
TRAN EPA-830569 F

United States
Environmental Protection
Agency

Office of Water
Criteria and Standards Division
Washington, DC 20460

EPA 440/2-83-014

FINAL

ENVIRONMENTAL IMPACT STATEMENT (EIS)
for
SAVANNAH, GA, CHARLESTON, SC AND
WILMINGTON, NC
OCEAN DREDGED MATERIAL DISPOSAL SITES DESIGNATION

OCTOBER 1983

U.S. ENVIRONMENTAL PROTECTION AGENCY
Criteria and Standards Division
Washington, D.C. 20460

SUMMARY SHEET

ENVIRONMENTAL IMPACT STATEMENT (EIS)
for
SAVANNAH, GA, CHARLESTON, SC, AND WILMINGTON, NC
OCEAN DREDGED MATERIAL DISPOSAL
SITES DESIGNATION

( ) Draft
(x) Final
( ) Supplement to Draft

ENVIRONMENTAL PROTECTION AGENCY
CRITERIA AND STANDARDS DIVISION

1. Type of action.

   (x) Administrative/Regulatory action
   ( ) Legislative action

2. Description of the proposed action.

The proposed action is the permanent designation of Savannah, Georgia, Charleston, South Carolina, and Wilmington, North Carolina Ocean Dredged Material Disposal Sites (ODMDS), to be managed by the U.S. Environmental Protection Agency (EPA), Region IV. The Existing Site at Savannah is square-shaped, centered at 31°56'54"N, 80°45'34"W, covers 4.26 nmi^2, and is approximately 17.3 nmi southeast of Savannah, Georgia. The Existing Savannah Site is proposed to receive permanent designation for the disposal of dredged material.

Two disposal sites are proposed to receive designation at Charleston, South Carolina. The Existing Site is parallelogram-shaped, centered at 32°38'55"N, 79°45'39"W, and covers 11.8 nmi^2. This site is proposed to receive designation only for the disposal of dredged materials resulting from the Charleston Harbor Deepening Project, upon its approval. The second proposed site, hereinafter referred to as the Alternative Charleston Site is square shaped, centered at 32°39'17"N, 79°45'53"W, and covers 3 nmi^2. The site is appproximately 10 nmi southeast of Charleston, South Carolina and is proposed to receive permanent designation for the disposal of dredged materials.

The recommended Alternative Wilmington Site is centered at 33°48'30"N, 78°02'54"W, and covers 2.9 nmi^2. The Alternative Wilmington Site is approximately 30 nmi south of Wilmington, North Carolina, and is proposed to receive permanent designation for the disposal of dredged materials.

The purpose of the action is to recommend environmentally acceptable ocean locations for the disposal of dredged materials which comply with the environmental impact criteria of the Ocean Dumping Regulations (40 CFR Parts 220-229).

3. Environmental effects of the proposed action.

Adverse environmental effects of the proposed action may include: (1) mounding, (2) smothering of the benthos, and (3) possible habitat alteration of the site. Adverse impacts within the site are unavoidable, but the disposal operations will be regulated to prevent unacceptable environmental degradation outside site boundaries.

4. Alternatives to the proposed action.

The alternatives to the proposed action are: (1) no action, which would allow the interim designation of the Existing Savannah

Charleston, and Wilmington Ocean Dredged Material Disposal Sites to expire in February 1983, after which use of the sites would be discontinued, or (2) designate ocean disposal sites other than those recommended e.g., new sites in the mid-shelf or shelf break regions.

5. Federal, state, public, and private organizations from whom comments have been requested:

Federal Agencies and Offices

Council on Environmental Quality
Department of Commerce
  Maritime Administration
  National Oceanic and Atmoshperic Administration
Department of Defense
  Army Corps of Engineers
  Department of the Navy
Department of Health and Human Services
Department of the Interior
  Bureau of Land Management
  Bureau of Outdoor Recreation
  Fish and Wildlife Service
  Geological Survey
Department of State
Department of Transportation
  Goast Guard
National Science Foundation

States and Municipalities

Georgia Department of Natural Resources
Georgia Ports Authority
Savannah Metropolitan Planning Commission
South Carolina Ports Authority
South Carolina Wildlife and Marine Resources Department
South Carolina Coastal Commission
North Carolina Department of Natural and Economic Resources
North Carolina Ports Authority
Cape Fear Council of Governments

Private Organizations

American Littoral Society
Audubon Society
Center for Law and Social Policy
Environmental Defense Fund, Inc.
National Academy of Sciences
National Wildlife Federation
Resources for the Future
Sierra Club
Water Pollution Control Federation
The Georgia Conservancy
South Carolina Environmental Coalition
Carolina Power and Light Co.

Academic/Research Institutions

Skidaway Institute of Oceanography
University of South Carolina
University of North Carolina
Duke University

6. The final statement has been officially filed with the Director, Office of Environmental Review, EPA.

7. Comments on the Final EIS are due within 30 days from the date of EPA's publication of Notice of Availability in the Federal Register which is expected to be ______ ______.

Comments should be addressed to:

Mr. Michael S. Moyer
Criteria and Standards Division (WH-585)
Environmental Protection Agency
401 M Street S.W.
Washington, DC 20460

Copies of the Final EIS may be obtained from:

Environmental Protection Agency
Criteria and Standards Division (WH-585)
Washington, D.C. 20460
202/245-3036

Environmental Protection Agency, Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

The Final EIS may be reviewed at EPA Headquarters (Room 2404) or Region IV, Atlanta, Georgia.

SUMMARY

This Environmental Impact Statement (EIS) considers permanent designation of a Savannah, Charleston, and Wilmington Ocean Dredged Material Site (SCW-ODMDS)*, and the designation of a site to receive the dredged materials from the proposed Charleston Harbor Deepening Project (see Figures S-1 to S-3)**. Potential alternative ocean areas considered for disposal of dredged materials are located in mid-Shelf and Shelf-break regions.

This EIS in an integral part of the Environmental Protection Agency (EPA) procedure for designating the use of ocean sites for disposal of dredged materials. Evaluations of the suitability of the SCW-ODMDS. and Alternative mid-Shelf and Shelf-break areas are based on environmental data presented in the main body of this report. This summary describes the major conclusions and recommendations presented in this EIS.

BACKGROUND

Savannah, Charleston, and Wilmington are the major ports of Georgia, South Carolina, and North Carolina, respectively, and support large shipping commerce (with volumes of 11, 9.5, and 7.4 million tons, respectively, in 1978). Consequently, maintenance of these ports for navigation is vital to the economy of the South Atlantic United States.

* Boundary coordinates of the Existing Savannah and Alternative Charleston and Wilmington ODMDS are.

Savannah	Charleston	Wilmington
31°55'53"N, 80°44'20"W	32°40'27"N, 79°47'22"W	33°49'42"N, 78°02'54"W
31°57'55"N, 80°46'48"W	32°39'04"N, 79°44'25"W	33°48'30"N, 78°01'20"W
31°57'55"N, 80°44'20"W	32°38'07"N, 79°45'03"W	33°47'24"N, 78°02'54"W
31°55'53"N, 80°46'48"W	32°39'30"N, 79°48'00"W	33°48'30"N, 78°04'16"W

** Boundary coordinates of the Charleston Harbor Deepening Site are:

32°38'06"N, 79°41'57"W
32°40'42"N, 79°47'30"W
32°39'04"N, 79°43'48"W
32°36"28"N, 79°45'39"W

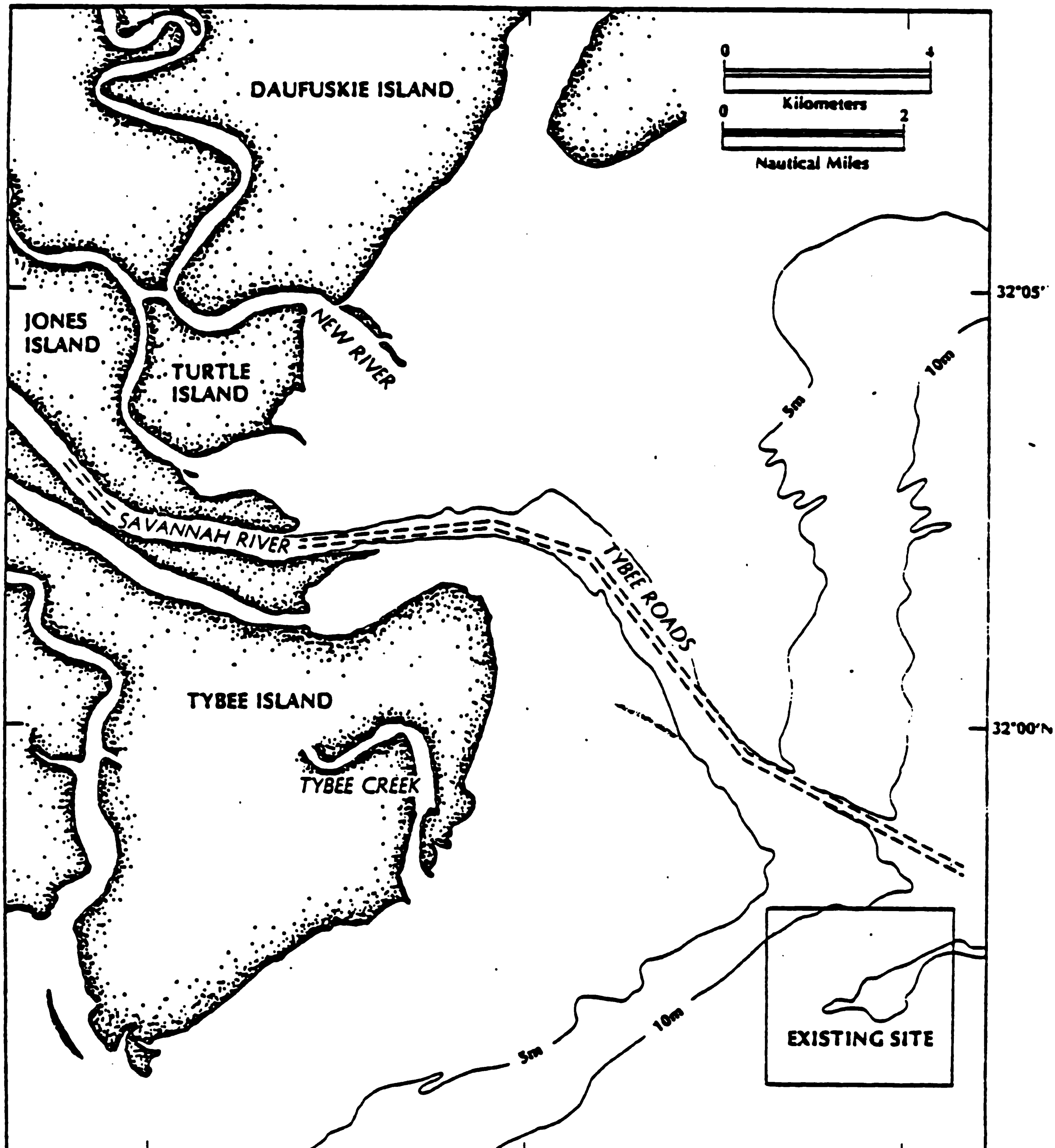

Figure S-1. Savannah ODMDS

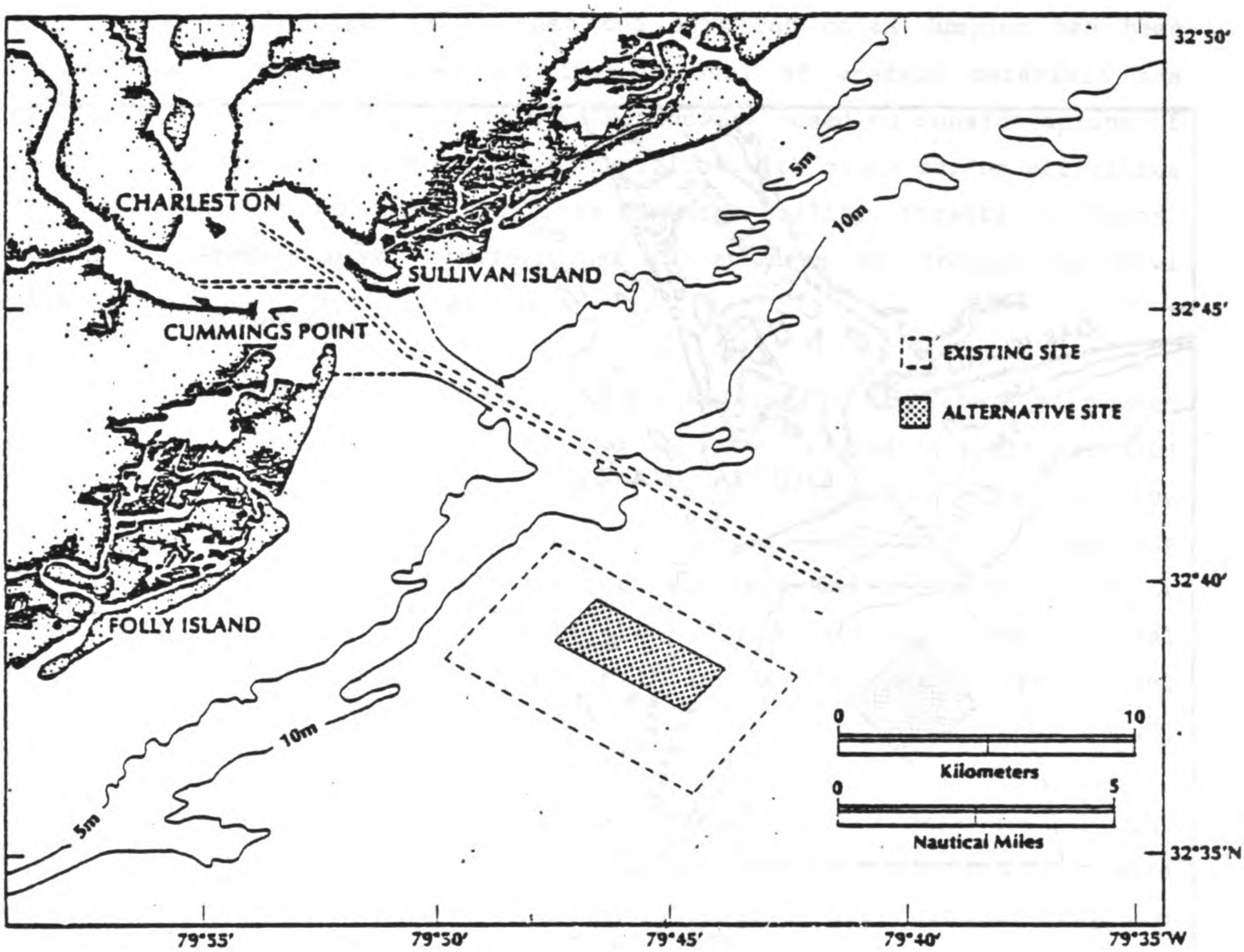

Figure S-2. Existing and Alternative Charleston ODMDS

Each year the entrance channels to Savannah, Charleston, and Wilmington Harbors must be dredged because natural processes cause them to shoal. Approximately 1 million yd^3 of sediments are dredged annually from the entrance channels to each harbor and dumped in ocean disposal sites adjacent to the respective dredging areas. Existing ocean dredged material disposal sites have been used since 1965.

SELECTION OF ALTERNATIVE SITES

The EPA and U.S. Army Corps of Engineers (CE) evaluate the need for and alternatives to ocean dumping according to Ocean Dumping Regulations

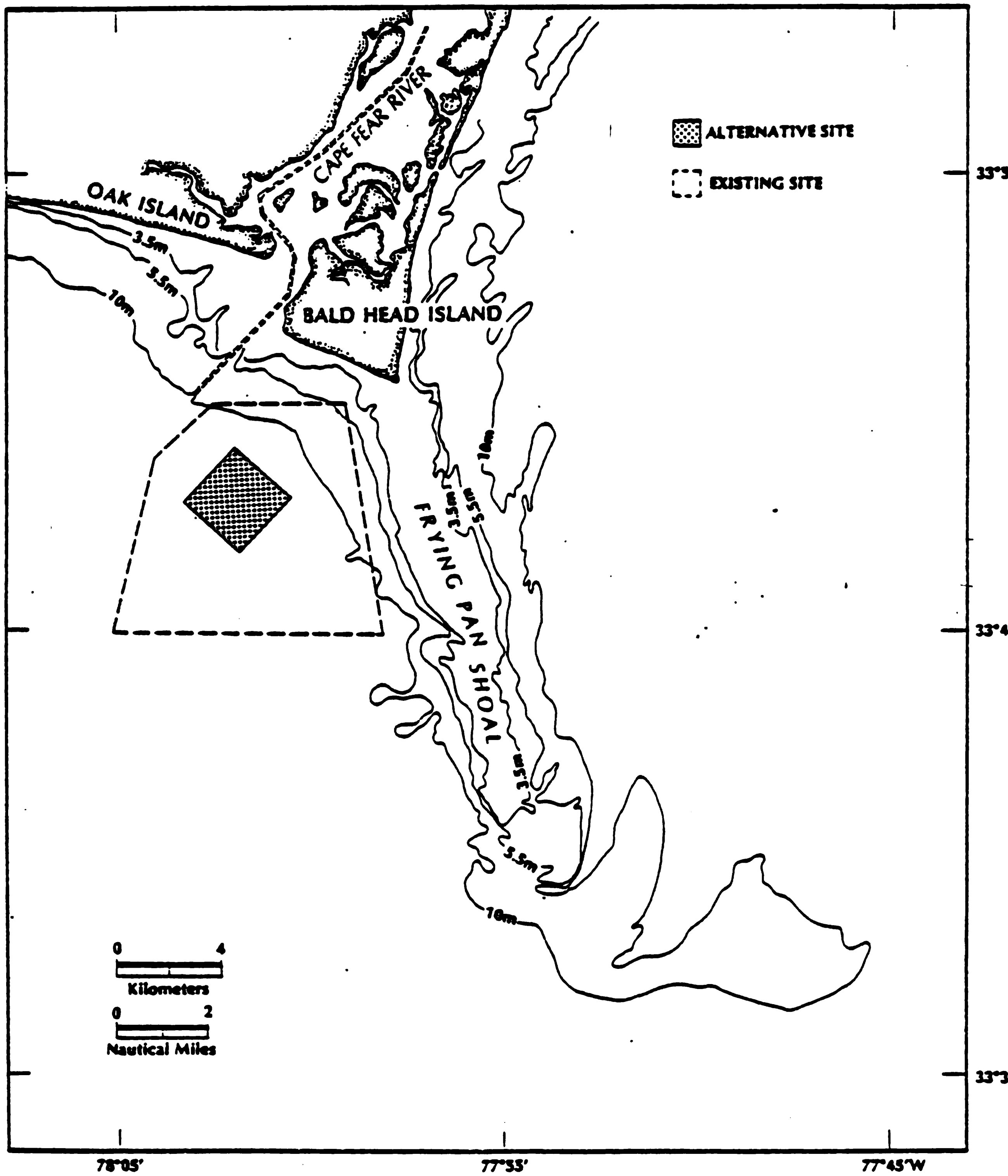

Figure S-3. Existing and Alternative Wilmington ODMDS

(40 CFR Part 227 Subpart C). When the need for ocean dumping has been established, potential sites for the disposal of dredged materials are evaluated. Criteria used for site selection are based on considerations of potential interferences by disposal operations with other marine activities and resources, potential perturbations of water quality, impacts on beaches or other amenity areas, previous use of an area of dredged material disposal, and geographic location.

The Existing Savannah, Charleston, and Wilmington ODMDS have been used since 1965 as primary disposal sites for sediment dredged from the entrance channels of Savannah, Charleston, and Wilmington Harbors. The Existing Savannah ODMDS is a 4.26 nmi^2 area, 3.7 nmi from shore. Existing Charleston and Wilmington ODMDS are both within 5 nmi of shore and cover areas of 11.8 and 29 nmi^2, respectively. The relatively large disposal site areas make site monitoring difficult and are not needed for present dredged material volumes.

The Proposed Alternative Wilmington ODMDS is a 2.9 nmi^2 area in the approximate center of the Existing Wilmington ODMDS. The new shoreward site boundary is 3 nmi from shore; thus, interferences with fishing and potential impacts on historical shipwrecks and nesting areas of endangered sea turtles would be minimized. The proposed Alternative Charleston ODMDS, located in the center of the Existing Charleston ODMDS, has an area of 3 nmi^2.

Dredged material disposal has not occurred previously in mid-Shelf or Shelf-break locations. Potential interferences with several resources and activities in mid-Shelf and Shelf-break areas are considered in Chapter 2. For example, hard-bottom reefs are scattered throughout the mid-Shelf and Shelf-break; reefs are unique habitats, support several species of commercially and recreationally important finfish, and are sensitive to the effects of dredged material disposal. Several proposed or active BLM oil and gas lease sites exist in mid-Shelf and Shelf-break regions.

Since 1972 dumping of dredged material in the ocean has been regulated by EPA. Section 102(a) of Title I of the Marine Protection, Research, and Sanctuaries Act (MPRSA) authorizes EPA to establish and apply criteria for reviewing and evaluating applications for permits for the dumping of materials into ocean waters. Section 103 of Title I requires the CE to consider in its evaluation of Federal projects and Section 103 permit applications the effects of ocean disposal of dredged material on human health amenities, the marine environment, ecological systems, and economic potentialities. Consequently, in 1977 EPA promulgated the Final Ocean Dumping Regulations and Criteria (40 CFR Parts 220 to 229), which approved the Existing Savannah, Charleston, and Wilmington ODMDS, and several other extant dredged material ocean disposal sites, for use on interim bases **"pending completion of baseline or trend assessment surveys and designation for continuing use or termination of use"** (40 CFR 228.12). Final designation of a site is based on compliance with specific criteria for site selection (40 CFR 228.6a), which ensures that disposal of dredged material will not degrade or endanger the marine environment and will not cause unacceptable human health effects or other permanent adverse effects. These criteria are used to assess potential effects caused by dredged material disposal at the SCW-ODMDS and Alternative mid-Shelf and Shelf-break areas (Chapter 2).

PROPOSED ACTION

After reviewing all reasonable alternatives, EPA and CE determined that ocean dumping at SCW-ODMDS offers an acceptable solution for disposal of dredged materials. The proposed action amends the 1977 interim designation of the EPA Ocean Dumping Regulations and Criteria by altering the boundaries of two sites and making final designations of each of the SCW-ODMDS. An additional action proposed in this EIS is the final designation of the existing interimly-designated Charleston Harbor Site to receive the dredged materials resulting from the proposed deepening project. The proposed actions do not exempt the use of these sites from additional environmental review, nor does it exempt the dredged materials from compliance with the Ocean Dumping Regulations and Criteria prior to disposal at a designated site.

The need for continual dredging in the Savannah, Charleston, and Wilmington Harbor areas has been demonstrated (Chapter 1). Taking no action towards final designation of the sites for continued use, or terminating their further use, would mean to refrain from designating an EPA-approved ocean site for dredged material disposal. The "No-Action" alternative is not considered acceptable. Land disposal or salt marsh disposal alternatives are not practical (Chapter 2). Ocean disposal of dredged materials is considered the most acceptable action for several reasons. The Existing Savannah, Charleston, and Wilmington ODMDS have been used for more than 15 years. Surveys of the disposal sites by Interstate Electronics Corporation (IEC) have not detected any substantial degradation of water or sediment quality or adverse impacts on the biota relative to adjacent control stations. Similarly, no adverse impacts to fishing, navigation, or other uses of the nearshore region have occurred. The proposed smaller Alternative Charleston and Wilmington ODMDS will facilitate site monitoring and minimize potential interferences from dumping with other uses of the respective nearshore regions.

In contrast, no previous dumping has occurred in mid-Shelf or Shelf-break areas. Consequently, the impacts of dumping in these regions are unknown. Few site specific data exist; predisposal data are needed so that subsequent site monitoring could detect environmental changes caused by dredged material disposal. No perturbations of water quality would be expected, although changes in sediment texture could result because dredged materials are not similar in composition to either mid-Shelf or Shelf-break sediments. Dumping might cause slight changes in the benthic community by smothering infauna. Monitoring and surveillance would be more difficult and expensive in mid-Shelf and Shelf-break areas because of deeper waters, higher frequency of rough weather, and paucity of site-specific data. Increased costs of disposal would also be appreciable because of the greater transport distances. Use of these areas during rough weather would be hazardous.

AFFECTED ENVIRONMENT

The nearshore region of each ODMDS is affected by river and salt marsh discharges and seasonal weather patterns. Nearshore waters are partially to completely mixed, turbid, and typically well-oxygenated. Sediments consist of fine-grained sands with variable amounts of fines and shell hash. Sediment resuspension and transport is frequent during winter storms. Benthic communities are composed of small-bodied species with short generation times, characteristic of unstable sand substrates. Several commercially- important finfish and shellfish species migrate through nearshore areas to the adjacent coastal estuaries.

The mid-Shelf environment is characteristically more stable than the nearshore region. Surface and bottom currents are generally sluggish, variable, and influenced by Gulf Stream intrusions and wind- and wave-induced currents. Surface and bottom waters are partially mixed, with high oxygen and low suspended sediment and nutrient concentrations. Episodic upwelling events occasionally supply nutrients to surface waters. Sediments consist of well-sorted, medium- to coarse-grained sand; sediment movement is infrequent. Biotic assemblages are characterized by low biomass, high diversity, and large seasonal variability. Commercially important nekton species are typically restricted to scattered reef areas.

Environmental characterisitics at the Shelf break are strongly influenced by the Gulf Stream. Surface waters are well-oxygenated with low suspended sediment and nutrients levels. Upwelling occasionally supplies dissolved nutrients to surface waters. Bottom sediments consist of poorly-sorted, fine sand and silt. Infaunal and epifaunal assemblages are heterogenous, associated with specific substrate types, and are characterized by low biomass and diversity. Commercially important demersal fish are associated with reef outcrops, while pelagic species occur in the Gulf Stream.

ENVIRONMENTAL CONSEQUENCES

The Existing Savannah, Charleston, and Wilmington ODMDS have been used since 1965. Dredged sediments are fine sands, with some silt and shell hash, which are chemically and texturally similar to disposal site sediments. Recent site surveys by IEC (Appendix A) detected no significant adverse effects to the water or sediment quality, or cumulative changes in the biota, which would be attributed to previous dumping. Concentrations of suspended particulate matter, trace metals, and organics in waters overlying each ODMDS were similar to those in adjacent controls stations, and typical of levels in uncontaminated nearshore waters. Similarily, sediment texture and sediment concentrations of trace metals and organics were characteristic of uncontaminated nearshore sediments. The dominant macrofauna and epifauna collected during the surveys were both seasonally and spatially variable. Large natural variabilities in species abundances obscured detection of possible impacts from previous dumping. Nevertheless, organisms collected during the surveys were characteristic of the variable, benthic communities present throughout the nearshore South Atlantic Bight.

Minor and temporary effects of dredged material disposal at the SCW-ODMDS may be limited to increases in suspended sediment concentrations, mounding, and smothering of benthic infauna. Nearshore waters are characteristically turbid, therefore increases in suspended particulate concentrations are considered insignificant. Persistent mounding or accumulation of sediments is precluded by sediment dispersion during winter storms. Bioassay and bioaccumulation tests of Charlestton and Wilmington dredged sediments demonstrate that the sediments are, in most cases, nontoxic to marine organisms in liquid, suspended particulate, and solid phases. Smothering of infaunal organisms is probably restricted to within site boundaries. Recolonization rates are dependent on larval recruitment and settling patterns and the abilities of infaunal organisms to burrow upward through deposited dredged material.

No previous dumping has occurred in mid-Shelf or Shelf-break areas. Therefore, the effects of dredged material disposal on the environment are speculative. No persistent changes in water quality would be expected; however, dredged material disposal may alter the existing sediment texture. No accumulation of toxic substances in bottom sediments would occur. Adverse impacts of dumping on biota would include smothering of infauna and alterations of the composition of benthic assemblages. No direct toxicity of dredged sediments to benthic organisms would be anticipated.

The possibility of emergency dumping on the mid-Shelf or outer Shelf may increase if offshore disposal sites were used. Interferences of dumping with fishing or navigation would not be expected, and no significant adverse impacts on aesthetics or public health and safety would occur, although use of offshore sites would incur a significantly greater economic burden because of the greater transport distances.

ORGANIZATION OF THE EIS

This EIS is organized as follows:

- Chapter 1 specifies the purpose and need for the proposed action, presents initial background information relevant to the dredging and disposal sites, and discusses the legal framework guiding EPA's selection and designation of disposal sites and the CE's responsibilities in ocean disposal of dredged material.

- Chapter 2 presents alternatives, including the proposed actions, the specific criteria used in evaluating alternatives, and applies the 11 site selection criteria to the SCW-ODMDS and Alternative mid-Shelf and Shelf-break areas.

- Chapter 3 describes the affected environment of the Alternative Sites and the history of dredged material disposal at Savannah, Charleston, and Wilmington ODMDS.

- Chapter 4 analyzes the environmental consequences of dredged material disposal at the SCW-ODMDS and Alternative mid-Shelf and Shelf-break areas.

Chapters 5 and 6 provide supplementary information. Chapter 5 lists the authors of the EIS. Chapter 6 contains a glossary and lists abbreviations and references cited in the text.

Appendix A presents results and discussions of the IEC survey data.

Appendix B presents comments on the DEIS and EPA's responses to these comments.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

ILLUSTRATIONS

CONTENTS (Continued)

TABLES

CONTENTS (Continued)

Chapter 1

PURPOSE OF AND NEED FOR ACTION

The ports of Savannah, Charleston, and Wilmington accommodate large volumes of domestic and foreign commodities, thus contributing to a major portion of the economies of Georgia, South Carolina, and North Carolina, respectively. Harbor access for deep-draft ships depends on annual dredging of the entrance channels and harbors. The action proposed in this EIS is the final designations of environmentally acceptable Savannah, Charleston, and Wilmington Ocean Dredged Material Disposal Sites.

The action proposed in this Environmental Impact Statement (EIS) is the permanent designation for continuing use of an Ocean Dredged Material Disposal Site (ODMDS) in the Savannah, Charleston, and Wilmington (SCW) areas. The EIS presents the information needed to evaluate the suitability of ocean disposal areas for final designation for continuing use and is based on one of a series of disposal site environmental studies. The environmental studies and final designation process are being conducted in accordance with the requirements of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), as amended (86 Stat. 1052, 33 USCA Part 1401 et seq.); the Environmental Protection Agency's (EPA) implementation of the Ocean Dumping Regulations and Criteria (40 CFR 220-229); and other applicable Federal environmental legislation.

The proposed action in this EIS is the permanent designation of the Existing (interim-designated) Savannah ODMDS and recommended Alternative Charleston and Wilmington ODMDS. The boundary coordinates of the Existing Savannah Site (Figure 1-1) are: 31°55'53"N, 80°44'20"W; 31°57'55"N, 80°46'48"W; 31°57°55"N, 80°44'20"W; 31°55'53"N, 80°46'48"W. The site is approximately 3.7 nmi offshore, has a average depth of 11.4m, and an area of 4.26 nmi^2. The boundary coordinates of the Alternative Charleston Site (Figure 1-2) are: 32°40'27"N, 79°47'22"W; 32°39'04"N, 79°44'25"W; 32°38'07"N, 79°45'03"W; 32°39'30"N, 79°48'00"W. The site is approximately 5 nmi offshore, has an average depth of 11m, and an area of 3.0 nmi^2. The boundary coordinates of the Alternative Wilmington Site (Figure 1-3) are: 33°49'42"N, 78°02'54"W; 33°48'30"N, 78°01'20"W; 33°47'24"N, 78°02'54"W; 33°48'30"N, 78°04'16"W. The site is approximately 3 nmi offshore, has an average depth of 13m, and an area of 3.0 nmi^2.

It is also proposed in this EIS that the Existing Site at Charleston be designated for the one-time disposal of dredged material resulting from the presently proposed harbor deepening project. The boundary coordinates of the Existing Site are: 32°38'06"N, 79°41'57"W; 32°40'42"N, 79°47'30"W; 32°39'04"N, 79°43'48"W; 32°36'28"N, 79°45'39"W. The site is 11.8 nmi^2 and has a average depth of about 11m.

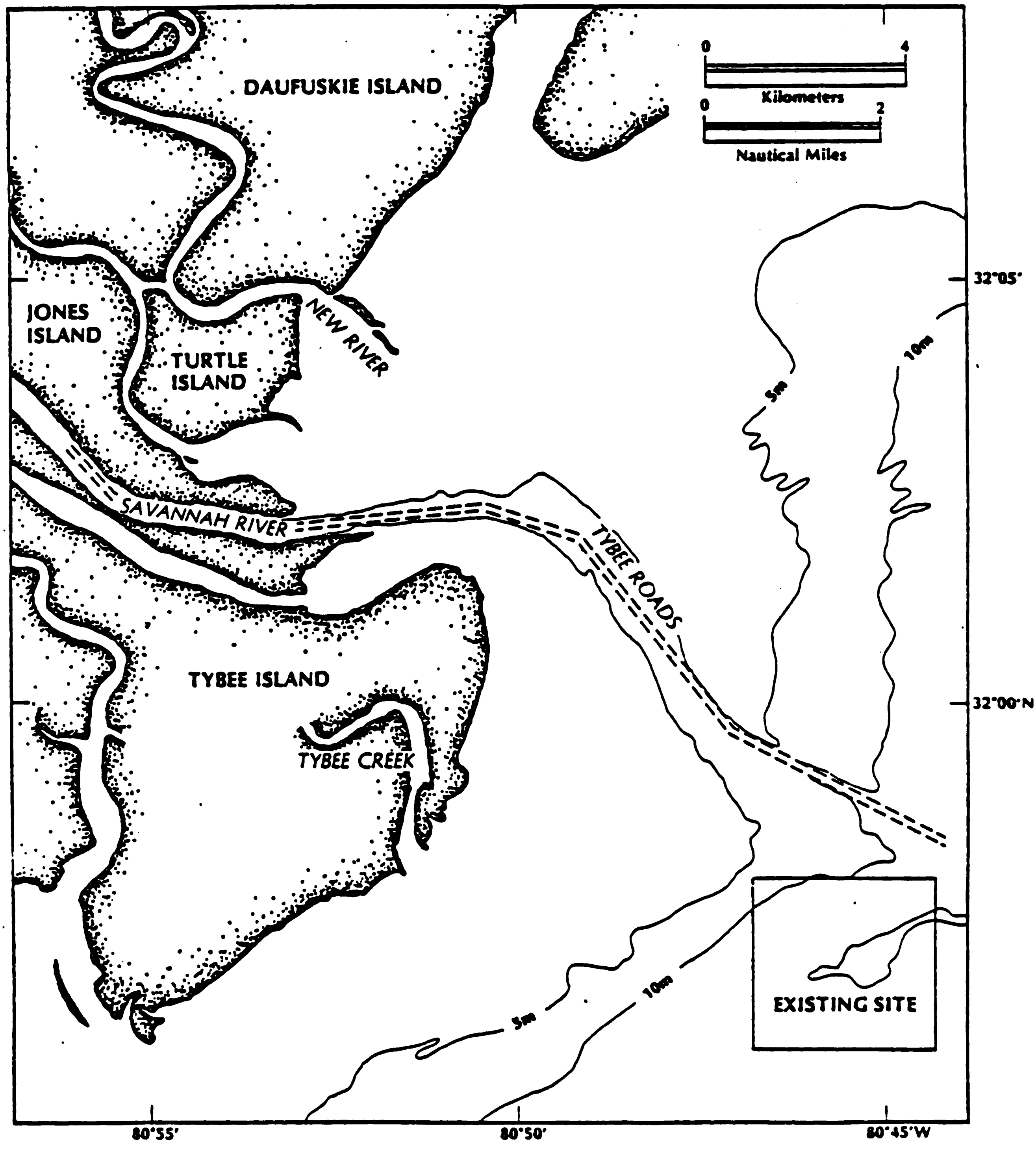

Figure 1-1. Savannah ODMDS

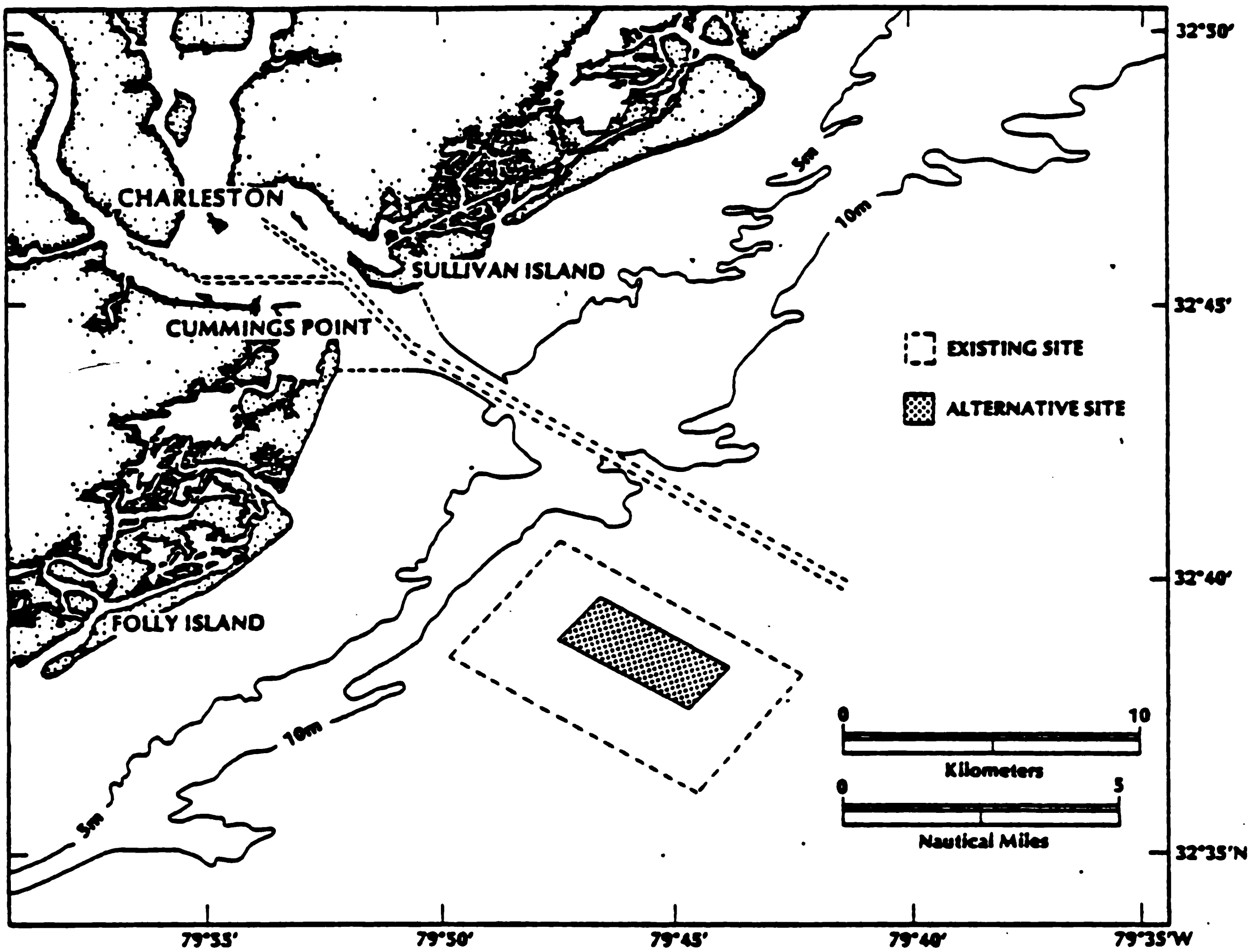

Figure 1-2. Charleston ODMDS

The Savannah, Charleston, and Wilmington ODMDS, as delineated above, would be designated for disposal of dredged material. The sites may be used for the disposal of dredged material only after evaluation of each Federal project or permit application has established that the disposal is within site capacity and in compliance with the criteria and requirements of EPA and the U.S. Army Corps of Engineers (CE) regulations. The Existing Charleston Harbor Site would be designated for the one-time disposal of up to about 28,000,000 yds^3 of dredged material resulting from the proposed Charleston Deepening Project. This proposed new work is described in the Corps of Engineers Environmental Impact Statement (CE, 1976) which evaluated the Existing Site as a disposal alternative. Use of the site for the one-time disposal would, of course, be dependent on approval of the deepening project. Upon completion of the disposal of the materials from the deepening project, the one-time designation would be depleted and the disposal site boundaries would revert back to the permanently designated alternative Charleston Site.

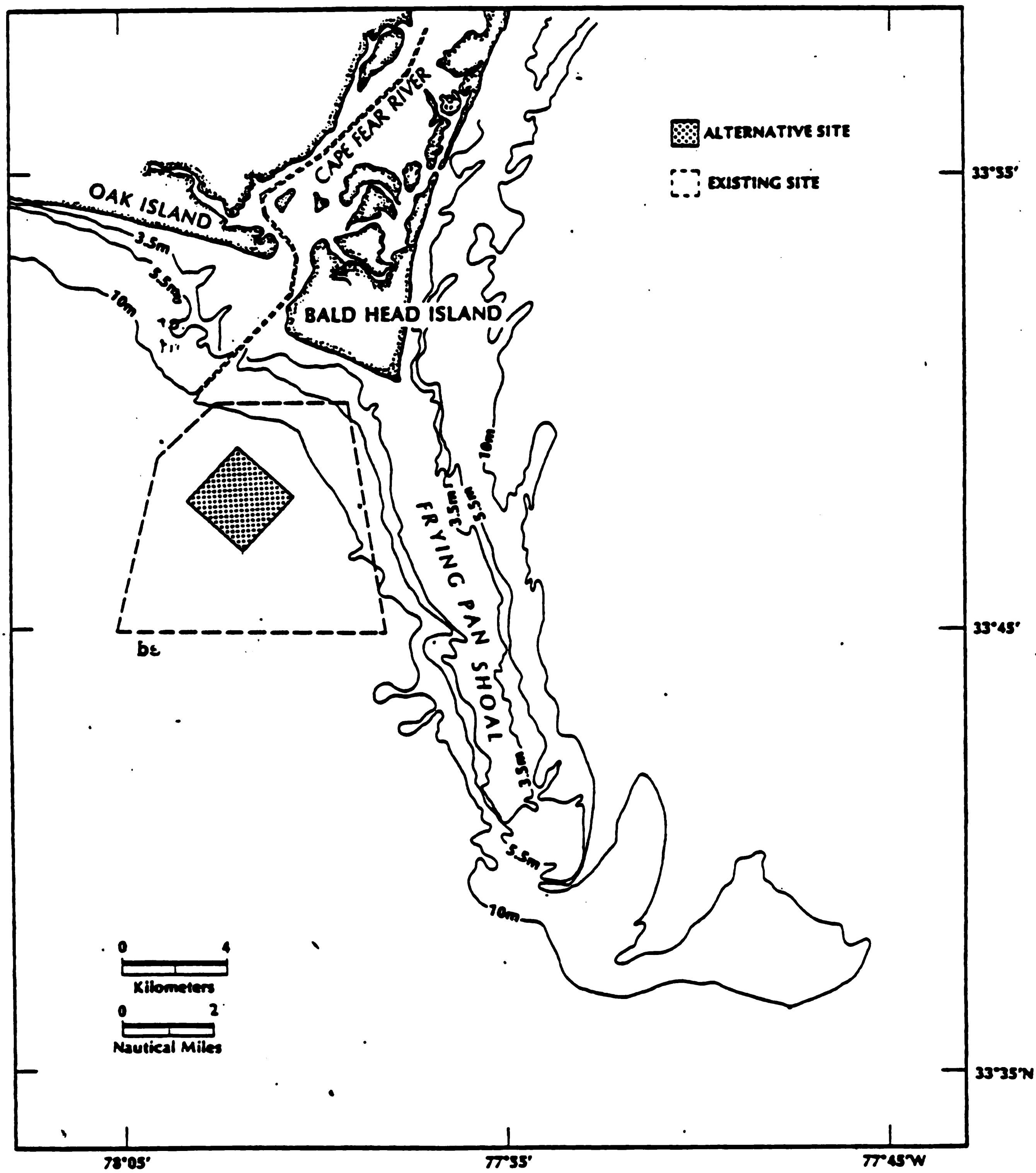

Figure 1-3. Wilmington ODMDS

PURPOSE AND NEED

MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

The MPRSA was enacted in October 1972. Congressional intent for this legislation as expressed in the act is:

> Sec. 2(b). The Congress declares that it is the policy of the United States to regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare, amenities, or the marine environment, ecological systems, or economic potentialities.
>
> (c). It is the purpose of this Act to regulate (1) the transportation by any person of material from the United States and, in the case of United States vessels, aircraft, or agencies, the transportation of material from a location outside the United States, when in either case the transportation is for the purpose of dumping the material into ocean waters, and (2) the dumping occurs in the territorial sea or the contiguous zone of the United States.

Title I of the MPRSA, which is the act's primary regulatory section, authorizes the Administrator of EPA (Section 102) and the Secretary of the Army acting through the CE (Section 103) to establish ocean disposal permit programs for nondredged and dredged materials, respectively. Title I also requires EPA to establish criteria, based on those factors listed in Section 102(a), for the review and evaluation of permits under the EPA and CE permit program. In addition, Section 102(c) of Title I authorizes EPA, considering criteria established pursuant to Section 102(a), to designate recommended ocean disposal sites or times for dumping of nondredged and dredged material.

CORPS OF ENGINEERS NATIONAL PURPOSE AND NEED

Section 103 of Title I requires the CE to consider in its evaluation of Federal projects and Section 103 permit applications the effects of ocean disposal of dredged material on human health, amenities, the marine environment, ecological systems, and economic potentialities. As part of this evaluation, consideration must be given to utilizing, to the extent feasible, ocean disposal sites designated by the EPA pursuant to Section 102(c). Since 1977 the CE has used those ocean disposal sites designated by EPA on an interim basis. Use of these interim-designated sites for ocean disposal has been an essential element of the CE's compliance with the requirements of the MPRSA and its ability to carry out its statutory responsibility for maintaining U.S. navigation waterways. To continue to maintain the Nation's waterways, the CE considers it essential that environmentally acceptable ocean disposal sites be identified, evaluated, and permanently designated for continued use pursuant to Section 102(c). These sites will be used after review of each project has established that the proposed ocean disposal of dredged material is in compliance with the criteria and requirements of EPA and CE regulations.

CORPS OF ENGINEERS LOCAL NEED

Savannah, Charleston, and Wilmington are the major ports of Georgia, South Carolina, and North Carolina, respectively, and support large shipping commerce (with a combined total of approximately 28 million tons in 1978) (CE, 1978). Maintenance of these ports is vital to the economy of the South Atlantic region.

Each year the entrance channels to Savannah, Charleston, and Wilmington harbors must be dredged because natural processes cause them to shoal. The CE is responsible for planning the maintenance dredging and conducting the necessary dredging and disposal operations. For CE's Savannah, Charleston, and Wilmington Districts to maintain the entrance channels of the respective harbors to their authorized depths, approximately 1 million yd^3 must be removed from each entrance channel on an annual basis.

The CE has requested the EPA to permanently designate ocean disposal sites suitable for continued disposal of dredged material from entrance channels to Savannah, Charleston, and Wilmington (not the upper channel) harbors. Studies conducted on these areas (CE, 1975, 1976, 1977) have indicated that non-ocean alternatives for disposal of dredged material are generally not available (see Chapter 2, "Land Disposal"). Additional O and M material are dredged from Charleston, Savannah and Wilmington projects Harbor and the Military Ocean Terminals Sunny Point, North Carolina, approximately in the quantities 4,6.5, 1.5, and 2 million yd^3/year, respectively. This material is currently going into diked disposal areas but could be disposed of at the ODMDS if it is shown to eet the appropriate requirements of the Ocean Dumping Regulations and Criteria.

EPA PURPOSE AND NEED

As previously stated, the CE has indicated a need for locating and designating environmentally acceptable ODMDS to carry out its responsibilities under the MPRSA and other Federal statutes. Therefore, in response to the CE's stated need, EPA, in cooperation with the CE, has initiated the necessary studies pursuant to the requirements of 40 CFR 228.4(e) to select, evaluate, and possibly designate the most suitable sites for the ocean disposal of dredged material. This document has been prepared to provide the public and decisionmakers with relevant information to assess the impacts associated with the final designation for three of the sites proposed for final designation, Savannah, Charleston, and Wilmington ODMDS. It is not anticipated that the CE will conduct any further environmental studies with respect to the selection of these sites.

INTERIM DUMPING SITES

On 11 January 1977, EPA promulgated final Ocean Dumping Regulations and Criteria to implement MPRSA. The Regulations set forth criteria and procedures for the selection and designation of ocean disposal sites. In addition, the regulations designated 129 ocean sites for the disposal of dredged material to allow the CE to fully comply with the purpose and procedural provisions of the MPRSA. These sites could be used for an interim period by the CE, pending completion of site designation studies as required by the Regulations. Use of the interim-designated sites by the CE would be dependent on compliance with the requirements and criteria contained in EPA's Ocean Dumping Regulations and Criteria.

Those sites given interim designation were selected by EPA in consultation with the CE, with the size and location of each site based on historic use. The interim designation would remain in force for a period not to exceed 3 years from the date of the final promulgation of the Regulations. However, due to the length of time required to complete the necessary environmental studies and operating restraints of both a technical and budgetary nature, environmental studies were not completed within the approved 3-year period.

As a result, the Regulations were amended in January 1980 to extand the interim designation for those sites currently under study for a period not to exceed 3 years, while the remaining sites' interim status was extended indefinitely pending completion of studies and determination of the need for continuing use.

SITE STUDIES

In mid-1977, EPA, by contract, initiated environmental studies on selected nondredged material disposal sites. The studies were designed to characterize the sites' chemical, physical, and biological features and to provide the data needed to evaluate the suitability of each site for continuing use. All studies are being conducted in accordance with the appropriate requirements of Part 228 of the EPA Ocean Dumping Regulations and Criteria. Results of these studies are being used in the preparation of an EIS for each site where such a statement is required by EPA policy. The CE, to assist EPA in its national program for locating and designating suitable sites for the ocean disposal of dredged materials, agreed in 1979 to join the contract effort by providing funds for field surveys to collect and analyze baseline data. Data from each field survey and other relevant information are being used by EPA in disposal site evaluation study and EIS's to ascertain the acceptability of an interim site and/or another site(s) for final designation. In addition to providing funds, the CE agreed to further assist EPA by providing technical review and consultation.

The EPA, in consultation with the CE, selected 25 areas containing 59 interim-designated ODMDS's for study under the EPA contract. Regional priorities and possible application of the data to similar areas were considered in this selection process. For some selected areas an adequate data base was found to exist; consequently, field studies for these areas were considered unnecessary for disposal site evaluation studies. For the remaining selected areas, it was determined that surveys would be required for an adequate data base to characterize the areas' physical, chemical, and biological features and to determine the suitability of one or more sites in these areas for permanent designation. Field surveys were initiated in early 1979 and were completed in mid-1981.

The studies are directed to the evaluation of alternative ocean disposal sites for the disposal of dredged material in an area. Based on the data from the disposal site evaluation study and other relevant information, an EIS will be prepared for each of the 25 selected areas. These EIS's only address those issues germane to the selection, evaluation, and final designation of environmentally acceptable ODMDS's. As a result, the data and conclusions contained in Chapters 2, 3, and 4 are limited to those significant issues relevant to site designation (i.e., analyses of impacts on site and adjacent area from the disposal of dredged material). Non-ocean disposal alternatives (e.g., upland, beach nourishment) are not addressed in the EIS's. However, in the event that non-ocean disposal alternatives have been previously addressed by Federal projects or Section 103 permit application EIS's, a summary of the results and conclusion is included in Chapter 2.

SITE DESIGNATION

In accordance with the EPA's Ocean Dumping Regulations and Criteria, site designation will be by promulgation through formal rulemaking. The decision by EPA to designate one or more sites for continuing use will be based on appropriate Federal statutes, disposal site evaluation study, EIS, supporting documentation and public comments on the Draft EIS, Final EIS, and the public notice issued as part of the proposed rulemaking.

In the event that one or more selected areas are deemed suitable for final designation, it is EPA's position that the site designation process, including the disposal site(s) evaluation study and the development of the EIS, fulfill all statutory requirements for the selection, evaluation, and designation of an ODMDS.

The EIS and supporting documents provide the necessary information to determine whether the proposed site(s) is suitable for final designation. In the event that an interim-designated site is deemed unacceptable for continuing use, the site's interim designation will be terminated and either the no-action alternative will be selected (no site being designated) or one or more alternative sites will be selected/designated. Furthermore, final site designation infers only EPA's determinations that the proposed site is suitable for the disposal of dredged material. Approval for use of the site will be determined only after review of each project to ensure that the proposed ocean disposal of dredged material is in compliance with the criteria and requirements of EPA and CE regulations.

LEGISLATION AND REGULATION BACKGROUND

FEDERAL LEGISLATION

Despite legislation dating back almost 100 years for the control of disposal into rivers, harbors, and coastal waters, ocean disposal of dredged material was not specifically regulated in the United States until passage of the MPRSA in October 1972. The first limited regulation was provided by the Supervisor of New York Harbor Act of 1888, which empowered the Supervisor (a U.S. Navy line officer) to prevent the illegal deposit of obstructive and injurious materials in New York Harbor, its adjacent and tributary waters, and Long Island Sound. In 1952 an amendment provided that the Secretary of the Army appoint a Corps of Engineers officer as Supervisor and, since that date, each New York District Engineer has automatically become the Supervisor of the Harbor. In 1958 an amendment extended the act to apply to the harbors of Hampton Roads, Virginia, and Baltimore, Maryland. Under the 1888 act, the Supervisor of the Harbor established sites in the Hudson River, Long Island Sound, and Atlantic Ocean for dumping certain types of materials. Further limited regulation was provided by the River and Harbor Act of 1899, which prohibited the unauthorized disposal of refuse into navigable waters (Section 13) and prohibited the unauthorized obstruction or alteration of any navigable water (Section 10).

The Fish and Wildlife Coordination Act was passed in 1958. Its purpose was "...to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs...." The law directed that water-resource projects, including channel deepening, be performed "with a view to the conservation of wildlife resources by preventing loss of and damage to such resources...." This was a first step towards concern for ocean areas. After the passage of this law, the CE (backed by judicial decisions) could refuse permits if the dredging or filling of a bay or estuary would result in significant unavoidable damage to the marine ecosystem.

Passage of the National Environmental Policy Act (NEPA) of 1969 (PL 91-190, 42 USC Parts 4321-4347, 1 January 1970) reflected public concern over the environmental effects of man's activities. Subsequently, particular attention was drawn to the effects of dredged materials by the River and Harbor Act of 1970 (PL 91-611). This act initiated a comprehensive nationwide study of dredged material disposal problems. Consequently, the CE established the Dredged Material Research Program (DMRP) in 1973, a 5-year, $30-million research effort. Objectives were (1) to understand why and under what conditions dredged material disposal might result in adverse environmental impacts, and (2) to develop procedures and disposal options to minimize adverse impacts (CE, 1977).

Two important acts were passed in 1972 that specifically addressed the control of waste disposal in aquatic and marine environments: (1) the Federal Water Pollution Control Act Amendments (FWPCA), later amended by the Clean Water Act of 1977, and (2) the MPRSA. Section 404 of the FWPCA established a permit program, administered by the Secretary of the Army acting through the Chief of Engineers, to regulate the discharge of dredged material into the waters of the United States (as defined at 33 CFR 323.2[a]). Permit applications are evaluated using guidelines jointly developed by EPA and the CE. Section 404(c) gives the EPA Administrator authority to restrict or prohibit dredged material disposal if the operation will have unacceptable adverse effects on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding grounds), wildlife, or recreational areas. Procedures to be used by EPA in making such a determination are found at 40 CFR 231.

MPRSA regulates the transportation and ultimate dumping of barged materials in ocean waters. The act is divided into three parts: Title I—Ocean Dumping, Title II—Comprehensive Research on Ocean Dumping, and Title III—Marine Sanctuaries. This EIS is concerned only with Title I of the act.

Title I, the primary regulatory section of MPRSA, establishes the permit program for the disposal of dredged and nondredged materials, mandates determination of impacts and alternative disposal methods, and provides for enforcement of permit conditions. The purpose of Title I is to prevent or strictly limit the dumping of materials that would unreasonably affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. Title I of the act provides procedures for regulating the transportation and disposal of materials into ocean waters under the jurisdiction or control of the United States. Any person of any nationality wishing to transport waste material from a U.S. port, or under a U.S. flag, to be dumped anywhere in the oceans of the world, is required to obtain a permit.

Title I prohibits the dumping into ocean waters of certain wastes, including radiological, biological, or chemical warfare agents, and all high-level radioactive wastes. In March 1974, Title I was amended (PL 93-253) to bring the act into full compliance with the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, discussad below under "International Considerations." The provisions of Title I include a maximum criminal fine of $50,000 and jail sentence of up to 1 year for every unauthorized dump or violation of permit requirements, or a maximum civil fine of $50,000. Any individual may seek an injunction against an unauthorized dumper with possible recovery of all costs of litigation.

FEDERAL CONTROL PROGRAMS

Several Federal departments and agencies participate in the implementation of MPRSA requirements, with the lead responsibility given to EPA (Table 1-1). In October 1973, EPA implemented its responsibility for regulating ocean dumping under MPRSA by issuing the Final Ocean Dumping Regulations and Criteria (hereinafter "the Regulations" or "Ocean Dumping Regulations") which were revised in January 1977 (40 CFR 220-229). The Ocean Dumping Regulations established the procedures and criteria to apply for dredged material permits (Part 225), enforce permit conditions (Part 226), evaluate permit applications for environmental impact (Part 227), and designate and manage ocean disposal sites (Part 228).

TABLE 1-1
RESPONSIBILITIES OF FEDERAL DEPARTMENTS AND AGENCIES FOR REGULATING OCEAN DISPOSAL UNDER MPRSA

Department/Agency	Responsibility
U.S. Environmental Protection Agency	Issuance of waste disposal permits, other than for dredged material Establishment of criteria for regulating waste disposal Enforcement actions Site designation and management Overall ocean disposal program management Research on alternative ocean disposal techniques
U.S. Department of the Army Corps of Engineers	Issuance of permits for transportation of dredged material for disposal Recommendation of disposal site locations
U.S. Department of Transportation Coast Guard	Surveillance Enforcement support Issuance of regulations for disposal vessels Review of permit applications
U.S. Department of Commerce National Oceanic and Atmospheric Administration	Long-term monitoring and research Comprehensive ocean dumping impact and short-term effect studies Marine sanctuary designation
U.S. Department of Justice	Court actions
U.S. Department of State	International agreements

OCEAN DUMPING EVALUATION PROCEDURES

The Ocean Dumping Regulations specify the procedures for evaluating the effects of dredged material disposal. The EPA and CE evaluate Federal projects and permit applications for non-Federal projects to determine (1) whether there is a demonstrated need for ocean disposal and that other environmentally sound and economically reasonable alternatives do not exist (40 CFR 227 Subpart C), and (2) compliance with the environmental impact criteria (40 CFR 227 Subparts B, D, and E). Figure 1-4 outlines the cycle used to evaluate the acceptability of dredged material for ocean disposal.

Under Section 103 of MPRSA, the Secretary of the Army is given the authority, with certain restrictions, to issue permits for the transportation of material dredged from non-CE projects for ocean disposal. For Federal projects involving dredged material disposal, Section 103(e) of MPRSA provides that "the Secretary [of the Army] may, in lieu of the permit procedure, issue regulations which will require the application to such projects of the same criteria, other factors to be evaluatad, the same procedures, and the same requirements which apply to the issuance of permits..." for non-Federal dredging projects involving disposal of dredged material. Consequently, both Federal and non-Federal dumping requests undergo identical regulatory reviews. The only difference is that, after the review and approval of the dumping request, non-Federal projects are issued an actual permit. The CE is responsible for evaluating disposal applications and granting permits to dumpers of dredged materials; however, dredged material disposal sites are designated and managed by the EPA Administrator or his designee. Consequently, dredged material generated by Federal and non-Federal projects must satisfy the requirements of the MPRSA (as detailed in the Ocean Dumping Regulations) to be acceptable for ocean disposal.

ENVIRONMENTAL IMPACT CRITERIA

Section 103(a) of the MPRSA states that dredged material may be dumped into ocean waters after determination that "the dumping will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, or economic potentialities." This applies to the ocean disposal

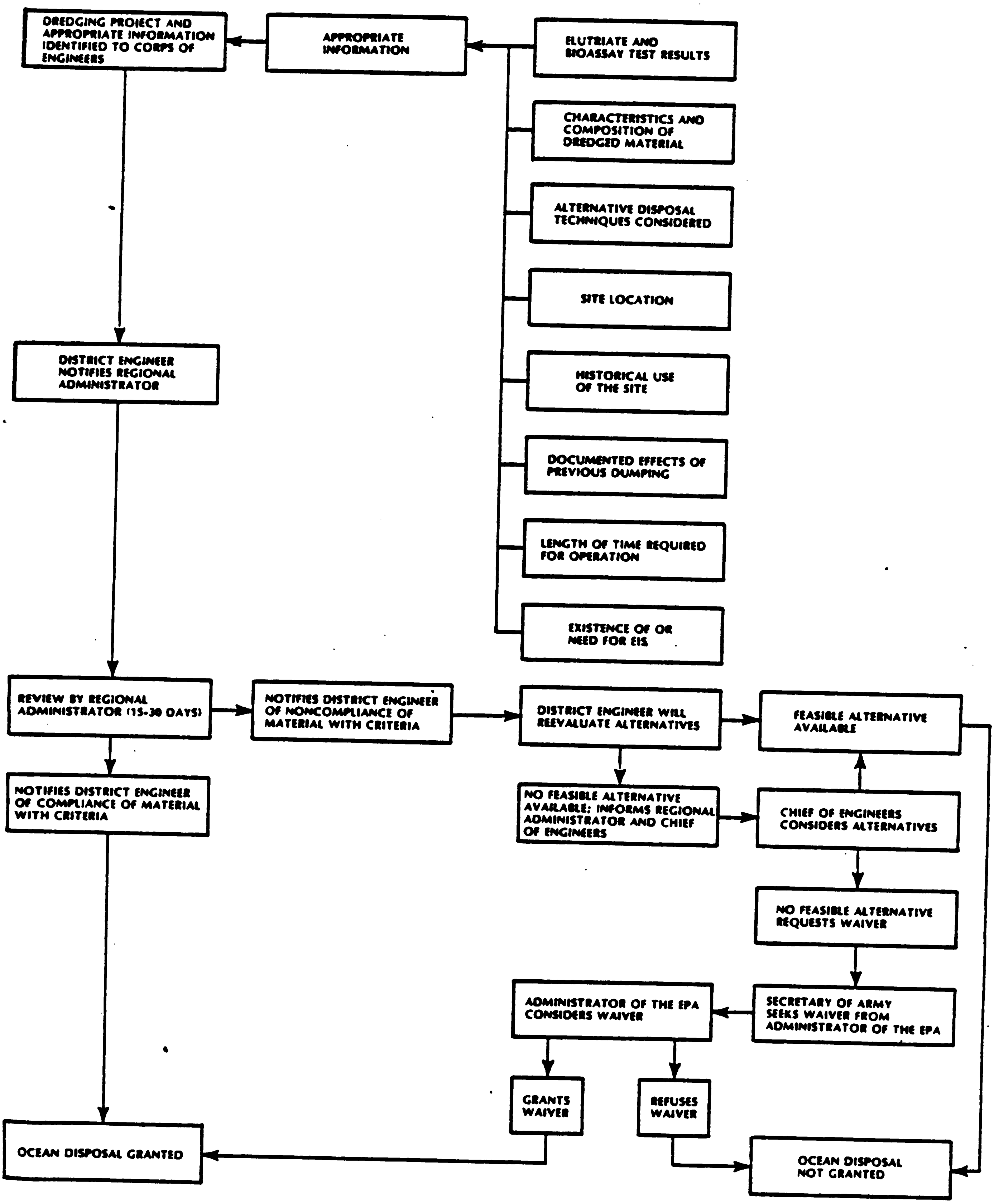

Figure 1-4. Dredged Material Evaluation Cycle

of dredged materials from both Federal and non-Federal projects. To ensure that dumping in the ocean will not unreasonably degrade or endanger public health and the marine environment, the Ocean Dumping Regulations restrict the transportation of all materials for dumping, specifically:

- Prohibited materials: High-level radioactive wastes; materials produced or used for radiological, chemical, or biological warfare; materials insufficiently described to apply the Criteria (40 CFR 227); and persistent inert synthetic or natural materials which float or remain suspended and interfere with fishing, navigation, or other uses of the ocean.

- Constituents prohibited as other than trace contaminants: Organohalogens; mercury and mercury compounds; cadmium and cadmium compounds; oil; and known or suspected carcinogens, mutagens, or teratogens.

- Strictly regulated materials: Liquid waste constituents immiscible with or slightly soluble in seawater (e.g., benzene), radioactive materials, wastes containing living organisms, highly acidic or alkaline wastes, and wastes exerting an oxygen demand.

Dredged material is environmentally acceptable for ocean disposal without further testing if it satisfies any one of the following criteria:

- Dredged material is composed predominantly of sand, gravel, rock, or any other naturally occurring bottom material with particle sizes larger than silt, and the material is found in areas of high current or wave energy...

- Dredged material is for beach nourishment or restoration and is composed predominantly of sand, gravel, or shell...

- When: (i) the material proposed for dumping is substantially the same as the substrate at the proposed disposal site; and (ii) the [proposed dredging] site...is far removed from known existing and historical sources of pollution so as to provide reasonable assurance that such material has not been contaminated by such pollution. (40 CFR 227.13[b])

If dredged material does not meet the above criteria, then further testing of the liquid, suspended particulate, and solid phases is required. The Ocean Dumping Regulations require that the liquid phase "not contain... constituents in concentrations which will exceed applicable marine water quality criteria after allowance for initial mixing" (40 CFR 227.6), and that "bioassays on the liquid phase of the dredged material show that it can be discharged so as not to exceed the limiting permissible concentration..." (40 CFR 227.13).

The suspended particulate and solid phases must be tested using bioassays which can demonstrate that dredged materials will not cause the "occurrence of significant mortality or significant adverse sublethal effects including bioaccumulation due to the dumping..." and that the dredged material "can be discharged so as not to exceed the limiting permissible concentration...." The bioassays ensure that "no significant undesirable effects will occur due either to chronic toxicity or to bioaccumulation." The required testing ensures that dredged material contains only constituents which are:

> (1) present in the material only as chemical compounds or forms (e.g., inert insoluble solid materials) non-toxic to marine life and non-bioaccumulative in the marine environment upon disposal and thereafter, or (2) present in the material only as chemical compounds or forms which, at the time of dumping and thereafter, will be rapidly rendered non-toxic to marine life and non-bioaccumulative in the marine environment by chemical and biological degradation in the sea; provided they will not make edible marine organisms unpalatable; or will not endanger human health or that of domestic animals, fish, shellfish, or wildlife. (40 CFR 227.6)

PERMIT ENFORCEMENT

Under MPRSA the Commandant of the U.S. Coast Guard (USCG) is assigned responsibility by the Secretary of Transportation to conduct surveillance of disposal operations to ensure compliance with the permit conditions and to discourage unauthorized disposal. Alleged violations are referred to EPA for appropriate enforcement. Civil penalties include a maximum fine of $50,000; criminal penalties involve a maximum fine of $50,000 and/or a 1-year jail term. Where administrative enforcement action is not appropriate, EPA may request the Department of Justice to initiate relief actions in court for violations of the terms of MPRSA. Surveillance is accomplished by means of spot checks of dump vessels for valid permits, interception or escorting of dump vessels, use of shipriders, and aircraft overflights during dumping.

The Commandant of the Coast Guard has published guidelines for ocean dumping surveillance and enforcement in Commandant Instruction 16470.2B, dated 29 September 1976. An enclosure to the instruction is an Interagency Agreement between the CE and the USCG regarding surveillance and enforcement responsibilities over federally contracted ocean dumping activities associated with Federal Navigation Projects. Under the agreement, the CE "recognizes that it has the primary surveillance and enforcement responsibility over these activities." The CE directs and conducts the surveillance effort over CE contract dumpers engaged in ocean disposal activities, except in New York and San Francisco; the USCG retains primary responsibility for surveillance in these two areas. In all other areas, the USCG will respond to specific requests from the CE for surveillance missions. The USCG retains responsibility for surveillance of all dredged material ocean dumping activities that are not associated with Federal Navigation Projects.

OCEAN DISPOSAL SITE DESIGNATION

EPA is conducting intensive studies of various disposal sites in order to determine their acceptability. The agency has designated a number of existing disposal sites for use on an interim basis until studies are completed and formal designation or termination of each site is decided (40 CFR 228.12, as amended 16 January 1980, 45 FR 3053).

Under Section 102(c) of MPRSA, EPA is authorized to designate sites and times for ocean disposal of acceptable materials. Therefore, EPA established criteria for site designation in the Regulations. These include general and specific criteria for site selection and procedures for designating the sites for disposal. If it appears that a proposed site can satisfy the general criteria, then the specific criteria for site selection will be considered. Once designated, the site may be monitored for adverse disposal impacts. The criteria for site selection and monitoring are detailed in Chapter 2.

INTERNATIONAL CONSIDERATIONS

The principal international agreement governing ocean dumping is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention), which became effective in August 1975, upon ratification by 15 contracting countries including the United States (26 UST 2403: TIAS 8165). There are now 47 contracting parties. Designed to control dumping of wastes in the ocean, the Convention specifies that contracting nations will regulate disposal in the marine environment within their jurisdiction and prohibit disposal without permits. Certain hazardous materials are prohibited (e.g., radiological, biological, and chemical warfare agents, and high-level radioactive matter). Certain other materials (e.g., cadmium, mercury, organohalogens and their compounds; oil; and persistent, synthetic, or natural materials which float or remain in suspension) are also prohibited as other than trace contaminants. Other materials (e.g., arsenic, lead, copper, zinc, cyanides, fluorides, organo-silicon, and pesticides) are not prohibited from ocean disposal, but require special care. Permits are required for ocean disposal of materials not specifically prohibited. The nature and quantities of all ocean-dumped material, and the circumstances of disposal, must be periodically reported to the Inter-Governmental Maritime Consultative Organization (IMCO), which is responsible for administration of the Convention.

U.S. ocean dumping criteria are based on the provisions of the London Dumping Convention (LDC) and include all the considerations listed in Annexes I, II, and III of the LDC. Agreements reached under the LDC also allow exclusions from biological testing for dredged material from certain locations. These agreements are also reflected in the U.S. ocean dumping criteria. Thus, when a material is found to be acceptable for ocean dumping under the U.S. ocean dumping criteria, it is also acceptable under the LDC.

Chapter 2

ALTERNATIVES INCLUDING THE PROPOSED ACTION

Alternative sites for ocean disposal of dredged material from Savannah, Charleston, and Wilmington Harbors are discussed herein. The 11 specific site selection criteria listed in 40 CFR 228.6 are the bases for comparing the environmental impacts associated with disposal at each alternative site. Minor environmental impacts resulting from previous disposal of dredged materials at the Existing Savannah, Charleston, and Wilmington ODMDS consist of temporary sediment accumulation, smothering of benthic organisms, and increases in turbidity and suspended sediment concentrations. Impacts associated with use of mid-Shelf and Shelf-break disposal areas are generally unknown, although potentials exist for temporary increases in turbidity, alteration of sediment texture, and smothering of benthic organisms. The SCW-ODMDS are environmentally and economically acceptable for dredged material disposal. On the basis of previous use and the absence of significant adverse impacts, EPA proposes permanent designation of the Existing Savannah and Alternative Charleston and Wilmington Ocean Dredged Material Disposal Sites and the final designation of the Existing Charleston Site to receive harbor deepening material.

The proposed actions (described in Chapter 1) are the permanent designation of the Existing Savannah and Alternative Charleston and Wilmington ODMDS, and the final designation of the Existing Charleston Harbor ODMDS to receive materials from the proposed Deepening Project. The decision to reduce the Charleston and Wilmington sites is based on past and anticipated dredging activities in the respective areas. The proposed reduced size of each is sufficient for the expected disposal volumes, and a smaller area facilitates monitoring activities. In addition, the proposed smaller sites are located a safer distance from shore. Alternatives to the proposed action include no action and use of alternative ocean disposal sites. Alternative ocean disposal areas in nearshore, mid-Shelf, and Shelf-break regions are considered; evaluations and comparisons of the proposed and alternative disposal sites are based on 11 specific site selection criteria listed at 40 CFR 228.6 (Ocean Dumping Regulations). Additional recommendations for use and monitoring of the ocean dredged materials disposal sites are discussed in this chapter.

NO-ACTION ALTERNATIVE

The no-action alternative to the proposed action would be refrain from designating an EPA-approved ocean site for the disposal of dredged material from Savannah, Charleston, and Wilmington areas. Existing sites are currently designated on an interim bases. Interim designations are scheduled to expire in February 1983, unless formal rulemaking is completed earlier, that either (1) designates the interim (existing) sites for continuing use, or (2) selects and designates alternative sites.

By taking no action, the present ocean sites would not receive final designation, nor would alternative ocean disposal sites be designated. Consequently, the CE would not have EPA-recommended ocean disposal sites available in these areas, thus precluding ocean dumping as a disposal method for dredged material at these sites. Therefore, the CE would be required to either: (1) justify an acceptable alternative disposal method (e.g., land based), or (2) develop information sufficient to select acceptable ocean sites for disposal, or (3) modify or cancel a proposed dredging project that depends on disposal in the ocean as the only feasible method for the disposal of dredged material.

As discussed below, results of CE studies indicated that land-based disposal is not feasible for the Savannah, Charleston, and Wilmington dredging projects, and demonstrated the need for ocean disposal. Based on theses factors the "No-Action" alternative is not considered to be an acceptable alternative to the proposed action.

LAND-BASED DISPOSAL

The subject of land-based disposal of any other feasible alternatives mentioned in the Ocean Dumping Regulations and Criteria (40 CFR 227.15) are not being permanently set aside in favor of ocean disposal. The need for ocean dumping must be demonstrated each time an application for ocean disposal is made. At that time, the availability of other feasible alternatives must be assessed. Land-based and ocean disposal methods are currently used for materials dredged from the inner habors and entrance channels to Savannah, Charleston, and Wilmington Harbors.

The Savannah CE (Brown, personal communication*) examined the land disposal alternative and concluded the following:

> Several alternatives to ocean dumping have been considered. The dredged material from the bar channel could be pumped to existing upland disposal areas near the mouth of Savannah Harbor. However, these areas are used for maintenance material from the inner harbor, and using them for bar channel material would shorten their useful life. The district is already studying means to extend the life of the inner harbor disposal sites in view of a potential shortage of capacity in these areas in the near future. The material could also be pumped to a new upland area; however, no such site exists near the bar channel. Tybee Island is the nearest high ground and there is not enough room that is not already extensively developed for high value residential, commercial, or public use on the island to establish such an area. In lieu of ocean disposal, the material could be pumped to a disposal site established in the vast amount of wetlands in the project vicinity; however, this is considered undesirable and/or illegal from an environmental standpoint.

The Charleston CE also evaluated land disposal sites with respect to their need for a Charleston ocean disposal site. CE (1980) stated:

> ...the Corps has made...an independent determination as to other possible methods of disposal and as to appropriate locations for the dumping. There are no practicable alternative disposal practices for disposal locations which would have less impact on the environment. (p. 96).

Futhermore,

> ...upland disposal areas would temporarily destroy valuable farmland, wildlife habitat, woodlands and a variety of plants and bushes. Because of this detrimental effect on upland areas, and the fact that the bioassay and benthic studies reveal minimal effect from ocean dumping, it appears that ocean disposal would be the preferred method ... (p. D-7).

---

*C.C. Brown, U.S. Army Corps of Engineers, Savannah District (1981)

Upland disposal sites at Wilmington are discussed by CE (1977) and by Hight (1979); the latter concludes:

> [N]o environmentally acceptable alternative disposal sites are available. The only diked upland disposal site available which could accommodate the quantity of material to be ocean dumped is approximately 35 miles upstream of the dredging site. Use of that area is not only economically impractical, but is not included in the site's long-range plans as a disposal area.

Similarly, CE (1977) state:

> [O]ther forms of disposal are precluded due to the fact that other types of dredges are incapable of operating in an area which is so often beseiged by rough seas and varying currents...At the present time, ocean disposal is considered the most desirable means of disposing of shoal material for the reaches at the mouth of the river and across the ocean bar. (p. 68)

In general, land disposal sites are used by the Savannah, Charleston, and Wilmington CE for their respective dredging projects when either the quality of the dredged material is not acceptable for ocean disposal or the cost of transporting dredged material to an ocean disposal site is prohibitive. Upland disposal sites have limited capacities; therefore, increased disposal volumes required by exclusive utilization decrease the lifetime of the sites.

DISPOSAL IN THE OCEAN

Ocean disposal of sediments dredged from the Savannah, Charleston, and Wilmington Harbors is the most practical alternative based on economic, technical, and environmental reasons (CE, 1975, 1976, 1977). Selection of an appropriate ocean disposal site(s) requires identification and evaluation of suitable areas for receiving the dredged sediments. Identification of these areas relies on available information obtained from previous site-specific and synoptic oceanographic studies. Specific alternative (or candidate) sites may be identified within these areas, based on historic and current use of the area, existence of previsouly used disposal sites, and recommendations from state and Federal resource agencies and the district and division offices of the CE.

SELECTION OF ALTERNATIVE SITES

General criteria used to select an ocean disposal site are:

- The dumping of materials into the ocean will be permitted only at sites or in areas selected to minimize the interference of disposal activities with other activities in the marine environment, perticularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation.
- Locations and boundaries of the disposal sites will be so chosen that temporary perturbations in water quality...can be... reduced to normal ambient seawater levels or to undetectable contaminant concentrations or effects before reaching any beach, shoreline, marine sanctuary, or known geographically limited fishery or shellfishery.
- The sizes of ocean disposal sites will be limited in order to localize any immediate adverse impacts and permit the implementation of effective monitoring and surveillance programs to prevent adverse long range impacts.
- ...wherever feasible, designate ocean dumping sites beyond the edge of the Continental Shelf and other such sites that have been historically used. (40 CFR 228.5)

Areas of the nearshore, mid-Shelf and Shelf break are evaluated as possible locations for ocean disposal sites using the general criteria listed above. Those areas which contain valuable economic or cultural resources, support unique biological communities or endangered species, or are unavailable for economical or technical reasons are identified and eliminated from further consideration. Evaluations of specific alternative sites are based on 11 specific site criteria listed at 40 CFR 228.6 of the Ocean Dumping Regulations.

NEARSHORE

The physical and biological characteristics of the nearshore region of the South Atlantic Bight (SAB) are influenced by coastal processes: runoff from rivers and salt marshes, longshore sediment transport, winter storm effects, and anthropogenic inputs. Nearshore sediments consist mainly of fine to very fine-grained sands with some river-derived silts. Chemical processes are affected by seasonal nutriant cycling and river runoff. Nearshore biological communities are characterized by benthic infaunal assemblages with low abundances and high diversity, productive penaeid shrimp and anadromous fish species, and hard-bottom assemblages. Low-relief, hard-bottom areas are scattered throughout the nearshore region and subject to temporary burial by mobile, nearshore sediments and disturbance from scouring. Periodic hurricanes and tropical cyclones can severely disturb bottom sediments and associated infauna.

Selection of alternative, nearshore disposal sites is based on (1) proximity to shrimp fishing areas, (2) density of historic shipwrecks, (3) proximity to hard-bottom areas, (4) direction of net sediment transport, and (5) importance of the local pelagic, demersal, and anadromous fisheries. Throughout the SAB nearshore areas within 5 km (3 nmi) of shore support productive shrimp fisheries and should be avoided by dredged material disposal operations (Pequegnat, 1978). Low-relief, hard-bottom areas are scattered throughout the nearshore areas in water depths of 15 to 25m (BLM, 1978). Due to frequent and temporary burial by nearshore sediments, the importance of nearshore hard-bottom areas to attached macroinvertebrates and commercial finfish species is unknown (NOAA, 1980). The specific locations of nearshore reefs are not well known, but their occurrence is a primary consideration in identifying feasible alternative nearshore disposal sites (Pequegnat, 1978). Although little is currently known about the exact locations and numbers of shipwrecks occurring along the South Atlantic coast, the greatest density (approximately 97%) of historic shipwrecks, including blockade runners, ships of war, and merchantmen, occur within 3 nmi of shore (Spence, personal communication*; NOAA, 1980).

---

* E. Lee Spence, Marine Archaeologist, Charleston, South Carolina, 1980

The proposed SCW-ODMDS are all within the nearshore region, but greater than 3 nmi from shore, and therefore seaward of areas used extensively for shrimping and with high densities of historical shipwrecks. No known hard-bottom areas occur within or in close proximity to ODMDS boundaries. Bottom sediments in the disposal sites are generally fine-grained sands, similar to the respective dredged materials. The associated benthic infauna are characteristic of seasonally variable sand communities, with low abundances and high diversities.

SAVANNAH

Nearshore locations north of the entrance channel to the Savannah River (Tybee Roads) are unsuitable for dredged material disposal because southwesterly longshore transport would bring dredged sediments back into the project area and accelerate the shoaling rate. Areas to the south of the entrance channel and inshore from the Existing Savannah ODMDS are productive fishing grounds for shrimp, blue crab, and several anadromous finfish species, and therefore unsuitable for dumping dredged materials. Other nearshore areas south of Tybee Roads and greater than 3 nmi from shore are environmentally similar to the Existing Savannah ODMDS, and therefore offer no significant benefits which would compensate for the greater transit distances and disposal costs. Grays Reef, 28 nmi south of the Existing Savannah ODMDS, is a marine sanctuary and would be adversely affected by dumping in adjacent areas (NOAA, 1980). Continued use of the Existing Savannah ODMDS minimizes interference with fisheries and nearshore reef communities, and does not significantly affect cultural or economic resources, or other uses of nearshore areas.

The Existing Savannah ODMDS is 3.7 nmi from shore, in water depths of 8 to 15m, and covers an area of 4.26 nmi^2. The biological community is characterized by low abundances of benthic infauna and demersal fish typical of sandy bottom, nearshore environments (Oertel, 1974, 1975, 1979; Tenore, 1979). The Existing Savannah ODMDS is searward of valuable fishing grounds and is not adjacent to hard-bottom or artificial reef areas. Furthermore, no known cultural or economic resources occur within the vicinity of the site. Dredged material disposal has occurred at this site since 1964 and only minor, temporary increases in turbidity, smothering of benthic infauna, and sediment accumulation have been detected (Oertel, 1979). Prior to 1964 an undefined area immediately seaward of Tybee Roads was used as a disposal site.

CHARLESTON

In 1972 the South Carolina Water and Marine Resources Department (SCWMRD) investigated the feasibility of using alternative ocean areas for dredged material disposal. This report (SCWMRD, 1972) concluded:

> ...the present offshore site used for disposal of hopper dredged bottom materials from the Harbor entrance channel is quite suitable for such purposes. This large area has been utilized for at least six years as a disposal site with no evidence of sediment buildup or adverse ecological effects. This area is located just offshore of commercial shrimping grounds and several miles inshore of major sea bass ("Blackfish") banks, and has a comparatively barren bottom composed largely of coarse and fine sands, and shell...Disposal in this area has resulted in no significant conflicts with commercial or recreational fishing interests, as would probably be the case if the site were located farther inshore or offshore. The existence of fishing grounds and artificial fishing reefs to the north and south of the offshore disposal area also tend to favor the existing site. (pp. 88-89)

Furthermore, appreciable quantities of silt-sized sediments present in the dredged material preclude their use for beach nourishment.

The Alternative Charleston ODMDS is 5 nmi from shore, in water depths of 10 to 15m, and covers an area of approximately 3 nmi^2. The environmental characteristics of the site (sediment texture and transport, concentrations of nutrients and trace constituents, and biological features) are influenced by river discharge and nearshore currents and waves. The biological assemblage consists of low abundances of benthic infauna and demersal fish, similar to the nearshore, sandy-bottom communities occurring throughout the SAB (Tenore, 1979).

The Existing Charleston ODMDS proposed to receive habor-deepening dredged materials covers an area of 11.8 nmi^2 and has been used for dumping dredged materials from the entrance channel of Charleston Harbor since 1966. No other ocean sites have been used previously for dredged material disposal offshore from Charleston. The impacts are limited to temporary burial of infauna and increased turbidity.

The Alternative Charleston ODMDS located within the boundaries of the Existing Site covers an area approximately one-fourth the size of the Existing Charleston Site. The 3 nmi^2 area is sufficient for present disposal volumes (1 million yd^3/yr) and a smaller disposal site area facilitates effective site monitoring programs (40 CFR 228.5).

WILMINGTON

Major fisheries species (shrimp, blue crab, and anadromous finfish). occur throughout the nearshore Wilmington area; however, these species are more abundant within 3 nmi of shore, and inside the Cape Fear Estuary and adjacent salt marshes. Additional commercial and recreational finfish species are concentrated in the vicinity of Frying Pan Shoals. Coastal beaches on Baldhead Island are used as nesting areas by endangered loggerhead turtles (Caretta caretta) (BLM, 1978). In addition, several shipwrecks considered for nomination to the National Register of Historic Places are scattered throughout the nearshore area, from the mouth of the Cape Fear River to Frying Pan Shoals (Moore, personal communication*).

Tracts within 3 nmi of the shore are unsuitable for dredged material disposal because of potential interferences with productive finfish and shellfish fisheries, nesting areas of an endangered turtle species, and sites of historic shipwrecks. Nearshore locales to the west of the entrance channel are unsuitable for dredged material disposal because of the presence of artificial fish havens and bottoms having hard substrate, dissimilar with dredged materials. Furthermore, easterly longshore currents would transport sediments back into the dredging area. Regions directly northeast of the Existing Wilmington Site are also unsuitable because Frying Pan Shoals

---

* David D. Moore, Division of Archives and History, North Carolina Department of Cultural Resources, 1980

support productive recreational fisheries, and shallow-water depths preclude hopper dredge movement. Several unique coral reefs north of the Existing Wilmington ODMDS in Onslow Bay are susceptible to adverse effects of dredged material and would not be a suitable alternative. Nearshore areas southeast of the entrance channel are biologically and geologically similar to the Existing Wilmington Site and support demersal shrimp and finfish fisheries. Water depths and dilution volumes are not significantly greater than those occurring at the Existing Wilmington Site. Thus, using another nearshore site provides no significant benefits to compensate the increased transit time and costs. The dredged material contains as much as 40% silt-sized sediments, thus dumping dredged material onshore for beach nourishment would be desirable. The Wilmington CE (CE, 1977) contends:

> **...relocation of the ocean disposal site could be a feasible alternative. Presently, however, such a move would be of doubtful benefit. The histori-ically used site already contains disturbed bottom communities; therefore, continued placement constituents less of an impact than if the material were placed on an undisturbed community. (p. 76)**

The Existing Wilmington ODMDS has been used since 1965 for disposal of sediments dredged from Baldhead Shoal, Smith Island, Southport, and Battery Island Channels. Impacts of dumping include increased turbidity and smothering of some benthic organisms. Historical data for characterizing the long-term effects of dumping at the Existing Wilmington Site are unavailable. No other ocean disposal sites have been used by the Wilmington CE.

The Alternative Wilmington ODMDS is a square-shaped 2.9 nmi^2 area in the center of the Existing 29 nmi^2 Site, 3 nmi from shore, in water depths ranging from 11 to 12.5m. The Alternative Wilmington Site is situated in a high-energy, nearshore area influenced by river discharge and nearshore mixing processes, and supports a seasonally variable sandy-bottom community.

The Alternative Wilmington Site covers only 10% of the area of the Existing Wilmington Site, but has sufficient capacity to accommodate projected future dredged volumes. A smaller area facilitates effective site monitoring and minimizes potential adverse impacts on adjacent turtle nesting areas, cultural resources, and fisheries resources in adjacent Frying Plan Shoals.

MID-SHELF

Physical and biological characteristics of the mid-Shelf region of the SAB are influenced by seasonal oceanographic and climatic patterns, and episodic Gulf Stream intrusions. The mid-Shelf is covered with medium-grained sands with scattered low to moderate relief, hard-bottom terrain. Rocky reefs support diverse and productive invertebrate assemblages, and demersal and pelagic finfish species. Consequently, reefs are important to commercial and recreational fisheries. Primary productivity in mid-Shelf waters is limited by nutrient inputs from Gulf Stream intrusions and upwelling. Soft-bottom, benthic communities have high biomass relative to nearshore areas, especially in areas contiguous with reefs (Tenore, 1979).

Major criteria for evaluating alternative mid-Shelf areas are the location, density, and potential impact of dumping on hard-bottoms. However, since the locations of reefs are not well known, identifying specific sites suitable for dredged material disposal is difficult. Relative to nearshore areas the mid-Shelf has a greater density of high-relief reefs (Henry and Giles, 1979). The biota associated with mid-Shelf reefs are not generally subject to periodic burial by resuspended sediments (e.g., during storms). Therefore, dredged material disposal in the vicinity of mid-Shelf hard-bottom areas could have greater adverse impacts on the macroinvetebrates and demersal fish. Pequegnat (1978) claims "these outcrops are considered to be unique or productive biotopes in the South Atlantic Bight, and as such should be given prime consideration in selecting dredged material disposal sites" (p. 473). Another criteria for evaluating suitable mid-Shelf areas is the location of oil and gas lease tracts (BLM, 1978 and 1980).

Mid-Shelf locations with sand substrates suitable for dredged material disposal are tentatively identified in Figure 2-2, and verified using results from previous benthic surveys (TII, 1979). For example, the South Carolina Wildlife and Marine Resources Department (SCWMRD, 1972) identified an area

15 to 25 nmi southeast of Charleston, in depths of 30 to 45m, which is potentially suitable for dredged material disposal. "This area...is characterized by a flat, gradually sloping bottom having few natural reefs and is much less productive for bottom fishes than other areas in the mid-Shelf region farther inshore or offshore" (p. 39). Similar areas off Wilmington and Savannah could also be identified if sufficient data were available.

No mid-Shelf sites have been used previously for dredged material disposal. Three generalized mid-Shelf areas offshore Savannah, Charleston, and Wilmington, respectively, will be considered for dredged material disposal. Site-specific data for these locales are unavailable; however, the physical, chemical, and biological characteristics of the generalized mid-Shelf region have been described by BLM (1978) and TII (1979). Latitudinal trends for these characteristics are minimal; thus, the impacts of dumping in each of the three areas would be similar.

SHELF BREAK

The physical and chemical characteristics (seawater temperatures, salinities, nutrients, and trace metal concentrations) of the Shelf-break region of the SAB are strongly influenced by the Gulf Stream. Extensive but discontinuous *Lithothamnion* and Black Rock Reefs occur at depths of 100 to 200m, and are productive areas for invertebrate and demersal finfish species (Pequegnat, 1978). Sandy-mud bottom regions are characterized by depauperate, but heterogenous infaunal assemblages (Tenore, 1979).

Shelf-break reefs are considered unique and productive habitats and should be avoided for ocean dredged material disposal sites (Pequegnat, 1978). Another consideration for identifying alternative disposal sites is the dispersal capabilities of the Gulf Stream, since entrainment of fine-grained sediment in Gulf Stream intrusions may result in shoreward transport of dumped sediments and subsequent sedimentation on the Shelf. "Since the [Gulf Stream] rings can concentrate and hold aloft fine sediments with sorbed metals and organic toxins and move them over the slope and possibly deposit them on the Shelf, it is perhaps advisable to locate disposal sites outside of known southwesterly paths of these rings" (p. 557) (Pequegnat, 1978). Nevertheless, Pequegnat (1978) suggests that the Shelf break (seaward of the 200m depth contour) offers an extensive region "favorable for deep-ocean disposal of dredged material."

Alternative sites in the vicinity of hard-bottom areas are not suitable for ocean dumping because of the potential adverse impact on the habitat and disturbances to reef fisheries. Several oil and gas lease tracts are located in the Shelf-break region (BLM, 1978 and 1980). Dredged material disposal in the vicinity of lease tracts could result in interferences during the exploratory and extraction phases of oil and gas production.

Three generalized Shelf-break areas offshore Savannah, Charleston, and Wilmington will be considered as alternative ocean dredged material disposal sites. The areas do not overlie known hard-bottom areas or BLM oil and gas lease sites. No previous dredged material disposal has occurred in the Shelf-break region. Specific data for these three areas are unavailable, although the biological and physical characteristics of this region have been described by BLM (1978), TII (1979), and USGS (1979). Latitudinal trends in the environmental characteristics of the three generalized areas are minimal, thus the impacts of dumping at each of the areas are comparable.

SITES DROPPED FROM FURTHER CONSIDERATION

On the bases of the preceeding rationale, the following zones (regions of the SAB) are considered unsuitable for dredged material disposal:

- Fisheries within 3 nmi of shore (Figure 2-1)
- Nearshore, mid-Shelf, and Shelf-break hard-bottom areas (Figure 2-2)
- Active or proposed BLM oil and gas lease tracts (Figure 2-3)
- Areas upcurrent from the dredging sites
- Beach nourishment or shoreline sites

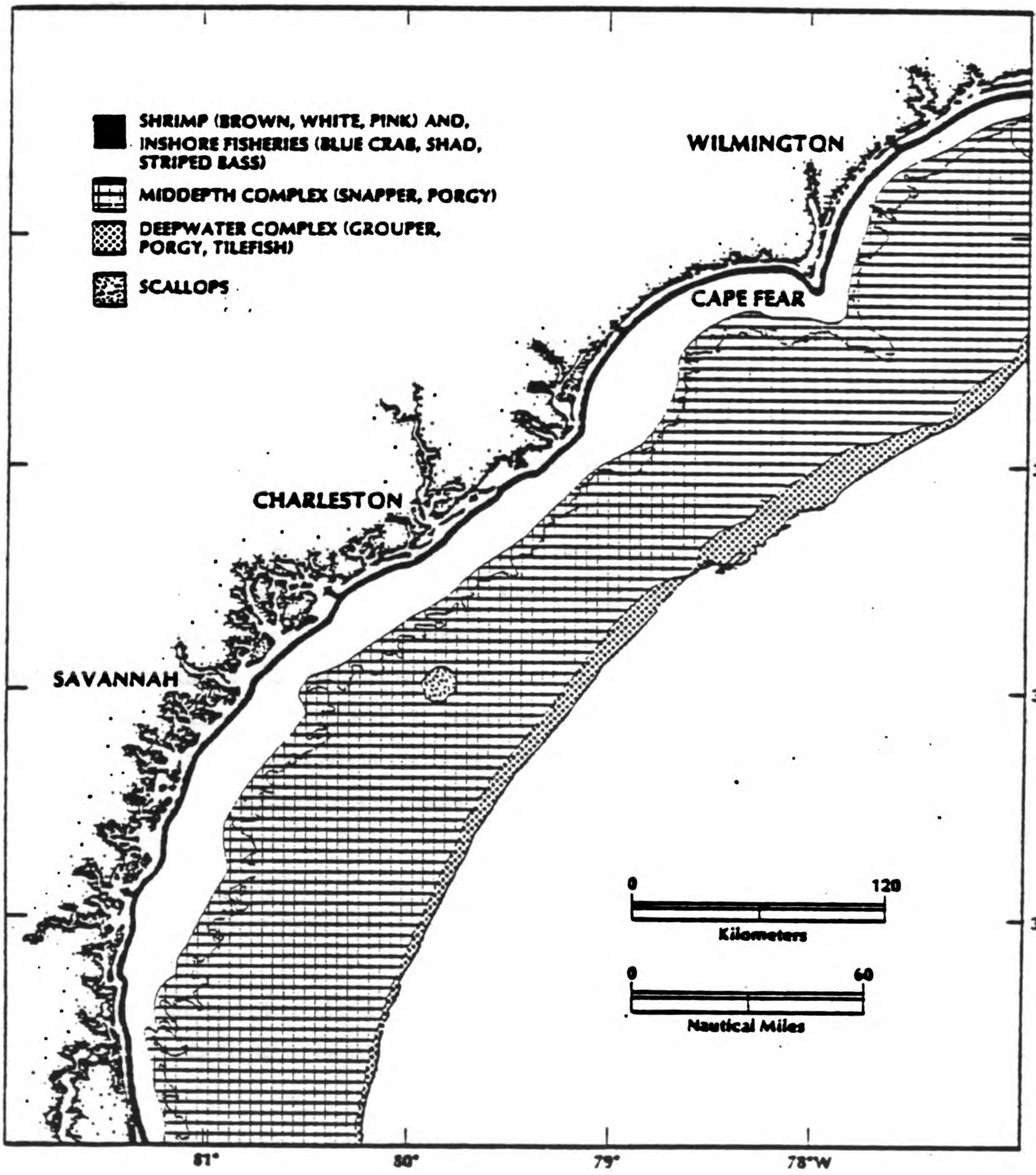

Figure 2-1. Fishing Areas in the South Atlantic Bight
Source: BLM, 1978

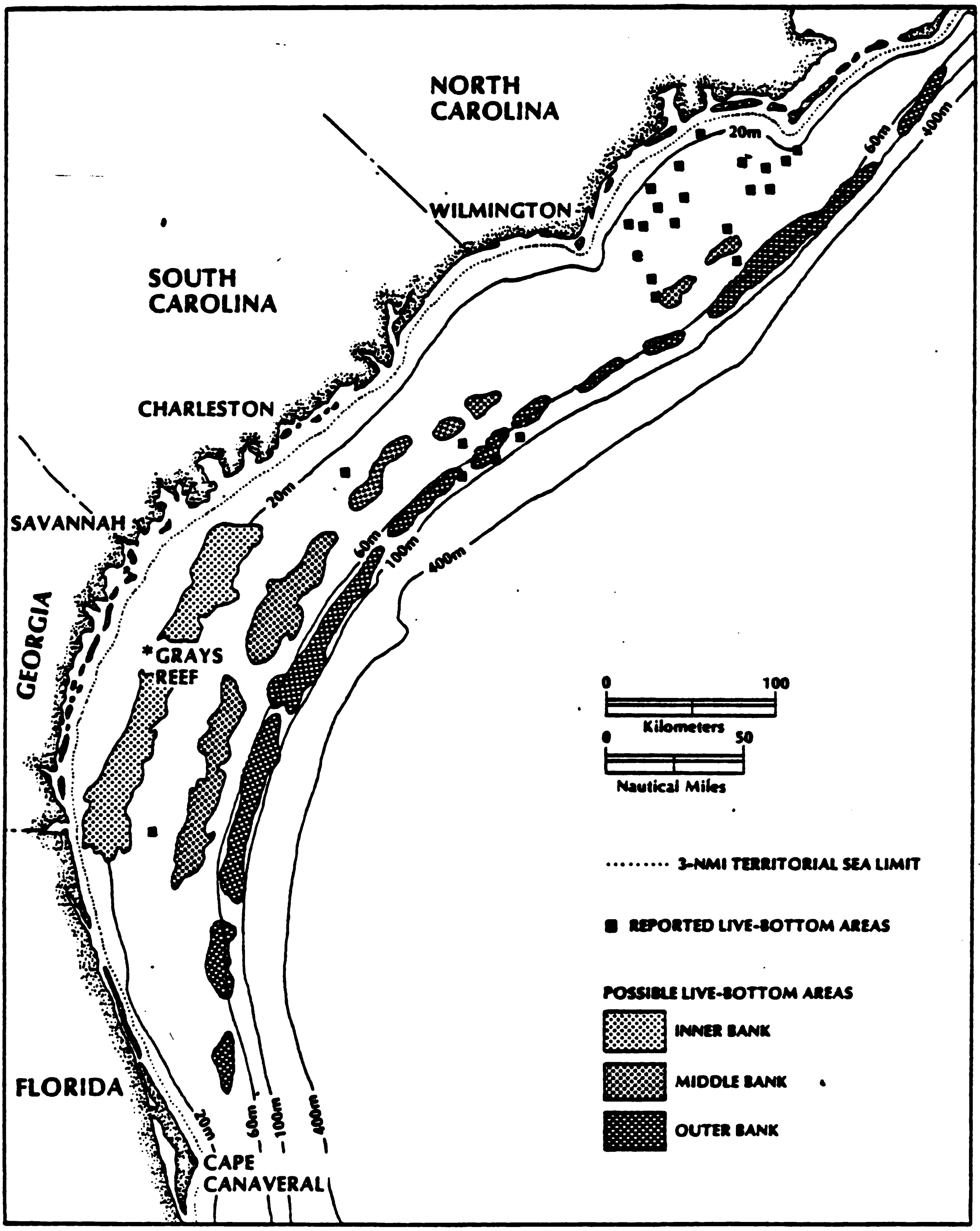

Figure 2-2. Reported and Possible Hard-Bottom Areas in the South Atlantic Bight
Source: NOAA, 1980

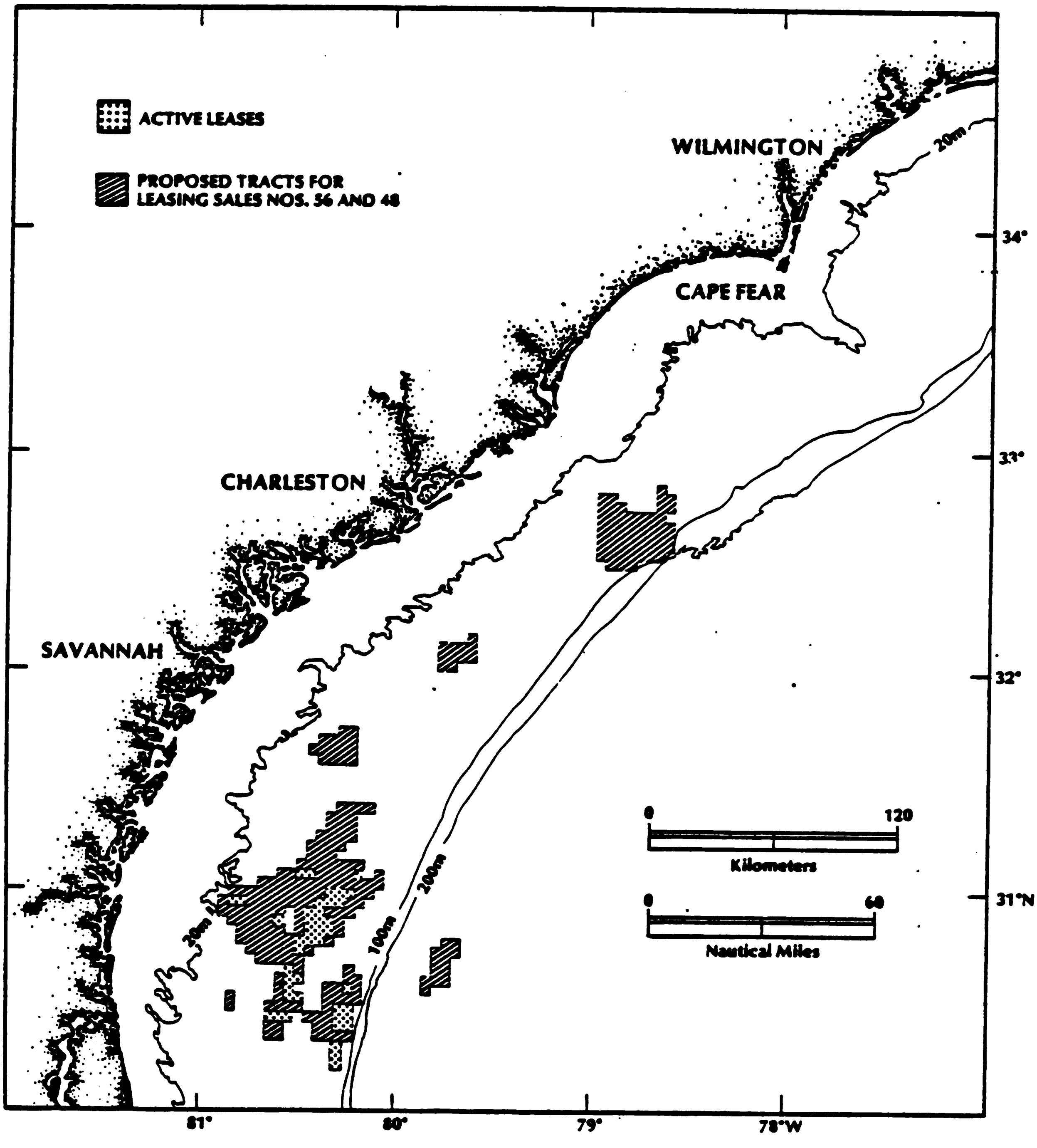

Figure 2-3. Active and Proposed BLM Oil and Gas Lease Tracts
Source: BLM, 1978

Dumping in these regions would either interfere with valuable marine resources or be impracticable. Therefore, these locations are dropped from further consideration.

In general, nearshore areas which are greater than 3 nmi from shore and not adjacent to dredging sites or nearshore hard-bottom areas would provide suitable alternative sites. However, these regions are environmentally similar to the SCW-ODMDS. Use of the Existing and Alternative Sites does not conflict with other uses of marine resources; therefore, other nearshore sites offer no significant benefits. Furthermore, with the exception of the Existing Savannah ODMDS, no other nearshore disposal sites have been historically used (use of the original Savannah disposal area was discontinued in 1964 when the need for a defined disposal site was required) (Oertel, 1979). Consequently, other nearshore areas will be dropped from further consideration in the evaluation for site designation.

SITES CONSIDERED IN GREATER DETAIL

- Existing Savannah and Alternative Charleston and Wilmington Sites (SCW-ODMDS): Existing Savannah ODMDS, 3.7 nmi from shore, with an area of 3.6 nmi^2; Alternative Charleston ODMDS, 5 nmi from shore, with an area of 3 nmi^2; Alternative Wilmington ODMDS, 3 nmi from shore, with an area of 2.9 nmi^2.

- Existing Charleston Site: within 5.0 nmi of shore with an area of 11.8 nmi^2. The field surveys performed by Interstate Electronics Corporation (IEC) at Charleston used the Existing Site boundaries as their study area (see Appendix A).

- Mid-Shelf area offshore Savannah, Charleston, and Wilmington: three generalized areas 25 to 36 nmi from shore are considered.

- Shelf-break area offshore Savannah, Charleston, and Wilmington: three generalized areas 55 to 72 nmi from shore are considered.

The locations of all Alternative Sites are shown in Figure 2-4. The Alternative Charleston and Wilmington ODMDS are discussed below instead of the 11 respective Existing (interim) Sites. However, since data was collected from the entire Existing Charleston Site and surrounding area, generalized statements made in reference to the alternative Charleston site also apply to the Existing Site (Proposed Deepening Site), unless otherwise noted. Both the Charleston and Wilmington Alternative Sites are small (approximately 3 nmi^2) areas within the larger Existing Sites. Smaller areas facilitate site monitoring and minimize interferences with other uses of the area, yet provide adequate capacity for present disposal volumes.

Final site selections are based on comparisons between the SCW-ODMDS and Alternative Mid-Shelf and Shelf-break Areas, using the 11 criteria listed at Part 228.6 of the Ocean Dumping Regulations. The criteria constitute **"an environmental assessment of the impact of the use of the sites for disposal."** Information contained in Chapters 3 and 4 and Appendix A is utilized in the following discussion for comparisons of the sites.

Generalized alternative areas are considered in this evaluation rather than specific alternative sites because site-specific information is unavailable. If an alternative location offers significant environmental benefits, specific sites could be selected from baseline surveys of the candidate areas. Mid-Shelf and Shelf-break tracts that may be acceptable locations for an ODMDS are identified in Figure 2-4. Latitudinal trends in the environmental conditions within each region are minimal; therefore, the impacts of dumping will be similar throughout the respective mid-Shelf and Shelf-break regions. The following assessments of the Alternative mid-Shelf and Shelf-break areas applies to each of the three areas within the respective region.

(1) GEOGRAPHICAL POSITION, DEPTH OF WATER, BOTTOM TOPOGRAPHY, AND DISTANCE FROM THE COAST (40 CFR 228.6[a][1])

The location, water depths, topography, and distances from shore of all Alternative Sites are summarized in Tables 2-1, 2-2, and 2-3.

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

The boundary coordinates of the Existing Savannah and Alternative Charleston and Wilmington ODMDS are presented in Chapter 1.

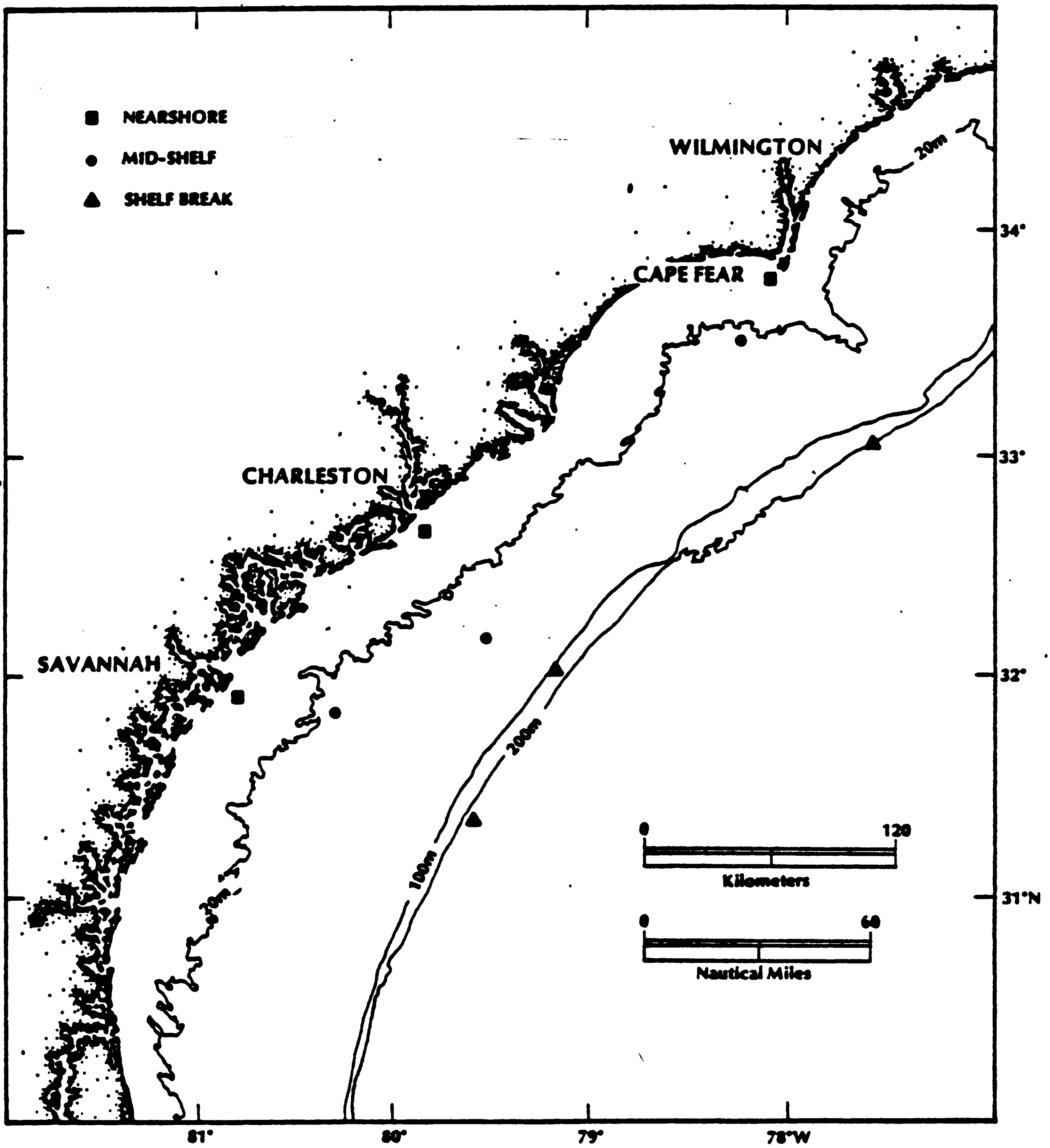

Figure 2-4. Nearshore, Mid-Shelf, and Shelf-Break Alternative Areas

TABLE 2-1
ALTERNATIVE DISPOSAL SITES AT SAVANNAH

Site	Center Coordinates	Depth (m)	Area (nmi)	Distance from Shore (nmi)	Bottom Characteristics
Existing	31°56'54"N 80°45'34"W	11.4	3.6	3.7	Flat; fine sand, silt, shell fragments
Mid-Shelf	31°48'00"N 80°17'00"W	25	3.0	30	Flat; medium-grained sand
Shelf-break	31°30'00"N 79°35'00"W	200	3.0	72	Steep; mud fine and sand

TABLE 2-2
ALTERNATIVE DISPOSAL SITES AT CHARLESTON

Site	Center Coordinates	Depth (m)	Area (nmi)	Distance from Shore (nmi)	Bottom Characteristics
Alternative Site	32°39'17"N 79°45'53"W	12	11.8	3.7	Flat; sand, with silt and shell fragments
Harbor Deepening (Existing) Site	39°38'35"N 79°45'39"W	12	11.8	3.7	Flat; sand, with silt and shell fragments
Mid-Shelf	32°10'10"N 79°45'39"W	37	3.0	36	Flat; medium-grained sand
Shelf break	32°00'00"N 79°10'00"W	200	3.0	55	Steep; fine sand and mud

TABLE 2-3
ALTENRATIVE DISPOSAL SITES AT WILMINGTON

Site	Center Coordinates	Depth (m)	Area (nmi)	Distance from Shore (nmi)	Bottom Characteristics
Alternative	33°48'30"N 78°02'54"W	12.9	2.9	3.0	Flat; fine sand
Mid-Shelf	33°30'00"N 78°15'00"W	24	3.0	25	Flat; medium-grained sand
Shelf break	33°03'00"N 77°34'00"W	200	3.0	55	Steep; fine sand and mud

The Existing Savannah Site is within 5 nmi from shore, in depths ranging from 8 to 15m. The sandy bottom slopes gently to the east; bottom topography has been characterized as "hummocky", with large natural sand ridges (Oertel, 1979). The disposal site is square, approximately 1.9 nmi on a side.

The Alternative Charleston Site is approximately 5 nmi from shore, at depths ranging from 10 to 15m. The bottom slopes gently to the southeast, and bottom sediments are composed of fine- to coarse-grained sand with shell fragments (SCWMRD, 1972). The Alternative Charleston Site is parallelogram shaped, 2.7 nmi by 1.1 nmi, aligned approximately northwest to southeast in the center of the Existing Charleston Site. The Existing Charleston Site is within 4 nmi of shore and has depth and bottom sediments similar to the Alternative Site.

The Alternative Wilmington Site is approximately 3 nmi from shore, with depths ranging from 11 to 12.5m. The predominately smooth sandy bottom slopes to the south. The Alternative Wilmington Site is square within the center of the Existing Wilmington Site, has an area of 2.9 nmi^2, and is aligned at an angle to the coast.

ALTERNATIVE AREAS

Generalized alternative areas in mid-Shelf and Shelf-break regions have been tentatively identified in Tables 2-1 through 2-3. The mid-Shelf extends from approximately 10 to 50 nmi from shore. In general, bottom depths on the Shelf increase gradually from 20 to 60m, with an average slope of 36 cm/km. The Shelf break occurs at depths of 50 to 70m, from approximately 50 to 70 nmi from shore. The Continental Shelf and Slope topographies are typically smooth, although medium- and high-relief reefs and sand waves occur sporadically throughout the offshore regions of SAB. No known reefs occur within either the Alternative mid-Shelf or Shelf-break areas.

(2) <u>LOCATION IN RELATION TO BREEDING, SPAWNING, NURSERY, FEEDING, OR PASSAGE AREAS OF LIVING RESOURCES IN ADULT OR JUVENILE PHASES</u> (40 CFR 228.6[a][2])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

Breeding, spawning, nursery, and passage activities of commercially important finfish and shellfish occur on a seasonal basis close to each of the Existing and Alternative Sites. However, the most extensive breeding, spawning, and nursery activities occur either in offshore waters or adjacent estuarine waters. Beaches adjacent to the disposal sites are occasionally used as nesting areas by endangered loggerhead turtles (*Caretta caretta*). The disposal sites are within passage areas for anadromous adult fish and larval finfish and shellfish migrating from the ocean to the estuary. However, these passage areas are not confined or geographically limited to areas coinciding with the disposal sites. The intensity of passage activities is seasonally variable, with peaks in spring and early fall for most commercially important finfish and shellfish species (Anonymous, 1980).

The impacts of previous dumping on breeding. spawning, nursery, and passage activities are unknown; however, the effects of breeding, spawning, and nursery are probably minimal. Due to the mobility of adult finfish, it is unlikely that dumping will have a significant impact on either anadromous or pelagic species. In general, increases in suspended sediment concentrations following dumping are localized and considered negligible (Oertel 1979). Consequently, interferences of suspended sediments with respiratory structures of fish are minimal. Some entrainment of larval fish within the disposal plume may occur, causing a minor detrimental effect within the disposal site.

The Existing and Alternative Sites are not close to hard-bottom areas; therefore, it is improbable that dredged material disposal will interfere with the habitats and breeding areas of reef biota. Similarly, the disposal sites are 3 to 5 nmi offshore; therefore, dumping should have little effect on sediment accumulation on local beaches or adverse impacts on the nesting areas of turtles.

ALTERNATIVE AREAS

Breeding, spawning, nursery, feeding, and passage activities of larval and adult finfish and shellfish and marine mammals occur in mid-Shelf and Shelf-break regions. Although specific spawning and nursery grounds have not been identified, many commercial species probably utilize hard-bottom areas and the Gulf Stream (Martin, 1977). Several pelagic species including bluefish, tuna, and swordfish (which support commercial and recreational fisheries in the SAB) feed and migrate through Shelf and Gulf Stream waters. In addition, several endangered turtle and whale species migrate through the Shelf and Shelf-break waters, as well as nearshore waters.

The effects of dredged material disposal on breeding, spawning, nursery, feeding, and passage activities in mid-Shelf and Shelf-break regions are unknown, although probably similar to those at the nearshore disposal sites. The mid-Shelf disposal areas are not near hard-bottom areas, thus it is unlikely that dumping would have serious impacts on reef fish habitats. A significantly greater horizontal dispersion and dilution of dredged materials would occur in the Gulf Stream. Therefore, the increased turbidity and suspended sediment concentrations following dumping would be rapidly reduced, and the potential effect on fishes would be minimal. Effects of dredged material disposal on whale and turtle migration paths are also expected to be negligible.

(3) <u>LOCATION IN RELATION TO</u>
<u>BEACHES AND OTHER AMENITY AREAS</u> (40 CFR 228.6[a][3])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

The SCW-ODMDS are within 3 to 5 nmi of adjacent beaches and estuaries, but are not close to known reefs. Longshore, tidal, and storm-generated currents may disperse dredged materials dumped at these sites. Net sediment transport at Savannah and Charleston is southwestward, parallel to shore. Sediment transport at Wilmington is probably eastward and away from adjacent beaches. Therefore, it is unlikely that appreciable quantities of dredged material will be transported onto beaches or hard-bottom areas. However, release of dredged sediments during flood tide may result in transport of an unknown amount of fine-grained, suspended sediments towards the mouth of the adjacent estuaries. Dredged materials are predominantly fine-grained sands; therefore, the extent of shoreward sediment transport during flood tide is probably not extensive. Detectable amounts of released dredged sediments are not expected to reach beaches or amenity areas adjacent to the disposal sites. Thus, use of the SCW-ODMDS will not adversely affect recreation, coastal development, or other uses of the shoreline.

ALTERNATIVE AREAS

Alternative sites in mid-Shelf regions are far enough offshore that sediment transport towards coastal beaches is unlikely. However, the density of hard-bottom areas is higher offshore. Sediments entrained in the Gulf Stream intrusions may be transported shoreward, and eventually onto Shelf or Shelf-break reefs (Pequegnat, 1978).

(4) <u>TYPES AND QUANTITIES OF WASTES PROPOSED TO BE DISPOSED OF, AND PROPOSED METHODS OF RELEASE, INCLUDING METHODS OF PACKING THE WASTE, IF ANY</u> (40 CFR 228.6[a][4])

Dredged material dumped in ocean disposal sites must comply with EPA dredged material criteria in Section 227.13 Subpart B of the Ocean Dumping Regulations (40 CFR 220 to 229).

Dredged sediments from entrance channels to the respective harbors are the only materials presently dumped at the SCW-ODMDS. The dredged materials are predominantly fine to very fine-grained sands, with some silt and shell fragments (Chapter 3), which are suitable for ocean disposal (Chapter 1). Dredged materials will be transported by hopper dredges equipped with a subsurface release mechanism, and will not be packaged in any manner. Annual disposal volumes average 1 million yd^3 at each site. Future dredged material volumes may exceed present volumes if navigational safety of the entrance channels necessitate expanded dredging operations. For example, the Charleston CE is currently considering a plan to expand and deepen navigation channels within Charleston Harbor. Some or all of the estimated 25 million yd^3 of dredged material from the expansion project could be dumped at the Existing Interim Site which is being proposed for designation for this purpose.

Travel time is a component of the total dredging cost. Increased transit distances to mid-Shelf and Shelf-break areas increase the cost of maintaining the respective harbors. The additional time and expense required by offshore ocean disposal are serious disadvantages to using mid-Shelf or Shelf-break disposal sites.

(5) FEASIBILITY OF SURVEILLANCE AND MONITORING (40 CFR 228.6[a][5])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

The U.S. Coast Guard is not currently performing surveillance at the SCW-ODMDS. However, due to the proximity of the SCW-ODMDS to shore, surveillance using shipriders or aircraft overflights would not be difficult. Monitoring is not a problem because the SCW-ODMDS are close to shore and in shallow water. During annual dredging the CE may survey the entrance channels and ODMDS bathymetry to identify shoaling or mounding areas.

ALTERNATIVE AREAS

Surveillance and monitoring would be more difficult at mid-Shelf or Shelf-break disposal areas due to the greater distances from shore and greater water depths. If offshore disposal sites are used, predisposal surveys are recommended because previous site-specific data are unavailable.

(6) DISPERSAL, HORIZONTAL TRANSPORT AND VERTICAL MIXING CHARACTERISTICS OF THE AREA, INCLUDING CURRENT DIRECTION AND VELOCITY, IF ANY (40 CFR 228.6[a][6])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

Oertel (1979) states "[s]ediment deposition and retention in the disposal area [Savannah ODMDS] are controlled by mechanics of deposition, physical forces, and sediment characteristics" (p. 100). The author also presents a paradigm of horizontal transport and vertical mixing characteristics of dredged material disposal at the Existing Savannah ODMDS, which is also applicable to the Charleston and Wilmington ODMDS. Sediments coarser than fine-grained sands sink rapidly and are not substantially displaced from the disposal track. A portion of the finer-grained sediments is typically transported laterally from the disposal track in the direction of net current movement. However, reversing tidal currents may cause a large percentage of fine-grained sediments to settle within site boundaries (ibid.).

Surface and bottom current velocities are variable, depending on the strengths of the tidal current, wind and wave current, and river discharge components. Savannah and Charleston longshore currents flow southward across the respective disposal sites with average velocities of 13.5 cm/s (Oertel, 1979; Neiheisal, 1959). Therefore, disposal plumes will typically be transported southwestward, away from the mouths of the respective channel entrances. Surface currents at the Existing Wilmington ODMDS usually flow westward across the mouth of the Cape Fear River (Carpenter and Yonts, 1979), while net eastward-flowing bottom currents adjacent to Cape Fear have been indicated (Bumpus, 1973; Langfelder et al., 1968). Therefore, sand-sized sediments sink rapidly within the site, while some finer-grained materials are transported westward across, and possibly into, the lower Cape Fear estuary. Winter storms can be expected to disperse accumulated sediments and transport them in a southwesterly direction at Savannah and Charleston (Oertel, 1979), and an easterly direction at Wilmington (Swift et al., 1972).

ALTERNATIVE AREAS

The degree of horizontal dispersion and vertical mixing is dependent on site-specific current strengths. In general, bottom currents over the Shelf tend to be sluggish and variable; however, winter storms may temporarily increase the intensities of wind and wave-induced current components. Sediments dumped over the Shelf should experience minor horizontal transport and vertical mixing, although landward transport of fine-grained sediments may occur during periods of Gulf Stream intrusions or storm conditions. Currents over the Shelf break are consistantly northerly, and relatively swift. Sediments dumped in the vicinity of the Gulf Stream will experience northward transport and rapid vertical mixing. Consequently, horizontal transport and vertical mixing is extensive and predictable at the Shelf break, and sluggish but variable over the mid-Shelf.

(7) EXISTENCE AND EFFECTS OF CURRENT AND PREVIOUS DISCHARGES AND DUMPING IN THE AREA (INCLUDING CUMULATIVE EFFECTS) (40 CFR 228.6[a][7])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

Previous disposal of dredged materials at the SCW-ODMDS has produced only minor and reversible effects: temporary increases in suspended-sediment concentrations, temporary localized mounding, smothering of some benthic organisms, and possible releases of ammonia and/or other trace constituents.

Natural concentrations of suspended particulates are high and seasonally variable due to river discharge and resuspension of nearshore bottom sediments. Because of the high background levels, increases in turbidity from dredged material disposal are minimal (Oertel, 1979). Consequently, adverse impacts on primary productivity or inhibitive effects on gills or feeding structures of organisms are minor. No persistent impacts of dumping on the concentrations of trace metals or organohalogens could be detected in waters overlying the respective disposal sites during the IEC surveys (Appendix A).

Discrete mounds of dumped sediments are dispersed during winter storms, thus precluding accumulation and eventual shoaling within the disposal sites.

Persistent or cumulative effects of dumping on sediment texture, or concentrations of trace metals or organics in sediments, were not detected during IEC surveys (Appendix A).

Smothering of benthic organisms is probably restricted to non-motile organisms, such as tube-dwelling polychaete and amphipod species. Motile finfish and shellfish generally are capable of escaping from released sediments. The similarity between dredged materials and disposal site sediments minimizes adverse impacts on the benthos due to alterations of the substrate. Specific recolonization rates by benthic organisms are unknown, but may depend on sediment texture, larval recruitment, and burrowing capabilities of buried organisms (Oertel, 1979). Results of bioassay and bioaccumulation tests using Charleston and Wilmington dredged sediments suggest that releases of trace constituents during dumping are, in most cases, neither directly toxic to marine organisms nor accumulated in tissues (JEA, 1979 and 1980). Bioassay and bioaccumulation tests have not been performed on Savannah dredged sediments. No evidence of any significant adverse impacts on macrofaunal or nekton abundances due to previous dredged material disposal was apparent during the IEC surveys.

ALTERNATIVE AREAS

Previous dredged material disposal has not occurred in mid-Shelf or Shelf-break areas.

(8) INTERFERENCE WITH SHIPPING, FISHING, RECREATION, MINERAL EXTRACTION, DESALINATION, FISH AND SHELLFISH CULTURE, AREAS OF SPECIFIC SCIENTIFIC IMPORTANCE AND OTHER LEGITIMATE USES OF THE OCEAN (40 CFR 228.6[a][8])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

Extensive commercial shipping, commercial and recreational fishing, and other recreational, cultural, and scientific activities occur in nearshore areas throughout the SAB. Commercial and recreational fishing activities are generally concentrated in estuaries, areas within 3 nmi of shore, and in the immediate vicinity of live-bottom areas. With the exception of the Existing Wilmington ODMDS, fisheries resources within the Existing and Alternative Sites are sparse, and dredged material disposal will not significantly affect adjacent nearshore fisheries. Nearshore areas within and adjacent to the Wilmington ODMDS are used by commercial shrimp fisheries. The most extensive fishing occurs within 3 nmi of shore; however, the shrimp fishing grounds extend up to 20 nmi from shore (Carpenter, personal communication*). The Alternative Wilmington ODMDS is 3 nmi offshore, thus some interferences with commercial shrimping may occur, although the disposal site represents only a small portion of the total fishing area.

Disposal sites are adjacent to major shipping channels; however, intermittent use of these sites should not impede commercial shipping or aggravate congestion within the shipping channel. Mineral extraction, desalination, and mariculture activities do not occur within the disposal sites. Recreational and scientific resources are extensive throughout the nearshore region, but they are not geographically limited in or near the SCW-ODMDS. Consequently, dumping at SCW-ODMDS does not significantly interfere with other beneficial uses of the ocean.

ALTERNATIVE AREAS

Fishing is localized over the mid-Shelf and Shelf break, especially near live-bottom areas. Commercial and recreational fishing is not expected to be as extensive over sand-bottom areas (e.g., the Alternative mid-Shelf and Shelf-break areas). Proposed and existing oil lease tracts (Figure 2-3) are also localized on the Shelf and Shelf break. The locations of the alternative disposal areas have been chosen to avoid conflict with oil exploration. Mineral extraction, desalination, and mariculture activities do not occur in the mid-Shelf or Shelf-break areas.

---

* R. Carpenter, North Carolina Division of Marine Fisheries, 1981

(9) EXISTING WATER QUALITY AND ECOLOGY OF THE SITE AS DETERMINED BY AVAILABLE DATA OR BY TREND ASSESSMENT OR BASELINE SURVEYS (40 CFR 228.6[a][9])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

The existing water quality is primarily affected by discharges from coastal rivers and anthropogenic inputs into nearshore waters. River discharges contribute appreciable quantities of suspended particulates, and smaller quantities of nutrients and trace pollutants, to nearshore waters.

Phytolankton near the Wilmington ODMDS consist primarily of diatoms, with seasonally variable standing crops and species diversity patterns. High standing stocks and low species diversity occur in summer, whereas relatively low standing stocks and high diversity occur in winter (Copeland and Birkhead, 1973). The phytoplankton at Savannah and Charleston ODMDS have not been investigated.

Copepods, larval crustaceans and molluscs, and larvaceans are the dominant zooplankters at Wilmington. Dominant organisms are most abundant in summer, and least abundant in fall and spring (Copeland and Birkhead, 1973). Zooplankton at the Savannah and Charleston ODMDS have not been previously sampled.

The SCW-ODMDS benthic communities are characterized by low abundances of diverse organisms, particularly infaunal polychaete and amphipod species, and demersal fish such as drums, searobins, and flatfish. The diversity and biomass of benthic communities exhibit considerable spatial and temporal variability, thus seasonal patterns are typically unpredictable (Frankenberg and Leiper, 1977).

Site surveys by IEC (Appendix A) have detected no significant differences in water quality or biological characteristics between areas within the Existing Sites and areas adjacent to the sites. Therefore, dredged material disposal at Existing Sites does not appear to significantly alter extant water quality or ecology.

ALTERNATIVE AREAS

Water quality in mid-Shelf areas beyond 5 nmi from shore is affected by Gulf Stream intrusions, upwelling, and occasionally, by coastal outwelling. Biological productivities are typically low throughout a major portion of the Shelf, but may be slightly higher in upwelling areas. The effects of dredged material disposal on mid-Shelf and Shelf-break environments are unknown; however, temporary but significant increases in suspended sediment concentrations and changes in sediment texture would be expected. A change in sediment texture may alter the species compositions of benthic communities.

(10) POTENTIALITY FOR THE DEVELOPMENT OR RECRUITMENT OF NUISANCE SPECIES IN THE DISPOSAL SITE (40 CFR 228.6[a][10])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

Surveys of the SCW-ODMDS have not detected the development or recruitment of nuisance species, and the similarity of dredged material to extant sediments suggest that the development of nuisance species at SCW-ODMDS is unlikely.

ALTERNATIVE AREAS

There are no components in dredged materials or consequences of their disposal that would attract nuisance species to alternative areas.

(11) EXISTENCE AT OR IN CLOSE PROXIMITY TO THE SITE OF ANY SIGNIFICANT NATURAL OR CULTURAL FEATURES OF HISTORICAL IMPORTANCE (40 CFR 228.6[a][11])

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

A large number of 18th and 19th Century shipwrecks occur within shallow-water regions of the SAB (Spence, 1974). Numerous charted and uncharted wrecks occur shoreward of the Alternative Charleston and Wilmington ODMDS

(Spence, personal communication*; Moore, personal communication**). Several of the Wilmington shipwrecks are being considered for nomination to the National Register of Historic Places..

ALTERNATIVE AREAS

Significant natural and cultural features of historical importance have not been identified in mid-Shelf and Shelf-break areas. Less than 3% of all pre-20th Century wrecks identified off the South Carolina coast occur in waters greater than 3 nmi from shore (Spence, personal communication*). It is unlikely that any historical features occur in mid-Shelf or Shelf-break areas.

CONCLUSIONS

Considerations for final site designation of the SCW-ODMDS, based on EPA Ocean Dumping Regulations 11 Site Criteria, are summarized below. Final site designations are recommended for the following reasons:

- Dredged material disposal has occurred at the SCW-ODMDS for the past 15 years. Recent IEC surveys (Appendix A) have detected no persistant or cumulative changes in the water quality or ecology at the disposal sites.

- Impacts resulting from dumping are temporary and restricted to site boundaries.

- Dredged materials are similar to disposal site sediments, thus changes in sediment texture and/or chemistry are unlikely.

- Surveillance and monitoring are facilitated because the disposal sites are nearshore and in shallow waters.

---

*op. cit., p. 2-6

**op. cit., p 2-9

- Dredged material disposal at SCW-ODMDS is significantly more cost effective.

- Interferences with fisheries, shipping, or other beneficial uses of the ocean are insignificant.

Dredged material disposal in either Alternative mid-Shelf or Shelf-break areas is not recommended for the following reasons:

- No dumping has occurred previously in either region of the SAB.

- Baseline studies would be needed to provide data on water quality, ecology, and the presence or absence of exploitable, natural, or cultural resources.

- The additional costs of transporting materials further would be significant.

- Dredged sediments are not physically similar to either mid-Shelf or Shelf-break sediments, thus the probability of altering sediment texture and adversely affecting benthic organisms is higher.

- Monitoring and surveillance would be more difficult due to the greater depths and distances from shore.

- The probability of inadvertant dumping of dredged materials on sensitive hard-bottom areas during rough weather is higher.

Therefore, EPA proposes in accordance with the regulations that the SCW-ODMDS receive final designations.

USE OF THE SITES

All future uses of the SCW-ODMDS for ocean dumping must comply with the EPA Ocean Dumping Regulations and Criteria. The use of the sites will be managed by the CE to minimize adverse effects.

PERMISSIBLE MATERIAL LOADINGS

Approximately 15 years of dredged material disposal at each of the Existing Sites, with volumes of approximately 1 million yd^3 per year, has caused only minor, reversible impacts (described in previous sections). Therefore, it is difficult to assign an upper loading limit, beyond which significant adverse impacts will occur. It is anticipated that continuation of historic annual dredging volumes of approximately 1 million yd^3 would have few, if any, significant adverse impacts. If dredged material volumes were significantly increased, the CE monitoring effort should be intensified to identify and mitigate potential adverse effects.

DISPOSAL METHODS

Present disposal methods practiced by the CE at the SCW-ODMDS are acceptable for future dumping. Material is dredged, transported by hopper dredge, and discharged from underwater ports, while the hopper dredge is underway and within the boundaries of the disposal sites.

MONITORING THE DISPOSAL SITES

Section 228.9 of the Ocean Dumping Regulations established that the impacts of dumping on a disposal site and surrounding marine environment will be evaluated periodically. The information used in making the disposal impact evaluation may include data from monitoring surveys. Thus, if necessary, the CE District Engineer (DE) and EPA Regional Administrator (RA) may establish a monitoring program to supplement the historical site data. The DE and RA develop the monitoring plan by determining the appropriate monitoring parameters, the frequency of sampling, and the areal extent of the survey. Factors considered in making determinations include the frequency and volumes of disposal, the physical and chemical nature of the dredged material, the dynamics of the site's physical processes, and the life histories of the species monitored.

The primary purpose of the monitoring program is to determine whether disposal at the sites is significantly affecting areas outside the sites, and to detect long-term adverse effects. Consequently, the monitoring study must survey the sites and surrounding areas, including control sites and areas likely to be affected, as indicated by environmental factors (e.g., prevailing currents and sediment transport). Knowledge of density and concentration gradients facilitates prediction of future impacts on areas surrounding the disposal sites, and provides direction for management of future disposal activities.

GUIDELINES FOR THE MONITORING PLAN

No significant adverse effects from previous disposal activities at SCW-ODMDS have been detected. Monitoring requirements for the sites are minimized by the similarity of the dredged materials (fine to very fine sand with some silt and shell hash) to sediments at the disposal sites and surrounding areas. Many physical parameters will not be significantly affected by disposal (e.g., temperature and salinity). Physical parameters showing variation during disposal (e.g., turbidity) rapidly return to ambient levels due to the high-energy environment of the SCW-ODMDS and the nature of the dredged material. However, the DE and RA may choose to monitor selected parameters which experience wide natural variability (e.g., sediment characteristics during high river runoff) in order to separate natural environmental fluctuations from those caused by dredged material disposal.

The requirements of the SCW-ODMDS monitoring plan can be determined by applying the following six considerations. Changes in the monitoring plan may be warranted, based on assessment of the results of the initial monitoring by the DE.

(1) MOVEMENT OF MATERIALS INTO ESTUARIES OR MARINE SANCTUARIES, OR ONTO OCEAN-FRONT BEACHES OR SHORELINES

Dredged sediments dumped in high-energy nearshore environments are resuspended and dispersed to an extent proportional to bottom current speed. Unstable fine-grained silts are easily resuspended and transported while coarser-grained sands are more stable and resistant to dispersion. Net sediment transport at the Charleston and Savannah ODMDS is southwesterly; sediment transport at the Wilmington ODMDS is predominantly easterly. Therefore, it is unlikely that dredged materials released at the SCW-ODMDS will move shoreward. Furthermore, because dredged materials are physically and chemically similar to ODMDS sediments, tracking dredged material movement would be difficult. Consequently, attempts to monitor sediment transport outside of site boundaries will not be useful and are not recommended.

The monitoring plan should include periodic bathymetric surveys of the Existing and Alternative Sites and adjacent areas. Surveys conducted infrequently (e.g., 2-year intervals) will detect any accumulation of dredged material.

(2) MOVEMENT OF MATERIALS TOWARDS PRODUCTIVE FISHERY OR SHELLFISHERY AREAS

The commercially important organisms occurring in areas adjacent to the ODMDS are mobile and adapted to natural bedload. The disposal material is similar to sediments in the disposal sites, thus the dumped material enters the natural transport cycle and presents minimal stresses to indigenous fisheries species. Consequently, monitoring dredged sediment movement towards fisheries areas is not necessary.

(3) ABSENCE FROM THE DISPOSAL SITES OF POLLUTION-SENSITIVE BIOTA CHARACTERISTIC OF THE GENERAL AREA

Baseline surveys of the Existing Site and adjacent areas have not detected the absence of pollution-sensitive biota from the sites (see Appendix A). In addition, the results of bioassays and bioaccumulation tests of Charleston and Wilmington dredged sediments suggest that dredged sediments are, in most cases, not toxic to marine organisms, and soluble constituents of the materials are not accumulated. Therefore, pollution-sensitive biota at Existing Charleston and Wilmington ODMDS are not significantly affected and not recommended for monitoring. Bioassay and bioaccumulation tests should be performed on Savannah dredged sediments.

Periodic bioassay testing using representative marine, benthic, and nektonic species will ensure that future dredged materials are also nontoxic to the biota. The DE and RA may choose suitable pollution-sensitive species that occur in the disposal sites and surrounding areas and are amenable to bioassay tests. The response of pollution-sensitive species to dredged material disosal can be monitored without relying on field surveys.

(4) PROGRESSIVE, NONSEASONAL CHANGES IN WATER QUALITY OR IN SEDIMENT COMPOSITION AT THE DISPOSAL SITES ATTRIBUTABLE TO DREDGED MATERIAL

Results of elutriate analyses of Savannah, Charleston, and Wilmington dredged sediments indicate that detectable amounts of nitrogen (as ammonia) and phosphorus (as orthophosphate) may be released subsequent to dumping (CE, 1975; JEA, 1979). Releases of trace metals or organics from dumped sediments were generally not significant (Appendix A). Rapid mixing of nearshore waters probably will dilute any released constituents to background levels within hours after dumping. In addition, river discharge and biological uptake may result in large natural variability, which obscures any effects from dredged material disposal (Appendix A). It is unlikely that water quality monitoring will detect any impacts from dumping in the SCW-ODMDS; therefore, it is not recommended.

Appreciable amounts of fine-grained sediments are dumped at the disposal sites. However, because silts are easily resuspended and transported, the probability of accumulating fine-grained sediments and subsequently altering existing sediment texture is low. No accumulation of fines within the Existing Sites or respective down-current areas were detected during the IEC surveys. Therefore, monitoring sediment composition is not recommended.

(5) PROGRESSIVE, NONSEASONAL CHANGES IN COMPOSITION OR NUMBERS OF DEMERSAL OR BENTHIC BIOTA AT OR NEAR THE DISPOSAL SITES ATTRIBUTABLE TO DREDGED MATERIAL

Mobile, demersal organisms are not generally affected by disposal. Benthic infauna may provide a more effective index for determining dredged material impacts, particularly tube-dwelling polychaete and amphipod species which are susceptible to smothering by released dredged material. However, the composition of benthic communities within the disposal sites and adjacent nearshore areas exhibited large seasonal and spatial variability during the IEC surveys (Appendix A). Dominant infaunal organisms consisted of opportunistic species that occur within a range of substrates (i.e., fine silts to medium-grained sands). If future surveys detect infaunal species which are restricted to specific substrates within and adjacent to the disposal sites and are potentially affected by dumping, the DE and RA may choose to monitor the abundances of these species.

(6) ACCUMULATION OF MATERIAL CONSTITUENTS (INCLUDIG HUMAN PATHOGENS) IN MARINE BIOTA AT OR NEAR THE SITES

Resident infaunal species characteristically are small (Appendix A); therefore, large numbers of animals would be required for tissue analyses. Previous attempts to collect a sufficient number of individuals of a single species for field bioaccumulation studies (JEA, 1979) were unsuccessful. Consequently, JEA concluded that no species occurred at the Existing Charleston, ODMDS suitable for field bioaccumulation studies. Similar situations are expected at Savannah and Wilmington. Therefore, subsequent bioaccumulation tests must be performed in the laboratory. The DE and RA can select appropriate marine species to test for accumulation of trace metals and chlorinated hydrocarbons with periodic bioaccumulation analyses.

Chapter 3

AFFECTED ENVIRONMENT

Chapter 3 describes the environmental characteristics of the SAB, where the SCW-ODMDS and alternative disposal areas are located. Nearshore waters overlying the SCW-ODMDS are influenced by river runoff and seasonal weather patterns. Mid-Shelf and Shelf-break waters are influenced by Gulf Stream intrusions and current patterns. Sediments at SCW-ODMDS are primarily fine to very fine sands. Mid-Shelf sediments are medium-grained sands; Shelf-break sediments are sand with silty mud. The nearshore SCW-ODMDS are inhabited by diverse and seasonally variable benthic and nektonic organisms. Mid-Shelf communities are typically more uniform and have higher biomass than nearshore communities. Shelf-break assemblages are influenced by the Gulf Stream and have relatively low biomass and diversity.

Environmental characteristics which either will affect or be affected by the proposed dredged material disposal operations are described below. Characteristics potentially affected by dumping are generally categorized as either geological, chemical, or biological. Ancillary meteorological and oceanographic information is also presented in this chapter because natural physical processes influence the fate of released dredged material and the impacts of subsequent disposal. A history of the dredging operation, and commercial and recreational resources which may be affected by dredged material disposal, are discussed below.

Regional and site-specific characteristics are summarized separately in the following sections. Site-specific surveys of the Existing Savannah, Charleston, and Wilmington ODMDS were conducted by Interstate Electronics Corporation (IEC), discussed in Appendix A. Site-specific data for the Alternative Mid-Shelf and Shelf-break areas are unavailable. However, information provided by previous synoptic oceanographic surveys in Shelf and Slope regions are suitable for general characterizations of the respective alternative areas (TII, 1979; USGS, 1979; BLM, 1978 and 1980; Roberts, 1974). The nearshore, mid-Shelf and Shelf-break environments are discussed in the following sections.

ENVIRONMENTAL CHARACTERISTICS

CLIMATE

Climatic parameters of interest at an ODMDS are air temperature, rainfall, wind statistics, storm occurrences, and fog. Air temperature interacts with surface waters and, particularly during warm periods, influences the vertical stability of the water column. Rainfall increases coastal runoff, thereby decreasing surface salinity and intensifying vertical stratification of the water. Coastal runoff may contribute suspended sediments and various chemical pollutants. Winds and storms generate waves and currents that may resuspend and transport dredged material. High incidence of fog during various seasons may affect navigation safety and limit disposal operations.

The temperate to subtropical climate of the South Atlantic Bight (SAB) is influenced by the relative location of the Azores high-pressure system. In winter when the high pressure is located offshore at its southern extent, contact between polar and tropical air masses results in storms with strong, gusty winds. Predominant offshore winter winds are northwesterly, although southwesterly winds are also frequent. Along the coast, winds typically are from the west with average velocities of 8 to 15 kn. During spring the Azores High migrates north and west, reaching its northern-most extent in summer. Summer is characterized by frequent showers and thunderstorms. Predominant summer winds weaken and become southerly along the coast, and southwesterly over the Shelf, with an average velocity of 6 to 10 kn. The frequency of calms range from 15 to 20% throughout the year (BLM, 1978).

Precipitation along the coast ranges from 121 to 142 cm/yr. Much of the precipitation is associated with cyclonic activity, and maximum rainfall generally occurs from July through September. Minimum seasonal rainfall occurs from November to February (BLM, 1978).

Radiation fog is frequent along the coast, but diminishes with distance from shore. Heavy fog is frequent at Savannah, occurring an average 44 days per year, but decreases in frequency northward to Wilmington, where heavy fog occurs about 25 days per year (BLM, 1978).

Extratropical cyclones are formed offshore between 30°N and 40°N, from November to April and are associated with strong northeasterly winds (BLM, 1978). Tornados associated with tropical and extratropical cyclones generally travel in a southwest to northeast direction through SAB, and strike coastal areas with a frequency of approximately 12 per year (ibid.). Hurricanes occurring in the SAB in late summer and early autumn travel east to west in a curved path, and have an 8% probability of impinging the southeastern U.S. Coast (ibid.). Between 1901 and 1963, 43 hurricanes and 51 tropical storms reached the Florida-Georgia coastline, and 27 hurricanes and 15 tropical storms reached the Carolina coastline (Pequegnat, 1978 from Cry, 1965).

PHYSICAL OCEANOGRAPHY

Physical oceanographic parameters determine the extent of mixing zones, which influence sediment transport and the chemical environment at an ODMDS. Strong temperature or salinity gradients inhibit or prevent mixing of surface and bottom waters; waves aid such mixing, resuspend bottom sediments, and affect water turbidity. Currents, especially bottom currents, determine the direction and influence the extent of sediment transport into and out of the ODMDS. Tidal currents, which may contribute to the transport of dumped materials, do not usually add net directional effects.

Shelf Waters of the SAB comprise two hydrographic zones: a neashore regime and a Shelf regime. A Gulf Stream regime occurs seaward of the Shelf regime, along the Shelf break. Nearshore waters immediately adjacent to the coast are composed of river effluent and Shelf Water, and generally delineated by lower temperatures and salinities and high suspended sediment concentrations (NOAA, 1980; Jacobson, 1974; Blanton and Atkinson, 1978). Shelf Waters characteristically have higher temperatures and salinities and low suspended sediment concentrations (NOAA, 1980). The Gulf Stream regime is characterized by a seasonally constant temperature and salinity, and low suspended sediment concentrations. Each of the Existing Savannah, Charleston, and Wilmington ODMDS are within the nearshore zone; Alternative mid-Shelf and Shelf-Break areas occur in Shelf and Gulf Stream regimes, respectively.

NEARSHORE WATERS

Several rivers and coastal marshes discharge low salinity water into the nearshore zone of the SAB. Maximum river discharge usually occurs in spring. Off the coasts of Georgia and South Carolina a zone of partially mixed, turbid, nearshore water extends 5 to 10 nmi offshore. Salinity and turbidity fronts produced by river discharge form a distinct boundary between coastal and Shelf Waters. The degree of mixing between the two water masses is dependent on the intensity of horizontal and vertical density gradients and tidal and wind-generated currents (Blanton and Atkinson, 1978).

Nearshore surface water temperatures vary seasonally from 10° to 25°C under the influence of river runoff and air temperatures. During IEC surveys water temperatures varied from 12.6° to 14.0°C at Savannah, and 13.5 to 18.0°C at Charleston in March and December, respectively; water temperatures at Wilmington varied from 17.1° to 28.3°C in November and July, respectively. Nearshore waters are typically well mixed, thus vertical temperature gradients are small.

Surface salinities typically vary from about 32 to 34^{o}/oo with seasonally fluctuating river disharge volumes. During IEC surveys surface salinities ranged from 29.8^{o}/oo in March to 30.2^{o}/oo in December at Savannah; from 29.4^{o}/oo in March to 32.7^{o}/oo in December at Charleston; and from 32.5^{o}/oo in November to 34.7^{o}/oo in July at Wilmington. The strengths of nearshore vertical salinity gradients are tidally dependent, reaching a maximum during ebb tide when low salinity water overlies more saline bottom water. The duration of vertical salinity gradients is related to the extent of tidal-, wind-, and wave-generated current mixing (NOAA, 1980; Blanton and Atkinson, 1978).

Longshore currents are controlled largely by seasonal winds. A transient southwesterly current exists off the coasts of South Carolina and Georgia. Easterly or southerly nearshore currents occur off North Carolina capes (e.g. Cape Fear) (Bumpus, 1973). Reversals in longshore current directions are episodic, lasting for several days, and are asociated with changes in the predominant wind direction (Blanton and Atkinson, 1978). Tidal currents are directed in onshore-offshore directions and are strongest near the mouths of coastal inlets (ibid.).

Savannah

The Existing Savannah ODMDS is located within a boundary between the turbid, nearshore waters and clear Shelf water masses (Oertel, 1976). Nearshore current velocities are variable, depending on river discharges and tidal-, wind-, and wave-driven currents (Oertel, 1979). Net current velocities are typically less than 0.4 kn along the bottom, although higher velocities are attained during storm activity. Storms from the northeast are common in fall and infrequent during spring and summer. The predominant longshore current movement is to the southwest.

Charleston

Velocities of surface and bottom currents at the Charleston ODMDS vary in relation to the intensity of river discharge, tidal currents, and wind and wave current components. Typical current velocities of 0.4 kn are similar to those at the Savannah ODMDS (Neiheisal, 1959). The intensity of nearshore currents and wave activity affects the extent of vertical mixing disposal site waters. Waters overlying the ODMDS may vary seasonally from partially stratified to completely mixed.

Wilmington

The Existing Wilmington ODMDS is offshore from Bald Head Island, and located within a boundary region between coastal water and Shelf Water regimes. The Cape Fear area is considered a dynamic, high-energy environment (Anonymous, 1980), and is influenced by discharge from the Cape Fear River and intrusions of Gulf Stream Waters along the Shelf.

Surface currents in the nearshore zone generally flow to the west, whereas bottom currents and littoral drift are oriented towards the east. Large tidal flows move in and out of the lower Cape Fear River, exhibiting a net westerly movement. This westerly surface drift is consistent throughout the year, unless westerly or southwesterly winds exceed 13 kn (Carpenter and Yonts, 1979). Near-bottom currents flowing to the east and southeast, with velocities up to 1 kn, have been measured inside and to the west of the ODMDS (ibid.). The predominant littoral drift along the southern face of Cape Fear is easterly-southeasterly (Langfelder et al., 1968). Seabed drifter data demonstrate convergence of bottom currents at Cape Fear (Bumpus, 1973).

SHELF WATERS

Shelf Waters are influenced to a greater extent by periodic Gulf Stream intrusions than by coastal weather patterns or runoff. Consequently, water temperatures and salinities are less variable. Seasonal seawater temperatures typically increase with distance from shore during the winter, from an average 13°C nearshore to 24°C in the Gulf Stream; isotherms parallel the coast. During summer surface seawater temperatures are uniform and average 27°C across the Shelf and Gulf Stream. Shelf Waters generally are well mixed and isothermal throughout much of the year. Shelf-break waters may experience vertical stratification during intrusions of Gulf Stream Waters or offshore movements of cold, inshore waters along the Continental Shelf (NOAA, 1980).

Surface salinities also tend to increase with distance from shore, ranging from 34 to 37°/oo over the Shelf (Atkinson et al., 1979). Bottom salinities typically increase with depth and distance from shore. Vertical density gradients intensify during intrusions of Gulf Stream Waters (NOAA, 1980).

Circulation over the Shelf is variable and controlled by cross-Shelf density differences, prevailing wind patterns, and the Gulf Stream (Jacobson, 1974; BLM, 1980). A predominant northerly flow exists in winter, spring, and early summer, resulting from a cross-Shelf density gradient nearshore, and from frictional drag exerted by the northward flowing Gulf Stream offshore (Jacobson, 1974). As the cross-Shelf thermal gradient diminishes in summer, the predominant surface current flows southward over the Shelf, probably due to cross-Shelf density gradients caused by salinity differences (ibid.). Surface currents over the Shelf are shown in Figure 3-1.

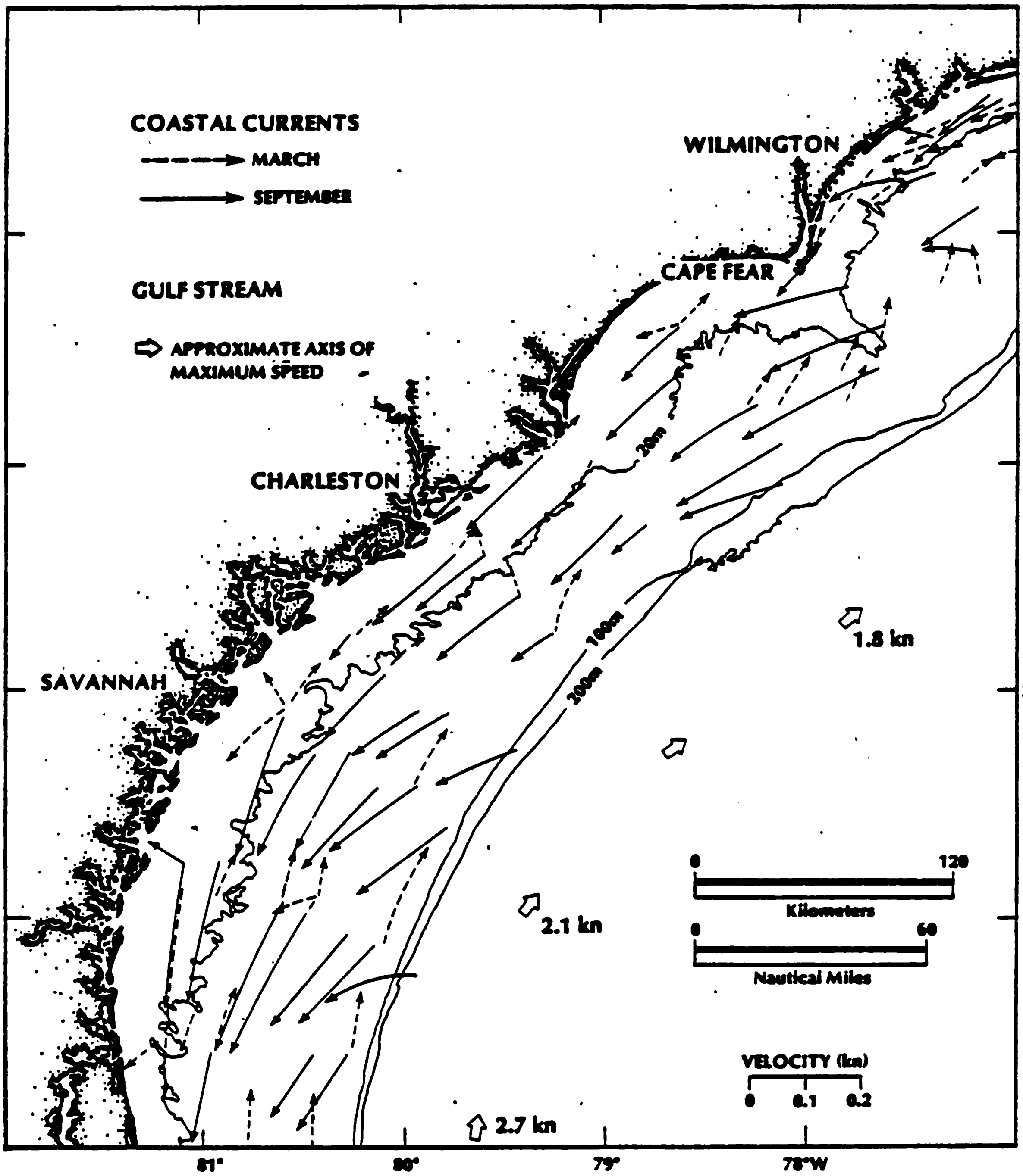

Figure 3-1. Surface Currents Over the South Atlantic Bight Shelf
Source: BLM, 1978

Bottom currents on the Shelf are influenced by periodic intrusions of the Gulf Stream (Bumpus, 1973) and by cross-Shelf semidiurnal tidal currents (Butman and Pfirman, 1979). Off the Georgia and South Carolina coasts the directions of bottom currents fluctuate frequently with little consistent pattern. Tidally induced current speeds range from 0.3 to 0.6 kn over the Shelf in onshore-offshore directions (ibid.).

Periodic upwelling is coupled with Gulf Stream intrusions, and supply cold, nutrient-rich waters to the mid- and outer Shelf. Upwelling in the outer Shelf occur throughout the year with an average frequency of one event within a 2-week period; upwelling occurs sporadically during summer in the mid-Shelf region (Lee et al., 1981).

Maximum wave heights occur in winter and autumn, associated with wave fronts from the north and west. Minimum wave heights occur during summer and spring when the wave direction is primarily from the south and southwest. Seas of less than 4 ft (1.2m) occur 59% of the time, whereas seas greater than 12 ft (3.6m) occur between 2 and 10% of the time (Figure 3-2) (BLM, 1978).

GULF STREAM

The Gulf Stream, which forms the eastern boundary of the SAB, is a fast (2 to 4 kn), deep western boundary current flowing northerly along the edge of the Continental Shelf. The temperature and salinity of Gulf Stream Waters are seasonally constant at 20° to 25°C and 36°/oo, respectively. Intrusions of Gulf Stream eddies into Shelf Waters have profound influences on surface and bottom currents, temperature, salinity, and nutrient concentrations (BLM, 1980; Tenore et al., 1978; Blanton, 1971).

GEOLOGY

Geological information relevant to a ODMDS includes bathymetry, sediment characteristics, and dredged material characteristics. Bathymetric data provide information on bottom stability, persistence of sediment mounds, and shoaling. The type of bottom sediments strongly influences the composition of resident benthic biota. Differences in sediment types between natural ODMDS

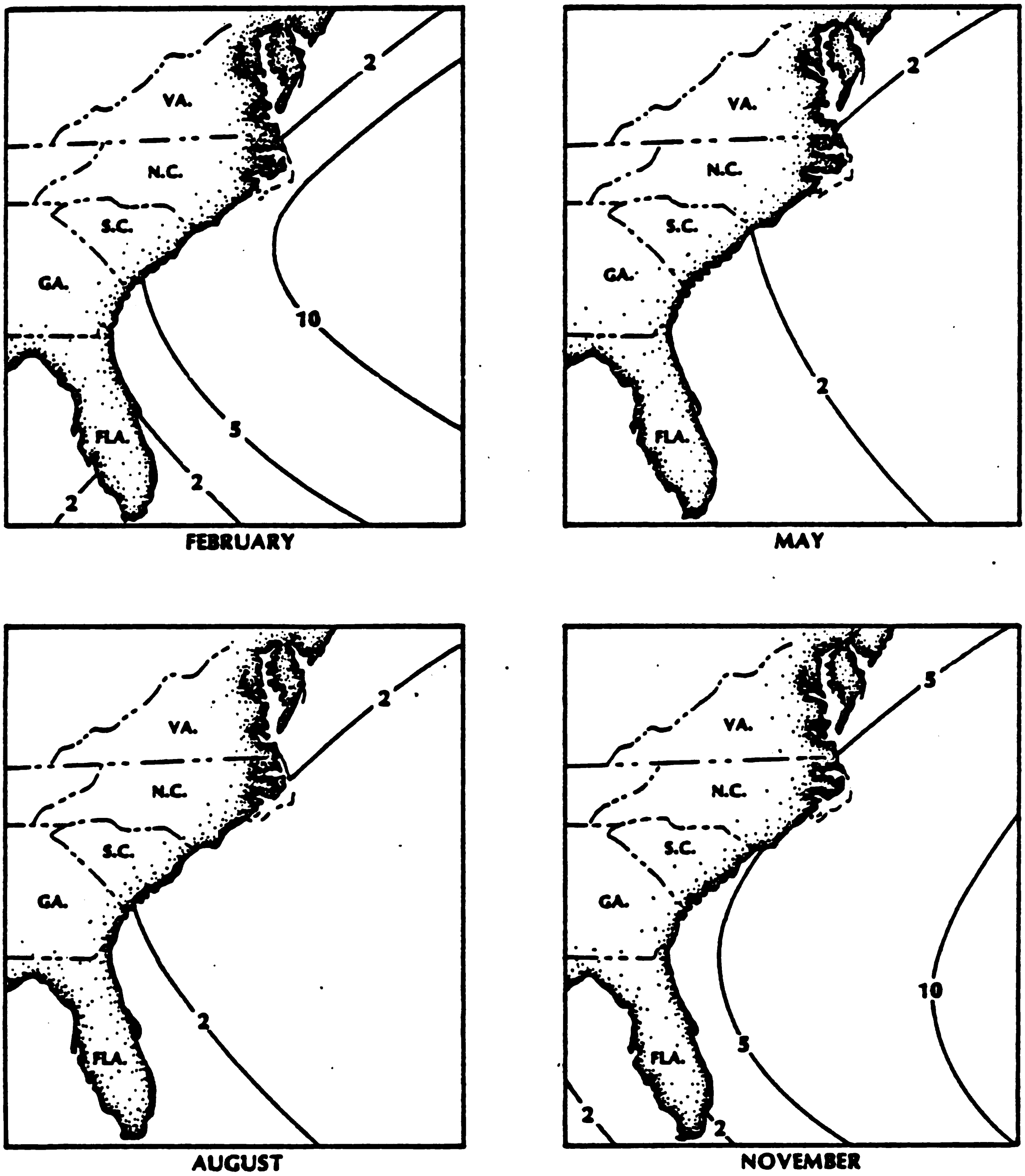

Figure 3-2. Frequency of Waves Greater Than 12 ft (3.6m)
in Height in the South Atlantic Bight
Source: BLM, 1978

sediments and dumped material may be used as tracers to determine areas of bottom influence due to dumping of dredged material. Changes in ODMDS sediment type by dumping may produce significant changes in chemical characteristics, and thus change the composition of benthic biota.

The South Atlantic Bight is bounded on the north by the Cape Fear Arch, on the south by the Florida Peninsula Arch, and on the east by the Gulf Stream. The coastline of the southern portion of the Atlantic Coastal Plain is characterized by low-lying barrier islands which front extensive salt marshes and lagoons. The broad, shallow Continental Shelf extends from a minimum distance of 15 nmi off the coast of Cape Hatteras, North Carolina, to a maximum distance of 65 nmi off Jacksonville, Florida. The Shelf is an extension of the Atlantic Coastal Plain, which slopes eastwards towards the Shelf break with an average gradient of 36 cm/km (Henry and Hoyt, 1968). The Shelf break occurs in water depths ranging from 50 to 70m landward of the Blake Plateau, a broad plain in which water depths range from 600 to 1,000m.

The surfaces of the SAB Shelf and Shelf break comprise three topographic regions or domains: (1) smooth, (2) undulating, and (3) rough. The smooth domain extends south from Cape Fear, from the surf zone to the 10m bottom contour, with the exception of an area southeast of Charleston which is covered with ridges. An undulating domain extends from the 10m contour to the Shelf break, and is characterized by sand swells 1 to 5m in height and 100 to 4,200m in width. These sand swells have an easterly trend with 1° to 2° slopes. The rough domain, extending south from Cape Lookout, consists of a 20-km-wide belt of rough topography at the base of the Florida-Hatteras Slope, with hills 20 to 80m in height (Uchupi and Tagg, 1966).

Numerous reefs are scattered throughout the Shelf. The exact locations of all patch reefs and continuous hardbanks of the SAB are unknown, although they may cover an estimated 10% to 20% of the total Shelf area (NOAA, 1980). Hard-bottom areas identified from side-scan sonar and seismic profile records by Henry and Giles (1979) are shown in Figure 3-3. Exposed hard-bottom areas are less common nearshore because of frequent burial by recently deposited sediments. Seaward of this recent sediment deposition zone, the frequency of hard-bottom areas increases (Henry and Giles, 1979). Low relief rocky

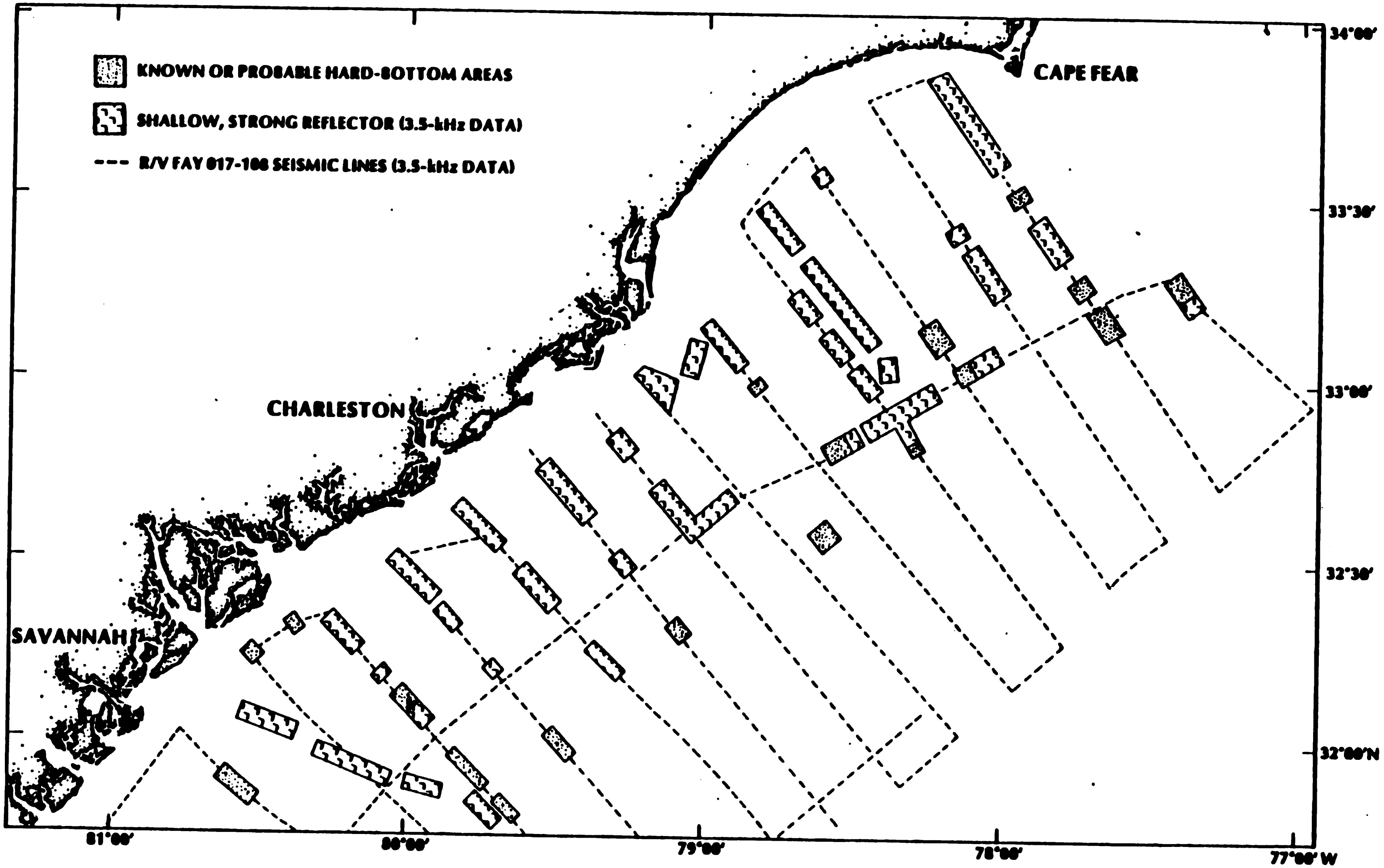

Figure 3-3. Hard-Bottom Areas of the South Atlantic Bight (identified from side-scan sonar and seismic profile records)
Source: Henry and Giles, 1979

outcrops occur discontinuously in depths of 15 to 25m from Jacksonville to Charleston. Reefs support large sessile invertebrate and fish communities, and are used extensively by sportsfishermen (BLM, 1978). Mid-Shelf reefs occur in depths of 30 to 40m offshore Jacksonville to Frying Pan Shoals. The density of these reefs is not well known. Terraces and ridges (discontinuous reefs) also occur from Southern Florida to Cape Hatteras in water depths of 50 to 80m. Shelf-break reefs are relict features of a lower sea level and have an algal origin (BLM, 1978).

NEARSHORE

The nearshore sedimentary regime is 5 to 10 nmi in width, and consists of modern (Holocene) sediments derived from coastal rivers, salt marshes, and areas north of Cape Hatteras. Nearshore surface sediments are primarily fine-grained sands (NOAA, 1980).

Sediments at the Savannah ODMDS consist of a mixture of modern fine-grained sediments with relict coarse-grained sands (Oertel, 1979). Finer-grained sediments are more frequent in deeper portions of the disposal site, whereas shallow sections of the site have higher concentrations of medium- to coarse-grained sand with abundant shell fragments (ibid.). Sediments collected from the Savannah ODMDS during IEC surveys consisted of approximately 94% sand and 4% fines, with median grain sizes of 0.23 to 0.33 mm.

Beach and nearshore sediments occurring in the vicinity of the Charleston Harbor entrance are primarily sand size, with a median diameter of 0.21 mm and a range of 0.09 to 0.90 mm (Neiheisal. 1959). Percentages of fine-grained sediments range from 0.1 to 31% and average 3% (ibid.). Higher concentrations of fines occur closer to shore and within the harbor mouth. Charleston ODMDS sediments during the IEC surveys consisted of 91 to 97% sand and 2.5 to 4.5% fines, with median grain sizes ranging from 0.18 to 0.42 mm.

Sediments within the Wilmington ODMDS consist of 89 to 98% sand, with median grain sizes ranging from 0.14 to 0.51 mm. During IEC surveys the percentage of fines (silt and clay) ranged from 0.3 to 10%.

The nearshore zone constitutes "an effective sediment trap, beyond which little sediment depositon occurs" (NOAA, 1980; p. 46). Sediment transport within the nearshore zone is complex due to interactions of wave surge and tidal currents. Net longshore sediment transport offshore Charleston and Savannah is southwesterly (Neiheisel, 1959; Oertel, 1979). The direction of net sediment transport off Wilmington is unknown. However, southeasterly bottom currents in the vicinity of the Wilmington ODMDS (Carpenter and Yonts, 1979), easterly longshore transport (Langfelder et al., 1968), and easterly sediment transport from Cape Fear (El-Ashry and Wanless, 1968) have been reported.

MID-SHELF

The Continental Shelf of the SAB constitutes a transition zone between a predominantly terrigenous sedimentary province off Cape Hatteras and a carbonate province off southern Florida (Figure 3-4) (Paull and Dillon, 1979). The offshore sedimentary regime consists of relict (Pleistocene) sediments composed of quartz, biogenic calcium carbonate, phosphorite and localized glauconite. Average grain size increases with increasing distance from shore out to the Shelf break; sediments typically are well-sorted, medium-grained (0.25 to 0.50 mm diameter) sands which possess a unimodel and symmetrical grain size distribution (Figure 3-5) (BLM, 1978). The heterogeneity of sediment lithofacies indicate that regional mixing and long distance transport of surficial Shelf sediments are not appreciable in the SAB (Butman and Pfirman, 1979).

Pilkey et al. (1979) and Pilkey and Field (1972) contend that little sedimentary material is presently being added to the Continental Shelf. Most river-borne sediments are trapped in estuaries, although some suspended sediments are transported offshore and eventually deposited on the Shelf or Continental Rise, or entrained in the Gulf Stream (Pilkey et al., 1979). Cross-Shelf transport of suspended materials is prevalent in the vicinity of high-energy capes (e.g. off North Carolina) (Edsall, 1979; Buss and Rodolfo, 1972). Between the capes, nearshore Shelf sediments may be transported shoreward by storm-generated bottom currents or tidal currents in shallow waters (Pilkey and Fields, 1972).

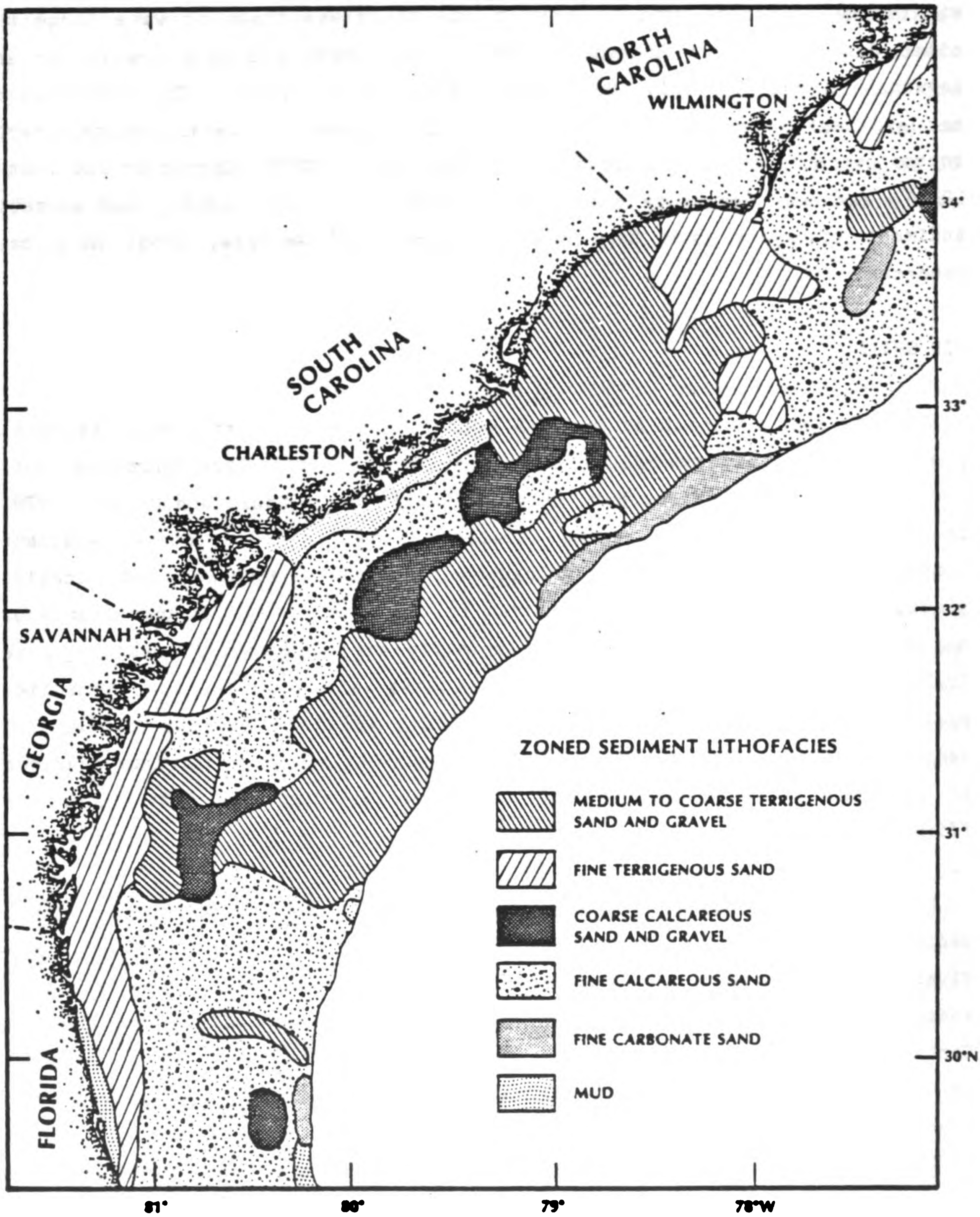

Figure 3-4. Areal Distribution of Sediment Lithofacies; Cape Romain to Cape Canaveral
Source; Pilkey et al., 1979

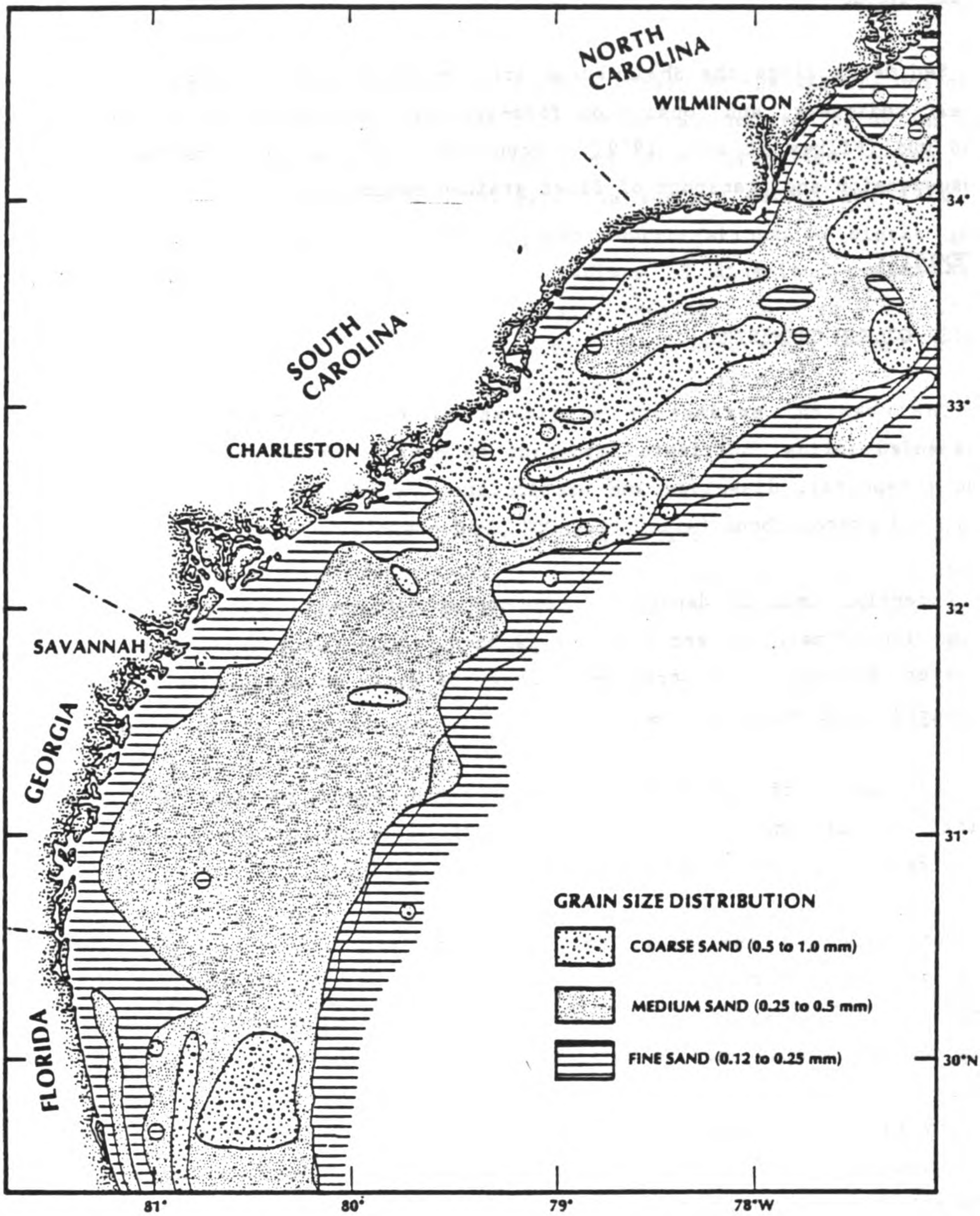

Figure 3-5. Areal Distribution of Mean Grain Size; Cape Romain to Cape Canaveral Source: Pilkey et al., 1979

SHELF BREAK

Sediments along the Shelf-break are typically finer grained than adjacent Shelf sediments, and consist of fine-grained, calcareous and carbonate sands and mud (Pilkey et al., 1979). Scouring by bottom currents may result in resuspension and transport of finer grained sediments.

CHEMISTRY

WATER COLUMN CHEMISTRY

The chemical parameters pertinent to evaluation of a ODMDS include suspended solids, nutrients important to phytoplankton growth (e.g., nitrate and phosphate), dissolved and particulate trace elements (e.g., Cd, Hg, and Pb), and hydrocarbons (e.g., PCB, DDT, and phenol).

Potential impacts depend on the concentrations of constituents released from dredged material and physical factors such as mixing and dilution rates, however, because of the transient nature of water masses, adverse effects are expected to be minor in most cases.

High levels of suspended solids may reduce light penetration through the water column and thereby inhibit phytoplankton productivity, or clog respiratory structures of fishes and other organisms.

Nutrients are essential for growth and reproduction of phytoplankton; however, under certain conditions, and at elevated levels, nutrients may promote eutrophication with subsequent depletion of dissolved oxygen, or in the case of ammonia, may be toxic to organisms in the water.

Several trace elements are necessary micronutrients in the life processes of organisms; however, many can be toxic, such as mercury and cadmium, if present in relatively high levels in water, or in food sources such as suspended particulates. Many chlorinated or petroleum hydrocarbons are toxic, and may be bioaccumulated by marine organisms if ingested in sufficient quantities.

Dissolved Oxygen

Concentrations of dissolved oxygen in surface waters of the SAB are uniform and typically at or above saturation levels. Concentrations are influenced by water temperature and oxidation of organic matter. Dissolved oxygen in nearshore waters range from 5 to 7 ml/liter in surface waters and 4 to 7 ml/liter in bottom waters, with the highest concentrations in winter and lowest concentrations in summer. Concentrations of dissolved oxygen are typically lower in Shelf and Shelf-break waters, ranging from 4 to 6 ml/liter and 3 to 5 ml/liter, respectively. Shelf-break bottom waters may become 40 to 70% undersaturated in dissolved oxygen (Atkinson et al., 1979).

Nutrients

Major nutrient inputs into the SAB are from upwelling of nutrient-rich Gulf Stream Water and discharge from coastal rivers and salt marshes. Density fronts 10 nmi offshore Georgia and South Carolina inhibit mixing and nutrient exchange between nearshore and mid- and outer-Shelf waters (Haines and Dunstan, 1975; Tenore et al., 1978). Shelf-break upwelling supplies nutrients to outer-Shelf waters with an approximate frequency of 1 pulse per 2 weeks throughout the year (Lee et al., 1981). Mid-Shelf surface waters are infrequently affected by either coastal runoff or upwelling, and are therefore typically depauperate of dissolved nutrients (Tenore et al., 1978).

Nitrate concentrations in nearshore, mid-Shelf, and Shelf-break surface waters are generally less than 1 μmole/liter (Atkinson, 1978). Episodic upwelling supplies nitrate to the euphotic zone in the outer Shelf and Shelf break (Bishop et al., 1980), resulting in concentrations as high as 10 μmole/liter (Lee et al., 1981). River runoff, nitrogen fixation, and nutrient recycling processes also supply nitrate to nearshore and Shelf Waters. Nutrient input into coastal waters from rivers and marshes is seasonally variable. Phosphate concentrations are generally less than 0.1 μmole/liter in Shelf and Shelf-break surface waters, but slightly higher (up to 0.5 μmole/liter) in coastal waters due to river inputs. Similarly, silica concentrations are relatively high in nearshore waters (1 to 20 μmole/liter) due to river discharge, low in Shelf Waters (1 to 2 µmole/liter), and increase with depth at the Shelf break (up to 10 µmole/liter at depths of 100m) (Atkinson, 1978).

Trace Metals

Trace metal concentrations in Shelf Waters are influenced by Gulf Stream intrusions and, in localized nearshore areas, by river and salt marsh discharge, (Windom and Betzer, 1979; Windom and Smith, 1972). In general, concentrations of dissolved cobalt, nickel and zinc average 0.17 µg/liter, 1.0 µg/liter and 7.4 µg/liter, respectively, north of 31°N, and 0.06 µg/liter, 0.3 µg/liter and 2.2 µg/liter, respectively, south of 31°N (Windom and Smith, 1972). Copper concentrations in surface waters range from 0.02 to 0.34 µg/liter; concentrations are lower north of Cape Fear than between Cape Fear and Cape Canaveral (Windom and Smith, 1979). Major input sources for Cu, Ni, and Zn are Gulf Stream intrusions (Windom and Smith, 1972). No cross-Shelf variations in dissolved trace metal concentrations are apparent, with the exception of dissolved zinc and mercury, which are higher near river mouths (BLM, 1978).

Concentrations of particulate and dissolved trace metals in waters overlying the Existing Savannah, Charleston, and Wilmington ODMDS during the IEC surveys are presented in Table 3-1. Dissolved and particulate mercury concentrations were less than 0.08 µg/liter and 0.02 µg/liter, respectively, at all sites. Windom et al. (1975) reported concentrations of total mercury ranging from 0.026 to 0.300 µg/liter in nearshore waters of the SAB. Particulate and dissolved cadmium levels were typically within the respective ranges of 0.002 to 0.02 µg/liter and 0.01 to 0.06 µg/liter, whereas dissolved and particulate lead ranged from 0.03 to 0.12 µg/liter and 0.02 to 0.09 µg/liter, respectively. Windom and Smith (1972) reported total cadmium concentrations ranging from 0.03 to 0.23 µg/liter in coastal waters off Savannah. Concentrations of total lead ranging from 0.083 to 2.1 µg/liter in Shelf Waters were reported by Windom and Betzer (1979).

TABLE 3-1
CONCENTRATIONS OF SUSPENDED SOLIDS,
TRACE METALS, AND HYDROCARBONS IN WATERS OVERLYING
THE SAVANNAH, CHARLESTON, AND WILMINGTON ODMDS DURING IEC SURVEYS

Parameter	Savannah	Charleston	Wilmington
Total suspended solids (mg/liter)	1.65 to 3.95	0.87 to 2.15	0.4 to 16.9
Particulate Hg (µg/liter)	0.005 to 0.02	0.009 to 0.019	0.0007 to 0.003
Particulate Cd (µg/liter)	0.005 to 0.011	0.002 to 0.005	0.003 to 0.020
Particulate Pb (µg/liter)	0.063 to 0.077	0.023 to 0.079	0.046 to 0.089
Dissolved Hg (µg/liter)	<0.03 to 0.035	<0.03 to 0.076	0.015 to 0.03
Dissolved Cd (µg/liter)	0.051 to 0.653	0.040 to 0.493	0.012 to 0.062
Dissolved Pb (µg/liter)	0.079 to 0.114	0.032 to 3.20	0.06 to 0.12
PCB's (ng/liter)	ND	Aroclor 1016:0.296	Aroclor 1016:1.04
Pesticides (ng/liter)	ND	ND	pp'DDE:0.04

ND = Not detected

Suspended Sediments

Concentrations of suspended sediments are highest in spring, lowest in summer, and intermediate in winter and autumn, in response to seasonal discharges from rivers and resuspension during storms (Doyle et al., 1979). Suspended sediment concentrations decrease with increasing distance from shore, ranging from greater than 12 mg/liter in nearshore waters to 0.23 mg/liter at the Shelf break (Table 3-2). The decrease in concentration offshore is probably due to dilution and mixing of turbid fresh waters with large volumes of Shelf Waters (ibid.).

TABLE 3-2
SEASONAL AVERAGES FOR SUSPENDED PARTICLE
LOADS OVER THE SOUTHEASTERN ATLANTIC CONTINENTAL SHELF
(mg/liter)

	Inshore		Offshore	
	Surface	Bottom	Surface	Bottom
Winter	2.730 ± 1.708	3.116 ± 6.977	0.969 ± 0.380	1.040 ± 0.564
Spring	12.27 ± 1.708	9.023 ± 3.376	0.652 ± 0.497	0.994 ± 0.870
Summer	1.154 ± 0.727	1.373 ± 0.455	0.267 ± 0.110	0.351 ± 0.112
Autumn	1.099 ± 0.111	3.858 ± 3.963	0.234 ± 0.171	0.280 ± 0.138

Mean ± standard deviation

Source: Windom and Betzer, 1979

Suspended sediment concentrations at the Savannah, Charleston, and Wilmington ODMDS during IEC surveys are presented in Table 3-1. A large range in total suspended sediment concentrations (0.4 to 16.9 mg/liter) occurred at the Wilmington Site, whereas smaller ranges (1.65 to 3.95 mg/liter and 0.87 to 2.15 mg/liter, respectively) occurred at Savannah and Charleston ODMDS.

Hydrocarbons

Shelf Waters contain negligible amounts of petroleum hydrocarbons. Average seasonal concentrations of dissolved and particulate hydrocarbons in near-surface and bottom waters of the SAB are presented in Table 3-3. At the air-sea interface, tar concentrations range from 0.01 to 0.1 µg/liter, derived primarily from oil tanker traffic in the southwestern Atlantic (Cordes et al., 1980). Mean tar concentrations of 0.82 $\mu g/m^2$ were detected in surface waters 20 to 70 nmi offshore Savannah following the blowout of the Ixtoc-1 oil rig in Campeche Bay. The tar balls consisted of approximately 30% aromatic hydrocarbons (Cordes et al., 1980). Dissolved hydrocarbon concentrations in surface waters average 0.5 µg/liter; particulate hydrocarbons average 0.4 µg/liter and range from 0.1 to 0.2 µg/liter in summer and autumn, and from 0.5 to 0.7 µg/liter in winter and spring. Particulate hydrocarbon concentrations vary seasonally, whereas dissolved hydrocarbon concentrations are relatively constant (Lee, 1979).

TABLE 3-3
AVERAGE NEAR-SURFACE AND BOTTOM CONCENTRATIONS
OF PARTICULATE AND DISSOLVED HYDROCARBONS IN SAB WATERS

	Average Concentration µg/liter	
Particulate Hydrocarbons		
	Near Surface	Near Bottom
Winter	0.4	0.5
Spring	0.8	0.7
Summer	0.3	0.2
Autumn	0.1	0.1
Dissolved Hydrocarbons		
Winter	0.4	0.5
Spring	0.4	0.6
Summer	0.4	0.4
Autumn	0.3	0.4

Source: Lee, 1979

Concentrations of PCB's (Aroclor 1016 and 1254) and pesticides in Charleston and Wilmington ODMDS waters during IEC surveys are presented in Table 3-1. PCB concentrations of 0.296 ng/liter at Charleston and 1.32 ng/liter at Wilmington were detected. No dissolved PCB's or pesticides were detected at the Savannah ODMDS.

SEDIMENT CHEMISTRY

A variety of trace contaminants, such as trace metals, petroleum and chlorinated hydrocarbons, and other organic materials, commonly expressed as total organic carbon (TOC), may accumulate in sediments. Elevated levels of marine sediment contaminants are generally caused by anthropogenic inputs such as municipal and industrial wastes, urban and agricultural runoff, atmospheric fallout from urban centers, and accidental spillage.

Silty and clayey sediments exhibit greater absorptive capacities for trace contaminants, and have typically higher TOC levels than coarser materials, because of the large surface area to volume ratios and charge densities. Accumulation of trace elements, and chlorinated or petroleum hydrocarbons in sediments, may produce short- or long-term negative effects on marine organisms. Many benthic organisms are nonselective deposit feeders that ingest substantial quantities of suspended and bottom sediments. Thus, potential bioaccumulation of trace contaminants (e.g., mercury, cadmium, and lead, and some chlorinated hydrocarbons) by these organisms is an important environmental concern.

Significantly lowered oxygen levels in sediments or near-bottom waters may adversely affect marine organisms. High concentrations of organic materials in sediments could lead to anoxic conditions and production of hydrogen sulfide or metal sulfides. Oxidation of these sulfides is responsible for much of the initial consumption of oxygen immediately following dredged material disposal.

Concentrations of metals in inner-Shelf, mid-Shelf and Slope sediments are shown in Table 3-4. Concentrations of individual trace metals in bottom sediments are relatively similar throughout the Shelf, and no significant seasonal changes are observed (Windom and Betzer, 1979). Metal concentrations in sediments are strongly correlated with grain size. Slope sediments, which contain higher percentages of silt and clay, have relatively higher concentrations of trace metals than coarser-grained Shelf sediments. For example, sediment concentrations of chromium, iron, nickel, and zinc are consistantly low throughout the Shelf but are relatively higher and variable at the Slope (Windom and Betzer, 1979). Lead and copper concentrations in Slope and Shelf sediments, however, are not significantly different. Windom and Betzer (1979) postulated that Cr, Fe, Ni, and Zn may be associated with hydrated ferro-manganese phases, whereas Cu and Pb may be associated with refractory phases, possibly silicates. Low concentrations of aluminum (Al), barium (Ba), cadmium (Cd), chromium (Cr), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), and vanadium (V), and the uniformity

TABLE 3-4
TRACE METAL CONCENTRATIONS IN
NEARSHORE, MID-SHELF, AND SHELF-BREAK SEDIMENTS
(μg/g)

	Nearshore		Mid-Shelf		Shelf Break	
	Mean	Range	Mean	Range	Mean	Range
Al	1.0	0.08 to 3.5	1.2	0.09 to 3.6	4.0	0.2 to 13.8
Cd	0.030	0.022 to 0.038	0.022	0.011 to 0.04	0.104	0.039 to 0.184
Cr	2.4	0.5 to 4.2	3.0	2.5 to 3.7	1.0	5.3 to 20.0
Cu	0.28	0.05 to 0.70	0.16	0.08 to 0.23	0.44	0.19 to 0.60
Pb	0.74	0.56 to 0.81	0.83	0.26 to 1.68	0.47	0.30 to 0.68
Ni	0.50	0.28 to 0.81	0.50	0.09 to 0.86	1.4	0.23 to 2.5
Zn	2.0	1.3 to 3.4	1.5	0.8 to 2.4	5.7	0.7 to 7.7

Source: Windom and Betzer, 1979

of concentrations with depth in sediment cores, suggest that anthropogenic inputs of trace elements to Shelf sediments are minimal (Bothner et al., 1979).

Concentrations of metals in Savannah, Charleston, and Wilmington ODMDS sediments during IEC Surveys are summarized in Table 3-5. Typical ranges of sediment cadmium and lead levels (approximately 0.001 to 0.1 μg/g and 0.7 to 4.2 μg/g, respectively) are higher than those reported for other nearshore areas (Windom and Betzer, 1979). Concentrations of sediment mercury were consistantly below 0.005 μg/g. Comparable sediment mercury data for nearshore SAB sediments are unavailable.

Hydrocarbon concentrations are typically low in sediments of the SAB, averaging 0.6 μg/g and ranging from 0.04 to 2.2 μg/g (Lee, 1979). Concentrations of pesticides and PCB's (Aroclor 1254) in the Savannah, Charleston, and Wilmington ODMDS sediments during IEC surveys are summarized in Table 3-5. Concentrations of PCB's ranged from 0.01 ng/g in Wilmington ODMDS sediments to 0.492 ng/g in Charleston ODMDS sediments. Concentrations of DDE ranged from 0.003 ng/g in Savannah ODMDS sediments to 0.05 ng/g in Wilmington ODMDS sediments; 0.077 ng/g of DDD were also detected in Savannah ODMDS sediments.

TABLE 3-5
CONCENTRATIONS OF TRACE METALS,
CHLORINATED HYDROCARBONS, AND PERCENT FINES IN SAVANNAH,
CHARLESTON, AND WILMINGTON ODMDS SEDIMENTS DURING IEC SURVEYS

Parameter	Savannah	Charleston	Wilmington
% Fines	4.16 to 4.23	2.54 to 4.52	0.3 to 10.0
TOC (mg/g)	0.50 to 2.25	0.05 to 12.5	0.1 to 10.2
Hg (µg/g)	0.002 to 0.003	0.001 to 0.005	0.001 to 0.012
Cd (µg/g)	0.002 to 0.180	0.002 to 0.116	0.002 to 0.047
Pb (µg/g)	1.1 to 1.6	1.2 to 2.0	0.98 to 7.2
Pesticides (ng/g)	DDE:0.003 DDD:0.077	DDE:0.027-0.05	DDE:0.01
PCB's (ng/g)	Aroclor 1254:0.385 Aroclor 1016:0.037	Aroclor 1254:0.492 Aroclor 1016:0.118	Aroclor 1254:0.01 to 0.03 Aroclor 1016:0.08 to 0.26
Oil and Grease (mg/g)	0.007 to 0.058	0.009 to 0.063	0.013 to 0.144
Sediment Median Diameter (mm)	0.27 to 0.33	0.15 to 0.42	0.14 to 0.51

TISSUE CHEMISTRY

Concentrations of trace metals in SAB macroinvertebrates and finfish (Table 3-6) are highly variable within species (Windom and Betzer, 1979; Windom et al., 1973). Arsenic, cadmium, and mercury concentrations are low (less than 1.0 µg/g) in a variety of nearshore and offshore finfish (Windom et al., 1973). Variability in trace metal concentrations between different species may be related to size differences (ibid.) and not, in the case of demersal fish, to the concentrations of trace metals in adjacent sediments (Windom and Betzer, 1979).

Tissue concentrations of trace metals in shrimp (Penaeus) from Wilmington and Savannah ODMDS were analyzed during IEC surveys. Concentrations of

TABLE 3-6
TRACE METAL CONCENTRATIONS IN MACROINVERTEBRATES AND DEMERSAL FISHES

Species	Common Name	Al (mg/g)	Ca (mg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (µg/g)	Ni (µg/g)	Pb (µg/g)	V (µg/g)	Zn (µg/g)
Diplectrum formosum	Sand perch	3.5 (26) ±22.	5.8 (2) ±8.6	1.35 (24) ±3.16	1.50 (25) ±8.13	7.37 (25) ±9.41	34.0 (25) ±51.7	1.15 (19) ±1.68	1.49 (24) ±4.71	23. (14) ±34.	30.0 (25) ±31.7
Synodus poeyi	Blue striped lizard fish	2.9 (9) ±4.3	241. (1) —	1.66 (7) 2.17	0.70 (9) 0.68	4.77 (10) 3.06	29.8 (10) 29.2	0.69 (6) ±0.59	0.52 (10) ±0.45	21. (5) ±27.	30.6 (10) 15.3
Decapterus punctatus	Round scad	3.6 (11) ±7.6	1.3 (3) ±0.9	0.38 (12) ±0.69	1.24 (12) ±8.40	10.2 (12) ±7.4	84. (12) ±130.	1.36 (10) ±8.35	2.68 (11) ±6.12	31. (8) ±34.	56.4 (11) ±55.8
Synodus foetens	Inshore lizard fish	1.2 (10) ±2.3	180. (2) ±254.	0.93 (10) ±1.61	1.81 (9) ±1.80	12.0 (9) ±22.1	32.3 (10) ±31.9	0.73 (8) ±0.82	0.39 (10) ±0.30	39. (7) ±80.	40.6 (10) ±57.6
Urophycis regius	Spotted hake	12.5 (13) ±18.0	654. (7) ±505.	2.15 (8) ±2.53	1.80 (15) ±1.30	16.4 (15) ±25.1	84. (15) ±181.	1.88 (12) ±2.11	0.42 (15) ±0.33	90. (10) ±84.	86.6 (14) ±99.7
Sicyonia brevirostris	Rock shrimp	1.4 (27) ±2.2	178. (11) ±221.	1.93 (22) ±1.38	1.30 (28) ±2.06	64.7 (28) ±75.7	71. (28) ±109.	1.30 (26) ±0.96	0.74 (28) ±1.27	51. (22) ±62.	103. (28) ±61.
Loligo pealei	Squid	7.4 (28) ±23.	118. (9) ±142.	6.27 (23) ±8.44	1.31 (30) ±1.58	31.3 (30) ±21.2	45. (30) ±99.	0.61 (26) ±0.51	0.23 (29) ±0.16	29. (20) ±45.	65. (30) ±17.7
Asterias forbesii	Starfish	1.6 (11) ±2.0	442. (2) ±243.	0.30 (9) ±8.35	1.39 (11) ±1.29	1.95 (11) ±1.98	77. (11) ±73.	0.35 (9) ±0.19	0.27 (10) ±0.17	24. (9) ±41.	15.9 (11) ±13.0

Note: Mean and standard deviation dry weight basis

Source: Windom and Betzer, 1979

0.05 µg/g mercury, 0.18 µg/g cadmium, and 0.29 µg/g lead were detected in shrimp tissue from the Wilmington ODMDS, while concentration of 0.092 µg/g mercury, 0.025 µg/g cadmium, and 0.020 µg/g lead were detected in shrimp tissue collected at the Savannah ODMDS. No data for tissue concentrations of metals in organisms from the Charleston ODMDS are available.

Concentrations of saturated hydrocarbons in benthic invertebrates range from 5 to 30 µg/g, and in finfish from 2 to 40 µg/g. Concentrations are typically higher in summer and autumn than in winter and spring (Lee, 1979). Small quantities of PCB's (4.56 ng/g of Aroclor 1016 and 0.50 ng/g of Aroclor 1254) and pesticide residues (0.563 ng/g of op'DDE and 0.349 ng/g of pp'DDE) were detected in shrimp tissue from the Wilmington ODMDS during the IEC surveys. Shrimp tissue from the Savannah ODMDS contained higher concentrations of PCB's (78.9 ng/g of Aroclor 1016), but no detectable pesticide residues.

BIOLOGY

Biota in the water column and in benthic environments of the ODMDS are described in this section. Water column biota include phytoplankton, zooplankton, and nekton; benthic biota include infaunal and epifaunal organisms and demersal fish. Benthic biota, especially the infauna, are generally sedentary or sessile, and cannot readily emigrate from areas of disturbance. Infauna, therefore, are used as important indicators of environmental conditions. Dredged material disposal causes only short-term effects on planktonic communities because of the natural patchiness of the species and the transient nature of the watermasses they inhabit. Nekton, and to a lesser degree epifauna, are highly mobile and normally are unaffected by disposal of dredged material.

PHYTOPLANKTON

Physical processes supplying nutrients to the SAB regulate phytoplankton productivities in the inner, mid, and outer-Shelf zones. Within the nearshore zone, vertical mixing and retention of nutrients discharged from coastal rivers maintains a persistantly high phytoplankton biomass. Plankton biomass is relatively low in the mid-Shelf zone because waters are typically impoverished of nutrients. Episodic Shelf-break upwelling supplies nutrients to outer Shelf and less frequently, to mid-Shelf phytoplankton, resulting in pulses of high productivity (Bishop et. al., 1980). Seasonal patterns in plankton production in the SAB are not evident (Haines and Dunstan, 1975).

Haines and Dunstan (1975) measured primary productivity rates of 285 and 132 $gC/m^2/yr$ in nearshore and outer Shelf Waters, respectively, off the Georgia coast; the average Shelf productivity rate was 171 $gC/m^2/yr$. Bishop et al. (1980) suggest that previous outer Shelf productivity measurements may have missed ephemeral increases in productivity associated with upwelling events, and consequently underestimated the yearly primary production rates. Nearshore production rates, up to 546 $gC/m^3/yr$, reported by Thomas (1966) represent some of the highest coastal productivities previously recorded.

In general, diatoms dominate the phytoplankton in inshore and Shelf Waters, while coccolithophores are abundant in the Gulf Stream (Roberts, 1974; BLM, 1978). Marshall (1971) ideentified approximately 100 diatom species in the Shelf Waters; dominant species include Skeletonema costatum, Leptocylindrus danicus, and Nitszchia seriata. Coccolithophores are numerous in the Gulf Stream and Sargasso Sea; dominant species include Coccolithys huxleyi, Syracospheara mediterranea, and S. pulchra. Dinoflagellates are ubiquitous in the SAB during all seasons; major species include Ceratium furca, C. fusus, and C. tripos. A list of the common phytoplankton species found in the SAB is presented in Table 3-7.

ZOOPLANKTON

Zooplankton in nearshore waters are abundant and dominated by copepods and meroplankton (temporary planktonic larval stages of coelenterates, polychaetes, crustuceans, molluscs, fish, and other organisms). Acartia tonsa is a dominant nearshore copepod species. Other abundant copepod genera include Oithonia, Corycaeus, Centropages, Euterpina, and Pseudodiaptomus. Meroplankton are seasonally dominated by shrimp (mainly Penaeus), crab, and fish larvae.

Zooplankton are less abundant but more diverse in mid-Shelf and Slope Waters than in nearshore waters. Specific abundances and diversities may be associated with different water masses. For example, Bowman (1971) used copepod associations to identify coastal, Shelf, and oceanic water masses (Table 3-8). Copepods dominate the offshore zooplankton fauna, although coelenterates and chaetognaths (mainly Sagitta) are also abundant. No changes in zooplankton community structures occur between northern and southern portions of the SAB (BLM 1978).

SOFT-BOTTOM BENTHOS

Infauna (organisms which burrow in the substrate) and epifauna (organisms occurring on top of the substrate) in the SAB have been classified into three assemblages, arranged in bands parallel to shore, corresponding to the

TABLE 3-7
ABUNDANT PHYTOPLANKTON IN
SHELF WATERS DURING JANUARY 1968

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 stolterfothii	Inshore
Nitzschia closterium	Inshore
Nitzschia delicatissim	Inshore
COCCOLITHOPORES	
Coccolithys huxleyi	Widely distributed
Umbilicosphaera mirabilis	Widely distributed

Source: From Hulbert and MacKenzie, 1971

TABLE 3-8
GROUPS OF CALANOID COPEPODS
ASSOCIATED WITH WATER MASSES IN THE SOUTH ATLANTIC BIGHT

Water Mass		
Coastal	Shelf	Oceanic
Acartia tonsa	*Paracalanus parvus*	*Calanus minor*
Labidocera aestira	*Centropages furcatus*	*Undinula vulgaris*
	Eucalanus pileatus	*Euchaeta marina*
	Temora turbinata	*Clausocalanus furcatus*

Source: Bowman, 1971

nearshore, mid-Shelf, and Shelf-break regions (Table 3-9) (Day et al., 1971). The diversity, biomass, and composition of each assemblage may be influenced by water depth, temperature, substrate type, and primary productivity of overlying waters (Tenore, 1979; Tenore et al., 1978; Hansen et al., 1981). The boundaries of these three assemblages may shift seasonally in response to hydrographic conditions (George and Staiger, 1979).

Nearshore

The diversity and biomass of nearshore infaunal communities exhibit considerable spatial and temporal variability; thus, seasonal patterns are unpredictable (Frankenberg and Leiper, 1977). Hansen et al. (1981) suggested that nearshore benthic communities may be limited by "...an unstable sedimentary regime and low nutrient input..." Macrofaunal biomass values (for a station close to the Savannah ODMDS) of 9.7g wet wt/m^2 in March and 8.0g wet wt/m^2 in June have been reported by Tenore et al. (1978) and Hansen et al. (1981). Seasonal changes in biomass may reflect larval recruitment or a response to increased primary productivity (ibid.). Common macroinfaunal organisms of nearshore, fine-sand substrates include polychaetes (Spiophanes bombyx), bivalves (Tellina spp.), and cumaceans (Oxyurostylis smithi) (Boesch, 1977).

Common macrofauna of the Savannah, Charleston, and Wilmington ODMDS during the IEC surveys are described in Appendix A and summarized in Table 3-10. Infaunal assemblages were dominated by suspension and deposit-feeding polychaete and crustacean species. Abundances of the dominant species were both spatially and seasonally variable at each disposal site.

Epifauna in the nearshore regime are typically eurythermal (tolerant of large temperature ranges). Common nearshore species include commercially important penaeid shrimp (Penaeus aztecus and Penaeus setiferus) and blue crabs (Callinectes sapidus), which occur in sandy-mud substrates influenced by river runoff. Large seasonal variations in the composition and abundances of nearshore epifaunal communities are common (George and Staiger, 1979).

TABLE 3-9
MACROFAUNA SPECIES CHARACTERISTIC OF THE INSHORE, OUTER SHELF AND UPPER SLOPE ZONES OFFSHORE NORTH CAROLINA

Inshore Surf to 20m	Outer Shelf (40 to 120m)	Upper Slope (160 to 205m)
Renilla reniformis	Aspidosiphon misakiensis	Oclontosyllis sp.
Glycera dibranchiata	Nephtys squamosa	Nephtys squamosa
Goniadides sp.	Onuphis nebulosa	Lumbrineris cruzensis
Hemipodus roseus	Prinospio dayi	Prionospio dayi
Diopatra cuprea	P. pinnata	P. steenstrupi
Magelona papillicornis	Chaetozone setusa	Chaetozone setusa
Polygordius sp.	Ampharete acutifrons	Unciola irrorata
Platyischnopus sp.	Chione sp.	Cadulus agassizi
Protohaustorius sp.	Cadulus carolinensis	Nucula delphinodonta
Pagurus spp.	Astropecten cf. articulatus	Thyasira cf. obsoletus
Dissoclactylus mellitae		
Ensis minor		
Spisula ravenelli		
Mellita quinquiesperforata		
Branchiostoma caribaeum		

Source: Day et al., 1971

During IEC surveys epifauna collected at the Savannah, Charleston, and Wilmington ODMDS included the rock shrimp (Sicyonia brevirostris), squid (Loligo pealii), and echinoderms (Asterias forbesii). In general, large numbers of commercially important penaeid shrimp or portunid crabs did not occur within the disposal site.

Mid-Shelf

The composition of the macrofaunal communities on the mid-Shelf are more uniform than, and distinct from, the nearshore communities (Dorjes, 1977). A coarse-sand Shelf community may characteristically include bivalves (Chione sp.), polychaetes (Onuphus spp.), and cephalochordates (Branchiostoma caribaeum) (Boesch, 1977). Biomass and density of the mid-Shelf benthos are

TABLE 3-10
COMMON MACROFAUNA GENERA
FOUND IN THE NEARSHORE SOUTH ATLANTIC BIGHT

Group	Genera
Polychaetes	Nereis
	Glycera
	Heteropodarke
	Prionospio
	Spio
	Mediomastus
	Aricidea
Cumaceans	Cyclaspis
	Oxyurostylis
Amphipods	Acanthohaustorius
	Ampelisca
	Photis
	Trichophoxus
	Trion
	Unciola
Decapods	Callianassa
	Micropanope
	Pinnixa
	Portunus
Echinoderms	Amphiura
	Asterias
Sipunculids	Aspidosiphon
	Golfingia
Cephalochordate	Branchiostoma

Sources: TII, 1979; IEC, 1979 (Appendix A) typically higher than either the nearshore or Shelf-break benthos, and may "result from intrusion-related biological production" (Tenore, 1979). Patchiness in the densities of mid-Shelf macrofauna may also be related to the relative frequency of upwelling events, and subsequent increase in biological productivities (Hansen et al., 1981). In addition, frequent substrate agitation from wind-induced and tidal current scouring may limit the biomass, density, and species composition of infaunal species of the mid-Shelf (Tenore, 1979).

Common Shelf epifaunal species include starfish (Astropecten and Luidia), crab (Calappa flamea), and rock shrimp (Sicyonia brevirostris) (Boesch, 1977). Epifaunal biomass are typically low, but may vary seasonally in response to seasonal migrations of epifauna species over the Shelf (George and Staiger, 1979).

Shelf Break

Shelf-break macrofaunal communities are relatively heterogenous, and influenced by depth, water temperature, and sediment composition (Tenore, 1979). Abundant infaunal species on the Shelf-break include polychaetes (Exogene verugera and Cossura longicireata), amphipods (Ampelisca agassizi), and spinculans (Onchnesoma steenstrupi) (Boesch, 1977). The density and biomass of the Shelf-break macrofauna are significantly lower than those on the Shelf (Tenore, 1979).

Epifaunal species on the Shelf break are typically stenothermal (intolerant of wide temperature ranges), and characterized by squid (Loligo pealii) and crabs (Cancer borealis and Cancer irroratus). The biomass of Shelf-break epifauna is also low relative to the Shelf.

HARD-BOTTOM BENTHOS

Epifaunal communities associated with hard-bottom areas have a high diversity of algal and invertebrate species. These communities constitute one of the most diverse biotic assemblages in the SAB and consist of both temperate and tropical species. Although the specific compositions are generally unknown, typical inhabitants include sessile sea pens, sea fans, sea whips, hard corals, hydroids, anemones, ascidians, sponges and bryozoans (Boesch, 1977). Sessile species create additional substrate for a myriad of other invertebrates such as polychaetes, crustaceans, molluscs, and echinoderms. Many species of demersal and pelagic fish are attracted to these reef communities, representing a valuable natural resource.

NEKTON

Finfish can be classified into two broad groups: pelagic and demersal. The pelagic nekton range widely throughout the water column and feed on plankton or other nekton; examples include whales, turtles, schooling fish (e.g., herring, jacks, mackeral, and tuna), or solitary fish species (e.g., swordfish). Demersal fish are associated with bottom communities, more restricted in their movements, and feed predominantly on a wide variety of benthic invertebrates. A detailed discussion of commercially important pelagic and demersal nekton species (including invertebrates) is presented below in the Fisheries section.

Hard-bottom areas support diverse fish assemblages, especially in Shelf and Shelf-break regions from Cape Hatteras to northern Florida. The most abundant species include snappers (Lutjanus, Rhomboplites), groupers (Epinephelus, Mycteroperca), and porgies (Calamus, Pagrus). Many tropical species of finfish occur in hard-bottom areas. For example, Huntsman and MacIntyre (1971) recorded 25 tropical species associated with coral patches in Onslow Bay, North Carolina. Reef fish species are typically sedentary and restricted to a relatively small area (within a few kilometers) of the reef or hard bottom. Hard-bottom areas seaward of the 20m contour are generally more productive than the shallow-water reefs (NOAA, 1980).

In contrast to the hard-bottom communities, the demersal fish assemblages occurring over the soft bottom are both less abundant and diverse. The lack of sufficient macrofaunal or epifaunal food resources could explain the limited abundance of demersal fish in these areas. Hake, drums, sea robins, and flatfish species are among the most common fishes of soft-bottom areas of the SAB (TII, 1979) (Table 3-11).

TABLE 3-11
COMMON DEMERSAL FISH COLLECTED FROM SOFT-BOTTOM AREAS IN THE SOUTH ATLANTIC BIGHT

Family - Species	Common Name
CARCHARHINIDAE (requiem sharks)	
Mustelus canis	Smooth dogfish
RAJIDAE (skates)	
Raja eglanteria	Clearnose skate
CONGRIDAE (conger eels)	
Ariosoma sp.	Conger eel
CLUPEIDAE (herrings)	
Clupeidae, unidentified herrings	
ENGRAULIDAE (anchovies)	
Anchoa cubana	Cuban anchovy
SYNODONTIDAE (lizard fishes)	
Synodus foetens	Inshore lizard-fish
S. intermedius	Sand diver
Trachinocephalus myops	Snakefish
BATRACHOIDIDAE (toadfishes)	
Porichthys porosissimus	Atlantic midshipman
GADIDAE (codfishes)	
Urophycis earlli	Carolina hake
U. floridanus	Southern hake
U. regius	Spotted hake
OPHIDIIDAE (cusk eels)	
Ophidion grayi	Blotched cusk-eel
O. selenops	Mooneye cusk-eel
SYNGNATHIDAE (seahorses and pipefish)	
Hippocampus erectus	Lined seahorse
Syngnathus springeri	Bull pipefish
SERRANIDAE (sea basses)	
Diplectrum formosum	Sand perch
PRIACANTHIDAE (bigeyes)	
Pristigenys alta	Short bigeye
CARANGIDAE (jacks and pompanos)	
Decapterus punctatus	Round scad
Seriola dumerili	Greater amberjack
POMADASYIDAE (grunts)	
Haemulon aurolineatum	Tomtate
SPARIDAE (porgies)	
Lagodon rhomboides	Pinfish
Stenotomus chrysops	Scup
SCIAENIDAE (drums)	
Equetus lanceolatus	Jackknife-fish
Leiostomus xanthurus	Spot
Menticirrhus americanus	Southern kingfish
LABRIDAE (wrasses)	
Hemipteronotus novacula	Pearly razorfish
DACTYLOSCOPIDAE (stargazers)	
Dactyloscopus tridigitatus	Sand stargazer
BLENNIIDAE (combtooth blennies)	
Hypleurochilus geminatus	Crested blenny
STROMATEIDAE (butter fishes)	
Peprilus triacanthus	Butterfish
TRIGLIDAE (searobins)	
Prionotus carolinus	Northern searobin
P. ophryas	Bandtail searobin
P. scitulus	Leopard searobin
P. tribulus	Bighead searobin
BOTHIDAE (lefteye flounders)	
Ancylopsetta dilecta	Three-eye flounder
A. quadrocellata	Ocellated flounder
Bothus sp.	Flounder
Citharichthys macrops	Spotted whiff
Cyclopsetta fimbriata	Spotfin flounder
Etropus crossotus	Fringed flounder
E. microstomus	Smallmouth flounder
Paralichthys dentatus	Summer flounder
Scophthalmus aquosus	Windowpane
Syacium micrurum	Channel flounder
CYNOGLOSSIDAE (tonguefishes)	
Symphurus diomedianus	Spotted fin tonguefish
S. plagiusa	Blackcheek tonguefish
S. urospilus	Spottail tonguefish
BALISTIDAE (triggerfishes and file fishes)	
Aluterus schoepfi	Orange filefish
Monacanthus ciliatus	Fringed filefish
M. hispidus	Planehead filefish
OSTRACIIDAE (boxfishes)	
Lactophrys triqueter	Smooth trunkfish
TETRAODONTIDAE (puffers)	
Sphoeroides maculatus	Northern puffer

Source: TII, 1979

Comparisons of hard- and soft-bottom finfish diversity and abundances demonstrate the relative importance of hard-bottom areas to the biological productivity of the SAB. NOAA (1980) concludes "the open-shelf of the South Atlantic is primarily a depauperate sandy bottom with only infrequent emergence of inhabitable reef areas. These so-called live-bottom areas serve as a biological oases supporting rich demersal populations and occasional foraging pelagic species." (p. 74).

MARINE MAMMALS

Marine mammals occurring in the SAB, including cetaceans (whales, dolphins, and porpoises), pinnipeds (seals and sea lions), and sirenians (manatees), are listed along with their migration routes, distribution and primary food sources, in Table 3-12. With the exception of harbor seals (Phoca vitulina concolor), California sea lions (Zalophus californianus), Atlantic bottlenose dolphin (Tursiops truncatus), and Florida manatee (Trichechus manatus), most of the marine mammal species are typically found in offshore waters (BLM, 1976). Harbor seals, California sea lions, and bottlenose dolphins frequently occur nearshore and in coastal estuaries (ibid.).

Florida manatees usually occur in inland waterways and the shallow coastal waters of southern Georgia and Florida, but have been sited as far north as South Carolina (ibid.).

THREATENED AND ENDANGERED SPECIES

Threatened and endangered species occurring in SAB are listed in Table 3-13. Whales generally migrate northward during summer and southward during winter through offshore waters of the SAB. Turtles migrate from the Carribean into the SAB and nest along the coast from May through late September, where they frequent shallow reefs and lagoons (NOAA, 1980). Three endangered bird species also occur within the region; however, only the brown pelican (Pelicanus occidentalis) is encountered in offshore waters. Brown pelicans nest at several sites along the southeastern coast, and feed primarily on fish in nearshore waters. Manatees (Trichechus manatus latirostrus) occur infrequently off the coasts of Georgia and the Carolinas.

TABLE 3-12
SPECIES OF MARINE MAMMALS KNOWN TO OCCUR IN THE REGION BETWEEN CAPE HATTERAS AND CAPE CANAVERAL

Common Name	Scientific Name	Population	Migration	Distribution	Primary Food Source
Black right whale	*Eubalaena glacialis*	Increasing	Inshore movement, January-March	North Carolina-Florida	Zooplankton, copepods
Humpback whale	*Megaptera novaeangliae*	Increasing	Southward, winter	North Carolina-Florida	Krill and schooling fish
Sei whale	*Balaenoptera borealis*	Declining	No data		Krill, schooling fish, and copepods
Bryde whale	*B. edeni*	Stable	No data	North Carolina-Florida	Krill, squid, small fish
Fin whale	*B. physalus*	No data	No data	North Carolina-Florida	Krill, squid, small fish
False killer whale	*Pseudorca crassidens*	Stable	No data	North Carolina-Florida	Squid and large fish
Killer whale	*Orcinus orca*	Stable	No data	North Atlantic-Florida	Squid, fish, sea turtles,sea birds, and other mammals
Short-finned pilot whale	*Globicephala macrorhyncha*	Stable	No strong seasonal movement	North Carolina-Florida	Squid and fish
Sperm whale	*Physeter catodon*	Above maximum substance levels	Northward, spring and summer; southward fall	North Carolina-Florida	Squid and fish
Pygmy killer whale	*Feresa attenuata*	Stable	None	Florida	Squid
Pygmy sperm whale	*Kogia breviceps*	Stable	None	North Carolina-Florida	Squid
Dwarf sperm whale	*K. simus*	Stable	No data	North Carolina-Florida	Squid
Antillean beaked whale	*Mesoplodon europaeus*	Stable	No data	North Carolina-Florida	Squid
True's beaked whale	*Mesoplodon mirus*	Stable	No data	North Carolina-Florida	No data
Dense beaked whale	*M. densirostris*	Stable	No data	North Carolina-Florida	Squid
Goose beaked whale	*Ziphius cavirostris*	Stable	No data	North Carolina-Florida	Squid
Rough-tooth whale	*Steno bredanensis*	Stable	No data	North Carolina-Florida	Squid
Risso's dolphin	*Grampus griseus*	Stable	No data	South 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, North Carolina-Florida	Fish, squid, and crustaceans
Spinner dolphin	*Stenella longirostris*	Stable	No data	North Carolina-Florida	Squid
Bridled dolphin	*S. frontalis*	Stable	No data	North Carolina-Florida	Squid and small fish
Spotted dolphin	*S. plagiodon*	Stable	Continental Shelf, moves inshore, spring; close to shore, spring and summer	North Carolina-Florida	Squid
Harbor porpoise	*Phocoena phocoena*	Stable	No data	Pamlico, South & North Carolinas	Bottom fish, molluscs, and crustaceans
West Indian manatee (Florida)	*Trichechus manatus*	Stable and increasing	Northward in summer into shallow waters and warm springs and rivers	South Carolina-Florida	Aquatic vegetation
California sea lion	*Zalophus califorianus*	Feral species few	No data	South Carolina-Florida	Squid and small fish
Harbor seal	*Phoca vitulina concolor*	Feral species few	No data	North Carolina-NE Florida	Fish, molluscs, and crustaceans
Hooded seal	*Cystophora cristata*	Feral species few	No data	North Carolina-Florida	Fish, molluscs, and crustaceans

Source: Caldwell and Golley, 1965

TABLE 3-13
ENDANGERED AND THREATENED SPECIES

Common Name	Specific Name	Status
	Whales	
Blue whale	Balaenoptera musculus	E
Bowhead	Balaena mysticetus	E
Finback	Balaenoptera physalus	E
Humpback	Megaptera novaeangliae	E
Right	Eubalaena sp.	E
Sei	Balaenoptera borealis	E
Sperm	Physeter catodon	E
	Turtles	
Green sea	Chelonia mydas	E
Hawksbill	Eretmochelys imbricata	E*
Kemps ridley	Lepidochelys kempi	E*
Loggerhead	Caretta caretta	T**
Olive	Lepidochelys olivacea	E†
	Fishes	
Shortnose sturgeon	Acipenser brevirostrum	E
	Sirenians	
West Indian manatee	Trichechus manatus latirostrus	E
	Birds	
Bald eagle	Haliaeetus leucocephalus	E
Brown pelican	Pelicanus occidentalis	E
Peregrine falcon	Falco perigrinus	E

E = Endangered

T = Threatened

* Rare north of Florida

† Range unknown

** South Carolina and Georgia; nest along North Carolina coast

Source: NOAA, 1980

The short-nosed sturgeon (Acipenser brevirostrom) occurs in estuaries and nearshore waters from central South Carolina to southeastern Canada. Although the sturgeon is protected, the populations continue to decline as a result of accidental capture by shad fisherman (BLM, 1980).

HISTORY OF DREDGING ACTIVITIES

SAVANNAH

Prior to 1822 channel depths of 13 ft (4m) existed between the Port of Savannah and the Atlantic Ocean. Congressional authority for maintenance of Savannah Harbor was granted in 1829, and between 1868 and 1872 the U.S. Corps of Engineers (CE) was authorized to maintain 10.5 ft (3.2m) channel depths. Dredged sediments from the entrance channel were dumped at the seaward edge of the outer tidal delta (Oertel, 1979). Navigational improvements required deepening the entrance channel to 26 ft (7.9m) in 1902, 30 ft (9.1m) in 1930, and 34 ft (10m) in 1945, to accommodate larger and deep-draft vessels. In 1967 the controlling depths of the entrance channel were increased to 42 ft (13m), and the channel widths to 600 ft (183m), and have subsequently been maintained from the seaward end of the entrance channel to the mouth of the Savannah River.

Dredged sediments were dumped in the vicinity of the seaward end of the tidal delta until 1964, when the boundaries for a specific ocean disposal site were defined. The Existing Savannah Site is a 3.6 nmi^2 area, 3.7 nmi from shore, due south of the entrance channel, with an average water depth of 11.4m. Maintenance dredging generally occurs from June to January in the entrance channel and Savannah River. Approximately 1 million yd^3 of sediment are dredged annually from the 10.8 nmi entrance channel.

CHARLESTON

The Charleston Harbor Project was authorized by the River and Harbor Act of 18 June 1878, and updated in 1940, 1945, and 1960, and specifies entrance channel depths of 35 ft (11m) and 1,000 ft (305m) channel widths. The Project also provides a 40-ft depth and 1,000-ft width "to be presented only as found necessary in the interest of national defense.." (CE, 1976; p.1). Since 1965 dredged materials, ranging in volume from 370,000 to 1.4 million yd^3, have been dredged from the 10 nmi entrance channel and dumped in the offshore disposal site. A harbor deepening project (CE, 1980) would increase the entrance channel depth from 35 to 42 ft (11m to 13m), extend the channel from River Mile - 10.4 seaward to the 42 ft (13m) depth contour and dredging new and enlarging existing turning basins. This work would necessitate dumping an additional 27 million yd^3 in the proposed Existing Site. The location of the Existing Charleston ODMDS was selected on the basis of recommendations by the South Carolina Wildlife and Marine Resource Department (CE, 1976).

Approximately 9 million yd^3 of sediments are also dredged annually from the inner harbor, landward of a line between Sullivan Island and Point Cummings, and placed in various upland and diked disposal areas. The 1942 Santee-Cooper Diversion Project increased the shoaling rate within the harbor from 500,000 yd^3/yr to the present rate of 9 million yd^3/yr, and resulted in the subsequent degradation of the harbor water and sediment quality (CE, 1976). Dredging in the entrance channel and inner harbor occurs annually from June to January.

WILMINGTON

In 1829 the CE initiated a 10-year dredging and maintenance program for the Wilmington ship channel, extending from the ocean up to and beyond the confluence of the Cape Fear and Northeast Rivers. The shipping channel was widened and deepened to 100 ft (30.5m) and 12 ft (13.6m), respectively, in 1871, and 270 ft (82.3m) and 20 ft (6.1m), respectively, in 1890. The 1912 River and Harbor Act provided 26 ft (7.9m) depth with a channel width of 400 ft (122m) at the ocean bar, and 26 ft (7.9m) depth and 300 ft (91.4m) width from the ocean upriver to Wilmington. The depths over the ocean bar were increased to 35 ft (11m) in 1950 and 40 ft (12m) in 1971, with channel width of 500 ft (152m).

The Existing Wilmington ODMDS, 1 nmi southeast of the end of Baldhead Shoal Channel, receives approximately 1 million yd^3/yr of sediments dredged from

Baldhead Shoal, Smith Island, Caswell, Southport, and Battery Island Channels. Annual dredged material disposal volumes are presented in Table 3-14. An additional 1.4 million yd^3 of sediments are dredged annually from the shipping channel in the lower Cape Fear Estuary, and placed in various diked and upland disposal areas. Dredging occurs annually between the months of September and January (CE, 1977).

DREDGED SEDIMENT CHARACTERISTICS

SAVANNAH

Sediments dredged from the entrance channel to the Savannah River are composed of broken shells, gravel, and very fine to coarse-grained sands (CE, 1975). Compositions of Savannah dredged sediments are presented in Table 3-15. Sources of these sediments are littoral sands and fine-grained river-borne sediments (Oertel, 1979).

Limited data from bulk chemical analyses of the dredged sediments are presented in Table 3-16. Concentrations of volatile solids and zinc exceed EPA "Criteria for Determining Acceptability of Dredged Spoil Disposal to the Nations Waters" (CE, 1975). However, the sediment samples passed the elutriate test after the 10 times dilution factor had been applied (ibid.). Bioassay and bioaccumulation tests have not been performed with the dredged materials.

CHARLESTON

Sediments dredged from the entrance channel to the Charleston River are composed primarily of quartz sands with some silts and shell fragments. Results of grain size and liquid-phase analyses of Charleston dredged sediments are presented in Tables 3-17 and 3-18.

TABLE 3-14
DREDGED MATERIAL DISPOSAL VOLUMES (1973 TO 1980)
(yd^3)

	Savannah	Charleston	Wilmington
1973	NA	1,159,000	NA
1974	NA	369,000	NA
1975	NA	239,000	NA
1976	1,173,530	NA	1,157,000
1977	1,229,763	1,035,000	218,645
1978	5,118,000	3,141,700	523,800
1979	239,423	719,000	600,000
1980	NA	960,000	500,000

NA = Data not available

Source: CE, 1975, 1977, and 1980

TABLE 3-15
COMPOSITION OF SAVANNAH DREDGED SEDIMENTS

Sample Number	Composition (% wt)		
	Gravel	Sand	Fines
1	2	96	2
4	0	98	2
5	5	93	2
7	0	72 to 90	10 to 28

Source: CE, 1975

TABLE 3-16
CHEMICAL COMPOSITION OF SAVANNAH DREDGED SEDIMENTS

	Volatile Solids (%)	COD* (%)	Total K Nitrogen (%)	Oil and Grease(%)	Hg	Pb	Zn
					(ppm)		
Sediments	6.2	4.7	0.06	0.09	0.03	12	74
EPA Criteria	6.0	5.0	0.14	0.15	1.0	50	50

*COD = Chemical oxygen demand

Source: CE, 1975

The results of bioassays, using sediments dredged from Charleston Harbor are summarized in Table 3-19. JEA (1979) concluded there is no indication of toxicity in solid-phase bioassay, and no limiting permissible concentration (LPC) would be equaled or exceeded, with the exception of cadmium, during dredged material disposal. Chemical analyses indicated that cadmium concentrations were not significantly greater in liquid phase than in seawater controls; however, the cadmium levels in the seawater controls were 14 times higher than the EPA standards for marine waters. No pesticides or PCB's were detected in any samples. Consequently, JEA (1979) concluded sediments from the entrance channel comply with Federal regulations for safe ocean disposal of dredged materials.

WILMINGTON

Sediments from the entrance channel to the Wilmington Harbor are composed primarily of medium- to fine-grained sands with variable amounts of silts and clay (0 to 30% fines) derived from littoral transport and sedimentation of riverborne sediments (JEA, 1980). Grain size and chemical analyses of sediment elutriate tests are presented in Tables 3-20 and 3-21, respectively. Bioassay tests (summarized in Table 3-22) demonstrate that dredged sediments do not differ significantly from reference sediments in their effect on marine species. Similarly, bioaccumulation tests demonstrated that mercury and cadmium are not taken up in significantly elevated levels by marine organisms.

TABLE 3-17
COMPOSITION OF CHARLESTON DREDGED SEDIMENTS

Sample	Quartz Sand	$CaCO_3$ Shell	Composition (% wt)			Rock Fragments
			Silt	Clay	Phosphorite	
1	78	22				
2	71	29				
3	75	25				
4	63	35				
5	85	15				
6	87	13				
7	72	28				
8	64	36				
9	90	8		2		
10	32	2	20	46		
11	9	2	74	15		
12	20	6	56	18		
13	16	4	52	28		
14	71	10	13	6		
15	79	19	1	1		
16	60	40			2	
17	60	38				2
18	56	42				39
19	36	25				
20	44	56				
21	33	50				17

Source: SCWMRD, 1979

TABLE 3-18
RESULTS OF LIQUID-PHASE ANALYSES OF CHARLESTON DREDGED SEDIMENTS

Constituent	Mean Concentration		Range
	Disposal Site Water (n = 4)	Liquid Phase (n = 3)	
NO_2-N[1]	<0.01	0.34	0.01 to 1.1
NO_3-N[1]	<0.5	0.05	0.05
NH_3-N[1]	<0.1	5.3	3.4 to 7.4
OP-PO_4[1]	0.2	0.36	0.2 to 0.84
TOC-C[1]	10	7.5	11 to 18
Oil and Grease[2]	13	27	11 to 69
As[1]	0.03	0.04	0.03 to 0.08
Be[1]	0.3	0.3	0.3
Cd[3]	0.07	0.07	0.06 to 0.07
Cr[1]	0.3	0.3	0.3
Cu[4]	0.09	0.07	0.06 to 0.07
Hg[5] µg/liter	0.1	0.1	0.1
Ni[6]	0.42	0.41	0.40 to 0.43
Pb[6]	0.50	0.58	0.52 to 0.69
Se[6] µg/liter	2	2	2
Zn[6]	0.13	0.15	0.11 to 0.17

Marine standards suggested by U.S. EPA 1976 Quality Standard for Water (EPA-440/9/76/023) are:

(1) None suggested
(2) 0.01 times the 96 hour LC_{50} in flowing water bioassays
(3) 5.0 µg/liter
(4) 0.1 times the 96 hour LC_{50}
(5) 0.10 µg/liter
(6) 0.01 times the 96 hour LC_{50}

Note: Values are in mg/liter (= ppm) except as noted

Source: JEA, 1979

TABLE 3-19
BIOASSAY TEST RESULTS OF CHARLESTON DREDGED SEDIMENTS

Sample No.	C-14	C-15	C-16	C-17
Suspended Particulate Phase				
Grass shrimp	30/30	30/28	29/29	29/27
Silverside minnows	29/26	29/1*	27/30	27/30
Mysids	29/25	29/27	29/26	29/25
Zooplankton	29/27	29/28	27/28[3]	27/28[3]
Liquid Phase				
Grass shrimp	30/30	30/23	29/28	29/25
Silverside minnows	29/30	29/1*	27/26	27/30
Mysids	29/30[1]	27/30	27/27[2]	29/28[1]
Zooplankton	29/30	29/28	27/28[3]	27/24
Solid Phase				
Quahogs	91/92	91/95	91/91	91/89
Grass shrimp	97/93	97/93	97/95	97/85
Mysids	96/94	96/97	96/90	96/94
Haustorids	100/90*	100/97	100/98	100/99

1 = 8-hour counts
2 = 24-hour counts
3 = 48-hour tests
* = Significantly different from control (0.05 level)

Ratios are control/test sediments. Numbers are total number of survivors at the end of the test. All differences not significant unless marked by an asterisk (*).

Source: JEA Inc., 1979

TABLE 3-20
COMPOSITION OF WILMINGTON DREDGED SEDIMENTS

Sample	Composition (wt%)		
	Sand	Silt	Clay
1	63	29	8
2	85	9	6
3	75	16	9
4	75	20	5
5	77	21	2
6	98	2	0
7	100	0	0
8	100	0	0
Mean	84	12	4

Source: JEA, 1980

Levels of petroleum hydrocarbons and chlorinated hydrocarbons were undetectable in test organisms. Since the LC_{50} exceeded 100%, and none of the sediment constituents approached the Limiting Permissible Concentration (LPC), sediments from the entrance channel meet the biological testing criteria for safe ocean disposal (JEA 1980).

OTHER RESOURCES

FISHERIES

From 1971 to 1976 commercial fishing in the SAB accounted for 6% of the total U.S. fish landings and dollar value, and provided jobs in processing and wholesale plants for an estimated 10,000 people (BLM, 1980). Of the four coastal states in the SAB, North Carolina had the largest fish landings and annual revenue (BLM, 1980).

The commercial fishieries in the SAB consists of inshore and estuarine, pelagic, and demersal components. The inshore and estuarine commercial species consist of oysters (*Crasseostrea virginica*), clams (*Mercenaria mercenaria*), crab (*Callinectes sapidus*) and shrimp (*Penaeus aztecus*, *P. duorarum*, and *P. setiferus*). The pelagic component comprises primarily bluefish (*Pomatomus saltatrix*), mackeral (*Scomberomorus cavalla* and *S.*

TABLE 3-21
MEAN CONCENTRATIONS OF TRACE CONSTITUENTS
IN LEACHATE OF SEDIMENTS DREDGED FROM WILMINGTON ENTRANCE CHANNEL

Parameter	Mean Concentration (n = 3)	Range
Ammonia	0.81	<0.1 to 1.9
Oil and Grease	356	262 to 487
Aliphatic Hydrocarbons	76	36 to 106
Aromatic Hydrocarbons	9.4	<1.0 to 15.9
Phenol	0.16	0.075 to 0.213
Pesticides		
n - Aryl Carbamates	<0.001	<0.001
o - Aryl Carbamates	<0.001	<0.001
Organochlorine	<0.001	<0.001
Organophosphorus	<0.001	<0.001
Polychlorinated Biphenyls	<0.001	<0.001
Methyl Mercury	<0.001	<0.001
Arsenic	3.0	2.9 to 3.2
Cadmium	0.53	<0.02 to 1.12
Chromium	51.4	4.7 to 120
Cobalt	8.5	3.4 to 18
Copper	<0.02	0.02
Iron	1,886	1,417 to 2,476
Lead	1.4	1.1 to 1.9
Manganese	295	164 to 547
Mercury	0.024	0.0043 to 0.041
Nickel	120	6.4 to 333
Selenium	0.306	0.08 to 0.71
Vanadium	0.621	0.213 to 0.85
Zinc	55.6	31.9 to 89.9

Note: Sediments leached with 1 N HCL; results in µg/liter

Source: JEA, 1980

TABLE 3-22
BIOASSAY TEST RESULTS FOR WILMINGTON DREDGED SEDIMENTS

	SPP	LP
Sediment 1		
Menidia menidia	30/30/26*	30/30/27
Neomysis americana	28/25/25	28/24/23
Acartia tonsa	29/29/30	29/29/29
Sediment 3		
Menidia menidia	30/30/30	30/30/30
Neomysis americana	28/25/23	28/24/18*
Acartia tonsa	29/29/28	29/29/29
Sediment 4		
Menidia menidia	30/30/30	30/30/29
Neomysis americana	28/25/26	28/24/21
Acartia tonsa	29/29/29	29/29/30

Solid Phase†

	Control	Ref.	Sed. 1	Sed. 3	Sed. 4
Palaemonetes pugio	100	94	100	97	99
Mercenaria mercenaria	99	100	100	100	100
Neanthes arenaceodentata	99	97	92	97	98

SPP = Suspended particulate phase
LP = Liquid phase

* Significantly different from reference ($p \leq 0.05$, t-test)
† Numbers represent survivors after 10 days out of 100 at start

Note: Numbers of survivors after 96 hours out of 30 at start. Ratios are control/reference/test sediment. No difference from reference is satistically significant unless marked by an asterisk (*).

Source: JEA, 1980

maculatus), tuna (Thunnus obesus), swordfish (Xyphias gladius), and menhaden (Brevoortia tyrannus). These species are caught with purse seines and longlines; fishing is most prevalent during summer. Menhaden are the primary component of the pelagic fishery, both in weight of landings and dollar value; however, recent catch data for this species are not available (Martin, 1977). Demersal species of commercial importance include groupers (Epinephelus nigritus and E. niveatus), porgies (Pagrus pagrus), snappers (Lutjanus campechanus and L. vivanus), flounder (Paralichthys dendatus, P. lethostigma, and P. albigutta), and grunts (Haemulon plumieri). Commercial fishing occurs year-round; however, the highest catches occur during late summer (BLM, 1980).

The SAB is also a major recreational fishing area. The National Marine Fisheries Service (NMFS) estimated that in 1970 2 million recreational fishermen fished offshore Georgia and the Carolinas. The estimated value of the marine recreational fisheries is $300 million (BLM, 1976). Big-game fisheries occur offshore (over the Shelf break) for sailfish (Istiophorus platypterus), marlin (Makaira nigricans and Tetrapturus albidus), and bluefish. Pier fishing is restricted to coastal and migratory species such as croaker (Micropogonias undulatus), striped bass (Morone saxatilis), shad (Alosa sapidissima), and bluefish. Charter or head boats fish from 5 to 50 nmi from shore, depending on season and target species (BLM, 1976).

SAVANNAH

The Port of Savannah serves both Chatham County, Georgia and Jasper County, South Carolina. However, the total fish and shellfish landings for Jasper County are negligible compared to those of Chatham County; therefore the Jasper County landings have been omitted in the following discussion. A summary of fish landings for 1979 is presented in Table 3-23.

In 1979 approximately 10 million lb (4.5 million kg) of fish and shellfish were landed in Chatham County, with a total value of $17.5 million, representing 63% of the State total (NMFS, 1980). Approximately 99% of the total Chatham County fish and shellfish catch consists of shrimp, shad, blue crabs, and groupers.

TABLE 3-23
CATCH DATA FOR CHATHAM COUNTY, GEORGIA (1979)

Species	Weight (lb)	Value ($)
Blue crab	2,664,490	466,285
Bluefish	—	—
Carp	780	140
Catfish and bullhead	7,953	4,008
Cobia	105	21
Croaker (unidentified)	18,637	5,423
Dolphin	1,407	1,026
Black drum	—	—
Red drum	535	307
Eels (common)	50	44
Flounder	32,908	14,348
Grouper	75,601	64,866
Grunts	907	191
Hickory shad	3,701	1,925
King mackerel	10,394	8,014
King whiting	45,795	14,380
Mullet	681	319
Oysters	1,751	1,999
Sea bass	8,348	5,111
Seatrout, Spotted	1,484	1,221
Scup and Porgy	39,563	25,123
Shad	129,326	109,2280
Shrimp	6,480,830	16,778,869
Snapper, Red	25,927	54,136
Snapper, Vermillion	4,065	5,416
Snapper (unidentified)	105	138
Spanish mackeral	1,460	326
Spot	150	46
Sturgeon	497	233
Squid	281	106

TABLE 3-23 (continued)

Species	Weight (lb)	Value ($)
Tilefish	50	12.5
Triggerfish	203	62
Warsaw grouper	60	4.8
Unidentified finfish for food	1,731	902

---- Data not available

Source: NMFS, 1980

The shrimp fishery is dependent on catches of brown shrimp (Penaeus aztecus), white shrimp (P. setiferus), and rock shrimp (Sicyona brevirostris). The commercial fishery for both penaeid species operates within the 15m isobath, less than 5 nmi from shore (BLM, 1978). The rock shrimp fishery lies between 12 and 200 nmi from shore. Shrimp are caught over sand and mud bottoms with purse seines. The shrimp fishing season extends from approximately April to October.

Blue crabs and shad are also important inshore commercial species. Crabs are taken with otter trawls and roller trawls from coastal sounds and estuaries in summer. Shad are caught throughout the year in rivers and bays with gillnets.

Groupers are the major commercial finfish species of the Georgia demersal fishery. Fishing occurs year-round along high-relief areas of the Shelf break (BLM, 1980).

CHARLESTON

In 1979 total commercial fish landings in the port of Charleston had a value of $12.3 million, accounting for 47% of the total South Carolina fish and shellfish catch revenue (NMFS, 1980b). Weights and value of the commercial fish and shellfish landings are listed in Table 3-24. Groupers, blue crab, shrimp, and swordfish are the primary components of the

TABLE 3-24
FISH CATCH FOR CHARLESTON COUNTY (1979)

Species	Weight (lb)	Value ($)
White shrimp (heads off)	1,639,849	6,811,074
Brown shrimp (heads off)	639,751	2,612,800
Pink shrimp (heads off)	3,627	2,837
Rock shrimp (heads off)	399,931	415,351
Blue crab	1,819,315	553,719
Squid	18,965	5,345
Clams	121,839	290,157
Oysters	63,374*	151,296
Bluefish	6,615	1,837
Croaker	6,834	1,399
Flounder	65,834	24,028
Grouper	341,157	257,620
Grunts	5,205	735
King whiting	58,339	11,428
King mackeral	33,212	23,291
Menhaden	1,090	89
Mullet	1,844	328
Porgy	243,420	150,671
Scup	22,460	9,875
Seabass	115,031	59,214
Seatrout	4,713	1,219
Shad	3,538	2,295
Snapper, Red	31,514	67,247
Snapper, Vermilion	81,894	118,669
Snapper (unidentified)	6,095	8,954
Swordfish	575,761	723,561
Tilefish	17,718	5,024
Triggerfish	7,804	2,080

* Bushels

Source: NMFS, 1980b

Charleston-based fishery, comprising 90% of the annual catch. The grouper-flounder fishery is centered in the mid- and outer Shelf. Groupers are taken in the vicinity of reefs and hard-bottom areas, while flounders are taken over flat, sandy bottoms. Fishing occurs year-round.

Shrimp fishing for pink, white, and brown shrimp occurs within 3 nmi from shore, and for rock shrimp between 40 and 50 nmi from shore. Shrimp trawlers operate from May through December; however, the greatest catch occurs in late summer (BLM, 1976).

WILMINGTON

Wilmington Harbor provides port facilities for both Brunswick and New Hanover Counties. In 1974, 5.7 million lb (2.6 million kg) of finfish and shellfish were landed in the Port, with an estimated value $5.6 million (NMFS, 1980c). Commercial species and their estimated dollar value for the Port of Wilmington are shown in Table 3-25. The three major commercial fisheries components—shrimp, clams, and groupers—account for approximately 59% of the total catch.

Pink, white, and brown shrimp are the three main species of the shrimp fishery. Shrimp fishing off North Carolina occurs from March through December within 20 nmi of shore, although the major fishery is within 3 nmi of shore.

Small numbers of rock shrimp (Sicyonia brevirostris) also are caught offshore; however, small populations and low market prices have depressed the fishery. Clamming is restricted to coastal estuaries and sounds.

Groupers are caught offshore in live-bottom areas on the Shelf and reefs on the Shelf break in depths of 100 to 400m. Fishing for grouper typically occurs in summer and fall.

MINERAL RESOURCES

Mineral resources in the South Atlantic Bight (Figure 3-6) include phosphorite, sand, gravel, and ceramic muds which occur at levels presently

TABLE 3-25
FISH CATCH FOR BRUNSWICK AND NEW HANOVER COUNTIES, NORTH CAROLINA (1979)

Species	Weight (lb)	Value ($)
Bluefish	374,200	134,678
Croaker	49,400	14,590
Eels (common)	36,000	30,644
Flounders	142,870	62,247
Groupers	649,700	437,217
Grunts	20,400	3,692
King mackeral	72,300	52,647
King whiting	85,000	23,373
Mullet	132,200	35,319
Scup/Porgy	367,300	211,831
Sea bass	452,800	230,236
Sea trout	89,200	23,393
Shad	51,800	28,463
Snapper, Red	59,300	108,222
Snapper, Vermilion	90,000	132,747
Snapper (unclassified)	114,700	176,035
Spot	207,100	58,673
Striped bass	16,200	23,285
Swellfish	7,600	3,336
Tilefish	17,300	4,151
Triggerfish	9,000	2,679
Tuna	2,300	912
Crab	1,023,500	181,832
Shrimp	934,600	2,128,418
Clams	114,200	408,356
Octopus	10,600	13,653
Oysters	114,700	142,286
Others	279,200	204,085

Source: NMFS, 1980c

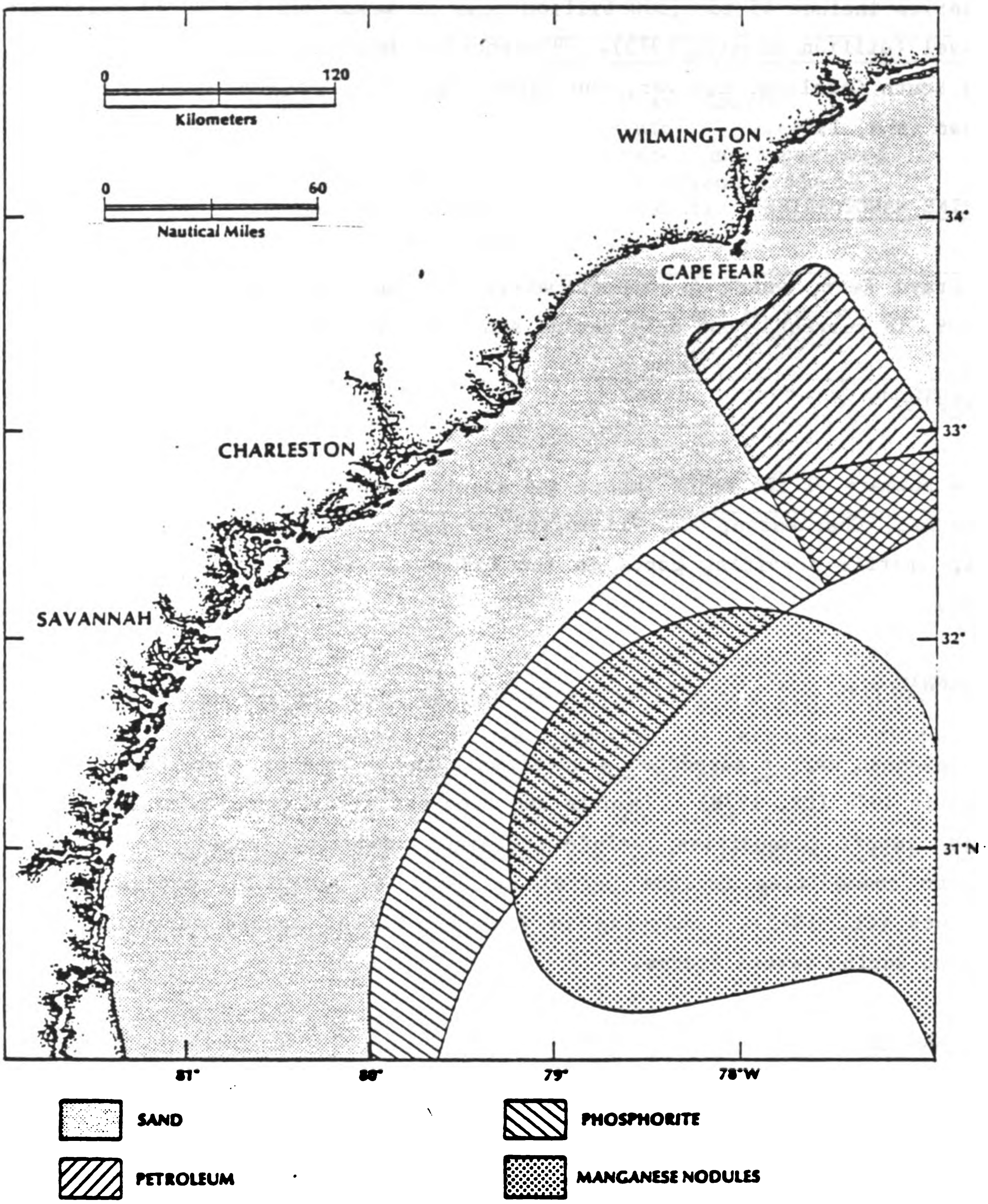

Figure 3-6. Mineral Resources in the South Atlantic Bight and Blake Plateau
Source: Emery, 1968

too low for economically feasible recovery (BLM, 1976). Outer Shelf mineral reserves include 45 to 4,500 billion tons of sands and 1.4 to 50 billion tons of gravel (Dillion et al., 1975). Phosphorite deposits exist in Georgia and North and South Carolina; however, the extent and value of nearshore deposits are not known (BLM, 1976).

MARINE SANCTUARIES

Grays Reef, which is approximately 25 nmi south of the Existing Savannah ODMDS, is currently the only marine sanctuary in the SAB (BLM, 1980).

SHIPPING

A summary of the major import and export commoditites to and from the Ports of Savannah, Charleston, and Wilmington is presented in Table 3-26. Most of the ship traffic servicing ports in the SAB occur 25 to 50 nmi from shore (NOAA, 1980).

SAVANNAH

Savannah Harbor supported a total shipping volume of approximately 11 million tons in 1978 (CE, 1978). Imports and receipts exceed exports by a factor of two. Major import commodities include petroleum products, lumber, and cement; major export commodities include petroleum products, woodpulp, kaolinite clay, and peanuts (CE, 1975). Shipping in Savannah Harbor occurs throughout the year, except during severe storms.

CHARLESTON

In 1978 Charleston Harbor had a total shipping volume of 9.5 million tons (CE, 1978). Major import commodities are building cement, petroleum products, and nonferrous ores. Major export commodities include soybeans, paper products, and lumber.

TABLE 3-26
IMPORT AND EXPORT COMMODITIES

Harbor	Imports	Exports
Savannah	Residual fuel oil Crude petroleum Limestone Basic textile products Iron and steel shapes Coke, petroleum asphalts, solvents	Clay (Kaolin) Pulp Paper and paperboard Petroleum products Peanuts
Charleston	Residual fuel oil Cement Chemical products Plywood	Farm products Pulp and paper products Textile products Soybeans
Wilmington	Residual fuel oil Gasoline, petroleum distillates Iron ore Fertilizers	Paper, paperboard and pulp Textile products Tobacco Fabricated metal products

Source: NOAA, 1980

WILMINGTON

Total shipping volume for the Port of Wilmington in 1978 was 7.4 million tons (CE, 1978); imports and receipts exceed exports. Petroleum products, fertilizers, and ferrous and nonferrous ores are the major import commodities. Tobacco, wood pulp, and fabricated metal products are major export items (CE, 1977). Shipping generally occurs throughout the year, although severe wave conditions from winter storms may temporarily interrupt shipping.

MARINE RECREATION

The southeastern coast of the United States is a major recreational area (BLM, 1980). Recreational activities include fishing (surf, pier, day, and deepsea), boating, beachcombing, swimming, and shellfishing. A summary of marine related recreational activities is presented in Table 3-27.

MILITARY

The U.S. Navy, with a major base in Charleston harbor, performs a variety of activities in the SAB, including surface-to-aerial gunnery, bombing and torpedo firing, missile firing, and aircraft and submarine operations. Naval Fleet Operting Areas cover a major portions of the SAB (NOAA, 1980).

TABLE 3-27
MARINE RECREATIONAL ACTIVITIES

State of Residence	Saltwater fishing	Shell-fishing	Swimming	Sailing	Pleasure Boating	Beach-combing	Diving
North Carolina	1,120	445	1,689	187	693	1,274	70
South Carolina	396	283	842	76	319	608	34
Georgia	557	251	1,055	112	494	732	51

Note: Estimated number of people participating by state of residence and type of recreational activity (1974)

Source: Mabry et al., 1977

Chapter 4

ENVIRONMENTAL CONSEQUENCES

The similarity between the dredged material and respective disposal site sediments minimizes adverse impacts on the ecosystem and public health and safety. Previous use of the existing sites for dredged material disposal has caused minor impacts on benthic organisms, temporary increases in suspended sediment concentrations associated with a turbidity plume, and temporary mounding. Site-specific data for mid-Shelf and Shelf-break areas are not available and no previous dumping has occurred in these regions.

Effects of dredged material disposal, described in this chapter, are classified under two broad categories: (1) ecosystem and (2) public health and safety. The ecosystem section describes the environmental effects of dredged material disposal and emergency dumping on water and sediment chemistry and the biota. The public health and safety section includes effects on commercial and recreational fishing, navigation, and aesthetics. Unavoidable adverse environmental effects and mitigating measures, short-term use versus long-term productivity, and irreversible and irretrievable commitments of resources are discussed. This chapter provides the scientific and analytical bases for evaluation and comparisons of the alternatives described in Chapter 2.

Environmental characteristics of each of the three Alternative mid-Shelf areas, and each of the three Alternative Shelf-break areas, are comparable to the other areas within the same respective region. Thus, the environmental consequences of dumping at each of the mid-Shelf and Shelf-break areas would be similar. The following discussion of environmental consequences of dumping in the mid-Shelf region applies to each of the three Alternative mid-Shelf areas; consequences of dumping in the Shelf-break region apply to each of the Shelf-break areas.

EFFECTS ON THE ECOSYSTEM

Specific information for the Existing Savannah and Alternative Charleston and Wilmington ODMDS and surrounding environment include: (1) IEC (1980) survey data, (2) investigations of the geological and biological characteristics of the existing Savannah ODMDS by Oertel (1974, 1975, 1979), (3) biological, geological, and chemical characteristics of the Existing Charleston ODMDS by SCWMRD (1972, 1979), and (4) biological and oceanographical characteristics of the Cape Fear Estuary and adjacent nearshore region by Carolina Power and Light (Anonymous, 1980). IEC investigated the environmental characteristics of the Existing Sites and areas immediately adjacent to the sites to assess the effects of dumping on the marine environment and to augment historical environmental data. Results of these studies are discussed in Appendix A and summarized in the following sections.

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

WATER QUALITY

Dumping dredged materials at the SCW-ODMDS should not significantly degrade the water quality in regions adjacent to the sites. Brokew and Oertel (1976) concluded that turbidity increases from dredged material disposal are minimal compared to the normal background levels. Wright (1978) concluded that at most dredged material disposal sites increases in turbidity persisted for only a few hours and, in addition, "storms, river discharge and other natural phenomena resulted in turbidity increases of much greater magnitude than those associated with disposal" (p. 48).

Detectable quantities of ammonia may be released during dredged material disposal, especially from sediments with high percentages of silts (Windom, 1973). Ammonia releases from Charleston dredged sediments were substantiated by chemical analyses of sediment leachates by JEA (1979). Nearshore phytoplankton are typically nitrogen limited (Ryther and Dunstan, 1971), thus temporary and localized increases in dissolved nitrogen may slightly stimulate primary productivity. Elevated concentrations of ammonia would be temporary, and the duration of elevated levels is dependent on rates of nearshore mixing and phytoplankton uptake rates.

Dredged sediments may also contain elevated levels of certain trace metals (e.g., zinc) (CE, 1975). However, analyses of liquid phases and leachates, and calculations of initial dilutions suggest that significant amounts of metals will not be released at the disposal site (JEA, 1979, 1980). Scavenging of released metals by suspended sediments and insoluble iron hydroxides occurs during the release of dredged sediments. After deposition of hydroxides, adsorbed metals may be released and subsequently become available for biological uptake (Windom, 1972, 1973, 1975). However, results of the CE Dredged Material Research Program (DMRP) suggest that releases of metals are transient and concentrations approach predisposal levels within periods of minutes to hours after dumping (Wright, 1978).

No consistently elevated levels of trace metals or chlorinated hydrocarbons (CHC) were detected in disposal site waters during the IEC surveys relative to either control stations or other nearshore waters in the South Atlantic Bight (Windom and Betzer, 1979; Lee, 1979). However, it is doubtful whether dissolved or particulate chemical species released from dredged material could be detected due to the rapid dilution and mixing of nearshore waters.

SEDIMENT QUALITY

Sediments dredged from the entrance channels are derived from both longshore transport of marine sediments and sedimentation of river-borne silts. Consequently, dredged sediments are not chemically or physically different from existing sediments at the disposal sites. No elevated levels of trace metals, oil and grease, or CHC's in sediments within or downcurrent from the Existing Sites were detected during the IEC surveys. Similarly, substantial differences in the disposal site sediment textures relative to adjacent areas were not detected. These results suggest that previous dumping at the Existing Sites has not significantly altered either sediment chemistry or sediment texture.

BIOTA

In general, dredged material disposal presents four potential problems to aquatic organisms: (1) temporary increases in turbidity, (2) changes in the physical and chemical characteristics of habitat, (3) smothering by burial, and (4) the possible introduction of pollutants. It is often difficult to distinguish adverse effects caused by sediment disposal from changes due to natural variability in species abundances. Paucity of site-specific data limit conclusions on the impacts of dumping at the Existing Sites.

Plankton

Effects of dredged material disposal on phytoplankton and zooplankton are difficult to assess because of high natural variability. The influences of tidal and river discharges, as well as diel changes in zooplankton abundances, increase the difficulty of measuring disposal effects. Sullivan and Hancock (1977) concluded that for most oceanic areas, natural plankton population fluctuations are so large that field surveys would not be useful for detecting the impacts of dredged material disposal.

Dredged material disposal creates a temporary turbidity plume, consisting of fine-grained silt and clay (CE, 1975, 1976, 1977). Entrainment of phytoplankton, zooplankton, and ichthyoplankton within a turbidity plume has a minor potential for localized plankton mortality. Elevated suspended-sediment concentrations within the disposal plume may inhibit filter-feeding planktonic larvae, although the extent of this impact is unknown. However, existing (background) suspended-sediment levels are high nearshore due to river discharges, and dumping causes negligible increases in suspended sediment (Oertel, 1979). Furthermore, Hirsch et al. (1978) concluded "[m]ost organisms are not seriously affected by the suspended sediment conditions created in the water column by dredging and disposal operations" (p. 2). Results of the IEC survey elutriate tests (Appendix A) indicate that releases of soluble pollutants from dredged materials to receiving waters are negligible. Therefore, adverse impacts of dredged material disposal on plankton should be minimal. Static bioassays (discussed in Chapter 3) demonstrate that dredged sediments from Charleston and Wilmington typically were not toxic to representative zooplankton species (Paleomenetes pugio and Neomysis americana). However, toxicity was observed in one of three liquid-phase bioassays of Wilmington sediments with mysids Neomysis americana) (JEA, 1979 and 1980). Bioassays have not been performed on Savannah dredged materials.

Benthos - Benthic organisms at the SCW-ODMDS are exposed to increased suspended sediment concentrations, burial, and temporary changes in water quality. Effects due to increased suspended sediment concentrations and alterations of sediment texture are negligible because of high natural suspended sediment loads and the similarity between dredged material and disposal site sediments.

Bioassay and bioaccumulation tests with dredged sediments from Charleston and Wilmington entrance channels were used to investigate the potential for adverse impacts due to water quality changes caused by ocean dumping on representative benthic organisms. Solid-phase bioassays indicated no potential for toxicity in the quahog (Mercenaria mercenaria), amphipod (Neohaustorius schmitzi), or polychaete (Neanthes arenaceodentata). No bioaccumulation of metals (cadmium and mercury) or petroleum and chlorinated hydrocarbons were detected in M. mercenaria, which were exposed to Charleston and Wilmington dredged sediments (JEA, 1979 and 1980). Results of these tests are summarized in Chapter 3.

Direct effects of dumping (e.g., burial of organisms) are restricted to the immediate areas of the disposal sites (Hirsch et al., 1978). The authors concluded, however, that "[t]he more naturally variable the environment, the less effect dredging and disposal will have, because animals and plants common to the unstable areas are adapted to stressful conditions and have life cycles which allow them to withstand the stresses imposed by dredging and disposal... Habitat disruption can also be minimized by matching the physical characteristics of the dredged material to the substrate found at the disposal site." (p. 17). As mentioned previously, the SCW-ODMDS are located in a high-energy nearshore environment, and the dredged sediments are physically and chemically similar to the existing sediments. Therefore, alterations of the environments and adverse impacts on the biota within and adjacent to the SCW-ODMDS are considered minimal. SCWMRD (1979) stated "no effects of dredged material disposal [at the existing Charleston ODMDS] were detectable in either epifaunal or infaunal communities. Such practices have probably had little lasting impact on the macrobenthos because of the similarity of dredged materials to the existing sediments of the disposal area." (p. 47).

Previous investigations of the effects of burial of benthic infauna demonstrated that adverse impacts are typically limited to non-motile species (Richardson et al., 1977). Dredged material disposal at the SCW-ODMDS will smother some non-motile organisms. Consequently, benthic densities and abundances may temporarily decline.

Recently deposited sediments may be recolonized by motile, infaunal organisms burrowing up through dredged sediments and by opportunistic species from adjacent undisturbed areas (Hirsch et al., 1978). Recolonization typically occurs within several months, although these rates are dependent on the nature of the dredged sediment (ibid.). Rates are higher in naturally variable environments (e.g., SCW-ODMDS) and when the dredged sediments are similar to the existing sediments (ibid.). Many of the dominant species found within the Existing Sites during IEC surveys are considered opportunistic. These species may represent an altered community (i.e., altered by dredged material disposal), although significant differences in specific abundances between the disposal site and adjacent areas generally were not detectable, and many of the species present are considered representative of nearshore, sandy bottom benthic communities of the SAB (Boesch, 1977).

Fish and Shellfish

Sufficient data to characterize the effects of dumping on fish and shellfish at the Existing Sites are unavailable. However, results of the DMRP (Wright, 1978) suggest that fish are not typically affected by dredged material disposal. The mobility of finfish and shellfish preclude adverse impacts due to sediment inundation or gill-clogging. Results from bioassays suggest that finfish will not be affected by acute or long-term exposure to trace contaminants. Suspended particulate and liquid phases of Charleston dredged sediment demonstrated no toxicity to silverside minnows (Menidia menidia) (JEA, 1979). Toxicity of Wilmington dredged sediment was observed in one of three suspended particulate phase bioassays using M. menidia (JEA, 1980).

Localized burial of benthic infauna will result in temporary decreases in fish prey items and may cause localized changes in finfish abundance or diversity. Similar results were noted during the DMRP (Wright, 1978). The author concludes that "[s]ome question exists as to whether this behavior represented avoidance of the [dredged] material or was the result of the normal seasonality and the sampling techniques that were used." (p. 50). A study of the effects of dumping on demersal finfish at the Existing Savannah ODMDS was limited in duration and extent, however a general "attractive effect" for bottom-feeding fish during disposal operations was noted (Oertel, 1975).

The effects of burial and exposure to higher concentrations of suspended sediments and trace constituents on shellfish in the Existing Sites have not been investigated. As mentioned previously, high suspended-sediment concentrations associated with the turbidity plume may cause damage to respiratory structures of larval fish. However, results of the DMRP (Hirsch et al., 1978) indicate that no significant adverse impacts from temporary increases in suspended sediment concentrations would be expected. Nevertheless, the CE restrict dredging and dumping during spring and summer, when larval fish abundances are high, to minimize interferences with fish migrating from the ocean to adjacent estuaries (CE, 1975, 1976, 1977).

Marine Mammals

Dredged material disposal involves negligible risk to marine mammals. Marine mammals tend to avoid man's activities; therefore, the probability of released dredged sediments directly affecting mammals is small. In addition, the SCW-ODMDS represent only a small portion of the geographic range of marine mammals; thus, migration routes and feeding and breeding areas are not significantly restricted. The results of bioaccumulation tests (JEA, 1979 and 1980) suggest that contaminants from dredged materials are not concentrated in the food items of marine mammals; therefore, indirect toxicity is unlikely.

ENDANGERED SPECIES

Several species of baleen whales and sperm whales (Table 3-13) migrate offshore through the SAB. Infrequent and localized ocean dumping of dredged material should have no significent effect on the food source or passage of whales in the SAB. Manatees and short-nosed sturgeon occur infrequently in the vicinity of the Existing and Alternative Sites; the habitat or food source of these species should not be affected by dredged material disposal at the ODMDS. Endangered sea turtles or brown pelicans may occur infrequently as transients at the Existing Sites; however, loggerhead turtles and brown pelicans nest on coastal beaches directly north (within 3 nmi) of the Existing Wilmington ODMDS. The effects of ocean dumping at the Alternative Wilmington ODMDS on turtle and pelican nesting areas are unknown, but are not expected to be detrimental because longshore transport will move sediments eastward, and not onto adjacent beaches (Langfelder et al., 1968). Ocean dumping will have no significant impact on the food source or habitat of bald eagles or peregrine falcons because these species rarely occur offshore.

ALTERNATIVE MID-SHELF AND SHELF-BREAK AREAS

WATER QUALITY

Effects of dredged material disposal on water quality in either the mid-Shelf or Shelf-break regions would not be appreciably different than in nearshore regions. Dilution volumes offshore are slightly greater; therefore, released nutrients or trace metals would be diluted more rapidly to background levels. However, temporary increases in the suspended sediment concentrations would be significantly higher than the background concentrations.

SEDIMENT QUALITY

Greater dissimilarities exist between the physical and chemical characteristics of dredged sediments and sediments covering mid-Shelf and Shelf-break regions. Sediments in soft-bottom mid-Shelf regions are typically coarse-grain and resistant to horizontal transport. Dumping in mid-Shelf regions would add fine-grained, mobile sediments which would alter the existing sediment texture. Shelf-break sediments consist of fine-grain silts and muds. Therefore, the median grain size of dredged sediments is larger than the Shelf-break sediment size. Altering sediment texture may have an adverse impact on benthic infauna.

BIOTA

Dumping dredged materials in mid-Shelf and Shelf-break areas of the SAB would alter existing sediment textures and result in burial of infaunal and epifaunal organisms. The consequences of altering sediment texture in mid-Shelf and Shelf-break areas are unknown. However, Hirsch et al. (1978) stated "[w]hen disposed sediments are dissimilar to bottom sediments at the sites, recolonization of the dredged material will probably be slow and carried out by organisms whose life habits are adapted to the new sediment. The new community may be different from that originally occurring at the site." Furthermore, "exotic sediments (those in or on which the species in question do not normally live) are likely to have more severe effects when organisms are buried than sediments similar to those of the disposal site." (p. 18).

EMERGENCY DUMPING

Distances from dredging areas to the respective SCW-ODMDS vary from approximately 0.5 to 5 nmi. Because of proximity of the SCW-ODMDS to the respective dredging sites, emergency dumping is not considered a significant problem. In addition, short dumping near the SCW-ODMDS would not cause an appreciable change in sediment texture.

If, however, mid-Shelf or Shelf-break disposal areas are used, the possibility of emergency dumping increases, particularly during marginal or deteriorating weather conditions. Potential adverse effects are more likely offshore because existing sediments are texturally different than the dredged sediments, thus emergency dumping would alter the substrate. Inadvertent dumping on hard-bottom areas would have severe impacts on productive and geographically limited ecosystems.

SUMMARY OF EFFECTS ON THE ECOSYSTEM

Effects of dredged material disposal on biota at SCW-ODMDS are limited primarily to localized burial of benthic infaunal organisms. Potential adverse impacts of dredged material disposal in mid-Shelf and Shelf-break regions would include burial of benthic organisms and alterations of the substrate, with the potential for subsequent alteration in the benthic community.

Results of the DMRP (Hirsch et al., 1978) indicate that "physical habitat disruptions due to disposal are minimized at sites which have naturally unstable or shifting substrates due to wave or current action. Habitat disruptions can also be minimized by matching the physical characteristics of the dredged material to the substrate found at the disposal site." The nearshore region of the SAB, where the SCW-ODMDS are located, is a dynamic environment influenced by waves and currents. In addition, dredged materials are similar to the Existing Site sediments, but texturally dissimilar to either mid-Shelf or Shelf-break areas. Consequently, adverse impacts due to dredged material disposal may be less severe at SCW-ODMDS than at mid-Shelf or Shelf-break areas.

EFFECTS ON PUBLIC HEALTH AND SAFETY

The impacts of dredged material disposal on human health and economics of the local area are other primary concerns. Potential impacts of dumping on fisheries, navigation, and aesthetics are considered in the following sections for the Existing and Alternative Sites (SCW-ODMDS) and Alternative mid-Shelf and Shelf-break areas.

EXISTING AND ALTERNATIVE SITES (SCW-ODMDS)

FISHERIES

Fisheries resources within the SCW-ODMDS are relatively sparse. In general, the major portion of the commercial fisheries for penaeid shrimp, crab, menhaden, and a number of anadromous species, occurs within estuaries and areas immediately adjacent to the coast (within 3 nmi). Fisheries that are dependent on reef species (e.g., black bass and snapper) are localized over the Shelf and not active in the vicinity of the SCW-ODMDS. Thus, dredged material disposal at the SCW-ODMDS sites has little potential for significantly affecting existing fisheries resources.

Few species of commercial importance have been detected within or immediately adjacent to the Savannah ODMDS during either the IEC (1979) or Oertel (1974) surveys. No hard-bottom areas occur within the ODMDS. Therefore, effects of dumping on pelagic or reef fisheries should be minimal.

Few commercially important finfish or shellfish were collected at the Charleston ODMDS during the IEC surveys. The SCWRD (1972) concluded "[d]isposal in this area has resulted in no significant conflicts with commercial or recreational fishing interest, as would probably be the case if the site were located further inshore or offshore." (pp. 88-89).

Few commercial or recreational fish were captured at the Wilmington ODMDS, or adjacent control sites, during the IEC surveys. Most commercial species are taken within the estuary or in the vicinity of Frying Pan Shoals. Shrimp are taken from 0 to 20 miles of shore, although the most intense fishing occurs within 3 nmi of shore. Previous interferences from dredged material disposal at the Existing Wilmington Site with shrimp fishermen have been reported (Carpenter, personal communication*). However, dredged material disposal should have minimal impacts on adult fish or shellfish because increases in turbidity are negligible and suspended, liquid, and solid phases of dredged sediments are generally nontoxic (JEA, 1980).

A study by Carolina Power and Light identified the nearshore region surrounding the Wilmington ODMDS as a "staging area" for ocean-spawned fish larvae migrating into the Cape Fear estuary (Anonymous, 1980). The effect of dumping on fish larvae is not known. Ocean-spawned larvae have a high natural mortality rate; thus, the impact of dumping on larval fish could not be easily assessed.

NAVIGATION

The disposal of dredged materials could present two potential problems to navigation: (1) mounding of sediments within the disposal sites and (2) interference of the hopper dredge with commercial shipping traffic during transit to and from the disposal site.

Mounding

Medium-grained sands released during dumping operations are deposited directly beneath the path of the hopper dredge. Sand-sized sediments are relatively stable within the disposal site during nonstorm conditions. Sediment mounds are reworked by waves and storm currents, and the lighter sediments are dispersed horizontally (Oertel, 1979). Storm conditions tend to disperse mounds or displace ridges, "leaving behind a platform that is approximately equal in depth to storm-wave base" (Oertel, 1979; p. 106). Consequently, long-term sediment accumulation and mounding are precluded at

*op. cit. p 2-29

the disposal sites. Net sediment transport offshore of Savannah and Charleston is southwestward; thus, dispersed sediment will not be transported back into the entrance channel. Longshore transport off Cape Fear near the Wilmington ODMDS is probably eastward; consequently, portions of the dredged sediments dumped at the ODMDS will be transported eastward.

Interference with Shipping Traffic

Hopper dredges used in maintaining the entrance channels to Savannah, Charleston, and Wilmington harbors are not as hazardous to navigation as pipeline or bucket dredges because there is no need for anchor lines, pipelines, or barges. Intermittent hopper dredge traffic from the dredging site to the disposal site should not significantly interfere with commercial shipping traffic.

AESTHETICS

Dredged material disposal at SCW-ODMDS will result in temporary increases in surface water turbidity. Turbidity plumes will be dispersed by nearshore currents, and represent only a minor increase in suspended sediment concentrations. Excessive noises or odors are not expected.

ALTERNATIVE MID-SHELF AND SHELF-BREAK AREAS

FISHERIES

Fisheries resources are localized over the mid-Shelf and Shelf-break regions, especially in the vicinity of hard-bottom areas and Shelf-break reefs. The relative importance of hard-bottom areas to finfish species of the SAB was discussed by NOAA (1980): "only 5.7 percent of the entire U.S. Fishery Conservation Zone is available as suitable habitat for reef finfish species (GMFMA, 1980). The open-shelf of the South Atlantic is primarily depauperate sandy bottom ocean with only infrequent emergence of inhababitable reef areas. These so-called live bottom areas serve as biological oases supporting rich demersal populations and occasional foraging pelagic species." (p. 70).

Dredged material disposal at mid-Shelf or Shelf-break areas would have minimal interferences with fisheries. The alternative areas are not hard-bottom areas; thus, the snapper-grouper fishery in the SAB would not be jeopardized. Migratory and pelgic finfish within the vicinity of the alternative areas are mobile, and capable of avoiding dredged material plumes.

NAVIGATION

Neither the transit nor the discharge phases of dredged material disposal in mid-Shelf or Shelf-break areas should interfere with commercial shipping. However, use of offshore sites would be restricted to periods of calm weather and sea conditions because the hopper dredge cannot operate in rough weather.

AESTHETICS

Dredged material disposal at Alternative mid-Shelf or Shelf-break areas will not degrade the aesthetic quality of the SAB. Excessive noise or odors resulting from ocean dumping are unlikely at either location.

SUMMARY OF EFFECTS ON PUBLIC HEALTH AND SAFETY

Previous dredged material disposal has had no detectable impact on the public health and safety at the Existing Sites. Dredged materials do not contain toxic substances which are accumulated in marine organisms used for human consumption or result in the development of nuisance species. Changes in disposal site bathymetry because of mounding of dredged sediments are temporary, and do not present a hazard to navigation. Finally, dredged material disposal at SCW-ODMDS will not degrade the scenic quality of the respective coastal areas. Dredged material disposal in the mid-Shelf or Shelf break would not produce adverse impacts on public health and safety.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS AND MITIGATING MEASURES

The environmental effects of dredged material disposal at the Existing Sites have not caused an observable degradation of the marine environment outside the sites. Therefore, mitigating measures to protect the environment contiguous with the SCW-ODMDS are not needed.

Minor adverse effects have occurred within SCW-ODMDS boundaries. Unavoidable effects within the disposal site may include temporary changes in bathymetry and sediment texture, turbidity plumes and releases of soluble trace constituents, and temporary changes in benthic community composition. Persistent mounding is precluded by sediment dispersion during winter storms. Results of bioassay and bioaccumulation tests suggest that Charleston and Wilmington dredged sediments meet biological testing criteria for ocean disposal (JEA, 1979, 1980). Periodic monitoring of Savannah, Charleston, and Wilmington dredged sediments will ensure that future dumping will not be toxic to marine organisms.

RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The Existing Sites have been used for approximately 15 years each. Adverse impacts from previous dumping on the resources of the nearshore SAB (e.g., fisheries and mineral and cultural resources) are difficult to quantify. Nevertheless, results of the DMRP (Wright, 1978) suggest that significant adverse impacts from dredged material disposal on the physical or biological features of a dynamic and naturally variable environment, as found at the SCW-ODMDS, are not expected. Therefore, the long-term productivity or utilization of resources within or adjacent to the SCW-ODMDS should not be jeopardized.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Irreversible or irretrievable resources committed to the dredged material disposal operation at the proposed sites are:

- Loss of energy (i.e., fuel used by hopper dredges)
- Loss of economic resources due to costs of the disposal operation

The losses are insignificant in comparison with the advantages of disposing dredged material from the entrance channels at the SCW-ODMDS (Chapter 2).

CHAPTER 5

COORDINATION

PREPARERS OF THE DRAFT EIS

The Draft EIS was issued by the Environmental Protection Agency's Ocean Dumping EIS Task Force. This document was based on a Preliminary Draft prepared by Interstate Electronics Corporation Contract No. 68-01-4610. Reviews and revisions were prepared by Michael S. Moyer. Additional reviews and support were provided by the members of the EIS Task Force:

William C. Shilling, Project Officer
Frank G. Csulak
Christopher S. Zarba

Reviews of the Draft EIS were also provided by:

Department of the Army
Waterways Experiment Station
Corps of Engineers
P.O. Box 631
Vicksburg, MI 39180

U.S. Environmental Protection Agency
Region IV
Ecological Review Section
345 Courtland Street, N.E.
Atlanta, GA 30365

PREPARERS OF THE PRELIMINARY DRAFT OF THE EIS

Preparation of the Savannah, Charleston, and Wilmington Preliminary Draft EIS was a joint effort of the scientific and technical staffs of Interstate Electronics Corporation, Anaheim, California. Table 5-1 presents the authors of each section.

TABLE 5-1. LIST OF PREPARERS

		Chapter				Appendix
Author	Summary	1	2	3	4	A
Charles Phillips	X	X	X	X	X	X
John Dorsey				X		X
Monteith Heaton						X
Peter Jepson				X		X
Bessie Lee						X

CHARLES PHILLIPS

Mr. Phillips, the principal author of the EIS, received a B.A. degree in Biological Sciences from University of California, Santa Barbara and an M.A. Degree in Marine Biology from San Francisco State University. He is an Oceanographer at Interstate Electronics Corporation (IEC).

CONTRIBUTING AUTHORS

JOHN DORSEY

Mr. Dorsey authored the Benthic Biology sections of Chapter 3 and Appendix A. He received his M.A. and B.S. in Marine Science from California State University, Long Beach, and is expected to receive his Ph.D. from Melbourne University, Austrialia.

MONTEITH HEATON

Mr. Heaton authored the Physical and Chemical Parameters section in Appendix A. He received a B.S. degree in Chemistry from State University of New York, Oneonta, and an M.S. in Marine Environmental Sciences from the Marine Sciences Research Center, State University of New York, Stony Brook.

PETER JEPSEN

Mr. Jepsen received a B.S. in Oceanography. He assisted in writing Chapter 3 and the Physical and Chemical sections of Appendix A.

BESSIE LEE

Ms. Lee holds a B.S. degree in Oceanography and Biology from Humboldt State University, and is a candidate for the M.S. degree in Microbiology at California State University, Long Beach.

REVIEWERS OF THE EIS

The entire EIS was edited and reviewed by Drs. Richard Terry and Andrew Lissner. Mr. Monty Heaton and Ms. Karen Green provided final technical reviews, and Ms. Roxanne Mills of IEC was responsible for final editing.

Chapter 6

GLOSSARY, ABBREVIATIONS, AND REFERENCES

ABUNDANCE — The number of individuals of a species inhabiting a given area. Normally, a community of several component species will inhabit an area. Measuring the abundance of each species is one way of estimating the comparative importance of each component species.

ADSORB — To adhere in an extremely thin layer of molecules to the surface of a solid or liquid.

ALKALINITY — The number of milliequivalents of hydrogen ions neutralized by 1 liter of seawater at 20°C. Alkalinity of water is often taken as an indicator of its carbonate, bicarbonate, and hydroxide content.

AMBIENT — Pertaining to the undisturbed or unaffected conditions of an environment.

AMPHIPODA — An order of crustaceans (primarily marine) with laterally compressed bodies, which generally appear similar to shrimp. The order consists primarily of three groups: hyperiideans, which inhabit open ocean areas; gammarideans, which are primarily bottom dwellers; and caprellideans, common fouling organisms.

ANTHROPOGENIC — Relating to the effects or impacts of man on nature. Construction wastes, garbage, and sewage sludge are examples of anthropogenic materials.

APPROPRIATE BENTHIC MARINE ORGANISMS — Pertaining to bioassay samples required for ocean-sensitive dumping permits, "at least one species each representing filter-feeding, deposit-feeding, and burrowing species chosen from among the most sensitive species accepted by EPA as being reliable test organisms to determine the anticipated impact on the site" (CFR 40 227.27).

APPROPRIATE MARINE ORGANISMS — Pertaining to bioassay samples required for ocean-sensitive dumping permits, "at least one species each representative of phytoplankton or zooplankton, crustacean or mollusk, and fish species chosen from among the most sensitive species documented in the scientific literature or accepted by EPA as being reliable test organisms to determine the anticipated impact of the wastes on the ecosystem at the disposal site" (CFR 40 227.27).

ASSEMBLAGE — A group of organisms sharing a common habitat.

BACKGROUND LEVEL	The naturally occurring concentration of a substance within an environment which has not been affected by unnatural additions of that substance.
BASELINE CONDITIONS	The characteristics of an environment before the onset of an action which can alter that environment; any data serving as a basis for measurement of other data.
BASELINE SURVEYS AND BASELINE DATA	Surveys and the data collected prior to the initiation of actions which may alter an existing environment.
BENTHOS	All marine organisms (plant or animal) living on or in the bottom of the sea.
BIGHT	A gentle bend in a coast forming a large open bay; a bay formed by such a bend.
BIOACCUMULATION	The uptake and assimilation of materials (e.g., heavy metals) leading to elevated concentrations of the substances within organic tissue, blood, or body fluid.
BIOASSAY	A method for determining the toxicity of a substance by the effect of varying concentrations on growth or survival of suitable plants, animals, or micro-organisms; the concentration which is lethal to 50% of the test organisms or causes a defined effect in 50% of the test organisms, often expressed in terms of lethal concentration (LC_{50}) or effective concentration (EC_{50}), respectively.
BIOMASS	The quantity (wet weight) of living organisms inhabiting a given area or volume at any time; often used as a means of measuring the productivity of an ecosystem.
BIOTA	Animals and plants inhabiting a given region.
BIOTIC GROUPS	Assemblages of organisms which are ecologically, structurally, or taxonomically similar.
BLOOM	A relatively high concentration of phytoplankton in a body of water resulting from rapid proliferation during a time of favorable growing conditions generated by nutrient and sunlight availability.
BOD	Biochemical Oxygen Demand or Biological Oxygen Demand; the amount of dissolved oxygen required by aerobic micro-organisms to degrade organic matter in a sample of water usually held in the dark at 20°C for 5 days; used to assess the potential rate of substrate degradation and oxygen utilization in aquatic ecosystems.
CARCINOGEN	A substance or agent producing a cancer or other type of malignancy.

CEPHALOPODS — Exclusively marine animals constituting the most highly evolved class of the phylum Mollusca (e.g., squid, octopus, and Nautilus).

CHAETOGNATHA — A phylum of small planktonic, transparent, worm-like invertebrates known as arrow-worms; they are often used as water mass tracers.

CHLOROPHYLL a — A specific chlorophyll pigment characteristic of higher plants and algae; frequently used as a measure of phytoplankton biomass.

COCCOLITHOPHORIDS — Microscopic, planktonic unicellular, golden-brown algae characterized by an envelope of interlocking calcareous plates.

COELENTERATA — A large diverse phylum of primarily marine animals, members possessing two cell layers and an incomplete digestive system, the opening of which is usually surrounded by tentacles. This group includes hydroids, jellyfish, corals, and anemones.

COLIFORMS — Bacteria residing in the colons of mammals; generally used as indicators of fecal pollution.

CONTINENTAL MARGIN — A zone separating the emergent continents from the deep-sea bottom; generally consists of the Continental Slope, Continental Shelf, and Continental Rise.

CONTINENTAL SHELF — That part of the Continental Margin adjacent to a continent extending from the low water line to a depth, generally 200m, where the Continental Shelf and the Continental Slope join.

CONTINENTAL SLOPE — That part of the Continental Margin consisting of the declivity from the edge of the Continental Shelf down to the Continental Rise.

CONTOUR LINE — A line on a chart connecting points of equal elevation above or below a reference plane, usually mean sea level.

CONTROLLING DEPTH — The least depth in the approach or channel to an area, such as a port, governing the maximal draft of vessels which can enter.

COPEPODS — A large diverse group of small planktonic crustaceans representing an important link in oceanic food chains.

COST/BENEFIT RATIO — A comparison of the price, disadvantages, and liabilities of any project versus profit and advantages.

CRETACEOUS — The last period of the Mesozoic Era or the corresponding system of rocks; between 136 and 65 million years ago.

CRUSTACEA	A class of arthropods consisting of animals with jointed appendages and segmented exoskeletons composed of chitin. This class includes barnacles, crabs, shrimps, and lobsters.
CTENOPHORA	An animal phylum, superficially resembling jellyfish, ranging in size from less than 2 cm to about 1m in length. Commonly known as "sea walnuts" or "comb jellies", these animals prey heavily on planktonic organisms, particularly crustaceans and fish larvae.
CUMACEANS	Small motile crustaceans which usually inhabit the surface layers of sediment, although some species exhibit diurnal vertical migrations in the water column; their presence is often indicative of unstable sediment conditions.
DECAPODA	The largest order of crustaceans; members have five sets of locomotor appendages, each joined to a segment of the thorax; includes crabs, lobsters, and shrimps.
DEMERSAL	Living at or near the bottom of the sea.
DENSITY	The mass per unit volume of a substance, usually expressed in grams per cubic centimeter (1g water in reference to a volume of 1 cc @ 4°C).
DETRITIVORES	Animals which feed on detritus; also called deposit feeders.
DETRITUS	Product of decomposition or disintegration; dead organisms and fecal material.
DIATOMS	Microscopic phytoplankton characterized by a cell wall of overlapping silica plates. Sediment and water column populations vary widely in response to changes in environmental conditions.
DINOFLAGELLATES	A large diverse group of flagellated phytoplankton with or without a rigid outer shell, some of which feed on particulate matter. Some members of this group are responsible for toxic red tides.
DISCHARGE PLUME	The region of water affected by a discharge of waste that can be distinguished from the surrounding water.
DISPERSION	The dissemination of discharged matter over large areas by natural processes (e.g., currents).
DISSOLVED OXYGEN	The quantity of oxygen (expressed in mg/liter, ml/liter, or parts per million) dissolved in a unit volume of water. Dissolved oxygen (DO) is a key parameter in the assessment of water quality.

DIVERSITY (Species)	A statistical concept that generally combines the measure of the total number of species in a given environment and the number of individuals of each species. Species diversity is high when it is difficult to predict the species or the importance of a randomly chosen individual organism, and low when an accurate prediction can be made.
DOMINANT SPECIES	A species or group of species which, because of their abundance, size, or control of the energy flow, strongly affect a community.
DRY WEIGHT	The weight of a sample of material or organisms after all water has been removed; a measure of biomass when applied to organisms.
EBB CURRENT, TIDE	Tidal current moving away from land or down a tidal ebb stream.
ECHINODERMS	Exclusively marine animals which are distinguished by radial symmetry, internal skeletons of calcareous plates, and water-vascular systems which serve the needs of locomotion, respiration, nutrition, or perception; includes starfishes, sea urchins, sea cucumbers, and sand dollars.
ECOSYSTEM	The organisms in a community together with their physical and chemical environments.
EDDY	A circular mass of water within a larger water mass which is usually formed where currents pass obstructions, either between two adjacent currents flowing counter to each other, or along the edge of a permanent current. An eddy has a certain integrity and life history, circulating and drawing energy from a flow of larger scale.
EFFLUENT	Liquid waste of sewage or industrial processing.
ENDEMIC	Restricted or peculiar to a locality or region.
ENTRAIN	To draw in and transport by the flow of a fluid.
EPIFAUNA	Animals that live on or near the bottom of the sea.
EPIPELAGIC	Of, or pertaining to, that portion of the oceanic zone into which enough light penetrates to allow photosynthesis; generally extends from the surface to about 200m.
ESTUARY	A semienclosed coastal body of water which has a free connection to the sea, commonly the lower end of a river, and within which the mixing of saline and fresh water occurs.

EUPHAUSIIDS Shrimp-like, planktonic crustaceans which are widely distributed in oceanic and coastal waters, especially in cold waters. These organisms, also known as krill, are an important link in the oceanic food chain.

FACIES The makeup or appearance of a community or species population; the visible characteristics of a rock or stratigraphic unit (e.g., general appearance or composition).

FAUNA The animal life of any location, region, or period.

FINFISH Term used to distinguish "normal" fish (e.g., with fins and capable of swimming) from shellfish. Usually in reference to the commercially important species.

FLOCCULATION The process of aggregating a number of small, suspended particles into larger masses.

FLOOD TIDE, FLOOD CURRENT Tidal current moving toward land or up a tidal stream.

FORAMINIFERA Benthic or planktonic single-celled marine organisms possessing a shell (usually of calcium carbonate) enclosing an ameboid body.

GASTROPODS Molluscs which possess a distinct head (generally with eyes and tentacles), a broad, flat foot, and usually a spiral shell (e.g., snails).

GEOSTROPHIC CURRENT A current resulting from the balance between gravitational forces and the Coriolis force.

GLAUCONITE A mixture of hydrous silicates of iron and potassium.

GULF STREAM The relatively warm, swift, well-defined northward-moving ocean current which flows up the North American East Coast. It originates where the Florida current and the Antilles current begin to curve eastward from the Continental Slope off Cape Hatteras, North Carolina.

GYRE A closed circulation system, usually larger than an eddy.

HEAVY METALS ELEMENTS Metals with specific gravities of 5.0 or greater (e.g., 5 times the density of water).

HERBIVORES Animals that feed chiefly on plants.

HOLOCENE Recent.

HOLOTHURIAN An echinoderm of the class Holothuroidea, characterized by a cylindrical body, smooth, leathery skin, and feeding tentacles; includes the sea cucumbers.

HOPPER DREDGE	A self-propelled vessel with capabilities to dredge, store, transport, and dispose of dredged materials.
HYDROGRAPHY	That science which deals with the measurement of the physical features of waters and their marginal land areas, with special reference to the factors which affect safe navigation, and the publication of such information in a form suitable for use by navigators.
ICHTHYOPLANKTON	That portion of the planktonic mass composed of fish eggs and weakly motile fish larvae.
INDICATOR SPECIES	An organism so strictly associated with particular environmental conditions that its presence is indicative of the existence of such conditions.
INDIGENOUS	Having originated in, being produced, growing, or living naturally in a particular region or environment; native.
INFAUNA	Aquatic animals which live in the bottom sediment.
INITIAL MIXING	Dispersion or diffusion of liquid, suspended particulate, and solid phases of a waste material which occurs within 4 hours after dumping.
IN SITU	(Latin) in the original or natural setting (in the environment).
INTERIM DISPOSAL SITES	Ocean disposal sites tentatively approved for use by the EPA.
INVERTEBRATES	Animals lacking a backbone or internal skeleton.
ISOBATH	A line on a chart connecting points of equal depth below mean sea level.
ISOPODS	Small crustaceans with flattened bodies and reduced heads and abdomens. They are an important intermediate link in marine food chains.
ISOTHERMAL	Approximate equality of temperature throughout a geographical area.
LARVA	A young and immature form of an organism that must usually undergo one or more form and size change(s) before assuming characteristic features of the adult.
LC_{50}	Lethal Concentration -50; in bioassay studies the concentration of a contaminant that causes 50% mortality in the population of test organisms during a unit time (usually 96 hours).

LIMITING PERMISSIBLE CONCENTRATION	A concentration of a waste material which, after initial mixing, does not exceed marine water quality criteria, or cause acute or chronic toxicity, or other sublethal (LPC) adverse effects.
LITHOGENIC	Of or derived from rock.
LITTORAL	Of or pertaining to the seashore, especially the regions between tide lines.
LONGSHORE CURRENT	A current which flows in a direction parallel to a coastline.
LORAN-C	LOng Range Aid to Navigation, type C; Low frequency radio navigation system having a range of approximately 1,500 mi radius.
MACROZOOPLANKTON	Planktonic animals which can be recognized by the unaided eye.
MAIN SHIP CHANNEL	The designated shipping corridor leading into a harbor.
MAINTENANCE DREDGING	Periodic dredging of a waterway, necessary for continued use of the waterway.
MICRONEKTON	Small, weak-swimming nekton (e.g., mesopelagic fish, small squid, gelatinous organisms, and fish larvae).
MICRONUTRIENTS	Microelements, trace elements, or substances required in minute amounts; essential for normal growth and development of an organism.
MICROZOOPLANKTON	Planktonic animals between 20 and 200 um in length; composed mainly of protozoans and juvenile copepods.
MIOCENE	A geologic epoch of the Tertiary period, extending from the end of the Oligocene to the beginning of the Pliocene; 7 to 26 million years ago.
MIXED LAYER	The upper layer of the ocean which is well-mixed by wind and wave activity.
MLLW	Mean Lower Low Water; the average height of daily low tides calculated over a long time period; used as a sea level reference.
MODEL	A mathematical or physical system, obeying certain specified conditions, whose behavior is used to understand an analogous physical, biological, or social system.
MOLLUSCA	A phylum of unsegmented animals, most of which possess a calcareous shell; includes snails, mussels, clams, and oysters.

MONITORING	As used herein, observation of environmental effects of disposal operations through biological and chemical data collection and analyses.
MUTAGEN	A substance which increases the frequency or extent of mutations (changes in hereditary material).
NEKTON	Free-swimming aquatic animals which move independently of water currents.
NERITIC	Pertaining to the region of shallow water adjoining the seacoast, and extending from the low-tide mark to a depth of about 200m.
NUISANCE SPECIES	Organisms of no commercial value, which, because of predation or competition, may be harmful to commercially important organisms.
OMNIVOROUS	Pertaining to animals that feed on animal and plant matter.
ORGANOHALOGEN PESTICIDES	Pesticides whose chemical constitution includes the elements carbon and hydrogen, plus a common element of the halogen family: bromine, chlorine, fluorine, or iodine.
ORGANOPHOSPHATE PESTICIDES	Phosphorus-containing organic pesticides (e.g., malathion or parathion).
ORTHOPHOSPHATE	One of the salts of orthophosphoric acid; an essential nutrient for plant growth.
OSTRACODA	A subclass of the class, crustacea, inclusive of small benthic forms with bodies completely enclosed within a round bivalve carapace; also called "seed shrimps."
OXIDE	A binary chemical compound in which oxygen is combined with another element, metal, nonmetal, gas, or radical.
PARAMETER	Values or physical properties that describe the characteristics or behavior of a set of variables.
PATHOGEN	An entity producing or capable of producing disease.
PCB(s)	Polychlorinated biphenyl(s); any of several chlorinated compounds having various industrial applications. PCB's are highly toxic pollutants that tend to accumulate in the environment.
PELAGIC	Pertaining to water of the open ocean beyond the Continental Shelf and above the abyssal zone.
PERCENT DRY WEIGHT	An expression of the concentration of a constituent in relation to its contribution (in percent) to the total weight of dried sample material.

PERTURBATION	A disturbance of a natural or regular system; any departures from an assumed steady state of a system.
pH	The acidity or alkalinity of a solution, determined by the negative logarithm of the hydrogen ion concentration (in gram-atoms per liter), ranging from 0 to 14 (lower than 7 is acid, higher than 7 is alkaline).
PHOSPHORITE	Concretionary rocks consisting mainly of calcium phosphate.
PHOTIC ZONE	The layer of a body of water which receives sufficient sunlight for photosynthesis.
PHYTOPLANKTON	Minute passively floating plant life in a body of water; the base of the food chain in the sea.
PLANKTON	The passively floating or weakly swimming, usually minute animal and plant life in a body of water.
PLEISTOCENE	The earlier epoch of the Quaternary, 1 to 11 million years before present.
PLUME	A patch of turbid water, caused by the suspension of fine particles following a disposal operation.
POLYCHAETA	The largest class of the phylum Annelida (segmented worms); benthic marine worms distinguished by paired, lateral, fleshy appendages provided with bristles (setae) on most segments.
PRECIPITATE	A solid that separates from a solution or suspension by chemical or physical change.
PRIMARY PRODUCTIVITY	The amount of organic matter synthesized by producer organisms (primarily plants) from inorganic substances per unit time and volume of water. Plant respiration may or may not be subtracted (net or gross productivity, respectively).
PYCNOCLINE	A vertical density gradient in a body of water, positive with respect to depth, and much greater than the gradients above and below it.
QUALITATIVE	Pertaining to the non-numerical assessment of a parameter.
QUANTITATIVE	Pertaining to the numerical measurement of a parameter.
RADIATION FOG	A major type of land fog produced when radiational cooling reduces the air temperature to or below its dew point; strictly a nighttime occurrence, although the fog may begin to form by evening, and often does not dissipate until after sunrise.
RADIONUCLIDES	Species of atoms which exhibit radioactivity.

RECRUITMENT	Addition to a population of organisms by reproduction or immigration of new individuals.
RELEASE ZONE	An area defined by the locus of points 100m from a vessel engaged in dumping activities; will never exceed the total surface area of the dumpsite.
RUNOFF	That portion of precipitation upon land which ultimately reaches streams, rivers, lakes, and oceans.
SALINITY	The amount of salts dissolved in water; expressed in parts per thousand (^{o}/oo, or ppt).
SHELF WATER	Water which originates in, or can be traced to the Continental Shelf, differentiated by characteristic temperature and salinity.
SHELLFISH	Any invertebrate, usually of commercial importance, having a rigid outer covering, such as a shell or exoskeleton; includes some molluscs and arthropods; term is the counterpart of finfish.
SHORT DUMPING	The premature discharge of waste from a vessel anywhere outside designated disposal sites. This may occur legally under emergency circumstances, or illegally to avoid hauling to a designated site.
SIGNIFICANT HEIGHT	The average height of the one-third highest waves of a WAVE given wave group.
SIPHONOPHORA	An order of planktonic, colonial, marine coelenterates; includes jellyfish and the Portugese man-of-war.
SLOPE WATER	Water which orginates from, occurs at, or can be traced to, the Continental Slope, differentiated by characteristic temperature and salinity.
SPECIES	A group of morphologically similar organisms capable of interbreeding and producing fertile offspring.
STANDARD ELUTRIATE ANALYSIS	A test used to determine the types and amounts of constituents that can be extracted from a known volume of sediment by mixing with a known volume of water.
STANDING STOCK	The biomass or abundance of living material per unit volume of water, or area of sea bottom.
SUBSTRATE	The solid material upon which an organism lives, or to which it is attached (e.g., rocks, sand).
SURVEILLANCE	Systematic observation of an area by visual, electronic, photographic, or other means for the purpose of ensuring compliance with applicable laws, regulations, permits, and safety.

SUSPENDED SOLIDS	Finely divided particles of a solid temporarily suspended in a liquid (e.g., soil particles in water).
TEMPORAL DISTRIBUTION	The distribution of a parameter over a period of time.
TERRIGENOUS SEDIMENTS	Sedimentary deposits composed of eroded terrestrial material.
THERMOCLINE	A vertical temperature gradient in some layer of a body of water, which is appreciably greater than the gradients above or below it; a layer in which such a gradient occurs.
TOTAL SEDIMENT ANALYSIS	A test wherein sediment samples are digested over heat with concentrated acid, and the resultant solution analyzed for inorganic constituents of interest (generally trace metals).
TRACE METAL OR ELEMENT	An element found in the environment in extremely small quantities; usually includes metals constituting 0.1% (1,000 ppm) or less, by weight, in the earth's crust.
TREND ASSESSMENT SURVEYS	Surveys conducted over long periods to detect shifts in environmental conditions within a region.
TROPHIC LEVELS	Discrete steps along a food chain in which energy is transferred from the primary producers (plants) to herbivores, and finally to carnivores and decomposers.
TURBIDITY	Cloudy or hazy appearance in a naturally clear liquid caused by a suspension of colloidal liquid droplets, fine solids, or small organisms.
TURNOVER RATE	The time necessary to replace the entire standing stock of a population; generation time.
UPWELLING	The rising of water toward the surface from subsurface layers of a body of water. Upwelled water is cooler and rich in nutrients; regions of upwelling are generally areas of rich fisheries.
WATER MASS	A body of water, identified by its temperature-salinity values, or chemical composition, consisting of a mixture of two or more water types.
WATER TYPE	Ocean water of a specified temperature and salinity; defined as a single point on a temperature-salinity diagram.
ZOOPLANKTON	Weakly swimming animals whose distribution in the ocean is ultimately determined by current movements.

ABBREVIATIONS

BLM	Bureau of Land Management
C	Carbon
°C	Degrees Centigrade
CE	U.S. Army Corps of Engineers
CFR	Code of Federal Regulations
DA	District Administrator (CE)
DMRP	Dredged Material Research Program
DMDS	Dredged Material Disposal Site
DO	Dissolved Oxygen
DOC	U.S. Department of Commerce
DOI	U.S. Department of the Interior
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration
FWPCA	Federal Water Pollution Control Act
FWPCAA	Federal Water Pollution Control Act Amendments
g	gram(s)
hr	hour
IMCO	Inter-Governmental Maritime Consultative Organization
k	kilogram
kHz	kilohertz
km	kilometer(s)
kn	knot(s)
m	meter(s)
m^2	square meter
mg	milligram(s)
mlt	mean low tide
mlw	mean low water
mm	millimeter(s)
MPRSA	Marine Protection, Research, and Sanctuaries Act
N	north
ng	nanogram
NEPA	National Environmental Policy Act

nmi	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOO	Naval Oceanographic Office
NTU	Nephelometric turbidity units
OCS	Outer Continental Shelf
ODMDS	Ocean Dredged Material Disposal Site
PL	Public Law
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand = $^{o}/oo$
$^{o}/oo$	parts per thousand
%	percent
RA	Regional Administrator (EPA)
s	second(s)
SAB	South Atlantic Bight
SCW	Savannah, Charleston, and Wilmington
SCWMRD	South Carolina Water and Marine Resources Department
TOC	total organic carbon
TSS	total suspended solids
μ	micron
μg	microgram
μmole	micromole
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
W	west
wt	weight
yd^3	cubic yard(s)
yr	year(s)

REFERENCES

Anonymous. 1980. Brunswick Steam Electric Plant; Cape Fear Studies, Interpretive Report. Prepared for Carolina Power and Light Co.

Atkinson, L.P. 1978. The results of four oceanographic cruises in the Georgia Bight. Ga. Mar. Sci. Ctr. Tech. Rpt. 78-1.

Atkinson, L.P., J.O. Blanton and E.B. Haines. 1978. Shelf flushing rates based on the distribution of salinity and freshwater in the Georgia Bight. Estuarine and Coastal Marine Science. 7:465-472.

Bishop, S.S., J.A. Yoder and G.A. Paffenhofer. 1980. Phytoplankton and nutrient variability along a cross-shelf transect off Savannah, Georgia, U.S.A. Estuarine and Coastal Marine Science. 11:359-368.

Blanton, J.O. 1971. Exchange of Gulf Stream Water with North Carolina Shelf Water in Onslow Bay during stratified conditions. Deep-sea Research. 18(2):167-178.

Blanton, J.O. and L.P. Atkinson. 1978. Physical transfer processes between Georgia tidal inlets and nearshore waters. pp. 515-532 In: M.L. Wiley [ed.] Estuarine Interactions. Academic Press, Inc.

BLM. See Bureau of Land Management.

Boesch, D.F. 1977. A summary and analysis of environmental information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. pp. viii:1-71. Prepared for the Bureau of Land Management by the Center for Natural Areas; S. Gardiner, ME.

Bothner, M., P. Aruscavage, W. Ferrebee, and J. Lathrop. 1979. Trace metal concentrations in sediment cores from the Continental Shelf off the southeastern United States. pp. 292-322 In. South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management, Washington, DC.

Bowman, T.E. 1971. The distribution of calanoid copepods off the southeastern United States between Cape Hatteras and Southern Florida. Smithson. Contrib. Zool. 96. 58 pp.

Brokaw, R. and G.F. Oertel. 1976. Suspended sediment data from nearshore waters of Georgia. Ga. Mar. Sci. Ctr. Tech. Rpt. Series, No. 76-3.

Bumpus, D.F. 1973. A description of the circulation on the Continental Shelf of the East Coast of the United States. Progress in Oceanography. 6:111-157.

Bureau of Land Management. 1976. Marine environmental study plan for the South Atlantic Outer Continental Shelf area, Georgia Embayment and Blake Plateau regions. U.S. Department of the Interior, New Orleans, LA.

_____1978. Final environmental impact statement, proposed 1978 Outer Continental Shelf Oil and Gas Lease Sale, South Atlantic, OCS Sale No. 43. U.S. Department of the Interior, New Orleans OCS, Louisiana. Volumes I-III.

_____1980. Draft environmental impact statement. Proposed 1981 Outer Continental Shelf Oil and Gas Lease Sale No. 56. New Orleans, LA.

Buss, B.A. and K.S. Rodolfo. 1972. Suspended sediments in Continental Shelf waters off Cape Hatteras, North Carolina. Pages 263-279 In: D.J.P. Swift, D.B. Duane, and O.H. Pilkey [eds.]. Shelf Sediment Transport: Process and Patterns. Dowden, Hutchinson and Ross, Inc. Stroudsburg, Pennsylvania.

Butman, B. and S. Pfirman. 1979. Observations of bottom current and bottom sediment movement in the Southeast Georgia Embayment, 1977. pp. 104-137 In: South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management, Washington, DC.

Carpenter, J.H. and W.L. Yonts. 1979. Dye tracer and current meter studies, Cape Fear Estuary, NC 1976, 1977 and 1978. Brunswick Steam Electric Plant Cape Fear Studies, Vol. 1, for Carolina Power and Light Company, Raleigh, NC. 331 pp.

Caldwell, D.K. and F.B. Golley. 1965. Marine mammals from the coast of Georgia to Cape Hatteras. J. of the Mitchell Society. 81:24-32.

Copeland, B.J. and W.S. Birkhead. 1973. Baseline ecology of the lower Cape Fear Estuary and ocean off Oak Island, N.C., 1971-72. Second Annual Report to Carolina Power and Light Co., Raleigh, North Carolina.

Cordes, C., L. Atkinson, R. Lee and J. Blanton. 1980. Pelagic tar off Georgia and Florida in relation to physical processes. Marine Pollution Bulletin. 11:315-317.

Cry, G.W. 1965. Tropical cyclones of the North Atlantic Ocean. U.S. Weather Bureau Tech. Paper 55. 148 pp.

Day, J.H., J.G. Field, and M.P. Montgomery. 1971. The use of numerical methods to determine the distribution of the benthic fauna across the Continental Shelf of North Carolina. J. Animal Ecol. 40:93-125.

Dillon, W., O. Gerard, E. Weed, R. Sheridan, G. Dalton, E. Sable, H. Krivoy, M. Grim, E. Robbins, and E. Rhodehamel. 1975. Sediments, structural framework, petroleum potential, environmental conditions, and operational considerations of the United States Atlantic Outer Continental Shelf: U.S. Geological Survey Open-File Report 75-411. 269 pp.

Dorjes, J.D. 1977. Marine macrobenthic communities of the Sapelo Island, Georgia region. pp. 399-421. In: B.C. Coull [ed.]. Ecology of Marine Benthos. University of South Carolina Press, Columbia.

Doyle, L.J., P.R. Betzer, M. Peacock, and F. Wall. 1979. Seston of the southeast Georgia Embayment. pp 3-40. In: South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management, Washington, DC.

Edsall, D.W. 1979. Southeast Georgia Embayment high-resolution seismic-reflection survey. pp 382-410 In:South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management.

El-Ashry, M.T. and H.R. Wanless. 1968. Photo interpretation of shoreline changes between Capes Hatteras and Fear (North Carolina). Marine Geol. 6:347-379.

Emery, K.O. 1968. Relict sediments on continental shelves of the world. Amer. Assoc. Petrol. Geol. Bull. 52(3):445-464.

Frankenberg, D. and A.S. Leiper. 1977. Seasonal cycles in benthic communities of the Georgia continental shelf. In: B. Coull [ed.]. Ecology of marine benthos. University of South Carolina Press, Columbia. 6:383-398.

George, R.Y. and J.S. Staiger. 1979. Epifauna: benthic invertebrate and demersal fish populations of South Atlantic/Georgia Bight. Pp. 235-280 In: South Atlantic Benchmark Program Volume, 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Prepared by Texas Instruments Incorporated for Bureau of Land Management.

GMFMC. See Gulf of Mexico Fishery Management Council.

Gulf of Mexico Fishery Management Council. 1980. Draft environmental impact statement and fishery management plan for reef fish resources of the Gulf of Mexico. Prepared by the Florida Sea Grant College, Gainsville, FL. 164 pp.

Haines, E.B. and W.M. Dunstan. 1975. The distribution and relation of particulate organic material and primary productivity in the Georgia Bight, 1973-1974. Estuarine and Coastal Marine Science. 3(4):431-441.

Hanson, R.B., K.R. Tenore, S. Bishop, C. Chamberlain, M.M. Pamatmat, and J. Tietjen. 1981. The response of the benthic community in the South Atlantic Bight to Gulf Stream intrusions and estuarine outwelling (in press). J. Mar. Research.

Henry, V.J., Jr. and J.H. Hoyt. 1968. Quaternary paralic and shelf sediments of Georgia. Southeastern Geology. 9:195-214.

Henry, V.J., Jr. and R.T. Giles. 1979. Distribution and occurrence of reefs and hardgrounds in the Georgia Bight. Pp 324-381 in: South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management, Washington, DC.

Hight, A.A. 1979. Wilmington Harbor Ocean Dumping; Environmental Assessment and Statement of Findings. U.S. Army Corps of Engineers, Wilmington District.

Hirsch, N.D., L.H. DiSalvo, and R. Peddicord. 1978. Effects of dredging and disposal on aquatic organisms. Dredged Material Research Program Technical Report DS-78-5. U.S. Army Corps of Engineers Waterways Experiment Station. Vicksburg, MS.

Hulbert, E.D. and R.S. MacKenzie. 1971. Distribution of phytoplankton species at the western margin of the north Atlantic Ocean. Bull. Mar. Sci. 21:603-612.

Huntsman, G.R. and I.G. MacIntyre. 1971. Tropical coral patches in Onslow Bay. Am. Litt. Soc. Bull. 7(2):32-34.

Jackson, J.B. 1980. Outer Continental Shelf oil and gas activities in South Atlantic (U.S.) and their onshore impacts: A summary report, July 1980. Prepared for the U.S. Department of the Interior, Geological Survey, Bureau of Land Management, and Council on Environmental Quality by Rogers, Golden and Halpern, Inc. Reston, VA. 62 pp.

Jacobson, J.P. 1974. A socio-economic environmental baseline summary for the South Atlantic Region between Cape Hatteras, North Carolina and Cape Canaveral, Florida. Vol. 1 Physical Oceanography. Virginia Institute of Marine Science, Gloucester Point, VA.

JEA. See Jones, Edmunds and Associates, Inc.

Jones, Edmunds and Associates, Inc. 1979. Results of bioassay evaluation of Charleston Harbor sediments. Prepared for Department of Army Charleston District, Corps of Engineers.

_____ 1980. Grain size analysis, bioassays, and bioaccumulation potential assessment; Smith Island and Bald Head Shoal Channels, Wilmington Harbor. Prepared for U.S. Army Engineer District, Wilmington.

Langfelder, J., D. Stafford, and A.M. Amein. 1968. A reconnaissance of coastal erosion in North Carolina. Coastal Research Program, North Carolina State University. Raleigh, NC. Project ERD-238.

Lee, R.F. 1979. Hydrocarbons in water, sediment, zooplankton, benthic fauna, and demersal fishes of South Atlantic/Georgia Bight. Pages 83-152. In: South Atlantic Benchmark Program. Volume 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Prepared by Texas Instruments Incorporated for Bureau of Land Management, Washington, DC.

Lee, T.N., L.P. Atkinson and R. Legeckis. 1981. Observations of a Gulf Stream frontal eddy on the Georgia Continental shelf, April, 1977. Deep sea Research. 28:347-378.

Mabry, E., D. Deuel and A. Kirsch. 1977. Participation in marine recreational fishing, Southeastern United States, 1974. Current Fishery Statistics No. 7333, NOAA/NMFS, Washington, DC.

Marshall, H.G. 1971. Composition of phytoplankton off the southeastern coast of the United States. Bull. Mar. Sci. 21(4):807-825.

Martin, F.D. 1977. Commercial Fisheries. Chapter IX. In: A Summary and Analysis of Environmental Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. Volume 1, Book 2. Prepared for the Bureau of Land Management by the Center for Natural Areas; S. Gardiner, ME.

National Marine Fisheries Service. 1980. Summary of monthly landings for Chatham County, Georgia, 1979-80. Unpublished data.

_____ 1980b. Summary of monthly landings for Charleston County, South Carolina, 1979. Unpublished data.

_____ 1980c. Summary of monthly landings for New Hanover and Brunswick Counties, North Carolina. Unpublished data.

National Oceanic and Atmospheric Administration. 1980. Draft environmental impact statement on the proposed Gray's Reef Marine Sanctuary. U.S. Dept. of Commerce, Office of Coastal Zone Management, Washington, DC.

Neiheisel, J. 1959. Littoral drift in vicinity of Charleston Harbor. Jour. of Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers. WW2:99-113.

NMFS see National Marine Fisheries Service.

NOAA see National Oceanic and Atmospheric Administration.

Oertel, G.F. 1974. Report on the hydrologic and sedimentologic study of the offshore spoil disposal area, Savannah, Georgia. Final report to the Savannah District of the Corps of Engineers. 101 pp.

_____ 1975. Report on a biologic and sedimentologic study related to the Tybee Island Beach nourishment project and the offshore area for dredge material disposal. Final report to the Savannah District of the Corps of Engineers. 111 pp.

_____ 1976. Characteristics of suspended sediments in estuaries and nearshore waters of Georgia. Southeastern Geology. 18:107-118.

_____ 1979. Depositional characteristics of sediments at a low energy ocean disposal site, Savannah, Georgia. Pp 97-107. In: Palmer, H.D. and M.G. Gross [eds.]. Ocean Dumping and Marine Pollution. Dowden, Hutchinson and Ross Inc. 268 pp.

Paull, C. and W. Dillon. 1979. The geology of the Florida-Hatteras Slope and Inner Blake Plateau. pp 411-483. In: South Atlantic Outer Continental Shelf Geological Studies Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management, Washington, DC.

Pequegnat, W.E. 1978. An assessment of the potential impact of dredged material disposal in the open ocean. Dredged Material Research Program, Tech. Rep. D-78-2. Waterways Experiment Station, Vicksburg, MS.

Pilkey, O.H. and M.E. Field. 1972. Onshore transportation of Continental Shelf sediment: Atlantic southeastern United States. pp 429-446. In: D.J.P. Swift, D.B. Duane, and O.H. Pilkey [eds.]. Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Ross, Inc. Stroudsburg, Pennsylvania.

Pilkey, O.H., F. Kerr, and S. Kerr. 1979. Surficial sediments of the U.S. Atlantic Southeastern United States Continental Shelf. pp 138-181. In: South Atlantic Outer Continental Shelf Geological Studies Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for Bureau of Land Management, Washington, DC.

Richardson, M.D., A.G. Carey, J.A. Colgate, and W.A. Colgate. 1977. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Appendix C: The effects of dredged material disposal on benthic assemblages. Dredged Material Research Program Tech. Rep. D-77-30.

Roberts, M.H., Jr. 1974. A socio-economic environmental baseline summary for the South Atlantic region Cape Hatteras, North Carolina and Cape Canaveral, Florida. Vol. III. Chemical and biological oceanography. A report to Bureau of Land Management, U.S. Department of the Interior, prepared by Virginia Institute of Marine Science, Gloucester Point, VA.

Ryther, J.H. and W.M. Dunstan. 1971. Nitrogen, phosphorus and eutrophication in the coastal marine environment. Science. 171:1008-1013.

SCWMRD. See South Carolina Wildlife and Marine Resources Department.

South Carolina Wildlife and Marine Resources Department. 1972. A study of the Charleston Harbor Estuary with special reference to deposition of dredged sediments. SCWMRD Office of Marine Conservation, Management and Services, in cooperation with the U.S. Army Corps of Engineers. 112 pp.

_____ 1979. Benthic and sedimentologic studies on the Charleston Harbor ocean disposal area, Charleston Harbor Deepening Project. SCWMRD Marine Resources Division for the Charleston District, U.S. Army Corps of Engineers. 193 pp.

Spence, E.L. 1974. A look at South Carolina's underwater heritage. Nelson's Southern Printing, Charleston, SC. 22 pp.

Sullivan, B. and D. Hancock. 1977. Zooplankton and dredging research perspectives from a critical review. Water Resources Bull. 13:461-467.

Swift, D.J.P., J.W. Kofoed, F.P. Saulsbury, and P. Sears. 1972. Holocene evolution of the shelf surface, central and southern Atlantic shelf of North America. Pp. 499-575. In: D.J.P. Swift, D.B. Duane, and O.H. Pilkey (eds.). Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Ross, Inc. Stroudsburg, PA.

Tenore, K.R. 1979. Macroinfaunal benthos of South Atlantic/Georgia Bight. Pp. 281-308. In: South Atlantic Benchmark Program. Volume 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Prepared by Texas Instruments Incorporated for Bureau of Land Management, Washington, DC.

Tenore, K.R., C.F. Chamberlain, W.M. Dunstan, R.B. Hanson, B. Sherr, and J.H. Tietjen. 1978. Possible effects of Gulf Stream intrusions and coastal runoff on the benthos of the Continental Shelf of the Georgia Bight. Pp 577-598. In: M.L. Wiley [ed.]. Estuarine Interactions. Academic Press, Inc.

Texas Instruments Incorporated. 1979. South Atlantic OCS Benchmark Program 1977 Report. Volume 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Final Report prepared for Bureau of Land Management. 474 pp.

Thomas, J.P. 1966. The influence of the Altamaha River on primary production beyond the mouth of the river. M.S. Thesis, University Georgia. 88 pp.

TII. See Texas Instruments Incorporated.

Uchupi, E. and A.R. Tagg. 1966. Microrelief of the Continental Margin south of Cape Lookout, North Carolina. Geol. Soc. America Bull. 77:427-430.

U.S. Geological Survey. 1979. South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Department of Interior, Bureau of Land Management, Washington, D.C.

U.S. Army Corps of Engineers. 1974. Charleston Harbor Deepening Project, Charleston Harbor and Shipyard River, South Carolina. Revised Draft Environmental Statement, U.S. Army Corps of Engineers, Charleston District.

_____1975. Operation and maintenance, Savannah Harbor, Georgia. Final Environmental Impact Statement. U.S. Army Corps of Engineers Savannah, District. 47 pp.

_____1976. Maintenance dredging of Charleston Harbor, Ashley River, and U.S. Navy Channels in Cooper River, Charleston and Berkeley Counties, South Carolina. Final Environmental Impact Statement. U.S. Army Corps of Engineers, Charleston District.

_____1977. Maintenance of Wilmington Harbor, North Carolina. Final Environmental Impact Statement. U.S. Army Corps of Engineers, Wilmington District, North Carolina.

_____1978. Waterborne commerce of the United States, Calender Year 1977. Part 1: Waterways and Harbor, Atlantic Coast. U.S. Army Engineer Division, Lower Mississippi Valley, Corps of Engineers, Vicksburg, Mississippi. 202 pp.

_____1980. Charleston Harbor, Deepening and Extending Channels for Navigation. U.S. ACOE, Charleston District. 120 pp.

U.S. Environmental Protection Agency. 1977. Ocean dumping final revision of regulations and criteria. Federal Register. 42(70):2461-2490.

USGS. See U.S. Geological Survey.

Windom, H.L. 1972. Environmental aspects of dredging in estuaries. Jour. of Waterways, Harbors and Coastal Engineering Division, Proceedings of the American Society of Civil Engineers. WW4:475-487.

_____ 1973. Processes responsible for water quality changes during pipeline dredging in marine environments. Proc. Fifth World Dredging Conference, Hamburg, Germany. June 1973.

_____ 1975. Water quality aspects of dredging and dredge spoil disposal in estuarine environments. pp 559-571. In: L.E. Cronin [ed.] Estuarine Research Volume 2:Geology and Engineering. Academic Press, Inc. NY.

_____ 1978. Trace element geochemistry of Continental Shelf waters of the southeastern United States. In: K.K. Turekian and A.I. Simonov (eds.) First American-Soviet Symposium on Chemical Pollution of the Marine Environment, 1977. Publ. by U.S. Environmental Protection Agency, Washington, DC.

Windom, H.L. and P.R Batzer. 1979. Trace metal chemistry of south Atlantic/Georgia Bight. Pp. 153-196. In: South Atlantic Benchmark Program Volume 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Prepared by Texas Instruments Incorporated for Bureau of Land Management, Washington, DC.

Windom, H.L., R. Stickney, R. Smith, D. White, and F. Taylor. 1973. Arsenic, cadmium, copper, mercury, and zinc in some species of North Atlantic finfish. J. Fish. Res. Bd. Canada. 30(2):275-279.

Windom, H.L., F.E. Taylor, and E.M. Waiters. 1975. Possible influence of atmospheric transport on the total mercury content of southeastern Atlantic Continental Shelf surface waters. Deep-sea Research. 22:629-633.

Windom, H.L. and R.G. Smith., Jr. 1972. Distribution of cadmium, cobalt, nickel and zinc in southeastern United States Continental Shelf waters. Deep-Sea Res. 19:727-730.

_____ 1979. Copper concentrations in surface waters off the southeastern Atlantic coast, U.S.A. Marine Chemistry. 7:157-163.

Wright, T.D. 1978. Aquatic dredged material disposal impacts. Dredged Material Research Program Technical Report DS-78-1. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Appendix A

SURVEY METHODS, RESULTS, AND INTERPRETATIONS

Appendix A

CONTENTS

ILLUSTRATIONS

CONTENTS (Continued)

TABLES

CONTENTS (Continued)

Appendix A

SURVEY METHODS, RESULTS, AND INTERPRETATIONS

Field surveys at the Savannah and Charleston ODMDS were conducted in March and December 1979, and at the Wilmington ODMDS in November 1979 and July 1980 by Interstate Electronics Corporation (IEC) under contract to the EPA (Contract Number 68-01-4610). The purpose of the surveys was to collect and evaluate environmental data to assess the effects of dredged material disposal on the marine environment; and to augment historical biological, chemical, geological, and oceanographic information from the area. A major consideration of survey design was to assess whether any adverse effects measured within the ODMDS were detectable outside of the site boundaries.

Survey results are presented and discussed herein and are compared briefly with historical data; additional comparisons are presented in Chapter 3 of this EIS. Methods of data collection, results, and interpretations of the survey data are presented in the following sections.

A.1 METHODS

All survey operations were conducted using the Ocean Survey Vessel (OSV) ANTELOPE. Loran-C and radar range and bearing positioning were used for navigation, providing accuracy within 0.25 nmi.

Two stations were sampled at the Savannah ODMDS, while 10 stations were sampled at both Charleston and Wilmington ODMDS. At Savannah ODMDS, Station 11 was inside the ODMDS and Station 12 was outside and to the southeast of the ODMDS (Figure A-1). At Charleston and Wilmington ODMDS, Stations 1 to 5 were located inside the ODMDS, and Control Stations 6 to 10 were positioned in upcurrent and downcurrent directions outside the site (Figures A-2 and A-3). Coordinates and water depths for all sampling stations are presented in Table A-1. Station locations were designed to determine whether transport of dredged material was occurring outside of the site boundaries. Sampling requirements for each station are shown in Table A-2.

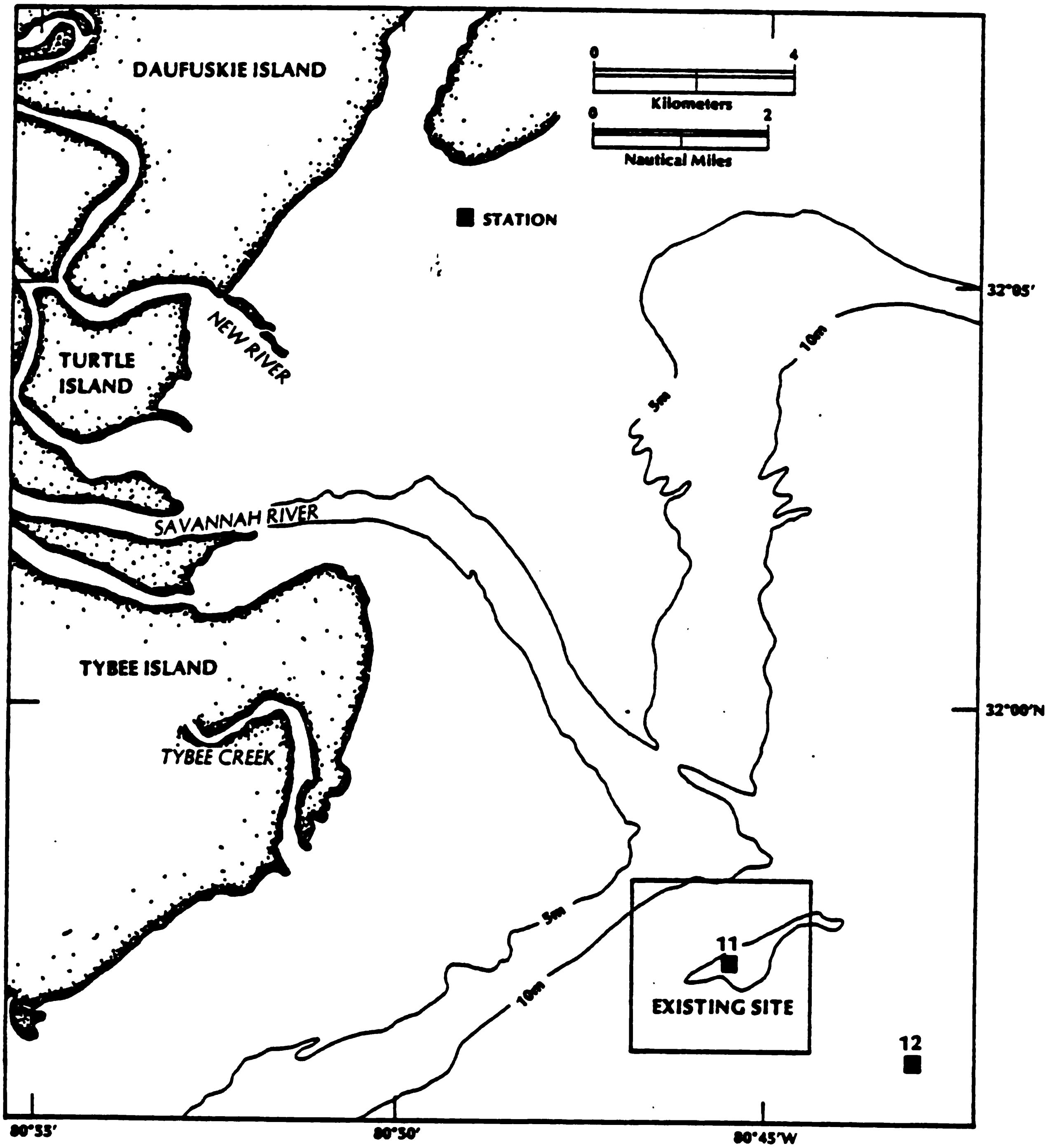

Figure A-1. Sampling Station Locations at the Savannah ODMDS (March and December 1979)

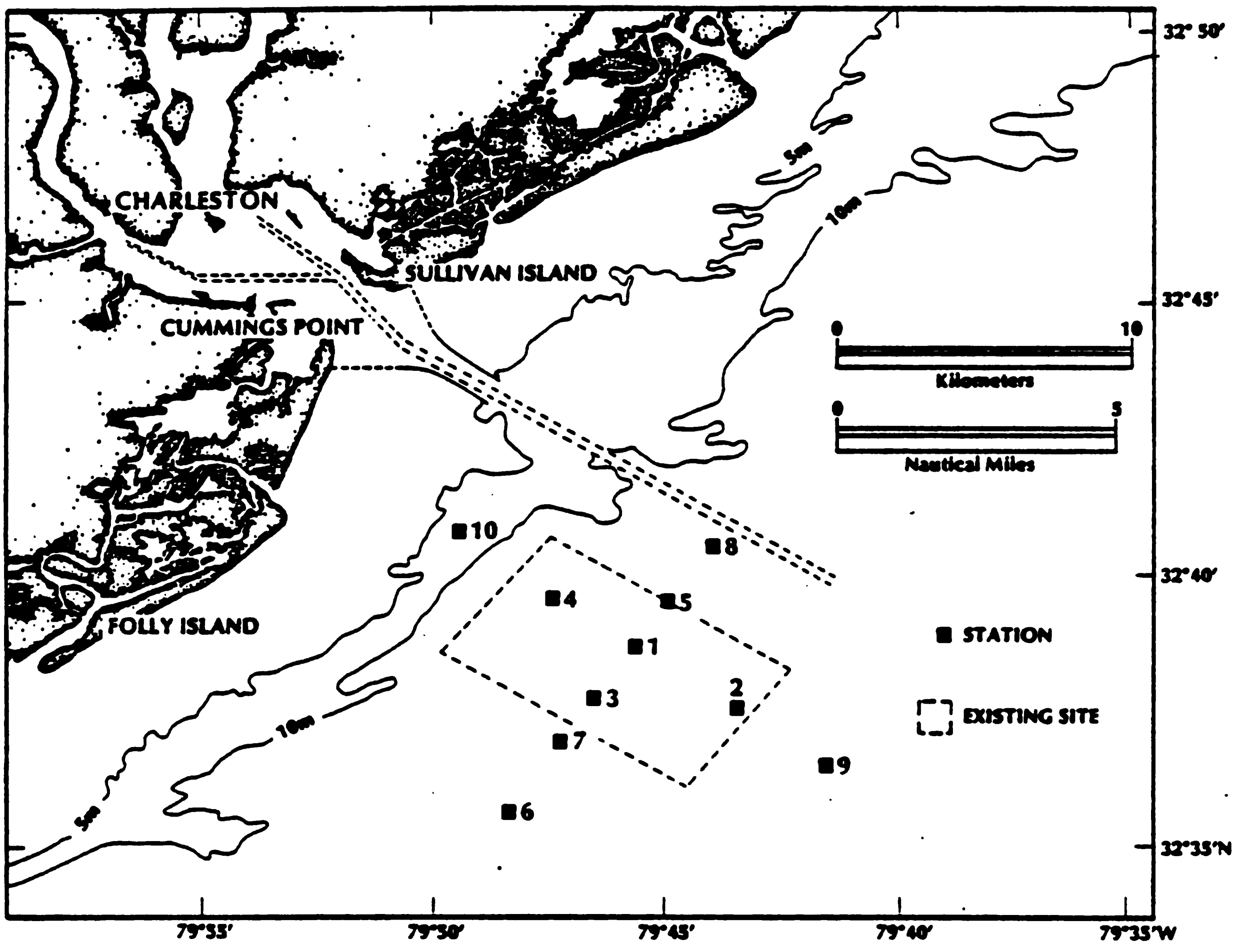

Figure A-2. Sampling Station Locations
at the Charleston ODMDS (March and December 1979)

Microbiological analyses of sediments and tissues, and physical oceanographic measurements were performed aboard the ANTELOPE; all other detailed chemical, geological, and biological analyses were performed at shore-based laboratories listed in Table A-3.

Sampling equipment, procedures, and preservation methods were in accordance with the "Oceanographic Sampling and Analytical Procedures Manual" (IEC, 1980). A summary of these methods is presented in the following sections.

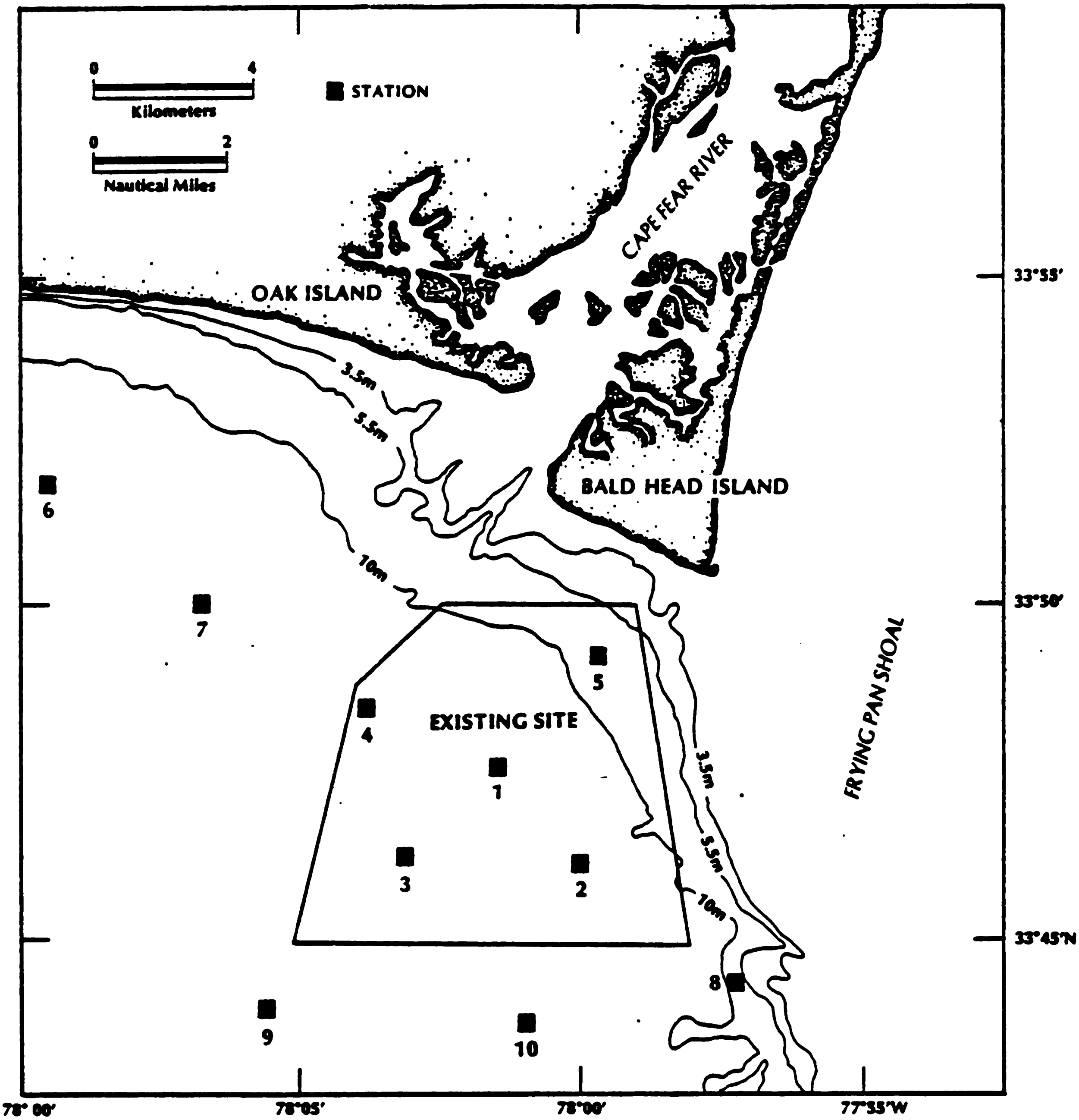

Figure A-3. Sampling Station Locations at the Wilmington ODMDS (November 1979 and July 1980)

TABLE A-1
STATION LOCATIONS

Station Number	Latitude	Longtitude	Water Depth (m)
		Savannah	
11	31°56.9'N	80°45.6'W	14
12	31°55.7'N	80°43.0'W	13
		Charleston	
1	32°38.6'N	79°45.7'W	14
2	32°37.7'N	79°43.6'W	14
3	32°37.7'N	79.46.6'W	14
4	32°39.5'N	79°47.6'W	11
5	32°39.5'N	79°45.0'W	13
6	32°35.6'N	79°48.4'W	13
7	32°36.8'N	79°47.3'W	14
8	32°40.5'N	79°44.0'W	13
9	32°36.4'N	79°41.6'W	13
10	32°40.7'N	79°49.5'W	9
		Wilmington	
1	33°47.5'N	78°01.5'W	13
2	33°46.1'N	78°00.0'W	13
3	33°46.2'N	78°03.2'W	14
4	33°48.4'N	78°03.9'W	13
5	33°49.1'N	77°59.8'W	8
6	33°51.8'N	78°09.7'W	11
7	33°50.0'N	78°06.8'W	12
8	33°44.4'N	77°57.2'W	11
9	33°44.0'N	78°05.7'W	15
10	33°43.8'N	78°01.0'W	10

TABLE A-2
SAMPLING REQUIREMENTS FOR SAVANNAH, CHARLESTON, AND WILMINGTON ODMDS

		WATER COLUMN						SEDIMENT									BIOTA			
		INSTRUMENT ARRAY	WATER SAMPLING ROSETTE					BOX CORER, 7 DROPS									DREDGE/TRAWL			
		1 PROFILE/STATION	GO-FLOW 2 SAMPLES/STATION SURFACE AND BOTTOM		GO-FLOW TEFLON LINED 1 SAMPLE/STATION MIDWATER			GEOLOGICAL - CHEMICAL 2 CORES/STATION						BIOLOGICAL 5 CORES/STATION			EPIFAUNA & MACROINFAUNA TISSUES 2 TRAWLS/SITE			
	STATION NUMBER	PROFILES OF SALINITY, pH TEMPERATURE & TURBIDITY	CALIBRATION SAMPLES: SALINITY, TURBIDITY, pH, & TEMPERATURE	SUSPENDED SOLIDS	DISSOLVED TRACE METALS	PARTICULATE TRACE METALS	CHLORINATED HYDROCARBON SCAN	GRAINSIZE, ARTIFACTS	TOTAL ORGANIC CARBON	TRACE METALS	CHLORINATED HYDROCARBON SCAN*	ELUTRIATE	OIL & GREASE	GRAIN SIZE & ARTIFACTS	MACROINFAUNA, TAXONOMY	TOTAL & FECAL COLIFORMS	TRACE METALS**	CHLORINATED HYDROCARBON SCAN**	TOTAL & FECAL COLIFORMS**	MACROFAUNA, TAXONOMY
CHARLESTON	1	●	●	●	QC	QC	QC	QC	QC	QC	QC	●	●	●	●	●	QC	QC	●	●
	2							●	●	●			●	●	●					
	3							●	●	●			●	●	●					
	4							●	●	●			●	●	●					
	5							●	●	●			●	●	●					
	6	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	7	●	●	●				●	●	●			●	●	●					
	8	●	●	●				●	●	●			●	●	●					
	9	●	●	●				●	●	●			●	●	●					
	10							●	●	●			●	●	●					
SAVANNAH	11	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	12	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WILMINGTON	1	●	●	●	QC	QC	QC	QC	QC	QC	QC	●	●	●	●	QC	QC	●	●	●
	2			●				●	●	●				●	●					
	3			●				●	●	●				●	●					
	4			●				●	●	●				●	●					
	5			●				●	●	●				●	●					
	6	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	7			●				●	●	●				●	●					
	8			●				●	●	●				●	●					
	9			●				●	●	●				●	●					
	10	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

QC - ONE QUALITY CONTROL SAMPLE WILL BE TAKEN IN ADDITION TO THE SAMPLES BEING COLLECTED.

* - COMPOSITE SAMPLE FROM BOTH BOX CORES.

** - COMPOSITE SAMPLES FROM ALL DREDGES AND TRAWLS, PLUS SAMPLES OF OPPORTUNITY FROM GEOLOGICAL CHEMICAL BOX CORES: SPECIES IDENTIFIED ON BOARD BEFORE ANALYSIS AND PRESERVATION.

TABLE A-3
LABORATORIES PERFORMING ANALYSIS OF
SAMPLES FROM SAVANNAH, CHARLESTON, AND WILMINGTON ODMDS

Biology	Chemistry	Geology
Taxon, Inc. Salem, MA	ERCO, Inc. Cambridge, MA	ERCO, Inc.
Barry A. Vittor & Associates Mobile, AL	LFE, Inc., Richmond, CA*	Taxon, Inc.
* Dr. Donald Reish California State University Long Beach, CA		
* La Mer San Pedro, CA		

* Denotes Quality Control Laboratory

A.1.1 WATER COLUMN MEASUREMENTS

A.1.1.1 Shipboard Procedures

Conductivity and temperature profiles were measured with a Plessey CTD, and data were stored on 9-track disks. A rosette sampler equipped with 30-liter Go-Flo bottles was used to collect surface and near-bottom samples for suspended solids and salinity and temperature calibration samples; middepth samples were collected for analyses of dissolved and particulate trace metals and dissolved chlorinated hydrocarbons. Salinity samples were analyzed with a Beckman salinometer. Surface and bottom water temperatures were measured using reversing or bucket thermometers. Turbidity was measured with a Hach laboratory turbidimeter; pH was measured with a Beckman pH meter. Water samples for total suspended solids and trace metals (particulate and dissolved) analyses were transferred from Go-Flo bottles to 2-liter pressure filtration bottles, then filtered through Nucleopore filters. The filtrate was collected for dissolved trace metals analysis in precleaned bottles acidified with Ultrex nitric acid. Measured water volumes were pressure-fed directly from Go-Flo bottles through an Amberlite XAD resin column for extraction of chlorinated hydrocarbons (Osterroht, 1977). Filters for particulate trace metals and suspended solids, and resin columns for chlorinated hydrocarbons (CHC) were processed in a positive pressure clean hood and frozen until extraction and analysis.

A.1.1.2 Laboratory Methods

Total suspended solids were determined gravimetrically on an electrobalance (Meade et al., 1975). Filters containing particulate trace metal samples were leached for 2 hours with 1N Ultrex nitric acid. Leachates were analyzed for Cd and Pb by graphite furnace atomic absorption spectrophotometry (AAS), and for Hg by cold-vapor AAS (EPA, 1979).

Dissolved Hg was analyzed by cold vapor AAS following an acid-permanganate digestion and reduction with hydroxylamine sulfate (EPA, 1979). Dissolved Cd and Pb were concentrated using a chelation-solvent extraction method (Sturgeon et al., 1980), and analyzed by graphite furnace AAS.

CHC's were eluted from resin columns with acetonitrile. The eluate was extracted three times with hexane, evaporated to near dryness, fractionated on florisil columns, and analyzed by electron capture gas chromatography (Osterroht, 1977). The chromatogram was scanned for presence of polychlorinated biphenyls (PCB) (Aroclor 1016, 1221, 1232, 1242, 1248, 1254, 1260, and 1262), and various pesticides and derivatives (aldrin, dieldrin, endrin, heptachlor, βBHC, DDT, DDD, DDE, and heptachlor epoxide).

A.1.2 GEOCHEMISTRY AND GRAIN SIZE ANALYSIS

A.1.2.1 Shipboard Procedures

Fifty grams of sediment were removed from each of seven 0.065 m^2 box cores per station, and frozen for grain size analysis. Sediment samples for geochemical analyses (trace metals, oil and grease, total organic carbon [TOC], and CHCs) were collected from the surface 2 cm of two cores per station, stored in acid-cleaned Teflon jars, and frozen.

Total and fecal coliforms in sediments were determined from the two box core samples taken for sediment geochemistry. Approximately 30g of sediment from the surface 1 cm of each sample was collected aseptically; analysis was initiated within 6 hours after collection. Coliforms were determined using a modified Most Probable Number (MPN) technique (APHA, 1975).

A.1.2.2 Laboratory Methods

Sediment grain size was determined by washing sediment samples through 2,000- and 62-um mesh sieves to separate gravel, sand, and silt/clay fractions following a procedure described by Folk (1978). Sand/gravel fractions were separated with 1 phi (ϕ) interval sieves, dried, and weighed. The silt/clay fractions were analyzed using a pipette method (Rittenhouse, 1933).

Trace metals (Cd and Pb) were leached from 5 to 10g of sediments for 2 hours with 25 ml of 1N nitric acid, and analyzed by graphite furnace AAS. Mercury was leached from 5 to 10g of sediment at 95°C with aqua regia and potassium permanganate, reduced using hydroxylamine sulfate and stannous sulfate, and analyzed by cold-vapor AAS (EPA, 1979).

Oil and grease were extracted from 100g sediment samples with an acetone-hexane mixture, dried and quantified gravimetrically (APHA, 1975). TOC in sediments was measured with a Perkin-Elmer Model 240 Elemental Analyzer (Gibbs, 1977).

CHC's were soxhlet extracted from sediment samples using a 1:1 acetone-hexane solvent. The extract was evaporated, cleaned using a florisil column, fractionated on a silicic acid column, and analyzed using electron capture gas chromatography (EPA, 1974). An additional acid cleanup step was required for analysis of PCB's. Petroleum hydrocarbons were extracted from sediments with a methylene dichloride-methanol azeotropic mixture, and analyzed with a column and glass capillary gas chromatography technique (Brown et al., 1979).

Elutriate analyses were performed in accordance with the specifications of EPA/CE (1977). Sediments and unfiltered disposal site water were mixed at a 1:4 ratio, and mechanical- and air-agitated for 30 minutes. After a 1-hour settling period, test water was filtered, acidified with Ultrex hydrochloric acid, and analyzed for trace metals using techniques described above.

A.1.3 BIOLOGICAL MEASUREMENTS (Including Tissue Chemistry and Coliforms)

A.1.3.1 Shipboard Procedures

Five macrofaunal samples were collected at each station using a $0.065m^2$ box core and washed through a 0.5-mm screen; organisms were preserved in 10% formalin in seawater and stored until analysis. Two trawls, one inside and one outside of the site, were conducted using a 7.6m otter trawl to collect epifauna for tissue concentrations of CHC's, trace metals, and total and fecal coliforms. In addition, information from the catch was used to further characterize the benthic and nektonic communities.

Epifauna from the trawls were sorted in stainless steel trays and enumerated. Tissue was combined from at least three individuals of each of the commercially important species captured, aseptically homogenized in a blender, and cultured within 6 hours for total and fecal coliforms using a modified APHA (1975) technique described in IEC (1980). Other specimens were transferred from the trays to acid-rinsed plastic buckets, and then into clean plastic bags and frozen for trace metal analyses. Additional specimens were transferred to stainless steel buckets with stainless steel forceps, wrapped in aluminum foil, placed in polyethylene bags, and frozen for CHC analysis.

A.1.3.2 Laboratory Methods

Six dominant macrofauna species were selected by Interstate biologists for enumeration in all samples. Selection of species was based on the inspection of initial laboratory data (species abundance throughout the site), feeding type, and known association with environmental conditions, particularly substrates. Each of the six dominant species was enumerated in all five station replicates, and mean species abundances were calculated for each station. All samples were transferred to 70% alcohol for storage.

Analysis of Cd and Pb concentrations in tissues followed techniques described by EPA (1977). Approximately 5g to 10g of homogenized tissue were digested with nitric acid and hydrogen peroxide while heated. The digests were then evaporated, diluted to volume with deionized water, and analyzed with flame or flameless AAS. Analyses of Hg concentrations in tissue required digestion of an 8g to 10g sample with concentrated nitric and sulfuric acids and potassium permanganate, reduction of the ionized mercury with hydroxylamine and stannous sulfate, and analysis with cold-vapor AAS (EPA, 1979).

Tissue analyses for CHC's required homogenizing 50g of tissue with sodium sulfate, extraction with hexane, cleanup, fractionation, and analysis with electron capture gas chromatography (EPA, 1974).

A.1.4 COMPUTER DATA ENTRY AND ANALYSIS

All data were entered into the Interstate computerized Oceanic Data and Environmental Evaluation Program data base (ODEEP). Statistical analysis included calculation of means, variances, correlations, and analysis of variance. These statistics were run for survey and station partitions in the data. ANOVA's were not run for the Savannah data because only two stations were sampled. Correlations were run between parameter values measured within given sediment samples (casts).

A.2 RESULTS AND DISCUSSION

A.2.1 SAVANNAH ODMDS

A.2.1.1 Water Column Characteristics

Results of water column measurements of temperature, salinity, pH, turbidity, and total suspended solids at the ODMDS taken in March and December are presented in Table A-4. Dissolved and particulate trace metal concentrations are listed in Table A-5. Historical dissolved trace metal and CHC data for waters in the vicinity of Savannah ODMDS are not available for comparisons.

TABLE A-4
PHYSICAL WATER COLUMN PROPERTIES AT
SAVANNAH ODMDS IN MARCH AND DECEMBER 1979

Station	Depth (m)	Temperature (°C)		Salinity (°/oo)		pH		Turbidity (NTU)		Total Suspended Solids (mg/liter)	
		Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec
	2	12.65	14.00	29.746	30.265	8.20	8.47	2.80	2.60	1.647	3.950
11	5	-	-	-	32.358	-	8.49	2.10	1.60	-	3.021
	7	11.50	15.00	32.030	33.007	8.18	8.49	3.50	1.90	2.206	2.358
	2	11.74	15.00	31.703	32.898	8.18	8.52	2.20	1.20	0.224	1.981
12	7	-	-	-	33.291	-	8.32	-	1.00	-	1.315
	12	11.50	15.50	32.578	33.607	8.15	8.50	2.40	1.20	1.889	1.841

Dash (-) indicates no measurement was taken

TABLE A-5
DISSOLVED AND PARTICULATE TRACE METALS
AND CHLORINATED HYDROCARBONS AT SAVANNAH
ODMDS AND CONTROL STATIONS IN MARCH AND DECEMBER 1979

Parameter	Station 11		Station 12	
	Mar	Dec	Mar	Dec
Particulate Trace Metals (μg/liter)				
Hg	.02	.005	.04	.008
Cd	.005	.011	.005	.002
Pb	.077	.063	.135	.020
Dissolved Trace Metals (μg/liter)				
Hg	.035	.030	.045	.030
Cd	.653	.051	.033	.118
Pb	.114	.079	.098	.069
Dissolved Chlorinated Hydrocarbons (ng/liter)				
Pesticides: pp'DDE	ND	ND	ND	.403

ND = Not Detected

Physical - Physical characteristics observed for waters in the vicinity of the Savannah ODMDS were typical of partially mixed nearshore waters of the South Atlantic Bight (SAB) (Blanton and Atkinson, 1978). Water temperatures in the area of the site were lower in March than December. The range in water temperatures in March was 11.5 to 12.6°C, and in December from 14.0 to 15.5°C. Temperatures decreased with depth in March and increased with depth in December. Salinities were lower in March than December and increased with depth and increasing distance from shore during both surveys. These trends are likely related to coastal fresh-water runoff, which is greater during spring and has its most pronounced effect on waters closest to shore. Salinity ranges were about 29.7 to 32.6°/oo in March, and 30.3 to 33.6°/oo in December. Variations in pH at the ODMDS were small; values for both surveys ranged from 8.2 to 8.5.

Concentrations of total suspended solids (TSS) and turbidity were similar during both surveys. TSS ranged from about 0.2 to 4.0 mg/liter and turbidities from about 1.0 to 3.5 NTU. During both surveys, turbidity and TSS levels decreased from ODMDS Station 11 to Station 12, located further offshore. March values for both parameters tended to increase with depth, possibly due to sediment resuspension. December values showed a general decrease with depth; the reason for this trend is unclear. TSS concentrations increased from March to December, whereas turbidity decreased. Since turbidity measurements are most affected by fine-grained material (Schubel et al., 1978), suspended sediments in March may have been finer-grained than those in December. Levels of TSS near the disposal site have been reported to fluctuate between 1 and 19 mg/liter as a function of tidal flow, and magnitudes of river discharge and sediment resuspension (Oertel, 1974).

Chemical - Concentrations of dissolved and particulate trace metals were consistently low (<0.7 μg/liter) during both surveys. Dissolved mercury, cadmium, and lead levels ranged from 0.030 to 0.045 μg/liter, 0.051 to 0.653 μg/liter and 0.069 to 0.118 μg/liter, respectively. The dissolved mercury and cadmium concentrations were comparable to concentrations measured in the S Shelf Waters (Windom, 1978; Windom and Betzer, 1979). Levels for particulate metals over both surveys ranged from 0.005 to 0.040 μg/liter for mercury, 0.002 to 0.011 μg/liter for cadmium, and 0.020 to 0.135 μg/liter for lead.

Variations in trace metal concentrations showed no consistent trends between stations or surveys. Observed concentrations of total cadmium and mercury (dissolved plus particulate fractions) were below EPA quality criteria for marine waters (EPA, 1976). In the absence of appropriate bioassay data, concentrations of total lead cannot be compared to EPA criteria (0.01 times the 96-hr LC_{50}).

Dissolved CHC's were not detected in waters overlying the ODMDS in either March or December. However, trace quantities (0.403 ng/liter) of the pesticide derivative pp'DDE were detected in the control station waters in December. PCB's were not detected at the ODMDS or control stations during either survey.

A.2.1.2 Sediment Characteristics

Physical - Sediment characteristics at the Savannah ODMDS are summarized in Table A-6. Sediments within the disposal site and control stations consisted primarily of sand (approximately 94%) with small amounts of silt and clay (approximately 2 to 4%) and gravel (approximately 2 to 4%). Higher percentages of fines and lower percentages of gravel occurred at the disposal site during both surveys. Slightly higher proportions of fines occurred at both stations in December, possibly due to seasonal sediment transport processes (Oertel, 1979).

Chemical - Concentrations of trace metals, total organic carbon (TOC), chlorinated hydrocarbons, and oil and grease in sediments in the vicinity of Savannah ODMDS are listed in Table A-7. Mercury and cadmium concentrations were relatively low and showed no consistent spatial trends for either survey. March lead values are not reported because of the questionable accuracy of the analytical technique (colorimetry), and the order of magnitude differences with both the lead concentrations measured in ODMDS sediments in December (analyzed by AAS) and lead concentrations reported for other SAB sediments (Bothner et al., 1979; Windom and Betzer, 1979). Overall, sediment cadmium concentrations ranged from 0.002 to 0.180 μg/g and were slightly higher in December than March. Mercury ranged from <0.001 to 0.003 μg/g with no

TABLE A-6
SEDIMENT CHARACTERISTICS AT SAVANNAH ODMDS DURING MARCH AND DECEMBER 1979

Station	% Gravel		% Sand		% Fines	
	Mar	Dec	Mar	Dec	Mar	Dec
11	1.70 ± 2.67	2.06 ± 1.42	94.1 ± 2.38	94.2 ± 2.86	4.16 ± 1.13	4.23 ± 2.57
12	4.00 ± 3.36	3.13 ± 3.89	93.4 ± 4.03	93.0 ± 3.67	2.60 ± 1.36	2.92 ± 0.02

Note: Values for percentages are mean ± one standard deviation; n = 7

TABLE A-7
CONCENTRATIONS OF TOC, OIL AND GREASE, TRACE METALS, AND CHC'S IN SEDIMENTS AT SAVANNAH ODMDS DURING MARCH AND DECEMBER 1971

Station	TOC (mg/g)		Oil and Grease (mg/g)		Trace Metals (μg/g) Hg		Trace Metals (μg/g) Cd		Trace Metals (μg/g) Pb		Pesticides (ng/g)		PCB's (ng/g)	
	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec
11	0.70	0.75	0.058	0.007	0.003	0.003	0.003	0.180	-	1.60	ND	0.003 (pp'DDE)	ND	0.037 (Aroclor 1016)
	0.50	2.25	0.044	0.010	0.003	0.002	0.016	0.020	-	1.10		0.077 (pp'DDD)		0.385 (Aroclor 1254)
12	<0.05	0.55	0.033	0.024	0.002	0.003	0.006	0.020	-	1.10	ND	0.032	ND	0.304
	1.3	0.88	0.051	0.017	<0.001	0.002	0.002	0.170	-	1.30		(pp'DDE)		(Aroclor 1254)

Dash (-) indicates that March lead values are not presented (reasons explained in the text)

Note: All replicate values are shown

ND = Not detected

apparent trend. Lead concentrations in December ranged from 1.1 to 1.6 μg/g. These values are within the respective ranges reported for the general South Atlantic Bight region (ibid.).

TOC and oil and grease concentrations were all low, ranging from <0.05 to 2.25 mg/g and 0.007 to 0.058 mg/g, respectively. No spatial trends were apparent; however, TOC levels increased slightly from March to December, and oil and grease levels showed a small decrease. No historical values for TOC or oil and grease are available for comparisons with IEC data.

Low levels (<0.5 ng/g) of DDT derivatives (DDD, DDE) and PCB's were detected in sediments at both stations in December; however, no CHC's were found during March. December values were similar for both stations. No historical CHC data are available for comparisons.

Elutriate Tests - Elutriate tests showed no substantial transfer of metals from sediments to the dissolved phase. Mercury and cadmium levels in test waters were generally within the range (<0.7 μg/liter) measured in waters of the ODMDS region (Table A-8). Lead showed small releases in elutriate tests for both ODMDS and control station sediments; concentrations in test waters ranged from 0.26 to 3.1 μg/liter for ODMDS sediments and <0.26 to 0.65 μg/liter for control site sediments. It is not known whether the greater lead releases from ODMDS sediments relative to reference sediments were related to previous dredged material disposal.

A.2.1.3 Tissues

Concentrations of trace metals and CHC's in tissue from the ODMDS and control stations are presented in Table A-9. Mercury ranged from undetectable levels to 0.21 μg/g in crabs (*Ovalipes ocellatus*). Concentrations in other species (*Sicyonia brevirostris* and *Penaeus* sp.) were intermediate. Observed mercury concentrations were lower than the Food and Drug Administration (FDA) action level (1.0 μg/g) in commercial fish (FDA, 1980). Cadmium concentrations varied from 0.025 to 0.056 μg/g in shrimp tissue during December, and from 0.44 to 0.98 μg/g in crabs during March. Lead concentrations in tissue were undetectable in March and equal to or less than 0.20 μg/g in December. Observed cadmium concentrations in shrimp are slightly lower than those reported by Windom and Betzer (1979); comparable values for lead are not available.

Pesticide (op'DDE, pp'DDE) concentrations ranged from 3.7 to 39 ng/g, and were considerably lower than the FDA action limit of 5 μg/g (FDA, 1980). Trace concentrations (<0.2 μg/g) of PCB's (Aroclor 1016 and 1254) detected in crabs (*O. ocellatus*) during March were lower than the 5 μg/g FDA action limit.

TABLE A-8
RESULTS OF ELUTRIATE TESTS OF
SAVANNAH ODMDS SEDIMENTS IN DECEMBER 1979

	Station 11	Station 12	ODMDS Water (Range)
Mercury	<0.05	<0.05	0.03 to 0.04
	≤0.05	<0.05	
	0.09	0.34	
Cadmium	0.65	0.11	0.05 to 0.65
	0.19	0.11	
	0.39	1.4	
Lead	3.1	0.65	0.08 to 0.114
	0.26	<0.26	
	2.1	0.53	

Notes: All replicate values are shown. Units: µg/liter

TABLE A-9
CONCENTRATIONS OF TRACE METALS AND CHC's IN
TISSUE FROM SAVANNAH ODMDS IN MARCH AND DECEMBER 1979

Species	Common Name	Station	Metals (µg/g dry wt)			PCB's (µg/g dry wt) Aroclor		Pesticides (µg/g dry wt)	
			Hg	Cd	Pb	1254	1016	pp'DDE	op'DDE
MARCH									
Ovalipes ocellatus	Crab	11	0.21	0.98	<0.39	0.117	ND	0.039	ND
Ovalipes ocellatus	Crab	12	<0.015	0.44	<0.23	0.071	ND	0.031	ND
Parapenaeus longirostris	Rock shrimp	12	0.020	0.130	<0.150	ND	ND	0.0037	0.0049
DECEMBER									
Penaeus sp.	Shrimp	11	0.092	0.025	0.20	ND	0.0709	ND	ND
Penaeus sp.	Shrimp	12	0.064	0.056	0.15	ND	ND	ND	ND

ND = Not detected

A.2.1.4 Biological Characteristics

Macrofauna - Numerically dominant macrofauna collected during the March and December surveys, and their mean abundances, are listed in Table A-10. A total of 28 species were common, 9 of which were present during both surveys. Polychaetes and crustaceans comprised 58% and 28%, respectively, of the dominant macrofauna collected.

The majority of polychaete and crustacean species at Savannah ODMDS are small-bodied (<5 cm in length) deposit feeders common to sandy substrates of the SAB (Boesch, 1977). Only 4 of the 16 polychaete species (Hemipodus roseus, Goniadides carolinae, Prionospio dayi, and Spio pettibonae) were present during both March and December. Large numbers of Spiophanes bombyx, Mediomastus ambiseta, and Magelona papillicornis were present within the ODMDS in March, but absent during the December survey. Similarly, only 4 of the 10 crustacean species were present at either the ODMDS or control station during both surveys, illustrating the seasonal variability in the macrofaunal composition. Similar seasonal variability in the composition of nearshore benthic communities of the SAB has been reported previously by Frankenberg and Leiper (1977).

Six macrofaunal species were selected for further analysis, based on their abundance during both surveys and association with known environmental conditions. These dominant species included the sea lancelet Branchiostoma caribaeum, the amphipods Platyischnopus mirabilis and Trichophoxus floridanus, the polychaetes Spio pettibonae and Goniadides carolinae, and the cumacean Oxyurostylis smithi. These species represent a variety of trophic levels. For example, the amphipods P. mirabilis and T. floridanus, and polychaete S. pettibonae, are deposit feeders, whereas B. caribaeum and O. smithi are suspension feeders. The feeding ecology of G. carolinae is unknown, although other members of this family (Goniadidae) are considered omniverous and/or carniverous, and probably feed on detritus and small organisms (Fauchald and Jumars, 1979). Abundances of the dominant species during the March and December surveys are listed in Table A-10.

TABLE A-10
MACROFAUNA ABUNDANCES AT
SAVANNAH ODMDS DURING MARCH AND DECEMBER 1979

	Feeding Type	March		December	
		Sta 11	Sta 12	Sta 11	Sta 12
ANNELIDA					
Synelmis albini	C	—	—	4 ± 0	4 ± 0
Syllis cornuta	C	—	—	5 ± 0	—
Hemipodus roseus	C	5 ± 0	—	17 ± 0	—
Goniadides carolinae	C	—	14 ± 21	—	11 ± 12
Lumbrineris latreilli	O	—	3 ± 0	—	—
Nerinides unidentata	D	13 ± 0	—	—	—
Prionospio cristata	D	32 ± 3	19 ± 23	—	—
Prionospio dayi	D	22 ± 0	—	22 ± 15	33 ± 0
Spio pettibonae	D	38 ± 62	1 ± 1	13 ± 15	4 ± 4
Spiophanes bombyx	D	239 ± 253	5 ± 3	—	—
Magelona papillicornis	D	66 ± 0	—	—	—
Tharyx annulosus	D	—	—	—	35 ± 0
Armandia agilis	D	—	9 ± 3	—	—
Capitella capitata	D	—	9 ± 0	—	—
Mediomastus ambiseta	D	98 ± 0	—	—	—
Lysilla alba	S	—	—	—	29 ± 0
Hesionidae unident	?	—	—	—	28 ± 0
Protodrilus symbioticus	D	78 ± 133	16 ± 10	—	10 ± 0
ARTHROPODA					
Sarsiella capsula	D	—	—	—	141 ± 55
Cyclaspis varians	D	23 ± 0	—	—	—
Oxyurostylis smithi	S	20 ± 24	18 ± 8	12 ± 6	4 ± 3
Acanthohaustorius intermedius	D	—	—	9 ± 1	—
Monoculodes sp.	?	14 ± 0	—	—	—
Platyischnopus mirabilis	D	4 ± 5	—	1 ± 13	1 ± 1

TABLE A-10 (Continued)

	Feeding Type	March		December	
		Sta 11	Sta 12	Sta 11	Sta 12
Oedicerotidae	D	3 ± 0	—	—	—
Tiron sp.	D	—	—	—	16 ± 0
Trichophoxus floridanus	D	8 ± 9	3 ± 4	9 ± 16	12 ± 17
Ostracoda	D	—	6 ± 0	—	—
MOLLUSCA					
Strigella mirabilis	D	—	—	2 ± 0	—
ECHINODERMATA					
Ophiophragmus wurdemani	O	—	—	19 ± 10	17 ± 0
CHORDATA					
Branchiostoma caribaeum	S	—	27 ± 15	8 ± 11	69 ± 39

Note: Mean number/0.06m^2 ± one standard deviation; n = 5

— Not present
C = Carnivore
O = Omnivore
D = Deposit feeder
S = Suspension feeder
? = Unknown

The nonparametric Mann-Whitney U-Test (Sokal and Rohlf, 1969) was used to compare abundances of each species between the ODMDS and control stations; results are presented in Table A-11. Abundances of *B. caribaeum* and *G. carolinae* were significantly higher within the control station during both surveys, while *P. mirabilis* and *O. smithi* were more numerous within the ODMDS during March and December respectively. There was no difference in the abundance of either *S. pettibonae* or *T. floridanus* between ODMDS and control stations during either survey.

Results from a previous survey of the Savannah ODMDS by Oertel (1975) suggest that differences in grain size and sediment stability, associated with the natural ridge and swale topography, may have an effect on the composition

TABLE A-11
RESULTS OF MANN-WHITNEY U-TESTS OF
ABUNDANCES OF DOMINANT SPECIES BETWEEN THE
SAVANNAH ODMDS AND CONTROL STATIONS DURING MARCH AND DECEMBER 1979

Species	March	December	Remarks
Spio pettibonae	NS	NS	
Goniadides carolinae	NS	*	Absent from ODMDS in March and December
Oxyurostylus smithi	NS	*	Significantly higher in ODMDS in December
Branchiostoma caribaeum	*	*	Absent from ODMDS in March; abundances lower in ODMDS in December
Trichophoxus floridanus	NS	NS	
Platyischnopus mirabilis	*	NS	Absent from control station in March

* Significant ($p \leq 0.05$)
NS = Not significant ($p \geq 0.05$)

and abundances of macrofauna within the site. The observed distributions of the dominant species within the ODMDS may be related to specific sediment preferences, and the spatial variability of sediment types associated with the ridge and swale topography. Relationships between species abundances and sediment composition were examined using Pearson product-moment correlations; significant relationships are presented in Table A-12. Platyischnopus mirabilis and T. floridanus may show a preference for disposal site sediments since the species abundances and percent fines were both higher within the site. Conversely, abundances of B. caribaeum which were less abundant in the disposal site were negatively correlated with percent clay ($r = -0.446$); this species may have a preference for coarser sediments outside the disposal site.

All of the dominant macrofauna are deposit feeders, with the exception of B. caribaeum (filter feeder) and G. carolinae (carnivore). The dominant deposit feeding organisms were typically more abundant within the disposal site, possibly reflecting the characteristic preference of deposit feeders for finer sediments. The suggested preference of B. caribaeum for the slightly

TABLE A-12
SIGNIFICANT ($p < 0.05$) CORRELATION COEFFICIENTS
BETWEEN SPECIES ABUNDANCES AND PERCENT CLAYS IN SEDIMENTS

Species	n	% Clay
Branchiostoma caribaeum	20	-0.446
Platyischnopus mirabilis	20	0.599
Trichophoxus floridanus	20	0.384

coarser control station sediments is consistant with its feeding mode: filter feeders generally are less common in finer sediments that can clog delicate feeding structures. Slightly finer sediments within the ODMDS may result from either natural depositional processes (i.e., from river discharge) or from previous dredged material disposal. However, Oertel (1975) stated "[a]pparently the natural sorting of dredged material in the water column did not sufficiently change that sediment character enough to effect the ecology of the benthic infauna associated with sand ridges and troughs." (p. 44)

Disposal of dredged material may directly disturb a benthic community through burial and smothering of organisms (Diaz and Boesch, 1977). The overburden may be recolonized by some individuals that survive burial and can vertically migrate back to their former levels in the sediment (Richardson et al., 1977; Maurer et al., 1981). However, the major process of recolonization appears to be caused by larval settlement (Oliver and Slattery, 1973; Oliver et al., 1977). Oliver et al. (1977) have shown that the first colonizers will be opportunistic species that are capable of rapid population growth and possess flexible life histories (Grassle and Grassle, 1974). Gray (1979) has shown that these species are often the dominant inhabitants of disturbed areas. Many opportunistic macrofauna are small-bodied deposit feeders, such as spionid and capitellid polychaetes, or corophiid amphipods (for example, see Dorsey, 1981).

A knowledge of the diversity, abundance, and feeding methods of species inhabiting an ODMDS would enable identification of the presence of a disturbed benthic community. Comparison of the ODMDS community with surrounding benthic communities undisturbed by disposal will facilitate the detection of effects caused by the disposal of dredged material. For example, a high abundance of opportunistic species, and a trophic structure dominated by deposit feeders, would stand out from undisturbed areas with a greater diversity of species and feeding methods (e.g., more suspension feeders, carnivores). Therefore, an analysis of the feeding (trophic) relationships was performed to further characterize the macrofauna in the area of the Savannah ODMDS. The species listed in Table A-10 were assigned to feeding categories based on Barnes (1974) and Fauchald and Jumars (1979). Four categories were used:

(1) Deposit feeders that ingest sediment and detrial particles

(2) Suspension feeders that filter food particles from the water

(3) Omnivores that feed on a variety of plant, animal, detrital and sediment material

(4) Carnivores that feed on living animal tissue

Mean abundance of common species were summed for each trophic category at each station, and percentages were calculated and presented graphically in Figure A-4.

In most cases each of the four trophic levels was represented at both the ODMDS and control stations. However, the larger percentages of macrofauna at both stations were deposit feeders, typically polychaetes (e.g., *Spiophanes bombyx*, *Prionospio dayi*, and *Mediomastus ambiseta*) and crustaceans (e.g., *Sarsiella capsula*, and *Trichophoxus floridanus*). Total numbers of deposit feeders at either station were seasonally variable and reflect the presence or absence of a few opportunistic species (i.e., *S. bombyx* and *S. capsula*). Suspension feeders consisted primarily of *Oxyurostylis smithi* and *Branchiostoma caribaeum*. Carnivores were represented by several polychaete species (e.g., *Hemipodus roseus*, and *Syllis cornuta*). Omnivores were represented primarily by the echinoderm *Ophiophragmus wurdemani*, which only

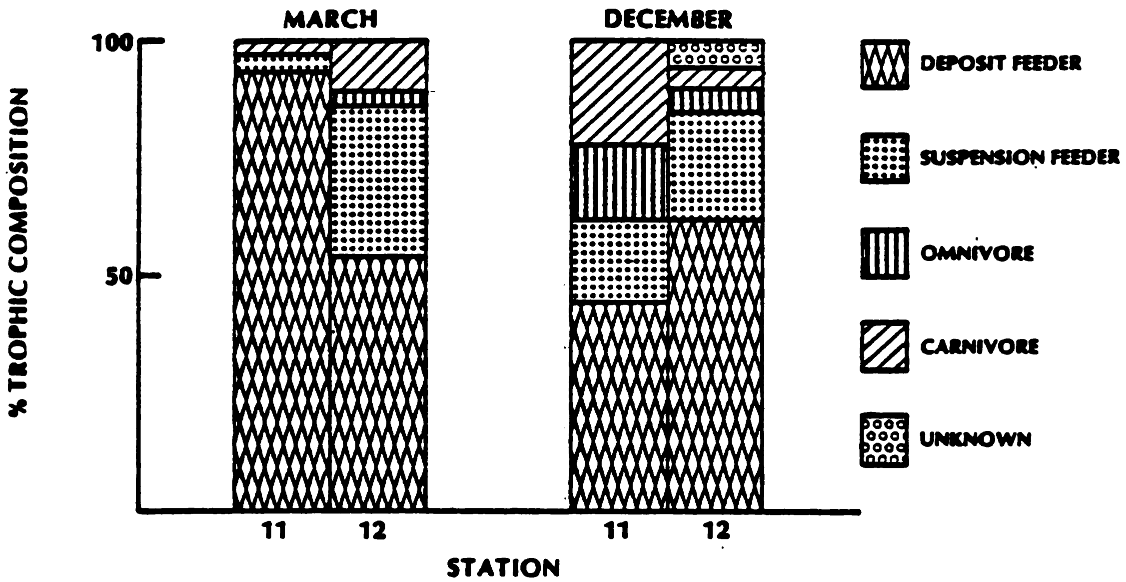

Figure A-4. Percent Trophic Composition of Common Macrofauna at the Savannah ODMDS and Control Stations in March and December 1979

was present at the ODMDS and control station in December. Seasonal changes in the trophic composition may reflect the presence or absence of opportunistic species, primarily deposit feeders.

Results of the IEC and other previous surveys at the Savannah ODMDS (e.g., Oertel, 1975) suggest that abundances of macrobenthos are both seasonally and spatially variable, and the patchiness of individual species may be related to substrate composition. During IEC surveys the large standard deviations relative to mean abundances of each species are probably typical the "patchy" environment of the Savannah ODMDS and adjacent area. Similarly, "Frankenberg and Leiper (1977) concluded that the macrobenthic communities of the Georgia Shelf are very variable spatially and temporally and that large and, in some respects, unpredictable seasonal variations were the rule" (Boesch, 1977; p. VIII-35). The effects of dredged material disposal on abundances of macrofauna within and outside the ODMDS may be difficult to ascertain because of the large variability. The composition of the macrobenthic community within the ODMDS was similar to other undisturbed nearshore, sandy bottom areas of the SAB (Boesch, 1977). The results of IEC and Oertel's (1975) survey suggest that previous dumping has not substantially altered the composition of the fauna in the area of the ODMDS.

EPIFAUNA

Epifaunal and nektonic organisms collected during the March and December surveys are listed in Table A-13. Few species were present during both surveys. Several species, including the crustaceans Sicyonia brevirostris and Ovalipes ocellatus, echinoderm Asterias forbesii, and fish Urophycis regius and Prionotus cardinus, were common in March and absent from either the ODMDS or control station in December. Appreciable numbers of shrimp (Trachypenaeus constrictus and Parapenaeus longirostris), as well as smaller numbers of several fish species, including Symphurus nebulosus, Menticirrhus saxatilis, and Peprilus tricanthus, were present in the study area in December. Most of the epifaunal and nekton species collected were characteristic of the inner Shelf faunal assemblage of the SAB (George and Staiger, 1979).

Differences between the composition and abundances of epifauna and nekton collected during the March and December surveys are probably typical of the seasonal variability of epibenthic organisms in the nearshore SAB. Oertel (1975) sampled nekton at two stations within the ODMDS, and a control station before, during, and after dumping. Oertel (ibid.) noticed a decrease from September to January in the total number and diversity of fish. This change could reflect seasonal changes in the physical regime or migratory habits of the nekton. Adverse effects from dumping on epifauna were not detected by Oertel, and could not be determined from IEC survey data.

Microbiology - Total and fecal coliform counts in the Savannah ODMDS and control station sediments and shellfish are presented in Table A-14; no shellfish were collected for analysis in March. Anomolously high total and fecal coliforms were detected in the ODMDS sediment during the March survey; however, coliforms were not detected in either sediments or organisms from the ODMDS in December. The reasons for the high March coliform counts are unknown. No historical data for coliform counts in the Savannah ODMDS sediments are available for comparisons.

TABLE A-13
NEKTON COLLECTED AT SAVANNAH ODMDS IN MARCH AND DECEMBER 1979

Species	March		December	
	Station 11	Station 12	Station 11	Station 12
CNIDARIA			5	
c.f. *Lepidomuricea grandis*	Present			
CTENOPHORE (unidentified)	33	33		
MOLLUSCA				
Illex illecebrosus	10	8	5	
Oliva sayana		1		
Polinices duplicatus		1		
ARTHROPODA				
Batrachonotus fragosus				
Hepatus epheliticus			2	
Ovalipes ocellatus	12	38		
Emerita benedicti	2			
Pagurus longicarpus			1	
Parapenaeus longirostris	10	10		28
Persephona punctata aquilonaris		1	1	
Portunus anceps			2	
Portunus depressifrons				Present, no number
Sicyonia typica				Present, no number
Sicyonia brevirostris	13			
ARTHROPODA				200
Squilla empusa	2	2		
mysid	1			
ECHINODERMATA				
Asterias forbesii		14		
Asterias vulgaris	1			
Astropecten articulatus		3		
Astropecten duplicatus		1		
Clypeaster subdepressus	1	2		
Astropectinidae		10		
Encope emarginata		2		
Hemipholis elongata		1		
Ophiolepsis elegans		5		
Luidia clathrata		6		
CEPHALOCHORDATA				
Branchiostoma caribaeum		100		
CHORDATA				
Ogcocephalus radiatus (Ogcocephalidae)				Present, no number
Urophycis regius (Gadidae)	18	35		
Anchoa hepsetus (Engraulidae)			5	
Antennarius ocellatus (Antennariidae)				1
Lepophidium profundum (Ophidiidae)	1			
Lepophidium cervinum (Ophidiidae)	1			
Monacanthus hispidus (Balistidae				
Prionotus carolinus (Triglidae)	1			Present, no number
Prionotus scitulus		18		
Peprilus triacanthus (Stromateidae)			17	
Ancylopsetta quadrocellata (Bothidae)		1		
Citharichthys arctifrons		4		
Scophthalmus aquosus		2	5	
Chaetodipterus faber (Ephippidae)			1	
Centropristis striatus (Serranidae)			1	
Stenotomus chrysops (Sparidae)				Present, no number
Symphurus nebulosus (Cynoglossidae)			11	
Symphurus plagiusa		1		
Sphoeroides maculatus (Tetraodontidae)	1			Present, no number
Cynoscion regalis (Sciaenidae)			1	
Leiostomus xanthurus			6	Present
Menticirrhus saxatilis			9	

TABLE A-14
TOTAL AND FECAL COLIFORM COUNTS AT
SAVANNAH ODMDS DURING MARCH AND DECEMBER 1979

	Sediments		Shellfish		
Station	Total Coliforms (MPN/100g)	Fecal Coliforms (MPN/100g)	Species	Total Coliforms (MPN/100g)	Fecal Coliforms (MPN/100g)
11*	35,000	780	NC	---	---
12*	750	200	NC	---	---
11†	< 154	< 154	*Parapenaeus longirostris* (shrimp)	< 286	< 286
12†	< 154	< 154	*Trachypenaeus constrictus* (shrimp)	< 154	< 154

NC = Not collected

* March
† December

A.2.2 CHARLESTON ODMDS

A.2.2.1 Water Column Characteristics

Water column measurements of temperature, salinity, pH, turbidity, and suspended solids (TSS) at the Charleston ODMDS during March and December are presented in Table A-15. Dissolved and particulate trace metal data are listed in Table A-16, along with data for dissolved chlorinated hydrocarbons.

Physical - Physical characteristics determined for waters in the vicinity of the Charleston ODMDS were consistent with previous observations of partially mixed nearshore waters of the South Atlantic Bight (SAB) (Blanton and Atkinson, 1978). Temperatures decreased slightly with greater water depth during March, but increased slightly with depth during December. Temperatures in December were higher than those in March and showed greater spatial variability, especially near the surface. Surface temperatures ranged from

TABLE A-15
WATER COLUMN CHARACTERISTICS AT
CHARLESTON ODMDS AND CONTROL STATIONS DURING MARCH AND DECEMBER 1979

Station	Depth (m)	Temperature °C		Salinity (o/oo)		TSS (mg/liter)		Turbidity (NTU)		pH	
		Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec
1	2	13.51	18.00	29.358	32.699	2.150	1.588	2.20	1.00	8.22	8.21
	7	—	—	—	—	—	—	1.50	—	—	—
	12	12.15	—	32.905	—	0.870	—	1.20	—	8.17	—
	15	—	18.50	—	33.624	—	2.038	—	1.40	—	8.35
6	2	13.51	13.00	31.193	31.040	0.884	3.424	1.10	2.10	8.22	8.04
	7	—	—	—	33.772	—	1.779	0.70	1.00	—	8.06
	12	12.45	—	32.913	—	0.988	—	1.00	—	8.22	—
	15	—	15.00	—	33.781	—	1.977	—	1.20	—	8.08
7	2	13.47	17.80	30.850	31.592	1.251	1.298	1.20	1.10	8.18	8.25
	10	—	16.50	—	33.027	—	2.001	—	1.20	—	8.24
	12	12.31	—	32.966	—	0.716	—	1.10	—	8.22	—
8	2	12.90	17.00	31.673	31.931	1.421	1.756	1.10	1.40	8.21	8.16
	11	11.93	—	32.759	—	2.169	—	1.50	—	—	—
	12	—	19.00	—	34.051	—	3.123	—	2.30	8.22	8.18
9	2	12.85	13.70	32.662	32.588	1.096	1.638	0.70	1.20	8.21	8.24
	12	12.49	—	33.265	—	0.981	—	0.90	—	8.21	—
	14	—	15.50	—	34.137	—	1.002	—	1.10	—	8.22

(—) Measurements not taken

about 12.8°C to 13.5°C in March, and from 13.0°C to 18.0°C in December. Temperature ranges in bottom waters (12m to 15m) were 11.9°C to 12.5°C in March and 15.0°C to 19.0°C in December. Temperatures were generally lower offshore during December.

Salinity increased with depth and increasing distance from shore during both surveys and was slightly higher in December than March. Surface salinity ranged from about 29.4^{o}/oo to 32.7^{o}/oo in March and from 31.0^{o}/oo to 32.7^{o}/oo in December. Bottom salinities ranged from 32.9^{o}/oo to 33.3^{o}/oo in March and from 33.0^{o}/oo to 34.1^{o}/oo in December. The pH of the waters in the area of the ODMDS was essentially uniform with depth and showed no consistent temporal or spatial trends. The overall pH range was 8.17 to 8.35.

Turbidity and TSS concentrations in the vicinity of the Charleston ODMDS vary with tidal flow and volume of river discharge. Turbidity and TSS levels decreased with distance from shore and were generally higher in December than

TABLE A-16
PARTICULATE AND DISSOLVED METALS AND ORGANOHALOGEN CONCENTRATIONS IN THE WATER COLUMN OF CHARLESTON ODMDS DURING MARCH AND DECEMBER 1979

Parameter	Station 1		Station 6	
	Mar	Dec	Mar	Dec
Particulate Trace Metals (µg/liter)				
Mercury	0.019	0.009	0.014	0.002
Cadmium	0.0021	0.005	0.0019	0.004
Lead	0.079	0.023	0.078	0.039
Dissolved Trace Metals (µg/liter)				
Mercury	0.049 0.076	<0.03	0.035	<0.03
Cadmium	0.320 0.493	0.040	0.019	0.038
Lead	0.378 3.200	0.032	0.126	0.044
Chlorinated Hydrocarbons (ng/liter)				
Aroclor 1016	ND	0.296	ND	0.405
op'DDE	ND	ND	ND	0.235
pp'DDD	ND	ND	0.07	ND

ND = Not detected

March. No consistent vertical trends were observed. Turbidity ranged from 0.7 to 2.2 NTU in March and from 1.0 to 2.3 NTU during December. TSS ranges for March and December were about 0.9 to 2.2 mg/liter and 1.0 to 3.4 mg/liter, respectively. March TSS concentrations were lower than the average spring particulate load (12.3 mg/liter) measured in the general area by Windom and Betzer (1979), but similar to February-March values reported by Doyle et al. (1979).

Chemical - Trace metal (mercury, cadmium, and lead) concentrations were generally slightly higher in March than December, especially in the dissolved phase at Station 1. Results of the DMRP (Saucier et al., 1978) suggest that detectable levels of trace metals are not typically released from dredged sediment. Therefore, the slightly higher levels of dissolved metals overlying the ODMDS were probably due to natural variability or sampling error. Dissolved mercury levels were less than 0.03 μg/liter in December and ranged from about 0.04 to 0.08 μg/liter in March. Dissolved cadmium levels were about 0.04 μg/liter in December and up to about 0.5 μg/liter in March. Dissolved lead showed the largest changes between surveys with December and March values ranging from about 0.03 to 0.04 μg/liter and 0.1 to 3.2 μg/liter, respectively. The greater March levels of the dissolved metals may be related to greater runoff in spring than winter. Particulate trace metal levels were all extremely low, never exceeding 0.1 μg/liter. Total mercury, cadmium, and lead concentrations were within the ranges reported for SAB Shelf Waters by Windom and Betzer (1979), Windom and Smith (1972), and Windom et al. (1975). Concentrations of total mercury and cadmium were below the respective EPA quality criteria for marine life (EPA, 1976).

Trace concentrations of dissolved pesticide derivatives (op'DDE and/or pp'DDD) (<0.5 ng/liter) were detected during both surveys while dissolved PCB's were detected only during December. The observed levels are within the general range of SAB concentrations reported by Bidleman and Olney (1974) and Harvey et al. (1974). Concentrations of PCB's and pesticides were below the EPA water quality criteria for marine life (EPA, 1976).

A.2.2.2 Sediment Characteristics

Physical - Grain size characteristics of sediments at the Charleston ODMDS and adjacent area are summarized in Table A-17. The sediments consisted primarily of sand (79% to 97%), with smaller and variable fractions of fine-grained (2% to 13%) and gravel-sized (0.4% to 17%) sediments. Highest percentages of fine-grained sediments were reported at nearshore Station 10, possibly indicating the deposition of riverborne silts. Relatively high percentages of gravel-sized sediments occurred at Station 8 during both surveys and at Station 5 during March. These observations are consistent with those reported by SCWMRD (1979). No consistent differences in sediment texture either between surveys or between site and control stations were detected with ANOVA's.

Chemical - Sediment concentrations of trace metals, TOC, oil and grease, and chlorinated hydrocarbons for the area of the Charleston ODMDS are listed in Table A-18. Lead concentrations for the March survey are not presented for the reasons explained earlier (see page A-14).

TABLE A-17
SEDIMENT CHARACTERISTICS AT
CHARLESTON ODMDS DURING MARCH AND DECEMBER 1979

Station	% Gravel		% Sand		% Fines	
	Mar	Dec	Mar	Dec	Mar	Dec
1	4.05 ± 4.8	5.27 ± 7.44	93.5 ± 5.02	90.8 ± 6.19	2.54 ± 0.87	3.95 ± 1.74
2	2.80 ± 3.38	0.48 ± 0.29	93.1 ± 4.79	95.5 ± 2.77	3.66 ± 1.86	3.99 ± 2.76
3	0.91 ± 0.81	1.73 ± 1.60	94.5 ± 3.71	94.8 ± 1.83	4.52 ± 3.71	3.42 ± 2.20
4	0.35 ± 0.22	0.28 ± 0.16	96.4 ± 2.03	96.9 ± 1.29	3.17 ± 2.03	2.76 ± 1.28
5	11.4 ± 13.2	1.12 ± 2.02	91.0 ± 8.88	95.8 ± 1.53	2.74 ± 1.26	3.06 ± 1.69
6	2.55 ± 2.86	1.56 ± 1.46	94.9 ± 3.05	95.3 ± 2.05	2.54 ± 0.79	3.02 ± 1.80
7	0.68 ± 0.37	3.03 ± 6.01	97.0 ± 1.06	94.1 ± 6.50	2.27 ± 0.92	2.83 ± 1.81
8	10.5 ± 15.8	16.8 ± 15.2	85.4 ± 15.5	79.5 ± 15.5	4.10 ± 3.06	3.65 ± 1.80
9	2.90 ± 3.67	8.51 ± 11.2	95.3 ± 3.13	88.0 ± 12.0	1.84 ± 1.48	3.48 ± 2.16
10	2.33 ± 1.63	1.38 ± 1.24	91.7 ± 1.65	85.1 ± 9.90	6.00 ± 2.07	13.5 ± 10.5

Note: Values for percentages are mean ± standard deviation; n = 5

TABLE A-18

CONCENTRATIONS OF TRACE METALS, OIL AND GREASE, TOC, AND CHLORINATED HYDROCARBONS IN CHARLESTON ODMDS SEDIMENTS DURING MARCH AND DECEMBER 1979

Station	Trace Metals (µg/g)						Oil and Grease (µg/g)		TOC (mg/g)		Chlorinated Hydrocarbons (ng/g)	
	Hg		Pb		Cd							
	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar	Dec
1	.002	.002	-	1.4	.006	.006	.014	.014	.845	.845		0.076 (op'DDE)
	.004	.001	-	1.9	.004	.048	.058	.028	.80	.178	0.50 (pp'DDE)	0.027 (pp'DDE)
												0.118 (Aroclor 1016)
												0.492 (Aroclor 1254)
2	.002	.002	-	1.8	.002	.116	.040	.025	12.4	.608	NA	NA
	.003	.002	-	2.0	.002	.032	.059	.037	1.50	.989		
3	.001	.001	-	1.4	.002	.005	.024	.011	1.10	.497	NA	NA
	.002	.001	-	1.2	.002	.001	.063	.009	.30	.654		
4	.003	.001	-	2.0	.002	.018	.044	.022	2.50	.487	NA	NA
	.001	.002	-	2.0	.002	.020	.037	.034	1.10	1.20		
5	.004	.005	-	1.5	.022	.009	.032	.014	1.40	.481	NA	NA
	.003	.001	-	1.4	.014	.045	.022	.013	0.40	.783		
6	.003	.001	-	1.7	.001	.010	.028	.020	1.80	.557	Not Detected	0.211 (Aroclor 1016)
	.002	.001	-	1.4	.001	.004	.059	.017	1.10	.449		
7	.001	.001	-	2.1	.002	.011	.038	.015	10.1	1.47	NA	NA
	.001	.001	-	1.8	.004	.011	.041	.011	0.05	.426		
8	.004	.003	-	1.6	.008	.050	.061	.027	1.00	.369	NA	NA
	.004	.002	-	1.5	.016	.003	.077	.021	1.10	2.06		
9	.003	.003	-	1.6	.002	.001	.035	.033	9.70	.714	NA	NA
	.001	.001	-	1.4	.001	.001	.067	.017	1.20	.639		
10	.003	.003	-	1.5	.004	.013	.066	.051	0.70	.594	NA	NA
	.004	-	-	-	.006	-	.099	-	7.20	-		

Note: All replicate values are shown

NA = Not analyzed

Dash (-) indicates March lead values are not presented (reasons explained in the text)

ANOVA's of trace metal concentrations in sediments showed no consistant differences between surveys or stations. Mercury and lead concentration ranges were only 0.0003 to 0.005 µg/g and 1.2 to 2.1 µg/g, respectively. Cadmium concentrations exhibited the greatest variability (0.001 to 0.116 µg/g); however, observed values typically were within the range reported by Windom and Betzer (1979) for SAB sediments. No indications of higher trace metal levels in sediments within the ODMDS, relative to outside the site, were found. SCWMRD (1979) reported concentrations of <0.5 to 1.9 µg/g lead, 0.12 to 1.1 µg/g cadmium, and 0.1 to 0.4 µg/g mercury in the Charleston ODMDS sediments. Mercury and cadmium levels reported by SCWMRD were substantially higher than concentrations measured during IEC surveys. The reason for this discrepency is unknown, but may be due to differences in analytical methodology.

Concentrations of TOC were generally higher and more variable during March than December; ranges were 0.05 to 12.4 mg/g and about 0.4 to 2.1 mg/g, respectively. The reason for this disparity is unclear, expecially since the amounts of fine sediment, which are generally positively correlated with TOC, were relatively constant between surveys. High March TOC levels occurred at Stations 2, 7, 9, and 10, with no consistent differences between ODMDS and control stations. Oil and grease concentrations were consistantly low (<0.1 mg/g) during both surveys; the overall range was from 0.009 to 0.099 mg/g. SCWMRD (1979) reported oil and grease concentrations of 0.03 to 0.22 mg/g and TOC levels of <10 mg/g in the Charleston ODMDS sediments.

Low concentrations (<0.2 ng/g) of DDT derivatives were detected in sediments during both surveys at Station 1, but none were measured at control Station 6. PCB's were detected at both stations during December, but none were present at either station in March. The reasons for these findings are unclear from survey data; however, variability may be related to either physical processes (i.e., sediment transport during storms) or anthropogenic inputs.

These data suggest that disposal of dredged material at the Charleston ODMDS has not resulted in any substantial physical or chemical sediment alterations within the site. Slightly higher levels of cadmium and chlorinated hydrocarbons occurred within the ODMDS; however, more detailed studies would be necessary to substantiate these results.

Elutriate Tests - Elutriate tests indicated mercury, cadmium, and lead were not released from sediments to any substantial degree (Table A-19). Concentrations in test waters ranged from 0.05 to 0.38 μg/liter for mercury, 0.13 to 0.17 μg/liter for cadmium, and <0.26 to 2.6 μg/liter for lead. Slightly higher trace metal levels were observed for tests of site sediments (Station 1) relative to reference sediments (Station 6), but all were generally within the ranges measured for dissolved metals in ambient site water during the surveys (Table A-16).

Tissues - Tissue samples were not analyzed during the March or December Charleston ODMDS surveys.

TABLE A-19
RESULTS OF ELUTRIATE TESTS OF
CHARLESTON ODMDS SEDIMENTS IN DECEMBER 1979

	Station 1	Station 6	ODMDS Water (Range)
Mercury	0.16	< 0.05	< 0.03 to 0.08
	< 0.05	< 0.05	
	0.38	< 0.05	
Cadmium	0.13	0.09	0.04 to 0.49
	0.13	0.14	
	0.17	0.31	
Lead	< 0.27	< 0.25	0.03 to 3.2
	2.6	< 0.25	
	< 0.26	< 0.26	

Note: All replicate values are shown. Units = μg/liter.

A.2.2.3 Biological Characteristics of the Charleston ODMDS

Macroinfauna - Common marcofauna collected during the March and December surveys are listed in Tables A-20 and A-21. A total of 82 species were identified, 28 of which were present during both sampling periods.

Polychaetes comprised the largest taxonomic group, accounting for approximately 60% and 50% of the species collected during the March and December surveys, respectively. Arthropods and molluscs also accounted for approximately 25% and 10%, respectively, of the common macrofaunal species.

In August 1978 SCWMRD (1979) sampled the benthic infauna in the vicinity of the Charleston ODMDS and identified 493 invertebrate species from 40 sampling stations. Polychaetes accounted for 37.5% of the total number of organisms

MACROFAUNA ABUNDANCES
AT CHARLESTON ODMDS DURING MARCH 1979

Species	Feeding Type	Stations 1	2	3	4	5	6	7	8	9	10
ANNELIDA											
Hesionidae sp.	O	-	-	-	-	-	-	-	-	-	16 ± 0
Syllidae sp.	C	-	-	-	-	-	-	-	-	6 ± 0	-
Syllidae sp. A	C	-	-	-	-	-	9 ± 0	-	-	-	-
Syllides sp.	C	-	-	-	-	-	-	-	-	-	16 ± 0
Syllis cornuta carolinae	C	-	-	-	-	-	-	-	-	5 ± 0	-
Ceratocephale loveni	O	6 ± 0	-	-	-	-	-	-	-	-	-
Micronephthys minuta	C	-	-	-	-	6 ± 0	17 ± 0	11 ± 0	-	-	-
Nephtys bucera	C	-	-	-	-	-	-	-	-	4 ± 0	-
Nephtys dispora	C	-	6 ± 0	-	-	-	-	-	-	-	-
Nephtys incisa	C	-	-	6 ± 0	-	-	-	-	-	-	29 ± 0
Nephtys picta	C	7 ± 0	-	16 ± 0	-	-	6 ± 0	31 ± 0	15 ± 0	2 ± 0	21 ± 0
Glycera papillosa	C	-	-	-	-	17 ± 20	8 ± 3	-	-	-	-
Glycera tesselata	C	-	-	-	-	6 ± 0	-	-	-	-	-
Goniadides carolinae	C	-	-	-	-	1 ± 1	7 ± 15	0.2 ± 0.4	0.4 ± 0.9	4 ± 6	9 ± 20
Onuphis eremita	O	9 ± 0	9 ± 6	5 ± 1	-	10 ± 0	7 ± 0	8 ± 0	-	-	-
Lumbrineris latreilli	O	-	-	-	-	6 ± 0	-	-	-	-	-
Lumbrineris paradoxa	O	-	-	-	-	-	-	-	-	2 ± 0	-
Nerinides unidentata	D	-	-	-	-	-	9 ± 0	-	-	4 ± 0	-
Polydora socialis	D	-	433 ± 823	-	-	15 ± 0	-	-	-	-	-
Prionospio dayi	D	-	-	-	-	-	6 ± 0	5 ± 0	-	-	-
Prionospio cristata	D	-	-	-	-	60 ± 44	20 ± 19	-	64 ± 0	-	-
Scolecolepides viridis	D	-	64 ± 4	-	-	-	-	-	-	-	-
Spio setosa	D	-	-	-	-	-	-	-	14 ± 0	-	-
Spiophanes bombyx	D	54 ± 84	46 ± 21	22 ± 15	14 ± 15	10 ± 15	32 ± 9	25 ± 15	38 ± 22	2 ± 3	407 ± 364
Magelona phyllisae	D	-	-	-	-	-	-	-	-	-	36 ± 14
Aricidea fragilis	D	19 ± 0	-	-	-	-	-	-	19 ± 0	-	-
Aricidea sp.	D	-	-	-	-	4 ± 0	-	-	-	-	-
Aricidea wassi	D	-	-	-	17 ± 0	10 ± 0	-	-	-	-	-
Cirrophorus lyriformis	D	-	-	-	-	-	-	-	-	-	40 ± 0
Paraonis lyra	D	-	-	-	-	12 ± 0	-	-	-	-	-
Paraonis pygoenigmatica	D	-	-	-	-	-	6 ± 0	-	-	-	-
Mediomastus ambiseta	D	-	-	-	-	-	12 ± 0	-	-	-	59 ± 0
Armandia americana	D	200 ± 0	128 ± 0	-	-	-	6 ± 0	-	-	-	-
Asabellides oculata	D	-	36 ± 16	-	-	-	-	-	91 ± 0	-	112 ± 67
Protodrilus symbioticus	D	36 ± 9	36 ± 19	16 ± 16	31 ± 57	16 ± 3	13 ± 0	22 ± 16	116 ± 90	5 ± 3	8 ± 0
OLIGOCHAETA	D	-	-	3 ± 0	-	-	8 ± 0	-	-	5 ± 0	-
MOLLUSCA											
Bivalvia sp. B	?	-	-	-	-	-	25 ± 20	29 ± 23	-	-	-
Macrocallista nimbosa	S	0.3 ± 0.5	0.4 ± 0.9	-	-	-	0.4 ± 0.8	-	-	-	-
Parvilucina multilineata	D	-	19 ± 0	22 ± 26	-	-	-	-	-	-	-
Retusa obtusa	C	-	-	-	-	-	-	-	-	3 ± 0	-
Solen viridis	S	4 ± 4	12 ± 22	0.2 ± 0.4	0.4 ± 0.5	5 ± 9	7 ± 11	-	94 ± 146	0.4 ± 0.9	6 ± 7
Tellina sp.	D	-	-	40 ± 0	-	-	29 ± 27	31 ± 8	-	-	-
Tellina agilis	D	0.5 ± 0.6	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	0.6 ± 1	0.4 ± 0.5	0.2 ± 0.4	-	-	10 ± 12
Caecum pulchellum	D	-	-	-	-	-	-	6 ± 0	-	-	-
ARTHROPODA											
Ostracoda	D	-	-	-	-	-	-	-	-	9 ± 1	-
Oxyurostylis smithi	S	22 ± 36	4 ± 3	6 ± 5	6 ± 4	11 ± 11	2 ± 4	5 ± 4	48 ± 34	0.2 ± 0.4	99 ± 189
Calathura sp.	D	-	-	-	-	-	-	-	-	2 ± 0	-
Cyathura polita	D	-	-	-	-	12 ± 0	-	-	-	-	-
Acanthohaustorius shoemakeri	D	-	-	-	-	-	-	-	-	6 ± 3	-
Bathyporeia parkeri	D	-	21 ± 1	-	44 ± 25	-	14 ± 4	-	60 ± 8	6 ± 4	-
Erichthonius brasiliensis	S	-	14 ± 0	8 ± 0	-	-	-	-	-	-	-
Monoculodes edwardsi	D	7 ± 0	-	-	-	-	-	-	-	-	-
Monoculodes intermedius	D	-	-	7 ± 0	-	-	-	-	-	-	-
Oedicerotidae sp.	D	-	-	-	-	-	-	-	-	-	10 ± 0
Platyischnopus mirabilis	D	11 ± 7	3 ± 5	4 ± 4	11 ± 6	4 ± 7	4 ± 5	8 ± 2	2 ± 4	3 ± 4	0.6 ± 0.9
Cyclaspis varians	D	38 ± 29	16 ± 0	-	-	7 ± 0	-	-	41 ± 17	-	-
Protohaustorius deichmannae	D	-	-	-	-	-	-	-	35 ± 0	-	-
Protohaustorius wigleyi	S	-	-	-	40 ± 25	-	-	13 ± 0	-	6 ± 3	-
Trichophoxus floridanus	D	24 ± 8	11 ± 13	3 ± 2	20 ± 11	2 ± 1	7 ± 9	11 ± 5	3 ± 4	4 ± 6	-
SIPUNCULA		-	-	-	-	-	-	-	-	-	25 ± 0
ECHINODERMATA											
Ophiophragmus wurdemani	O	-	-	-	-	-	12 ± 0	-	-	-	-
CHORDATA											
Branchiostoma caribaeum	S	-	-	-	-	-	11 ± 0	-	-	11 ± 1	-

Note: Values are mean abundances/0.04 m^2 ± one standard deviation; n = 5
Dash (-) indicates that the species is not present

D = Deposit feeder C = Carnivore
S = Suspension feeder ? = Unknown
O = Omnivore

TABLE A-21
MACROFAUNA ABUNDANCES
AT CHARLESTON ODMDS DURING DECEMBER 1979

Species	Feeding Type	Stations 1	2	3	4	5	6	7	8	9	10
CNIDARIA											
Renilla reniformis	S	-	-	-	7 ± 6	-	-	-	-	-	-
PLATYHELMINTHES											
Stylochus ellipticus	C	-	-	-	-	-	-	-	-	-	34 ± 23
ANNELIDA											
Syllis hyalina	C	-	-	-	-	-	-	-	13 ± 0	-	-
Nephtys picta	C	-	-	-	-	-	-	-	-	4 ± 0	11 ± 0
Glycera americana	C	-	-	7 ± 0	4 ± 0	5 ± 1	7 ± 0	5 ± 0	13 ± 0	5 ± 1	-
Glycera papillosa	C	-	-	-	-	6 ± 0	-	-	-	-	-
Hemipodus roseus	C	-	-	-	-	-	-	-	-	-	-
Goniadides carolinae	C	11 ± 24	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	16 ± 37	22 ± 24	20 ± 34	0.2 ± 0.4
Onuphis eremita	O	-	-	14 ± 0	-	-	21 ± 0	3 ± 0	-	-	-
Onuphis emalina	O	-	-	-	5 ± 0	-	-	-	-	-	-
Lumbrineris latreilli	O	-	-	-	-	-	-	-	9 ± 0	-	-
Nerinides unidentata	D	-	-	27 ± 0	-	-	-	-	-	-	-
Paraprionospio pinnata	D	-	-	-	-	-	-	-	-	-	91 ± 0
Prionospio cristata	D	300 ± 0	-	35 ± 0	-	-	-	663 ± 0	51 ± 49	231 ± 0	-
Prionospio dayi	D	24 ± 2	83 ± 46	37 ± 47	28 ± 24	-	32 ± 22	28 ± 0	-	18 ± 0	37 ± 0
Spio pettiboneae	D	17 ± 0	-	38 ± 28	-	-	19 ± 1	14 ± 0	20 ± 11	11 ± 0	-
Spiophanes bombyx	D	0.4 ± 0.5	5 ± 4	12 ± 12	6 ± 5	2 ± 1	11 ± 10	4 ± 3	0 ± 0	8 ± 9	1 ± 1
Magelona phyllisae	D	-	-	-	-	-	-	-	-	-	46 ± 13
Tharyx annulosus	D	39 ± 0	-	-	-	-	-	-	-	-	-
Prisidea voogi	D	-	-	-	7 ± 3	10 ± 5	8 ± 0	5 ± 0	-	-	-
Cirrophorus lyriformis	D	-	-	-	-	-	-	40 ± 0	25 ± 8	-	-
Amastigos sp.	D	29 ± 0	-	-	17 ± 0	-	-	-	-	-	14 ± 0
Mediomastus ambiseta	D	-	-	70 ± 0	-	-	-	-	-	105 ± 0	115 ± 58
Asabellides oculata	D	12 ± 0	-	-	6 ± 0	-	-	-	-	-	-
Oligochaeta	D	199 ± 0	-	-	-	14 ± 1	21 ± 0	79 ± 0	34 ± 1	21 ± 1	-
Protodriloides symbioticus	D	73 ± 36	94 ± 65	20 ± 12	17 ± 14	16 ± 10	23 ± 14	11 ± 0	19 ± 0	26 ± 0	-
MOLLUSCA											
Macrocallista nimbosa	S	4 ± 6	6 ± 5	6 ± 10	0.2 ± 0.4	7 ± 3	3 ± 5	5 ± 7	0 ± 0	1 ± 2	0 ± 0
Mactra fragilis	S	0 ± 0	0 ± 0	0 ± 0	3 ± 5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2960 ± 1409
Parvilucina multilineata	D	16 ± 6	46 ± 25	28 ± 0	14 ± 4	-	0 ± 0	14 ± 4	-	-	-
Solen viridis	S	0 ± 0	0 ± 0	0 ± 0	0.6 ± 0.9	0 ± 0	0 ± 0	0 ± 0	0.6 ± 0.9	0 ± 0	88 ± 102
Strigilla mirabilis	D	-	-	-	7 ± 0	-	-	7 ± 0	-	-	-
Tellina agilis	D	0.6 ± 0.9	1.6 ± 1.5	2 ± 3	0.8 ± 1	0.8 ± 0.8	0.4 ± 0.9	0.4 ± 0.9	0 ± 0	0.5 ± 0.9	2 ± 2
ARTHROPODA											
cf. Sarsiella sp.	D	-	-	7 ± 0	-	6 ± 0	-	-	-	16 ± 4	-
Gastrosaccus dissimilis	?	-	-	-	-	-	-	3 ± 0	-	-	-
Cyclaspis varians	D	-	-	-	-	-	-	-	-	54 ± 0	-
Oxyurostylis smithi	S	5 ± 4	5 ± 4	10 ± 23	2 ± 1	13 ± 13	8 ± 9	8 ± 12	3 ± 4	27 ± 51	24 ± 21
Edotea triloba	D	-	-	-	-	-	-	-	-	-	60 ± 0
Acanthohaustorius intermedius	D	-	-	-	8 ± 3	9 ± 2	-	-	-	-	-
Bathyporeia parkeri	D	-	38 ± 11	-	-	-	10 ± 0	-	-	4 ± 0	-
Platyischnopus mirabilis	D	7 ± 5	20 ± 12	4 ± 4	6 ± 5	9 ± 6	3 ± 2	3 ± 3	1 ± 3	3 ± 4	0.2 ± 0.4
Protohaustorius deichmannae	D	11 ± 0	22 ± 10	7 ± 0	-	-	-	-	-	-	-
Protohaustorius wigleyi	S	-	18 ± 0	-	54 ± 34	-	23 ± 0	-	-	-	-
Tiron sp.	D	48 ± 0	24 ± 0	7 ± 0	-	8 ± 0	38 ± 0	5 ± 0	13 ± 0	19 ± 6	-
Trichophoxus floridanus	D	16 ± 17	31 ± 13	10 ± 6	9 ± 12	4 ± 2	15 ± 8	3 ± 3	3 ± 4	2 ± 3	2 ± 2
ECHINODERMATA											
Ophiophragmus wurdemani	D	-	-	-	-	-	-	98 ± 0	34 ± 0	30 ± 0	-
Echinoidea sp.	?	-	-	-	-	-	-	6 ± 0	-	-	-
Thyone briareus	D	-	-	-	-	-	-	-	-	-	13 ± 0
CHORDATA											
Branchiostoma caribaeum	S	-	-	-	-	-	-	23 ± 18	38 ± 7	22 ± 23	22 ± 23
SIPUNCULIDA											
Aspidosiphon sp.	D	35 ± 0	-	-	-	-	-	-	-	-	-

Note: Mean number/0.04 m^2 ± one standard deviation; n = 5

Dash (-) indicates that the species was not present

- Not present

D = Deposit feeder
S = Suspension feeder
O = Omnivore
C = Carnivore
? = Unknown

collected, whereas amphipods composed 10% and molluscs 7%, of the macroinvertebrates. The most abundant species was the cephalochordate Branchiostoma caribaeum. Several of the macrofaunal species collected by SCWMRD were also common during the IEC surveys.

Macrofaunal species listed in Tables A-20 and A-21 were assigned to one of four feeding categories (deposit feeder, suspension feeder, omnivore, or carnivore), as discussed previously (Section A.2.1.4). The percent trophic composition was calculated for each station and presented in Figure A-5. In most cases, all of the four trophic levels were represented at each station, and the respective percentages were similar during both surveys.

Deposit feeding polychaetes and crustaceans typically contributed the largest numbers of species and individuals to the macrofauna. Representative deposit feeders include the polychaete Spiophanes bombyx, amphipod Trichophoxus floridanus, and archiannelid Protodrilis symbioticus. Several species of polychaetes and crustaceans occurred sporadically throughout the study area, or were present during only one survey. For example, the polychaete Polydora socialis was present at two stations within the ODMDS in March (with mean abundances of 15 and 433 individuals per 0.06 m^2), but absent from all stations in December. Although the percentages of deposit feeding organisms were relatively uniform throughout the ODMDS, total numbers of deposit feeders varied depending on the presence of several opportunistic species. These results are similar to those at the Savannah ODMDS, and indicate the spatial and temporal variability of the macrofauna at the Charleston ODMDS. Percentages of deposit feeders at stations inside the ODMDS were comparable to those outside the ODMDS.

Suspension feeders represented a variable proportion (1% to 88%) of the macrofauna at each station, although percentages were typically less than 20%. Representative species included the cumacean Oxyurostylus smithi, mollusc Macrocallista nimbosa, and cephalochordate Branchiostoma caribaeum. The mollusc Mactra fragilis occurred at Station 10 in December, with a mean abundance of 2960 individuals per 0.06 m^2, but was either absent or present only in small numbers at other stations (Station 4) during the same period,

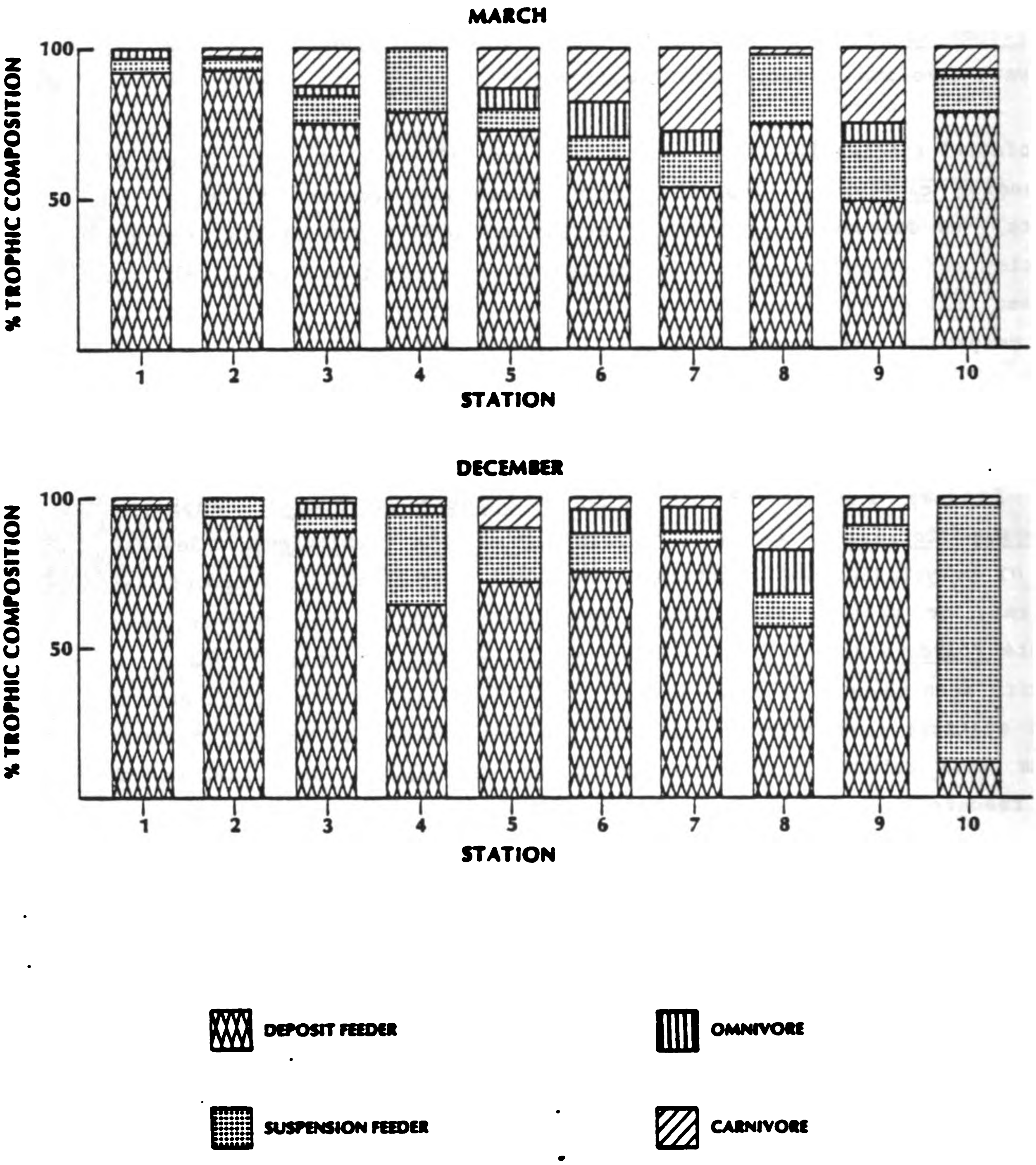

Figure A-5. Percent Composition of Feeding Types at Charleston ODMDS During March and December 1979

and absent from the study area in March. The large number of M. fragilis accounts for the relatively high percentage of suspension feeders observed in December.

Total numbers of omnivores and carnivores were relatively low at all stations during the March and December surveys, and species in these categories generally comprised less than 20% of the trophic composition. Representative omnivore species included the polychaetes Onuphus cremita and Lumbrineris latreilli and the echinoderm Ophiophragmus wurdemani. Representative species of carnivore include the polychaetes Nephtys picta and Goniadides carolinae.

Eight macrofaunal species were selected for further analysis based on their abundances during both surveys and association with known environmental conditions. Dominant species include the polychaetes Spiophanes bombyx and Goniadides carolinae; molluscs Macrocallista nimbosa, Solen viridis, and Tellina agilis; and crustaceans Oxyurostylis smithi, Platyischnopus mirabilis, and Trichophoxus floridanus. Species abundances during the March and December surveys are listed in Tables A-20 and A-21, respectively. The dominant macrofaunal species are common in nearshore sand-bottom environments throughout the SAB, and represent several trophic levels. Spiophanes bombyx, P. mirabilis, T. floridanus, and T. agilis are deposit feeders, and O. smithi, M. nimbosa, and S. viridis are suspension feeders. As mentioned previously, G. carolinae is considered a carnivore.

Densities of most of the dominant macrofauna exhibited considerable variability between surveys and between stations. However, densities of O. smithi, S. viridis and T. agilis tended to be slightly higher at the nearshore station; densities of P. mirabilis and T. floridanus were typically higher, while densities of G. carolinae were lower within the ODMDS; densities of S. bombyx were extremely variable, especially in March, with no discernable pattern in their distribution; M. nimbosa were relatively uniform throughout the region, except for their absence from the nearshore and northernmost stations. Sources of variation in species densities were examined with an analysis of variance. Significant differences in densities between surveys ($p < .05$) were detected for only one species (Macrocallista nimbosa). No significant differences in densities between stations were detected for any of the dominant species.

Differences in the densities of dominant species between the ODMDS and control stations were examined with a nonparametric comparison test as follows. Stations along a similar isobath were separated into two groups: (1) a control group (Stations 6, 7, and 8) and (2) a ODMDS group (Stations 1, 3, and 5). For each of the dominant species, all density information from the replicates was pooled for each group of stations to form two samples. Differences between these samples were tested using a Mann-Whitney U-Test (Sokal and Rohlf, 1969). Significant differences in abundances ($p < 0.05$) of Spiophanes bombyx between ODMDS station group and the control station group were detected during the December survey; S. bombyx were more abundant at the ODMDS stations. Abundances of the other dominant macrofauna were not significantly different between control and ODMDS station groups.

The South Carolina Wildlife and Marine Resource Department (SCWMRD, 1979) detected no significant differences in the abundances, species diversity, or species richness between stations inside and outside of the disposal site. Comparisons of individual species abundances in both the IEC and SCWMRD indicate considerable temporal and spatial variability. Similar variation in nearshore infaunal communities have been discussed by Frankenberg (1971). The patchy station-to-station distribution and high replicate sample varibility "reflect density peaks associated with uneven settling of the meroplanktonic larvae that are characteristic of subtropical benthos" (Thorson, 1966 cited in Tenore, 1979). High variability in species densities among replicate casts during the IEC surveys is indicated by the large standard deviation relative to the station abundance means, and may account for the inability to distinguish significant differences in species densities between either surveys or stations.

Pearson product-moment correlations were computed for species abundances and concentrations of several abiotic parameters to investigate whether abiotic factors might be related to patterns of infaunal densities. Densities of Solen viridis were correlated with percentages of sediment silt (r = 0.305), and densities of Tellina agilis were positively correlated with percentages of sediment clay (r = 0.176). The low correlation coefficients suggest that other factors (biological, chemical or physical) are responsible for variability in species densities. Correlations between the abundances of the other dominant species and physical parameters were not statistically significant.

Results from both IEC and SCWMRD surveys indicate that macrofauna in the Charleston ODMDS have high temporal and spatial variability in both diversity and abundance. Nevertheless, no significant differences in trophic composition or species densities between stations within and outside the ODMDS were detettable during either the IEC or SCWMRD surveys.

Epifauna - A list of epifauna and nekton collected during the December survey are presented in Table A-22; no trawls were performed in March because of problems with sampling gear. The diversity and abundances of epifauna were low within the ODMDS but higher elsewhere. For example, a greater diversity of fish, especially black seabass (Centropristis striatus) and scup (Stenotonus chrysops), occurred at Station 6 outside the ODMDS.

Results from the SCWMRD (1979) survey suggest that the distribution and abundances of sessile epifauna (e.g., hydroids) are dependent on the availability of a suitable substrate. Relatively higher epifaunal densities occur in areas with greater accumulations of large shells. Epifaunal assemblages are expected to vary areally and seasonally similar to the infauna. The large annual variability in species abundances may obscure impacts of dredged material disposal on both infaunal and epifaunal organisms. However, SCWMRD (1979) concluded "no effects of dredged material disposal were detectable in either epifaunal or infaunal communities. Such practices have probably had little lasting impact on the macrobenthos because of the similarity of dredged materials to the existing sediments of the disposal area." (p. 47)

TABLE A-22
EPIFAUNA AND NEKTON COLLECTED AT CHARLESTON ODMDS IN NOVEMBER 1979

Species	Common Name	Station 1	Station 6
CNIDARIA			
Cubomedusae	Jelly fish	-	50
Gorgonacea	Whip coral	4	-
MOLLUSCA			
Diodora cayenensis	Keyhole limpet	1	-
Illex illecebrasus	Boreal squid	-	77
ARTHROPODA			
Micropanope xanthiformis	Mud crab	-	1
Penaeus setiferous	White shrimp	-	1
Podochela rusei	Crab	-	3
Synalpheus minas	Pistol shrimp	1	-
ECHINODERMATA			
Arbacia punctulata	Purple sea urchin	-	1
Pachythone briareus	Sea cucumber	-	1
CHORDATA			
Amaroucium constellatum	Sea squirt	1 colony	-
Osmeridae			
Osmeris mordax	Rainbow smelt	-	7
Serranidae			
Centropristis striatus	Black seabass	-	59
Sparidae			
Stenotonus chrysops	Scup	-	25
Sciaenidae			
Equetus acuminatus	High hat	-	1
Trigilidae			
Prionotus carolinus	Northern searobin	-	2
Bothidae			
Scopthalmus aquosus	Windowpane flounder	-	3
Balistidae			
Monocanthus hispidus	Planehead filefish	-	1
Diodontidae			
Chilomyctenus schoepfi	Striped burrfish	-	1

Microbiology - Total and fecal coliform counts from sediments collected from Stations 1 and 6 during the IEC December survey are presented in Table A-23. No shellfish were collected for tissue coliform analyses. Total and fecal coliforms were detected (3833/100g and 3333/100g sediments, respectively) in ODMDS sediments, whereas no coliforms were detected in the reference station sediments. It is not known whether the presence of coliforms in ODMDS sediments is a result of previous dredged material disposal.

A.2.3 WILMINGTON ODMDS

A.2.3.1 Water Column Characteristics

Water column characteristics (temperature, salinity, pH, turbidity, and total suspended solids) of the Wilmington ODMDS during November and July are presented in Table A-24. Dissolved and particulate trace metal concentrations are summarized in Table A-25.

Physical - Temperatures generally increased with depth in November and decreased with depth in July; however, overall temperature variations were small vertically as well as spatially. November surface temperatures ranged from 17.5° to 20.5°C; bottom temperatures ranged from 18.1°C to 19.7°C. July surface temperatures ranged from 26.9°C to 28.1°C; bottom temperatures ranged from 26.8°C to 28.3°C. Measured surface and bottom temperatures were generally similar to the respective temperatures reported by Atkinson et al. (1979).

Salinities in July were uniform over the survey area, ranging from 34.2 to 34.7°/oo, with little or no variation with depth. Nearshore (e.g., Stations 5, 6, and 7) salinities were 0.1 to 0.5°/oo less than offshore (e.g., Stations 8, 9, and 10), possibly as a result of land runoff. Salinities exhibited greater variability in November, with a minimum of 32.5°/oo at the surface at Station 4, and a maximum of 36.0°/oo to 36.2°/oo near the bottom at offshore Stations 3, 9, and 10. Surface salinities were 0.1 to 3.3°/oo less than bottom salinities with the greatest vertical differences occurring in deeper waters. Surface and bottom salinities were similar to values reported for

TABLE A-23
TOTAL AND FECAL COLIFORM COUNTS IN CHARLESTON ODMDS SEDIMENTS DURING DECEMBER 1979

Station	Total Coliforms (MPN/100g)	Fecal Coliforms (MPN/100g)
1	3833	3333
6	<154	<154

Note: Shellfish were not collected for coliform analyses

TABLE A-24
WATER COLUMN CHARACTERISTICS AT WILMINGTON ODMDS AND CONTROL STATIONS DURING NOVEMBER 1979 AND JULY 1980

Station	Depth (m)	Temperature (°C)		Salinity (°/oo)		Total Suspended Solids (mg/liter)		pH		Turbidity (NTU)	
		Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul
1	2	18.5	27.2	34.847	36.690	0.39	1.33	8.25	8.58	0.48	0.90
	5	—	—	35.652	34.684	2.53	2.49	8.23	8.57	2.50	1.00
	9	19.0	27.0	35.701	34.684	5.22	1.63	8.24	8.57	4.00	1.00
2	2	20.5	27.4	34.742	35.791	0.62	0.79	8.25	8.57	0.40	0.04
	11	19.5	28.3	35.711	36.987	7.66	3.64	8.24	8.56	4.70	0.13
3	2	17.5	26.9	32.990	34.665	1.77	0.81	8.23	8.42	1.80	0.55
	10	19.0	26.8	36.192	34.629	6.06	1.53	8.26	8.42	5.80	0.65
4	2	17.1	27.4	32.468	34.741	1.85	2.39	8.20	8.54	1.30	1.13
	9	18.1	28.2	35.816	34.638	16.90	0.99	8.24	8.55	9.10	0.59
5	2	18.4	28.0	34.252	—	2.90	5.17	8.22	8.53	2.20	0.32
	6	18.4	27.4	35.551	—	11.52	11.76	8.20	8.45	9.70	0.54
6	2	18.0	28.1	33.066	34.491	1.50	1.88	8.25	8.51	1.20	0.11
	5	—	—	35.727	34.480	3.41	3.51	8.24	8.50	3.30	0.15
	10	19.0	27.6	35.876	34.472	6.41	0.94	8.24	8.51	5.40	0.11
7	2	18.0	27.9	32.942	34.554	1.89	2.11	8.26	8.50	1.30	0.10
	10	19.7	27.3	35.890	34.565	5.94	9.78	8.26	8.49	4.30	0.35
8	2	19.6	27.7	35.706	—	3.70	0.76	8.27	8.57	2.30	0.54
	10	19.1	27.2	35.732	—	14.80	2.09	8.25	8.56	7.50	1.13
9	2	18.0	26.7	32.830	34.734	1.19	0.77	8.27	8.42	1.20	0.45
	12	19.2	26.6	36.260	34.733	6.96	0.43	8.28	8.42	5.20	0.45
10	2	18.2	27.2	34.633	34.167	0.38	0.70	8.24	8.56	0.37	0.50
	5	—	—	35.747	34.355	1.84	2.23	8.24	8.57	1.80	1.00
	9	18.6	26.7	35.963	—	7.89	1.59	8.25	8.57	5.40	1.50

Dashes (—) indicate measurement was not taken

TABLE A-25
WATER COLUMN TRACE METALS AND CHLORINATED
HYDROCARBONS AT WILMINGTON ODMDS DURING NOVEMBER 1979 AND JULY 1980

Parameter	Station 1		Station 6		Station 10	
	Nov	Jul	Nov	July	Nov	Jul
Particulate Trace Metals (μg/liter)						
Hg	.003	< .0007	.002	<.0007	.003	<.0007
Cd	.003	.020	.006	.042	.008	.012
Pb	.089	.046	.124	.071	.069	.037
Dissolved Trace Metals (μg/liter)						
Hg	<.03	.015	<.03	.020	<.03	.020
Cd	.062	.012	.072	.012	.069	.015
Pb	.060	<.12	.062	<.12	.125	<.12
Chlorinated Hydrocarbons (ng/liter)						
PCB's:						
Aroclor 1016	1.04	ND	.631	ND	.939	ND
Aroclor 1254	ND	ND	ND	ND	1.32	ND
Pesticide:						
pp'DDE	0.042	ND	ND	ND	ND	ND

ND = Not detected

nearshore SAB waters by Atkinson et al. (1979). The pH of the water within and near the Wilmington ODMDS was uniform spatially and with depth, but slightly higher in July (8.42 to 8.58) than November (8.20 to 8.27).

Turbidity and TSS concentrations for waters within and near the site varied widely between surveys, stations, and sample depth. In general, turbidity and TSS concentrations were higher in November than July, particularly near the bottom. Higher near-bottom concentrations in November are probably the result of greater storm and wave energy relative to July. Surface TSS concentrations were usually slightly higher in July, possibly due to greater plankton productivity. Maximum surface and bottom turbidity and TSS concentrations were found at nearshore stations, and may have resulted from runoff from the Cape Fear estuary and/or sediment resuspension in these relatively shallow areas. Minimum surface and bottom values in November were observed at the deeper offshore stations in the southwest corner of the ODMDS. Turbidity ranged from 0.4 to 0.7 NTU in November and from 0.04 to 1.12 NTU in July. TSS concentrations ranged from about 0.4 to 16.9 mg/liter in November and from 0.8 to 11.8 mg/liter in July. Rohl (1980) measured middepth TSS concentrations of 2.1 to 2.6 mg/liter and near-bottom concentrations of 4.6 to 8.3 mg/liter in waters immediately to the west of the ODMDS in August.

Chemical - Concentrations of dissolved and particulate trace metals (mercury, cadmium, and lead) were generally similar between stations and showed no consistent seasonal trends. Dissolved mercury concentrations were consistently below 0.03 μg/liter. Dissolved cadmium ranged from 0.012 to 0.072 μg/liter. The concentrations for mercury and cadmium were below EPA marine water quality criteria (EPA, 1976). Dissolved lead concentrations ranged from 0.060 to 0.125 μg/liter. EPA water quality criteria for lead (0.01 times the 96-hr LC_{50}) are not comparable to values reported here. Particulate metal concentrations were all below 0.2 μg/liter with little variation. Ranges for mercury, cadmium, and lead were 0.0007 to 0.003 μg/liter, 0.003 to 0.042 μg/liter, and 0.037 to 0.124 μg/liter, respectively. Rohl (1980) reported concentrations of dissolved and particulate cadmium ranging from 0.04 to 0.10 μg/liter and 0.015 to 0.033 respectively; dissolved and particulate lead ranged from 0.27 to 0.35 μg/liter and 0.02/liter respectively, in middepth waters west of the ODMDS. No historical dissolved or particulate mercury data are available for comparisons. All trace metal concentrations were within or below the normal range for uncontaminated coastal and offshore waters (Segar and Cantillo, 1976; Abdullah et al., 1972; Brewer, 1975).

Dissolved pesticides, pesticide breakdown products, and PCB's in three water samples for each survey were either undetectable or present in trace amounts. Concentrations of PCB's (Aroclor 1016 and 1254) were less than 1.5 ng/liter during the November survey; no PCB's were found in July. Trace amounts (0.04 ng/liter) of the pesticide derivative, pp'DDE, were found in waters overlying the ODMDS (Station 1) during November. No other pesticides or products were found in the survey area, indicating that these waters were relatively free of chlorinated hydrocarbon contaminants. No historical dissolved chlorinated hydrocarbon data are available for comparison.

A.2.3.2 Sediment Characteristics

Physical - Sediment characteristics at the Wilmington ODMDS are summarized in Table A-26. Sediments in the survey area are predominantly sand (71 to 99%), with small amounts of gravel (0.1 to 27%) and silt and clay (0.3 to 10%). Variation in the sediment texture between surveys consisted of a decrease in percent silt and clay, with a corresponding increase in percent sand between the November and July surveys. This variability may be due to natural sediment transport processes or an artifact of analysis (different laboratories analyzed the grain size samples for the two surveys).

Considerable spatial variability in the composition of bottom sediments was evident. For example, during November bottom sediments at Station 7, outside the site, contained substantial amounts (27%) of gravel. Appreciable quantities of silt and clay (10%) occurred at Station 5 within the site; however, similar proportions of fines were also found outside the site at Stations 9 and 10. Further, the minimum value of percent fines (0.3% in July) was also found at Station 5. Rohl (1980) reported silt contents of 0.1% to 8.8%, and gravel contents from 2.5% to 16%, in sediments within the Wilmington ODMDS during August. Overall, no evidence was found to indicate differences between sediment texture inside versus outside the site, which might be attributed to dredged material disposal.

Chemical - Concentrations of trace metals, TOC, and oil and grease in the sediments of the Wilmington ODMDS are listed in Table A-27. Metal concentrations were similar and uniformly low for both surveys. Sediment mercury concentrations ranged from 0.001 to 0.006 μg/g. Sediment cadmium concentrations ranged from 0.002 to 0.063 μg/g, and lead concentrations ranged from 0.64 to 4.4 μg/g. Analyses of variance showed no differences in sediment trace metal concentrations between stations. Rohl (1980) reported concentrations of 0.013 to 0.076 μg/g cadmium and 2.88 to 4.08 μg/g lead in sediments from the ODMDS in August. The concentrations were within the range reported by Windom and Betzer (1979) for SAB bottom sediments.

TABLE A-26
SEDIMENT CHARACTERISTICS OF
WILMINGTON ODMDS DURING NOVEMBER 1979 AND JULY 1980

Station	% Gravel		% Sand		% Fines	
	Nov	Jul	Nov	Jul	Nov	Jul
1	1.6 ± 2.7	1.2	93.8 ± 3.0	98.5	4.5 ± 2.2	0.3
2	0.8 ± 0.6	2.7	94.6 ± 3.8	89.4	4.2 ± 2.7	7.8
3	1.0 ± 1.5	0.4	89.0 ± 9.6	95.9	8.6 ± 4.7	3.6
4	2.6 ± 2.4	4.9	92.3 ± 3.8	94.7	5.2 ± 2.2	0.4
5	0.4 ± 0.6	1.2	89.7 ± 6.7	95.0	10.0 ± 4.5	3.8
6	3.2 ± 5.8	3.8	89.5 ± 6.6	91.6	5.7 ± 3.1	4.6
7*	27.1	-	71.2	-	1.6	-
8	0.2 ± 0.2	1.7	95.6 ± 2.6	97.8	4.2 ± 2.4	0.5
9	0.4 ± 0.4	0.1	90.2 ± 2.0	94.7	9.4 ± 1.9	5.1
10	0.4 ± 0.5	0.3	91.2 ± 6.7	99.3	8.1 ± 5.5	0.4

* n = 2 in November; no samples were collected at Station 7 in July

Note: Values for percentages in November are mean ± one standard deviation, n = 7; values for July are mean, n = 2

Analyses of variance detected no significant differences in the concentrations of TOC and oil and grease between stations. TOC concentrations ranged from 2.47 to 12.2 mg/g in November and from 0.9 to 17.0 mg/g in July. The minimum TOC concentration was found at Station 1 in July, while the maximum TOC level occurred at Station 7 in November. Rohl (1980) reported TOC levels in ODMDS sediments ranging from 0.9 to 1.9 mg/g during August. Oil and grease concentrations ranged from 0.012 to 0.318 mg/g in November and from 0.012 to 0.279 mg/g in July. The minimum mean concentration (0.013 mg/g) was found at Station 1 in July, and the maximum (0.287 mg/g) at Station 9 in November. Station 9 also had relatively higher proportions of fine-grained sediments; however, other stations with similar fine-grained percentages had low levels of oil and grease. Absence of the expected relationship between percent fines and oil and grease may be due to the possible discrepancy in grain size determinations mentioned previously. No historical oil and grease data are available for comparisons.

TABLE A-27
CONCENTRATIONS OF TRACE METALS, OIL AND GREASE, TOC, AND CHC's IN WILMINGTON ODMDS SEDIMENTS DURING NOVEMBER 1979 AND JULY

Station	Trace Metals (µg/g) Hg		Cd		Pb		Oil and Grease (mg/g)		TOC (mg/g)		Chlorinated Hydrocarbons (ng/g)									
	Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov	Jul	Nov					Jul				
											(a)	(b)	(c)	(d)	(e)	(a)	(b)	(c)	(d)	(e)
1	.001	.002	.006	.003	2.18	1.30	.044	.012	6.69	0.90	0.01	0.01	.26	.03	ND	ND	.05	ND	ND	1.4
	.001	.001	.003	.002	1.30	1.10	.012	.014	3.49	0.90	ND	ND	.08	.01	ND	-	-	-	-	ND
2	.003	.012	.004	.032	2.28	7.20	.029	.279	3.55	17.0		NA					NA			
	.001	.001	.006	.002	1.69	0.98	.020	.009	2.47	3.40										
3	.004	.005	.024	.047	3.36	3.70	.115	.189	6.72	6.00							NA			
	.001	.002	.044	.037	2.78	2.00	.027	.042	4.23	3.70										
4	.002	.002	.017	.002	2.30	1.50	.028	.014	5.30	7.90		NA					NA			
	.002	.002	.026	.004	2.98	1.20	.037	.024	8.53	6.10										
5	.002	.003	.014	.019	2.69	2.30	.100	.116	3.19	2.40		NA					NA			
	.003	.003	.015	.017	3.49	2.20	.105	.037	4.73	3.20										
6	.004	.005	.024	.018	3.16	3.00	.108	.151	4.40	3.50	ND	.02	.10	.05	ND	ND	ND	ND	ND	ND
	.0003	.006	.006	.021	1.49	3.00	.115	.136	10.7	7.60	ND	.01	.24	ND	ND	-	-	-	-	-
7	.003	NA	.002	NA	1.49	NA	.025	NA	12.2	NA		NA					NA			
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA										
8	.001	.001	.046	.004	2.30	0.97	.034	.027	5.47	2.60		NA					NA			
	.001	.001	.047	.003	2.07	0.88	.040	.019	5.09	5.30										
9	.005	.006	.034	.063	2.67	4.40	.318	.195	6.39	5.70		NA					NA			
	.002	.005	.047	.051	2.66	4.10	.156	.157	5.28	5.90										
10	.001	.002	.024	.004	1.48	.85	.063	.019	4.42	2.60	ND	ND	.13	.41	ND	ND	ND	ND	ND	3.3
	.0003	.002	.011	.003	1.19	.64	.014	.017	2.48	1.60	ND	ND	.35	ND	ND	-	-	-	-	-

Note: All replicate values are shown

(a) = op'DDE
(b) = pp'DDE
(c) = Arclor 1016
(d) = Arclor 1254
(e) = Chlordane

ND = Not detected
NA = Not analyzed

Chlorinated hydrocarbons were generally undetectable in sediments both within (Stations 1 and 2) and outside (Stations 6 and 10) the disposal area. With the exception of chlordane, concentrations of pesticides and PCB's in sediments were all less than 0.5 ng/g. Chlordane was detected during July in sediment at Station 1, inside the ODMDS (1.4 ng/g), and at control Station 10 (<3.3 ng/g). No chlordane was found in sediments during November. Relationships between sediment chlorinated hydrocarbon concentrations and other sediment parameters (i.e., grain size, TOC trace metals) were not evident. Historical data for CHC concentrations in ODMDS sediments are unavailable. Overall, sediment physical and chemical data did not indicate any trends attributable to dredged material disposal.

Elutriate Tests - Elutriate tests indicated that mercury, cadmium, and lead were not released to site water to any substantial degree (Table A-28). Mercury levels in test water were <0.05 µg/liter; lead values ranged from 0.04 to 0.08 µg/liter, and cadmium from 0.05 to 0.09 µg/liter. Concentrations of dissolved lead and mercury in ODMDS waters during November and July were similar to concentrations observed in elutriate test water; cadmium concentrations were slightly higher in elutriate test waters than ODMDS waters. However, this difference could easily be due to analytical variability. No previous elutriate tests of ODMDS sediments have been conducted.

Tissues - Concentrations of trace metals, PCB's, and pesticides in tissue from organisms collected at Wilmington ODMDS are presented in Table A-29. Mercury concentrations ranged from 0.05 to 0.84 µg/g in shrimp (*Sicyonia brevirostris*), and were below the 1.0 µg/g FDA action level. Cadmium and lead ranged from 0.04 to 0.40 µg/g and 0.14 to 0.52 µg/g, respectively. Cadmium concentrations in *S. brevirostris* were lower than those presented by Windom and Betzer (1979); comparable numbers for lead are not available.

Concentrations of pesticides (0.349 and 0.917 ng/g for pp'DDE and 0.563 ng/g for op'DDE) detected in crabs (*Portunus spinimanus*) and shrimp (*S. brevirostris*) were well below the 5 ng/g FDA action levels. Trace concentrations of PCB's (Aroclor 1016 and 1254) ranged from 3.46 to 4.56 ng/g and

TABLE A-28
RESULTS OF ELUTRIATE TESTS OF WILMINGTON ODMDS SEDIMENTS IN NOVEMBER 1979

	Station 1	Station 6	Station 10	ODMDS Water (Range)
Mercury	<0.05	<0.05	<0.05	<0.03
	0.05	0.05	0.05	
	0.05	0.05	0.05	
Cadmium	0.06	0.02	0.28	0.01 to 0.06
	0.05	0.03	0.33	
	0.09	0.05	0.25	
Lead	<0.04	<0.04	<0.04	<0.12
	0.05	<0.04	<0.04	
	0.08	0.23	0.13	

Notes: All replicate values are shown. Units = µg/liter.

0.272 to 0.50 ng/g, respectively, in crab and shrimp tissues. No historical values for chlorinated hydrocarbons in crab and shrimp tissues from Wilmington ODMDS are available for comparison.

A.2.3.3 Biological Characteristics

Macrofauna - Macrofauna collected during the July survey are listed in Table A-30; samples were not collected from Stations 6 and 7 because the hard substrate prevented box coring. Infaunal samples from the November survey were collected but not analyzed due to laboratory error that resulted in the loss of the "floated" organisms for many samples. Thirty macrofauna species were identified from the July survey, including 17 polychaete species and 6 crustacean species. Polychaetes were numerically dominant, and comprised from 44% to 93% of the total number of organisms at all stations. Representative

TABLE A-29
CONCENTRATIONS OF TRACE METALS AND CHC's
IN TISSUE FROM WILMINGTON ODMDS DURING NOVEMBER 1979

Species	Station	Metals (µg/g dry wt)			PCB's (ng/g) Aroclor		Pesticides (ng/g dry wt)	
		Hg	Cd	Pb	1016	1254	op'DDE	pp'DDE
Sicyonia brevirostris (Rock shrimp)	1	0.05	0.18	0.29	4.56	0.500	0.563	0.349
Sicyonia brevirostris	6	0.84	0.04	0.14	3.46	ND	ND	ND
Portunus spinimanus (Swimming crab)	10	0.10	0.40	0.52	ND	0.272	ND	0.917

ND = Not detected

polychaete species included Amastigos caperatus, Nephtys picta, and Magelona longicornis. Each of the crustacean species occurred sporadically throughout the study area, and were present at only one or two stations. With the exception of the common polychaete species, only the mollusc Tellina alternata and cephalochordate Branchiostoma caribaeum occurred at more than two stations during July. The absence of uniformity in species distribution, and high standard deviations relative to the mean abundance, suggests a variable spatial distribution of macrofauna similar to the Savannah and Charleston ODMDS.

Macrofaunal species listed in Table A-30 were assigned to one of four feeding categories as described in Section A.2.1.4. Mean abundances were summed for each category at each station, and the percent trophic composition was calculated; results are presented in Figure A-6. Except for the absence of omnivores from Stations 3 and 9, all trophic levels were represented at each station. Deposit feeders generally contributed the largest numbers of individuals (356% to 89%) and species. Deposit feeding polychaetes (A. caperatus and P. cristata) characteristically contributed the largest numbers

TABLE A-30
MACROFAUNA ABUNDANCES AT WILMINGTON ODMDS DURING JULY 1980

Species	Feeding Type	Station 1	2	3	4	5	8	9	10
NEMERTINA									
Nemertean sp. K	C	9 ± 14	-	3 ± 1	-	-	-	-	-
ANNELIDA									
Ancistrosyllis hartmanae	O	4 ± 2	15 ± 17	-	4 ± 5	-	5 ± 7	-	-
Brania wellfleetensis	C	5 ± 6	15 ± 17	-	-	-	-	-	3 ± 3
Aglaophamus verrilli	C	-	-	-	-	4 ± 2	-	7 ± 2	-
Nephtys picta	C	28 ± 33	20 ± 33	2 ± 3	3 ± 2	3 ± 3	7 ± 2	3 ± 4	4 ± 2
Goniadides carolinae	C	-	18 ± 18	2 ± 1	8 ± 7	-	-	-	9 ± 14
Onuphis eremita	O	-	-	-	-	-	-	-	4 ± 3
Apoprionospio dayi	D	-	-	-	-	-	-	5 ± 1	-
Paraprionospio pinnata	D	-	-	-	-	-	-	7 ± 8	-
Prionospio cirrifera	D	-	7 ± 7	-	-	-	-	-	-
Prionospio cristata	D	13 ± 9	39 ± 51	0 ± 0	3 ± 2	0.2 ± 0.4	13 ± 5	0.6 ± 1	11 ± 6
Spiophanes bombyx	D	-	-	-	-	13 ± 15	-	-	-
Magelona longicornis	D	-	-	8 ± 6	-	29 ± 19	-	28 ± 8	-
Armandia maculata	D	3 ± 2	11 ± 14	-	-	-	5 ± 3	-	4 ± 4
Cirrophorus lyra	D	3 ± 2	5 ± 6	-	2 ± 3	-	-	-	-
Amastigos caperatus	D	27 ± 34	25 ± 28	2 ± 3	10 ± 17	6 ± 7	154 ± 69	2 ± 4	5 ± 5
Owenia fusiformis	S	-	-	-	-	-	-	7 ± 3	-
Pista cristata	D	-	-	-	-	-	-	-	6 ± 2
Polygordius sp. A	D	10 ± 12	15 ± 17	-	4 ± 3	-	15 ± 18	-	7 ± 5
MOLLUSCA									
Tellina alternata	D	2 ± 4	2 ± 3	1 ± 2	0.3 ± 0.5	0.8 ± 0.8	2 ± 0.7	2 ± 2	0.6 ± 1
ARTHROPODA									
Cyclaspis sp. A	D	-	-	-	-	-	-	6 ± 3	9 ± 6
Oxyurostylis smithi	S	-	-	-	-	-	7 ± 4	-	-
Batea catharinensis	D	-	-	-	-	22 ± 42	-	-	-
Tittakurama sp. A	D	-	-	-	-	-	4 ± 3	-	-
Callianassa biformis	S	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.5	8 ± 6	0 ± 0	0 ± 0	0 ± 0
Pinnixa chaetopterana	O	-	-	-	-	15 ± 12	-	-	-
SIPUNCULA									
Golfingia murinae bilobatae	D	-	-	-	-	-	-	6 ± 6	-
PHORONIDA									
Phoronis architecta	S	-	-	3 ± 2	-	-	-	9 ± 10	-
BRANCHIOPODA									
Glottidia pyramidata	S	-	-	-	-	-	-	-	8 ± 4
CEPHALOCHORDATA									
Branchiostoma caribaeum	S	2 ± 2	2 ± 3	0 ± 0	0.5 ± 0.6	0 ± 0	4 ± 5	0 ± 0	50 ± 18

Note: Values are mean number/0.06 m^2 ± one standard deviation; n = 5 at all stations, except Station 4 where n = 4. Stations 6 and 7 not sampled.

Dash (-) indicates the species was either absent or not numerically abundant

D = Deposit feeder
S = Suspension feeder
C = Carnivore
O = Omnivore

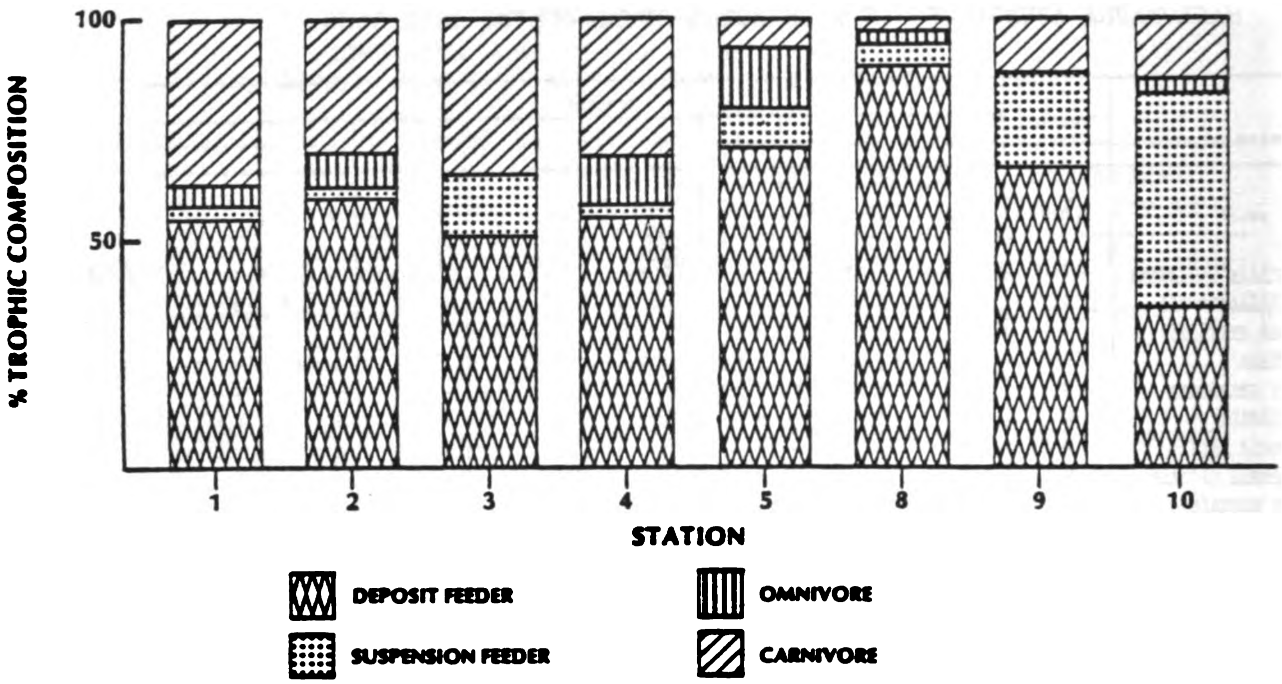

Figure A-6. Percent Composition of Feeding Types at Wilmington ODMDS During July 1980 (Stations 6 and 7 were not sampled)

of macrofaunal individuals. Carnivores and suspension feeders comprised varying percentages (3.2 to 40% and 0.9 to 48%, respectively) of the macrofauna. Carnivores were represented by polychaetes Nephtys picta and Goniadides carolinae, while suspension feeders included the crustacean Callianassa biformis and cephalochordate Branchiostoma caribaeum. Omnivores represented a small but variable percentage (0 to 14%) of the Wilmington ODMDS macrofauna. This trophic group consisted of three species (Ancistrosyllis hartmanae, Onuphus eremita, and Pinnixa chaetopterana), which occurred sporadically throughout the area.

Six macrofaunal species were selected for further analysis, based on their abundance and association with known environmental conditions. Dominant species include the polychaetes Nephtys picta, Prionospio cristata, and Amastigos caperatus; the mollusc Tellina alternata; the crustacean Callianassa biformis; and the cephalochordate Branchiostoma caribaeum. Species abundances during July are presented in Table A-30. The dominant macrofaunal species are small-bodied and common in nearshore sandy environments of the SAB (Boesch, 1977). Callianassa biformis and B. caribaeum are suspension feeders; P. cristata, A. caperatus, and T. alternata are deposit feeders, while N. picta is a carnivore.

With the exception of N. picta and T. alternata, the mean abundances of most of the dominant species were spatially variable. For example, Branchiostoma caribaeum occurred in large numbers only at Station 10. Callianassa biformis occurred at only two stations; abundances were highest at Station 5, adjacent to Frying Pan Shoal. Mean abundances of A. caperatus varied from 2 individals per 0.06 m^2 at Station 3 to 154 individuals per 0.06m^2 at Station 8. Abundances of P. cristata ranged from zero individuals at Station 3 to 39 individuals per 0.06 m^2 at Station 2. Mean densities of N. picta and T. alternata were relatively uniform throughout the eight stations.

Differences in species abundances at ODMDS Stations 3 and 4 and control Station 10 were examined with a nonparametric Mann-Whitney U-Test, as discussed previously. Significant differences ($p < 0.05$) in densities were detected for only one species, B. caribaeum, which was more abundant outside the ODMDS (Station 10). As mentioned previously, C. biformis occurred only at Stations 4 and 5 within the ODMDS; however, the differences in abundances between station groups were not statistically significant. Analyses of variance in species abundances between surveys were not tested because macrofaunal data were available for one survey only.

Relationships between species abundances and abiotic factors (physical and chemical composition of sediments) were investigated with Pearson product-moment correlations, discussed previously. No significant relationships were detected; therefore, the sources of variability in species densities at Wilmington ODMDS cannot presently be identified. Results from the surveys of the Charleston and Savannah ODMDS suggest that abundances of the dominant infaunal species may be related to substrate preferences. Spatial variability in the composition of the Wilmington ODMDS sediments will probably influence the densities of macrofaunal species; however, the small sample size and large natural heterogeneity may have obscured these relationships during the July survey. The effects of dredged material disposal on the abundances of benthic organisms are difficult to quantify because of the large area of the Existing Wilmington ODMDS (29 nmi^2) and the spatial variability in macrofaunal densities.

Epifauna - Epifauna and nekton collected during November and July Wilmington surveys are listed by station in Table A-31. During the November survey 17 species and 42 individuals were collected. The most abundant epifaunal species included the rock shrimp (Sicyonia brevirostris) the purple sea urchin (Arbacia punctulata), and the slender sea star (Luidia alternata). During the July survey a total of 24 species and 222 individuals were present. Several Atlantic bumper (Chloroscombrus chrysurus), longspine porgy (Stenotomus caprinus), and spot (Leiostomus xanthurus), were collected. Several midwater species such as ctenophores and the anchovy (Anchoa hepsetus) were probably taken while the trawl net was being raised and lowered through the water.

With the exception of the rock shrimp, commercial fisheries species were not present in large numbers at the Wilmington ODMDS during either the November or July surveys. Previous studies of nearshore nekton populations have demonstrated a large seasonal variability in the abundances of commercially important nekton species, especially during spring and summer migrations to and from the adjacent Cape Fear Estuary (Anonymous, 1980).

Microbiology - The results of total and fecal coliform counts from sediments and tissue collected at the Wilmington ODMDS in November and July are presented in Table A-32. Coliforms were not detected in shrimp (Sicyonia brevirostris) or crab (Portunus spinimanus) tissue in November or sediments in July. Sediments were not collected in November and tissue samples were not collected in July for coliform analyses.

A.3 SUMMARY

In general, the water column and sediment characteristics of the Existing Savannah, Charleston, and Wilmington ODMDS are similar. Temperature, salinity, turbidity, and total suspended solids at each of the sites were seasonally and spatially variable, but similar to conditions reported for

TABLE A-31
EPIFAUNA AND NEKTON SPECIES COLLECTED AT WILMINGTON ODMDS IN NOVEMBER 1979 AND JULY 1980

Species	Common Name	November 1979 Station 6 Tow 1	November 1979 Station 6 Tow 2	July 1980 Station 1 Tow 1	July 1980 Station 1 Tow 2	July 1980 Station 10 Tow 1	July 1980 Station 10 Tow 2
CTENOPHORA	Comb jelly	-	-	20	15	3	6
MOLLUSCA							
Loligo cf. *pealei*	Long-finned squid			2	-	-	-
Lolliguncula brevis	Brief squid			-	3	-	-
ARTHROPODA							
Libinia emarginata	Common spider crab			-	1	-	-
Ovalipes stephensoni	Lady crab			-	2	-	1
Portunus sp.	Juvenile swim crab			2	1	-	-
Portunus spinimanus	Swim crab	-	1				
Sicyonia brevirostis	Rock shrimp	-	22				
Squilla empusa	Mantis shrimp			1	1	1	-
ECHINODERMATA							
Arbacia punctulata	Purple sea urchin	-	3				
Asterias forbesii	Asterid sea star			-	2	-	-
Astropecten articulatus	Margined sea star			-	-	2	1
Luidia alternata	Slender sea star	-	2				
TUNICATA							
Tunicate	Sea squirt	-	1				
CHORDATA							
Carcharinidae							
Rhizoprionodon terraenovae	Atlantic sharp nose shark			2	-	-	-
Rajidae							
Raja eglanteria	Clearnose skate	-	1				
Dasyatidae							
Dasyatis centroura	Roughtail stingray	1	-				
Clupeidae							
Opisthonema oglinum	Atlantic thread herring			1	1	-	-
Engraulidae							
Anchoa hepsetus	Striped anchovy			50	30	-	-
Synodontidae							
Synodus foetens	Inshore lizard fish			-	1	-	1
Ophidiidae							
Lepophidium cervinum	Fawn cusk-eel	-	2				
Serranidae							
Centropristis striata	Black seabass	-	1				
Pomatomidae							
Pomatomus saltatrix	Bluefish			1	-	-	-
Carangidae							
Chloroscombrus chrysurus	Atlantic bumper			15	10	-	-
Decapterus punctatus	Round scad			-	-	3	-
Sparidae							
Lagodon rhomboides	Pinfish			-	-	-	5
Stenotomus caprinus	Longspine porgy			5	10	-	-
Stenotomus chrysops	Scup	-	1				
Sciaenidae							
Leiostomus xanthurus	Spot	-	1	10	-	-	-
Pogonias cromis	Black drum	-	1				
Scombridae							
Scomberomorus maculatus	Spanish mackerel			1	-	-	-
Stromateidae							
Peprilus triacanthus	Butterfish	-	1				
Triglidae							
Prionotus tribulus	Bighead searobin	-	1	3	-	-	2
Bothidae							
Ancylopsetta quadrocellata	Ocellated flounder			-	1	-	-
Paralichthys dentatus	Summer flounder	-	1				
Cynoglossidae							
Symphurus nebulosus	Tonguefish	-	1				
Symphurus plagiusa	Tonguefish	-	1	3	2	-	-

TABLE A-32
TOTAL AND FECAL COLIFORM COUNTS FROM WILMINGTON
ODMDS SEDIMENTS AND SHELLFISH DURING NOVEMBER 1979 AND JULY 1980

Station	Sediments		Species	Shellfish	
	Total Coliforms (MNP/100g)	Fecal Coliforms (MNP/100g)		Total Coliforms (MNP/100g)	Fecal Coliforms (MNP/100g)
November 1979					
1	NC	NC	*Sicyonia brevirostris*	<250	<250
6	NC	NC	*S. brevirostris*	<200	<200
10	NC	NC	*Portunus spinimanus*	<333	<333
July 1980					
1	<11	<11	NC		
2	<11	<11			
3	<12	<12			
4	<18	<18			
5	<12	<12			
6	<11	<11	NC		
8	<12	<12			
9	<12	<12			
10	<11	<11			

NC = Not collected

other nearshore areas of the SAB influenced by river discharge and seasonal weather patterns. Dissolved and particulate trace metal concentrations were within the expected ranges for uncontaminated coastal waters. Trace quantities of chlorinated hydrocarbons were detected in waters overlying each of the disposal sites; however, concentrations were comparable to previously reported values. No substantial differences in concentrations of trace metals or CHC's in waters overlying the ODMDS and respective control stations were detected during the IEC surveys.

Sediments within each of the ODMDS consisted primarily of medium to fine sands. No differences in sediment composition between ODMDS and control stations were detected at Charleston or Wilmington. Slight differences in the percentages of fines were observed at Savannah, where higher proportions of finer sediments occurred in the ODMDS. Concentrations of contaminant trace metals, organics, and chlorinated hydrocarbons in disposal site waters and sediments at Savannah, Charleston, and Wilmington were typically within or below the respective ranges for other noncontaminated regions of the SAB. Detectable changes in water chemistry, or sediment chemistry and texture due to previous dredged material disposal, were not observed during IEC surveys.

Macrofaunal assemblages at Savannah, Charleston, and Wilmington ODMDS are characterized by small-bodied deposit feeders, comprising several polychaete, crustacean, and mollusc species. Dominant infaunal species were characteristic of nearshore sandy substrate areas of the SAB. Common or abundant species collected during IEC surveys displayed large spatial and/or seasonal variability. Frequent substrate agitation and uneven larval settling patterns may explain the observed patchy environment and spatial variability of macrofaunal densities. No detectable differences in the trophic compositions at stations within and outside the ODMDS were observed during IEC surveys. Spatial variability in species abundances could not be explained by the distributions of abiotic factors alone.

The abundances and diversity of epifauna at each of the ODMDS and adjacent areas varied considerably between surveys. Commercially important shellfish or finfish species were typically absent from Savannah, Charleston, and Wilmington ODMDS during IEC surveys. Large seasonal and spatial variability in the composition and abundances of epifaunal and infaunal organisms obscured any impacts of dredged material dispoal on the biota.

REFERENCES

Abdullah, M.L., L.G. Royle and A.W. Morris. 1972. Heavy metal concentrations in coastal waters. Nature 235:158-160.

Atkinson, L.P., R.T. Barber, and M.J. Wade. 1979. Hydrography, nutrients, chlorophyll and organic carbon of South Atlantic/Georgia Bight. Pg 15-82 In: South Atlantic OCS Benchmark Program 1977 Report, Volume 3. Prepared by Texas Instruments, Inc. for the Bureau of Land Management.

American Public Health Association. 1975. Standard methods for the examination of water and wastewater. 14th edition.

Anonymous. 1980. Brunswick Steam Electric Plant, Cape Fear studies interpretive report. Prepared for Carolina Power and Light Company.

APHA. See American Public Health Association.

Barnes, R.D. 1974. Invertebrate Zoology. Third edition. Saunders Company. 870 pp.

Bidleman, T.F. and C.E. Olney. 1974. Chlorinated hydrocarbons in the Sargasso Sea atmosphere and surface water. Science (183):516-518.

Blanton, J.O. and L.P. Atkinson. 1978. Physical transfer processes between Georgia tidal inlets and nearshore waters. pp 515 - 532. In: M.L. Wiley [ed.] Estuarine Interactions. Academic Press, Inc.

Boesch, D.F. 1977. Benthos. Chapter VIII In: A summary and anaylsis of environmental information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. Prepared for the Bureau of Land Management by the Center for Natural Areas.

Bothner, M., P. Aruscavage, W. Ferrebee, and J. Lathrop. 1979. Trace metal concentrations in sediment cores from the Continental Shelf off the southeastern United States. pp 292 - 322. In: South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976; Geology. U.S. Geological Survey Final Report prepared for Bureau of land Management.

Brewer, P.G. 1975. Minor elements in seawater. pp. 415 - 496. In: J.P. Riley and G. Skirrow [eds.] Chemical Oceanography, Volume 1, 2nd Edition. Academic Press, N.Y.

Brown, D.W., S. Ramos, M.Y. Uyeda, A.J. Freidman, and W.D. MacLeod, Jr. 1979. Ambient-temperature extraction of hydorcarbons from marine sediment - comparison with boiling-solvent extraction. In: L. Petrakis and F.T. Weiss [eds.] Petroleum in the Marine Environment. Advances in Chemistry Series No. 185.

Diaz, R.J. and D.F. Boesch. 1977. Impact of fluid mud dredged material on benthic communities of the tidal James River, Virginia. U.S. Army Engineers Waterways Experiment Station, Tech. Rept. D-77-45, 1-38.

Dorsey, J.H. 1981. The intertidal community offshore from the Werribee sewage-treatment farm: An opportunistic infaunal assemblage. Aust. J. Mar. Freshwater Res. 34: (in press).

Doyle, L.J., P.R. Betzer, M. Peacock, and F. Wall. 1979. Seston of the Southeast Georgia Embayment. pp 3 - 40. In: South Atlantic Outer Continental Shelf Geological Studies, Fiscal Year 1976: Geology. U.S. Geological Survey Final Report prepared for the Bureau of Land Management.

EPA. See U.S. Environmental Protection Agency.

Fauchald, K. and P.A. Jumars. 1979. The diet of worms: a study of polychaete feeding guilds. Oceanogr. Mar. Biol. Ann. Rev. 17:193-284

FDA. See U.S. Department of Health, Education and Welfare.

Folk, R.L. 1978. Petrology of Sedimentary Rocks. Hemphill Publ. Co., Texas, 192 p.

Frankenberg, D. 1971. The dynamics of benthic communities off Georgia, USA. Thalassia Jugoslavica 7:49-55.

Frankenberg, D. and A.S. Leiper. 1977. Seasonal cycles in benthic communities of the Georgia Continental Shelf. pp. 383 - 398. In: B. Coull [ed.] Ecology of Marine Benthos. Univ. of S. Carolina Press, Columbia, S.C.

George, R.Y. and J.C. Staiger. 1979. Epifauna: benthic invertebrate and demersal fish populations of South Atlantic/Georgia Bight. Pg 253-280 In: South Atlantic OCS Benchmark Program 1977 Report, Volume 3. Prepared by Texas Instruments, Inc. for the Bureau of Land Management.

Gibbs, R.J. 1977. Effect of combustion temperature and time and of the oxidation agent used in organic carbon and nitrogen analysis of sediments and dissolved organic material. Jour. of Sed. Petrol. 47:547-560.

Grassle, J.F. and J.P. Grassle. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. J. Mar. Res. 32:253-294.

Gray, J.S. 1979. Pollution-induced changes in populations. Phil. Trans. R. Soc. Lond. B. 286:545-561.

Hansen, R.B., K.R. Tenore, S. Bishop, C. Chamberlain, M.M. Pamatmat, and J. Tietjen. 1981. The response of the benthic community of the South Atlantic Bight to Gulf Stream intrusions and estuarine outwelling. Jour. of Marine Research (In Press).

Harvey, G.R., W.G. Steinhauer, and H.P. Miklas. 1974. Decline of PCB concentrations in North Atlantic surface waters. Nature, 252(5482), pp. 387-388.

IEC. See Interstate Electronics Corporation.

Interstate Electronics Corporation. 1980. Oceanographic Sampling and Analytical Procedures Manual. Prepared for U.S. Environmental Protection Agency.

Manheim, F.T., R.H. Meade, and G.C. Bond. 1970. Suspended matter in surface of waters of the Atlantic Continental Margin from Cape Cod to the Florida Keys. Science 167:371-376.

Maurer, D., R.T. Keck, J.C. Tinsman, and W.A. Leathem. 1981. Vertical migration and mortality of benthos in dredged material--Part I: Mollusca. Mar. Environ. Res. 4:299-319.

Meade, R.H., P.L. Sacha, F.T. Manheim, J.C. Hathaway, and D.W. Spencer. 1975. Sources of suspended matter in waters of the Middle Atlantic Bight. Jour. of Sed. Petrol. 46:171-188.

Oertel, G.F. 1976. Characteristics of suspended sediments in estuaries and nearshore waters off Georgia. Southeastern Geology 18:107-118.

_____ 1975. Report on a biologic and sedimentologic study related to the Tybee Island Beach nourishment project and the offshore area for dredge material disposal. Final Report to the Savannah District of the Corps of Engineers. 111 pp.

_____ 1974. Report on the hydrologic and sedimentologic study of the offshore spoil disposal area, Savannah, Georgia. Final Report of the Savannah District of the Corps of Engineers. 101 pp.

Oliver, J.S. and P.N. Slattery. 1973. Dredging, dredge spoil disposal, and benthic invertebrates in Monterey Bay. Mar. Lab. Rept., Moss Landing, California, 130 p.

Oliver, J.S., P.N. Slattery, L.W. Hulberg, and J.W. Nybakken. 1977. Patterns of succession in benthic infaunal communiities following dredging and dredged material disposal in Monterey Bay. U.S. Army Waterways Experiment Station, Tech. Rept. D-77-27, 186 p.

Osterroht, C. 1977. Development of a method for the extraction and determination of non-polar, dissolved organic substances in seawater. Jour. of Chromatography 101:289.

Richardson, M.D., A.G. Carey, and W.A. Colgate. 1977. Aquatic disposal field investigations Columbia River Disposal Site, Oregon. U.S. Army Waterways Experiment Station. Tech. Rept. D-77-30, 1-411.

Rittenhouse, G. 1933. A suggested modification of the pipette method. J. Sed. Petrol. 3:44-45.

Rohl, R. 1980. Physical and chemical mechanisms of trace element transport in estuaries: a hydrogeochemical study of the Cape Fear Estuary in North Carolina. Unpublished PhD Thesis, Duke University. 271 pp.

Saucier, R.T., C.C. Calhoun, Jr., R.E. Engler, T.R. Patin, and H.K. Smith. 1978. Executive overview and detailed summary. Dredged Material Research Progam Tech. Rept. D-5-78-22. U.S. Army Corps of Engineers, Waterways Experiment Station. 189 pp.

Schubel, J.R., H.H. Carter, R.E. Wilson, W.M. Wise, M.G. Heaton, and M.G. Gross. 1978. Field investigations of the nature, degree, and extent of turbidity generated by open-water pipeline disposal operations. Dredged Material Research Program Technical Report D-78-30. 297 pp.

SCWMRD. See South Carolina Wildlife and Marine Resource Department.

Segar, D.A. and A.Y. Cantillo. 1976. Trace metals in the New York Bight. pp 171 - 198. In: M.G. Gross [ed.] Middle Atlantic Continental Shelf and the New York Bight, Special Symposia Volume 2, American Society of Limnology and Oceanography; Allen Press, Lawrence, Kansas.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. Freeman and Co. Publishers. 776 pp.

South Carolina Wildlife and Marine Resources Department. 1979. Benthic and sedimentologic studies on the Charleston Harbor ocean disposal area, Charleston Harbor Deepening Project. SCWMRD Marine Division for the Charleston District, U.S. Army Corps of Engineers. 193 pp.

Strickland, J.D.H. and T.R. Parsons. 1972. A Practical Handbook of Seawater Analysis. Bull. 167 Fisheries Research Board of Canada. 2nd Edition. 310 pp.

Sturgeon, R.E., S.S. Berman, A. Desaulniers, and D.S. Russell. 1980. Pre-concentration of trace metals from sea-water for determination by graphite furnace atomic absorption spectrophotometry. Talanta 27:85-94.

Tenore, K.R. 1979. Macrofaunal benthos. pp. 283 - 307. In: South Atlantic Benchmark Program, Volume 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Prepared by Texas Instruments, Inc. for Bureau of Land Management.

Thorson, G. 1966. Some factors influencing the recruitment and establishment of marine benthic communities. Neth. J. Sea Res. 3:267-293.

U.S. Department of Health, Education, and Welfare. 1980. Action levels for poisonous or deletarious substances in human food and animal feed. Bureau of Foods, Food and Drug Administration, Washington, D.C. 16 pp.

U.S. Environmental Protection Agency. 1979. Manual of methods for chemical analysis of water and wastes. Environmental Protection Agency, Environmental Research Center, Cincinnati, Ohio.

_____ 1977. Interim methods for the sampling and analysis of priority pollutants and fish tissue. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

_____ 1976. Quality Criteria for waters. Washington, D.C. 256 pp.

_____ 1974. Analysis of pesticide residues in human and environmental samples, a compilation of methods selected for use in pesticide monitoring programs.

U.S. Environmental Protection Agency and U.S. Corps of Engineers. 1977. Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters. Implementation Manual for Section 103 of PL 92-532. Environmental Effects Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Second Printing April, 1978.

Windom, H.C. 1978. Trace element geochemistry of Continental Shelf waters of the southeastern United States. In: K.K. Turekian and A.I. Simonov [eds.] First American-Soviet Symposium on Chemical Pollution of the Marine Environment, 1977. Publ. by U.S. Environmental Protection Agency.

Windom, H.L. and P.R. Betzer. 1979. Trace metal chemistry of South Atlantic Georgia Bight. pp 153 - 196. In: South Atlantic Benchmark Program Volume 3: Results of Studies of Georgia Bight of South Atlantic Ocean. Prepared by Texas Instruments Inc. for Bureau of Land Management.

Windom, H.L. and R.G. Smith. 1972. Distributions of cadmium, cobalt, nickel and zinc in southeastern United States Continental Shelf waters. Deep-Sea Research 19:727-730.

Windom, H.L., F.E. Taylor, and E.M. Waiters. 1975. Possible influence of atmospheric transport on the total mercury content of southeastern Atlantic Continental Shelf surface waters. Deep-Sea Research 22:629-633.

APPENDIX B

COMMENTS AND RESPONSES TO COMMENTS ON THE DRAFT EIS

The Draft EIS (DEIS) was issued 8 October 1982. The public was encouraged to submit written comments. This Appendix contains copies of the written comments received by EPA on the DEIS.

Comments on the DEIS are numbered in the margins of the letters, and responses presented for each numbered item.

The EPA sincerely thanks all those who commented on the DEIS, especially those who submitted detailed criticism that reflected a thorough analysis of the EIS.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550
October 27, 1982

OFFICE OF THE
ASSISTANT DIRECTOR
FOR ASTRONOMICAL,
ATMOSPHERIC, EARTH,
AND OCEAN SCIENCES

Mr. Michael S. Moyer
Criteria and Standards Division (WH-585)
EPA
401 M Street, SW
Washington, D.C. 20460

Dear Mr. Moyer:

1-1 The National Science Foundation has no comment on the Draft EIS for Savannah, Georgia; Charleston, South Carolina; and Wilmington, North Carolina Ocean Dredged Material Disposal Sites Designation.

Sincerely,

Barbara E. Onestak
Acting Chairman,
Committee on Environmental
Matters

South Carolina Department of Health and Environmental Control

2600 Bull Street
Columbia, S.C. 29201

October 28, 1982

Mr. Michael S. Moyer
Criteria and Standards Division (WH-585)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

RE: Comments on Draft EIS for Savannah, Georgia; Charleston, South Carolina; and Wilmington, North Carolina Ocean Dredged Material Disposal Sites Designation

Dear Mr. Moyer:

2-1 *We have reviewed this draft EIS and agree, based on the data included in the report, that past disposal practices have had little negative impact on the disposal site and that permanent designation of the site for ocean dredged disposal should have little impact in the future.*

2-2 *However, it is our understanding that additional information exists, at least for the Charleston area, supporting the conclusions of the draft EIS which was not included or was only briefly referenced in the document. Inclusion of this additional data in the final EIS would make it a more complete document and allow comparison with future test results.*

2-3 *Specifically, additional information or explanation is needed concerning the Jones, Edmunds and Associates, Inc. study which found high levels of cadmium in liquid phase tests and in sea water controls. Also, additional information is needed concerning excess mortality of silverside minnows in certain phases of the bioassay tests conducted by Jones, Edmunds and Associates, Inc. Additional information from the August 1978 S.C. Wildlife and Marine Resources Department study should also be included.*

2-4 *We also encourage EPA and the Corps of Engineers to develop a monitoring plan to determine future impacts of ocean disposal of dredged material off Charleston. With declining availability of upland disposal sites,*

Mr. Michael S. Moyer
October 28, 1982
Page Two

it is conceivable the Charleston ocean disposal site may be utilized for disposal of harbor sediments in the future not just entrance channel spoil. Good baseline data will be essential in determining any impacts from the disposal of potentially more contaminated sediments from the upper reaches of the harbor.

Thank you for the opportunity to comment on this study.

Sincerely,

Chester E. Sansbury
Manager, Impact Analysis and
Standards Section
Water Quality Assessment and
Enforcement Division
Bureau of Water Pollution Control

CES:LET:bg

rec'd 11/23

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

(404) 452-4095
November 15, 1982

. Michael S. Moyer
iteria and Standards Division (WH-585)
vironmental Protection Agency
1 M Street, S.W.
shington, D.C. 20460

ar Mr. Moyer:

have reviewed the Draft Environmental Impact Statement (EIS) for the
vannah, Georgia, Charleston, South Carolina, and Wilmington, North Carolina
ean Dredged Material Disposal Sites Designation. We are responding on
half of the U.S. Public Health Service. According to the EIS, previous
edged material disposal at the existing sites has had no detectable impact
public health and safety.

have no additional comments to offer at this time and appreciate the
portunity to review the Draft EIS. Please send us one copy of the final
cument when it becomes available.

Sincerely yours,

Frank S. Lisella, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Center for Environmental Health

Chris Shilling

DEPARTMENT OF THE ARMY
WATER RESOURCES SUPPORT CENTER, CORPS OF ENGINEERS
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060

REPLY TO
ATTENTION OF:

WRSC-D

18 NOV 1982

Mr. Patrick Tobin, Acting Director
Criteria and Standards Division (WH-585)
U. S. Environmental Protection Agency
401 M Street, S. W.
Washington, D. C. 20460

Dear Mr. Tobin: Pat

4-1 Inclosed are the Corps comments on the EPA Draft Environmental Impact Statement (EIS) for Savannah, Charleston and Wilmington Ocean Dredged Material Disposal Sites Designation, dated August 1982, Incl 1. Our technical review comments on the Preliminary EIS documents for these sites were provided to your office by WESEV letters of June 30, 1981 and November 23, 1981.

Our major concerns with the document are as follows:

a. Discussions in the document on restrictive dredging and disposal contain many inaccuracies which should be corrected. Specific examples are provided in Incl 1.

4-2 b. Document rationale for reduced site boundaries at Charleston and Wilmington appear to be based solely on historical disposal requirements and not on the projected future disposal needs as provided your office by WRSC-D letter of May 25, 1982. These projected needs include increased quantities of maintenance material from the Charleston Harbor and Wando River deepening projects, which have previously been coordinated with your Regional Office, as well as projected increased ocean disposal requirements associated with the Military Ocean Terminal (MOT) at Sunny Point, North Carolina. The MOT project includes significant defense aspects. If the EPA position is that the existing and projected future needs can be accommodated by the reduced areas, the EIS should include computations to confirm this position. I continue to feel that the reduced areas are not adequate to meet our dredging requirements for any reasonable period of time.

4-3 c. Economic factors associated with our disposal operations were apparently not considered in the establishment of revised site boundaries for the Wilmington and Charleston sites.

4-4 As a minimum, I feel that the following alternative coordinates should be established for the Wilmington site based on economic factors:

WRSC-D
Mr. Patrick Tobin, Acting Director

18 NOV 1982

North Corner - 78°02'54", 33°49'42"
East Corner - 78°01'20", 33°48'30"
South Corner - 78°01'20", 33°48'30"
West Corner - 78°04'16", 33°48'30"
Center Point - 78°02'54", 33°48'30"

This, in essence, would translate the disposal site to the northeast edge of the existing site as per Figure S-3 of the subject EIS. This site is exactly the same size as the proposed alternative site. The reasons for the requested move are based on the economics of having the site as close to the channel as possible to minimize travel time of the dredge to and from the disposal area. The new site has been used extensively in previous disposal operations, is in deeper water and there are no data which indicate that the new site would have any significant impact on the environment.

The Charleston District is presently conducting hydrographic surveys of the historic Charleston site to determine if a more cost effective location can also be established for this site. Therefore, it is requested that your staff coordinate directly with our Charleston District on this effort prior to finalizing the Charleston site designation.

Sincerely,

MAXIMILIAN IMHOFF
Colonel, CE
Commander and Director

1 Incl
As stated

Specific Comments on the DRAFT EIS for Charleston, Wilmington, Savannah Ocean Site Designations

4-5 a. Page V. Change "Covers 3.6 nmi^2" to read "Covers 4.26 nmi^2". Change "approximately 10 nmi" to read "approximately 17.3 nmi". The changes on page V result in changes on pages XV, 1-1, 2-7, and 3-18 to reflect "4.26 nmi^2" instead of "3.6 nmi^2".

4-6 b. Page xi. The 1981 Water Resources Development in North Carolina by the U. S. Army Corps of Engineers, Wilmington, reports a 1978 commerce of 9.9 million tons. Additionally, the Military Ocean Terminal at Sunny Point (MOTSU) ships large amounts of military oriented cargo via the river channel.

4-7 c. Page 1-6, last paragraph, 3rd sentence. Suggest the sentence be revised to state additional O&M material are dredged from Charleston, Savannah, and Wilmington Harbor projects and Military Ocean Terminal Sunny Point, NC approximately in the quantities 4, 6.5, 1.5, and 2 million yd^3/year, respectively.

4-8 d. Page 1-6. It is important to note that the terms "entrance channel to Wilmington" refer only to the Baldhead Shoal, Smith Island, Caswell-Southport, Southport, and Battery Island Channels. The remaining distance upriver to Wilmington, some 25 miles, is not included.

4-9 e. Page 1-8, 1st para, 1st sentence. Should the word "nondredged" be "dredged"?

4-10 f. Page 2-1. Were the MOTSU dredged material disposal requirements considered? Critical dredged material disposal capacities at MOTSU may force ocean disposal of those materials in the near future.

4-11 g. Page 2-4. This is a critical point for the Wilmington Harbor Project and the Military Ocean Terminal, Sunny Point. There is a minimal finite capacity for containment of dredged material in the diked upland disposal areas in the vicinity of the Cape Fear River and the only alternative will be ocean disposal. The size of the disposal site must reflect potential disposal requirements.

4-12 h. Page 2-7, 2nd para. The data presented in Table 3-15, page 3-41, indicate that most of the sediments dredged from Tybee Roads are suitable for beach nourishment.

4-13 i. Page 2-9. Anadromous fish are not a major fishery resource of the nearshore ocean area of the Cape Fear region. Carolina Power and Light Company's Cape Fear River studies identified shrimp, spot, croaker, menhaden, star drum, and trout as nekton species which are abundant in the Cape Fear River and adjacent waters. The above species should be mentioned and potential impacts on them discussed.

4 j. <u>Page 2-10.</u> Live bottom areas do exist in Onslow Bay. The transportation of dredged material around the Frying Pan Shoals to a disposal area coincidental with the coral reef areas in Onslow Bay is simply not feasible. If the sentence means that dredged material disposal in the existing Wilmington or Alternate ODMDS may have an adverse effect on the coral reef areas then the sentence needs to be clarified and the effects discussed further.

5 k. <u>Page 2-10.</u> Potential needs for disposal at Wilmington such as 2 million yards annually from MOTSU must be considered. Restriction of size based only on present dredging practices would constitute poor planning.

6 l. <u>Page 2-22.</u> Our determination of consistency with the N.C. Coastal Management Program (dated 23 September 1981) states that the Wilmington Harbor Ocean Dumping, Baldhead Shoal, and Smith Island Channel will be performed on an annual basis at any time during the year. The State of North Carolina interposes no objection to dredging and ocean dumping there at any time of year as evaluation will take place under MPRSA and not PL 92-500.

7 m. <u>Pages 2-22, and 4-4.</u> Statements on these pages indicate that the paucity of site specific data limited conclusions on the impacts of dumping at the existing sites. Yet, statements throughout the DEIS indicate that disposal of dredged material at these sites has minimal or no impacts on the biological communities.

8 n. <u>Page 2-22, 2nd para.</u> A statement is made to the effect that Savannah District attempts to restrict dredging operation to the winter months to minimize potential impacts to passing fish. The District schedules their dredging on the basis of the availability of hopper dredges. It has been a coincidence in the recent past that the hopper dredge and equipment has been available for our work during the winter months. A statement is made on page 4-11 that the Savannah District does not dredge between the months of February and May to avoid interference with migrating and spawning activities of larval fish. On Page 4-15, the DEIS stated that no disposal should take place during the summer months. If we were to conduct our dredging activities based on these two statements, bar channel dredging could only be done three (3) months out of the year (November, December and January). Charleston could only dredge two (2) months out of the year (November and December). The statement of page 4-11 should also be clarified to indicate the species that might require protection by not dredging between February and May. The only species of fish that spawn at the time are anadramous. Also, note page 2-34.

9 o. <u>Page 2-26.</u> In several places, the DEIS stated that mounding is not a problem because winter storms displace the material. However, the last sentence in the first paragraph indicated that the large portion of the fine-grained materials may settle within the sites. The statements are contradictory, especially since fine grained materials are more susceptible to displacement:

p. <u>Page 2-30.</u> The phytoplankton and zooplankton sampling by Copeland and Birkhead (1973) was not "at the Wilmington" ODMDS, but rather shoreward and west of the Wilmington ODMDS. While the assumption that the phytoplankton and zooplankton populations of the sampled areas and the ODMDS are similar is probably valid, the implication that specific ODMSD samples were taken is not.

4-21 q. <u>Pages 2-33 and 2-34.</u> The third sentence is incomplete, but indicates that only entrance channel sediments will be disposed at the sites. This contradicts the correct statement on page 2-25 which indicates that Charleston CE is currently considering the possibility of disposing of dredged material from within the Charleston Harbor in Charleston ODMDS.

4-22 r. <u>Page 2-34.</u> CE (1977) which is referenced in this section is the EIS for the Wilmington Harbor project. That project extends from the mouth of the Cape Fear River to Wilmington, NC, approximately 30 miles upstream. The seasonal dredging restrictions described are applied to the upper (upstream) portions of the river channel, but they are not applied to the portions of the Wilmington Harbor project which are associated with ocean disposal. What is the basis of the statement that the dredging schedules "have proven feasible and minimize potential impacts on larval and spawning fish and shellfish?" Carolina Power and Light Company's work on the Cape Fear described two periods of larval and post larval abundance corresponding to winter-spring recruitment of ocean spawned species (spot, croaker, flounder, menhaden, mullet, and brown shrimp) and summer recruitment of estuarine or ocean spawned species (anchovies, trout, gobies, white shrimp, and pink shrimp). Considering the information discussed above, the value of seasonal dredging restrictions is not proven or clear.

4-23 s. <u>Page 2 37, 2nd para.</u> The sentence in this paragraph states the bioassay and bioaccumulation tests should be performed on Savannah dredged sediments. However, the Savannah Bar channel sediments meet conditions 1 and 3 (see page 1-16) that are environmentally acceptable for ocean disposal without further testing. Although the bar channel sediments do contain some silt-size particles in some locations, most of the dredged material is composed predominatly of sand with some shell. Recently completed analyses of sediments from the lower harbor, for 129 priority pollutants, did not reveal any concentrations of these pollutants that are of concern. Since bar channel sediments are even further removed from sources of pollution in the harbor, it is logical to reason that the levels of contaminants would be lower in these sediments.

4-24 t. <u>Page 3-16.</u> This is highly unlikely given the dynamic nature of the nearshore waters.

4-25 u. <u>Page 3-17.</u> DO is measured mg/L not ml/L.

4-26 v. <u>Page 3-39.</u> Some of the incremental changes in channel width and depth have been left out. For example, in 1930 the river channel was deepened to 30 feet with increased width in river bends and in 1945 when the width of the ship channel was increased. An accurate project history is in the referenced CE report (1977), pages 11-13.

4-27 w. <u>Page 3-41.</u> 1980 data will not be included in a reference dated 1977.

4-28 x. <u>Page 3-56.</u> The shipping activities associated with MOTSU should be mentioned.

29 y. Page 3-58. See comment b above.

30 z. Page-3-58. There is no U. S. Navy base associated with Wilmington.

31 aa. Page 4-7. See comment r above.

32 bb. Page 4-8, Endangered and Threatened Species. The DEIS discusses endangered species in several sections, but the statement presents no evidence that the authors have coordinated with NOAA and obtained a list of threatened or endangered species. In view of the incident at Canaveral Harbor where loggerheads were encountered while dredging the outer channel, the DEIS should note that NOAA has been consulted and that the problem is not thought to exist in the three (3) harbors addressed in the DEIS. On page 4-8, it is acknowledged loggerhead nesting occurs directly north of the existing Wilmington site on Tybee Island. Limited loggerhead nesting occurs on Tybee Island.

33 cc. Page 4-12. The Wilmington CE does not absolutely restrict dredging from February through August, the period of highest larval abundances.

34 dd. Page 4-15. The statement that dredged material disposal should continue to be restricted during biologically productive summer months is not warranted in view of the above comments.

United States Department of the Interior

OFFICE OF ENVIRONMENTAL PROJECT REVIEW

Southeast Region / Suite 1384
Richard B. Russell Federal Building
75 Spring Street, S.W. / Atlanta, Ga. 30303

November 19, 1982

ER-82/1622

Mr. Michael S. Moyer
Criteria and Standards Division (WH-585)
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Dear Mr. Moyer:

5-1 The Department of the Interior has reviewed the draft Environmental Impact Statement for the Savannah, GA; Charleston, SC; and Wilmington, NC Ocean Dredged Material Disposal Site Designation as requested.

5-2 We do not expect approval of the proposed disposal sites to affect mineral leasing and operations in the area because these sites are located so close in to shore. However, we feel that the discussion of mineral resources should be updated to reflect current information and events in Atlantic Outer Continental Shelf mineral leasing and exploration activities. The attached information sheet will provide you with data to update the section on pages 3-53 through 3-56.

5-3 Some of the material to be dredged may be of high enough quality at times to be used for beach nourishment or for creation of marshes, if suitable sites were available. The final EIS should discuss the possibility of using some of the material in this manner in order to keep the options open for beneficial uses of the dredged material.

5-4 Section 7 of the Endangered Species Act of 1973, as amended, requires agencies to provide a biological assessment for the listed species and provide a determination of "may affect" or "no affect" on listed species. If the agencies conclusion is "may affect" then the agency needs to formally request a biological opinion from the Fish and Wildlife Service. These procedural steps and the actions to date to insure compliance should be addressed more fully in the final EIS. The Asheville Endangered Species Field Station will be glad to assist you in reviewing the consultation history on endangered species relative to the proposed project and provide advice on how to proceed. Please contact the Field Supervisor, U.S. Fish and Wildlife Service, Plateau Building, Room 5A, 50 South French Broad Avenue, Asheville, North Carolina 28801, telephone (704) 258-2850, Ext. 382.

Thank you for the opportunity to review this draft EIS.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

Attachment

South Atlantic Outer Continental Shelf Leasing and Exploration Activity Update

Lease Sale No. 43

Sale date: March 28, 1978
Active leases: 32
Exploration: Six wells drilled to date

Lease Sale No. 56

Sale date: August 4, 1981
Active leases: 47
Exploration: Two drilling plans approved for off of Wilmington, North Carolina

Lease Sale RS-2 (South Atlantic portion)

Sale date: August 5, 1982
Active leases: Nine
Exploration: None

Undiscovered Recoverable Resource Estimate

Carolina Trough (area offshore of these three ODMDS's): 600 million barrels of oil; 2,800 billion cubic feet of gas rec'd 11/29

North Carolina Department of Administration

116 West Jones Street Raleigh 27611

James B. Hunt, Jr. Governor
Jane Smith Patterson, Secretary

Margaret C. Riddle
Coordinator
Office of Policy and Planning
(919) 733-4131

November 19, 1982

Mr. Michael S. Moyer
Criteria and Standards Division
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Moyer:

RE: SCH File #83-E-0000-5075; Draft EIS for Ocean Dredged Material Disposal Sites Designation, Wilmington, N.C.

6-1 The State Clearinghouse has received and reviewed the above referenced project. As a result of this review, the State Clearinghouse finds that no comment is necessary on this project at this time.

Sincerely,

Chrys Baggett (Mrs.)
Clearinghouse Director

CB/jcp

cc: Region "O"

NATIONAL WILDLIFE FEDERATION

1412 Sixteenth Street, N.W., Washington, D.C. 20036 202—797-6800

November 22, 1982

Mr. Michael S. Moyer
Criteria and Standards Division (WH-585)
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Re: Comments on Draft Environmental Impact Statement for the Savannah, Georgia, Charleston, South Carolina, and Wilmington, North Carolina, Ocean Dredged Material Disposal Site Designations

Dear Mr. Moyer:

7-1 Following are the comments of the National Wildlife Federation on the referenced draft EIS:

1. Consideration of Alternative Sites

7-2 As we have noted in previous ODMDS comments,* the analyses of alternative sites (other than existing interim sites or alternative sites located within the boundaries of existing interim sites) are particularly deficient. This applies not only to land disposal alternatives but also to mid-shelf and shelf-break alternatives. Have alternative sites been seriously considered, or have they been merely mentioned to satisfy NEPA requirements?

For example, the draft EIS notes that there is a "paucity of site-specific data" relating to the mid-shelf and shelf-break areas. DEIS at xvii. How does EPA compare environmental values to determine the benefits of individual disposal site alternatives on the basis of little or no data?

See: National Wildlife Federation comments on: Hawaii ODMDS, January 15, 1980; San Francisco Channel Bar ODMDS, January 8, 1981; New York ODMDS, April 5, 1982; and Sabine-Neches ODMDS, October 1, 1982.)

At the mid-shelf, the draft EIS notes that "since the locations of reefs are not well known, identifying specific sites suitable for dredged material disposal is difficult." DEIS at 2-11. Nevertheless, suitable mid-shelf disposal sites have been "tentatively identified . . . and verified using results from previous benthic surveys." DEIS at 2-11. The draft EIS points out that the South Carolina Wildlife and Marine Resources Department (SCWMRD) has identified one mid-shelf site off Charleston and "similar areas off Wilmington and Savannah could also be identified if sufficient data were available." DEIS at 2-12, emphasis added. This statement strongly suggests that not only has there been no real attempt to collect environmental data at the mid-shelf for alternative site comparisons, but no real alternative sites have been identified.

At the shelf-break, the draft EIS states that three generalized areas off of Savannah, Charleston, and Wilmington will be considered as alternatives, but again "specific data for these three areas are unavailable." DEIS at 2-13. The draft EIS notes that shelf-break reefs are "unique and productive habitats," that entrainment of deposited material in the Gulf Stream could affect shelf-break reef ecosystems, and that dredged material disposal might interfere with OCS oil and gas development. DEIS at 2-12, 2-13. Nevertheless, one scientist has suggested that the shelf-break area seaward of the 200-meter depth contour "offers an extensive region 'favorable for deep ocean disposal of dredged material'." DEIS at 2-13. If the ecosystem effects and use conflicts are real, why is the Charleston shelf-break alternative located landward of the 200-meter depth contour? DEIS at 2-19, Figure 2-4.

7-3 Finally, nowhere in the draft EIS is there any comparison of the costs of dredged material disposal at the different alternative sites, although the draft EIS does state that "the additional time and expense required by offshore ocean disposal are serious disadvantages to using mid-shelf or shelf-break disposal sites." DEIS at 2-25. Such a cost comparison would be helpful especially in the case of the Charleston harbor deepening project. The reasons for this are elaborated below.

2. Savannah, Georgia, ODMDS

7-4 The existing interim site appears to be adequate for the purpose of dredged material disposal from the Tybee Roads channel. It is disturbing to note, however, that no bioassay or bioaccumulation tests have been conducted on Savannah dredged sediments. This is disconcerting in light of the fact that "concentrations of volatile solids and zinc exceed EPA 'Criteria for Determining Acceptability of Dredged Spoil Disposal to the Nation's Waters'" according to a Corps of Engineers study in 1975. DEIS at 3-40. In addition, Interstate Electronics Corporation (IEC) in its 1979-1980 study found that "in the absence of appropriate bioassay data, concentrations of total lead cannot be compared to EPA criteria." DEIS at A-14.

We suggest that the appropriate bioassay and bioaccumulation tests be conducted on dredged sediments obtained from the Savannah disposal site.

. Charleston, South Carolina, ODMDS

The reduced size of the proposed alternative disposal site ppears to be an adequate alternative. The draft EIS supports he reduction in disposal site size because it is "sufficient for he expected disposal volumes," monitoring activities are facilitated, nd the site is "located a safer distance from shore." DEIS at -1. The latter point, without reference to the kind of "safety" eeded, implies that the larger existing interim site may be ess safe, or even unsafe.

Perhaps the safety factor involves concentrations of trace etals. Solid-phase bioassays revealed cadmium concentrations hat exceeded the limiting permissible concentration. DEIS at 3-42. or some inexplicable reason, seawater "controls" contained levels f cadmium "14 times higher than EPA standards for marine waters." EIS at 3-42. IEC noted that of all trace metals in sampled ediments, "cadmium concentrations exhibited the greatest variability." EIS at A-32. IEC also mentioned that "mercury and cadmium levels eported by SCWMRD were substantially higher than concentrations easured during IEC surveys." DEIS at A-32.

Again, tissue samples were not analyzed for the Charleston ite. DEIS at 3-25, A-33. This has effectively precluded comparison f lead concentrations with EPA criteria. DEIS at A-31. Since EC found "slightly higher levels of cadmium and chlorinated ydrocarbons" within the ODMDS, it suggested that "more detailed tudies would be necessary to substantiate these results." DEIS t A-33. We recommend that the appropriate bioassay and bioaccumulation ests be conducted on dredged sediments obtained from the harleston disposal site.

Moreover, consideration should be given to selecting a "safer" ite than the existing interim site for the disposal of materials rom the harbor deepening project. SCWMRD has identified an area n the mid-shelf "which is potentially suitable for dredged material isposal," although proximity to productive reef ecosystems may reclude selection of a mid-shelf alternative. Consideration hould also be given to a shelf-break alternative, beyond the 200-eter isobath, for the one-time disposal of dredged material from he harbor deepening project.

. Wilmington, North Carolina, ODMDS

The proposed alternative site appears to be adequate for the urpose of dredged material disposal from the Cape Fear channel.

The draft EIS quotes a 1977 Corps of Engineers study to xplain why land disposal is unacceptable at Wilmington: "other orms of disposal are precluded due to the fact that other types f dredges are incapable of operating in an area which is so ften beseiged [sic] by rough seas and varying currents." DEIS at -4. This statement is confusing and seems to imply that disposal ite selection is primarily dependent on the type of dredge nployed.

5. <u>Miscellaneous Comments</u>

'-11 The Bureau of Land Management charts used in figures 2-1, 2-3, and 2-4 are remarkably incompatible with the NOAA chart used in figure 2-2. DEIS at 2-14, 2-15, 2-16, 2-19. It is virtually impossible to tell where live-bottom areas are located with respect to the existing interim sites and the alternative sites. We recommend that one type of chart be used to depict resource and use locations.

7-12 The draft EIS notes that "in general, land disposal sites are used by the Savannah, Charleston, and Wilmington CE for their respective dredging projects when either the quality of the dredged material is not acceptable for ocean disposal or the cost of transporting dredged material to an ocean disposal site is prohibitive." DEIS at 2-4. Nowhere in the draft EIS has it been explained that the quality of the dredged material might be unacceptable. In light of the uncertainty that surrounds trace metal concentrations at Savannah and Charleston, the final EIS should promote the continued use of the land sites for disposal of the more highly contaminated dredged materials. The proposed ocean sites should be reserved for the disposal of relatively clean dredged materials.

We appreciate the opportunity to communicate these comments and concerns and trust that the final EIS will adequately address the need for adequate testing in considering viable alternatives.

If you have any questions, or desire clarification, regarding any of the points raised in this letter, please feel free to contact us.

Sincerely,

Porter Hoagland
Conservation Intern
Pollution and Toxic Substances Division

Kenneth S. Kamlet
Director
Pollution and Toxic Substances Division

cc: Colonel Charles E. Dominy, Savannah District COE
Colonel Robert K. Hughes, Charleston District COE

U.S. Department of Transportation
Office of the Secretary of Transportation

400 Seventh St., S.W.
Washington, D.C. 20590

November 24, 1982

Mr. Michael S. Moyer
Criteria and Standards Division
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Moyer:

We appreciate the opportunity to review the Draft Environmental Impact Statement for Ocean Dredged Material Disposal Sites Designation at Savannah, Georgia, Charleston, S.C., and Wilmington, N.C.

This office has no comments to offer. However, we enclose for your consideration comments prepared by the Office of Port and Intermodal Development of the Maritime Administration. We note that the Coast Guard is on the distribution list for this EIS, and assume that you will hear from them directly.

Sincerely,

Eugene L. Lehr

Eugene L. Lehr, Chief
Environmental Division
Office of Economics

Enclosure

Memorandum

U.S. Department of Transportation
Maritime Administration

Subject: INFORMATION: Environmental Impact Statement (EIS) for Savannah, GA, Charleston, S.C. and Wilmington, N.C. Ocean Dredged Material Disposal Sites Designation

Date: November 18, 1982

From: Carl J. Sobremisana
Carl J. Sobremisana, Project Manager
Office of Port and Intermodal Development

Reply to Attn. of: MAR-830x64357

To: Daniel W. Leubecker
Head, Environmental Activities Group

8-2 The Office of Port and Intermodal Development has reviewed the Draft Environmental Impact Statement for Savannah, GA., Charleston, S.C. and Wilmington, N.C., Designating Ocean Dredged Material Disposal Sites, dated August, 1982. Our Analysis of the EIS is predicated on the need to protect shipping channels and sea lanes from interruptions by dredged disposal operations, and the promotion of adequate disposal sites to maintain existing channel systems for the future development of new channel systems.

From the outset we generally concur with the recommendations, as set forth in the EIS, to designate the ODMDS sites located in the vicinity of the Ports of Savannah and Charleston. Furthermore, we agree with EPA's recommendation for the alternative Wilmington disposal site as geographically defined and depicted.

8-3 The area we do have some reservation and concern is related to Federal regulations promulgated under 40 CFR 228, which address specific general criteria for site selection of sites. 40 CFR 228.5(d) reads "The sizes of ocean disposal sites will be limited in order to localize for identification and control any immediate adverse impacts and permit the implementation of effective monitoring and surveillance programs to prevent adverse long-range impacts. The size, configuration, and location of any disposal site will be determined as a part of the disposal site evaluation or designation study."

We question the wisdom of the findings in the EIS on page XV, paragraph 2, line 6, which states: "The relatively large disposal site area makes site monitoring difficult and are not needed for present dredged material volumes."

It is our contention that this requirement to restrict the size of the Charleston and Wilmington ODMDS could inhibit future port development in the region. It postpones to a future date the requirement to initiate the site selection process all over again, thus creating additional costs and time delays, which in the final analysis could inhibit development activities.

No hard technical evidence has been shown to date that the present dredged material is harmful to the ocean environment or will be in the future. On the other hand, there is sufficient evidence that the South Atlantic Ports of Savannah, Charleston and Wilmington are growing and expanding ports and will continue to grow in the future.

In conclusion, we recommend that the existing site monitoring system be upgraded. An investment in an effective monitoring system now precludes future time delays, undue costs and duplicative regulatory requirements for both the governmental and private sectors. We would appreciate your reaction to our response at your earliest convenience.

#

cc: P-37
J. Carman
J. Pisani

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (G-VP-4)
WASHINGTON, D.C. 20593
PHONE: (202) 426-3300

16477.4
01 DEC 1982

Mr. Michael S. Moyer
Criteria and Standards Division
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Moyer:

We have reviewed the Draft Environmental Impact Statement for Ocean Dredged Material Disposal Site Designations at Savannah, Georgia, Charleston, S.C. and Wilmington, N.C. We have no comments at this time.

Sincerely,

W. R. Riedel
Chief, Planning, Coordination
and Analysis Staff
By direction of the Commandant

RESPONSES TO WRITTEN COMMENTS

1-1 EPA appreciates the response from the National Science Foundation.

2-1 EPA appreciates the response from the South Carolina Department of Health and Environmental Control .

2-2 Although additional supporting evidence may exist, EPA feels that data presented in the EIS is sufficient to support the recommendations proposed.

2-3 As stated in the Ocean Dumping Regulations [40 CFR 227.13(c)] "when dredged material proposed for ocean dumping does not meet the criteria of paragraph (b) of this section [dealing with acceptable material], further testing of the liquid, suspended particulate, and solid phases, as defined in §227.32 is required." Section 227.13(c) further states "based on the results of such testing dredged material can be considered to be environmentally acceptable for ocean dumping only under the following conditions: (3) Bioassays on the suspended particulate and solid phases show that it can be discharged so as not to exceed the limiting permissable concentrations as defined in paragraph (b) of §227.27." EPA believes that while some anomalies are present in the bioassay data, the conclusions reached by JEA are valid.

2-4 Section 228.9 of the Ocean Dumping Regulations establishes that the impact of dumping in a disposal site and surrounding marine environment will be evaluated periodically for certain types of effects. The information used to make the disposal impact evaluation may include data from monitoring surveys. Thus, "if deemed necessary," the CE District Engineer (DE) and EPA Regional Administrator (RA) may establish a monitoring program to supplement the historical site data (40 CFR §228.9). The CE and RA develop the monitoring plan by determining appropriate monitoring parameters, frequency of sampling, and the areal extent of the survey.

3-1 EPA thanks the Department of Health, Human Services Public and Health Service for its response.

4-1 EPA thanks the COE for its comments on the DEIS.

4-2 It is EPA's position that the proposed site boundaries are adequate based on past and proposed future operation and maintenance dredging. As stated in pages vi xvi, and 1-1, the EIS also proposes that the Existing Site be designated on a one-time basis to receive dredged material resulting from the proposed Charleston Harbor Deepening Project.

4-3 EPA considers economic factor associated with significant changes in the distance dredged materials must be hauled. Since a reduction in the size of site does not, in EPA option, significantly increase the hauling distance, economic factors were not considered.

4-4 EPA agrees with the recommendation and the coordinates of the site have been changed in the FEIS.

4-5 Recommended changes have been included in the FEIS.

4-6 EPA appreciates the additional information supplied by the CE.

4-7 Suggested changes have been incorporated into the FEIS.

4-8 EPA added this point of clarification in the Final EIS.

4-9 Nondredged is the correct terminology.

4-10 Ocean disposal sites are being permanently designated to receive dredged material which meets the criteria as establised in the Ocean Dumping Regulations (40 CFR 227), as stated on page 1-3 of the FEIS. Disposal of the quantities of material dredged from Military Ocean Terminal Sunny Point (MOTSU) were considered in the designation process. (See response 4-7)

4-11 See response to comment 4-10.

4-12 Data presented in Table 3-15 concerning the % composition of the Savannah dredged sediments is valid. The value presented on page 2-7 of the DEIS cannot be documented and is eliminated from the test.

4-13 See page 2-22 of EIS for a discussion of effects of disposal operations on the areas fishery.

4-14 The discussion at the top of page 2-10 of the EIS refers to potential adverse effects to coral reefs north of the Existing ODMDS if the site were relocated to that area. The last sentence on page 2-9 clarifies this by stating that such areas support productive recreational fisheries. A point of further clarification has been added to the first sentence on page 2-10.

4-15 See response 4-10. Site restrictions were based on present and future planned dredging.

4-16 Statements in the EIS referring to dredging time restrictions have been eliminated.

4-17 Based on evaluation historical data and information, as presented in the EIS, it was concluded that continued disposal of dredged material at the sites would not affect threatened or endangered species. Monitoring should reveal any changes that may take place.

4-18 See response 4-16.

4-19 The fine grained materials may settle within the site and cause some temporary mounding. However, as stated on the bottom of page 2-26. "winter storms can be expected to disperse accumulated sediments..."

4-20 The FEIS has been changed to reflect additional information.

4-21 The sentence in question has been deleted.

4-22 EPA agrees that evidence is not provided to support seasonal dredging and has removed the paragraph. However, EPA does feel that seasonal dredging may be necessary in the future if data shows that dredging/disposal activities are interfering with spawning migrating and/or the reproductive cycles of estuarine organisms.

4-23 Dredged material is acceptable for ocean disposal without further testing if it satisfies the criteria of 40 CFR 227.13[b]. If sediment analyses exist which document acceptability of Savannah dredged material for ocean disposal no further testing is necessary. If such information is not available, EPA recommends that bioassay and bioaccumulation tests be performed on the Savannah dredged sediments.

4-24 Response is not possible since commenter did not specify to which paragraph comment refers.

4-25 ml/L is the correct unit for dissolved oxygen measurements taken in salt water.

4-26 The summary information provided in the EIS in adequate. More detail is not necessary for the site designation process.

4-27 Source dates have been corrected.

4-28 See comment response 4-6.

4-29 See comment response 4-6.

4-30 Reference to a Navy base in Wilmington has been eliminated in the Final EIS.

4-31 See comment response 4-21.

4-32 See comment Table 3-13 on page 3-37 is a list of the endangered and threatened species obtained from NOAA.

4-33 Referenced statement has been deleted.

4-34 Referenced statement has been deleted.

5-1 EPA thanks USDI's Office of Environmental Project Review, Southeast Region for its review.

5-2 EPA appreciates the information provided. Information in FEIS is a summary of the active oil and gas lease activity.

5-3 As stated on page 1-16 of the EIS and in 40 CFR 227.13(b) dredged material can be used for beach nourishment if it is composed predominantly of sand, gravel. or shell. ." The proposed action made in this EIS does not limit the option of using dredged materials for beach nourishment.

5-4 The threatened and endangered species are listed on page 3-37 and discussed on pages 3-35 to 3-38. The discharge of the dredged material within the designated sites will have no effects on these species. The sites are quite small with respect to the total range of the species.

6-1 EPA thanks the North Carolina Department of Administration for its response.

7-1 EPA appreciates the National Wildlife Federation's review of the Draft EIS.

7-2 See EPA's response to those comments in the corresponding Final EIS's.

As correctly stated in the DEIS and in your comment, no baseline surveys have been made of the alternative site. The lack of baseline surveys plus the paucity of historical data and information on the alternative sites makes their evaluation difficult. The evaluations leading to the DEIS indicated the existing historically used areas are environmentally acceptable. The alternative sites may also be enviornmentally acceptable. However, it is not believed that moving from an environmentally acceptable site with know characterisitcs to a possibly environmentally acceptable site with many unknows would be wise.

7-3 Cost comparisons are helpful when the additional expense associated with sediment transport to different alternative sites is a major factor in the elimination of certain areas from consideration as potential disposed sites. This is not the case at the proposed S-C-W ODMDS's.

7-4 See response to comment 2-3.

7-5 There was not specific mention of the safety factor(s) involved because it is not possible at this point to single out any one factor as being more or less safe than any other.

7-6 Refer to comment 7-7.

7-7 As stated on page 2-35 of the FEIS, the "purpose of the monitoring program is to determine whether disposal at the sites is significantly affecting areas outside the sites, and to detect long-term adverse effects." On page 2-36. The paragraph continues stating, "the DE and RA may chose to monitor selected parameters which experience wide variability". Future bioassay and bioaccumulation surveys are means of determining the presence of specific parameter variability.

7-8 At the present time, the existing data indicates the site proposed for the one-time disposal of the harbor deepening materials is adequate for those reasons given within the FEIS.

7-9 EPA thanks the NWF for its comment.

7-10 This is a direct quote from the CE, 1977 study.

7-11 Since alternative sites are generalized areas in the mid-shelf and shelf-break areas, their exact locations cannot be shown on a map. EPA does not agree with the commenter that the maps are incompatible. Each figure is presenting different information and they are not intended to be comparable.

7-12 Pages 1-14 to 1-17 of the FEIS present the criteria which must be met to assure that dredged material is environmentally acceptable for ocean disposal. Land disposal is an alternative which must be considered if dredged material is found to be unacceptable for disposal in the ocean.

8-1 EPA appreciates the response from DOT's Environmental Division.

8-2 EPA appreciates the review by DOT's Office of Port and Intermodal Development.

8-3 As stated in the Proposed Action on page xvi of the FEIS, recommendations are made to designate the existing interimly-designated Charleston Harbor ODMDS to receive the dredged materials resulting from the proposed harbor deepening project. EPA believes that the size of disposal sites must be limited for precisely the reasons given in 40 CFR 228.5(d).

8-4 EPA appreciates the recommendations. Future monitoring of all sites is under study.