard or the EPA for inland waters. Each of these agencies maintains Regional Response Centers where equipment and/or communications are located. In addition, the Coast Guard maintains a strike force on each coast which handles major spills and harbors most major cleanup equipment.

The U.S. South Atlantic proposed sale area is located within the jurisdiction of the Southeast Region Oil Spill Contingency Plan administered by the Region IV EPA Headquarters in Atlanta, Ga. Included are North Carolina, South Carolina, Georgia, and Florida. Although the Regional Response Center is Atlanta, Ga., the organization is broken down into additional subregions consisting of individual states.

Two Coast Guard Districts have responsibility for the proposed South Atlantic Sale Area. District 5 at Portsmouth, Virginia, covers North Carolina, and District 7, at Miami, Florida, covers South Carolina, Georgia and Florida. Regional Response Centers are located at Portsmouth, Va. and Miami, Florida. In general, OCS responsibilities have been delegated by the Districts to Captains of the Ports. The Marine Safety Offices commanded by the Port Captains are located at Miami, Jacksonville, Savannah, Charleston, and Wilmington. The Captain of the Port handles the operation of clean-up and calls on the Atlantic Strike Force. The Atlantic Strike Force of the Coast Guard is located at Elizabeth City, North Carolina. The Districts rely on the Strike Force equipment maintained by the Atlantic Strike Force.

Use of dispersants for oil spills is also regulated under the national and regional plans. Data on dispersants which might be used must be provided to EPA which can then advise OSC's regarding their use. Use of dispersants in Regions II and III in inland waters is considered only in extreme fire hazard conditions, particularly when considering use directly onto water bodies. The Coast Guard Districts discourage and/or prohibit the use of chemical dispersants. Use of dispersants under the plan is, in all cases, at the discretion of the OSC's who must consider hazards to human life, toxic effects on other organisms, as well as effectiveness of other methods before approving their use.

2. State Programs

Several of the U.S. South Atlantic states are updating their contingency plans and considering new legislation, more stringent requirements for oil handling facilities, increased or broadened liability, and more sophisticated and integrated spill response equipment and mechanisms which may be in existence in the near future. Information concerning proposed legislation or requirements is unavailable at this time although it is understood that such changes have been proposed in some states. At this time there is a general reliance on the Federal and private sectors, with states most active in enforcement activities.

3. Existing and Proposed Oil Spill and Containment Capabilities in the Region

The Bureau of Land Management is not aware of any existing oil spill containment capabilities within the U.S. South Atlantic OCS area.

In the Gulf of Mexico OCS region, companies involved in oil and gas operations have formed cooperatives to provide and maintain oil spill containment and clean-up equipment. Clean Gulf Associates is an example of a cooperative which maintains oil spill containment and clean-up equipment at four primary bases in the Gulf of Mexico OCS region.

A group of 16 companies have formed a cooperative, Clean Atlantic Associates, to provide oil spill containment and clean-up equipment for the U.S. South Atlantic OCS region. O. J. Shirley, Chairman of Clean Atlantic Associates (personal communication, October 1976) indicated that the cooperative has established a shore base at Davisville, R.I. for the Mid-Atlantic OCS region. Clean Atlantic Associates has acquired and/or ordered fast response sea and bay skimmer systems, an open sea containment boom, and other ocean and beach protection and clean-up equipment, for this base. It is planned to maintain a 24-hour readiness, and be able to respond within 12 hours to a spill as far as 201 km (125 miles) from its shore base, under normal conditions. Equipment sufficient to handle one spill, with back-up capacity to commence cleanup of a second concurrent spill is envisioned.

Mr. Shirley also indicated that a similar shore base would be established for the U.S. South Atlantic OCS region, if oil and gas development occurs in this region. The base would be located near other onshore oil and gas supply operations.

4. Status of Oil Spill Containment and Cleanup Technology

When oil is spilled on water, the first priority is to contain it or, in a river, direct it to a collection point and remove it by absorption, adsorption, or skimming. Presently available equipment is adequate for calm or enclosed waters but fails in rough seas conditions in excess of one knot currents and several foot waves (Boesch, et al. 1974).

Booms are used for containment and various types are available. They normally fail when the accumulated oil behind the barrier is carried underneath it by the current. Most often booms available break apart in high sea states and are not easily deployable in rough weather. The Coast Guard has developed a High Seas Containment Barrier that is capable of withstanding 6m (20 ft) waves and 13 km/hr (7 knot) currents (Boesch, et al., 1974), and of operating well in 1.2-1.8 m (4-6 ft) waves, 3.7 km/hr (2 kt) currents, and 37 km/hr (20 kt) winds (Atlantic Strike Team, 1974). It can be transported by plane or truck and deployed fairly rapidly. Exxon has developed a boom that has been shown capable of surviving in 6 m (20 ft) waves, 3.7 km/hr (2 kt) currents, and 37 km/hr (20 kt) winds (CEQ, 1974b). However, the boom is cumbersome and not easily deployed. To date, the best boom performance that has been reported (Exxon) is containment in 1.8-2 m (6-8 ft) seas with 32 km/hr (20-mile) winds and 2 km/hr (1.25 kt) currents. Improvements are being made but the effectiveness of booms is reaching its upper limit (CEQ, 1974b).

After containment, the oil must be collected. Straw is rapidly being replaced by mechanical skimmers and synthetic sorbents in this task. Skimmers operate on various principles and some types are now available that work well in 1.8-2 m (6-8 ft) waves, 5.5 km/hr (kt) currents, and 74 km/hr (40 kt) winds (Atlantic Strike Team, 1974), however, these latter types operate at low recovery rates (1 to 5 bbls/min). The Coast Guard is developing a combination boom and skimmer system, but this will not be available for some time. Recovered oil can then be transferred to a refinery for recycling.

When the oil slick becomes too thin to be collected by these devices absorbents and adsorbents like straw or the newer synthetic materials can be used. The synthetic sorbents include polyurethane foam, alkylstyrene beads and other coleophilic products. These absorb or adsorb 5-30 times their weight in oil, and some can be wrung out and reused. The problem with sorbents is that they themselves must be collected either mechanically or manually to prevent them from contaminating the environment.

Various chemicals may also be used to assist in collecting, dispersing, or removing the oil. Surface tension modifers and collecting agents prevent or restrict the spreading of oil on the water's surface and "thicken" the oil slick for easier collection by the skimmers and mops. Their use is authorized when it will result in the least overall damage to the environment or interference with designated water uses. Dispersants can be used to form oil-in-water emulsions that facilitates the dispersal of oil into the water column. As previously indicated, the use of these chemicals is limited, however, because of their potentially toxic effects on marine organisms. Biological agents that encourage biodegradation of the oil may also be used if previously approved. Burning agents that improve the combustibility of oil may be applied if they have been approved by EPA, and if their use will reduce imminent danger to life, limb, or property and will result in the least environmental harm when compared to other methods. The use of sinking agents is not allowed on the navigable waters of the United States.

All of the above methods are effective in calm harbor and nearshore waters but face severe limitations on the open seas, not the least of which are the 12 or more hours required to respond to a spill several miles offshore as might be the case in this proposed sale area. Oil spill containment on the open seas, then, is severely limited. However, because of the effectiveness or efficiency of recovery for any particular spill depends on a combination of wind and wave conditions, and other physical parameters, no estimate can be made of what percentage of a spill could be recovered or what amount could be recovered.

Toxicity studies involving the various chemicals available for use for collecting, dispersing, and removing of oil are, by requirement, available through EPA.

5. OCS Operating Orders

Proposed OCS Operating Order 7 for the U.S. South Atlantic (Appendix G) requires that, prior to the initiation of operations, the lessee must prepare and have approved by the Area Supervisor, Geological Survey, an Oil Spill Contingency Plan. In order to implement the plan, the lessee must maintain or have available to him, the pollution control equipment and materials necessary to effectuate containment and cleanup. The equipment must be the most effective available, given the current state of oil pollution containment and cleanup technology. A memorandum of understanding between the Departments of the Interior and Transportation outlines the respective responsibilities of the Geological Survey (GS) and the Coast Guard (CG), regarding the supervision of abatement, containment, and cleanup efforts required by the proposed Orders. Essentially, the GS is responsible for the coordination and direction of measures to abate the source of pollution, whereas the CG is responsible for containment and removal operations, as further detailed previously.

C. Mitigations Included for Specific Aspects of the Proposed Action

1. Offshore Structures and Pipelines

Currently, there are no established commercial shipping fairways in the U.S. South Atlantic OCS region (USDT-CG, 1976). Therefore, none of the proposed lease tracts would impinge on commercial shipping fairways.

The Corps of Engineers and U.S. Coast Guard have regulations pertaining to obstructions to navigation in the navigable waters of the United States. The Corps of Engineers issues navigational permits for offshore structures and the U.S. Coast Guard has requirements for audio-visual warning devices to be installed on these structures (Appendix F). These regulations would function to mitigate potential impacts between sea traffic and offshore structures.

The U.S. Geological Survey Oil and Gas Supervisor must consider the views of commercial fishing organizations and fishermen with regard to placement of platforms. The Supervisor must also coordinate with the Department of Commerce, Fish and Wildlife Service (FWS) and the Bureau of Land Management (BLM), in the decision-making process of approving or disapproving platform installation. Recent changes in 30 CFR 250.34 (Section IV.A.1.b). require that the development plan, minus proprietary data, be submitted in advance to Governors of adjacent states. Under that arrangement, states have an opportunity to comment on platform placement.

Platforms are designed for removal after their operational life. Following the depletion of all producing zones developed from a platform, wells will be plugged and abandoned. Drilling and production equipment dismantled and removed, the deck units removed, well conductors and platform piling will be cut below the mudline and removed, and the site restored in accordance with permit requirements.

Proposed OCS Order No. 7 and Environmental Protection Agency (EPA) regulations prohibit the disposal of solid waste offshore from operations which might result from this proposed sale.

As mentioned previously, should producible quantities of oil and/or gas be discovered the BLM will conduct pipeline corridor management studies in an effort to determine the most technically and environmentally practical route(s).

At present, the cooperative effort between the Department of the Interior, Corps of Engineers, National Marine Fisheries Service (NMFS) and State conservation agencies is responsible for minimizing the impact of pipeline (and other) construction in navigable waters of the U.S. in the following manner. The Corps of Engineers, through authority of the Rivers and Harbors Act of 1899 (33 U.S.C. 403), asserts authority over, and requires a permit for, construction in all navigable waters subject to the Submerged Lands Act (43 U.S.C. Sec. 1301) and includes all lands permanently or periodically covered by tidal waters up to the line of mean high tide.

The EPA reviews and comments on dredging projects in navigable waters in accordance with a memorandum of understanding with the Corps of Engineers dated July 13, 1967.

The Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) (through NMFS) has been vested with responsibility for participation in matters relating to marine and estuarine areas. The FWS, with assistance from appropriate State and Federal agencies, including NMFS, now reviews all applications to the Corps of Engineers for permits to construct pipelines in navigable waters and assess their potential impact on fish and wildlife resources and the environment. Especially sensitive areas such as any area of special biological significance, bay, or estuary occupied by rare or endangered species would be examined very critically. When appropriate, the agency recommends to the Corps specific modifications of project plans which are needed to reduce impact on these resources.

In addition to the above effects to mitigate potential impacts associated with pipeline, the BLM and USGS, by virtue of memorandum of understanding (Appendix D), have taken steps to clearly define their respective administrative and operational roles. The purposes and objectives are to: (1) minimize or eliminate environmental damage; (2) better serve industry and public interests; and (3) streamline the regulations and procedures for most efficient and uniform administration, operation, and industry compliance. This clarifies the administrative and operational roles of both BLM and USGS in regards to OCS pipeline management.

Each application for a pipeline right-of-way will be reviewed on a case by case basis by the BLM New Orleans OCS Office. When a decision is issued for approval of a pipeline application, it is stipulated that all valves and taps must be buried to a minimum of 0.3 m (1 ft) below the ocean floor at any depth. When the water depth of the right-of-way is less than 61 m (200 ft) the pipeline must be jet buried to a minimum of 0.9 m (3 ft) below the ocean floor. The Manager reserves the right to require or not require the burial of any BLM-permitted pipeline at any water depth. If a pipeline is not buried, the Manager reserves the right to require a permittee to later bury that line should it cause interference with commercial fishing activities. It is also stipulated upon approval by the manager that the proposed pipeline be designed, constructed, operated and maintained in compliance with applicable Department of Transportation Regulations.

2. Measures Involving Military Uses of the OCS

Before tracts are offered for lease the Department of the Interior in consultation with the Department of Defense delete tracts which could unduly conflict with the national defense. Military operations offshore and nearshore could be scheduled to avoid conflict with oil and gas operations. A special stipulation (Section IV.D.) provides for surveying the ocean floor in tracts where military munitions are suspected to have been jettisoned or lost.

None of the proposed lease tracts are located south of the thirtieth parallel, thereby avoiding conflicts with the primary zone of missile activity originating from the Kennedy Space Center.

3. Onshore Facilities

Of the four southeastern Atlantic states, the area of most intensive development pressure is in the three northerly states in the vicinities of their coastal cities: Wilmington, Charleston, Savannah and Brunswick. The Florida coast has almost continuous development from the Jacksonville area south to Cape Canaveral.

Although not exercising any direct control over land use except on federal lands such as military reservations, national parks and recreation areas, the federal government plays an increasingly important indirect role in the control of land use, particularly in coastal areas. Federal programs in certain fields are well established and exert a key role affecting land use in coastal areas. Most recent are the protective measures being introduced in coastal areas under the Coastal Zone Management Act of 1972, which authorized $171 million in grants to the states over five years to encourage the establishment of programs for planning, management, use, protection, and development of the Nation's coastal areas (VIMS, 1974).

The Coastal Zone Management Act Amendments of 1976, contained in the Report of the Committee of Conference (June 24, 1976) provides for additional means for states to study, plan for, manage, and control the impact of energy facility and resource development which affects their coastal zones. Energy facility means any equipment or facility which is used in the exploration for, or the development, production, conversion, storage, transfer, processing, or transportation of any energy resource or for the manufacture, production, or assembly of equipment, machinery, products, or devices which are involved in any activity described above. The amendments provide for a procedure to be followed in the event that a management program decision is in conflict with any local zoning ordinance, decision or other action.

A notice, proposed for inclusion in the leases awarded as a result of this proposed sale, provides that the lessee shall provide to the state and local communities for their review and comment a "Notice of Support Activity for the Exploration, Development, or Production Program". This notice would be provided to states with approved coastal zone management programs. The Notice shall include a description of the facility, the location and size, the number of persons to be employed, an estimate of the types and costs of equipment to be obtained within the state, and other information.

Regional planning is well established in the southeast coastal areas. Since 1965, this activity has been fostered by the activities of the Coastal Plains Regional Commission, a multistate economic development organization.

Since the main development control powers rest with counties and cities in this area, as they do in most southern states, the activities of the regional planning district councils are, with the exception of Florida, largely advisory to county and city governments. These Councils have become strong participants in the decision-making process, particularly where they have professional planning staffs which offer and frequently provide planning services to counties and communities in their region. Their advisory project review role is greatly strengthened in the case of any federally aided projects by the A-95 review procedures required by the Office of Management and Budget. Many of the councils have been designated as Regional or Metropolitan Clearinghouses for this purpose, and thus play an important role in the planning and development decision-making process in the counties and cities within their jurisdiction (VIMS, 1974).

a. Onshore operations bases

Any Federal involvement in regulating the siting of operation bases would be limited to situations where dredging and filling of navigable waters were involved. In those situations, a permit would be required from the Corps of Engineers after review and comment by appropriate agencies. Stipulations can be placed on the construction of such facilities as prerequisites to the issuance of a permit.

State involvement in the siting of an operations base would occur where their regulatory or review responsibilities apply or in their formal comments to the USGS on OCS operator supplied development (minus proprietary information) plans.

b. Pipelines

Federal responsibility in regard to onshore pipelines, both oil and gas, is divided among several agencies. The Materials Transportation Bureau in the Department of Transportation (DOT) has the primary responsibility for assuring pipeline safety. Their concerns address safety through pipeline design as well as construction and operational practices. Their responsibility is basically one of setting standards. Similar to offshore pipelines, the MTB is involved in pipeline safety and inspection to cause, by those responsible for the pipelines, the prompt reporting of any potential leaks or safety problems, and report annually to the President, the Congress, the

Secretary of the Interior, and the Interstate Commerce Commission of any potential leaks or actual explosions and spillages in these pipelines.

The Federal Power Commission can authorize the bringing ashore of natural gas pipelines by issuing a Certificate of Public Convenience and Necessity. If the FPC feels it necessary, the agency prepares an environmental impact statement to evaluate marine and onshore impact of potential production from the pipeline.

The Corps of Engineers also becomes involved where a proposed pipeline crosses navigable waters. The wetlands legislation in the respective states could require permitting and environmental impact statements for pipelines proposed for construction through wetlands.

The Department of Interior and the Department of Transportation share responsibility for pipelines on the Outer Continental Shelf. According to information published in the Federal Register, (Vol. 41, No. 157, August 12, 1976) pipelines known as "flow lines" and "gathering lines" are under the jurisdiction of the Department of Interior. The Department of Transportation exercises exclusive responsibility for the safety regulation of oil and gas offshore pipelines downstream to the shore from the outlet flange of each facility where hydrocarbons are produced, or where produced hydrocarbons are first separated, dehydrated, or otherwise processed, whichever facility is farther downstream.

The Bureau of Land Management issues rights-of-way for pipelines, other than gathering or flowlines on the Outer Continental Shelf. It is the intent of the Bureau of Land Management to require transportation of crude hydrocarbons produced from leases awarded by this proposed sale by means of pipelines whenever the installation of pipelines is economically and environmentally feasible.

A stipulation has been proposed for incorporation into all leases awarded as a result of this proposed sale.

"If laying pipelines is environmentally and economically feasible, no crude production will be transported by surface vessel from offshore production sites to onshore facilities except in case of emergency. Determinations as to emergency conditions and the environmental and economic feasibility of pipeline laying will be made by the appropriate federal permitting agency."

"The lessor specifically reserves the right to require that any pipeline to be used for transporting crude production from this lease across federal controlled areas be placed in certain designated locations."

c. Terminal and storage facilities

The Federal Water Pollution Control Act (FWPCA), as amended in 1972, provides for a National Oil and Hazardous Substances Pollution Contingency Plan for which the Environmental Protection Agency (EPA) and the Departments of Interior, Transportation and Defense all share responsibility. EPA, however, has the authority over onshore non-transportation facilities, such as terminal and storage areas. The operators of such facilities are required to prepare and implement Spill Prevention Control and Countermeasure Plans. The 1970 Amendments to the Clean Air Act established minimum standards for pollutants generated by evaporation from oil storage facilities. The facility operator must make any design and operational adjustments necessary to meet the standards before the state will issue a permit to operate the facility. The four southeastern Atlantic states have approved state air plans pursuant to the Act. Consequently, the permitting programs are administered by the respective states with EPA having monitoring and oversight responsibility. These controls affect only the manner of operation of a facility. The location aspects are limited to the possibility that different locations may more readily accommodate additional facilities.

The primary means of affecting the siting of an oil terminal and storage area is the zoning power of the local government.

d. Gas processing plants

The air emissions and water discharges emanating from these facilities would require permits under both the 1972 Amendments to the FWCPA and the 1970 Amendments to the Clean Air Act. In the latter case, all four southeastern Atlantic states have plans approved by EPA and consequently, the permitting systems are operated by the respective states with monitoring and oversight by EPA.

D. Special Stipulations

Leases for oil and gas exploration and development are subject to all OCS operating orders and regulations. Additionally, in some cases, leases offered in a particular OCS lease sale include special stipulations for added protection of a particular resource or activity.

For this proposed sale, lease stipulations have been recommended to the Secretary of the Interior to provide for the protection of human, biological and cultural resources while allowing the orderly development of oil/gas resources in the South Atlantic OCS. Also included are stipulations which would require the lessee to provide information to coastal states and to assume responsibility for operations within military warning areas.

It should be noted that stipulations 1 and 2 may, where required, be satisfied by a single survey which would utilize common instruments and procedures.

The following stipulations be included in any lease issued, except as otherwise indicated below:

1. Prior to any drilling activity or placement of any fixed structure or pipeline or any other exploration or production activity, the lessee will submit to the Supervisor as part of his exploration and/or production plan a bathymetry map, prepared utilizing remote sensing and/or other survey techniques. This map will include interpretations for the presence of "live" or hard bottom areas. These areas are defined as containing biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans and hard corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and whose lithotrope favors accumulation of turtles, and pelagic and demersal fish. The lessee will also submit to the Supervisor bottom photographs of the 3 initial proposed exploratory well locations and any proposed platform sites. A minimum of 5 bottom photographs will be required for each exploratory drilling location or platform site.
2. Cultural Resource Survey—If the Supervisor, having reason to believe that a site, structure, or object of historical or archaeological significance, hereinafter referred to as "cultural resource", may exist in the lease area, gives the lessee written notice that the lessor is invoking the provisions of this stipulation, the lessee shall upon receipt of such notice comply with the following requirements:

Prior to any drilling activity or the construction or placement of any structure for exploration or development on the lease, including but not limited to, well drilling and pipeline and platform placement, hereinafter in this stipulation referred to as "operation", the lessee shall conduct geophysical surveys to determine the potential existence of any cultural resource that may be affected by such operations. All data (including magnetometer and sidescan records) produced by such geophysical surveys shall be examined by the Supervisor to determine if anomalies are present which suggest the existence of a cultural resource that may be adversely affected by any lease operation. If such anomalies exist the lessee shall: (1) locate the site of such operation so as not to adversely affect the anomaly identified; or (2) establish, to the satisfaction of the Supervisor, on the basis of further archaeological investigation conducted by a qualified marine archaeological surveyor using such survey equipment and techniques as deemed necessary by the Supervisor, either that such operation will not adversely affect the anomaly identified or that the potential cultural resource suggested by the occurrence of the anomaly does not exist. A report of this investigation prepared by the marine archaeological surveyor shall be submitted to the Supervisor for review. Should the Supervisor determine that the existence of a cultural resource which may be adversely affected by such operation is sufficiently established to warrant protection, the lessee shall take no action that may result in an adverse effect on such cultural resource until the Supervisor has given directions as to its disposition.

The lessee agrees that if any site, structure, or object of historical or archaeological significance should be discovered during the conduct of any operations on the leased area, he shall report immediately such findings to the Supervisor, and make every reasonable effort to preserve and protect the cultural resource from damage until the Supervisor has given directions as to its disposition.

3. Ordnance Survey—The lessee shall conduct remote sensing and/or other surveys as specified by the Supervisor to determine the existence of any unexploded ordnance, (munitions, mines, or bombs). The lessees' report to the Supervisor should document all indications of anomalies on the sea floor.
4. To provide information to coastal states and thus to assist them in planning for the impact of activities during exploration under this lease, the lessee shall submit, for review and comment, to the Governor of each South Atlantic state a "Notice of Support Activity for the Exploration Program" (herein called "Notice").

For the purpose of this stipulation South Atlantic states include North Carolina, South Carolina, Georgia, and Florida. The lessee shall not be required to include privileged information in this Notice. At his discretion, the lessee may submit either a separate Notice for each Exploration Plan submitted on a lease under 30 CFR 250.34, or a Notice for two or more Plans on one or more leases. The Notice shall not be subject to approval or disapproval by the Supervisor.

A copy of the Notice shall be submitted to the Supervisor no later than the date of submission of the Exploration Plan, with a certification that the Notice has already been submitted to the Governor of each South Atlantic state. A lessee who submits a Notice for two or more Exploration Plans shall not be required to supply additional copies of the Notice, but may instead refer to that prior submission. Before the Supervisor approves or disapproves the Exploration Plan, he shall allow at least 30 days from the date of receipt of the certification for the Governors to submit comments on the Notice to the lessee. Subsequent to submission of the certification, significant changes in estimated support activities will be forwarded by the lessee, as an amendment to the Notice to the Governors of the South Atlantic states and the Supervisor.

The Notice shall include with respect to the lessee and his contractors:

(1) A description of the onshore and nearshore support facilities, including site and size, expected to be constructed, leased, rented, or otherwise procured in affected areas;
(2) Amount and location of acreage expected to be required within the state for facilities, including the need for storage space for supplies;
(3) An estimate of the frequency of boat and aircraft departures and arrivals, on a monthly basis, and the possible onshore location of terminals;
(4) The approximate number of persons who are expected to be engaged in onshore support activities and transportation, the approximate number of local personnel who are expected to be employed by or in support of the exploration program;
(5) Estimates of the approximate addition to the population, on a county basis, due to the exploration program and the approximate number of persons needing housing and other facilities;
(6) An estimate of any significant quantity of major supplies and equipment to be procured within the state; and

(7) The onshore address of the lessee's operation officers and of the contractors' offices involved in the exploratory operation.

5. Barging of production will be permitted only in case of emergency or under special circumstances as determined by the Supervisor. Continuous barging of production will not be permitted. The United States reserves the right to specify the method of transportation of production.

6. (*To be included only in leases resulting from this sale for tracts 1 through 56.*)

(1) Whether or not compensation for such damage or injury might be due under a theory of strict or absolute liability or otherwise, the lessee assumes all risks of damage or injury to persons or property, which occurs in, on, or above the Outer Continental Shelf, to any person or persons or to any property of any person or persons who are agents, employees or invitees of the lessee, its agents, independent contractors or subcontractors doing business with the lessee in connection with any activities being performed by the lessee in, on, or above the Outer Continental Shelf, if such injury or damage to such person or property occurs by reason of the activities of any agency of the U.S. Government, its contractors or subcontractors, or any of their officers, agents or employees, being conducted as a part of, or in connection with, the programs and activities of the Operating Area Coordinator, Naval Base, Charleston, South Carolina. The lessee assumes this risk whether such injury or damage is caused in whole or in part by any act or omission, regardless of negligence or fault, of the United States, its contractors or subcontractors, or any of their officers, agents, or employees. The lessee further agrees to indemnify and save harmless the United States against, and to defend at its own expense the United States against all claims for loss, damage, or injury sustained by the agents, employees, or invitees of the lessee, its agents or any independent contractors or subcontractors doing business with the lessee in connection with the programs and activities of the United States, its contractors or subcontractors, or any of their officers, agents, or employees and whether such claims might be sustained under theories of strict or absolute liability or otherwise.

(2) The lessee agrees to control his own electro-magnetic emissions and those of his agents, employees, invitees, independent contractors or subcontractors emanating from individual designated defense warning areas in accordance with requirements specified by the commander of the appropriate onshore military installation, i.e., Operating Area Coordinator, Naval Base, Charleston, South Carolina, to the degree necessary to prevent damage to, or unacceptable interference with Department of Defense flight, testing or operational activities, conducted within individual designated warning areas. Necessary monitoring, control, and coordination with the lessee, his agents, employees, invitees, independent contractors or subcontractors, will be effected by the commander of the appropriate onshore military installation conducting operations in the particular warning area; *Provided, however*, That control of such electromagnetic emissions shall in no instance prohibit all manner of electromagnetic communication during any period of time between a lessee, its agents, employees, invitees, independent contractors or subcontractors and onshore facilities.

(3) The lessee, when operating or causing to be operated on its behalf boat or aircraft traffic into the individual designated warning areas shall enter into an agreement with the commander of the appropriate onshore military installation, i.e., Operating Area Coordinator, Naval Base, Charleston, South Carolina utilizing an individual designated warning area prior to commencing such traffic. Such agreement will provide for positive control of boats and aircraft operating into the warning areas at all times.

7. (*To be included only in leases resulting from this sale for tracts 57 through 225.*)

(1) Whether or not compensation for such damage or injury might be due under a theory of strict or absolute liability or otherwise, the lessee assumes all risks of damage or injury to persons or property, which occurs in, on, or above the Outer Continental Shelf, to any person or persons or to any property of any person or persons who are agents, employees, or invitees of the lessee, its agents, independent contractors or subcontractors doing business with the lessee in connection with any activities being performed by the lessee in, on, or above the Outer Continental Shelf, if such injury or damage to such person or property occurs by reason of the activities of any agency of the U.S. Government, its contractors or subcontractors, or any of their officers, agents or employees, being conducted as a part of, or in connection with, the programs and activities of the Operating Area Coordinator, Naval Air Station, Jacksonville, Florida. The lessee assumes this risk whether such injury or damage is caused in whole or part by any act or omission, regardless of negligence or fault, of the United States, its contractors or subcontractors, or any of their officers, agents, or employees. The lessee further agrees to indemnify and save harmless the United States against, and to defend at its own expense the United States all claims for loss, damage, or injury sustained by the agents, employees, or invitees of the lessee, its agents or any independent contractors or subcontractors doing business with the lessee in connection with the programs and activities of the United States, its contractors or subcontractors, or any of their officers, agents, or employees and whether such claims might be sustained under theories of strict or absolute liability or otherwise.

(2) The lessee agrees to control his own electro-magnetic emissions and those of his agents, employees, invitees, independent contractors or subcontractors, emanating from individual designated defense warning areas in accordance with requirements specified by the commander of the appropriate onshore military installation, i.e., Operating Area Coordinator, Naval Air Station, Jacksonville, Florida, to the degree necessary to prevent damage to, or unacceptable interference with Department of Defense flight, testing or operational activities, conducted within individual designated warning areas. Necessary monitoring, control, and coordination with the lessee, his agents, employees, invitees, independent contractors or subcontractors, will be effected by the commander of the appropriate military installation conducting operations in the particular warning area; *Provided, however*, That control of such electromagnetic emissions shall in no instance prohibit all manner of electromagnetic communication during any period of time between a lessee, its agents, employees, invitees, independent contractors or subcontractors and onshore facilities.

(3) The lessee, when operating or causing to be operated on its behalf boat or aircraft traffic into the individual designated warning areas shall enter into an agreement with the commander of the appropriate onshore military installation, i.e., Operating Area Coordinator, Naval Air Station, Jacksonville, Florida, utilizing an individual designated warning area prior to commencing such traffic. Such agreement will provide for positive control of boats and aircraft operating into the warning areas at all times.

E. Other Mitigating Measures

1. Notices to Lessees and Operators

Notices to Lessees and Operators are used when expeditious clarifications, corrections, or additions to the OCS Orders and regulations are necessary. By issuing Notices to Lessees and Operators, the extensive amount of time necessary to amend and republish orders and regulations is avoided. None have been prepared to-date for the U.S. South Atlantic OCS.

However, an example of such a "Notice" which has been issued in other OCS areas and that may be issued in this U.S. South Atlantic proposal is a "Notice of Support Activity for the Exploration Program". This "Notice" is intended to assist coastal states and communities in planning for the impact of activities during exploration activities. It may require that the lessee must submit for review and comment to the governor of the directly affected states a reporting of activities that will be needed for his exploration program. The lessee will not be required to include privileged information in the Notice. He will have the option whether to submit a separate Notice for each exploration plan submitted under 30 CFR 250.34 on a lease or to submit a Notice in connection with two or more plans on one or more leases. The Notice shall not be subject to approval or disapproval by the USGS Supervisor, but the Supervisor, in acting on an exploration plan, will take into account the comments of the states.

A copy of the Notice shall be submitted to the Supervisor simultaneously with or prior to the exploration plan with a certification that it has already been submitted to the governors of the states that will be directly affected by activities under the plan. If the lessee submits a Notice in connection with two or more exploration plans, he will not be required to submit additional copies of the Notice, but may, instead, refer to that previous submission. Before the USGS Supervisor approves or disapproves the exploration plan, he will allow at least 30 days from the date of receipt of the certification for the governor to submit comments on the Notice to him as well as to the lessee. Subsequent to the submission of the certification, significant changes in estimated support activities will be forwarded by the lessee as an amendment to the Notice to the governors that will be directly affected by the program and the USGS Supervisor.

The Notice shall include with respect to the lessee and his contractors:

a. A description of the facilities including site and size that may be constructed, leased, rented or otherwise procured in affected areas.

b. The location and amount of acreage required within the state for facilities including the need for storage of various supplies.

c. An estimate of the frequency of boat and aircraft departures and arrivals on a monthly basis, and the onshore location of terminals.

d. The approximate number of persons who will be engaged in onshore support activities and transportation, the approximate number of local personnel who will be employed for or in support of the exploration program, the approximate total number of persons who will be employed for the exploration program.

e. The approximate addition to the population of the local jurisdiction because of the exploration program and the approximate number of persons needing housing and other facilities.

f. An estimate of any significant quantity of major supplies and equipment to be procured within the state.

g. The onshore addresses of the lessee's operation offices and of the contractor's offices involved with the exploratory operation.

2. Waivers of OCS Orders

A departure (waiver) from OCS Orders or other rules of the USGS Supervisor may be granted under 30 CFR 250.12(b) when such a departure is determined to be necessary for one of the following reasons:

a. The proper control of a well;
b. Conservation of natural resources;
c. Protection of aquatic life;
d. Protection of human health and safety;
e. Protection of property;
f. Protection of the environment.

3. Unitization of Producing Fields

The following regulations enable the Department of the Interior to require that a producing oil and/or gas field be unitized and the manner in which it is to be carried out, although no unitization requirement has been decided on as yet for this proposed sale:

30 CFR 250.50 grants the Director of the USGS authority to demand pooling or unitization which the Secretary is authorized to require under the OCS Lands Act in the interest of conservation.

30 CFR 250.51 refers to the unit plan regulations contained in 30 CFR 226 with regard to obtaining approval of units or cooperative agreements.

30 CFR 250.52 lists purposes for which the Area Oil and Gas Supervisor of the USGS may approve pooling or drilling agreements.

Unitization has taken place in the operating areas where a field overlies adjacent tracts (usually two to four) and each tract is owned by different operators. The authority to unitize may be utilized for purposes of conservation, controlling withdrawals of oil and gas from the field, more efficient production, and reservoirs pressure maintenance during initial stages of operation.

4. Geophysical Information Concerning Geological Hazards

Knowledge of near-surface structural conditions is fundamental to a sound lease management program for the OCS. Geophysical data which show the shallow structural and sedimentary environment are used to predict, and thus minimize, any geological hazards to drilling operations and consequent possible dangers to the environment from pollution. Surface and shallow subsurface geologic hazards, when properly identified and correlated with surrounding strata, seldom create insurmountable obstacles to a minimal risk program of exploration and exploitation of economically attractive structures.

High resolution geophysical data covering all tracts to be offered for this proposed sale are presently being analyzed by geophysicists and geologists of the USGS Conservation Division. These data, in the area of coverage, provide definitive information on thickness of the unconsolidated sediment, structural configuration on shallow seismic horizons, sea floor anomalies, slumps, shallow subsurface faults, unstable bottoms, near-surface gas pockets, and buried subsurface channels. Preliminary analyses have already been conducted on high resolution geophysical records collected by the USGS Geologic Division in Woods Hole as part of the BLM environmental studies program; the records are also being examined by personnel of the USGS Conservation Division, Eastern Region Office (Washington, D.C.).

Interpretations of high resolution subbottom profile data made by potential lessees that will disclose bottom subsurface conditions posing special environmental hazards for drilling or producing operations in the U.S. South Atlantic offshore area, will be made available to the Bureau of Land Management prior to the decision to issue a lease, and to the Geological Survey prior to the approval of legislative drilling operations.

F. Other Possible Mitigating Measures

In addition to the mitigating measures proposed and previously discussed, there are other actions which, if implemented, could further mitigate adverse impacts. The following actions are of that type and not part of this proposal; they are evaluated for their environmental effect in Section VIII.

1. Requiring the use of bird repelling techniques during appropriate oil spill situations

The use of scare devices to repel marine birds for sustained periods of time from the area of an oil spill have proven practical and effective for several species of water-oriented birds. These devices are available in the U.S. South Atlantic region in case of spills, but there are no requirements for their use. It should be pointed out that the devices are not effective for all species and more research is needed to produce greater success.

2. Implementing energy facility siting legislation at the state level

At present, none of the U.S. South Atlantic states have the legislative authority to affirmatively identify and study specific sites that could appropriately accommodate key energy-related facilities.

Existing state actions focus on regulating the placement of such facilities after a specific site has been identified by the proposer. In essence, the States' regulatory functions are reactionary in that they are not activated until a specific proposal has been made. Affirmative action by the state in identifying and, as appropriate, acquiring specific locations for such facilities would minimize adverse impacts of a facility, provide direction to desired economic growth, and significantly decrease the usual time lag between project proposal and actual implementation.

Section V

Adverse Environmental Impacts Which Cannot be Avoided Should the Proposal be Implemented

A. Marine Organisms

As has been discussed above in Section III. B.1., routine oil and gas operations that will result should this proposed sale be approved will impact marine organisms only in the immediate location of platforms, wells and pipelines. These impacts are considered temporary and minor, especially in view of the vast areas that will not be affected. Stipulations, OCS Operating Orders, and U.S. Coast Guard regulations all serve to minimize these unavoidable impacts. To recapitulate, these impacts are: 1. A minor decrease in primary productivity will occur due to turbidity caused by the disposal of drill muds and cuttings and the bottom sediments stirred up during pipeline laying and burying operations. It is likely that in the vicinity of live (hard) bottom fishing areas this impact will be further mitigated by the shunting of the muds and cuttings to within about 10 m of the bottom, reducing the turbidity plume. In any event, turbidity will only be present during the drilling, laying, and burying operations, and will affect only a very small portion of the South Atlantic. 2. The drill muds and cuttings, and the sediments displaced during pipeline burial, eventually settle on the sea floor and in doing so may smother benthic organisms if the settling is heavy enough. Again, the area affected will be quite small and the impact temporary. In the case of muds and cuttings, the extent of the area affected may be reduced by shunting. In any event, there will be some burial, but experience has shown that the area will be rapidly recolonized. 3. In both 1 and 2 above, the possibility exists that toxic materials used in the mud mixtures (such as bacteriocides) may adversely affect some organisms. However, during long and extensive oil and gas operations in the Gulf of Mexico no ill effects due to such toxicity have been noted, and several studies have failed to document any toxic effect, probably because concentrations used are very low and the muds are rapidly dispersed and diluted in the sea water. Study of this aspect is continuing, however.

It is thus concluded that adverse impacts due to normal and routine operations will be minimal, insignificant, and temporary. The adverse impact that should be the most cause of concern is that of a major oil spill that reaches the shore or water shallow enough to allow the oil to reach the bottom (see also Section III.B.1.). Such a spill is certainly not considered routine or normal, but it must be considered. OCS Operating Orders and routine industry procedures and safety precautions should work to minimize the likelihood of such a spill and then operate to prevent a spill, should one occur, from reaching shallow water, but as discussed in Section III.A.5., it can be predicted statistically that some oil will reach such waters sometime during the operations proposed by this action. It should be noted, however, that such predictions do not consider either clean-up and containment action nor degradation of the oil during a lengthly time exposed to the sea. Taking all this into consideration, it is believed that due to the distance from shore of the wells that there will be little if any adverse impact to shallow waters or the shoreline due to any oil spill in the lease areas.

Finally, there is the possibility of an oil spill from a pipeline or a tanker close enough to these sensitive areas to cause a major adverse impact. Strict adherence to operating procedures and safety precautions must be ensured. Rapid response to any spills by cleanup and containment teams must be ensured. Regardless of such adherence, however, there will be some oil contamination of the environment due to chronic low level discharge ("leakage") if not to a major spill. While every effort must be made to minimize the damage due to such contamination, some damage should be expected if this lease sale is held, and must be considered part of the cost of developing oil and gas on the OCS.

B. Shipping and Navigation

Interference between offshore structure and vessel traffic will occur, but it will be minimal. An estimated maximum of 10-25 platforms may be required to develop the proposed lease area. Only a small portion (2-5 ha) of the lease would be utilized by platforms in such a case. As there are no navigational fairways established for the South Atlantic OCS region any platform placed in the region has the potential of constituting a navigational hazard for vessels moving through the immediate vicinity. The small number of platforms projected and the fact that all platforms and offshore facilities must be equipped in accordance with United States Coast Guard regulations (Appendix F) to maximize visibility and minimize collision hazard indicates that the impact will be minimal.

C. Commercial Fisheries

As described in Section III.C.4., trawling operations suffer interference and inconvenience from oil and gas operations in several ways. A small area of the sea floor, up to 0.017% (approximately 0.4 hectare) of each tract leased, is occupied by drilling rigs and platforms and is unavailable to trawl fishermen. Based on past exploration success rates, up to 101 hectares of sea floor (less than two percent of the total acreage offered) may be occupied by platforms resulting from this proposed sale. Trawl nets reportedly become snagged on underwater stubs and unburied pipelines, causing damage or loss of the nets. Less frequently, large objects which were lost overboard from supply boats and platforms are caught in trawling nets, resulting in damage to the net and/or its catch of fish; however, frequency of occurrences of this type of incident is low.

Commercial fishermen would probably not trawl in the area of an oil spill, as spilled oil could coat or contaminate commercial fish species, rendering them unmarketable. This would be another adverse effect to commercial fishing.

D. Recreation and Allied Resources

Oil spills (including those from pipelines) which may occur as a result of OCS oil and gas operations could result in unavoidable adverse effects on recreation areas and coastal recreation activities. Since recreation is the predominant use of shoreline in much of this region, it is possible that the oil from any such spill could beach in areas that are used for recreation purposes. Such occurrences could result in the localized short-term curtailment and/or dislocation of recreation participation. The magnitude of the effects on recreation opportunities could vary significantly based on a number of relevant factors: the size of the spill, location of the beaching, time of the year and availability of clean-up equipment. A large spill beaching on a popular recreation area such as Cape Hatteras National Seashore during the summer, for example, would unavoidably impact the thousands of recreationists who would normally enjoy this beach area during the days or weeks required to remove the contamination and restore the sand. Although adverse effects on recreation are not certain to result from oil spills, and actions can be taken to minimize their likelihood, they are nevertheless not totally unavoidable. Spilled oil and debris which would float in the water or wash up on a shoreline recreation area would also severely detract from the aesthetic value of the contaminated area as well as adjoining areas or within perceptible range of the unavoidable damage.

The onshore facilities associated with OCS development have the potential to generate adverse impacts but such potential can be eliminated through preventative actions.

Unavoidable damage to cultural resources would occur when structures are not preserved or are not identified in time to take action for their preservation. Archaeological sites or artifacts may not be detected with total certainty by surveys. Those which remain undiscovered could be damaged or destroyed partially or wholly if excavation occurs; however, the incidence of damage on the Outer Continental Shelf is likely to be low.

Other damage to archaeological resources could come from oil contamination. Historical and archaeological materials soiled by an accidental oil spill may not survive subsequent cleaning and restoration efforts. Porous materials could be rendered unsuitable for carbon dating techniques. The probability of such a polluting event for significant resource destruction appears small although it does exist.

E. Beaches and Wetlands

Unavoidable adverse impacts to beaches and wetlands as a result of this proposed sale would be caused by oil spills and pipeline emplacement. Oil that may be spilled in the vicinity of the proposed lease tracts and does reach land would be primarily in the form of tar balls or heavy residues, whereas spills nearer to shore (from tankers or pipelines) may produce heavy coatings or patches. Heavily contaminated beaches will be rendered unsuitable for recreation so long as they remain coated with oil. Tar patches or balls would reduce recreational use or enjoyment until the beaches are cleaned. Beaches are most sensitive to impacts on recreation during the spring and summer, their seasons of greatest use. If any beach area is contaminated by oil, an undetermined amount of wildlife habitat would be damaged, primarily for birds, crustaceans, and molluscs. Oil that is buried or seeps into sand may not be totally degraded over time, thus, possibly returning to the surface in the future and providing a problem for recreational use.

Removal of oil contaminated sand may lead to erosional problems unless enough materials are available to replace it. Beaches that have been affected by an oil spill during the recreational off-season may suffer a negative impact during the following spring until the publicity of the spill has dissipated and the evidences of the clean-up are removed. Use of dredging equipment to remove contaminated marsh would impart further damage by increased turbidity and disturbance of mud bottoms. It may take up to several years for a dredged area to fully revegetate.

Oil spills which impact a salt marsh would kill vegetation and damage biological habitats from a few months to as much as several years before recovery.

From zero to two pipelines may come ashore, crossing beach or marsh or both, causing short term damage in 9-15 m (30-50 ft) wide swaths. All vegetation and non-motile animals lying directly in the path of the pipeline would be killed during pipeline laying. Some slight damage may also be rendered to beach and vegetation in adjacent areas by machinery used in the operation. Shoreline will return to its natural state over a few tidal cycles in the swath zone, however, beach ridges and dunes may take up to several years to recover. Long term impacts of crossing marshes may include salt water intrusion, possible alterations in localized flora, and increases in marsh erosion at the site where the pipeline crosses the marsh. If the pipeline crosses a fresh water marsh, which serves as a recharge area for a ground water aquifer(s), some local ground water supplies could be contaminated.

F. Vegetation

Some impacts resulting from pipeline burials and related construction activities on the vegetation will be unavoidable. Pipelines and construction activities can be located to avoid fragile areas and will be evaluated in a separate pipeline corridor study. Impacts will be localized and restricted to construction sites.

Vegetative communities have been shown to suffer adverse impacts from chronic exposure to oil which can result in denudation. The impact of a single oil spill depends, to a large extent, on various factors such as type of oil, time of year and plant species involved. It is believed that plant communities could survive moderate oilings.

G. Wildlife

Pipeline burials and related construction activities will have some unavoidable impact. This type of impact, however, can be minimized by avoiding particularly sensitive habitat areas. Unavoidable impacts of this activity will be evaluated in more detail in a separate pipeline study if an economical oil and/or gas reserve has been found in the South Atlantic lease area.

Oil spills also pose an unavoidable threat to wildlife. Near shore spills resulting from pipeline or tanker accidents (if tankers are used) pose the highest threat. Areas surrounding pipeline routes would be the most vulnerable to nearshore spills. Previous spills indicate that sea birds such as gannets, pelicans, petrels and phalaropes receive the greater impacts and their fatalities can be large. Onshore species such as the American oyster catcher, piping plover and Wilson's plover can also suffer from spills due to loss of feeding and nesting habitats.

Time of day, time of year, sea conditions and type of oil all are some significant factors which will determine the extent of adverse impacts.

Opossums, raccoons, muskrats, minks and other small game animals can also suffer fatalities resulting from spills. While some species may experience direct impacts, they could also be effected from ingesting the oil during grooming activities. Scavengers and foragers could also eat oil-contaminated food, thereby ingesting petroleum. While ingesting hydrocarbons can be toxic to some species, hydrocarbon ingestion in animals in general is not well understood at present (Appendix I).

H. Land Use

The impact of facilities and growth induced as a result of the proposal, and their effect on land use could be significant on a community or sub-county basis, but it is perhaps the most susceptible to mitigation of all sale-induced impacts.

Unavoidable land use impacts, such as those resulting from pipelaying and other land disturbances are localized and short-term in nature, affecting 50-100 foot corridors or individual parcels of land. There will be a long-term commitment of between 45 and 112 ha of land for OCS-related facilities. This would consist of up to 36 ha of industrial land for operation bases and service support facilities, up to 47 ha of rural land for processing plants or terminals, up to 24 ha of waterfront land for barge terminals and supply boat bases, and about 0.5 ha of office space. Also the development of an additional amount of land as a result of incremental induced development and population, is unavoidable. The greatest amount of development is anticipated to occur in the areas around Savannah, Ga. and Charleston, S.C. Development may also occur around Jacksonville, Fla. and possibly Brunswick, Ga.

Possible long-term land use conflicts which could result from this sale, such as conflicts between different adjoining land uses and competition for different uses, are usually avoidable through exercising existing regulations and controls. The implementation of coastal zone management plans beginning in 1977 should allow further prevention of land use conflicts in coastal areas.

I. Socioeconomic

Increases in the population of a particular area due to net in-migration as a result of direct investment in the area, in addition to the locating of primary industrial facilities to support the action, cannot be avoided should the action be taken and recoverable amounts of oil and gas be found. Primary facilities include exploratory rigs, platforms, terminals, storage facilities, onshore operations bases, gas processing plants, and service support facilities. Population increases would be directly related to the locational and investment tendencies associated with these facilities.

Unavoidable adverse impacts upon the physical and service system infrastructure as a result of OCS-induced population impacts would depend upon the availability, capability and elasticity of the infrastructure system of the area in which the induced population growth takes place. Visible adverse impacts, such as overutilization of infrastructure systems, inability of the systems to absorb and/or accommodate the additional population, will be most pronounced in areas having limited or underdeveloped infrastructure systems and/or comparatively small populations.

In large highly urbanized and industrialized areas the influx of population would not be as great due to labor force availability within the area. Because of the larger existing population, OCS-associated increases would not be perceptible. The ensuing infrastructural impacts, though unavoidable, would be negligible.

A part of the problem in determining the adverse socio-economic impact that may result from proposed sale related activities lies in the relative capability of the existing infrastructure in two areas, the area in which emigration occurs, and the area in which immigration occurs, and the ability of the existing infrastructure to provide the required services. Population movements from an area characterized by an insufficient supply of public services to an area with a more adequate supply of public services can be perceived as an action that would not be expected to increase the stress on the total infrastructure of both regions. And, conversely, a movement from an area with an adequate infrastructure to an area lacking in the capability to serve additional population could be conceived as having an adverse impact on the total ability of both infrastructures to provide the same level of services that formerly prevailed.

The migration of labor, capital, and materials to primary impacted areas from areas outside and within the U.S. South Atlantic coastal region during the early years of oil and gas operations, and the subsequent out-migration of some of these resources during the later years cannot be avoided should the action be taken and recoverable amounts of oil and gas be found.

When a given area is unable to absorb needed increased infrastructure expenditure and economic activity and excess resources are unable to be shifted elsewhere, problems in shortages of supply of services may develop.

Because of the diversity of the coastal regions of these states, development could be expected to occur in areas with varying degrees of industrialization and population density, although probably only to a limited extent in any area. Therefore, a combination of the impacts described above could be expected to occur.

A condition of uncertainty and less than perfect information will also create adverse impacts. To the degree that decisions are based on predictions or estimates that prove to be in error over time, adverse impacts will occur to firms in the form of commercial ventures that do not cover their costs. It is not likely that uncertainty could be completely removed from the decision making process. Uncertainty with regard to the level of recoverable resources in the leasing area, the actions of others, and the economic climate is sure to remain. Private industry and government, while basing their decisions on as much information as possible, will be unable to avoid the adverse impacts caused by uncertainty.

An additional complication is evident in that socio-economic impacts resulting from this proposed sale will occur in a future socio and economic climate that will be the resultant of trends currently developing, as well as factors that may be of increasing importance in the near future, and that the socio-economic changes induced by proposed sale related activities will be only a portion of the changes expected to take place.

J. Water Quality

1. Offshore

Normal offshore operations would have unavoidable effects of varying degrees on the quality of the surrounding water if the proposal is implemented. Drilling, construction, and pipelaying would cause an increase in the turbidity of the affected waters for the duration of the activity, and, in the case of pipelines, could disturb settled pollutants in old dump site areas. The total amounts of resuspension of sediment as a result of a pipelaying activities can only be estimated because the width of the trench varies with the compactness and fluidization point of the sediment. If the trench were roughly two meters deep by two to four meters wide, and a parabolic cross-section is assumed, approximately 1,400 to 3,800 cubic meters per kilometer would be removed, some of which would be resuspended. A turbidity plume 20 m wide and 800 m long (plumes of this approximate size have been observed in the Gulf of Mexico) would also be created by the discharge of drill cuttings and the adherent drilling fluids. This, would only affect waters in the immediate vicinity of the rigs. The discharge of treated sewage would increase the levels of suspended solids, nutrients, chlorine, and BOD in a small area near the discharge point. Formation waters carrying mineral salts and regulated concentrations of hydrocarbons (present limits are set at 50 ppm, after 1977, the limit will be 48 ppm, after 1983, it will be 30 ppm) would also affect the water quality of the area when discharged. Throughout a 25 year production life, it can be estimated that the ratio of the total barrels of produced salt water to the total barrels of produced crude oil will be 1:1 (Appendix B). This would amount to approximately 0.282 to 1.009 billion barrels of produced water and approximately 8,460 to 30,270 barrels of oil introduced into the sea. This oil would create an incremental increase in the volume of oil lost to the sea each year. As such it could add to the overall deterioration of the ocean's quality. All of the above discharges are regulated by proposed OCS Orders and EPA regulations.

In the case of an accidental spill or pipeline break, unavoidable deleterious effects would result. Spilled oil that is not recovered would release hydrocarbons and trace metals that would have toxic or narcotic effects on any nearby life forms as it dissolves and evaporates. The quality of the surface, near surface, and to a lesser extent, deeper waters would therefore deteriorate during the life of the spill. If oil is entrapped in bottom or on shoreline sediments this degradation would continue over weeks or months as the oil is slowly reintroduced into the system.

2. Onshore

Increases in the population, commercial, and industrial sectors would undoubtedly add to the pollutant loadings of the waters of the region. The water quality is already in a poor state in some urban areas such as Charleston, S. Carolina, Savannah, Georgia and Jacksonville, Florida. The already over taxed treatment plants would not be able to handle an increase, however, these plants are presently under re-evaluation and improvement are being made to increase their capacity. Increases of 10-100% in municipal sewage loadings and industrial effluents could occur, but their effects would be at least partially mitigated by the enforcement of permit programs for point sources and more stringent water quality standards. The water pollution resulting from the runoff from new construction sites would also be an unavoidable effect. Estimates of volume are not currently available.

K. Air Quality

1. Offshore

Normal offshore operations will have unavoidable effects on the quality of the air surrounding rigs and platforms but because of the isolation of the structures, the low levels of emissions, and the prevailing winds, any increase in pollutants would be incremental and the overall air quality would not deteriorate. In the case of an accident, oil and gas would be introduced into the environment and unavoidable, deleterious effects would result. Escaping natural gas would introduce methane, hydrogen sulfide and other hydrocarbons into the air. These, however, would disperse almost immediately. If the gas burned, carbon dioxide, water vapor, nitrogen oxides and sulfur dioxide would be produced. If a gas pipeline leak occurred near shore, the sulfur dioxide and nitrogen oxides could cause problems of malodorous smells, depending on the volumes released. If the accident involved oil, either an accidental spill or pipeline break, various types of hydrocarbons would volatilize and mix with the air mass which could produce toxic or narcotic effects on the local biota. If the oil burns, carbon dioxide, water vapor, sulfur dioxide, particulate carbon, nitrogen dioxide, and partially oxidized compounds would be produced and would lower the existing level of air quality in the area. If this occurred near shore, the pollutants would also create problems of haze and soiling on land. The actual degree of degradation is not predictable at present.

2. Onshore

The Harris Model indicates that for the region as a whole during peak production years in the mid 1980's the increase in population is less than one percent in most commercial and industrial sectors. The additional amounts of pollutants that would be added to the air would be insignificant. However, any effects that might occur would be mitigated by EPA's emission controls of automobiles, air emission guidelines for industries, and limitations on the allowed increments of pollutants in various areas (non-significant deterioration of air quality limitations). If most of the development occurs in metropolitan or industrialized areas only incremental percentage changes in the pollutant level of the air would occur. The most likely increase would be in suspended particulate matter. These increases could cause significant problems only in those localities in which standards were being exceeded at the time such as Charleston, S. C., Savannah, Ga. and Jacksonville, Fla. However, if development occurs in the less densely populated and less developed areas within the region, greater percentage increases will result although, since the air quality in these areas is good, the actual effects would be modified by a large dilution factor. Temporary, localized increases in levels of hydrocarbons and carbon monoxide, due to the increase in automobile and truck traffic, would be especially notable. In both cases, the rise in levels of surfur oxides resulting from treatment of gas at the processing plants would represent the greatest change. In no area would the increased activity be expected to cause air quality standards to be exceeded if they were not being exceeded already.

Since onshore development is anticipated to take place in areas with varying degrees of industrialization, population density and ambient air quality, a combination of the impacts described above could occur. However, the extent of development which may take place in major metropolitan areas is expected to be limited.

Section VI

Relationship Between Short-Term Uses of the Environment and Enhancement of Long-Term Productivity

The proposed leasing of 518,400 hectares (1,280,966 acres) of the Southeast Georgia Embayment area is the first Federal oil and gas leasing proposal in the South Atlantic OCS. In general, the leasing for oil and gas development as a result of this proposal would not result in any large tradeoffs between short-term uses of the environment and the long-term productivity of the environment with regard to a specific natural resource. Rather, it will result in tradeoffs, in both the short-term and the long-term, between the use and allocation of different resources.

The principal exception would be the use of extracted oil and gas resources, expected to range from 0.3 to 1.0 billion barrels of oil and 1.0 to 6.8 trillion cubic feet of gas. The extraction and consumption of mineral resources would preclude their use at a later date and would result in lower reserves in the long-term, since at least in the human time-frame, oil and gas are nonrenewable resources. The short-term use of oil and gas resources over the estimated 25-year field life of this proposed sale would not, however, necessarily affect long-term development and production or availability of energy sources in general, or the long-term productivity of the environment. This would especially be the case should either no oil and gas be discovered, or if oil and gas are not found in commercial quantities as a result of this proposed sale.

However, this proposal could result in the discovery of recoverable resources over the high end of the estimated range (1.0 billion barrels of oil and 6.8 trillion cubic feet of gas, see Appendix B), thereby opening this area to successive future sales similar to events in the Gulf of Mexico. If this should occur, that period considered short-term (25 years) could extend considerably beyond this time-frame, to 30 to 40 years, and therefore could be considered as having long-term effects on the productivity of the offshore and onshore components of the South Atlantic environment. Such future sales and the resulting extension of OCS-related oil and gas activities in this South Atlantic region could especially effect the long-term productivity of the biological communities, fishing activities in the vicinity of offshore facilities, onshore areas utilized for facilities directly associated with OCS operations and support facilities by extending the periods of impact as discussed in Section III.

With regard to this proposed sale, the induced development and populations increase may result in short-term adverse impacts to communities. A strain on existing infrastructure would be expected if new OCS-related facilities are located in areas of low population with little current industrial base. However, in the long-term, a return to equilibrium can be expected as population gains and induced industrial development are absorbed in the expanded communities. Incremental long-term gains in levels of employment per capita income can be expected to accrue.

Short-term impacts to the marine coastal environment would result from this proposal. There would be short-term adverse effects as a result of construction operations, in the form of resuspension of sediments, turbidity and land disturbance affecting local populations of organisms. Short-term adverse affects to these populations would also occur as a result of oil spills.

Short-term impacts could also occur to the recreation values and tourism economy of the area if an oil spill of considerable size should occur.

There would also be an unknown amount of long-term degradation of the environment due to the chronic introduction, through operations, of small amounts of oil and other substances, such as trace amounts of heavy metals from drilling muds, into the marine and coastal environment over the life of this proposed oil and gas operation. Evidence available at this time does not indicate any long-term adverse impacts on biological productivity as a result of the introduction of such substances into the environment; however, it is not possible at present to conclude that no adverse long-term impacts would result.

In addition, the short-term use of the OCS for mineral extraction will preclude fishing in the immediate vicinity of oil and gas operations removing a maximum of approximately 873-1821 ha (2156-4499 acres) at any one time from commercial fishing activity.

Approximately 45-89 ha (110-220 acres) of land utilized for facilities directly associated with OCS operations will be excluded from other uses over the 25-year life of the field; however, only a portion of this land area may continue to be utilized after production ceases.

In summary, short-term localized adverse environmental and socio-economic impacts would result from this proposed sale. Long-term adverse environmental effects can be expected, potentially some of which are unknown at this time. Oil and gas reserves would be lowered as well. Few long-term productivity or environmental gains with regard to natural resources are expected as a result of this proposed sale. Benefits as a result of this proposed action are to be expected in other realms--principally those brought about as a result of increased supplies of domestic oil and gas.

It should be noted that since this proposal would be a first sale in a frontier area, this action could lead to future sales in the area. While a decision to hold a sale is made on an individual, sale-specific basis, a sale in a frontier area, if resources are discovered, would undeniably provide incentive for additional sales. Any future proposals for additional sales in the South Atlantic is subject to the same procedures to which this proposed sale is subject, including environmental assessments, and environmental impact statements.

Section VII

Irreversible and Irretrievable Commitment of Resources

A. Minerals Resources

Leasing of the tracts in this proposed sale would permit development and extraction of the oil and gas resources contained therein. Estimates by USGS of net recoverable resources range from 0.3 to 1.0 billion barrels of oil and from 1.9 to 6.8 trillion cubic feet of gas. More than one mineral lease may be issued for the same area for the retrieval of other types of minerals, but CFR 43, Part 3307, 4-5 provides that other leases may not unreasonably interfere with or endanger operations of any existing lease.

Technology presently exists to extract sand, gravel, phosphorite and manganese deposits from the ocean floor. No impact on future mining of these resources as a result of oil and gas operations may be expected except in the case of production and pipeline facilities. That portion of the bottom used for those purposes would be removed from any future dredging operations during the lifetime of the field. Leasing of the proposed tracts could represent an irreversible and irretrievable commitment of hydrocarbon resources.

B. Fish and Wildlife Resources

An irreversible or irretrievable commitment of fish and wildlife resources and their habitats could occur in the area of a massive oil spill or if frequently subject to chronic low levels of oil pollution. It is anticipated, however, that an affected area will recover from a spill and that the natural flora and fauna would eventually reoccupy spill areas. While individuals of the 19 endangered species found within the area of this proposed sale (see Table E-15, Section II.) may be eliminated, it is considered highly unlikely that an entire species or population of a species could be eliminated due to any actions resulting from this proposed sale. It is noted that the species involved are highly mobile and can avoid oil spills. The greatest danger to these species would occur if oil from a spill destroyed a nesting area, but the arrival of sufficient quantities of oil ashore to cause such destruction is considered unlikely. Construction of facilities ashore could also damage habitat, and care must be taken in siting such facilities so as to preclude damage. There is insufficient evidence to conclude that low-level spillage or other activities associated with the proposed sale can lead to an irreversible commitment of fish and wildlife resources.

C. Recreational and Allied Resources

Any damage to cultural resources such as archaeological or historical sites or artifacts either known or undiscovered would result in an irretrievable commitment of nonrenewable resources. Their usefulness and value would be either lessened or lost as the result of oil spills or construction damage. Likewise public appreciation of cultural or wildlife resources irretrievably lost as a result of this proposed sale would be foregone.

D. Land Resources

The proposed sale would require approximately 45-89 ha (110-220 acres) of land for large OCS-related facilities with possibly another 14 ha (35 acres), for small facilities as well as acreage for pipeline rights-of-way. In addition, an undetermined amount of land to accomodate induced population growth would be required. Potentially, additional land for facilities stimulated in part by this proposed sale could also be required. Land use requirements for induced population growth have not been estimated because they would depend in part on how much of the population increase could be absorbed by existing excess capacity (in housing for example) in localities which receive the increases.

While these uses may be long-term, they are not generally considered irreversible. However, where new land uses result in the disruption or destruction of natural features or processes, such that return to the previous land use is not possible, an irreversible commitment of resources would occur. An example of such a commitment would be the conversion of wetland areas to other uses. Because of the relatively small amount of acreage required and the land use controls available to states and localities, we do not believe that such an irreversible commitment of those resources would result from this proposed sale.

E. Human Resources

Since 1954, when Outer Continental Shelf leasing began, through February 1976, there have been 75 deaths directly associated with drilling operations in the Gulf of Mexico. In addition, there have been numerous deaths associated with oil and gas production on the OCS including helicopter crashes and boat accidents. It will be impossible to avoid all human casualties, but they have been minimized through measures already implemented which are continually updated to improve the safety of OCS operations. Fatalities and/or permanent impairment as a consequence of accidents and personnel error will result in an irreversible and irretrievable commitment of human resources.

F. Economic Resources

This proposed sale would result in production of certain OCS-related goods and services, including investments in required facilities, stimulation of certain industries within the region, and if recoverable resources are proved, oil and gas. To the extent that resources would be drawn away from other uses, production of goods and services in other areas or of other types would possibly have to be foregone. Limited resources such as steel products, specialized manpower and capital constitute required resources and the use of these resources to develop this proposal would mean that other opportunities for their use might have to be foregone. While these resources may be reclaimed over time, their use as a result of this proposed sale would constitute an irreversible and irretrievable commitment of resources at a given point in time.

To the extent that unemployed resources are used, the employment of resources as a result of this proposed sale would not constitute a cost to society in the form of foregone opportunities.

G. Summary

Except for the potential loss of: human life, investment, oil and gas resources, and archaeological resources; there are no other irreversible and irretrievable commitment of resources.

Section VIII

Alternatives to the Proposed Action

A. Hold the Proposed Sale in Modified Form

1. Substitution of Tracts Within the Area of the Call For Nominations (Figure VIII-1).

One alternative considered during the tract selection process relating to proposed OCS Sale 43 was the offering of a different group of tracts included within the area of the call for nominations. In response to the call for nominations, industry expressed interest in a total of 778 tracts.

Proposed Sale No. 43 consists of 225 tracts, and therefore did not include all of the tracts for which nominations were received. An alternative sale offering consisting of 225 tracts could have been selected from the area included within the call for nominations.

For example, an offering of 225 tracts, all of which had some degree of industry interest, could have been composed of the following blocks (See Figure VIII-1). Reference is made to the production areas defined in the discussion of the Department of the Interior Oil Spill Trajectory Model (See Appendix M).

Production Area 1 and vicinity
Protraction Diagram James Island NI 17-12
Blocks 67, 68, 111, 112, 155, 156, 198-206, 242-250, 286-294, 330-338, 374-382. Total 51 blocks
Production Area 2 and vicinity
Protraction Diagram NH 17-3
Blocks 6, 7, 50, 51, 52. Total 5 blocks
Production Area 3 and vicinity
Protraction Diagram Savannah NH 17-11
Blocks 299-302, 343-346, 387-389. Total 11 blocks
Production Area 4 and vicinity
Protraction Diagram Brunswick NH 17-2
Blocks 780-786, 825-830, 868-878, 912-922, 956-966, 1000-1010,
Protraction Diagram Jacksonville NH 17-5
Blocks 33-42. Total 67 blocks
Production Area 5 and vicinity
Protraction Diagram Savannah NH 17-2
Blocks 911, 955, 999
Protraction Diagram Jacksonville NH 17-5
Blocks 29-32, 73-75, 117-119, 161-163, 205-206. Total 18 blocks
Production Area 6 and vicinity
Protraction Diagram Jacksonville NH 17-5
Blocks 76-81, 120-123, 164-168, 207-211, 254-256, 297-298, 341-342, 385-386, 429-430, 473-474, 516-518. Total 36 blocks
Production Area 7 No blocks offered Total 0 blocks
Production Area 8 and vicinity
Protraction Diagram Jacksonville NH 17-5
Blocks 257, 299-301, 343-344, 387-388, 431-436, 475-479, 519-523, 562-566, 606-609, 650-653. Total 37 blocks

If this group of blocks had been included in the tracts offered in the sale instead of the tracts included within proposed Sale 43, some changes and modifications may have resulted in impact producing factors, such as the number of wells and platforms and quantities of drill cuttings, muds, produced waste water and solid waste.

However, the Geological Survey, in response to a request for estimates relating to Sale No. 43 pointed out that estimates of resource potential are inherently speculative, particularly so in areas, such as the South Atlantic OCS, where geologic information is limited and the presence of oil and gas has not been demonstrated. Further, the Geological Survey emphasized that operational projections and estimates are highly speculative and represent a possible development scheme based on many variables and assumptions.

This group of blocks considered for leasing contains a number of blocks in which industry interest was less than in the blocks included within proposed Sale 43, and it is possible that, if this alternative selection had been offered, fewer blocks would have been leased, and a lesser number of wells and platforms would be required. It is also possible that lesser quantities of oil and gas would be discovered.

However, it is considered most likely that the numbers of wells and platforms, and quantities of oil and gas, cuttings, and solid waste, and other estimated impacts that would be anticipated to result from this alternative selection of tracts would be within the same ranges as the estimates specifically provided for proposed Sale 43, and therefore, the basic development assumptions remain the same as described in Section I.

The risk of an oil spill impacting another resource is believed to be the same as the risk present in the proposed sale, and no modification in the estimated onshore locations of service, transportation, or support facilities would be required.

Impacts from this Alternative

The impacts associated with this alternative would probably be the same as the impacts discussed within this impact statement, since the development assumptions remain the same.

This alternative offering would have included an additional number of tracts within the possible area of "live bottoms", possibly as many as 60 blocks. Thus the effect on fishing would be greater than described in Section III.C.6.

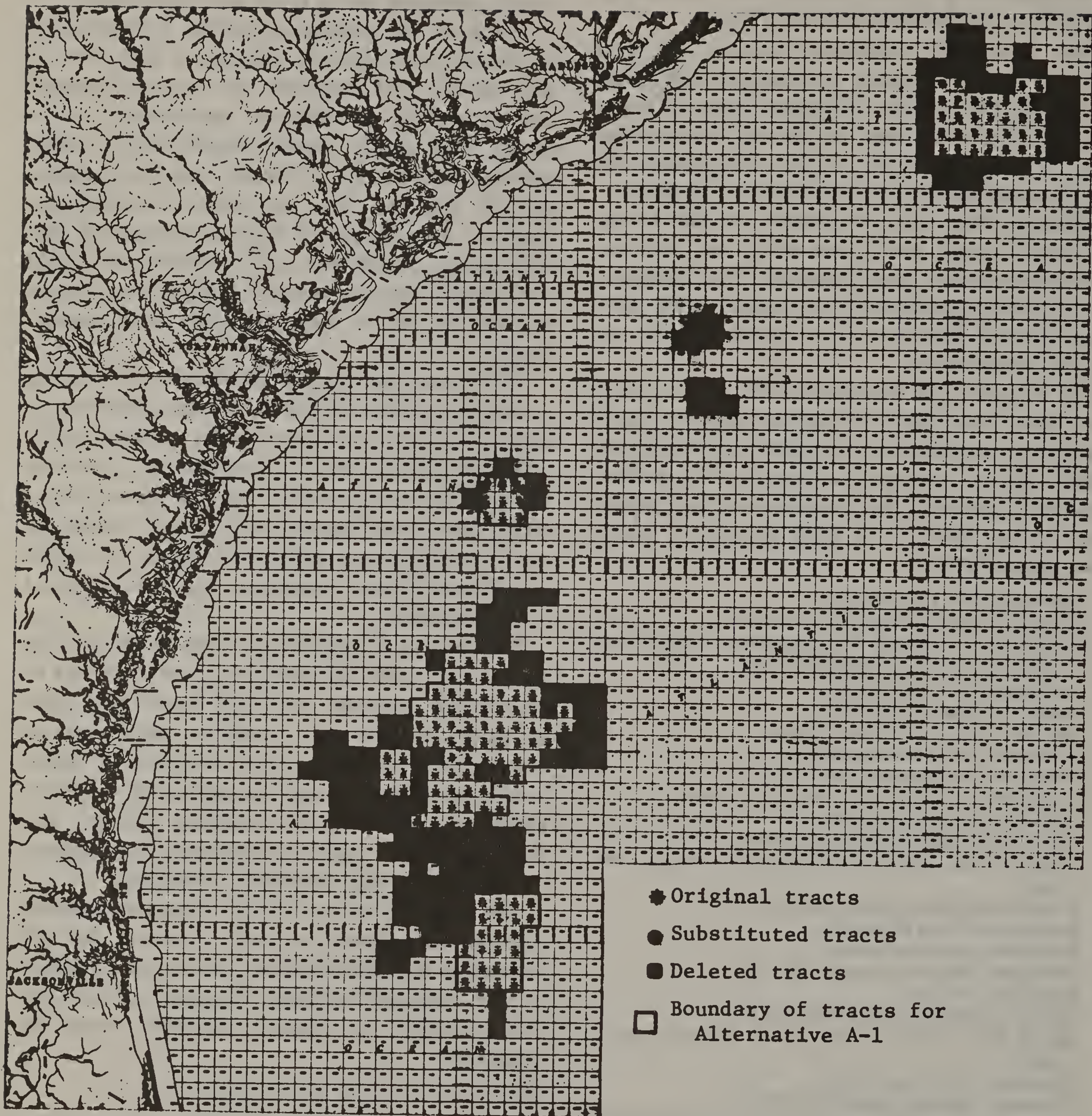


Figure VIII-1. Alternative A-1 substitution of tracts within the area of the Call for Nominations.

The cumulative impact of this and subsequent sales is believed to be about the same as discussed in the portion of the EIS concerned with the environmental impact of the proposed sale.

2. Substitution of alternate tracts for tracts located in reported and possible "Live Bottom" areas (Figure VIII-2).

"Live Bottoms" have been identified as a resource of concern. "Live Bottoms" are rock ledges supporting benthic epifauna and demersal and pelagic fish communities. While the actual extent of these communities is not known, a trend believed to contain these areas has been identified for the general area of proposed leasing for proposed Sale No. 43. This trend is based on information available to the New Orleans OCS Office concerning known live bottom areas, substrate type, and other environmental factors. Reference to Visual No. 4S shows tracts overlaid on live bottom areas.

Utilizing the resource groups identified for the Department of the Interior oil spill risk analysis model (Appendix M), the following groupings of tracts proposed for leasing in this sale fall within the live bottom trend and snapper bank areas.

Resource Area No. 1; 1-3, 6-14, 16-20, 22-25, 30-33, 37-41, 43-51
Resource Area No. 2; 52, 54, 55
Resource Area No. 4; 69-71, 74, 75, 77, 78, 80-82, 84, 85, 87-92, 95-101, 106-113, 120-126, 133-138, 149
Resource Area No. 5; 102-105, 114, 116-119, 127, 130-132, 139, 140, 143-145, 152-154
Resource Area No. 6; 146-149, 155-158, 162-166, 169-173, 175-177, 179-182, 184-186, 189-191, 196-198
Resource Area No. 7; 206-208, 213, 214
Resource Area No. 8; 183, 187, 188, 192-195, 199-205, 209-212, 215-225.

These reported or potential live bottom area tracts represent about 79 percent of all of the tracts proposed for leasing in this sale, or 177 tracts.

These live bottom areas, while possibly sensitive to disruption, may be a common feature of the South Atlantic OCS. However, because of the biological productivity of these communities, and because their extent has not been defined at this time, one alternative to the proposed sale would be to reduce by about one half the area proposed to be offered for sale which is identified as live bottom trend.

Impacts

Given the assumption that the possibilities for drilling operations, and hence impacts to live bottom areas, are equal for each tract, this option could reduce by approximately one half the impact of the proposed sale upon live bottoms; and therefore, lessen somewhat the impact upon the benthos and commercial fisheries.

The following tracts are proposed under this alternative for deletion (Figure VIII-2):

As hydrocarbon potential and industry interest were major criteria in the original tract selection process, it may be assumed that tracts not among the 225 tracts originally proposed for leasing may have not been chosen because industry interest and geologic and geophysical information indicated low hydrocarbon potential. Therefore, this alternative may result in lower production of oil and gas resources than would result from the original proposal.

Resource Area No. 1; 2, 3, 6-13, 16-19, 23-25, 45-51
Resource Area No. 2; 54
Resource Area No. 4; 69-75, 77, 88-90, 97, 101, 111-113, 124-126, 133-138, 149
Resource Area No. 5; 114, 139
Resource Area No. 6; 146-148, 158, 166, 182, 184-186, 189-191, 196-198
Resource Area No. 7; 206-208
Resource Area No. 8; 183, 187-188, 192-195, 199-202, 209, 215, 219, 223-225.

This alternative would substitute 80 tracts outside of the identified live bottom trend areas. These substitute tracts include the following (tracts are identified by protraction diagrams and their numbering system):

James Island NI 17-12; 205-207, 251, 295, 328, 339, 372, 382-383, 416, 424-427, 465-471, 509-515
Brunswick NH 17-2; 298, 386, 604-607, 647-651, 691-693, 735-737, 779, 780, 823, 824, 866, 867, 910
Jacksonville NI 17-5; 161, 162, 201, 204-206, 245-249, 289-292, 333-337, 377-381, 421-425, 465-469.

As many of the tracts seaward of the originally proposed tracts are also areas of live bottom trend, this alternative considers the leasing of a substantial number of tracts (57) closer to shore than does this original proposal. Increased risk of spills impacting shoreline resources may result with consequent impact on beaches.

To the extent that lower production occurs, oil and gas-related employment and local and regional incomes would increase by lesser amounts.

The cumulative effects that might result from the adoption of this alternative should not be greater than would occur with the proposal and should be less.

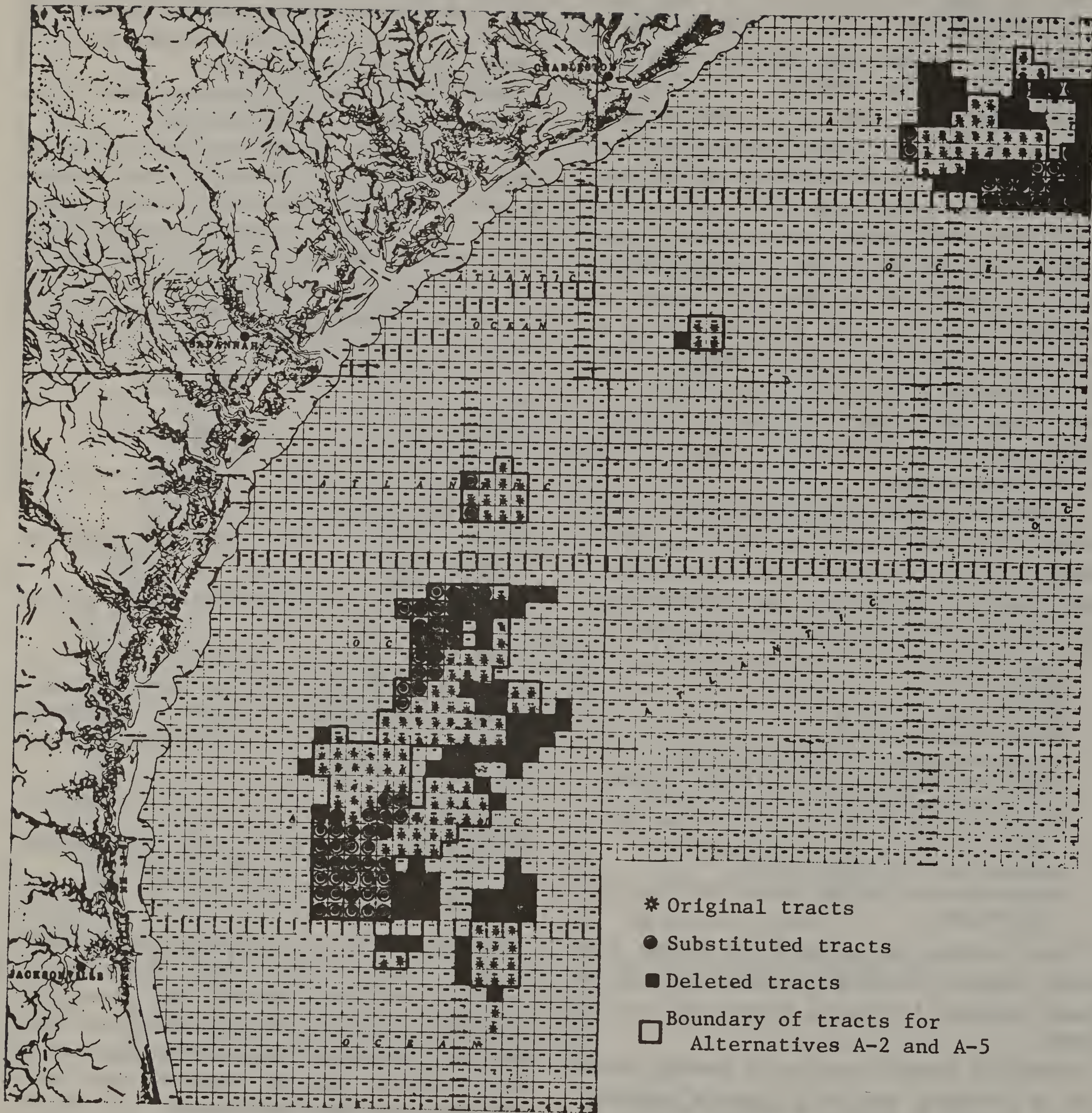


Figure VIII-2. Alternative A-2 substitution of alternative tracts for tracts located in reported and possible "live bottom" areas. Alternative A-5 delete tracts located within known and possible "live bottom" trends.

3. Substitution of new tracts for tracts located in reported "live bottom" areas (Figure VIII-3).

A resource of particular concern known as "live bottom" are rocky ledges supporting benthic epifauna such as anemones, hydroids, bryozoa and hard corals, as well as associated demersal and pelagic fish populations. While the actual extent of these systems is not known (their occurrence is thought to be discontinuous) a trend believed to contain these areas has been identified for the general area of proposed leasing for proposed Sale No. 43. This trend is based on information available to the New Orleans OCS Office concerning reported live bottom areas, substrate and other environmental factors. (Reference Visual). The following tracts (160) proposed for leasing in this sale fall within the live bottom trend identified: 1-3, 6-14, 16-20, 22-25, 30-33, 37-41, 43-52, 54-55, 69-71, 74-75, 77, 78, 80-82, 85, 87-92, 95-114, 116-127, 130-140, 143-149, 152-158, 162-166, 169-173, 175-177, 179-225.

These live bottom areas, while possibly sensitive to disruption, may be a common feature of the South Atlantic OCS. However, these communities are biologically very productive, and their extent is not defined at this time. One alternative to the proposed sale would be to reduce the area proposed to be leased which is identified as live bottom trend.

The matrix analysis of potential impacts on major resources and activities (Section III.F.) has assigned sensitivity values for oil spills and structures to various resources. For "live bottom" areas, this analysis assigned a rating of maximum potential impact to live bottom areas as a result of structure emplacement and operation. Sensitivity of live bottoms to oil spills was determined on the basis of water depths to which oil can be expected to be entrained in the water column. Table J-3 (Appendix J) indicates the results of the matrix analysis for live bottoms. Five tracts were identified as presenting maximum potential impact to live bottom and 52 tracts moderate potential impacts.

However, the matrix analysis assumed live bottom systems on all tracts. If these tracts are examined in relation to identified live bottom trend, it can be seen that no tracts identified as having maximum impact potential fall within live bottom trend areas. Twenty five tracts with moderate potential impact to live bottom systems do fall within live bottom trend areas. These tracts are: 2, 95, 96, 98-100, 106-110, 120-123, 127, 139, 140, 163-166, 171-173.

In addition, 25 tracts proposed for leasing are known live bottom areas. These are tracts: 3, 10, 12, 13, 16, 33, 40, 41, 43, 45, 46, 49, 69, 116-118, 130-132, 143-145, 203, 223, and 224. An alternative would consider substitution of 50 tracts not originally proposed for leasing. These 50 tracts, which are also outside of live bottom trend areas are (Figure VIII-3);

James Island NI 17-12; 207, 251, 295, 339, 383, 425-427, 465-471, 509-515.
Jacksonville NI 17-5; 161, 162, 204-206, 246-249, 290-292, 334-338, 378-381, 422-425, 467-469.

(Tracts are identified by protraction diagrams and their numbering system).

Twenty-eight of the tracts proposed for substitution lie immediately shoreward of production area 6 and south of production area 5, as defined in the Department's oil spill risk analysis. The other 22 tracts lie seaward of production area 1.

Production area 5, 6 and 1 are rated as second, fourth and fifth, respectively, out of eight areas in terms of risk on a per unit of oil production basis. Thus 28 of the tracts proposed under this alternative would add to the number of tracts relatively close to shore, thus possibly increasing the oil spill risk of the proposal.

IMPACTS

As hydrocarbon potential and industry interest were considered during the original tract selection process, it may be inferred that tracts not among those originally selected may not have been chosen because industry interest and geologic and geophysical information indicated low hydrocarbon potential. Then this alternative may result in lower production of oil and gas resources than would result from the original proposal.

To the extent that lower production occurs, lesser increases in oil and gas-related employment and resulting increases in local and regional income would result.

Impacts which would differ from the original proposal would be 1) a reduction in benefits of domestically and regionally produced petroleum resources, including employment and income as discussed above, 2) a reduced potential for impact to live bottom areas and therefore, the benthos and commercial fisheries, and 3) a possibility of a slightly higher risk of oil spills impacting shoreline resources, such as beaches.

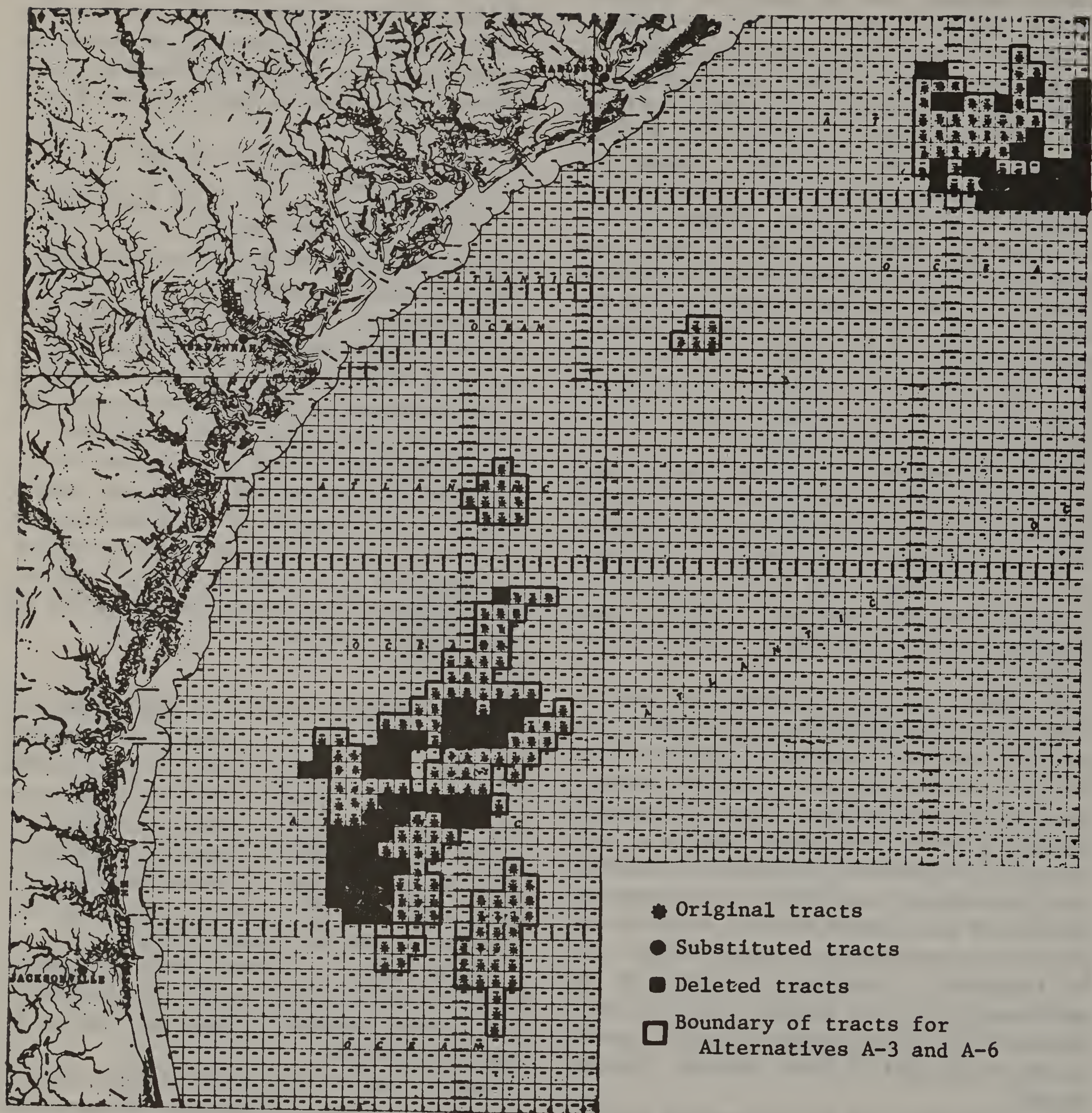


Figure VIII-3. Alternative A-3 substitution of tracts for tracts located in reported "live bottom" areas.
Alternative A-6 delete tracts located within known "live bottom" trends.

4. Delete tracts posing a relatively high potential of impacting biological and recreational resources (Figure VIII-4).

The Departments oil spill risk model was utilized to analyze spill risk for proposed Sale No. 43 (see Appendix M). Resulting from this analysis are rankings of relative risk among eight production areas. The rankings are given on the basis of risk per unit oil production (trajectories only as discussed above) and total risk over the estimated production life (taking into account resource potential as discussed above).

The analysis indicates that production areas 2 and 3 (tracts 52-56 and 57-67 respectively) rank among the three groups posing the highest risk of oil spills on a unit oil production basis. On the other hand, areas 2 and 3 rank seventh and fifth respectively when ranked by total risk. This would indicate that relative to the oil production potential of these production areas, their risk, in relation to other production areas, is high.

One alternative which could be considered would be to delete the 16 tracts which compose production areas 2 and 3 (Figure VIII-4). This alternative would reduce the proposed sale to 209 tracts, a seven percent reduction from the sale as originally proposed. It would also reduce by an undetermined amount the hydrocarbon expected to be produced as a result of the proposed sale. Since it would eliminate two scattered "production areas", exploration and any subsequent development would be limited to two major groups of tracts (that composed of production area 1 and that composed of production area 4-8). This would limit the areal extent of the South Georges Embayment which would be tested for oil and gas resources.

Impact of this Alternative

The adoption of the alternative would reduce the risk of environmental damage resulting from oil spills on 14 resource groups. The principal resources exposed to the highest probability of impact in the event of a spill are sandy beaches in Florida and North Carolina, the arctic peregrine falcon migration routes, some species of shrimp, and crabs and oysters. The reduction in acreage offered could result in the installation of 1 to 2 fewer platforms, the drilling of 18 to 50 fewer wells, and a reduction in the weight of drill cuttings ranging from 12,276 to 53,950 tons.

The adoption of this alternative would have the most significant cumulative impact on the arctic peregrine falcon. The migration route of the falcon passes along the coastal portions of the Atlantic Seaboard where additional OCS lease sales have been held or are being considered. The potential for the falcon to come into contact with spilled oil, either directly or indirectly, would be mitigated to some slight extent by the elimination of these tracts.

An incremental reduction in oil production could reduce the necessity for tanker transportation of crude petroleum to refining centers. In the event that crude petroleum was transported to refining centers receiving crude oil produced from the Mid Atlantic and North Atlantic OCS, an incremental reduction in tanker traffic, on the order of 1 voyage in a two week period, might result.

5. Delete tracts located within known and possible "live bottom" trends (Figure VIII-2).

In developing this alternative and identifying tracts for deletion, an effort was made to maintain groupings of tracts to protect "live bottom" areas and to provide for orderly development. Approximately half of the live bottom trend tracts in each previously identified resource area are deleted under this alternative. Based on the assumption of equal impact potential per tract, described above, this deletion scheme could halve the impact potential of the proposal relative to live bottom and at the same time retain those tracts which may be most prospective for oil and gas resources.

This alternative would delete 88 tracts of the 177 tracts identified within live bottom trend areas; and would reduce the proposed sale from 225 tracts to 137 tracts.

The reduction in the proposed sale size by approximately 39 percent could result in a proportional decrease in the amount of wells drilled, platforms installed, drilling muds, and formation waters utilized and produced, although this would depend on the hydrocarbon resources contained in the remaining 137 tracts.

The tracts proposed for deletion under this alternative include the following: Tracts 2, 3, 6-13, 16-19, 23-25, 45-51, 54, 69-75, 77, 88-90, 97, 101, 111-114, 124-126, 133-139, 146-149, 158, 166, 182-202, 206-209, 215, 219, 223-225.

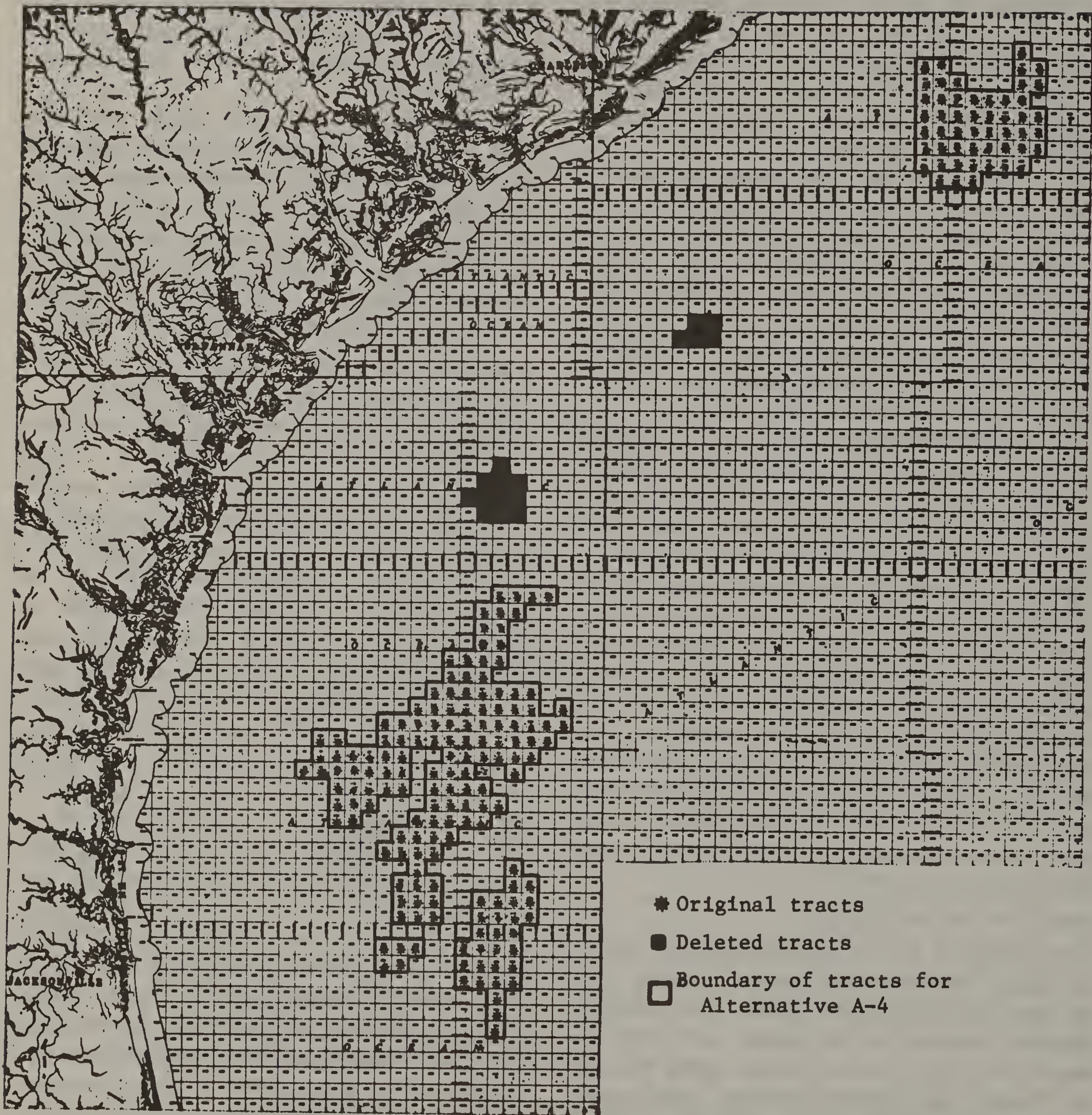


Figure VIII-4. Alternative A-4 delete tracts posing a relative high potential of impacting biological and recreational resources.

Impacts

Deletion of 88 tracts from the proposed sale would reduce the hydrocarbon potential of the proposed sale area by an undetermined amount. This alternative could be estimated to reduce the recoverable resources expected from the proposed sale to 180 to 650 million barrels of oil, and 1.2 to 4.4 trillion cubic feet of gas.

The reduced amount of exploration, development and production facilities required to develop hydrocarbon resources of the 137 tracts would result in lower increases in oil and gas-related employment and local and regional income than would be anticipated for the original sale proposal. However, as the distribution of remaining tracts would be approximately the same as that for the originally proposed leasing of 225 tracts, the distribution of onshore support facilities and services may remain similar to that expected for the originally proposed lease sale.

The reduction in size of the sale would also reduce the potential for accidental oil spills and could be expected to reduce low level chronic oil pollution. This, in combination with reduced numbers of wells, platforms, drill cuttings, drilling mud and formation waters could be expected to reduce the overall impact to marine organisms.

The principal reduction in tracts offered would be in Production Areas 1, 4, 6, 7, 8 and would reduce the amount of drill cuttings anticipated to result from the sale by 53,878 to 271,908 tons.

Since live bottom areas support populations of demersal and pelagic fishes, the deletion of half of the tracts within the identified live bottom trend could serve to reduce the impact on existing or future recreation and commercial fishing efforts by reducing the area and the number of offshore structures which could interfere with fishing in and around live bottom areas.

The probability of an oil spill in this area impacting a commercial fishing area is greater than 99.5 percent, and the deletion of tracts, by reducing the amounts of crude oil produced, could be expected to diminish the risk of interference with commercial fishing activity. In the event of a major spill, approximately 2 per cent of the commercial fishing area may be impacted.

The cumulative impacts associated with this alternative would be expected to be about the same as those discussed above.

6. Delete tracts located within known "live bottom" trends (Figure VIII-6).

The following 25 tracts were estimated to pose a moderate potential impact to live bottom systems. Tracts 2, 95, 96, 98-100, 106-110, 120-123, 127, 139, 140, 163-166, 171-173.

The following 25 tracts are located within known "live bottom" areas. Tracts 3, 10, 12, 13, 33, 40, 41, 43, 45, 46, 49, 69, 116-118, 130-132, 143-145, 203, 223-224.

Deleting this total of 50 tracts from the sale would provide a greater measure of protection to the known "live bottoms", and potential benefit to fishing activities and scientific investigation of the live bottom areas.

One alternative to the proposed sale would be to delete all tracts known to have live bottom systems and those tracts within the identified live bottom trend which have been identified as presenting moderate potential impact to live bottom systems as a result of potential oil spills.

This would result in deletion of 50 tracts from the proposed sale, reducing the size of the sale from the originally proposed 225 tracts to 175 tracts.

Impacts

This alternative of deletion of 50 of the tracts originally proposed for leasing could reduce by an undetermined amount the potential production of hydrocarbon resulting from the proposed sale. While several tracts proposed for deletion under this alternative are scattered throughout the proposed leasing area, two concentrations of tracts (163-166, 171-173 and especially 95, 96, 98-100, 106-110, 120-123) represent major groupings of tracts within the largest group of tracts proposed to be offered in proposed Sale 43.

With the exception of eight of these tracts (33, 40, 41, 45, 46, 49, 222 and 225) proposed under this alternative for deletion, these tracts are also identified in the matrix analysis as posing maximum risk to commercial and sport fishing as a result of structures and/or spills. Deletion of these tracts would, then, also afford reduced impact to fish populations and fishing efforts.

The reduction in the proposed sale size by approximately 22 percent could result in a proportional decrease in the amount of wells drilled, platforms installed and drilling muds, cutting and formation waters utilized or produced. Should the tracts deleted contain a substantially greater percentage of the resource estimated for the entire proposed sale area, a greater decrease in these facilities and activities would result. A reduction in the size of the sale would also reduce the potential for accidental oil spills and could be expected to reduce chronic low level oil pollution stemming from oil and gas operations. This would result in an overall reduction in the potential for impacts to marine organisms.

The reduction in the amount of exploration, development and production facilities which would be required to develop hydrocarbon resources of the 175 tracts would also reduce oil and gas-related employment increases which would otherwise be expected from proposed Sale 43. Increases in local and regional income would be reduced as well.

This alternative could be expected to result in production of less than the 0.282 to 1.009 billion barrels of oil and 1,890 to 6,810 trillion cubic feet of gas which is estimated to result from proposed Sale 43 as originally proposed. This would reduce those benefits which would stem from increased domestic production of petroleum. It would also reduce those benefits which could accrue to the region as a result of regionally produced petroleum resources.

Preliminary estimates indicate that total sale related employment may be less by approximately 350 to 1200 jobs in the event this alternative is chosen. The reduction in the amount of drill cuttings could amount to between 31,372 and 140,270 tons, and between 2 and 4 platforms would not be required.

In the event that these tracts were not offered at future sales, the cumulative impacts would be the same as the impacts relating to this alternative.

B. Delay the Proposed Sale

The proposed OCS Lease Sale No. 43 could be delayed from three to five years. If the proposed sale should be held at a later date, both geological hazards and any unique biological communities would have been identified and delineated. This data could be used for deletion of a tract or tracts prior to holding a sale. This alternative examines the assumption of delaying the proposed sale and its effects.

Coastal Zone Management Plans would probably be in effect in all of the coastal states. A delay in the proposed sale would provide additional time for environmental studies. If environmental studies were carried out during this period, notices to lessee, or changes in OCS Operating Orders could be developed and could be more specifically tailored to the U.S. South Atlantic OCS region so that during the production phase, regional oil and gas resources could be most advantageously exploited while also providing maximum protection to the environment.

In the event that leasing and exploration activities were being carried forward in other marine areas, both domestic and foreign, during the period of delay for proposed Sale No. 43, it is probable that at least some of the manpower and equipment would be used in exploration activities in these other areas. The provision of platforms, terminals, and pipelines required as a result of proposed OCS Sale No. 43 would also be delayed.

IMPACTS FROM THIS ALTERNATIVE

Delay of proposed OCS Sale No. 43 would result in the postponement of risk to alternative resource uses, particularly beaches, migration routes and commercial fishing, resulting from the exploration, production, and transportation of mineral resources that may be discovered as a result of proposed Sale No. 43. Delay of the proposed sale would not result in the postponement, or delay, of all risk to alternative resource uses in the area, since the existing energy needs within the area are partially met by the water transportation of petroleum products, and to the extent that this marine traffic continues, the risk of oil spills would be present from this source.

During the initial years of exploration and production activity, crude oil produced from these leases would probably be shipped by tanker to refineries located in other parts of the nation, and this traffic would be an addition to the marine transportation of petroleum products into the region. Delay of the sale would eliminate the incremental risk of oil spill damage due to the production and transportation of crude oil. The postponement of the sale would delay the placement of structures, pipelines, and terminals, and eliminate the impact of these facilities during the period of delay.

The cumulative impacts associated with a delay of proposed Sale 43 would be partially dependent on the results of the initial exploratory drilling.

Since proposed OCS Sale No. 43 is the initial sale on the South Atlantic OCS, a delay in this proposed lease offering may have an effect on subsequent offerings, and development related to these possible subsequent offerings.

The estimate crude oil production that may result from OCS Sale No. 43 amounts to between 56,000 and 170,000 barrels of oil per day. During October, 1976, the refiner acquisition cost of imported crude petroleum was estimated to be $13.47 per barrel by the Federal Energy Administration, indicating a cost approximately $2.00 per barrel above the cost of new domestic crude oil production. Delay of the proposed sale, therefore, implies an additional economic cost of $124 million per year for the use of more expensive imported crude oil during the period of delay.

C. Withdraw the Proposed Sale

Another option is to cancel the proposed sale. This would be considered the no action alternative. This option would reduce future OCS oil and gas production and would thus necessitate continuing foreign imports or reducing energy consumption by reduced demand or supply shortfalls, or developing alternative energy sources, or some combination of these.

It is anticipated that the oil and gas that would become available from this proposal in the next 25-year period could provide significant additions to the nation's domestic production, particularly for use in the U.S. South Atlantic region. However, if the subject sale were cancelled, the following energy actions or alternative sources might be used as substitutes:

- Energy conservation
- Energy alternatives
  - Coal
  - Hydroelectric power
  - Nuclear power
  - Oil shale
  - Solar energy
  - Geothermal energy
  - Energy imports
- Other energy sources
- Combination of alternatives

The above are more fully examined in the OCS Programmatic FES 75 (July 7, 1975). For more detailed information on each of these energy sources and environmental impacts, refer to the study "Energy Alternatives: A Comparative Analysis", prepared for the Bureau of Land Management by the Science and Public Policy Program of the University of Oklahoma. Copies of this study (stock number 641-011-00025-4) may be purchased for $7.45 from the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402. Table C-1 contains estimates of energy required from other sources as replacement for sale related energy.

Impacts from this Alternative

Adverse impacts from not holding a large sale would affect the socio-economic environment. The reduction in potentially producible oil would increase the amount of time which the United States, and the Atlantic coastal states particularly, would continue to be reliant on foreign sources of petroleum. The reduced possible increase in oil and gas-related employment and lower increases in local and regional income would negatively impact those areas already suffering the effects of unemployment.

The smaller amount of produced natural gas and overall delay in producing potential OCS resources could also result in more use of coal or oil fuels for heating and industry. Additional delays in reducing air pollution consequently would adversely affect human health, and some industries which cannot afford to change to other fuels or which can only use natural gas may have to close (thus worsening the impact on the regional economy).

The immediate and probably environmental affect of withdrawing the sale would be to preclude all of the environmental impacts described in Chapter III of this EIS. Over the longer term, effects would be felt in the national energy mix. Environmental effects would be felt in the national energy mix. Environmental effects will be experienced from the use of alternate sources of energy. Those applicable to the damage to environmental factors due to tanker and barge transportation of petroleum products for consumption within the area.

In the event that production from proposed Sale 43 is tankered to shore terminals, and shipped from the area to be refined elsewhere, withdrawing the sale would decrease the total marine transport of crude oil and petroleum products.

In the event that production from proposed Sale 43 was pipelined to shore terminals, and exported as crude oil for refining elsewhere, withdrawal of the sale would remove the additional risk due to transport of crude products by pipeline and tanker.

But if OCS crude petroleum was pipelined to a refinery in the area, should one be constructed with a distribution system relying less on water transportation, withdrawal of the sale would mean the continuation of marine transportation of petroleum products into the area, with the attendant risk of oil spills from this source.

Table C-1. Energy Needed from Other Sources to Replace Anticipated Oil and Gas Production from Proposed South Atlantic Sale No. 43

	Range	
	Low	High
Total Crude Oil Production (barrels)	0.3×10^9	1.0×10^9
Annual Average (25 year life)		
Total Natural Gas Production (cubic ft.)	1.9×10^{12}	6.8×10^{12}
Annual Average (25 year life)		
Btu Equivalent		
Crude Oil Btu Equivalent	1.68×10^{15}	5.65×10^{15}
Natural Gas Btu Equivalent	1.94×10^{15}	6.95×10^{15}
Total Oil and Gas Equivalent	3.62×10^{15}	12.60×10^{15}
Daily Average Btu	396.7×10^9	1380.8×10^9
Primary Energy Source Equivalents		
Oil Equivalent (barrels		
Total	0.6×10^9	2.3×10^9
Annual Average	25.9×10^6	90.9×10^6
Daily Average	70,800	246,600
Gas Equivalent (cubic feet)		
Total	3.5×10^{12}	12.3×10^{12}
Annual Average	141.6×10^9	493.6×10^9
Daily Average	0.4×10^9	1.4×10^9
Coal Equivalent (tons)		
Total	151×10^6	525×10^6
Annual Average	6×10^6	21×10^6
Daily Average	16,500	57,500
Secondary Energy Sources		
Gas from Coal (High Btu gas')		
Number of plants (250×10^9 Btu/day/plant)	2	6
Coal Requirement: Total (tons)	430.7×10^6	$1{,}292.1 \times 10^6$
Coal Requirement: Annual (tons)	17.2×10^6	51.7×10^6
Coal Requirement: Daily (tons)	47,200	141,600
Oil from Oil Shale[2]		
Oil Shale Requirement: Total (tons)	857×10^6	$3{,}286 \times 10^6$
Oil Shale Requirement: Annual (tons)	34×10^6	131×10^6
Oil Shale Requirement: Daily (tons)	93,900	360,100

Table C-1 (continued)

	Range	
	Low	High
Electricity from Nuclear Energy		
Number of light water reactors		
(1000 MW(e) capacity)	2	5
First core fuel U_3O_8[4]	60 tons	150 tons
Annual Reload	20 tons	50 tons

Conversion Factors:

1 barrel of oil = 5.6×10^6 Btu
1 cubic foot of natural gas = 1,021 Btu
1 ton of coal = 24×10^6 Btu

D. Other Alternatives Within the Proposed Action

1. Notification of onshore facilities required for exploration activity.

The Coastal Zone Act Amendments of 1976 require that exploration and development plans receive a certificate of concurrence with state CZM plans, once states have approved programs under Section 306 of the CZM Act. A six month period is granted in order for the states to review these plans prior to a decision as to concurrence. Delay of the sale until CZM plans are implemented would assure that no exploration or development plans resulting from the proposed sale are approved without this certificate.

On the other hand, proposed Stipulation 3 (Section IV.) would require that information regarding support facilities be provided to the governors of affected states prior to approval of exploration plans. OCS Order No. 15 contains a similar provision for development plans. While these regulations would not require state approval of proposers' plans, they would provide information essential to planning and thus aid in mitigating any adverse affects of onshore facility siting.

The impact of this proposal would permit early identification of the possible locations of support facilities, employment, and boat and helicopter traffic which would originate at the facility. This knowledge would permit consideration to be given to the provision of additional facilities required for the conduct of exploration work. Specific requirements for housing, air traffic and boat traffic requirements, and such public needs as schools, hospitals and solid waste disposal would be known on a site specific basis as soon as possible.

The cumulative impacts of this alternative would be to continue the earliest possible planning to deal with anticipated impacts.

2. Government Exploratory Drilling prior to Leasing

Exploratory drilling conducted or sponsored by the Federal Government prior to holding a lease sale would be an alternative within the proposed action. This would involve an alternative approach to one aspect of the present Federal leasing program. For such drilling to be done by the Federal government under existing law, it would have to be justified or accomplished within the confines of Section II of the OCS Lands Act (43 U.S.C. 1340). At the present time there is little exploratory drilling on the OCS prior to leasing. In addition, the U.S. Geological Survey receives all engineering and geological data from companies which have drilled on leases issued on the OCS. These data, and geophysical data purchased on the open market, are used by the Geological Survey to develop OCS lease policies and evaluate tracts prior to leasing.

By conducting such an exploratory program, the Government might obtain valuable data on stratigraphy and structure of the potential leasing areas. It might also obtain more detailed information on which to base resource estimates and evaluate tracts (and their monetary value) before leasing. In addition, coastal states might be able to obtain a better concept of expected development onshore.

To properly evaluate the range of potential hydrocarbon traps in the proposed sale area upwards of 95 or more exploratory wells might be required.

The impact of this alternative could result in the delay of leasing in order to evaluate the data, further increasing domestic reliance on foreign supplies of oil and gas during that period and do nothing to alleviate any near-term shortages of oil and gas during that period. It would be possible that some less remote though promising areas would not be explored, in favor of other more obvious prospective areas.

A potential benefit could be the ability of the Federal government to evaluate tracts prior to leasing.

The cumulative impact of this alternative, if it were applied to all OCS areas, would be the potential to more precisely locate those areas having the greatest likelihood of furnishing oil and gas resources.

3. State Participation in Development Decisions

On November 4, 1975, the Department of the Interior published an amendment to the drilling and development plan regulation (30 C.F.R. 250.34), providing *inter alia*, for State participation in decisions concerning the development of OCS leases. The revised regulation appeared in 40 Federal Register 51199-51200. Prior to being revised, 30 C.F.R. 250.34 required that a lessee submit a development plan to the Supervisor for approval before the commencement of a development program on a lease. That regulation now requires, *inter alia*, that the Supervisor shall provide the Governors of directly affected States with a copy of the plan for their review and comment at least 60 days before the Supervisor approves the plan.

30 C.F.R. 250.34, as revised, also provides for the State to receive information to better assess and plan for the onshore-offshore impacts of OCS development. At least 30 days before a lessee submits a development plan to the Supervisor for approval, he must deliver to the Governor of each directly affected State information about the development to be proposed. The information to be provided, which is not a part of the development plan itself, shall include a description of all onshore and offshore facilities and operations related to the proposed development, including location, size, requirements for land, labor, materials and energy, and timing of development and operations, and any other related information as may be required by the Supervisor. A Governor has 30 days after the final delivery of this supplementary information within which to notify the Supervisor whether the information meets the requirements of the regulation. If the Governor notifies the Supervisor that it does not, the Director of the Geological Survey shall review the information and either order the lessee to submit additional information or determine that the information meets the requirements of the regulation. If the Director determines the latter, the 60-day period within which the Governor has to review the development plan shall begin from the date of the Director's decision.

A Governor of a directly affected State will therefore have a minimum of 60 days within which to review and comment on a development plan. This period does not include the period of at least 30 days he has to acquaint himself with the supplementary onshore-offshore impact information, and any additional time he may have because of delays before the 60-day period begins.

In drafting these new regulations, the Department considered both shorter and longer periods of time for State review of development plans and the effect of delays in potential lease development that might result from longer review periods. The Department always has the option to amend the regulations if the procedures for State participation in reviewing development plans are found to be inadequate.

A possible timeframe alternative to the new 30 C.F.R. 250.34 available to the Secretary when considering a period for State review of development plans is to suspend leases for a greater period of time between the exploration and development plans that is provided for under the new regulation. This potentially prolonged period of review might be beneficial where the plans involve onshore facilities, such as pipeline landing sites and onshore support facilities, the ultimate approval of which would be within the jurisdiction of the State. State and local officials have expressed the view that they would be forced to make hasty and ill-informed decisions regarding potential onshore facilities without such a review period. Customary suspension between exploratory and development phases could provide a more orderly and efficient procedure for Federal and State decisions concerning those potential offshore and onshore aspects of OCS lease development within exclusive or concurrent jurisdiction of the respective governments.

On the other hand, the adoption of a period of suspension between the exploration and development stages would result in a longer period of delay in initiating potential development operations. Delays increase costs to the operator which might be passed on to the consumer; it is possible that in marginal fields, lengthy delays might preclude production of the oil and gas, depending on the price of oil at the time.

However, before ordering a suspension of operations as described above, the Secretary would have to show that the suspension is in the interest of conservation of natural resources, as contemplated by Section 5(a) of the OCS Lands Act (43 U.S.C. 1334(a)). Also, for the suspension to be legally supportable, it must hold promise of the right of development at some future time. If the Secretary, in certain circumstances, should decide that public interest requires termination of an OCS lease at the end of the exploratory phase, he would be unable to cancel the lease without enactment of special legislation by Congress. This legislation might take the form of either separate leases for exploration and then development, or exploration with the possibility of lease termination at the discretion of the Secretary before development can occur. Since the results from these legislative alternatives are not known, we cannot say more than without incentives to take risk, petroleum companies may reduce the amount and number of bids for lease or they may not bid at all.

In a different context, a period of six months has been provided under the Coastal Zone Management Act of 1972 (16 U.S.C. 1451-1464), to a State with a Federally-approved coastal zone management program to indicate whether or not it concurs with a certification by an applicant for a Federal permit subject to the Act, that a proposed activity is consistent with said program.

Another potential alternative available to the Secretary is to require a plan of development to include more comprehensive information than required in the new regulation. The plan could be required to include such additional information on the following: (1) the number and bottom hole locations of wells to be drilled from each platform; (2) all abnormal pressure maps; (3) all information on shallow hazards; (4) anticipated disposition of all produced hydrocarbons; and (5) an environmental assessment of all potential offshore and onshore impacts of the operations described in the specific plan of development. This information would give States a more specific indication of the magnitude of anticipated production and resulting impacts. The problem is that it would require lessees to divulge privileged information and might ultimately discourage the exploratory development and production of oil and gas resources on the OCS.

If it is determined that approval of a plan of development involves a major Federal action significantly affecting the quality of the human environment, and if the action has not been covered previously in an environmental impact statement, an EIS would be prepared in accordance with Section 102(c) of the National Environmental Policy Act of 1969 before taking action on a request for approval of the development plan.

In summary, the impact of the adoption of one of these alternatives to the new 30 C.F.R. 250.34 regulation could allow for an even more orderly and comprehensive review of plans of development than that established under the new regulation itself. Additional time would be allowed for more cooperation and coordination between Federal and State Governments in making decisions which bear upon those aspects of potential OCS operations and siting of facilities within the exclusive or concurrent jurisdiction of said governments.

A greater period of delay in securing potential development of OCS oil and gas resources and consequent delay in channeling such production into the domestic supply of energy could occur depending upon the duration of the suspension period. While a period of three, four, or more months for State review and comment might be provided, it is not possible to predict the additional period of time that might be involved in the evaluation of in depth State comments and potential efforts of the parties to resolve any differences that might arise.

4. Implementation of Energy Facility Siting Legislation at the State level.

At present, none of the U.S. South Atlantic states have the legislative authority to affirmatively identify and study specific sites that could appropriately accommodate key energy-related facilities. Existing state actions focus on regulating the placement of such facilities after a specific site has been identified by the proposer. In essence, the states' regulatory functions are reactionary in that they are not activated until a specific proposal has been made.

The proposed Sale No. 43 could be delayed until such time as the adjacent coastal states have developed and implemented legislation which would guide and/or control energy related facility siting. This might take the form of identification of specific sites for such facilities and/or acquisition of such sites by states. Such a positive approach to facility siting could minimize adverse impacts of energy-related facilities by providing a mechanism to assure that facilities are compatible with their environment. Positive impacts would also result through providing direction to desired economic growth.

Section 305(b)(8) of the Coastal Zone Act, as amended, provides stimulus for this approach. That section states that "the management program for each coastal state shall include . . . a planning process for energy facilities likely to be located in, or which may significantly affect, the coastal zone, including, but not limited to, a process for anticipating and managing the impacts from such facilities." Energy facilities, in the context of the amendment, includes OCS related facilities such as crew and supply bases, platform fabrication yards, gas processing plants and pipelines and associated terminals.

The Coastal Zone Management Act Amendments provide that the states have until October, 1978 to implement this section, even when state programs have already received approval under Section 306.

The impacts associated with this alternative would be the provision of detailed site requirements to states adjacent to the sale area, but might cause delay of the proposed sale.

Planning for anticipated impacts, covering a broad range, could be carried forward, but the level of mitigation of these impacts is not yet quantifiable.

5. Requirement of Bird Repelling Techniques during Appropriate Oil Spill Situations.

Through a Notice to Lessees, amendment to Operating Order No. 7 (both of which would have to be implemented by the U.S. Geological Survey) or a lease stipulation (which could be implemented by BLM), the storage and use of bird scare techniques could be required of those operating under leases issued as a result of proposed Sale 43. Birds sensitive to impact due to oil spills in the South Atlantic would be mostly wintering or migrating waterfowl and other coastal birds, rather than birds rafting offshore. Therefore, such a regulation could mandate storage of such devices at onshore areas where oil spill containment and clean-up equipment is kept. Such a regulation could also mandate deployment of these devices to susceptible shoreline areas in the event of an oil spill. Propane guns or best available technology could be required.

The coastal area of the South Atlantic supports large and varied populations of birds. It is also a part of the Atlantic flyway utilized for migration between southern wintering areas and northern nesting areas. National Wildlife Refuges such as Cape Romain and Merritt, as well as state wildlife management areas are located along the South Atlantic coast.

The Department of the Interior's Oil Spill risk analysis (Appendix M) indicates a fairly low risk to coastal birds as a result of oil spills. Probabilities of at least one major spill occurring and impacting refuges, brown pelicans and coastal or pelagic rookeries range from 2% to 9% (Table 4, Appendix M). Probabilities for impact to marshes and wetland areas in general, both important avian habitat areas, are 14% to 17%.

However, the risk of impact to birds may be further reduced by implementation of this alternative. The use of scare devices to repel marine birds for sustained periods of time from the area of an oil spill has proven practical and effective for several species of water-oriented birds. The devices are presently available in the South Atlantic for use in the case of spill, but no requirements for their use or deployment are presently in effect. It should be pointed out, however, that the devices are not effective for all species and more research may be required.

6. Alternative Administrative Procedure to Protect Cultural Resources and "Live" Bottom Areas and Mitigate Potential Impact from Unexploded Munitions.

The potential impacts of the proposed sale upon cultural resources and "live" bottom areas, and impacts resulting from the presence of unexploded munitions, have been discussed in Section III. This includes impacts connected with operational aspects of platform and pipeline siting. Proposed special stipulations to mitigate these impacts, or part of them, have been formulated and are described in Section IV.D.

In order to provide further protection of "live" bottom areas and associated sport or commmercial fishing activities, cultural resources and protection from impacts connected with the presence of unexploded munitions, the following stipulations are offered as alternatives to their counterpart stipulations discussed in Section IV.D:

1. Biological Survey - Prior to any drilling activity or placement of any fixed structure or pipeline or any other exploration or production activity, the lessee will submit to the Supervisor as part of his exploration and/or production plan a bathymetry map, prepared utilizing remote sensing and/or other survey techniques. This map will include interpretations for the presence of "live" or hard bottom areas. These areas are defined as containing biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans and hard corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and whose lithotope favors accumulation of turtles and pelagic and demersal fish. The lessee will also submit to the Supervisor bottom photographs of the three initial proposed explora-

tory well locations and any proposed platform sites. A minimum of five bottom photographs will be required for each exploratory drilling location or platform site. An interpretation of geologic or engineering hazards, e.g., shallow gas, geopressure, sediment stability fractures and/or such dangers that could destroy platforms or drilling rigs and thereby harm the biota shall be mapped as documented evidence, acceptable to the Supervisor.

2. Cultural Resource Survey - The lessee shall conduct a remote sensing and/or other survey as specified by the Supervisor on the recommendation of the Manager, New Orleans OCS Office, Bureau of Land Management to determine the possible existence of a cultural resource that may be affected by the lessee's operation. The lessee's report shall document through the use of a qualified marine survey archaeologist's analysis of all survey data (including magnetometer and sidescan records), all indications of objects, on or directly below the seabottom, which may be historic shipwrecks or which may have been the locations of early man living sites. This report shall be submitted to the Supervisor and the Manager for review. If the Supervisor, after consultation with the Manager, determines that a potential cultural resource might be affected by proposed operations, the lessee shall either: (a) locate the site of any operation so as not to adversely affect the potential cultural resource identified, or (b) determine, to the satisfaction of the Supervisor, on the basis of further investigation conducted by a qualified marine archaeologist or marine survey archaeologist that such operations will not adversely affect the potential cultural resource identified, or that the object is not a cultural resource.

The lessee shall take no action that may result in an adverse effect on the cultural resource until the Supervisor has given directions as to its disposition.

If the presence of a cultural resource has been confirmed and it cannot be avoided, the lessee shall mitigate, under supervision of a qualified marine archaeologist, the adverse effect, as directed by the Supervisor.

If any site, structure, or object of cultural resource significance should be discovered during the conduct of any operations related to the leased area, the lessee shall make every reasonable effort to preserve and protect the cultural resource from damage until the Supervisor has given directions as to its disposition.

3. Ordnance Survey - The lessee shall conduct remote sensing and/or other surveys as specified by the Supervisor to determine the existence of any unexploded ordnance (munitions, mines or bombs). The lessee's report to the Supervisor should document all indications of magnetic or sidescan sonar anomalies on the sea floor. Inspection of all anomalies shall be made by a geophysicist experienced in marine magnetic and sidescan sonar detection and record interpretation.

Rationale

The current proposed mitigating measures provide for geophysical surveys by a lessee to determine the potential existence of cultural and other resources where the USGS Supervisor has reason to believe that such resource may exist in a leased area. The alternatives offered hereunder would provide for geophysical surveys of all leased blocks prior to any drilling activity or placement of any fixed structures or pipelines. This would provide greater assurance that any existing "live" bottom areas, cultural resources, and unexploded munitions occurring in the proposed sale area have been located and would be evaluated for significance.

Adoption of this alternative could lead to the identification and location of these and other resources at a time critical to the protection of these resources. That is, prior to the onset of activities such as drilling, and platform and pipeline siting, which could cause damage to these resources the existence of which might not be known unless the surveys in question were conducted.

Geophysical surveys for the resources referred to hereunder could be conducted under a single multi-sensor marine survey procedure, together with any survey which a lessee is required to make to determine the location and nature of geological hazards. The expense to a lessee attributable to the surveys described under this alternative would add an incremental cost of about 10% to the cost of staging and conducting the geological hazards surveys of equivalent line spacing.

While there is no prior experience in the South Atlantic OCS area in conducting the surveys referred to hereunder, a considerable amount of data and interpretive experience has been gathered in recent years during the course of OCS lease operations in the Gulf of Mexico. This experience shows that surveys conducted according to the following requirements contributed useful information for the protection of cultural and other resources:

a. Magnetometer-proton precision-towed near the bottom.
b. Side scan sonar-dual-towed near the bottom.
c. Subbottom profiles high resolution.
d. Survey vessel positioning - electronic - accuracy of 50 meters (169 ft) at 161 kilometers (100 miles), at a line spacing of 150 m (492 ft) or less.
e. Interpretation made by qualified marine archaeological surveyors, marine biologists and geologists, marine geophysicists (magnetics).

IMPACTS OF ALTERNATIVE STIPULATIONS

The following beneficial environmental effects could be expected to result from adoption of the stipulations discussed in this alternative.

1. Biological Survey - "Live" bottom areas are reported to be distributed in the proposed OCS Sale 43 area in a patchy manner surrounded by seafloor covered by sand waves. These "live or hard" bottom areas are the major habitat for fish in this area of the South Atlantic OCS. Approximately 164 to 329 hectares (406 to 812 acres) of "live" bottom growth could be smothered if drill muds and cuttings were dispersed in a 10 cm (4 in) thick layer in the vicinity of the projected areas. This would impact feeding areas for sport and commercial fish, and movement of sports fish from areas generally visited by headboat fishermen would have a significant impact on that recreational value. Loss of the recreational and commercial fishing values in these circumstances is estimated at nearly half a million dollars.

2. Cultural Resource Survey - More than 500 vessels of archaeological value have been recorded within 32 km (20 mi) of the coast in this area of the South Atlantic OCS. The MONITOR has recently been established as a marine sanctuary and several other vessels of equivalent cultural value were sunk in this area. Most of the cultural resource impacts would be created by damage from pipeline operations, however, exploratory drilling could also create a significant impact if not properly mitigated. Mechanical damage to cultural resources is an obvious concern because of the potential for inhibiting useful study of these valuable antiquities by marine archaeologists.

3. Ordnance Survey - Avoidance of sunken ships containing live munitions and/or petroleum fuels would be less certain if the surveys referred to hereunder are not taken and analyzed. Department of Defense operating areas encompass the proposed sale area and foreign and domestic munitions ships, warships, and fuel tankers are known to have sunk on the South Atlantic OCS during the World War II conflict. Some may still be relatively intact on the bottom. Loss of life and property could occur if sunken munitions were to explode. Oil spills could occur if fuel tanks in the sunken vessels were ruptured. This would lead to oil spill impacts discussed earlier in this statement. Platform occupancy is from zero to 50 people with value of the structure ranging from $6 to $12 million. Drillship or semi- submersible occupancy is from 50 to 115 people with value of the vessel ranging from $25 to $60 million. The value of resources that may be damaged by spilled oil incident to a munitions accident is unknown for this case.

E. Alternative Scenarios of Development

The basic scenario incorporated into the discussion of impacts contained in Section III of this impact statement is described in Scenario D, Section III.E.1. That hypothetical development scheme incorporates the high resource estimates provided by the Geological Survey (Table C-1, page 12) as well as specified transportation systems and onshore locations for terminals, processing plants and operating bases as shown in Section I also.

Although we would most likely expect such a pattern of development to take place from what is known today, other possible scenarios may occur. Events may be affected by future decisions dependent upon the quantity and location of resources that are found and by actions chosen by local and State governments in the course of their coastal zone planning. Due to uncertainty about the location and amounts of oil and gas that may be discovered, and in the event that permission to construct onshore facilities or to establish transportation routes for petroleum products across non-Federal jurisdiction is refused by one of the coastal states, modifications to the basic scenarios discussed in Section I are examined also. They represent potential alternative development scenarios to the base case covering changes in assumed conditions. There are four such alternative cases that seem reasonable to consider. These are evaluated below:

1. Alternative E-1 (Scenario A)

This alternative envisions an assumed operations base located in Chatham County, Georgia to provide support for all sale related drilling and production activities. In this scenario, it is assumed no gas would be produced or transported, and all produced oil would be gathered in an offshore storage and treatment facility and transported by tankers to refineries located outside the southeastern coastal region (i.e., in the Caribbean, Bahamas or Gulf of Mexico). The low resource estimate (Table C-1, Section I.) and the low level of development facilities are utilized.

Impacts of Alternative E-1

The impacts that would be expected to be associated with this alternative are generally the same as those described in Section III of this impact statement with the following exceptions:

Beaches: The impact on beaches as a result of this alternative would differ from that of the original proposal in two ways. There would be no pipeline landfall; therefore, the beach environment would be spared the disruption created by pipeline construction and burial. However, offshore transfer to tankers may increase the tarring of beaches thereby creating an increased potential in a negative aesthetic impact.

Wetlands: The impacts on wetlands as a result of this alternative might differ from that of the original proposal in two ways. The absence of pipelines would prevent such adverse effects as disruption of marsh vegetation, salt-water intrusion, accelerated runoff and increased tidal exchange which would potentially reduce marsh productivity. Also, fewer operations bases would likely result in less effect on wetland areas.

On-shore Water Quality: Due to the planned increase in sewage treatment facilities, this alternative would not cause water quality impacts differing from the impacts discussed in Section III. However, the construction of an operations base would result in local, short-term increased in turbidity and siltation in localized streams and estuaries in Georgia.

Onshore Air Quality: Air quality under this alternative would be significantly less since there is no gas processed in onshore facilities. Also the projected population increases, construction activities, and increased transportation (See Section III.D.6.) decrease under the base case.

Economic Factors

Employment: The peak employment associated with this scenario is 2,682 by the year 1984, which is considerably less than the maximum employment of 7,818 associated with the scenario examined in Section III.

Population: The peak population associated with this scenario is 5,321 in the year 1984, compared to 22,111 in the year 1988. This is a significant decrease in population to be expected from the development.

Income: Per capita income is estimated to increase by a maximum of $12 per capita per year in this alternative, compared to $15 per year in the base scenario. The total increased personal income amounts to $50 million, compared to $141 million in the base scenario.

2. Alternative E-2 (Scenario B)

This alternative incorporates the low resource estimates provided by the Geological Survey (Table Cd1, Section I). An operations base is located in Chatham County, Georgia. Crude oil is transported to shore via pipeline to a terminal in Duval County, Florida and then transhipped by tanker to existing refineries in other areas, such as the Caribbean, Mid Atlantic, or Gulf of Mexico.

Natural gas would be assumed to be transported by pipeline to processing facilities in Charleston County, South Carolina.

IMPACTS OF ALTERNATIVE E-2

The impacts that would be associated with this alternative are as follows. All impacts not specifically mentioned are believed to be about the same as described in Section III.

Transportation: Fewer tanker trips would be required for transporting the reduced crude oil resources incorporated in this scenario, only approximately 28% of the trips expected in the base case.

Land Use: These impacts would be less in this scenario due to fewer facilities required and reduced population impacts.

Beaches: Due to the lower number of tanker trips required by the lower resource estimates, smaller amounts of residue oil would be present on the beaches than are discussed in Section III:

Wetlands: If we assume that all construction resulting from this alternative was to occur on filled wetland, then as a maximum, 20 ha (50 acres) in Chatham County, Georgia; 16 ha (40 acres) in Duval County, Fla., and 8 ha (20 acres) in Charleston County, South Carolina. The effect would be a lesser impact on wetlands than would be caused by the base case.

Onshore Water Quality: The gas processing facility envisioned under this alternative could lead to a significant degradation of the water quality in localized areas of Charleston County, South Carolina by bringing about the construction of such auxiliary facilities as chemical and plastic plants. However, the impact under this scenario would be less than described in Section III.

Onshore Air Quality: The reduction in the number of gas processing plants by one (Duval County, Florida) means that the impacts of this alternative are about 50% lower than those discussed in Section III. A gas processing plant could increase SO_X levels by 2-5% and NO_X by 9-22% in a given locality.

ECONOMIC FACTORS

Employment: The maximum employment associated with this alternative amounts to 1999 by the 1996, significantly below the estimated 7,818 in the year 1988 projected for the scenario examined in Section III.

Population: The maximum population associated with this alternative amounts to 3,540 in the year 1984, compared to 22,111 in the year 1988 for the scenario examined in Section III.

Income: The maximum income effect associated with this scenario amounts to $10 per capita in the year 1996 compared to $15 per capita in the year 1988 as discussed in Section III. Increased total personal income amounts to $42 million, compared to $141 million in the base scenario. Employment, population and per capita income changes would likely be smaller in the event that this scenario were to take place.

ALTERNATIVE E-3 (SCENARIO C)

This alternative assumes the location of an operating base at Chatham County, Georgia; pipeline transportation of crude oil from the producing area to a terminal in Glynn County, Georgia, and overland pipeline transportation to a refinery in Chatham County, Georgia. Natural gas would be assumed to be transported via pipeline to Charleston County, South Carolina for processing. This scenario is also based on the low resource estimates provided by the Geological Survey (Table C-1, Section I.).

IMPACTS OF ALTERNATIVE E-3

The impacts associated with this alternative are about the same as those discussed in Section III with the following exceptions.

Onshore Water Quality: The operation of a refinery in Chatham County, Georgia would lead to a small increase in local water pollution effects.

Onshore Air Quality: The presence of a refinery in Chatham County, Georgia would likely lead to increased air quality deterioration in the event that crude oil with higher sulfur levels was processed. Also, increased amount of particulates, hydrocarbons, and other pollutants would result.

Transportation: Fewer tanker trips would be required for transporting the reduced crude oil resources incorporated in the scenario.

Beaches: This alternative would probably have the same or lesser effects due to the smaller quantities of resources, then was described in Section III.

Wetlands: In addition to impacts described in Section III, wetlands could be impacted further by this alternative due to the overland pipeline from Glynn County to Chatham County, Georgia.

Land Use: Land use impacts related to this alternative would probably be lower than those discussed in Section III, due to the smaller number of facilities required and the lower increase in population. The hypothetical oil refinery would also imply a land use committed to crude oil processing.

Economic Factors

Employment: The maximum employment associated with this scenario amounts to 1,843 persons in the year 1984, compared to 7,818 persons in the year 1988 in the base case.

Population: The maximum population impact associated with this alternative amounts to 3,380 persons, a significant reduction from the estimated 22,111 persons estimated in Section III.

Income: The maximum increase in income associated with this alternative amounts to about $9 per capita, considerably less than the $15 per capita forecast in Section III. The estimated additional personal income amount to approximately $35 million annually, compared to approximately $141 million annually in the base case.

Alternative E-4 (Scenario E)

This alternative incorporates the high resource estimates provided by the Geological Survey (Table C-1, Section I). The principal difference between the assumptions incorporated in this scenario and those included in Section III is the existence of a hypothetical petroleum refinery in Chatham County, Georgia. An oil pipeline terminal is assumed for Chatham County, Georgia and gas terminals are located in Glynn County, Georgia and Charleston County, South Carolina rather than Duval County, Florida and Charleston, South Carolina.

Impacts of Alternative E-4

The impacts that would be expected to be associated with this alternative are generally the same as those described in Section III of this impact statement with the following exceptions.

Transportation: The presence of the hypothetical refinery with pipeline transportation of the crude oil for processing reduces the number of pipelines and the requirements for tanker transportation of crude petroleum below that estimated in Section III.

Onshore Air Quality: The total adverse impact on air quality due to gas processing is the same, however, a different location has been assumed for one of the plants, Glynn County, Georgia. The presence of the hypothetical refinery in Chatham County would cause more adverse impacts locally than are estimated in the base case estimated in Section III.

Onshore Water Quality: The presence of an oil refinery would probably increase the adverse impact on water quality at localized sites in Chatham County.

Beaches: The impacts of this alternative would probably not differ from those described in Section III.

Wetlands: If the hypothetical refinery is located near wetlands, the productivity of this ecosystem could be reduced by the effects of refinery effluents.

Land Use: The lower population levels associated with this alternative suggest lower demand for residential land and housing, but the presence of the refinery implies a commitment of land to oil processing facilities above that contained in the discussion in Section III.

Economic Factors

Employment: The maximum increase in employment estimated under this alternative is 5,903, less than the 7,818 persons estimated in Section III.

Population: The maximum increase in population estimated for this alternative is 15,570, less than the 22,111 persons estimated in Section III.

Income: The maximum increase in income amounts to $17 per year per person compared to $15 per year per person estimated in Section III. The total maximum annual increase in personal income amounts to $113 million, compared to $151 million in Section III.

Section IX

Consultation and Coordination with Others

A. Preparation of the Draft Environmental Statement

1. Federal Agencies

Numerous Federal agencies were contacted for information and suggestions throughout the environmental assessment and statement preparation process.

Federal agencies contacted include:

Department of Agriculture
- Forest Service
- Soil Conservation Service

Department of Commerce

National Oceanic and Atmospheric Administration
- Marine Ecosystems Analysis Program (MESA)
- National Data Buoy Center
- National Marine Fisheries Service
- National Oceanographic Data Center
- National Weather Bureau
- Office of Coastal Zone Management

Department of Defense
- U.S. Army Corps of Engineers
- U.S. Air Force
- U.S. Navy
  - Commander Eastern Sea Frontier
  - Naval Oceanographic Office

Department of the Interior
- Bureau of Mines
- Bureau of Outdoor Recreation
- Fish and Wildlife Service
- Geological Survey
- National Park Service

Department of Transportation
- Federal Aviation Administration
- Office of Pipeline Safety
- U.S. Coast Guard

Environmental Protection Agency
- Region III
- Region IV
- Office of Research and Development

Federal Energy Administration

Federal Power Commission

National Aeronautics and Space Administration

2. State and Local Governments

In May, 1975, a letter from the BLM New Orleans OCS Office was sent to the Governors' designated contacts in the Southeast Atlantic States, requesting data and information regarding key state programs and resources. These requests were followed by direct requests to specific State agencies and visits to various agencies to collect information.

During the last quarter of 1975 and first quarter of 1976 personal contacts were made with selected county governments and regional planning commissions, requesting information on land use plans and critical environmental areas. Subsequent requests were made to these agencies asking for population, socio-economic and other pertinent information.

Continued liaison with state agencies has been maintained. In some cases, contact and information has been provided through a single State agency serving as a clearinghouse for all data requests and input. In other cases, the New Orleans OCS Office contacted individual state agencies each time information or input was needed. The process followed in each case was that requested by the individual or agency named by the respective Governor to coordinate with the New Orleans OCS Office regarding OCS activities. Meetings were held with representatives of one or more agencies of the Southeast Atlantic states as a group (exclusive of conferences regarding environmental baseline studies) on three occasions: June 25-26 and July 1, 1975. These meetings were arranged to discuss the scope, assessment procedures, data needs, and coordination mechanisms with regard to the environmental impact statement. A working draft of the Description of the Environment (Section II) was circulated to State agencies for review. In September, 1976, preliminary drafts of the DES were sent to State agencies for review. In all cases, the DES was a working version, for which identification of data omissions, errors, and suggestions for completeness were requested. Subsequent to review by the States, staff members of the BLM New Orleans OCS Office travelled to the States to discuss suggestions and problems identified by each of the States.

Contacts through BLM-sponsored meetings, meetings at the State level, and direct solicitation of information were made to numerous State and local governmental agencies, including, but not limited to those listed below.

State Agencies
- North Carolina
  - Department of Administration
  - Department of Agriculture
  - Department of Conservation and Development
    - Division of Marine Fisheries
    - Division of Commercial and Sport Fishers
  - Department of Human Resources
    - Division of Health Services
  - Department of Natural and Economic Resources
    - Division of Archives and History
    - Division of Environmental Management
    - Division of Parks and Recreation
    - Division of Resource Planning
  - Office of Intergovernmental Relations
  - Office of State Planning
  - State Budget Office
  - State Geological Survey
  - State Ports Authority, Morehead City, N.C.
  - Wildlife Resources Commission
- South Carolina
  - Department of Archives and History
  - Department of Environmental Quality

Solid Waste Management Division
Division of Air Quality Control
Department of Health and Environmental Control
Division of Industrial Waste Water
Department of Parks, Recreation and Tourism
Department of Wildlife and Marine Resources
Division of Wildlife and Freshwater Fisheries
Disaster Preparedness Agency
Division of Administration
Division of General Services
Employment Security Commission
State Board for Technical and Comprehensive Education
State Development Board
Geology Division
Research Division
Highway Department
Tax Commission
Water Resources Commission

Georgia
Attorney General's Office
Coastal Area Planning and Development Commission
Department of Community Development
Department of Natural Resources
Coastal Fisheries Office
Earth and Water Division
Environmental Protection Division
Game and Fish Division
Historical Preservation Office
Land Protection Division
Marshland Protection Division
Office of Planning and Research
Parks and Recreation Division
Resource Planning
Department of Transportation
Georgia Ports Authority
Georgia State Archaeologist
State Geological Survey
Office of Planning and Research

Florida
Bureau of Coastal Zone Management
Department of Administration
Division of State Planning
Department of Commerce
Department of Legal Affairs
Department of Natural Resources
Division of Recreation and Parks

3. Professional and Industry Firms and Associations, Academic Institutions, Public Interest Groups, and Others

In May, 1975, a letter was sent from the BLM New Orleans OCS Office to the many agencies and offices in the Southeast Atlantic region explaining that the Office was commencing work on an environmental assessment for the purpose of preparing an environmental impact statement on proposed OCS Sale No. 43. Interested parties who felt that they could contribute input to the draft environmental statement were invited to designate a contact and indicate interest.

In the course of the environmental assessment and draft statement preparation process, numerous agencies, companies, individuals and institutions were contacted for information.

In September, 1976, at the time when invitations were extended to State and Federal agencies to review the working draft of the DES, groups which had at some time expressed an interest in providing input into the statement were invited to review the working draft.

Institutions, associations and groups which were contacted for information or input include, but are not limited to the following:

Academic Institutions

North Carolina
Duke Marine Laboratory, Beaufort, N.C.
Duke University, Geology Department, Durham, N.C.
North Carolina State University, Raleigh, N.C.
University of North Carolina, Chapel Hill, N.C.
Department of Marine Science
Research Laboratory of Anthropology

South Carolina
University of South Carolina
Belle W. Baruch Institute for Coastal Research
Department of Biology
George D. Grice Marine Biological Laboratory, Charleston, S.C.
Institute of Archaeology and Anthropology
School of Engineering
School of Geology

Georgia
Institute of Technology, Atlanta, Ga.
Office of Interdisciplinary Programs
University of Georgia, Athens, Ga.
Institute of Community and Area Development
Marine Extension, Brunswick, Ga.
Skidaway Institute of Oceanography, Savannah, Ga.
Institute of Natural Resources

Florida
University of Florida, Gainsville

Industrial Firms
API Production Subcommittee
New England Petroleum Company
Offshore Operators Committee

Public Interest Groups
South Carolina Audubon Society, Columbia, S.C.
South Carolina Wildlife Federation
Florida Audubon Society
Marine Mammal Commission

Others
Coastal Plains Regional Commission

4. Review of Pre-Draft of the Draft Environmental Impact Statement

The four South Atlantic States: North and South Carolina, Georgia and Florida were invited to review the working draft of the draft environmental impact statement for the purposes of identifying any errors and omissions, or making any suggestions for completeness prior to the draft statement's submission to the Washington

BLM headquarters office for formal review and submission to the Council on Environmental Quality.

Section X

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Section XI

Appendices

Appendix A

CALL FOR NOMINATIONS AND TENTATIVE TRACT SELECTION FOR PROPOSED SOUTH ATLANTIC OCS SALE NO. 43

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Land Management

South Atlantic Outer Continental Shelf

(Tentative Sale No. 43)

Call for Nominations of and Comments on Areas of Oil and Gas Leasing

Pursuant to the authority prescribed in 43 CFR 3301.3 (1974), nominations are hereby requested for areas in the South Atlantic Outer Continental Shelf (OCS) for possible oil and gas leasing under the Outer Continental Shelf Lands Act (43 U.S.C. 1331-1343 (1970)). Nominations will be considered for any or all of the following mapped areas located offshore the States of North Carolina, South Carolina, Georgia, and Florida:

OCS Official Protraction Diagrams

1. **NI 17-9 (Georgetown) - All**
2. **NI 17-12 (James Island) - That portion landward of a line starting at the NE corner of Block 39 running South to the SE corner of Block 655 thence West to the NE corner of Block 686 thence South to the SE corner of Block 994.**
3. **NI 17-11 (Savannah) - All**
4. **NH 17-3 - That portion landward of a line starting at the NE corner of Block 25 running South to the SE corner of Block 597, thence West to the NE corner of Block 622, thence South to the SE corner of Block 974, thence West to the SW corner of Block 969.**
5. **NH 17-2 (Brunswick) - All**
6. **NH 17-5 (Jacksonville) - All**
7. **NH 17-8 (Daytona Beach) - All**
8. **NH 17-11 (Orlando) - That portion landward of a line starting at the NE corner of Block 43 running South to SE corner of Block 527, thence West to the three mile limit.**

These protraction diagrams may be purchased for $2.00 each from the Manager, New Orleans Outer Continental Shelf Office, Bureau of Land Management, Hale Boggs Federal Building, 500 Camp Street, Suite 841, New Orleans, Louisiana 70130. All nominations must be described in accordance with the Outer Continental Shelf Official Protraction Diagrams prepared by the Bureau of Land Management, Department of the Interior and referred to above. Only whole blocks or properly described subdivisions thereof, not less than one quarter of a block, may be nominated. Although individual company nominations are considered to be privileged and confidential information, the names of persons or entities submitting nominations or comments will be of public record.

In addition to requesting nominations of tracts for possible oil and gas leasing within the specified areas, this notice also requests the identification of particular tracts recommended to be either specifically excluded from oil and gas leasing or leased only under special conditions because of conflicting values and environmental concerns. Particular geological, environmental, biological, archaeological, socio-economic or other information which might bear upon potential leasing and development of particular tracts is requested where available. Information on these subjects will be used in the preliminary selection of tracts which precedes any final selection by the Director pursuant to 43 CFR 3301.4. This information is requested from Federal, State and local governments; industry; universities; research institutes; environmental organizations; and members of the general public. Comments may be submitted on blocks or portions thereof, as required for nominations, or on all areas or portions thereof as described above. They should be directed to specific factual matters which bear upon the Department's decision whether to make a preliminary selection of particular tracts within these areas for further environmental analysis pursuant to the National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347 (1970)), and possible leasing. Comments relating to the general matters which would be applicable to oil and gas operations in any part of the OCS are not sought at this time.

Nominations and comments should be submitted not later than November 3, 1975, in envelopes labeled "Nominations of Tracts for Leasing on the Outer Continental Shelf—South Atlantic" or "Comments on Leasing on the Outer Continental Shelf—South Atlantic" as appropriate. They must be submitted to the Director, Bureau of Land Management, Attention: 720, Department of the Interior, Washington, D.C. 20240. Copies must be sent to the Conservation Manager, Geological Survey, Eastern Region, Suite 316, 1825 K Street, N.W., Washington, D.C. 20006 and to the Manager, New Orleans Outer Continental Shelf Office, Bureau of Land Management, at his address cited above.

This call for nominations and comments does not in any way commit the Department to leasing in the South Atlantic. It is an information gathering component of the Department's leasing procedure.

Final selection of tracts for competitive bidding will be made only after compliance with established Departmental procedures and all requirements of the National Environmental Policy Act of 1969. Notice of any tracts finally selected for competitive bidding will be published in the Federal Register stating the conditions and terms for leasing and the place, date, and hour at which bids will be received and opened.

/s/ Curt Berklund
Director, Bureau of Land Management

Approved:

/s/ Kent Frizzell
Acting Secretary of the Interior

BUREAU OF LAND MANAGEMENT

For Release April 27, 1976, Robinson (202) 343-5717

INTERIOR MAKES TRACT LIST AVAILABLE FOR POSSIBLE OFFSHORE SALE (OCS No. 43) IN SOUTH ATLANTIC

A list of 225 tracts (blocks) totaling 518,400 hectares (1,280,966 acres) has been selected for intensive environmental study for a proposed mid-1977 Outer Continental Shelf oil and gas lease sale (OCS No. 43), the Department of the Interior's Bureau of Land Management announced today.

All of the submerged lands lie in a subsea geologic feature known as the Southeast Georgia Embayment off the coasts of the States of North Carolina, South Carolina, Georgia, and Florida from approximately 48 to 120 km (30 to 74 mi) from the shore in water approximately 13 to 165 m (43 to 541 ft) deep.

Tract selection is the result of evaluation of structure potential by the Department's Geological Survey, of industry nominations of tracts they would like to bid on if a sale is held, and comments from a wide variety of other government and private sources concerning tracts which they believe should not be offered for sale because of environmental or resource use conflicts.

A BLM multidisciplinary team of scientists and other environmental specialists assigned to BLM's New Orleans OCS Office will study the area on a tract by tract basis in preparing a draft environmental impact statement on which public hearings will be held following publication. The hearing record contributes to a final environmental impact statement.

None of these steps constitute an actual decision to hold a sale. They are all part of the series of steps which are required by the Environmental Policy Act of 1969 guidelines issued by the President's Council on Environmental Quality (CEQ), and Department regulations before a decision can be made.

The final statement is submitted to CEQ for 30 days' review, after which the Secretary of the Interior is authorized to decide if there shall be a sale. If he decides to hold a sale, he will also determine how many tracts to offer and what special lease requirements shall be imposed on lessees.

When BLM issued its call for nominations and comments on September 22, 1975, nine petroleum companies nominated 778 tracts totaling 1,792,536 ha (4,429,298 acres) they would like to bid on if a sale is held.

Interior's tentative selection of 225 tracts totaling 518,400 ha (1,280,966 acres) for environmental study does not mean all of these tracts would be offered in the event of a sale. It means that these tracts will be studied intensively to determine if there is sufficient environmental hazard or other resource use conflict reason to rule them out from eventual sale, BLM emphasized.

BLM will seek maximum public input by inviting other Federal, State and local government representatives and many professional groups and private organizations to participate during the preparation of the impact statement.

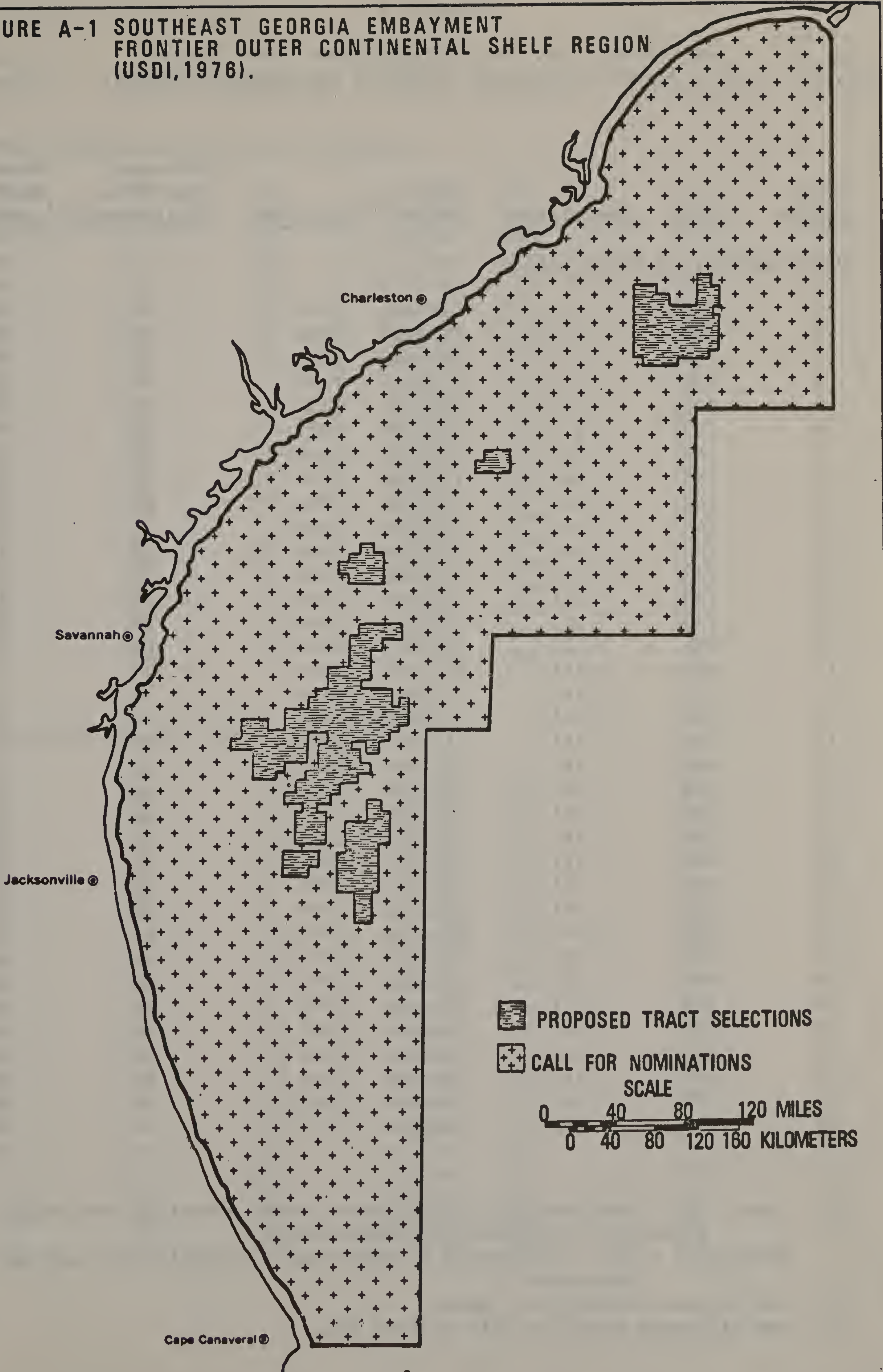
Industry interest was seaward of the coastal areas from Charleston, S.C., to Daytona Beach, Fla. where 13 Federal and State government and private organizations commented that special consideration should be given to environmental concerns or resource use conflicts which were potential impacts of offshore development.

The Southeast Georgia Embayment is in what is termed a frontier OCS area; that is, one in which no offshore development has taken place. The U.S. Geological Survey, an Interior agency, has declared that the frontier areas hold the most promise for finding new OCS oil and gas deposits.

The tentative tract list may be obtained from the Manager, New Orleans OCS Office, BLM, Hale Boggs Federal Building, 500 Camp Street, Suite 841, New Orleans, La. 70130, or from the Director (720) BLM, Washington, D.C. 20240.

A map showing the location of the tracts selected for environmental study is attached.

FIGURE A-1 SOUTHEAST GEORGIA EMBAYMENT FRONTIER OUTER CONTINENTAL SHELF REGION (USDI, 1976).



APPENDIX A

Tract List for Proposed Lease Sale No. 43
(refer to Visuals 1N and 1S for tract locations)

Tract Number	Block	Description	Type/ Reser.1/	Hectares2/	Distance From Shore (Kilometers)3/	Water Depth (Meters)
James Island, NI 17-12 (JI)						
1	115	All	III/O&G	2304	64	36
2	153	All	III/O&G	2304	63	29
3	154	All	III/O&G	2304	68	31
4	159	All	III/O&G	2304	92	36
5	160	All	III/O&G	2304	97	38
6	197	All	III/O&G	2304	48	31
7	198	All	III/O&G	2304	52	33
8	199	All	III/O&G	2304	55	35
9	203	All	III/O&G	2304	68	35
10	204	All	III/O&G	2304	71	36
11	241	All	III/O&G	2304	49	31
12	242	All	III/O&G	2304	55	33
13	243	All	III/O&G	2304	58	35
14	244	All	III/O&G	2304	61	35
15	245	All	III/O&G	2304	64	35
16	246	All	III/O&G	2304	68	35
17	247	All	III/O&G	2304	71	35
18	285	All	III/O&G	2304	55	33
19	286	All	III/O&G	2304	58	33
20	287	All	III/O&G	2304	61	35
21	288	All	III/O&G	2304	64	37
22	289	All	III/O&G	2304	68	38
23	290	All	III/O&G	2304	71	38
24	291	All	III/O&G	2304	74	40
25	292	All	III/O&G	2304	78	46
26	329	All	III/O&G	2304	58	31
27	330	All	III/O&G	2304	61	33
28	331	All	III/O&G	2304	64	38
29	332	All	III/O&G	2304	68	42
30	333	All	III/O&G	2304	71	42
31	334	All	III/O&G	2304	74	42
32	335	All	III/O&G	2304	77	42
33	336	All	III/O&G	2304	80	91
34	373	All	III/O&G	2304	61	38
35	374	All	III/O&G	2304	64	40

1/ Type: III - designates a wildcat tract whose potential for being productive is completely unexplored.
Reservoir: - O&G - designates a tract with a potential oil and gas reservoir

2/ One hectare equals 2.471 acres

3/ One kilometer equals 0.6214 statute mile

Appendix A (continued)

Tract Number	Block	Description	Type/ Reser.	Hectares	Distance From Shore (Kilometers)	Water Depth (Meters)
James Island, NI 17-12 (JI) (continued)						
36	375	All	III/O&G	2304	68	40
37	376	All	III/O&G	2304	71	41
38	377	All	III/O&G	2304	74	43
39	378	All	III/O&G	2304	77	44
40	379	All	III/O&G	2304	80	46
41	380	All	III/O&G	2304	84	91
42	417	All	III/O&G	2304	63	40
43	418	All	III/O&G	2304	71	38
44	419	All	III/O&G	2304	74	40
45	420	All	III/O&G	2304	77	42
46	421	All	III/O&G	2304	80	46
47	422	All	III/O&G	2304	84	55
48	423	All	III/O&G	2304	87	91
49	462	All	III/O&G	2304	70	46
50	463	All	III/O&G	2304	76	45
51	464	All	III/O&G	2304	76	64
52	843	All	III/O&G	2304	69	35
53	844	All	III/O&G	2304	72	40
54	886	All	III/O&G	2304	69	35
55	887	All	III/O&G	2304	76	40
56	888	All	III/O&G	2304	78	42
Brunswick NH 17-2 (Br)						
57	256	All	III/O&G	2304	66	26
58	299	All	III/O&G	2304	60	27
59	300	All	III/O&G	2304	64	27
60	301	All	III/O&G	2304	69	29
61	342	All	III/O&G	2304	57	27
62	343	All	III/O&G	2304	66	27
63	344	All	III/O&G	2304	69	27
64	345	All	III/O&G	2304	72	33
65	387	All	III/O&G	2304	68	27
66	388	All	III/O&G	2304	69	29
67	389	All	III/O&G	2304	71	35
68	608	All	III/O&G	2304	84	40
69	609	All	III/O&G	2304	89	42
70	610	All	III/O&G	2304	92	40
71	611	All	III/O&G	2304	97	40
72	651	All	III/O&G	2304	85	39
73	652	All	III/O&G	2304	89	41
74	653	All	III/O&G	2304	92	43
75	695	All	III/O&G	2304	93	39
76	696	All	III/O&G	2304	97	42
77	739	All	III/O&G	2304	84	40

Appendix A (continued)

Tract Number	Block	Description	Type/ Reser.	Hectares	Distance From Shore (Kilometers)	Water Depth (Meters)
Brunswick NH 17-2 (Br) (continued)						
78	740	All	III/O&G	2304	95	42
79	781	All	III/O&G	2304	85	35
80	782	All	III/O&G	2304	89	36
81	783	All	III/O&G	2304	92	38
82	784	All	III/O&G	2304	95	40
83	825	All	III/O&G	2304	85	33
84	826	All	III/O&G	2304	89	35
85	827	All	III/O&G	2304	92	36
86	868	All	III/O&G	2304	77	29
87	869	All	III/O&G	2304	81	31
88	870	All	III/O&G	2304	86	33
89	871	All	III/O&G	2304	91	35
90	872	All	III/O&G	2304	96	37
91	873	All	III/O&G	2304	103	42
92	874	All	III/O&G	2304	106	44
93	911	All	III/O&G	2304	74	27
94	912	All	III/O&G	2304	78	15
95	913	All	III/O&G	2304	84	16
96	914	All	III/O&G	2304	89	18
97	915	All	III/O&G	2304	92	37
98	916	All	III/O&G	2304	98	22
99	917	All	III/O&G	2304	103	24
100	918	All	III/O&G	2304	108	26
101	920	All	III/O&G	2304	115	46
102	953	All	III/O&G	2304	65	27
103	954	All	III/O&G	2304	70	31
104	955	All	III/O&G	2304	74	15
105	956	All	III/O&G	2304	78	16
106	957	All	III/O&G	2304	84	17
107	958	All	III/O&G	2304	89	19
108	959	All	III/O&G	2304	93	21
109	960	All	III/O&G	2304	98	24
110	961	All	III/O&G	2304	103	24
111	962	All	III/O&G	2304	105	42
112	963	All	III/O&G	2304	110	44
113	964	All	III/O&G	2304	115	46
114	993	All	III/O&G	2304	53	26
115	994	All	III/O&G	2304	58	26
116	997	All	III/O&G	2304	65	27
117	998	All	III/O&G	2304	70	29
118	999	All	III/O&G	2304	75	31
119	1000	All	III/O&G	2304	80	16
120	1001	All	III/O&G	2304	85	18
121	1002	All	III/O&G	2304	74	20
122	1003	All	III/O&G	2304	95	22
123	1004	All	III/O&G	2304	98	23
124	1005	All	III/O&G	2304	103	42
125	1006	All	III/O&G	2304	108	42
126	1007	All	III/O&G	2304	113	44

Appendix A (continued)

Tract Number	Block	Description	Type/ Reser.	Hectares	Distance From Shore (Kilometers)	Water Depth (Meters)
Jacksonville NH 17-5 (Ja)						
127	25	All	III/O&G	2304	55	25
128	26	All	III/O&G	2304	60	27
129	27	All	III/O&G	2304	64	29
130	28	All	III/O&G	2304	69	29
131	29	All	III/O&G	2304	74	13
132	30	All	III/O&G	2304	78	15
133	33	All	III/O&G	2304	92	39
134	34	All	III/O&G	2304	97	40
135	35	All	III/O&G	2304	102	40
136	36	All	III/O&G	2304	107	40
137	37	All	III/O&G	2304	112	42
138	38	All	III/O&G	2304	117	42
139	68	All	III/O&G	2304	51	24
140	69	All	III/O&G	2304	55	25
141	70	All	III/O&G	2304	60	29
142	71	All	III/O&G	2304	62	31
143	72	All	III/O&G	2304	67	31
144	73	All	III/O&G	2304	74	15
145	74	All	III/O&G	2304	78	17
146	76	All	III/O&G	2304	87	39
147	77	All	III/O&G	2304	92	39
148	78	All	III/O&G	2304	97	39
149	81	All	III/O&G	2304	110	42
150	114	All	III/O&G	2304	58	29
151	115	All	III/O&G	2304	63	31
152	116	All	III/O&G	2304	68	33
153	117	All	III/O&G	2304	73	33
154	118	All	III/O&G	2304	78	35
155	120	All	III/O&G	2304	88	37
156	121	All	III/O&G	2304	95	39
157	122	All	III/O&G	2304	98	39
158	123	All	III/O&G	2304	102	40
159	158	All	III/O&G	2304	58	26
160	159	All	III/O&G	2304	64	29
161	160	All	III/O&G	2304	68	31
162	164	All	III/O&G	2304	88	36
163	165	All	III/O&G	2304	93	20
164	166	All	III/O&G	2304	97	20
165	167	All	III/O&G	2304	102	22
166	168	All	III/O&G	2304	107	40
167	202	All	III/O&G	2304	60	26
168	203	All	III/O&G	2304	65	27
169	207	All	III/O&G	2304	84	35
170	208	All	III/O&G	2304	88	37
171	209	All	III/O&G	2304	95	20
172	210	All	III/O&G	2304	100	22
173	211	All	III/O&G	2304	105	23

Tract Number	Block	Description	Type/ Reser.	Hectares	Distance From Shore (Kilometers)	Water Depth (Meters)
Jacksonville NH 17-5 (Ja) (continued)						
174	250	All	III/O&G	2304	82	35
175	251	All	III/O&G	2304	86	35
176	252	All	III/O&G	2304	95	36
177	253	All	III/O&G	2304	98	40
178	293	All	III/O&G	2304	77	33
179	294	All	III/O&G	2304	82	35
180	295	All	III/O&G	2304	87	35
181	296	All	III/O&G	2304	92	37
182	339	All	III/O&G	2304	86	37
183	345	All	III/O&G	2304	115	44
184	382	All	III/O&G	2304	81	35
185	383	All	III/O&G	2304	86	35
186	384	All	III/O&G	2304	91	37
187	389	All	III/O&G	2304	115	46
188	390	All	III/O&G	2304	120	64
189	426	All	III/O&G	2304	81	33
190	427	All	III/O&G	2304	86	35
191	428	All	III/O&G	2304	91	37
192	431	All	III/O&G	2304	104	42
193	432	All	III/O&G	2304	109	44
194	433	All	III/O&G	2304	114	55
195	434	All	III/O&G	2304	119	91
196	470	All	III/O&G	2304	80	35
197	471	All	III/O&G	2304	85	35
198	472	All	III/O&G	2304	90	37
199	475	All	III/O&G	2304	103	42
200	476	All	III/O&G	2304	108	44
201	477	All	III/O&G	2304	113	55
202	478	All	III/O&G	2304	118	101
203	519	All	III/O&G	2304	105	44
204	520	All	III/O&G	2304	110	46
205	521	All	III/O&G	2304	115	64
206	557	All	III/O&G	2304	75	35
207	558	All	III/O&G	2304	80	35
208	559	All	III/O&G	2304	85	37
209	562	All	III/O&G	2304	98	40
210	563	All	III/O&G	2304	105	44
211	564	All	III/O&G	2304	108	53
212	565	All	III/O&G	2304	114	91
213	601	All	III/O&G	2304	74	35
214	602	All	III/O&G	2304	79	35
215	606	All	III/O&G	2304	98	40
216	607	All	III/O&G	2304	101	46
217	608	All	III/O&G	2304	108	55
218	609	All	III/O&G	2304	111	91
219	650	All	III/O&G	2304	98	42

Appendix A (continued)

Tract Number	Block	Description	Type/ Reser.	Hectares	Distance From Shore (Kilometers)	Water Depth (Meters)
Jacksonville NH 17-5 (Ja) (continued)						
220	651	All	III/O&G	2304	101	46
221	652	All	III/O&G	2304	108	55
222	653	All	III/O&G	2304	110	165
223	696	All	III/O&G	2304	104	82
224	740	All	III/O&G	2304	103	91
225	784	All	III/O&G	2304	102	110

Appendix B

REPORT ON ESTIMATES FOR THE PROPOSED SOUTH ATLANTIC OCS SALE NO. 43

UNITED STATES DEPARTMENT OF THE INTERIOR

Geological Survey

Reston, Virginia 22092

July 2, 1976
Memorandum
TO: Director, Bureau of Land Management
THROUGH: Deputy Assistant Secretary—Energy and Minerals; Deputy Assistant Secretary—Land and Water Resources
FROM: Acting Director—Geological Survey
SUBJECT: Request for estimates and information for proposed OCS Lease Sale No. 43, South Atlantic

Enclosed for your information is our reply to the subject request. It should be pointed out that estimates of resource potential are inherently speculative and particularly so in areas where geological information is limited and the presence of oil and gas has not been demonstrated. It should also be emphasized that the operational projections and estimates are highly speculative and represent a possible development scheme based on many variables and assumptions.

It will be noted that certain requests relating to employment impacts, locations of transportation facilities, and magnitudes of support related industry impacts were not addressed in the enclosed report. At this stage of planning, comments on these subjects were felt inappropriate. Furthermore, since the material requested by items 7 and 8 have been previously furnished to BLM, New Orleans, in the summary report, they were also deleted from the enclosed report.

/s/ Henry W. Coulter
Acting Director

Enclosure

REPORT ON ESTIMATES FOR THE PROPOSED SOUTH ATLANTIC OCS SALE NO. 43

Amounts of Recoverable Resources (Range and Mean)

In making this forecast, the proposed sale tracts were identified as those tentatively selected by GS and BLM on the Southeast Georgia Embayment and publicly announced on April 27, 1976. The 225 tracts announced constitute approximately 1,280,966 acres (518,400 hectares). Figure 1 illustrates tract locations.

The method chosen for estimating recoverable resources in the selected frontier area tracts is based on a volumetric concept and utilizing proprietary geophysical data. First, from available seismic mapping, it can be calculated that the proposed sale tracts contain an area of closure of about 403,456 acres. This area of closure considered geologic interpretations of structural and stratigraphic traps, as well as possible sub-basement prospects. Next, assuming that only 20 percent of the structural area identified will contain hydrocarbon and that a 50 percent fill-up exists on these entrapment features, it can be calculated that only 40,346 acres would be productive. Finally, it was assumed that recovery factors would range from a low of 7,000 barrels per acre (based on certain Gulf Coast fields of similar age) to a high of 25,000 barrels per acre (based on an average of giant Mesozoic fields in the U.S.). The resultant recoverable resource estimates therefore are as follows:

	Low	*High*	*Mean*
Oil (Billions of barrels).........	0.282	1.009	0.65
Gas (Trillions of cubic feet)...	1.890	6.810	4.30

The assumptions on the range of recovery factors and the portions of structures that could be hydrocarbon productive involve subjective judgments. Considering the high degree of uncertainty associated with these variables, collectively, it is cautioned that a zero lower limit for resource estimates does exist. Secondly, since the sale tracts were for the most part selected on the basis of their favorable geologic setting, and since the regional statistical analysis procedures for resource estimates are not directly comparable to the above tract specific estimates, probabilities for the above values, including a zero estimate, should not be assigned. The above estimates were developed principally to assist socio-economic impact scenarios specifically related to OCS Sale No. 43.

Wells and Drilling Schedule

The number of wells and predicted work schedules of exploratory wells, development wells, exploratory rigs and development platforms that might be associated with a search for the volume of resource described above is summarized (yearly) in two scenarios. Table I presents a scenario based on the low end of the range of the resource estimates. Table II presents a scenario based on the high end of the range.

Certain of the assumptions used for construction of Tables I and II are shown as footnotes.

OIL AND GAS PRODUCTION RATES — LOW RESOURCE SCENARIO

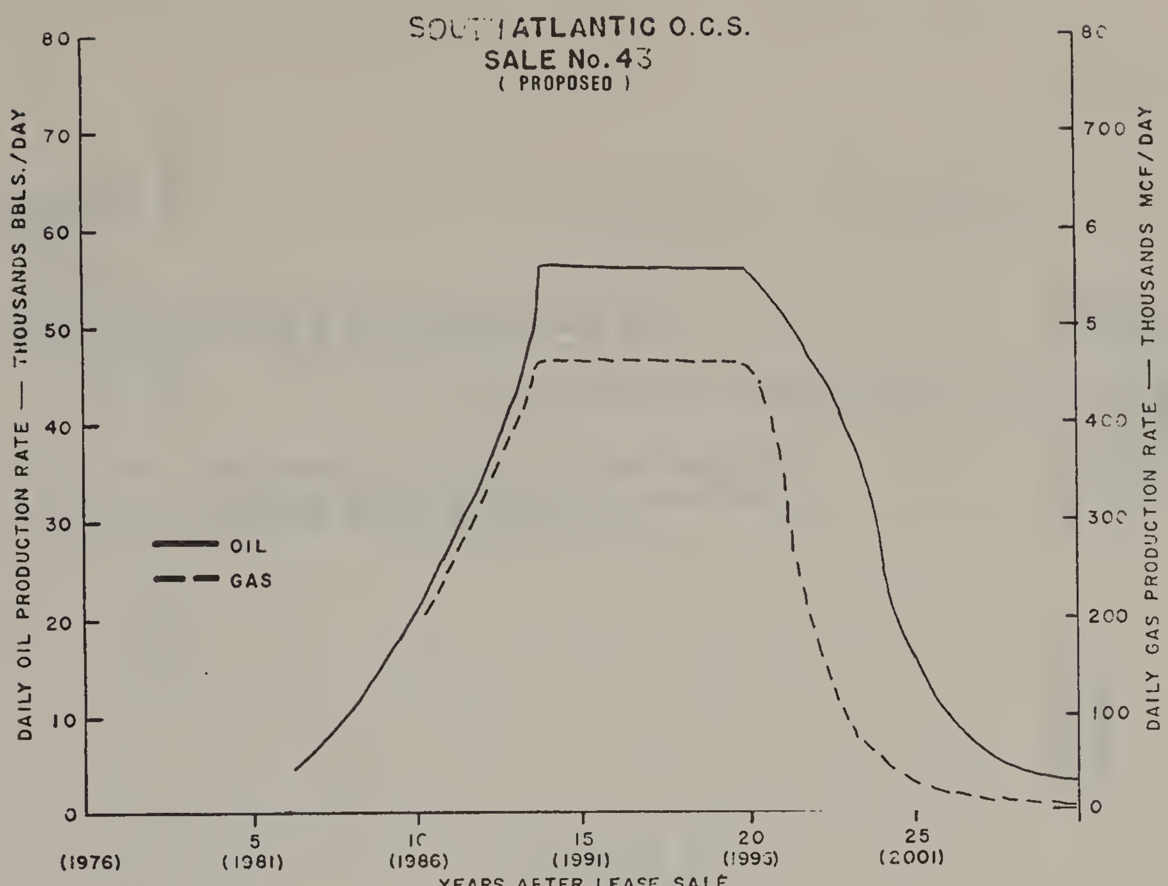


FIGURE B-1

OIL AND GAS PRODUCTION RATES — HIGH RESOURCE SCENARIO

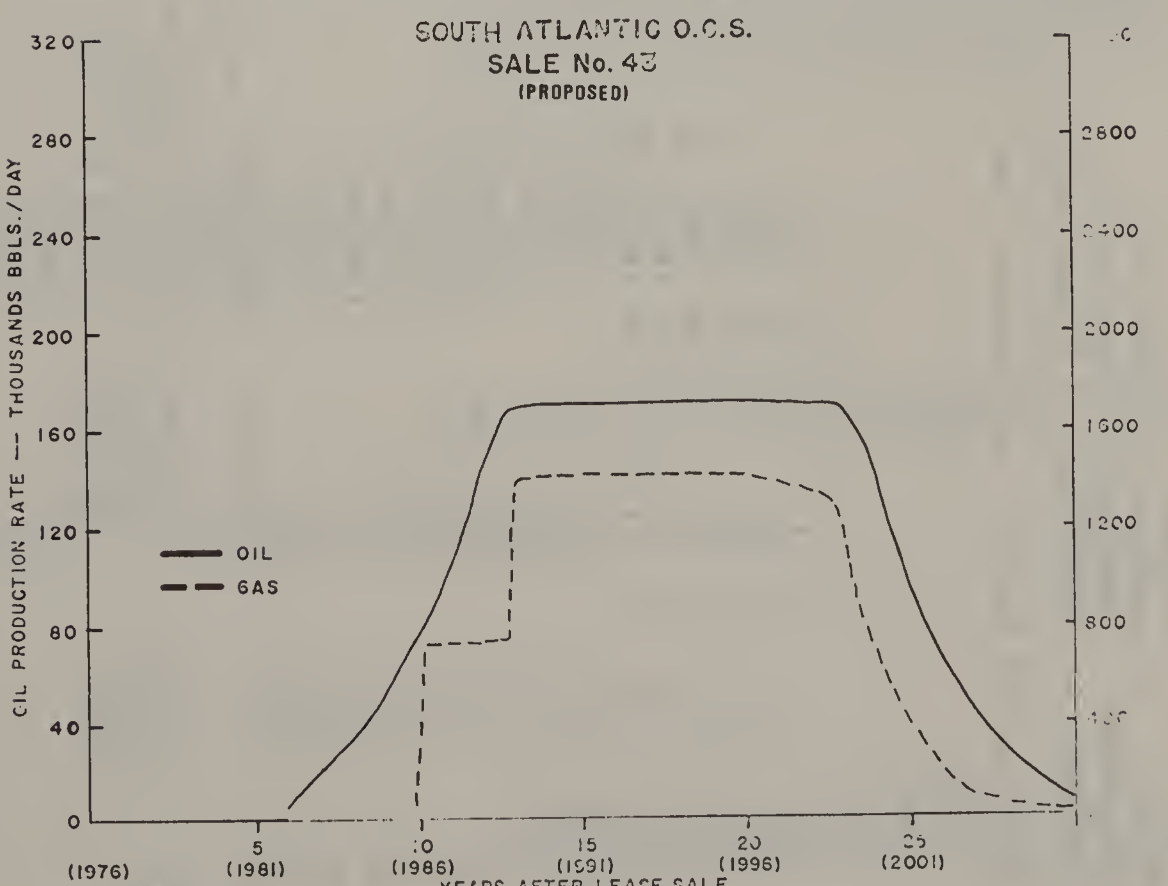


FIGURE B-2

Table 1

SOUTH ATLANTIC OCS SALE #43
Low Recoverable Resource Scenario
Schedule of Exploration, Development and Production

Year	Explor. Rigs/Wells Drilled	Platforms and Equip. Installed (Producing)	Dev. Wells Drilled (Producing O/G)	Large Diam. Oil Pipelines (Offshore Miles)	Onshore Terminals	Annual Production Quantity Sold Oil MM Bbls.	Annual Production Quantity Sold Gas MMMCF
1976	(Proposed OCS Sale #43 - as scheduled - Nov. '76 or later)						
77	4/12						
78	5/15						
79	5/15						
80	3/9						
81	3/9	1	5				
82	2/5	1 (1)	15 (4/0)			1.1	0
83	2/5	2 (3)	25 (11/0)			2.5	0
84	2/5	2 (5)	40 (19/0)			4.0	0
85	2/5	2 (7)	30 (30/0)	1 (80)-oil	1	5.8	0
86	1/3	1 (8)	20 (45/7)	1 (80)-gas		8.4	73
87	1/3	1 (9)	20 (60/10)			10.9	100
88	1/3	(10)	5 (74/12)			13.5	125
89	1/3	(10)	(92/15)			16.4	154
90	1/3	(10)	(110/18)			20.6	170
91		(10)	(110/18)			20.6	170
92		(10)	(110/18)			20.6	170
93		(10)	(110/18)			20.6	170
94		(10)	(110/18)			20.6	170
95		(10)	(110/18)			20.6	170
96		(10)	(110/18)			20.6	170
97		(10)	(108/18)			18.6	110
98		(10)	(105/17)			16.4	66
99		(10)	(105/17)			14.6	30
2000		(8)	(70/10)			9.1	15
01		(7)	(58/8)			6.6	10
02		(3)	(37/7)			3.7	4
03		(2)	(26/4)			2.2	4
04		(2)	(26/4)			1.8	3
05		(1)	(17/3)			1.1	3
06		(1)	(16/2)			1.1	3
Totals	95	10	160	2 (160)	1	282	1,890

* Footnotes on separate page

Working Staff Draft

Table 11

SOUTH ATLANTIC OCS SALE #43
High Recoverable Resource Scenario
Schedule of Exploration, Development and Production

Year	Explor. Rigs/Wells Drilled	Platforms and Equip. Installed (Producing-O/G)	Dev. Wells Drilled (Producing	Large Diam. Pipelines (Offshore Miles)	Onshore Terminals	Annual Production Quantity Sold: Oil MM bbls.	Annual Production Quantity Sold: Gas MMMCF
1976	(Proposed OCS Sale #43 - as scheduled - Nov. '76 or later)						
77	4/12						
78	10/30						
79	10/30						
80	10/30						
81	7/21	2	10				
82	5/15	2 (2)	25 (10/0)			3	0
83	5/15	3 (4)	50 (32/0)			9	0
84	5/15	3 (6)	70 (53/0)			15	0
85	5/15	3 (8)	75 (75/0)	1 (80)-oil	1	20	0
86	3/9	3 (13)	60 (108/18)	1 (80)-gas		28	256
87	3/9	3 (16)	60 (146/24)			36	265
88	3/9	3 (19)	60 (214/36)	1 (80)-oil	1	49	265
89	1/3	3 (21)	40 (275/46)	1 (80)-gas		59	496
90	1/3	(23)	25 (300/56)			61	510
91	1/2	(25)	20 (326/57)			62	510
92	1/2	(25)	5 (343/57)			62	510
93		(25)	(343/57)			62	510
94		(25)	(343/57)			62	510
95		(25)	(343/57)			62	510
96		(25)	(343/57)			62	502
97		(25)	(343/57)			62	493
98		(25)	(343/54)			62	493
99		(25)	(343/50)			61	470
2000		(23)	(300/45)			55	270
01		(23)	(257/26)			45	160
02		(20)	(154/23)			26	47
03		(18)	(137/15)			19	15
04		(15)	(95/10)			14	7
05		(12)	(62/8)			7	7
06		(10)	(52/3)			5	4
07		(4)	(17/0)			1	0
Totals	220	25	500	4 (320)	2	1,009	6,810

* Footnotes on separate page

Footnotes for Table 1 and 11.

1. Assumed 4 to 12 exploratory drilling rigs will be initially working in the sale area.

2. Drilling rate of exploratory rigs will be 2 to 4 wells/yr.

3. Convention platforms (normally) will be installed.

4. The development wells drilled for each platform will range from 10 to 20.

5. The success rate for development drilling will be 80%.

6. Development platforms will use 1 or 2 rigs each.

7. Development drilling on platforms will be 5 wells/per rig/year.

Investments/Costs

The following are estimates (only) of the expenditures associated with the low and the high exploration and development scenarios presented above.

Production costs per barrel:

For the purposes of this forecast, the oil will be valued at $11.00 per barrel and gas at $1.00 per MCF.

Gross value of oil and gas will range from $5.0 to $17.9 Billions

(low case) (282,000,000 bbls. of recoverable oil x $11.00)
+(1,890,000,000 MCF of recoverable gas x $1.00) =
$4,992 Millions

(high case) (1,009,000,000 bbls. of recoverable oil x $11.00)
+(6,810,000,000 MCF of recoverable gas x $1.00) =
$17,909 Millions

Average Annual Royalties for oil and gas will range from $35.7 to 125.1 Millions

(low case) oil @ 11,280,000 bbls/yr x 1/6 x $11.00 = $20.7 Millions
+ gas @ 90,000,000 MCF/yr x 1/6 x $1.00 = $15.0 Millions
$35.7 Millions

(high case) oil @ 38,800,000 bbls/yr x 1/6 x $11.00 = $71.1 Millions
+ gas @ 324,300,000 MCF/yr x 1/6 x $1.00 = $54.0 Millions
$125.1 Millions

Average Annual Operating Costs will range from $63.7 to $236.0 Millions

	(low case)	(high case)
Royalty	$33.3 (Millions)	119.4 (Millions)
Labor	3.0	15.0
Transportation (Personnel & Cargo)	6.0	20.4
Workover	3.0	15.0
Well Servicing	6.0	20.0
Equipment Maintenance	5.0	17.2
Overhead	1.0	6.0
Transportation (oil and gas)	3.4	12.0
Misc.	3.0	11.0
Total	$63.7 Millions	$236.0 Millions

Assuming that operating costs for oil and gas are proportional to their gross value:

- average annual operating cost for oil should be about - $3.64 /Bbl.

(low case) $\frac{3.10}{4.99}$ x \$ 63.7 Millions = \$ 39,573,000

$\frac{\$\ 39,573,000/yr}{11,280,000\ bbls/yr}$ = \$ 3.50

(high case) $\frac{11.10}{17.91}$ x \$ 236.0 Millions = \$ 146,264,000

$\frac{\$\ 146,265,000/yr}{38,800,000\ bbls/yr}$ = \$ 3.77

- average annual operating cost for gas should be about - \$ .28/MCF

(low case) $\frac{1.89}{4.99}$ x \$ 63.7 Millions = \$ 24,127,000

$\frac{\$\ 24,127,000/yr}{90,000,000\ MCF/yr}$ = \$ .27/MCF

(high case) $\frac{6.81}{17.91}$ x \$ 236.0 Millions = \$ 89,735,000

$\frac{\$\ 89,735,000/yr}{324,300,000\ MCF/yr}$ = \$ .28/MCF

Major Capital Investments are also shown as a range based on the low and the high development scenarios.

	Low Case $ Millions		High Case $ Millions	
High bonus bids @ $1250/acre for 130 tracts	930		930	
Exploration wells @ $2.0 million	190	(95)	440	(220)
Platforms w/prod. equipment @ $25 million	250	(10)	625	(25)
Development wells @ $0.5 million	80	(160)	250	(500)
Miles of oil pipelines @ $1/million/mi	80	(1)	160	(2)
Miles of gas pipeline @ $1/million/mi	80	(1)	160	(2)
Onshore oil terminals @ $250 million	250	(1)	500	(2)
Onshore gas processing @ $400 million	400	(1)	800	(2)
Pollution containment	50		50	

Total Capital Exp. $2,310 Millions to $3,915 Millions

In summary, capital investment could be expected to range from $2.3 to $3.9 Billions. Probably the most uncertain category are those items associated with transportation.

Comparisons with OCS development areas, principally the Gulf of Mexico, represents the basis for these assumptions.

The depth of wells for the proposed sale area is estimated to range from 5,000 feet to 15,000 feed below the seafloor. An average depth might be 10,000 feet. These assumptions on well depths are based on the expected depth ranges of targets within Cretaceous and Jurassic age Mesozoic sediments.

Platforms

Because of the water depth (50 to 330 feet), the expected number of small structures, and the modest resource estimates, the majority of platforms will probably be of the conventional type. Use of gravity structures seems unlikely. In areas which may be sensitive to heavy bottom loading, it is conceivable that underwater well completions and subsea or floating production systems may also be used. The number of platforms could be forecast to range from 10 to 25, based on the development schedules enclosed.

Production Schedule

A yearly production schedule based on the above resource and drilling forecast data is also shown on Tables I and II for the low and the high scenarios, respectively. Peak production rates are expected to be reached 12 to 14 years after the sale date and are forecast to achieve levels of from about 56,000 BOPD and 466,000 MCFPD to about 170,000 BPOD and 1,400,000 MCFPD. Graphs of the daily production rates for the low and the high scenarios are attached as Figures 2 and 3, respectively.

Muds, Drill Cuttings and Brines

From 230 tons to 1,000 tons of commercial drilling mud components will be used in each well, depending upon depth. This range of material is given for a 10,000 ft. to 15,000 ft. well. An estimate of the ratio of water base drilling fluid to oil base drilling fluids could range from 30:1 to 50:1 based on the projected number of wells and reservoirs.

It can be estimated that 682 tons (9,460 cu. ft.) to 1,079 tons (15,000 cu. ft.) of formation cuttings will result from drilling each 10,000 ft. to 15,000 ft. well.

Initial production will be low in water volume, but throughout a 25-year production life, it can be estimated that the ratio of the total barrels of produced salt water to the total barrels of produced crude oil will be 1:1.

Transportation/Storage/Refining

Transportation of the predicted production under both of the scenarios discussed above will be treated as the one question. Due to the modest production rates forecast, transportation facilities would seem to indicate no significant onshore impact. The variations in possible transportation scenarios would likewise be limited.

It can be anticipated that, due to the dispersion of tract locations in proposed sale area, their distance from shore, and the anticipated small pool sizes, initially transportation of oil would be via tankers. Tankers would probably be of the 16,000 to 25,000 dwt class. Furthermore, unless or until strategically convenient deliverability of about 70,000 BOPD, the construction of an oil pipeline to shore is doubtful. Based on this empirical rule of thumb, no more than 3 oil pipelines can be predicted to result from the subject sale. However, until after the sale when the leased tract locations and distribution become available, and because of the low resources anticipated, it is difficult to firmly predict that more than two oil pipelines will be constructed.

The initial dependence on tanker transport is foreseen for 3 to 5 years after production is commenced. This time frame of course is subject to the timing and quantity of resource discoveries. Therefore, in the period 1978–84, and investment decision can be anticipated on whether or not to construct an oil pipeline to shore.

As to the positioning and land fall for pipelines, it appears too conjectural to predict at this time.

Assuming no new southeastern refinery is constructed, crude oil brought ashore in tankers or in pipelines would have to be processed at existing facilities. The intercoastal tanker linkage of the South and Mid-Atlantic areas is also a possible consideration.

Until a pipeline to transport associated and nonassociated gas is installed, the majority of the produced gas would be injected into oil reservoirs. Using the empirical rule that a gas pipeline will be installed for each 700,000 MCFPD of deliverability, it is estimated that 1 or 2 gas pipelines will be installed. A minor amount of gas flaring on a temporary basis can also be anticipated.

Probably not more than 2 gas processing plants will be constructed to provide for the handling of produced gas. They would be located in the coastal areas adjacent to discoveries and have a capacity of 300,000 to 500,000 MCFPD.

If logistics and environmental conditions permit, it is conceivable that both oil and gas pipelines will utilize the same corridor to shore. Under environmental safeguards, pipelines will probably be buried from shore out to 200 feet of water depth and wherever they would represent a hazard to multiple use of the sea floor. From 3,000 to 8,000 cu. yds. of sediment are estimated to be disturbed for each mile of buried pipeline. Onshore distances and volume of disturbance are too speculative to estimate.

Whether or not oil pipelines are determined to be economically feasible, the dispersion of selected tracts seems to indicate that transportation scenarios should include some offshore storage in conjunction with tankering. Crude storage would probably initially be on surface with the later consideration of permanent subsea storage tank(s) awaiting the decision on a pipeline. Single-moored buoy loading facilities for tankers might also be expected.

No refinery is expected to be constructed in South Atlantic as a result of this sale. The refinery question appears to be mutually exclusive of the sale. The investment forecast discussed below, therefore, does not include such a contingency.

Appendix C

OIL AND GAS OPERATIONS

DESCRIPTION OF OFFSHORE OPERATIONS EXPECTED IN THE SOUTH ATLANTIC OCS

Exploration

Before drilling commences on any tracts that may be leased in this proposed South Atlantic sale area, additional geophysical studies may be conducted (after obtaining permission of the United States Geological Survey) in order to further define the location of prospects, design the drilling mud program and coring strategies, and choose the safest drilling sites.

In seismic exploration, a ship travels along a predetermined path, towing signal generating and recording equipment. The signal generated by the energy source is a series of small amplitude seismic pulses that travel at the speed of sound through the water and sediment below, where they are reflected and refracted by the underlying strata. An array of sensitive detectors towed by the vessel receive incoming seismic waves which are then recorded on magnetic tape. After extensive computer processing, the recordings are displayed in the form of vertical cross-sections. The seismic profiles are then interpreted to identify the location, size and shape of geologic structures favorable to oil and gas accumulation. This information is normally displayed as a series of subsurface seismic contour maps.

It is assumed that the generation of signals will be by sources other than dynamite since these modern devices, which include sparkers, air guns and gas guns have become widely accepted and account for over 95% of marine seismic energy sources currently in use.

Industry officials anticipate that drilling rigs will be brought up from the Gulf of Mexico and that jack-ups, semi-submersibles, and drillships will be used.

The bottom supported rigs (jack-ups) are floated from one location to another, and are most vulnerable to damage or loss while in transit. Shallow (less than 350 feet or 100 meters) water exploratory drilling is commonly carried out using a "jack-up" type drilling rig (see Figure 1) while deeper waters require the use of semi-submersible rigs or drillships. The jack-up rig is towed into position and the legs jacked downward to contact the bottom and lift the platform nine to 15 meters above the water surface.

Semi-submersibles are large, advanced-design floating rigs that have better motion characteristics in rough seas than do ships or barges (see Figure 1). These rigs are floated to the site, partially submerged and held in place by anchors. These units can work in water depths up to 300 meters and beyond. The semi-submersibles as well as drillships, if used, would be connected to seafloor equipment by buoyant riser pipes.

Winds, waves and ocean currents tend to push floating drill platforms off location regardless of how good the mooring system. This can put excessive stresses on a riser. One company uses an acoustic position reference system whereby acoustic signals from a beacon located near the wellhead on the seafloor are received by three shipboard hydrophones (see Figure 2). In use, the vessel's position is determined by comparing, at each of the three shipboard hydrophones, the signal either emitted by or reflected from the seafloor beacon. The correct position, with reference to the wellbore, is shown on the shipboard console viewing screen and the vessel kept in position by adjusting mooring lines or using the ship's engines plus special horizontal thruster engines. If, for some reason, the drillship should have to move off location, the seafloor beacon or reflector is used to reposition the vessel upon return.

Once the drilling rig is in place, the drive pipe, blowout preventers and riser are installed. Drilling then commences with drilling mud circulating through the wellbore to provide pressure control, lubrication of the drill bit, and circulation of wellbore cuttings out of the hole.

In spite of considerable research, it is still not always possible to predetermine, for wildcat wells, the formation pressure and the fracture pressure that the wellbore will encounter. During drilling there are several means of determining the trend in pressure. They include measurements such as formation temperature (as evidenced by the temperature of the returning mud), shale density and changes in the penetration rate of the drill bit.

If the hydrostatic gradient of the drilling fluid may enter the wellbore from the formation being drilled, the influx displaces some drilling fluid, thereby causing reduction in the hydrostatic head in the annular space between the drillpipe and the borehole (Figure 3).

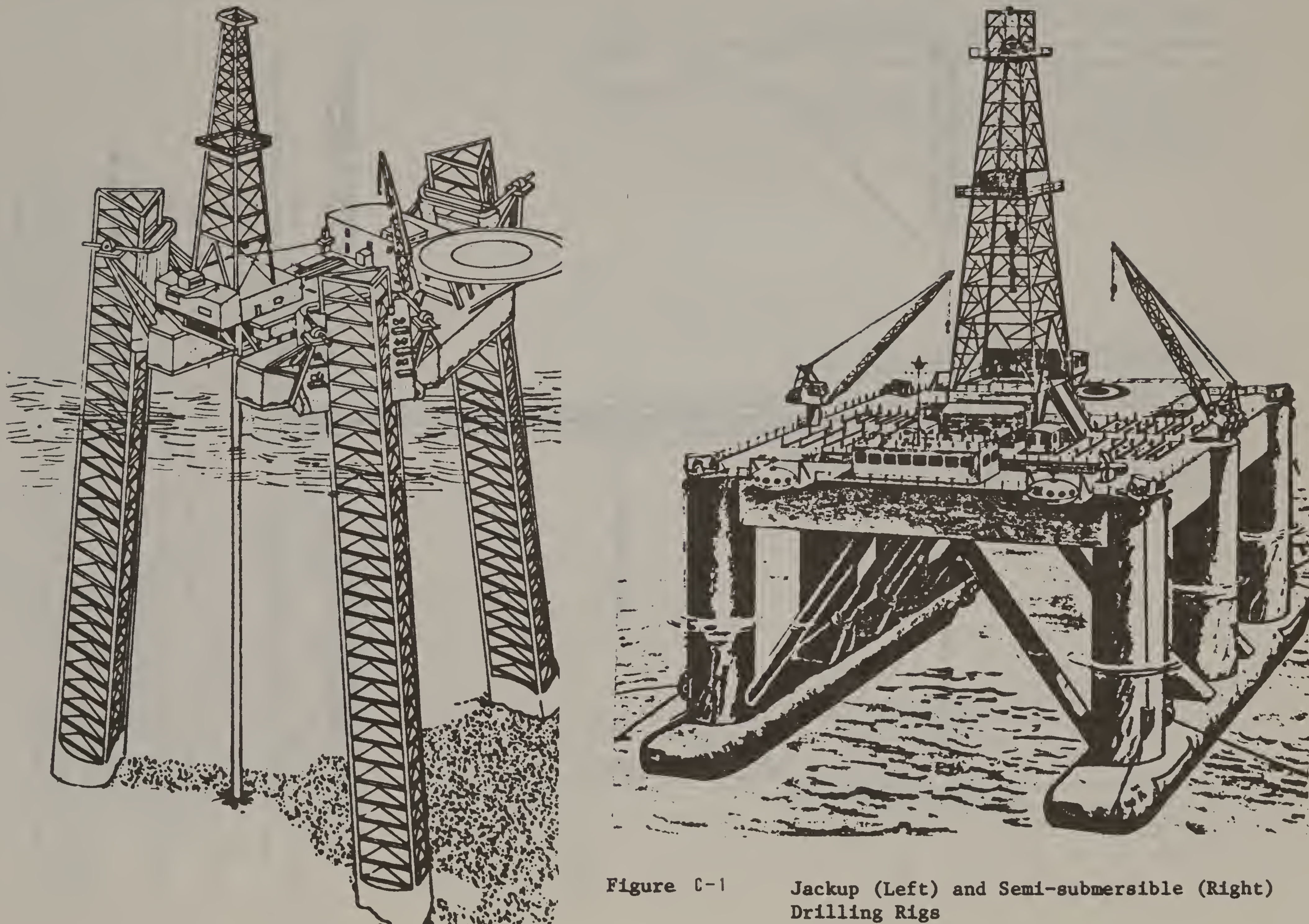


Figure C-1 Jackup (Left) and Semi-submersible (Right) Drilling Rigs

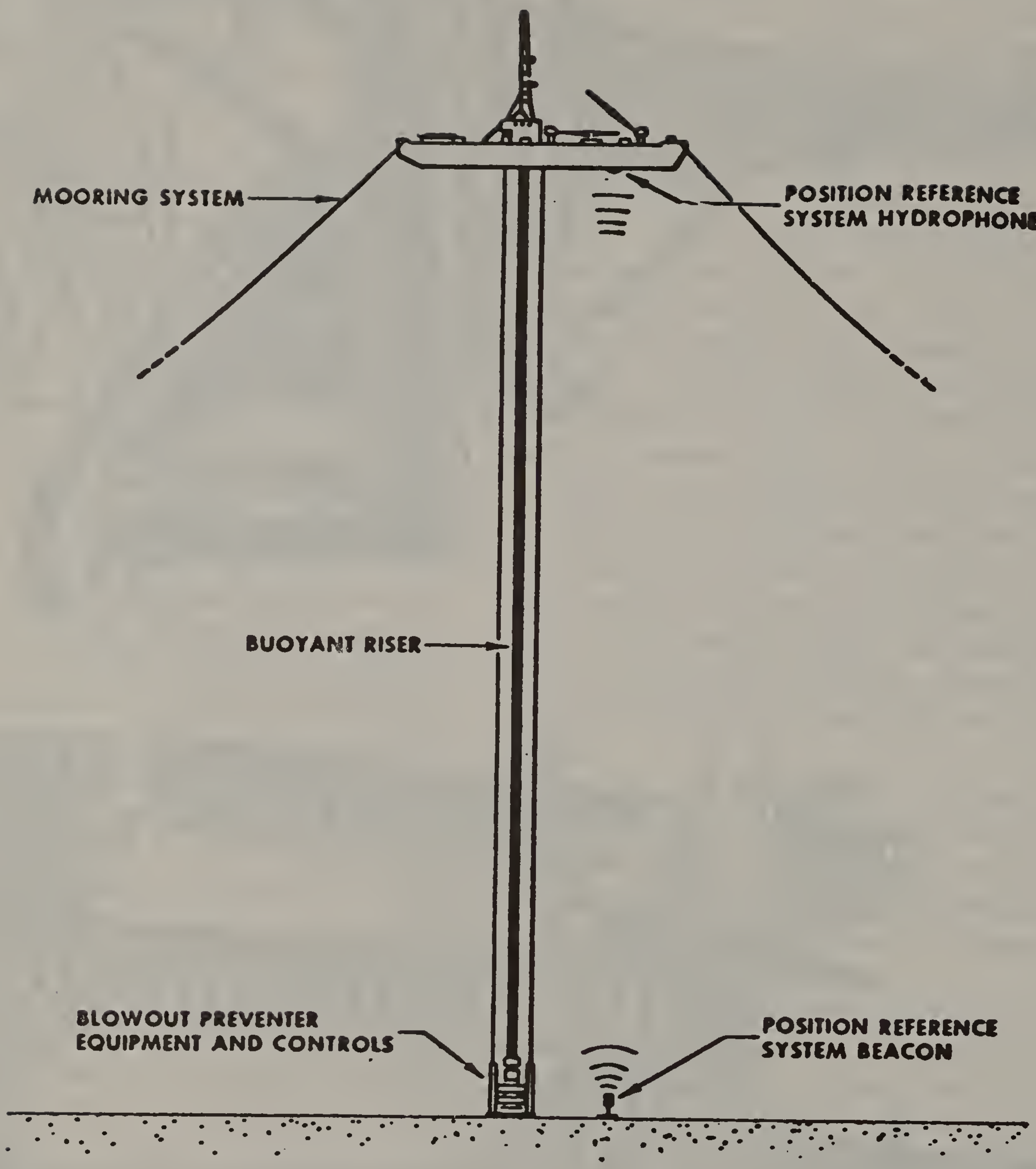


Figure C-2 Drill Ship Operations

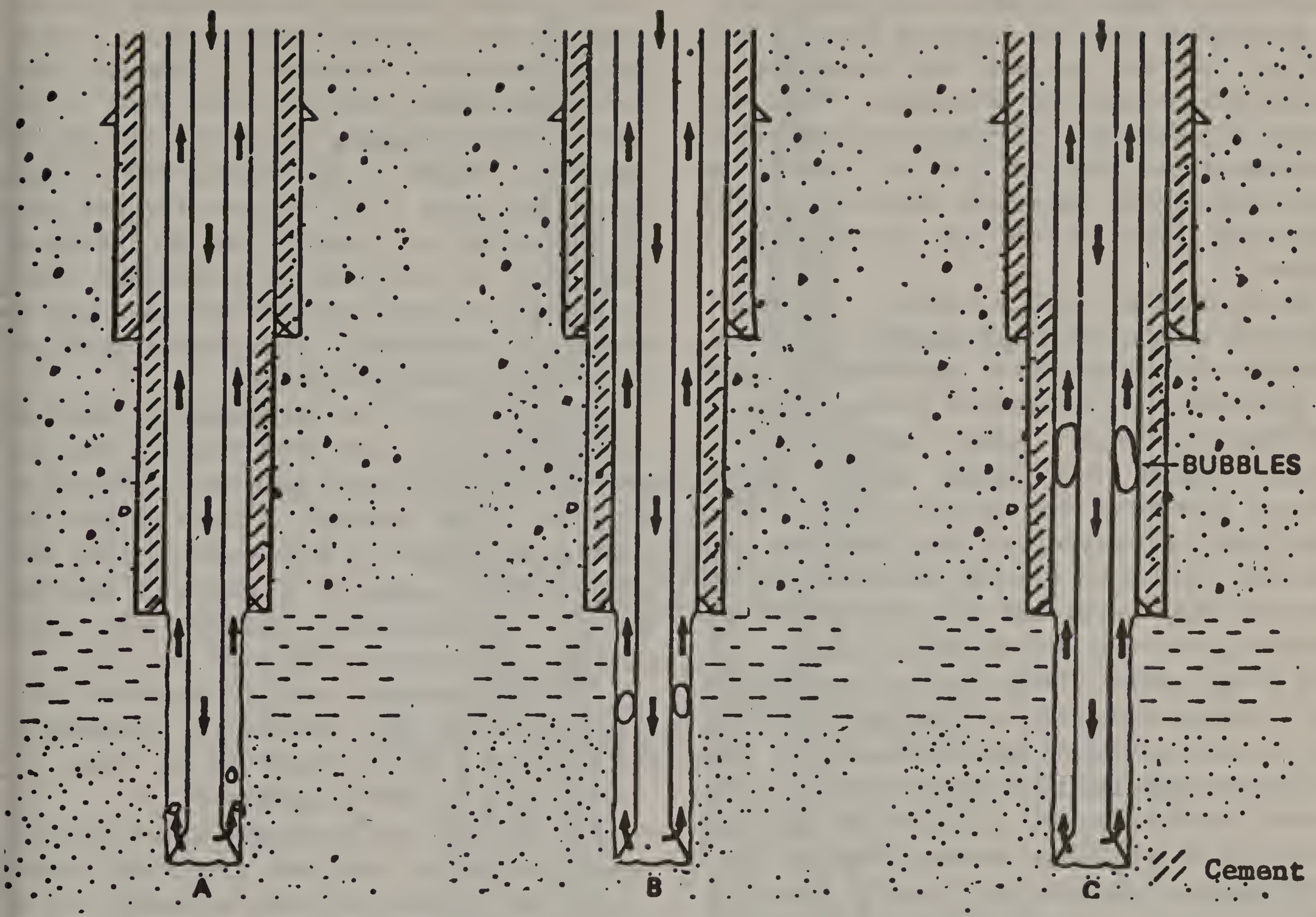


Figure C-3 A "kick" is a gas or liquid influx that reduces the hydrostatic head in the annulus. Here, the kick is a gas bubble (A). As it rises (B and C), it expands causing a sudden increase in the upflow of the mud. When the bubble reaches the top, if it has not been allowed to expand, the bottom-hole pressure reaches a maximum--the sum of mud pressure and gas pressure. This pressure maximum, if excessive, can exceed the formation fracture pressure, and lead to a loss of drilling mud to the formation, thus further decreasing the hydrostatic pressure. This could cause an influx of formation fluids into other formations, or the fractured formation taking fluid from another formation, commonly referred to as an underground blowout.

If the volume of the influx is not excessive, and a surface indication (increased mud tank volume) is observed in time, the unwanted influx of fluid or gas can be circulated and adherence to preplanned emergency procedures. From the record of a kick, the bottom-hole pressure can be determined and with this pressure known, the mud weight can be adjusted to provide the correct hydrostatic head for the safe continuation of drilling.

An uncontrolled kick is called a "blowout". Blowouts seldom occur and usually can be controlled by implementation of preplanned emergency procedures and actuation of devices known as "blowout preventers" which are mounted on every offshore well during drilling. Actual blowout preventers used offshore are of at least three types; a bag-type, one with blind rams, and one with pipe rams. Blowout preventers are essentially large valves that can close around the drill string or across an open hole and seal off the well at the surface. These valves are so powerful that some are equipped with shear rams that can cut the drill pipe should this procedure aid in controlling the well. The blowout preventer stack can also be mounted on the sea floor and remotely controlled at the drilling console. These sea floor BOP stacks are designed to be used in any water depth and have reaction times of 10 seconds or less. Blowouts can occur downhole when a low-pressure formation fractures, and fluids from a higher-pressure zone flow into the fractured formation. Such underground blowouts, like surface blowouts, require the careful use of preplanned emergency techniques to regain control. Blowout preventers and other well-control equipment must meet the requirements of OCS Orders. This equipment is tested on a schedule set by prudent practice, but not less often than regulations specify.

To ensure that adequate provisions have been made for safety and well control, the casing program and drilling fluid, or mud program must be approved by the Geological Survey before a drilling permit is issued. Along with adequate casing, it is important that enough cement be spotted between the casing and the wall of the hole to seal off and isolate all sensitive geological formations such as hydrocarbon zones and freshwater sands, and to separate zones of abnormal pressure from those with normal pressures. Mud components are described in Chapter III.A.

Should the initial test be dry, an exploratory well is usually plugged and abandoned. Cement plugs are set to confine formation fluids in their parent subsurface formations, to prevent them from intermingling, and to prevent flow to the surface. During plugging operations, well-control equipment remains in use. When a well is abandoned, the casing is cut off below the mud line, all obstructions are removed, and the bottom is dragged to be sure that no obstructions were overlooked. In some cases, it may be necessary to drill several exploratory wells on each block before a lease is totally condemned.

If well tests show that commercial quantities of natural gas or oil have been found, it may be necessary to drill several additional confirmation tests before the company is satisfied that the reserves will support a development drilling and well completion program. If petroleum deposits prove to be commercial in quantity, one of two courses of action may be followed:

(1) The exploratory well may be deemed expendable and be permanently abandoned. Procedures followed would be the same as above for a dry-hole abandonment.

(2) The well may be deemed useful as a future production well and temporarily abandoned. In this case, a mechanical bridge plug is placed in the smallest string of casing and the well head capped and left for future entry when production activity commences. This results in the temporary existence of an underwater "stub". The Coast Guard District Commander requires that such stubs be marked by a buoy at the surface if located in 60 meters of water or less, and that the buoy be lighted if located in 26 meters of water or less.

Development

Offshore drilling and production operations are usually conducted on fixed, bottom-founded, water surface-piercing platforms. If exploratory efforts are successful in proving a hydrocarbon reserve, production operations are initiated by installing platforms (Figure 4) to serve as a base for drilling development wells and for subsequent producing operations. A number of wells may be directionally drilled to develop a large area from a single platform.

During the history of OCS oil operations around the world, industry has gained a good understanding of the physical forces acting on

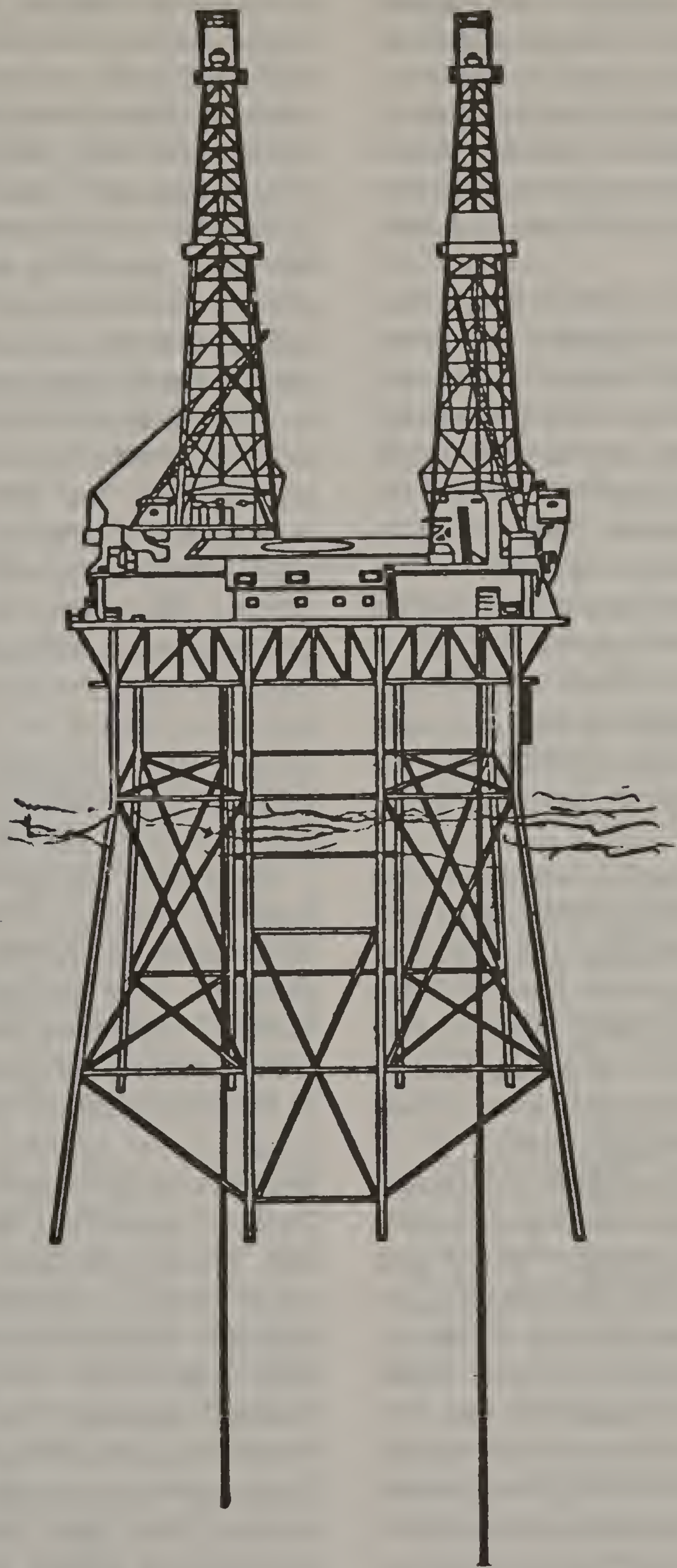


Figure C-4 Offshore development platform with drilling rigs in place offshore platforms. Appropriate design procedures are outlined in API Recommended Practices RP 2A and various API specifications. These guidelines have been prepared to cover engineering design and operation of offshore structures and related equipment. United States Geological Survey Outer Continental Shelf Orders define regulatory approval procedures for platform design and installation.

There are at least three subsea production systems currently under development which are designed to serve multiple wells. They are described in the following section (Production). Each provides for gathering, measurement and control of well streams and enables, through the flowline (TFL), well maintenance. Subsea completions will result in sea floor obstructions that could foul trawling gear; however, should a trawl snag a subsea completion the possibility that it would damage any of the wellhead assembly to the extent of causing uncontrolled flow is remote because of the strength and durability of the material that would be used in the sea floor structure.

Wells usually are produced through tubing placed inside the final or production string of casing. During tubing installation, the blowout preventers remain in use to ensure control of the well. A system of in-tubing safety valves, plus other casing and tubing valves at the surface or sea floor, is installed to control well flow. Actuation is usually at the producing platform.

Of major concern in the operation and control of every production platform are the downhole control devices. Production tubing is fitted with one or more safety valves that are installed and located at least 30 meters below the mud line or sea floor. In the past, velocity actuated choke valves (“storm chokes”) designed to shut off production when the flow rate exceeds predetermined limits have been used. Such valves should close if surface equipment failure results in an excessive flow through the tubing. These chokes are particularly susceptible to failure from internal erosion in areas where sand is produced along with the oil and gas.

Certain types of subsurface fail-safe valves do not depend on the velocity of well fluids for actuation, but are held open by hydraulic or other fluid pressure applied from the surface. The valve is designed to close automatically, shutting off the flow of fluid from the well in the event some undesirable situation on the platform interrupts the pressure holding the valve open. Essentially all wells drilled since December 1, 1972, are equipped with valves that are actuated from the surface. These valves provide highly reliable protection and may be tested frequently to insure proper operation. Their use will increase costs significantly, but the need for more reliable valves has been shown by past incidents in the Gulf of Mexico and elsewhere. The increased degree of safety offered by use of the fail-safe valves should justify their installation.

Technology presently exists to install platforms in water depths to at least 300 meters, and industry contends that the practical limit can be extended to 365 meters. It is assumed that since water depths encountered in this proposed sale will be 200 meters or less, development drilling and production platforms can be used. In typical template-type structures, the lower portion, or jacket, is barged to sea, launched, upended and secured to the sea floor with piling driven through the legs. The deck section is then lifted into place and secured by welding.

The drilling rig, power plants, generators, living quarters, storage sheds and other components, constructed in modular form, are added to the platform, and development well drilling commences. Equipment anticipated for use on deep water platforms is similar to that being used safely in current shallow water operations, and will be installed and operated in accordance with safe practices accumulated from industry experience. These practices are incorporated in OCS Orders and specify multiple, redundant controls and safety devices including safety shut-in valves, high-low pressure pilots, high-low level controls, high-temperature shutdowns, gas detectors, shielded ignitions, fire prevention and detection equipment, and pressure relief systems. Drain and sump systems are also designed to collect any spillage that might occur on the platform. The sequence of drilling operations for development and production wells is essentially the same as for exploratory wells.

Blowout preventers as well as downhole control devices have proven to be extremely valuable in time of accidents and emergencies to prevent large amounts of oil from escaping into the environment. When hurricanes have passed through offshore oil and gas fields, entire platforms have been swept away with only a minimal spillage.

Blowout preventers on drilling wells and the redundant combination of wellhead valves and subsurface safety valves have proven effective in maintaining control of wells when the normal controlling devices (drilling mud and production regulators and chokes) have failed. Once shut-in, the wells can be reentered through either the blowout preventers or wellhead valve with drill-pipe or tubing to perform remedial work and bring the well back under control. This can be done if the blowout preventer or wellhead is on the sea floor the same as if they were located on a platform. However, should a well get completely out of control and crater around and outside the surface casing so that the well could not be reentered, then an offset relief would have to be drilled.

As with exploratory drilling, the casing and mud programs for each development well must be approved by the Geological Survey before a drilling permit is issued.

Production

The production platform contains all the equipment and performs the same function as a field gathering station does at an onshore location. The fluid produced from the well is some mixture of gas, oil and water in varying proportions. Depending upon the flowing wellhead pressure, this mixture may be subject to as many as three stages of gas-oil separation. The stage separation process recovers the driest gas and the largest volume of liquid.

The gas may be further processed through scrubbers to remove any entrained oil, water or other impurities before it is compressed and sent ashore by pipeline. If there is insufficient gas to sell to a trunkline, it may be reinjected into the producing formation as a pressure maintenance measure, used for gas lift, or used as engine fuel to drive pumps and compressors. Only on rare occasions is gas flared and then a permit from the OCS Area Supervisor of USGS is required.

The oil/water mixture that comes from the gas-oil separator goes first to a free water knock-out where the free water is separated by gravity from the oil. Should some water be emulsified with the oil, this mixture is sent through heater and/or chemical treaters to break the emulsion and separate the oil and water. The oil is pumped ashore by pipeline and the water is further filtered and treated to meet EPA effluent standards before being disposed of overboard.

The production platform is basically that of the development platform minus the drilling rigs. Facilities consist of gas-oil separators, oil-water separators, gas scrubbers, compressors, pumps, storage tanks, instruments, and controls. As mentioned previously, multiple redundant controls and safety devices are required by OCS operating orders to prevent accidents and degradation of the environment.

The possibility does exist that subsea completions would be used as a result of this proposed sale. Wells can be drilled vertically from locations conforming to the desired spacing pattern of the field. In this case flow lines are required from each well to a common point. This common point may be either a surface production facility, an ocean floor production and test manifold, or, possibly, a subsea production facility.

There are two principal drawbacks in developing a field in this manner.

There is a practical limit to the length of flow line that can be considered. Depending on the production characteristics, wellhead pressure and fluid viscosity in particular, there will be a pressure drop per unit length of line. In some cases this pressure drop could be enough to prevent production from reaching the central collecting point and certainly, as the reservoir pressure declines during the life of the field, problems will develop.

Depending on the type of well completion, the production tree in particular, flow line lengths are critical. If the well is to be maintained by divers and/or surface vessels, the flow line length may not be too important, but where maintenance is to be carried out by pump down, through the flow line (TFL) tools, the length of flow line would be important. Also, if the well is to be remotely controlled, hydraulic lines and/or electric cables may be required to actuate well controls. These would normally parallel the flow line.

Normally, subsea wells are drilled within three miles of the central collecting point but longer distances are being planned. If conventionally moored vessels are used in field development, and later in field maintenance, the presence of a number of lines on the sea floor may hinder the use of anchors and increase the hazard of rupturing the lines.

If the productive formation is deep enough below the sea floor, wells can be drilled directionally from a common site on the sea floor to bottom in widely-spaced locations to meet the needs of optimum field spacing. Generally, some type of base plate or template is employed to space well heads. These templates may be elaborate and combine functions other than wellhead spacing or the templates can be simple and merely replace the temporary guide base.

This system is called the cluster concept for subsea completions and the wells can be conveniently connected to a common subsea test and production manifold. In this case only two lines carrying production to the surface are required, one to carry the total production from the cluster and the second to carry an individual well's production to a test facility. Depending on the field development plan, additional lines to handle well and manifold control functions may also parallel the flow lines.

Down hole completion procedures for subsea wells are as discussed above. After tubing is hung and plugged, the BOP stack is removed and the wellhead is set and connected in place.

Wellhead equipment for subsea wells is functionally similar to the equipment described for platform wells and includes all the safety devices previously described. The control equipment is necessarily modified in accordance with the type of basic control design—that is diver operated, remote control from the surface, control at atmospheric pressure in encapsulated wellheads, etc.

In the simplest form the subsea production tree can be the same as those used on land. The tree is installed by divers and manipulation of well controls would also require divers. Divers also make up the flow line connections. The tree valves can be controlled hydraulically from a remote point through hydraulic control lines. Four trees of this type were installed by Phillips Petroleum Company in the El Molino Field in the Santa Barbara Channel in 1963 in 60 meters of water.

The problem with diver operated systems is the diver depth, though present working dives are routinely carried out in water depths to 183 meters and they have been carried out in depths of 330 meters.

A remote controlled, hydraulically manipulated tree is installed without diver assistance using the same techniques as those used to make up blowout preventer and riser pipe connections during drilling. All valves are controlled hydraulically, or electro-hydraulically where distance attenuates hydraulic response time from a remote control point. All valves are also of the fail-close type, which means they will automatically shut in the well should loss of hydraulic pressure occur. Four of these trees are installed in 70 meters of water in the Ekofisk field in the North Sea operated by Phillips Petroleum Company.

An encapsulated tree is a conventional tree installed in a chamber that is maintained at atmospheric pressure and includes a means of access from a personnel vehicle. The personnel vehicle can be considered a diving bell with means of connection to the subsea chamber over the wellhead. In this manner, non-diving technical personnel have access to the wellhead controls and can perform all of the functions possible on a land well, including wire line work.

Several subsea production systems have been developed, and they are discussed more fully below. One of these, the Lockheed system, was installed by Shell Oil Company in the Gulf of Mexico in September 1972, in 114 meters of water. In 1973 the well was successfully reentered for routine maintenance.

This concept can be expanded to include a complete production system. The advantage of course is that well work can be performed at surface conditions (atmospheric pressure) and that the work can be done using conventional oil field tools and techniques with no reliance on sophisticated remote control techniques. These systems are presently viable to at least 457 meters and even greater depths can be anticipated in the future.

A subsea manifold would perform the same function as a manifold on a surface production installation. The purpose of this series of valves is to collect the production from several wells and combine it to a single stream for delivery to a separation facility. There must also be a means of segregating individual well production for metering and testing. This is accomplished by the series of valves included in the manifold.

The manifold, which can be operated hydraulically or electro-hydraulically from a remote control point can be "wet" or it can be encapsulated. The value of such a system is to permit a cluster of subsea wells and avoid the number of flow lines required if wells were widely spaced.

A subsea production system was installed in the Zakum field of Abu Dhabi Marine Areas Ltd. in the Arabian Gulf in 1970. The field is operated by British Petroleum and Cie. Francaise du Petroles. The system is electrically operated and diver maintained; the site is in 21 meters of water and was selected so as to be readily available for diver maintenance. The system includes all well controls, a gas-oil separator, and a gas driven generator for electrical power. The system is purely experimental, but is operating and indicates what may be possible in the future.

Exxon's submerged production system (SPS) has been proposed as a possibility for the development of the Santa Ynez Unit in the Santa Barbara Channel and was discussed in the U.S. Geological Survey's environmental impact statement covering this subject. Exxon's submerged production system (SPS) which provides facility for three wells has successfully completed land tests. The SPS is a cluster of subsea wells and associated production controlling, separating and pumping equipment mounted on a subsea structure. The produced fluids are transported to surface processing facilities via pipelines to shore, to a platform or to a production riser connected to a floating vessel. The subsea equipment is remotely controlled and monitored from the surface facilities by an electro-hydraulic supervisory control system. Pump-down tools are used to service wellbore equipment and a manipulator operated from the surface is used to replace non-operative subsea equipment. All elements of the system have been designed and land tested. Work is in progress to perform an offshore test of the complete system.

The system essentially consists of a cluster of wells drilled through a seafloor template and connected through a manifold system. The manifold system is surrounded by a track on which a wellhead and manifold manipulator runs. The manipulator is controlled from the surface and can control all well control functions. Provision is also made for access to the annulus of each well. The manipulator maintenance system is shown in Figure 5.

The submerged production system (SPS) provides equipment and procedures which span the production requirements of a field from the time development drilling starts to field abandonment and from wellbore equipment at the completion interval to the processing equipment at the common carrier custody transfer point. The SPS is composed of eight functional subsystems as follows: 1) the drilling and completion subsystem, 2) the manifold subsystem, 3) the remote control subsystem, 4) the pump/separator subsystem, 5) the template subsystem, 6) the pipeline connection subsystem, 7) the production riser and floating facility subsystem and 8) the maintenance manipulator.

The final series of land tests on a prototype, 3-well, subsea production manifold and a maintenance manipulator were performed in a water-filled pit where the underwater production equipment was automatically operated to control well streams simulating liquid, gas-liquid, and sand laden production. In this testing, the prototype equipment met or exceeded design specifications. In addition, the maintenance manipulator was deployed from a surface vessel to a mock-up installation in 130 meters of water to demonstrate its ability to land on its track which surrounds the underwater equipment. This development test, when coupled with the pit test, proved the manipulator to be capable of performing the maintenance tasks. Results of tests on the SPS wellbore equipment and on a pre-prototype pump/separator subsystem have indicated the utility of these equipment subsystems in performing their functions. Tests simulating operating conditions have permitted the design of prototype pipeline connecting equipment needed for the SPS.

An offshore test of the Exxon SPS is underway in the Gulf of Mexico off Louisiana. In this offshore test, installation, production and maintenance operations in the Gulf of Mexico will be performed in a manner representative of producing a deepwater field with an SPS and the full-scale depth-capable equipment will be used. The purpose of the test is to evaluate the cost and performance of the equipment and technique during installation, operation and maintenance activities. The results of extensive land testing indicate that the equipment will function properly and this offshore test will provide data necessary to evaluate both equipment and procedures.

The test includes a template with producing equipment placed on the sea floor in 52 meters of water in West Delta 73 Field which is 43 km southeast from Grand Isle, Louisiana. Three wells in the test will deliver production to a manifold which surrounds the well bay, then to a subsea separator and fluid pumps. At that point, gas will flow via pipeline to the nearby "F" platform. Liquid will be pumped using submersible electrical pumps via an articulated production riser to producing facilities on the platform. The riser will be tested to confirm its capability although no oil will be loaded to a service ship in the pilot test. The test plan for the template calls for all work on the sea floor to be done remotely without the use of divers, simulating deep water application.

The template was fabricated and equipment installed and tested in McDermott's yard in Morgan

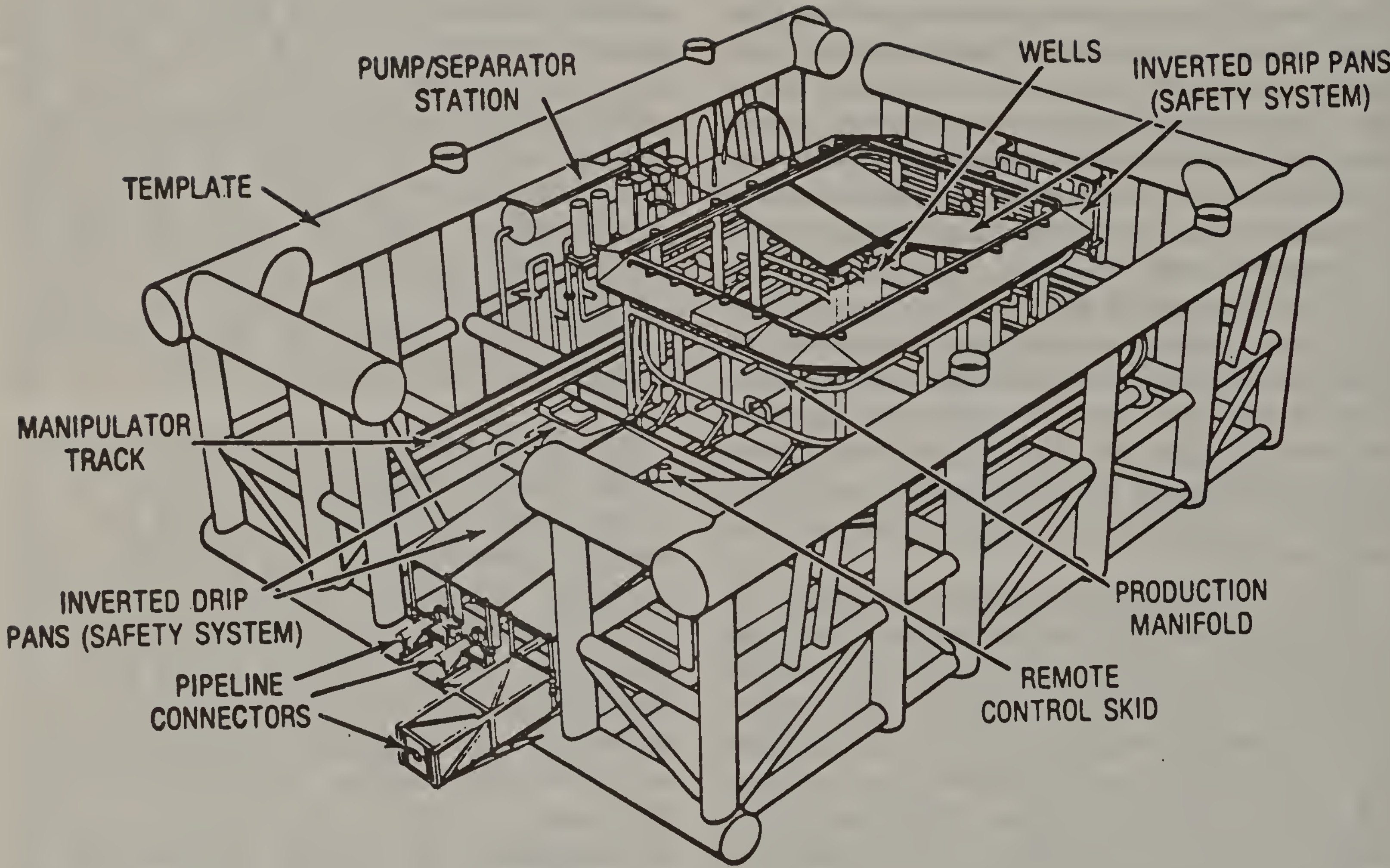


Figure C-5 EXXON SPS Manipulator System
(Source: EXXON Company, U.S.A., 1971, Supplemental Plan of Operations, Santa Ynez Unit

City, Louisiana, over a period of 15 months beginning in May, 1973. The template was launched much like a conventional platform jacket on October 19, 1974. Subsequently, the unit keelhauled under a drill ship, the Glomar "GRAND BANKS", then lowered to the sea floor with the rig draw works. Four pilings have been drilled in and cemented to the floor and the template leveled. Pump caissons have been installed.

Five pipelines have been laid and connected to the template by remotely controlled operations. Two of these lines (2.5–7.6 cm ID pump down tool line and the 20 cm gas line) connect directly to the "F" platform. The other three lines (a 7.6 cm ID pump down tool line, 7.6 cm ID gas injection line and 20 cm oil line), also terminate at the "F" platform by way of the production riser. The two cables, a 35 kv cable supplying power to the fluid pumps and a 5 kv remote control cable, have been laid. As of November 1975, three wells had been drilled and the maintenance manipulator deployed to make planned connections on the sea floor equipment. Pipeline pumps have not yet been installed. Although there have been problems as would be expected in a test of this magnitude, no basic flaws have been detected in the SPS to date.

The test will have a minimum duration of three years but producing and maintenance operations will probably be continued until they can no longer be justified.

Shell Oil Company and Lockheed Petroleum Services joined efforts to develop and field test an ocean-floor system for completing and producing wells. The system is based on the concept of housing more-or-less standard equipment in one-atmosphere chambers. The chambers can then be linked together with subsea pipelines to form a complete producing system. Servicing the equipment inside the chambers can be performed by experienced oilfield workers, transported to and from the chambers in a dry, one-atmosphere diving capsule.

The current joint program consists of three phases. Phase I, the Lockheed Petroleum Services (LPS) one atmosphere system was completed and installed in 1972, for Shell Oil Company in the Gulf of Mexico (Main Pass Block 290) at a 114 meter water depth. There have been no major technical problems with the wellhead chamber and the well has produced over one-half million bbls. of oil.

Phase II, the subsea manifold center, has been installed in Eugene Island Block 331 Field. Work has been temporarily suspended until spring 1976 awaiting better weather conditions. The LPS wellhead cellar is supported on the casing head housing and is surrounded by the guide frame whose base is one to two meters above the sea floor. This is all supported by a 75 cm diameter drive pipe penetrating the sea floor. Foundation for the manifold center is a barge that carries the system to the site and is sunk to form the base on the sea floor. All LPS equipment and materials have been carefully selected for the appropriate pressure rating and subjected to extensive testing. Every well is equipped with automatic fail-close valves and remote shut-in controls actuated hydraulically from the platform.

A control panel on the platform regulates all the sensing and remote functions and includes:

1) Remote actuation and position control of all remotely operated valves and chokes.
2) Pressure sensors in pipelines.
3) Sequential shut-in system.
4) Testing of the emergency shut down system (ESD).

An ESD condition will sequentially close the manifold center's hull valves and subsea Christmas-tree's fail-safe valves (all master and wing valves simultaneously). The tubing removable surface controlled sub-surface safety valves (SCSSV) at Eugene Island is a ball type which was updated from the storm choke used in Main Pass to meet OCS Order No. 5.

All oil and gas pipelines will be equipped with automatic shut-in valves connected to ESD and remote shut-in systems. Hydraulic lines are equipped with back-up systems if the ESD fails.

The third phase will consist of a subsea clustered well system. It is anticipated that data from this system will provide the sound basis necessary to project design and cost criteria for application in up to 914 meters of water.

In September 1973, Shell, utilizing the atmospheric diving system of Lockheed Petroleum Services, Ltd., successfully reentered and performed maintenance in a subsea wellhead chamber at atmospheric pressure in 114 meters of water in the Gulf of Mexico, offshore Louisiana. The primary purposes for the reentry were to locate and repair a leak in the hydraulic control system, observe the condition of the chamber and tree components after one year of operation, and provide diving experience for Shell personnel.

The chamber and internal components were found to be in excellent condition during the first dive. Nine dives were made and all work was completed as planned under ideal weather conditions during the seven day period.

In the first three years the well has produced 950,000 barrels of oil and 8.5 million cubic meters of gas and is currently producing at a rate of 950 barrels of oil per day and 20 thousand cubic meters of gas per day. Maintenance and remedial experience has included six TFL (through-the-flowline) operations, where tools are pumped through the tubing, to service subsurface controls and acidize the lower zone, and three entries into the WHC (wellhead chamber) for routine maintenance.

Two examples of the Lockheed system for wellhead equipment are shown in Figure 6. The chambers shown are those permanently installed on the wellhead and the upper hatch indicates where the service capsule is attached.

After the capsule is connected, the chamber below the capsule and above the entry hatch to the work chamber, is pumped dry and the atmosphere is tested prior to opening the hatches.

Subsea Equipment Associates Limited (SEAL) has been principally funded by British Petroleum, Mobil Oil Company, Compagnie Francaise du Petroles, Westinghouse Electric Corporation, and Group Deep, the latter a consortium of European Contractors. Associate members of the group include Conoco, Sunoco, Phillips, ELF/ERAP, and Petrobras.

SEAL currently has under development three subsea oil and gas production systems. Two of the systems undergoing tests are designed for use in foreign fields where high production rates are prevalent. SEAL is also testing a subsea oil production system in the Gulf of Mexico which is designed primarily for utilization with large numbers of domestic low-production wells of less than 1,000 barrels per day which in turn generally require significant maintenance. Sun Oil Company is participating in the test project in the Gulf.

Essentially, the SEAL system is similar to the Shell-Lockheed system where working areas are enclosed in atmospheric chambers and access is available through personnel transfer capsules lowered from a surface vessel. Systems have been designed for individual well completions, cluster type well completions, a production manifold station, a subsea separation facility and a subsea pumping station.

As in other similar systems a base plate is hydraulically connected to the wellhead. For a multiple well system the base serves as a drilling template for directionally drilled wells and part of the structural piping is used in the manifolding system for the wells. The subsea work enclosure is then connected to the base structure and has provisions for personnel entry through a hatch from a personnel transfer chamber. The configuration of the work chamber can be varied depending on the water depth, number of wells associated, production rates, etc. The chamber provides a dry working environment on the ocean floor at atmospheric pressure.

Phillips Petroleum Company is presently completing exploratory wells in the Ekofisk field in the North Sea in about 67 meters of water using this method. They are completing the well and connecting the base plate and lower master valve before releasing the drilling rig. The upper portion of the wellhead assembly (the work chamber and associated valves and piping) will be installed when production facilities are available. This installation can be made with a small support vessel without requiring the services of an expensive drilling vessel. Previously, exploratory wells were either abandoned, or temporarily abandoned. Abandonment represents a loss of considerable investment and if temporarily abandoned, a drilling vessel would be required to reenter and complete the well.

Another test of the SEAL system was made in the Gulf of Mexico. This involved a multi-well system and it is described in a paper titled "Subsea Manifold System" by Chatas and Richardson, Seal Petroleum Company. It is numbered OTC 1967 and was presented at the 1974 Offshore Technical Conference in Houston, Texas.

Testing started by simulating field production on dry land in 1971, in Long Beach, California, where the prototype was constructed. In 1972, the unit was transported to the Gulf of Mexico and installed in 75 meters of water, 245 meters from a Sun Oil Company production platform at Main Pass 293A. First tests were conducted by diverting production from wells on the platform through the manifold system. After processing, the production was returned to the platform; additional drilling operations were started in December, 1973, and the test was completed in September, 1974.

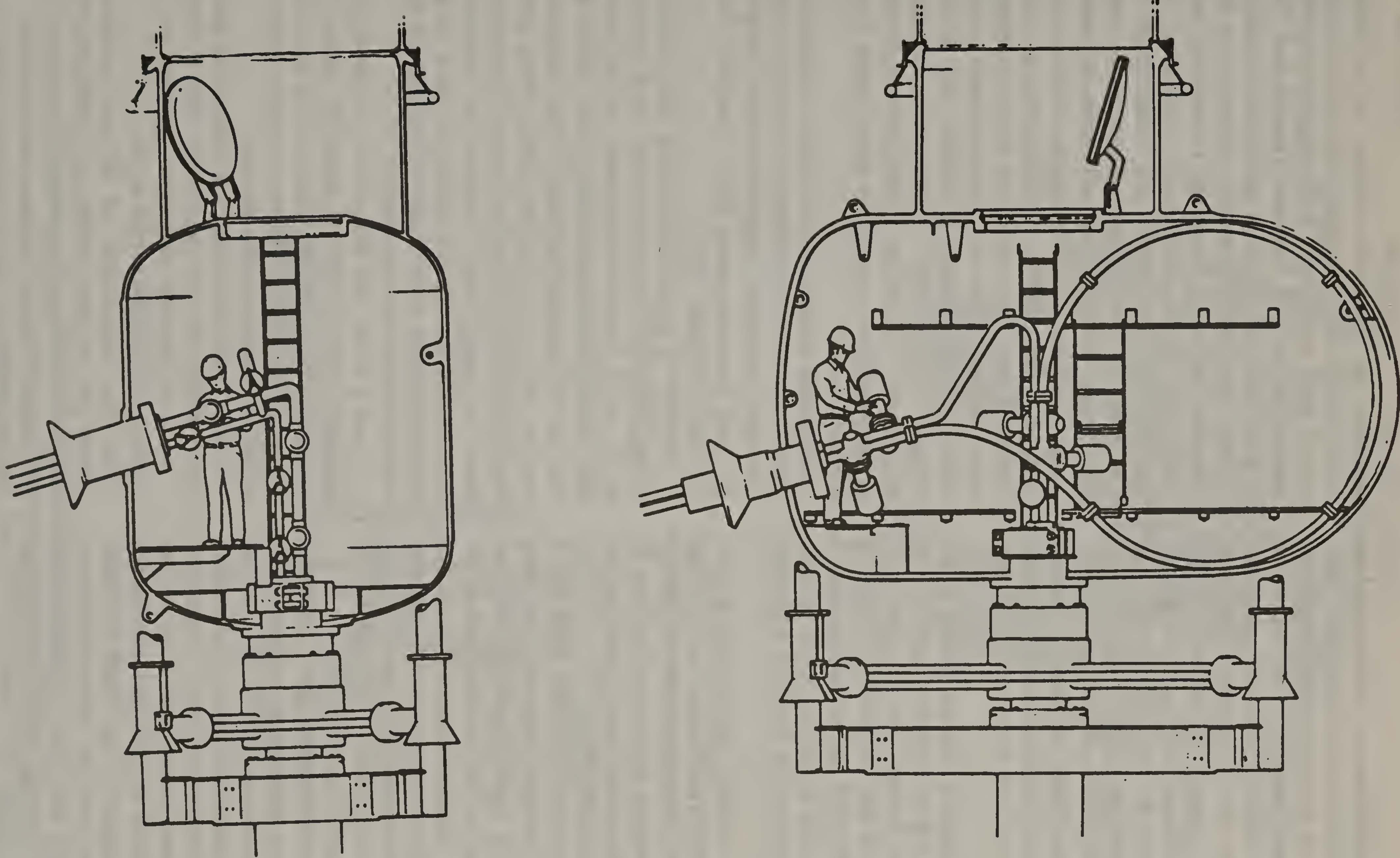


Figure C-6 Lockheed One-Atmosphere Subsea Completion System
a. For Wellhead Installation Where TFL Tools are not required.
b. A Wellhead Cellar Designed to Enclose the TFL Tubing Loop.

(Source: Lockheed Petroleum Services, Ltd. (Also presented at the Sixth Annual Offshore Technology Conference, Houston, Texas, May 6-8, 1974)

During the commissioning and check-out phase of the test, 56 entries by personnel were made into the subsea work enclosure (SWE). Most of these personnel were not divers, but regular oil company personnel. Over 90 automatic operations of pump-down tools were performed, principally to remove paraffin deposits in the wells. These tools were pumped through the flow line network, to the platform, down the well and returned. The personnel transfer bell used in these tests is capable of transporting five men into the subsea structure. The base of the SEAL Atmospheric System (SAS) and the subsea work enclosure (SWE) used in the Gulf of Mexico test are shown on Figure 7.

The SEAL Atmospheric System (SAS), which was tested in the Gulf of Mexico, was based on the use of a large habitat type structure permanently installed on the sea floor to house oil field equipment. The SAS system incorporates a subsea manifold system in which various oil field production equipment can be installed depending on the application.

The three major elements investigated in conjunction with the SAS Test Program were as follows: 1) the Subsea Work Enclosure (SWE), 2) the automatic production control system, and 3) automatic well maintenance system based on use of TFL (through-the-flowline) test.

A test separator located within the SWE was a vertical two-phase separator capable of handling produced volumes of approximately 400 bbl/day of oil and 760,900 scf of gas per day. Due to the characteristics of wells produced through the SWE during the tests, the separator was operated at full capacity and demonstrated repeatability of each well tested and correlated accurately with production data available on each well.

The separator instrumentation was of a conventional nature utilizing temperature, pressure, and differential pressure on a gas meter run, a net oil computer and a displacement meter to give quantity and percentages of oil and water.

A common approach in the SEAL systems has been the use of trained oil field personnel on the sea floor. The maintenance personnel are transported from the surface to the subsea structure in a Personnel Transfer Bell. Test operations have proven conclusively that the vehicles are efficient and can be operated safely.

Future applications of this concept would be as a manifold center, a test separator center or a complete oil production system. In a similar manner to the other systems, men are transported to and from the Subsea Work Enclosure (SWE) through the use of a Personnel Transfer Bell. The men perform their duties at atmospheric pressure.

Other submerged production systems are in the design or test stage. Deep Oil Technology, Inc., Transworld Drilling Company (a subsidiary of Kerr-McGee Corporation), and Standard Oil of California all have systems that have not yet been fully developed. The Transworld system is similar to the Lockheed and SEAL systems where an underwater work chamber at atmospheric pressure is utilized. The main difference is that wellheads would be maintained in a wet atmosphere except when work was actually in progress with the underwater work chamber in place. Construction is in progress on prototype models and the system is designed to be operable in water depths to at least 457 meters.

A possible production system where production from subsea wells is directed to a surface vessel containing separation equipment is more likely to be used in deep water where platform costs become prohibitive.

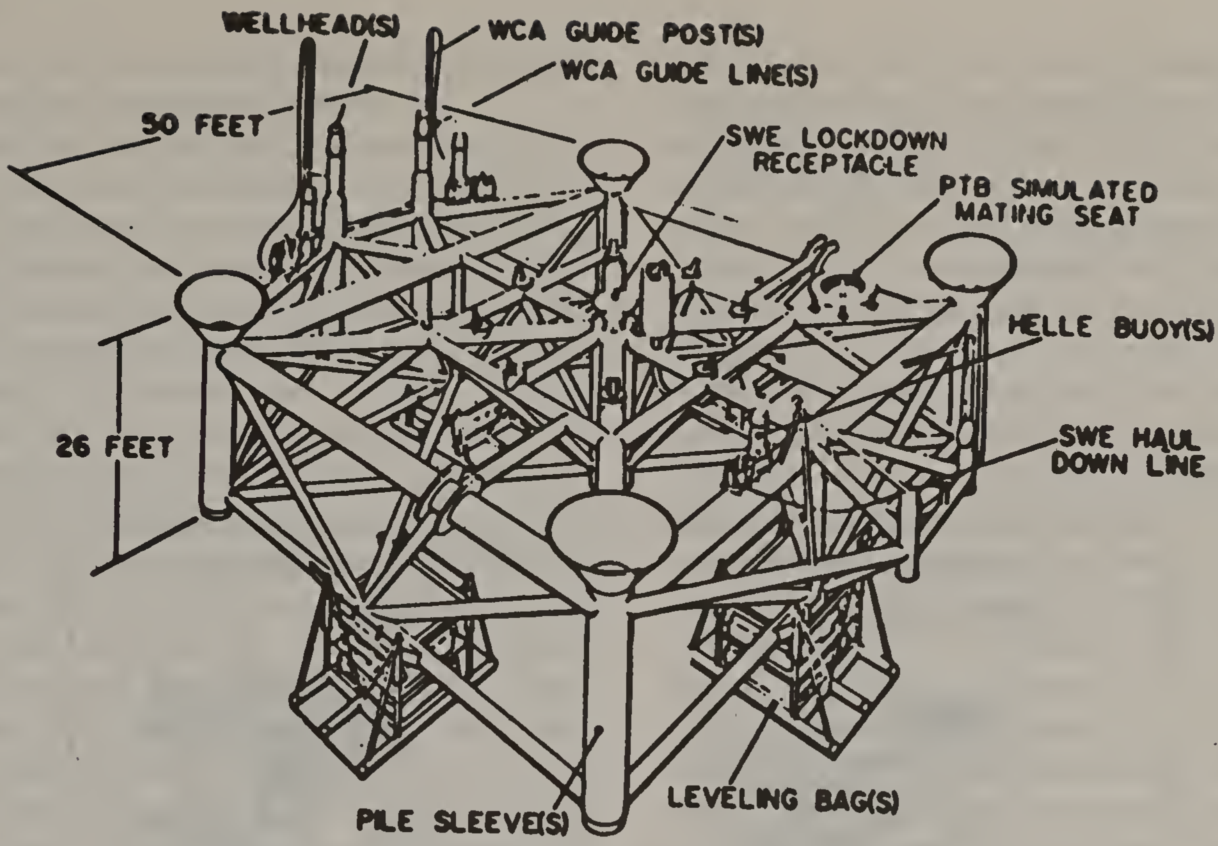
To meet the needs of producing large amounts of oil from deep water tracts with hard bottoms in the harsh physical environment of the North Sea, many petroleum companies have turned to the use of concrete platforms. These structures rest on the ocean bottom by virtue of the great weights—upwards of 300,000 tons (272,340 metric tons) or more. Each platform is completed onshore and then towed upright to the development site, where ballast tanks are flooded and the structure settles to the seafloor.

Figure 8 shows the designs of two North Sea platforms to be installed in about 152 meters of water. Each platform is similar in size and construction methods and will have storage capacities of 900,000 barrels of oil in the base.

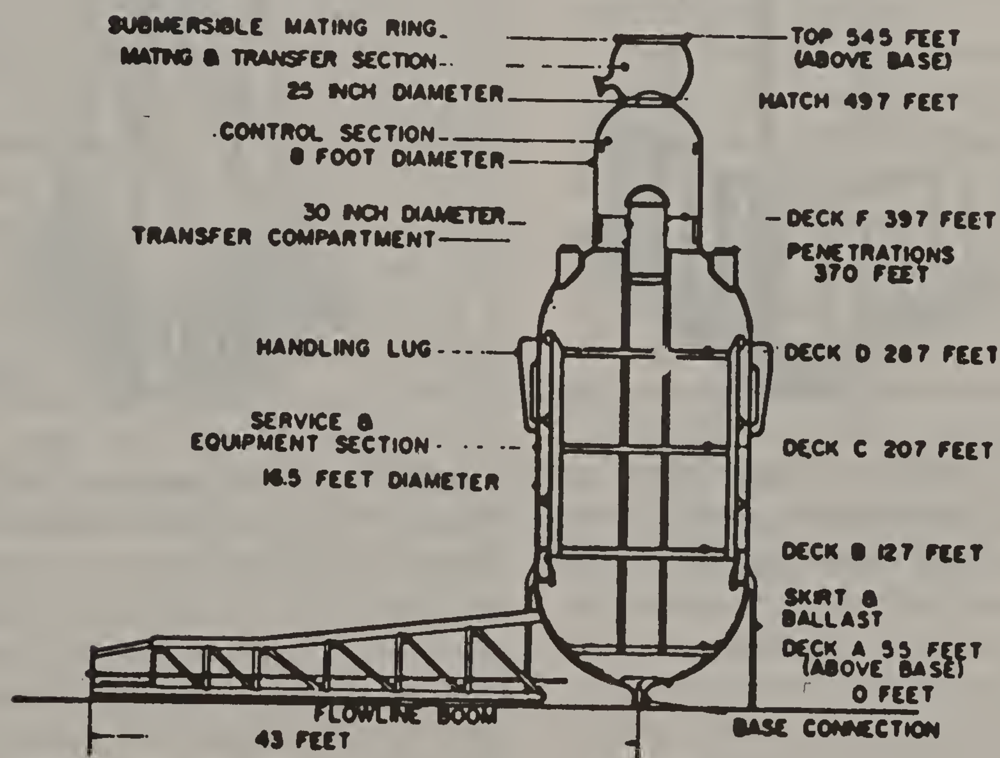
A large concrete storage tank has been in place in the North Sea field since 1973. This structure is 93 m in diameter and 90 m high and has a capacity of 1,000,000 barrels of oil.

Sea floor requirements of all these structures include (1) an even bottom, (2) strong bearing capacity of surficial and underlying sediments, (3) little lateral variability of these same sediments.

Because of the size of anticipated finds, expected production, production by pipeline, and availability of steel fabrication yards, it is not an-



a. Base & wellhead connector assembly



b. Subsea work enclosure

Figure C-7 Seal Subsea Manifold System
(Source: Subsea Equipment Associates, Ltd. (Also presented at the Sixth Annual Offshore Technology Conference, Houston, Texas, May 6-8, 1974)

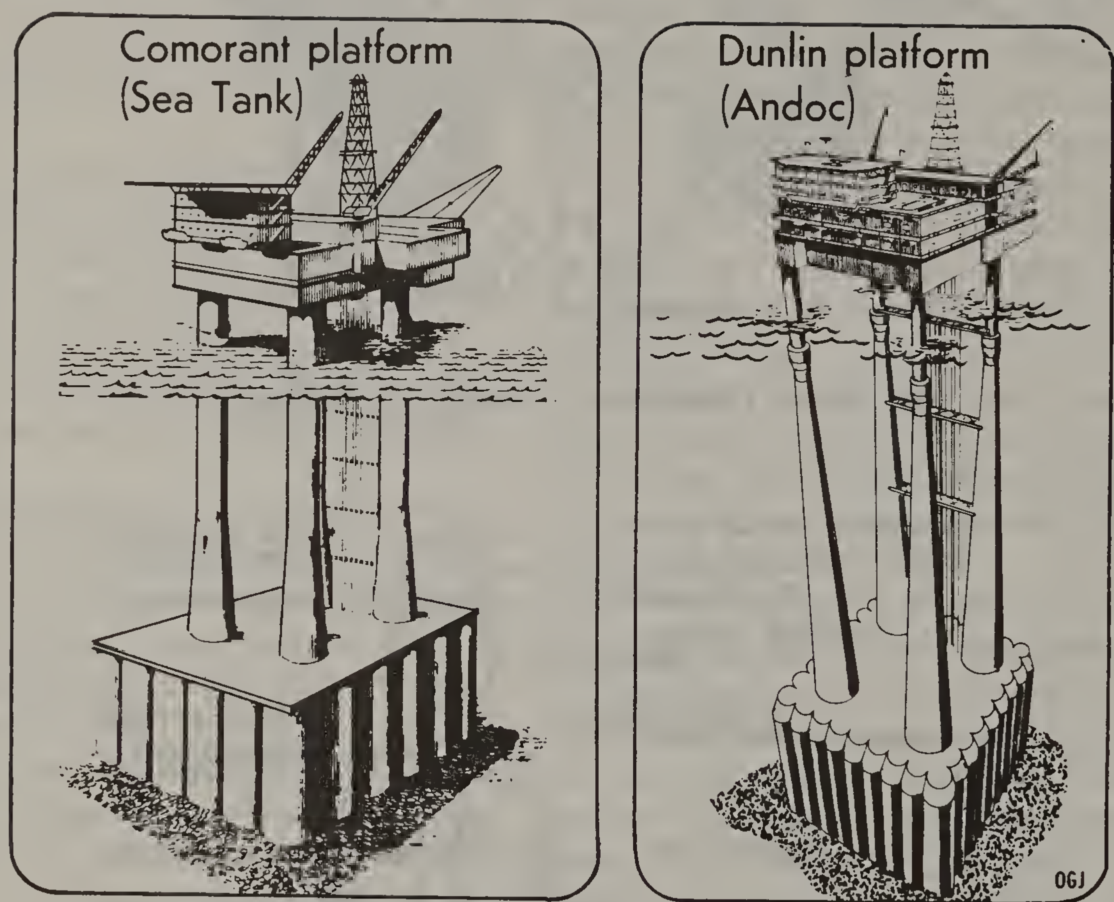


Figure C-8 Gravity Type Steel and Concrete Combination Drilling, Production and Storage Platforms. (From Oil and Gas Journal, May 27, 1974, Vol. 72 (21):34).

ticipated that concrete gravity structures will be used as a result of this proposd sale.

The waters associated with oil and gas reservoirs and which are frequently produced along with the oil and gas are called formation waters. It is highly unlikely that any of the produced formation water resulting from this proposed sale would ever be piped ashore. Both economic and environmental considerations weigh heavily towards choosing to treat and release the water into the ocean at the platform site or reinject it into subsurface formations. Reinjection is utilized where feasible as a secondary recovery technique by pumping formation water, under pressure, back into the lower levels of the petroleum-producing zone and thus maintaining good reservoir pressure. Disposal of formation water into other than the producing formation is not done because of the expense involved. This method of disposal requires a separate well plus some water treatment to insure that the injected water is compatible with the host reservoir. Formation water which is to be discharged into the ocean is first passed through a water-treating facility that removes all but traces of entrained oil. However, the water is still void of dissolved oxygen and contains large quantities of dissolved minerals, but in any case must meet EPA standards.

Since petroleum production involves the handling of flammable fluids under pressure, the safety systems control is of utmost importance to preclude hazardous conditions. Nowhere is this hazard greater than during workover, or remedial operations on a well in order to improve its production rate or to replace faulty downhole equipment. Since workover operations are potentially hazardous, they must be planned carefully, both to keep wells from getting out of control and to prevent or minimize the release of oil to the environment. Currently under review within the U.S. Geological Survey is a proposal to revise OCS Operating Orders to reduce or prohibit simultaneous production and drilling from the same platform. The restrictions would apply to workover operations as well as to drilling and production operations.

To reduce pollution, specially treated salt water that can be weighted with various materials is used for hydrostatic control when reentering the wells in wire-line or swabbing operations.

To increase production, acid or other fluids and suspended particulate matter may be pumped through the well bore into producing formations. The function of this treatment is to enlarge flow channels leading to the well. The spent acid returns up the well when production is resumed, and is handled as are other fluids from the well. Oil and water contaminated with spent acid are transported with the rest of the production to the refinery.

Sand produced along with the well fluids can cause the wells to plug, and "sand-up", periodically and must be removed. Other procedures to increase productivity and oil recovery include the injection of high-pressure steam, water, and/or gas into specially prepared injection wells. The water used for this purpose may be taken from the ocean or from formation water. Water too contaminated to be treated and discharged is either reinjected into formations or transported ashore for further treatment and disposal. Suitable precautions are taken to ensure that fresh water aquifers will not be contaminated by oil or salt water. Gas produced from the well may be reinjected for pressure maintenance where feasible or piped to shore for sale.

From the safety standpoint, completion and workover operations must be conducted carefully, and it is their critical nature that, in all likelihood, makes these operations safer than they otherwise might be. Operators of swabbing and wire-line units are well aware of the hazardous nature of their work and are extremely cautious. Despite the potential hazard, safety records during wire-line and swabbing unit work are excellent.

Offshore pipelines, particularly large diameter or long lines, are usually installed using a barge specially constructed for marine pipelining called a "lay barge". This barge is a self-contained unit including all of the facilities required to join the pipe by welding, cover the weld with protective coating, and to lower the pipe in place on the ocean floor. The pipe is coated on shore and delivered to the lay barge in uniform lengths or "joints" with the ends prepared for welding. Several anchors, at least two at each corner, are used to hold the barge in position. Joints of pipe are welded together on the deck of the lay barge to form a continuous length. When a weld is finished, inspected and coated, the barge is moved forward allowing the assembled pipeline to extend over the stern of the barge and to sag downward to lie on the ocean floor. A new length of pipe is added to the "forward" end of the pipeline and the process is repeated. Making a high-quality pipeline weld requires a reasonable amount of time. Therefore to obtain rapid production, "assembly line" techniques are used allowing welding to take place at several stations simultaneously. To do this the work on the barge must take place in an almost level position. From the barge to the ocean floor the pipe will assume a double curve or "S" shape. If the pipe is too stiff to reach the bottom unsupported, a buoyant pontoon or slide called a "Stinger" is used to provide support for the upper section of the pipeline. To help support the weight of the pipe and to prevent buckling, a carefully controlled tension force is applied to the pipe by constant tension machines mounted on the barge.

The pipe assembly process utilizes the latest technology and the best welding techniques currently available. All joints are given a complete X-ray inspection for quality and then covered with corrosion resistant material prior to leaving the barge. The shore pipelines are designed and installed to meet the same codes and specifications as onshore pipelines, such as API, ANSI, ASME, etc. After the line is completed, it is tested to make sure that it has been properly installed and will withstand the anticipated operating pressures safely. The pipe is further protected by cathodic protection systems to supplement the corrosion resistant coating.

The technology now exists to lay large diameter pipelines in depths of 350 meters or more in harsh environments. For example, the semisubmersible pipelay/derrick barge Semac I, presently under construction in Mobile, will be capable of laying large diameter pipe in up to 350 meters of water in sea conditions encountered in the northern North Sea. With additional equipment the unit will be capable of laying pipeline in even deeper water (USGS, Written Comments, DES Proposed OCS Lease Sale No. 40, 1976).

Burial is effected by jetting sediment away from underneath the pipeline and allowing it to sink into the resulting trench. The equipment used in this operation consists of a work barge equipped with high volume/high pressure water pumps and air compressors. From the barge, a multiple membered towline consisting of a strength member, water line, and air line extends downward to a U-shaped structure which straddles the pipelines and glides along it on rollers. Affixed to the U-shaped jetting device are several nozzles which direct water and air, under high pressure, ahead and below the pipeline. Sediments are blasted out of the narrow trench by the water jets, partially lifted by the air and deflected to the sides by various types of fins. The suspended sediments fall diffusely along either side of the trench. As the jetting device is pulled forward, the pipeline settles into the trench and is partially buried quite soon by the reworked sediment as it slips and settles back into the depression. Complete burial and restoration of original bottom contours may require additional time. In shallow waters, experience has shown contour restoration to be quite rapid, whereas in deeper waters, more than a year may be required.

Even though a buried line is protected from fluid forces it is not necessarily stable. If it is too light, it will gradually work its way up through the soil and become exposed to the water forces. If it is too heavy, it will gradually sink in the soil and impose additional tensile stress in the line. Design procedures for determining the vertical stability of the line in sands and clays have been developed and are available in the industry.

Difficulties have been experienced in burying pipe in cohesionless sands. In this case the sand will often refill the jetted trench before the pipe can settle into it. Another method, fluidization of the sand, enables successful burial in this type of substrate.

To prevent corrosion, pipelines are carefully coated with such material as epoxy compounds or thick asphaltic mastic. If extra weight or mechanical protection (from fisheries trawling for example) is needed, these, in turn, are covered with a layer of dense concrete. The lines are protected from electrolysis by both impressed-current systems and by sacrificial anodes (zinc is commonly used). Corrosion prevention measures are now required by 49 CFR Part 195. Although offshore pipelines are relatively inaccessible as compared to onshore pipelines, they nonetheless can be repaired by divers. Methods of using submersibles to latch on to a subsea line and repair it with mechanical arms and special tools are under study and nearing the point of practical demonstration.

As in the case of workover operations, the expense of the pipeline installations, coupled with the catastrophic implications for the local marine environment should a major break occur, have combined to dictate a highly conservative design, emplacement, and operating philosophy.

As the pipeline construction approaches and traverses the shoreline, it is buried deep enough to avoid its being exposed by storm-associated beach erosion.

Onshore, the pipe laying method depends upon the type of terrain transgressed. If a pipeline were to be allowed to cross wetlands in which there was no firm ground to support equipment, a canal 12 to 15 meters wide would be needed. Lay barges are usually utilized in such areas. The dredged material would be placed alongside the canal and form a low, flat levee. With required openings and bulking (plugging the ends), erosion and salt water intrusion would be minimized, as would disruption of drainage patterns; although these problems may still persist to some degree. In firmer wetland areas; a smaller canal, about three meters wide would be dredged and backfilled. On firm land, the routine trench and backfill method is used which is the same technique by which water and sewer lines, cables, and so forth are buried.

A rough estimate of the width of land disturbed by pipelines laid through wetlands or on land would be 15 to 18 meters disturbed by equipment and a band of perhaps nine to 12 meters of soil and vegetations removed. On land, a swath of perhaps 15 meters would need to be maintained free of trees and large shrubs to permit maintenance vehicles access and surveillance for leakage.

The safe operation and maintenance of a pipeline system requires several redundant monitoring systems to ensure the integrity of the line and detect leaks. The primary leak detection system in use (required on all lines built after March 13, 1970, by 49 CFR Part 195.406 and 195.408) is a set of automatic pressure sensing recorders on both ends of each pipeline system. These devices are equipped to either shut down the flow automatically or sound an alarm to alert personnel of an abnormal pressure level. In this way, a leak of substantial rate is detected immediately. This system is insensitive to leaks which do not produce a decrease in line pressure greater than 300–500 psi. It is essentially a safeguard to prevent the escape of large volumes of oil due to a catastrophic line break.

The second system of leak detection is the routine patrolling of the offshore wetlands routes by boat or aircraft, and onshore by wheeled vehicle or aircraft. A minimum patrolling frequency, with intervals between inspections not exceeding two weeks, is required by 49 CFR Part 195.412, but in actual practice is performed more often. This type of monitoring would result in the detection of all sizes of leaks of course, but would be of little consequence in preventing the loss of a large amount of petroleum in the event a large line were severed. The appeal of a system of regular pipeline patrolling is that it allows detection of small leaks and therefore complements the pressure-sensing system described above. With volume of airborne and waterborne traffic expected over the potential oil producing area of the South Atlantic, it is considered highly improbable that any spill would go undetected for any appreciable length of time.

The third system for leak detection consists of a series of volume-recording flow meters on either end of a pipeline system. Because nearly all crude oil moves from OCS areas to shore by common carrier lines, it must be metered in the offshore pipeline gathering system and again at the onshore pipeline terminal in order that each producer be properly credited for his share of the common stream. The flow sensors continually measure input and output in real time; thus when attendant personnel record these readings for inventory control they are able to discover a decrease in output which would indicate the possibility of a leak. This is usually done on a shift schedule, once every eight hours or more frequently.

One more safety feature which would be built into all pipelines resulting from this proposal, according to industry spokesmen, is that remotely operated mainline block valves will be provided at remotely controlled pipeline facilities in order to allow isolation of segments of the pipeline. Isolating valves are required by CFR 195.260 and remote operation of these valves, while voluntary, would be one of the primary objectives of a remote controlled pipeline facility. Table A shows the relationship between the diameter of a pipeline and the volume contained per kilometer of line.

Surveillance of pipelines can be performed by a variety of means. Side-scan sonar can be used to locate the pipeline and determine if it is buried. Underwater TV cameras can be extended from a vessel to examine the pipeline without using more expensive means. Divers can go down to actually inspect the line, burial depth, and condition of coatings. Miniature submarines can perform the same tasks with the added advantage of shirt sleeve environment, longer underwater duration, radio contact with the surface, and close examination of seafloor conditions by trained technicians. Measurements of cathodic-protection of the pipelines can be taken by divers and from manned submarines.

Appendix D

MEMORANDUM OF UNDERSTANDING BETWEEN BUREAU OF LAND MANAGEMENT AND U.S. GEOLOGICAL SURVEY FOR OCS PIPELINES

This Memorandum of Understanding is entered into in order to define clearly the administrative and operational roles of the Bureau of Land Management (BLM) and the Geological Survey (USGS) relating to pipelines on the Outer Continental Shelf (OCS), to provide consistent and standardized procedures, and to minimize or eliminate dual and overlapping functions.

Unless otherwise provided herein, pipelines are defined as any line transporting oil, gas, water, sulphur or other minerals, including lines sometimes referred to as flow on gathering lines.

The objectives of this Memorandum of Understanding are to:

A. Provide an efficient mechanism for approving pipeline routes through the submerged lands of the OCS.
B. Initiate measures to provide safety and to minimize or eliminate environmental damage which may be associated with the installation and operation of pipelines originating on the OCS.
C. Be responsive to the interests of the oil and gas industry, other users of the OCS, and the public with respect to pipelines.
D. Streamline implementation of the regulations and procedures for more efficient and uniform administration of the Department's authority with respect to pipelines.

PIPELINE MANAGEMENT

I. BLM Role

A. Conduct pipeline routing studies and, with the concurrence of the USGS, designate pipeline corridors on the OCS for all pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator.
B. Maintain a central office of record for the location of all existing and future pipelines as specified in paragraph I.A. and associated structures on the OCS.
C. Receive applications for rights-of-way for pipelines to be installed on the OCS pursuant to 43 U.S.C. 1334(c) and 43 CFR 2883.
D. Prepare environmental assessments, pipeline system planning studies, economic studies, and environmental impact statements when necessary or appropriate, prior to approving applications for rights-of-way pursuant to 43 U.S.C. 1334(c) and 43 CFR 2883.
E. After considering the potential impact of the pipeline on the environment, the relationship of the application to existing pipeline routes on the OCS, and other factors, approve or disapprove the application pursuant to 43 CFR 2883.
F. Conduct field studies relating to the long range environmental impact of all pipelines and associated structures, thereby providing a basis for continuous assessment of existing environmental safeguards applied to such pipelines.

II. USGS Role

A. Consider all applications from a lessee or operator for a right of use and easement to construct and maintain pipelines and associated structures on the OCS pursuant to 30 CFR 250.18 and 250.19. Prior to granting approval of such applications for any pipeline other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator, consult with the BLM so that the routing of such pipelines may be coordinated with existing lines or designated pipeline corridor.
B. Review technical aspects of OCS pipeline design, installation, maintenance and operation in accordance with appropriate regulations and standards designed for safety and environmental protection, and to avoid undue interference with other uses of the OCS and its superjacent waters.
C. Prepare environmental assessments or impact statements when necessary prior to approving applications filed pursuant to 30 CFR 250.18 and 250.19.
D. Provide the BLM with the location, as installed, of all pipelines approved by the USGS as specified in paragraph II.A.

PROCEDURES

1. BLM will receive right-of-way applications pursuant to 43 CFR 2883 for pipelines and associated structures for the transportation of oil, gas, sulphur and other minerals on the OCS. A copy of the application will be sent to USGS for review. The reviews by USGS will focus on the technical aspects of OCS pipeline design, installation, maintenance and operation in accordance with appropriate regulations and standards designed for safety and environmental protection, and to avoid undue interference with other uses of the OCS and its superjacent waters. The BLM will issue a decision granting the right-of-way after having been notified in writing by the USGS that the technical aspects of the proposed pipeline are acceptable. BLM will prepare environmental assessments and impact statements prior to granting such pipeline rights-of-way when necessary or appropriate.
2. The USGS will approve rights of use and easement for gathering and flow lines pursuant to 30 CFR 250.18 and 250.19. For any such pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator, the USGS will transmit a copy of the pipeline application to the BLM. The BLM will review the application as to whether the pipeline route conflicts with any existing or proposed pipeline and pipeline corridors or would otherwise not be consistent with good pipeline management for the OCS. The BLM will advise the USGS in writing of the results of its review prior to a USGS determination for approval or disapproval of the application.
3. The BLM will conduct field studies relating to the immediate and long term environmental impact of pipelines and associated structures on the OCS in order to assess the adequacy of environmental safeguards. Reports of the results of the BLM field studies with recommendations for minimizing the impact of pipelines on the environment will be released to the public and distributed to appropriate agencies with jurisdiction over pipelines on the OCS.
4. The BLM and USGS will periodically review existing procedures for reviewing applications and issuing rights-of-way and rights of use and easements and propose improvements in such procedures as appropriate. The procedures shall include the assessment of the environmental impact and the minimization of the number and locations of pipelines on the OCS.
5. The BLM and USGS will consult with each other in the preparation of environmental analyses and impact statements and will also consult with the Bureau of Sport Fisheries and Wildlife, the National Park Service, the Bureau of Outdoor Recreation, and other Federal and State agencies as appropriate.
6. The BLM will assume the responsibility for overall studies of pipeline routing on the OCS and, with the concurrence of the USGS, designate pipeline corridors for all pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized

operation or a single operator. To assist in this, the USGS will furnish BLM with a copy of all approvals and drawings showing the proposed and installed locations of all pipelines, as described in this paragraph, and associated structures erected in connection with approvals of rights of use and easements.

/s/ V. E. McKelvey
Director, USGS

/s/ George L. Turcott
Director, BLM

August 1, 1974

Appendix E

SECRETARIAL ORDER NO. 2974

April 30, 1975

ORDER NO. 2974

Subject: Inter-bureau coordination in the Outer Continental Shelf (OCS) minerals program

Sec. 1 Purpose

The purpose of this order is to improve and formalize the planning and operating functions of the OCS minerals program by enabling the Bureau of Land Management (BLM) and the Geological Survey (USGS) to obtain expert advice from each other and from the Fish and Wildlife Service (FWS) with respect to environmental research and monitoring and operational activities associated with the OCS minerals program.

Sec. 2 Environmental Research and Monitoring

Environmental research and monitoring activities are those data collection activities conducted in specific geographic areas as a part of the OCS mineral leasing program. These activities are carried out in the context of a BLM program for administration, management, funding, and constructing of baseline studies, which includes bench mark data collection, subsequent monitoring, and special investigations. For the purpose of this order, bureau responsibilities are as follows:

(a) The BLM will consult with FWS and others, as appropriate, in designing the studies In this connection, BLM will inform FWS of its study plan schedule and request FWS recommendations concerning:

(1) specific elements to be incorporated in studies (including scope, intensity, timing, required funding, etc.)

(2) allocation of funds and level of effort among various study elements.

(b) FWS and BLM shall, by mutual agreement, provide for FWS involvement in the performance or management of studies under any of the arrangements detailed below:

(1) FWS may perform or manage particular studies or specific study elements as may be determined by mutual agreement among FWS, BLM, and others as appropriate. BLM and FWS shall develop a memorandum of understanding which provides for reimbursement of stipulated study costs to FWS and other pertinent activities under this arrangement.

(2) FWS may perform or manage elements of a larger study which another Federal agency manages for BLM. In this instance, FWS would arrange with the other Federal agency for its participation.

(3) FWS, acting in effect as sub-contractor, may perform or manage elements of a comprehensive study effort which is managed for BLM by a contractor, e.g., a university consortium.

(c) FWS will participate with BLM and others, as appropriate, as a member of the OCS Technical Proposal Evaluation Committee.

(d) FWS will participate with BLM in monitoring those study elements of special interest to FWS.

(e) FWS will participate in the overall study program design for each separately identified geographical area in which baseline or other studies are planned.

(f) If, for good and sufficient reasons, FWS does not agree with the overall study program designs as prescribed in paragraph (e) above and is unable to secure mutually acceptable changes through discussions with BLM, the issues will be referred for resolution through the appropriate Assistant Secretaries to the Assistant Secretary—Program Development and Budget (AS-PD&B).

Sec. 3 OCS Operational Activities

OCS operational activities refer to the implementation of OCS regulations administered by BLM under 43 CFR, Part 3300 and USGS under 30 CFR, Part 250.

(a) When an OCS area is initially being considered for leasing, the Director, BLM, shall request, pursuant to 43 CFR 3301.2, a Fish and Wildlife resources report from the Director, FWS. Such reports may include but are not limited to:

(1) Information concerning results of periodic studies on problems relating to the impact of mineral exploration and exploitation on estuarine and coastal resources.

(2) Information which relates directly or indirectly to the assessment of potential environmental impact of the administration and supervision of mineral exploration and production on OCS lands by BLM or USGS.

(3) Information useful in the identification and designation of restricted use areas including, but not limited to, Marine Preserves, Marine or Estuarine Sanctuaries and National Wildlife Refuges.

(b) During the period when tracts are evaluated for leasing, the manager of the appropriate OCS Office, BLM, shall obtain the views of the appropriate Regional or Area (Alaska) Director, FWS, concerning the potential effects of oil and gas development on biotic and other resources.

(c) BLM, in the writing of any special lease stipulations that may be required to protect biotic and other resources, shall obtain the advice and participation of FWS and USGS.

(d) BLM will give FWS the opportunity to review Notices of Lease Offer and to make written recommendations thereon, prior to their publication in the Federal Register.

(e) BLM, with the participation of FWS and others as appropriate, will plan the alignment of pipelines which will extend between OCS and onshore locations. The FWS should prepare and submit reports to BLM concerning the potential effects on biotic resources of placement of pipelines along such alignments.

(f) The appropriate Area Oil and Gas Supervisor, USGS, will consult with and receive recommendations from the appropriate Regional or Area (Alaska) Director, FWS and the appropriate OCS Area Manager, BLM:

(1) Prior to issuance of draft OCS orders.

(2) Prior to granting rights of use or easements to lessees to construct and maintain platforms, fixed structures, artificial islands and pipelines on areas of the OCS.

(3) Prior to approval of the design and plan of installation of platforms, fixed structures, artificial islands and pipelines.

(4) Prior to approval of exploratory drilling plans.

(5) Prior to approval of plans of development.

(g) In order to implement the consultative procedures described in Section 3(f) above, USGS will send copies of all relevant documents to the appropriate representatives in FWS and BLM. USGS will defer final action until FWS and BLM have indicated their intention to offer recommendations or until ten days have elapsed, at which time FWS and BLM will be presumed to have no recommendations to offer. If either FWS or BLM has, during this ten-day period, notified USGS of its intention to comment, USGS shall defer final action until the written recommendations are received or until twenty days have elapsed from the date of receiving such notice.

(h) BLM, with the participation of FWS, will design any biological sampling or monitoring plan that may be required in connection with special lease stipulations for the protection of biotic resources.

Sec. 4 Committees

(a) A committee will be formed at the headquarters level consisting of representatives from AS-PD&B, FWS, BLM, USGS and the Solicitor's Office to serve as the formal mechanism for coordination and planning, implementing the provisions in Sections 1 to 3, and providing a forum for exchanging of views among the participants. The chairman of the committee will be the representative of AS-PD&B. Meetings will be scheduled at least monthly and more frequently if necessary, at the call of the chairman. Provision may be made for convening special meetings at the call of any participating agency.

(b) Field-level committees will be formed for Mid-Atlantic, North Atlantic, Gulf of Mexico, Southern California, Alaska and, at the direction of the AS-PD&B, any other regions where OCS field operations are centered and will consist of representatives from all the agencies and offices named in Section 4(a). The field-level committees will serve as the formal field-level mechanism for coordination and planning, implementing the provisions in Sections 1 to 3, and providing a forum for exchanging of views among the participants. The chairmen of the field committees will be appointed by the top ranking field level officials of the involved agencies and offices and meetings will be arranged in the same manner as described for the headquarters committee. For reasons of economy and convenience, the members of the committee may decide to confer by telephone rather than meet as a group.

(c) The committees described in this Section shall be established and operate in accordance with the provisions of 308 DM 4.

Sec. 5 Resolution of Disagreements

If BLM, USGS and FWS disagree for good and sufficient reasons on any of the operational aspects detailed in Section 3, the matter in dispute will be resolved as follows:

(a) If it is a field level issue, it will first be considered together by the appropriate top ranking representatives of BLM, USGS and FWS. If the issue cannot be resolved satisfactorily in this manner, it will be referred for resolution to the concerned Directors at headquarters level.

(b) If it is a policy issue or one which is otherwise handled at headquarters level, the issues will be referred for resolution through the appropriate Assistant Secretaries to AS-PD&B.

Sec. 6 Effective Date

This Order is effective immediately. Its provisions shall remain in effect until the Order is amended, superseded or revoked, whichever occurs first. However, in the absence of the foregoing actions, the provisions of this Order shall terminate on December 31, 1976. A comprehensive review of experience in implementing the Order shall be made by the AS-PD&B by November 30, 1976, with the objective of recommending an appropriate course of action.

/s/ Rogers C. B. Morton
Secretary of the Interior

The pertinent regulations summarized below are found in the Code of Federal Regulations, No. 33, Navigation and Navigable Waters, Part 67, Subpart 67.20.

The varied depths of water and marine commerce traffic routes which exist in the waters over the Outer Continental Shelf, and in other waters, permit the classification of structures according to their location in such waters. The structures in the area seaward of the line of demarcation specified by the Commandant and published in the Federal Register are designated as Class "A". This designation includes OCS platforms.

General requirements for lights specify that structures having a horizontal dimension of over 15 m (50 ft.) on any one side or in diameter, shall be required to have an obstruction light on each corner, or 90° apart in the case of circular structures. Each light is to have a 360° lens. Where two or more obstruction lights are required by the size of the structure they must be in the same horizontal plane and not less than 6 m (20 ft.) above mean high water.

They shall be installed in a manner that will permit a mariner to hold sight of at least one of them until he is within 15 m (50 ft.) of the structure. Class "A" structure lights shall be white, powered from a reliable power source, and display a quick flash characteristic of approximately 60 flashes per minute. The lights shall be of sufficient candlepower to be visible at a distance of 9 km (5 naut. mi.) 90% of the nights of the year, and they shall be displayed at all times between sunset and sunrise local time, commencing at the time construction of the structure is begun.

The fog signal shall have a frequency range above 100 cycles and a loudness level of 55 phons and shall be sounded every 20 seconds (sound two seconds, silent 18 seconds). For Class "A" structures this signal shall have an audible range of not less than 3 km (2 mi.) (under no wind condition) in all directions from the structure it marks, whenever visibility is less than 8 km (5 mi.) in any direction.

Changes in these rules may be permitted upon approval of the District Commander when warranted by circumstances, such as proximity of structures.

Appendix G

PROPOSED OCS OPERATING ORDERS FOR THE U.S. SOUTH ATLANTIC REGION

On December 8, 1975, a draft set of Proposed Operating Orders for the Mid-Atlantic OCS was published in the Federal Register; the Orders issued included 1, 2, 3, 4, 5, 7, and 12. Comments have been received on those Orders and changes made when applicable. The following pages contain the latest draft of the Orders.

These Orders will be finalized prior to a sale in the Mid-Atlantic, if it were to be held. Orders 6, 8, 9, 11, 13, 14, and 15 will be available for Federal and State review prior to the filing of operator's development plans. A proposal to issue OCS Order No. 14 was printed in the Federal Register on December 19, 1975; this has been included in this Appendix. A discussion of all OCS Orders, is included in Section IV. A.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION
EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 1

Effective July 1, 1976

"IDENTIFICATION OF WELLS, PLATFORMS, STRUCTURES, AND SUBSEA OBJECTS"

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.37.

The operator shall comply with the following requirements. All departures from the requirements specified in this Order must be approved pursuant to 30 CFR 250.12(b).

1. *Identification of Fixed Platforms or Structures.* Platforms and structures shall be identified at two diagonal corners by a sign with letters and figures not less than 30 centimetres (12 inches) in height with the following information: The name of lease operator, the area name shown on OCS Official Protraction Diagrams (or, where no name has been assigned, the Protraction Diagram number), the block number in which the platform or structure is located, and the platform or structure designation. The information shall be abbreviated as in the following example:

"The Blank Oil Company operates "C" platform on Block 999 of the Salisbury Area"

The identifying sign on the platform would indicate:

"BOC–SAL–999–C."

2. *Identification of Nonfixed Platforms or Structures.* Floating semi-submersible platforms, bottom-setting mobile rigs, and drilling ships shall be identified by one sign with letters and figures not less than 30 centimetres (12 inches) in height affixed to the derrick so as to be visible from off the vessel and containing the following information: The name of the lease operator, the area designation based on OCS Official Leasing Maps, the block number, the OCS lease number, and the well number.

3. *Identification of Wells.* The OCS lease and well number shall be painted on, or a sign affixed to, each singly completed well. In multiple completed wells each completion shall be individually identified at the well head. All identifying signs shall be maintained in a legible condition.

4. *Identification of Subsea Objects.* All subsea objects resulting from lease operations, and presenting a hazard to navigation or to deployment of commercial fishing devices, shall be identified with navigational markings. Such identification shall be in accordance with a design approved by the Supervisor and shall not be inconsistent with applicable U.S. Coast Guard regulations. These navigational markings shall be maintained on-sight and operable at all times so long as the obstruction remains.

/s/ HARRY A. DUPONT
Area Oil and Gas Supervisor

APPROVED:

RUSSELL G. WAYLAND
Acting Chief, Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION
EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 2
Effective July 1, 1976

DRILLING PROCEDURES

This Order is established pursuant to the authority prescribed in 30 CFR 250.11. All exploratory and development wells drilled for oil and gas shall be drilled in accordance with 30 CFR 250.34, 250.41, 250.91, and the provisions of this Order which shall continue in effect until field drilling rules are issued. When sufficient geologic and engineering information is obtained through exploratory drilling, operators may make application or the Area Supervisor may require an application for the establishment of field drilling rules. After field drilling rules have been established by the Area Supervisor, development wells shall be drilled in accordance with such rules.

All wells drilled under the provisions of this Order shall have been included in an exploratory or development plan for the lease as required under 30 CFR 250.34. Each Application for Permit to Drill (Form 9–331C) shall include all information required under 30 CFR 250.91, and shall include a notation of any proposed departures from the requirements of this Order. All departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

The operator shall comply with the following requirements. All applications for approval under the provisions of this Order shall be submitted to the appropriate District Supervisor. References in this Order to approvals, determinations, or requirements are to those given or made by the Area Supervisor or his delegated representative.

1. *Drilling Platforms and Vessels*

A. All drilling platforms and drilling vessels shall be capable of withstanding the oceanographic and meteorological conditions for the proposed area of operations. The operator must furnish evidence of the fitness of the drilling platform or vessel to perform the planned drilling operation at the proposed drilling location. Applications for drilling from mobile drilling platforms and drilling vessels shall include the following:

(1) Design, drawings, equipment specifications, and performance data.

(2) Operational criteria and a critical operations plan as described in Section 8 of this Order.

(3) Environmental conditions expected.

(4) Current classification or certification of fitness with operational limitations.

B. Prior to commencing operations, all drilling platforms and drilling vessels shall be given a complete inspection by a representative of the U.S. Geological Survey to insure compliance with OCS Orders and regulations.

C. Operators shall collect and report oceanographic, meteorological, and performance data during the period of operations. The type of information and the method of collecting shall be set forth in the proposed plan of operations.

2. *Well Casing and Cementing.* All wells shall be cased and cemented in accordance with the requirements of 30 CFR 250.41(a)(1), and the Application for Permit to Drill shall include the casing design safety factors for collapse, tension, and burst. In cases where cement has filled the annular space back to the ocean floor, the cement may be washed out or displaced to a depth not exceeding 12 metres (40 feet) below the ocean floor to facilitate casing removal upon well abandonment. For the purpose of this Order, the several casing strings in order of normal installation are drive or structural, conductor, surface, intermediate, and production casing.

For the surface, intermediate, and production casing strings, if there are indications of improper cementing such as lost returns, cement channeling, or mechanical failure of equipment, the operator shall recement or make the necessary repairs and run a temperature or cement bond log to verify that the casing has been adequately cemented.

The design criteria for all wells shall consider all pertinent factors for well control, including formation fracture gradients and pressures and casing setting depths. All casing, except drive pipe, shall conform to the specifications contained in "API Spec 5A—Thirty-second Edition, March 1973—Casing, Tubing, and Drill Pipe," as amended by supplement 2, March, 1975, or supplements thereto as approved by Area Supervisor, shall be new pipe or reconditioned used pipe that has been tested to insure that it will meet API specifications for new pipe.

A. *Drive or Structural Casing*. This casing shall be set by drilling, driving, or jetting to a minimum depth of 30 metres (100 feet) below the ocean floor or to such depth, approved by the Supervisor, required to support unconsolidated deposits and to provide hole stability for initial drilling operations. If this portion of the hole is drilled, the drilling fluid shall be of a type that is in compliance with the liquid disposal requirements of OCS Order No. 7, and a quantity of cement sufficient to fill the annular space back to the ocean floor shall be used.

B. *Conductor and Surface Casing*. Casing design and setting depths shall be based upon all engineering and geologic factors, including the presence or absence of hydrocarbons or other potential hazards and water depths.

(1) *Conductor Casing*. This casing shall be set at a depth in accordance with paragraph 2B(3) below. A quantity of cement sufficient to fill the annular space back to the ocean floor shall be used.

(2) *Surface Casing*. This casing shall be set at a depth in accordance with paragraph 2B(3) below and cemented in a manner necessary to protect all freshwater sands and provide well control until the next string of casing is set.

This casing shall be cemented with a quantity sufficient to fill the calculated annular space to at least 460 metres (1,500 feet) above the surface casing shoe and at least 60 metres (197 feet) inside the conductor casing or as approved by the District Supervisor. After drilling a maximum of 30 metres (100 feet) below the surface casing shoe, a pressure test shall be obtained to aid in determining a formation fracture gradient either by testing to formation leak-off or by testing to a predetermined equivalent mud weight. The results of this test and any subsequent tests of the formation shall be recorded on the driller's log and used to determine the depth and maximum mud weight to be used in drilling the intermediate hole.

(3) *Conductor and Surface Casing Setting Depths*. These strings of casing shall be set at the depth specified below, subject to approved variation to permit the casing to be set in a competent bed, or through formations determined desirable to be isolated from the well by pipe for safer drilling operations; provided, however, that the conductor casing shall be set immediately prior to drilling into formations known to contain oil or gas, or, if unknown, upon encountering such formations. These casing strings shall be run and cemented prior to drilling below the specified setting depths. For those wells which may encounter abnormal pressure or conditions and for the initial wells in an area, the District Supervisor may prescribe an additional casing string and the exact setting depths. Except as otherwise may be prescribed, conductor casing setting depths shall be between 90 metres (295 feet) and 300 metres (984 feet) (TVD below ocean floor), and surface casing setting depths shall be between 300 metres (984 feet) and 1,400 metres (4,592 feet) (TVD below ocean floor).

Engineering, geophysical, and geologic data used to substantiate the proposed setting depths of the conductor and surface casings (such as estimated fracture gradients, pore pressures, shallow hazards, etc.) shall be furnished with the Application for Permit to Drill.

C. *Intermediate Casing*. One or more strings of intermediate casing shall be set when required by anticipated abnormal pressure, mud weight, sediment, and other well conditions. The proposed setting depth for intermediate casing will be based on the pressure tests of the exposed formation immediately below the surface casing shoe or on subsequent pressure tests. If before reaching the proposed setting depth, the mud weight has been increased to within 0.06 kg/dm^3 (0.5 ppq) of the equivalent mud weight of the most recent pressure test of the formation below the surface casing shoe, the operator shall discontinue drilling and set an intermediate casing string.

A quantity of cement sufficient to cover and isolate all hydrocarbon zones and to isolate abnormal pressure intervals from normal pressure intervals shall be used. Sufficient cement shall be used to provide annular fill up to a minimum of 150 metres (492 feet) above the zones to be isolated or 150 metres (492 feet) above the casing shoe in cases where zonal coverage is not required. If a liner is used as an intermediate string, the cement shall be tested by a fluid entry or pressure test to determine whether a seal between the liner top and next larger string has been achieved. The test shall be recorded on the driller's log. When such liner is used as production casing, it shall be extended to the surface and cemented to avoid surface casing being used as production casing.

D. *Production Casing*. This string of casing shall be set before completing the well for production. It shall be cemented in a manner necessary to cover or isolate all zones which contain hydrocarbons, but in any case, a calculated volume sufficient to fill the annular space at least 150 metres (492 feet) above the uppermost producible hydrocarbon zone must be used. When a liner is used as production casing, the testing of the seal between the liner top and the next larger string shall be conducted as in the case of intermediate liners. The test shall be recorded on the driller's log.

E. *Pressure Testing of Casing*. Prior to drilling the plug after cementing, all casing strings, except the drive or structural casing, shall be pressure-tested as shown in the table below. The test pressure shall not exceed the internal yield pressure of the casing. The surface casing shall be tested with water in the top 30 metres (100 feet) of the casing. If the pressure declines more than 10 percent in 30 minutes, or if there is other indication of a leak, corrective measures shall be taken until a satisfactory test is obtained.

Casing	*Minimum Surface Pressure*
Conductor	1,400 kilopascals (kPa) (203 psi)
Surface	6,900 kPa (1,000 psi)
Intermediate	10,400 kPa (1,508 psi) or
Liner, and Production	5 kPa/m (0.22 psi/ft.), whichever is greater

After cementing any of the above strings, drilling shall not be commenced until a time lapse of eight hours under pressure for conductor casing string or 12 hours under pressure for all other strings. Cement is considered under pressure if one or more float valves are employed and shown to be holding the cement in place or when other means of holding pressure are used. All casing pressure tests shall be recorded on the driller's log.

3. *Directional Surveys*. Wells are considered vertical if inclination does not exceed three degrees from the vertical. Inclination surveys shall be obtained on all vertical wells at intervals not exceeding 150 metres (492 feet) during the normal course of drilling.

Wells are considered directional if inclination exceeds three degrees from the vertical. Directional surveys giving both inclination and azimuth shall be obtained on all directional wells at intervals not exceeding 150 metres (492 feet) during the normal course of drilling and at intervals not exceeding 30 metres (100 feet) in all angle change portions of the hole.

On both vertical and directional wells, directional surveys giving both inclination and azimuth shall be obtained at intervals not exceeding 150 metres (492 feet) prior to, or upon, setting surface or intermediate casing, liners, and total depth.

Composite directional surveys shall be filed with the District Supervisor. The interval shown will be from the bottom of conductor casing, or, in the absence of conductor casing, from the bottom of drive or structural casing to total depth. In calculating all surveys, a correction from true north to Universal Transverse Mercator-Grid north shall be made after making the magnetic to true north correction.

4. *Blowout Prevention Equipment*. Blowout preventers and related well-control equipment shall be installed, used, and tested in a manner necessary to insure well control. Prior to drilling below the drive pipe or structural casing and until drilling operations are completed, blowout prevention equipment shall be installed and maintained ready for use as follows:

A. General Requirements

(1) *Blowout Prevention Equipment*. Blowout prevention equipment shall consist of an annular and a specific number of ram-type preventers. (Subsea blowout-preventer stacks used with floating drilling vessels shall be equipped with one set of blind-shear rams). The pipe rams shall be of proper size to fit the pipe in use. The bore of all preventers and spools shall be of sufficient size to accommodate the largest equipment that is expected to be run into the casing below the preventers. The working pressure of any blowout preventer shall exceed the maximum anticipated surface pressure to which it may be subjected. Information submitted with the Application for Permit to Drill shall include the maximum anticipated surface pressure and the criteria used to determine this pressure. A fail safe design shall be incorporated into the blowout-prevention system and shall include dual control systems fail safe valving on critical lines and outlets. In addition, for subsea blowout-preventer stacks, a subsea accumulator system is required to provide fast closure of preventers and for cycling all critical functions in case of loss of connection to the surface.

All preventers shall be equipped with:

(a) A hydraulic actuating system that provides sufficient accumulator capacity to close all blowout prevention equipment units with a 50 percent operating fluid reserve at 8300 KPa (1,204 psi). A high pressure nitrogen or other accumulator back-up system shall be provided with sufficient capacity to close all blowout preventers and hold them closed. Locking devices shall be provided on the ram-type preventers.

(b) An operable remote blowout-preventer-control station shall be provided, in addition to the one on the drilling floor.

(c) A drilling spool with side outlets, if side outlets are not provided in the blowout preventer body, shall be installed to provide for a kill line and choke manifold. An auxiliary connection for an emergency kill or choke line shall be provided below any preventer that is in use and not located on the sea floor.

(d) A kill line with a master valve located next to the well. This valve shall not be used for normal opening or closing on flowing fluids. The kill line shall have at least one control valve in addition to the master valve.

(e) A choke manifold equipped with a hydraulic control valve, a master valve, three adjustable chokes of which one shall be a hydraulic adjustable choke, and an accurate pressure gauge. The choke manifold outlets shall be connected in such a manner that the returns may be directed to the mud system or other appropriate storage.

(f) A fill-up line.

(g) The annular type preventer shall be equipped with an alternate control to be used in case the primary controls fail.

(h) All valves, pipes, and fittings upstream of and including the choke manifold that can be exposed to pressure from the wellbore shall be of a pressure rating at least equal to that required of the blowout-prevention equipment.

(2) *Auxiliary Equipment.* The following auxiliary equipment shall also be provided:

(a) A top kelly cock shall be installed below the swivel, and an essentially full-opening kelly cock of such design that it can be run through blowout preventers shall be installed at the bottom of the kelly.

(b) An inside blowout preventer and an essentially full opening drill string safety valve in the open position shall be maintained on the rig floor at all times while drilling operations are being conducted. Valves shall be maintained on the rig floor to fit all pipe that is in the drill string. A safety valve shall be available on the rig floor assembled with the proper connection to fit the casing string that is being run in the hole.

B. *Drive Pipe or Structural Casing.* Before drilling below this string, at lease one remotely controlled, annular-type blowout preventer or pressure-rotating, pack-off-type head and equipment for circulating the drilling fluid to the drilling structure or vessel shall be installed.

When the blowout-preventer system is on the ocean floor, the choke and kill lines or equivalent vent lines, equipped with necessary connections and fittings, shall be used for diversion. An annular preventer or pressure-rotating, pack-off-type head, equipped with suitable diversion lines as described above and installed on top of the marine riser, to permit the diversion of hydrocarbons and other fluids, may be utilized for diversion. The diverter system providing at least the equivalent of two 15 centimetre (6-inch) lines (or equivalent in internal cross-sectional area) and full-open or butterfly valves shall be installed in order to permit the full diversion of hydrocarbons and other fluids. The diverter system shall be equipped with automatic, remote-controlled valves which open prior to shutting in the well, with at least two lines venting in different directions to accomplish downwind diversion. A schematic diagram and operational procedure for the diverter system shall be submitted with the Application for Permit to Drill (Form 9–331C) to the District Supervisor for approval.

In drilling operations where a floating or semi-submersible type of drilling vessel is used and formation competency at the structural casing setting depth is not adequate to permit circulation of drilling fluids to the vessel while drilling conducter hole, a program which provides for safety in these operations shall be described and submitted to the District Supervisor for approval. This program shall include all known pertinent and relevant information, including seismic and geologic data, water depth, drilling-fluid hydrostatic pressure, schematic diagram from rotary table to proposed conductor casing seat, and contingency plan for moving off location. In all areas where shallow hazards or hydrocarbons are unknown, seismic data shall be obtained, and a small-diameter initial pilot hole from the bottom of drive or structural casing to proposed conductor casing seat shall be drilled to aid in determining the presence or absence of these hazards. All seismic data shall be made available to the Supervisor, and an analysis of the geologic hazards shall be furnished with the Application for Permit to Drill.

C. *Conductor Casing*. Before drilling below this string, at least one remotely controlled, annular-type blowout preventer and equipment for circulating the drilling fluid to the drilling structure or vessel shall be installed. A diverter system as described in paragraph 4B above shall be installed.

D. *Surface Casing*. Before drilling below this string, the blowout prevention equipment shall include a minimum of: (1) three remotely-controlled, hydraulically operated blowout preventers, including one equipped with pipe rams, one with blind rams, and one annular type: (Subsea blowout-preventer stacks used with floating drilling vessels shall be equipped with one set of blind-shear rams); (2) a drilling spool with side outlets, if side outlets are not provided in the blowout preventer body; (3) a choke line and manifold; (4) a kill line separate from choke line; and (5) a fill-up line.

E. *Intermediate Casing*. Before drilling below this string, the blowout prevention equipment shall include a minimum of: (1) four remote-controlled, hydraulically operated blowout preventers with a working pressure which exceeds the maximum anticipated surface pressure, including at least two equipped with pipe rams, one with blind rams, and one annular type. (Subsea blowout-preventer stacks used with floating drilling vessels shall be equipped with one set of blind-shear rams); (2) a drilling spool with side outlets, if side outlets are not provided in the blowout preventer body; (3) a choke line and manifold; (4) a kill line separate from choke line; and (5) a fillup line.

F. *Testing*.

(1) *Pressure Test*. Ram-type blowout preventers and related control equipment shall be tested to the rated working pressure of the stack assembly, or at the working pressure of the casing, whichever is the lesser. Annular-type preventers shall be tested to 70 percent of these pressure requirements. They shall be tested: (a) when installed, (b) before drilling out after each string of casing is set, (c) not less than once each week while conducting drilling operations, and (d) following repairs that require disconnecting a pressure seal in the assembly.

(2) *Actuation*. While drill pipe is in use, the ram-type blowout preventers equipped with pipe rams shall be actuated at least once each day. If a tapered drill string is in use, the smaller size rams shall be actuated on the appropriate size pipe, once each trip. The blind rams shall be actuated while out of the hole once each trip. Accumulators or accumulators and pumps shall maintain a pressure capacity reserve at all times to provide for repeated operation of hydraulic preventers. An operable remote blowout-preventer-control station shall be provided in addition to the one on the drilling floor. Each control station will be tested for proper operation once each day when the pipe is out of the hole.

Each control system shall alternately be tested to ensure proper functioning. If either system is not functional, further drilling operations shall be suspended until that system becomes operable.

(3) *Drills*. A blowout-prevention drill shall be conducted weekly for each drilling crew to insure that all equipment is operational and that crews are properly trained to carry out emergency duties.

(4) *Records*. All blowout-preventer tests and crew drills shall be recorded on the driller's log.

(5) *Mud Program*. The characteristics, use, and testing of drilling mud and the conduct of related drilling procedures shall be such as are necessary to prevent the blowout of any well. Quantities of mud materials sufficient to insure well control shall be maintained readily accessible for use at all times.

A. *Mud Control*. Before starting out of the hole with drill pipe, the mud shall be properly conditioned. Proper conditioning requires either circulation with the drill pipe just off bottom to the extent that the annular volume is displaced, or proper documentation in the driller's log prior to pulling the drill pipe that: (1) there was no indication of influx of formation fluids prior to starting to pull the drill pipe from the hole, (2) the weight of the returning mud is not less than the weight of the mud entering the hole, and (3) other mud properties recorded on the daily drilling log are within the specified ranges at the stage of drilling the hole to perform their required functions. In those cases when the hole is circulated, the driller's log shall be so noted.

When coming out of the hole with drill pipe, the annulus shall be filled with mud before the mud level drops 30 metres (100 feet). A mechanical device for measuring the amount of mud required to fill the hole shall be utilized, and any time there is an indication of swabbing, or influx of formation fluids, the necessary safety devices and action shall be employed to control the well. The mud shall not be circulated and conditioned, except on or near bottom, unless well conditions prevent running the drill pipe back to bottom. The mud in the hole shall be circulated or reverse-circulated prior to pulling drill-stem test tools from the hole.

The hole shall be filled by accurately measured volumes of mud. The number of stands of drill pipe and drill collars that may be pulled between the times of filling the hole shall be calculated and posted. The number of barrels and pump strokes required to fill the hole for this designated number of stands of drill pipe and drill collars shall be posted. For each casing string, the maximum pressure which may be applied to the blowout preventer before controlling excess pressure by bleeding through the choke shall be posted near the driller. Drill pipe pressure shall be monitored during the bleeding procedure for well control.

An operable degasser shall be installed in the mud system prior to the commencement of drilling operations and shall be maintained for use throughout the drilling and completion of the well.

B. *Mud Test Equipment*. Mud test equipment shall be maintained on the drilling rig at all times, and mud tests shall be performed once each tour, or more frequently as conditions warrant. Such tests shall be conducted in accordance with procedures outlined in API RP 13B, "Recommended Practice for Standard Procedure for Testing Drilling Fluids," Sixth Edition, April 1976, or subsequent revisions as approved by the Supervisor, and the results recorded and maintained at the drill site. The following mud-system monitoring equipment shall be installed (with derrick floor indicators) and used at the point in the drilling operation when mud returns are established and throughout subsequent drilling operations:

(1) Recording mud pit level indicator to determine mud pit volume gains and losses. This indicator shall include a visual and audio warning device.

(2) Mud volume measuring device for accurately determining mud volumes required to fill the hole on trips.

(3) Mud return indicator to determine that returns essentially equal the pump discharge rate.

(4) Gas-detecting equipment to monitor the drilling mud returns.

C. *Mud Quantities*. The operator shall state in the Application for Permit to Drill the minimum quantities of mud material, including weighting material, to be maintained at the drill site for emergency use. This quantity shall not be less than the amount necessary to make a mud volume equal to twice the calculated capacity of the active down hole and surface mud system. The minimum quantity of weighting material to be maintained at the drill site shall be sufficient to overcome the highest anticipated formation pressure with the mud weight at least one pound per gallon greater than the weight required to overcome such formation pressure. Daily inventories of mud materials, including weighting material, shall be recorded and maintained at the drill site. Drilling operations shall be suspended in the absence of approved minimum quantities of mud materials for emergency use.

6. *Supervision, Surveillance, and Training.*

A. *Supervision.* A representative of the operator shall provide, on site, supervision of drilling operations on a 24-hour basis.

B. *Surveillance*. From the time drilling operations are initiated and until the well is completed or abandoned, a member of the drilling crew or the toolpusher shall maintain rig floor surveillance continuously, unless the well is secured with blowout preventors or cement plugs.

C. *Training*. Company and drilling contractor supervisory personnel including drillers shall be trained in and qualified for present-day well control. Records of such training and qualification shall be maintained at the drill site. Training shall include but is not limited to:

(1) Abnormal pressure detection methods.

(2) Well-control methods and procedures.

The operator shall additionally require well-control training for drillers in addition to the required weekly blowout prevention drills. Written verification of compliance with these provisions shall be filed with the Supervisor. As standards for training are developed for all members of the drilling crew, they will be incorporated into this Order. Compliance shall be considered a prerequisite to approval of any drilling operation.

7. *Hydrogen Sulfide*. When drilling operations are undertaken to penetrate reservoirs known or expected to contain hydrogen sulfide (H_2S), or, if unknown upon encountering H_2S, the preventive measures and operating practices set forth in U.S. Geological Survey Outercontinental Shelf Standard No. 1, (GSS–OCS–1), "Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment," February 1976, shall be followed.

8. *Critical Operations and Curtailment Plans.* Certain operations performed in drilling are more critical than others with respect to well control, fire, explosion, oil spills, and other discharge or emissions. These operations may occur during drilling, running casing, logging, drill-stem testing, well completion, or wire-line operations.

Each operator shall file with the Supervisor for approval of a Critical Operations and Curtailment Plan for the lease, which shall contain:

A. A list or description of the critical drilling operations that are or are likely to be conducted on the lease. Such list or description shall specify the operations to be ceased, limited, or not to be commenced under given circumstances or conditions. The list shall include operations such as:

(1) Drilling in close proximity to another producing well.

(2) Drill-stem testing.

(3) Running and cementing casing.

(4) Cutting and recovering casing.

(5) Logging or wireline operations.

(6) Well-completion operations.

(7) Moving the drilling vessel off location in an emergency; repositioning the vessel on location; and reestablishing entry into the well.

3. A list or description of circumstances or conditions under which such critical operations shall be curtailed. This list or description shall be developed from all the factors and conditions relating to the conduct of operations on the lease, and shall consider but necessarily not be limited to the following:

(1) Whether the drilling operations are to be conducted from mobile or fixed platforms.

(2) The availability and capability of containment and cleanup equipment.

(3) Abnormal or unusual characteristics expected to be encountered during drilling operations.

(4) Spill control system response time.

(5) Known or anticipated meteorological or oceanographical conditions.

(6) Availability of personnel and equipment for the particular operation to be conducted.

(7) Other factors peculiar to the particular lease under consideration.

C. When any such circumstance or condition listed or described in the plan occurs or other operational limits are encountered, the operator shall notify the Supervisor and shall curtail the critical operations as set forth under A above. In the conduct of the critical operations, full consideration shall be given to pertinent factors such as supply of well control materials, subsurface conditions, inventory of spill-containment equipment, weather conditions, particular esthetic conditions, fire hazards, available transportation equipment spill-control response time, and nature of work planned.

D. Any deviations in the plan shall require prior approval by the Supervisor except in case of an emergency in which event the Supervisor shall be notified as soon as possible.

E. The operator shall review the plan at least annually. Notification of the review and any amendments or modifications to the plan shall be filed with the Supervisor.

/s/ HARRY A. DUPONT
Area Oil and Gas Supervisor

APPROVED:

RUSSELL G. WAYLAND
Chief, Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION
EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 3

Effective

PLUGGING AND ABANDONMENT OF WELLS

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.15. The operator shall comply with the following minimum plugging and abandonment procedures which have general application to all wells drilled for oil and gas. Plugging and abandonment operations must not be commenced prior to obtaining approval from an authorized representative of the Geological Survey. Oral approvals shall be in accordance with 30 CFR 250.13. All departures from the requirements specified in this Order must be approved pursuant to 30 CFR 250.12(b).

1. *Permanent Abandonment.*

A. *Isolation in Uncased Hole.* In uncased portions of wells, cement plugs shall be spaced to extend 30 meters (100 feet) below the bottom to 30 meters (100 feet) above the top of any oil, gas, and fresh water zones so as to isolate them in the strata in which they are found and to prevent them from escaping into other strata. Additional cement plugs may be required to protect other minerals, or to prevent migration of fluids in the well bore. No more than 762 meters (2,500 feet) of uncased hole shall be left without a cement plug of at least 30 meters (100 feet) in length in wells requiring a mud weight in excess of 1.44 kg/decimeters (12.0 ppg) for control.

B. *Isolation of Open Hole.* Where there is open hole (uncased and open into the casing string above) below the casing, a cement plug shall be placed in the deepest casing string by (1) or (2) below, or in the event lost circulation conditions exist or are anticipated, the plug may be placed in accordance with (3) below:

(1) A cement plug placed by displacement method so as to extend a minimum of 30 meters (100 feet) above and 30 meters (100 feet) below the casing shoe.

(2) A cement retainer with effective back pressure control set not less than 15 meters (50 feet), nor more than 30 meters (100 feet), above the casing shoe with a cement plug calculated to extend at least 30 meters (100 feet) below the casing shoe and 15 meters (50 feet) above the retainer.

(3) A permanent type bridge plug set within 46 meters (150 feet) above the casing shoe with 15 meters (50 feet) of cement on top of the bridge plug. This plug shall be tested prior to placing subsequent plugs.

C. *Plugging or Isolating Perforated Intervals.* A cement plug shall be placed opposite all open perforations (perforations not squeezed with cement) extending a minimum of 30 meters (100 feet) above and 30 meters (100 feet) below the perforated interval or down to a casing plug, whichever is less. In lieu of the cement plug, the following two methods are acceptable, provided the perforations are isolated from the hole below:

(1) A cement retainer with effective back pressure control set not less than 15 meters (50 feet) nor more than 30 meters (100 feet) above the top of perforated interval with a cement plug calculated to extend at least 30 meters (100 feet) below the bottom of the perforated interval and 15 meters (50 feet) above the retainer.

(2) A permanent type bridge plug set within 46 meters (150 feet) above the top of the perforated interval with 15 meters (50 feet) of cement on top of the bridge plug.

D. *Plugging of Casing Stubs.* If casing is cut and recovered, a cement plug 61 meters (200 feet) in length shall be placed to extend 30 meters (100 feet) above and 30 meters (100 feet) below the stub. A retainer may be used in setting the required plug.

E. *Plugging of Annular Space*. No annular space that extends to the ocean floor shall be left open to drilled hole below. If this condition exists, the annulus shall be plugged with cement.

F. *Surface Plug Requirement*. A cement plug of at least 46 meters (150 feet), with the top of the plug 46 meters (150 feet) or less below the ocean floor, shall be placed in the smallest string of casing which extends to the surface.

G. *Testing of Plugs*. The setting and location of the first plug below the top 46-meter (150-foot) plug, will be verified by either (1) placing a minimum pipe weight of 6,800 kilograms (15,000 pounds) on the plug, or where this plug is placed utilizing a cement retainer or bridge plug, it is only necessary that the setting of the retainer or bridge plug be verified by placing at least 6,800 kilograms (15,000 pounds) on it prior to placing cement on top, or (2) testing with a minimum pump pressure of 6,894 kPA (1,000 psi) with no more than a 10 percent pressure drop during a 15-minute period.

H. *Mud*. Each of the respective intervals of the hole between the various plugs shall be filled with mud fluid of sufficient density to exert hydrostatic pressure exceeding the greatest formation pressure encountered while drilling such interval.

I. *Clearance of Location*. All casing and piling shall be severed and removed to that depth below the ocean floor approved by the area Supervisor after a review of data on the ocean bottom conditions. The operator shall verify that the location has been cleared of all obstructions.

2. *Temporary Abandonment*. Any drilling well which is to be temporarily abandoned shall be mudded and cemented as required for permanent abandonment except for requirements F and I of section 1 above. When casing extends above the ocean floor, a mechanical bridge plug (retrievable or permanent) shall be set in the casing between 4.6 and 61.0 meters (15 and 200 feet) below the ocean floor.

/s/ HARRY A. DUPONT
Area Oil and Gas Supervisor

APPROVED:

/s/ RUSSELL G. WAYLAND
Chief, Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION
EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 4

Effective

SUSPENSIONS AND DETERMINATION OF WELL PRODUCIBILITY

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.12(d)(1). An OCS lease provides for extension beyond its primary term for as long as oil or gas may be produced from the lease in paying quantities. The term "paying quantities" as used herein means production in quantities sufficient to yield a return in excess of operating costs. An OCS lease may be maintained beyond the primary term, in the absence of actual production, when a suspension of production has been approved. All applications for suspension of production for an initial period should be submitted prior to the expiration of the term of a lease. The Area Supervisor may approve a suspension of production provided at least one well has been drilled on the lease and determined to be capable of producing in paying quantities. The temporary or permanent abandonment of a well will not preclude approval of a suspension of production as provided in 30 CFR 250.12(d)(1). All departures from the requirements specified in this Order must be approved pursuant to 30 CFR 250.12(b).

To provide data necessary to determine that a well may be capable of producing in paying quantities, the following are minimum requirements:

1. *Oil Wells.* A production test of at least two hours duration, following stabilization of flow.
2. *Gas Wells.* A deliverability test of at least two hours duration, following stabilization of flow, or a four-point back-pressure test.
3. *Well Data.* All pertinent engineering, geologic, and economic data shall be submitted to the District Supervisor and will be considered in determining whether or not a well is capable of being produced in paying quantities.
4. *Witnessing and Results.* All tests must be witnessed by an authorized representative of the Geological Survey. Test data accompanied by operator's affidavit, or third-party test data, may be accepted in lieu of a witnessed test provided prior approval is obtained from the District Supervisor.

/s/ Harry A. DuPont
Area Oil and Gas Supervisor

/s/ Russell G. Wayland
Chief, Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION

EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 5

Effective

SUBSURFACE SAFETY DEVICES

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.41(b). The operator shall comply with the following requirements. All departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b). All applications for approval under the provisions of this Order shall be submitted to the District Supervisor. Reference in this Order to approvals, determinations, or requirements are to those given or made by the Area Supervisor or his delegated representative.

1. *Installation.* All tubing installations open to hydrocarbon-bearing zones shall be equipped with a surface-controlled subsurface safety device. The surface controls may be located onsite or remotely. The device is to be installed at a depth of 30 metres (100 feet) or more below the ocean floor unless, after application and justification, the well is determined to be incapable of flowing. These installations shall be made within two days after stabilized production is established. The well shall not be left unattended while open to production before a subsurface safety device is installed.

A. *Shut-in Wells.* A tubing plug shall be installed in lieu of, or in addition to, other subsurface safety devices if a well has been shut in for a period of six months. Such plugs shall be set at a depth of 30 metres (100 feet) or more below the ocean floor and shall be of the pump-through type. All wells perforated and completed, but not placed on production, shall be equipped with a subsurface safety device or tubing plug within two days after completion.

B. *Injection Wells.* Surface controlled subsurface safety devices shall be installed in all injection wells unless, after application and justification, it is determined that the well is incapable of flowing which condition shall be verified annually.

2. *Design, Testing, and Inspection.* Subsurface safety devices shall be designed, adjusted, installed, and maintained to insure reliable operation. During testing and inspection procedures, the well shall not be left unattended while open to production unless a properly operating subsurface safety device has been installed in the well.

A. *Surface-Controlled Subsurface Safety Devices.*

(1) *Quality Assurance and Performance.* The operator shall use subsurface safety devices that comply with the minimum standards set forth in "API Spec 14 A, First Edition, October 1973, Subsurface Safety Valves," as amended by supplement 2, February, 1976 or supplements thereto as approved by the Area Supervisor, for quality assurance including design, material, and functional test requirements, and for verification of independent party performance testing and manufacturer functional testing of such valves.

(2) *Installation and Testing.* The operator shall comply with the minimum recommended practices set forth in "API RP 14 B, First Edition, October 1973, Design, Installation, and Operation of Subsurface Safety Valve Systems," or supplements thereto as approved by the Area Supervisor, which contain procedures for design calculations, safe installation, and operating and testing. Each surface-controlled subsurface safety device installed in a well shall be tested in place for proper operation when installed, or reinstalled, at least monthly for the next six months and quarterly thereafter. If the device does not operate properly, it shall be promptly removed, repaired, and reinstalled or replaced and tested to insure proper operation.

B. *Tubing Plugs*. A shut-in well equipped with a tubing plug shall be inspected for leakage by opening the well to possible flow at intervals not exceeding six months. If sustained liquid flow exceeds 400 cm^3/min (.014 ft^3/min) or gas flow exceeds 425 dm^3/min (15 ft^3/min), the plug shall be promptly removed, repaired, and reinstalled or an additional tubing plug installed to prevent leakage.

3. *Temporary Removal*. Each wireline or pumpdown-retrievable subsurface safety device may be removed, without further authorization or notice, for a routine operation which does not require approval of a Sundry Notice and Report on Wells (Form 9–331) for a period not to exceed fifteen days. The well shall be clearly identified as being without a subsurface safety device and shall not be left unattended while open to production. The provisions of this paragraph are not applicable to the testing and inspection procedures specified in section 2 (Design, Testing, and Inspection) above.

4. *Additional Protective Equipment*. All tubing installations in which a wireline or pumpdown-retrievable subsurface safety device is to be installed shall be equipped with a landing nipple, with flow couplings or other protective equipment above and below, to provide for setting of the subsurface safety device. All wells in which a subsurface safety device or tubing plug is installed shall have the tubing-casing annulus packed off above the uppermost open casing perforations, and at least 30 metres (100 feet) below the measured top of cement on the production string or the intermediate string. The control system for all surface-controlled subsurface safety devices shall be an integral part of the platform shut-in system.

5. *Departures*. All departure applications will be considered for approval pursuant to 30 CFR 250.12(b) and the requirements of this Order. All applications for departures shall include a detailed statement of the well conditions, efforts made to overcome any difficulties, and proposed alternate safety measures.

6. *Emergency Action*. All tubing installations open to hydrocarbon-bearing zones and not equipped with a subsurface safety device as permitted by this Order shall be clearly identified as not being so equipped, and a subsurface safety device or tubing plug shall be available at the field location. In the event of an emergency, such device or plug shall be promptly installed, due consideration being given to personnel safety.

7. *Records*. The operator shall maintain the following records for a minimum period of one year for each subsurface safety devices and tubing plug installed, and these records shall be available to any authorized representative of the Geological Survey.

A. *Field Records*. Individual well records shall be maintained at or near the field and shall include, as a minimum, the following information:

(1) A record which will give design and other information; i.e., make, model, type, spacers, bean and spring size, pressure, etc.

(2) Verification of assembly by a qualified person in charge of installing the device and installation date.

(3) Verification of setting depth and all operational tests as required in this Order.

(4) Removal date, reason for removal, and reinstallation date.

(5) A record of all modifications of design in the field.

(6) All mechanical failures or malfunctions, including sand cutting, of such devices, with notation as to cause or probable cause.

(7) Verification that failure report was submitted.

B. *Other Records*. The following records, as a minimum shall be maintained at the operator's office:

(1) Verified design information of subsurface safety devices for the individual well.

(2) Verification of assembly and installation according to design information.

(3) All failure reports.

(4) All laboratory analysis reports of failed or damaged parts.

(5) Quarterly failure-analysis report.

8. *Reports*. Well completion reports (Form 9–330) and any subsequent reports of workover (Form 9–331) shall include the type and the depth of the subsurface safety devices and tubing plugs installed.

To establish a failure-reporting and corrective-action program as a basis for reliability and quality control, each operator shall submit a quarterly failure-analysis report to the Area Supervisor, identifying mechanical failures by lease and well, make and model, cause or probable cause of failure, and action taken to correct the failure. The report shall be submitted within 30 days following the periods ending December 31, March 31, June 30, and September 30 of each year.

/s/ HARRY A. DUPONT
Area Oil and Gas Supervisor

APPROVED:

/s/ RUSSELL G. WAYLAND
Chief, Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION
EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 7

Effective

POLLUTION AND WASTE DISPOSAL

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.43. The operator shall comply with the following requirements. All departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *Pollution Prevention.* In the conduct of all oil and gas operations, the operator shall prevent pollution of the ocean. Furthermore, the disposal of waste materials into the ocean shall not create conditions which will adversely affect the public health, life or property, aquatic life or wildlife, recreation, navigation, or other uses of the ocean.

A. *Liquid Disposal.*

(1) Drilling mud containing free oil shall not be disposed of into the ocean.

(2) The operator shall submit with the Application for Permit to Drill (Form 9–331C) a detailed list of drilling mud components including the common chemical or chemical trade name of each component, and a list of the drilling mud additives anticipated for use in meeting special drilling requirements. Disposal of drilling mud shall be by methods which will minimize the adverse effects to marine life. These methods shall not be inconsistent with applicable Federal Regulations. Approval of drilling mud disposal procedures will be site specific and on a case-by-case basis.

(3) Curbs, gutters, and drains on platforms and structures shall be installed and maintained in accordance with the provisions of OCS Order No. 8.

(4) Discharges from fixed structures including sanitary waste, produced water, and deck drainage are subject to Environmental Protection Agency permitting procedures pursuant to the Federal Water Pollution Control Act as amended.

B. *Solid Waste Disposal.*

(1) Drill cuttings, sand, and other solids containing oil shall not be disposed of into the ocean unless all of the free oil has been removed.

(2) Mud containers and other similar solid waste materials shall be incinerated or transported to shore for disposal in accordance with Federal, State, or local requirements.

2. *Personnel, Inspections and Reports.*

A. *Personnel.* The operator's personnel shall be thoroughly instructed in the techniques of equipment maintenance and operation for the prevention of pollution. Nonoperator personnel shall be informed in writing, prior to executing contracts, of the operator's obligations to prevent pollution.

B. *Pollution Inspection Schedules.* Operators shall inspect their facilities as follows:

(1) Manned facilities shall be inspected daily.

(2) Unattended facilities, including those equipped with remote control and monitoring systems, shall be inspected at frequent intervals. The District Supervisor may prescribe the frequency of inspections for these facilities.

(3) All production facilities, such as separators, tanks, treaters, and other equipment shall be designed to prevent pollution. Maintenance or repairs necessary to prevent pollution of the ocean shall be undertaken immediately.

C. *Pollution Reports.* All pollution reports required shall be submitted on Form 9–1880, entitled Pollution Report.

(1) All spills of oil and liquid pollutants shall be recorded showing the cause, size of spill, and action taken, and the record shall be maintained and available for inspection by the District Supervisor. All spills of less than 2.5 cubic metres (15 barrels) shall be reported orally to the District

Supervisor within 12 hours and shall be confirmed in writing.

(2) All spills of oil and liquid pollutants of 2.5 to 8 cubic metres (15 to 50 barrels) shall be reported orally to the District Supervisor within four (4) hours and shall be confirmed in writing.

(3) All spills of oil and liquid pollutants of more than 8 cubic metres (50 barrels) shall be reported orally without delay to the District Supervisor and the Coast Guard. All oral reports shall be confirmed in writing. The District Supervisor shall notify the Governor, or his designee, of all such spills without delay.

(4) Operators shall notify each other upon observation of equipment malfunction or pollution resulting from another's operation.

3. *Pollution Control Equipment and Oil Spill Contingency Plan.*

A. *Equipment*. Standby pollution control equipment and materials shall be maintained by, or shall be available to, each operator at an offshore or onshore location. This shall include containment booms, skimming apparatus, cleanup materials and chemical agents, and shall be available prior to the commencement of operations. No chemicals shall be used without prior approval of the Area Supervisor. The equipment and materials shall be inspected monthly and maintained in good condition for use. The results of the inspections shall be recorded and maintained at the site.

B. *Oil Spill Contingency Plan*. The operator shall submit an oil spill contingency plan for approval by the Area Supervisor before consideration can be given to approval of an application for permit to conduct operations. This plan shall contain the following:

(1) Provisions to assure that full resource capability is known and can be committed during an oil discharge situation including the identification and inventory of applicable equipment, materials, and supplies which are available locally and regionally, both committed and uncommitted, and the time required for deployment.

(2) Provisions for varying degrees of response effort depending on the severity of the oil discharge.

(3) Establishment of notification procedures for the purpose of early detection and timely notification of an oil discharge including a current list of names, telephone numbers, and addresses of the responsible persons and alternates on call to receive notification of an oil discharge, as well as the names, telephone number, and addresses of regulatory organizations and agencies to be notified when an oil discharge is discovered.

(4) Provisions for well defined and specific actions to be taken after discovery and notification of an oil discharge including:

(a) Specification of an oil discharge response operating team consisting of trained, prepared and available operating personnel.

(b) Predesignation of an oil discharge response coordinator who is charged with the responsibility and delegated commensurate authority for directing and coordinating response operations.

(c) A preplanned location for an oil discharge response operations center and a reliable communications system for directing the coordinated overall response operations.

4. *Spill Control and Removal*. Immediate corrective action shall be taken in all cases where pollution has occurred. Corrective action taken under the Oil Spill Contingency Plan shall be subject to modification when directed by the Area Supervisor. The primary jurisdiction to require corrective action to abate the source of pollution and to enforce the subsequent cleanup by the lessee or operator shall remain with the Area Supervisor pursuant to the provisions of this Order and the memorandum of understanding between the Department of Transportation (U.S. Coast Guard) and the Department of the Interior (U.S. Geological Survey) dated August 16, 1971.

Annual Contingency Plan Assessment. Annual contingency plan assessments will be conducted in conjunction with the Plan of Development review. Upon request of the Area Supervisor, revised contingency plans reflecting changes in personnel, equipment, and methods shall be submitted.

/s/ HARRY A. DUPONT
Area Oil and Gas Supervisor

APPROVED:

/s/ RUSSELL G. WAYLAND
Chief, Conservation Division

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY—CONSERVATION DIVISION
EASTERN AREA

SOUTH ATLANTIC OCS ORDER NO. 12

Effective

PUBLIC INSPECTION OF RECORDS

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.97 and 43 CFR Part 2. Requests for information made under the Freedom of Information Act, 5 U.S.C. sec. 552, will be governed by the provisions of 43 CFR Part 2 (40 F.R. 7304, February 19, 1975). Section 2.13 of 43 CFR says:

It is the policy of the Department of the Interior to make the records of the Department available to the public to the greatest extent possible, in keeping with the spirit of the Freedom of Information Act.

Section 2.15(c) of 43 CFR says:

A request for a record may be denied only if it is determined that (1) the record is exempt from disclosure (under the Freedom of Information Act) and (2) that withholding of the record is required by statute or Executive Order or supported by sound grounds.

The operator shall comply with the following requirements. All departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *Availability of Records*. It has been determined that certain records pertaining to leases and wells in the Outer Continental Shelf and submitted under 30 CFR 250 shall be made available for public inspection, as specified below, in the Area office. Certain other portions of these records have been determined to be exempt from disclosure. The reason for these exemptions is discussed in Section 4 of this Order.

A. *Form 9–152—Monthly Report of Operations*: All information contained on this form shall be available except the information required in the Remarks column.

B. *Form 9–330—Well Completion or Recompletion Report and Log*.

(1) Prior to commencement of production, all information contained on this form shall be available, except Item 1a, Type of Well; Item 4, Location of Well, at top production interval reported below: Item 22, if Multiple Completion, How many; Item 24, Producing Interval; Item 26, Type Electric and Other Logs Run; Item 28, Casing Record; Item 29, Liner Record; Item 30, Tubing Record; Item 31, Perforation Record; Item 32, Acid, Shot, Fracture, Cement Squeeze, etc.; Item 33, Production; Item 37, Summary of Porous Zones; and Item 38, Geologic Markers.

(2) After commencement of production, all information shall be available, except Item 37, Summary of Porous Zones; and Item 38, Geologic Markers.

(3) If production has not commenced after an elapsed time of five years from the date of filing Form 9-330 as required in 30 CFR 250.38(b), all information contained on this form shall be available, except Item 37, Summary of Porous Zones; and Item 38, Geologic Markers. Within 90 days prior to the end of the 5-year period, the lessee or operator shall file a Form 9-330 containing all information requested on the form, except Item 37, Summary of Porous Zones; and Item 38, Geologic Markers, to be made available for public inspection. Objections to the release of such information may be submitted with the completed Form 9-330.

C. *Form 9–33l—Sundry Notices and Report on Wells*.

(1) When used as a "Notice of Intention to" conduct operations, all information contained on this form shall be available, except Item 4, Location of Well, at top production interval; and Item 17, Describe Proposed or Completed Operations.

(2) When used as a "Subsequent Report of" operations, and after commencement of

production, all information contained on this form shall be available, except information under Item 17 as to subsurface locations and measured and true vertical depths for all markers and zones not placed on production.

D. *Form 9–331C—Application for Permit to Drill, Deepen or Plug Back.* All information contained on this form, and location plat attached thereto, shall be available except Item 4, Location of Well at Proposed Production Zone; and Item 23, Proposed Casing and Cementing Production Program.

E. *Form 9–1869—qarterly Oil Well Test Report.* All information contained on this form shall be available.

F. *Form 9–1870—Semi-Annual Gas Well Test Report.* All information contained on this form shall be available.

G. *Multi-point Back Pressure Test Report.* All information contained on this form used to report the results of required multi-point back pressure test of gas wells shall be available.

H. *Sales of Lease Production.* Information contained on monthly Geological Survey computer printout showing sales volumes, value, and royalty of production of oil, condensate, gas and liquid products, by lease, shall be made available.

2. *Filing of Reports.* All reports on Forms 9–152, 9–330, 9–331, 9–331C, 9–1869, 9–1870, and the forms used to report the results of multi-point back pressure tests, shall be filed in accordance with the following: All reports submitted on these forms shall include a copy with the words "Public Information" shown on the lower right-hand corner. All items on the form not marked "Public Information" shall be completed in full; and such forms, and all attachments thereto, shall not be available for public inspection. The copy marked "Public Information" shall be completed in full, except that the items described in 1(A), (B), (C), and (D) above, and the attachments relating to such items, may be excluded. The words "Public Information" shall be shown on the lower right-hand corner of this set. This copy of the form shall be made available for public inspection.

3. *Availability of Inspection Records.* All accident investigation reports, pollution incident reports, facilities inspection data, and records of enforcement actions are also available for public inspection.

4. *Information Exempt from Public Inspection.* It has been determined that certain information as discussed in paragraphs 1.A, 1.B, 1.C, 1.D, and 2 of this Order is exempt from disclosure under exemption 9 of the Freedom of Information Act (5 U.S.C. 552(b)(9)). This information has been determined to qualify as "geological and geophysical information and data including maps concerning wells."

/s/ HARRY A. DUPONT
Area Oil and Gas Supervisor

APPROVED:

/s/ RUSSELL G. WAYLAND
Chief, Conservation Division

Appendix H

TITLE 30 CODE OF FEDERAL REGULATIONS PART 250.34 DRILLING AND DEVELOPMENT PROGRAM

FROM FEDERAL REGISTER VOL. 40, NO. 213—TUESDAY, NOVEMBER 4, 1975

CHAPTER II - GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Part 250—Oil and Gas Sulphur Operations in the Outer Continental Shelf

DRILLING AND DEVELOPMENT PROGRAMS

On pages 42559 and 42560 of the September 15, 1975, edition of the Federal Register (40 FR 42559-42560) there was published a proposal to modify regulation 30 CFR 250.34, Drilling and Development Programs. Page 43036 of the September 18, 1975, edition (40 FR 43036) contained a correction. The intent of the proposed modification is to set forth procedures for State consideration of developments proposed by lessees of Federal Outer Continental Shelf Lands. The proposed modification will provide affected States with information and an opportunity to review and comment concerning developments of oil and gas by such lessees. Lessees will be required to deliver information on planned developments to affected States before submitting development plans to the U.S. Geological Survey.

The regulation recognizes that development plans often contain information which the lessee considers to be confidential. Two specific classes of information often contained in development plans are exempted from disclosure under the Freedom of Information Act. These will not be disclosed under the proposed modification.

The Outer Continental Shelf Lands Act (43 U.S.C. 1331-1343) provides in section 5(b) (2) that leases may be cancelled for failure to comply with "regulations issued under this Act and in force and effect on the date of issuance of the lease". In keeping with this provision, the revised regulation 30 CFR 250.34 herein promulgated will be applicable only to leases issued after the date of this rulemaking.

Interested persons were given until October 15, 1975, to submit comments regarding the proposed modification of 30 CFR 250.34. The notice of the proposed modification indicated that significant comments would be published at the time of the final rulemaking. Because of the volume of the comments received, they are not published herein but are available on request from the Director of the U.S. Geological Survey, National Center, Reston, Virginia 22092. The comments received represented a wide range of views on the necessity, value, legality and consequences of the proposed modification.

After considering the comments received the following revisions were made in the proposed modifications:

1. Added provisions to paragraphs (b) and (c) allowing States to waive review of development plans and receipt of information.
2. Added provisions to paragraphs (b) and (c) requiring that Governors' comments on development plans and information be sent to both the Supervisor and the lessee.
3. Added a procedure to paragraph (b) for treatment of amendments to development plans made before their approval.
4. Clarified requirements for information under paragraph (c). (Further clarification will be forthcoming in relevant OCS Orders).
5. Added a provision to paragraph (c) which allows previously published information to be incorporated by reference rather than duplicated in the information for States.
6. Added a provision to paragraph (c) providing for extension of the term of the lease in cases where review requires delays in excess of the 60-day period.
7. Added to paragraph (e) the condition that the Supervisor determine that proposed modifications of approved development plans significantly affect the interest of a State before requiring that the procedures under paragraphs (b) and (c) be applied.

The proposed modification to 30 CFR 250.34 is adopted as set forth below and is effective immediately. OCS Orders will be issued subsequently to define more specifically the content and timing of information to be provided by lessees to the States.

/s/ THOMAS S. KLEPPE,
Secretary of the Interior

OCTOBER 31, 1975

Section 250.34 is revised to read as follows:

NO. 250.34 DRILLING AND DEVELOPMENT PROGRAMS.

(a) Exploratory drilling plan. Prior to commencing each exploratory drilling program on a lease, including the construction of platforms, the lessee shall submit a plan to the Supervisor for approval. Each plan for the leased area shall include (1) a description of drilling vessels, platforms, or other structures showing the location, the design, and the major features thereof, including features pertaining to pollution prevention and control; (2) the general location of each well including surface and projected bottom hole location for directionally drilled wells; (3) structural interpretations based on available geological and geophysical data; and (4) such other pertinent data as the Supervisor may prescribe.

(b) Development plan. Prior to commencing each development program on a lease, the lessee shall submit a plan to the Supervisor for approval. The plan shall include all information specified in paragraph (a) of this section in detail. The development plan except for those portions which the lessee shall designate, with the Supervisor's approval as (1) trade secrets and commercial or financial information which are privileged or confidential or (2) geological and geophysical information, data and maps concerning wells, shall be provided by the Supervisor to the Governors of directly affected States, as designated by the Supervisor. Any State not wishing to review a development plan may so indicate to the Supervisor. Prior to the Supervisor's approval of the plan, a period of 60 days, commencing with the date of the Governor's receipt of the development plan, shall be provided to each Governor for review of the plan and the submission of comments, to both the Supervisor and the lessee. If the Governors' comments are received before the 60 day period ends, the Supervisor may then proceed to act upon the plan without further delay. After the 60 day period ends, the Supervisor may act upon the plan even if comments have not been received from the Governor. Amendments to development plans may be submitted during the period before this approval. Such amendments shall be sent by the Supervisor to the Governors who have received copies of the development plans. In such cases, the Supervisor shall determine if the amendment is significant and warrants an extension of the 60 day review period.

(c) Information for States. Prior to submission of a development plan, the lessee shall deliver to the Governor of each directly affected State, as designated by the Supervisor, information about the development to be proposed. Any State not wishing to have such information may so indicate to the Supervisor. The final delivery of such information shall be made at least 30 days before submission of the relevant development plan, at which time the lessee shall notify both the Governor of each directly affected State and the Supervisor that such final delivery has been made. When submitting a development plan, the lessee shall certify to the Supervisor that he has, at least 30 days before such submission, provided the required information about the development proposed in that plan to the Governor of each directly affected State. The information provided to the States under this paragraph (c) which is not to be a part of the development plan itself, shall include a description of all offshore and onshore facilities and operations proposed by the lessee or directly related to the proposed development including location, size, requirements for land, labor, materials and energy, and timing of development and operation, and other related information as may be required by the Supervisor. Information available in previously published documents, such as Environmental Impact Statements, may be incorporated by reference. Copies of all information given to Governors under this paragraph shall be provided to the Supervisor. A State provided such information shall indicate to the Supervisor and to the lessee at the earliest practicable time whether the State concurs that the information meets the requirements of this paragraph and any subsequent implementing Orders issued by the Supervisor. If a State fails to provide such notification within 30 days after the final delivery of the information, the State's concurrence will be conclusively presumed. If a State notifies the Supervisor that the information does not in its judgment satisfy the requirements, then the Director shall review the information, the specific comments of the Governor, and the position of the lessee and shall make a determination either that the information satisfies the requirements or that the lessee must provide additional information. The Director shall make his review and determination as expeditiously as possible after receipt of such notification. In the event the Director determines that the information satisfies the requirements, then the 60 day period for comments shall begin on the date of his determination. In the event the Director determines that the requirement has not been satisfied, the 60 day comment period will not begin until the State shall have received the additional information required. If, with respect to any non-producing lease, the procedures specified under paragraphs (B) and (C) require delay in excess of the 60 days for review specified in those paragraphs, and the delay is in the interest of conservation and is not caused by the lessee, there shall, if the lessee so requests, be a suspension of operations for a period equal to the delay in excess of 60 days and the lease shall be extended for a period of time equal to the period of suspension.

(d) Drilling applications. Prior to commencing drilling operations either under an exploratory or development plan, the lessee shall submit an Application for Permit to Drill (Form 9-331C) to the Supervisor for approval. The application shall include the integrated blowout prevention, mud, casing and cementing program for the well, and shall meet the requirements specified in No. 250.41(a), and contain the information specified in No. 250.91(a), and shall conform with the approved exploratory or development plan.

(e) Modifications. The lessee shall submit: (1) All requests for modifications of an approved exploratory or development plan in writing to the Supervisor for approval and (2) all notices of changes to plans set forth in approved Application for Permit to Drill on Sundry Notices and Reports on Wells (Form 9-331), except that these requirements shall not relieve the lessee from taking appropriate action to prevent or abate damage, waste, or pollution of any natural resource or injury to life or property. When the Supervisor shall determine that the proposed modification of an approved development plan is major and would directly and significantly affect the interest of a State, he shall require the lessee to follow the same procedures with respect to the State as those provided in No. 250.34(b) and (c).

Appendix I

INFLUENCES OF PETROLEUM HYDROCARBONS AND HEAVY METALS ON MARINE FOOD WEBS

APPENDIX I

THE INFLUENCES OF PETROLEUM HYDROCARBONS AND HEAVY METALS ON MARINE FOOD WEBS

1. Biogenic and Petroleum Hydrocarbons
2. Uptake of Petroleum Hydrocarbons and Heavy Metals
3. Storage and Metabolism
4. Discharge or Depuration
5. Food Web Magnification
6. Microbial Decomposition
7. Carcinogenicity
8. Heavy Metals
9. Bibliography

1. Biogenic and Petroleum Hydrocarbons

Marine organisms contain and synthesize hydrocarbons under natural conditions. Some of the biogenic hydrocarbons which are important to the survival of the organism can be the same as or similar to the petroleum hydrocarbons (PHC) found in crude or refined oil. This fact has several implications. The detection of the origin of hydrocarbons can be difficult for the analytical chemist. Misidentification by consuming organisms or interference with chemical cues can have pronounced ecological effects. Because many petroleum hydrocarbons are natural components of the biosystem, they may be incorporated in the system without the interference or harm caused by others such as chlorinated hydrocarbons. Other petroleum hydrocarbons, however, may cause harm or interference with certain biological processes.

Examination of crude oils and most refined products indicates that they are extremely complex mixtures of organic compounds of which hydrocarbons comprise the most numerous and abundant fractions.

In their extensive literature review, Anderson, Clark and Stegeman (1974) indicated some basic differences between biogenic and petroleum hydrocarbons. Crude oil and oil products are varied mixtures that contain molecules of different size in fairly even distribution ratios. Conversely, organisms possess specific biosynthetic pathways which favor the production of hydrocarbons in preferred and consequently narrower size ranges. Petroleum hydrocarbons are rich in toxic aromatic hydrocarbons and cycloparaffins. They also contain isoprenoid hydrocarbons (alkanes with methyl branches) ranging from about C_{11} to C_{22} and beyond, while organisms are limited to isoprenoids in the range C_{19} to C_{20}. Crude oil is devoid of the olefins or alkenes which are abundant in most organisms.

Anderson et al. (1974) summarized the occurrence of the various classes of hydrocarbons from petroleum and biological origins.

a. Saturated hydrocarbons (alkanes or paraffin)

Both short and long-chain alkanes occur naturally in marine organisms. They are not as toxic to organisms at low concentrations as the aromatics are, but they may cause anaesthesis and narcosis or interfere directly with reception of the chemical cues. They can interfere with feeding, nutrition and communication in aquatic organisms (Goldacre, 1968; Whittle and Blumer, 1970; Blumer et al., 1972). Branched alkanes including pristane, an isoprenoid, have been found in marine macroorganisms. In some plankton and fish, pristane is the most abundant alkane present. In organisms, the biogenic alkanes of C_{60} and smaller are predominantly odd-numbered chains, while in petroleum odd and even numbered chains occur in a 1:1 ratio.

Petroleum contains abundant amounts of saturated hydrocarbons. Crude oil and most refined oil contain a series of n-alkanes with chain lengths of C_1 to C_{60}. Branched alkanes, including the isoprenoids pristane, farnsane and phytane, are also present. Long chain saturated hydrocarbons occur in petroleum and refined products except for lubricating oil.

b. Unsaturated hydrocarbons (olefins or alkanes)

Alkenes often account for a major percentage of the hydrocarbons found in aquatic organisms, and include squalene in basking shark liver oil and cod liver oil, and the polyolefins, hexeicosahexane and carotene, prevalent in algae. According to Blumer (1969) alkenes may serve in biochemical communications, but their exact biological roles are poorly understood.

Olefinic hydrocarbons are rarely present in crude oils, but are formed in some refining processes and are present in gasoline and cracked petroleum products.

c. Alicyclic hydrocarbons

Hydrocarbons containing one to three non-aromatic rings are present in several herbs and other land plants. Most are classified as terpenes because of their biosynthetic origin from isoprene.

d. Aromatic hydrocarbons

Although Gerarde and Gerarde (1961) reported several instances of low-boiling aromatic hydrocarbons in land plants, the occurrence of aromatics in marine organisms is debatable. Blumer et al. (1969) did not isolate aromatic hydrocarbons from plankton, and DiSalvo et al. (1975) were unable to detect aromatics in mussels (*Mytilus californianus*) taken from unpolluted environments. As suggested by Borneff et al. (1968), higher boiling aromatics may be synthesized by marine organisms. Many species, including bacteria, metabolize polynuclear aromatics and excrete the oxidation products.

Aromatics, particularly naphthalenes, have repeatedly been reported as the most toxic of the hydrocarbons. Their interference with feeding activities and other biological processes is important and should be given prime consideration.

Aromatic hydrocarbons represent a large percentage of the components of crude oil and an even larger percentage of the components of a refined product.

e. Nonhydrocarbon compounds in petroleum

Although more than 75% of most petroleum is composed of hydrocarbons, many other compounds (some toxic) are present in varying concentrations. These include cresols, xylenols, naphthols, quinolines, pyridines and hydroxybenzoquinolines which are of particular concern because of their great toxicity and solubility in water.

Apparently, except for the UV-fluorescent examinations by Zitko and Carson (1970), no analyses of nonhydrocarbon components for use in estimating petroleum contamination of aquatic organisms have been reported. Unfortunately, no degradation studies using these compounds are in the commonly-accessible literature (Anderson et al. 1974).

2. Uptake of Petroleum Hydrocarbons

Hydrocarbons are available to marine organisms in several different physical and chemical forms and uptake is greatly influenced by these factors. Hydrocarbons are essentially hydrophobic compounds and consequently have very low solubilities in water, generally in the part per million (ppm) to part per billion (ppb) range (National Academy of Sciences, 1975). Because of this hydrophobic characteristic, most of the oil in a slick will remain on the ocean surface or adsorb to particulate matter and become incorporated into the bottom sediments instead of dissolving in the water column. The relative percentages of hydrocarbons involved in each of these processes depend upon environmental variables such as temperature, wind speed, wave action, etc. Various types of hydrocarbons in the petroleum mixture, in other words, low molecular weight paraffins (alkanes) and aromatics, have relatively high solubilities in water, however, these compounds are relatively volatile and are for the most part, lost to the atmosphere by evaporation. Petroleum, therefore, is presented to pelagic organisms in dissolved, dispersed, or suspended (floating tar lumps) forms and to benthic organisms in dissolved, dispersed, suspended or sedimented forms.

Petroleum hydrocarbons (PHC) may enter the food web by several means. Petroleum adsorbed to living or dead particles may be ingested. Uptake of PHC by the ingestion of prey species which have accumulated PHC within the body tissues can also occur. Another method is the uptake of dissolved or dispersed petroleum via the gills or body surface.

The importance of several of these uptake methods is still largely unknown, but will vary with the species involved, the method of feeding and respiration of the organisms involved, the habitat, the state of the sea, and the petroleum itself. Evidence indicates that the majority of hydrocarbons enter molluscs, crustaceans and fish via gill membranes (Anderson, Clark, and Stegeman, 1974). It would seem logical then that this would also be an important method of uptake in other marine groups, although the relative importance of transport through the body surface of marine worms with exposed soft bodies is unknown. Although ingestion of contaminated food and sediment particles may be important in marine mammals and some fish, its relative relationship to the transport across body surface membranes is still unknown.

According to the National Academy of Sciences report (1975):

> Equlibration of hydrocarbons can occur between organisms and the seawater that passes over their gills or other membranes exposed to seawater. This may be the most important route for most aquatic animals since they process such large amounts of water during food collection and respiration. One can calculate from the hydrocarbons measured in coastal waters (Stegeman and Teal, 1973; Brown et al. 1973) of 10 μg/liter and a level in food of 10 mg/g that an animal would be exposed to more than an order of magnitude larger amount of hydrocarbons in the water processed to obtain oxygen for metabolism of the food than that amount present in the food itself. Stegeman and Teal believe that uptake from the water is the major route by which oysters accumulated hydrocarbons from the water. In other situations, uptake from sediments could also be important.

Dissolved hydrocarbons were taken up by the gill tissue of the mussel *Mytilus edilus*, and then transferred to other tissues (Lee et al. 1972a). Electron microscopic studies on the uptake of iron suggest that the gill tissue of this mussel has a micellar layer on the surfaces of the gill that is responsible for the adsorption of hydrophobic compounds (Pasteels, 1968). Work on the uptake of dissolved hydrocarbons by marine fish also demonstrated the entrance of hydrocarbon through the gills (Lee et al. 1972b).

Yevich and Barry (1970) reported on tissue damage brought about by exposure to crude oils and other pollutants; such damage includes sloughing of the epithelium and atypical basal cell hyperplasia of the ciliated inner gills of quahogs (*Mercenaria mercenaria*). The question also arises, then, as to the effect the loss of the protective membrane coatings of the gills has on the rate of absorption of hydrocarbons from water.

Invertebrates such as molluscs and barnacles, which have the ability to isolate themselves from the environment through shell closure may employ a behavior mechanism which protects them for limited amounts of time from excessive uptake of PHC. Stegeman and Teal (1973) exposed oysters, *Crassostrea virginica*, to varying concentrations of No. 2 fuel oil for two days. The data suggested that, for concentrations up to 450 ug/l (ppb), there was a direct relationship between the hydrocarbon concentration in the water and uptake rate, while at higher concentrations the rate of uptake fell (Figure I-1). The reason for this was that the oysters remained tightly closed when exposed to concentrations of 900 mg/l. Even though oysters can tolerate many forms of environmental irritants so common in estuaries by shell closure and similar behavior mechanisms (Menzel, 1955), other marine molluscs may not exhibit the same degree of adaptability.

Even though PHC are taken into the gut through ingestion, they may not necessarily become incorporated into body tissues, but may instead be passed directly through the organism as feces. Following the *Arrow* incident in Chedabucto Bay, plankton were observed to ingest large quantities of Bunker C oil and eliminate them in the form of fecal matter (up to 7% Bunker C oil by weight) (Conover, 1971). The plankton always voided the small "oil" particles within 24 hrs. and showed no signs of stress when viewed under a dissecting microscope. No chemical analysis of the fecal matter or of the whole copepods was reported, however, which might have provided some indication of whether and what degree of degradation or partitioning of the oil took place.

Parker (1970) also demonstrated the presence of considerable quantities of oil in the guts and fecal pellets of copepods and barnacle larvae. The fact that the oil passes unchanged into the fecal material is of considerable interest since oil from a slick can be grazed by the plankton and the ingested oil concentrated in the feces. Parker (1971) calculated that copepods (*Calanus finmarchicus*) could encapsulate up to 1.5 X 10^4 g of oil per day per individual. For example, a population of 2,000 individuals/m^3 covering an area of 1 km^2 to a depth of 10 m could remove as much as three tons of oil daily if the oil's concentration is 1.5 ppm or greater. Fecal pellets can then be eaten by other members in the food web.

Alyakrinskaya (1966) found that the mussel *Mytilus galloprovincialis* in the Black Sea could tolerate high concentrations of oil (up to 20 ml/liter of an undefined type of oil). During filtration of oil-polluted water, the molluscs formed pseudofeces from oil connected by mucous—to a degree comparable with transferring the oil to large, denser particles as Conover and Parker have suggested for copepods.

According to Anderson et al. (1974), a significant amount of PHC is taken up and accumulated, at least temporarily, within the body tissues of most fishes and invertebrates during spills. Data shown in Table I-1 (presumably contaminated tissues) and Table I-2 (natural tissue hydrocarbon levels) should be treated with a certain amount of caution, however, because of the number of variables involved. The methods of analyses, UV absorption spectrophotometry, infrared spectrometry, mass spectrometry and the various chromatography proceudres, measure hydrocarbons in a different manner and consequently produce slightly different results. The other significant variable is the composition of the oil itself.

According to Anderson et al. (1974)

> Levels of PHC contamination in a wide variety of edible marine organisms are listed in Table I-1. The data shown in this table relate to organisms collected from localities presumed to be high in PHC contamination, and therefore the compounds detected are likely to be petroleum derived. These samples, presumed by

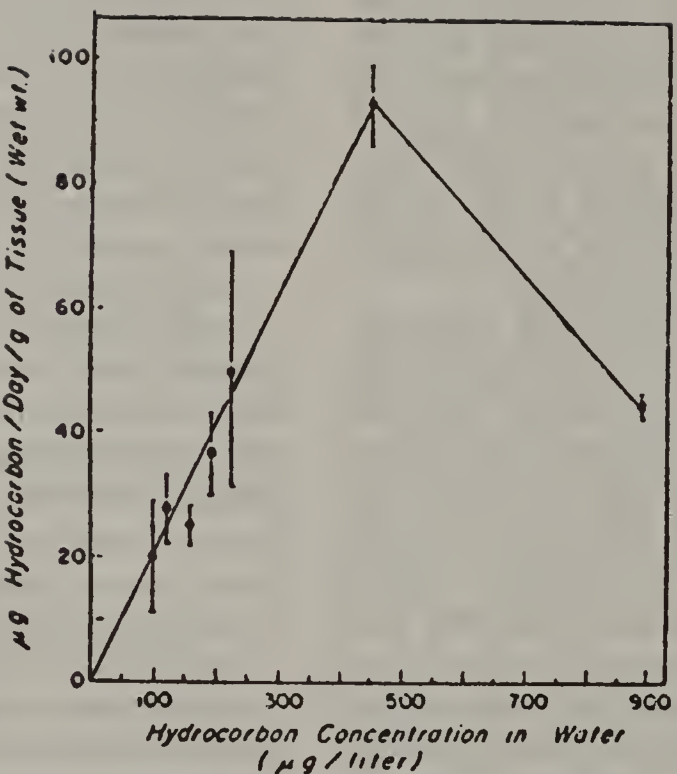


Fig1-1 *Crassostrea virginica*. Initial rate of petroleum hydrocarbon uptake by oysters versus hydrocarbon concentration in the water. Oysters were assayed after 2 days exposure at indicated hydrocarbon concentration. Each point represents average of 2 determinations using high fat-content oysters

Table I-1 Tissue Samples - Presumably Contaminated (from Anderson et al., 1974)

SPECIES	PROBABLE SOURCE	HC TYPE [1]	ANALYSIS	WET ug/g	REFERENCE
Macro algae					
Fucus sp.	Spill - Bunker C	n-paraffins	GC	5.8	Clark *et al.*, 1973
Snails					
Littorina littorea	Spill	Bunker C aromatics	Fluoro	27-600	Scarratt & Zitko, 1972
Thais lamellosa	Spill -#2 fuel oil	n-paraffins	GC	5.4	Clark, 1974
Clams					
Mercenaria mercenaria	Sewage effluent	C_{16-32}	GC	16	Farrington & Quinn, 1973
Mya arenaria	Spill	#2 fuel oil	GC/MS	26	Blumer *et al.*, 1970b
Oysters					
Crassostrea vriginica	Chronic	paraffins, mono & di-aromatics	GC/MS TLC	236	Ehrhardt, 1972
	Harbor	C_{17-32}	GC	10	Stegeman, 1974
	Spill	#2 fuel oil	GC/MS	70	Blumer et al., 1970a
	Chronic	Polynuclear aromatics	UV	1	Cahnmann & Kuratsane, 1957
	Chronic-harbor	Saturates	GC/MS	15	Meiggs, 1973 (Galveston)
	" "	"	GC	13-29	" " (San Francisco)
	" "	Total HC	GC	160	R.D.Anderson, 1973 (Galveston Red Bluff Reef)
	" "	Saturates, C_{12-24}	GC	11.2	R.D.Anderson, 1973 (Galveston Halfway Reef)
		Dimethylnaphthalenes	GC	0.6	"
		Trimethylnaphthalenes	GC	0.6	"
Mussels					
Modiolus modiolus	Spill	#2 fuel oil	GC	218	Burns & Teal, 1971
	Spill	Bunker C aromatics	Fluoro	21-372	Scarratt & Zitko, 1972

1/ Though only n-paraffins were indicated in some cases, the probable presence of other petroleum-type hydrocarbons, e.g. aromatics, is not to be excluded.

Table I-1 (continued)

SPECIES	PROBABLE SOURCE	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Mytilus edulis	Spill	Bunker C aromatics	Fluoro	77-103	Zitko, 1971
	Chronic harbor	n-paraffins	GC	0.97	Clark & Finley, 1973b
	Spill-#2 fuel oil	"	GC	1.4	"
Mytilus californianus	Spill-Bunker C	"	GC	0.87	"
Scallops					
Acquipecten irradians muscle	Spill	#2 fuel oil	GC	7-14	Blumer et al., 1970b
Barnacles					
Mitella polymerus	Spill-Bunker C	n-paraffins	GC	11.8	Clark et al., 1973
Crabs					
Cancer irroratus	Spill	Bunker C aromatics	Fluoro	7-11	Scarratt & Zitko, 1972
Hemigrapsus nudus	Spill-Bunker	n-paraffins	GC	2.9	Clark et al., 1973
Lobster					
Homarus americanus-gut	Spill	Bunker C aromatics	Fluoro	103-130	Scarratt & Zitko, 1972
stomach	"	"	"	15-230	"
claw-muscle	"	"	"	2-3	"
Abdominal muscle	"	"	"	1-4	"
Urchins					
Stronglyocentrotus droebachiensis	Spill-Bunker C	Bunker C aromatics	Fluoro	17-94	Scarratt & Zitko, 1972
Mullet					
Mugil cephalus-flesh	Chronic-harbor	Kerosene taint	GC/MS	~860	Shipton et al., 1970
Whitefish-flesh	Spill	Diesel oil	GC	29-88	Ackman & Noble, 1973
Flatfish	Chronic-coast	C_{14-20}	GC	4	Bowen, 1971

TABLE I-2 Natural Tissue Hydrocarbon Levels (from Anderson et al., 1974)

SPECIES	LOCALITY	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Macro Algae					
Nereocystus' (kelp)	Puget Sound, Wash.	n-paraffins	GC	0.74	Clark, 1974
Ulva sp. (sea lettuce)	"	"	"	20.3-23.0	"
Fucus sp.	Puget Sound, Wash.	n-paraffins	GC	3.03-55.7	"
	Washington Coast	"	"	9.51-57.2	"
	New Hampshire	"	"	8.96	Clark & Blumer, 1967
	Woods Hole, Mass.	"	"	34.9	"
	Falmouth, Mass.	"	"		"
Snails					
Thais lamellosa	Puget Sound, Wash.	n-paraffins	GC	0.06-1.5	Clark, 1974
Littorina littorea	Eastern Canada	Aromatics	Fluoro	11	Zitko, 1971
Littorina sp.	Valdez, Alaska	n-paraffins	GC	16.1	Clark, 1974
Limpets					
Notoacmea scutum	Puget Sound, Wash.	n-paraffins	GC	2.5	Clark, 1974
Chiton					
Mopalia sp.	Puget Sound, Wash.	n-paraffins	GC	0.50	Clark, 1974
Clams					
Mercenaria mercenaria	Narrangansett Bay, R.I.	Total HC	GC	2.9	Farrington & Quinn, 1973
Mya arenaria	Eastern Canada	Aromatics	Fluoro	8	Zitko, 1971
Mya sp.	Valdez, Alaska	C_{16-28}	GC	1.1	Kinney, 1973
Rangia cuneata	Trinity Bay in Galveston, Texas	Naphthalene	UV Spec	0.16	Cox & Anderson, 1974
		Methylnaphthalene	"	0.11	"
		Dimethylnaphthalene	"	0.06	"
Oysters					
Crassostrea virginica	Redfish Reef in Galveston Bay	Saturated HC	GC/MS	1.5	Meiggs, 1973
	Aransas Bay, Texas	Saturated HC	GC/MS	1	Meiggs, 1973
	Quisset, Mass.	Total HC	GC	1-2	Stegeman & Teal, 1973
	Galveston Island				
	East Lagoon	Total HC	GC	<2.0	R.D.Anderson, 1973
	Eight Mile Road Reef	"	"	<2.0	"

Table I-2 (continued)

SPECIES	LOCALITY	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
	Eight Mile Road Reef	Saturated	GC	<0.1	R.D. Anderson, 1973
	"	Aromatics	"	<0.1	R.D. Anderson, 1973
Ostrea edulis	Newport, Oregon	n-paraffins	GC	0.35	Clark et al., 1974
Mussels					
Mytilus edulis	Puget Sound, Wash.	n-paraffins	GC	0.37-21.6	Clark, 1974
	Valdez, Alaska	"	"	0.40-0.95	"
	Newport, Oregon	"	"	0.34	Clark et al., 1974
	Eastern Canada	Aromatics	Fluoro	3	Zitko, 1971
	Valdez, Alaska	C_{16-28}	GC	1.9	Kinney, 1973
Mytilus californianus	Washington coast	n-paraffins	GC	0.45	Clark & Finley, 1973b
	Puget Sound, Wash.	"	"	0.088-0.58	Clark, 1974
Barnacles					
Mitella polymerus	Washington coast	n-paraffins	GC	1.41	Clark et al., 1973
	Puget Sound, Wash.	"	"	1.22-4.54	Clark, 1974
Balanus cariosus	Washington coast	n-paraffins	GC	0.66	Clark, 1974
Scallop					
Acquipecten irradians	Waquoit Bay, Mass.	Saturates	GC	2.3-55	Blumer et al., 1970a
Shrimp					
Pandalis borealis	North Atlantic	Saturates	GC	43.6	IDOE, 1972
Unidentified species	Artic Ocean	n-paraffins	GC	0.37-21.6	Clark, 1974
Palaemonetes pugio	Galveston Island Marsh at Eight Mile Road	Saturated Total (C_{20-31})	GC	24.8	Tatem & Anderson, 1974
		(C_{22-26}, each)	"	3.1-3.9	"
		C_{23}	"	3.8	"

Table I-2 (continued)

SPECIES	LOCALITY	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Palaemonetes pugio	Marsh at Eight Mile Rd	Saturated Total (C_{21-26})	GC	10.9	Tatem & Anderson, 1974
		C_{23}	"	3.9	"
Penaeus setiferus (postlarvae)	Mariculture by Dow Chemical	Saturated Total	GC	15.0	Cox & Anderson, 1974
		Aromatics Total	"	8.0	"
Crabs					
Hemigrapsus nudus	Washington coast	n-paraffins	GC	0.28	Clark *et al.*, 1973
	Puget Sound, Wash.	"	"	0.082-3.65	Clar, 1974
Cancer irroratus	Eastern Canada	Aromatics	Fluoro	7	Zitko, 1971
Uca minax		Naphthalene	UV Spec	0.24	Cox & Anderson, 1974
		Methylnaphthalene	"	0.15	"
		Dimethylnaphthalene	"	0.09	"
Sesarma cinereum	Trinity Bay in Galveston Bay	Naphthalenes	UV Spec	0.22	Cox & Anderson, 1974
		Methylnaphthalenes	"	0.10	"
		Dimethylnaphthalenes	"	0.08	"
Lobster					
Homarus americanus					
stomach	Eastern Canada	Aromatics	Fluoro	19	Zitko, 1971
gut	"	"	"	57	"
claw muscle	"	"	"	4	"
abdominal muscle	"	"	"	5	"
Urchin					
Strongylocentrotus sp.	Eastern Canada	Aromatics	Fluoro	22	Zitko, 1971
S. purpuratus	Washington coast	n-paraffins	GC	0.18	Clark, 1974
Flounder					
Syncium gunteri	Gulf of Mexico	n-paraffins	GC	8.7	IDOE, 1972
Unidentified species	Alaska	"	"	8.0	"

Table I-2 (continued)

SPECIES	LOCALITY	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Pseodopleuronectes americanus	Eastern Canada				
gut		Aromatics	Fluoro	21	Zitko, 1971
skin and flesh		"	"	0	"
Perch					
Sebastes marinus-livers	North Atlantic	Hydrocarbons	GC	110	IDOE, 1972
	George Bank	"	"	20.6	"
Haddock					
Gadus aeglefinus-livers	North Atlantic	Hydrocarbons	GC	210	IDOE, 1972
	George Bank	"	"	252	"
Pollock					
Pollachius verins-livers	Georges Banks	Hydrocarbons	GC	262	IDOE, 1972
Greenland halibut					
Reinhandtius hippo-lossoides-livers	North Atlantic	Hydrocarbons	GC	230	IDOE, 1972
	Gulf of Maine	"	"		
Whitefish-flesh	Alberta, Canada	Diesel oil-like	GC	4-14	Ackman & Noble, 1973
Yellow sole					
Lamanda	Valdez, Alaska	C_{16-28}	GC	0.15-0.97	Kinney, 1973
Herring eggs					
Clupea pallasil	Puget Sound, Wash.	n-paraffins	GC	3.1	Clark, 1974
Cod					
Gadus callarias-livers	North Atlantic	Saturates	GC	128-345	IDOE, 1972
Gadus morhua-livers	"	"	"	332	"
Boreogadus esmarki	"	"	"	117	"
	Arctic Ocean	n-paraffins	"	12.6	Clark, 1974

Table I-2 (continued)

SPECIES	LOCALITY	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Mackerel *Scomberomorus cavalla*	Gulf of Mexico	n-paraffins	GC	11.3	IDOE, 1972
Barracuda *Sphyraena barracuda*	Texas	n-paraffins	GC	22.6	IDOE, 1972
Atlantic salmon *Salmo salar*	Eastern Canada	Aromatics	Fluoro	10	Zitko, 1971

the authors to be contaminated with petroleum, were in general judged so based on the types of hydrocarbons present, keeping in mind the differences between petroleum and biogenic mixtures. The hydrocarbon types are listed in Table I–1 as indicated by the authors, and though only one class, or a range, of hydrocarbons is given for some samples, it does not exclude the presence of other types of compounds in the sample. Usually the samples analyzed by fluorescence yield low numbers and in most samples the concentration would be much higher if compounds other than polycyclic aromatic hydrocarbons were included. Those samples listing only "paraffins" should also be considered as reflecting a very small part of the total hydrocarbons. This is perhaps especially true for shellfish (Stegeman, 1974).

It is evident that high concentrations of PHC can be found in organisms from spill areas as well as areas of chronic contamination. In many cases, the hydrocarbon level of the waters from which organisms have been taken have not been reported. In other cases, under prolonged exposures, the concentrations could have fluctuated over such a wide range that such information would not realistically reflect the true exposure concentrations. The relative amount of accumulation varies greatly with the organism involved, concentration of hydrocarbon in the water, and composition of the petroleum, etc. On a dry weight basis, the actual amount accumulated can be quite substantial. Di Salvo et al. (1975) reported a preliminary determination of surface hydrocarbons showed the presence of 1.25 ppb while dry weight tissue from mussels, *Mytilus edulis*, exposed for 90 days was recorded as 300 ppm.

In contrast to the PHC concentrations in presumably contaminated organisms, concentrations of hydrocarbons in supposedly uncontaminated populations (Table I–2) are consistently much lower. This is particularly true for the molluscs, where concentrations of 1 to 2 ppm or less are approximately 10 to 100 times lower than those of the contaminated organisms. "Natural" concentrations in some fish and crustaceans appear somewhat higher and in a few cases might be suspect, although these samples were all considered uncontaminated by the authors based on parameters other than the total hydrocarbon content (Anderson et al. 1974).

A striking feature of Table I–2 is that these low levels occur in organisms from all coastal regions of the continent. The concentrations from 0.01 to 10 ppm are the lower limits of analysis based on current techniques and may in many cases represent mostly biogenic compounds. In such cases a few compounds can be expected to constitute the major portion of the hydrocarbon components.

There have to date been a number of studies describing the experimental accumulation of PHC by marine organisms. Table I–3 summarizes results of most of these studies and indicates tissue levels of PHC which can be achieved under a variety of exposure conditions (Anderson et al. 1974). Most of the studies in Table I–3 were performed under static conditions for relatively short periods, i.e. hours to days. The majority used very high exposure levels of emulsions, dispersions, water soluble fractions or slicks ranging from approximately 50 to 10,000 ppm.

These could be taken as partially resembling the situation early in the history of an oil spill. Others were very brief status exposure to single compounds (Lee et al. 1972a), or long term exposure to low levels of whole fuel oil in a flow-through system (Stegeman and Teal, 1973). The last experiment could be considered to represent the conditions of an exposure to chronic sources of contamination in harbors, etc. In fact, the 335 ppm total hydrocarbon accumulated by oysters after seven weeks (Stegeman and Teal, 1973) was not very different from the 236 ppm total hydrocarbons in oysters from the Houston ship channel (Ehrhardt, 1972) shown in Table I–1.

Based on dry tissue weight, Di Salvo et al. (1975) found hydrocarbon concentrations as high as 530 ppm in mussels exposed to low level chronic oil pollution in San Francisco Bay.

3. Storage and Metabolism

Although it has been demonstrated that hydrocarbons concentrate in certain organs, it is actually with the lipids that they become associated (Blumer et al. 1972). Stegeman and Teal (1973) found a direct relation between the lipid content of oysters and the amount of hydrocarbons accumulated. Shipton et al. (1970) reported the dark meat and the fatty layer adjacent to the skin were more severely tainted with a hydrocarbon similar to kerosene than the white meat, and that the tainted flesh had a higher fat content than

Table I-3 Tissue Hydrocarbon Levels Resulting from Laboratory Exposure

SPECIES	EXPOSURE CONDITIONS	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Clams					
Rangia cuneata	1000 ppm #2 fuel oil, 48 hr	Total saturated	GC	26	Anderson, 1973
		Mono- & diarom.	"	481	"
		Poly aromatics	"	34	"
Mya arenaria	Bunker C	Aromatics	Fluoro	87	Zitko, 1971
Oysters					
Crassostrea virginica	1000 ppm #2 fuel oil. 48 hr	Total saturated	GC	4	Anderson, 1973
		Mono- & diarom.	"	121	"
		Poly aromatics	"	5	"
	1000 ppm #2 fuel oil,	Total saturated	"	3.1	"
		Naphthalenes	"	84.1	"
		Triaromatics	"	9.5	"
	106 ppb #2 fuel oil, 7 weeks	Saturates & arom.	"	335	Stegeman & Teal, 1973
	1000 ppm Kuwait crude, 96 hr	Total saturated	"	46.0	Anderson, 1973
		Naphthalenes	"	55.1	"
		Triaromatics	"	6.0	"
Crassostrea gigas	50 ppm #2 fuel oil, 11 days	Saturated	GC	1.3	Vaughn, 1973
Ostrea lurida	10% outboard motor effluent, 10 days	n-paraffins	GC	0.96	Clark et al., 1974
Mussels					
Mytilus edulis	0.1 ppm mono- & diaromatics 4-24 hrs	Same	Radio.	6	Lee et al., 1972a
	0.1 ppm poly aromatics	"	"	0.6	"
	Slick, #2 fuel oil 48 hrs.	n-paraffins	GC	7.9	Clark & Finley, 1974
	Slick, #5 fuel oil 32 hrs.	"	"	7.4	"
	1C% outboard motor 1 day	"	"	1.10	Clark et al., 1974

(From Anderson et al., 1974).

Table I-3 (continued)

SPECIES	EXPOSURE CONDITIONS	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Shrimp *Penaeus aztecus*	20% WSF[1] #2 fuel oil, 24 hr.	Sat. (individual peaks)	GC	0.1	Cox & Anderson, 1974
		Nephthalenes	"	0.1	"
		Methylnaphthalenes	"	1.4	"
		Dimethylnaphthalenes	"	0.3	"
		Trimethylnaphthalenes	"	0.6	"
Penaeus aztecus	Underslick of #2 fuel oil for 24 hr in a pond exposure	Saturated Total	GC		Cox & Anderson, 1974
		(C_{13-24})	"	6.2	"
		(C_4-Benzenes)	"	1.2	"
		Naphthalene	"	3.3	"
		1-Methylnaphthalenes	"	8.0	"
		2-Methylnaphthalenes	"	8.9	"
		Dimethylnaphthalenes	"	19.2	"
		Trimethylnaphthalenes	"	4.2	"
		Pheanthrenes	"	12.7	"
Palaemonetes pugio	0.9 ppm OWD[2] #2 fuel oil for 2 hr.	Naphthalenes	GC	3.1	Tatem & Anderson, 1974
	6 hr.	Naphthalenes	GC	5.5	"
	10 hr.	Naphthalenes	UV	4.0	"
Lobster Homarus americanus gut	10,000 ppm Bunker C 6 1/2 days	Aromatics	Fluoro	1,810	Scarrett & Zitko, 1972
stomach		"	"	2,840	"
abdominal muscle		"	"	137	"
claw muscle		"	"	33	"

1/ A water-soluble fraction (WSF) was prepared by mixing 1 part oil over 9 parts water for 20 hours, and the water phase was diluted to 20% of its original concentration of hydrocarbons (see Anderson et al., 1974)

2/ Oil was added to water such that 500 ml contained 0.9 ppm of oil. This mixture was shaken at 200 chcles/min. for 5 min. and after 60 min. the animals were placed in the mixture.

Table I-3 (continued)

SPECIES	EXPOSURE CONDITIONS	HC TYPE	ANALYSIS	WET ug/g	REFERENCE
Perch					
Cymatogaster aggregata	50 ppm #2 fuel oil, 96 hr	Saturated	GC	2.3	Vaughn, 1973
		Diaromatics	"	19	"
Flounder					
Pseudopleuronectes	Bunker C				
americanus Gut		Aromatics	Fluoro	622	Zitko, 1971
skin		"	"	182	"
flesh		"	"	7	"

the untainted flesh of fish caught at the same time. Vale et al. (1970) examined livers with optical and electron microscopes and found excessive amounts of free fat, typical of fatty infiltration, in tainted fish as compared with untainted mullet. Fatty liver in higher animals can be caused by petroleum distillates (Browning, 1953).

Roubal (1973), working with excised spinal cord tissues of coho salmon, indicated that hexane and similar hydrophobic compounds are directed away from nerve membrane surface to sites in the lipid bilayer of the membrane, while aromatic hydrocarbons and benzyl alcohol contribute to membrane surface changes. The complex lipoproteins of plasma membranes and organelle membranes of all tissues are possible storage sites (NAS, 1975).

According to a summary paper by Anderson et al. (1974a), accumulated petroleum hydrocarbons are rapidly transferred to the gall bladder, brain and other neural tissues, and the liver of fish and to the digestive gland of shrimp. Damage to fish having concentrations of petroleum hydrocarbons in the nervous system can be seen as an increase in nonadaptive behavior responses.

Lee et al. (1972b) and Anderson et al. (1974a) found localization of hydrocarbons in the gall bladder, liver, and brain of marine fish. During depuration in clean water the hydrocarbons were apparently transported to the liver and gall bladder for detoxification and excretion. A significant amount of contamination remained in the heart and brain until the point of final release. Since the compounds are transported by the blood, it is not surprising that the concentration in the heart is high, but an explanation for high levels in the brain requires further investigation.

Cox and Anderson (1974) reported that brown shrimp, *Penaeus aztecus*, accumulate the naphthalene fraction of hydrocarbons primarily in the digestive gland or hepatopancreas throughout the exposure period. The content of these compounds in the other organs and tissues decreases steadily, even during exposure. The gill tissue maintains a relatively consistent level of contamination (approximately 0.6 ppm) during the depuration until the point of final release by the digestive gland (about 250 hours). Since the gills are richly supplied with blood, the contamination level found may well represent contamination level in the blood of the shrimp.

Scarratt (1971) reported commercial species of scallops which had ingested Bunker C oil had a detectable amount of Bunker C hydrocarbons in the mantle, digestive gland, adductor mussel and gonad. Di Salvo et al. (1975) reported hydrocarbons in the gonads of mussels. Operation Oil (1970) reported that oil was present in the muscle tissue, digestive tract and other organs in scallops, periwinkles, sea urchins, and other intertidal benthos examined after Bunker C oil had been spilled in the *Arrow* accident. Blumer and Sass (1972a) also reported hydrocarbons in adductor muscles of oysters after the West Falmouth spill.

The danger to the human consumer from PHC-contaminated sea food is lessened because hydrocarbons are primarily concentrated in certain organs such as the liver, gall bladder, and much of the nervous system which are discarded prior to consumption. The danger to humans who consume contaminated oysters, which are eaten in their entirety, would be significantly greater. Apparently some danger of oil contamination can occur from eating other molluscs which may have accumulated oil in muscle tissue.

Metabolism of hydrocarbons is discussed in the summary paper by the National Academy of Sciences (1975).

> The metabolic pathways involving oxidases and other enzymes, important in the degradation of aromatic and paraffinic hydrocarbons by mammalian systems, have been well studied. In the case of aromatic hydrocarbons, hydroxylation is followed by conjugation with sulfate or glucose and finally excretion of the water-soluble product. Straight chain hydrocarbons are hydroxylated at the terminal end and further oxidized to the fatty acid that can be broken down by b-oxidation. Highly branched chain hydrocarbons, such as pristane and phytane, are probably oxidized to an acid (e.g. phytanic acid), which can be further oxidized by a combination of a and b oxidation.

Metabolism of hydrocarbons in marine organisms is less well understood, but several studies have been conducted. Degradation of sizeable quantities (between 10 and 500 ug) of aromatic and paraffinic hydrocarbons did occur in marine fish and some marine invertebrates (Stegeman and Teal, 1973; Lee et al., 1972a,b). Other benthic marine invertebrates, phytoplankton, and some zooplankton, over a period of a month, were unable to oxidize either paraffinic or aromatic hydrocarbons. Several species of copepods were unable to metabolize hydrocarbons but could degrade paraffinic hydrocarbons (National Academy of Science, 1975). The liver or the liver-like organ in some invertebrates, the hepatopancreas, is assumed to be the site of hydrocarbon degradation. Unaltered hydrocarbons are sent to these organs where hydroxylation and other detoxification reactions occur. In those invertebrates where degradation does not occur, some of the detoxifying microsomal oxidases in the hepatopancreas may be missing.

A somewhat less efficient and slower hydrocarbon metabolizing system has been reported in crustaceans (Anderson et al., 1974a). Studies with molluscs have failed to demonstrate the presence of any hydroxylase activity (Carlson, 1972a) also failed to observe formation of metabolites of hydrocarbons by mussels.

According to Anderson et al. (1974a)

> Though it is clear that levels accumulated vary with exposure conditions, some generalizations can be made: (1) In all types of exposures high levels of PHC can be found in the organisms. Here again the listing of only one type of hydrocarbon does not mean that other types of hydrocarbon were not present. In fact, the identification of only saturated compounds may yield numbers much lower than the total PHC present. (2) Mono-aromatics and diaromatics appear to be more readily accumulated than either saturated compounds or PAH. In addition, long term exposure results indicate that changes in the composition of the retained hydrocarbons, especially a relative decrease in paraffins, occur throughout the exposure period. (3) It appears that the muscle tissue of fish and crustaceans accumulate relatively low levels of hydrocarbons. With the exception of molluscs which are entirely consumed by man, muscle is generally the edible portion of marine organisms.

4. Discharge or Depuration of Hydrocarbons

Throughout the relatively short period since studies on oil accumulation in aquatic organisms began, evidence confirming and denying the ability to depurate accumulated hydrocarbons has been presented.

Blumer et al. (1970) reported that when oysters *Crassostrea virginica* are exposed to water-oil mixtures, they nonselectively accumulate a wide variety of PHC in their tissues which are retained for several months or perhaps indefinitely.

Results from Blumer and Sass (1972b) study on highly aromatic No. 2 fuel oil suggest that oil becomes part of the organism's lipid (fatty) pool. Blumer noted that the oil in specimens observed from a Massachusetts oil spill remained relatively unchanged in composition or quantity. He reasoned that if the oil were localized within the digestive tract, a shellfish could eliminate it rapidly. But the persistence of the hydrocarbon over a time period of six months, its presence in adductor muscle tissue, and the lack of further degradation of these hydrocarbons indicated that it becomes part of the organism's lipid pool.

Lee et al. (1972a) exposed the mussel *Mytilus edulis* to isotopically labeled petroleum-derived alkanes and aromatic hydrocarbons and showed that the molluscs released more than 90% of the accumulated hydrocarbons within two weeks of return to isotope free sea water.

Simulating the conditions of an oil spill, Anderson et al. (1974a) have presented evidence that estuarine fish and macroinvertebrates completely depurate accumulated hydrocarbons after short term exposures of four days or less.

Anderson (1973) presented the detailed hydrocarbon composition of clam *Rangia cuneata* and oyster *Crassostrea virginica* tissue exposed to crude and refined oils for periods up to four days. The subsequent release of HC's accumulated from No. 2 fuel oil and South Louisiana crude oil by oysters was also reported. The levels of tissue contamination decreased to less than detectable concentrations (0.1 ppm) in from 24 to 52 days (Figure I-2). The aromatic hydrocarbons were accumulated to the greatest extent and retained the longest in these studies.

Anderson and Neff (1974b) have shown comparative data for the uptake and release of naphthalenes from No. 2 fuel oil by clams, fish, and shrimp. While approximately 0.8 ppm of total naphthalenes was still present in the clams *Rangia cuneata* at 360 hours, the fish *Fundulus similis* and shrimp *Penaeus aztecus* had released the hydrocarbons to background levels. It is interesting that even during the 24 hours of exposure the concentration in shrimp tissue dropped from about 70 ppm at 1 hour to approximately 3 ppm of total naphthalenes after 24 hours.

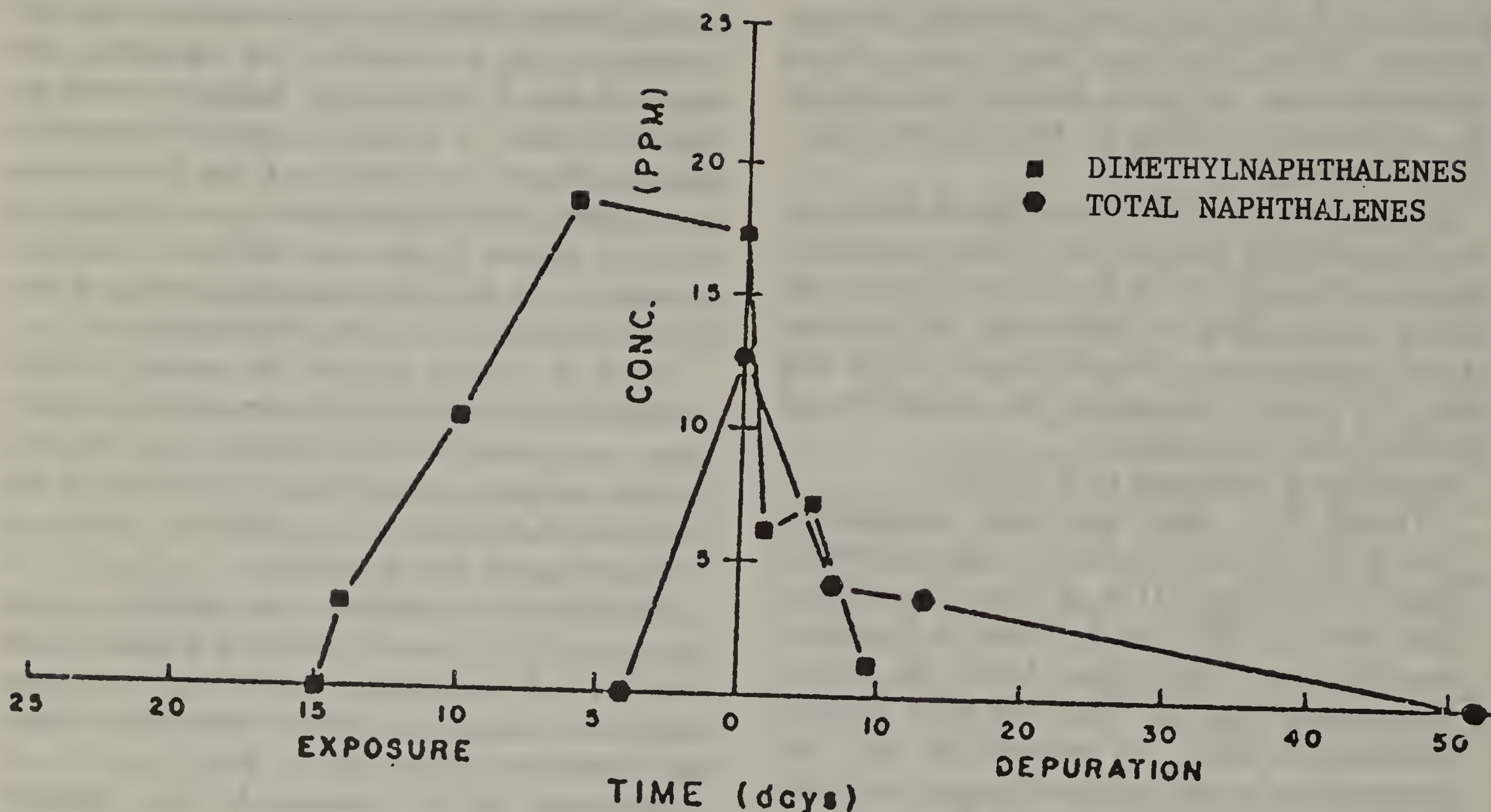


Figure 1-2 Levels of petroleum hydrocarbons in the tissues of marine organisms after various periods of exposure and depuration (in clean water). The levels of dimethylnaphthalenes in the tissues of Pacific oysters exposed to 50 ppm of South Louisiana crude oil (Vaughan, 1973); exposure of the American oyster, Crassostrea virginica, to an oil-water dispersion of #2 fuel oil total naphtalenes (Anderson, 1973). All data are expressed in µg/g fresh weight of organisms (ppm). (From Anderson et al. 1973).

Further evidence of the importance of naphthalenes in the contamination of the marine organisms is shown by the work of Vaughan (1973). During 15 days of exposure to oil, Pacific oysters were found to accumulate significant amounts of dimethylnaphthalenes. On removal from the contaminated water, the tissue content of dimethylnaphthalenes decreased to a level slightly above the background within nine days in clean flowing sea water (Figure I-2).

It should not be assumed that only aromatic HC's are accumulated by marine animals, as Clark and Finley (1974) have demonstrated uptake of paraffins by mussels *Mytilus edulis* reaching a level of 112 ppm dry weight (7.9 mg/g wet weight) after 48 hours of exposure to No. 2 fuel oil. While the majority of these accumulated HC's were released during the first two weeks of maintenance in clean sea water, approximately 6 ppm (dry weight) was present at 14 and 35 days of depuration (Figure I-3).

Mussels collected at Scripps showed a buildup of petroleum hydrocarbons for several days after a fuel oil spill. But three weeks later, none of the material could be found in the mussels (Lee and Benson, 1973). Fish from Alaskan waters were able to completely depurate accumulated hydrocarbons after short term exposures (Rice, 1975). Several studies either designed to simulate chronic oil pollution or actually conducted in chronic field conditions, have indicated that, although over 90% efficient, molluscs do not completely depurate accumulated hydrocarbons.

Stegeman and Teal (1973) exposed oysters, *Crassostrea virginica*, to No. 2 fuel oil at a concentration of 106 ug/l (ppb) for 50 days. In terms of total wet body weight, hydrocarbon accumulation increased rapidly for 13 days, then more slowly until equilibrium was reached in five to six weeks. In terms of lipid content, equilibrium was not reached during the 50 day exposure period. The amount of accumulation was dependent upon the fat content of the oysters, reaching 334 mg/g (ppm) in high fat oysters but only 161 mg/g (ppm) in low fat oysters. When placed in clean water having a background hydrocarbon level of 11 ug/l (ppb), oysters depurated 90% within the two week holding period, but retained a concentration of 34 mg/g (ppm), a concentration of over 30 times that before exposure (Figures I-3 and I-4). They concluded that at least some of the PHC had become a stable component having a slow turnover rate. There is a physiological advantage for marine organisms to avoid loss by equilibration of important biogenic hydrocarbons, and a certain amount of petroleum hydrocarbons were probably confused with biogenic hydrocarbons and retained this way.

Working with mussels, *Mytilus edulis* and *M. californianus*, in the natural environments of polluted (San Francisco Bay) and unpolluted (Northern California coast) areas, Di Salvo et al. (1975) reported incomplete depuration when mussels held in polluted areas for 90 days were transferred to nonpolluted areas and held for 10 weeks.

The evidence indicated there may be two forms of hydrocarbons accumulation in bivalve molluscs; (1) A short-term form where PHC are taken up rapidly and depurated completely or to background levels within several weeks to two months (Lee and Benson, 1973; Rice, 1975 and Anderson et al., 1974a). This reflects the response during an oil spill. (2) A long-term hydrocarbon burden accumulated in tissues that is not completely discharged (Blumer et al., 1970; Blumer, 1969; Stegeman and Teal, 1973; Di Salvo et al., 1975). This reflects chronic oil pollution exposure when primarily aromatic hydrocarbons are accumulated in lipids. A similar residual hydrocarbon burden may be present in certain species of zooplankton, if it is possible to expose them to oil for a long enough period.

Because they apparently have the ability to metabolize hydrocarbons, shrimp, fish, and marine mammals would probably not retain the residual hydrocarbon concentration as do the molluscs.

The National Academy of Sciences (1975) reported on the avenues of depuration of accumulated hydrocarbons. In molluscs and certain zooplankton which cannot degrade hydrocarbons, bile salts or some other natural detergents are able to emulsify hydrocarbons and allow passage through the gut and into the feces or pseudofeces. Fish make water soluble products from the hydrocarbons, and the main avenue of discharge appears to be through the urine via the gall bladder and kidney. In mammals, aromatic hydrocarbons are also converted to water soluble products that go through the bile and into the feces and urine. The avenue for the discharge of hydrocarbons by the lobster and related invertebrates has not been determined.

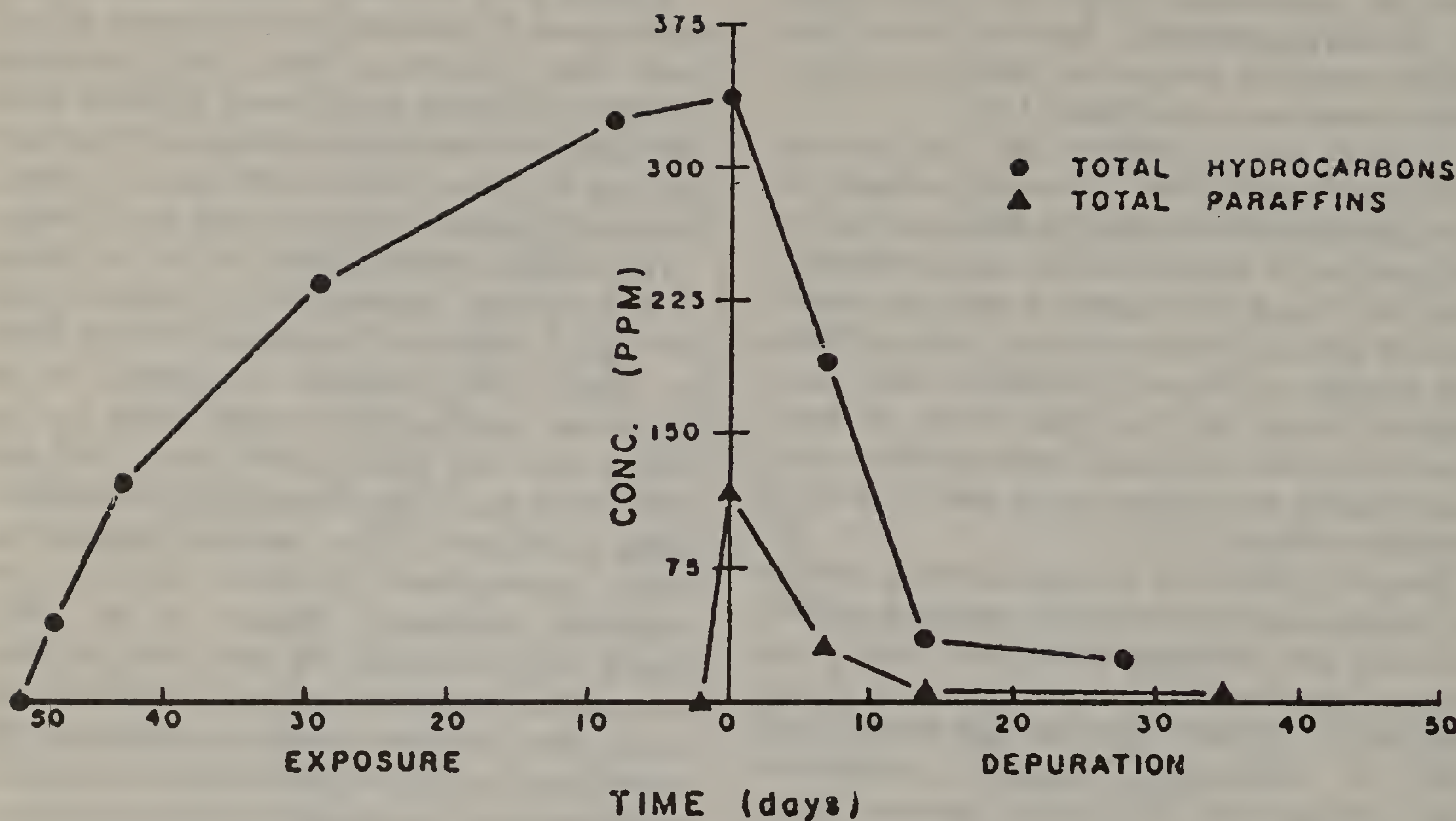
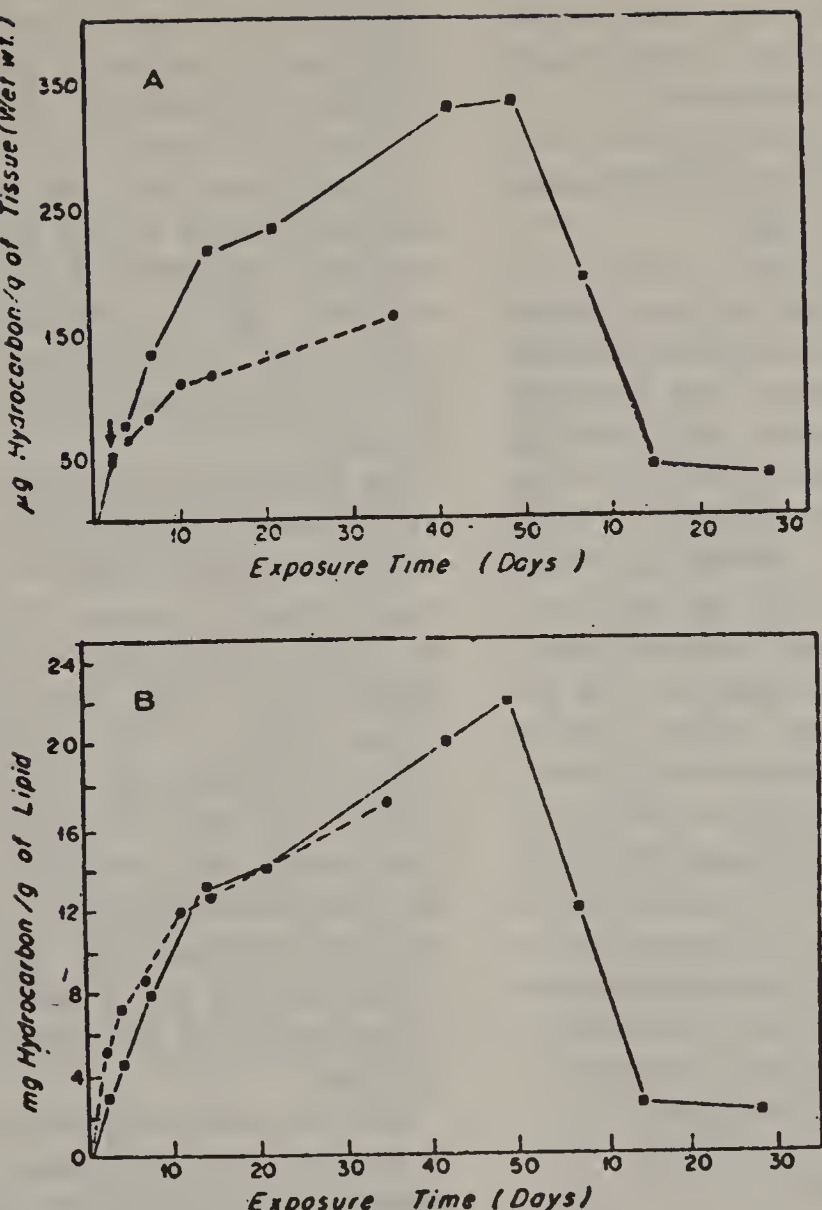


Figure 1-3 Levels of petroleum hydrocarbons in the tissues of marine organisms after various period of exposure and depuration (in clean water). Exposure of oysters to #2 fuel oil in a flowing system at a concentration of 106 ppb total hydrocarbons (Stegeman and Teal, 1973); the mussel, Mytilus edulis, exposed for 48 hours to surface oil slick total paraffins (Clark and Finley, 1974). With the exception of the data points for Mytilus which are expressed in µg/g dry weight of tissue, all additional data are expressed in terms of µg/g fresh weight of organism (ppm). (From Anderson et al. 1973).



Magnification Factors

2 Day Exposure
■ 4.25×10^2
● 4.17×10^2
49 Day Exposure
■ 3.15×10^3
● 1.72×10^3
28 Day Discharge
■ 3.09×10^3

2 Day Exposure
■ 2.66×10^4
● 4.51×10^4
49 Day Exposure
■ 2.07×10^5
● 1.95×10^5
28 Day Discharge
■ 1.96×10^5

Figure 1-4 Crassostrea virginica. Uptake and release of petroleum hydrocarbons by high fat-content (squares) and low fat-content (circles) oysters. Concentration of hydrocarbons expressed on (A) wet-weight basis, (B) lipid basis. The concentration of hydrocarbons in the water was 106 µg/l. At Day 50, high fat-content oysters were transferred to system with 11 µg hydrocarbon/l water. Each point represents determination of hydrocarbons in 3 oysters, with determinations in duplicate samples of three at Days 2 and 14. Magnification factors refer to concentration in the water. Concentration in low-fat oysters at Day 49 was determined by extrapolation. (From Stegeman and Teal, 1973).

Di Salvo et al. (1975) mention that another potential for the release of hydrocarbons may be in the eggs which, in mussels, were found to be enriched particularly with aromatic hydrocarbons compared to the total body concentration.

The present knowledge of depuration of petroleum hydrocarbons in marine animals is summarized by Anderson et al. (1974a).

It would seem that reduction of a body burden of hydrocarbons by metabolisms could have possible significance in fish, but probably not crustaceans or molluscs. As indicated above, however, all three groups are capable of disposing of accumulated PHC. The mechanisms responsible for disposal have yet to be clearly defined, particularly for crustaceans and molluscs, and for all three groups the real extent to which disposal occurs by release across gill membranes is still an unanswered question. With fish, where metabolism is a distinct possibility, there is information for only a few species and that very cursory. Rates of PHC metabolism in vivo under various environmental conditions are at this point impossible to guess. Furthermore, in terms of the consumer, we have no information regarding what percentage of PHC metabolites, some of which may be toxic, are retained or excreted by fish under varied conditions.

5. Food Web Magnification

There is increasing evidence that classical food web magnification (an increasing concentration of hydrocarbons per weight of tissue or lipid at successively higher trophic levels) of petroleum hydrocarbons does not occur. The principal evidence for this is: (1) Organisms so far tested have the ability to depurate at least the majority of accumulated hydrocarbons. Food chain magnification is dependent upon long term retention of the pollutant in tissues. (2) Much of the hydrocarbon ingested by zooplankton and other organisms passes through the gut without ever becoming accumulated into the body tissues. (3) The most important method of hydrocarbon accumulation is apparently transference across the gill surface. According to the National Academy of Sciences (1975) "Apparent food chain magnification may more likely be a function of the ability of different species to accumulate hydrocarbons from the water than a function of their position in the food web."

The possibility exists of some selective hydrocarbon buildup in the food chain in chronically polluted areas through molluscs which retain a portion of the toxic aromatic hydrocarbons. Although magnification would not occur, greater than normal levels of aromatic hydrocarbons could be passed on to the next trophic level. The resultant damage to the predator is not known, but would depend upon the concentration of aromatics in the prey, frequency of consumption, and toxicity or carcinogenicity of the particular aromatic hydrocarbons with the tissue of the prey organism.

The fact that the animals tested do accumulate hydrocarbons in rather large quantities in a relatively short time indicates that temporary food chain buildup can occur. The naphthalenes, which are among the most toxic petroleum fractions, remain within the prey species the longest (Anderson et al., 1974a). The carcinogen benzo-a-pyrene acts similarly to naphthalenes in animal tissues. If the temporary accumulation of naphthalenes and/or benzo-a-pyrene reached high enough concentrations in predators, death or cancer could result. The impacts would be of far shorter duration and of less impact on the marine ecosystem than if the classical food web buildup did occur.

There are other nonhydrocarbon components of oil (including but not limited to those discussed in Section 1) which could be magnified through the food web. Very little information is available for many of these compounds and, although most occur in small concentrations, the long range effects are not completely understood.

Another possible implication of oil spills in the marine environment is a decrease in the available food supply due to the death of prey species which have succumbed to the toxic fractions of oil. A detailed discussion of this factor is beyond the scope of this paper.

6. Microbial Decomposition

A necessary part of the food cycle in all systems is the decomposition of organic matter. Decomposition of petroleum hydrocarbons will be briefly discussed.

According to the report by the National Academy of Science (1975),

> It must be emphasized that with this multivariable system it is impossible to predict with either ease or accuracy the rate of microbial oil

removal. Few reliable field measurements have been made in the marine environment (Blumer et al., 1972c; Robertson et al., 1973); laboratory experiments, in which conditions, are optimal for oxidation can only give some indication of maximum rates. Even under laboratory conditions, the various fractions of oil or oil products will disappear at rates that can be measured on a time scale of weeks in some instances and that are immeasurable slow in others. Environmental stresses such as temperature and salinity changes, wave action, and sunlight not only directly affect the growth and metabolism of the microorganisms but also alter the physical state (for example, emulsification) and ultimately the chemical nature (for example, oxidation) of the hydrocarbons.

In sediments, chemical degradation of oil can occur but is restricted to the layer of the bottom penetrated by ultraviolet light. Ahearn and Meyers (1973) stated that research on microbial utilization of hydrocarbons for treatment of oily pollutants in the environment, though more intensive in recent times, is still in an early stage of development. It is known that microorganisms can degrade much of a crude oil, particularly the less toxic paraffinic compounds. No single species can degrade all the compounds, but many different species together can metabolize a large number of the compounds.

Microbial degradation is principally aerobic and large quantities of oxygen are needed. It has been estimated, for instance, that complete oxidation of 1 gallon of crude oil would require all of the dissolved oxygen in 320,000 gallons of water. It is reasonable to assume, however, that an oxygen deficient environment could occur under some oil slicks and in oil contaminated sediments. Much of the oil from the Santa Barbara blowout, for example, is believed to have settled in the Santa Barbara Channel (Battelle Northwest, 1970) where oxygen is already deficient and is probably insufficient for further decomposition.

Blumer and Sass (1972b) noted that "The preservation of hydrocarbons in marine sediments for geologically long time spans is one of the accepted key facts in current thought on petroleum formation." However, in spite of the stability of hydrocarbons in marine sediments, there are characteristic differences between hydrocarbons found in polluted and unpolluted areas. Tissier and Oudin (1973) found that hydrocarbons in polluted sediments differed from those of unpolluted sediments by having lower percentages of heavy components having an odd carbon dominance in the n-alkanes, and having polycyclic aromatic hydrocarbons with alkyl sidechains.

Numerous intermediates and end products have been identified in laboratory experiments (Friede et al., 1972; Klug and Markovetz, 1971), some of which may be disruptive to chemotaxic mechanisms of marine forms (Mitchell et al., 1972; Zafiriou, 1972). The microorganisms that digest oil may be pathogenic or produce toxins (Traxler, 1973).

The influences of environmental factors on decomposition rates has been summarized by the National Academy of Science (1975) report.

> Temperature increases may accelerate growth rates, thereby increasing biodegradation (Friede et al., 1972; ZoBell, 1973). A rise in temperature also increases the rate of evaporation of more volatile components, some of which are degradable and some of which are toxic (Atlas and Bartha, 1972b; see also previous section). Viscosity is lower at higher temperatures, thereby increasing the chance of emulsification and increasing the surface area available for microbial activity and solubility (ZoBell, 1973). Temperature decreases may not necessarily reduce the overall rate of microbial biodegradation significantly if special psychrophilic cultures develop (Robertson et al., 1973; Traxler, 1973).

Oxygen content is probably always sufficient for degradation of oil at the surface layer and in the upper water column in the open ocean (Friede et al., 1972). The degree of turbulence directly affects the availability of oxygen, as well as the physical dispersion and emulsification of the oil. If the water or sediments become anoxic, then rates of biodegradation will be markedly reduced (Davis, 1967).

Nitrogen and phosphorus concentrations strongly influence the rate of oxidation in laboratory experiments (Gunkel, 1967, 1968; Atlas and Bartha, 1972a). These nutrients may more commonly be limiting in the open oceans than in inshore regions.

Numerous other factors influence biodegradation, for example, presence of sufficient hydrocarbon substrate to develop a viable culture, presence of alternative carbon sources and microbial predators (Gunkel, 1968; Friede et al., 1972), but data are generally insufficient to precisely determine in situ effects on microbial oil utilization.

7. Carcinogenicity

As far as man is concerned, some doubt remains as to the direct carcinogenicity of crude oil and crude oil residues in marine organisms.

A literature search and evaluation conducted for the U.S. Coast Guard by Batelle Memorial Institute (1967) noted that shellfish, although alive, may have been unfit for consumption because of the carcinogenic hydrocarbon 3, 4-benzopyrene in their bodies. Oysters that were heavily polluted and contaminated with ship fuel oil were reported to contain 3, 4-benzopyrene. The Batelle review also reported that barnacles attached to creosoted poles contained the same carcinogenic hydrocarbon. Sarcomas were developed when extracts from the barnacles were injected into mice.

The carcinogenic benzo-a-pyrene behaves similarly to naphthalenes in pattern of uptake, retention, and release in clams (Anderson and Neff, 1974). As indicated earlier, they reported that organisms accumulated naphthalenes in tissues in greater amounts than the other hydrocarbons and released them more slowly.

Hyperplasia (increase in the rate of cell division) in reproductive cells of bryozoan in response to the addition of coal tar derivatives was reported by Powell, et al. (1970).

They noted that similar abnormalities may have occurred in coastal fauna exposed to spills such as the *Torrey Canyon* and the Santa Barbara blowout. However, most observations of these spills were concerned with mortality and may not have detected the sublethal effects. Straughan and Lawrence (1975) investigated the response of a number of bryozoan species to exposure to natural oil seepage, but found normal cell formation.

ZoBell (1971) reported the natural synthesis and metabolism of carcinogenic hydrocarbons by several marine organisms. Thus, oil pollution is certainly not the only source for carcinogenic hydrocarbon introduction into marine food webs. Suess (1972) recognized that carcinogens were in seafoods but concluded that they would probably not be dangerous unless the foods contained an excess amount of polynuclear aromatic hydrocarbon carcinogens. Carcinogenesis from oil contaminated marine organisms has not been proven, but Ehrhardt (1972) expressed a need for carcinogenic testing of hydrocarbon fractions extracted from marine organisms contaminated by exposure to oil.

According to the National Academy of Sciences (1975) workshop on petroleum in the marine environment:

> Although our information is limited, the effect of oil contamination on human health appears not to be cause for alarm. From our calculation, we estimate that the carcinogen benzo-a-pyrene concentration on a dry weight basis arising from a high level of contamination by petroleum is comparable with that of common terrestrial foods. We, of course, do not recommend eating contaminated seafood, but in most cases, because of the taste factor, not many will be tempted to do so. It is clear that this is an area in which our knowledge is grossly inadequate and that the contamination of seafood by oil is clearly undesirable.

Recent work by Yevich, of the National Marine Water Quality Laboratory in Naragansett, Rhode Island, has further implicated petroleum as a carcinogen. During two oil spills involving No. 2 fuel oil and a No. 5 diesel oil, he found two types of cancer in soft shell clams. One type forms in gonadal tissue and quickly spreads to other organs, while the other is a blood cell form similar to leukemia (Yevich, in press).

If Yevich's results prove to be valid, there should be greater cause for alarm than indicated by the National Academy of Science report.

8. Heavy Metals

a. Natural occurrence and sources from offshore petroleum operations

Heavy metals occur naturally in sea water in relatively low concentrations. Table I-4 lists average background concentrations in the open ocean for several heavy metals that have been associated with offshore petroleum operations. The residence time of the metal ions and their complexes is an estimate of turnover time in the marine environment. It must be emphasized that there are many dynamic physical and biological processes in the ocean that continually affect these "average" concentrations. Generally the concentrations in Table I-4 would be applicable to the open ocean area away from the direct influence of the coastal zone. In the coastal zone, especially in estuaries, near river mouths and in areas of high levels of industrial or municipal

Table I-4 Background Concentrations of Most Heavy Metals in the Ocean

Element	Seawater conc. ug/l (ppb)	Principal Dissolved Species	Residence Time in Ocean (Years)
- V	2	$VO_2\ (OH)^{-2}$	8.0×10^4
- Cr	0.5	CrO_4^{-2}, Cr^{+3}	2.0×10^4
- Mn	2	Mn^{+2}	1.0×10^4
- Fe	3	-	2.0×10^2
- Co	0.4	Co^{+2}	1.6×10^5
- Ni	7	Ni^{+2}	9.0×10^4
- Cu	3	Cu^{+2}	2×10^4
- Zn	10	Zn^{+2}	2×10^4
- As	2.6	$HAs\ O_4^{-2}$	5×10^4
		$H_2As\ O_4^{-1}$	
- Cd	0.1	Cd^{+2}	-
- Ba	20	Ba^{+2}	4×10^4
- Hg	0.2	$Hg\ Cl_4^{-2}$,	8×10^4
		$Hg\ Cl^o_2$	
- Pb	0.03	Pb^{+2}	2.0×10^3
- Ag	0.04	Ag^{+1}	2.1×10^6

Modified from: Goldberg et al. (1971)

discharges, the concentrations can be several times higher.

Natural sources of heavy metals to the ocean are river water, wind blown material from land following the weathering of rocks and tectonically active ridges where heavy metals are emitted in heavy brines. In coastal regions, additional major sources of heavy metals include sewage discharges, industrial effluents and atmospheric pollution. As an example of the atmospheric source, Patterson and Settle (1974, as cited by NSF/IDOE, 1974) found that atmospheric particle input is a major source of industrial lead in the Southern California Bight, comparable to the input of lead from storm runoff, rain and sewage. The atmospheric lead originates from cars burning leaded gasoline.

Many heavy metals in trace amounts are essential for animal and plant life. At present 14 trace elements are known to be essential for animal life: iron, zinc, copper manganese, cobalt, iodine, molybdenum, selenium, chromium, tin, nickel, fluorine, silicon and vanadium. These elements serve as components of enzymes or enzyme systems, enzyme activators, and components of vitamins, hormones and respiratory pigments. A few heavy metals such as arsenic, lead, cadmium and mercury are often referred to as toxic elements since they are toxic to marine organisms at relatively low concentrations and have no other known biological significance (Underwood, 1974). However, any of the heavy metals normally accumulated by marine organisms can be toxic if they are ingested or taken up at sufficiently high levels for long enough periods. Heavy metals and other trace metals in marine organisms are held by strong chemical bonds and are not readily released into the marine environment (Goldberg, 1965).

Offshore petroleum operations are potential sources of heavy metals to the coastal waters. Heavy metals are present in petroleum, formation waters (oil field brines) and drilling fluids. Crude oils vary greatly in trace element composition, and variations in trace element groups can occur from well to well in a particular geological formation (Filby and Shah, 1971). Concentrations of heavy metals and other trace elements in several crude oils are presented in Table I-5. Nickel (Ni) and vanadium (V) are generally the most abundant metallic elements in crude, but as shown in Table I-5, cobalt (Co), mercury (Hg), iron (Fe) and zinc (Zn) can be abundant in some crudes, in this case California crude. According to Filby and Shah (1971), very little is known of the forms of occurrence of trace elements other than Ni and V in crude oil. Ni and V occur partly as porphyrin complexes and partly in non-porphyrin type compounds associated with the high-molecular-weight material of the oil. The resins and aspahltenes contain most of the trace elements. These groups are not definite classes of compounds but are colloidal materials covering broad molecular-weight and polarity ranges (Filby and Shah, 1971).

Formation waters contain heavy metals in various concentration ranges. Formation waters are either discharged into the ocean after separation of oil fractions or reinjected into formation reservoirs. Median concentrations of various trace metals in formation waters are given in Table I-6.

Drilling muds used during drilling operations may be discharged periodically or accidentally into the ocean. Because of this, concern has been expressed over the introduction into the marine environment of toxic substances since the two major components of drilling mud are barite (barium sulfate) and ferrochrome lignosulfonate which contain the elements barium and chromium, known to be toxic in certain of their elemental states. A recent conference on the environmental aspects of chemical use in well-drilling operations in May, 1975 in Houston, Texas addressed these and other problems. The following information can be found in the report of the conference.

Barium sulfate, used as a weighting agent during drilling, is also used as a contrast medium for roentgenographic purposes and as an antidiarrheal and demulcent powder. Toxicity studies using *Mollienisias latipinna* (mollies) show that heavy concentrations of barium sulfate (up to 100,000 ppm for 96 hrs) exhibit no toxicity to fish (Grantham and Sloan, 1975).

Another report shows low toxicity but some physical problem with *Salmo salar*, Atlantic salmon because of suspended solids (Zitko, 1975). Concentrations of these magnitudes would exist only at the point of discharge.

Ferrochrome lignosulfonate is used as a deflocculant or thinning agent in drilling muds. Whereas chromium itself is highly toxic to certain species, when bound it is less toxic (Zitko, 1975) and it has been shown that in ferrochrome lignosulfonate the chromium is firmly chelated and may

Table I-5 Trace Element Contents of 6 Crude Oils[a]

Elemental Conc (ug/g)[b]	Oil Number					
	RF-1	RF-2	RF-3	RF-4	RF-5	RF-6
Ni	93.5	113.0	78.6	116.8	1.28	20.5
V	7.5	6.0	4.9	112.0	26.0	8.2
Co	12.7	13.9	14.5	0.198	0.001	0.0354
Hg	21.2	1.49	1.46	0.139	0.0143	0.0898
Fe	73.1	77.2	89.5	36.9	<5.0	4.94
Zn	9.32	19.50	19.60	2.619	<0.0907	9.08
Cr	0.634	0.685	0.729	0.380	<0.1	0.081
Mn	2.54	3.10	2.96	0.21	<1.50	0.79
As	0.656	1.63	0.67	1.20	<0.2	0.0773
Au	$2.8x10^{-6}$	......	....	$3.0x10^{-6}$	$<10^{-7}$	$6.4x10^{-5}$
Sb	0.0517	0.061	0.11	0.273	$<10^{-3}$	0.055
Se	0.364	0.484	0.333	0.369	0.009	0.128
Sc	$8.8x10^{-3}$	$9.0x10^{-3}$	$4.6x10^{-3}$	$4.4x10^{-3}$	$9.5x10^{-5}$	$<10^{-5}$
Cu	0.93	1.25	1.13	0.21	<0.2	0.19
Na	11.1	65.2	15.5	25.0	<1.0	13.0
Ca	192.0	75.1	103.0	150.0	<20.0	<20.0

[a]Oils RF-1, 2, 3 from California; RF-4, Venezuela; RF-5, Louisiana and RF-6, Libya

[b]Conc = concentrations in ppm

From Filby and Shah (1971)

TABLE I-6. MEDIAN CONCENTRATION OF TRACE METALS IN PRODUCED WATERS[1]

Median Concentration (equaled or exceeded by 50% of the samples) in Each Area[2]

	Number of Samples	Total Solids (madian) (g/1)	Co	Cr	Cu	K	Li	Mg	Mn	Ni	Sn	Sr	Ti	V	Zr
Illinois Basin	22	98	ND	2p	10p	300	15	6,000	175p	ND	< 1p	300	<10p	ND	<10p
Louisiana and Texas Gulf Coast	79	69	ND	<1p	<25p	300	ND	250	3.5	<1p	< 1p	85	<10p	ND	<10p
East Texas	88	66	ND[3]	ND	< 1	<50	ND	250	3.3	<1p	3p	350	ND[3]	ND[3]	ND
North Texas	24	222	ND	<1p	150p	300	ND	5,000	45	15p	12p	450	7p	ND	<10p
West Texas and New Mexico	148	111	ND	2p	1p	350	15	1,000	1.8	<1p	< 1p	200	<10p	ND	ND
Permian only	74	143	ND	2p	2p	400	10	1,000	1.7	<1p	< 1p	90	<10p	< 1p	ND
Pennsylvania only	34	115	ND	3p	< 1p	300	10	1,000	2.8	<1p	< 1p	300	<10p	< 1p	ND
Silurian-Devonian only	15	55	ND	2p	4p	300	10	400	300p	<1p	1p	90	<10p	ND	ND
Ordovician-Cambrian only	21	67	ND	<2p	4p	400	15	800	400p	<1p	1p	250	<10p	ND	ND
Anadarko Basin[4]	118	137	ND	10p	10p	250	10	1,550	5.6	6p	2p	300	<10p	< 1p	<10p
Williston Basin, post-Paleozoic	25	59	<5p	<2p	<25p	300	ND	250	300p	<3p	< 1p	100	ND	< 1p	ND
Williston Basin, Paleozoic	55	173	ND	3p	3p	800	35	600	660p	ND	< 1p	95	<10p	< 1p	ND
Powder River Basin	22	5	<5p	<2p	<25p	300	ND	40	450p	<3p	< 1p	25	<10p	< 1p	<10p
Other Wyoming	28	5	ND	ND	ND	300	ND	100	300p	ND	< 1p	20	<10p	< 1p	ND
Colorado	18	5	<5p	ND	<25p	300	ND	30	300p	<3p	<10p	20	<10p	< 1p	<10p
California	116	18	ND	5p	5p	45	ND	90	950p	10p	2.5p	10	<10p	< 1p	ND
Seawater	-	35	0.27p	0.04p-0.07p	1p-15p	380	0.1	1,272	1p-10p	5.4p	3p	13	Present	0.3p	ND
Estimated Detection Limit	-	-	1p	1p	1p	50	2	10	1p	1p	1p	16	10p	1p	10p

1/ Taken from Rittenhouse, Fulton, Grabowski, and Bernard

2/ ND = below detection limits; p = concentration in parts per billion, otherwise parts per million

3/ No data; less sensitive methods of analysis used.

4/ Includes Oklahoma Platform and Ardmore Basin.

Source: "Environmental Aspects of Produced Waters from Oil and Gas Extraction Operations in Offshore Coastal Waters, prepared by OOC, Sept., 1976.

not be removed from the lignosulfonate complex even by strong ion-exchange resins and that the chromium is in the trivalent oxidation state (McAtee and Smith, 1969). Toxicity studies using *Mollienisias latipinna* (mollies) have indicated that the compound itself is of low toxicity (killed some test animal at 70 to 450 ppm concentrations). These concentrations could be found near discharge points (Hollingworth and Lockhart, 1975).

Heavy metals can also be introduced into sea water by the dissolution of drilling platform legs and pipelines. The metals released would be iron with lesser amounts of nickel and molybdenum. The time required for metal decomposition through chemical and microbial erosion is not presently known, but with present safeguards, may be around ten years. Dissolution would occur at a very slow rate and should not appreciably add to the concentration of heavy metals around platforms and pipelines in the water column or in sessile marine organisms, although this has yet to be demonstrated.

Concerning the levels of concentration of heavy metals in the marine environment, IDOE (1972) concluded that with the possible exception of lead, the current levels of heavy metals in marine ecosystems are derived primarily from natural rather than technological sources. However, local inputs in the estuarine and coastal environments can increase the levels in the water column, sediments and marine organisms. In a study of the effects of offshore petroleum operations on the environment, in the Gulf of Mexico, the Gulf Universities Research Consortium (GURC) concluded that all the heavy metals observed in the water column were in the ranges reported for oceanic waters except for barium for which the results were inconclusive. A zinc concentration gradient was found that decreased with distance from the oil platforms (GURC, 1974). However, the investigation did not analyze distribution of heavy metals in the marine organisms or in the sediments.

b. Uptake

Marine organisms can accumulate heavy metals by absorption across body surfaces and gills from the water or by ingestion of food containing heavy metals. Food sources can include heavy metals absorbed onto suspended particles or plankton, heavy metal compounds that have precipitated into the sediments and been ingested by deposit feeders, and heavy metals concentrated by organisms and preyed upon by other organisms in higher levels of the food web.

Once heavy metals are introduced into the ocean, concentrations are lowered by dilution and removed from sea water by precipitation, absorption, and absorption by marine organisms. The amount of dilution depends on the currents, mixing and circulation patterns in the area of discharges as well as the medium in which the metals are discharged. For example, heavy metals introduced in crude oil or formation water of greater density than the surrounding water would probably tend to mix less with the ambient water mass and retain their higher concentrations for a longer period of time. The use of diffuser technology in many sewage outfalls helps to dilute the effluents faster and prevents a large dose of highly concentrated effluent impacting one area at one time.

Precipitation of a metal to the sediments occurs if the concentration of the metal is higher than the solubility of the least soluble compound that can be formed between the metal and anions in the water such as carbonate, hydroxyl or chloride. The concentrations of heavy metals which can remain in solution are orders of magnitude higher than those usually found in the sea and normally the sea is considerably undersaturated with heavy metals (Bryan, 1971).

Adsorption of metals can occur on the surfaces of suspended and deposited particulate matter such as clays, phytoplankton, hydrated ferric oxide and hydrated manganese dioxide. However, all heavy metals are not equally readily absorbed. Zinc, copper and lead are probably readily adsorbed by both hydrated ferric oxide and hydrated manganese dioxide, but cobalt and nickel prefer hydrated manganese dioxide while silver is not readily adsorbed by either (Bryan, 1971). According to Lowman et al. (1971), surface adsorption, including ion exchange, is probably an important uptake path for phytoplankton. Glooschenko (1969) found that the greatest uptake of mercury-203 (^{203}Hg) per cell in a population of coastal marine diatoms (*Chaetoceros costatum*) was by adsorption onto a population killed with formalin rather than uptake by absorption of living cells. This passive uptake for the dead cells could also be due to increased membrane permeability to the mercury. In either case, the uptake by adsorption was greater than the active adsorption process of live cells.

It has been found that heavy metals in natural waters are predominantly associated with particles suspended in water. Whenever attempts have been made in the natural environment to detect the amounts of heavy metals in solution versus the amount adsorbed onto or part of particles, investigators have discovered that only a small percentage of the heavy metals are in solution. It is not known if the particles that have adsorbed the heavy metals can be absorbed. It is generally thought that the particles must be ingested or taken into cells by phagocytosis and that the metal must be solubilized to be absorbed in solution (Hartung, 1972).

Uptake by absorption from sea water through the gills, body surface or gut wall is an important pathway for heavy metals to enter marine organisms. As noted by Anderson et al. (1974a), the accumulation of heavy metals by marine organisms from dilute sea water solutions has been well demonstrated. The amount of heavy metal absorbed depends on many physical and chemical factors such as the concentration of the heavy metal in solution, the chemical form of the complex, the ligands available for complexing the metals, particle size, the nature of the particles available for adsorption in the water, pH and alkalinity. Biological characteristics of the organism also affect the absorption rate and amount: the species of the organism, age, metabolic rate, and previous health (Hartung, 1972). A further complicating factor is that an equilibrium may be established between the organism, its food and the concentration of the heavy metal in the water (Lowman et al., 1971).

Concentration factors for various marine organisms for several elements including heavy metals are given in Table I-7. It can be seen that these factors range up to more than a million or more for the heavy metals. Concentration factor is defined as "the ratio of the concentration of an element or radionuclide in an organism or its tissues to that concentration directly available from the organism's environment under equilibrium or steady-state conditions" (Lowman et al., 1971). However, marine organisms accumulate heavy metals and other elements from many sources including food, water, suspended particles and deposited sediments. Therefore, the concentration factors listed should be viewed as indicators that can be changed by biological and environmental factors.

Absorption from solution through the gills of the lobster *Homarus vulgaris* results in a concentration of 7ppm of zinc in the lobster blood flowing through the gills, or 10^3 to 10^4 times the concentration in sea water. Before the zinc diffuses through the gill epithelium probably attached to proteins, zinc is first adsorbed onto the cuticle covering of the gills (Bryan, 1971). Anderson et al. (1974a) summarized recent studies of heavy metal uptake from sea water in marine animals as follows:

> Among the more recent studies, Eisler et al. (1972) have shown that mummichogs or common killifish, *Fundulus heteroclitus*, scallops, *Aquipecten irradians*, oysters, *Crassostrea virginica* and northern lobsters, *Homarus americanus*, exposed for 21 days to flowing sea water containing 10 ug/L (ppb) of cadmium accumulated the metal to levels equivalent to 45, 114, 352 and 41 percent, respectively, higher per unit wet weight than baseline levels of cadmium in the controls. Pentreath (1973) determined that exposure of the estuarine mussel, *Mytilus edulis* to zinc, manganese, iron and cobalt in sea water solution for 49 days resulted in maximum concentration factors of approximately 500, 250, 5000, 1000 respectively. Vernberg and O'Hara (1972) studied the effects of temperature-salinity stress on mercury uptake and accumulation in the gill and hepatopancreas tissues of the fiddler crab *Uca pugilator* and found significant uptake over 72 hours of exposure, with gill tissue accumulating greater amounts than hepatopancreas under all conditions.
>
> The NSF/IDOE (National Science Foundation/International Decade of Ocean Exploration) Pollutant Transfer Workshop reported on more recent findings of heavy metal uptake by marine organisms. The Skidaway group at the University of Georgia found that the marine plant *Spartina alterniflora* takes up mercury through its roots. Subsequently, the mercury is transferred to the leaves and then released to estuarine waters. The root system apparently concentrates inorganic mercury, while the leaves concentrate methylmercury (NSF/IDOE, 1974). Eelgrass (*Zostera marina*) in the coastal waters of Alaska absorb trace metals from the water and sediments and concentrate zinc, copper and cadmium in their roots, rhizomes and leaves. The eelgrass helps to recycle these trace elements in the food web that would normally be lost to the sediments (NSF/IDOE, 1974).

At the California Institute of Technology it has been discovered that the form of the heavy metal lead in sea water is critical to the knowledge of its behavior in the food chain. For example, the investigators found that much of the lead in sea water may be adsorbed on the mucilage of algae (NSF/IDOE, 1974). This is consistent with the findings of Flooschenko (1969) discussed earlier for the marine diatom *Chaetoceros costatum*. Chow et al. (1974) have also discovered that excessive amounts of lead collect on the epidermal mucous of fish. These observations are important since the biologically active fraction of lead in marine organisms might be small compared to the large

TABLE I-7 Ranges of Element Concentration Factors[a] in Marine Organisms at Various Trophic Levels[b]

	Algae		Grazers		Predators		
Element	Sessile	Plankton (Phytoplankton and Sargassum)	Plankton (Copepods, Pteropods, Salps, Doliolid)	Shellfish	Plankton [Euphausiids, Planktonic Amphipods, Shrimp (Acanthephyra, Paleomonetes)]	Fish	Squid
Ag	(18) 100-1,000	(1) <100-220	(1) <100	(2) $330-2 \times 10^4$	(1) <45-900		(1) 900-3,000
Cd	(12,13) 11-20	(1) <350-6,000	(1) $<80-10^5$	(2) $10^5-2 \times 10^6$	(1) $<300-10^4$	(12) >10	(1) 2,800
Ce	(14) 100-3,300[c]	(4) 2,000-4,500[c]		(14) 40-300[c]		(14) 5-12[c]	
Co	(13,14,16) 15-740	(1,13,17) 75-1,000	(1) $<110-10^4$	(7) 24-260 (14) 18[c]	(1) <70-1,300	(14) 28-560	(1) $<200-5 \times 10^4$
Cr	(14) 100-500	(1) <70-600	(1) $<15-10^4$	(2) $6 \times 10^4-3 \times 10^5$	(1) <55-3,900	(8) 3-30	(1) <70
Cs	(14) 16-50	(14) 16-22	(3) 6-15[c]	(14) 3-15[c]		(14) 6-10	
Fe	(14) $10^3-5 \times 10^3$	(1) $750-7 \times 10^4$	(1) $440-6 \times 10^4$	(2) $7 \times 10^4-3 \times 10^5$	(1) $3 \times 10^3-3 \times 10^4$	(14) $400-3 \times 10^3$	(1) $10^3-3 \times 10^3$
I	(14) $160-7 \times 10^3$			(14) 40-70		(14) 10	
Mo	(9,16) 10-200	(1) <3-17	(1) 2-175	(2) 30-90	(1) <2-14	(9) ~200	(1) <10
Mn	(14) $20-2 \times 10^4$	(1,14) $300-7 \times 10^3$	(1) $21-4 \times 10^3$	(2,14) $3 \times 10^3-6 \times 10^4$	(1) 270-1,600	(14) $95-10^5$	(1) 10^3
Ni	(13,16) $50-10^3$	(1) 25-300	(1) $2-10^3$	(2) $4 \times 10^3-10^4$	(1) 17-90		(1) 30-80
Pb	(13) $8 \times 10^3-2 \times 10^4$ (14)	(1,17) $10^3-3 \times 10^6$	(1) $3 \times 10^3-2 \times 10^6$	(2,6) $39-5 \times 10^3$ (14)	(1,15) $200-6 \times 10^4$ (11)	(10) $5-10^4$ (14)	(1,15) $100-2 \times 10^5$

TABLE I-7 (continued)

Ru	$100-10^{3c}$			$1-16^{c}$	10^{c}	10^{c}	
	(18) <200-1,200	(1) <200	(1) $<10-6 \times 10^{3}$		(1) <160-2,400		(1) <400-2,100
Sr	(14) 0.1-90	(1) 0.9-54	(1) 1-85	(5) $\sim 50^{c}$	(1) 1.2-10	(14) 4-5	(1) 0.9-1.2
Ti	(18) $200-3 \times 10^{4}$	(1) $600-10^{4}$	(1) $28\text{->}3 \times 10^{4}$		(1) $110-2 \times 10^{4}$		(1) 300-3,000
Zn	(14,16) 80-3,000	(1) 200-1,300	(1) 125-500	(2,14) $1{,}400-10^{5}$	(17) ~50	(14) $280-2 \times 10^{4}$	(1) 2,500
Zr	(14) $200-3{,}000^{c}$	(1) $<1{,}000-2 \times 10^{4}$	(1) $360-3 \times 10^{4}$	(14) $8-36^{c}$	(1) $<800-4 \times 10^{4}$	(14) 5^{c}	(1) 2×10^{4}

a Concentration in whole, fresh organism versus concentration in seawater.
b Literature references are shown in parentheses in upper left of box and listed below. No attempt has been made to achieve completeness; the ranges of concentration factors are for illustration, but are believed to be representative.
c Concentration from radionuclide tracer experiments.

(1) Bowen et al., unpublished; some data from Nicholls et al., 1959.
(2) Brooks and Rumsby, 1965.
(3) Bryan, 1963.
(4) Chapman, 1958.
(5) Cigna et al., 1963.
(6) Costa and Molina, 1957.
(7) Fukai, 1968.
(8) Fukai and Broquet, 1965.
(9) Fukai and Meinke, 1962.
(10) Goldberg, 1962.
(11) Hiyama and Khan, 1964.
(12) Hiyama and Shimizu, 1964.
(13) Ishibashi et al., 1964.
(14) Polikarpov, 1966.
(15) Tamotsu et al., 1964.
(16) Young and Langille, 1958.
(17) Vinogradova and Kovalskiy, 1962.
(18) Black and Mitchell, 1952.

From Lowman et al. (1971)

amounts of biologically inactive adsorbed lead on these organisms. This distinction has often been ignored in the past (NSF/IDOE, 1974).

The path of uptake can also depend on the element itself. Bryan (1964) found that zinc and copper were absorbed indirectly from the water into the lobster *Homarus vulgaris*, while Bryan and Ward (1965) discovered that manganese uptake was mostly from food for the same species of lobster. Pentreath (1973) investigated uptake of radioisotopes of zinc manganese, cobalt and iron by the mussel *Mytilus edulis* and reported that accumulation from sea water was minor compared to food accumulation. Pentreath indicated that uptake was from food particles as well as from mucous accumulation of metals in soluble form. Results of Hoss (1964) as reported by Bryan (1971) using zinc-65 in the flounder, *Paralychthys*, suggest that food is a more important source of zinc than sea water. Likewise, Preston and Jeffries (1969, as cited by Bryan, 1971) have shown that zinc and cobalt are absorbed from ingested particles through the gut rather than from sea water solution for the oyster *Ostrea edulis*.

In contrast, Polikarpov (1966) contends that chemical mineral substances are more generally accumulated directly from water than indirectly through the food chain. According to Lowman et al. (1971) the degree to which a trace element is taken up in a marine organism depends on the relative concentrations of the element in the water and food. When an element is concentrated in food only slightly above its concentration in water, the food supplies a relatively low fraction of the element for marine organisms. However, when the element is highly concentrated in food compared to sea water, a major fraction of the element may be accumulated from the food through the gut. The relative importance of uptake of heavy metals from water compared to uptake from food is still being studied and is by no means resolved for marine organisms. As mentioned above, it probably varies for different elements and organisms as well as for various relative concentrations.

Bryan (1973) reported a seasonal variation in the concentrations of trace metals in two scallop species from the English Channel. Variations between species were observed, but the highest values of metals occurred in the autumn and winter when phytoplankton productivity was low, while the values decreased when phytoplankton production increased. The metals looked at were Ag, Co, Cr, Cu, Mn, Ni, Pb, Zn, Al, Cd and Fe and they were concentrated in the kidneys and digestive glands to the greatest extent. Bryan reasoned that the seasonal variation was due to three factors:

1) More food from increased phytoplankton productivity in spring and summer results in increased metabolic activity for the scallop and increased excretion of wastes, including excess heavy metals.
2) The uptake of metals by phytoplankton decreases the concentration in the water. Also extracellular products from the phytoplankton may chelate metals in the water thereby reducing their availability to the scallops.
3) In the times of high productivity, the amount of metal/phytoplankton cell decreases, since the cell members increase and the metal concentrations remain virtually the same.

Other organisms besides particle feeders like the scallops probably have seasonal variations in their uptake of heavy metals, although there has been little investigation to date of this environmental variable.

Storage and Metabolism

Once heavy metals are taken up by marine organisms they are usually used in enzyme systems or stored in a particular body tissue, sometimes for just a temporary period. The place of storage in the organism and its subsequent pathway through the organism is dependent on several variables including the type of metal, the form of the metal complex, the method of uptake, species and the age of the organism. In general, elements that are concentrated in marine organisms can be grouped into one of the five categories: (1) structural elements—carbon, nitrogen and phosphorus (silicon, calcium and strontium, in some cases); (2) catalyst elements—iron, copper, zinc, manganese and cobalt (nickel, chromium, cadmium and silver may follow these elements); (3) elements easily hydrolyzed at sea water pH; (4) heavy halogens; and (5) heavy divalent ions—barium, radium and lead (Lowman et al., 1971). Most of the heavy metals of concern occur in the catalyst element group.

Different groups of marine organisms are able to accumulate and store heavy metals in their tissues depending on their ability to regulate the concentration in their body compared to the environmental concentration. This involves not only uptake and storage of heavy metals but also release of the metals back to the environment. For example, according to Bryan (1971) when the concentrations of metals such as zinc or copper in sea water are increased, the concentrations in oysters increased appreciably while the concentrations in the flesh of crustaceans such as crabs or lobsters remain relatively constant. Storage sites for most organisms include the digestive glands, muscle tissue, skeletal tissue and gills.

For small marine crustaceans (*Euphausia pacifica*, *Thysanoessa spinifera*, *Pandulus stenolepis* and *P. platyceros*) Fowler et al. (1970) found that zinc-65 fed through a food chain accumulated primarily in the interstitial spaces between muscle fibers, in the eye, within the exoskeleton and on the interior surface of the exoskeleton. These locations were the same as those for storage of zinc-65 from water absorption processes. However, the source of the zinc affected the saturation levels of the tissues. When uptake was from food, the muscle tissue (and hepatopancreas at times) contained a higher percentage of the total zinc level in shrimps and euphausiids than the exoskeleton. When uptake was from water, the percentage of total zinc level was higher in the exoskeleton. The fact that a significant percentage of zinc was located in the exoskeleton from labelled food uptake suggests that the zinc was transported rapidly by the haemolymph from the gut to the exoskeleton (Fowler et al., 1970). The investigators concluded that since most of the zinc-65 was located between cells rather than inside of cells, most ingested zinc apparently accumulates in excess of the animals' needs and is not used metabolically.

In other marine crustaceans primary storage has been found to occur in the hepatopancreas for excess zinc in lobster blood and for excess copper in the shrimp *Crangon vulgaris* (Bryan, 1971). Another crustacean, the fiddler crab *Uca pugilator*, concentrated mercury primarily in the gill tissues with lesser amounts in the hepatopancreas and green gland. Very small amounts were found in the carapace and muscle tissues (Vernberg and Vernberg, 1972). See Figure I-5. The mode of uptake by the crab, however, was absorption of mercury from sea water.

Molluscs accumulate heavy metals in the digestive glands and kidneys primarily (Bryan, 1971; Bryan, 1973; Pentreath, 1973). Anderlini (1974) discovered high concentrations of cadmium (up to 1400 ppm) in the digestive glands of the red abalone *Haliotis rufescens* from samples along the California coast. He looked at eight heavy metals (silver, cadmium, chromium, copper, lead, mercury, nickel and zinc) and reported varying concentrations in the gills, mantle, digestive gland and foot muscle. The concentrations in the different tissues varied with the metal type, the concentrations of the metal in the sea water and the method of uptake. For example, nickel had the highest concentrations in the gill (up to 100 ppm), more than 2-3 times the nickel levels in other tissues. This was probably due to absorption and accumulation of nickel into the mucous sheets of the gills as well as absorption by the gills themselves (Anderlini, 1974). An investigation of several heavy metals in North Atlantic finfish revealed that muscle tissue of these Osteichthys species concentrated arsenic, cadmium, copper, mercury and zinc in varying amounts. Mercury and cadmium concentrations in muscle tissues of Chondrichthys species studied tend to be higher than those of Osteichthys while arsenic concentrations were definitely higher. The liver of Chondrichthys had higher concentrations of arsenic, cadmium, copper and zinc compared to other Chondrichthys tissues (Windom et al., 1973a). Silver, cadmium, chromium, copper, nickel, lead and zinc concentrate mainly in the gonads and liver of the Dover sole with smaller amounts in the epidermis. Specimens were taken from outfall and control areas off Southern California (SCCWRP, 1974). Chow et al. (1974) found lower concentrations of lead in tuna muscle than had been reported previously. Muscle tissue contained about 0.003 ppm of lead while epidermis had about 2 ppm in wet tissue. High concentrations in fish fins from tuna is due to the mucin secreted by the mucous cells of the epidermis which forms a mucous slime from a glycoprotein. The authors conclude that it is likely that strong heavy metal complexing sites in the proteins take up leak from sea water and incorporate it into the slime. They conclude that most of the lead in time is probably contained in this epidermal mucous layer and that it is unlikely that much lead passes through the skin barrier from sea water (Chow et al., 1974). Analysis of epidermal mucous and kidneys from an adult sculpin (*Scopaena guttata*) exposed to large concentrations of lead acetate over three months resulted in accumulation of lead in the mucous. The lead did not increase in the muscle tissue, but did increase in the kidney and bone. Apparently the kidney is metabolizing the accumulated lead and some of it is deposited in the bone (NSF/IDOE, 1974).

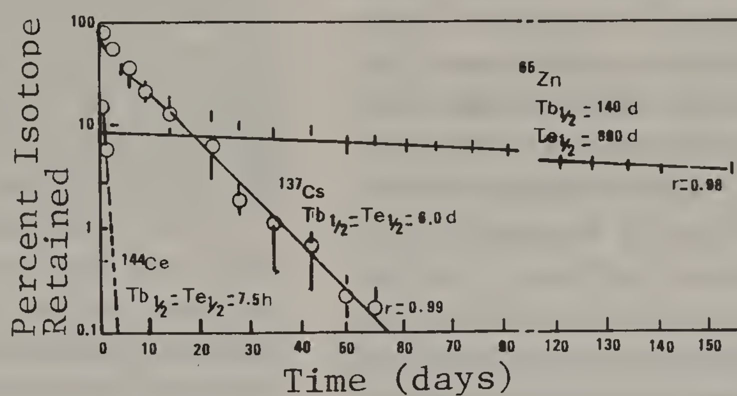


Figure 1-5 <u>Euphausia pacifica</u>. Loss of three radionuclides from similar-sized euphasiids (Mean dry weight 2.4 mg). ^{65}Zn, n-3; ^{137}Cs, n-5; ^{144}Ce, n-2; r: correlation coefficient. Bars indicate ranges of animal activity. All data were corrected for physical decay of the isotope except ^{137}Cs. Tb½: biological half-life; Te½: effective half-life; 10°C. d: days. (From Fowler et al. 1971).

Evidence that the form of the metal compound is important for the storage site derives from observations of 70% of the total mercury in carnivorous fish muscle occurring as methylmercury. For invertebrate omnivores, the percentage of methylmercury is less. Samples of liver and spleen from sharks contained low amounts of methylmercury compared to total mercury (NSF/IDOE, 1974). At the cellular level, the distribution of lead-210 in sea cucumber embryos (*Strongylocentrotus purpuratus*) has been investigated by Nash (1975). He reported that embryos can absorb significant amounts of lead from levels as low as 4.81×10^{-6} ppm. Most of the absorbed lead was concentrated in the nuclear portion of the cell homogenate.

All of these investigations indicate that there are many variables involved in the storage and metabolism of heavy metals in marine organisms. At present little is still known about the pathways of uptake, metabolism, storage and release of heavy metals and their transport through the marine ecosystems.

c. Discharge and release into the marine environment

There have been few studies to date of the release or depuration of heavy metals from marine organisms to the marine environment. Although data on retention times are scanty, there are indications that metals concentrated in animal tissues are retained at significant concentrations for several months (Andersen et al., 1974b). Discharge of heavy metals from marine organisms can take place by ion exchange across cell membranes of gill and body surfaces, loss by molting exoskeletons that have concentrated heavy metals, excretion of heavy metals into the gut and loss by feces and excretions in the urine. All of these processes help an organism to regulate the concentration of heavy metals and other substances accumulated from sea water or food, but the extent and rate of their release is poorly known for heavy metals.

Bryan (1971) reports that excretion of metals across the gills appears to occur: in the shore crab, *Carcinus maenas*, and in the rainbow trout, *Salmo gairdnerii*. The cypiid larva of the barnacle, *Balanus amphitrite niveus*, excretes excess copper into the lumen of the gut and the octopus, *Octopus dofleini*, excretes both copper and zinc into the rectal fluid. Crustaceans can excrete copper, zinc, cobalt, manganese and mercury in the urine. Little information is known about excretion of heavy metals from fish except that excretion of zinc in the urine of the rainbow trout is relatively unimportant (Bryan, 1971). The rate of loss of methyl mercury from species of carnivorous fish is very slow. Methyl mercury in fish has a half-life of about two years according to Miettinen et al. (1971, as cited by Hartung, 1972).

A long-term experiment concerning the elimination of zinc-65, cesium-137 and cerium-144 by euphausiid shrimps determined that approximately 96% of the initial body concentration was eliminated over a five month period (Fowler et al., 1971). The biological half-life of ^{65}Zn was 140 days, and the percentage of ^{65}Zn lost in molts compared to the total in the organism was 1%. Assuming that loss through fecal pellets is small, the major mechanism for ^{65}Zn loss for euphausiids would be isotopic exchange with the water. From Figure I-5 it can be observed that approximately 90% of the ^{65}Zn was lost after 30 days.

In a study of the mussel, *Mytilus edulis*, and its accumulation of some heavy metal isotopes from sea water, Pentreath (1973) observed that the greatest accumulation was in the stomach and digestive gland for all isotopes. However, after two weeks iron-59 occurred in the mussel foot in the byssus gland area that attaches the mussel to the substrate. Following another two week period, the iron-59 clusters disappeared. The author postulated that the iron might be secreted into new byssus threads. After 42 days in filtered sea water, the loss of the metals from the stomach and digestive gland was as follows:

Percent loss in dry weight from stomach and digestive gland: Zinc, 23.1; Manganese, 14.3; and Iron, 52.2.

There was no loss from the adductor muscle (Pentreath, 1973). Yound and Folsom (1967, as cited by Pentreath, 1973) recorded a long half-life for zinc-65 in the mussel, *Mytilus californianus*, as 76 ± 3.5 days.

Other observations of release of heavy metals by molluscs include a biological half-life of 193 days for manganese excretion from scallops (Bryan, 1973). No appreciable decrease in the concentrations of cadmium and zinc in dog whelps and limpets was found in the Bristol Channel after seven weeks and three weeks cleansing in clean sea water. A crab (*Carcinus* *maenas* L) lowered its zinc concentration significantly but not the cadmium concentration after seven weeks cleansing (Peden et al., 1973).

Therefore, from these few investigations one can find evidence that marine organisms can release heavy metals back to the environment, but the time of release is relatively long. There is some evidence to indicate that molluscs may not be able to regulate heavy metal concentrations in their tissues as well as crustaceans (Bryan, 1971). However, it is not known if this difference is due to separate pathways of uptake and storage, different methods of release or differences in the bonding of the metals and their complexes in the tissues.

d. Food web magnification

There is ample evidence to indicate that heavy metals accumulate in the marine food web in a variety of organisms at various trophic levels and through a variety of uptake pathways. As can be seen from the preceding discussion, heavy metals can be concentrated by absorption across gills, body surfaces and gut wells; adsorption into organisms, suspended and deposited particles; and taken up from food sources. The concentration factors listed in Table I-9 reflect tremendous abilities for marine organisms to concentrate elements from very dilute solutions in sea water. However, as mentioned previously the significance of the concentration factors is observed by the many variables and pathways involved in the uptake of heavy metals by marine organisms. Classical food web magnification, or the increasing concentrations of an element per weight of tissue in successively higher trophic levels, for heavy metals is complicated by not only the various uptake pathways but also by the ability of some organisms to release the heavy metals back to the marine environment eventually and therefore regulate concentrations in their tissues against environmental gradients. The whole process is just not well enough understood at this time.

Most of the characteristics of heavy metals in the marine environment favor their magnification in the food web. Like PCS's and synthetic chemicals, heavy metals are relatively resistant to chemical and biological degradation. Evidence has been presented that the half-life of metals in tissues is relatively long before being excreted. The half-life can range up to two years for methylmercury compounds in fish. The longevity of the metals in tissues and the high concentration factors of many marine organisms suggest that food web magnification can take place. Most of the incidents of high levels of heavy metals found in marine organisms in the ocean occur in coastal waters and point sources near pollution sources from land. A toxic effect on a consumer in the higher levels of the marine food web, including man, can result from feeding on organisms further down in the food web that have concentrated heavy metals at levels that have no apparent effect on the food organisms.

Besides the much publicized occurrence of mercury compounds in high concentrations in some tuna and swordfish, heavy metals such as arsenic, cadmium, copper, zinc, chromium, lead, nickel and silver have been reported in various organisms from the marine environment throughout the world (LeBlanc and Jackson, 1973; Stenner and Nickless, 1975; Peden et al., 1973; Stenner and Nickless, 1974; Anderlini, 1974; Windom et al., 1973a; Windom et al., 1973b; Chow et al., 1974; and Bryan, 1973). In a study of mercury in plankton in the North Atlantic, Windom et al. (1973b) reported concentrations of less than 0.2 to 0.4 ppm in open ocean plankton compared to 5.3 ppm in nearshore plankton in polluted areas. The samples included mostly copepods and arrow worms with eleven samples containing phytoplankton.

The authors hypothesized that the mercury was possibly transported from the nearshore plankton to the open ocean food web rather than through direct transport in the water since the dilution factors over the distances involved would be tremendous.

In a related study from the same area in the higher levels of the food web, Windom et al. (1973a) analyzed several heavy metals in various species of fin fish. In this investigation they found no tendency for onshore-offshore differences in concentrations for Osteichthys or Chondrichthys. There were differences in levels of accumulation and storage places for different metals in both groups as mentioned previously in this discussion. For Osteichthys arsenic concentrations ranged from less than 1.0 to 6.4 mg/g (ppm) and mercury concentrations from 0.1 to 3.0 mg/g. However, what is significant is that copper, cadmium and zinc concentrations were similar in all fish studied except for the smaller plankton-eating fish (anchovies and myctophids) which had much larger concentrations of these metals than the other fishes. This would suggest depletion of these metals up the food chain, and not magnification, since the plankton on which these fish feed have an even higher concentration of these metals (Windom et al., 1973a).

A similar instance of food chain accumulation, but not magnification, could be found in predators of the red abalone, *Haliotis rufuscens*, off the California coast. Anderlini (1973) reported a high concentration of cadmium (up to 1400 ppm) in the digestive glands of the red abalone. However, cadmium levels in the kidneys of mollusc-eating sea otters (*Enhydra lutris*) off the California coast ranged from 89 to 300 ppm. Although this was higher than cadmium in fish-eating sea lions (from 18 to 63 ppm) from a comparable level in the food web, the point is that the cadmium levels did not approach those found in the abalone. Therefore, the cadmium was probably accumulated in the food chain, but classical magnification probably does not take place. Whether or not the levels of cadmium were increased in the next trophic level, the large amounts of cadmium in the higher level predators would be cause for concern. Other marine mammals, birds, fish and man at the upper levels of the marine food web can be affected by high concentrations of certain heavy metals accumulated in the food web.

What does this mean for heavy metals introduced into the ocean from offshore petroleum operations? Evidence has been presented that heavy metal concentrations in petroleum, formation waters and drilling fluids can range from 10 to 10^5 times the natural background levels of the open ocean (see Tables I-4-8). Therefore, events such as accidental massive or chronic oil spills, accidental loss of drilling fluids and the discharge of formation waters can introduce higher loads of heavy metals into the ocean. The introduced metals are then diluted by sea water, precipitated out, adsorbed on particles or other organisms and absorbed by some marine organisms to various degrees. These discharges would be localized sources occurring around drilling platforms for the most part.

Therefore, there could be some uptake of metals especially by the sessile organisms around the platforms. It is not known to what extent this occurs and to what levels the heavy metals would concentrate in the water column, sediments or marine organisms as a result of petroleum operations. The only investigation conducted so far concerning effects of heavy metals from offshore petroleum operations indicated that the concentration ranges of heavy metals in the water column was within the ranges for the metals in open ocean water except for barium where the data was inconclusive and a zinc gradient around the platforms probably due to the decomposition of the sacrificial covering of the platform legs (GURC, 1974).

The input of heavy metals to the marine environment and accumulation in the food web due to offshore petroleum operations should be far less significant than sources of heavy metals from land in most coastal waters such as river runoff, sewage effluent and industrial wastes. Since the effects of heavy metal input from offshore petroleum operations into the marine food web are largely unknown, it is advisable to continue to observe and monitor the marine environment for possible accumulation in the food web.

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Appendix J

MATRIX ANALYSIS TABLES OF POTENTIAL IMPACTS ON MAJOR RESOURCES AND ACTIVITIES

1. Purpose

The purpose of this matrix analysis is to analyze some of the potential impacts of the proposed OCS lease sale by way of a matrix analytical technique in an attempt to provide the decision-maker and reviewer with an array of factors which must be considered in order to form value judgements concerning the importance of these interactions.

In this section, each tract is included in a table designed to describe its distance from shore, water depth and expected type of production. In addition, the sensitivity of major resources and activities to impacts of oil spills, should one occur, and to impacts of offshore structures, should the tract be developed, is evaluated by means of a sensitivity rating for both spills and structures.

2. Significant Resource Factors

The matrix analysis examines major resource categories which could sustain negative impacts as a result of the development of the tracts included in the proposed lease sale. Significant resource factors appear on the horizontal axis of each matrix and for purposes of this analysis have been identified to consist of:

- littoral systems
- hard (live) bottom systems
- other benthic systems
- endangered species
- commercial and sport fishing
- shipping
- aesthetics
- outdoor recreation
- cultural resources

All evaluations of the above categories were based on measurement from the edge of the tract closest to the resource potentially affected.

3. Impact Producing Factors

This evaluation considers the sensitivity of significant resources and activities to the occurrence of oil spills and offshore structures within the proposed sale area as being the primary factor. "Oil spills" in this context refers to spills of 100,000 gallons (2,381 bbls) or more (the volume designated as a major spill by the National Oil and Hazardous Substances Pollution Contingency Plan), and structures include platforms or other fixed structures and artificial islands.

Other impact-producing factors such as debris resulting from drilling activities and pipeline construction are non-specific and difficult to analyze on a tract-by-tract basis, and therefore, are not included in this matrix section. However, these and other related factors were discussed on the basis of this proposed sale in Sections III.B. and C.

4. Sensitivity Rating

Each tract has been assigned sensitivity values for oil spills and structures based primarily on the distance from a particular resource.

A series of scales has been devised for the purpose of assigning a range of values to indicate sensitivity to each impact-producing factor. These scales are presented below and consist of three levels of potential magnitude of impact:

3—Maximal potential impact
2—Moderate potential impact
1—Minimal potential impact

The judgement of the importance of any specific impact is at the discretion of the decision-maker or reviewer.

a. Offshore Structures

An estimate of the impact of offshore structures on the environment consists of two factors: quantity—in this case, it is estimated that all tracts will average two structures per tract, even though some tracts may never be developed, and time—all structures will remain on site for an average period of fifteen to twenty years.

Structures are considered to be potentially negative impacts to four of the significant resource factors namely: hard (live) bottom systems, commercial and sport fishing, shipping and aesthetics.

Live bottom systems containing benthic epifauna and demersal fishes may be very sensitive to disturbances such as the turbidity created by the discharge of drill muds and cuttings. Also, demersal fish population distribution may be affected by the presence of a structure. Therefore, the sensitivity ratings for live bottom systems reflects these considerations and is purposely conservative due to our lack of information with regard to the distribution of drill muds and cuttings under operational conditions in marine systems and the distribution of this system type (live bottom) within the lease area. Therefore, we have assumed the presence of live bottom systems throughout the lease area.

Structures interfere with commercial fishing by removing trawling and purse seining areas. Approximately 70% of the catch by these two methods in the Southeast Georgia Embayment is shoreward of the 20 m (66 ft.) isobath. The remainder of the catch by these methods is concentrated between the 20 m (66 ft.) and the 40 m (130 ft.) isobath with only nominal effort expended beyond these depths.

Structures pose a collision hazard to shipping and boating, in general, but are especially hazardous when placed near shipping lanes and are rated accordingly.

The aesthetic sensitivity ratings are based on the visibility from sea level of a 22 m (72 ft) tall structure. Within 16 km (10 mi) of shore, such a structure would be obvious, whereas 17 km (11 mi) to 25 km (15 mi) from shore the aesthetic impact would be greater than 25 km (15 mi) from shore the aesthetic impact would be negligible except from the point of view of the boating community.

Based on the above considerations, the sensitivity scale for structures was developed (Table J-1).

b. Oil spills

The same two factors for estimating the impact of oil spills on the environment are as follows: quantity—our analysis is based on spills of 100,000 gallons or more (2,381 bbls), and time—the toxicity of oil is known to decrease with weathering time which depends on the rate of travel of an oil slick. For analytical purposes, we have assumed a rate of 0.9 km/hr (0.5 kts) which for weathering times of 24, 48, and 72 hours gives impact zones of 19.3, 38.6, and 57.9 km (12, 24 and 36 naut. mi). Using toxicity at 24 hours as a base, laboratory bioassays indicate a decrease of toxicity by a factor of 0.90 for 48 hours weathering and 0.54 for 72 hours weathering (Hannah, 1976). Therefore, assigned sensitivity values of biological systems are adjusted for distance from a potential spill site by the appropriate weathering factor.

Oil spills are considered to be potentially damaging to all of the previously listed resource factors except shipping.

If a spill were to occur within the 16 km (10 mi) of any resource, it probably could not be effectively contained before contacting the resource. For this reason, the highest sensitivity rating was established for 16 km (10 mi) or less from littoral systems, endangered species, aesthetics, outdoor recreation and cultural resources. Within 17 km (11 mi) to 32 km (20 mi) the probability that oil would contact a resource is sufficient enough to warrant concern. Beyond 32 km (20 mi), the possibility of contact still exists but is considered to be minimal.

The sensitivity ratings for benthic systems and sport and commercial fishing are based upon water depths to which oil can be expected to be entrained into the water column. In nearshore areas 15 m (49 ft) or less in depth, a spill will almost certainly contact bottom sediments increasing the potential for damage to benthic systems and tainting of demersal species. Under extreme conditions of mixing energy, the depth to which oil might be entrained can be assumed to be 30 m (99 ft) or less. Sediments at water depths greater than 30 m (99 ft) have little chance of being contaminated with the exception of, the immediate vicinity of the spill site.

Based on the above assumptions, the sensitivity scale for oil spills was developed (Table J-2).

To derive additional information from the matrix analysis tables (Table J-4) potential impacts upon individual resource and activity categories are totaled, on a tract-by-tract basis, resulting in a cumulative impact for each proposed lease tract. This is divided by the total possible cumulative value (12 for offshore structures, Table J-1 and 24 for oil spills, Table J-2) resulting in an impact index. These impact indexes are then summed resulting in an additive impact for each proposed lease tract. For example, tract number one has a cumulative impact for structures of 7.0 out of a possible total of 12 for an impact index of 0.58 for offshore structures. The same tract has a cumulative impact for 7.08 for oil spills out of a possible total of 24 for an impact index of 0.30. These are summed for an additive impact of 0.88 (0.58 + 0.30 = 0.88).

The evaluation of the impact index and additive impact ratings are listed in Table J-3. Utilization of the impact index and additive impact ratings found in the matrix analysis tables indicate that none of the proposed 225 lease tracts will have potential maximal impact on a tract-by-tract basis.

Abbreviations Used in the Matrix Analysis Tables

Tract designations in the matrix analysis tables are listed by tract number followed by the lease block locations. Lease block locations are shown on Visuals 1N and 1S. A description of each tract can be found in Appendix A.

JI - James Island, NI 17-12

Br - Brunswick, NH 17-2

Ja - Jacksonville, NH 17-5

OG - Oil and/or Gas Prone Tract

NA - Not Applicable

St/OS - Upper left portion of each analysis block pertains to the impact rating for Structures; lower right portion pertains to Oil Spills.

Table J-1. Sensitivity Scale for Structures

Hard (Live) Bottom Systems

3 - 1.5 km or less from known live bottom
2 - 1.5 to 5 km from known live bottom
1 - greater than 5 km from known live bottom

Sport and Commercial Fishing

3 - within 20 m depth contour
2 - within 40 m depth contour
1 - outside 40 m depth contour

Shipping

3 - within 1.5 km of shipping lane
2 - 1.5 to 5 km of shipping lane
1 - greater than 5 km from shipping lane

Aesthetics

3 - within 16 km of shore
2 - 17 to 25 km from shore
1 - greater than 25 km from shore

Table J-2. Sensitivity Scale for Oil Spills

Littoral System

3 - within 16 km of shore
2 - 17 to 32 km from shore
1 - greater than 32 km from shore

Hard (Live) Bottom System

3 - 15 m depth or less
2 - 16 to 30 m depth
1 - greater than 30 m depth

Other Benthic System

3 - 15 m depth or less
2 - 16 to 30 m depth
1 - greater than 30 m depth

Endangered Species

3 - within 16 km of known habitat
2 - 17 to 32 km from known habitat
1 - greater than 32 km from known habitat

Commercial and Sport Fishing

3 - 15 m depth or less
2 - 16 to 30 m depth
1 - greater than 30 m depth

Aesthetics

3 - within 16 km of shore
2 - 17 to 32 km from shore
1 - greater than 32 km from shore

Outdoor Recreation

3 - within 16 km of shore
2 - 17 to 32 km from shore
1 - greater than 32 km from shore

Cultural Resources

3 - within 16 km of shore
2 - 17 to 32 km from shore
1 - greater than 32 km from shore

Table J-3. Evaluation of Impact Index and Additive Impact Rating

Impact Index

1.00 - 0.78 maximal potential impact
0.77 - 0.56 moderate potential impact
0.55 - 0.33 minimal potential impact

Additive Impact

2.00 - 1.44 maximal potential impact
1.43 - 0.89 moderate potential impact
0.88 - 0.33 minimal potential impact

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location1/	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
1 JI 115	64	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
2 JI 153	63	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
3 JI 154	68	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
4 JI 159	92	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
5 JI 160	97	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
6 JI 197	48	31	OG	NA / .90	3 / 1	NA / 1	NA / .90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.80	.58 / .33	.91
7 JI 198	52	33	OG	NA / .90	3 / 1	NA / 1	NA / .90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.80	.58 / .33	.91
8 JI 199	55	35	OG	NA / .90	3 / 1	NA / 1	NA / .90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.80	.58 / .33	.91
9 JI 203	68	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
10 JI 204	71	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
11 JI 241	49	31	OG	NA / .90	3 / 1	NA / 1	NA / .90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.80	.58 / .33	.91
12 JI 242	55	33	OG	NA / .90	3 / 1	NA / 1	NA / .90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.80	.58 / .33	.91
13 JI 243	58	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
14 JI 244	61	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
15 JI 245	64	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
16 JI 246	68	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
17 JI 247	71	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
18 JI 285	55	33	OG	NA / .90	3 / 1	NA / 1	NA / .90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.80	.58 / .30	.88
19 JI 286	58	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
20 JI 287	61	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
21 JI 288	64	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
22 JI 289	68	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
23 JI 290	71	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
24 JI 291	74	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

1/ Tract designations in the matrix analysis tables are listed by tract number followed by the lease block location. Appendix A presents a detailed description of each tract.

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
25 JI 292	78	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
26 JI 329	58	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
27 JI 330	61	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
28 JI 331	64	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
29 JI 332	68	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
30 JI 333	71	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
31 JI 334	74	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
32 JI 335	77	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
33 JI 336	80	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
34 JI 373	61	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
35 JI 374	64	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
36 JI 375	68	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.56 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
37 JI 376	71	41	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
38 JI 377	74	43	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
39 JI 378	77	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
40 JI 379	80	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
41 JI 380	84	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
42 JI 417	63	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
43 JI 418	71	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
44 JI 419	74	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
45 JI 420	77	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
46 JI 421	80	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
47 JI 422	84	55	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
48 JI 423	87	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
49 JI 462	70	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
50 JI 463	76	45	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
51 J1 464	76	64	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
52 JI 843	69	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.B8
53 J1 844	72	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.8B
54 J1 886	69	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
55 JI 887	76	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
56 JI 888	78	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
57 Br 256	66	26	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
58 Br 299	60	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.0B	.58 / .42	1.00
59 Br 300	64	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
60 Br 301	69	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.5B / .42	1.00
61 Br 342	57	27	OG	NA / .90	3 / 2	NA / 2	NA / .90	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.80	.58 / .45	1.03
62 Br 343	66	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
63 Br 344	69	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
64 Br 345	72	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
65 Br 3B7	68	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
66 Br 388	69	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
67 Br 389	71	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
68 Br 608	84	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
69 Br 609	89	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
70 Br 610	92	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.5B / .30	.88
71 8r 611	97	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
72 Br 651	85	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.5B / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
73 Br 652	89	41	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
74 Br 653	92	43	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
75 Br 695	93	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
76 Br 696	97	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
77 Br 739	84	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
78 Br 740	95	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
79 Br 781	85	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
80 Br 782	89	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
81 Br 783	92	38	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
82 Br 784	95	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
83 Br 825	85	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
84 Br 826	89	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
85 Br 827	92	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
86 Br 868	77	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
87 Br 869	81	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
88 Br 870	86	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
89 Br 871	91	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
90 Br 872	96	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
91 Br 873	103	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
92 Br 874	106	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
93 Br 911	74	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	.92
94 Br 912	78	15	OG	NA / .54	3 / 3	NA / 3	NA / .54	3 / 3	1 / NA	1 / 1	NA / 1	NA / 1	8 / 13.08	.67 / .55	1.22
95 Br 913	84	16	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
96 Br 914	89	18	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
97 Br 915	92	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
98 Br 916	98	22	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
99 Br 917	103	24	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
100 Br 918	108	26	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
101 Br 920	115	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
102 Br 953	65	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
103 Br 954	70	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
104 Br 955	74	15	OG	NA / .54	3 / 3	NA / 3	NA / .54	3 / 3	1 / NA	1 / 1	NA / 1	NA / 1	8 / 13.08	.67 / .55	1.22
105 Br 956	78	16	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
106 Br 957	84	17	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
107 Br 958	89	19	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
108 Br 959	93	21	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
109 Br 960	98	24	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
110 Br 961	103	24	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
111 Br 962	105	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
112 Br 963	110	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
113 Br 964	115	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
114 Br 993	53	26	OG	NA / .90	3 / 2	NA / 2	NA / .90	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.80	.58 / .45	1.03

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
115 Br 994	58	26	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
116 Br 997	65	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
117 Br 998	70	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
118 Br 999	75	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
119 Br 1000	80	16	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
120 Br 1001	85	18	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
121 Br 1002	74	20	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
122 Br 1003	95	22	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
123 Br 1004	98	23	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
124 Br 1005	103	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
125 Br 1006	108	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
126 Br 1007	113	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
127 Ja 25	55	25	OG	NA / .90	3 / 2	NA / 2	NA / .90	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.80	.58 / .45	1.03
128 Ja 26	60	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
129 Ja 27	64	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
130 Ja 28	69	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
131 Ja 29	74	13	OG	NA / .54	3 / 3	NA / 3	NA / .54	3 / 3	1 / NA	1 / 1	NA / 1	NA / 1	8 / 13.08	.67 / .55	1.22
132 Ja 30	78	15	OG	NA / .54	3 / 3	NA / 3	NA / .54	3 / 3	1 / NA	1 / 1	NA / 1	NA / 1	8 / 13.08	.67 / .55	1.22

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
133 Ja 33	92	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
134 Ja 34	97	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
135 Ja 35	102	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
136 Ja 36	107	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
137 Ja 37	112	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
138 Ja 38	117	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
139 Ja 68	51	24	OG	NA / .90	3 / 2	NA / 2	NA / .90	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.80	.58 / .45	1.03
140 Ja 69	55	25	OG	NA / .90	3 / 2	NA / 2	NA / .90	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.80	.58 / .45	1.03
141 Ja 70	60	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
142 Ja 71	62	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
143 Ja 72	67	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
144 Ja 73	74	15	OG	NA / .54	3 / 3	NA / 3	NA / .54	3 / 3	1 / NA	1 / 1	NA / 1	NA / 1	8 / 13.08	.67 / .55	1.22

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
145 Ja 74	78	17	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
146 Ja 76	87	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
147 Ja 77	92	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
148 Ja 78	97	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
149 Ja 81	110	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
150 Ja 114	58	29	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
151 Ja 115	63	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
152 Ja 116	68	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
153 Ja 117	73	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
154 Ja 118	78	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
155 Ja 120	88	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
156 Ja 121	95	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
157 Ja 122	98	39	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
158 Ja 123	102	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
159 Ja 158	58	26	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
160 Ja 159	64	29	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
161 Ja 160	68	31	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
162 Ja 164	88	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
163 Ja 165	93	20	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
164 Ja 166	97	20	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
165 Ja 167	102	22	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
166 Ja 168	107	40	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
167 Ja 202	60	26	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
168 Ja 203	65	27	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
169 Ja 207	84	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
170 Ja 208	88	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
171 Ja 209	95	20	OG	NA / .54	3 / 2	NA / 2	NA / .54	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	8 / 10.08	.67 / .42	1.09
172 Ja 210	100	22	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
173 Ja 211	105	23	OG	NA / .54	3 / 2	NA / 2	NA / .54	2 / 2	1 / NA	1 / 1	NA / 1	NA / 1	7 / 10.08	.58 / .42	1.00
174 Ja 250	82	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
175 Ja 251	86	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
176 Ja 252	95	36	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
177 Ja 253	98	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
178 Ja 293	77	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
179 Ja 294	82	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
180 Ja 295	87	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
181 Ja 296	92	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
182 Ja 339	86	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
183 Ja 345	115	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
184 Ja 382	81	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
185 Ja 383	86	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
186 Ja 384	91	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
187 Ja 389	115	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
188 Ja 390	120	64	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
189 Ja 426	81	33	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
190 Ja 427	86	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
191 Ja 428	91	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.58 / .30	.88
192 Ja 431	104	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
193 Ja 432	109	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
194 Ja 433	114	55	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
195 Ja 434	119	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
196 Ja 470	80	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
197 Ja 471	85	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
198 Ja 472	90	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
199 Ja 475	103	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
200 Ja 476	108	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
201 Ja 477	113	55	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
202 Ja 478	118	101	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
203 Ja 519	105	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
204 Ja 520	110	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
205 Ja 521	115	64	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
206 Ja 557	75	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
207 Ja 558	80	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
208 Ja 559	85	37	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
209 Ja 562	98	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
210 Ja 563	105	44	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
211 Ja 564	108	53	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
212 Ja 565	114	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
213 Ja 601	74	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
214 Ja 602	79	35	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
215 Ja 606	98	40	OG	NA / .54	3 / 1	NA / 1	NA / .54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	7 / 7.08	.58 / .30	.88
216 Ja 607	101	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
217 Ja 608	108	55	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
218 Ja 609	111	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
219 Ja 650	98	42	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
220 Ja 651	101	46	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
221 Ja 652	108	55	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
222 Ja 653	110	165	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80

TRACT DATA				RESOURCE AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (kilometers)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Hard (Live) Bottom Systems	Other Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
223 Ja 696	104	82	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
224 Ja 740	103	91	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
225 Ja 784	102	110	OG	NA / .54	3 / 1	NA / 1	NA / .54	1 / 1	1 / NA	1 / 1	NA / 1	NA / 1	6 / 7.08	.50 / .30	.80
			OG	NA		NA	NA		NA		NA	NA			
			OG	NA		NA	NA		NA		NA	NA			
			OG	NA		NA	NA		NA		NA	NA			

Appendix K

ECONOMIC STUDY OF THE POSSIBLE IMPACTS OF A PROPOSED OIL AND GAS LEASE SALE OFF THE U.S. SOUTH ATLANTIC COAST

INTRODUCTION

The task of measuring economic impacts of an event that occurs in the future might be seen by some to be an almost hopeless task. Not only does one need to have a clear idea of the extent of the action that is causing the impact but one needs a clear idea of the future in order to measure the impacts. In the case of the exploration and development of oil and gas resources on the Outer Continental Shelf (OCS) in a frontier area the problems are greatly compounded. First, the degree of uncertainty of any resource estimates in a frontier area is great. Second, the geographic dispersion of the potential resources is such that the onshore impact area that must be considered is large. The potential for impacts includes four states and twenty-nine coastal counties. The number of potential locations for pipeline landfalls, onshore terminals and onshore bases is large and when one starts considering the number of possible combinations the problem can quickly become unmanageable. Further, the large size of the area and the diversity of the economic activities adds complexity to any predictions that can be made about the future. Third, besides being affected by the level of resources, the location of resources, the physical availability of good onshore sites, direct impacts will be dependent upon the decision that will be made both by industry developers and local governments. New coastal zone management legislation, zoning restrictions, a tax incentive offered by one community, or a strong local opposition will ultimately be as important in locational decisions as any of the other factors.

Two approaches exist in trying to assess impacts. The first approach is descriptive, where the economist describes the general movements and trends that economic logic predicts. An example of this approach would be the statement that population will be expected to increase in an area with new industries. The second approach is a quantitative approach that attempts to measure relative magnitudes of changes as well as directions. Current environmental assessments put great emphasis on the importance of these measurements. To try to derive a quantitative measure of impacts an economist must model the situation. An economic model is nothing more than an attempt to abstract from a complex reality certain predictive structural relationships. It can be as simple as a statement that for every new job created, one new family will move into town consisting of a husband, a wife, two children and one dog; or as complex as the dynamic multicomponent models that must be run in stages because of the lack of a computer large enough to run the entire program.

The level of complexity in the problem attached to OCS hydrocarbon development suggests that a fairly complex model will have to be developed. Fortunately a predictive model of economic behavior on a county basis exists that lends itself quite well to OCS impact analysis. The Harris Model was developed by Dr. Curtis B. Harris, Jr. of the University of Maryland (Harris, 1972, 1973). Dr. Thomas Grigalunas of the University of Rhode Island, and the Bureau of Land Management, New York OCS Office, have used the Harris Model to measure impacts of the development of the Georges Bank (Grigalunas 1975, BLM in press). The New York OCS Office also used the Harris Model to measure impacts of development in the Baltimore Canyon Trough (BLM 1974). A related application was a study made to trace the economic effects of locating strip mining coal production in Montana (Fisher and Krutilla 1975).

Several reasons exist for our decision to use the Harris Model in the South Atlantic. The primary reason is the use of the Harris Model in the Mid and South Atlantic areas. In effect our work has been lessened by the effort that has gone before us in adapting the model and ironing out specific problems involved in the OCS application. Further, the use of the same model in different areas facilitates comparative analysis between the areas. All projections that come out of the Harris Model are consistent with a set of national and regional totals. Although local models might give a better quality of locally specific data, no other models that we were aware of covered the entire coastal region necessary for the Sale 43 analysis. The interstate consistency provided by the Harris Model is an important element of the impact analysis.

BLM's use of the Harris economic model to project the extended economic and demographic effects of Mid-Atlantic OCS development represents an important effort to improve on conventional impact estimation methodologies by use of a new analytic technique. The Harris Model goes beyond conventional input/output models of industrial economic activity by attempting to explain the location of economic activities and impacts on a very detailed sub-regional scale. Indeed, the model predicts, on a county-specific basis, the level of such variables as production, employment and earnings by industry, consumer expenditures, unemployment, investment, government expenditures, personal income and intercounty migration. Such an array of output data is impressive, and is indicative of a commendable effort (*Resource Planning Associates 1976*).

This study is divided into three chapters. Chapter I describes the Harris Model. In particular it deals with the logic of the model, some of the more important structural relationships, some of the more important assumptions and the data sources. An assessment of some of the advantages and disadvantages of the model is also included. Chapter II discusses the specific application of the model to the proposed Sale 43 impact analysis. The logic behind the development of alternative scenarios along with all of the scenario-specific assumptions is included.

A final word of caution should be given here. Economic modeling is an abstraction from reality. In the South Atlantic we did not feel confident enough about any one view of the future to use it exclusively for our impact analysis. Instead, two alternative futures without development were compared with five development scenarios. This gives us a range of hypothetical impacts. The final result of development will not mirror any of the proposed scenarios. Hopefully it will vindicate our analysis and fall somewhere within our estimated range but we cannot even promise this with certainty. Analysis of this nature might be able to serve as a planning guide but only with considerably more work on area specific analysis and only after the approximate location of reserves were known. Further, this analysis only measures economic variables and as such is not a measure of social welfare. Other social goals must be given a weight in planning that is commensurate with their importance. Economic analysis of the type presented here can never be more than a step of a more comprehensive analysis.

CHAPTER I

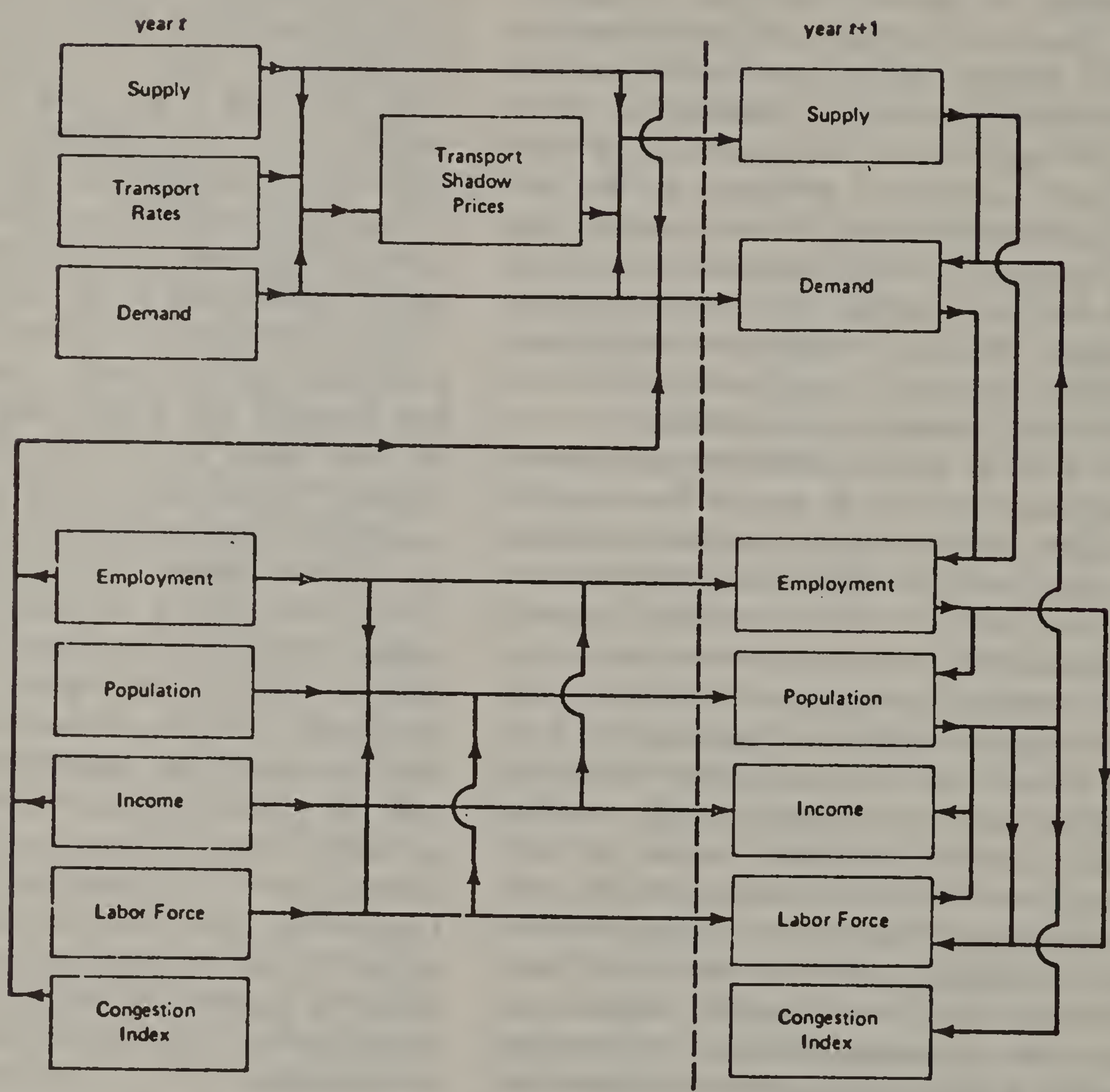
The Harris Model

What up to now has been referred to as the Harris Model describes a multiregional, multi-industrial forecasting model that has been developed by Dr. Curtis B. Harris, Jr. of the University of Maryland. This chapter hopes to present a concise explanation of some of the major components of the model. A more complete explanation can be found in *Locational Analysis* (Harris, 1972), and *The Urban Economics, 1985* (Harris, 1973), and *The Urban Economics, 1985: A Numerical Supplement* (Harris, 1976). The reader is urged to consult these sources for a more detailed overview.

The driving mechanism of the Harris Model is the postulate that a firm will try to maximize profits when making decisions on where to locate. An individual firm in an unfavorable location might not move in the short run because of the sunken costs of immobile capital equipment. However, in the long run, capital will be allowed to depreciate and new investments will occur in favorable locations causing shifts in the geographic distribution of an industry. The location of each industry is therefore a function of geographically different prices, restrictions, and markets (demand and supply) that face the industry for both inputs and outputs and "agglomeration variables" which Harris uses as a measure of locational externalities that are not fully captured in the different prices. Employment follows the industrial shifts and in turn is used to predict population, earnings and personal income. The final demand sectors, consumption, governmental expenditures, investment, and foreign exports are then calculated. The model is recursive in that it uses the values calculated for the first year, t+1, as input variables to forecast the values in the second year t+2, which in turn are used to forecast the values in t+3, etc., for as long as the model is run. A simplified flow diagram of the model is included as Figure 1. A more detailed discussion of the various components of the model follows.

The Harris Model divides industrial output into 99 industrial sectors. The 99 sectors represent an aggregation of the thousands of different industrial plants in the United States. The 99 sectors used by Harris correspond closely to the Office of Business Economics (OBE) input-output sectors of the U.S. economy. In order to facilitate our analysis, these sectors were further aggregated in the output produced for the South Atlantic model runs into 20 sectors, all model calculations were performed at the intermediate 99 sector level of aggregation. Table 1 shows the various levels of

Figure I - Simplified Flow Chart of Multiregional, Multi-industry Forecasting Model.



Source: Harris, 1973.

Table 1

Sectors Used in Forecasting Model

South Atlantic Output Sectors	Harris Model Industrial Sectors	SIC Numbers
A. Agricultural & Food Processing	1. Livestock	Part 01, Part 02
	2. Crops	Part 01, Part 02
	4. Agricultural Services	071, 072, 073, 074
	14. Meat Packing	201
	15. Dairy Products	202
	16. Canned & Frozen Foods	203
	17. Grain Mill Products	204
	18. Bakery Products	205
	19. Sugar	206
	20. Candy	207
	21. Beverages	208
	22. Miscellaneous Food Products	209
	23. Tobacco	21
B. Forestry and Fisheries	3. Forestry and Fishery Products	08, 09
C. Non Petroleum Mining	5. Iron Ore Mining	101, 106
	6. Non Ferrous Ore Mining	102,103,104,105,108,109
	7. Coal Mining	11, 12
	9. Mineral Mining	141,142,144,145,148,149
	10. Chemical Mining	147
D. Petroleum Mining	8. Petroleum Mining	13
E. Apparel and Textiles	24. Fabrics and Yarn	221,222,223,224,226,228
	25. Rugs, Tire Cord, Misc. Textiles	227, 229
	26. Apparel	225,23,3992,-239
	27. Household Textiles and Upholstery	239
F. Lumber and Wood Products	28. Lumber and Production Excl. Containers	24, -244
	29. Wooden Containers	244
	30. Household Furniture	251,
	31. Office Furniture	25, - 251
	32. Paper and Production Excl. Containers	26, -265
	33. Paper Containers	265

Table 1 (continued)

South Atlantic Output Sectors	Harris Model Industrial Sectors	SIC Numbers
G. Chemical and Plastics	35. Basic Chemicals	281,286,287,289
	36. Plastics and Synthetics	282
	37. Drugs, Cleaning, and Toilet Items	283, 284
	38. Paint and Allied Products	285
	40. Rubber and Plastic Products	30
H. Petroleum Refining	39. Petroleum Refining	29
I. Leather, Glass and Stone	41. Leather Tanning	311, 312
	42. Shoes and Other Leather Products	31, -311, -312
	43. Glass and Glass Products	321, 322, 323
	44. Stone and Clay Products	324,325,326,327,328,329
J. Iron and Steel	45. Iron and Steel	331, 332, 339
K. Other Metals	46. Copper	3331, 3351, 3362
	47. Aluminum	3334, 3352, 3361
	48. Other Non Ferrous Metals	3332,3333,3339,334, 3356,3357,3369
	49. Metal Containers	341, 3491
	50. Heating, Plumbing, Structural Metal	343, 344
	51. Stamping Screw Machine Products	345, 346
	52. Hardware, Plating, Wire Products	342,347,348,349,-3491
L. Machinery and Miscellaneous Manufacturing	13. Ordnance	19
	53. Engines and Turbines	351
	54. Farm Marhinery and Equipment	352
	55. Construction and Mining Machines	3351, 3352, 3533
	56. Material Handling Equipment	3534, 3535, 3536
	57. Metal Working Machinery and Equipment	354
	58. Special Industrial Machinery	355
	59. General Industrial Machinery	356
	60. Machine Shops and Misc. Machinery	359

Table 1 (continued)

South Atlantic Output Sectors	Harris Model Industrial Sectors	SIC Numbers
L. Machinery and Miscellaneous Manufacturing	61. Office and Computing Machines	357
	62. Service Industry Machines	358
	63. Electric Apparatus and Motors	361, 362
	64. Household Appliances	363
	65. Electric Light and Wiring Equipment	364
	66. Communication Equipment	365, 366
	67. Electronic Components	367
	68. Batteries and Engine Elec. Equipment	369
	69. Motor Vehicles	371
	70. Aircraft and Parts	372
	71. Ships, Trains, Trailers, Cycles	373, 374, 375, 379
	72. Instruments and Clocks	381, 382, 384, 387
	73. Optical and Photographic Equipment	383, 385, 386
	74. Misc. Manufactured Products	39, -3992
M. Transportation	75. Transportation	40,41,42,44,45,46,47
N. Communications	34. Printing & Publishing	27
	76. Communication	481, 482,489
	77. Radio, Television, Broadcasting	483
O. Utility	78. Electric Utility	491, 4931
	79. Gas Utility	492, 4932
	80. Water Utility	494, 495, 496, 497
P. Wholesale Trade	81. Wholesale Trade	50
Q. Finance, Insurance and R. E.	82. Finance and Insurance	60,61,62,63,64,66,67
	83. Real Estate and Rental	65, -654
R. Amusement and Service	84. Motels, Personal and Repair Service	70,72,76,-7694,-7699
S. Retail Stores	85. Business Services	654,63,7694,7699,81,39, -736,-892
	89. Lumber, Housewares, Farm Equip. Stores	52

Table 1 (continued)

South Atlantic Output Sectors	Harris Model Industrial Sectors	SIC Numbers
S. Retail Stores	90. General Merchandise Stores	53,-532
	91. Food Stores	54
	94. Apparel, Accessory Stores	56
	95. Furniture Stores	57
	96. Eating, Drinking Places	58
	97. Drug and Proprietary Stores	591
	98. Other Retail Stores	59, -591
	99. Nonstore Retailers	532
T. Medical and Educational Inst.	88. Medical and Educational Institutions	736,80,82,84,86,892
U. Auto Dealers and Service	86. Automobile Repair Services	75
	92. Automotive Dealers	55, -554
	93. Gasoline Service Stations	554
V. Construction	11. New Construction	Part 15, Part 16, Part 17
	12. Maintenance Construction	Part 15, Part 16, Part 17

aggregation with the corresponding Standard Industrial Classification numbers.

An equation to explain the locational decision was developed for 84 out of the 99 industrial sectors in the locational analysis with the remaining sectors (all construction, transportation, and trade sectors) location being considered dependent upon the 84 sectors. It postulates that the change in the locational concentration of an industry sector, measured by the change in the output of that sector, is a function of the different marginal costs that it faces and the agglomeration variables. The generalized equation is shown as Figure II. The equation simply states that the change in the value of output of an industry in a region is a function of the marginal costs and the agglomeration variables faced by the industry in the region.

One of the most important elements of the marginal costs faced by an industry is the costs of transportation of both the inputs into the production process and the outputs that must be transported to the demand locations. A major component of the Harris Model is the linear programming transportation algorithms performed on the primary sectors to determine the transporation shadow prices (which can be shown to be equivalent to the marginal transportation costs under optimal conditions). Two sets of shadow prices are estimated through this procedure: 1) the cost of shipping a marginal dollar's worth of goods produced by industry i from region j, and 2) the cost of receiving a marginal dollar's worth of goods produced by industry i to region k. The variables that have been calculated originally entered as independent variables in the location equations. In the current version of the model the transportation variables are converted into a location rent (discussed below). The transportation costs that enter into the model are computed for each county, by weight class, using the lowest rate available of either the rail or highway freight rates.

Besides the costs of transportation, other costs that differ geographically include the costs of capital, land values, and regional wage rates. Land values and regional wage rates are self-explanatory and vary over time in response to demand and supply conditions. However, capital costs may vary in many ways. Geographic variations in the costs of borrowing money were found to be small and were not used in estimating equations. Although it was recognized that the marginal costs of constructing new capital might vary significantly no variable could be found to measure this effect. Another way that capital costs influence locations is through the existence of capital stock. To incorporate this influence two explanatory variables enter the equations, the capital equipment purchased by the industry and the prior level of output.

Some of the agglomeration variables used to try to capture the locational economies and diseconomies include population density, the output of major supplying industries and measures of major buyers. An example of how this measures externalities might be that an area with a high concentration of a type of industry would be expected to have a well developed labor market and support infrastructure.

Figure III shows the actual equations that have been used in various formations of the model to determine the change in output. The equations are fairly self-explanatory. All small i's refer to the sector classifications shown in Table I. Small j's refer to regional area that the equation is being run on. The dependent variable is the change in output excluding output resulting from defense expenditures, which is treated as exogenously determined. All of the independent variables can be classified as marginal costs (or proxy input prices when no measure of marginal costs was available) or agglomeration variables. The original structure of the equations is shown by equation 1. Equation 2 represents the improved version.

Both equations have the same theoretical formation. In equation 1 the marginal costs associated with the transporation algorithm are shown as input costs (TI) or the output prices (TQ). Only 4 major transportation costs variables are allowed to enter into the equation. Input prices include the wage rate, defined as a wage-output ratio (WR) and the value of land (VL). Proxies for the influence of capital costs are the level of output (Q) and the prior equipment purchases (EQ). Agglomeration variables include a measure of the major buyers (MB), the major suppliers (MS), and the population density (DEN).

Equation 2 was designed from equation 1 to reduce the multicollinearity problems that caused many of the hypothesized variables in the original equations to be excluded from the forecasting equations (the statistical technique used is described below). The possible 18 variables of equation 1 have been combined into six variables in equation 2.

Figure II: A Generalized Equation to Forecast Regional Change in an Industry's Value of Output.

$$\Delta Q_{kj} = f(MC_{1j}, \ldots, MC_{mj}; AG_{1j}, \ldots, AG_{gj})$$
$$(j = 1, \ldots, NR; k = 1, \ldots, NI)$$

where ΔQ_{kj} = change in value of output of industry k in region j,

MC_{ij} = marginal cost of obtaining the ith input in region j.,

AG_{ij} = a variable measuring the agglomeration effects i in region j,

m = number of inputs,

g = number of agglomeration variables,

NR = number of regions,

NI = number of industries.

Source: Harris, 1972.

Figure III. Equations to Forecast Regional Change in an Industry's Value of Output

(1) $\Delta QD^{t}_{ij} = f_{i1}(TQ^{t-1}_{ij}, TI^{t-1}_{s_k j}, WR^{t-1}_{j}, Q^{t-1}_{ij}, VL^{t-1}_{j}$
$EQ^{t-1}_{hj}, DEN^{t-1}_{j}, MB^{t-1}_{ijk}, MS^{t-1}_{ijk})$

(i = 1, ..., NI)
(j = 1, ..., NR)
$(k \rightarrow 4)$
$(s_k \max q_{si})$
$(h \rightarrow 1)^{s}$

(2) $\Delta QD^{t}_{ij} = f_{i2}(S^{t-1}_{ij}, LR^{t-1}_{ij}, D^{t-1}_{ij}, IS^{t-1}_{ij}, VL^{t-1}_{j},$
$EQ^{t-1}_{hj})$

(i = 1, ..., NI)
(j = 1, ..., NR)
$(h \rightarrow i)$

where

D^{t}_{ij} = Total demand for goods classified by industry i located in region j in year t.

DEN^{t}_{j} = Population density (per square mile) in region j in year t.

EQ^{t}_{j} = Equipment purchases by equipment purchasing sector i located in region j in year t.

IS^{t}_{ij} = Input scarcity of goods required by industry i in region j in year t.

LR^{t}_{ij} = Locational rent associated with industry i located in region j in year t.

MB^{t}_{ikj} = Major buying sector k located in region j that bought goods from industry i in year t.

MS^{t}_{ikj} = Major supplying sector k located in region j that sold goods to industry i in year t.

NI = Number of industries.

NR = Number of regions.

Q^{t}_{ij} = Output of industry i located in region j in year t.

QD^{t}_{ij} = Output less defense expenditures of industry i located in region j in year t.

S^{t}_{ij} = Total supply of goods classified by industry i located in region j in year t.

TI^t_{ij} = Transport cost of obtaining a marginal unit of input from industry i into region j in year t.

TQ^t_{ij} = Transport cost of shipping a marginal unit of output from industry i out of region j in year t.

VL^t_j = Value of land per acre in region j in year t.

WR^t_{ij} = Annual earnings per worker in labor sector i working in region j in year t.

q^t_{ik} = Input-output technical coefficient (national sales from industry i to industry k per unit of output for industry k) in year t.

f_{ik} = Denotes the functional relationship in sector i in equation k.

Source: Harris, 1976.

The location rent variable (LR) replaces up to 6 variables; (1) the variable for shipping products to market (TQ); (2) the 4 (maximum) transportation variables for obtaining inputs (TI); and (3) the wage rate (WR). The output price variable (TQ) is turned into a locational rent variable by changing its sign. The input cost variable TI are turned into locational rent values by calculating the difference paid by the county and the county in the worst location. National input-output coefficients are then used to weigh the "rents" which are then combined to obtain the total locational rent. All of the input prices are allowed to enter into the equation. The locational rent of the wage-output ratios is the difference between the wage-output ratio of a county and the maximum wage-output ratio in the industry. The three locational rents are summed together to obtain (LR).

The demand variable (D) replaces the variables that represented major buyers (MB). Originally up to 4 major buyers were separately identified. Now all major demanders are identified and combined into one variable referred to as total demand (D).

Input scarcity (IS) replaces the up to 4 variables identified as major suppliers (MS). It is an estimate of the total value of inputs that have to be imported into a county that are used for the production of other commodities.

The supply variable (S) which includes domestic production and foreign imports, replaces the output variable (Q). The value of land (VL) and equipment purchases (EQ) are the same in both equations. The density variable (DEN) was dropped because of its high correlation with the value of land (VL).

Because of the importance of equation 2 and the driving equation of the model something needs to be said about the estimating techniques. A step-wise linear regression technique was used where the variables were entered in steps by their rank of theoretical importance. Before a variable was accepted as part of the equation it must have met three tests; 1) the standard (t) test of statistical significance, 2) the sign of the variable must have the postulated theoretical sign and 3) the variable must not have severe multicollinearity with other variables already in the equation. In this way a tight control was kept over the theoretical aspects of the model. This resulted in a locational equation which emphasized sound economic theory rather than a high multiple regression coefficient. The order of entry of variables into the equation is the order established in equation 2.

All regional variables are entered as a share of a national total. This mechanism constrains the sum of all regional forecasts to be no more than the national forecast. The national forecasts are from an input-output model of the U.S. economy developed by Dr. Clopper Almon (Almon, 1974). The Almon model is a flexible input-output model that predicts changing technical coefficients and a changing product mix (due to changes in prices and final demand) over time. The updating of the Almon model is an ongoing process. Output from the Almon model is used not only to constrain the output equations but to constrain most of the Harris model's other forecasts that will be discussed below.

Data on the value of output was entered for all counties where a sector was located for the years 1965-1966. Where data was not available it was estimated with care taken to keep state or regional totals at the known levels. This resulted in a potential of 3,112 observations but in all cases the actual number of observations were less than this maximum. All of the locational equations along with information on the number of observations and threshold levels can be found in one of Dr. Harris' books (Harris 1972, Harris 1973, and Harris 1974).

In using the output equations to forecast regional output one other modification was made. If a region is in a favorable position for an industrial sector, but no previous output exists in that region, the model will try to locate output in that region. It will be allowed to do so only if the output level reaches a predetermined threshold level. The threshold is determined by the median reporting plant size provided that this plant size is below the average plant size. All threshold levels are given in terms of the value of output.

A thorough explanation of the remaining equations is not included as part of this study. A brief description of some of the more important structural relationships follows:

1. Federal government expenditures are generally treated as exogenous and held at a constant level.
2. State and local government and "general" federal government (mainly the post office) expenditures are considered a function of the prior level of personal income and grow as personal income grows.
3. Investment is determined by the forecast level of total output. Investment includes equipment purchases and industrial construction.
4. Employment is forecast by relating to the appropriate levels of output and equipment purchases. Employment by industry is the number of jobs located at the place of work. The number of persons employed by place of residence is ob-

tained by adjusting the number of jobs by the number of multi-job holders and the number of commuters in an area.

5. Population is forecast by equations that explain population migration, births, and deaths. Population migration in the working age groups is a function of economic factors including changes in the level of employment, the regional labor surplus or deficit and the average regional wage rates. Migration of youths is a function of the migration of the working groups while migration of retirement groups is a function of the prior level of population in these areas.
6. Total labor force is estimated by relating it to population in working age groups and the population associated with the labor surplus or deficit.
7. Personal income is defined as the sum of earnings, transfer payments and property income minus the social insurance payments made by employees. Earnings are forecast for all 99 industry sectors with regional shares of employment and equipment and equipment purchases used as explanatory variables. Transfer payments were forecast as a function of population and unemployment. Property income is estimated by relating it to earnings by place of residence.

Most of the variables that are forecast have a constraint on the amount that they can grow in a time period. The constraint is based on the average deviation of a variable's regional shares and is applied to the regional share. If, for example, one of the forecast variables was constrained at 10% and zero growth was forecast at the national level, the maximum regional growth rate would be 10%. If, however, the national growth rate was positive, the regional growth rate could be more than 10%, and conversely if the national rate was negative the regional rate would have to be less than 10%. Examples of the constraint levels are:

1. Output cannot increase more than 10% or decrease more than 5%.
2. Productivity cannot increase more than 10% or decrease more than 2%.
3. Wage rates cannot increase more than 5% or decrease more than 2%.
4. Unemployment cannot increase more than 10% or decrease more than 5%.

The constraints are not hit very often and are usually only hit in small counties with undeveloped infrastructures. For the South Atlantic we have required that the computer be programmed to indicate every time a constraint is hit.

Dr. Harris has indicated three principal limitations of the model: 1) the disequilibrium nature of the model, 2) the derivation of transportation variables from linear programming, and 3) the data used in the application of the model (Harris, 1972). These will be discussed along with other critiques that the Harris model has received.

Because the model is a disequilibrium model it is not a good predictive model for industries that are close to equilibrium. Although it is not likely that any given industry is in equilibrium, some are obviously closer than others to equilibrium. This implies the model is more applicable to some industries than to other industries.

The shadow prices computed for the transportation linear programming algorithm are only equal to the marginal transportation costs under optimum conditions. If an optional trade flow existed no cross-hauls should be observed. A cross-haul is simply the output from any one sector moving from region A to region B, and from region B to region A. The fact that they are observed can be attributed to several factors. One factor is the level of aggregation that goes into the modeling. For example both industrial chemicals and fertilizers are included as basic chemicals but their output is not interchangeable. Hence we might observe trade going between two regions when each region had the sector, basic chemicals. The other reason for observing cross-hauls is the definition of the geographic unit. Trade may be flowing from region A to region B in the northern part of the region and from region B to A in the southern part of the region. By doing the analysis on an area as small as a county this kind of cross-haul is minimized.

By far the weakest area of the model is the data base. Over one thousand data items are entered for each county. In the present version of the model, output estimates are based on two years observations, 1965 and 1966, and data on employment and population is based on 1970. Since the model's output observations were restricted to two years it was necessary to use output where changes in output would have more theoretical desirability. If more than two years' data was available an appropriate system of lags could be determined. Because of disclosure problems, data during these two years were not available for all counties. When data was not available it had to be estimated from other variables. Although careful controls were maintained with known totals this still introduces a potential source of error. Once again, the smaller underdeveloped counties will be the ones most prone to errors of this type. Under an existing contract with the Bureau of Land Management, data on employment for 1971 and 1972 and earnings and output for 1970 and 1971 are being calculated and will be included in the model shortly to improve the data estimates.

One of the most eloquent critiques of the Harris Model appears in *Identification and Analysis of Mid-Atlantic Onshore OCS Impacts* by Resource Planning Associates, Inc. An evaluation of their four major concerns follows:

1. One of the concerns expressed is the often weak statistical significance of some of the output equations used in the model. The statistical significant weakness of some of the equations can be caused by any one of the factors that are discussed above, and as Resource Planning Associates point out "underscores the complexity of explaining economic behavior on such a finely detailed level". Two additional points, however, need to be considered. The first point is that a low multiple regression coefficient does not necessarily lead to a bad forecast. The low multiple regression coefficient means that a large residual term remains. The residuals are incorporated into the regional forecasts which means that the model has a strong bias to leave the regional distribution of these industries constant. Since many of these industries have strong natural resource ties (i.e., mining sectors), a factor not accounted for in the model, or large capital requirements within, this bias is probably correct. In the case of industries with large capital requirements, the threshold levels also tend to restrict geographic mobility. The second point is that the statistical significance of the model's derived geographic distribution of total output is very high in all cases. This helps confirm its validity for use in geographic economical analysis.

2. Resource Planning Associates are concerned about the constraints placed on the percent growth in output that can occur in any given sector in a region. They feel that "such a constraint limits the ability of this model to explain economic change in any area where a new industry is entering and experiencing considerable economic growth". We share their concerns but after discussions with Dr. Harris we are not convinced that the constraints are utilized to an extent that would impair the model's usefulness. An industry has an incentive to locate where input supplies and output demands are located. Given the kinds of locations available in the South Atlantic, growth will most likely occur around already developed areas. Nevertheless we have requested that the model indicate every time a constraint is used. If this appears to be a problem in the analysis different assumptions will be used.

3. The third concern has to do with problems of using national coefficients in regional analysis. National coefficients do not take into consideration changes in the input mix caused by local input prices if they vary from national prices. This concern has also been raised by others who point out the better regional specification of industry inputs incorporated into many regional studies. The ideal situation would be a model that incorporated many finely detailed regional models into a national whole. The Harris model is capable of including regional coefficients if a consistent set of regional coefficients was available. In the South Atlantic we were faced with a tradeoff between several regional models, none of which covered our entire sale area, and the Harris model. The reasons for picking the Harris model are discussed in the introduction. We recognize that the use of national coefficients is a limitation of the Harris model, but we still feel that the Harris model results are generally valid despite this limitation.

4. The last concern deals with the interpretation of the model's results to quote: Finally, it is perhaps too easy to treat the model's predictions of the location of economic and demographic impacts as though those impacts had been determined by a completely internal, consistent set of locational relationships. In fact, the locational impacts are not primarily due to the model; rather, they are primarily determined by the initial assumed allocation of direct OCS activities and facilities to specific counties within the region. In this respect, and as mentioned by BLM, the model predictions represent a limited scenario built on specific assumptions regarding the location, timing, and magnitude of primary OCS development impacts.

We concur that the primary element that determines the model's results is the scenario assumptions that are used as inputs.

We have broadened the scope of the analysis to consider more than one set of assumptions. The development of these assumptions will be the subject of the next chapter. However, it should be emphasized that our assumptions are just that, and any interpretation of the results of the model should be made with full knowledge of all of the limitations of the model and the assumptions going into it.

CHAPTER II

O.C.S. Scenario Development

A total of seven model runs have been made on the proposed South Atlantic Sale 43. These represent five specific OCS development scenarios and two base cases. To explain the logic that goes into the building of the scenarios, this chapter has been broken into four separate sections that follow the logical sequence of scenario development.

The first two sections deal with the initial assumptions that were developed before the sale-specific scenarios. These involve assumptions on economic variables that are used in forecasting the future; and assumptions on the levels of resources that might be producible if the proposed sale is held.

Given the above sets of assumptions, five scenarios were developed. The scenario developments described in the third section were made after consultations with industry and government figures on likely paths that they see for the future development in the South Atlantic states. The development of the scenarios represented a multi-disciplinary effort to arrive at the level of detail necessary for the computer analysis.

Table II represents an integral part of this section. It details all of the important assumptions by year and county for all scenarios and base cases. It is hoped that the material presented in this fashion will help the reader to distinguish between the inputs to the various scenarios.

The remaining section shows the format of the output sections and explains some of the data classifications. This is to give the reader some idea of the types of data forecast by the Harris Model to help in the interpretation of the model's results.

Economic Assumptions

Economic variables that were specified can be divided between those that were used to define structural relationships in the U.S. economy and those that describe the future economic climate of the South Atlantic coastal region. Assumptions concerning the unemployment rate, price of oil and gas, material and labor availability, type of leasing system, and oil and gas imports all are assumptions that describe the future U.S. economy. These assumptions stay the same for all base cases and scenarios. The only assumption on the future South Atlantic economy that we entered was the specification of the amount of refining capacity. This enters the model as two cases—with and without refining and will be discussed later.

Table II shows a comparison of the different scenarios. Assumptions on the U.S. economy are not included as part of this table because they stay constant throughout. A discussion of the economic assumptions follow:

1) It is assumed that the civilian unemployment rate will be 9% in 1975, 6% in 1976, and 4% in subsequent years.

In formulating this assumption, it was decided that a steady rate of unemployment would expedite the analysis. A higher unemployment rate, or an unemployment rate that followed a cyclical pattern might have been a more realistic assumption. Our application of the model, however, is primarily concerned with using the Harris Model to show the effects of incremental changes in the economy produced by the proposed South Atlantic Sale 43 and we were interested in changes caused by (or impact of) development rather than the absolute level of development. If cyclical swings had been incorporated the impact analysis would have been complicated by the effort to sort out the effects of cyclical swings from the effects of OCS development. The unemployment rate goes into the model as a national unemployment rate. Regions can vary from this rate depending on forecast regional conditions.

2) The well-head prices of oil and natural gas are: oil—$11.00 per barrel, and natural gas—$1.50 per thousand cubic feet.

The price of oil and gas we are estimating is a long-term real price for the period beginning three to five years from the date of the lease sale, and extending 15 to 20 years into the future.

On July 27, 1976, the Federal Power Commission announced officially a new uniform national base rate for interstate gas of $1.42 per MCF with a four cent escalator per annum. This rate is applicable for (1) sales of natural gas made from wells commenced on or after January 1, 1975, and (2) sales made pursuant to contracts executed on or after January 1, 1975, for the sale of natural gas in interstate commerce. Since natural gas produced from the OCS is classified as interstate gas, the FPC's ruling directly affects our price assumption for natural gas for use in the economic impact analysis model. The price of gas was determined based on the fact that when appropriate BTU adjustments are added to the new

Table II - Comparison of Base Cases and Scenarios

	Year	Base I	Base II	A	B	C	D	E
OCS Resource Estimates								
Oil (Billion Barrels)		no development		.282	.282	.282	1.009	1.009
Gas (Trillion Cubic Feet)		"	"	0	1.890	1.890	6.810	6.810
Average daily production Oil:	1982	no development		3000	same rate as A		8000	Same rate as D
	1983	"	"	7000	"	"	25000	" "
	1984	"	"	11000	"	"	41000	" "
	1985	"	"	16000	"	"	55000	" "
	1986	"	"	23000	"	"	77000	" "
	1987	"	"	30000	"	"	99000	" "
	1988	"	"	37000	"	"	134000	" "
	1989	"	"	45000	"	"	162000	" "
	1990	"	"	56000	"	"	170000	" "
	1991	"	"	56000	"	"	170000	" "
	1992	"	"	56000	"	"	170000	" "
	1993	"	"	56000	"	"	170000	" "
	1994	"	"	56000	"	"	170000	" "
	1995	"	"	56000	"	"	170000	" "
	1996	"	"	56000	"	"	170000	" "
Gas:	1986	no development of gas			200	same rate as B	701	same rate as D
	1987	"	"	"	274	" "	726	" "
	1988	"	"	"	342	" "	726	" "
	1989	"	"	"	421	" "	1359	" "
	1990	"	"	"	466	" "	1397	" "
	1991	"	"	"	466	" "	1397	" "
	1992	"	"	"	466	" "	1397	" "
	1993	"	"	"	466	" "	1397	" "
	1994	"	"	"	466	" "	1397	" "
	1995	"	"	"	466	" "	1397	" "
	1996	"	"	"	466	" "	1397	" "
Operations Base Location	1977	no development		Chatham,Ga.	Chatham,Ga.	Chatham,Ga.	Glynn,Ga. Charleston Duval,Fla.	Glynn,Ga. Charleston,S.C. Duval, Fla.
	1978							
	1979							

Comments

1) Any oil and gas production that is shown is sold. Oil and gas production continues until 2006 Only the 20 years that are modeled are shown.

2) OCS oil production replaces imports in the rest of the nation in A: B: and C; and in D and E production replaces imports to a hypothetical refinery in the South Atlantic

3) No gas is produced and sold in A.

4) Special assumption B and C: oil is located in the southern tract area and gas is located in the northern tract area.

1) All operations bases are based on an estimate from the Offshore Operators Committee on the size base necessary to provide supply and support for 56,000 b/d of stable production
a) Cost = $1,027,000
b) Employment = 103 persons

2) Area operation base locations are assumed to serve as place of employment for all offshore personnel.

Table II - continued

Comparison Factors	Year	Base I	Base II	A	B	C	D	E
Exploration								
# Drilling vessels/ # wells drilled	1977	no development		4/12	same rate as A		4/12	same as D
	1978	"	"	5/15	"	"	10/30	"
	1979	"	"	5/15	"	"	10/30	"
	1980	"	"	3/9	"	"	10/30	"
	1981	"	"	3/9	"	"	7/21	"
	1982	"	"	2/5	"	"	5/15	"
	1983	"	"	2/5	"	"	5/15	"
	1984	"	"	2/5	"	"	5/15	"
	1985	"	"	2/5	"	"	5/15	"
	1986	"	"	1/3	"	"	3/9	"
	1987	"	"	1/3	"	"	3/9	"
	1988	"	"	1/3	"	"	3/9	"
	1989	"		1/3	"	"	1/3	"
	1990	"	"	1/3	"	"	1/3	"
	1991	"	"				1/2	"
	1992	"	"				1/2	

Comments

1) Assumptions used for all scenarios
   a) Cost - $2,000,000/well
   b) Drilling rate - 3 wells/year/ drilling vessel
   c) Employment - 113/drilling vessel

2) The decision not to produce gas in A was assumed to have no impact on exploratory drilling expenditures

3) All investment and employment is assigned in scenarios A, B, C to Chatham Co., Ga., and in scenarios D, E it is evenly divided between the three operations bases except during years of declining exploration where the one drilling vessel operates out of Glynn County, Ga.

Comparison Factors	Year	Base I	Base II	A (Chatham County, Georgia)	B (Chatham County, Georgia)	C (Chatham County, Georgia)	D & E: Duval	D & E: Glynn	D & E: Charleston
Development									
#Platforms: Location of invest. timing	1980	no development		1	1	same as B	0	1	1
	1981	"	"	1	2	"	1	0	1
	1982	"	"	2	2	"	0	2	1
	1983	"	"	2	2	"	2	0	1
	1984	"	"	1	1	"	0	2	1
	1985	"	"	1	1	"	0	3	0
	1986	"	"		1		3	0	0
	1987	"	"				1	1	1
	1988	"	"				0	1	2

Comments

1) Assumptions common to all scenarios:
   a) no more than 2 drilling rigs on each platform, no more than 20 wells per platform
   b) each rig can drill 5 wells per year
   c) development wells cost $500,000/ well
   d) drilling rigs employ 65 persons/ rig
   e) scenarios A,B,C, after initial drilling is complete one rig remains active doing service wells and workovers, in scenarios D, E this is increased to 2 rigs
   f) platforms cost $25,000,000/ platform
   g) permanent platform employ 22 persons

2) Scenario A eliminates all GS predicted gas wells and two platforms

Table II - continued

Comparison Factors	Year	Base I	Base II	A	B	C	D		E	Comments
				Chatham County, Georgia			For both D and E			
							Duval	Glynn	Charleston	
#Wells: Location of invest. timing	1981	no development		5	5	same as B	0	5	5	
	1982	"	"	13	15	"	6	7	12	
	1983	"	"	22	25	"	7	21	22	
	1984	"	"	34	40	"	6	27	27	
	1985	"	"	26	30	"	11	40	24	
	1986	"	"	17	20	"	0	50	10	
	1987	"	"	17	20	"	20	40	0	
	1988	"	"	4	5	"	20	20	20	
	1989	"	"	4	5	"	0	23	17	
	1990	"	"	4	5	"	0	12	13	
	1991	"	"	4	5	"	0	11	9	
	1992	"	"	4	5	"	0	3	2	
	1993	"	"	4	5	"	1	2	2	
	1994	"	"	4	5	"	1	2	2	
	1995	"	"	4	5	"	0	4	1	
	1996	"	"	4	5	"	2	2	1	

Table II - continued

Comparison Factors	Base I	Base II	A	B	C	D	E	Comments
					All oil to refinery in Chatham		All oil to refinery in Chatham	
Transportation of OCS products								
Oil	none	none	All oil tankered; offshore storage treatment facility constructed 1982-1985; all oil tankered outside the area	Initial tankering of oil, pipeline built to Duval Co.,Fa. (65 miles) in 1985; oil then is tankered outside the region	Initial tankering of oil, in 1985 a pipeline built to nearest shore point-Glynn (40 miles marine) then overland to refinery; pipeline mileage by county: Glynn - 16 Brynn - 12 Chatham - 24 McIntosh - 46 Liberty - 8	Initial tankering of oil; 1985 90 miles of pipeline built to Duval Co, Fa.; 1988, 65 miles of pipeline built to Charleston Co.,S.C., all oil is then tankered from these ports to the rest of nation	Initial tankering of oil; 1985, 175 miles of marine pipeline and 5 miles land pipeline built to a refinery in Chatham Co., Ga.	1) Investment per mile of major pipeline was estimated at: $1,000,000/mile marine; $300,000/mile on land. All investment costs were allocated to the county that contained the land fall in the case of marine, or the county that it occurred in for overland pipelines 2) All land distances include an additional 20% assumed to be necessary for finding a suitable right-of-way.
Gas	none	none	none	68 miles of marine natural gas pipeline built to Charleston in 1986	68 miles of marine natural gas pipeline built to Charleston in 1986	82 miles of marine natural gas pipeline built to Duval Co., Fa. in 1986. 70 miles of marine natural gas pipeline built to Charleston S.C. in 1989	75 miles of marine natural gas pipeline built to Glynn Co.,Ga. in 1986. 70 miles of marine natural gas pipeline built to Charleston,S.C. in 1989	3) All gas pipeline is assumed to have an additional 5 miles of land pipeline for tie in to existing distribution systems. 4) Oil pipelines that go on-shore to the refinery in Chatham has an extra 5 miles of overland pipeland to connect with refinery.

Table II - continued

Comparison Factors	Base I	Base II	A	B	C	D	E	Comments
Terminals and Processing Facilities Gas Processing	none	none	none	500 mmcf/day processing plant built in Charleston S.C., in 1985	500 mmdf/day processing plant built in Charleston S.C., in 1985	700 mmcf/day processing plant built in Charleston S.C., in 1988; and Duval Co., Fla., 1985	700 [redacted]cf/day processing plant built in Glynn Co., Ga. 1985; and in Charleston Co., S.C. in 1988	1) Cost of 500 mmcf/day gas processing plant $40,000,000; employment 25 persons. 2) Cost of 700 mmcf/day gas processing plant costs $60,000,000 and employs 30 persons
Oil Terminals	none	none	Offshore oil terminal	Terminal and tankering port in Duval CO., Fla., 1985	Terminal and pumping station, Glynn Co., Ga. 1985	Terminal and tankering port Duval Co., Fla.,1985 Charleston, S.C., 1989	Terminal-pumping facility in Chatham, Co. Ga., 1985	1) Terminal facilities, by scenario: A. Offshore Terminal Investment schedule; 1982-$2,100,000; 1983 - $15,200,000; 1984-$50,900,000; 1985-$5,600,000 Employment - 36 B. Terminal connected with port facility costs-$4,000,000 Employment - 13 C. Terminal and pumping station $3,000,000 Employment - 9 D. Terminals connected with port $4,000,000 Employment - 13 E. Terminal and pumping station $4,000,000 Employment - 17

Table II - continued

Comparison Factors	Year	Base I	Base II	A	B	C	D	E	Comments
Petroleum Refining Constrained level of output - Chatham Co., Ga. (million dollars)	1976	188	188	same as Base I		same as Base II	same as Base I	same as Base II	1) Petroleum refining sector constrained to level proportional with growth in total output (minus petroleum sector) in Base I
	1977	197	197	"	"	"	"	"	
	1978	206	206	"	"	"	"	"	2) Base II is constrained in the same manner until the completion of a fully integrated refinery in 1982
	1979	215	215	"	"	"	"	"	
	1980	224	224	"	"	"	"	"	3) Petroleum refinery completed Chatham Co., Ga., 1982, specifications: Capacity - 200,000 barrels/day; Costs - $500 million; Employment - 550
	1981	232	232	"	"	"	"	"	
	1982	241	no constraints	"	"	"	"	"	
	1983	249	" "	"	"	"	"	"	
	1984	258	" "	"	"	"	"	"	
	1985	268	" "	"	"	"	"	"	
	1986	278	" "	"	"	"	"	"	
	1987	287	" "	"	"	"	"	"	
	1988	297	" "	"	"	"	"	"	
	1989	307	" "	"	"	"	"	"	
	1990	316	" "	"	"	"	"	"	
	1991	325	" "	"	"	"	"	"	
	1992	334	" "	"	"	"	"	"	
	1993	350	" "	"	"	"	"	"	
	1994	366	" "	"	"	"	"	"	
	1995	383	" "	"	"	"	"	"	
	1996	399	" "	"	"	"	"	"	
Miscellaneous Central Office Employment Starts - 1977 and continues throughout		no development		30	30	30	42	42	1) A central office employment is located in Chatham Co., Ga. No new office is required
Pollution Containment Equipment investment:	1977	no development					same for D and E		1) Pollution containment and cleanup equipment is located at operations base.
1) Location Costs				Chatham, Ga. $300,000	Chatham, Ga. $300,000	Chatham, Ga. $300,000	Glynn, Ga. $300,000		
2) Location Costs	1978						Charleston, S.C. $300,000		2) The refinery at Chatham is assumed to have its own pollution equipment.
3) Location Costs	1981			Chatham, Ga. $470,000	Chatham, Ga. $470,000	Chatham, Ga. $470,000	Glynn, $470,000	Charleston $470,000	
4) Location Costs	1982						Duval, Fa. $470,000		

base rate of $1.42, which is based heavily on the cost of production reports submitted by producers, the national average wellhead price for regulated interstate gas will be about $1.50 per MCF. Therefore, $1.50 in constant price is reasonable for use in the economic impact analyses. The price for oil was arrived at after consideration of several factors. Based on the second stage of implementation of the Energy Policy and Conservation Act, the FEA estimated that domestically produced new oil price will be $13.95 (in current price) at the end of the 40-month control period. However, there is a good possibility for the price control to be extended repeatedly and influence price levels well beyond the 40-month period of control. Therefore, an upward price movement could be adjusted by a ceiling price imposed by regulation. Consequently, about $11 per barrel of domestically produced new oil looks quite reasonable as a long-term real price.

3) No material or labor constraints are assumed to exist in the South Atlantic.

A full discussion of this assumption is contained in Section III of the Draft Environmental Statement, OCS Sale 43.

4) No new refinery is expected as a direct result of the proposed South Atlantic Sale 43.

It is felt that a new refinery would not be built as a direct result of crude oil from the leasing area. Decisions to build new refineries are highly complex. They include consideration of demand, market location, supply of crude, availability and cost of capital, time for amortization, cost of crude, price of product, site availability, State and local receptivity to refinery development, and air and water quality standards. These factors are affected by regional and national concerns.

Currently, there is no fully integrated refinery in the South Atlantic. Refining activity is limited to the Standard Industrial Classifications sectors, paving and roofing materials (SIC 295), and miscellaneous products (SIC 299). A variety of factors, however, could result in a fully integrated refinery being built in the South Atlantic. If such a refinery is built a minimum capacity of 200,000 barrels of oil per day could be expected. A refinery in the area would have implications in our scenario development. Two possible futures are considered and are modeled in the South Atlantic; Base I is the future without a refinery, and Base II is the future with a refinery. The specific assumptions concerning the refinery are included in Table II.

One of the weaknesses of the model is the level of aggregation necessary in the industrial sectors. Because of the high level of demand for refinery products in the South Atlantic that is currently supplied by imports into the region, the model located new output in the region. This would be a logical step except that it avoided the threshold levels by locating most of the growth in Chatham County, Georgia, which already had a refining sector. Chatham's refining sector, however, is composed of paving and roofing materials and miscellaneous petroleum products. The level of growth in output predicted by the model would be excessive without a fully integrated refinery (a fully integrated refinery is a refinery that produces a full range of petroleum products). To correct this the level of output in refining was constrained in Chatham County to be directly proportional to the level of growth in output. It is hoped that this will allow the meeting of a level of demand for specialized petroleum products. In Base II investment capable of building a fully integrated 200,000 barrel/day refinery in Chatham County was added into the model in 1982 and the constraint on output removed. Three scenarios (A, B, and D) were developed under the assumption of no refinery and two scenarios (C and E) were developed with a refinery.

5) It was assumed that South Atlantic OCS production will replace imported crude oil in the United States.

Currently with no fully integrated refineries in the South Atlantic, oil imports consist mainly of final products such as gasoline. The only port that currently receives any crude imports is Savannah. Unless a new refinery is constructed, a large increase in crude imports would not be expected. Hence it was assumed that all oil produced in the scenarios without refining in the South Atlantic would go to the rest of the nation and reduce the level of foreign imports. This assumption is consistent with a policy of decreasing United States dependence on foreign sources of energy. This assumption will not decrease the level of economic activity in the counties which are now used as ports because the mode of transportation will be the same between foreign and OCS crude.

If a refinery is constructed in the South Atlantic, foreign crude would most likely constitute a large percent of the feed stock. Any OCS production would partly replace these imports. In Base

II crude is imported to feed the hypothetical refinery. In the scenarios that include the refinery, foreign imports are replaced by OCS production.

6) No deep water oil ports are assumed.

This assumption was made to allow the effects of offshore activity to be clearly analyzed, separating them from any effects a deep water port may have. A deep water oil port, if large enough, could reduce the cost of imported crude, hence the value of crude landed from the OCS.

7) A competitive cash bonus leasing system is assumed. A royalty rate of 1/6 of the wellhead price is assumed with Federal control of revenue.

This is the present system used most often by BLM. Some uncertainty exists in this area and until some alternative is decided upon, this assumption will be used. The economic model does not explicitly determine government revenue but does quantify government expenditure. The level of royalty payments by year assumed and used as input into the economic model is computed by multiplying the produced oil and gas specified for the different scenarios by the royalty rate and the appropriate price of the oil or gas. Produced oil and gas is discussed in the next section. This enters the model on the national level and is allocated back to the regions, partly on a fixed historical basis and partly by the level of personal income.

Coastal zone legislation recently signed by President Ford might increase the government expenditure levels in counties affected by OCS activities. This was not included into the model because it was not possible to access the monetary impacts at this time.

Resource Assumptions

All resource assumptions were developed by the United States Geological Survey. At our request these were developed as a low and a high estimate. Estimates of employment by activity identified by USGS were developed from estimates from the Offshore Operators Committee of the American Petroleum Institute. The resources estimates that we received from USGS are included as Appendix B. A brief summary of the basic assumptions is included below:

1) Total oil reserves are estimated to range from 0.282 to 1.009 billion barrels of oil. Oil production expressed as a stable daily production rate ranges from 56,000 to 170,000 barrels of oil per day. Table II shows the complete production schedule.

2) Total natural gas reserves are estimated to range from 1.890 to 6.810 trillion cubic feet. Expressed as a stable daily production rate, natural gas production ranges from 466 million cubic feet to 1,397 million cubic feet of gas per day. Table II shows the complete production schedule.

3) Exploration activity requires a maximum of 5-10 active drilling vessels per year. The total number of exploration wells ranges from 95-220. The scheduling of exploration activity is shown on Table II, along with additional assumptions on costs and employment.

4) Platforms required to totally develop the resource range from 10-25 (8 if no gas is produced). Development wells drilled range from 160 to 500 wells. Scheduling, costs, and employment assumptions are shown in Table II.

Estimates of offshore and onshore development requirements beyond these basic assumptions were refined, using the GS estimates, to scenario specific estimates and are discussed in the next section.

Scenario Development and Comparisons

After reviewing all of the above assumptions it was decided that the minimum number of scenarios that would be needed was four. This includes a high and low scenario with a refinery, and a high and low scenario without a refinery. It was decided that a fifth alternative should be examined. This alternative is the proposal for an offshore gathering, storage, and terminal facility with no oil coming onshore in the South Atlantic. The reader is referred to Table II for a complete list of all of the assumptions used in the scenarios. A description of the methodology used in the specific resource siting will be followed by a general overview of the base cases and scenarios.

One of the most important elements in the development of any scenario-specific assumptions is a knowledge of the location of the resources. A good knowledge of resource location will not be obtained until well into the exploratory activity. A good predictive rule of oil company behavior is that any development will follow a path calculated to maximize profits. This assumption can provide guidance in locating onshore development. For example, because of the expense of marine pipeline, an oil or gas pipeline will come ashore at the nearest environmentally and technologically feasible point.

Any analysis of the South Atlantic is complicated by the geographic spread of the tracts that are offered. Given the geographical dispersion of the tracts it was decided that some system of allocating resources would have to be determined. The method used located platforms (with only one platform located per block) and allocated resources evenly between platforms. To locate platforms, all tracts in the sale were assigned sequential numbers determined by the number of nominations they had received. For example, a tract receiving six nominations might be numbered 100-105, while the next tract, which received two nominations, would be numbered 106-107. A drawing was made using a table of random numbers to determine both the location and timing of the resource development. This technique was used in all scenarios.

All employment and investment is assigned to the county that contains the operations base. When more than one operations base exists, platforms are assumed to be serviced by the nearest base and employment and investment are accordingly proportioned. Assigning investment to the operations base is a logical assumption because it approximates the point of delivery for offshore equipment. Assigning employment to the operations bases is not as good an assumption. The terms of employment very often are 7 days on, 7 days off, or some other on/off arrangement. For offshore workers residence in close proximity of work is not as important of a consideration as those with daily work schedules. Contacts with industry indicate that it is not uncommon for workers to live 250 miles away. Hence, our assumption will overestimate employment in these counties.

All investment costs do not include the costs of land on which the facility will be located. This is because cost of land is one of the variables that is used to determine the location of the industry in the output equations, hence the value of land enters independent of the facility cost.

Two base cases were developed. Base I is the case without a fully integrated refinery. Output in the existing petroleum refining sectors was constrained in Chatham County, Georgia, to be equal to a direct proportion of output (minus petroleum refining) predicted by an early run of the model. The constrained levels are shown in Table II.

Base II is the case with a new fully integrated refinery in the South Atlantic. The refinery was located in Chatham County, Georgia. Inputs to the Harris Model were based on a study done by the State of Georgia on potential refinery locations. The modeled refinery has a capacity of 200,000 barrels of oil throughput per day. Its costs were estimated at $400 million and with employment estimated at 550 persons. The constraints on refinery output were removed in the model upon completion of the refinery. Scenarios C and E are consistent with the refinery assumption, and Scenarios A, B, and C are consistent with no fully integrated refinery assumptions. A discussion of the scenarios follows.

Scenario A models the case where no oil production comes onshore in the South Atlantic and no gas production exists. The scenario was developed using the low resource estimates. It will have the least onshore impacts and as such represents the bottom line of the range of impacts from development. The scenario could have easily been based on the high resource estimates. The low resource scenario was chosen to provide the bottom figure for our range.

The low resource estimates indicate that the building of an oil or gas pipeline will be marginal unless the resources are geographically concentrated. For Scenario A we assumed that the gas resources were randomly distributed throughout the offered tracts. If this occurs, it will be uneconomical to build pipelines to shore and no gas production will occur.

The economics of oil production are not as dependent upon pipeline economics if the surface transportation of oil is allowed. For Scenario A, we assumed that oil resources were sufficiently concentrated to allow the building of a centralized gathering, and storage, tanker terminal. Inputs for the terminal were based on a similar proposal by Exxon for use offshore California. Conoco has also suggested that a similar system might be employed in the North Atlantic. With no major refinery in the South Atlantic the oil production is forecast to go to Mid-Atlantic or Gulf Coast refineries.

The decision not to produce gas was assumed to have no impact on the exploration activity. The number of platforms and development wells were scaled to reflect the lack of gas production. A detailed list of the specific assumptions and the scheduling of exploration and development is included in Table II and Table III shows total direct employment. A summary of the basic components follows:

1. An onshore operations base is established in Chatham County, Georgia, in 1977 which employs 103 people. Investment in pollution containment and pickup equipment occurs at the beginning of development phases of production.
2. A centralized gathering, storage, and treatment offshore terminal is constructed in 1985. All oil is tankered to domestic refineries outside the region. The offshore terminal employs 36 persons.

3. No production of natural gas occurs. Investment and employment have been scaled down from the low recovery estimates to reflect this.

All investment and employment has occurred in Chatham County, Georgia (Savannah). An analogy can be drawn between this run and the potential that because of resource location all investment and employment occurs in alternative metropolitan areas such as Duval County, Florida (Jacksonville), or Charleston County, South Carolina (Charleston).

Scenario B arbitrarily places all gas production in the northern tracts and all oil production in the southern tracts. This assumption allows an oil and gas pipeline to be an economical alternative. Specific assumptions on scheduling and investment are found in Table II and employment assumptions are found in Table III. A summary of the basic components follows:

1. An onshore operations base is established in Chatham County, Georgia in 1977 which employs 103 persons. Pollution containment and pickup equipment investment occurs at the beginning of the exploration and at the beginning of the development phases of production.
2. Initially oil is stored and tankered from individual platforms. A 65 mile major marine pipeline is constructed with a landfall in Duval Co., Fla., in 1985. Terminal facilities also constructed in 1985 cost $4,000,000. All oil is tankered outside the South Atlantic region. It was assumed that one half of the production would be tankered to refineries along the East Coast and one half of the production would be sent to the Gulf Coast refineries.
3. A 68 mile major marine gas pipeline is built in 1986 with a landfall in Charleston, S. C. It was assumed that another 5 miles of overland pipeline would be needed to transport the gas to the processing plant and tie in with existing distribution systems. A 500 mcf/day processing plant is built in 1985, coming on stream in 1986. The plant costs $40,000,000 and employs 25 persons.

Scenario C includes the same resource assumptions as Scenario B, i.e., gas in the northern sale area and oil in the southern sale area. In Scenario C, however, a fully integrated refinery has come on stream in Chatham County, Georgia in 1982. The existence of a refinery in the area implies that a major proportion of the OCS crude will remain in the area. In Scenario C we assumed that the oil would be transported to the refinery by pipeline. Detailed assumptions on scheduling and investment is in Table II and a summary of employment is in Table III. A summary of the major components follows:

1. An onshore operations base is established in Chatham County, Georgia in 1977 which employs 103 persons. Pollution containment and pickup equipment investment occurs at the beginning of the exploration and at the beginning of the development phases of production.
2. Initially oil is stored and tankered from individual platforms. In 1985, a major marine oil pipeline is constructed to the nearest point onshore and then overland to a refinery in Chatham County. The distance transversed was plotted on a map and then an additional 20% added to allow for right-of-way consideration. All investment occurs in 1985, pipeline investment by county follows:

County	Investment
Chatham, Ga.	$7,200,000
Brynn, Ga.	3,600,000
Glynn, Ga.	44,800,000
McIntosh, Ga.	13,800,000
Liberty, Ga.	2,400,000

A terminal and pumping station will be built in Glynn County in 1985 at the cost of $3,000,000. All oil produced goes to the refinery in Chatham Co., Ga. OCS oil replaces imported oil that is supplying the refinery's feed stock.
3. A 68 mile major marine gas pipeline is built in 1986 with a landfall in Charleston, S.C. It was assumed that another 5 miles of overland pipeline would be needed to transport the gas to the processing plant and tie in with existing distribution systems. A 500 mcf/day processing plant is built in 1985, coming on stream in 1986. The plant costs $40,000,000 and employs 25 persons.

Scenario D is based on the high resource estimates. No refinery is assumed. All resource assumptions are based directly on USGS estimates and stay constant between the Scenarios D and E. Specific resource assumptions are found in Table II along with assumptions on the scheduling of development and investment. Table III summarizes employment in this scenario. A summary of the scenario's basic components follows:

1. Oil resources are evenly divided between 21 oil platforms and gas resources are evenly divided between 4 gas platforms. To develop the resources three onshore operations bases were postulated as follows: Glynn County, Georgia in 1977; Charleston County, South Carolina in 1978, and Duval County, Florida in 1979. The exploration effort is divided evenly between the three bases development platforms and wells were allocated to the nearest operations base.

Investment in pollution containment and pickup equipment was determined by the scheduling of exploration and development phases. Investment occurs as follows:

Year	County	Investment
1977	Glynn, Georgia	$300,000
1978	Charleston, South Carolina	300,000
1981	Glynn, Georgia	470,000
	Charleston, South Carolina	470,000
1982	Duval, Florida	470,000

2. Initial oil production is stored on the platforms, gathered and tankered out of the area. After the completion of the oil pipelines (90 miles to Duval in 1985, and 65 miles to Charleston in 1988), oil is conveyed to onshore terminals via these pipelines. Terminal facilities cost $4,000,000 and are constructed in 1985 in Duval Co., Fla., and in 1988 in Charleston, County, S.C. All crude oil is tankered outside the South Atlantic region.
3. Two major marine gas pipelines, consisting of 82 miles to Duval County, Florida, and 70 miles to Charleston County, South Carolina, were constructed to two 700 mmcf/day gas

TABLE III Timing of Total Direct Nonconstruction Employment - Total Offshore Employment Low Recovery - Sale 43

Year	Production 10^3 bld	Production 10^6 cf/d	Exploration Vessels	Employment	Development Rigs	Employment	Platforms	Employment	Total Offshore Employment
1976									-
1977			4	452					452
1978			5	565					565
1979			5	565					565
1980			3	339					339
1981			3	339	1	65			404
1982	3		2	226	3	195	1	22	443
1983	7		2	226	5	325	3	66	617
1984	11		2	226	8	520	5	110	856
1985	16		2	226	6	390	7	154	770
1986	23	200	1	113	4	260	8	176	549
1987	30	274	1	113	4	260	9	198	571
1988	37	342	1	113	1	65	10	220	398
1989	45	421	1	113	1	65	10	220	398
1990	56	466	1	113	1	65	10	220	398
1991	56	466			1	65	10	220	285
1992	56	466			1	65	10	220	285
1993	56	466			1	65	10	220	285
1994	56	466			1	65	10	220	285
1995	56	466			1	65	10	220	285
1996	56	466			1	65	10	220	285
1997	51	301			1	65	10	220	285
1998	45	181			1	65	10	220	285
1999	40	82			1	65	10	220	285
2000	25	41			1	65	8	176	241
2001	18	27			1	65	7	154	219
2002	10	11			1	65	3	66	131
2003	6	11			1	65	2	44	109
2004	5	8			1	65	2	44	109
2005	3	8			1	65	1	22	87
2006	3	8			1	65	1	22	87

TABLE III Timing of Total Direct Nonconstruction Employment - Total Offshore Employment, High Recovery - Sale 43

Year	Production 10^3 bld	Production 10^6 cf/d	Exploration Vessels	Employment	Development Rigs	Employment	Platforms	Employment	Total Offshore Employment
1976									
1977			4	452					452
1978			10	1,130					1,130
1979			10	1,130					1,130
1980			10	1,130					1,130
1981			7	940	2	135			1,075
1982	8		5	565	5	325	2	44	934
1983	25		5	565	10	650	4	88	1,303
1984	41		5	565	14	910	6	132	1,607
1985	55		5	565	15	975	8	176	1,716
1986	77	701	3	339	12	780	13	286	1,405
1987	99	726	3	339	12	780	16	352	1,471
1988	134	726	3	339	12	780	19	418	1,537
1989	162	1,359	1	113	8	520	21	462	1,095
1990	167	1,397	1	113	5	325	23	506	944
1991	170	1,397	1	113	4	260	25	550	923
1992	170	1,397	1	113	2	130	25	550	793
1993	170	1,397			2	130	25	550	680
1994	170	1,397			2	130	25	550	680
1995	170	1,397			2	130	25	550	680
1996	170	1,375			2	130	25	550	680
1997	170	1,351			2	130	25	550	680
1998	170	1,351			2	130	25	550	680
1999	170	1,288			2	130	25	550	680
2000	151	740			2	130	25	550	680
2001	123	438			2	130	23	506	636
2002	71	129			2	130	23	506	636
2003	52	41			2	130	20	440	570
2004	38	19			2	130	18	396	526
2005	19	19			2	130	15	330	460
2006	14	11			2	130	12	264	394
2007	3	0			2	130	10	220	350
					2	130	4	88	218

TABLE III Timing of Total Direct Nonconstruction Employment - Scenario A Sale 43 (Low Recovery)

Year	Offshore 1/ (exclud. Terminal)	Offshore Terminal	Office	Operation's Base	Total Employment Scenario A
1976					
1977	452		30	103	582
1978	565		30	103	698
1979	565		30	103	698
1980	339		30	103	472
1981	426		30	103	559
1982	487		30	103	620
1983	661		30	103	794
1984	683		30	103	816
1985	770	36	30	103	939
1986	427	36	30	103	596
1987	549	36	30	103	718
1988	354	36	30	103	523
1989	354	36	30	103	523
1990	354	36	30	103	523
1991	241	36	30	103	410
1992	241	36	30	103	410
1993	241	36	30	103	410
1994	241	36	30	103	410
1995	241	36	30	103	410
1996 2/	241	36	30	103	410

2/ Employment is only shown for the 20 years on which the model is run.
1/ Employment has been scaled to reflect no gas production.

TABLE III Timing of Total Direct Nonconstruction Employment - Scenario B Sale 43 (Low Recovery)

Year	Total Offshore	Office	Operation's Base	Gas Processing Plant	Pipeline Terminal and Tanker Port	Total Employment Scenario B
1976						
1977	452	30	103			585
1978	565	30	103			698
1979	565	30	103			698
1980	339	30	103			472
1981	404	30	103			537
1982	443	30	103			576
1983	617	30	103			750
1984	856	30	103			989
1985	770	30	103		13	916
1986	549	30	103	25	13	720
1987	571	30	103	25	13	742
1988	398	30	103	25	13	569
1989	398	30	103	25	13	569
1990	398	30	103	25	13	569
1991	285	30	103	25	13	456
1992	285	30	103	25	13	456
1993	285	30	103	25	13	456
1994	285	30	103	25	13	456
1995	285	30	103	25	13	456
1996*	285	30	103	25	13	456

* Employment is only shown for the 20 years on which the model is run.

TABLE III Timing of Direct Nonconstruction Employment - Scenario C Sale 43 (Low Recovery)

Year	Total Offshore	Office	Operation's Base	Gas Processing Plant	Oil Pipeline Terminal	Total Employment Scenario C	Refinery[1]
1976							
1977	452	30	103			585	
1978	565	30	103			698	
1979	565	30	103			698	
1980	339	30	103			472	
1981	404	30	103			537	
1982	443	30	103			576	550
1983	617	30	103			750	550
1984	856	30	103			989	550
1985	770	30	103		9	912	550
1986	549	30	103	25	9	716	550
1987	571	30	103	25	9	738	550
1988	398	30	103	25	9	565	550
1989	398	30	103	25	9	565	550
1990	398	30	103	25	9	565	550
1991	285	30	103	25	9	452	550
1992	285	30	103	25	9	452	550
1993	285	30	103	25	9	452	550
1994	285	30	103	25	9	452	550
1995	285	30	103	25	9	452	550
1996*	285	30	103	25	9	452	550

* Employment is only shown for the 20 years on which the model is run.

1 Refinery employment is not included in the total estimate because it is not generated by the OCS development.

TABLE III Timing of Direct Nonconstruction Employment – Scenario D Sale 43 (High Recovery)

Year	Total Offshore	Office	Operation's Base	Gas Processing Plant	Oil Terminals and Tanker Ports	Total Employment Scenario D
1976						
1977	452	30	103			585
1978	1,130	36	206			1,372
1979	1,130	42	309			1,481
1980	1,130	42	309			1,481
1981	1,075	42	309			1,426
1982	934	42	309			1,285
1983	1,303	42	309			1,654
1984	1,607	42	309			1,958
1985	1,716	42	309		13	2,080
1986	1,405	42	309	30	13	1,799
1987	1,471	42	309	30	13	1,865
1988	1,537	42	309	30	26	1,944
1989	1,095	42	309	60	26	1,532
1990	944	42	309	60	26	1,381
1991	923	42	309	60	26	1,360
1992	793	42	309	60	26	1,230
1993	680	42	309	60	26	1,057
1994	680	42	309	60	26	1,057
1995	680	42	309	60	26	1,057
1996*	680	42	309	60	26	1,057

* Employment is only shown for the 20 years on which the model is run.

TABLE III Timing of Direct Nonconstruction Employment -
Scenario E Sale 43 (High Recovery)

Year	Total Offshore	Office	Operation's Base	Gas Processing Plant	Oil Pipeline Terminal	Total Employment Scenario E	Refinery[1]
1976							
1977	452	30	103			585	
1978	1,130	36	206			1,372	
1979	1,130	42	309			1,481	
1980	1,130	42	309			1,481	
1981	1,075	42	309			1,426	
1982	934	42	309			1,285	550
1983	1,303	42	309			1,654	550
1984	1,607	42	309			1,958	550
1985	1,716	42	309		17	2,084	550
1986	1,405	42	309	30	17	1,803	550
1987	1,471	42	309	30	17	1,869	550
1988	1,537	42	309	30	17	1,905	550
1989	1,095	42	309	60	17	1,523	550
1990	944	42	309	60	17	1,372	550
1991	923	42	309	60	17	1,351	550
1992	793	42	309	60	17	1,221	550
1993	680	42	309	60	17	1,108	550
1994	680	42	309	60	17	1,108	550
1995	680	42	309	60	17	1,108	550
1996*	680	42	309	60	17	1,108	550

* Employment is only shown for the 20 years on which the model is run.

1 Refinery employment is not included in the total estimate because it is not generated by the OCS development.

processing plants. Investment costs and employment by county and year are as follows:

Year	County	Investment	Employment
1985	Duval, Fla.	$60,000,000	30
1988	Charleston, S.C.	60,000,000	30

Scenario E is based on the high resource estimates and the refinery assumption. Resource, exploration, and initial development assumptions are the same as Scenario D. A refinery is assumed to be on stream in Chatham County, Georgia in 1982. A mainly marine pipeline connects the OCS production areas to the refinery. Detailed scheduling and investment assumptions are shown in Table II while a summary of employment assumptions are shown in Table III. A summary of the scenario's basic components follows:

1. Three onshore operations bases were postulated as follows: Glynn County, Georgia in 1977; Charleston County, South Carolina in 1978, and Duval County, Florida. The exploration effort is divided evenly between the three bases development platforms and wells were allocated to the nearest operations base.

Investment in pollution containment and pickup equipment was determined by the scheduling of exploration and development phases. Investment occurs as follows:

Year	County	Investment
1977	Glynn, Georgia	$300,000
1978	Charleston, South Carolina	300,000
1981	Glynn, Georgia	470,000
	Charleston, South Carolina	470,000
1982	Duval, Florida	470,000

2. Initial oil production is stored on the platforms, gathered, and tankered to the refinery in Chatham County, Georgia. After the completion of the oil pipeline in 1985 (176 miles to Chatham County) all oil is piped directly to the refinery. A pipeline terminal is built at the landfall; with a cost of $4,000,000. Oil imports to feed the 200,000 barrel/day refinery are shipped to Chatham County. OCS production replaces these imports.
3. Two gas pipelines, a 75 mile pipeline to Glynn County, Georgia and a 70 mile pipeline to Charleston County, South Carolina, connecting with two 700 mmcf/day gas processing plants are included in this scenario. Investment costs and employment by county and year are as follows:

Year	County	Investment	Employment
1985	Glynn, Ga.	$60,000,000	30
1988	Charleston, S.C.	60,000,000	30

Model Information

For each base case and scenario data has been obtained for the following levels of aggregation:

1. County (including independent cities)
2. State coastal regions
3. Mid-Atlantic coastal region as a whole
4. United States as a whole.

The county, State, and regional aggregations included only the following counties:

Florida	Georgia	North Carolina	South Carolina
Baker	Bryan	Brunswick	Beaufort
Clay	Camden	Columbus	Berkeley
Duval	Chatham	New Hanover	Charleston
Falgler	Effinghan	Pender	Colleton
Nassau	Glynn		Dorchester
Putnam	Liberty		Georgetown
St. Johns	Long		Hampton
	McIntosh		Harry
			Jasper
			Williamsburg

The value of output, along with employment, earnings, demand, value added, foreign exports and imports, and personal consumption expenditures is determined for 22 industrial sectors shown in Table I. Output is shown for the years 1975, 1976, 1980, 1984, 1988, 1992, and 1996.

Equipment purchasing sectors and construction sectors are shown in Table IV and Table V. The value of equipment purchases (12 categories) and construction (20 categories) is shown for all years 1976-1996. All output is in 1972 prices. Other output categories shown for 1975, 1976, 1980, 1984, 1988, 1992, and 1996 include:

Civilian Labor Force
Net Commuters
Civilian Persons Employed
Civilian Unemployment
Civilian Unemployment Rate
Population Density
Multi-Job Holders
Net Population Migration
Population Associated with Labor Force Surplus
Population
Personal Income
Earnings
Property Income
Social Insurance Payments
Transfer Payments
Agricultural Value of Land Per Acre
Federal Government Expenditure (Excl. Const. & Emp. Comp.)
State & Local Government Expenditure (Excl. Const. & Emp. Comp.)
Federal Government Purchases (Excl. Const.)
State and Local Government Purchases (Excl. Const.)
Personal Consumption Expenditures
Private Investment
Gross Regional Product
Per Capita Income
Total Supply
Total Demand
Domestic Output
Competing Imports
Noncompetitive Industry Imports
Noncompetitive Consumer Imports
Gross Foreign Exports
Value Added
Equipment Purchases
Construction
Federal Defense Expenditures

TABLE IV Equipment Purchasing Sectors

A	Farm (1), Meat Products (6), Tobacco (7), Dairy Products (62), Canned and Frozen Foods (63), Grain Mill Products (64), Bakery Products (65), Sugar (66), Confectionery (67), Beverages (68), Miscellaneous Foods (69)
B	Mining (2)
C	Oil and Gas Wells (3)
D	Construction (4)
E	Fabrics and Yarn (8), Rugs, Tire Cord (9), Apparel (10), Household Textiles and Upholstery (11)
F	Lumber and Productions Excluding Containers (12), Wooden Containers (13), Household Furniture (14), Office Furniture (15), Paper, Excluding Containers (16), Paper Containers (17)
G	Basic Chemicals (19), Drugs, Cleaning, and Toilet Items (21), Paint (22), Plastics and Synthetics (20), Rubber and Plastic (24)
H	Petroleum Refining (23)
I	Leather Tanning (25), Shoes and Other Leather Products (26), Glass and Products (27), Stone and Clay Products (28)
J	Iron and Steel (29)
K	Non Ferrous Metals (30), Metal Containers (31), Heating, Plumbing, Structural Metal (32), Stampings, Screw Machine Products (33), Hardware, Plating, Wire Products, and Valves (34)
L	Ordnance (5), Engines and Turbines (35), Farm Machinery and Equipment (36), Construction and Material Handling Equipment (37), Metal Working Machinery (38), Special Industrial Machinery (39), General Industrial Machinery (40), Machine Shops and Miscellaneous (41), Office and Computing Machines (42), Service Industry Machinery (43), Electric Apparatus and Motors (44), Household Appliances (45), Electronic Components (48), Batteries, X-Ray and Engine Electrical Equipment (49), Motor Vehicles (50), Aircraft and Parts (51), Ships, Trains, and Cycles (52), Instruments (53), Optical and Photographic Equipment (54), Miscellaneous Manufacturing (55)

Equipment Purchasing Sectors (Continued)

M	Transportation (56)
N	Printing and Publishing (18), Communication (57)
O	Utility (58)
P	Trade (59)
Q	Finance and Insurance (60)
R	Service (61)

* All numbers in parenthesis refer to Harris Model industrial sectors

Source: Harris 1972

Table V Construction

A	Residential (1), Additions and Alterations to Residences (2), Nonhousekeeping Residential Construction (3)
B	Offices (5), Stores, Restaurants and Garages (6), Miscellaneous Nonresidential Buildings (10), All Other Private Construction (17)
C	Industrial (4)
D	Religious (7)
E	Educational (8)
F	Hospital and Institutional (9)
G	Farm Construction (11)
H	Oil and Gas Well Drilling and Exploration (12)
I	Railroad (13)
J	Highway (18)
K	Telephone (14)
L	Electric Utility (15)
M	Gas and Petroleum Pipelines (16)
N	Sewer Systems (21), Water Systems (22)
O	Conservation (20)
P	Public Residential (23)
Q	Public Industrial Construction (24)
R	Public Educational (25)
S	Public Hospital (26)
T	Military (19), Other Public Structures (27), Miscellaneous Public (28)

* All numbers in parenthesis refer to Harris Model Industrial sectors

Source: Harris, 1972.

CHAPTER III

Results of the Initial Harris Model Scenarios

The approach followed in presenting the scenario results will concentrate primarily on the changes induced in industrial sectors as a result of the proposed OCS leasing program This will be followed by a discussion of some of the other social and economic variables predicted by the model.

There are two reasons for this approach. First, the approach follows the logic of the model which uses changes in industrial output as the primary determinant of changes in other economic variables. Second, the purpose of this paper is to provide a technical guide to the Harris Model's South Atlantic application. Hence, this chapter will focus on the cause and effect relationships between direct oil and gas development and induced changes in other economic variables.

A more generalized impact analysis using the results of the model is found in the main body of the *Draft Environmental Statement, Proposed Sale 43*. The reader is referred to the section on economic impacts for a more detailed discussion of the predicted variables

Table VI shows output by industrial sector expressed as a percentage of the total for the South Atlantic coastal region and the U.S. for the years 1976 and 1996. Table VII and Table VIII show a similar breakdown for the coastal region of each state. Major differences in the structures of the two economies are found in the sectors of lumber and wood processing (percentage output in the South Atlantic coastal region is 11.0%, compared to 3.2% in the U.S.) and machinery and miscellaneous manufacturing (13.9% in the U.S., compared to 2.8% in the South Atlantic). The South coastal areas have a greater than average percentage of output in transportation and wholesale trade reflecting its position as an import center for the interior regions and in agricultural and food processing, forestry and fisheries, and lumber and wood processing reflecting the region's agricultural base. A greater than average percentage of output also was shown in the chemical and plastics sector. The region's below average percentages in petroleum refining (Base I only), iron and steel, other metals, and machinery and miscellaneous manufacturing indicate a lack of a strong industrial base.

Output sectors in 1976 show a great deal of variation between the states. Apparel and textile sectors are large in North and South Carolina while small in the rest of the region. Although lumber and wood processing represents a greater precent of output in all of the South Atlantic states than the U.S. (3.2%), it is particularly large in Georgia (18.0%) and North Carolina (10.5%). Georgia has a large chemical and plastics sector (17.4%). The wholesale trade (11.2%) and transportation (5.0%) sectors in Florida reflect the importance of the port at Jacksonville. Finance, insurance and real estate sectors are larger in Florida (15.1%) and South Carolina (22.5%) than the national average (13.2%) while the same sectors are smaller than average in Georgia (6.4%) and North Carolina (8.8%).

Changes that occurred between 1976 and 1996 were relatively minor with only a few sectors showing a major change. Florida's agricultural and food processing, lumber and wood products, and chemicals and plastics increase while finance, insurance and real estate and retail stores decline. In Georgia, the most significant changes in Base I occur in the decline of the forestry and fishery and lumber and wood processing sectors and the increase in the chemical and plastic sectors. In Base II, petroleum refining increases from 4.3% to 12.4% of total output. Trends in the other sectors are accentuated. North Carolina's agricultural and food processing sectors decline dramatically while apparel and textiles, lumber and wood processing, and machinery and miscellaneous manufacturing all show increases. The financial, insurance and real estate sector in South Carolina grows to 31.2% of total output compared to a 5.6% average in the South Atlantic coastal area and a national average of 13.7% sectors which show decline percentages in South Carolina are agricultural and food processing, forestry and fisheries, lumber and wood processing and chemical and plastics.

One of the most striking results apparent from an examination of Base I and Base II is the lack of economic linkages between the coastal counties. Although the location of a refinery in Chatham County had important effects within the county, effects on adjacent counties or other coastal counties were minor. Impacts from OCS related developments behaved in a similar fashion. This implies that trade probably moves from coastal areas to areas inland rather than

Table VI

Comparison of U.S. and South Atlantic Coastal Region's Economies - Percent Output

Industry Grouping	1976 USA Base I	1976 South Atlantic Base II	1996 USA*	1996 South Atlantic Base I	1996 South Atlantic Base II
Ag. & Food Process.	11.2	13.2	9.5	11.7	11.5
Forestry & Fishing	.1	.5	.0	.1	.1
Non Petrol Mining	.7	.1	.7	.0	.0
Petroleum Mining	.8	.0	.8	.0	.0
Apparel & Textiles	3.3	3.7	3.0	4.3	4.2
Lumber & Wood Prod.	3.2	11.0	3.0	10.0	9.9
Chemical & Plastics	4.5	6.4	5.6	8.7	8.5
Petroleum Refining	1.8	1.3	1.7	1.3	3.0
Leather, Glass, & Stone	1.4	1.5	1.3	1.5	1.5
Iron & Steel	2.1	.9	1.5	.9	.9
Other Metals	3.7	1.3	3.3	1.2	1.2
Machinery & Misc. Mfg.	13.9	2.8	14.5	2.5	2.5
Transportation	3.3	4.1	3.6	4.2	4.2
Communications	3.6	3.4	3.9	3.7	3.6
Utility	3.4	2.4	3.3	2.1	2.1
Wholesale Trade	5.0	7.1	5.6	7.4	7.3
Fin. Ins., & Real Estate	13.2	14.7	13.7	15.9	15.6
Amusement & Service	2.1	2.7	1.9	2.1	2.1
Retail Stores	12.2	11.8	12.9	11.8	11.6
Medical & Ed. Inst.	4.8	3.9	5.0	4.3	4.2
Auto. Dealers & Service	2.7	3.9	2.6	3.4	3.4
Construction	3.0	3.4	2.7	2.7	2.6
Total	100.0	100.0	100.0	100.0	100.0

* No changes occur in USA percentages between Base I and II.

Table VII

Comparison of South Atlantic States
Costal Economies - 1976
Percent Output

Industry Grouping	State Costal Regions Florida	Georgia	North Carolina	South Carolina	South Atlantic
Ag. & Food Processing	13.8	10.7	12.6	14.4	13.2
Forestry & Fisheries	.4	.6	.2	.6	.5
Non Petrol. Mining	.1	.0	.0	.1	.1
Petroleum Mining	.0	.0	.0	.0	.0
Apparel & Textiles	.3	.8	13.4	7.6	3.7
Lumber & Wood Prod.	9.3	18.0	10.5	8.7	11.0
Chemical & Plastics	2.4	17.4	9.8	3.2	6.4
Petroleum Refining	.5	4.2	.0	.9	1.3
Leather, Glass & Stone	1.2	2.4	.9	1.5	1.5
Iron & Steel	.8	.4	.0	1.7	.9
Other Metals	1.5	1.6	2.4	.4	1.3
Machinery & Misc. Mfg.	2.0	2.8	4.4	3.5	2.8
Transportation	5.0	3.8	4.7	2.8	4.1
Communications	4.2	2.6	3.4	2.6	3.4
Utility	2.2	2.0	3.3	2.4	2.4
Wholesale Trade	11.2	4.0	4.6	4.0	7.1
Fin. Ins. & Real Estate	15.1	6.4	8.8	22.5	14.7
Amusement & Service	3.2	2.5	1.8	2.4	2.7
Retail Stores	13.8	10.1	10.1	10.4	11.8
Medical & Ed. Inst.	4.7	2.7	3.5	3.7	3.9
Auto Dealers & Service	4.8	3.3	3.0	3.4	3.9
Construction	3.5	3.6	2.7	3.4	3.4
Total	100.0	100.0	100.0	100.0	100.0

Table VIII

Comparison of South Atlantic States Costal Economies - 1996
Percent Output

Industry Grouping	Base I Florida	Base I Georgia	Base I North Carolina	Base I South Carolina	Base I South Atlantic	Base II Florida	Base II Georgia	Base II North Carolina	Base II South Carolina	Base II South Atlantic
Ag & Food Processing	14.7	10.6	5.7	10.4	11.7	14.7	9.6	5.7	10.4	11.5
Forestry & Fisheries	.1	.1	.0	.1	.1	.1	.1	.0	.1	.1
Non Petrol. Mining	.1	.0	.0	.0	.0	.1	.0	.0	.0	.0
Petroleum Mining	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Apparel & Textiles	.2	1.9	16.3	7.6	4.3	.2	1.7	16.3	7.6	4.2
Lumber & Wood Prod.	10.7	11.0	13.6	7.3	10.0	10.7	10.0	13.6	7.3	9.9
Chemical & Plastic	4.4	27.9	10.1	1.8	8.7	4.4	25.6	10.1	1.8	8.5
Petroleum Refining	1.8	4.3	.0	.4	1.3	.8	12.4	.0	.4	3.0
Leather, Glass & Stone	1.5	2.0	.8	1.5	1.5	1.5	1.8	.8	1.5	1.5
Iron & Steel	.9	.5	.0	1.4	.9	.9	.4	.0	1.4	.9
Other Metals	1.6	1.7	1.2	.4	1.2	1.6	1.6	1.2	.4	1.2
Machinery & Misc. Mfg.	1.6	1.5	8.0	2.5	2.5	1.6	1.4	8.0	2.5	2.5
Transportation	5.4	3.8	4.7	2.8	4.2	5.4	3.5	4.7	2.8	4.2
Communications	4.8	3.5	3.4	2.3	3.7	4.8	3.2	3.4	2.3	3.6
Utility	2.3	1.9	1.5	2.3	2.1	2.3	1.7	1.5	2.3	2.1
Wholesale Trade	11.9	4.3	4.8	4.1	7.4	11.9	4.0	4.8	4.1	7.3
Fin., Ins. & Real Estate	12.9	3.2	6.7	31.2	15.9	12.9	2.9	6.7	31.2	15.6
Amusement & Service	2.8	2.2	1.2	1.5	2.1	2.8	2.0	1.2	1.5	2.1
Retail Stores	11.2	11.2	14.1	12.4	11.8	11.2	10.2	14.1	12.4	11.6
Medical & Ed. Inst.	5.4	2.5	3.2	4.3	4.3	5.4	2.3	3.2	4.3	4.2
Auto Dealers & Service	4.2	3.0	2.5	2.9	3.4	4.2	2.8	2.5	2.9	3.4
Construction	2.7	3.0	2.1	2.6	2.7	2.7	2.7	2.1	2.6	2.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

between coastal counties. It should be noted however, that the transportation algorithms only consider highway and rail transportation rates. If shipping rates are lower than the alternative rail or highway transportation rates between coastal counties, linkages predicted by the model might be considerably understated.

Changes in the value of output by the industry sector for the South Atlantic coastal region are shown in Table IX. Percentage changes from the base value of the sector are also shown. Changes in the value of petroleum mining dominates the changes in the value of output. Value of petroleum mining is an input variable into the model and reflects the discoveries on the OCS. Value of output in the construction sector is partially specified as an input variable and partially represents induced development. The only other industrial sector which shows large induced increases when compared to the base level is petroleum refining. Increases are largest in the no refinery scenarios, where as a percentage of the original base, induced development represented as much as a 24% increase. The petroleum refinery sector will be discussed in greater detail below.

Other sectors which showed lesser changes over the base amounts are machinery and miscellaneous manufacturing and transportation and wholesale and retail trade. Increases in wholesale and retail trade were estimated at approximately 20 million dollars although it represented less than a 1% increase over the base level.

Table X shows changes in total value of output minus the value of petroleum mining by county. Petroleum mining was excluded to give some approximation of induced output. The value is an imperfect approximation however, because it does have some direct (versus induced) elements included in the construction sectors.

The change in induced output is less than 1% in all counties in all years modeled with the exception of Glynn County, Georgia. Glynn County base output is smaller than most of the areas that have direct OCS development. Induced output in 1996 accounted for 2% of total output in Scenario D and 3% of total output in Scenario E.

The lack of economic linkages between counties is shown in Table X. When output is compared to scenario inputs, it can be shown that changes in output occur almost exclusively in counties which received input specifications. Changes that occur in other counties are small in both actual magnitude, with most changes being under $500,000 and no change being over $1,000,000.

The number of jobs created by OCS development is shown in Table XI. The sectors which showed the greatest increase in jobs are the construction, wholesale and retail trade, transportation, machinery and miscellaneous manufacturing, state and local governments, and petroleum mining. Increases in jobs in wholesale and retail trade and state and local government are primarily induced by OCS generated increases in population and personal income. Jobs in transportation, machinery and miscellaneous manufacturing and petroleum mining reflect changing industrial structures. Jobs in construction are induced by both factors.

Jobs were not summarized by county or state. The same distribution that occurred in output also occurs in jobs. Counties that received direct inputs represented most of the increase in jobs with other counties accounting for a very small percent of the created jobs.

Civilian persons employed is derived from number of jobs by adjusting jobs by the number of multi-job holders. The civilian labor force is derived by adjusting the employment by the number of commuters. A discussion of the predicted values for these variables are included in the main body of the impact statement.

Two industrial sectors are treated in greater detail below. These are petroleum refining, which had a large increase in value of output and transportation which had substantial increases in number of jobs. Other sectors which had large increases can be explained directly by the specification of inputs (construction) or changes in population and the level of personal income (wholesale and retail trade, and state and local governments) and are not treated separately.

The value of output in petroleum refining is shown by state and selected county in Table XII. No refining activity was specified in the scenarios and all refining activity shown should be considered as induced by OCS development. An investment in refinery capacity was specified in Base II of $400 million (200,000 barrel/day refinery). In the model the investment shows up as an approximate $500 million value of output. OCS generated refining output reaches a maximum value of $85 million, which indicates that the refining capacity generated is small.

TABLE IX
Value of Output Induced by OCS Development in the
South Atlantic 1984

Value of Output ($1000's)	Base Base I	Scenario A (Low)	%	Minus B (Low)	%	Base D (High)	%	Base Base II	Scenario C (Low)	%	Minus Base E (High)	%
Ag. & Food Process	2,277,306	31		30		170		2,277,302	31		163	
Forestry & Fisheries	52,607	0		0		0		52,627	0		0	
Non Petrol. Mining	8,234	0		0		0		8,234	0		0	
Petroleum Mining	412	0		23,097	5606.1	-4	-1.0	412	23,587	5725.0	88,448	21468.0
Apparel & Textiles	727,595	3		2		2		727,597	2		1	
Lumber & Wood Prod.	1,968,646	11		-1		13		1,968,629	1		12	
Chemical & Plastics	1,390,126	91		89		176		1,390,840	88		199	
Petroleum Refining	235,211	4		2,597	1.1	10		733,293	2		9	
Leather, Glass & Stone	290,581	149	.1	66		91		290,931	67		98	
Iron & Steel	173,414	217	.1	218	.1	293	.2	173,457	218	.1	296	.2
Other Metals	243,948	203		106		176		245,536	105		180	
Machinery & Misc. Mfg.	460,095	1,636	.4	1,642	.4	4,416	1.0	460,066	1,618	.4	4,414	1.0
Transportation	766,594	3,873	.5	3,060	.4	5,203	.7	767,968	3,051	.4	7,057	.9
Communications	623,598	132		129		541	.1	623,471	133		511	.1
Utility	412,798	9		55		312	.1	412,806	8		310	.1
Wholesale Trade	1,327,432	5,880	.4	3,929	.3	7,914	.6	1,329,521	3,898	.3	7,932	.5
Fin., Ins., & Real Estate	2,773,971	38		35		-49		2,774,011	40		-49	
Amusement & Service	441,636	170		164		283	.1	441,749	163		268	.1
Retail Stores	2,121,864	6,967	.3	4,639	.2	9,428	.4	2,124,365	4,599	.2	9,452	.4
Medical & Ed. Inst.	745,944	343		332		696	.1	746,217	331		687	.1
Auto Dealers & Service	679,076	1,966	.3	1,384	.2	2,805	.4	679,968	1,374	.2	2,849	.4
Construction	591,482	25,368	4.3	16,171	2.7	34,809	5.9	593,590	16,158	2.7	35,128	5.9

TABLE IX (Continued)
Value of Output Induced by OCS Development in the
South Atlantic 1988

Value of Output ($1000's)	Base Base I	Scenario A (Low)	%	Minus B (Low)	%	Base D (High)	%	Base Base II	Scenario C (Low)	%	Minus Base E (High)	%
Ag. & Food Process	2,593,324	67		80		377		2,593,327	61		203	
Forestry & Fisheries	41,597	0		0		0		41,597	0		0	
Non Petrol. Mining	8,696	0		0		1		8,696	0		1	
Petroleum Mining	614	-1		187,323	30508.6	721,900	117573.3	612 *	192,069	31383.8	720,861	117787.7
Apparel & Textiles	864,723	5		5		8		864,731	6		9	
Lumber & Wood Prod.	2,225,551	-3		4		85		2,225,557	2		52	
Chemical & Plastics	1,694,844	123		290		707		1,697,095	200		767	
Petroleum Refining	271,580	5		22,403	8.2	10,487	3.9	769,544	6,812	2.5	3,668	1.4
Leather, Glass & Stone	332,663	206	.1	225	.1	434	.1	333,126	208	.1	325	.1
Iron & Steel	199,384	330	.2	690	.3	991	.5	199,446	537	.3	941	.5
Other Metals	273,750	400	.1	567	.2	1,125	.4	275,548	508	.2	1,264	.5
Machinery & Misc. Mfg.	521,863	2,484	.5	2,697	.5	10,358	2.0	521,757	2,503	.5	9,838	1.9
Transportation	892,607	1,778	.2	5,143	.6	25,025	2.8	894,650	5,044	.5	23,136	2.6
Communications	735,461	290		557	.1	1,038	.1	735,121	390	.1	101	
Utility	468,132	15		622	.1	1,463	.3	468,177	231		1,172	.3
Wholesale Trade	1,548,321	2,717	.2	2,039	.1	15,735	1.0	1,551,440	1,711	.1	12,892	.8
Fin., Ins., & Real Estate	3,267,218	73		3		-270		3,267,618	105		-501	
Amusement & Service	488,483	342	.1	361	.1	600	.1	488,649	314	.1	386	.1
Retail Stores	2,458,508	3,109	.1	2,320	.1	17,855	.7	2,462,014	1,956	.1	15,421	.6
Medical & Ed. Inst.	881,094	716	.1	898	.1	1,705	.2	881,586	820	.1	1,457	.2
Auto Dealers & Service	766,238	1,185	.2	1,281	.2	5,922	.8	767,552	1,149	.2	5,401	.7
Construction	642,972	5,087	.8	6,260	1.0	59,883	9.3	645,200	6,178	1.0	42,112	6.5

*31383.8

TABLE IX (Continued)
Value of Output Induced by OCS Development in the
South Atlantic 1992

Value of Output ($1000's)	Base Base I	Scenario A (Low)	%	Minus B (Low)	%	Base D (High)	%	Base Base II	Scenario C (Low)	%	Minus Base E (High)	%
Ag. & Food Process	2,932,263	99		120		463		2,932,317	89		22	
Forestry & Fisheries	33,563	0		0		0		33,563	0		0	
Non Petrol. Mining	9,188	0		0		0		9,188	0		0	
Petroleum Mining	884	0		267,733	30286.5	809,407	91561.9	880	268,605	30385.2	808,555	91465
Apparel & Textiles	1,025,486	9		9		12		1,025,500	10		13	
Lumber & Wood Prod.	2,509,473	1		12		46		2,509,537	18		67	
Chemical & Plastics	2,043,133	164		633		1,791	.1	2,047,075	418		1,886	.1
Petroleum Refining	307,756	6		52,489	17.1	42,764	13.9	805,627	21,754	2.7	21,087	2.6
Leather, Glass & Stone	378,913	231	.1	347	.1	805	.2	379,491	324	.1	594	.2
Iron & Steel	224,104	382	.2	782	.3	1,530	.7	224,184	625	.3	1,320	.6
Other Metals	307,206	454	.1	666	.2	1,393	.5	309,215	548	.2	1,600	.5
Machinery & Misc. Mfg.	602,784	3,191	.5	3,532	.6	13,624	2.3	602,583	2,980	.5	12,828	2.1
Transportation	1,033,004	1,657	.2	8,154	.8	21,634	2.1	1,035,258	7,747	.7	21,090	2.0
Communications	869,298	406		931	.1	1,761	.2	869,078	439	.1	-454	-.1
Utility	528,450	21		1,734	.3	4,471	.8	528,573	791	.1	3,310	.6
Wholesale Trade	1,798,620	2,549	.1	4,160	.2	7,939	.4	1,802,072	3,547	.2	7,114	.4
Fin., Ins., & Real Estate	3,827,467	119		-168		-700		3,828,512	-17		-1,015	
Amusement & Service	540,403	458	.1	536	.1	811	.2	540,643	386	.1	100	
Retail Stores	2,856,495	2,816	.1	4,630	.2	9,203	.3	2,859,810	3,760	.1	7,828	.3
Medical & Ed. Inst.	1,033,633	1,000	.1	1,323	.1	2,927	.3	1,034,418	1,170	.1	2,150	.2
Auto Dealers & Service	861,943	1,176	.1	2,401	.3	5,612	.7	863,452	2,169	.3	5,436	.6
Construction	697,181	1,811	.3	3,824	.5	8,696	1.2	699,393	3,572	.5	8,555	1.2

TABLE IX (Continued)
Value of Output Induced by OCS Development in the
South Atlantic 1996

Value of Output ($1000's)	Base Base I	Scenario A (Low)	%	Minus B (Low)	%	Base D (High)	%	Base Base II	Scenario C (Low)	%	Minus Base E (High)	%
Ag. & Food Process	3,282,898	126		17[illegible]		490		3,282,317	144		-325	
Forestry & Fisheries	26,444	0		0		0		26,444	0		0	
Non Petrol. Mining	9,629	0		0		0		9,629	0		0	
Petroleum Mining	1,260	-1		267,785	21252.8	802,341		1,252	268,658	21458.3	801,544	64021.1
Apparel & Textiles	1,211,269	12		14		18		1,211,290	15		21	
Lumber & Wood Prod.	2,815,806	6		35		58		2,815,943	57		114	
Chemical & Plastics	2,433,581	218		1,135		3,074	.1	2,439,316	681		3,220	.1
Petroleum Refining	359,492	9		84,727	23.6	79,225	22.0	857,276	37,805	4.4	41,249	4.8
Leather, Glass & Stone	428,292	251	.1	487	.1	1,167	.3	428,985	455	.1	852	.2
Iron & Steel	247,007	415	.2	857	.3	1,721	.7	247,105	694	.3	1,474	.6
Other Metals	343,761	510	.1	821	.2	1,629	.5	345,984	599	.2	1,789	.5
Machinery & Misc. Mfg.	700,595	3,622	.5	4,132	.6	15,567	2.2	700,307	3,282	.5	14,635	2.1
Transportation	1,189,262	1,862	.2	8,729	.7	23,105	1.9	1,191,700	8,111	.7	22,159	1.9
Communications	1,024,987	503		1,591	.2	2,619	.3	1,025,084	803	.1	-104	
Utility	592,262	24		3,050	.5	7,368	1.2	592,435	1,461	.2	5,327	.9
Wholesale Trade	2,077,879	2,878	1.4	5,106	.2	10,504	.5	2,081,653	4,163	.2	9,054	.4
Fin., Ins., & Real Estate	4,445,558	162		-169		-1,039		4,447,482	63		-1,121	
Amusement & Service	596,586	570	.1	883	.1	1,287	.2	597,035	529	.1	57	
Retail Stores	3,316,866	3,090	.1	5,469	.2	11,897	.4	3,319,882	4,023	.1	9,372	.3
Medical & Ed. Inst.	1,202,329	1,285	.1	1,837	.2	3,958	.3	1,203,477	1,604	.1	2,770	.2
Auto Dealers & Service	964,476	1,287	.1	3,137	.3	7,584	.8	966,163	2,777	.3	7,143	.7
Construction	752,858	1,849	.2	4,107	.5	7,122	.9	755,065	3,719	.5	6,749	.9

TABLE X
Value of Output Induced by OCS Development - 1984
(Total Minus Value of Output in Petroleum Mining)

County, State	Base I	Scenario A (Low)	Minus B (Low)	Base D (High)	Base II	Scenario C (Low)	Minus Base E (High)
Baker	23,277	4	4	6	23,279	4	6
Clay	222,663	0	1	0	222,666	1	0
Duval	6,456,467	282	3,636	18,818	6,456,422	226	18,701
Flagler	30,945	2	2	2	30,947	2	2
Nassau	241,828	0	1	0	241,832	2	0
Putnam	583,819	-3	-1	-5	583,826	0	-5
St. Johns	180,971	8	8	16	180,978	8	15
Florida	7,739,971	291	3,650	18,836.99	7,739,949	243	18,720
Bryan	23,618	8	8	15	24,794	9	15
Camden	85,356	-1	-1	-2	85,357	-1	-2
Chatham	2,612,552	46,417	30,693	874	3,122,502	31,327	3,200
Effingham	54,521	7	6	10	54,502	7	11
Glynn	685,862	53	19	23,646	685,871	19	23,644
Liberty	78,248	7	6	9	78,249	6	9
Long	15,422	4	4	8	15,400	5	8
Mc Intosh	22,312	4	4	8	22,315	5	8
Georgia	3,577,891	46,499	30,740	24,568	4,087,821	31,376	26,891
Brunswick	149,150	10	10	17	149,159	10	16
Columbus	431,184	4	3	4	431,187	4	4
New Hanover	1,180,116	27	16	21	1,180,120	18	22
Pender	91,217	0	0	0	91,219	0	0
North Carolina	1,851,667	41	29	42	1,851,685	31	42
Beaufort	709,019	25	24	32	709,029	24	32
Berkeley	249,235	-2	-1	-3	249,236	-1	-3
Charleston	2,115,254	212	179	23,772	2,115,283	182	23,795
Colleton	259,561	-5	-3	-7	259,562	-2	-6
Dorchester	199,179	3	2	2	199,184	3	3
Georgetown	368,910	0	0	1	368,910	1	2
Hampton	156,960	0	0	-1	156,961	0	-1
Horry	768,892	23	20	31	768,910	22	32
Jasper	55,806	2	2	5	55,809	3	5
Williamsburg	260,245	1	3	7	260,248	5	4
South Carolina	5,143,060	262	228	23,840	5,143,133	235	23,861
South Atlantic	18,312,588	47,093	34,647	67,286	18,822,587	31,885	69,518

TABLE X (cont.)
Value of Output Induced by OCS Development - 1988
(Total Minus Value of Output in Petroleum Mining)

County, State	Base I	Scenario	Minus	Base	Base II	Scenario	Minus Base
		A (Low)	B (Low)	D (High)		C (Low)	E (High)
Baker	26,071	6	6	8	26,079	5	7
Clay	262,870	2	3	-6	262,879	4	3
Duval	7,350,721	66	20,391	51,653	7,350,700	144	25,503
Flagler	35,007	3	4	6	35,020	6	8
Nassau	286,163	5	8	1	286,195	12	14
Putnam	717,738	11	15	-13	717,779	20	12
St. Johns	214,279	14	20	30	214,346	28	49
Florida	8,892,850	105	20,445	51,678	8,892,998	220	25,596
Bryan	25,036	19	22	32	26,266	241	50
Camden	93,106	0	1	-3	93,112	2	0
Chatham	3,004,514	18,513	17,932	1,077	3,518,973	20,110	10,969
Effingham	62,230	11	10	15	62,188	15	27
Glynn	765,409	15	16	22,751	765,435	94	35,620
Liberty	92,155	3	4	11	92,164	-8	12
Long	20,863	11	10	18	20,826	16	26
Mc Intosh	23,175	16	17	27	23,202	-28	30
Georgia	4,086,487	18,589	18,015	23,930	4,601,000	20,441	46,734
Brunswick	172,539	15	19	26	172,605	28	45
Columbus	486,003	5	6	6	486,024	9	14
New Hanover	1,360,578	25	34	55	1,360,657	47	85
Pender	100,362	1	1	-1	100,368	1	0
North Carolina	2,119,482	45	61	86	2,119,653	86	146
Beaufort	892,019	24	19	23	892,079	20	23
Berkeley	284,427	0	0	-7	284,434	2	-3
Charleston	2,488,433	118	7,843	77,757	2,488,626	7,864	46,012
Colleton	312,989	1	2	-12	312,998	3	-4
Dorchester	232,585	4	8	5	232,635	15	22
Georgetown	428,854	3	3	14	428,865	6	6
Hampton	168,007	1	1	-1	168,009	2	1
Horry	911,613	31	39	50	911,739	54	87
Jasper	64,663	8	11	11	64,692	15	19
Williamsburg	295,213	-1	-1	-4	295,311	10	8
South Carolina	6,078,803	189	7,926	77,836	6,079,389	7,989	46,170
South Atlantic	21,177,620	18,928	46,447	153,530	21,693,039	28,737	118,645

TABLE X (cont.)
Value of Output Induced by OCS Development - 1992
(Total Minus Value of Output in Petroleum Mining)

County, State	Base I	Scenario Minus Base A (Low)	Scenario Minus Base B (Low)	Scenario Minus Base D (High)	Base II	Scenario Minus Base C (Low)	Scenario Minus Base E (High)
Baker	29,246	22	25	40	29,261	27	47
Clay	305,315	0	4	7	305,334	6	16
Duval	8,338,817	88	39,236	69,090	8,338,894	209	16,925
Flagler	39,005	4	6	11	39,020	7	14
Nassau	336,031	12	27	54	336,111	34	83
Putnam	866,406	17	36	60	866,503	46	102
St. Johns	251,004	20	53	105	251,160	67	169
Florida	10,165,824	163	39,386	69,367	10,166,282	397	17,357
Bryan	27,069	45	79	129	28,179	231	228
Camden	104,552	1	4	6	104,565	5	11
Chatham	3,451,952	15,935	16,719	1,277	3,968,623	19,450	13,271
Effingham	72,606	11	15	31	72,566	23	51
Glynn	850,989	14	25	15,394	851,038	250	27,192
Liberty	107,948	5	10	23	107,968	3	31
Long	28,447	17	25	51	28,421	36	80
Mc Intosh	25,612	26	33	57	25,671	-87	71
Georgia	4,669,174	16,054	16,911	16,969	5,186,182	19,910	40,934
Brunswick	199,053	21	51	94	199,206	64	156
Columbus	549,384	7	21	33	549,437	21	48
New Hanover	1,571,589	37	90	166	1,571,814	116	280
Pender	110,655	1	5	29	110,688	7	32
North Carolina	2,430,681	65	168	321	2,431,145	207	515
Beaufort	1,098,232	28	58	97	1,098,356	70	152
Berkeley	324,695	-1	4	8	324,713	5	15
Charleston	2,929,938	163	29,381	37,630	2,930,335	29,475	33,919
Colleton	373,967	5	23	47	374,034	30	84
Dorchester	267,039	5	31	60	267,154	43	113
Georgetown	494,352	3	9	15	494,377	12	27
Hampton	181,827	2	3	6	181,833	3	8
Horry	1,074,000	40	96	187	1,074,283	124	302
Jasper	75,088	14	29	47	75,168	37	80
Williamsburg	336,429	8	15	27	336,503	18	30
South Carolina	7,155,566	266	29,650	38,126	7,156,757	29,817	34,730
South Atlantic	24,421,244	16,548	86,115	124,782	24,940,363	50,332	93,534

TABLE X (cont.)

Value of Output Induced by OCS Development - 1996

(Total Minus Value of Output in Petroleum Mining)

County, State	Base I	Scenario A (Low)	Minus B (Low)	Base D (High)	Base II	Scenario C (Low)	Minus Base E (High)
Baker	32,691	35	41	66	32,713	41	75
Clay	349,865	1	7	13	349,893	11	28
Duval	9,400,951	94	58,450	93,535	9,401,147	282	16,576
Flagler	42,599	4	8	16	42,619	9	22
Nassau	390,316	17	50	102	390,456	64	167
Putnam	1,028,412	23	67	121	1,028,581	81	203
St. Johns	289,669	25	97	200	289,924	119	328
Florida	11,534,505	197	58,718	94,051	11,535,331	611	17,401
Bryan	30,297	99	310	466	30,834	482	745
Camden	119,527	2	6	12	119,546	8	21
Chatham	3,974,296	17,865	18,794	1,603	4,493,297	21,297	13,594
Effingham	85,243	17	117	150	85,303	39	95
Glynn	941,662	15	39	14,183	941,736	254	29,091
Liberty	125,219	6	16	32	125,250	8	48
Long	40,592	27	52	126	40,630	72	175
Mc Intosh	30,228	43	63	112	30,337	-157	145
Georgia	5,347,063	18,075	19,398	16,685	5,866,994	22,001	43,913
Brunswick	228,064	25	89	175	228,301	108	294
Columbus	621,071	9	28	53	621,145	34	140
New Hanover	1,813,149	49	176	343	1,813,566	219	582
Pender	123,145	1	10	40	123,189	11	53
North Carolina	2,785,428	85	305	613	2,786,201	373	1,070
Beaufort	1,324,545	34	93	177	1,324,738	110	272
Berkeley	367,786	-3	8	21	367,813	9	33
Charleston	3,439,852	192	47,236	65,055	3,440,477	47,412	60,434
Colleton	438,847	9	51	108	438,977	62	186
Dorchester	300,302	5	61	126	300,480	78	228
Georgetown	564,288	4	15	28	564,326	18	49
Hampton	198,303	2	7	13	198,316	9	20
Horry	1,253,802	47	167	332	1,254,235	206	605
Jasper	87,771	20	57	105	87,920	72	177
Williamsburg	380,604	10	25	38	380,722	26	47
South Carolina	8,356,100	321	47,720	66,004	8,358,004	48,000	62,050
South Atlantic	28,023,094	18,678	126,141	177,352	28,546,527	70,987	124,434

TABLE XI

Number of Jobs Created by OCS Development - 1984
South Atlantic Coastal Region

Industrial Sector	Base I	Scenario Minus Base A	Scenario Minus Base B	Scenario Minus Base D	Base II	Scenario Minus Base C	Scenario Minus Base E
Ag. and Food Process.	35491	0	0	2	35491	0	2
Forestry and Fisheries	311	0	0	0	311	0	0
Non Petrol. Mining	213	0	0	0	213	0	0
Petroleum Mining	4	243	243	571	4	243	571
Apparel and Textiles	24177	0	0	0	24177	0	0
Lumber and Wood Prod.	42842	0	0	0	42842	0	0
Chemical and Plastics	13367	1	1	2	13373	1	2
Petroleum Refining	1062	0	8	0	1612	0	0
Leather, Glass and Stone	6212	3	2	2	6220	1	2
Iron and Steel	4473	5	5	7	4474	5	7
Other Metals	5855	5	3	4	5890	2	4
Machinery and Misc. Mfg.	15064	32	33	87	15063	32	87
Transportation	34981	105	83	140	35018	82	189
Communications	15587	2	2	12	15584	3	11
Utility	4110	0	0	4	4110	0	4
Wholesale Trade	51907	194	130	261	51976	128	261
Fin., Ins., and Real Estate	62096	0	0	-3	62096	0	-3
Amusement and Service	41851	13	12	22	41859	12	21
Retail Stores	134904	466	310	627	135069	308	628
Medical and Ed. Inst.	52330	18	17	36	52344	17	36
Auto Dealers and Service	28910	87	59	120	28944	60	122
Construction	50162	1384	800	1572	50258	802	1579
Federal Civil. Govt.	39808	92	83	154	39854	82	155
State and Local Govt.	105830	228	193	426	105993	191	430
Armed Forces	34094	0	0	0	34094	0	0
Domestic Services	28417	25	21	48	28435	22	49
TOTAL	834059	2903	2004	4092	835303	1992	4157

TABLE XI (cont'd.)

Number of Jobs Created by OCS Development - 1985
South Atlantic Coastal Region

Industrial Sector	Base I	Scenario Minus Base A	Scenario Minus Base B	Scenario Minus Base D	Base II	Scenario Minus Base C	Scenario Minus Base E
Ag. and Food Process.	33634	0	0	4	33633	1	3
Forestry and Fisheries	187	0	0	0	187	0	0
Non Petrol. Mining	197	0	0	0	197	0	0
Petroleum Mining	5	309	395	881	5	378	881
Apparel and Textiles	25961	1	1	1	25962	0	0
Lumber and Wood Prod.	45082	0	0	2	45082	0	1
Chemical and Plastics	13856	0	2	10	13871	3	7
Petroleum Refining	1091	0	58	27	1640	19	10
Leather, Glass and Stone	6462	4	5	9	6471	5	7
Iron and Steel	5110	7	15	22	5111	12	21
Other Metals	5980	8	11	23	6015	10	25
Machinery and Misc. Mfg.	14972	43	47	185	14970	44	175
Transportation	35980	42	122	593	36029	122	583
Communications	16551	6	11	21	16544	8	2
Utility	4226	0	7	13	4226	4	11
Wholesale Trade	56464	83	63	483	56560	52	396
Fin., Ins., and Real Estate	70626	0	-1	-12	70628	-2	-27
Amusement and Service	45175	25	26	46	45189	22	27
Retail Stores	145582	195	141	1109	145805	125	962
Medical and Ed. Inst.	59679	37	47	88	59705	42	75
Auto Dealers and Service	30850	43	39	227	30898	34	203
Construction	53538	232	54	3796	53637	47	2040
Federal Civil. Govt.	41791	65	86	204	41845	84	216
State and Local Govt.	114554	213	261	596	114751	253	639
Armed Forces	33470	0	0	0	33470	0	0
Domestic Services	27849	22	27	62	27870	26	66
TOTAL	888872	1335	1419	8386	890301	1288	6322

TABLE XI (cont'd.)

Number of Jobs Created by OCS Development - 1992
South Atlantic Coastal Region

Industrial Sector	Base I	Scenario Minus Base A	Scenario Minus Base B	Scenario Minus Base D	Base II	Scenario Minus Base C	Scenario Minus Base E
Ag. and Food Process.	31969	1	1	5	31969	1	1
Forestry and Fisheries	114	0	0	0	114	0	0
Non Petroleum Mining	182	0	0	0	182	0	0
Petroleum Mining	5	309	396	995	5	379	978
Apparel and Textiles	27798	0	0	0	27798	0	0
Lumber and Wood Prod.	47386	0	0	1	47387	0	1
Chemical and Plastics	14298	1	6	19	14322	4	15
Petroleum Refining	1105	0	124	101	1654	53	51
Leather, Glass and Stone	6695	4	6	15	6705	6	11
Iron and Steel	5730	8	17	34	5731	14	30
Other Metals	6120	8	12	25	6156	9	28
Machinery and Misc. Mfg.	15031	52	58	227	15027	49	214
Transportation	36844	35	174	458	36893	165	450
Communications	17620	7	16	30	17614	8	-8
Utility	4316	1	12	31	4317	6	23
Wholesale Trade	61247	73	120	229	61346	103	206
Fin., Ins., and Real Estate	79929	0	-2	-26	79935	-2	-59
Amusement and Service	48710	32	38	59	48731	27	6
Retail Sotres	157246	167	274	532	157463	234	469
Medical and Ed. Inst.	67717	50	66	148	67756	59	109
Auto Dealers and Service	32858	40	75	166	32910	66	158
Construction	56933	103	150	380	57029	139	395
Federal Civil. Govt.	43671	52	85	194	43725	77	196
State and Local Govt.	122927	158	243	508	123128	215	515
Armed Forces	32859	0	0	0	32859	0	0
Domestic Services	27161	15	23	48	27180	21	49
TOTAL	946471	1116	1893	4178	947940	1628	3833

TABLE XI (cont'd.)

Number of Jobs Created by OCS Development - 1996
South Atlantic Coastal Region

Industrial Sector	Base I	Scenario Minus Base A	Scenario Minus Base B	Scenario Minus Base D	Base II	Scenario Minus Base C	Scenario Minus Base E
Ag. and Food Process.	30365	1	1	5	30365	1	-1
Forestry and Fisheries	68	0	0	0	68	0	0
Non Petrol. Mining	166	0	0	0	166	0	0
Petroleum Mining	6	309	396	996	6	379	979
Apparel and Textiles	29594	0	0	0	29594	0	0
Lumber and Wood Prod.	49619	1	1	1	49622	0	1
Chemical and Plastics	14645	1	8	26	14674	6	22
Petroleum Refining	1140	0	181	169	1689	83	90
Leather, Glass and Stone	6904	5	8	19	6916	7	13
Iron and Steel	6314	10	20	39	6317	15	33
Other Metals	6251	8	13	26	6286	10	39
Machinery and Misc. Mfg.	15126	56	64	243	15122	50	227
Transportation	37528	35	165	436	37574	152	421
Communications	18717	7	23	39	18715	12	-2
Utility	4368	0	19	45	4369	9	33
Wholesale Trade	66058	78	138	284	66160	113	245
Fin., Ins., and Real Estate	89708	1	-2	-34	89720	0	-83
Amusement and Service	52352	39	63	103	52385	45	23
Retail Stores	169385	173	306	646	169593	241	541
Medical and Ed. Inst.	76234	63	91	195	76290	80	137
Auto Dealers and Service	34805	41	91	212	34859	79	195
Construction	60204	105	163	332	60299	144	313
Fed. Civil Govt.	45358	51	88	172	45411	78	166
State and Local Govt.	131255	164	272	551	131461	230	527
Armed Services	32259	0	0	0	32259	0	0
Domestic Services	26329	14	23	48	26347	20	46
TOTAL	1004758	1160	2134	4552	1006267	1754	3956

TABLE XII

Value of Output Induced by OCS Development - Petroleum Refining

Year	County and State	Base I	A(Low)	B(Low)	D(High)	Base II	C(Low)	E (High)
1984	Florida	52008	2	2603	0	51982	1	-1
	Duval	52008	2	2603	0	51982	1	-1
	Georgia	149478	1	-5	2	647583	1	3
	Chatham	139745	0	-5	0	637898	0	0
	Glynn	0	0	0	0	0	0	0
	North Carolina	0	0	0	0	0	0	0
	South Carolina	33725	1	-1	8	33728	0	7
	Charleston	33725	1	-1	8	33728	0	7
	South Atlantic	235211	4	2597	10	733293	2	9
1988	Florida	66190	1	15607	10489	66122	-8	-5
	Duval	66190	1	15607	10489	66122	-8	-5
	Georgia	171603	3	-22	-6	669628	-7	3665
	Chatham	160977	0	-21	-11	659130	-11	0
	Glynn	0	0	0	0	0	0	3658
	North Carolina	0	0	0	0	0	0	0
	South Carolina	33787	0	6818	4	33794	6828	7
	Charleston	33787	0	6818	4	33794	6828	7
	South Atlantic	271580	5	22403	10487	769544	6812	3668
1992	Florida	81542	0	30750	27318	81435	-27	-26
	Duval	81542	0	30750	27318	81435	-27	-26
	Georgia	192172	6	-26	18	690149	-7	5860
	Chatham	180598	0	-24	-24	678751	-12	-11
	Glynn	0	0	0	0	0	0	5863
	North Carolina	0	0	0	0	0	0	0
	South Carolina	34042	0	21765	15464	34048	21788	15253
	Charleston	34042	0	21765	15464	34048	21788	15253
	South Atlantic	307756	6	52489	42764	805627	21754	21087
1996	Florida	97686	1	46935	46311	97548	-52	-52
	Duval	97686	1	46935	46311	97548	-52	-52
	Georgia	227589	8	-30	20	725525	-5	9331
	Chatham	214965	0	-29	-29	713117	-14	-14
	Glynn	0	0	0	0	0	0	9325
	North Carolina	0	0	0	0	0	0	0
	South Carolina	34217	0	37822	32934	34203	37862	31970
	Charleston	34217	0	37822	32934	34203	37862	31970
	South Atlantic	359492	9	84727	79225	857276	37805	41249

The value of refining output as a percent of the base value is significant for all counties involved in direct OCS development except Chatham where refinery investment is specified in Base II. The increase is most dramatic in the Charleston area where output climbs from $34 million to $72 million, an increase of 211%. These results should be interpreted with caution because of the lack of pipeline and water transportation being incorporated into the model, both of which are important transportation modes for petroleum products in the region.

Table XIII shows the change in the value of output and Table XIV shows the change in the number of jobs in transportation in the states and selected counties in the South Atlantic. The number of jobs created in transportation is a more significant variable than the value of output. Both tables were included to allow the reader to compare the relationship between the value of output and the number of jobs. The only time the percentage change over base levels is significant is in Georgia in Scenario E. Employment in transportation increases 50% in Glynn County in 1996.

No OCS induced changes occurred in the value of foreign competitive imports or foreign exports except the displaced foreign imports to the hypothetical refinery in Savannah in Base II.

Changes in population responds to changes in the number of jobs.

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Table XIII

OCS Induced Changes in the Value of Output in Transportation

Year	State and County	Base I	Scenario - Base A	Scenario - Base B	Scenario - Base D	Base II	Scenario - Base C	Scenario - Base E
1988	Florida	468,184	7	1,884	11,030	468,186	21	2,046
	Duval	438,085	6	1,881	11,035	438,082	19	2,047
	Georgia	156,597	1,760	1,679	2,387	158,620	3,443	13,693
	Chatham	149,398	1,752	1,674	169	151,415	3,412	6,279
	Glynn	4,013	1	1	2,214	4,015	-23	7,407
	North Carolina	100,051	2	4	9	100,055	5	11
	South Carolina	167,775	9	1,577	11,599	167,789	1,576	7,387
	Charleston	128,500	7	1,577	11,603	128,505	1,574	7,391
	South Atlantic Region	892,607	1,778	5,143	25,025	894,650	5,044	23,136
1992	Florida	541,873	13	2,960	12,401	541,885	30	1,546
	Duval	504,465	9	2,954	12,390	504,465	23	1,531
	Georgia	178,495	1,625	1,758	1,889	180,697	4,276	14,409
	Chatham	170,007	1,621	1,752	189	172,193	4,258	7,934
	Glynn	4,775	1	1	1,691	4,777	9	6,460
	North Carolina	114,168	3	8	16	114,183	8	21
	South Carolina	198,467	17	3,429	7,330	198,494	3,433	5,113
	Charleston	151,432	13	3,421	7,314	151,442	3,422	5,092
	South Atlantic Region	1,033,004	1,657	8,154	21,634	1,035,258	7,747	21,090
1996	Florida	621,983	13	3,163	12,579	622,007	37	1,565
	Duval	576,417	9	3,153	12,562	576,421	26	1,538
	Georgia	202,885	1,825	1,948	1,767	205,232	4,449	14,078
	Chatham	192,802	1,817	1,959	207	195,144	4,451	7,933
	Glynn	5,720	1	2	1,564	5,723	9	6,144
	North Carolina	130,466	4	13	23	130,491	14	36
	South Carolina	233,928	19	3,605	8,736	233,970	3,611	6,480
	Charleston	178,098	15	3,593	8,713	178,114	3,596	6,444
	South Atlantic Region	1,189,262	1,862	8,729	23,105	1,119,700	8,111	22,159

Table XIV

OCS Induced Changes in the Number of Jobs in Transportation

Year	State and County	Base I	Scenarios Minus Base A	B	D	Base II	Scenario Miunus Base C	E
1988	Florida	17,184	-1	44	241	17,184	0	47
	Duval	15,716	0	45	262	15,716	1	48
	Georgia	8,826	42	41	56	8,875	84	359
	Chatham	8,383	42	40	3	8,431	81	150
	Glynn	223	1	1	53	224	-1	208
	North Carolina	4,149	0	0	0	4,150	0	0
	South Carolina	5,820	1	38	277	5,821	37	176
	Charleston	4,304	0	38	277	4,304	38	177
	South Atlantic Region	35,980	42	122	593	36,029	122	583
1992	Florida	17,630	0	63	262	17,630	1	32
	Duval	16,077	0	63	262	16,077	0	32
	Georgia	8,938	35	38	40	8,986	91	309
	Chatham	8,483	34	37	3	8,530	91	169
	Glynn	231	0	0	36	231	0	138
	North Carolina	4,211	0	0	-1	4,211	0	0
	South Carolina	6,065	1	74	156	6,066	73	109
	Charleston	4,482	0	73	155	4,482	73	109
	South Atlantic Region	36,844	35	174	458	36,893	165	450
1996	Florida	17,949	0	60	238	17,950	0	28
	Duval	16,324	0	60	238	16,324	0	28
	Georgia	9,005	35	36	32	9,049	83	269
	Chatham	8,537	35	38	3	8,582	85	152
	Glynn	238	0	0	30	238	0	118
	North Carolina	4,277	0	0	0	4,278	0	0
	South Carolina	6,296	1	69	167	6,297	69	124
	Charleston	4,653	0	69	166	4,653	69	123
	South Atlantic Region	37,528	35	165	436	37,574	152	421

Appendix L

MIT OIL SPILL MODEL

a. MIT Model

One of the first trajectory studies for the U.S. South Atlantic OCS area was conducted by Stewart et al. (1974) at the request of the Council on Environmental Quality. In developing their model, they decided to use the observation of Smith (1968) that oil on the surface tends to move at a velocity approximately equal to the vectorial sum of three percent of the surface wind velocity plus the current velocity. In using Smith's observations, Stewart et al. (1974) modified it somewhat so that the current velocity was divided into two components: the tidal current and the residual current. The formula thus takes on the following form:

$$\vec{U}_{oil} = 0.03\vec{U}_{wind} + \vec{U}_{tidal} + \vec{U}_{residual}$$

The residual current is defined by the authors as meaning all currents whose period of fluctuation is large with respect to life of the spill. Using this definition, the model ignores medium scale phenomena, such as Gulf Stream eddies and shelf waves, which introduces some degree of error. Another reason for error is the lack of sufficient wind and current data for the Atlantic OCS. The authors were forced to use the only information available: drift bottles and card data, current charts, the geostrophy of the region, and plain old ''oceanographic intuition''. This assumption will generate minor errors as long as the spill trajectory covers a sizable number of tidal cycles, in which case the net transport due to tidal action will be quite small within U.S. South Atlantic region.

Wind movements were incorporated into the model with a number of assumptions: that the wind changes direction every three hours, that the wind blows from only eight directions, and that the directional shift only depends on the wind's present direction. Wind changes can occur more frequently than every three hours, and smaller-scale fluctuations may be missed due to the use of three hourly intervals. Furthermore, the wind does not blow from only eight directions plus calm but rather can come from any point of the compass. The randomizing process which is used to pattern wind movements has not been shown to accurately pattern true wind histories, although Stewart (1973) determined that the above assumptions account for only a 10% error of net spill dispersion.

Finally, as was the case with the currents, there is a lack of reliable wind data available. The authors of the model were therefore forced to obtain most of their wind data from onshore weather stations. This greatly limits the wind model since frequently onshore wind data differ considerably from offshore wind data.

In determining oil spill trajectories for offshore regions, the problem regarding the uncertainty surrounding the specification of the ambient current components is encountered. The best available data was used, however, it is recognized to be very sparse and based on drift bottles studies which are few and have sometimes only resulted in a portion of the drift bottles being recovered. It was further assumed that the nonwind-related motions, of which these currents are composed, are weak compared to the wind-induced motions.

In order to test the validity of the trajectory model, it was decided to conduct tests using ballasted drift bottles launched in the areas of the hypothetical drill sites. For the purposes of characterizing the tests, the following parameters were used: percentage recovered, recovery region and minimum and average time to recovery. Due to various probabilities tests, it was decided that the drift bottles do not act independently but rather that they travel in a group. This statement implies, therefore, that the surface boundary layer is characterized by large scale, random fluctuations.

MIT computed the trajectories of offshore oil spills for several hypothetical Eastcoast Drilling Sites (EDS's) within the Georgia Embayment Region (Figure L-1). Hypothetical spills were launched by EDS 10, 11, 12, 13 to determine if location affected results. The trajectory analysis covers the probability of a spill reaching the shore, the average time to reach shore, and the minimum time to reach shore (oil not reaching shore within 150 days was defined as not reaching shore) (CEQ, 1974b). The calculations of the model assume that no containment or cleanup measures are taken during the life of the spill.

Table L-1 summarizes the probabilities of spilled oil coming ashore along the Southeast Atlantic Coast. The results are listed for spills occurring at locations 25, 50, 75 and 100 miles from shore on an east-west transect through each EDS center (Figure L-2). The results are in terms of

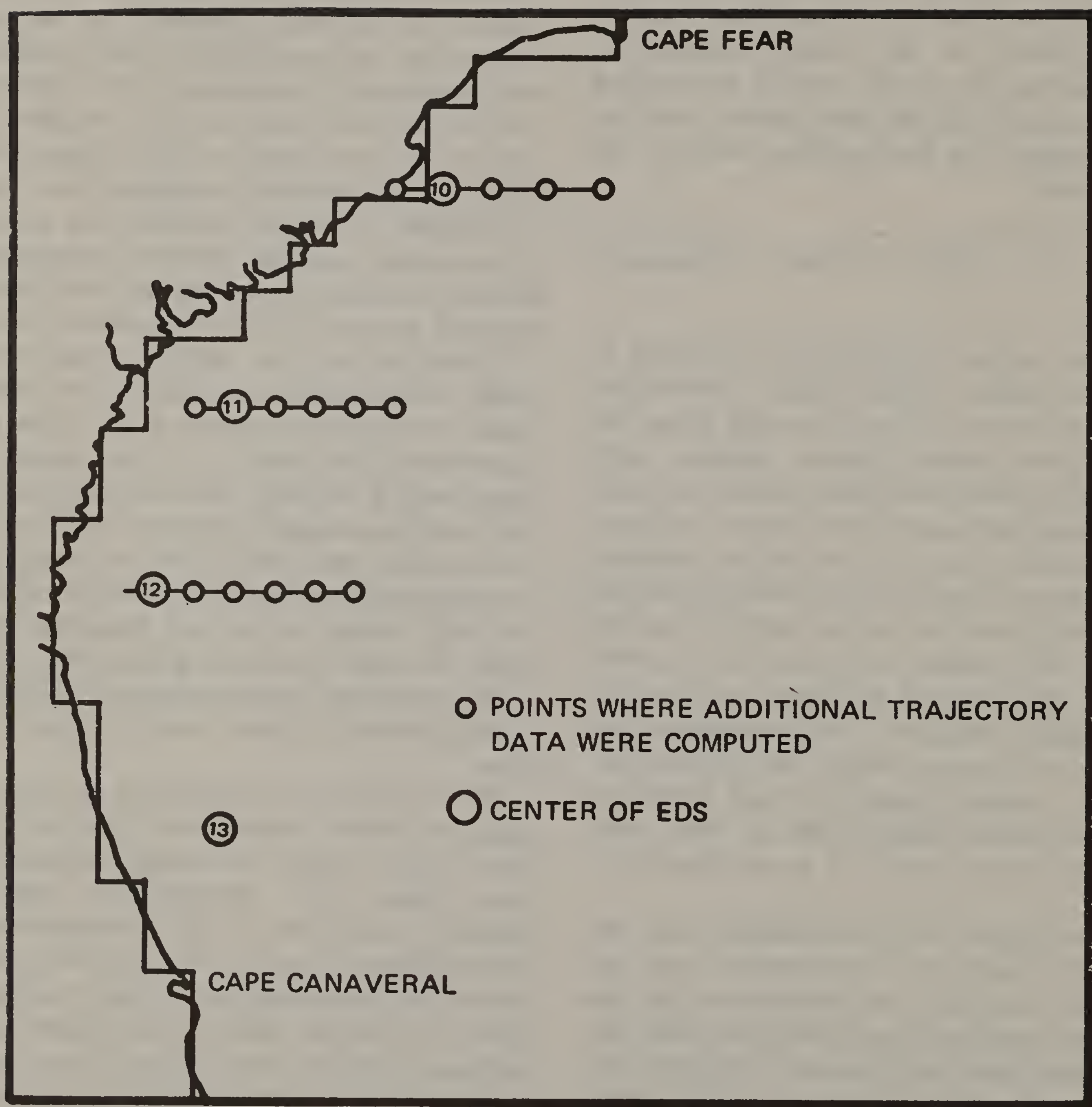

Figure L-1 Points in the Georgia Embayment Region for Which Detailed Trajectories Were Calculated

Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

TABLE L-1

Probabilities of Oil Spills Coming Ashore from Hypothetical Spill Sites in the Atlantic Ocean

Shore point	Season 1/	Distance from shore						Center of EDS
		10 miles east	25 miles east	50 miles east	75 miles east	100 miles east	125 miles east	
Cape Romain, S.C.	Spring	-	95	65	Near 0	-	-	95 (EDS 10)
	Autumn	-	Near 0	Near 0	Near 0	-	-	Near 0 (EDS 10)
Savannah	Spring	-	95-100	95	80	20	-	95-100 (EDS 11)
	Autumn	-	20	5	Near 0	Near 0	-	5 (EDS 11)
Fernandina Beach, Fla.	Spring	-	95	55	20	0-5	-	90 (EDS 12)
	Winter	-	15	10	Near 0	Near 0	-	15 (EDS 12)
Daytona Beach, Fla.	Summer	-	-	-	-	-	-	50 (EDS 13)
	Autumn	-	-	-	-	-	-	Near 0 (EDS 13)

- Computer model not run at this point.

1/ Two seasons are listed for each area. In the first season, oil spilled has the highest probability of reaching shore; in the second season, oil spilled has the lowest probability. Probabilities are intermediate in the unlisted seasons.

Source: CEQ, 1974b.

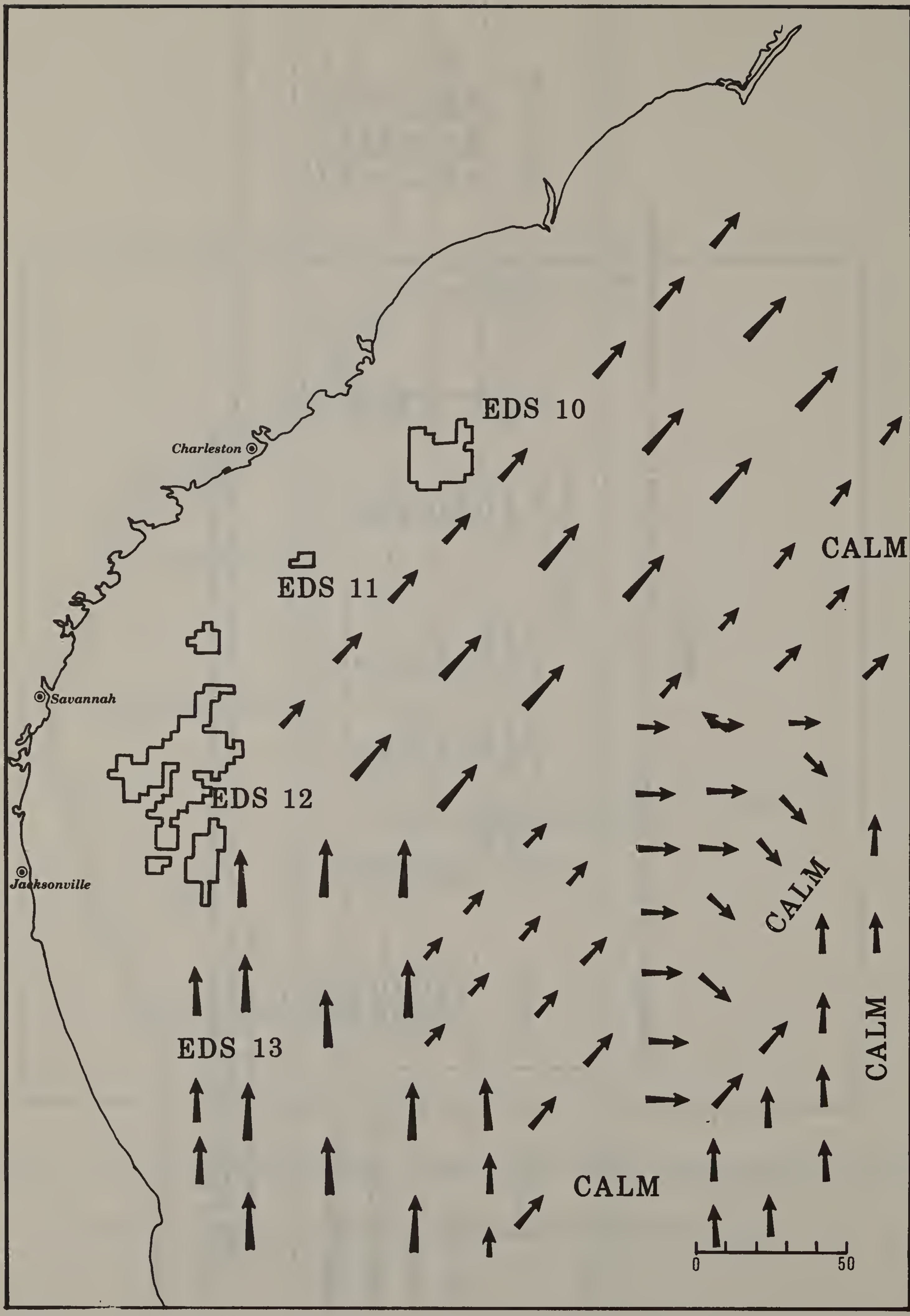

FIGURE L-2 HYPOTHETICAL EASTCOAST DRILL SITES (EDS'S) AND HYPOTHESIZED CURRENT PATTERN FOR GEORGIA EMBAYMENT REGION. (CEQ, 1974A) the percentage of the time that a spill would beach during the "best" and "worst" seasons (CEQ, 1974b). "Spills reaching the shore from the Georgia Embayment sites (EDS 10 to 12) appear very sensitive to distance from shore (see Table L-1). Probabilities drop markedly as the distance from shore increases. Spills nearer shore (within 25 miles) have a high probability of coming ashore—at the sample drilling sites, spring and summer probabilities are over 90%. Even 50 miles from the coast, chances are higher than 50% that a spring or summer spill will reach the coast. Most summer spills from EDS 12 would come ashore near St. Augustine, Fla., or southeastern Georgia. Spills at EDS 10 would beach at Cape Romain or elsewhere in South Carolina.

Beach time is generally shorter for the Georgia Embayment sites than for other areas. The minimum time to shore for a spill in the spring at EDS 10 is 5 days; at EDS 12 the minimum is 20 days."

Appendix M

AN OIL SPILL RISK ANALYSIS FOR THE SOUTH ATLANTIC OUTER CONTINENTAL SHELF LEASE AREA

ABSTRACT

An oilspill risk analysis was conducted to determine relative environmental hazards of developing oil in different regions of the South Atlantic Outer Continental Shelf lease area. The study analyzed probability of spill occurrence, likely path of pollutants from spills, and locations in space and time of recreational and biological resources likely to be vulnerable, paying particular attention to "worst-case" conditions. These results are combined to yield estimates of the overall oilspill risk associated with development of the lease area.

INTRODUCTION

The Federal Government has proposed to lease 1,280,966 acres of Outer Continental Shelf (OCS) lands off the South Atlantic coast for oil and gas development. Estimated recoverable petroleum resources for the proposed 225 tract sale area range from 280 million to 1 billion barrels. Contingent upon actual discovery of this quantity of oil, production is expected to span a period of about 25 years.

Oilspills clearly represent one of the major concerns associated with offshore oil and gas development in the South Atlantic. An important fact that stands out when one attempts to evaluate the significance of accidental oil spillage for this, or any proposed lease area, is that the problem is fundamentally probabilistic. A great deal of uncertainty exists, for example, concerning the number and size of spills that might occur during the course of development, as well as the wind and current conditions that would exist and give direction to the oil slick at the specific times spills do occur. While some of the uncertainty reflects incomplete and imperfect data, considerable uncertainty is simply inherent in the problem.

In view of the inability to predict with certainty future oilspill impacts, it is important to consider the range of possible impacts that could accompany oil and gas development, paying particular attention to "worse-case" conditions. It is equally important, however, in attempting to maintain perspective on the problem, to associate these potential impacts with quantitative estimates of the probability of their occurrence.

This report summarizes results of an oilspill risk analysis conducted for the South Atlantic OCS lease sale. The study had the objective of determining relative risks associated with oil and gas development in different regions of the proposed lease area and was undertaken to facilitate final selection of tracts to be offered for sale. The analysis was conducted in three more or less independent parts corresponding to different aspects of the overall problem. The first part dealt with the probability of spill occurrence, the second with likely spill trajectories for the times and places spills might occur, and the third part with the spatial and temporal location of specific biological and recreational resources thought to be vulnerable to oilspills. Results of the individual parts of the analysis were then combined to give estimates of the overall oilspill risk associated with oil and gas development in the lease area.

Much of the data and information used in the analysis were compiled by the Bureau of Land Management in the course of preparing the environmental statement for the South Atlantic sale. These results, then, represent synthesis and analysis of existing information rather than presentation of new material.

We would like to express special appreciation to John Meier of the Bureau of Land Management for his assistance in gathering the necessary data and information for the study.

Methods

A detailed mathematical description of the models used in this analysis is given in a forthcoming Geological Survey publication by Smith, Slack, and R. K. Davis. The present discussion focuses on the conceptual framework of the models, and on data sources and limiting assumptions.

Spill Frequency Estimates

Statistical distributions for estimating probabilities of oilspill occurrence were taken from Devanney and Stewart (1974) and Stewart (1975). In addition to the fundamental assumption that realistic estimates of future spill frequency can be based on past OCS experience, use of these distributions requires the further, specific assumptions that spills occur independently of each other (that is as a Poisson process) and that accident rate is dependent on volume of oil produced and handled.

Spill frequency estimates were calculated separately for eight subdivisions of the proposed lease area (Fig. 1) based on estimated petroleum resources for individual prospects within those areas (U.S. Geological Survey, proprietary data).

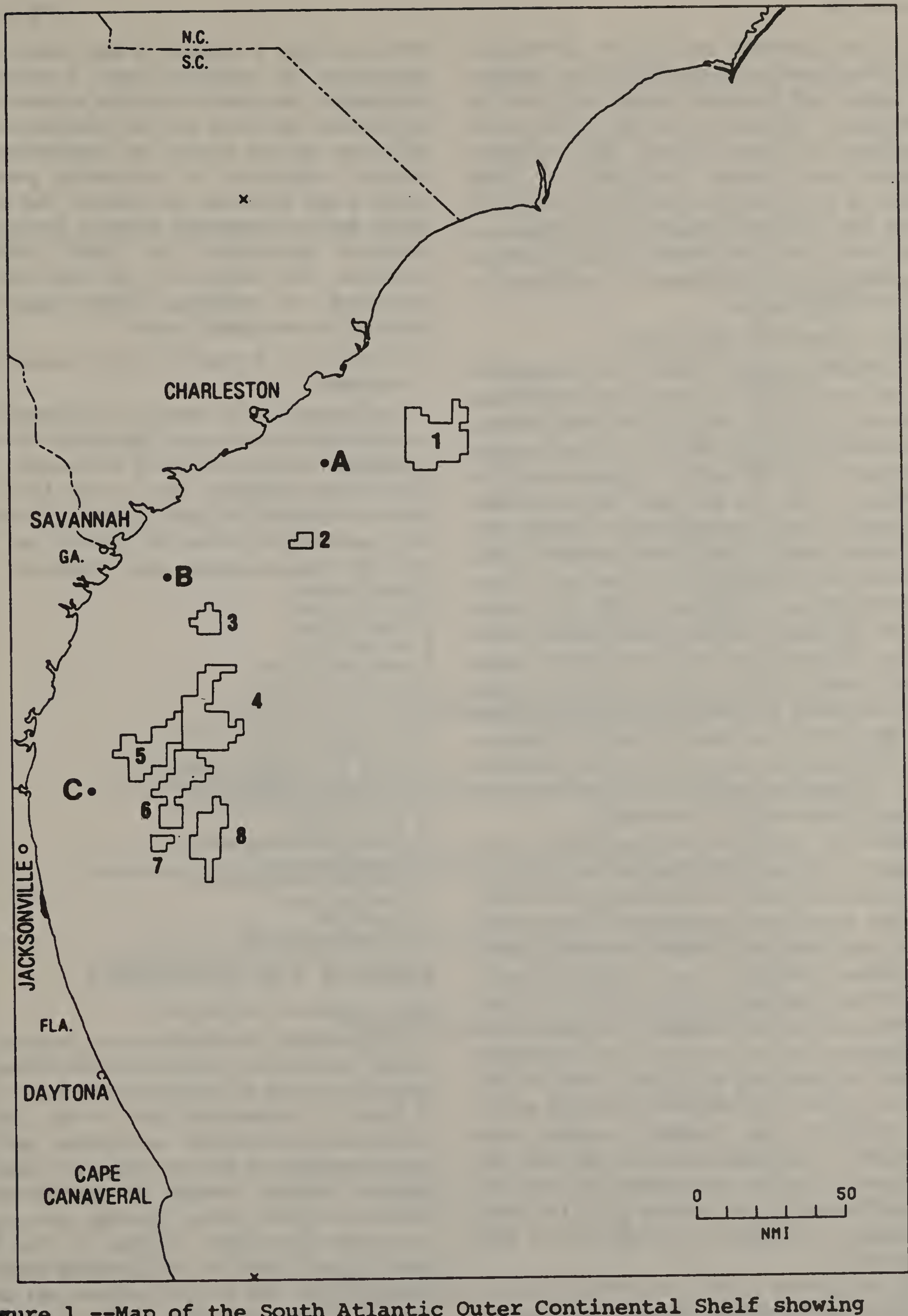

Figure 1.--Map of the South Atlantic Outer Continental Shelf showing subdivision of the lease area and hypothetical transportation routes.

Use of the Devanney and Stewart distributions permitted separate estimates of platform, pipeline, and tanker spill frequency which could then be combined to compare the two alternative modes of transport of crude to shore. Spill frequency estimates were further categorized for spills between 50 and 1,000 bbls, and greater than 1,000 bbls in size. The size grouping is somewhat arbitrary but, as discussed below, is very important in considering the significance of weathering in reducing oilspill impacts.

Oilspill Trajectory Simulations

An oilspill trajectory model was constructed and used to analyze movements of hypothetical oil slicks on a digital map of the South Atlantic coast between lat. 28° and 35′ N. and between about long. 76° 20′ W. and the Atlantic coast. The coordinate system for this area was established with a grid size of 1 nautical mile. Monthly surface current velocity fields were provided by Bureau of Land Management staff and were based on drift-bottle data (Bumpus, 1973). Short-term patterns in wind variability were characterized with a probability matrix for successive 3-hour velocity transitions (first order Markov process). Wind transition matrices were evaluated from U.S. Weather Service records from the Jacksonville, Fla. and Charleston, S.C. weather stations (7 years continuous record each) and were established separately for four seasons.

Trajectories of 500 hypothetical oilspills were simulated in Monte Carlo fashion for spill sites within each of the eight subdivisions of the lease area and along three hypothetical transportation routes, under wind and current conditions for the four seasons, yielding a total of 22,000 trajectories. Surface transport of the oil slick for each spill was simulated as a series of straightline displacements of a point in space, each representing the joint influence of wind and current on the slick for a 3-hour period. Wind transition probability matrices were randomly sampled each period for a new wind speed and direction, and the current velocity was updated as the spill changed location in the velocity field. The wind-drift factor was taken to be 0.035 with a drift angle of 20°.

The final product of trajectory model runs consists of a large number of simulated oilspill trajectories or pathways which collectively reflect both the general trend and variability of winds and currents (see Figs. 4 through 7), and which can be summarized in statistical terms. It should be emphasized that these trajectories represent only hypothetical pathways for the transport of oilslicks and do not involve any consideration of cleanup, dispersion, or weathering processes which would determine the quantity and quality of oil that may eventually come in contact with biological populations or other important resources. The significance of dispersion and weathering in mitigating oilspill impacts is discussed in more detail below.

Locations of Biological and Recreational Resources

The locations of 19 categories of biological and recreational resources were digitized in the same coordinate system as that used in trajectory simulations (See Appendix, Figs. A-1 to A-19). The monthly sensitivity of these resources (For example, spawning or migration period) was also recorded. Resource groups were as follows:

1. Sandy beaches
2. Recreation areas
3. Wildlife refuges
4. Historical sites
5. Marsh and wetlands
6. Turbid water zone
7. Brown pelican rookeries
8. Coastal or pelagic bird rookeries
9. Bald eagle nesting sites
10. Dusky seaside sparrow habitat
11. Arctic peregrine falcon migration routes
12. White, brown, and pink shrimp
13. Royal red shrimp
14. Commercial fishing grounds
15. Sport fishing areas
16. Commercial scallop grounds
17. Crabs and oysters
18. Bay scallops
19. Sea turtle nesting sites

RESULTS AND DISCUSSION

Spill Frequency Estimates

The probability distribution on the frequency of oilspills greater than 1,000 bbls in size during the production life of the proposed lease area is given in Figure 2. Probabilities apply to the total of production platform spills and pipeline spills assuming transport of the total product to shore via pipeline. Although transport by pipeline is the preferred method, tanker or barge transport is considered a possibility, at least for the early years of production. The corresponding frequency distribution for the total of platform and tanker spills is presented in figure 3 for comparison. Means of the distributions in Figures 2 and 3 are indicated with arrows.

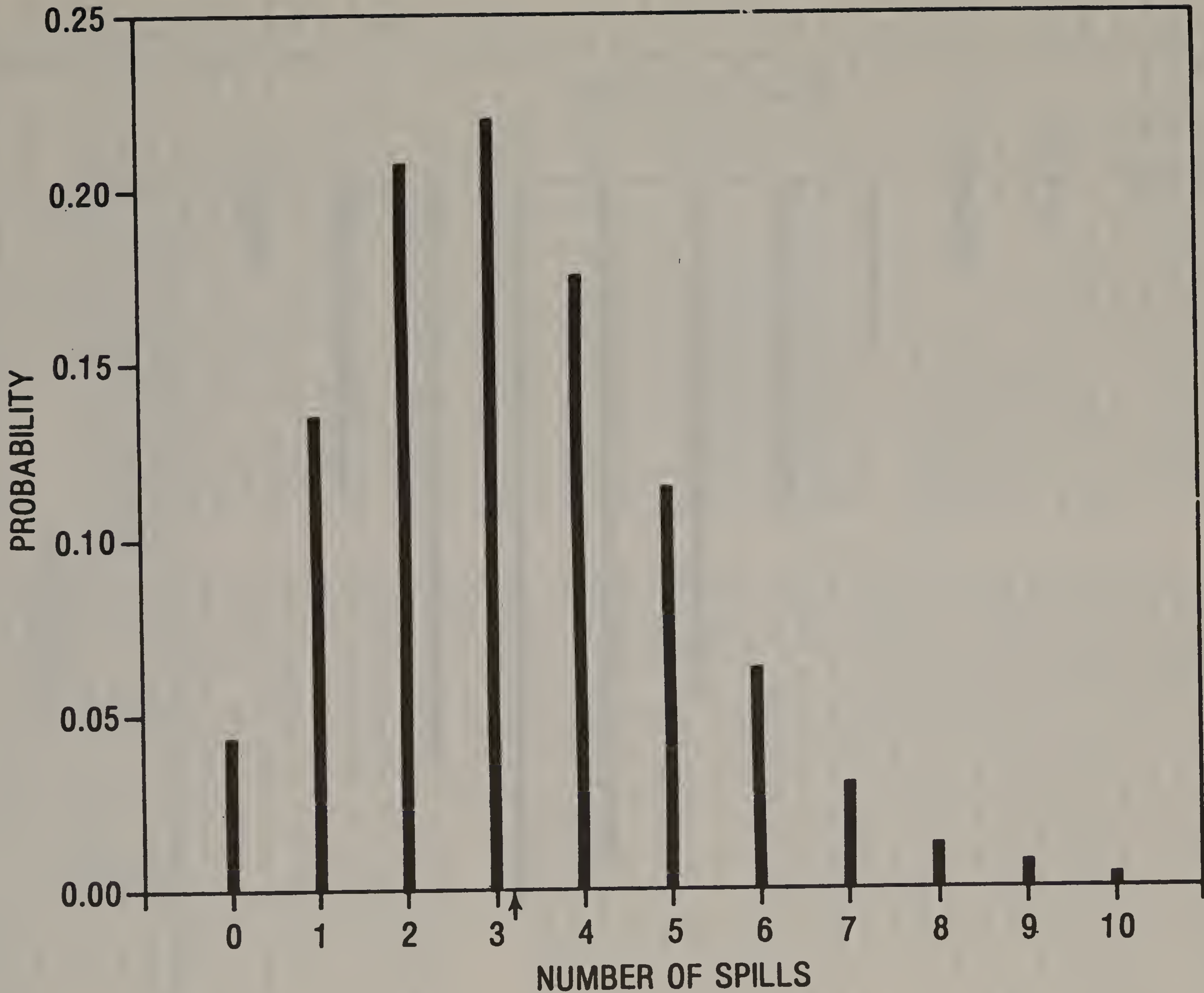

Figure 2.--Spill frequency distribution for platform and pipeline spills greater than 1,000 bbls during the production life of the lease area.

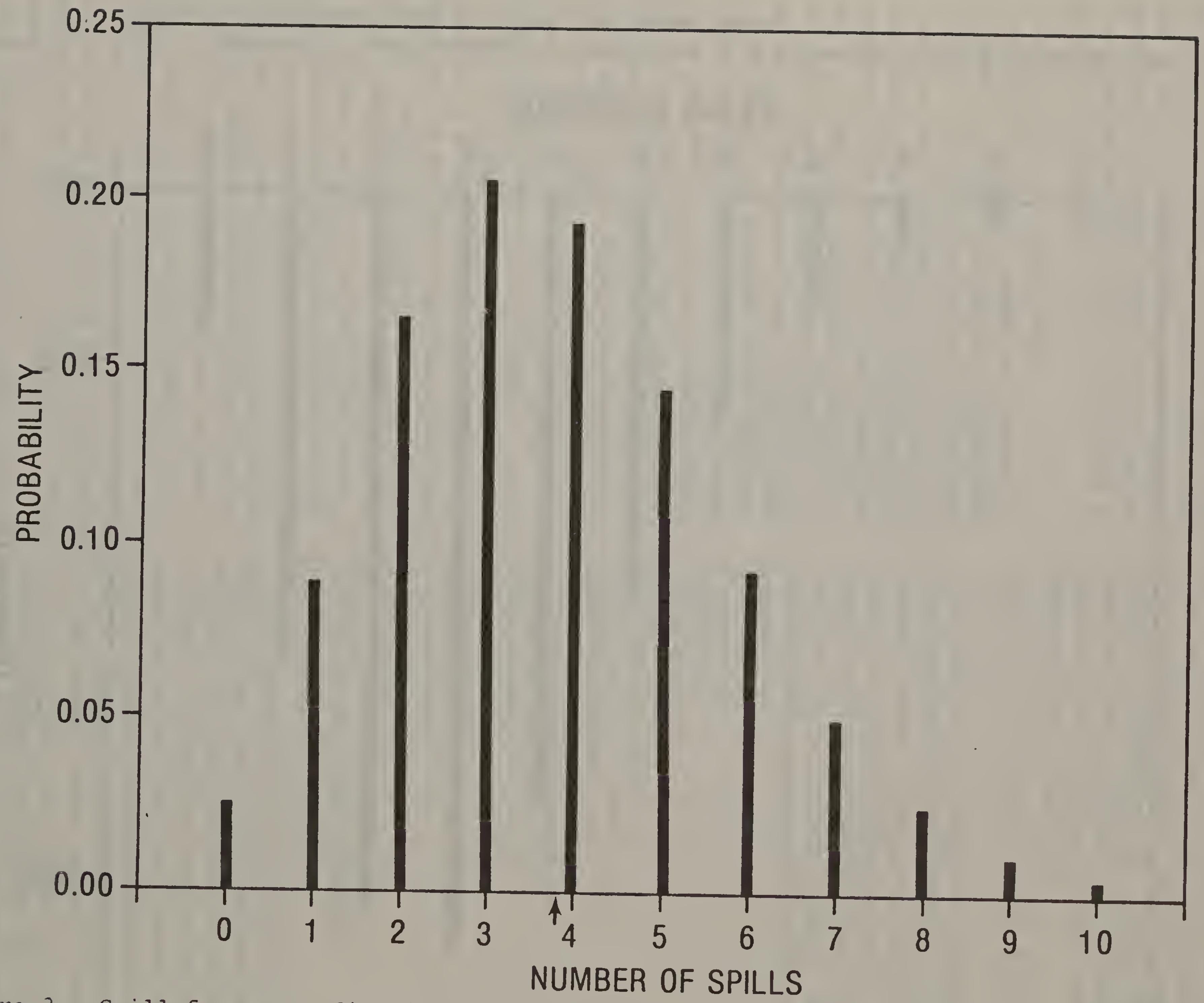

Figure 3.--Spill frequency distribution for platform and tanker spills greater than 1,000 bbls during the production life of the lease area.

In the absence of refinery construction in the South Atlantic region, it is expected that any crude oil transported by pipeline from the lease area to storage facilities on shore (e.g., Charleston, Savannah, or Jacksonville) would be subsequently carried by tanker from these terminals to existing refineries elsewhere. Thus it should be noted that in addition to the spill risk associated with production and transport to shore (Fig. 2), there would be a further increment of risk associated with this tanker traffic in and out of southern ports. An estimate of tanker spill frequency based on estimated production from South Atlantic oilfields is given in table 1. Only a fraction of this risk, however, applies to the South Atlantic coastal region, the remainder being distributed along the tanker routes to refineries and within the estuaries and ports where terminals are located.

One of the advantages of making predictions about oilspill frequency in the form of a probability distribution is that such data give not only an estimate of the most likely number of spills that would be expected to occur but some measure of the uncertainty that exists about that prediction. Figure 2, for example, indicated that the expected number of spills greater than 1,000 bbls is about 3 spills (mean of 3.2), but that there is only about 22-percent probability that there would be exactly 3 spills and an 85-percent chance the number would be anywhere from 1 to 5 spills (obtained by summing the probabilities over that range). Noting that the probability of zero oilspills greater than 1,000 bbls is only about 4 percent, one can conclude that the probability of at least one spill (i.e., sum of the probabilities for one and greater) is about 96 percent. Again, these probabilities apply to the sum of platform and pipeline spills over the field life of the entire proposed lease area. A breakdown of these data for platform, pipeline, and tanker spills appears in table 1A. Expected frequencies for spills in the size range of 50-1,000 bbls and less than 50 bbls over the production life of the total area are given in tables 1B and 1C. Available sources do not provide for a meaningful separation of pipeline and platform spill statistics for spills smaller than 1,000 bbls.

Recent Trends in Spill Statistics

All of the above figures are subject, of course, to the validity of earlier stated assumptions, the most important of these being that accident rates per unit production of future South Atlantic fields would be the same as those observed to date in other areas. One might question this assumption either from the point of view that safety records might be expected to improve with time, or from the standpoint that accident rates are not transferable to a newly opened OCS area.

With regard to the question of improvement in accident rates, recent statistics from U.S. Coast Guard files show no clear trend in spillage rates for production platforms and pipelines during the period 1971-75. Spill frequency estimates given above (table 1) for platform and pipeline spills were based on Gulf of Mexico statistics for the years 1971 and 1972, for which the accident rate was 3.6 incidents per million bbls produced and handled (all sizes). The corresponding accident rates for the years 1973-1975 were 3.9, 4.2 and 3.2 incidents per million bbls respectively.

There is evidence, however, of recent improvement in the incidence of tanker spills. Frequency estimates given above for tanker spills were based on world statistics for the years 1969-72 (spills over 1,000 bbls) and U.S. Coast Guard data for the years 1971-72 (spills under 1,000 bbls) for which the overall accident rate was 0.45 incidents per million bbls handled (all sizes). The corresponding rate for the years 1973-74 was only about 0.07 incidents per million bbls, although some of the apparent improvement is due simply to a change in the method of estimating volumes of crude handled in U.S. ports.

Oilspill Trajectories

The results of trajectory model runs consist of a large number of hypothetical oilspill trajectories (22,000) which collectively reflect both the general trend and variability of winds and currents and which can be described in statistical terms. Ten trajectories based on wind and current conditions for each of the four seasons have been randomly selected as examples from a total of 2,000 trajectories released from location 3 near the center of the lease area and are shown in Figures 4-7. The patterns evident in trajectory simulations vary with the seasons. In the winter, the trajectories tend to wander northward. In the spring, the trajectories move more quickly toward shore in various directions. In the summer, the trajectories generally travel north and south parallel to the shore. In the autumn, the trajectories tend to move southward quickly toward shore. These pat-

Table 1.--Oilspill frequency estimates by potential source for the South Atlantic lease area based on distributions of Devanney and Stewart, 1974.

	Expected number	Probability of at least one spill
A. Spills >1,000 bbl		
Platforms	1.5	0.78
Pipelines	1.7	.81
Tankers	2.2	.89
Platforms and pipelines	3.2	.96
Platforms and tankers	3.8	.98
B. Spills 50-1,000 bbl		
Platforms and pipelines	32	>0.99
Tankers	16	> .99
C. Spills 0-50 bbl (mean size approx = 1 bbl)		
Platforms and pipelines	2,338	>0.99
Tankers	277	> .99

Figure 4.--Example oilspill trajectory results for a spill site near the center of the proposed lease area: winter conditions. Number on trajectory reaching the coast gives time to land in days.

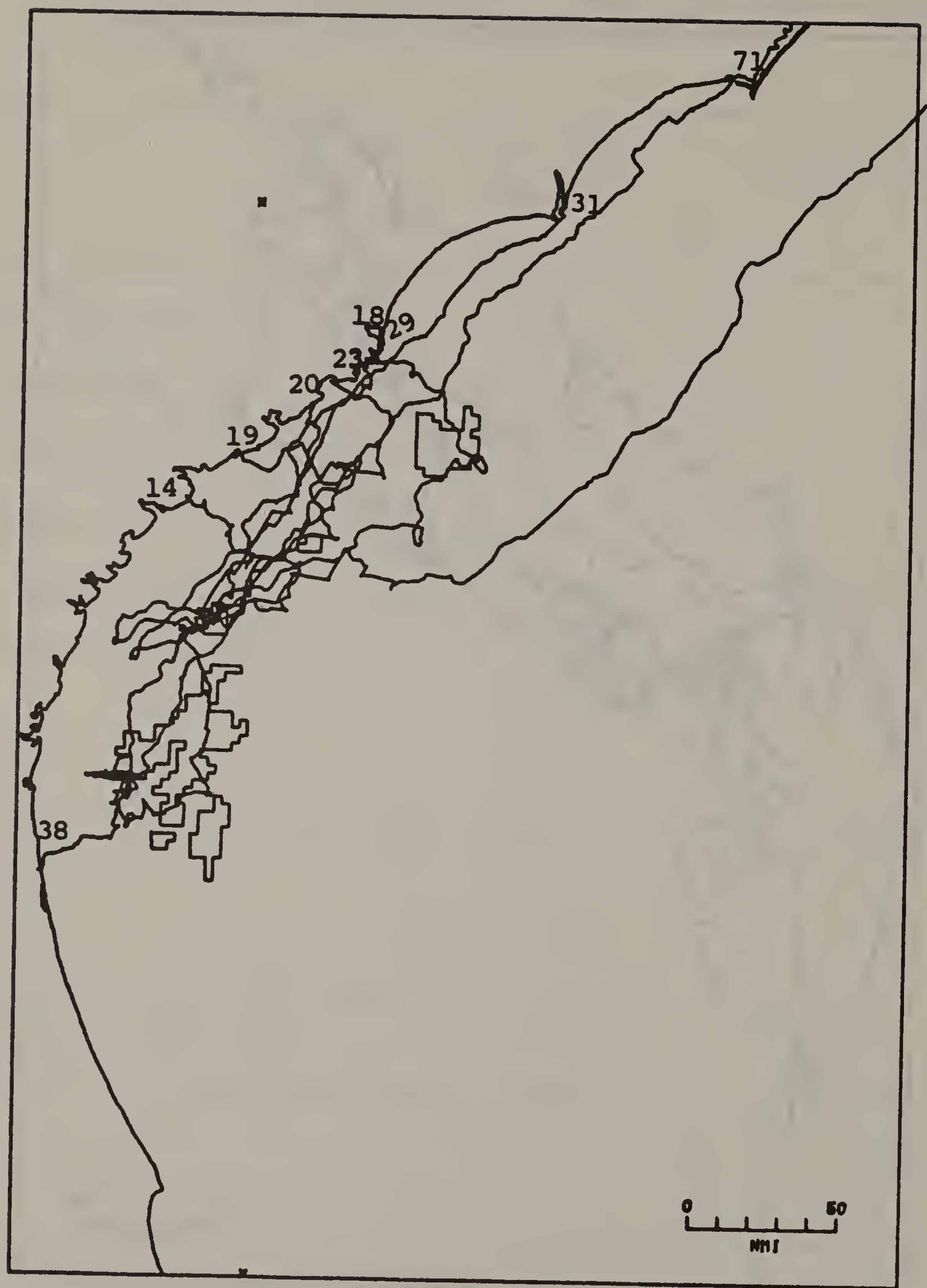

Figure 5.--Example oilspill trajectory results for a spill site near the center of the proposed lease area: spring conditions. Number on trajectory reaching the coast gives time to land in days.

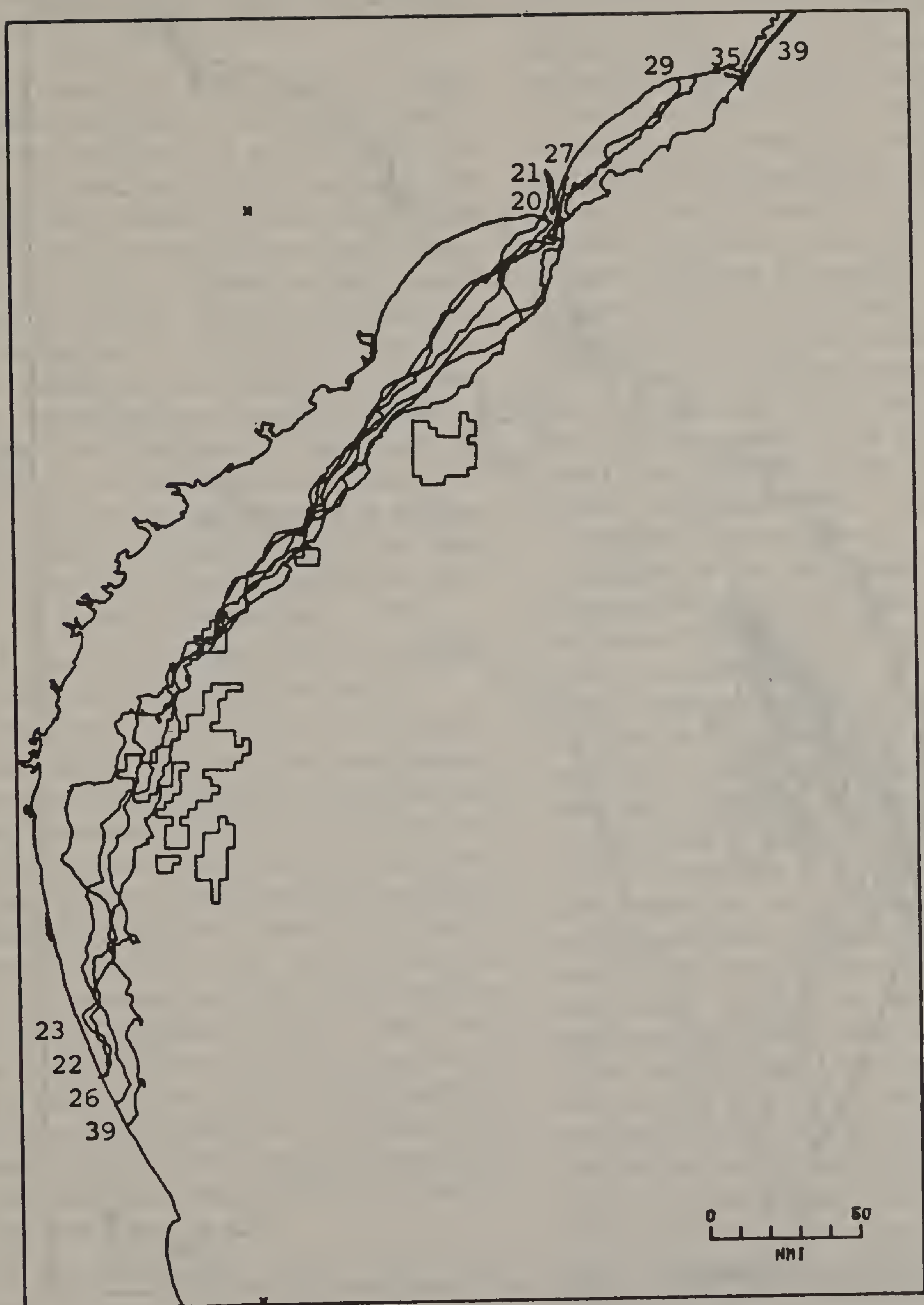

Figure 6.--Example oilspill trajectory results for a spill site near the center of the proposed lease area: summer conditions. Number on trajectory reaching the coast gives time to land in days.

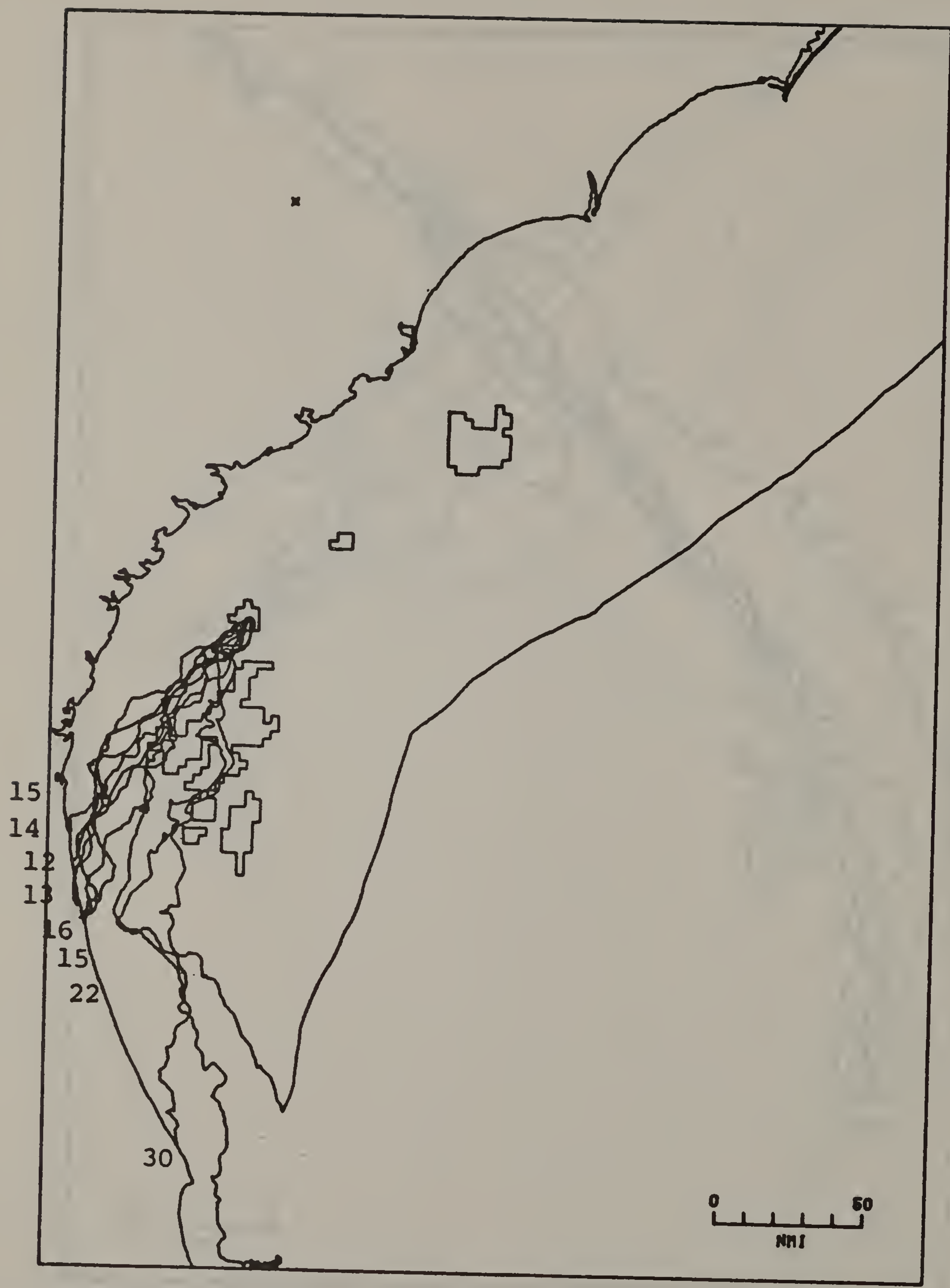

Figure 7.--Example oilspill trajectory results for a spill site near the center of the proposed lease area: autumn conditions. Number on trajectory reaching the coast gives time to land in days.

terns largely hold true for the other seven sites except that the northern sites have more northerly tendencies and the southern sites have more southerly tendencies. The east-west trajectories in figures 5 and 7 show the effects of the Gulf Stream.

The spatial disposition of the trajectory simulations is shown in figure 8. The final location of each trajectory was recorded and the results for each spill site (weighted by the estimated spill frequencies) were averaged. Thus, according to figure 8, 44 percent of the spill trajected ashore on the Florida coast, 3 percent on the Georgia coast, about 12 percent on South Carolina, and about 23 percent on North Carolina. Three percent of the trajectories were left at sea; i.e., after 90 days of tracking they had neither beached or left the map. The tendency for trajectories to travel parallel to the coast, as seen in figure 4, is reflected in figure 8. The highest rates of landings occurred northeast and southwest of the lease area. The coast immediately west of the lease area received relatively few landings.

Oilspill Trajectories in Relation to Biological Resources and Recreation Areas

Oilspill trajectory simulations were conducted keeping track of the frequency with which trajectories intersected the locations of biological and recreational resources. Trajectories were recorded as impacting a resource only in cases where the resource was listed as being vulnerable to oilspills in the month the impact took place. Table 2 gives the probability of impact on each of the 19 categories of biological resources and recreation areas for a spill originating at the 11 spill sites within the lease area (see Fig. 1). As one would expect, the likelihood that a given spill trajectory would beach at the location of a specific land based resource during critical seasons is generally smaller than the 84-percent probability of coming ashore anywhere.

Estimates of Weathering Rates and Slick Dispersion

It must be emphasized that up to this point the analysis has dealt only with trajectories for the transport of surface oil by winds and currents and has not involved any consideration of dispersion or weathering processes which would progressively reduce the quantity of oil contained in the slick as it traveled towards shore. The probabilities given in table 2, therefore, represent a worst-case analysis in the sense that some fraction of the spills occurring more than 50 miles off shore in the lease area would be expected to deteriorate to the point of insignificance before reaching land. Some attempt at quantifying weathering and dispersive effects and accounting for them in probability estimates is thus in order.

One important factor determining the significance of weathering in reducing oilspill impacts is the time required for spills to reach land. Times to land for simulated trajectories, in fact, covered a very wide range, and it is therefore particularly important to consider this factor in interpreting results of the spill trajectory analysis. Table 3 shows the mean number of days at sea for trajectories which reached the coast within 90 days from the spill sites. The mean time to land from the production areas tend to vary quite widely both from site to site and from season to season reflecting the various trajectory "corridors" discussed above.

Included in the list of factors which would determine the potency of spills at the time of impact would be spill size, of course, as well as the quality or composition of the oil, since lighter weight crudes evaporate at a much more rapid rate than those with a large proportion of high molecular weight hydrocarbons. This latter factor being hard to predict in advance, the significance of weathering is difficult to quantify despite its obvious importance in interpreting these results. Some suggestion as to South Atlantic oil quality may be contained in test well results from Sable Island in the North Atlantic; oil sample gravities there ranged from 36° to 41° API, indicating a medium to light weight crude (Smith, 1975).

The most important conclusion to be reached from the data in table 3 is that times to shore for most spills will be so long that they will no longer exist as an identifiable slick but rather will have fragmented into a large number of discrete particles or "blobs" by the time any oil arrives on shore. Observations by Jeffrey (1973) of actual spills in the North Atlantic indicate breakup of the slick can be expected within about 4 days, and that the particles of residual oil typically consist of spongy emulsions of oil of widely varying sizes. Moreover, it is generally agreed that large fractions of the original volume of oil will evaporate in the first few days of weathering and that further loss to the atmosphere occurs at a very slow rate. Data from Nelson (1958) for crude

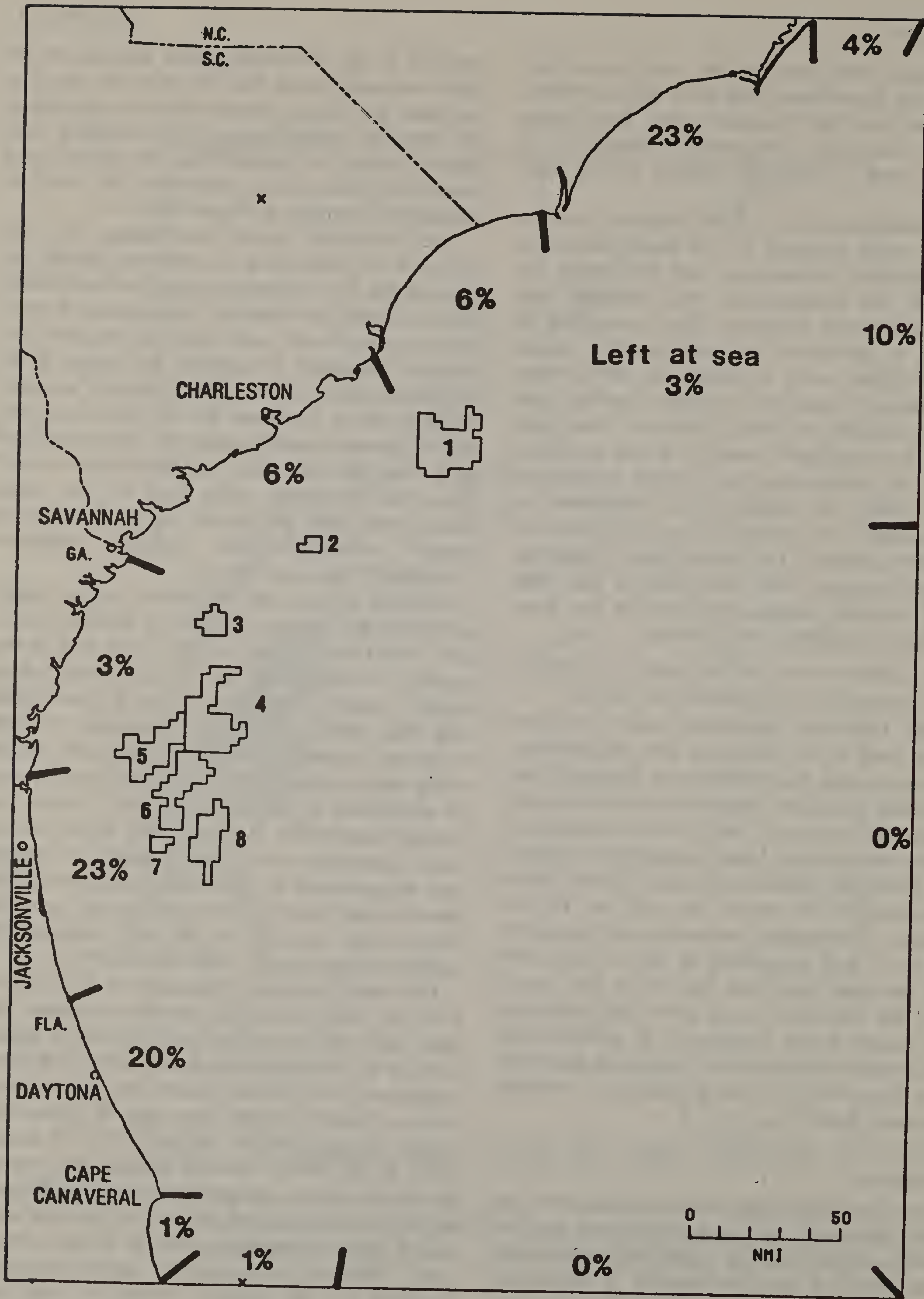

Figure 8.--Probability that if an oilspill occurs in the South Atlantic lease area, it will reach a particular geographic location.

Table 2.--Percent probabilities that an oilspill occurring at potential production areas in the South Atlantic lease area would impact important biological resources and recreation areas.

Resources Group	Production Area 1	2	3	4	5	6	7	8	Transportation Route A	B	C
Sandy beaches	69	73	84	84	88	89	93	90	79	86	97
Recreation areas	16	14	15	16	17	16	13	12	12	15	21
Wildlife refuges	1	2	4	2	2	2	2	2	4	4	5
Historical sites	19	17	10	11	10	10	7	7	16	6	4
Marsh and wetlands	6	7	5	4	4	4	3	4	7	8	3
Turbid water zone	19	27	28	23	26	26	27	24	32	31	30
Brown pelican rookeries	*	*	1	1	1	2	2	1	*	1	2
Coastal or pelagic bird rookeries	4	4	3	3	2	2	2	2	3	2	2
Bald eagle nesting sites	*	*	*	*	*	*	*	*	*	*	*
Dusky seaside sparrow habitat	*	*	*	*	*	*	*	*	*	*	*
Arctic peregrine falcon migration routes	57	60	73	75	77	79	83	82	63	71	88
White, brown, and pink shrimp	31	31	34	30	31	27	27	25	31	33	35
Royal red shrimp	*	*	1	1	*	1	1	2	*	*	*
Commercial fishing grounds	g	g	g	94	g	g	g	97	g	g	g
Sport fishing area	2	1	1	2	2	2	1	3	1	1	*
Commercial scallop grounds	32	22	16	19	15	15	11	13	19	8	7
Crabs and oysters	34	37	27	21	21	18	14	16	49	28	10
Bay scallops	4	3	2	2	2	1	*	*	3	1	*
Sea turtle nesting sites	35	38	40	37	39	36	34	34	40	38	37
Overall probability ashore	69	73	86	86	90	91	95	93			

* Less than 0.5 percent probability.

g Greater than 99.5 percent probability.

Table 3.--Mean time to shore (in days) for spills originating on the South Atlantic OCS.

	Site	Season			
		Winter	Spring	Summer	Autumn
Production Areas	1	55	24	38	39
	2	58	24	28	29
	3	51	26	24	20
	4	48	33	31	17
	5	46	29	27	13
	6	40	35	30	13
	7	29	36	25	10
	8	38	38	31	13
Transportation Routes	A	57	14	22	24
	B	49	12	12	15
	C	19	22	10	7

oil of API gravity 40°, for example, indicate about 50 percent of the original spill volume would be lost to evaporation.

Thus for oilspills in the South Atlantic lease area it would appear that an important consideration is the extent to which fragments of the slick are dispersed by the time they reach shore. Using lateral dispersion coefficients from Csanady (1974) estimates of slick dispersion were made for various travel times and for two spill sizes, 1,000 bbls and 50 bbls, assuming 50 percent loss of the original volume by evaporation. The resulting distribution of oil along an assumed straight shoreline is given in Figure 9. It is important to note that the profiles will flatten considerably as the coastline becomes more irregular. In any case, it appears that residual oil from a single spill as small as 50 bbls would not be easily detected on the beach after 30 days at sea.

Combined Analysis: Spill Frequency Estimates and Oilspill Trajectories

It is worth briefly summarizing some of the important points to be drawn from the results presented thus far. Data in table 1 indicate that although more than 2,300 oilspill incidents would be expected during the course of oil production in the South Atlantic, only a very few (and possibly none at all) are likely to exceed 1,000 bbls. Furthermore, consideration of travel time to shore (table 3), evaporation rates, and rates of slick dispersion (Fig. 9) leads to the conclusion that an individual spill would need to be as large as 1,000 bbls in size in order to have significant ecological impact. The probabilities in table 2 give the chances that if a major spill occurs in the lease area it would come ashore and hit any of various important resources; these probabilities are discussed in combination with the frequency estimates for major oilspills in paragraphs that follow.

Further consideration should be given first, however, to the significance of small scale, chronic spillage which, according to table 1, might amount to about 100 accidents annually over a 25-year period. The question arises whether a large number of small spills occurring during the course of oil and gas development in the lease area would have significant cumulative impact in the form, for example, of tar and other petroleum residues washing up on South Altantic beaches. In attempting to answer this question, results of the spill trajectory model runs were used to estimate the distribution of petroleum residues along the South Atlantic coast that would result from the 2,370 spills smaller than 1000 bbls projected during the production life of the area. Results of this analysis are shown on a map of the area in Figure 10. The mean size of spills in the range of 0-1000 is estimated to be about 3 bbls. Concentrations of petroleum residues given in Figure 10 are based on the assumption of a 50 percent loss of the original spill volume to evaporation and the worst case assumption of no success in spill containment efforts. It has been estimated (Offshore Oil Task Group, 1973) that offshore containment efforts might be successful in seas of less than 5 feet although it is questionable whether the equipment would be deployed for spills smaller than 50 bbls.

According to Figure 10, total quantities of petroleum residues that would be expected to come ashore over the 25-year production life of the area as a result of chronic, small-scale spillage range from a high of 500-1,000 grams per meter of beach along the Florida coast and places in North Carolina to less than 100 grams per meter near the Georgia-South Carolina border. It is helpful to compare the concentrations in Figure 10 with actual measurements of tar and oil residues on Florida beaches reported by Dennis (1959, 1974) and believed to result from tanker traffic and natural seeps. He found rates of fouling in the Miami area during recent years to be about 700 grams per meter per year, an annual accumulation, in other words, that is of the same order of magnitude as that projected to result from the entire 25 years of OCS operations.

Returning to consideration of major spills (i.e., greater than 1000 bbls), the data presented in table 2 represent only a partial solution to the problem of assessing oilspill risks to important resources. The overall oilspill risk posed by oil and gas development in the proposed sale area must be assessed as a joint function of the probability that spills will occur in the course of development as well as the likelihood that spills will follow certain trajectories. Thus, the data in table 2 must be combined with the spill frequency estimates presented in Figures 2 and 3 above to obtain a total probability distribution for impacts on specific resources.

Despite the intuitive logic of simply multiplying the probabilities in Figure 2 by those in table 2,

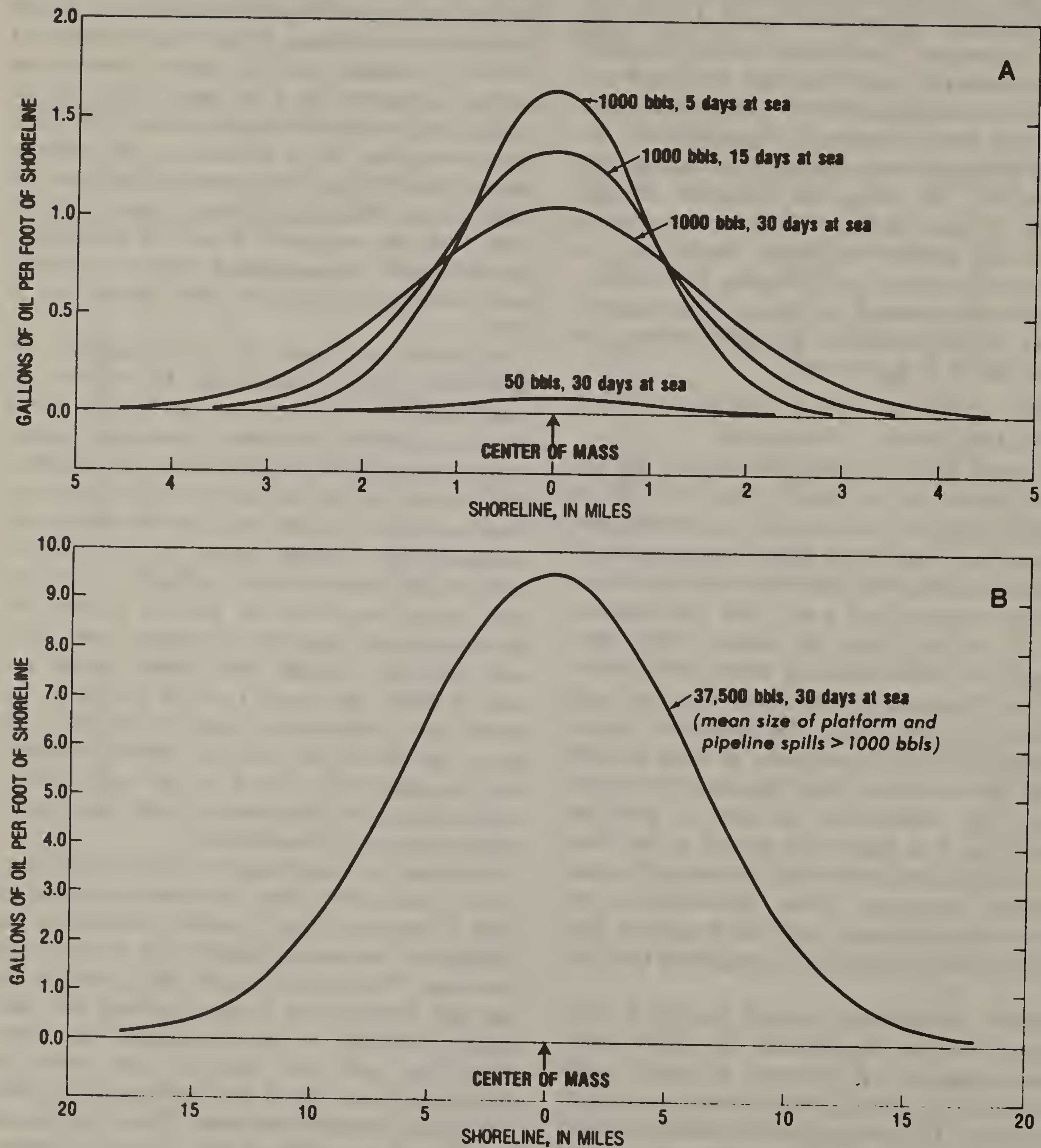

Figure 9.--Density of beached residual oil along idealized shoreline for various travel times and initial sizes.

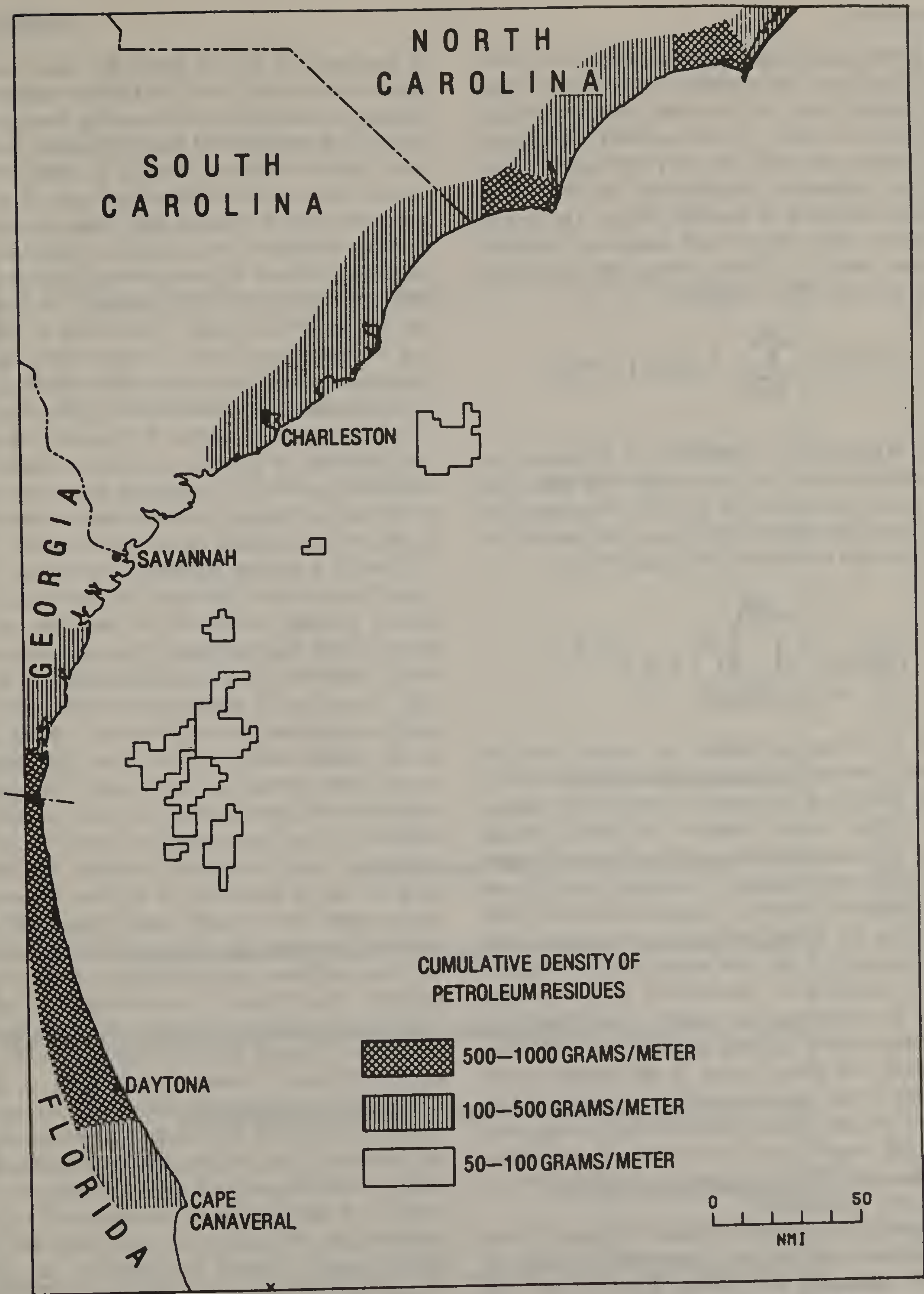

Figure 10.--Projected cumulative distribution of petroleum residues on South Atlantic beaches resulting from small scale, chronic spillage during the production life of the lease area. Estimated densities do not include existing background levels resulting from tanker washings and natural seeps.

the correct computation of the overall or "total" probability is in fact somewhat more complicated. This results from the fact that the probabilities presented in table 2 are actually conditional probabilities and refer to the probabilities of impacts on resources "conditioned" on the chance of spills occurring in the first place. The overall probability that oilspills will impact a particular resource exactly k times during the production life of the area, P(k), is given by

$$P(k) = \sum_{n=k}^{\infty} P(k|n)\ P(n)$$

where P(k/n) is the probability of k impacts on the resource given the occurrence of n spills, and P(n) is the probability of n spills occurring. The conditional probability P(k/n) can be assumed to be distributed binominally and is given by

$$P(k|n) = \binom{n}{k} p^{k} (1-p)^{n-k}$$

where p is the probability of impact on the resource given the occurrence of a spill, (table 2).

The combined probability distribution calculated in the above manner for spills coming ashore is presented in Figure 11. The distribution is based on spill frequency estimates from Figure 2 and therefore refers to impacts from all spills originating as 1,000 bbls or greater during the production life of the total lease area and assumes pipeline transport to Jacksonville and Savannah. Figure 11 indicates that there is an 8-percent probability that no oilspills greater than 1,000 bbls will occur and come ashore in the course of oil production in the proposed lease area. The chances are therefore, 92 percent that at least one such spill would occur and come ashore during the production life of the area (sum of the probabilities of 1 and greater).

Probability distributions similar to Figure 11 can be developed and likewise interpreted for each of the 19 categories of biological resources and recreation areas. Probabilities of at least one major spill occurring during the production life of the area and impacting the various resource groups are given in table 4. The data have been calculated separately for two alternative methods of transport of the oil from the lease area, by pipeline and tanker, and are further separated according to assumptions concerning transportation routes. It is emphasized that probability estimates refer only to chances that oil in some form or another from a spill originating larger than 1,000 bbls will come in contact with some portion of a resource thought to be potentially vulnerable. The mitigating effects of weathering processes and clean-up efforts are only indirectly reflected in the probabilities in table 4 by virtue of the fact that estimates apply only to large spills. Figure 9 provides a rough description of the likely effects of evaporation and dispersion on spills of various sizes as a function of time. To this must be added the likelihood of at least some, and perhaps considerable, success in containing oil in the course of the days or weeks separating the occurrence of a spill on the OCS and its arrival on shore.

There is a natural tendency for impact probabilities in table 4 to be larger for resources which occupy a large portion of the shoreline or continental shelf than for those that are restricted to small, localized areas. The significance of an oilspill impact on a biological resource, however, may be somewhat inversely related to areal extent of the habitat since recovery from spill damages would likely depend on the fraction of the population effected. Consequently, in order to give perspective to the risk values in table 4, a fifth column of data is provided showing the size of each of the 19 resources in relation to the estimated mean size of spills larger than 1,000 bbls. Onshore resources are compared with spill size on the basis of linear measure (estimated mean spill diameter after 30 days of weathering is 25 mi; see Fig. 9) and offshore resources are compared on the basis of areal extent (estimated mean spill area is 490 mi^2). Thus, after 30 days at sea, a 37,500 bbl spill would be dispersed over an area equal to only about 2 percent of commerical fishing grounds in the region, but upon reaching the coast, would deposit oil over a length of shore equal to at least one tenth the length of exposed marshes and wetlands in the area. Tides and nearshore currents would be expected to further spread the beached oil to some extent. Fortunately, the chances a major spill will hit marshes and wetlands is estimated to be less than 10 percent.

In general, resource groups showing the highest impact probabilities in table 4 are beaches and recreation areas as well as commercial fish and

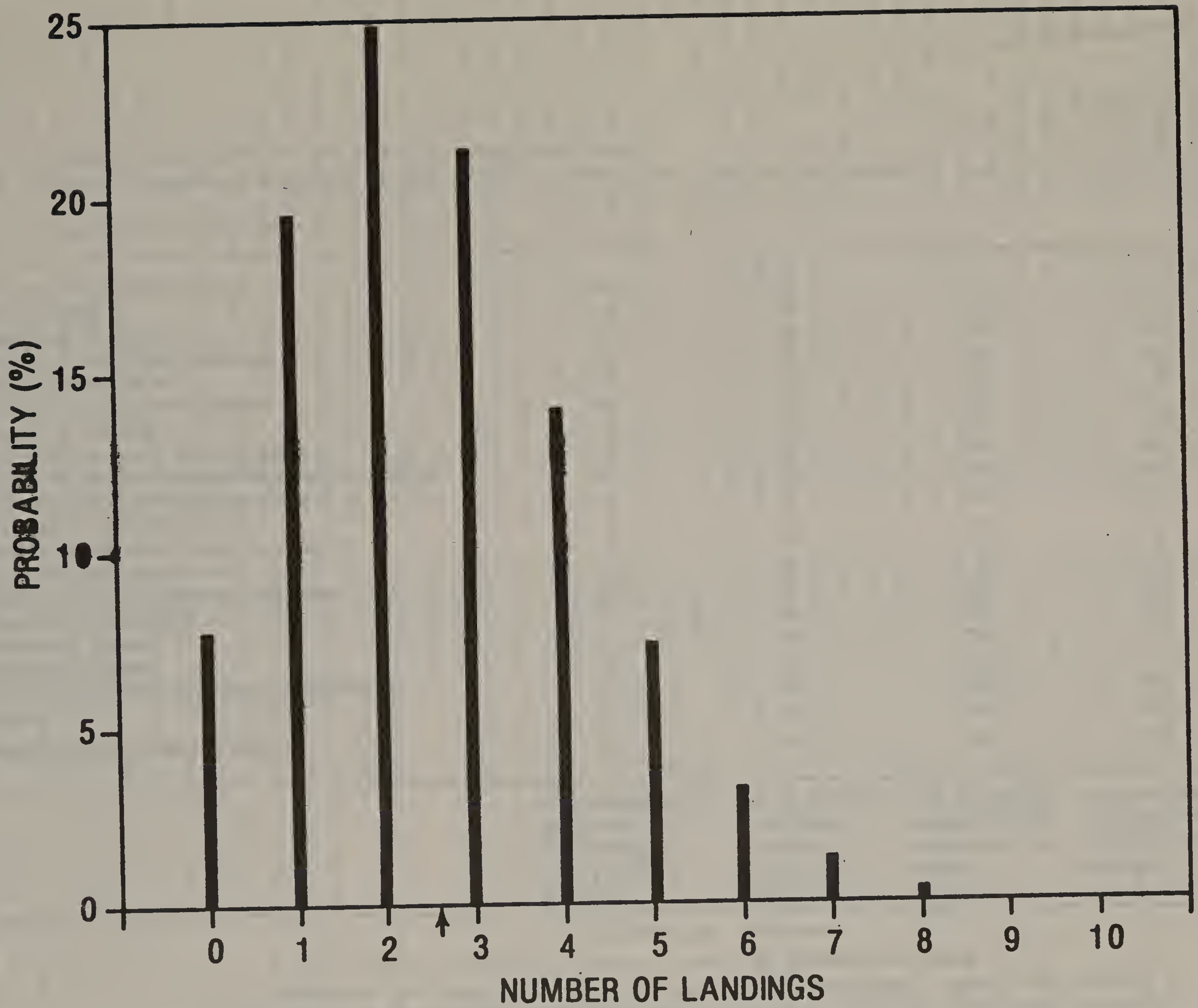

Figure 11.--Probability distribution on frequency of landings for oilspills greater than 1,000 bbls over the production life of the South Atlantic lease area. Based on pipeline transport to Jacksonville and Savannah.

Table 4.--Probabilities of one or more spills greater than 1,000 bbls occurring and impacting biological resources and recreational areas in the South Atlantic area over the production life of the entire lease area. Also, the size of a major spill in relation to the extent of exposed resource.

	Probability (percent)				
	Based on pipeline transport to Jacksonville and Savannah	Based on pipeline transport to Charleston and Savannah	Based on tanker transport to Jacksonville and Savannah	Based on tanker transport to Charleston and Savannah	Ratio of mean spill size to extent of exposed resource ǂ
Probability of coming ashore	93	92	96	95	.04
Beaches	93	92	95	95	.05
Recreation areas (State and Federal)	40	39	45	43	.24
Wildlife refuges	8	8	9	9	.53
Historical sites	29	32	33	33	1.0
Marsh and wetlands	15	16	17	14	.10
Areas of high sedimentation rate	55	55	61	62	.12
Brown pelican rookeries	3	2	4	3	3.33
Coastal or pelagic bird rookeries	8	8	9	9	.37
Bald eagle nesting sites	*	*	*	*	10.00
Dusky seaside sparrow habitat	*	*	*	*	25.00
Arctic peregrine falcon migration routes	89	89	93	93	.04
White, brown, and pink shrimp	62	62	69	69	.07
Royal red shrimp	2	2	2	2	2.5
Commercial fishing grounds	95	95	97	97	.02
Sport fishing area	4	5	5	5	.71
Commercial scallop grounds	43	44	47	49	.22
Crabs and oysters	53	58	59	65	.06
Bay scallops	6	7	7	7	.53
Sea turtle nesting sites	69	69	75	75	.05

* Less than 0.5 percent.

ǂ Onshore resources compared on the basis of length and offshore resources on the offshore resources on thé basis of area (see text).

shellfish grounds, while those showing relatively low risk include the habitats of most of the non-commercial fish and wildlife populations. The category, sandy beaches, is not discriminative of level of recreation usage or commercial importance and, thus would stand some further elaboration. According to Figure 8, which gives the geographical distribution of trajectory probability, the chances are 43 percent that if a spill occurs in the lease area, it will come ashore on the Florida coast north of Cape Canaveral, a stretch of coast that includes Jacksonville, Ft. Lauderdale, and Daytona Beach. Combining this probability with the spill frequency distribution (Figure 2 and equations 1 and 2) results in an estimate of 74 percent for the chances that at least one major spill would come ashore in this region sometime during the producing life of South Atlantic oilfields. By contrast, the corresponding probability estimate for one or more spills impacting the entire Georgia coast is only 9 percent over the field life. As with the estimates in table 4, these figures do not directly account for the mitigating effects of weathering or containment efforts and are based on the worst-case assumption that future accident rates will remain constant.

The high impact probabilities for commercial fish and shellfish areas in table 4, as in the case of beaches and recreation areas, reflect the fact that the extensive areas along the South Atlantic coast are involved in commercial fishing of one sort or another. The nature of effects of oil in fish and shellfish areas, however, is much less clear than is the problem of oil on beaches. Past experience with oilspills in shellfish areas has ranged from reportedly severe and lasting effects in the case of the West Falmouth spill, when toxic components of the oil were quickly churned into near-shore sediments (Blumer, 1970), to much more modest effects following the "Torrey Canyon" spill when more time was available for weathering before impact (Smith, 1968). There may be some significance to the fact that crab, oyster, and shrimp harvesting areas in the South Atlantic region are largely coincident with an area of relatively high sedimentation rate (see Appendix Figs. A-6, A-12, A-17) whereas commercial scallop grounds lie outside this region (see Appendix Figs. A-16 and A-18). The hazards of spilled oil to commercial fishing in deeper water offshore probably lies more in the possible oiling of nets and gear and possible effects on buoyant eggs of such species as menhaden, rather than in mortality of adult fish.

Biological resources showing the lowest impact probabilities in table 4 include a number of ecologically important but non-commercially sought fish and wildlife populations. Critical habitats of vulnerable bird populations, including known nesting sites and rookeries of the brown pelican, bald eagle and a variety of pelagic sea birds, as well as the remaining habitat of the endangered dusky seaside sparrow, all show impact probabilities of less than 10 percent for major spills over the oil producing life of the area.

Two wildlife categories that do show high impact probabilities, sea turtle nesting sites and the peregrine falcon coastal migration route, do so because lack of detailed information on critical elements of the habitat necessitated including in the analysis all possible locations of the organisms. Thus, along with the high probability estimates, it should be noted (table 4) that a 37,500 bbl spill would be expected to impinge on less than 5 percent of the potential habitat of these two populations.

Finally it is important that the distinction between the probabilities given in table 2 and those in table 4 be very clear. The data given in table 2 refer only to the likelihood that spills would follow certain trajectories and have nothing to do with the chances that spills will occur in the first place. The probabilities in table 4, by contrast, reflect both the expected frequency of spill occurrence as well as the likelihood of certain trajectories.

Relative Risks of Leasing in Different Parts of the Lease Area

One objective of the present study is to elucidate the relative risks of petroleum development in different regions of the proposed lease area, information which is necessary in selecting the tracts to be offered for sale. One consideration of importance in comparing the oil spill risk associated with different potential production areas is the value or weight to be assigned to each of the biological and recreational resources, since a given tract will pose proportionally greater risk to some resources than others, depending on location. With respect to offshore fishing areas, for example, tracts well off the coast show the highest probabilities of impact in the event of a spill (table 2), whereas with respect to resources along the shore, spills occurring in the westernmost subdivisions of the lease area show higher impact probabilities. For purposes of this analysis means of the impact probability distributions for the 17 resource groups will be averaged to give an overall index of risk for each of the subdivisions of the lease area, but it should be noted that this averaging implies to an equal weighting of the resources.

It is extremely important in comparing risk values for the different subdivisions of the lease area to distinguish between two fundamentally different ways of expressing relative risks. One can compare subdivisions of the lease area on the basis of impact probability given the occurrence of a spill using the data in table 2. This is equivalent, in fact, to making the comparison on the basis of risk per unit oil recovery, since the data in table 2 are conditioned on the occurrence of one spill and spill frequency is taken to be a direct function of oil production. Alternatively, one can make the comparison on the basis of total risk by using data computed as in table 4 which combine spill frequency estimates with the probabilities of observing certain trajectories.

The question of which is the most appropriate method of ranking the subdivisions of the lease area with respect to oilspill risk might be answered differently depending on one's perspective. If one is interested in the question of tradeoffs between the benefits of producing oil and the costs of possible spill impacts, then risk per unit oil is clearly of most interest. If one stands to lose a great deal personally in the event of a spill, a loss that is far out of proportion to one's expected gains from oil production, then absolute risk is of most interest.

In table 5, the 8 subdivisions of the lease area are ranked on the basis of risk to the 19 resource categories (equally weighted) using both methods of expressing relative risk. It is clear from table 5 that some of the tracts showing the highest total risk to resources in the South Atlantic, those in subdivisions 1 and 4, for example, are situated so that they actually pose less risk per unit oil production than tracts in several other subdivisions. That is, despite their safer location with respect to important resources and prevailing winds and currents, the expected high level of production in subdivisions 1 and 4, results in a higher overall chance of impacts from these areas. This theory is, of course, wholly dependent on a strong relationship between accident rate and production level.

Table 5. Rank ordering of 8 subdivisions of the South Atlantic lease area on the basis of oil spill risk to biological resources and recreation areas. Numbered subdivisions are shown in the map in Figure 1. and are listed here in order of decreasing risk.

Ranking on the basis of risk per unit oil production	Number of tracts and (area in hectares)	Ranking on the basis of total risk over the estimated production life	Number of tracts and (area in hectares)
3	11 (25,344)	1	51 (117,504)
5	36 (82,944)	4	52 (119,808)
2	5 (11,520)	5	36 (82,944)
6	36 (82,944)	6	36 (82,944)
1	51 (117,504)	3	11 (25,344)
4	52 (119,808)	8	29 (66,816)
7	5 (11,520)	2	5 (11,520)
8	29 (66,816)	7	5 (11,520)

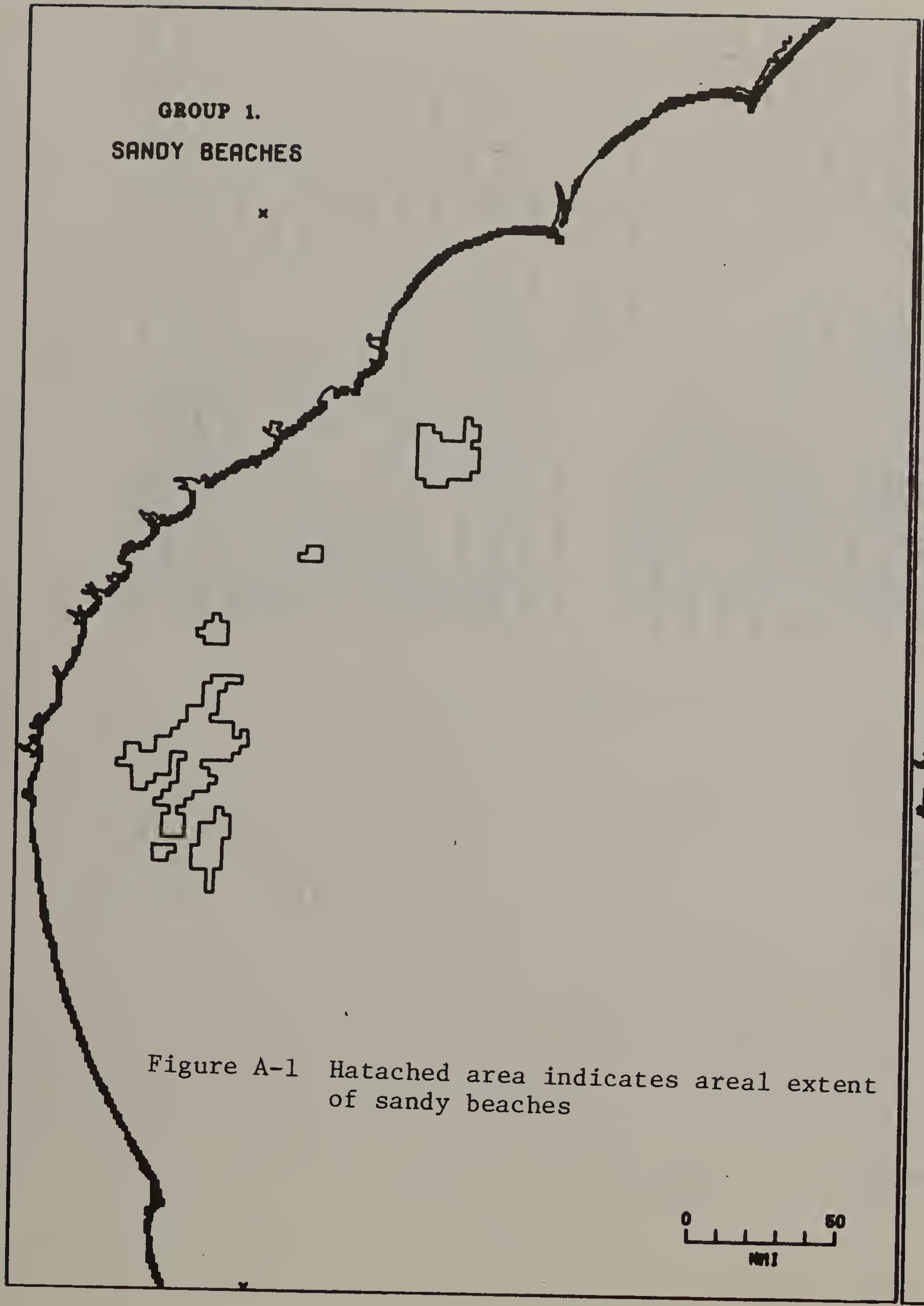

Figure A-1 Hatached area indicates areal extent of sandy beaches

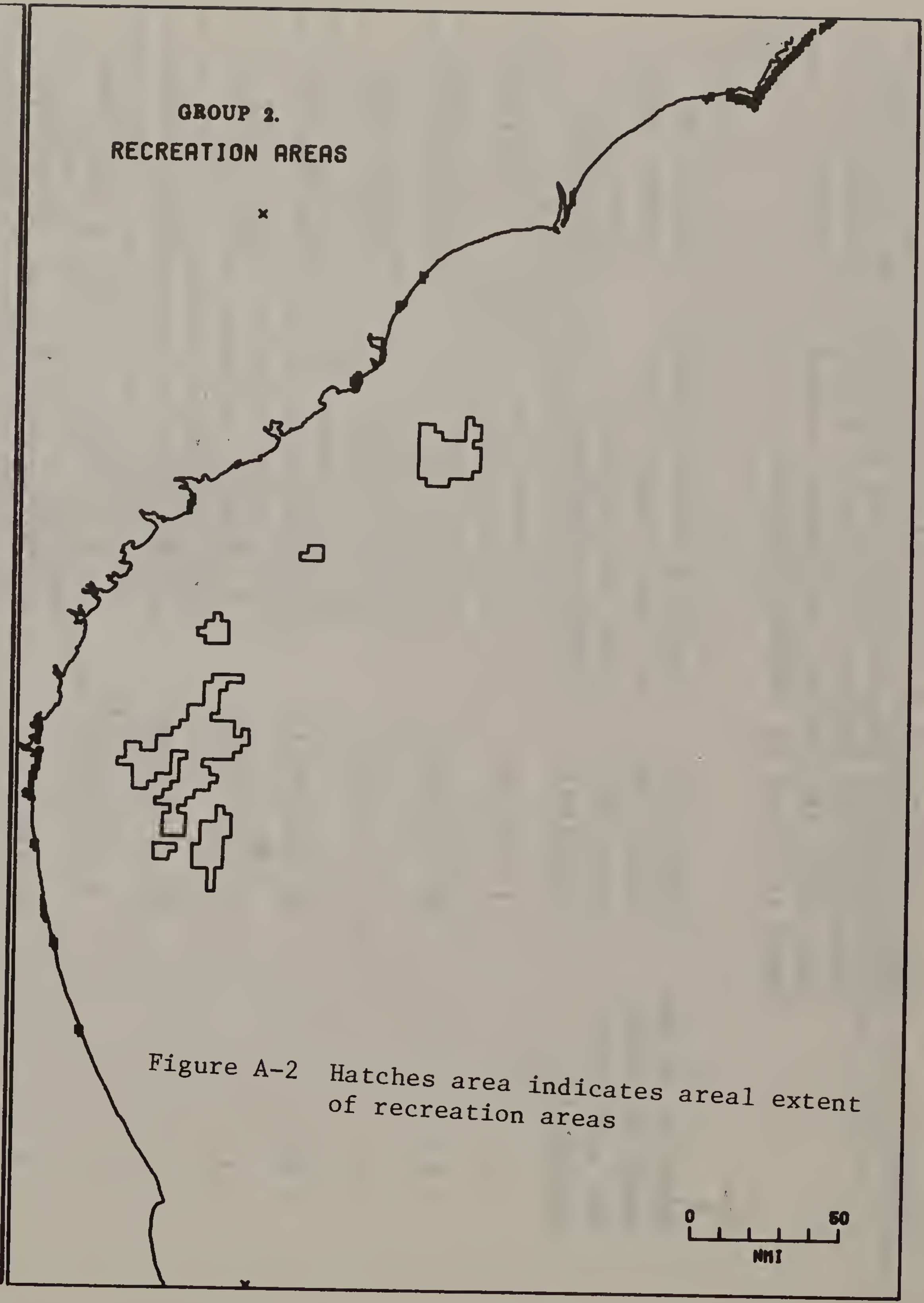

Figure A-2 Hatches area indicates areal extent of recreation areas

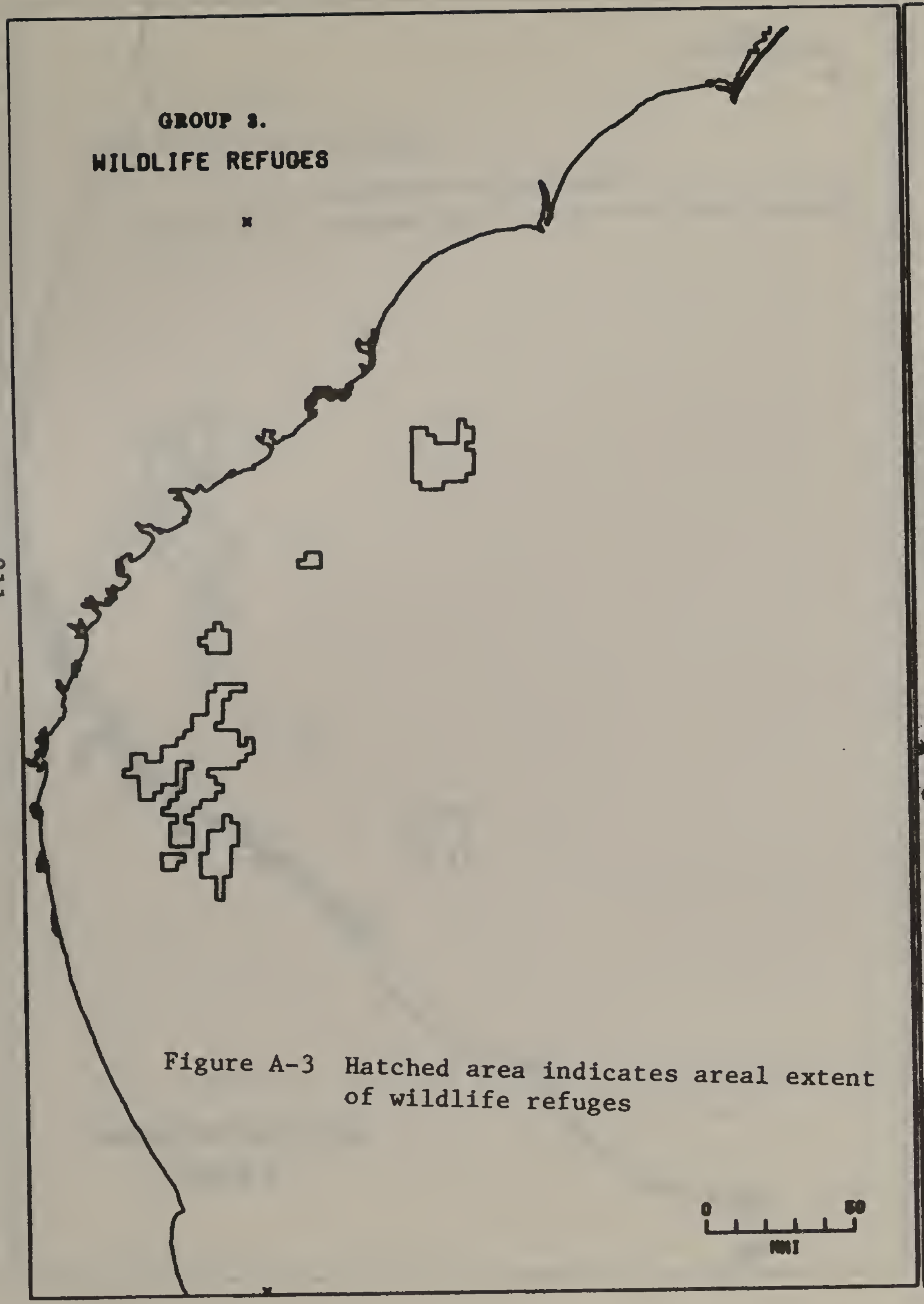

Figure A-3 Hatched area indicates areal extent of wildlife refuges

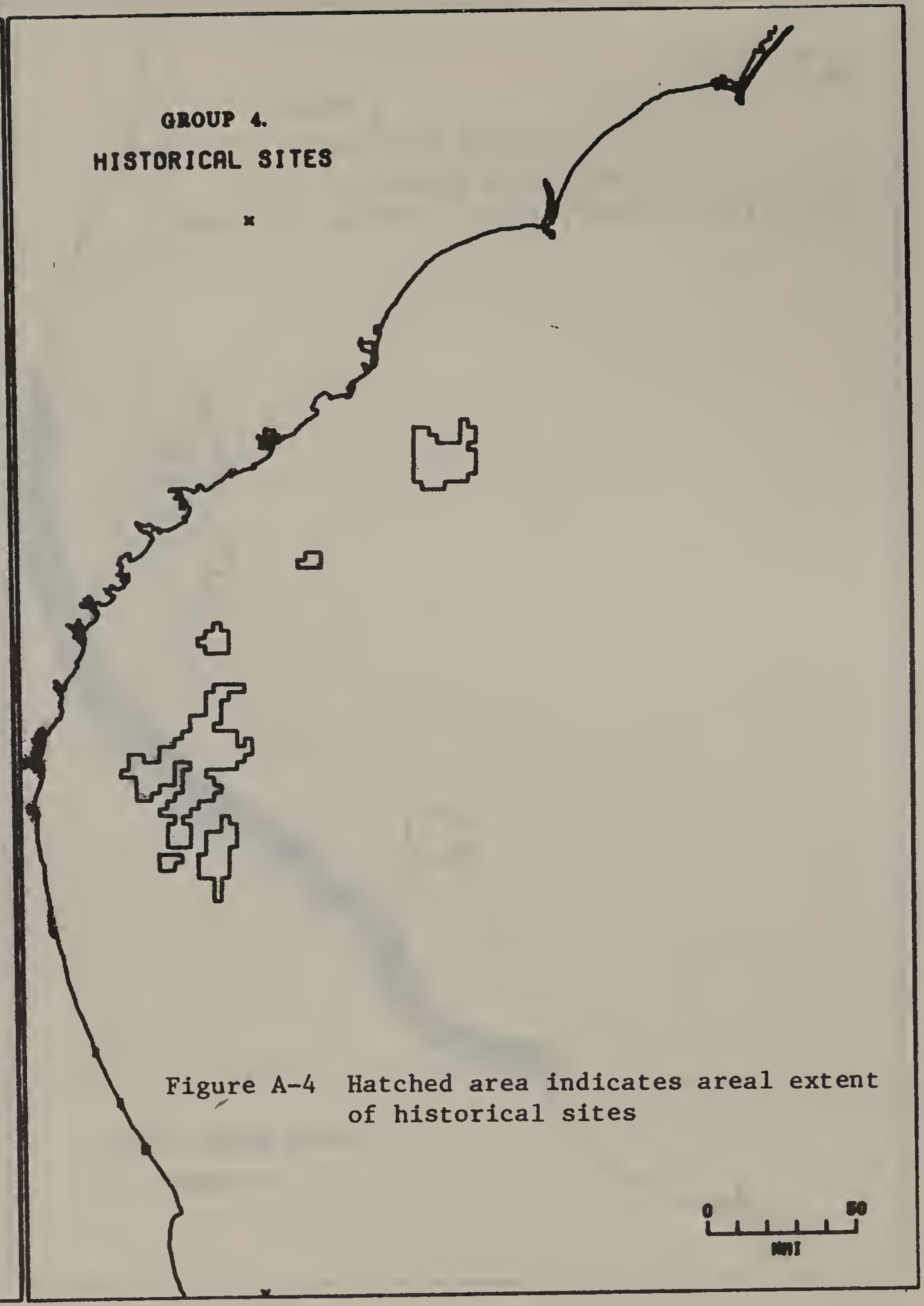

Figure A-4 Hatched area indicates areal extent of historical sites

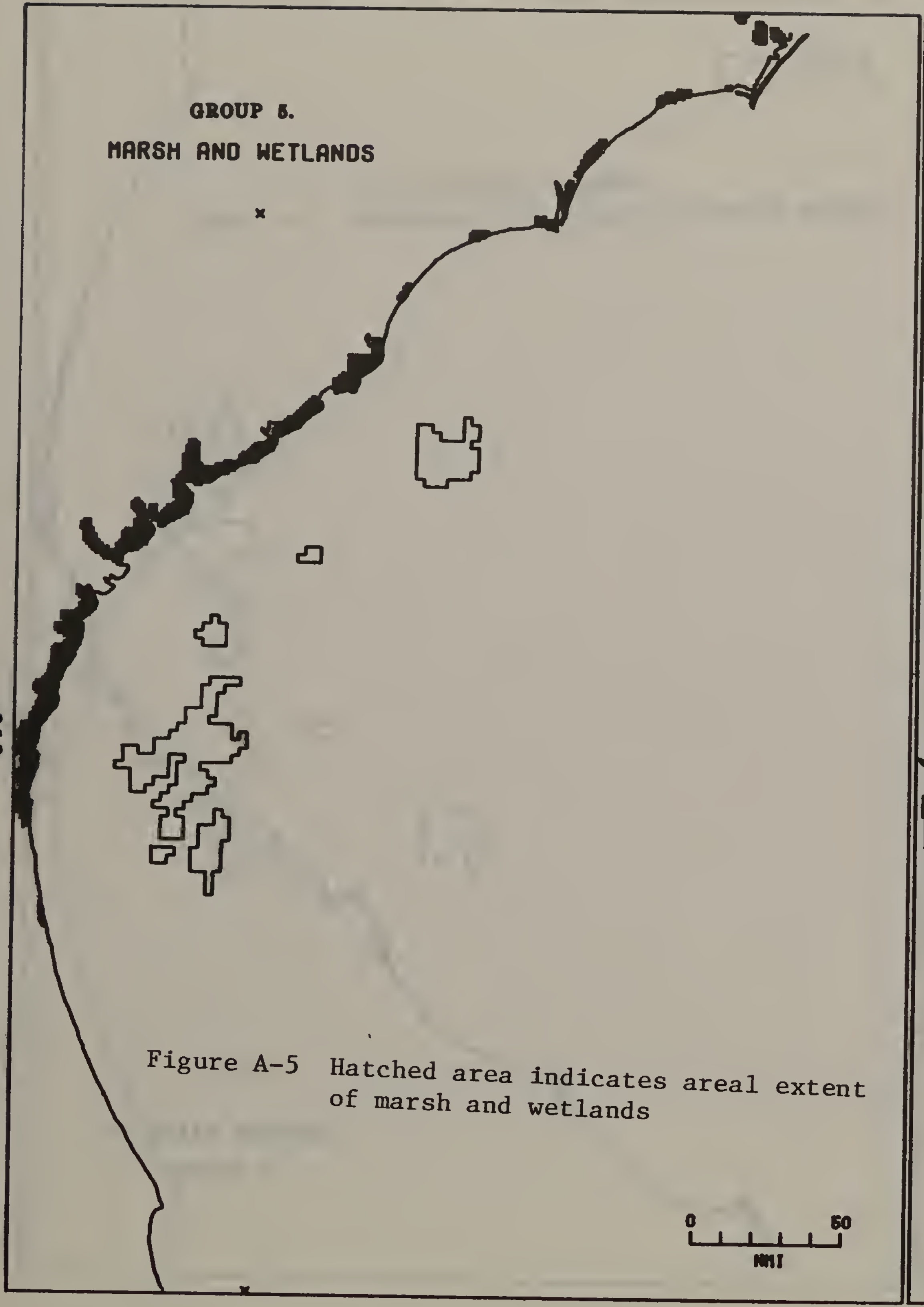

Figure A-5 Hatched area indicates areal extent of marsh and wetlands

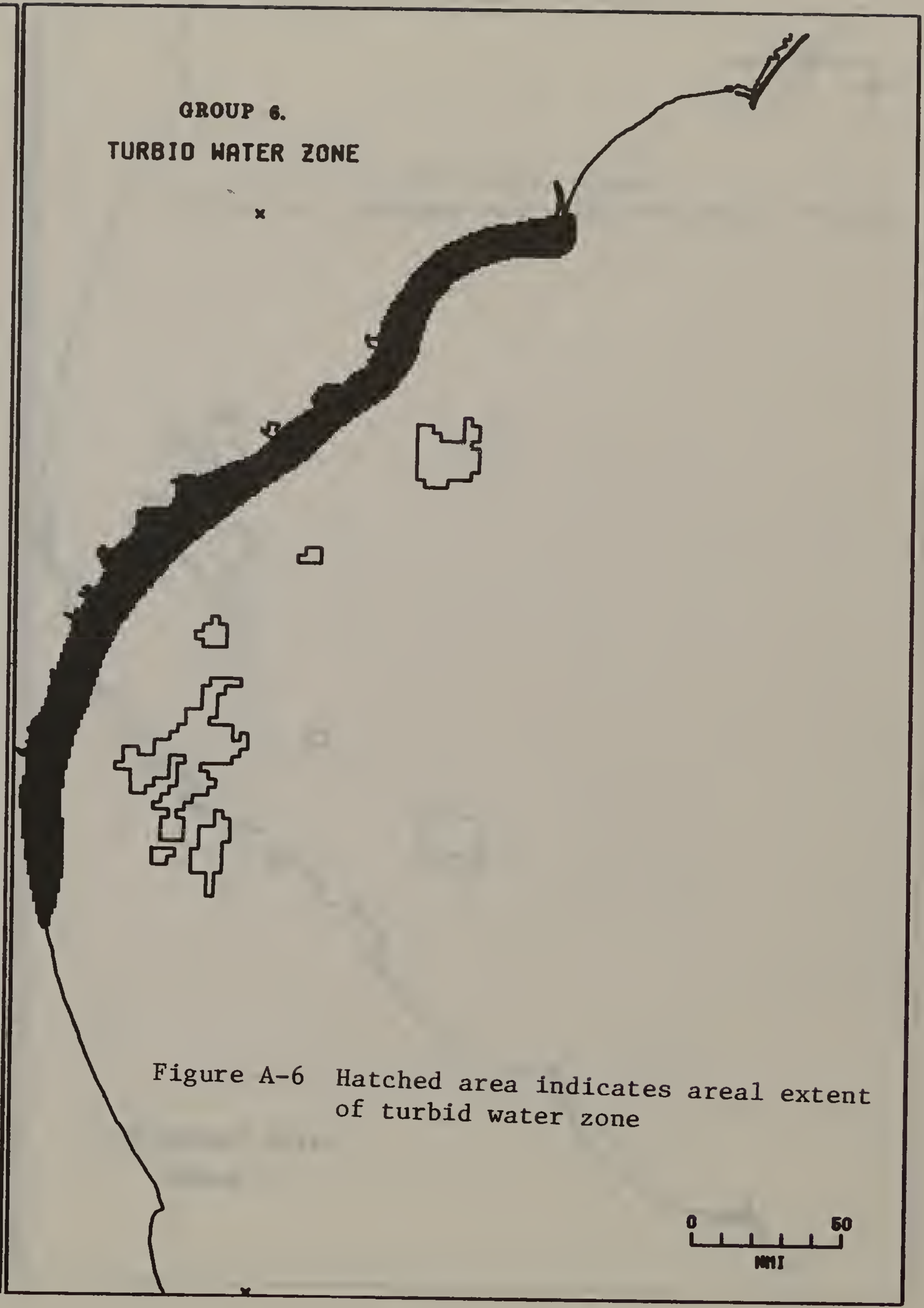

Figure A-6 Hatched area indicates areal extent of turbid water zone

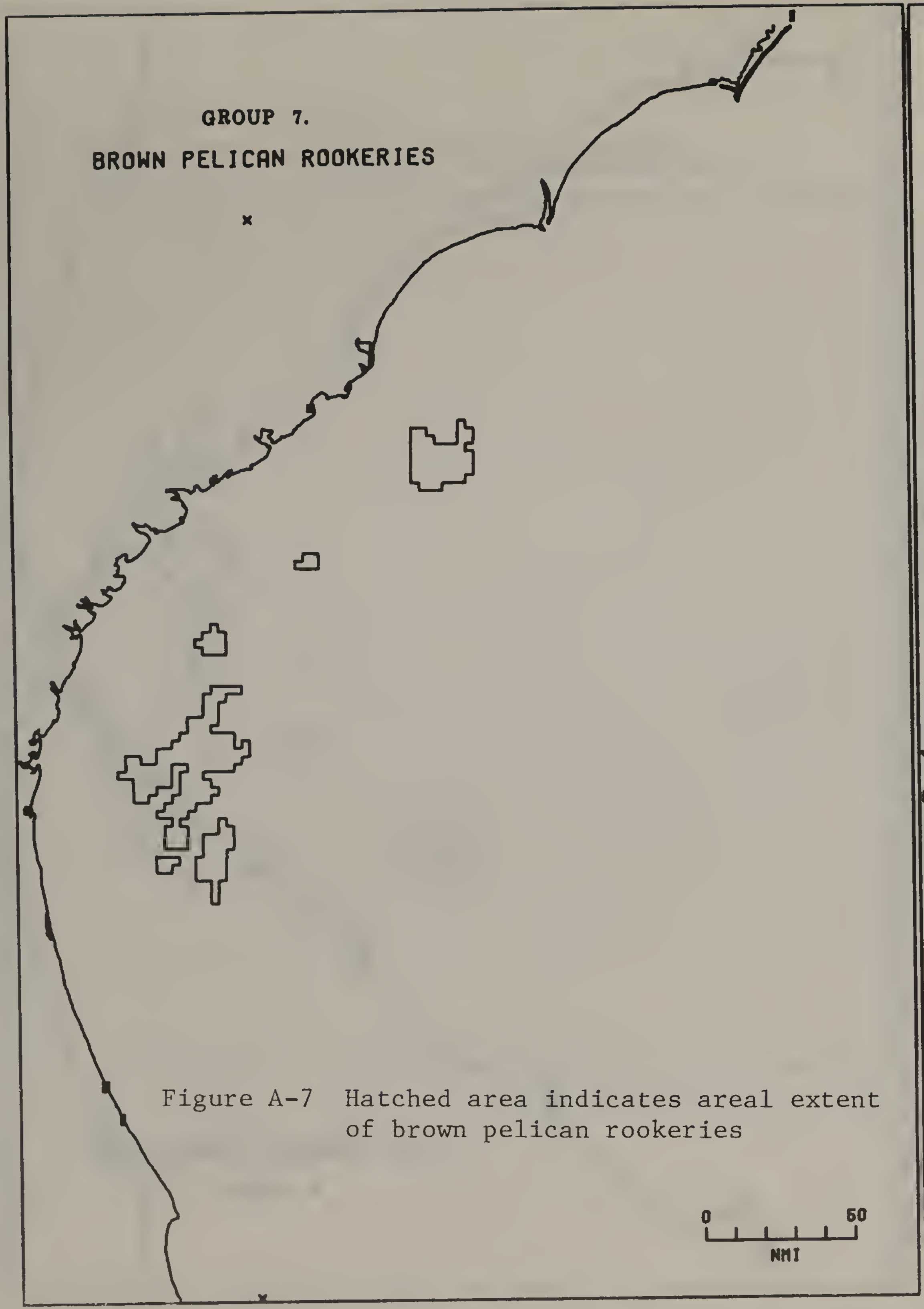

Figure A-7 Hatched area indicates areal extent of brown pelican rookeries

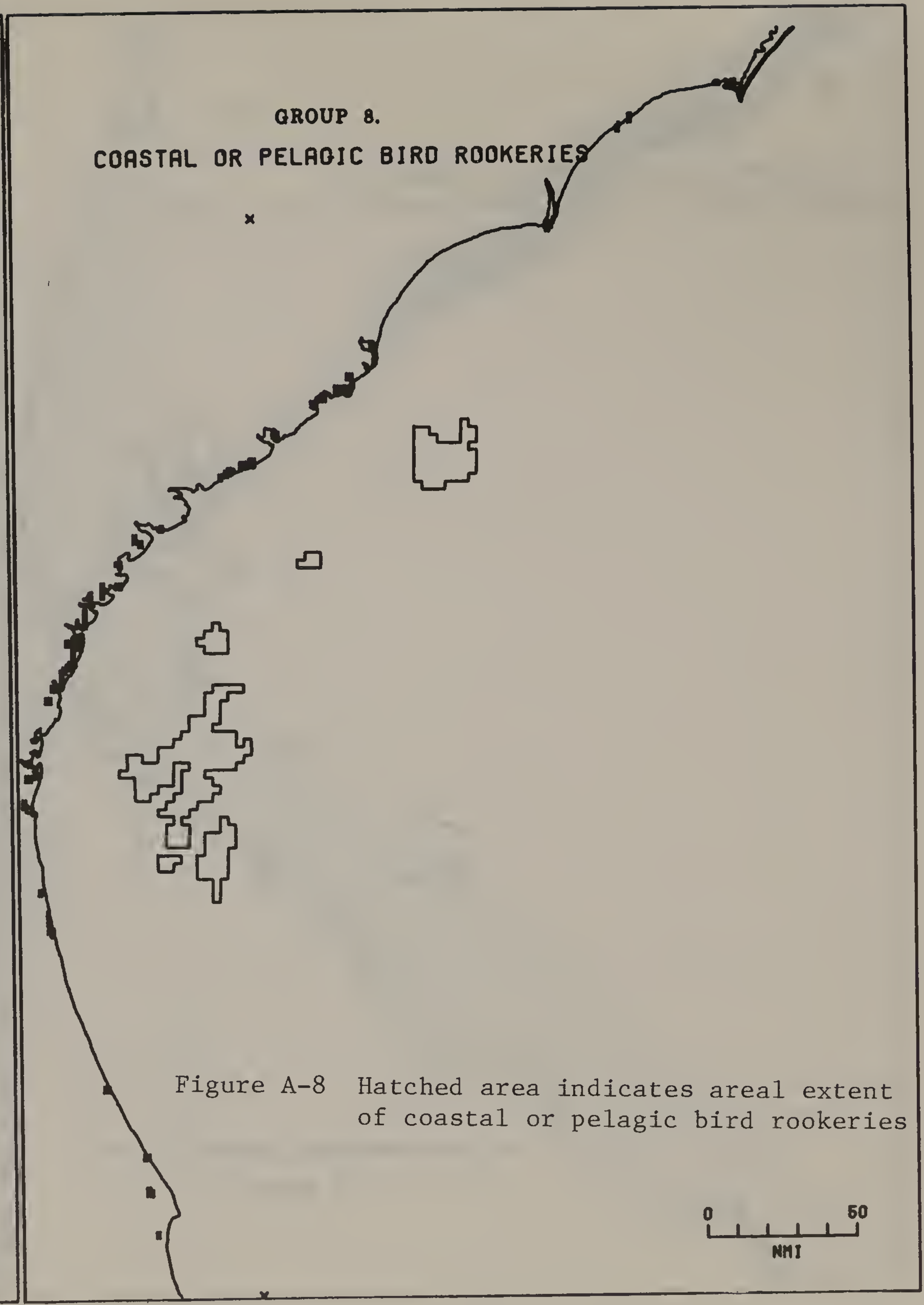

Figure A-8 Hatched area indicates areal extent of coastal or pelagic bird rookeries

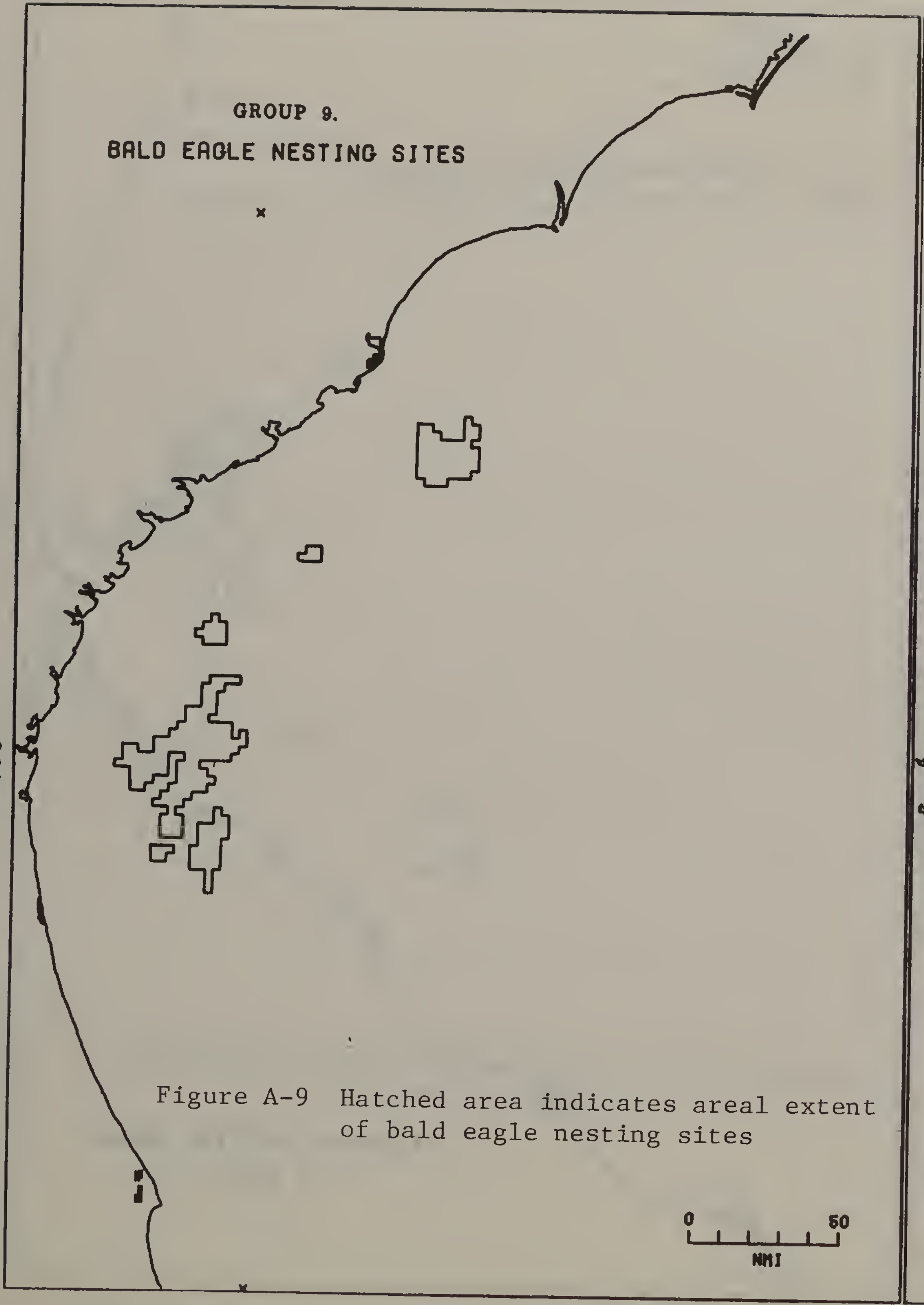

Figure A-9 Hatched area indicates areal extent of bald eagle nesting sites

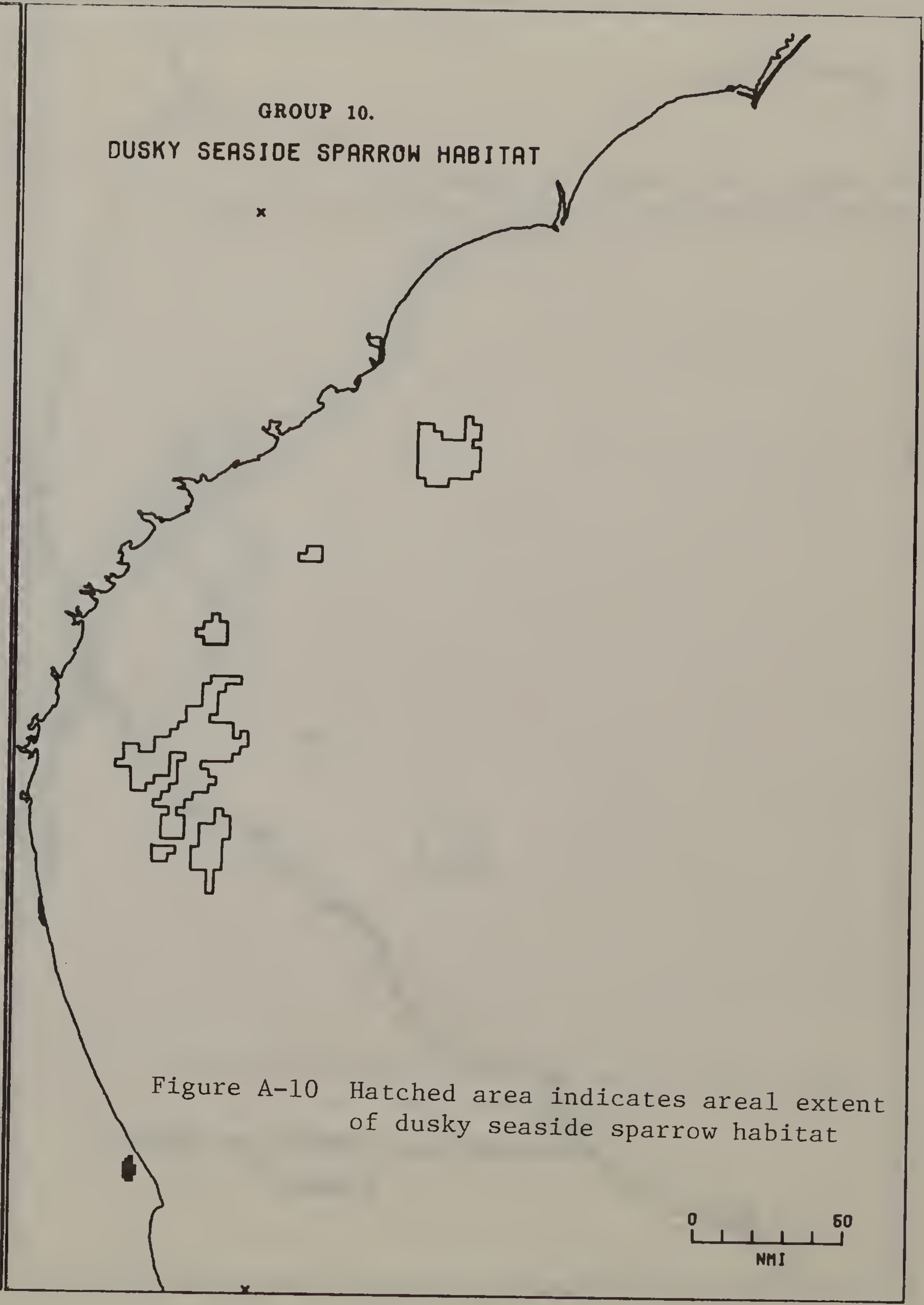

Figure A-10 Hatched area indicates areal extent of dusky seaside sparrow habitat

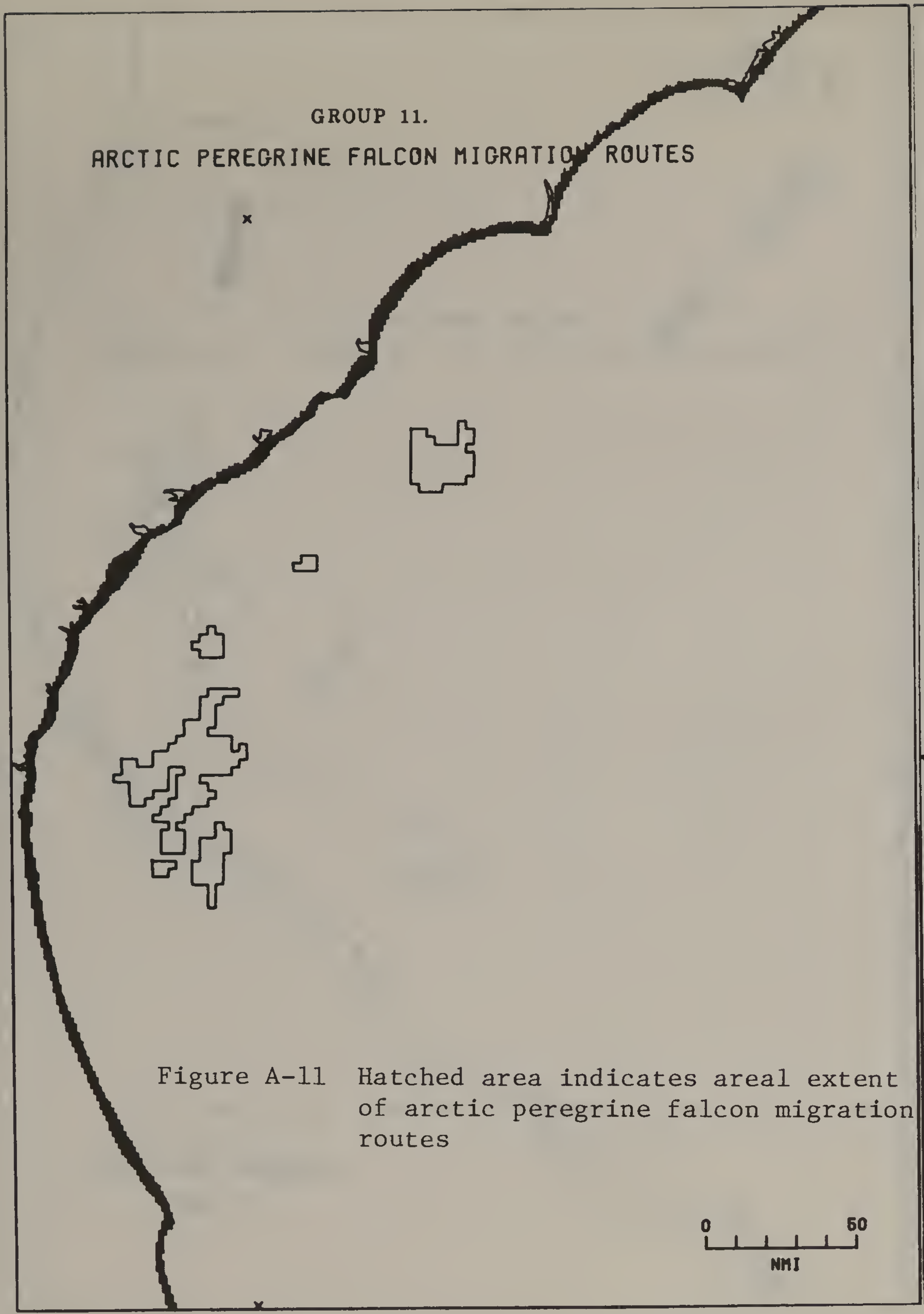

Figure A-11 Hatched area indicates areal extent of arctic peregrine falcon migration routes

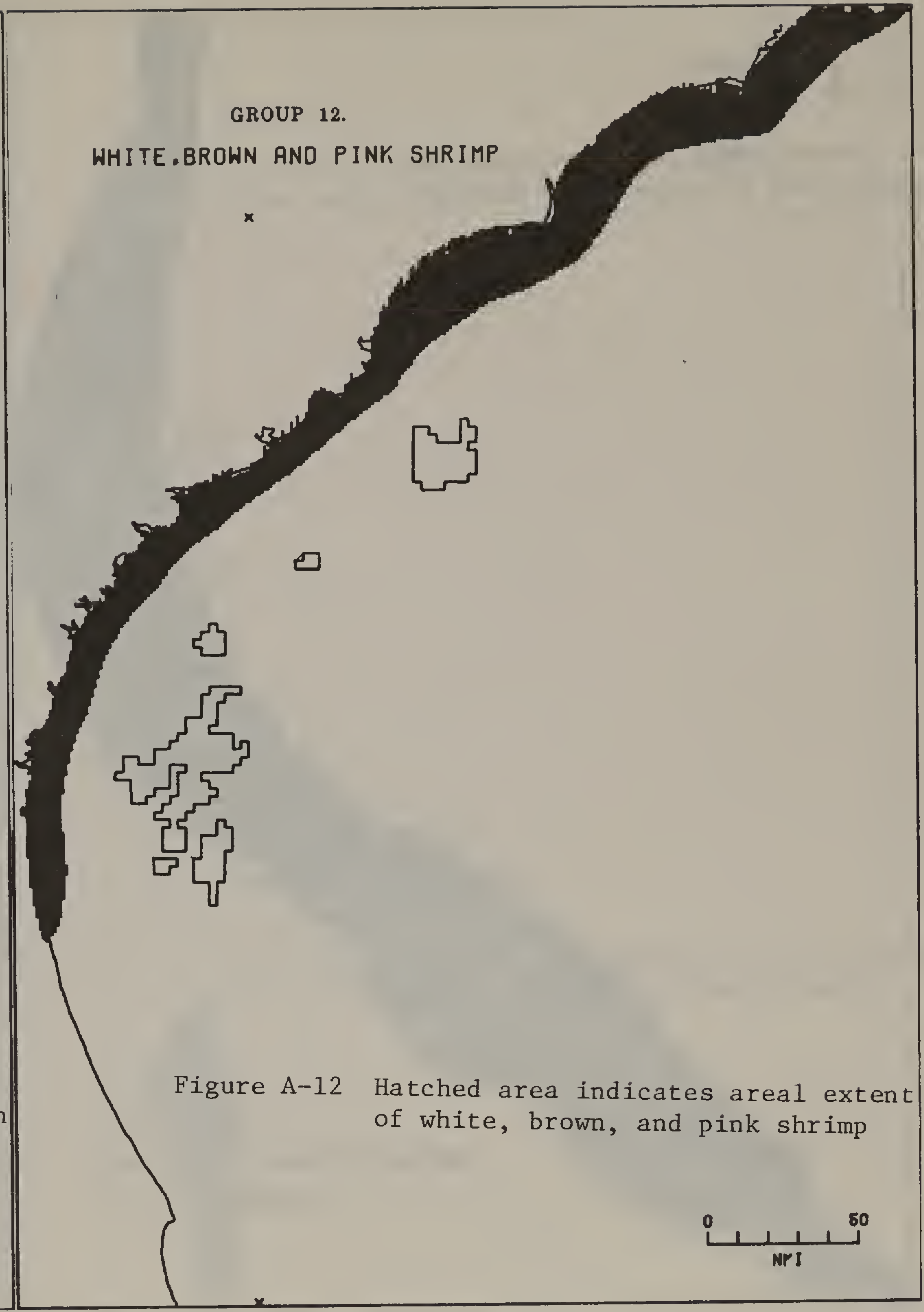

Figure A-12 Hatched area indicates areal extent of white, brown, and pink shrimp

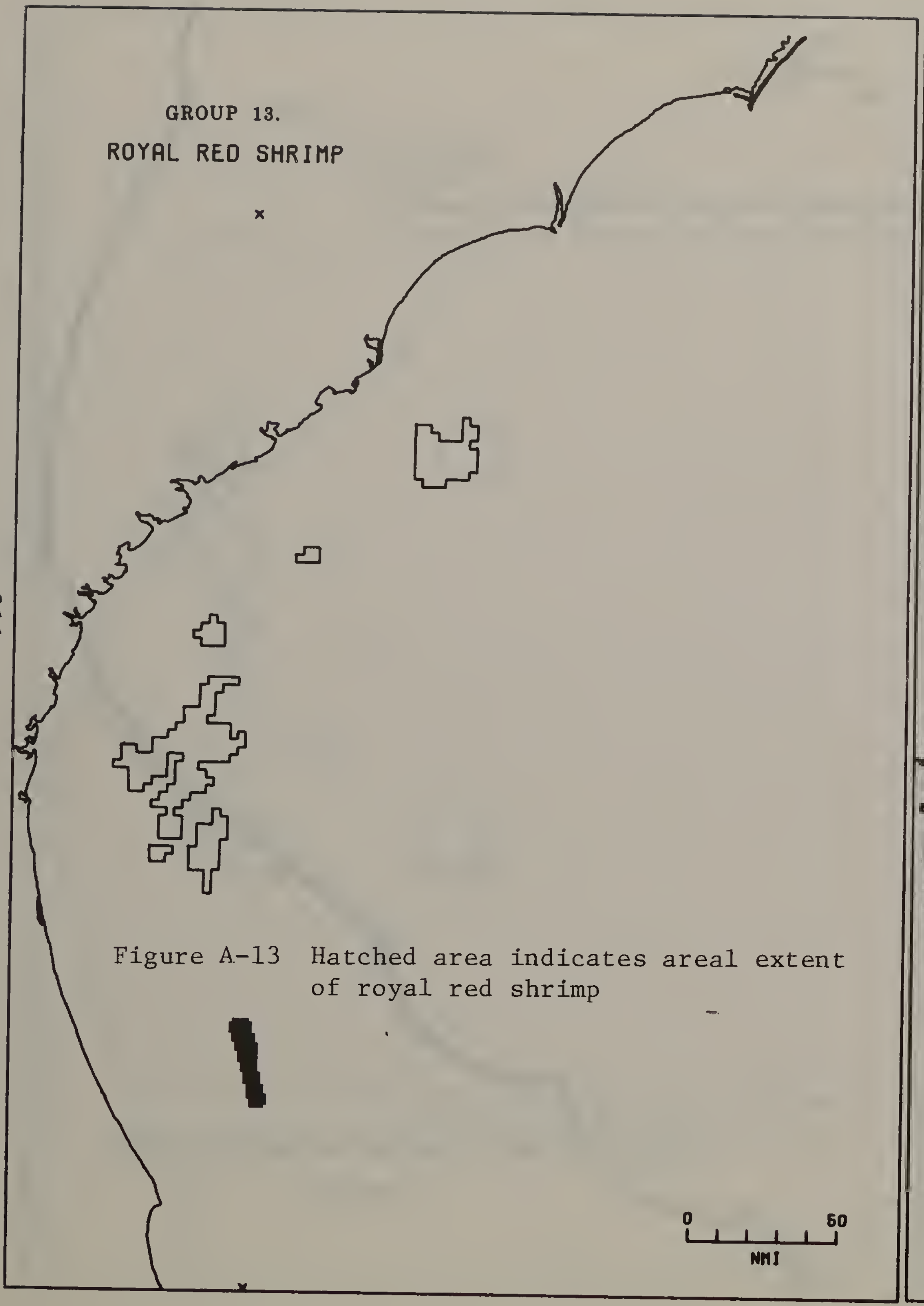

Figure A-13 Hatched area indicates areal extent of royal red shrimp

Figure A-14 Hatched area indicates areal extent of commercial fishing grounds

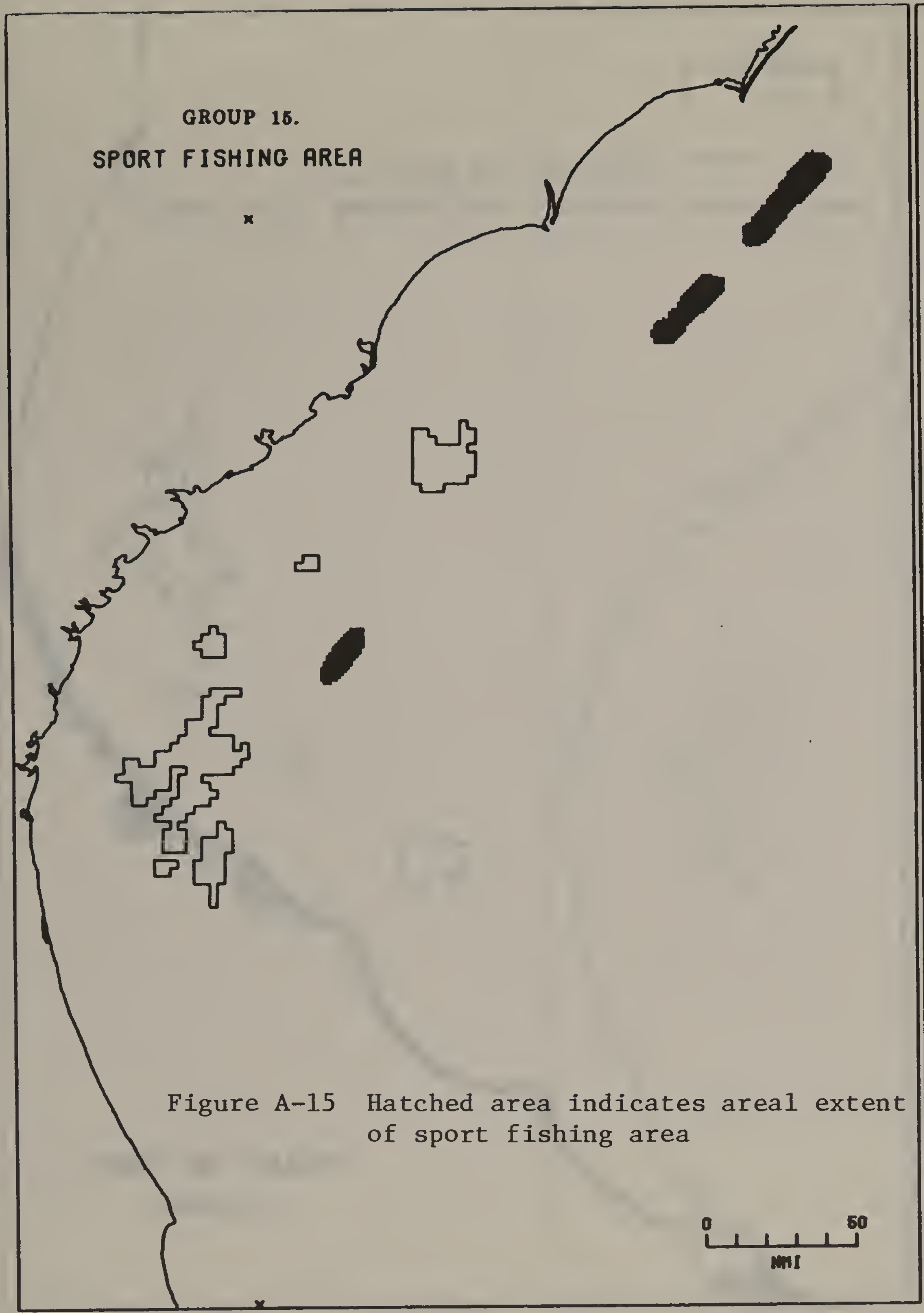

Figure A-15 Hatched area indicates areal extent of sport fishing area

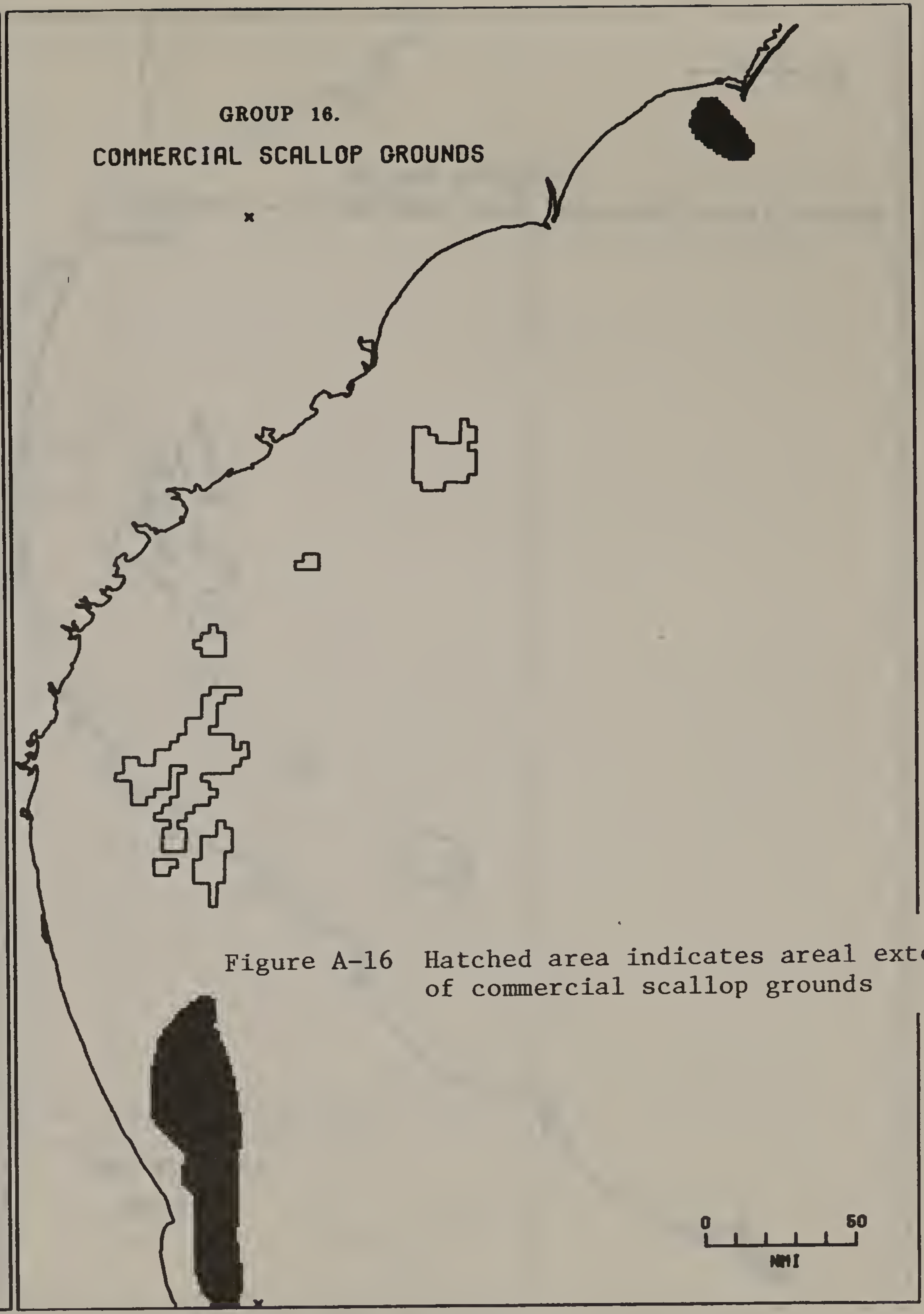

Figure A-16 Hatched area indicates areal extent of commercial scallop grounds

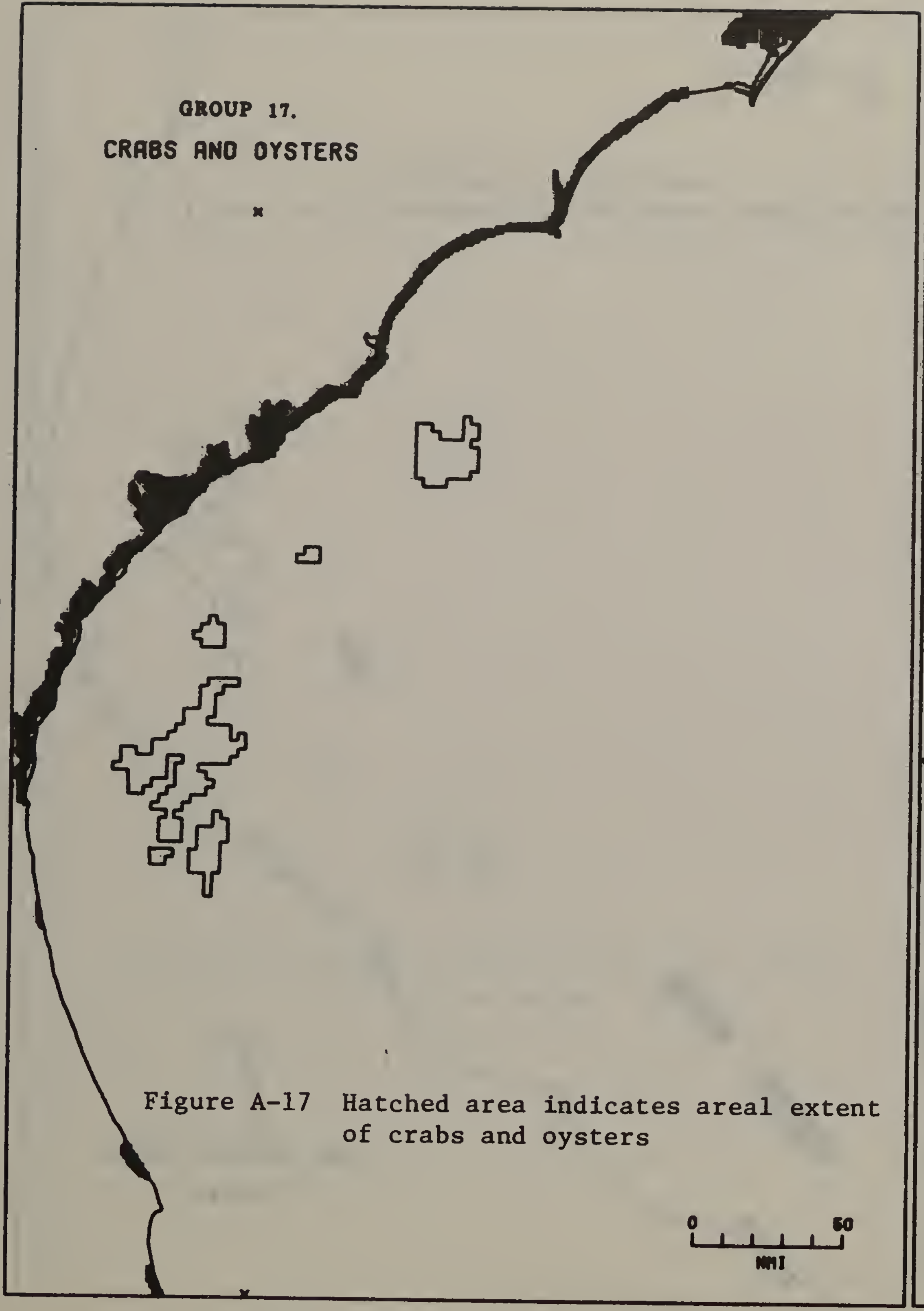

Figure A-17 Hatched area indicates areal extent of crabs and oysters

Figure A-18 Hatched area indicates areal extent of bay scallops

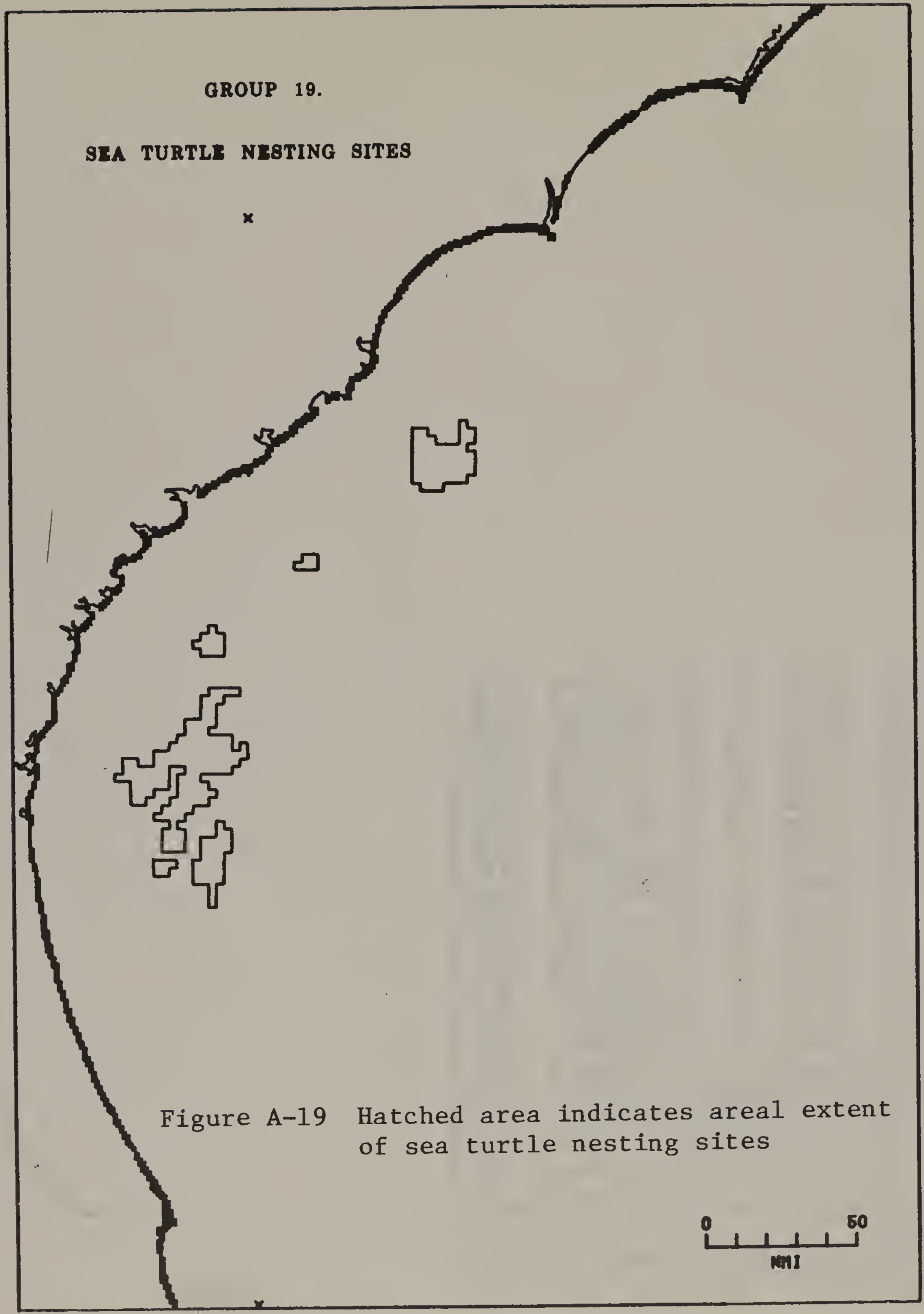

Figure A-19 Hatched area indicates areal extent of sea turtle nesting sites

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