United States
Environmental Protection
Agency

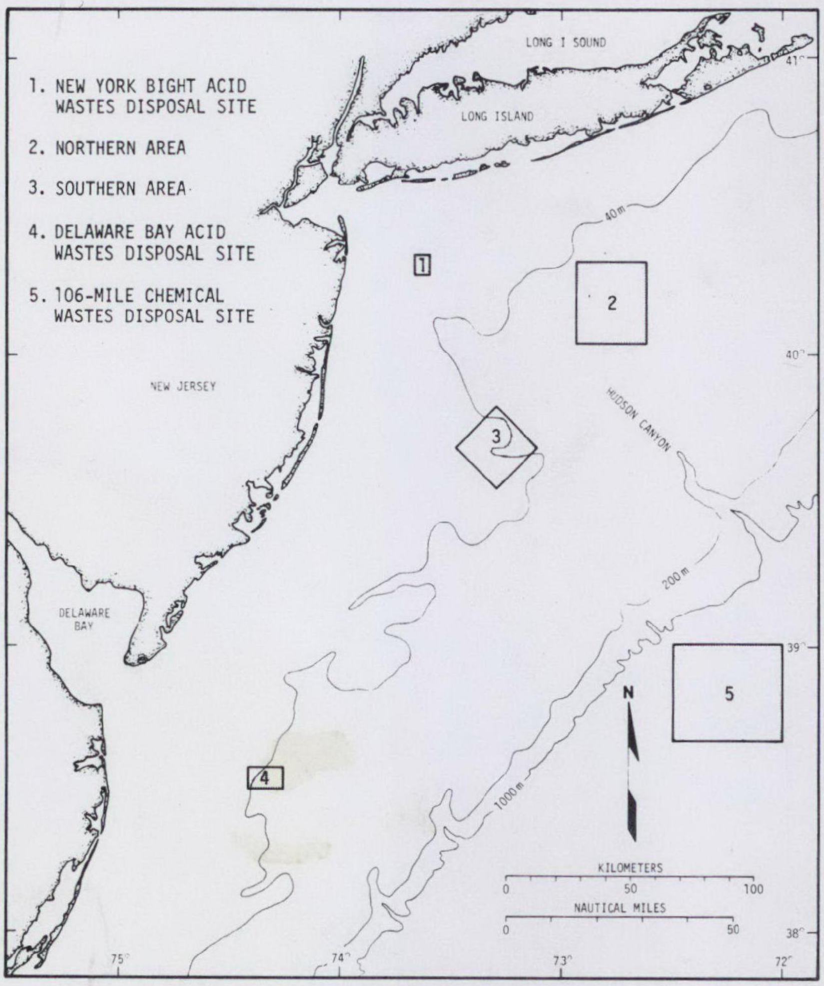
Oil and Special Materials
Control Division
Marine Protection Branch
Washington DC 20460

June 1979

Water

EPA

Environmental Impact DRAFT Statement (EIS) for 106-Mile Ocean Waste Disposal Site Designation



DRAFT

ENVIRONMENTAL IMPACT STATEMENT (EIS)
for
106-MILE OCEAN WASTE DISPOSAL SITE DESIGNATION

June 1979

Prepared Under Contract 68-01-4610
T. A. Wastler, Project Officer
for
U.S. ENVIRONMENTAL PROTECTION AGENCY
Oil and Special Materials Control Division
Marine Protection Branch
Washington, D.C. 20460

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ENVIRONMENTAL PROTECTION AGENCY
Draft Environmental Impact Statement On
106-Mile Ocean Waste Disposal Site Designation

Prepared By

Office of Water Program Operations
Marine Protection Branch

Environmental Protection Agency

Approved By

John F. [signature]

25 JUN 1979
(Date)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C 20460

TO ALL INTERESTED GOVERNMENT AGENCIES,
PUBLIC GROUPS, AND CITIZENS

Enclosed for your review is the draft Environmental Impact Statement for 106-Mile Ocean Waste Disposal Site Designation.

Ocean dumping has long been a convenient and economical means for the disposal of wastes and other material; until the passage of the Marine Protection, Research, and Sanctuaries Act in 1972 (MPRSA) and the coming into force of the International Ocean Dumping Convention, this practice was essentially unregulated either domestically or internationally. Since 1972, the Environmental Protection Agency (EPA) has had the responsibility of regulating the dumping of municipal and industrial wastes into ocean waters, and, as part of this mandate, also has the authority to select and designate sites in the ocean for the dumping of such wastes and dredged material.

EPA policy on the ocean dumping of any waste material has been that land-based methods of disposal must be used when they are available, even when ocean dumping would not result in unreasonable degradation of the marine environment. The designation of a particular location for the ocean dumping of certain materials does not constitute blanket approval of ocean dumping as a means of ultimate waste disposal, but merely the recognition that ocean dumping is necessary and appropriate in certain situations. When this is the case, a location must be designated which has the least adverse environmental impact for such dumping.

The determination as to whether or not a permit for dumping at a designated site will be issued in any particular situation is a separate action decided on a case-by-case basis, and the designation of a site for dumping certain wastes in no way prejudges the determination to be made on particular permit applications. Each applicant must demonstrate compliance with the EPA Ocean Dumping Criteria, including the lack of viable land-based alternatives, before a permit may be issued.

This present proposed action concerns a site off the Continental Shelf in the New York Bight area. This site, commonly known as the "106-mile site," has been used for many years as a location for the ocean dumping of industrial wastes. Between 1974 and 1978, the site was studied extensively by the National Oceanic and Atmospheric Administration, and the results of these studies form the primary technical basis for this analysis.

Over 100 different dumpers have utilized the 106-mile site for waste disposal since 1961. Now, only four permittees are using the site. Despite this large decrease in ocean disposal activity at the site, a present and future need exists for its continued use for those permittees whose wastes meet the environmental impact criteria and cannot be feasibly treated by current land-based methods. There will also be a continuing need to have available for use a site of known environmental characteristics for the disposal of some wastes under emergency conditions and for the disposal of new wastes which EPA deems acceptable for ocean disposal.

Designation of this site for use in this manner is also fully consistent with the requirements of Annex III of the Ocean Dumping Convention.

In making designations of sites for ocean dumping, EPA has made the voluntary commitment to prepare EIS's on proposed site designations as part of the documentation which demonstrates the suitability of the location chosen for dumping. This approach has been taken to provide the greatest possible degree of public participation in reaching a decision.

Comments on this Draft EIS should be provided as indicated in the EIS summary. A public hearing on this Draft EIS will be held on August 21 in Trenton, New Jersey. Recipients of the Draft EIS will be notified of exact time and place at a later date.

Sincerely,

John T. Rhett

John T. Rhett
Deputy Assistant Administrator
for Water Program Operations (WH-546)

ENVIRONMENTAL PROTECTION AGENCY

DRAFT
ENVIRONMENTAL IMPACT STATEMENT ON THE 106-MILE OCEAN WASTE DISPOSAL SITE DESIGNATION

Prepared by: U.S. Environmental Protection Agency
Oil and Special Materials Control Division
Marine Protection Branch
Washington, D.C. 20460

Approved by: T. A. Wastler — June 22, 1979

T. A. Wastler
Project Officer

Date

Summary Sheet

ENVIRONMENTAL IMPACT STATEMENT
FOR
106-MILE OCEAN WASTE DISPOSAL SITE DESIGNATION

(X) Draft
( ) Final
( ) Supplement to Draft

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAM OPERATIONS
MARINE PROTECTION BRANCH

1. Type of Action

   (X) Administrative/Regulatory action
   ( ) Legislative action

2. Brief description of background of action and its purpose indicating what States (and counties) are particularly affected.

   The proposed action is the designation of the 106-Mile Chemical Waste Disposal Site for continuing use. The Site is located approximately one hundred nautical miles east of Cape May, New Jersey, and is primarily used by industries located in the New York-New Jersey-Delaware area. The purpose of the action is to provide an environmentally acceptable area for the disposal of wastes which (1) comply with EPA's rigid marine environmental impact criteria, or (2) must be disposed of until a suitable, land-based disposal method is available.

3. Summary of major beneficial and adverse environmental and other impacts.

Ocean disposal has occurred at the 106-Mile Site since 1965, and long-term adverse effects caused by the various waste types dumped have not been demonstrated. There are short-term adverse effects, especially on the plankton, but the ecosystem recovers very rapidly. EPA's permit program mitigates these adverse effects as much as possible. None of the environmental effects caused by waste disposal at the 106-Mile Site are irreversible or irretrievable.

4. Major alternatives considered.

The alternatives considered in this EIS are (1) no action, which would force the use of land-based methods or the shutdown of the waste producing manufacturing processes, and (2) use of another ocean site for these wastes--the New York Bight Acid Wastes Site, the Delaware Bay Acid Site, and the Northern and Southern Areas near the Hudson Canyon.

5. Comments have been requested from the following:

<u>Federal Agencies and Offices</u>

Council on Environmental Quality
Department of Commerce
- National Oceanic and Atmospheric Administration
- Maritime Administration

Department of Defense
- Army Corps of Engineers
- Office of the Oceanographer of the Navy
- Department of the Air Force

Department of Health, Education, and Welfare
Department of the Interior
- Fish and Wildlife Service
- Bureau of Outdoor Recreation
- Bureau of Land Management
- Geological Survey

Department of Transportation

Coast Guard

National Aeronautics and Space Administration

Water Resources Council

National Science Foundation

States and Municipalities

Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, Virginia

New York City, N.Y.; Camden, N.J.; Office of the Public Advocate, Trenton, N.J.; Philadelphia, Pa.

Private Organizations

National Wildlife Federation

American Eagle Foundation

Sierra Club

Environmental Defense Fund, Inc.

Resources for the Future

Water Pollution Control Federation

National Academy of Sciences

American Littoral Society

Center for Law and Social Policy

American Chemical Society

Manufacturing Chemists Association

Academic/Research Institutions

Lamont-Doherty Geological Observatory

University of Rhode Island

Woods Hole Oceanographic Institute

University of Delaware

New York State University

Rutgers University

6. The draft statement was officially filed with the Director, Office of Environmental Review, EPA, on or about June 22, 1979.

7. The 60-day review period for comments on the Draft EIS is estimated to begin on June 29, 1979.

Comments should be addressed to:

Mr. T.A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

Copies of the Draft EIS may be obtained from:

Environmental Protection Agency
Marine Protection Branch (WH-548)
Washington, D.C. 20460

Environmental Protection Agency
Region II
Surveillance and Analysis Division
Edison, N.J. 08817

The draft statement may be reviewed at the following locations:

Environmental Protection Agency
Public Information Reference Unit, Rm 2404 (rear)
401 M Street, SW
Washington, D.C.

Environmental Protection Agency
Region II
Library, Room 1002
26 Federal Plaza
New York, N.Y.

Environmental Protection Agency
Region II
Woodbridge Ave.
GSA Raritan Depot
Edison, N.J.

NOAA/MESA NY Bight Project
Old Biology Bldg.
State University of New York
Stony Brook, N.Y.

SUMMARY

DATE: June 1979

TYPE OF STATEMENT: Draft Environmental Impact Statement

RESPONSIBLE FEDERAL AGENCY: U.S. Environmental Protection Agency

ATTENTION: Mr. T.A. Wastler

Marine Protection Branch (WH-548)

Oil and Special Materials Control Division

U.S. Environmental Protection Agency

Washington, D.C. 20460

TYPE OF ACTION: Final designation of 106-Mile Chemical Waste Disposal Site

> This EIS serves several purposes: It primarily provides documentation of data and analysis necessary for the consideration of the supporting formal designation of the 106-Mile Chemical Waste Disposal Site for continued ocean waste disposal; secondly, it evaluates the types of industrial materials which may be disposed of at the site; in an environmentally sound manner; thirdly, it presents a rationale for consideration of the Site as an alternate site for the emergency disposal of sewage sludge; finally, the EIS provides guidance for the permitting authority to manage the site through the ocean dumping permit program.

ORGANIZATION OF THE ENVIRONMENTAL IMPACT STATEMENT

This EIS has several levels of detail. The Summary presents highlights of all the EIS chapters, and is written to permit the reader to achieve a level of understanding of the major points of the document, without reading the entire text. The main body of the text contains reduced technical information. Highlights from each chapter are summarized at the start of the chapter. Appendices contain supplemental technical information, and are included for the benefit of the reader who desires details. Reading the appendices is not necessary for an understanding of the rest of the document.

Chapter 1 specifies the purpose of and need for the proposed action and presents background material relevant to ocean waste disposal. It also describes the legal framework by which EPA selects, designates, and manages ocean waste disposal sites, and by which EPA grants ocean disposal permits for use of the sites.

Chapter 2 presents alternatives to designating the 106-Mile Site, outlines procedures by which alternatives were chosen and subsequently evaluated, and summarizes the relevant comparisons of all alternative site locations.

Chapter 3 describes the environments of the 106-Mile Site and the alternative sites. Descriptions of previous waste disposal activities are provided for alternative locations that have been historically used as disposal sites. Finally, other uses of the ocean at and near the site are evaluated.

Chapter 4 discusses the environmental consequences of all alternatives, including the proposed action. Chapter 5 discusses the feasibility of sewage sludge disposal at the 106-Mile Site, Chapter 6 lists the primary authors of the EIS, and Chapter 7 contains a glossary and list of references.

Several appendices are included: Appendix A is a compendium of environmental data and information on the 106-Mile Site; Appendix B discusses in detail current and historical waste disposal practices at the 106-Mile Site; and Appendix C provides information on present monitoring practices at the Site, and defines general guidelines for future site monitoring. Appendix D presents Chapter III of the Final Environmental Impact Statement on the ocean dumping of Sewage Sludge in the New York Bight (EPA, 1978), describing ocean dumping alternatives.

PROPOSED ACTION

EPA proposes to designate the 106-Mile Chemical Waste Disposal Site for continuing use. This action proposes to fulfill the need for a suitable location off the Middle Atlantic States for the disposal of certain wastes meeting the criteria for ocean disposal under the U.S. EPA's ocean dumping permit program. The criteria are based on a demonstrated need for ocean disposal over land-based alternatives and an evaluation of the potential impact on the marine environment.

As this EIS demonstrates, there is a need for ocean disposal of some chemical wastes and sewage sludge in the northeastern United States. This need comprises four categories of materials:

(1) Materials that meet the marine environmental impact criteria and whose land-based disposal alternatives are less acceptable than ocean disposal;

(2) Material that meets the impact criteria and for which land-based alternatives are under development;

(3) Materials that do not meet the impact criteria but for which land-based alternatives will be imposed by 1981; and

(4) Material which must be ocean dumped under emergency conditions, either because it represents a health hazard, or because no feasible alternative is available at the time of the emergency.

The 106-Mile Site was first used for waste disposal in 1961. In 1973, the Site was by EPA designated for disposal of industrial wastes on an interim basis, pending completion of trend assessment surveys. Designation of the Site for continued use will permit approved disposal of industrial wastes currently ocean dumped and will provide for a disposal site for new wastes judged acceptable for disposal.

Although over 100 industries have dumped wastes at the 106-Mile Site, only four industrial permittees remain: E.I. duPont de Nemours and Co. (Edge Moor and Grasselli plants), Merck and Co., and American Cyanamid Co. Of the four, DuPont-Edge Moor, Merck, and American Cyanamid are scheduled to cease ocean disposal by the end of 1981 when they will complete implementation of land-based alternatives. DuPont-Grasselli, the remaining permittee, will continue ocean disposal since no viable land-based alternatives to ocean disposal are presently available which are environmentally acceptable and its waste presently complies with EPA's marine environmental impact criteria.

Municipal sewage sludge also has been dumped at the 106-Mile Site. The City of Camden, New Jersey, utilized the Site during 1977 and 1978; also, small amounts of digester clean-out sludges from New York/New Jersey metropolitan area wastewater treatment plants are dumped there. Permitting future use of the site for additional sewage sludge disposal, will be considered only upon a finding by EPA that the New York Bight ("12-Mile") Sewage Sludge Disposal Site cannot safely accommodate any more sewage sludge without endangering public health or degrading coastal water quality.

OVERVIEW

Ocean dumping, particularly in the heavily populated northeast, has been used as an ultimate means of waste disposal for generations in the United States. Prior to the early 1970's, there was very little regulation of ocean waste disposal. Limited regulation was primarily provided by the New York Harbor Act of 1888, which empowered the Secretary of the Army to prohibit disposal of wastes, except for that flowing from streets and sewers, into the harbors of New York, Hampton Roads, and Baltimore. Additionally, the Refuse Act of 1899 prohibited the disposing of materials into navigable waters when disposal impeded safe navigation. Under these Acts, selection of disposal locations by the U.S. Army Corps of Engineers (CE) and the issuance of permits for ocean disposal were based primarily on transportation and navigation factors rather than environmental concerns.

Public interest in the effects of ocean disposal was aroused in 1969 and 1970 by a number of incidents involving the disposal of warfare agents in the ocean. Coincidentally, studies by the National Oceanic and Atmospheric Administration (NOAA) and several universities identified potential adverse effects of sewage sludge and industrial waste disposal in the New York Bight. Then, in its 1970 report to the President, the Council on Environmental Quality (CEQ) identified poorly regulated waste disposal in the marine environment as a potential environmental danger.

CEQ's report and the increasing public awareness of the potential undesirable effects of poorly regulated ocean waste disposal were largely responsible for the enactment of the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972, the primary U.S. legislation now regulating barged waste disposal in the ocean. In the fall of 1972, when it became apparent that Congress would promulgate an act to regulate ocean disposal, EPA began developing criteria for an effective technical base for the regulatory program. During the development of the technical criteria, EPA sought advice and counsel from its own marine scientists, as well as from marine specialists in universities, industries, environmental groups, and Federal and State agencies. These criteria were published in May 1973, finalized in October 1973, and revised in January 1977. The criteria are utilized in evaluating the need for ocean waste disposal and its potential impact on the marine environment.

Ocean disposal became an international topic of concern and discussion in this same period. An intergovernmental conference, held in London in the fall of 1972, developed the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. This Convention regulates ocean waste disposal at the inte national level with provisions for prohibited materials and regulation of dumping by participating nations. The MPRSA was amended in March 1977 to bring the national legislation into full compliance with the international Convention.

The EPA Ocean Dumping Regulations and Criteria contain provisions for selecting, designating, and managing ocean disposal sites, and for issuing permits to use the sites for waste disposal. Thirteen interim municipal and industrial waste disposal sites (most of them located in the U.S. midAtlantic) were listed in EPA's Final Ocean Dumping Regulations and Criteria published in January 1977. These existing sites will continue to be used for the disposal of specific materials on an interim basis, pending completion of baseline or trend assessment surveys, and ultimate designation for continuing use or termination of use. EPA is presently conducting trend assessment surveys, as needed, and preparing Environmental Impact Statements (EIS's) on most sites proposed for continued use. The subject of this EIS is the proposed designation of the 106-Mile Chemical Waste Disposal Site for continued use and a determination of the types and quantities of wastes which can be disposed of at the Site in an environmentally acceptable manner.

MAJOR ALTERNATIVES

The major alternatives to designation of the 106-Mile Site are: (1) no action, thereby forcing current permittees to use other disposal methods (primarily land-based), or forcing shutdown of activities which generate wastes presently dumped at the Site; and (2) use of an alternative ocean disposal site, either an existing site or a new one. The mid-Atlantic Continental Shelf and adjacent off-Shelf area were evaluated as potential alternative disposal site locations. As a result of this evaluation, four alternative locations were selected for detailed evaluation as possible alternative sites: the New York Bight Acid Wastes Disposal Site, the Delaware Bay (formerly DuPont) Acid Waste Disposal Site, the New York Bight Southern Area, and the New York Bight Northern Area (see Figure 2-1, Chapter 2.)

Use of each alternative site was evaluated for environmental acceptability, monitoring and surveillance requirements, associated economic burden, and logistics implications, and compared to use of the 106-Mile Site. As a result of this evaluation, the 106-Mile Site was assessed to be the best alternative. Currently (1979), eight municipal and industrial waste disposal sites (not counting dredged material disposal sites) exist in the mid-Atlantic area on the Continental Shelf. Six of these sites are in the New York Bight and two are near Delaware Bay. Only two of these existing sites (the New York Bight and Delaware Bay Acid Waste Sites) are considered to be viable alternatives to the 106-Mile Site. The remaining sites are used for disposal of other wastes (wood, wrecks, construction debris, and sewage sludge); none are used for industrial waste disposal. Since the remaining sites are small, located in heavily utilized areas, and because the disposal of chemical wastes, in combination with other types of material, is generally an undesirable practice, only the two existing industrial acid sites were examined in detail, in addition to the 106-Mile Site.*

Two new site locations on the mid-Atlantic Continental Shelf were also examined in detail: the so-called Northern and Southern Areas, located mid-way between the nearshore alternative sites and the 106-Mile Site. These areas have been extensively surveyed as prospective sites for sewage sludge disposal. A small portion of the Northern Area is now a designated alternate sewage sludge disposal site.

AFFECTED ENVIRONMENT

The 106-Mile Site is located in the mid-Atlantic just beyond the edge of the Continental Shelf. The site is oceanic in nature: it is deep (1,500 meters to 2,700 meters) and the water masses and biology of the area are more like the open ocean to the east than the coastal environment to the west. The bottom terrain is a vast plain sloping to the east, punctuated by several submarine canyons. The Site is currently used primarily for ocean disposal of industrial chemical wastes and is managed by EPA Region II.

From 1961 to 1978, approximately 5.1 million metric tons of chemical wastes, 102 thousand metric tons of sewage sludge, and 287 thousand metric tons of digester residue were dumped at this site. Environmental monitoring of the 106-Mile Site and surrounding areas have shown no impact of dumping on either the water quality or biology of the disposal area. Since the Site is oceanic, it is not highly productive biologically and supports no commercial or recreational fishery.

The New York Bight Acid Wastes Site and the Northern and Southern Areas are located in the New York Bight, over the Continental Shelf. The sites are shallow (25 to 53 meters) and the water and biota are characteristic of the

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* **Disposal of industrial and municipal wastes at the 106-Mile Site is only acceptable because the immense size of the Site is sufficient to prevent mixing of the wastes.**

shelf region. The Hudson Canyon separates the Southern and Northern Areas and terminates near the Acid Site. Potentially valuable biological resources exist near the Acid Site and Southern Area. Mineral resource development is occurring near the Southern Area as well. Waste disposal in the Acid Site and Southern Area may conflict with these other uses. Activities which may conflict with waste disposal operations are not expected to occur in the Northern Area.

Only the New York Bight Acid Wastes Site located 15 n mi offshore, has been used for ocean waste disposal. From 1958 to 1978, 45.2 million metric tons of acid and caustic wastes were released at this site. After numerous special studies and a continuing environmental monitoring program, adverse effects from waste disposal have not been demonstrated. The contaminant load of the New York Bight Apex is high from all the sources of contamination; therefore, effects from any one source of contamination are difficult to trace. Waste disposal has not occurred in either the Southern or Northern Areas, although the Alternate New York Sewage Sludge Site has been designated for use, if required, in a small section on the east edge of the Northern Area.

The Delaware Bay Acid Waste Site is located just south of the New York Bight, approximately 30 n mi off the Delaware coast. The Site is located on the Continental Shelf and is shallow (38 to 45 meters). The water and biota are typical for other mid-Atlantic Shelf regions. Bottom sediments are medium to fine sands and the relatively smooth topography is punctuated with sand ridges and swales. Valuable shellfish resources exist in and near the Site, however, their exploitation is currently restricted because the area is closed to shellfishing. The Philadelphia Sewage Sludge Site is located only 5 n mi south. From 1973 to 1977, 2.3 million metric tons of DuPont-Edge Moor acid wastes were released at the site; it has been inactive since March 1977 when DuPont's dumping was transferred to the 106-Mile Site. Environmental studies and monitoring for impacts of acid disposal on the environment have been inconclusive. Preliminary studies identified elevated vanadium concentrations in shellfish from the Site vicinity.

ENVIRONMENTAL CONSEQUENCES

The environmental consequences from the disposal of industrial wastes at the proposed site and all alternative sites were assessed. Although some uncertainty of the environmental effects of waste disposal at the 106-Mile Site still exists (even after several years of monitoring and research studies), the 106-Mile Site is identified as the best alternative for several reasons:

- The depth of water and physical environment of the Site allow significant dilution and dispersion of aqueous wastes, and thereby prevent wastes from reaching the bottom in measurable concentrations.
- The Site is not located near any significant commercial or recreational fishery, so aqueous wastes released at the Site will not endanger fishery resources, or endanger human health, by contaminating edible fish or shellfish.
- The reduced biological productivity beyond the Continental Shelf, (as compared to on the Shelf), makes disposal at an off-Shelf site less likely to affect indigenous organisms.
- An extensive data base exists for predicting the effects of future waste disposal at the Site. Over the last six years, several Federal agencies, academic institutions, and industrial groups have studied the 106-Mile Site and the consequences of past disposal activities.
- Because non-dumping uses of the Site and vicinity are limited, designation of the Site for continued dumping will not interfere with the conduct of other activities.

Known negative consequences of ocean disposal are expected at the 106-Mile Site; however, these negative factors (primarily economic), do not outweigh the potential negative environmental consequences of using alternative sites:

- The extreme distance of the 106-Mile Site from ports requires the use of vessels for disposal and monitoring with extended sea-going capability. Also, increased wages, fuel costs, and other operating expenses, make waste disposal at a distant site economically disadvantageous for waste generators, compared to disposal at nearshore sites.

- Unless automatic surveillance is developed and implemented, surveillance at the 106-Mile Site will require a greater commitment of manpower, since this site is outside of the range of normal patrol ship and aircraft surveillance activities.

- Laboratory and field studies indicate that acute short-term mortality of sensitive plankton will occur upon immediate discharge of wastes; however, mortality will be mitigated by the rapid dilution and dispersion of wastes in seawater within the Site. This impact of disposal is not unique to the 106-Mile Site; it would occur at any ocean disposal site.

SEWAGE SLUDGE DISPOSAL

The feasibility of using the 106-Mile Site for municipal sewage sludge disposal is addressed as a special case. While it is acknowledged that the only reasonable long-term solution for disposal of harmful sewage sludge is through land-based processes, adverse conditions at the existing New York Bight Sewage Sludge Site could require moving sludge disposal to another site. Effects of past sludge disposal at The 106-Mile Site and at other sludge disposal sites were evaluated to provide a basis for determining impacts from future sludge disposal at the 106-Mile Site. On this basis, sludge disposal at the Site is determined to be feasible under certain restrictions.

RECOMMENDATIONS

After carefully evaluating all reasonable alternatives, EPA recommends that the 106-Mile Chemical Waste Disposal Site receive final designation for continued industrial waste disposal in accordance with the EPA Ocean Dumping Regulations and Criteria. However, in keeping with the MPRSA, exploration of alternatives to ocean disposal should continue, and such research and development should be a condition imposed on waste generators receiving ocean disposal permits.

Industrial wastes permitted for disposal at the Site should have the following characteristics:

- Aqueous, with concentrations of solids generally less than 1 percent
- Neutrally or slightly negatively buoyant in seawater
- Demonstrate low toxicity to representative planktonic and demersal marine organisms
- Contain no materials prohibited by the MPRSA
- Contain constituents in concentrations that are dispersed within 4 hours after discharge in the surrounding water so as not to be detectable outside of the site in concentrations above ambient.
- Dischargeable from a vessel underway, to enable rapid and immediate dilution.

Each waste load should be sufficiently small to permit adequate dispersal of the waste constituents prior to disposal of the next load, so that accumulation of waste materials does not occur with successive dumps. Vessels releasing wastes concurrently should be located in different quadrants of the site to provide for maximum dilution of wastes within the site boundaries.

It is recommended that all future permits contain the following conditions:

1. Independent shiprider surveillance of all disposal operation will be conducted by either the USCG or USCG auxiliary (the latter at permittee's expense).

2. Comprehensive monitoring for long-term impacts will be accomplished by Federal agencies and for short-term impacts by environmental contractors (the latter at permittee's expense). All monitoring studies are subject to EPA approval. Short-term monitoring should include laboratory studies of waste characteristics and toxicity,

and field studies of waste behavior upon discharge and its effect on local organisms. Long-term monitoring should include studies of chronic toxicity of the waste at low concentrations and field studies of the fate of materials, especially any particulates formed after discharge, in the waste.

3. EPA will enforce a discharge rate based on the limiting permissible concentration, disposal in quadrants of the Site, and maintenance of a 0.5 n mi separation distance between vessels.

4. Key constituents of the waste will be routinely analyzed in waste samples at a frequency to be determined by EPA on a case-by-case basis, but sufficient to accurately evaluate mass loading at the Site.

5. Routine bioassays will be performed on waste samples using appropriate sensitive marine organisms.

It is further recommended that use of the Site for sewage sludge disposal be decided by EPA case-by-case, on the basis of severity of need. Any permit issued should include provisions for adequate monitoring and surveillance to ensure against significant adverse impacts resulting from disposal. Sludge disposal should be allowed at the Site only under the following conditions:

- The existing New York Bight Sewage Sludge Site cannot safely accommodate more sludge disposal without endangering public health, severely degrading the marine environment, or degrading coastal water quality.

- Independent surveillance by the U.S. Coast Guard or USCG Auxiliary (the latter at the permittee's expense) be conducted.

- Monitoring for short- and long-term impacts be accomplished by Federal agencies and environmental contractors (the latter at the permittee's expense). This monitoring must include studies of the fate of solids and sludge microorganisms, both inside and outside of the Site, in addition to a comprehensive analysis of environmental effects.

- Vessels discharge the sludge into the wake so that maximum turbulent dispersion occurs.

- Vessels discharging sludge be separated from vessels discharging chemical wastes so that the two types of wastes do not mix.

- Key constituents of the sludge be routinely analyzed in barge samples at a frequency to be determined by EPA on a case-by-case basis, but sufficient to accurately evaluate mass loading at the Site.

- Routine bioassays be performed on sludge samples using appropriate sensitive marine organisms.

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APPENDICES

ILLUSTRATIONS

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Chapter 1

PURPOSE OF AND NEED FOR ACTION

Because of the need for an ocean disposal site, due to the unavailability of land-based disposal methods for some waste materials, EPA proposes to designate the 106-Mile Chemical Waste Disposal Site in the Atlantic Ocean for waste dumping according to the January 11, 1977, EPA Ocean Dumping Regulations and Criteria. This Chapter provides background information on the purpose of and need for the proposed action of designating this site. It sets the stage in terms of defining the action, the location of the proposed site, and the legal regime for identifying and establishing viable options.

Use of the ocean for waste disposal has been practiced for generations on an international scale. In the early 1970's, U.S. legislation and international agreements were enacted to control waste disposal into the marine environment. The number of industries and municipalities utilizing the ocean for waste disposal has decreased dramatically since passage of this legislation, as a result of the development of land-based alternatives. However, some industries and municipal waste treatment facilities produce wastes that cannot, using current technology, be treated or disposed of safely or economically on land, but can be disposed of in the ocean without seriously degrading the marine environment. Most of this waste-generating activity is centered around the heavily populated and industrialized East Coast. To help safely accommodate this need for ocean waste disposal, the U.S. Environmental Protection Agency (EPA) proposes to designate the 106-Mile Chemical Waste Disposal Site (hereafter 106-Mile Site) for continued use.*

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*The 106-Mile Site has also been known as Chemical Waste Site, Deepwater Dumpsite 106, Toxic Chemical Site, Industrial Waste Site.

The 106-Mile Site has been used intermittently for ocean disposal since 1961. A wide variety of waste materials have been released at the site and vicinity: among these are munitions, radioactive materials, acid, nonspecific chemical wastes, sewage sludge, and residues from sewage sludge digesters. In 1973, EPA designated the site primarily for the disposal of industrial chemical wastes on an interim basis until studies of the effects of waste disposal at the site were conducted. These monitoring studies have been underway since the spring of 1974. After five years of intensive study effort, no significant adverse effects have been demonstrated from disposal of any of the waste materials.

Over 100 different dumpers have utilized the 106-Mile Site for waste disposal since 1961. Now only four permittees are using the Site (E.I. duPont de Nemours and Co. (Edge Moor and Grasselli plants), Merck and Company, Inc., and American Cyanamid Co.) Despite this large decrease in ocean disposal activity at the Site, a present and future need exists for its continued use. The reasons for this continuing need are four-fold: (1) although three of the four current permittees (DuPont-Edge Moor, American Cyanamid, and Merck) will cease ocean disposal within the next two years, they must continue to ocean dispose their wastes while alternative land-based disposal methods are under development; (2) DuPont-Grasselli produces wastes which cannot be disposed of by land-based methods, but which can be dumped safely at the 106-Mile Site without degrading the environment; (3) some municipal permittees, who have been disposing of their sewage sludge at other sites, may have to move their ocean disposal operations to the 106-Mile Site if public health is endangered or marine water quality at the existing 12-Mile Site is severely degraded; and (4) a site of known environmental characteristics is required for disposal of some wastes under emergency conditions.

By January 1, 1982 only wastes that can be demonstrated to comply with EPA's environmental impact criteria and cannot be discarded on land, will be permitted to be disposed of in the ocean. For the short term, however, while land-based disposal methods are being developed, some industrial chemicals and sewage sludge must continue to be disposed of in the ocean, even though these materials have not been demonstrated to meet the impact criteria. Neither Merck, American Cyanamid, nor the municipal sludge permittees have demonstrated compliance with the impact criteria; however, because they have demonstrated an adequate need to ocean dump, accompanied by a schedule for developing suitable land-based alternatives, these dumpers are permitted to use the ocean for waste disposal on an interim basis.

As part of its decision-making process on whether to propose designating the 106-Mile Site for continued use, EPA has investigated all reasonable alternatives to using the 106-Mile Site. Two broad categories of alternatives exist: (1) take no action, thereby forcing the use of other disposal methods, or, in the event that other disposal methods are unavailable, causing cessation of the waste-producing processes; or (2) designate and use another ocean location for disposing of these wastes. After a careful review of the alternatives, EPA has determined that designation of the 106-Mile Site for continued use is the most favorable course of action.

Therefore, based upon the continued need for ocean disposal, the lack of any significant adverse impact as determined by the monitoring studies conducted at the Site, and the lack of a better alternative to designating this particular site, EPA proposes to designate the 106-Mile Site for continued use. Continued use of the Site will allow approved dumping of the wastes released at the Site under current ocean dumping permits and will provide for the disposal of new wastes which the EPA deems acceptable for ocean disposal. EPA Region II will manage the Site; regulate times, rates, methods of disposal, and quantities and types of materials disposed; develop and maintain effective monitoring programs for the Site; conduct disposal site evaluation studies; and recommend modifications in Site use or designation as necessary.

FEDERAL LEGISLATION AND CONTROL PROGRAMS

Prior to the early 1970's, there was very little regulation of ocean waste disposal. Limited regulation was primarily provided by the New York Harbor Act of 1888, which empowered the Secretary of the Army to prohibit disposal of wastes, except for that flowing from streets and sewers, into the harbors of New York, Hampton Roads, and Baltimore. Additionally, the Refuse Act of 1899 prohibited the disposing of materials into navigable waters when disposal impeded safe navigation. Under these Acts, selection of disposal locations by the U.S. Army Corps of Engineers (CE) and the issuance of permits for ocean disposal were based primarily on transportation and navigation factors rather than environmental concerns.

Public interest in the effects of ocean disposal was aroused in 1969 and 1970 by a number of incidents involving the disposal of warfare agents in the ocean. Coincidentally, studies by the National Oceanic and Atmospheric Administration (NOAA) and several universities identified potential adverse effects of sewage sludge and industrial waste disposal in the New York Bight. Then, in its 1970 report to the President, the Council on Environmental Quality (CEQ) identified poorly regulated waste disposal in the marine environment as a potential environmental danger.

CEQ's report and the increasing public awareness of the potential undesirable effects of poorly regulated ocean waste disposal were largely responsible for the enactment of the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972, the primary U.S. legislation now regulating barged waste disposal in the ocean. In the fall of 1972, when it became apparent that the Congress would promulgate an act to regulate ocean disposal, EPA began developing criteria for providing an effective technical base for the regulatory program. During the development of the technical criteria, EPA sought advice and counsel from its own marine scientists, as well as from marine specialists in universities, industries, environmental groups, andd Federal and State agencies. These criteria were published in May 1973, finalized in October 1973, and revised in January 1977. The criteria are utilized in evaluating the need for ocean waste disposal and its potential impact on the Marine environment.

Despite legislation dating back almost 100 years for controlling waste disposal into rivers, harbors, and coastal waters, ocean waste disposal was not specifically regulated in the United States until passage in October 1972 of the Marine Protection, Research, and Sanctuaries Act (MPRSA, PL 92-532, as amended). To enable better understanding of this important legislation, it is discussed here in detail together with other relevant Federal legislation, Federal control programs initiated by MPRSA, and EPA programs for ocean disposal site designation and issuance of ocean disposal permits.

The Clean Water Act (CWA) of 1977 (PL 95-217), which amended and replaced earlier legislation, established a comprehensive regulatory program for controlling discharge of pollutants from outfalls into navigable waters of the United States, including ocean waters. The primary objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. CWA regulates discharges through the promulgation of criteria to prevent degradation of the marine environment (Section 403), and the application of the criteria in the issuance of permits (Section 402). Thus, CWA and MPRSA are the primary Federal legislative means for controlling ocean waste disposal, whether through use of ocean outfalls or offshore disposal sites.

MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

The MPRSA regulates the transport via vessel, and ultimate dumping of waste 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 with Title I specifically Section 102(c), which charges EPA with the responsibility for designating sites or times for dumping.

Title I, the primary regulatory vehicle of the Act, establishes the permit program for the disposal of dredged and non-dredged materials, mandates determination of impacts, and provides for enforcement of permit conditions. Through Title I, the Act provides a mechanism for regulating ocean disposal of waste originating from any country into ocean waters under the jurisdiction or control of the United States. Likewise any transport for dumping in U.S. waters requires a permit. In addition, Title I requires that a permit be obtained by any person of any nationality wishing to transport waste material from any U.S. port or under a U.S. flag with the intention of disposing of it anywhere in the world's oceans.

Title I prohibits the dumping in ocean waters of certain wastes, among them biological, radiological, and chemical warfare agents, and all high-level radioactive wastes. Title I was amended in November 1977 (PL 95-153*) to further prohibit dumping of harmful sewage sludge after December 31, 1981. The provisions of Title I include criminal fines of $50,000 maximum and jail sentences of up to one year for every unauthorized dump or violation of permit requirement, and a civil fine of $50,000 maximum. Any individual may seek an injunction against an unauthorized dumper with possible recovery of all costs of litigation.

Title II of MPRSA provides for comprehensive research and monitoring of ocean dumping effects on the marine environment. Under Title II, The National Oceanic and Atmospheric Administration's (NOAA's) ocean dumping program has conducted extensive survey and laboratory investigations over the past several years at ocean waste disposal sites in the North Atlantic Ocean. This work aids EPA in its management of sites by providing data for site use decisions.

Several Federal departments and agencies share responsibility under the Act (Table 1-1). The major responsibility is mandated to EPA to review, grant, and enforce dumping permits for all wastes except dredged materials, and to designate and manage all disposal sites. In October 1973 EPA implemented its responsibility for regulating ocean dumping under MPRSA by issuing final Ocean Dumping Regulations and Criteria (hereafter the "Ocean Dumping Regulations"), which were revised in January 1977 (40 CFR, Parts 220 to 229). These regulations established procedures and criteria for: designating and managing ocean disposal sites (Part 228); reviewing ocean disposal permit applications and assessing impacts of ocean disposal and alternative disposal methods (Part 227); and enforcing permits. Interim disposal sites were authorized pending final designation for continuation or termination of use. The 106-Mile Site was one of 13 municipal and industrial sites approved for interim use.

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* Harmful sewage sludge is defined by PL 95-153 as sewage sludge that "may significantly degrade or endanger human health, welfare and amenities, the marine environment and ecological systems, or economic potential."

TABLE 1-1. RESPONSIBILITIES OF FEDERAL DEPARTMENTS AND AGENCIES FOR REGULATING OCEAN WASTE 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
U.S. Department of the Army Corps of Engineers	Issuance of dredged material disposal permits
U.S. Department of Transportation Coast Guard	Surveillance
U.S. Department of Commerce National Oceanic and Atmospheric Administration	Long-term monitoring and research Marine sanctuary designation
U.S. Department of Justice	Court actions
U.S. Department of State	International agreements

The U.S. Army Corps of Engineers (CE) issues permits for disposal of dredged material after determining compliance of the material with EPA's environmental impact criteria (40 CFR 227). Compliance with the criteria is subject to EPA's concurrence. Although the CE is responsible for evaluating disposal applications and granting permits to dumpers of dredged materials, dredged material disposal sites are designated and managed by EPA.

Under MPRSA, the U.S. Coast Guard (USCG) is assigned responsibility for conducting surveillance of disposal operations to ensure compliance with the permit conditions and to discourage unauthorized disposal. Violations are referred to EPA for enforcement. Surveillance is accomplished through spot checks of disposal vessels for valid permits; interception or escorting of dump vessels; use of shipriders; aircraft overflights during dumping; and random surveillance missions at land facilities. In addition, the USCG is testing the applicability of an automatic Ocean Dumping Surveillance System (ODSS), based on electronic navigation. This system has been field-tested, and is currently being evaluated by the USCG for future use in routine surveillance. For the present, shipriders are the primary means of surveillance at the 106-Mile Site.

Under Title II of MPRSA, NOAA conducts comprehensive monitoring and research programs on the effects of ocean dumping on the marine environment, including potential long-term effects of pollution, over-fishing, and man-induced changes in oceanic ecosystems. Some of the responsibility for conducting field investigations of ocean disposal effects has been shared by EPA. Title III of MPRSA authorizes NOAA to designate coastal marine sanctuaries, after consultation with other affected federal agencies, and to regulate all activities within these sanctuaries.

The Department of Justice initiates relief actions in court, at EPA's request in response to violations of the terms of MPRSA. When necessary, injunctions to cease ocean dumping are sought. Criminal fines, as well as jail sentences, may be levied, based on the magnitude of the violation.

The Department of State seeks effective international action and cooperation in protecting the marine environment by negotiating international agreements furthering the goals of MPRSA. Perhaps the most significant international negotiation regarding ocean dumping is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (hereafter "the Convention" or "the Ocean Dumping Convention," which is discussed later in this chapter).

The MPRSA has been amended several times since its enactment in 1972, and most amendments concern annual appropriations for administration of MPRSA.

However, two of the amendments are noteworthy. Passage of an amendment in March 1974 (PL 93-254), brought the Act into full compliance with the Convention. Also, an amendment (PL 95-153) passed in November 1977, prohibits disposal of harmful sewage sludge in ocean waters after December 31, 1981.

OCEAN DISPOSAL SITE DESIGNATION

Under Section 102(c) of the MPRSA, the EPA Administrator is authorized to designate sites and times for ocean disposal, provided that the waste does not contain prohibited materials and will not significantly degrade, or endanger, human health, welfare, and amenities, the marine environment and ecological systems, or economic potential. In response to this mandate, EPA established criteria for designating sites in its Ocean Dumping Regulations and Criteria (Part 228). These include criteria for site selection and procedures for designating the sites for disposal. General criteria for selection of sites, as provided in the Regulations, are:

(a) 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, particularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation.

(b) Locations and boundaries of disposal sites will be so chosen that temporary perturbations in water quality or other environmental conditions during initial mixing caused by disposal operations anywhere within the site can be expected to 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.

(c) If at anytime during or after disposal site evaluation studies, it is determined that existing disposal sites presently approved on an interim basis do not meet the criteria for site selection set forth in [Section] 228.5 to 228.6, the use of such sites will be terminated as soon as suitable alternate disposal sites can be designated.

(d) 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-term impacts. The size, configuration, and location of any disposal site will be determined as a part of the disposal site evaluation or designation study.

(e) EPA will, wherever feasible, designate ocean dumping sites beyond the edge of the continental shelf, and other such sites that have been historically used [Section 228.5].

Factors considered under the specific criteria for site selection relate more closely with conditions at the proposed sites by treating the general criteria in additional detail. If a proposed site can satisfy the specific criteria for site selection, it can meet the broader general criteria. The factors to be considered are:

- Geographical position, depth of water, bottom topography and distance from coast;
- Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases;
- Location in relation to beaches and other amenity areas;
- Types and quantities of wastes proposed to be disposed of and proposed methods of release, including methods of packing the waste, if any;
- Feasibility of surveillance and monitoring;
- Dispersal, horizontal transport and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any;
- Existence and effects of current and previous discharges and dumping in the area (including cumulative effects);
- Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance, and other legitimate uses of the ocean;
- The existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys;
- Potentiality for the development or recruitment of nuisance species in the disposal site;
- Existence at or in close proximity to the site of any significant natural or cultural features of historical importance [Section 228.6].

These factors are addressed for the 106-Mile Site in Chapter 2. (See p. 2-4, Chapter 2.)

Once designated, the site must be monitored for adverse impacts of waste disposal. EPA monitors the following types of effects in determining to what extent the marine environment has been affected by material released at the site:

- Movement of materials into estuaries or marine sanctuaries, or onto oceanfront beaches, or shorelines;
- Movement of materials toward productive fishery or shellfishery areas;
- Absence from the disposal site of pollution-sensitive biota characteristic of the general area;
- Progressive, non-seasonal, changes in water quality or sediment composition at the disposal site, when these changes are attributable to materials disposed of at the site;
- Progressive, non-seasonal, changes in composition or numbers of pelagic, demersal, or benthic biota at or near the disposal site, when these changes can be attributed to the effects of materials disposed of at the site;
- Accumulation of material constituents (including without limitation, human pathogens) in marine biota at or near the site [Section 228.10b].

EPA has established impact categories in its Ocean Dumping Regulations (Section 228.10) which specify impacts detected through site monitoring that require modifications in use of the disposal site:

> IMPACT CATEGORY I: The effects of activities at the disposal site shall be categorized in Impact Category I when one or more of the following conditions is present and can reasonably be attributed to ocean dumping activities:
>
> - There is identifiable progressive movement or accumulation, in detectable concentrations above normal ambient values, of any waste or waste constituent from the disposal site within 12 nautical miles of any shoreline, marine sanctuary designated under Title III of the Act, or critical area designated under Section 102 (c) of the Act; or

- The biota, sediments, or water column of the disposal site, or any area outside the disposal site where any waste or waste constituent from the disposal site is present in detectable concentrations above normal ambient values, are adversely affected by the toxicity of such waste or waste constituent to the extent that there are statistically significant decreases in the populations of valuable commercial or recreational species, or of specific species of biota essential to the propagation of such species, within the disposal site and such other area as compared to populations of the same organisms in comparable locations outside such site and area; or

- Solid waste material disposed of at the site has accumulated at the site or in areas adjacent to it, to such an extent that major uses of the site or of adjacent areas are significantly impaired and the Federal or State agency responsible for regulating such uses certifies that such significant impairment has occurred and states in its certificate the basis for its determination of such impairment; or

- There are adverse effects on the taste or odor of valuable commercial or recreational species as a result of disposal activities; or

- When any toxic waste, toxic waste constituent, or toxic byproduct of waste interaction, is consistently identified in toxic concentrations above normal ambient values outside the disposal site more than four hours after disposal.

IMPACT CATEGORY II: The effects of activities at the disposal site which are not categorized in Impact Category I shall be categorized in Impact Category II [Section 228.10c].

OCEAN DUMPING PERMIT PROGRAM

EPA's Ocean Dumping Regulations also establish a program for the application, evaluation, and issuance of ocean dumping permits. Once a site is selected and duly designated, permits for the use of the site can be issued by the EPA or CE permitting authority having jurisdiction over that site. The Ocean Dumping Regulations are specific about the mechanism used in evaluating permit applications and granting or denying such applications. EPA and the CE evaluate permit applications principally to determine whether there is (1) a demonstrated need for ocean disposal and that no other reasonable alternatives exist (40 CFR 227 Subpart C); and (2) compliance with the environmental impact criteria (40 CFR 227 Subpart B, D, and E).

Compliance with EPA's environmental impact criteria also ensures that the proposed waste disposal will not "unduly degrade or endanger the marine environment" and ensures that this disposal will not cause unacceptable adverse effects on human health, the marine ecosystem, or other uses of the ocean. The criteria are too lengthy to quote; however, the relevant points are briefly summarized here.

- Prohibited Materials: High-level radioactive wastes; materials produced for radiological, chemical, or biological warfare; unknown materials; persistent floatable materials that interfere with other uses of the ocean.

- Materials present as trace contaminants only: Organohalogens; mercury and mercury compounds; cadmium and cadmium compounds; oil; known or suspected carcinogens, mutagens, or teratogens.

- Trace contaminants in the liquid fraction do not exceed the marine water quality criteria (EPA, 1976) or exist in nontoxic and nonbioaccumulative form.

- Bioassays on the suspended particulate or solid fractions do not indicate occurrence of significant mortality or significant adverse sublethal effects, including bioaccumulation due to waste dumping.

- When bioassay methods are unavailable: Maximum concentrations of mercury and cadmium apply; organohalogen concentrations must be less than is known to be toxic to organisms; oils in the waste must not produce a visible sheen on the water.

- Trace contaminants do not render edible marine organisms unpalatable or endanger health of humans, domestic animals, shellfish, or wildlife.

Six types of ocean dumping permits may be issued: Interim, Special, General, Emergency, Research, and Incineration at Sea. With few exceptions, EPA has issued only Interim Permits. These permits are valid for one year maximum and are issued when the permittee cannot demonstrate compliance of the waste with the environmental impact criteria and can demonstrate that the need for ocean disposal is of greater significance to the public interest than possible adverse environmental impact. Moreover, Interim Permits cannot be issued to applicants who were not issued dumping permits prior to April 23, 1978. Holders of present Interim Permits must have a compliance schedule which will allow either the complete phaseout of ocean dumping or compliance with the environmental impact criteria by December 31, 1981. After that date, EPA will not issue Interim Permits and ocean disposal of harmful wastes will cease. At the 106-Mile Site, American Cyanamid and Merck are dumping under Interim Permits.

Special Permits, which are issued when the applicant can adequately demonstrate compliance of the wastes with the environmental impact criteria and can demonstrate a need for ocean disposal, may be issued for a maximum of three years and holders of Special Permits are not subject to the 1981 deadline for cessation of the ocean disposal of harmful wastes. Some industrial permittees and all CE permittees have been granted Special Permits. Specifically, at the 106-Mile Site, DuPont-Edge Moor and DuPont-Grasselli are holders of Special Permits.

General Permits may be issued for ocean disposal of small amounts of materials which will have minimal adverse effects on the environment. Examples of materials which warrant a General Permit include human remains or ashes for burial at sea, target vessels for ordnance testing, and derelict vessels transported for scuttling.

Emergency Permits may be issued for ocean disposal of materials which pose an unacceptable risk to human health and for which there is no other reasonable disposal technique. Emergency Permit requests are considered case-by-case by EPA on the basis of the waste's characteristics and the safest means for its disposal.

Research Permits may be issued for dumping material into the ocean as part of a research project when the scientific merit of the project outweighs the potential adverse impacts of the dumping. EPA designates the disposal site(s) to be used by Research Permit holders on the basis of the nature of the study project.

Incineration-at-Sea Permits are either Research, Interim, or Special permits. Current Incineration-at-Sea permits are Special Permits that are issued for disposal at the New York Bight Wood Incineration Site. As Special Permits, they are issued for a maximum of three years. Burning is conducted under controlled weather conditions and the ash is transported back to shore and used as land-fill. Research and Interim Permits have also been issued for the incineration of organochlorine wastes.

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 (Ocean Dumping Convention), which became effective in August 1975, upon ratification by 15 contracting countries. Designed to control dumping of wastes in the oceans, the Convention specifies that contracting nations will regulate disposal in the marine environment within their jurisdiction, disallowing all disposal without permits. Certain other hazardous materials are prohibited, such as biological and chemical warfare agents and high-level radioactive matter. Certain other materials (such as cadmium, mercury, organohalogens and their compounds, oil, and persistent synthetic materials that float) are also prohibited, except when present as trace contaminants. Other materials--arsenic, lead, copper, zinc, cyanide, fluoride, organosilicon, and pesticides--while not prohibited from ocean disposal, require special care. Permits are required for at-sea disposal of materials not specifically prohibited. The nature and quantities of all waste 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.

Chapter 2

ALTERNATIVES INCLUDING THE PROPOSED ACTION

Some chemical waste products from industrial processes cannot be disposed of using land-based methods, but can be safely dumped in the ocean while land-based disposal alternatives are being developed. Therefore, a suitable ocean location is necessary for disposal of these wastes. EPA investigated four alternative waste disposal locations in addition to the 106-Mile Site and evaluated them for environmental acceptability, ease of environmental monitoring and surveillance, economic burden, and logistics. Based on this evaluation, the 106-Mile Site was determined to be the best location for disposal of the chemical wastes under consideration.

Use of the 106-Mile Site for sewage sludge disposal is technically feasible and, under suitable conditions, the Site could provide an alternate location for the short-term disposal of sewage sludge.

In accordance with the Council on Environmental Quality (CEQ) recommended format, this chapter is the heart of the Environmental Impact Statement. It is based on the information and analyses presented in the other chapters and appendices, particularly the chapters on the Affected Environment (Chapter 3) and the Environmental Consequences (Chapter 4).

This Chapter specifically discusses the following alternatives:

- No Action
- Continued use of the 106-Mile Site (the proposed action)
- Use of the New York Bight Acid Wastes Disposal Site
- Use of the Delaware Bay Acid Waste Disposal Site
- Use of a new site on the Continental Shelf
  - Southern Area
  - Northern Area
- Use of a new site off the Continental Shelf

It presents "the environmental impacts of the [proposed action] and the alternative sites in comparative form, thus sharply defining the issues, and providing a clear basis for choice among options by the decision-maker and the public."

The following factors form the basis for comparison between alternative locations for the waste disposal proposed at the 106-Mile Site:

- Environmental acceptability
- Ease of monitoring
- Ease of surveillance
- Economic burden
- Logistical problems

This EIS does not specifically address land-based alternatives to ocean disposal because feasibility of using land-based disposal processes is assessed on a case-by-case basis as part of EPA's ocean dumping permit process. For example, Merck, American Cyanamid, and DuPont-Edge Moor, currently authorized to dump wastes at the 106-Mile Site, are only using ocean disposal while they develop land-based processes that permit them to reclaim the wastes or to dispose of them. On the other hand, current technology is inadequate to supply land-based disposal alternatives for DuPont-Grasselli's waste. Since DuPont-Grasselli has demonstrated that its waste meets EPA's environmental impact criteria, EPA has authorized disposal of this waste at the 106-Mile Site with the stipulation that DuPont continue to seek land-based alternatives for the waste.

Use of the 106-Mile Site as an alternate site for sewage sludge disposal was addressed in the Final EIS on The Ocean Dumping of Sewage Sludge in the New York Bight (U.S. EPA, 1978). This EIS presents additional considerations about the environmental acceptability of sewage sludge at the 106-Mile Site (Chapter 5) and includes Chapter III--Alternatives to the Proposed Action--of the earlier EIS as Appendix D. Land-based alternatives are also discussed in Appendix D.

NO ACTION ALTERNATIVE

The No Action alternative would result in canceling or postponing the designation of an industrial waste disposal site off the Middle Atlantic States, thus requiring disposal of industrial wastes by other means, or, if other means of disposal were unavailable, would require termination of the waste-producing processes. This alternative would only be feasible under limited conditions; e.g., (1) existence of technologically, environmentally, and economically feasible land-based disposal methods; and (2) evidence that ocean disposal causes sufficiently adverse environmental consequences to preclude it from consideration. Neither of these "No Action" conditions are pertinent to proposed waste disposal at the 106-Mile Site.

In Chapter 1, a need was established for designating the 106-Mile Site for continued use. EPA evaluates the feasibility of land-based disposal methods when evaluating applications for ocean dumping permits, and permits are not issued if a waste can be disposed of safely on land. Therefore, the present 106-Mile Site permittees have adequately demonstrated that land-based disposal is currently unfeasible for their wastes. The consequences of terminating the waste generation, because no disposal methods were available, would be dramatic. In the case of American Cyanamid, for example, shut-down of its Warners plant would result in the direct loss of 850 jobs, valued at $14,000,000 annually (Reid, 1978). The impact would not only be economic. American Cyanamid is the sole U.S. producer of malathion, a non-persistent insecticide, widely used for protection of crops and eradication of several disease-causing insects. Termination of malathion production would be felt around the world. Shut-down of any of the other permittees could also result in severe consequences.

Most important, there is no evidence that ocean disposal at the 106-Mile Site causes long-term adverse environmental consequences. (This subject is treated in more detail in Chapter 4.) Numerous monitoring studies, conducted since 1974, have shown that the wastes are quickly diluted and dispersed. Plants and animals at the site experience only short-term adverse effects while the dumping operation is underway.

CONTINUED USE OF THE 106-MILE SITE

The proposed action is to continue use of the 106-Mile Site for waste disposal. This section summarizes anticipated impacts, forming the basis for comparison with the other alternatives (discussed later in this chapter).

The 106-Mile Site was established in 1965 for the disposal of industrial wastes not suitable for land disposal. It is located 196 kilometers (160 n mi) southeast of Ambrose Light, New York, and 167 kilometers (90 n mi) east of Cape Henlopen, Delaware (Figure 2-1). The Site covers 1,648 square kilometers on the Continental Slope and Continental Rise, and its latitude and longitude are 38°40'N to 39°00'N, and 72°00'W to 72°30'W, respectively. Water depths at the site range from 1,440 meters (in the topographically rugged northwest corner) to 2,750 meters (in the relatively flat southeast corner). An inactive munitions waste disposal site is located within the Site boundaries, and an inactive radioactive waste disposal area is located 9 kilometers due south.

NOAA, assisted by other Government agencies and academic institutions, has been surveying this site for many years, and has published its observations in two summary reports (NOAA, 1975; 1977), several memoranda, public hearing testimony, and in its annual report to Congress (NOAA, 1978). A private contractor, acting on behalf of the permittees, has been monitoring the site for two years.

ENVIRONMENTAL ACCEPTABILITY

Continued use of the 106-Mile Site for Waste disposal would not directly endanger public health since the Site is not located in a commercially or recreationally important fishing or shellfishing area. Limited Foreign fishing does occur in the Site vicinity, but the organisms caught are highly migratory, and hence not likely to be contaminated by waste disposal at the Site.

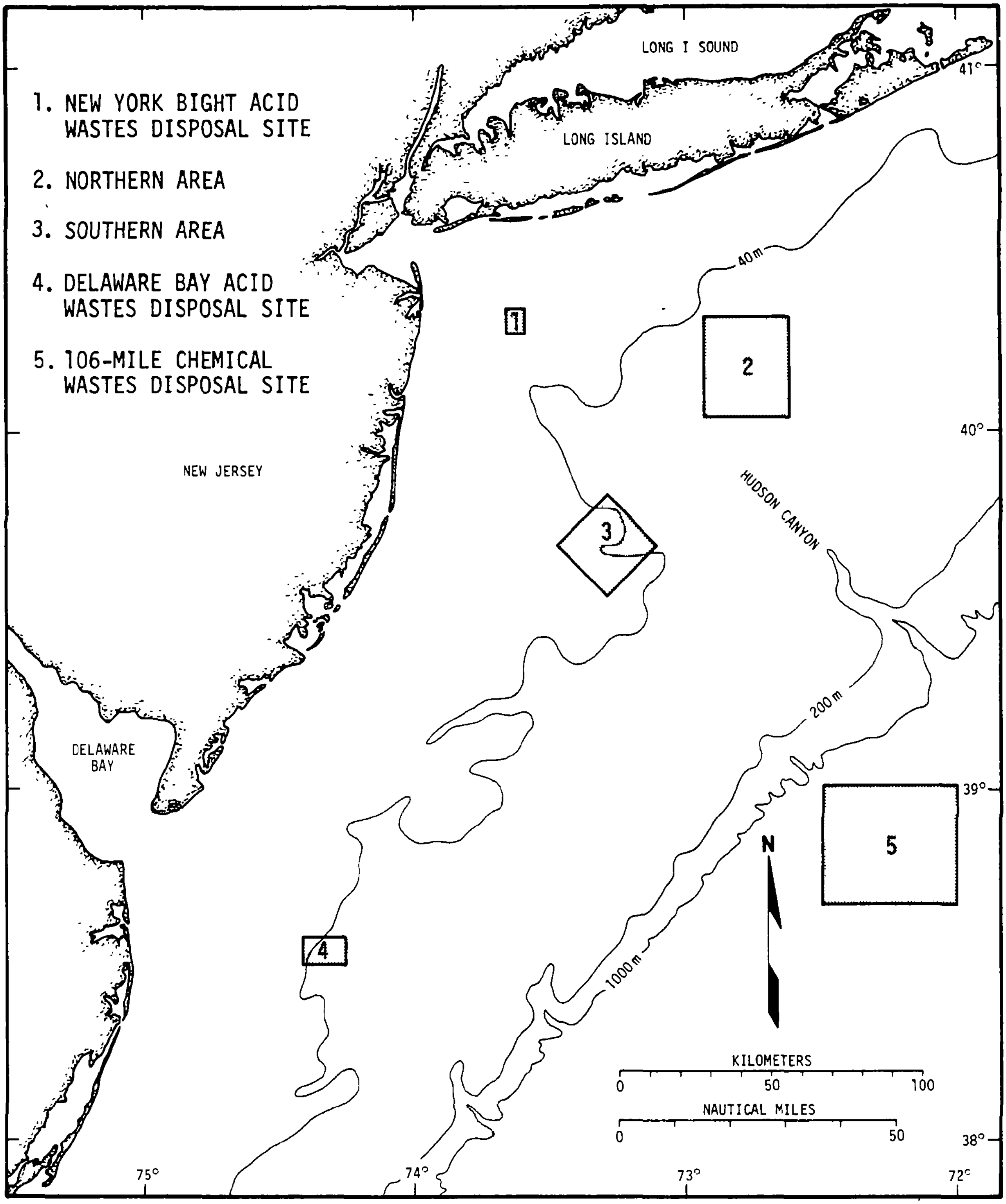

Figure 2-1. Proposed Site and All Alternative Sites

Wastes presently being disposed of at the Site have not caused demonstrable long-term adverse effects on water and sediment quality or on the site biota. The natural variability of the water at the Site, resulting from the interaction of three major water masses, causes much greater changes in the biotal assemblages of the site and vicinity than does waste disposal.

Routine laboratory bioassay tests performed on the waste, together with field dispersion data, indicate that levels of contaminants in the waste are rapidly diluted, and elevated concentrations of the waste contaminants do not remain for periods that permit significant mortality in organisms. Field monitoring by NOAA (1975; 1977) has confirmed these observations. Laboratory studies on wastes currently being released at the Site have shown adverse effects only at concentrations much higher than those occurring in the Site. Although laboratory studies cannot be directly extrapolated to the ocean environment, the difference between the concentrations found at the Site and the very high concentrations required for measurable effects in the laboratory, provides a safety factor for short-term and long-term adverse impacts. (Detailed discussion of environmental consequences of waste disposal at the Site appears in Chapter 4.)

Since the presently permitted wastes are primarily aqueous solutions and the site is in deep water where currents are strong, there is extensive dilution and dispersion of disposed wastes. Consequently, significant adverse bottom impacts are highly unlikely. This conclusion has been corroborated by benthic investigations at the Site. Future wastes with chemical and physical properties similar to present wastes are expected to behave in the same manner, hence, causing no adverse impacts.

Permitting sewage sludge disposal at the 106-Mile Site will be considered only upon a finding by EPA that the New York Bight (12-Mile) Sewage Sludge Site cannot safely accommodate additional sludge release without endangering public health or unacceptably degrading coastal water quality. (The other alternative sites discussed later in this chapter would be designated for industrial wastes only, not sewage sludge.) Chapter 5 discusses in more detail the environmental acceptability of releasing sewage sludge at the Site; the major findings are:

- Volumes of sludge requiring ocean disposal will increase 150 percent from 1978 to 1981.
- Settling of sludge particles will be strongly inhibited by the seasonal (about 60 meters in depth) and permanent (about 250 meters in depth) pycnoclines.
- Time to penetrate these pycnoclines will range from 12 hours (very unlikely) to 80 days. The particles will have traveled 400 to 450 nautical miles from the Site during the longer time period.
- Horizontal dispersion will probably exceed vertical settling by two orders of magnitude.
- If all sludge from one year (1978 volume) dumped at the Site settled within the Site boundaries, the particles would form a layer only 0.6 microns thick on the bottom.
- Only the more refractory constituents will reach the bottom and the probability of creating an anaerobic area in the deep sea is extremely remote.
- Sludge would add only 2 percent additional nitrogen to the Site. Therefore, excessive phytoplankton blooms are not expected.

ENVIRONMENTAL MONITORING

The purpose of monitoring a waste disposal site is to ensure that long-term adverse impacts do not develop unnoticed, especially adverse impacts that are irreversible or irretrievable. As NOAA has observed in its baseline report on effects of dumping at the 106-Mile Site, monitoring is more difficult at sites beyond the Continental Shelf:

> The environmental effects of disposal in deeper waters are...more difficult to measure and, hence, to predict. This is due to factors such as greater depths of water and distances from shore and also to the general paucity of environmental and biological information in off-the-shelf areas. In the case of [the 106-Mile Site], this situation is further complicated by the interactions of major water masses, Shelf Water, Slope Water, and Gulf Stream eddies.

The [site] is a complex oceanographic area in which to assess natural environmental conditions and the impact of man's activities upon those conditons (NOAA, 1977).

Another problem in monitoring involves the interaction of liquid wastes with the surrounding water and marine life. Under the dynamic conditions at the 106-Mile Site, long-term impacts will be nearly impossible to measure because affected plants and animals will most likely have moved out of the area, either carried by currents or by swimming. The difficulty of monitoring for long-term impacts in the water column in inherent in aqueous waste disposal at any oceanic site. Monitoring will be difficult until new techniques and more precise measurements are available.

SURVEILLANCE

Although nearshore sites permit use of patrol vessels and helicopters for surveillance, until other techniques are developed surveillance at the 106-Mile Site will require use of on board observers (shipriders) because the Site is located outside the range of other effective means of surveillance. The USCG has stated that they will monitor 75 percent of the disposal activity at all industrial waste sites (Mullen, 1977).

ECONOMICS

TRANSPORTATION COSTS

The cost of barging chemical wastes to the 106-Mile Site is estimated to be in the range of $8.80 to $11.00 per metric ton ($8.00 to $10.00 per ton). Therefore the total cost of ocean disposal at the Site in 1978 (612 metric tons) was about $4.4 to $5.6 million for all permittees. The port of departure affects the costs somewhat because vessels originating at ports in Delaware Bay must travel a greater distance to the Site than vessels originating in New York Harbor. This total cost will drop as some permittees phase out ocean disposal; however, the costs to individual permittees will rise as a result of inflation and increased fuel prices.

MONITORING COSTS

The costs of monitoring at the 106-Mile Site are high compared to other areas, because of the complexity of the environment and distance of the Site from shore. NOAA is responsible for biological monitoring. A cost to NOAA of $1 million per year has been estimated to conduct seasonal monitoring surveys based on a cost ranging from $200,000 to $300,000 for EPA or NOAA baseline surveys (Breidenbach, 1977). The NOAA Ocean Pulse Program, based at the NMFS Laboratory at Sandy Hook, New Jersey, monitors the entire mid-Atlantic, including the 106-Mile Site. The cost to permittees for monitoring is also high, due to the Site's distant location.

If new materials, industrial and/or municipal sludge for example, were permitted to be released at the Site, monitoring costs would substantially increase. The new permittees would be required to perform dispersion studies and other investigations concerned with short-term effects of waste discharges, and would augment the on-going monitoring program. NOAA would have to intensify its monitoring to determine if the biota is affected by interactions between waste types, and to assess long-term trends.

SURVEILLANCE COSTS

The current U.S. Coast Guard Instruction regarding surveillance and enforcement of ocean disposal sites requires 75 percent of all chemical waste disposal operations to be checked (USCG, 1976). Surveillance activities include a shiprider onboard the vessel for the disposal operation, random spot checks before the barge leaves port, and checking a vessel's log for departure and arrival times. The USCG presently assigns several full-time people to the surveillance of disposal activities in the Bight, including the 106-Mile Site. Surveillance of disposal activities at the 106-Mile Site requires more manpower than surveillance at nearshore sites, because shipriders are required since the Site is outside of the range of USCG patrol boats.

LOSS OF BIOTIC OR MINERAL RESOURCES

Almost all U.S. fishing activities are located over the Continental Shelf, and are therefore not directly affected by the wastes. Table 2-1 shows the most economically important finfish and shellfish taken in the mid-Atlantic. Fluke and lobster along the edge of the Continental Shelf are the only organisms from this list that remotely occur near the Site. Since the wastes would be extremely dilute when, and if, they reached the bottom where these animals dwell, and since these animals are demersal and highly mobile, it is unlikely that stocks would be adversely affected by disposal operations. Red crabs on the Continental Shelf/Slope break near the Site represent a potentially valuable resource that may be further exploited in the future. However, no crabs of commercial size occur in the Site, and the adult crabs are taken sufficiently far from the Site that wastes released at the Site are not likely to reach them. Foreign ships fish along the edge of the entire Continental Shelf from Georges Bank to Cape Hatteras, especially during the late winter and early spring. However, the Site is not a unique location for foreign fishermen, nor does it obstruct migration routes of species valuable to foreign fishermen. Therefore, the probability of foreign fish stocks being affected by disposal operations at the Site is extremely slight.

Future oil and gas development is possible near the Site, although virtually no mid-Atlantic oil exploration occurs presently off the U.S. Outer Continental Shelf. Waste disposal would not interfere with petroleum exploration or droduction activities. The only navigation hazard could be due to the barge traffic to and from the Site.

LOGISTICS

Use of the 106-Mile Site presents some logistical problems. A distant disposal site requires careful transport operation planning. Weather conditions in the mid-Atlantic are subject to rapid change, and must be carefully monitored for adequate "windows" to permit a barge or tanker to complete transits in safety. Emergency discharge of wastes prior to reaching the legal site (called "short dumping") becomes more likely in transit to a distant site, as the length of time spent at sea increases.

TABLE 2-1. 1974 FINFISH AND SHELLFISH LANDINGS BY STATES

(Adapted from NOAA-NMFS, 1977a)

	New York		New Jersey		Delaware		Total	
	000 Lb	$000	000 Lb	$000	000 Lb	$000	000 Lb	$000
Fish								
Fluke	2,487	846	3,499	1,153	-	-	5,986	1,999
Menhaden	576	18	107,307	2,735	13	0.5	107,896	2,753
Scup	3,635	852	6,040	880	-	-	9,675	1,732
Whiting	1,955	250	7,022	587	8	1	8,985	838
Shellfish								
Lobsters	731	1,396	1,191	1,916	26	55	1,948	3,367
Surf Clams	3,951	719	22,657	2,948	5,817	770	32,425	4,437
Scallops	884	1,158	344	531	-	-	1,228	1,689

Note: Landings are shown in round (live) weight except for clams, oysters (total meat), and scallops (edible meat).

On the other hand, the Site is outside the heavily used transit lanes to New York Harbor, and is convenient to the ports of New York, Philadelphia, and Baltimore. This location has advantages over several existing nearshore New York Bight sites that are located at the entrance to New York Harbor, an area congested with ship traffic of all types. Therefore, the dumping operation (which can take 5 to 6 hours) at the 106-Mile Site is less likely to adversely impact other ship traffic.

USE OF ALTERNATIVE EXISTING SITES

Eight municipal and industrial waste disposal sites (aside from dredged material sites and the proposed site) presently exist in the mid-Atlantic area (Figure 2-2): six in the New York Bight, and two near Delaware Bay. Two of the sites have been used for industrial chamical waste disposal (the New York Bight and Delaware Bay Acid Wastes Sites) and were considered viable alternatives, warranting careful consideration. (These sites are discussed in this section.) The other existing sites were eliminated from further consideration for several reasons:

- None of the sites have ever been used for chemical waste disposal.
- All of the sites are small and additional activity would create logistical problems.
- Because the sites are small, they could not safely accommodate more waste material.
- The sites are all located close to shore in areas that are heavily utilized for a wide variety of activities.

Consequently, most of the existing sites were eliminated from consideration for chemical waste disposal.

A discussion of the New York Bight and Delaware Bay Acid Wastes Disposal Sites follows, and these sites are individually compared to the 106-Mile Site.

NEW YORK BIGHT ACID WASTES DISPOSAL SITE

This disposal site was established in 1948 for the disposal of acid wastes generated by industries in the New Jersey-New York areas (Figure 2-1). The Site is situated on the Continental Shelf 26.8 kilometers (14.5 n mi) from the New Jersey and Long Island coasts, and covers 41.2 square kilometers (12 square nautical miles). The Site's boundaries are latitude 40°16'N to

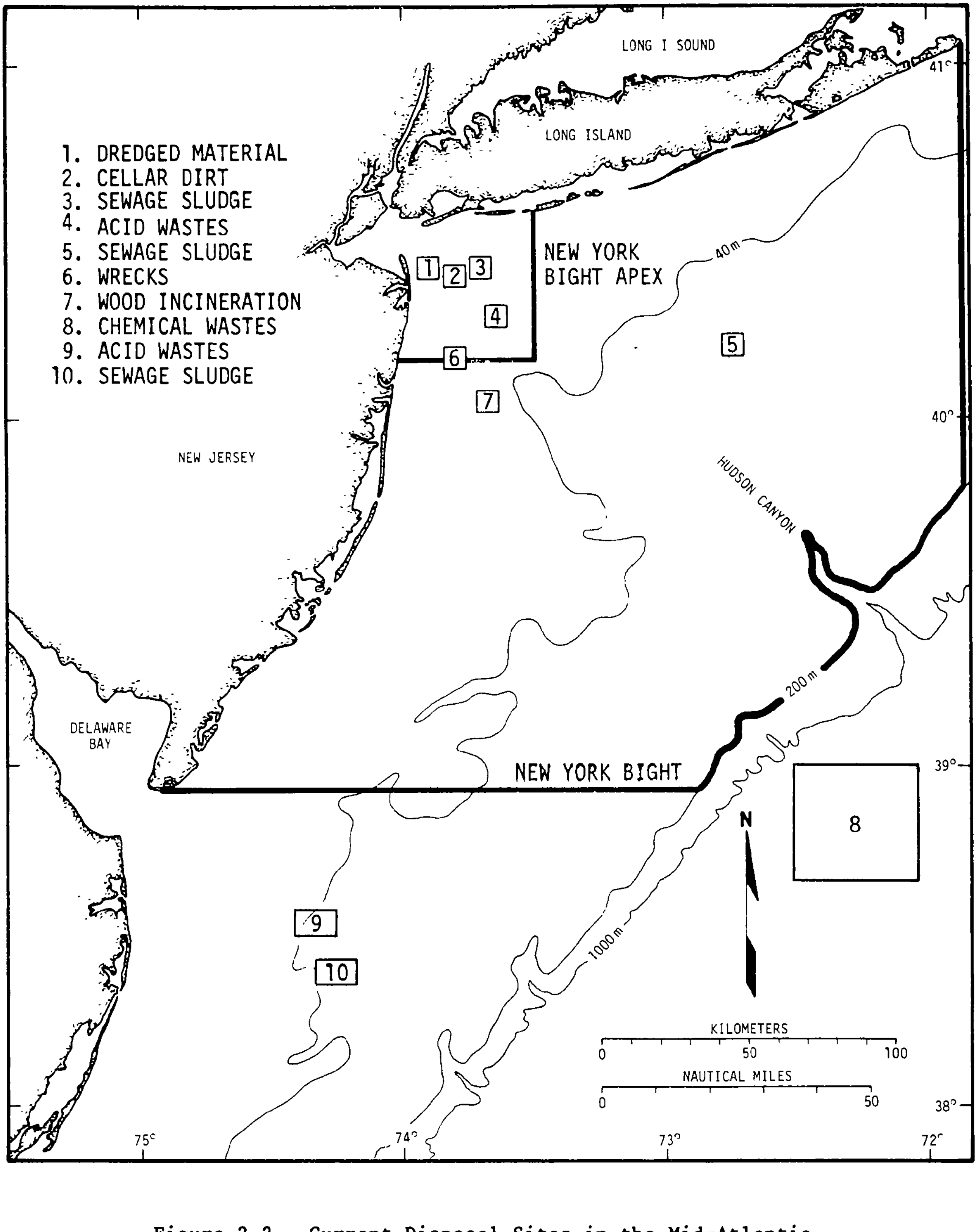

Figure 2-2. Current Disposal Sites in the Mid-Atlantic

40°20'N, and longitude 73°36'W to 73°40'W. Topographically, the bottom is relatively flat with an average depth of 25.6 meters (84 feet).

The dominant waste dumper since the Site was first established has been NL Industries, Inc., which presently dumps about 95 percent of the Site's total annual volume. The only other active permittee is Allied Chemical Corporation. DuPont-Grasselli released part of its caustic wastes at this site until 1975, when its waste disposal operation moved to the 106-Mile Site.

The effects of waste disposal on the Bight Apex, including those at the Acid Site, have been extensively investigated by the NOAA-Marine Ecosystems Analysis Program (MESA) New York Bight Project, the NFMS-Sandy Hook Laboratory, and the permittees. The site environment, the history of waste disposal at the Site, and the important waste constituents presently dumped there are described in Chapter 3. Chapter 4 includes a description of the environmental consequences of acid wastes disposal at this site.

ENVIRONMENTAL ACCEPTABILITY

Several materials are present in wastes currently barged to the 106-Mile Site which are not presently released at the Acid Site or at any other location in the New York Bight Apex. These include nonpersistent organophosphorus pesticides, surfactants, concentrated salts (sodium sulfate and calcium chloride), and by-products from the manufacture of rubber, mining, and paper, chemicals. Since these waste materials are not entering the Apex from other sources (Mueller et al., 1976), they would, if released at the Acid Site, be an additional contaminnant load on the environment of that area.

Several wastes constituents disposed of at the 106-Mile Site are also present in wastes discharged at the Acid Site. Compared to the present mass loading of wastes at the Acid Site, significant amounts of cadmium, mercury, oil and grease, and petroleum hydrocarbons would be added by dumping 106-Mile Site wastes at the Acid Site. However, additional loading of these contaminants at the Acid Site would be a small fraction of the total amount of material flowing into the area from rivers and land discharges (Table 2-2).

TABLE 2-2. COMPARISON OF CONTAMINANT INPUTS TO THE NEW YORK BIGHT, 1973 (metric tons/day) Adapted from Mueller et al., 1976

	All Sources	Acid Site Permittees	106-Mile Site Permittees
Cadmium	2.4	0.001	0.0003
Mercury	0.52	0.02	0.0002
Oil and Grease	782.7	0.1	0.09
Petroleum Hydrocarbons	No Data	0.08	0.2

The New York Bight Acid Wastes Site is located in relatively shallow water. The potential for accumulation of waste constituents in shellfish and other organisms marketed for human consumption exists and would be aggravated by further waste discharges in the area. However, to date, benthic populations at the New York Bight Acid Wastes Site have not shown evidence of uptake as the site is presently used. (Additional discussion of this subject is in Chapter 4.)

Considering environmental acceptability, disposal at the New York Bight Acid Wastes Site of wastes from the 106-Mile Site must be discouraged for several reasons:

- It would introduce materials not presently entering the Bight Apex, thus possibly placing greater strain on a system that is already suffering from man's wastes.

- Significantly greater amounts of waste constituents, which are presently disposed of at the Site, would be introduced.

- Some constituents of the wastes presently dumped at the deepwater 106-Mile Site, could adversely affect the bottom dwelling organisms at the shallow Acid Site.

ENVIRONMENTAL MONITORING

The Bight Apex, where the Acid Site is located, is one of the most intensively studied regions in the world. Beginning in 1973, the NOAA-MESA New York Bight project has coordinated the study of all oceanographic disciplines within the Bight and has provided data and guidance for environmental management decisions (NOAA-MESA, 1977). In addition, numerous studies of the Acid Site environment and the effects of waste disposal there have continued since 1948 (Redfield and Walford, 1951; Ketchum and Ford, 1948; Ketchum et al., 1958b, 1958c; Vaccaro et al., 1972). Lastly, the current permittees, in compliance with condition of their permits, are sponsoring a monitoring program to evaluate the short-term effects of their waste discharges.

Transferring wastes from the 106-Mile Site to the New York Bight Acid Site would cause difficulty in monitoring waste effects at the site. The three decades of studies of the Acid Site provide an excellent historical baseline for acid dumping, particularly by NL Industries. If subtle long-term changes are taking place as a result of acid waste disposal, other waste discharges would complicate the use of the data base for detecting these changes. Long-term changes in the environment caused by acid dumping would be difficult, if not impossible, to differentiate from impacts caused by the new waste materials.

SURVEILLANCE

The Acid Site is well suited for surveillance. Its proximity to shore permits the use of patrol vessels and aircraft to conduct surveillance and record dumping vessel sightings, activities, and positions. Shipriders, although an effective surveillance method, are rarely used at this site because of the significant commitment of manpower and the adequacy of other surveillance methods. Additional waste discharges at the site are not expected to create problems with respect to surveillance.

ECONOMICS

Transportation Costs

The costs of barging wastes to the Acid Site are estimated to be in the range of $0.90 to $2.50 per metric ton ($0.80 to $2.25 per ton). The total cost of ocean disposal in 1978 for 106-Mile Site permittees leaving New York Harbor, would therefore have ranged from $300,000 to $800,000 at the Acid Site. For permittees leaving Delaware Bay, the Acid Site is about the same distance as the 106-Mile Site, and the barging costs would not be significantly reduced by using the Acid Site instead of the 106-Mile Site. Using the previously calculated costs for disposal at the 106-Mile Site, the 1978 barging cost from Delaware Bay to the Acid Site would have been in the range of $2.5 to $3.2 million. Thus, the total transportation cost to the permittees would range from $2.8 to $4.0 million at the Acid Site. This total cost would drop as some permittees phased out ocean disposal however the cost to individual permittees would rise as a result of inflation and increased fuel prices.

Monitoring Costs

As previously mentioned several groups are currently studying the effects of waste disposal in the New York Bight Apex. Included are the NOAA-MESA Program at Stony Brook, Long Island; the Ocean Pulse Program at NMFS-Sandy Hook, New Jersey; and the permittees who barge wastes to disposal sites in the Apex. Except for the permittees authorized to use the Acid Waste Site, the other programs are not specifically orientated to evaluate the effects of acid waste disposal. However, if new wastes are released at the Site, NOAA and EPA programs would probably conduct special studies at the Site. New permittees would be required to conduct dispersion studies and participate in an on-going monitoring program to evaluate short-term effects of waste. Since other types of wastes are released at the Site, a rigorous monitoring program would be required to distinguish between the effects of the chemical wastes and the acid wastes currently permitted at the Site.

The cost of monitoring at this site cannot be reliably estimated. Although the Site is shallow and located close to shore, the costs would still probably be substantial. The Bight Apex has numerous sources of contaminants, and other waste types are released at the site; consequently, a substantial effort would be required to evaluate the effects of these new wastes. The cost would be borne by both the permittees, in determining waste dispersion and short-term effects, and the Federal government, in investigating trends and chronic, long term effects.

Surveillance Costs

The cost of surveillance for additional waste disposal operations in the Bight Apex would be relatively low. The Site is well within the normal range of Coast Guard ships and aircraft, and surveillance is routinely carried out for the current permittees using disposal sites in the Bight.

Loss of Biotic and Mineral Resources

Except for whiting, the most valuable commercial fish and shellfish taken in the New York Bight (Table 2-1) are either not present near the Site, would not be affected by the chemical waste, or have been contaminated by other pollutants. Disposal of additional chemical wastes at this site would threaten the commercial whiting fishery near the Site during the late Fall and Winter. No dollar value can be placed on these resources.

More important, the Bight Apex is a highly stressed ecosystem (NOAA-MESA, 1978), and adding new contaminants would only increase the stress. Since other disposal sites are nearby, interactions between different waste types could cause unpredictable adverse effects on the ecosystem. Although it does not appear that fishery resources in addition to these already mentioned, would be threatened, the possibility of a significant, deleterious change in the total Bight environment would exist with additional waste loading at the Site.

Acid-iron wastes currently released at the Acid Site apparently attract bluefish (a popular sport fish) and, during spring and summer, the area is a popular fishing ground (Westman, 1958). If bluefish are, in fact, attracted to the Site, the release of additional wastes could cause several problems: fisherman might avoid the area because of the increased barge traffic and the presence of wastes which are perceived as more toxic than those currently permitted at thee site; the fish might no longer concentrate in the area; or the fish might accumulate contaminants from the new wastes causing the area to be closed to fishing to protect public health. The loss of this fishing area would cause significant economic impact on the charter and party fishing boats which presently use the area. Potential mineral resources in the Bight Apex have been contaminated by other pollutant sources so there would be no additional loss from these chemical wastes.

LOGISTICS

The current permittees using the New York Bight Acid Wastes Site and the 106-Mile Site barge wastes approximately once daily. Use of the Acid Site for the wastes presently being dumped at the 106-Mile Site would double the disposal activity at the Site, thereby increasing the navigational hazards to waste disposal vessels and other shipping, since the Acid Site is located across the outbound lane and separation zone of the Ambrose-Hudson Canyon Traffic Lane. (See Chapter 3, Figure 3-10.)

OVERALL COMPARISON TO THE 106-MILE SITE

Permitting the industrial permittees to utilize the New York Bight Acid Wastes Site instead of the 106-Mile Site would result in decreased transportation costs for most dumpers, easier surveillance of the disposal operations, and, possibly, a better ability to monitor total impacts. However, the ability to monitor the specific impacts of the existing wastes released at the Site would be degraded, and there would be a significantly increased shipping hazard. Most important, contaminants not presently disposed of in the Bight Apex would be discharged, and these wastes could cause additional damage to an already highly stressed ecosystem. Therefore, this alternative is rejected in favor of the 106-Mile Site.

DELAWARE BAY ACID WASTE DISPOSAL SITE

This interim disposal site, centered approximately 64 kilometers (35 nautical miles) southeast of Cape Henlopen, Delaware, is bounded by latitude 38°30'N and 38°35'N, and longitude 75°15'W and 74°25'W (Figure 2-1). It encompasses a rectangular area of about 130 square kilometers (51 square nautical miles), with depths of water ranging from 38 to 45 meters (127 to 150 feet). The Philadelphia Sewage Sludge Site is located 9 kilometers (6 miles) southeast of the Site.

DuPont-Edge Moor disposed of its acid-iron wastes at this site from 1969 to 1977, when the operation was moved, at DuPont's request, to the 106-Mile Site. During this period, the Edge Moor plant's titanium dioxide manufacturing process changed from a sulfide process to a chloride process, producing different acid wastes.

DuPont sponsored several monitoring surveys at the Site Between 1969 and 1971. In 1973, EPA Region III initiated a monitoring program at this Site and the nearby sewage sludge site. EPA still maintains historical stations in and around the Site which are sampled twice yearly to monitor the Site's recovery toward natural conditions.

ENVIRONMENTAL ACCEPTABILITY

Using the Delaware Bay Acid Waste Site for disposal of wastes presently dumped at the 106-Mile Site would not be environmentally acceptable.

The Food and Drug Administration (FDA) closed this site to shellfishing in December 1976 at the same time the Philadelphia Sewage Sludge Site was closed. However, a potentially valuable ocean quahog resource exists southwest of the Site. Scallops are taken nearby. Renewed chemical waste disposal at the Acid Site could conceivably contaminate this shellfish resource since the Site is located in relatively shallow water.

In addition, use of the Acid Site, for chemical waste disposal instead of the 106-Mile Site would require transit by dump vessels from New York Harbor along the coast of New Jersey. Any emergency short dumping along this route could cause a health hazard for beaches, coastal industry, or the exteensive commercial and recreational fishing along this coast.

ENVIRONMENTAL MONITORING

Several years of background environmental data exist at the Delaware Bay Acid Waste Site. Pre-dumping surveys provide a marginal basis for comparison with post-dumping surveys, primarily because the latter work was much more extensive and more quantitative. However, there are enough data from the area to provide the basis for comparison.

Monitoring of the Delaware Bay Acid Waste Site would be complicated by the proximity of the Philadelphia Sewage Sludge Site. Although the primary net water movement in the area is to the southwest, storms may affect the direction of water movement, causing water from the vicinity of the sewage sludge site to migrate northward. Therefore, it would be difficult to clearly differentiate the effects of proposed chemical waste disposal and previous acid waste disposal from that of municipal waste disposal.

SURVEILLANCE

Since the Delaware Bay Acid Waste Site is presently inactive, the only ongoing USCG surveillance activities in the vicinity involve the nearby sewage sludge site. The current USCG policy is to monitor 10 percent of the sludge disposal operations, whereas they attempt to monitor 75 percent of the industrial waste discharges. Therefore, surveillance activities in this area would have to be increased substantially if the Site were activated for industrial waste disposal. However the increase in surveillance at the Acid Site would be concurrent with a decrease in surveillance at the 106-Mile Site.

ECONOMICS

Transportation Costs

Since this site is close to Delaware Bay, the hauling costs for vessels leaving New York Harbor will be significantly higher than for vessels originating in Delaware Bay. The Site is about the same distance from New York as the 106-Mile Site, and the annual barging costs will probably be about the same--$8.80 to $11.00 per metric ton, or $2.8 tó $3.6 million. The round trip would take between 54 and 72 hours (average speed 5 to 7 knots) through the coastal waters off New Jersey. The cost would be much less for vessels coming from Delaware Bay. Based on the respective distances to the Acid Site and the 106-Mile Site, barging costs would be from $2.20 to $2.75 per metric ton, or $0.6 to $0.8 million annually. Thus the annual total transport cost for this site would be about $3.4 to $4.4 million. This total cost would decrease as some permittees phased out ocean disposal; however the costs to individual permittees would rise as a result of inflation and increased fuel prices.

Monitoring Costs

The monitoring cost for the Delaware Bay Acid Waste Site id difficult to estimate, but would probably be lower than the cost of monitoring the 106-Mile Site. The effects of chemical wastes on the environment would have to be separated from the effects of nearby sewage sludge disposal as well as from the effects of water coming out Delaware Bay. EPA Region III has an ongoing monitoring program for the sewage sludge site, and these surveys could be expanded at a reasonable cost to evaluate long-term effects of chemical waste disposal. Since the Site was used until 1977, and was surveyedseveral times, sufficient data exist to recognize long-term environmental changes; extensive additional surveys would not be required.

Surveillance Costs

The Delaware Bay Acid Waste Site is near the limits of the normal range for Coast Guard ships and aircraft. Surveillance would require shipriders on some of the disposal vessels.

Loss of Biotic or Mineral Resources

Commercial surf clam beds exist in the vicinity of the Delaware Bay Acid Waste Site, but not close enough to be adversely affected by chemical waste disposal. Other shellfish, such as sea scallops and ocean quahogs, are abundant in the area, and scallops are presently being harvested. The Site is sufficiently shallow that wastes may reach the bottom and may contaminate these shellfish. Preliminary work by Pesch et al. (1977) indicates that previous acid waste disposal has contaminated scallops near the Site. At this time, the Site is still closed to shellfishing by FDA.

Mineral resources are not present at the Site. Chemical waste disposal at this site would not interfere with oil and gas exploration and development east of the Site.

LOGISTICS

The Delaware Bay Acid Waste Site is located outside of major shipping lanes and daily use, if maintained at the level occurring presently at the 106-Mile Site, would present few, if any, navigational hazards to the dumping vessels within the Site. However, its great distance from New York Harbor, would necessitate careful planning and scheduling.

OVERALL COMPARISON TO THE 106-MILE SITE

Although the Delaware Bay Acid Waste Site is more convenient to one of the permittees currently using the 106-Mile Site, little economic advantage would be gained in moving waste disposal operations from the 106-Mile Site to this location. The risks associated with renewed industrial waste discharges at the Acid Site and the possible adverse impact on potential fishery resources in the area make this alternative less preferable than continued use of the 106-Mile Site.

USE OF NEW SITES

In addition to the alternative of using existing interim disposal sites, use of new sites on or beyond the Continental Shelf (Figure 2-1), provides alternatives to disposal at the 106-Mile Site. The area under consideration is the New York Bight and the Continental Slope along the eastern edge of the Bight. To be considered a feasible alternative to existing sites, a new site for ocean dumping must meet the site selection criteria in Part 228 of the Ocean Dumping Regulations. The site must not conflict with other uses of the area, such as resource development or commercial fisheries; must not endanger human health or amenities; and should be located within the range of the current fleet of waste disposal vessels in order to make ocean disposal economically feasible.

LOCATIONS ON THE CONTINENTAL SHELF

The New York Bight is one of the busiest oceanic regions in the world, and includes extensive commercial shipping, fishing, shellfishing, recreation, resource development, and waste disposal. In selecting a site within the Bight for ocean waste disposal, other conflicting activities in the area must be evaluated for their potential effect on disposal operations and vice versa. In addition, adequate background environmental information on the area must presently exist so as to provide a firm basis for projecting impacts of waste disposal.

Most of the survey work in the Bight has centered around existing disposal sites. However, two candidate areas for sewage sludge disposal have also been studied extensively: the so-called Northern and Southern Areas (Figure 2-1). These areas were selected for study by NOAA, in part, to avoid conflict with living marine resources (NOAA-MESA, 1976) and therefore, were concluded to be the most reasonable new candidate locations for industrial waste disposal. Within the large areas suggested by NOAA for consideration, two smaller areas were studied in detail, the Northern and Southern Areas discussed below.

SOUTHERN AREA

The Southern Area (Figure 2-1) is square, centered at latitude 39°41'N and 73°18'W and compriser an area of 484 sq km (144 sq n mi). The average water depth in the Area is 40 m.

Environmental Acceptability

The Southern Area is located in an area of presently and potentially valuable commercial fishery resources. The surf clam, sea scallop, and ocean quahog are often found in numbers suitable for commercial harvesting. Therefore, there exists significant risk in using the Southern Area to dispose of chemical wastes since they contain elements that could be assimilated by organisms.

Environmental Monitoring

Due to the existence of the NOAA data base on predisposal conditions in the Southern Area, monitoring would be feasible. This site is outside the heavily contaminated Bight Apex, so monitoring waste disposal impacts at the site would not be confused by contaminants from other sources.

Surveillance

The Southern Area is outside of the range of USCG patrol vessels and aircraft normally used for surveillance, so shipriders would be required. This would not result in significant changes in the allocation of USCG manpower over surveillance at the 106-Mile Site.

Economics

Transportation Costs - The costs of transporting wastes to the Southern Area would be intermediate between those for a nearshore site and one beyond the Continental Shelf. The estimated barging costs for vessels leaving New York Harbor for the Southern Area would be \$2.70 to \$10.00 per metric ton, or \$0.9 to \$3.2 million annually. A round trip would take from 38 to 44 hours (average speed from 5 to 7 knots) through the coastal waters off New Jersey.

For permittees barging from Delaware Bay, the cost would probably be about three-quarters of the cost of barging to the 106-Mile Site (based on the distances to the respective sites): \$6.60 to \$8.25 per metric ton or from \$1.9 to \$2.4 million annually. The travel time would be 38 to 48 hours (average speed from 5 to 7 knots).

The total annual transportation cost for all waste disposal at the Southern Area would range from \$2.8 to 5.6 million. This total cost would decrease as some permittees phased out ocean disposal; however, the costs to individual permittees would rise as a result of inflation and increased fuel prices.

Monitoring Costs - Monitoring costs at the Southern Area would probably be lower than at either a nearshore or an offshelf site. Since NOAA has completed predisposal studies in the area (NOAA-MESA, 1976), and other contaminants are not present, monitoring would be fairly uncomplicated.

Surveillance Costs - The site location is outside the normal range of Coast Guard ships and aircraft; therefore, surveillance of actual ocean disposal operations would require shipriders and would be relatively costly. Surveillance of this site would not be significantly easier than the present requirements for the 106-Mile Site.

Loss of Biotic or Mineral Resources - Both biological and mineral resources exist near the Southern Area, and the potential loss of the former could be substantial. Economically important finfish (sculpin and whiting) and shellfish (lobster, surf clams, and scallops) occur in the Area. Another shellfish which may be exploited in the future, the ocean quahog, also is abundant in the area (EPA, 1978). Since the Area is located in relatively shallow water, wastes may reach the bottom and shellfish may be contaminated. Finfish may either avoid the Area or accumulate contaminants in their bodies from wastes. Thus, use of this location for chemical waste disposal could cause a significant adverse economic impact on these living resources, although the impact could not be reliably estimated because even the actual amount of fish and shellfish taken from the Area is unknown.

Use of the Southern Area for chemical waste disposal would not be expected to affect yearly mineral resource development.

Logistics

Navigation of dump vessels in this location might be complicated by traffic (work boats, supply ships, oil tankers, etc.) associated with development of nearby oil and gas lease tracts (see Chapter 3, Figure 3-3). The likelihood of these hazards occurring would depend on the speed and scope of oil and gas development in the Area and on the magnitude of ocean dumping at the site.

Overall Comparison with the 106-Mile Site

Waste disposal in the Southern Area would present some advantages over the 106-Mile Site, mainly in the ease of monitoring the site and reduced transportation costs. However, the existence of a fishery resource in the Area, the possibility of adversely affecting that resource, and the economic consequences of such an impact, make this alternative less favorable compared to the 106-Mile Site for the kinds of industrial wastes presently discharged at that site.

NORTHERN AREA

The Northern Area (Figure 2-1) is a rectangle centered at approximately latitude 40°10'N and longitude 72°46.5'W, and comprising 770 sq km (224 sq n mi) water depths in the Area average 55 m (180 ft). The inactive Alternate Sewage Sludge Disposal Site is located within the Northern Area at latitude 40°10.5'N to 40°13.5'N, and longitude 72°40.5'W to 72°43.5'W, comprising an area of 31 sq km (9 sq n mi).

Environmental Acceptability

Although the Northern Area is not known to be fished, it contains sea scallops and ocean quahogs which may be caught in the future. Because the shallowness of the site makes bottom effects from waste disposal possible, there is a slight to moderate possibility of modifying the benthic community of the Area or bioaccumulation contaminants in benthic organisms.

Environmental Monitoring

An adequate data base on predisposal conditions at this site exists for monitoring. Possible sewage sludge dumping near one edge of the study area could complicate the differentiation of industrial waste effects from sludge effects.

Surveillance

The Northern Area is outside of the range of USCG patrol vessels and aircraft normally used for surveillance, so shipriders would be required. This would not result in significant changes in the allocation of USCG manpower for surveillance.

Economics

Transportation Costs - Transportation costs for the Northern Area are similar to those for the Southern Area. The costs for hauling waste material to this site would be intermediate between those for a nearshore site and those for an off-shelf site. Estimated barging costs for vessels leaving New York Harbor are $3.60 to $7.50 per metric ton, or $1.2 to $2.4 million annually. A round trip would take between 38 and 44 hours (average speed 5 or 7 knots), through the coastal waters off Long Island.

For permittees barging from Delaware Bay, the cost would be about the same as present transportation costs for ocean disposal at the 106-Mile Site, since the Northern Area is about the same distance from the mouth of the Bay as the existing site. Thus, the estimated cost per metric ton would be $8.80 to $11.00, or $2.5 to $3.2 million annually. A round trip would take 54 to 72 hours.

Total annual transportation costs, of all waste disposal at this site would be from $3.7 to 5.6 million, slightly greater than costs for the Southern Area. This total cost would decrease as some permittees phased out ocean disposal, although the costs to individual permittees would rise as a result of inflation and increased fuel prices.

Monitoring Costs - Monitoring costs for the Northern Area would probably be similar to those for the Southern Area and less than those for a site located off the Shelf or a nearshore site with other sources of contaminants nearby.

Surveillance Costs - Since the Site is outside the normal range of Coast Guard ships and aircraft, so surveillance of actual disposal operations would require shipriders and be relatively costly. However, surveillance of this area would not be significantly more difficult than either the Southern Area or the 106-Mile Site.

Loss of Biotic or Mineral Resources - Although the Northern Area is located within the normal distribution of surf clams, they are not abundant at the site. Both ocean quahogs and sea scallops are abundant, and chemical waste disposal could possibly interfere with the development of these potentially valuable crops.

Ocean disposal in the Northern Area would not interfere with the development of mineral resources. The Site is approximately 110 kilometers (60 nautical miles) northeast of the oil and gas lease tracts identified on the Mid-Atlantic Shelf (see Chapter 3, Figure 3-3). Chemical waste disposal could not possibly interfere with exploration or development of the oil and gas reserves which are presumed to occur in the vicinity of the Southern Area.

LOGISTICS

No significant logistic problems would be expected in using the Northern Area for chemical waste disposal unless the Alternate Sewage Sludge Site located within the area was activated. The large volume of sludge that is presently dumped in the Bight requires a steady frequency of trips to the 12-Mile Site. If sewage sludge disposal operations were transferred to the Alternate Site, barge/vessel traffic in the Northern Area would increase. Thus use of this area for sludge disposal and chemical waste disposal would present problems in scheduling and navigation.

OVERALL COMPARISON TO THE 106-MILE SITE

Using the Northern Area for chemical waste disposal would have an economic advantage over the 106-Mile Site in transportation cost. However potential sludge disposal at the Alternative Sewage Sludge Site in addition to chemical waste diisposal would createe monitoring and logistics difficulties. Lastly, the Northern Area would not be environmentally favorable over the 106-Mile Site because of the presence of a potential shellfish resource that could be adversely affected by chemical waste disposal.

LOCATIONS OFF THE CONTINENTAL SHELF

Information on the mid-Atlantic Continental Slope and Continental Rise is generally lacking except for the vicinity of the 106-Mile Site (TRIGOM, 1976). The 106-Mile Site is located at the closest point to New York Harbor that is beyond the Continental Shelf (Figure 2-1). Immediately north of the Site is Hudson Canyon, a major migratory route for fish entering the New York Bight. Waste disposal near the Canyon would be environmentally unacceptable primarily because migrating organisms could accumulate toxic constituents from the waste, presenting a potential health hazard to humans consuming the contaminated animals. The environment immediately southwest of the 106-Mile Site along the Continental Slope is also unknown. Designating a site for waste disposal here would require extensive baseline survey work.

There are no data indicating that the 106-Mile Site is located over or near an especially unique portion of the Shelf. The same physical processes affect this entire region and the benthos is relatively uniform over large horizontal distances at these depths. Other localities, further northeast or south of the 106-Mile Site, would add considerable distance to round trips to the site without any clear environmental benefit. In addition, the increased traveltime raises the probability of an emergency occurring, which would result in short dumps.

OVERALL COMPARISON TO THE 106-MILE SITE

In selecting an ocean waste disposal site located beyond the Continentall Shelf, the 106-Mile Site is clearly the best viable alternative for a number of reasons. Unlike other areas off the Mid-Atlantic Shelf, the 106-Mile Site has been studied extensively, so adequate information exists for projecting impacts of disposal activities. Use of any other Continental Slope area would require extensive survey work to produce as much data as are presently available for the 106-Mile Site. The site is located on that portion of the Continental Slope closest to New York Harbor (Figure 2-1), and thus, is the Continental Slope location most convenient to potential users of the site. Lastly, no advantage would be gained by choosing another off-Shelf location over the 106-Mile Site.

SUMMARY

Several alternative locations on and off the Continental Shelf were evaluated as potential chemical waste disposal sites. A number of features of the 106-Mile Site make it the best choice among the alternatives examined:

- **It conforms with the MPRSA directive to use sites located off the Continental Shelf whenever feasible.**
- **It has been extensively studied for many years.**
- **No adverse environmental impacts resulting from waste disposal have been demonstrated at the Site from previous usage.**
- **Because the Site is located in deep water, dilution and dispersion of introduced aqueous materials are enhanced. The Gulf Stream ensures good mixing.**
- **The Site is not in an area of significant commercial or recreational fishing or shellfishing.**
- **The Site is convenient to the major ports in the Middle Atlantic states.**

Thus, in considering all reasonable alternatives to the proposed action, the proposal of designating the 106-Mile Chemical Wastes Disposal Site for continued use is the most favorable alternative for the foreseeable future.

Although there are risks involved in this action (discussed in detail in Chapter 4), the environmental risk of waste disposal at this site is judged to be less serious than the risk of disposing of wastes at locations on the Continental Shelf or other locations the Continental Slope or Continental Rise. If subsequent monitoring at the site shows negative impacts resulting from waste disposal to be greater than anticipated, EPA, as the management authority, may discontinue or modify use of the Site, in accordance with Section 228.11 of the Ocean Dumping Regulations.

Table 2-3 presents the comparative evaluation of the possible effects of chemical wastes at the five alternative sites discussed in this chapter. The effects on environmental acceptability, environmental monitoring, surveillance, economics, and logistics are summarized.

BASIS FOR SELECTION OF THE PROPOSED SITE

Part 228 of the Ocean Dumping Regulations describes general and specific criteria for selection of sites to be used for ocean waste disposal. In brief, the general criteria state that site locations will be chosen "to minimize the interference of disposal activities with other activities in the marine environment," and so chosen that "temporary perturbations in water quality or other environmental conditions during initial mixing...can be expected to 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." In addition, ocean disposal site sizes "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." Finally, whenever feasible, EPA will "designate ocean dumping sites beyond the edge of the Continental Shelf and other such sites that have been historically used." The 106-Mile Chemical Wastes Disposal Site meets all of these criteria.

TABLE 2-3. SUMMARY EVALUATION OF ALTERNATIVE CHEMICAL WASTE DISPOSAL SITES

	106-Mile Site	New York Bight Acid Wastes Site	Delaware Bay Acid Waste Site	Northern Area	Southern Area
ENVIRONMENTAL ACCEPTABILITY	Extremely slight potential for adversely affecting public health from spills during transit to site. Very slight potential for long-term impacts on ecosystem at site.	Moderate to severe potential for adverse impacts on public health because the site is located in area of commercial and recreational fishing and heavy ship traffic. Very slight to moderate potential for long-term impacts on the ecosystem.	Very slight to moderate potential for adversely affecting fishing from transit to the site, and on-site disposal operations. Slight to moderate potential for long-term impacts on the ecosystem.	None to very slight potential for adverse impacts on fishing: Very slight to slight potential for long-term impacts on the ecosystem.	Very slight to moderate potential for adverse impacts on public health. Very slight to slight potential for adverse long-term impacts on the ecosystem.
IMPACTS ON PUBLIC HEALTH	None to very slight potential for adverse impacts.	Moderate to severe potential for adverse impacts.	Very slight to moderate potential for adverse impacts.	None to very slight potential for adverse impacts.	Very slight to moderate potential for adverse impacts.
Commercial Fish and Shellfish	No potential for consumption of contaminated fish or shellfish as commercial fishing is not concentrated in this region.	Moderate potential for consumption of contaminated fish or shellfish.	Moderate potential for consumption of contaminated fish or shellfish as commercially abundant resources exist near the site.	Low potential for consumption of contaminated fish or shellfish as the area does not have commercially abundant fish and shellfish.	Moderate potential for consumption of contaminated fish or shellfish as commercially exploitable shellfish exist in the area.
Recreational Fish and Shellfish	No potential adverse effects since the site is beyond the normal range of recreational fisherman.	Moderate potential for adverse short and long-term effects.	None to very slight potential for adverse effects as the area is beyond the normal range of most fishing.	None to very slight potential for adverse effects since the area is beyond the normal range of most recreational fishing.	None to very slight potential for adverse effects as the area is beyond the normal range of most recreational fishing.
Navigational Hazards	Very slight risk because of the great distance to the site.	Severe risk because the site is small, located close to shore, and located within the central traffic lane to New York Harbor.	Slight risk because barge traffic must travel down coast of New Jersey and an accident could occur near fishing grounds.	No anticipated risk.	Slight risk because barges must transit through fishing areas.
IMPACTS ON THE ECOSYSTEM	Very slight potential for adverse impacts.	Very slight to moderate potental for adverse impacts.	Very slight to moderate potential for adverse impacts.	Very slight to slight potential for adverse impacts.	Very slight to slight potential for adverse impacts.

TABLE 2-3. (Continued)

	106-Mile Site	New York Bight Acid Wastes Site	Delaware Bay Acid Waste Site	Northern Area	Southern Area
ENVIRONMENTAL ACCEPTABILITY (Continued)					
Plankton	Very slight short-term effects. None to very slight potential for accumulation of contaminants.	Slight short-term adverse effects when the wastes are released. No potential accumulation of contaminants due to numerous other waste sources.	Slight short-term adverse effects when the wastes are released with potential of some accumulation of contaminants.	Slight short-term adverse effects when the wastes are released with potential of some accumulation of contaminants.	Slight short-term adverse effects when the wastes are released with potential of some accumulation of contaminants.
Nekton	Very slight potential of accumulation of contaminants.	Very slight potential for accumulation of contaminants.	Very slight potential for accumulation of contaminants.	Very slight potential for accumulation of contaminants.	Very slight potential for accumulation of contaminants.
Benthos	No potential for adverse effects because of the waste dilution occurring in the water.	Moderate potential for adverse effects. Difficult to differentiate from adverse effects of other nearby dumping.	Moderate potential for adverse effects.	Slight to moderate potential for adverse effects.	Slight to moderate potential for adverse effects.
Water Quality	Slight rise in concentration when wastes released, with very slight potential for longer term modification of ambient levels.	Slight rise in concentration when wastes released, with very slight potential for longer term modification of ambient levels.	Slight rise in concentration when wastes released, with very slight potential for longer term modification of ambient levels.	Slight rise in concentration when wastes released, with very slight potential for longer term modification of ambient levels.	Slight rise in concentration when wastes released, with very slight potential for longer term modification of ambient levels.
Sediment Quality	No potential for adverse effects.	Moderate potential for adverse effects. Difficult to differentiate from adverse effects of other nearby dumping.	Moderate potential for long-term accumulation.	Slight to moderate potential for long-term accumulation.	Slight to moderate potential for long-term accumulation.
Short Dumping	Slight potential for emergency because of extreme round-trip distance to site. No significant threat to commercial or recreational fisheries.	Very slight potential for emergency since site is so close to shore.	Slight potential for emergency because of extreme round-trip distance to site. Severe potential threat to commercial and recreational fisheries.	Slight potential for emergency.	Slight potential for emergency.

TABLE 2-3. (Continued)

	106-Mile Site	New York Bight Acid Wastes Site	Delaware Bay Acid Waste Site	Northern Area	Southern Area
ENVIRONMENTAL MONITORING	Extremely slight difficulty in monitoring short-term effects of waste since the site is so far from shore. Moderate to severe difficulties in detecting long-term trends as site's environment is complex. Data base is large and expanding.	No difficulty in monitoring short-term effects of waste. Severe difficulties in detecting long-term trends as other permittees use the site and other contaminant inputs would mask this waste. Monitoring is also complicated by close proximity of other disposal sites.	No difficulty in monitoring short-term effects of waste. Moderate difficulties in detecting long-term trends since the site was previously used and another disposal site is nearby.	No difficulty in monitoring short-term effects of waste. Slight difficulties in detecting long-term trends since existing data for area are few. Monitoring may be complicated if the alternate sewage sludge site is activated.	No difficulty in monitoring short-term effects of waste. Slight difficulties in detecting long-term trends since existing data for area are few.
SURVEILLANCE	Shipriders required.	Within the range of convential surveillance by aircraft and vessels.	Shipriders required.	Shipriders required.	Shipriders required.
ECONOMICS	High cost of transportation and monitoring. No conflict with other uses of the area.	Low cost of transportation and surveillance. Slight possibility of adversely affecting fishery resource.	High cost of transportation. Slight possibility of adversely affecting fishery resources.	Moderate transportation cost. Slight potential for adversely affecting future fishery resource.	Moderate transportation cost. Slight potential for adversely affecting present fishery resources.
TRANSPORTATION COSTS (Incl. ENERGY COSTS)	Estimated to be \$8.80 to \$11.00 per metric ton.	Estimated to be \$0.90 to \$2.50 per metric ton.	Estimated to be \$8.80 to \$11.00 per metric ton for wastes transported from New York Harbor.	Estimated to be \$3.60 to \$7.50 per metric ton for wastes transported from New York Harbor.	Estimated to be \$2.70 to \$10.00 per metric ton for wastes transported from New York Harbor.
MONITORING COSTS	Directly related to difficulty of monitoring. No dollar value available.	Directly related to difficulty of monitoring. No dollar value available.	Directly related to difficulty of monitoring. No dollar value available.	Directly related to difficulty of monitoring. No dollar value available.	Directly related to difficulty of monitoring. No dollar value available.
SURVEILLANCE COSTS	Expensive unless ODSS is implemented since area is outside normal Coast Guard patrol ranges. Present practices are more manpower entensive than alternate sites.	No exceptional expense as many disposal operations in the area undergo routine surveillance.	Expensive unless ODSS is implemented. Some mitigation of expense due to other site in area.	Expensive unless ODSS is implemented as area is outside normal Coast Guard patrol ranges.	Expensive unless ODSS is implemented as area is outside normal Coast Guard patrol ranges.

TABLE 2-3. (Continued)

	106-Mile Site	New York Bight Acid Waste Site	Delaware Bay Acid Waste Site	Northern Area	Southern Area
ECONOMICS (Continued)					
LOSS OF BIOTIC RESOURCES	No potential for loss of resource since populations are not exploitable. None to very slight potential of interference with a lobster or red crab fishery.	Slight potential for loss of significant portion of recreational resources.	Slight potential for loss of future commercial shellfish resource.	None to very slight potential for loss of future resource.	Slight potential for adverse effects on resources and very slight potential for loss of significant portion of resources.
LOSS OF MINERAL RESOURCES	No conflict.	No conflict.	No conflict.	No conflict.	Possible very slight conflict.
LOGISTICS	Moderate scheduling and operational difficulties because of extreme distance to site. No conflicts with shipping.	Some conflict with other shipping because the site is located in a traffic zone.	Moderate scheduling and operational difficulties because of distance from New York Harbor. No conflicts with shipping near site.	No conflict with shipping.	Very slight potential conflict with oil and gas development.

The eleven specific site selection criteria are presented in Section 228.6 of the Ocean Dumping Regulations. Each factor is briefly discussed in turn within this section. More detailed information for the eleven factors, contained elsewhere in the EIS, will be cited as appropriate to avoid needless repetition.

"GEOGRAPHICAL POSITION, DEPTH OF WATER, BOTTOM TOPOGRAPHY AND DISTANCE FROM COAST"

The 106-Mile Site is located beyond the mid-Atlantic Continental Shelf, over portions of the Continental Slope and Continental Rise (Figure 2-1). Its coordinates are latitude 38°40'N to 39°00'N and longitude 72°00'W to 72°30'W. Water depths range from 1,440 meters (in the topographically rugged northwest corner) to 2,750 meters (in the relatively flat southeast corner). The nearest point of land is the New Jersey coast north of Cape May, located roughly 200 km (110 n mi) from the northwest corner of the site.

"LOCATION IN RELATION TO BREEDING, SPAWNING, NURSERY, FEEDING, OR PASSAGE AREAS OF LIVING RESOURCES IN ADULT OR JUVENILE PHASES"

All of these activities occur in some measure within the oceanic region along the shelf break which contains the 106-Mile Site; however, no feature of the life history of valuable organisms is known to be unique to the 106-Mile Site or its vicinity.

Rare or endangered species may be present at the 106-Mile Site. However, the Site is not a concentration point for these animals, which are migratory and would be present for only a few hours. Both turtles (e.g. Hawksbill and Leatherback) and whales (e.g. sperm and right) may occasionally pass through the Site. The possibility that these animals would be affected by a waste disposal operation is extremely remote. Rare or endangered birds are not present at the Site (Gusey, 1976).

"LOCATION IN RELATION TO BEACHES AND OTHER AMENITY AREAS"

The Site is 200 km (110 nmi) from the nearest point of land, the coast of New Jersey. This distance is adequate to provide for extensive dilution and dispersion of wastes prior to reaching shore. Therefore, use of the Site should not impinge on recreation, coastal development, or any other amenities along the shoreline.

"TYPES AND QUANTITIES OF WASTES PROPOSED TO BE DISPOSED OF, AND PROPOSED METHODS OF RELEASE, INCLUDING METHODS OF PACKING THE WASTE, IF ANY"

Wastes to be disposed of at the Site must meet the EPA environmental impact criteria outlined in Part 227, Subparts B, D, and E of the Ocean Dumping Regulations, or, as in the case of some of the current permittees at the Site, dumping of wastes not meeting the impact criteria must be phased out by December 31, 1981. In all cases, in accordance with Subpart C, a need for ocean dumping must be demonstrated. Upon site designation, types and quantities of wastes currently dumped will apply. At this time, no new permit applications are anticipated. All wastes expected to be disposed of now, and following final site designation, will be aqueous industrial wastes (and possibly municipal sewage sludge) transported by vessels with subsurface release mechanisms. None of the wastes will be packaged in any way.

"FEASIBILITY OF SURVEILLANCE AND MONITORING"

Both activities are feasible at the 106-Mile Site, although costly. Additional discussion of this subject appeared earlier in this chapter.

"DISPERSAL, HORIZONTAL TRANSPORT AND VERTICAL MIXING CHARACTERISTICS OF THE AREA, INCLUDING PREVAILING CURRENT DIRECTION AND VELOCITY"

The physical oceanographic characteristics of the 106-Mile Site are described in detail in Appendix A. The physical action of the site environment, on the wastes currently disposed there, is described in Appendix B.

"EXISTENCE AND EFFECTS OF CURRENT AND PREVIOUS DISCHARGES AND DUMPING IN THE AREA (INCLUDING CUMULATIVE EFFECTS)"

No significant adverse in situ effects of current or previous waste disposal have been demonstrated at the Site. This subject is discussed further in Chapter 4.

"INTERFERENCE WITH SHIPPING, FISHING, RECREATION, MINERAL EXTRACTION, DESALINATION, FISH AND SHELLFISH CULTURE, AREAS OF SPECIAL SCIENTIFIC IMPORTANCE, AND OTHER LEGITIMATE USES OF THE OCEAN"

Present use of the 106-Mile Site interferes with none of the listed activities, nor is future use of the Site for dumping likely to cause an obstruction. Since most resource exploitation occurs on the Continental Shelf, use of a site off the Continental Shelf is not likely to adversely influence such activities. The only relevant consideration is the effect, if any, of transit to and from the Site. Emergency waste dumping could cause chemicals being transported to the Site to be short dumped in an area where other activites are occurring; however, such a situation would be expected to cause only short-term interference and short-term adverse impacts, if any.

"THE EXISTING WATER QUALITY AND ECOLOGY OF THE SITE AS DETERMINED BY AVAILABLE DATA OR BY TREND ASSESSMENT OR BASELINE SURVEYS"

No known pre-disposal baseline data from the Site vicinity exist; however, trend assessment surveys and limited laboratory studies have been conducted since waste disposal began at the Site. This work is detailed in Chapter 4 and Appendix A.

"POTENTIALITY FOR THE DEVELOPMENT OR RECRUITMENT OF NUISANCE SPECIES IN THE DISPOSAL SITE"

In several years of Site survey work, since waste discharging began, no development or recruitment of any nuisance species has been observed.

"EXISTENCE AT OR IN CLOSE PROXIMITY TO THE SITE OF ANY SIGNIFICANT NATURAL OR CULTURAL FEATURES OF HISTORICAL IMPORTANCE"

No such features are known to exist at or near the Site.

RECOMMENDED USE OF THE 106-MILE SITE

All future use of the 106-Mile Site for ocean waste disposal must comply with the EPA Ocean Dumping Regulations and Criteria--a requirement which also brings prospective dumping into compliance with the MPRSA and the London Ocean Dumping Convention. EPA determines compliance with the OCEAN DUMPING Regulations on a case-by-case basis as applications for disposal permits are evaluated. This section offers general guidelines for determining acceptability of applicant wastes once a clear need for oceann disposal has been demonstrated due to a lack of land-based disposal methods.

TYPES OF WASTES

Waste materials similar to those presently dumped at the Site will be provisionally acceptable since no significant adverse environmental effects have yet been demonstrated from dumping these wastes. If adverse effects are observed in later monitoring, dumping must be altered (reduced or stopped) according to Section 228.11 of the Ocean Dumping Regulations until such effects do not occur. For the present, however, industrial wastes having the following characteristics may be released at the site:

- Aqueous with concentrations of solids generally less than 1 percent
- Neutrally buoyant or slightly denser than seawater such that upon mixing with seawater the material does not float
- Demonstrate low toxicity and low bioaccumulation potential to representative marine organisms
- Contain no materials prohibited by the MPRSA and the Ocean Dumping Convention
- Contain constituents in concentrations that are not observed outside of the site in concentrations above ambient levels after four hours.

Sewage sludge represents a special category of waste being considered for dumping at the Site and is discussed in additional detail in Chapter 5.

WASTE LOADINGS

Since cumulative effects of past waste loading have not been demonstrated at the Site, no upper limit can be named beyond which effects could occur. The maximum historical input, roughly 750,000 metric tons of industrial wastes and sewage sludge in 1977, has not caused observable long-term adverse effects. However, the critical element for evaluating the effects of waste loading at the Site, is not the total annual input, but, rather, the input of each individual dump. The rate of release of each waste load must not be greater than the ability of the water to dilute it to acceptable levels within a short period of time. Compliance with Section 227.8 of the Ocean Dumping Regulations (limiting permissible concentration) should ensure that the marine environment will not be adversely or irreversibly impacted.

The total assimilative capacity of the Site is unknown because the physical conditions which cause waste dispersal there are still not well understood. Therefore, making accurate predictions of maximum permissible waste loading is impossible at this time. However, the emphasis of future NOAA research at the Site is to further define the physical characteristics of the Site and its action on the waste. Each waste proposed to be dumped must be evaluated, both individually and in relation to other wastes being dumped, for dispersion characteristics and input of toxic elements to the environment of the area. In the absence of more accurate information, waste loadings increased above the present level may be permitted as long as the Site is carefully monitored for adverse effects. However, the amount of material dumped in each barge load must not be greater than that amount which dispersal and mean transport of water at the Site can reduce to acceptable levels within the period of initial mixing (4 hours). EPA establishes the size of barge loads and rates of release of materials at the Site to meet this objective.

DISPOSAL METHODS

Present disposal methods practiced by permittees at the site appear acceptable for future waste disposal. Wastes are transported to the Site in specially constructed barges or self-propelled tankers and discharged from underwater valves while the barge/vessel is underway within the disposal site boundaries. The turbulence created in the barge/vessel wake causes immediate dilution of the waste. This method (or any other method that maximizes initial dilution upon discharge) is recommended for all future disposal.

DUMPING SCHEDULES

EPA presently manages the disposal operations so that different quadrants of the site are used seasonally by each permittee. This plan minimizes contact of wastes being released within the site at the same time and maximizes the dilution of wastes by using the entire Site for dumping. When two or more waste vessels are discharging wastes concurrently the vessels should be separated by the maximum possible distance (at least 0.5 nmi) within the quadrant to allow for adequate dilution of the wastes.

PERMIT CONDITIONS

EPA specifies special conditions for inclusion in individual permits as necessary. It is recommended that all future permits contain the following conditions:

1. Independent shiprider surveillance of all disposal operation will be conducted by either the USCG or USCG auxiliary (the latter at permittee's expense).

2. Comprehensive monitoring for long-term impacts will be accomplished by Federal agencies and for short-term impacts by environmental contractors (the latter at permittee's expense). All monitoring studies are subject to EPA approval. Short-term monitoring should include laboratory studies of waste characteristics and toxicity, and field studies of waste behavior upon discharge and its effect on local organisms. Long-term monitoring should include studies of chronic toxicity of the waste at low concentrations and field studies of the fate of materials, especially any particulates formed after discharge, in the waste.

3. EPA will enforce a discharge rate based on the limiting permissible concentration, disposal in quadrants of the Site, and maintenance of a 0.5 nmi separation distance between vessels.

4. Key constituents of the waste will be routinely analyzed in waste samples at a frequency to be determined by EPA on a case-by-case basis, but sufficient to accurately evaluate mass loading at the Site.

5. Routine bioassays will be performed on waste samples using appropriate sensitive marine organisms.

Chapter 3

AFFECTED ENVIRONMENT

> This Chapter describes the environments of the proposed site and the alternative sites. Because the 106-Mile Site is located in deep water off the Continental Shelf, it exhibits environmental features that are different from the alternative sites, which are located on the Continental Shelf in shallow water. These unique features of the 106-Mile Site make it a better location for chemical waste disposal than any of the alternative sites.

The Chapter is organized geographically. It begins with the 106-Mile Site (Figure 3-1), and then treats the New York Bight alternative sites together. The Chapter concludes with a discussion of the Delaware Bay Acid Site. For the alternative sites where waste disposal has already occurred, a brief history of the disposal operation is provided. For all sites, concurrent and future site studies and all other known activities in the site area are described.

THE PROPOSED 106-MILE SITE

Detailed information on the 106-Mile Site appears in Appendix A. The following discussion is excerpted from Appendix A.

PHYSICAL CONDITIONS

Because the Site is located just beyond the edge of the Continental Shelf within the influence of the Gulf Stream (Figure 3-2), surface water at the Site may belong to three different water masses, each having distinct physical, chemical, and biological characteristics: Shelf Water, Slope Water, and Gulf Stream Water. Slope Water normally occupies the Site; however, when the Shelf/Slope ocean front migrates eastward, Shelf Water of equal or lower salinity and temperature mixes with Slope Water, and the differing densities of the water masses cause them to form separate layers within the water column. Therefore, the mixing of waters at the Site can be quite complex, influenced both by predictable seasonal factors, and by highly unpredictable factors (Warsh, 1975b).

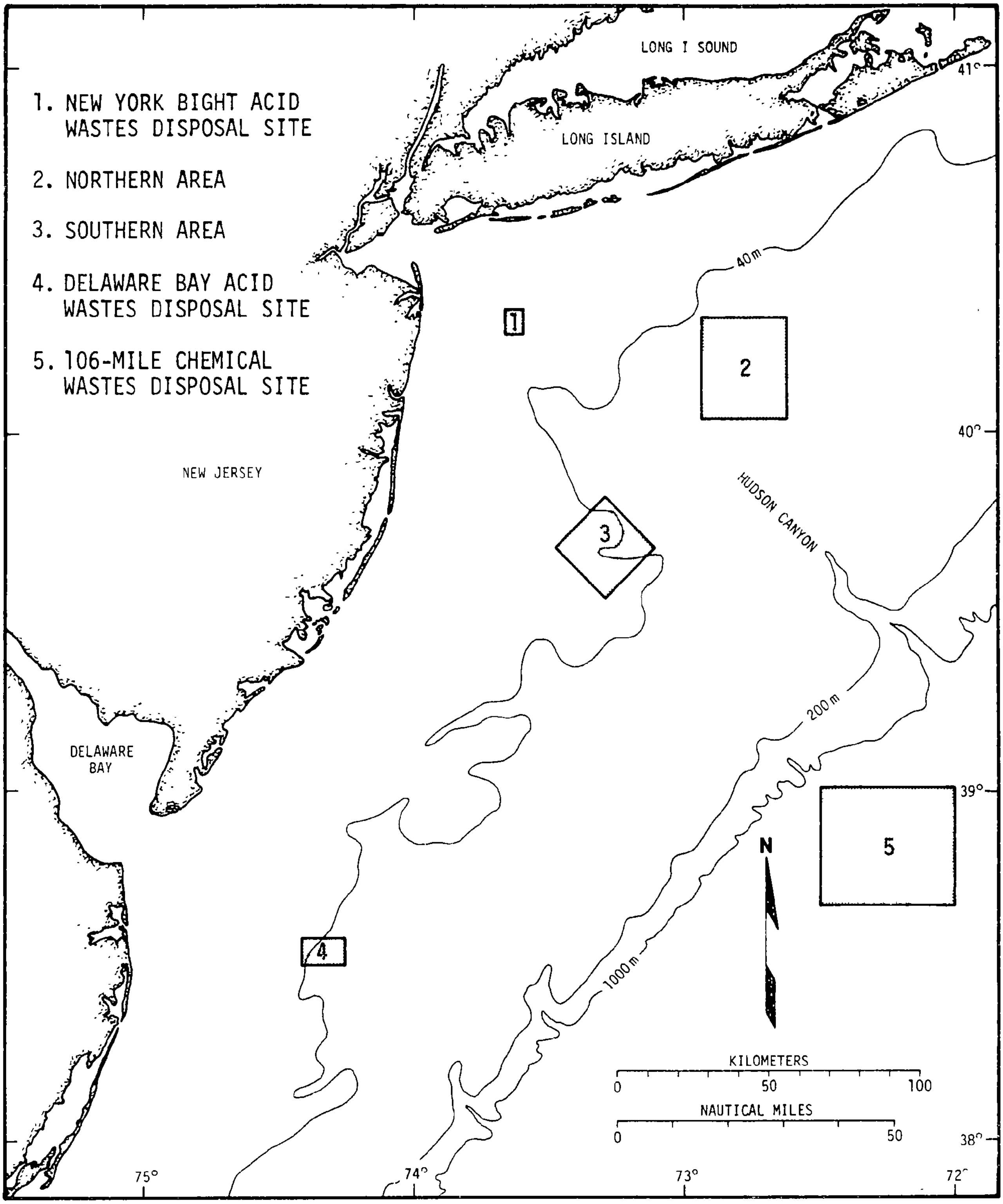

Figure 3-1. New York Bight and Alternative Disposal Sites

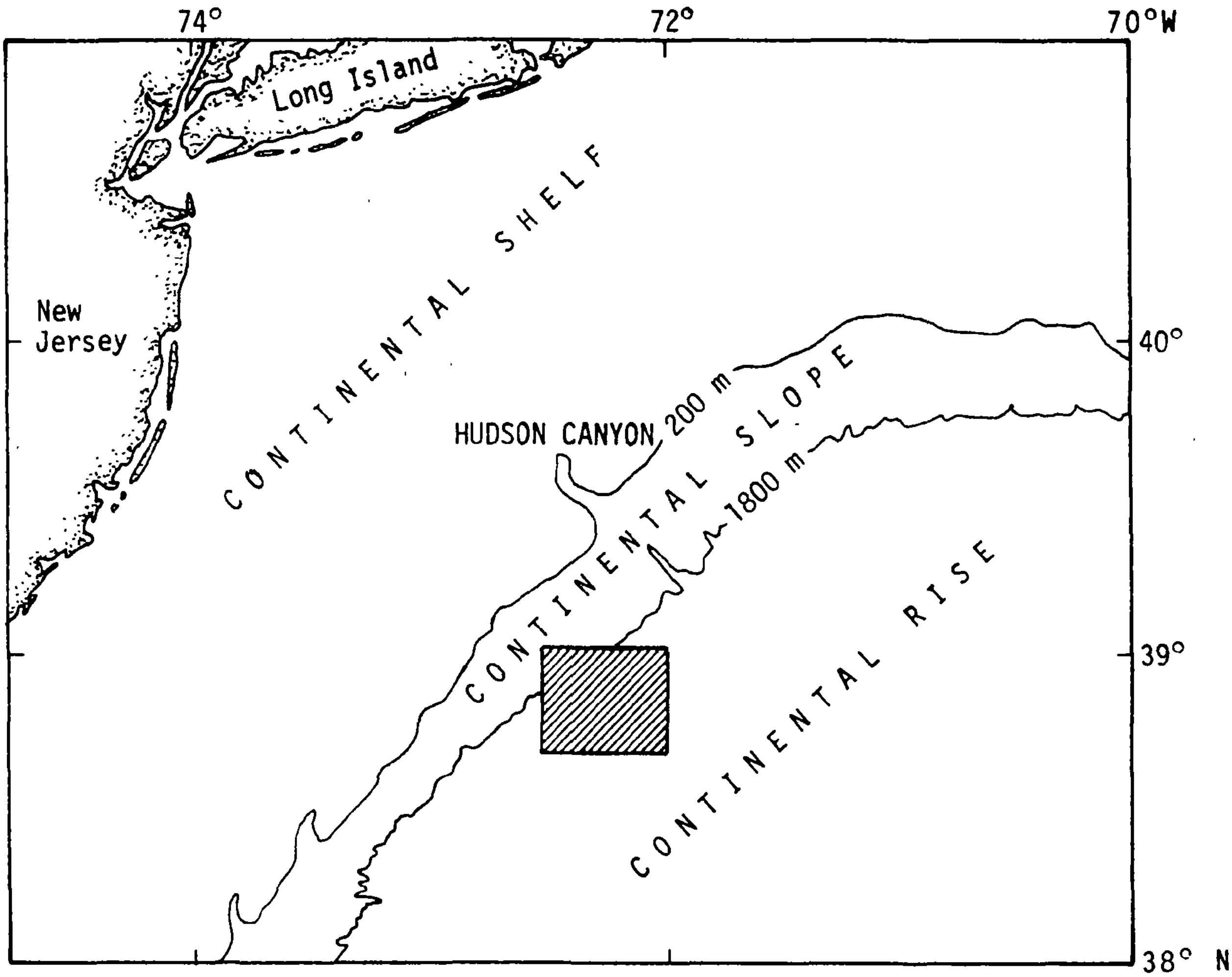

Figure 3-2. Location of the 106-Mile Site (Shaded) (Adapted from Warsh, 1975b)

Occasionally, warm-core rings of water (eddies), break off from the Gulf Stream and migrate through the Site, entraining other water or Gulf Stream water. The latter is of higher temperature and salinity than Slope Water. Although such eddies do not pass through the Site on a seasonal basis, they have been observed to touch or completely occupy the Site for about 70 days a year (Bisagni, 1976).

As the surface waters of the Site warm in late spring, a phenomenon occurs which causes the water to stratify within 10 to 50 meters of the surface, forming layers of water with different temperature, salinity, and density. The stratification persists until mid-fall or late fall, when cooling and storm activity destroy it. From fall through winter and into early spring, the temperature of the water column is the same from the surface to a depth of approximately 200 meters. At 200 meters, however, a permanent stratification level exists. Below that level, the water is uniformly lower in temperature. These physical characteristics are important because they greatly influence the ultimate fate of aqueous wastes dumped at the site.

Although few current measurements exist for the Site, the literature indicates that water at all depths in this area tends to flow southwest, generally following the boundary of the Continental Shelf and Continental Slope (Warsh, 1975b). Occasionally, the water flow may change direction, especially when Gulf Stream eddies pass through the area, and this effect has even been observed in the deep water of the Site.

Physical and chemical characteristics make the Site biologically complex because each water mass possesses unique associations of plants and animals.

GEOLOGICAL CONDITIONS

The Continental Slope within the disposal area has a gentle (4 percent) grade, which levels off (one percent) outside the Site, in the region of the upper Continental Rise. Sediments within the Site are principally sand and silt, with silts predominating (Pearce et al, 1975). Sediment composition is a major factor determining the amounts and kinds of animals capable of colonizing the bottom of the Site. Generally, greater diversity and abundance of fauna is associated with finer sediments (such as silt), although unusual physical conditions will alter this. Also, particularly fine-grained sediments are likely to contain higher concentrations of heavy metals. Sand, gravel, and rocky bottoms rarely contain these elements in high concentrations.

Continental Slope sediments in various parts of the site are subject to different dynamic forces. The Upper Continental Rise is an area of tranquil deposition, and the Lower Continental Rise is an area of shifting deposition. Erosional areas (caused by currents) lie between these two provinces. These different processes would largely determine the ultimate fate of any waste products that reached bottom (which are anticipated to be quite small). In areas swept by currents, waste products would be carried by currents out of the disposal site, and would be greatly diluted. In erosional areas and areas of shifting deposition, the same situation would exist, although the waste material could be temporarily motionless before moved. In areas of tranquil or slow deposition, waste products would be slowly buried.

CHEMICAL CONDITIONS

The amount of oxygen dissolved in seawater is a general indicator of the life-supporting capability of the waters. Dissolved oxygen levels below 4 mg/l stress animals. Dissolved oxygen concentrations at the 106-Mile Site are higher than 4 mg/l in surface water, and experience vertical gradients similar to the temperature gradients mentioned above. Thus, the permanent stratification level at 200 meters divides the water column into an upper and lower regime. The different water densities of these regimes (caused by the differences in temperatures) prevent the two layers from mixing. Unless storms or other conditions cause vertical mixing, neither layer will invade the other and influence the dissolved oxygen concentrations.

Dissolved oxygen levels are at a minimum at depths of 200 m to 300 m, and slowly increase with distance in either direction (vertically) from the stratification line. Summer and winter dissolved oxygen gradients at the Site are similar, with the main difference being the higher surface concentrations during winter. Any waste material which undergoes oxidation in seawater will consume oxygen, thus lowering the quantity of dissolved oxygen present in seawater.

Chemical baseline surveys and monitoring surveys at the 106-Mile Site have examined trace metal levels in the sediments, water, and selected organisms.

Metals in the sediments and water represent contaminants potentially available to Site organisms, and could possibly be assimilated (bioaccumulated) and concentrated by them in toxic quantities.

Since numerous metals are naturally present in seawater, only concentrations of metals which exceed natural background levels, and approach known or suspected toxicity levels, would be expected to pose a threat to marine organisms and man. The most recent studies of trace metal levels in the water of the 106-Mile Site found background levels typical of other uncontaminated Shelf-Slope regions (Kester et al., 1977; Hausknecht and Kester, 1976a, 1976b).

Trace metals in sediments all along the Continental Slope and Continental Rise (including the Site area) are elevated in comparison to Continental Shelf values (Greig et al., 1976; Pearce et al., 1975). However, because these values are so widespread, they cannot be attributed to waste disposal activities at the Site.

Analysis of trace metal concentrations in food chain organisms at the Site revealed high cadmium levels in three swordfish livers, mercury levels above the Food and Drug Administration action level ("unfit for human consumption") in most fish muscle samples, and low to moderate copper and manganese concentrations, similar to those in New York Bight finfish (Greig and Wenzloff, 1977; Greig et al., 1976). However, ocean waste disposal at the Site was not linked by investigators to the metal concentrations found in any of the analyzed benthic (bottom) and pelagic (open ocean) organisms because these organisms were transients (Pearce et al., 1975).

BIOLOGICAL CONDITIONS

Plankton are microscopic plants and animals which passively drift with the current or swim weakly. Plankton are divided into plants--the phytoplankton, and animals--the zooplankton. Since the plankton are the primary source of all food in the ocean, their health and ability to reproduce is of crucial importance to all life in the ocean, including fish and shellfish of commercial importance.

Plankton at the 106-Mile Site are highly diverse due to the influence of the Shelf, Slope, and Gulf Stream water masses, as discussed in the section on Physical Conditions, above. The high-nutrient Shelf waters primarily contribute diatoms to the Site while the low-nutrient Slope waters contribute coccolithophorids, diatoms, dinoflagellates, and other mixed flagellates (Hulbert and Jones, 1977). Mixed assemblages of zooplankters, common to the different water masses, have been found to occupy the Site during winter, spring, and summer (Sherman et al., 1977; Austin, 1975).

Fish have been surveyed at various depths within the Site. The diversity and abundance of those fish found only in surface waters, are relatively the same inside and outside the disposal site (Haedrich, 1977). The fauna, found primarily at, mid-depths (mesopelagic fish), are predominated by Slope water species with Gulf Stream anticyclonic (clockwise) eddies contributing some north Sargasso Sea species (Krueger et al., 1975, 1977; Haedrich, 1977). For some depths, particularly in the lower water column, the density of mesopelagic fish may be lower at the Site compared to non-disposal site areas (Krueger et al., 1977). Several migratory oceanic fish, usually associated with the Gulf Stream, can often be found in midwater regions of the Site. Benthic (bottom) fish in the site area are similar to assemblages in other Slope areas (Musick et al., 1975; Cohen and Pawson, 1977).

Abundance and diversity of invertebrates at the 106-Mile Site are similar to those in most other Slope localities of the Mid-Atlantic Bight. As in similar areas, the invertebrates situated on the bottom (the epifauna) of the 106-Mile Site are dominated by echinoderms (such as starfish), while segmented worms (polychaetes) are the dominant burrowing organism.

Although no mammal sightings have been reported at the Site, it is located within the distribution range of several species of whales and turtles, some of which are rare or endangered. However, disposal activities at the 106-Mile Site would not obstruct their migrations or harm them in any other forseeable way since they would only be in the Site a few hours, at most, and would tend to avoid dump vessels.

WASTE DISPOSAL AT THE SITE

Waste disposal at the 106-Mile Site is discussed in detail in Appendix B.

CONCURRENT AND FUTURE STUDIES

The NOAA Ocean Pulse Program plans to continue monitoring the 106-Mile Site. In addition, all permittees are required to monitor their waste discharges. Current permittees have contracted with a private company to conduct on-going monitoring.

OTHER ACTIVITIES IN THE SITE VICINITY

Few activities are occurring in the Site vicinity other than waste disposal operations at the Site itself. A large area immediately south of the Site has been proposed for ocean incineration. However, there are no other ocean disposal sites in the vicinity. Oil and gas lease tracts are located west and north of the Site, along the outer Continental Shelf (Figure 3-3). While the Hudson Canyon Navigational Lane crosses the Continental Slope north of the Site, no major shipping lanes approach 106-Mile Site boundaries.

Limited fisheries resources occur at the 106-Mile Site and vicinity. Due to the abyssal depths in and around the Site, none of the shellfish species commonly fished on the adjacent and shallower shelf/slope areas are found in the bottom life of the Site. Lobsters, which represent the most valuable resource in the New York Bight fisheries, are confined to areas shallower than 500 meters. The red crab (a potential fishery resource) is most abundant at depths between 310 and 914 meters; its maximum reported depth is 1,829 meters. Even if the red crab were abundant at the Site and immediate vicinity, present harvesting methods for such deep water areas would support, at best, an inefficient fishery of marginal value.

Present marine animal population data show that most commercially important species of finfishes in the New York Bight vicinity prefer to live and spawn

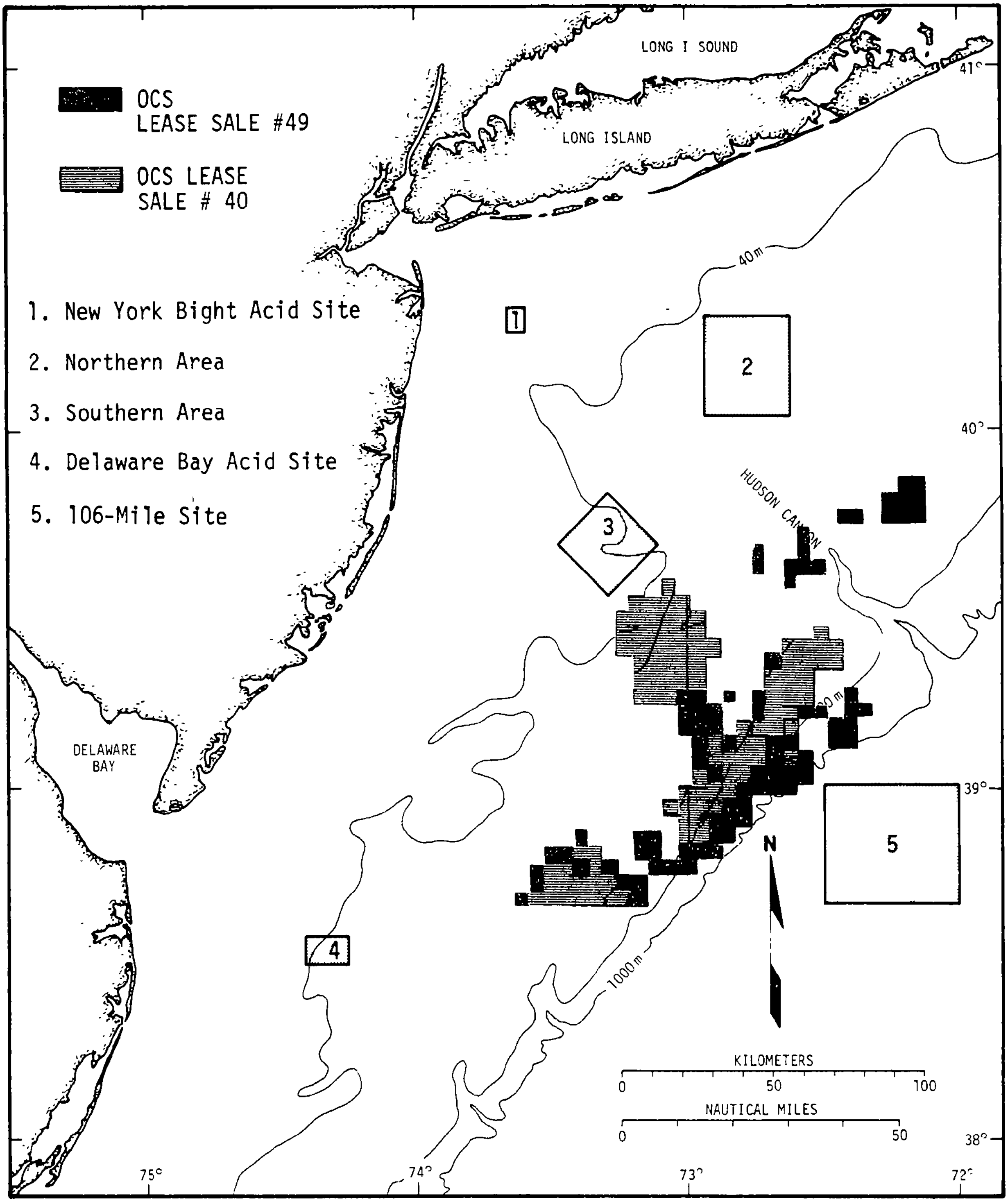

Figure 3-3. Oil and Gas Leases in the New York Bight
(Adapted from EPA, 1978)

in shelf areas and along the crest of the Continental Shelf-Slope break (NOAA-MESA, 1975; BLM, 1978; Chenoweth, 1976a). Consequently, most foreign and domestic fish trawling is conducted at depths shallower than 1,000 meters--much shallower than the 106-Mile Site. Waters near the Site have been used for the commercial longline fishing of marlin, swordfish, and tuna (Casey and Hoenig, 1977). However, only 1,041 fish of these species were caught between 1973 and 1974 in a very large ocean area of which the 106-Mile Site is only a small part (Casey and Hoenig, 1977). In general, catch statistics for Continental Slope areas are incomplete because fishing vessels wander from Shelf to Slope areas, mixing their catch of Slope species with Shelf species; landing records also fail to separate Shelf species from Slope species.

ALTERNATIVE SITES IN THE NEW YORK BIGHT

Three New York Bight Sites (Figure 3-1)--the existing New York Bight Acid Wastes Site, and the proposed alternative Northern and Southern Areas--were evaluated as alternative locations for the disposal of chemical wastes. Overall conditions for the New York Bight are described below, and conditions unique to the three sites are highlighted.

PHYSICAL CONDITIONS

The physical characteristics of the New York Bight are very complex. Seasonal patterns of temperature, salinity, insolation, and river runoff are complicated by strong meteorological events and intrusions of Slope Water (Bowman and Wunderlich, 1977).

The hydrography of the New York Bight exhibits clear seasonal cycles in the temperature, salinity, and density structures. Two distinct oceanographic regimes, with short transition periods in between, prevail during an annual cycle. Early winter storm mixing and rapid cooling at the surface create a well-mixed, unstratified water column. A moderate stratification develops in the early spring, which intensifies during the summer (Charnell and Hansen, 1974). The rapid formation of the seasonal thermocline divides the water column into an upper and lower layer. Bottom waters retain their characteristics with little modification until storms break up the thermocline in the late fall.

Conditions at the New York Bight Acid Wastes Site are more extreme than at the offshore areas because it is close to shore and is affected by the fresh water outflow from New York Harbor. The Site has a greater influx of fresh water and suspended particulate matter (discussed below) than Shelf areas farther offshore, due to its proximity to Hudson River drainage. The area also has colder winter water temperatures, since it lacks the tempering effect of deep waters and receives substantial cold-water runoff during the winter season.

GEOLOGICAL CONDITIONS

The Continental Shelf surface of the New York Bight is a vast sandy plain, underlain with clay (Emery and Schlee, 1963; Milliman et al., 1972). While sand is the most abundant textural component on the Shelf, significant deposits of gravel and mud are also present. Surface sediments of both the Acid Site and the Northern Area contain small percentages of mud, while the latter also contains some gravel. Surface sediments of the Southern Area are mostly sand. The most prominent feature of the bottom sediment in this area is a band of coarse, gravelly sand near the northeast rim of the site, parallel to the Hudson Shelf Valley.

Suspended particulate matter includes fine material from natural and man-made sources, which is suspended in seawater for long periods. It may be transported for some distance by waves and currents before sinking to the bottom. After reaching the bottom, the material may be resuspended by bottom currents or wave action and transported to other areas. A number of potential environmental effects have been attributed to suspended particulate matter. Higher levels of this material can decrease the depth to which light penetrates water, thereby significantly limiting the depth at which plants can photosynthesize and the amount of new life formed in the ocean. Suspended particulates can have toxic effects, or can bind or adsorb toxic materials, which are eventually carried to bottom life. While suspended in water, or lying on the bottom, the toxic material can be consumed by marine organisms, or taken up by absorption.

The highest concentrations of suspended particulate matter in New York Bight waters occur near shore. The New York Bight Acid Wastes Site, in particular, has higher suspended particulate matter levels due to its closeness to the coast and Hudson River runoff, a major source of this material. Lower levels of suspended particulates are transported to and from the Northern and Southern Areas by means of currents moving to replace water which has moved out of the area.

CHEMICAL CONDITIONS

The coastal metropolitan area is the primary source of heavy metals entering the New York Bight (Benninger et al., 1975; Carmody et al., 1973). The concentrations of dissolved heavy metals in the water of the New York Bight vary seasonally; background (natural) concentrations, however, are generally higher than those reported for the open ocean (Brewer, 1975). Heavy metal concentrations in bottom sediments are not uniformly distributed throughout the New York Bight, but vary according to sediment grain size, quality of organic material present, mineral composition, and proximity to the metropolitan area. In general, concentrations of dissolved heavy metals are highest in the Bight Apex, where man's influence is greatest.

Concentrations of heavy metals in sediments and water of the Northern and Southern Areas are low compared to those found in the Bight Apex, but all other chemical parameters are typical of the New York Bight. Higher levels of heavy metals have only occasionally been found in the water of the New York Bight Acid Wastes Site (Segar and Cantillo, 1976), and metal concentrations in the sediments of the Site are generally only half as high as those in the Hudson Submarine Canyon. Normally, waste material dumped at the Site is confined to the water column; however an iron flocculent, which forms as the acid-iron waste reacts with seawater, has contributed to high sediment-iron concentrations in the Site vicinity.

Surface waters of the New York Bight are saturated or nearly saturated with oxygen. Dissolved oxygen levels in bottom waters begin to decline in spring as the the surface mixing layer (thermocline) develops; by late summer, the oxygen levels have reached their lowest value. Oxygen saturation increases in the fall, following breakup of the surface mixed layer, and continues to increase as greater mixing occurs (Segar et al., 1975). Dissolved oxygen concentrations in surface, mid-depth, and bottom waters in the Northern and Southern Areas are moderately to highly saturated under winter, spring, and critical summer conditions. The saturation value for oxygen at these sampling depths probably does not fall below 50 percent at any time of year, and is usually much higher (75 to 110 percent).

Organic carbon, which may act as a trap (sink) and transport agent for toxic susbtances, is found at its highest levels near areas of wastewater discharge (outfalls) and sewage sludge, dredged material, and cellar dirt disposal sites. All three disposal sites have low levels of total organic carbon. No comprehensive studies of chlorinated hydrocarbons in the New York Bight have been made, but dredged material and sewage sludge disposal are probably the major sources of these materials to the Bight (EPA, 1975; Raytheon, 1975a, 1975b). Chemical waste generally contains low levels of chlorinated hydrocarbons.

BIOLOGICAL CONDITIONS

During most of the year, the ranges of daily phytoplankton production for inshore and offshore areas of the New York Bight do not differ significantly from one another (Ryther and Yentsch, 1958; Yentsch, 1963). Total annual production, however, is higher in coastal waters. In broad terms, phytoplankton populations are dominated by diatoms (cold months) and chlorophytes (warm months) in the Hudson River estuary and Apex, and by diatoms in the outer Bight. Zooplankton populations are dominated by copepods and larvae of vertebrates and invertebrates (summer only) in the estuary, and by copepods in the outer Bight.

The fish population of the New York Bight includes nonmigrating species, transitory species during migrations, and transitory species residing seasonally (NYOSL, 1973). Many species of coastal fishes use the New York Bight as a spawning ground, although no specific site is used exclusively or consistently by any one species. The benthic fauna show a subtle progression, in an offshore direction, from sand fauna to silty-sand fauna to silty-clay fauna as the sediments become more fine-grained (Figure 3-4).

At present, 21 species of finfish and 15 species of shellfish are commonly harvested from the New York Bight, and several other species are potentially important to future fishing. Because fish exhibit unrestricted movement, locations where specific finfish are caught vary considerably from year to year. This, plus the understandable lack of a requirement for fishermen to report their fishing grounds, makes mapping of finfisheries nearly impossible.

Locations of specific shellfishing grounds in the mid-Atlantic are also unknown. However, since shellfish movement is restricted, assessment surveys by NOAA's National Marine Fisheries Service (NMFS) are useful for locating areas inhabited by shellfish in marketable quantities, although whether or not these locations are fished is unknown. Large densities of two of the most heavily utilized Bight shellfish resources--the surf clam and sea scallop--are shown in Figure 3-5. The ocean quahog, although more a potential future resource than a present-day one, is also mapped. The assessment surveys which provided these data were conducted in the 1974 and 1975; actual locations and densities of these resources may have changed since that time. In addition, EPA (1978) reports that ocean quahogs are numerous around the Northern Area. The Northern Area was not sampled in the NMFS assessment surveys.

Commercial fishing activities are minor around the New York Bight Acid Wastes Site. A seasonal whiting fishery exists along the edge of the Hudson Shelf Valley near the Site during the winter, and lobster are taken inshore from the Site. Most of the Bight Apex is closed to shellfishing because of contamination from the sewage sludge and dredged material sites and the numerous effluent outfalls along the Long Island and New Jersey shore.

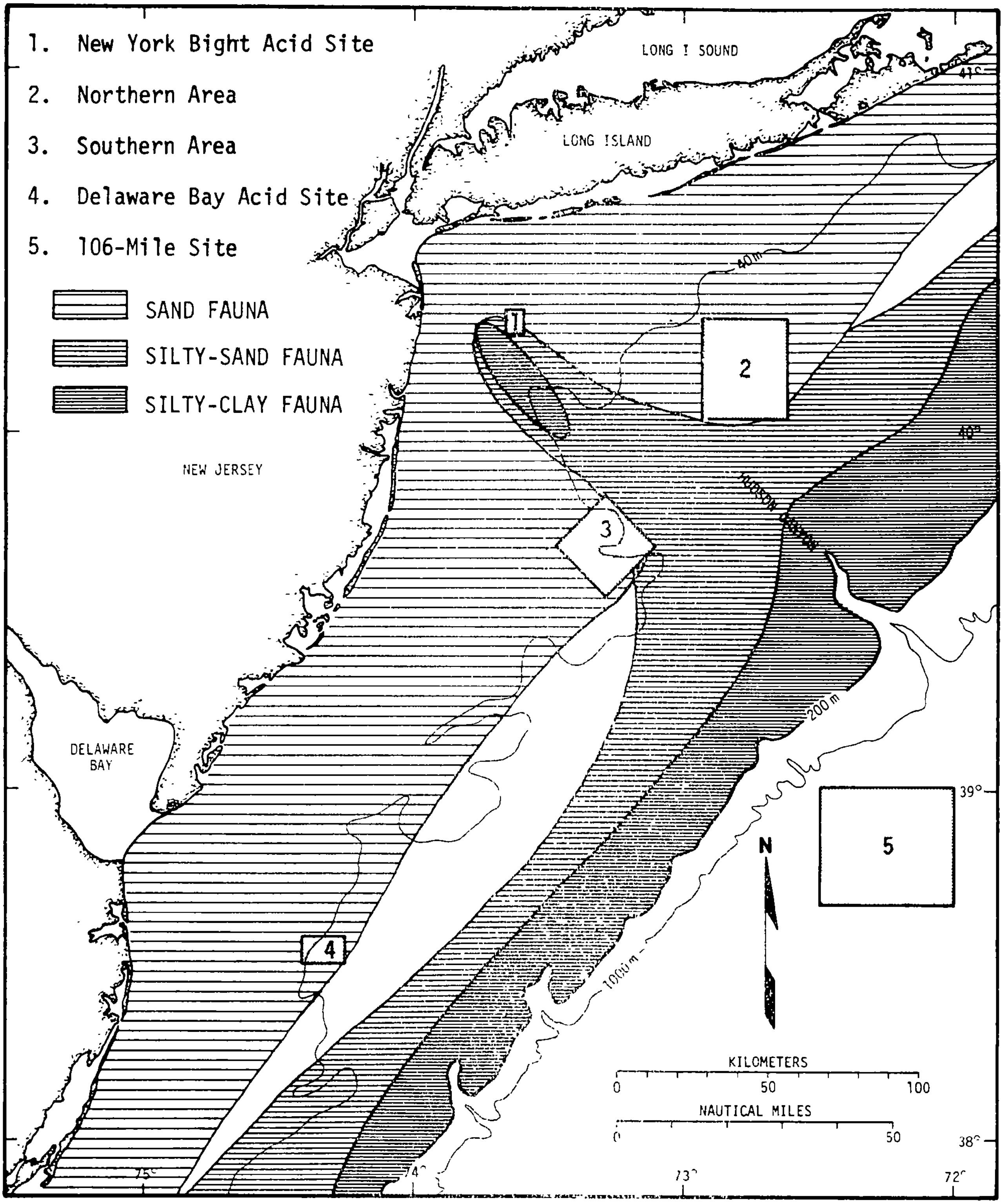

Figure 3-4. Benthic Faunal Types in the Mid-Atlantic Bight
(Adapted from Pratt, 1973)

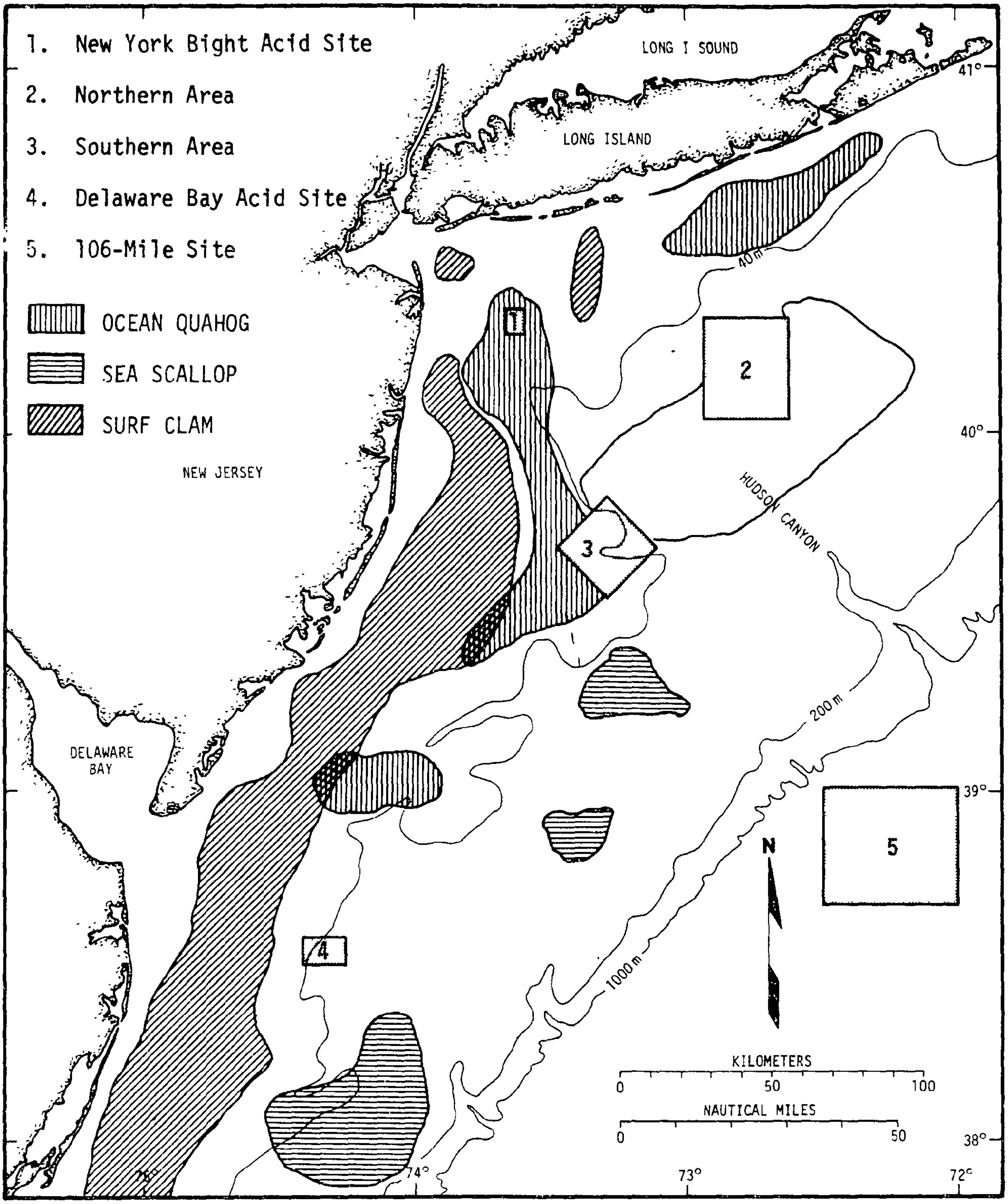

Figure 3-5. Distribution of Surf Clams, Ocean Quahogs, and Sea Scallops in the Mid-Atlantic (NOAA-NMFS, 1974, 1975)

Surf clams, sea scallops, and ocean quahogs inhabit the Northern and Southern Areas on a nonexclusive basis for most or all of their life cycles. Surf clams are more prevalent in the Southern Area and scallops are more prevalent in the Northern Area. However, neither area is known to be an active fishing area at this time.

WASTE DISPOSAL AT THE NEW YORK BIGHT ACID WASTES SITE

The New York Bight Acid Wastes Site was established in 1948 for the disposal of waste generated from industries in the New Jersey and New York areas. The Site location was chosen specifically to avoid conflict with fisheries. The present Site, established by EPA in 1973, is bounded by latitude 40°16'N to 40°20'N and 73°36'W to 73°36'W.

RECENT DISPOSAL PRACTICES

Three permittees were using the New York Bight Acid Wastes Site when it came under EPA regulation in April 1973. In 1974, DuPont-Grasselli moved its waste disposal operation out to the 106-Mile Site. Two permittees--NL Industries, Inc., and Allied Chemical Corporation--are currently using the Acid Wastes Site. The volume of waste discharged at the Site decreased 65 percent between 1973 and 1978 (Table 3-1), due to three factors:

(1) DuPont-Grasselli abandoned the site in late 1974. They accounted for 5 percent of the total quantity disposed in 1973 and 1974.

(2) Allied Chemical shut down certain manufacturing processes, and their waste volume decreased 74 percent between 1973 and 1978.

(3) NL Industries (the primary waste discharger) was either shut down or operating at a reduced capacity (due to a strike) for an extended period of time from 1976 to 1977. Normally, they contribute over 90 percent of the waste volume.

TABLE 3-1. DISPOSAL VOLUMES AT THE NEW YORK BIGHT ACID WASTES DISPOSAL SITE (Metric Tons/Year)

Permittee	Year 1973	1974	1975	1976	1977	1978	Total
NL Industries	2,300,000	1,987,000	1,842,000	1,234,000	605,000	849,000	8,822,000
Allied Chemical	59,000	56,000	48,000	47,000	29,000	15,000	254,000
DuPont-Grasselli	142,000	78,000	---	---	---	---	220,000
TOTAL	2,505,000	2,121,000	1,890,000	1,281,000	634,000	864,000	9,295,000

NL Industries

NL Industries, located in Sayreville, New Jersey, disposes of wastes produced from the manufacture of titanium dioxide, an inert, nontoxic white pigment, prepared in various grades for use in the paint, paper, plastic, drug, and ceramic industries. The waste material consists of approximately 8.5 percent (by volume) sulfuric acid (H_2SO_4) and 10 percent (by volume) ferrous sulfate ($FeSO_4$) dissolved in fresh water. When the waste is dumped, the ferrous sulfate colors the water a light green. The barge's wake turns brown as the ferrous iron is oxidized to form ferric hydroxide (rust). Insoluble materials, such as silica and unrecovered titanium dioxide, are also present in the waste. NL Industries' waste represented 97 percent of the total material dumped at the Acid Site between 1975 and 1978.

Allied Chemical Corporation

Allied Chemical, located in Elizabeth, New Jersey, discharges wastes from the manufacture of fluorocarbons. The waste material consists of approximately 30 percent hydrochloric acid (HCl), 2 percent hydrofluoric acid (HF) (both by volume), and trace constituents in aqueous solution. The principal trace metals are chromium, copper, lead, nickel, and zinc. The Allied Chemical wastes represented 3 percent of the total material disposed of at the Acid Wastes Site between 1975 and 1978.

PHYSICAL CHARACTERISTICS OF THE WASTE

The specific gravity of the waste is an important physical characteristic for dispersion prediction. The following ranges of specific gravity have been reported:

WASTE	Specific Gravity (Range)
NL Industries	1.082 to 1.174
Allied Chemical	1.116 to 1.172
Typical site seawater	1.025

Dispersion studies have been periodically conducted on NL Industries' wastes since waste disposal began in 1948. A summary of the dispersion studies for both NL Industries and Allied Chemical wastes is presented in Table 3-2, which shows that wastes rapidly dilute after discharge. Redfield and Walford (1951) reported that the maximum volume of water having an acid reaction was 162,000 cubic meters (640 meters long, 23 meters wide, and 11 meters deep); the acid was neutralized within 3-1/2 minutes after discharge. Recent EG&G studies (1977a, 1977b) also reported that the wastes did not penetrate the summer thermocline at 10 meters, and initial mixing was rapid. A detailed description of the barging operation can be found in Redfield and Walford (1951) and Peschiera and Freiberr (1968).

CHEMICAL CHARACTERISTICS OF THE WASTE

Trace Metals

The quantities of eight trace metals released at the Acid Wastes Site during the years 1973 to 1978 are summarized in Table 3-3. Only chromium, vanadium, and zinc are present in large quantities, and if the total contaminant inputs to the Bight are considered, these inputs from acid wastes are insignificant.

TABLE 3-2. REPORTED DILUTION VALUES FOR WASTES DUMPED AT THE ACID SITE

	Dilution Seconds		Dilution Minutes												Dilution Hours	
Permittee/ Reference	15	30	1	2	3	4	5	12	22	30	39	55	66	180-200	4	18
Industries:																
Refs: Redfield and Walford 1951		250														
Ketchum and Ford, 1952	700			1,200		1,500	1,200	3,000		3,900		5,600		2,700		
Vaccaro et al., 1972*																
EG&G Inc. 1977a											9,400		40,000	82,000	90,000	116,000
Allied Chemical Corporation Ref: EG&G Inc. 1977b			2,700		6,500	1,500			23,000					83,000	143,000	

* Reported that the highest particulate iron concentration observed was equivalent to a dilution of 39,000. The time after discharge was unknown but the acid plume was still visible.

TABLE 3-3. ESTIMATED VOLUMES OF TRACE METALS RELEASED ANNUALLY AT THE NEW YORK BIGHT ACID WASTES DISPOSAL SITE (Metric Tons/Year)

Metal	1973	1974	1975	1976	1977	1978	Total	Average
Cadmium	0.9	0.9	0.10	0.3	0.10	0.15	2.4	0.4
Chromium	30.7	25.5	19.2	5.4	58.3	8.2	147.3	24.5
Copper	15.3	6.5	8.8	2.1	2.2	3.1	38	6.3
Lead	5.7	2.6	2.5	3.0	0.9	1.3	16.0	2.7
Mercury	0.0	0.1	0.0	0.005	0.003	0.004	0.1	0.1
Nickel	13.3	14.3	9.6	3.8	3.4	4.8	49.2	8.2
Vanadium	215.5	127.7	112.5	NA*	NA	NA	NA	NA
Zinc	52.7	42.5	33.5	13.6	10.9	15.2	168.4	28.1

* Not analyzed

The total mass loads of several trace metals released into the New York Bight from various sources are listed in Table 3-4. Wastes discharged at the Acid Site contribute significant amounts of vanadium and, possibly, nickel to the Bight. Iron, not reported by Mueller et al. (1976), is a significant input as well. Redfield and Walford (1951) reported that the amount of iron barged to sea was about equal to the amount discharged in the Hudson River outflow. Recent work (NOAA-MESA, 1975) indicated that the Hudson estuary discharge is the major source of both dissolved and suspended particulate trace metals, particularly iron and manganese. Overall, the Acid Wastes Site ranks fourth or fifth among the five possible sources of these metals; ocean dumping at other sites (principally dredged material and sewage sludge) and outflow from New York Harbor are the dominant sources of these contaminants.

Acid

The acid in NL Industries' wastes is neutralized within a maximum of 40 minutes after discharge (EG&G, 1977a). Redfield and Walford (1951) calculated that at discharge, the sulfuric acid would be immediately diluted to 2 parts

TABLE 3-4. MASS LOADS OF TRACE METALS ENTERING THE NEW YORK BIGHT 1960-1974* (Metric Tons)

Metal	Ocean Dumping**	Atmosphere	Transect Zone†	New Jersey/ Long Island Coastal Zone	Acid Waste	Total
Cadmium	30	20	13	5	1	769
Chromium	880	27	803	81	31	1,822
Copper	2,573	146	2,263	54	15	5,051
Lead	1,993	2,154	2,117	32	6	6,302
Mercury	10	NR	94	7	0.01	111
Nickel	NR	NR	NR	NR	13	NR
Vanadium	NR	NR	NR	NR	216	NR

* Adapted from Mueller et al. (1976)
** Dredge Material and Sewage Sludge Sites
† Outflow from New York Harbor
NR - Not reported

in 10,000 and the seawater pH would not fall below 4.5. The actual pH depression observed two minutes after discharge was 6.9. The pH returned to normal levels (8.2) within seven minutes. The EG&G (1977a) study found only two stations where the pH was depressed more than 0.1 units for 40 minutes following the disposal of NL Industries' waste.

In Allied Chemical waste dispersion studies, EG&G (1977b) reported a minimum pH of 5.95 four minutes after disposal began. The pH increased (6.6 at 22 minutes; 7.3 at 37 minutes) and had returned to ambient levels within one to three hours.

EFFECT ON ORGANISMS

Prior to the regulation of ocean dumping by the EPA, numerous toxicity studies, both laboratory and field, had been performed on the wastes dumped at the Acid Site. Observations of relatively slight effects have been reported by Redfield and Walford (1951); PHSSEC (1960); Ketchum et al. (1958b, 1958c); Vaccaro et al. (1972); Wiebe et al. (1973); Grice et al. (1973); and Gibson (1973). In contrast, NOAA-NMFS (1972) reported severe effects due to acid waste disposal. However, the NMFS method and conclusions have been criticized (Buzas et al., 1972).

A variety of phytoplankters and zooplankters collected in the wake of an acid waste discharge have been analyzed. Animals may be immobilized immediately after disposal but recover quickly when the waste is diluted with an equal volume of seawater. Several investigators reported that the gastrointestinal tracts of copepods and ctenophores collected at the Site after a discharge were full of iron particles from the waste, but the animals did not exhibit any ill effects.

Laboratory work indicates that phytoplankton are unaffected by a concentration of acid waste four times higher than concentrations observed in the field. Zooplankton are chronically affected by concentrations of one part waste in 10,000 parts seawater, causing impaired reproduction and slowed development. However, this concentration of waste only persists for a few minutes after disposal, and is a strictly local phenomenon. Investigations of the effects of the pH change have shown that the pH change causes the adverse effects, rather than toxic elements in the waste. Neutralized acid waste is not toxic to the test organisms.

When the Site was first established, there was controversy over possible adverse effects on the migratory fish in the New York Bight. Westman has periodically surveyed the Site and other fishing areas in the Bight (Westman, 1958, 1967 1969; Westman et al., 1961), and concludes that bluefish and yellowfin tuna are attracted to the Site, and an active pelagic fishery occurs in the area. He did not observe adverse effects caused by the waste disposal.

The acid waste does not appear to be toxic to the bottom-dwelling animals. The Site supports a typical sand-bottom community, with the biomass and species diversity comparable to a control area (Vaccaro et al., 1972) although the number of animals is significantly less. Other investigators (Westman, 1967, 1969; NOAA-NMFS, 1972) have also reported anomalous benthic conditions at the Site. Recent samples (Pearce et al., 1976a, 1976b, 1977b) show that there was a wide natural variation at stations in and around the Site, and that such variability is common for a sandy bottom assemblage of animals.

CONCURRENT AND FUTURE STUDIES

Currently, several organizations are conducting research and survey activities in the New York Bight. The MESA-New York Bight Project is sponsoring work by a variety of Federal and academic investigators. This phase of the project is scheduled to end in 1981. A less intensive monitoring program will be developed and will continue under NOAA sponsorship.

The NOAA-National Marine Fisheries Service Laboratory at Sandy Hook, New Jersey, is periodically sampling and evaluating the Bight as part of their Ocean Pulse Program, designed to monitor and assess the health of the ocean's living resources on the Continental Shelf of the Northwest Atlantic Ocean. This program includes, as one of its objectives, the study of the effects of pollutants on important marine species.

EPA requires Acid Site permittees to perform waste dispersion studies and site monitoring surveys as a permit condition.

OTHER ACTIVITIES IN THE SITE VICINITY

COMMERCIAL FISHERIES

Extensive finfish and shellfish activities occur in the New York Bight. Most finfish fishing grounds lie in the inner Continental Shelf or near the edge of the Shelf. Most species of shellfish are located throughout the Bight, while certain species, such as lobster, are most abundant in Hudson Canyon or Continental Slope Areas.

Domestic

Table 3-5 shows the total yield and dollar value in 1974 for the five major species of commercial finfish in the New York Bight. Although the stock of most commercial species is still substantial, there has been an overall decrease in annual yields of finfish over the last two decades (Figure 3-7), with commercial landings of certain over-fished species (e.g. menhaden) declining. The yield of the domestic shellfishery has greatly increased since 1960 (Figure 3-6). While the once-important surf clam is becoming increasingly scarce, other shellfish species have only recently begun to be exploited (e.g. red crab), and potential resources (such as ocean quahog) still exist. Table 3-6 shows the total annual values in 1974 and 1976 for the more important shellfish species. The American lobster is the most important species fished along the Continental Shelf/Slope break, and is quickly becoming the most important fishery resource of the New York Bight (Chenoweth, 1976a).

TABLE 3-5. TOTAL LANDINGS IN 1974 OF FIVE MAJOR COMMERCIAL FINFISHES IN THE NEW YORK BIGHT (Adapted from NOAA-NMFS, 1977)

	New York		New Jersey		Total	
Species	000 Lb	$000	000 Lb	$000	000 Lb	$000
Fluke	2,487	846	3,499	1,153	5,986	1,999
Menhaden	576	18	107,307	2,735	107,883	2,753
Scup	3,635	832	6,040	880	9,675	1,712
Striped Bass	1,409	533	714	177	2,123	710
Whiting	1,955	250	7,022	587	8,977	837.

TABLE 3-6. TOTAL COMMERCIAL LANDINGS IN 1974 AND 1976 OF IMPORTANT SHELLFISH SPECIES IN THE NEW YORK BIGHT (NEW YORK-NEW JERSEY) NOAA-NMFS, 1977a, 1977b

	1974		1976	
Species	000 Lb	$000	000 Lb	$000
American Lobster	1,922	3,312	1,117	2,368
Hard Clams	9,769	15,164	10,072	19,396
Surf Clams	26,608	3,667	9,493	3,299
Oysters	2,563	4,778	2,256	5,642
Sea Scallops	1,228	1,689	1,953	3,170
Blue Crab	2,864	725	407	123

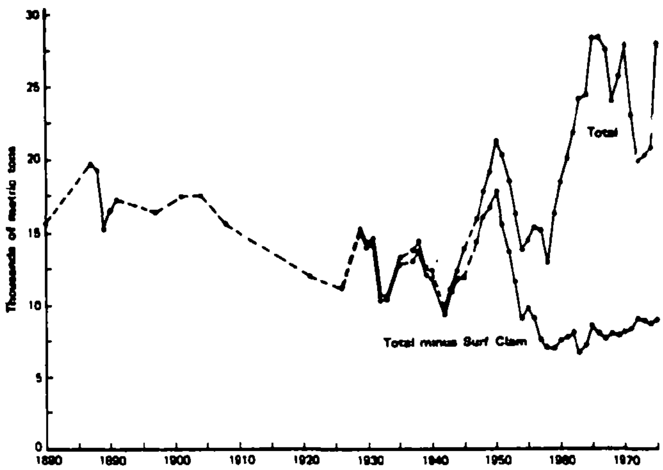

Figure 3-6. Total Commercial Landings of Marine Fishes and Shellfishes in the New York Bight Area, 1880-1975 (McHugh, 1978)

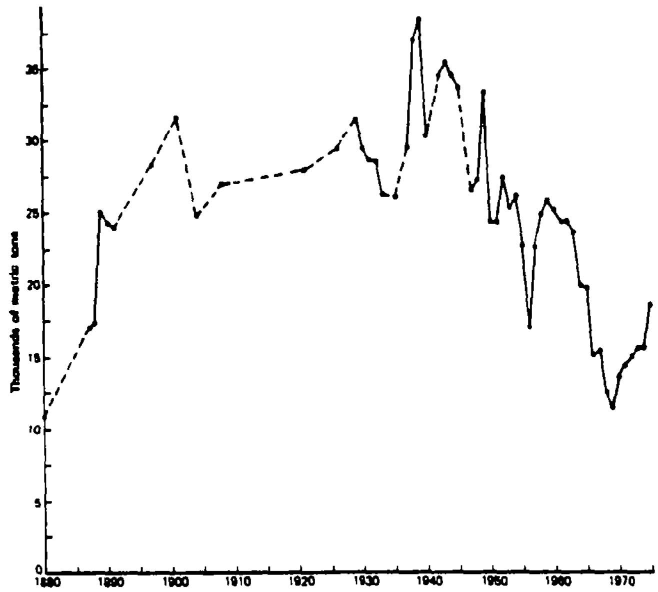

Figure 3-7. Total Landings of Commercial Marine Food Finfishes in the New York Bight Area, 1880-1975 (McHugh, 1978)

Foreign

Nearly all foreign fishing in the north and mid-Atlantic region of the United States is located on the Continental Shelf, with the majority of foreign vessels trawling in the outer Shelf region (Figure 3-8). Peak foreign fishing activity in the New York Bight occurs during spring and early summer, when the fleet moves south from its winter fishing grounds on the Georges Bank. The foreign fleet greatly increases in size during this period in order to harvest the greater numbers of fish which congregate at spawning grounds.

An average of 1,000 foreign vessels fish along the mid-Atlantic coast annually (Ginter, 1978). Foreign fishing in the New York Bight is dominated by the Soviet Union, followed by East Germany, Spain, and Japan. Major foreign fisheries are the herring, silver and red hake, and mackerel. The seasonal migrations of these species account for the north-to-south movement of the foreign fleet throughout the year. Recently, new fishing efforts have developed for squid, butterfish, tuna, and saury; this has moderated the strict north-south movement of foreign vessels.

Foreign vessels, while prohibited from fishing such exclusive United States fishery resources as lobster, are not required to report the magnitude of their annual harvest from United States waters. Consequently, no comprehensive foreign catch statistics are available.

RECREATIONAL FISHERIES

Most recreational fishing in the New York Bight vicinity is confined to the inner Continental Shelf waters, since this area is the most accessible to the public, and most sport species are found there (Chenoweth, 1976a). The important species are striped bass, weakfish, bluefish, and mackerel. The sport catch often equals or surpasses the commercial landings of certain species (e.g. striped bass), and has contributed significantly to the economics of several coastal areas. In 1970, 1.7 million anglers caught 2.7 million pounds of fish from the North Atlantic coast. Recreational species fished further offshore are limited primarily to bluefin tuna, marlin, and swordfish. There are no accurate catch statistics for these species.

SAND AND GRAVEL MINING

Sanko (1975) states that "sand deposits in the Lower Bay of New York Harbor have been the largest single source of commercial sand for the New York City metropolitan area since 1963." Although this is the only area in the New York Bight where sand is presently mined, recent geological surveys show that sand could be mined nearly anywhere in the New York Bight, with current technology limiting the outer boundary to the 50 m (165 ft) isobath. There is an estimated area of over 2,680 km^2 suitable for sand mining between the 50-meter isobath and the Long Island shoreline (Schlee, 1975). Most of this sand is of a uniform grain-size, and contains a low percentage of fine particles. Gravel deposits in the New York Bight have a much more limited distribution than sand. Potential mining areas for gravel are fewer and are located principally off the northern coast of New Jersey (Figure 3-9).

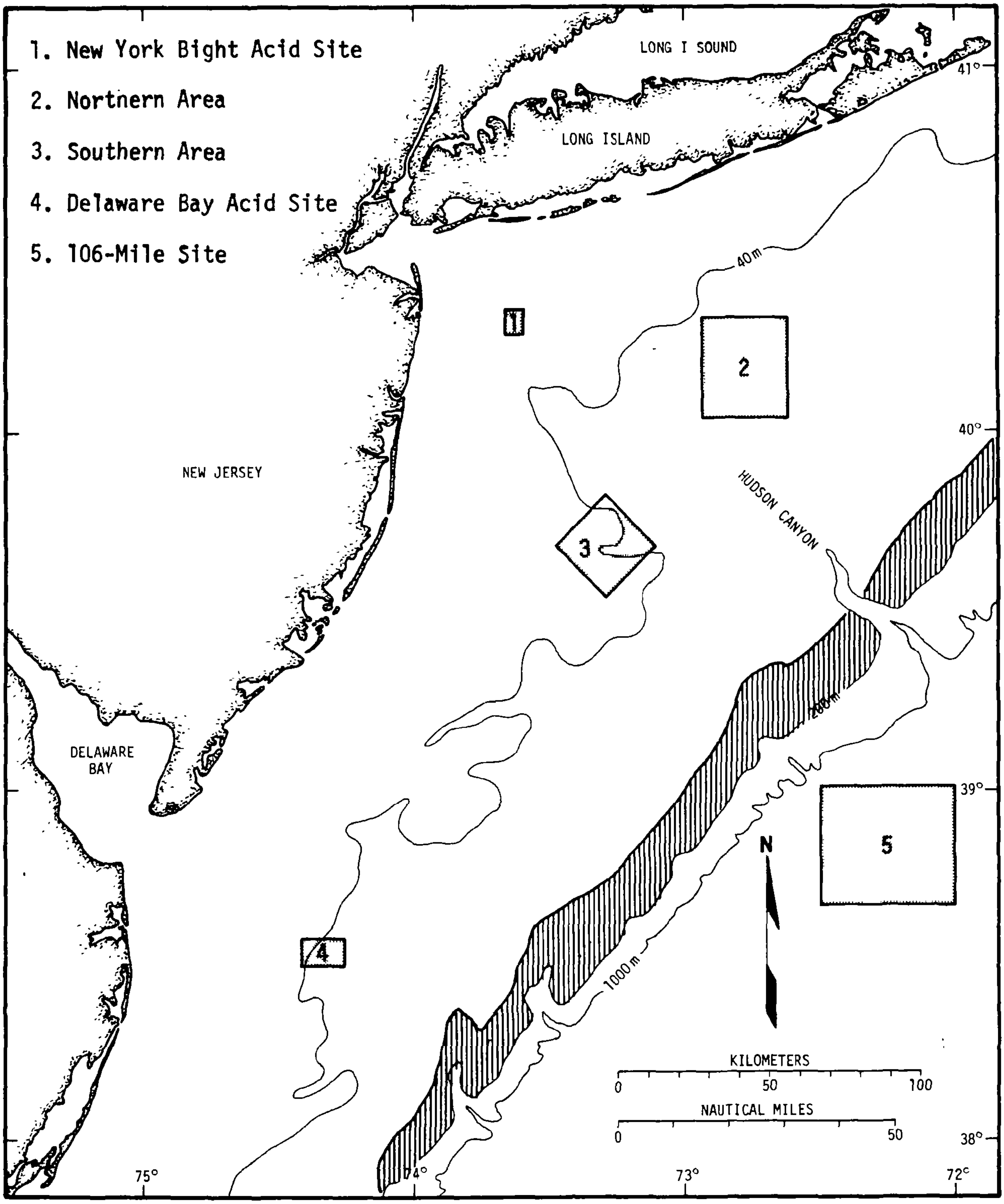

Figure 3-8. Location of Foreign Fishing off the U.S. East Coast
(Adapted from Ginter, 1978)

OIL AND GAS EXPLORATION AND DEVELOPMENT

There are no present or future oil and gas lease tracts located in any ocean disposal site (Figure 3-3). The U.S. Department of the Interior's Bureau of Land Management (BLM) completed its first sale of oil and gas leases on the Mid-Atlantic Outer Continental Shelf in August 1976 (Outer Continental Shelf [OCS] Sale No. 40). Exploratory drilling at six of the ninety-three tracts leased in OCS Sale No. 40 began in the spring and summer of 1978. On May 19, 1978, BLM published a draft EIS on the proposed OCS Sale No. 49, which includes 136 tracts totalling 313,344 hectares (774,273 acres). Sale No. 49 is tentatively scheduled for spring of 1979. A third sale (No. 59) is under consideration and is tentatively scheduled for August 1981 (BLM, 1978).

SHIPPING

The major trade routes charted by NOAA to serve the New York-New Jersey area coincide with three major shipping lanes, as designated by the USCG: the Nantucket, Hudson Canyon and Barnegat Navigational Lanes (Figure 3-10). Hudson Canyon Lane lies across the New York Bight Acid Wastes Site, and the other lanes straddle the Northern and Southern Areas. The trade routes which lie within the Navigational Lanes are usually the safest routes for shipping traffic, and the Coast Guard recommends that they be used by all major shipping traffic.

OCEAN WASTE DISPOSAL

The EPA currently permits ocean disposal at six locations in the New York Bight (Figure 3-11). The Acid Wastes Site is considered in this EIS as a possible alternative site for the chemical wastes presently released at the 106-Mile Site.

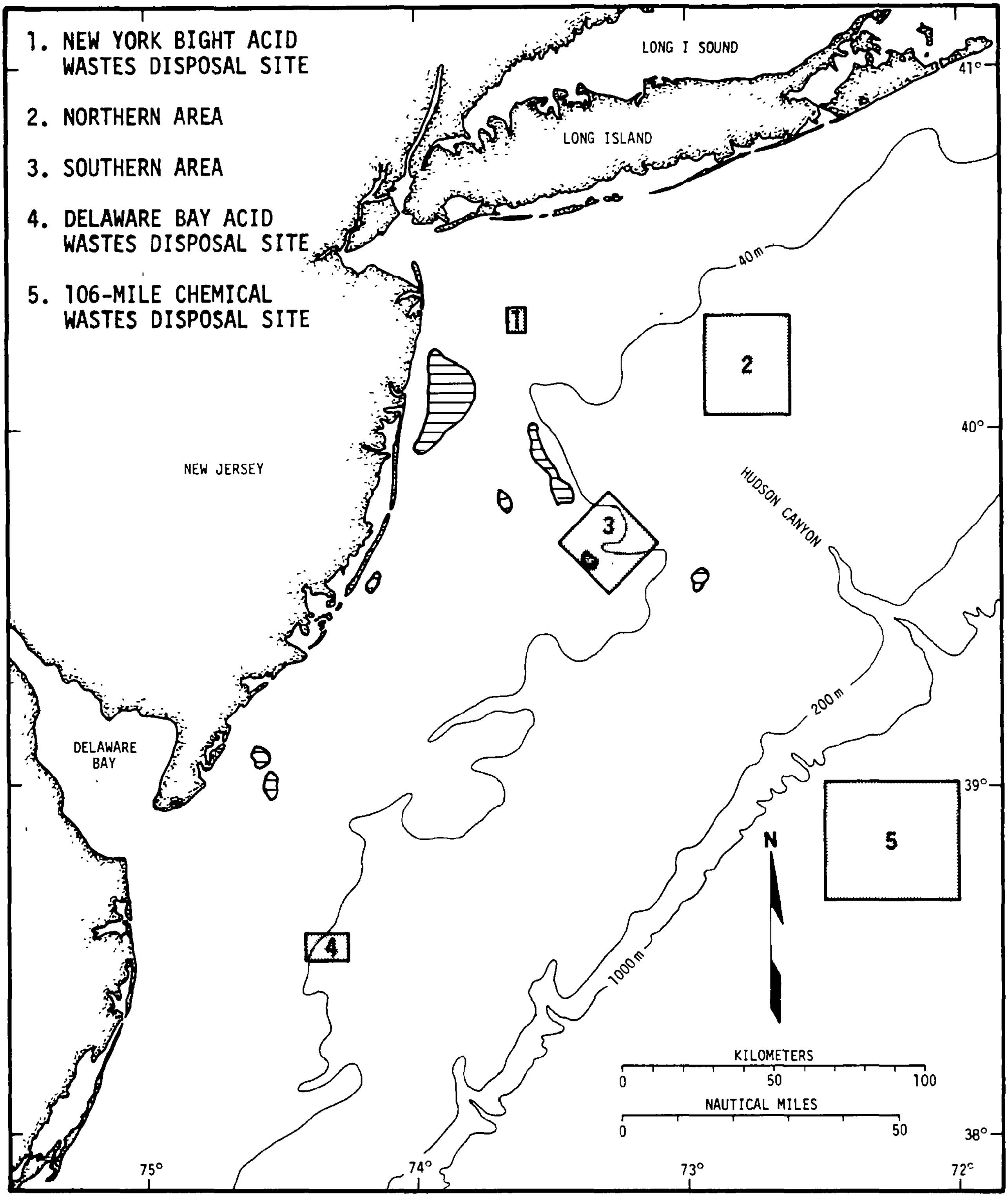

Figure 3-9. Gravel Distribution in the New York Bight (Schlee, 1975)

12-Mile Sewage Sludge Site

There are 13 permittees currently disposing of sewage sludge at this site, with the City of New York discharging far more than any other permittee. The total volume of sewage sludge to be disposed of by the 13 permittees in 1979 is estimated as 7,772 m^3, and is expected to reach 9,895 m^3 by 1981. The sludge is composed of municipal sewage wastes from primary and secondary treatment.

New York Bight Dredged Material Site

Several locations have been used historically as sites for the disposal of material dredged from navigable waterways in the New York-New Jersey metropolitan area. The present Site was designated in 1940 as the exclusive disposal site for this material. Until 1973, ash residues from fossil-fueled power plants were also permitted to be disposed of at the Site.

Each year, the volume of dredged material disposed of at this site exceeds that of any waste disposed of at any other disposal site. The average annual volume of dredged material dumped at the Site from 1960 to 1977 was approximately 6 million m^3. The annual volume is estimated to increase by 46,000 to 54,000 m^3. The dredged material is composed of particulate solids which, because of the proximity of the dredging sites to large metropolitan areas, contain higher levels of metals than any other waste material disposed of in the Bight.

New York Bight Cellar Dirt Site

The history of this Site is similar to the history of the Dredged Material Site. The Cellar Dirt Disposal Site has been relocated several times to prevent excessive build-up of material at the Site, and has occupied its present location since 1940. Relatively inert materials from land-based construction projects (demolition wastes) are disposed of at the Site,

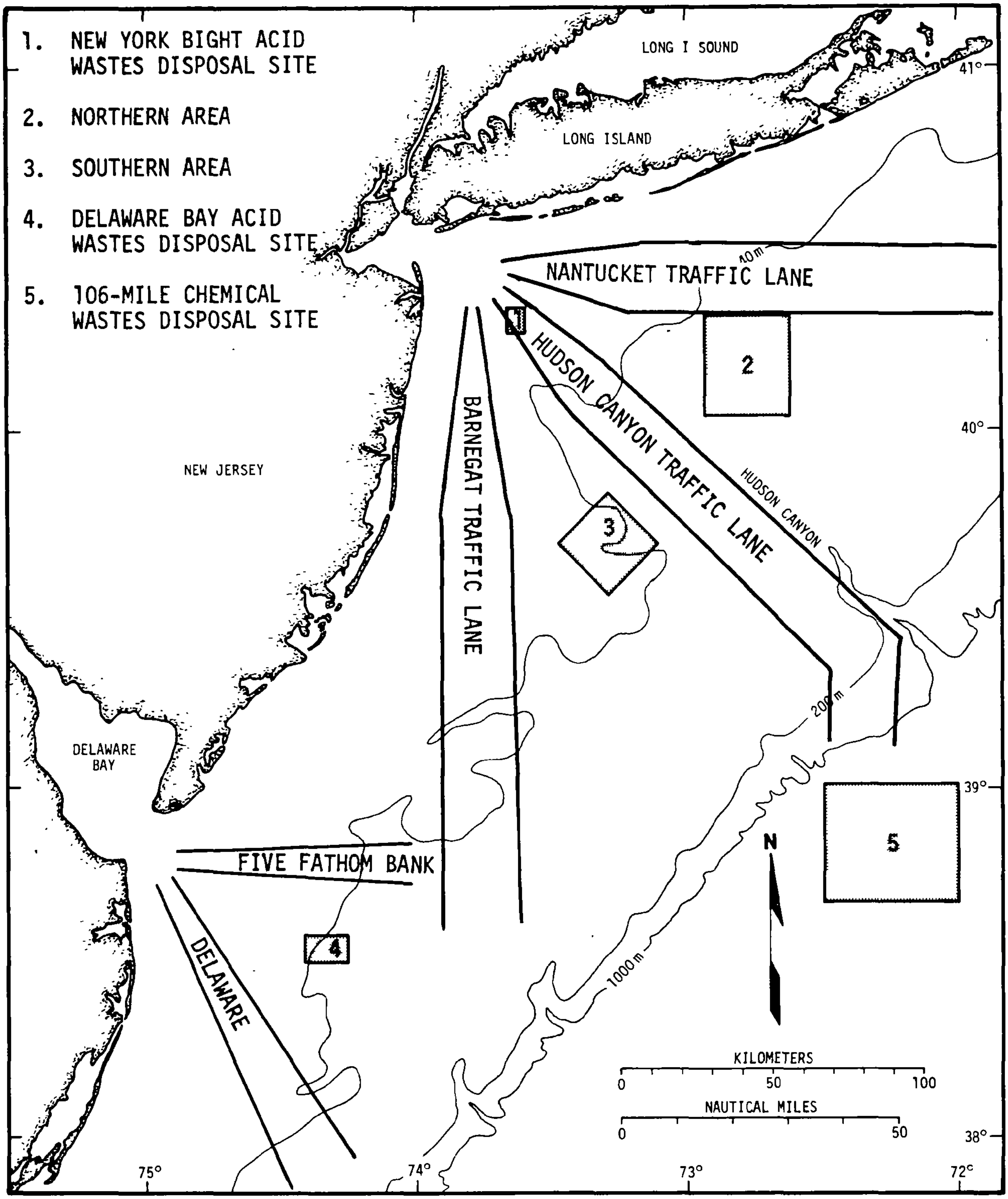

Figure 3-10. Navigational Lanes in the Mid-Atlantic

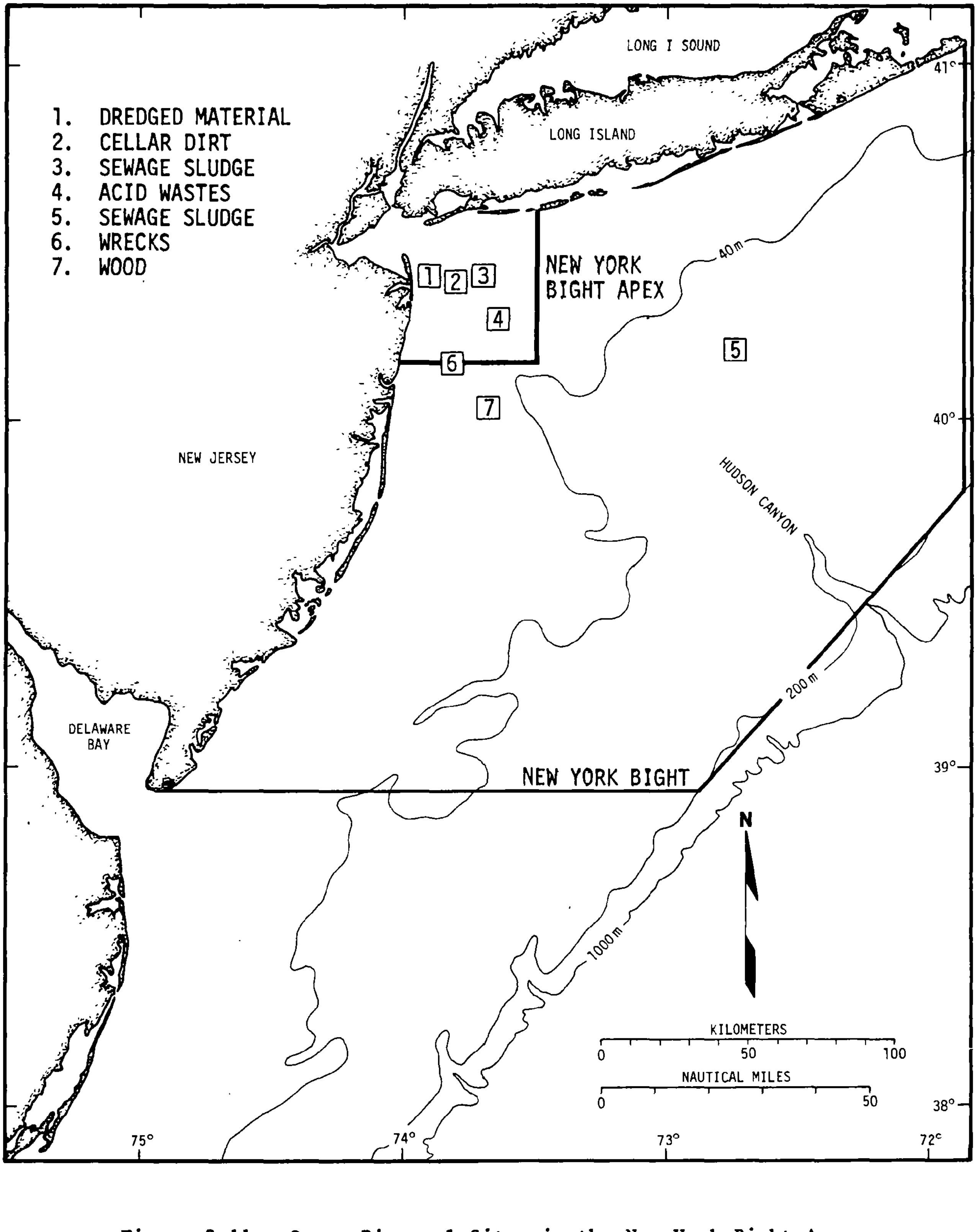

Figure 3-11. Ocean Disposal Sites in the New York Bight Apex (Boundary Shown by Dark Line)

including excavated earth, broken concrete, rock, and other non-floatable material. The average annual volume of cellar dirt disposed of at the Site from 1960 to 1977 was 450,000 m^3. The average annual volume will continue to fluctuate from year to year according to the activity of the construction industry.

Wreck Site

The Wreck Site has been designated by the EPA for derelict and wrecked vessels. The Site has been used infrequently for the past 17 years, and was moved to a new location outside of major navigational lanes in 1977.

Wood Incineration Site

The EPA has designated this site for burning scrap wood from decaying structures and construction sites. The Site is used as needed, and only the combustion products reach the ocean; the remaining ash is landfilled.

MARINE RECREATION

The New York Bight possesses many Federal and State beaches and wild life refuges, located on the coast and on offshore islands. Activities in these areas include swimming, hiking, and fishing.

DELAWARE BAY ACID WASTE DISPOSAL SITE

PHYSICAL CONDITIONS

Like the New York Bight, the physical environment offshore from Delaware Bay experiences marked changes with season. Warming of surface waters in late spring creates a strong thermocline which becomes more pronounced as summer progresses. Spring also causes a large flow of fresh water out of Delaware Bay, which lowers the salinity of the Site water. In late autumn and winter, temperature and salinity values stabilize throughout the water column from surface to bottom. The net current flow at the Site is to the southwest. Occasionally strong summer winds reverse the surface flow.

GEOLOGICAL CONDITIONS

The Continental Shelf off the Delaware coast is a gently sloping, relatively smooth plain superimposed with low elevation sand ridges and swales. Other small-scale relief is superimposed on the ridges, possibly due to the cumulative effects of seasonal storms or the effects of a particular storm. The sediments are composed of fine- and coarse-grained sands.

CHEMICAL CONDITIONS

Despite temporary, localized fluctuations, dissolved oxygen levels of waters offshore of Delaware Bay show seasonal patterns and values typical of the continental shelf. Values near peak saturation (10.5 mg/l) are found throughout the water column during winter, while the summer thermocline separates the saturated surface layer from a relatively depleted (usually less than 4 mg/l) bottom layer.

Discussions of sediment and water column trace metal chemistry for the site appear in Chapter 4.

BIOLOGICAL CONDITIONS

Like the New York Bight, the phytoplankton communities offshore of Delaware Bay are dominated by dinoflagellates in the summer and by diatoms in the winter (Smith, 1973, 1974). Zooplankton communities off of Delaware Bay are also characteristic of the Bight (Falk et al., 1974; Forns, 1973). Copepods are the most diverse and abundant taxon with abundance peaking in summer and fall.

The benthic macrofauna in this area are characteristic of the firm sand-shell-gravel community found elsewhere in the mid-Atlantic (Pratt, 1973, Falk et al., 1974; Lear et al., 1974). Annelid worms dominate in abundance and numbers of species. The offshore area probably serves as an incidental spawning ground for several commercially important species of fish generally found throughout the mid-Atlantic; however, the Site supports no known finfishery at this time. Sea scallops have been harvested near the Site and the ocean quahog, a species of potential commercial importance, is abundant throughout the area.

WASTE DISPOSAL AT THE SITE

HISTORY

The E.I. duPont de Nemours plant, located in Edge Moor, Delaware, was the only permittee using the so-called DuPont Disposal Site after implementation of the ocean dumping permit program in 1973. DuPont-Edge Moor began discharging acid wastes at sea on a temporary basis in September 1968, in an area centered about 19 km (10 nmi) southeast of the more recently used Site. This alternative site was used until July 1969, pending completion of the pre-disposal surveys in the primary area. Surveys were conducted in May and June of 1969, and barging began in the designated area in July 1969.

RECENT WASTE DISPOSAL PRACTICES

The volume of aqueous waste released at the Delaware Bay Acid Site decreased 92 percent, from 867,000 metric tons in 1973, to 69,000 metric tons in the first quarter of 1976. The actual volumes discharged by DuPont from 1973 to 1976 are shown in Table 3-7. The waste disposal operation was relocated to the 106-Mile Chemical Waste Disposal Site in March 1977.

TABLE 3-7. DUMPING VOLUMES AT THE DELAWARE BAY ACID WASTE DISPOSAL SITE

Year	Volume (Thousand of metric tons)
1973	867
1974	614
1975	365
1976	430
1977	69

In 1973, DuPont waste consisted of an aqueous solution of iron and miscellaneous chlorides, sulfates, and sulfuric and hydrochloric acid. It was 17 to 23 percent sulfuric acid, and 4 to 10 percent ferrous sulfate. The waste was generated from the production of titanium dioxide (TiO_2) by the chloride, sulfate, and color pigment processses. The waste was modified as manufacturing changed from a sulfide process to a chloride process. By 1976, the waste consisted of an aqueous solution of iron, miscellaneous chlorides, and hydrochloric acid. The material at that time was 30 percent hydrochloric acid, formed from the chlorine used in the manufacturing process. The process modification resulted in a decrease of waste production from 1,300 to 3,000 metric tons per day to 1,500 to 2,000 metric tons per day.

PHYSICAL CHARACTERISTICS OF THE WASTE

Specific gravity is an important physical characteristic for waste dispersion prediction. Analyses of barge loads dumped from 1973 to 1976 indicated a range of specific gravity for DuPont waste of 1.043 to 1.204, as compared to seawater, with a typical specific gravity of 1.025.

The in situ behavior of the DuPont ferrous sulfate waste was investigated at the Site from spring 1969 to spring 1971 by Falk et al (1974). The waste did not penetrate below the thermocline during summer, spring, and fall, but during the winter a portion of the waste did reach the sea floor under barging procedures used at that time. The water column pH was depressed following discharge, but returned to normal within four hours. Iron was used to trace the waste up to 18.5 km from the discharge point.

Falk and Phillips (1977) reported on a waste dispersion study conducted at the Site in September 1976 by EG&G. Dispersion of the ferric chloride waste was similar to that of the ferrous sulfate waste previously tested.

CHEMICAL CHARACTERISTICS OF THE WASTE

Heavy metals were the most significant waste constituents, both in terms of amounts present and potential toxicity. From 1973 to 1977, the individual proportions of metals discharged to the total volume of discharged material, remained relatively constant, both from quarter-to-quarter and from year-to-year (Table 3-8). The total mass loading of each metal decreased in a range from 28 to 76 percent. For 1973 to 1977, the most prevalent heavy metals in the waste, in order of decreasing mass load, were chromium, zinc, lead, nickel, copper, cadmium, and mercury.

EFFECT ON ORGANISMS

Routine bioassays and special tests investigated the toxic effects of DuPont's waste on diatoms, opossum shrimp, grass shrimp, brine shrimp, copepods, sheepshead minnows, and hard clams. The waste concentrations which caused significant mortality, or other effects, were much higher than the concentrations that occurred at the Site after initial dilution. Long-term tests produced reduced growth and decreased hatching success in minnows and shrimp. However, these effects were thought to result from the presence of a waste flocculate in the test water that impeded feeding, rather than from toxic chemical constituents in the waste (Falk and Phillips, 1977).

TABLE 3-8. ESTIMATED QUANTITIES OF TRACE METALS DUMPED ANNUALLY AT THE DELAWARE BAY ACID WASTE DISPOSAL SITE (Metric Tons)

Metal	Year				
	1973	1974	1975	1976	1977
Cadmium	0.1	0.3	0.001	0.001	0.001
Chromium	54.4	44.0	38.6	81.4	9.8
Copper	5.8	2.2	1.6	2.0	0.3
Lead	10.6	6.8	7.5	10.4	3.3
Mercury	0.035	0.01	0.001	0.001	0.001
Nickel	8.0	5.1	2.8	121.2	0.7
Zinc	34.2	21.4	15.6	83.7	4.0

Field studies at the Site did not detect any effect of the waste on water column organisms or benthic communities. However, elevated vanadium values were observed in scallops collected in the Site and southwest of the site (Pesch et al., 1977). In addition, an iron floc was observed overlying sediments in the vicinity, although the floc did not appear to harm organisms.

CONCURRENT AND FUTURE STUDIES

Although intensive monitoring work at the Delaware Bay Acid Waste Site ceased upon cessation of dumping, EPA Region III, with NOAA's help, still samples historical stations in the site as part of their study program at the nearby Philadelphia Sewage Sludge Disposal Site.

OTHER ACTIVITIES IN THE SITE VICINITY

COMMERCIAL AND RECREATIONAL FISHERIES

The area of the north and middle Atlantic, from Georges Banks to Cape Hatteras, represents "one large...fish-producing unit"; few species of fish migrate into or out of this area (McHugh, 1978). Consequently, most of the finfish harvested in the New York Bight are also pursued in the vicinity of the Delaware Bay Acid Waste Disposal Site, although smaller domestic harvests are reported for the latter (Table 3-9).

TABLE 3-9. COMMERCIAL LANDINGS OF THREE MAJOR SPECIES OF FINFISH FOR DELAWARE REGION, 1974 (McHugh, 1978)

Species	000 Lb	$000
Menhaden	13	0.5
Striped Bass	212	65
Whiting	8	1

The narrowness of the Continental Shelf in this region enables more recreational fishermen to reach the rich Shelf/Slope fishing grounds than in areas farther north. Although fishermen in the Delaware region are known to travel great distances offshore in order to fish large game fish, no recreational fishing has been reported at the Delaware Bay Acid Waste Site. In 1976, 1.8 million anglers landed over 246 million pounds of fish in the mid-Atlantic (Chenoweth, 1976a).

OIL AND GAS EXPLORATION AND DEVELOPMENT

Figure 3-12 shows the offshore oil and gas leases granted by OCS Sale No. 49.

SHIPPING

Delaware Bay is a major seaport, receiving nearly as much traffic as New York Harbor. Figure 3-10 shows the two major shipping lanes into Delaware Bay. The axes of these lanes are directed well to the north and south of the Delaware Bay Acid Waste Disposal Site, and neither shipping lane extends offshore as far as the vicinity of the Site. The Barnegat Navigational Lane passes to the east of the Site. Traffic travelling north or south along the mid-Atlantic coast utilizes the Barnegat Navigational Lane, or a corresponding southern lane, to either of the access routes into Delaware Bay, and does not normally enter the waters of the Acid Site. Only a limited amount of ship traffic crossing the Continental Shelf is likely to enter the Site's waters.

OCEAN WASTE DISPOSAL

The Philadelphia Sewage Sludge Disposal Site is located to the southeast of the Acid Waste Site and is the only other disposal site in its vicinity. The Sewage Sludge Site received an average annual volume of 604,000 metric tons of anaerobically digested sewage sludge from 1973 to 1977.

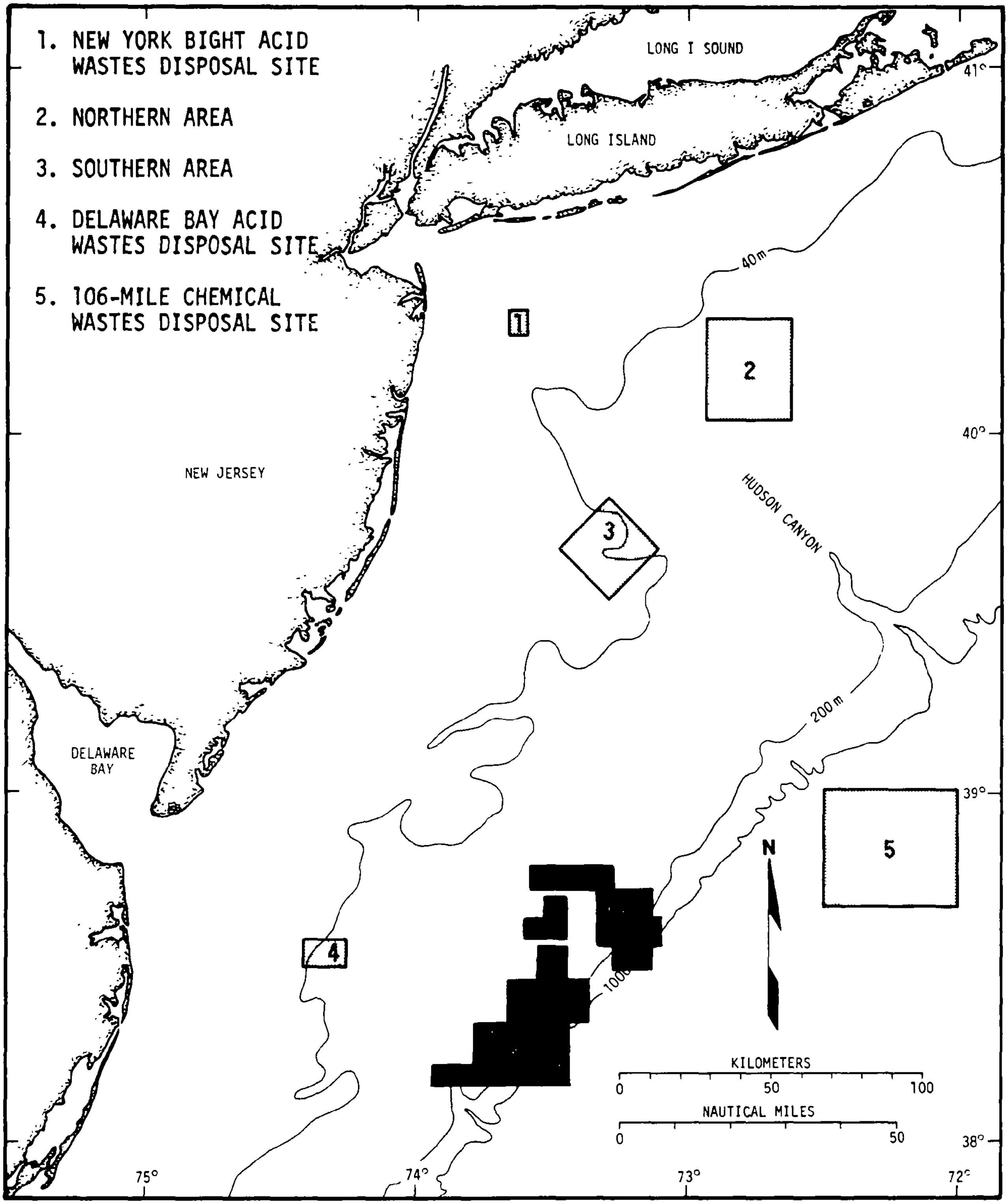

Figure 3-12. Oil and Gas Leases Near Delaware Bay (BLM, 1978)

Chapter 4

ENVIRONMENTAL CONSEQUENCES

The projected environmental consequences of dumping aqueous industrial wastes at the 106-Mile Site are minimal. Wastes released at the Site are diluted and dispersed quickly, and the natural biological productivity of the Site area is slight in comparison to the productivity on the Continental Shelf. A slight threat to local marine organisms (and possibly to public health) could result from additional waste loading at the New York Bight or Delaware Bay Acid Waste Sites, since they have received significant waste loadings in the past. The Northern and Southern Areas, although never before used for waste disposal, could sustain slight damage to benthic organisms if waste operations were moved there, since the sites are located in relatively shallow waters.

This Chapter forms the scientific and analytic basis comparison for evaluating alternatives in Chapter 2. The discussion includes the environmental impacts of the various alternative sites considered in Chapter 2, together with any adverse environmental effects which cannot be avoided should the proposed action be implemented; the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity; and any irreversible or irretrievable commitments of resources which would be involved in the proposal, should it be implemented.

The chapter first addresses the effects on public health, specifically through commercial or recreational fisheries and navigational hazards. Next, the environmental consequences of chemical waste disposal at each alternative site are assessed. This assessment includes effects on the biota, effects on water and sediment chemistry of the Site, and effects of short dumping in non-designated areas.

A large body of data was examined to evaluate the potential effects of chemical waste disposal at these sites. The principal data sources for each area are:

- 106-Mile Site: NOAA surveys, starting in 1974. Waste dispersion studies and monitoring of short-term disposal effects sponsored by the permittees. Public hearings concerning relocation of sewage sludge disposal sites and issuing of new permits.

- New York Bight Acid Waste Site: NOAA-MESA studies beginning in 1973. NMFS/Sandy Hook Laboratory study from 1968 to 1972. Site-specific studies sponsored by NL Industries, Inc. beginning in 1948. Routine monitoring surveys sponsored by the permittees.

- Delaware Bay Acid Waste Site: EPA surveys beginning in 1973. Studies sponsored by DuPont beginning in 1968.

- Southern Area: NOAA survey in 1975. Public hearings concerning the disposal of sewage sludge in the New York Bight.

- Northern Area: NOAA and Raytheon surveys in 1975. Hearings concerning the disposal of sewage sludge in the New York Bight.

Data from these and other sources were collected and compiled into an extensive data base dedicated to ocean environment data management and evaluation. The following discussion is based on an evaluation of the available data.

EFFECTS ON PUBLIC HEALTH AND SAFETY

A primary concern in ocean waste disposal is the possible direct or indirect link between contaminants in the waste and man. A direct link may affect man's health and safety. An indirect link may cause changes in the ecosystem which, although they do not appear to affect man, could lead to decreased quality of the human environment.

COMMERCIAL AND RECREATIONAL FISH AND SHELLFISH

The most direct link between man and waste contaminants released into the marine environment is through the consumption of contaminated seafood. Shellfishing, for example, is automatically prohibited by the Food and Drug Administration around sewage sludge disposal sites or other areas where wastes are dumped which may contain disease-producing (pathogenic) microorganisms. In this way the consumption of uncooked shellfish which may be contaminated with pathogens is eliminated or minimized. Harmful effects caused by eating fish containing high levels of mercury, lead, or persistent organohalogen pesticides have been documented (Subcommittee on the Toxicology of Metals, 1976). Certain compounds, such as oil, have been shown to make the flesh of fish and shellfish not only unhealthy, but unpalatable as well. Therefore, ocean disposal of wastes containing heavy metals, organohalogens, oil, or pathogens, must be carefully evaluated with respect to the possible contamination of commercially or recreationally exploitable marine animals.

Although a foreign long-line fishery exists on the Continental Slope, most U.S. fishing in the mid-Atlantic is restricted to waters over the Continental Shelf. Commercial and sportfishing on the shelf is wide-ranging and diverse; both finfish and shellfish (mollusks and crustaceans) are taken. The New York Bight is currently one of the most productive coastal areas in the North Atlantic and the region may be capable of even greater production as new fisheries develop.

Important spawning grounds and nursery areas lie within the Bight, but critical assessments of the effects of man-induced contamination on fish and shellfish populations are lacking. Many factors complicate the collection and assessment of these data. For example, normal short-term and long-term population cycles are not well understood, catch data may not be adequate, and the complete life cycle and distribution of the stock may be unknown. Natural population fluctuations, overfishing, and unusual natural phenomena may have a greater influence on the health and extent of the fisheries resource than does man-induced contamination. Therefore, assessing the effects of ocean disposal involves uncertainty due to the weaknesses of existing fisheries information.

106-MILE SITE

Waste disposal at this site will not directly endanger human health. This site is not located in a commercially or recreationally important fishing or shellfishing area. Although the NOAA resource assessment surveys do not extend beyond the Shelf, the density of fish eggs and larvae is low. Foreign fishermen are near the Site in the late winter, but usually catch highly migratory fish. The probability of these fish accumulating toxic levels of contaminants from the waste is extremely remote.

A small fishery for the deep sea red crab (Geryon quinquedens) exists near the Shelf-Slope break in the mid-Atlantic. Immediately north of the 106-Mile Site, crabs are found in moderate abundance (33 per half hour otter trawl), but the water depth is much shallower than at the Site (311 to 732 meters). At a station 130 kilometers northeast of the Site, at a comparable depth, no crabs are taken (Wigley et al., 1975). Although the Site is within the range of smaller crabs, none of commercial size are taken deeper than 914 meters. As with finfish, the probability of the wastes affecting a benthic animal is extremely low. Therefore, disposal at this site does not directly endanger human health by contaminating edible organisms.

Lobsters are taken in water depths less than 500 m all along the mid-Atlantic Continental Shelf/Slope break. Aqueous chemical wastes released at the 106-Mile Site will not contaminate lobsters since the Site is located some distance from the eddge of the Shelf, and wastes will not reach the sediments where these animals live.

NEW YORK BIGHT ACID WASTES SITE

There is a real, albeit relatively low, potential for endangering public health from additional chemical waste disposal at this site. The Site location was chosen 30 years ago because it had no history as a point of concentration for fish or fishing and because the sediments at the Site are seldom associated with productive fishing (Westman, 1958). Ironically, the Site has become a sportfishing area because the discoloration of the water caused by acid-iron waste disposal attracts fish to the area, including bluefish, a prized sport fish.

During the winter a commercial whiting fishery exists near the Acid Site. Since the Site will also continue to be utilized by recreational fishermen, there is a potential health problem if additional wastes are released. Increased waste disposal at the Site could lead to accumulation of materials in toxic concentrations within the tissues and organs of these fish, and subsequent consumption of contaminated fish could pose a threat to the public health. No health problems associated with sport fish caught at the Site have been reported. Although adverse effects have been observed in fish eggs exposed to moderately high concentrations of acid waste (Longwell, 1976), tainting or harmful accumulations of waste components in the flesh of fish taken from the area have not been reported.

Lobsters are the only shellfish which can be exploited near the Site. Waste constituents could reach bottom in this shallow site and be incorporated by the animals, but other sources of contamination are probably more significant. (The New York Bight Sewage Sludge Site is only 5 km from the Acid Site.) Overall, there is a real, but low, probability of chemical wastes directly endangering public health.

DELAWARE BAY ACID WASTE SITE

A potential exists for endangering public health from chemical waste disposal at this site. Although the Site and vicinity do not support a finfishery, a potentially valuable ocean quahog resource exists to the southwest. As a result of the decline in the surf clam (Spisula solidissima) fishery, the National Marine Fisheries Service has encouraged development of a market for the ocean quahog (Arctica islandica), another clam which is abundant in the coastal area containing the disposal site (Breidenbach, 1977). In addition, sea scallops (Placopecten magellanicus) are harvested. However, the extent of past fishing from the immediate vicinity of the disposal site is unknown. The Site is presently closed to fishing by the FDA.

Preliminary work indicates that past waste disposal at the Site caused elevated vanadium levels in scallops from the area (Pesch et al., 1977), but no correlation between the reported values and potential health problems has been made. Use of the Site for future waste disposal is not prudent in light of nearby fishing, and the potential for contaminating future commercial resources.

SOUTHERN AREA

There is a moderate potential for endangering public health from chemical waste disposal at this site. Although the Southern Area is situated where surf clams, ocean quahogs, and scallops are abundant, most commercial shellfishing presently occurs well to the west, near the New Jersey coast. However, declining harvests may cause the Southern Area to be exploited in the future (EPA, 1978). Recreational fishing is unlikely at this site due to its distance from shore and the competition provided by equally attractive sportfishing areas located closer to shore. If this area were used as a disposal site for wastes similar to those presently being disposed of at the 106-Mile Site, the potential for an accumulation of waste constituents in the flesh of shellfish could occur.

NORTHERN AREA

Disposal of aqueous chemical wastes in this area would probably not directly endanger public health. This site is not located in a known commercially or recreationally important fishing or shellfishing area. Shellfish are not present in commercially exploitable numbers in the Area. Since the area supports no commercially or recreationally abundant finfish or shellfish, the health hazard from eating animals contaminated by waste materials is slight.

NAVIGATIONAL HAZARDS

Navigational hazards may be separated into two components: (1) hazards resulting from the movement of transport barges/vessels to and from a site, and (2) hazards resulting from the barge's maneuvering within the site.

If an accident resulted in chemical wastes being released, the effects from the dumped waste would probably be equivalent to a short dump. The effects from the other ship would depend on the cargo and could be severe if the barge collided with an oil or liquified natural gas (LNG) tanker, for instance. There is the possibility of loss if life in any collision.

The following discussion concentrates on the barging operations from New York Harbor since most traffic to the 106-Mile Site originates in New York and New Jersey. DuPont-Edge Moor is the only permittee transporting wastes from elsewhere. The most serious hazard from any ocean dumping activity exists in the potential for an accident occurring close to shore where ship traffic is concentrated and the ramifications of a spill from a waste barge or tanker are most serious. This hazard is one that is associated with all ocean dumping, no matter where the disposal site is located, since all trips to an ocean disposal site begin in a coastal port. Accordingly, this section discusses only the relative risks associated with transporting wastes beyond the coastal ports out to each of the alternative disposal sites, and discusses the risks associated with on-site disposal operations.

Considering the alternative sites, the hazards associated with increased usage of the New York Bight Acid Waste Site are the most severe, due to the heavy shipping traffic associated with New York Harbor. Hazards could increase in the Southern Area as mineral development proceeded in that area. The 106-Mile Site is the preferred choice of the remaining three sites because if an accident occurred at the Site, wastes would not be released into coastal waters, possibly threatening fishing or other activities, but much farther offshore where such activity is limited.

106-MILE SITE

Barges in transit to the 106-Mile Site from New York Harbor use the Ambrose-Hudson Canyon traffic lane for most of the journey. Because of the long distance travelled there may be a slightly greater risk of collision during the round-trip transit to the 106-Mile Site than there would be if a site closer to shore were utilized.

Hazards resulting from maneuvers within the Site are negligible. The Site is extremely large, and permittees are required to use different quadrants of the Site. The frequency of all barging is low, averaging only 2 to 3 times per week. A moderate increase in frequency of dumping at the Site would not significantly affect navigation difficulties.

NEW YORK BIGHT ACID WASTES SITE

The New York Bight Acid Wastes Site is situated across one of the outbound traffic lanes from New York Harbor, but the current barging operations within the Site are designed to minimize interference with traffic. In 1976, an accident occurred southwest of the Acid Site involving a waste barge in transit to the 106-Mile Site.

The permittees currently using the Site barge wastes an average of once or twice a day. Increased usage of the Site would increase the possibility of collisions between barges or the heavy shipping traffic into and from New York Harbor since the Site is rather small. There is a risk that any accidents which did occur could be closer to New Jersey or Long Island beaches.

DELAWARE BAY ACID WASTE SITE

Use of the Delaware Bay Acid Waste Site would not be expected to pose significant navigational hazards, aside from accidents that might occur during round-trip transit from New York Harbor. Any accidents which did occur, however, would release wastes in the coastal waters off New Jersey where fishing and swimming are prevalent.

SOUTHERN AREA

The Southern Area lies outside of the traffic lanes for New York Harbor, so use of this site would pose few navigational hazards for shipping. However, increased ship traffic resulting from offshore oil and gas development would increase the hazard. The degree and extent to which such hazards became apparent would depend on the speed and magnitude of oil and gas development in the area. Any accidents would take place in the heavily fished coastal waters off New Jersey.

NORTHERN AREA

The Northern Area also lies outside the traffic lanes for New York Harbor so use of this site poses few navigational hazards. Mineral resources are not located in the area, so there is no probability of increased hazards from future resource development. Any accidents would be near coastal waters off Long Island.

EFFECTS ON THE ECOSYSTEM

The adverse effects of ocean disposal on the ecosystem (the interacting living and non-living components of the environment) can be subtle, and may not exhibit obvious direct effects on the quality of the human environment. However, these subtle adverse impacts can accumulate and combine with consequences which, over the long-term, are as serious as any readily observed direct impacts. For example, an organism may accumulate waste constituents in its tissues at concentrations that do not cause its death immediately but, instead, act at the sublethal or chronic level. Such adverse sublethal effects may reduce reproduction, reduce health of eggs and larvae, slow development of juveniles, or affect other facets of the life cycles of individual organisms and may ultimately result in adverse changes in the entire population of this organism. The population may eventually be eliminated from an area, not because it was immediately killed by a single waste discharge but because of the accumulation of sublethal effects over time. If that population were a major human food source or a food source for an organism that was commercially exploited, man would lose the resource. This "scenario" is vastly simplified, and is not a projection of what is currently resulting from industrial waste disposal in the ocean; however, it does illustrate that man, as an integral part of a complex ecosystem, may ultimately feel the results of adverse impacts on other parts of the ecosystem.

The magnitude of the effects of waste disposal on the marine ecosystem depends on several factors: (1) the type of waste constituents; (2) the concentration of toxic waste materials in the water and sediments; (3) the length of time that high concentrations are maintained in the water or the sediments; and (4) the length of time that marine organisms are exposed to high concentrations of these materials. Current disposal techniques for aqueous chemical wastes maximize the dilution and dispersion of the wastes, minimizing the chances for wastes to remain in the water column or reach the bottom in high concentrations.

PLANKTON

The plankton consists of plants (phytoplankton) and animals (zooplankton) that spend all or part of their lives floating or weakly swimming in the water column. Since aqueous wastes primarily affect the water column, plankton represent the first level of the ecosystem where the effects of waste disposal could be observed. Accordingly, numerous studies of the effects of wastes on planktonic organisms have been conducted.

106-MILE SITE

Numerous field and laboratory studies have investigated the effects of wastes dumped at the 106-Mile Site on plankton. Field studies of populations have shown that they are highly variable, primarily because of the presence of several water masses, each with different species (Austin, 1975; Sherman et al., 1977; Hulburt and Jones, 1977).

> **Plankton undergo large natural variations with changing water type and for this reason, assessment of the plankton of the region was difficult. Coastal waters are characterized by high nutrient concentrations and populations with wide seasonal variations in abundance and diversity. Oceanic waters have reduced nutrient levels and population densities, but photosynthetic processes extend to much greater depths. Mixing water types will produce a complex combination of these conditions (NOAA, 1977).**

Since the plankton data from the Site demonstrate high natural variability in populations, variability in species composition, abundance, and distribution as a result of waste disposal may never be demonstrated. Variations induced by waste disposal are probably obscured by variability created by natural events.

Some field work at the Site has concentrated on particular plankton population components rather than looking at whole populations or assemblages. Preliminary studies on the development of fish eggs and embryos collected from the Site when sewage sludge and acid waste were present showed "...severe cytotoxic-like effects on the chromosome and mitotic apparatus of the dividing embryos" and malformations in the more developed embryos (Longwell, 1977). The field sampling routine did not, however, result in the collection of a sample large enough to permit statistically valid conclusions to be reached. Therefore these laboratory data must be applied with caution to any assessment of the effects of waste disposal at this site.

Both field and laboratory studies have assessed the effects of waste on the native bacteria populations from the Site (Vaccaro and Dennett, 1977). These investigators tested the hypothesis that bacterial species at the Site would be more tolerant of environmental changes. Field collections showed no tolerance differences in bacteria taken from inside and outside the disposal site; however, laboratory "exposure of mixed bacterial populations to...Cyanamid waste resulted in...pure cultures showing an increase in waste tolerance." Both DuPont-Grasselli and American Cyanamid waste inhibited assimilation of organic carbon by bacteria. Additional work with DuPont-Edge Moor and DuPont-Grasselli waste indicates that "the principle toxic components of Edge Moor waste are trace metals, whereas organic species appear to dominate with regard to Grasselli waste" (Vaccaro and Dennett, 1978). The investigators did not attempt to correlate the laboratory work with actual conditons at the Site.

Preliminary laboratory results on the effects of DuPont-Grasselli waste on copepods (Capuzzo, 1978) confirmed that acute toxic effects were minimal, but indicated that sublethal effects (lowered feeding rates) require further investigation. Capuzzo (1978) also summarized the results of zooplankton responses to other liquid chemical wastes. In general, other investigators reported these wastes to be less toxic than DuPontGrasselli.

Continued use of the 106-Mile Site for disposal of wastes similar to those previously permitted, should not result in effects significantly different from those revealed by field and laboratory studies. The results of these studies demonstrate that much is unknown about the interaction of plankton and chemical wastes in marine waters. Furthermore, the application of controlled laboratory experiment to the situation existing at the disposal site during waste release is unclear. Finally, the mitigating effects of the rapid dilution and dispersion of the waste are not well understood. Therefore, it is difficult to predict the long-term consequences of waste discharge on plankton at this site; however, the short-term consequences are generally known and are limited to within the disposal site.

NEW YORK BIGHT ACID WASTES SITE

The effects of waste disposal on plankton at the New York Bight Acid Waste Site have also been extensively studied. Field studies during waste discharges have shown that acid-iron waste does not harm zooplankton populations (Wiebe et al., 1973; Redfield and Walford, 1951). Evidence of chromosomal damage in mackerel eggs collected in the vicinity of the Site has been reported (Longwell, 1976), but the cause of the damage cannot be definitely linked to the disposal of acid wastes. Interpretation of field results from this site is difficult; changes in plankton populations resulting from acid waste disposal at the New York Acid Waste Site cannot be reliably distinguished from changes caused by pollutants introduced from other sources within the New York Bight.

Laboratory studies show that the acid wastes released at this site can cause chronic effects in zooplankton only after prolonged exposure to waste concentrations that are much greater than those encountered under field conditions (Grice et al., 1973). Sublethal effects, such as failure to reproduce and extended developmental times, have been demonstrated in the laboratory after 21 days of exposure to waste concentrations that persist for only minutes after actual discharge of wastes at the Site (Vaccaro et al., 1972).

Additional release of chemical wastes similar to those disposed of at the New York Bight Acid Waste Site would not be expected to cause effects different from those presently seen at the Acid Site. However, dumping wastes with characteristics different from wastes disposed of previously at the Acid Site could have unanticipated effects.

DELAWARE BAY ACID WASTE SITE

No long-term effects of acid waste disposal on plankton at the Delaware Bay Acid Site have been demonstrated. Elevated concentrations of certain trace metals (nickel, mercury, and manganese) were observed in zooplankton collected in the area (Lear et al., 1974), but the values were extremely variable. Like other alternative sites, future chemical waste disposal at this site should not have any demonstrable long-term effects on plankton species composition, distribution, or abundance. The likelihood and magnitude of effects on other plankton parameters would depend on the disposal volumes and frequencies.

SOUTHERN AND NORTHERN AREAS

Use of either the Southern or Northern Areas for chemical waste disposal would not be expected to have significant long-term effects on plankton. These areas are located outside the highly stressed New York Bight Apex so their biota are unlikely to have had the opportunity to adapt to man-induced environmental factors. Specific effects would depend on the nature and volume of the waste and on the frequency of disposal. Based on the existing wastes and volumes, any effects would be difficult to demonstrate since plankton populations are so variable.

NEKTON

The nekton include animals, such as fish and mammals, capable of swimming and migrating considerable distances.

106-MILE SITE

Continued disposal of chemical wastes at this site should not significantly affect nekton other than causing them to temporarily avoid the area. The results of field investigations of effects of dumping on fish at the 106-Mile Site have been inconclusive because the field work has been conducted primarily during the infrequent presence of Gulf Stream eddies, so normal conditions have not been studied. NOAA (1977) reported:

> **Total fish catches within and without the dumpsite were not significantly different, although midwater fish were most abundant outside the dumpsite. The highest rate of fishless tows occurred the night after a dump, but whether the tows were still in water affected by the dumped material is not known.**

Investigations of histopathology in fish collected from the disposal site area (NOAA Pathobiology Division, 1978) have been inconclusive. Although lesions were observed in some fish, the sample size was too small to permit statistically valid conclusions. High cadmium levels were found in the livers of three swordfish from the site area, and high mercury levels were observed in muscle of almost all fish that were analyzed (Greig and Wenzloff, 1977). However, the elevated concentrations were not attributed to disposal operations at the 106-Mile Site because of the low amounts of these metals added to the area by disposal and the migratory nature of the large swordfish.

ALTERNATIVE SITES

None of the numerous studies on nekton at the New York Bight Acid Waste Site have detected long-term effects that are attributable to acid waste disposal. As a result of the many other contaminant inputs to the Bight Apex in addition to those at the Acid Site, it is unlikely that any deterioration of fish health or populations could ever be demonstrated to be solely the result of acid waste disposal. Therefore, the effects on fish populations of additional chemical waste disposal at this site are difficult to predict based on information obtained as a result of the present disposal operations. However, considering: (1) the dilution and dispersions of wastes presently released, (2) the absence of dead fish in the wake of disposal barges, and (3) the ability of fish to move away from temporarily stressed areas, it is unlikely that disposal of other chemical wastes (which comply with the impact criteria) at the New York Bight Acid Waste Site would have any demonstrably adverse consequences. This same conclusion also applies to the other alternative sites. The risks associated with the consumption of sportfish taken from the New York Bight Acid Waste Site were discussed earlier in Chapter 4 (page 4).

BENTHOS

The benthos consists of animals living on (epifauna) and in (infauna) the sediments. Epifauna are dominated by larger echinoderms and crustaceans while the infauna primarily include small annelid worms and mollusks. Benthic organisms are important as indicators of waste-related impacts because they are sedentary, thus incapable of leaving a stressed environment. They are also important because many are commercially valuable (e.g., shellfish), or are food sources (e.g. worms) for valuable species.

106-MILE SITE

No effects of chemical waste disposal have been observed in the benthos at the 106-Mile Site. The species composition and diversity at the Site are similar to those observed in nearby Continental Slope areas (Pearce et al., 1975; Rowe et al., 1977). Analyses of trace metal content in benthic invertebrates have shown values that are within the range of background values (Pearce et al., 1975). These results are not surprising since it is unlikely that the low density liquid waste could reach bottom in measurable concentrations. There is tremendous dilution due to the depth and movement of water at the Site. Therefore, continued disposal of low density aqueous wastes which are readily dispersed should not affect benthic organisms at, or in the vicinity, of the Site.

NEW YORK BIGHT ACID WASTES SITE

The New York Bight benthos shows a natural temporal and spatial variability substantially greater than any changes resulting from the disposal of acid wastes (Pearce et al., 1976a, 1976b). In addition, any effects arising from acid waste disposal are probably be overshadowed by effects from the numerous other contaminants introduced to the New York Bight, particularly from the Sewage Sludge and Dredged Material Sites and water flowing into the Bight from New York Harbor. As a result of this complex interplay between natural variability and contaminants introduced by other sources, it is extremely difficult to isolate and quantify effects at the Site which are due solely to the disposal of acid waste. Consequently it is difficult to predict the consequences of releasing wastes from the 106-Mile Site at the New York Bight Acid Waste Site. Since the ecosystem of the Bight Apex is already highly stressed, the major risk is that the disposal of additional materials may significantly increase that stress and cause serious environmental consequences.

DELAWARE BAY ACID WASTE SITE

Disposal of acid wastes at the Delaware Bay Acid Site resulted in a measurable accumulation of vanadium in the tissues of sea scallops (Pesch et al., 1977). Although vanadium is not known to be toxic to humans and probably does not have an effect on the sea scallops, this does show the possibility of accumulating other, more toxic, waste constituents. This would be an adverse, long-term impact resulting from the disposal of aqueous chemical waste. These effects are observable because of: (1) the relative shallowness of the Site (45 m), permitting solid waste fractions to reach bottom; (2) the lack of other contaminants inputs to obscure the effects of waste disposal; (3) the presence of the shellfish; and (4) the ability of the scallops to concentrate some metals in their tissues at levels much higher than the levels in the surrounding water or sediment. Future disposal of wastes at this site could possibly cause other effects in addition to those which have already been observed.

SOUTHERN AREA

The Southern Area benthos is similar to that observed at the Delaware Bay Acid Waste Site (see Chapter 3, p. 3-25). Since the sites are similar, especially the shallow water depth, similar effects are anticipated to occur at the Southern Area if industrial waste disposal is initiated there. Accordingly, use of the Southern Area for disposal of liquid chemical wastes, carries the risk of contaminating commercially valuable shellfish populations or otherwise changing the benthic community structure.

NORTHERN AREA

Chemical waste disposal at this site may have the same effects as at the Delaware Bay or Southern Area Sites because the Northern Area is located in similar water depths with virtually the same associated fauna.

WATER AND SEDIMENT QUALITY

106-MILE SITE

Recent investigations of water column levels of dissolved oxygen, pH, organic carbon, and trace metals after waste disposal at the 106-Mile Site have shown that within four hours after dumping the values are within the range of normal values reported from this site and similar oceanic regions (Hydroscience, 1978a-h, 1979 a-d).

NOAA (1977) summarized the results of 1974 and 1976 investigations on trace metals at the 106-Mile Site and at similiar, non-disposal areas:

> Results of the May 1974 cruise indicate that some metals were significantly elevated compared to normal ambient concentrations [Brezenski, 1975]. However, normal concentrations are only a very few parts per billion, and great care must be taken to avoid errors in measured values. A variety of factors can lead to misleading results, among them sample contamination during collection, storage, or analysis. More recent observations support the conclusion that heavy metal concentrations in the...[site]...water column are typical of shelf-slope regions [Kester et al., 1977; Hausknecht and Kester, 1976a,b]. Moreover, calculations show that the total amount of metals added in dumping contributes less than 1 percent to the total normal amount of metals in the water at the dumpsite region [Hausknecht, 1977]. None of the observations occurred near the time of or in the immediate vicinity of dumping, so that ambient concentrations would be expected to be typical of the background for the region.

Therefore, investigations by NOAA and Hydroscience of impacts of waste disposal on the water chemistry of the Site have not detected concentrations elevated above ambient conditions after the initial mixing period.

Table 4-1 presents an estimate of the potential effects of disposal-related metal input on the total metal concentrations in the water at the 106-Mile Site. This estimate is based on "worst-case" conditions consisting of a stable, nondispersing physical environment caused by the hypothetical presence of a Gulf Stream eddy. For the five metals examined, the possible percentage increase in metal concentrations as a result of waste disposal is less than 1.3 percent. Thus, even in a hypothetical worst-case conditions, the total input of metals from waste disposal is negligible compared to the concentration of metals occurring naturally.

TABLE 4-1. WORST-CASE CONTRIBUTION OF WASTE METAL INPUT TO THE TOTAL METAL LOADING AT THE 106-MILE SITE

	Cadmium	Copper	Lead	Mercury	Zinc
Background Concentration (ug/l)*	0.37	0.9	2.9	0.72	8.0
Total Amount (g) in 3.1×10^{13} liters**	1.1×10^7	2.8×10^8	9.0×10^7	1.6×10^7	2.5×10^8
Estimated Input from 1978 Dumping of Industrial Wastes and	1.7×10^5	1.9×10^6	1.3×10^7	11.0×10^3	5.3×10^7
Estimated Input in 22 Days (g)†	1.0×10^4	1.1×10^5	7.8×10^5	6.6×10^2	3.2×10^6
Percent of Loading due to Dumping during 22 Days	0.09	0.04	0.9	0.004	1.3

* From Hausknecht (1977)

** The total volume of the 106-Mile Site to 15 meters depth

† The maximum length of time of Gulf Stream eddy has been observed at the Site. Taken to be the upper limit for residence time of any one water parcel at the site.

Metal concentrations in sediments of the 106-Mile Site were measured in 1974 by Pearce et al. (1975), and in 1976 by Greig and Wenzloff (1977). The metal concentrations reported for 1976 are consistent with those for 1974. Sediment metal concentrations varied little in samples from depths greater than 180 meters. Although the heavy metal content of sediments taken beyond the Continental Shelf appears to be elevated relative to sediments on the Shelf/Slope break, the elevated metal concentrations can not be attributed to present disposal practices at the 106-Mile Site, since they are not unique to the Site vicinity. Therefore, there is no evidence that the wastes released at the Site have affected the sediments (Pearce et al., 1975).

Continued use of the Site for industrial waste disposal will probably produce similar results for measurements of the water and sediments. As NOAA (1977) stated, background values of elements at the Site, like trace metals, are in the parts per billion range. Sample collection, storage, treatment, and analytic procedures can introduce contamination, which affects the values resulting from analysis. Consequently, values slightly above background levels resulting from disposal may be masked by the contamination introduced from sample handling. Projections of disposal effects on the water column and sediments must be based on the present technology, realizing its inherent weaknesses. This also applies to trace metal chemistry work at the other disposal sites.

NEW YORK BIGHT ACID WASTES SITE

Although investigations of the effects of waste disposal at the New York Bight Acid Wastes Site have been ongoing for over 30 years, no changes in the water or sediment chemistry have been clearly linked to acid waste disposal. The New York Bight Apex is a difficult region in which to assess impacts because of the variety of contaminant sources and the existing high levels of most parameters as a result of the population density and the heavy industrialization of the region.

Most of the water column measurements at the Acid Site are within the range of values found within the Bight Apex. Reduced surface salinity at the Site, compared to a control area, has been reported (Vaccaro et al., 1972). Turbidity is greater at the Site because of the iron-floc which forms when acid-iron waste reacts with seawater (NOAA-MESA, 1975).

Most studies of trace metals (e.g. mercury, copper, lead, cadmium, zinc) have examined sediment levels. High sediment metal concentrations in the Bight Apex occur in the area of the nearby Dredged Material and Sewage Sludge Sites (Ali et al., 1975). Values at the Acid Site are much lower compared to other disposal sites. Some workers have reported concentrations of trace metals in Acid Site sediments that were elevated compared to sediments from supposedly uncontaminated areas (Vaccaro et al., 1972; EG&G, 1978). However, these values have generally been within the range of values from other locations in the Bight (NOAA-NMFS, 1972).

Potential effects of disposal-related metal input on the concentrations at the Acid Site have been estimated (Table 4-2). Sludge digester cleanout residue has not been included in this evaluation because it is assumed that this material will continue to be barged to the 106-Mile Site until ocean disposal of harmful sewage sludge ceases. Even in hypothetical worst conditions, the total input of metals to the Acid Site from 106-Mile Site wastes is negligible compared to the metal loading from river outflow and wastes at other disposal sites.

The effects of moving chemical wastes from the 106-Mile Site to the New York Bight Acid Waste Site are difficult to predict. Some wastes presently released at the 106-Mile Site would be new contaminants into the Bight. Therefore, no background information exists on which to base an estimate of the effects of dumping these materials. On the other hand, DuPont-Grasselli used the Acid Site for part of its wastes from (1973 to 1975) with no known adverse effects. In addition to new materials, 106-Mile Site wastes would introduce significant amounts of materials that are presently input to the Bight Apex by other sources. Since the New York Bight Apex is already a stressed environment, the amount of stress (i.e. contaminant levels) should be reduced, not increased. The environment's ability to assimilate contaminants is unknown, and increasing the waste load may produce severe degradation of the ecosystem.

DELAWARE BAY ACID WASTE SITE

Most values of water chemistry parameters measured at this site during past survey work are similar to values measured in similar areas within the mid-Atlantic region (Falk et al., 1974). All metals except iron have been present at ambient seawater concentrations, with little seasonal or depth variation. When acid-iron waste was released at the Site, iron levels were initially very high. In summer, when the seasonal thermocline slowed vertical dispersion of the waste, iron levels remained elevated up to 20 hours after disposal. In winter, with the thermocline absent, values returned to ambient levels within four hours or less.

TABLE 4-2. WORST-CASE CONTRIBUTION OF WASTE METAL INPUT TO THE TOTAL METAL LOADING AT THE NEW YORK BIGHT ACID WASTES SITE

	Cadmium	Copper	Lead	Mercury	Zinc
Background Concentration (ug/1)*	3.1	8.0	140	0.04	11.0
Total amount (g) in 7.7×10^{11} liters**	2.4×10^{6}	6.2×10^{7}	1.1×10^{8}	3.0×10^{4}	8.5×10^{6}
Estimated Input from 1978 106-Mile Site Dumping of Industrial Wastes	1.7×10^{5}	1.9×10^{6}	1.3×10^{7}	11.0×10^{3}	5.2×10^{7}
Estimated Input in 1 Day (g)†	4.7×10^{2}	5.2×10^{3}	3.6×10^{4}	3.0×10^{1}	1.4×10^{5}
Percent of Loading due to Dumping During 1 day	0.02	0.01	0.03	0.01	1.6

* From Klein et al., 1974

** The total volume of the Site to 10 meters depth

† The estimated flushing rate for the Site based on measurements by Redfield and Walford (1951).

Potential effects of disposal-related industrial metal input on the concentrations in water at the Site have been estimated (Table 4-3). The metal input appears high enough that the water column concentrations will be measureably affected, particularly by lead. The sewage sludge released at the nearby Philadelphia Sewage Sludge Site, however, contains about 101 metric tons of lead per year, which is seven times the probable input from chemical waste. Consequently, any effects from chemical waste constituents would be difficult to distinguish from effects caused by sewage sludge.

Concentrations of several metals have been reported from sediments at the Site and its vicinity (Johnson and Lear, 1974; Lear and Pesch, 1975; Lear, 1976; Lear et al., 1977). Although the range of natural variation in metal concentrations for this area is still undetermined, high concentrations have been observed at several stations in and near the Site (Lear, 1976; Lear et al., 1977). Sea scallops showed high concentrations of vanadium (Pesch et al., 1977). Thus, it appears that past acid waste disposal at this site has affected the sediments and benthos by raising metal concentrations. Deleterious effects due to acid waste disposal have not been demonstrated and, except for mercury and cadmium, the ecological effect of accumulating other trace metals is generally unknown.

Moving industrial waste dumping from the 106-Mile Site to the presently inactive Delaware Bay Acid Waste Site could cause additional accumulations of metals in the sediments and organisms, since one of the permittees using at the 106-Mile Site previously used the Acid Site. In addition, other effects could occur after such a move because some of the 106-Mile Site wastes have never been released into a nearshore marine environment.

SOUTHERN AND NORTHERN AREAS

The Northern and Southern Areas, which have never been utilized for waste disposal, share a number of environmental features in common with the Delaware Bay Acid Waste Site--depth being the principal one. While disposal of chemical wastes at these sites will probably have little effect on water chemistry, effects on the benthos similar to those observed at the Acid Site may occur. These effects would be more adverse from man's point of view in the Southern Area since exploitable shellfish populations exist near the Site. If a new site was established for chemical waste disposal, the environmental consequences of disposing the wastes would be much less at the Northern Area.

Potential effects of disposal-related industrial metal input on the concentrations in water at these sites have been estimated (Tables 4-4 and 4-5). Since the near surface currents in these areas are relatively strong (16-20 cm/sec), and the water's residence time is short, it appears that aqueous chemical waste disposal would not measurably raise the ambient concentrations of these metals.

TABLE 4-3. WORST-CASE CONTRIBUTION OF WASTE METAL INPUT TO THE TOTAL METAL LOADING AT THE DELAWARE BAY ACID WASTE SITE

	Cadmium	Copper	Lead	Mercury	Zinc
Background Concentration (ug/l)*	0.05	0.3	0.03	0.05	5.0
Total amount (g) in 2.1×10^{12} liters**	1.0×10^5	6.2×10^5	6.0×10^4	1.0×10^5	1.1×10^7
Estimated Input from 1978 106-Mile Site Dumping of Industrial Wastes (g)	1.7×10^5	1.9×10^6	1.3×10^7	11.0×10^3	5.2×10^7
Estimated Input in 5 Days (g)†	2.3×10^3	2.6×10^4	1.7×10^5	1.5×10^2	7.1×10^5
Percent of Loading due to Dumping During 5 days	2.3	4.2	280	0.2	6.5

* From EG&G (1975)

** The total volume of the Site to 15 meters depth

† Based on the lowest observed current velocity at the Site

TABLE 4-4. WORST-CASE CONTRIBUTION OF WASTE METAL INPUT TO THE TOTAL METAL LOADING AT THE SOUTHERN AREA

	Cadmium	Copper	Lead	Mercury	Zinc
Background Concentration (ug/l)*	1.6	7.0	2.7**	0.08**	18.3
Total amount (g) in 2.1×10^{12} liters	3.3×10^6	1.4×10^7	5.6×10^6	2.0×10^5	3.8×10^7
Estimated Input from 1978 106-Mile Site Dumping of Industrial Wastes (g)	1.7×10^5	1.9×10^6	1.3×10^7	11.0×10^3	5.2×10^7
Estimated Input in 2 Days (g)†	9.3×10^2	1.0 x 104	7.1×10^4	6.0×10^1	2.8×10^5
Percent of Loading due to Dumping during 2 days	0.03	0.07	1.3	0.03	0.7

* From NOAA-MESA (1976)
** From EPA (1976)
† Based on the lowest observed current velocity at the Site

TABLE 4-5. WORST-CASE CONTRIBUTION OF WASTE METAL INPUT TO THE TOTAL METAL LOADING AT THE NORTHERN AREA

	Cadmium	Copper	Lead	Mercury	Zinc
Background Concentration (ug/l)*	3.3	4.4	2.7**	0.082	33.3
Total amount (g) in 2.1×10^{12} liters	6.8×10^6	9.1×10^6	5.6×10^6	2.0×10^5	6.9×10^7
Estimated Input from 1978 106-Mile Site Dumping of Chemical Wastes (g)	1.7×10^5	1.9×10^6	1.3×10^7	11.0×10^3	5.2×10^7
Estimated Input in 2 Days (g)†	9.3×10^2	1.0×10^4	7.1×10^4	6.0×10^2	2.8×10^5
Percent of Loading due to Dumping During 2 days	0.01	0.1	1.3	0.03	0.4

* From NOAA-MESA (1976)
** From EPA (1976)
† Based on the lowest observed current velocity at the Site

SHORT DUMPING

The Ocean Dumping Regulations specify that, in emergency situations, the master of a transport vessel may discharge its waste load in any location and in any manner so as to safeguard life at sea. Such emergency situations may result from the severe weather conditions that are typical for the North Atlantic in late fall, winter, and early spring, from vessel breakdowns, equipment failure, or collisions with other vessels or stationary objects. The potential for illegal short dumping exists. The USCG ocean disposal surveillance program is designed to discourage such illegal activities through a system of shipriders, patrol vessels, aircraft overflights, and checking of vessel logs. Twelve violations of permit regulations sufficient to cause follow-up actions were reported to EPA Region II between 1973 and 1977 by the Coast Guard (EPA, 1978). Seven of these were for disposal outside of an authorized disposal site (this includes all disposal sites administered by Region II). Two other referrals to EPA Region II (from NASA and the Army Corps of Engineers) were also for dumping outside of the authorized site. Of these nine charges, one was upheld and a civil penalty assessed, two were pending in late 1978, and six had the charges withdrawn.

The probability of an emergency situation occurring rises as the round-trip transit time increases. (See Table 4-6 for estimated transit times.) Thus, the decision to locate a site far from shore carries with it the increased risk of emergencies resulting in short dumping. The effects of a short dump of toxic waste materials would depend on the location of the dump, and in particular, the water depth. Since chemical wastes are liquid and rapidly diluted upon discharge, a single pulse of waste input to an area might cause, local immediate acute effects, but should not cause any long-term adverse effects. Effects of emergency dumping during inclement weather would be mitigated by the rapid dilution caused by storm activity.

Use of any of the alternative sites involves the possibility of legal or illegal short dumping. Based on distance of a site from port, the probability of a short dump is highest for the 106-Mile Site or the Delaware Bay Acid Waste Site and lowest for the New York Bight Acid Waste Site. Except for the Bight Acid Site, however, the effects of a short dump should be short term and the ecosystem would rapidly recover. Short dumping at the New York Bight Acid Wastes Site or the Delaware Bay Acid Waste Site would cause more concern because of close proximity to shore and the possibility of waste constituents reaching the New Jersey or the Long Island shoreline.

TABLE 4-6. TRANSIT TIMES TO ALTERNATIVE SITES (ROUND TRIP)*

	New York Harbor		Delaware Bay	
Site	9 km/hr (5 kn)	13 km/hr (7 kn)	9 km/hr (5 kn)	13 km/hr (7 kn)
106-Mile Site	46	32	48	18
NYB Acid Wastes Site	7	3	45	17
Delaware Bay Acid Waste Site	48	36	14	5
Southern Area	22	16	36	14
Northern Area	21	16	51	19

* Does not include time in transit from the loading dock to the Rockaway-Sandy Hook transect (New York Harbor) or from ports in Delaware Bay to the Cape May-Cape Henlopen transect (Mouth of Delaware Bay).

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS AND MITIGATING MEASURES

Some unavoidable adverse environmental effects of disposal of aqueous chemical wastes will occur in whatever site is designated for use. These effects occur immediately upon release of the wastes and are mitigated by the rapid dilution of the wastes after release. Based on field and laboratory observations, the most important short-term impacts of waste disposal at the 106-Mile Site are:

- Acute mortality in plankton
- Rise in the concentrations of waste constituents in the water column
- Changes in pH
- Possible avoidance of the area by fish

The most important potential long-term impacts are:

- Possible inhibition of carbon uptake by bacteria
- Possible accumulation of waste constituents in the benthos at shallow sites
- Sublethal effects on zooplankton and fish. These have been observed only in the laboratory at higher waste concentrations than occur at the Site.

The volumes and rates of waste discharge, which are specified in the disposal permit, have been established to limit any impact at the disposal site and to reduce the possibility of short-term effects persisting more than four hours. The on-going monitoring program, both by the permittees and by the Federal Government, has been established to determine if short-term or long-term effects are occurring.

None of the effects described in this section apparently persist for more than a few hours after the waste is discharged; consequently, none of these impacts are irreversible.

RELATIONSHIP BETWEEN SHORT-TERM USE OF THE SITE AND LONG-TERM PRODUCTIVITY

Use of the 106-Mile Site should not produce conflicts between short-term use and long-term productivity. The Site is located outside of the range of commercial and recreational fishing and significant mineral resource development. After several years of studies, there is no evidence that the long-term biological productivity of the area has been adversely affected by the wastes.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Several resources will be irreversibly or irretrievably commited upon implementation of the proposed action:

- Loss of energy in the form of fuel required in transporting barges to and from the Site. Transport to distant sites requires more fuel than transport to nearshore sites.

- Loss of valuable constituents in the waste, such as metals, some of which are available only in short supply. However, present technology is not adequate to permit their recovery.

- Loss of economic resource because of the costs associated with ocean disposal at a site that is far from land. These ocean disposal costs, however, may be lower than the costs of land-based disposal methods.

Chapter 5

SEWAGE SLUDGE DISPOSAL AT THE 106-MILE SITE

> While it is acknowledged that the only reasonable long-term solution for disposal of harmful sewage sludge is through land-based processes, adverse conditions at the existing New York Bight Sewage Sludge Site could require moving the disposal operation to another site.
>
> Use of the 106-Mile Site for sewage sludge disposal would be technically feasible, but economically unrealistic for large-scale disposal. However, under suitable conditions, the 106-Mile Site could provide an alternative location for short-term disposal of sewage sludge.

Disposal of sewage sludge, a product of wastewater treatment, is accomplished by two broad classes of methods: (1) land-based treatment and disposal and (2) ocean disposal from barge or outfall. Barged ocean disposal of sewage sludge in the New York Bight has occurred since 1924. While it is acknowledged that the only reasonable solution for long-term disposal of environmentally harmful sludge is through land-based processes (addressed in a previous EIS [EPA 1978])there is an immediate need for ocean disposal while land-based alternatives are being developed. This need will last at least until December 31, 1981, when ocean disposal of sewage sludge that does not comply with EPA's environmental impact criteria will cease as mandated by laws.

The question of where to dispose of sewage sludge (either on land or in the ocean) in the New York metropolitan area pending implementation of land-based alternatives, has received much attention at scientific meetings, court hearings, Congressional committee meetings, and in the press. One EIS (EPA, 1978) has been prepared on the subject and has resulted in designation (F.R., May 18 1979) of an area 111 kilometers (60 nmi) from New York Harbor as an alternate sludge disposal site for use only if environmental conditions at the 12-Mile Site are sufficiently adverse to require movement of the disposal operation to another locality (Figure 5-1). EPA (1978) also addresses the
: Site as an alternate sludge disposal site.

Although the 106-Mile Site would be used primarily for disposing of industrial chemical wastes in the foreseeable future, it is conceivable that severely degraded environmental conditions in the Bight or threats to public health could require sewage sludge disposal at an alternate site beyond the Continental Shelf. Since the 106-Mile Site is the only off-Shelf location in the mid-Atlantic historically used to dispose of sewage sludge, it would be the logical choice as an alternate location. Table 5-1 summarizes the history of the proposal to relocate sludge disposal from the New York Bight to the 106-Mile Site.

The 106-Mile Site has been used in the past for limited disposal of the City of Camden's sewage sludge under both Interim and Emergency dumping permits. In addition, small amounts of sludge digester cleanout residues from treatment plants in the New York City area have been disposed of at the Site since 1973. No adverse effects of this sludge disposal have been demonstrated; however, studies of effects of sludge dumping at the Site have been sparse.

"Sewage sludge" is a generic term for the dark, humus-like waste material produced by municipal wastewater treatment processes which treat wastes from domestic and industrial sources. It is a mixture of sewage and settled solids that are removed from raw wastewater during treatment. Sludge dumped at the present New York Bight Sewage Sludge Disposal Site is primarily a combination of digested products of primary and secondary wastewater treatment. The degree of treatment that the material receives determines its ultimate composition. Primary treatment removes 50 to 60 percent of the suspended solids from raw wastewater. Secondary treatment removes approximately 85 percent of the suspended solids. Sludges produced by primary or secondary treatment can be subjected to anaerobic digestion to decompose the organic materials.

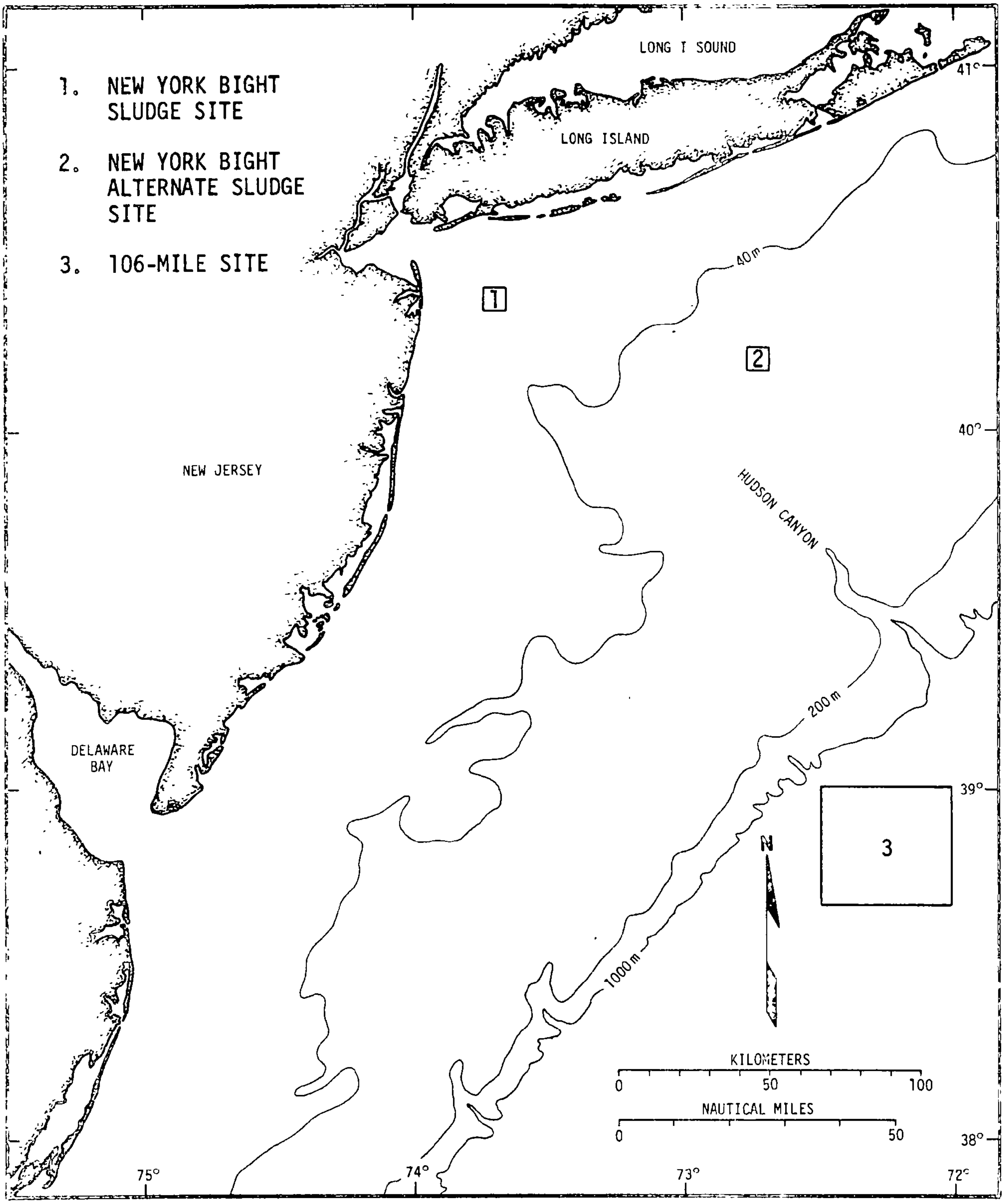

Figure 5-1. Alternative Sewage Sludge Disposal Sites

TABLE 5-1. HISTORY OF THE PROPOSAL TO RELOCATE SEWAGE SLUDGE DISPOSAL TO THE 106-MILE SITE

February 1976: The draft EIS on the ocean disposal of sewage sludge in the New York Bight was released for public review and comment.

July, August 1976: Long Island beaches bordering the New York Bight were contaminated with sewage-related material and other wastes propelled onshore by unusual summer winds. In addition, waters off the New Jersey coast experienced a massive algal bloom and depletion of oxygen in bottom waters which severely affected benthic marine organisms, especially surf clams. Blame for these events was levied at sewage sludge disposal operations in the New York Bight Apex, although later investigations revealed that sewage sludge was not the cause of the incidents. Nonetheless, consideration of moving sludge disposal operations farther offshore was fueled by adverse public comment directed at the nearshore disposal site.

May, June 1977: EPA Headquarters held a public hearing in Toms River, New Jersey, to consider the possibility of relocating sewage sludge disposal operations from the existing disposal site in the New York Bight Apex and the existing disposal site off the coast of Maryland (the Philadelphia Sewage Sludge Disposal Site) to a site farther offshore, possibly the 106-Mile Site. Many government, public, and academic critics and supporters of the proposition presented arguments, data, and opinions (EPA, 1976).

July 1977: EPA Headquarters awarded a 3-year contract to Interstate Electronics Corporation to perform environmental assessments and prepare EIS's on the designation of ocean disposal sites for different types of wastes. The 106-Mile Site EIS was assigned high priority.

September 1977: The hearing officer for the Toms River public hearing issued his report, recommending that neither the New York area nor the Philadelphia sewage sludge disposal operations be moved from the existing disposal sites. Regarding the 106-Mile Site, the hearing officer stated that "sludge dumping at the 106-Mile Site is not feasible because of the unknown but potentially adverse environmental consequences and the inability to monitor the site effectively." However, the same report recommended that "Preparation of an environmental impact statement on the issue of relocating the sludge...to the 106-Mile Site should begin immediately" (Breidenbach, 1977).

November 1977: Congress amended the MPRSA to require that ocean disposal of harmful sewage sludge be phased out by December 31, 1981 (PL 95-153).

March 1978: EPA Headquarters issued its decision on the Toms River public hearing, stating that both the New York Bight and Philadelphia Sewage Sludge Disposal Sites should continue in use, pending the phase-out of harmful sewage sludge disposal in 1981. The decision also directed that an assessment of sewage sludge disposal be included in the EIS on the 106-Mile Site (Jorling, 1978).

TABLE 5-1. (continued)

September 1978: EPA issued the final draft of the EIS (EPA, 1978) on ocean disposal of sewage sludge in the New York Bight including an assessment of the feasibility of using the 106-Mile Site. The Site was not judged favorable for sludge disposal based on an evaluation of several factors. The major limitations cited in the use of the 106-Mile Site were the unknown environmental effects of disposal there and the large associated costs of using the Site as compared to other sites. The EIS recommended the designation of a site farther offshore on the Shelf for use if conditions at the existing site require it. This EIS drew heavily on the material presented at the Toms River public hearing. No new data on sludge disposal effects at the 106-Mile Site were presented.
May 1979: EPA published notice of the final designation of the existing New York Bight Sewage Sludge Disposal Site and the Alternate Sewage Sludge Disposal Site for use in the event that the existing Site cannot safely accommodate any more sewage sludge.

By 1981, most of the waste treatment plants which currently practice ocean disposal and serve the New York metropolitan area are expected to provide secondary treatment. New Jersey plants will provide primary treatment. Thus, the character of dumped sewage sludge will gradually change over the next few years as present wastewater treatment plants are upgraded and new facilities are constructed to provide secondary treatment. Table 5-2 compares the physical and chemical characteristics of present New York metropolitan area sewage sludge with the industrial chemical wastes presently dumped at the 106-Mile Site.

AMOUNTS OF SLUDGE DUMPED

From 1960 to 1978, the amount of sewage sludge dumped annually in the Bight ranged between 2.5 million metric tons and 6.4 million metric tons. By 1981, the amount of sludge dumped in the Bight is expected to be about 10 million metric tons, one and a half times greater than the 1978 amount. Table 5-3 presents the estimated volumes of the individual waste generators that will be dumping sludge in the Bight during the period from 1979 to 1981. Projections of the effects of sludge disposal at the 106-Mile Site are based on anticipated 1981 sludge volumes.

TABLE 5-2. COMPARISON OF TYPICAL PHYSICAL, CHEMICAL, AND TOXICOLOGICAL CHARACTERISTICS OF SEWAGE SLUDGE AND INDUSTRIAL WASTE DUMPED AT THE 106-MILE SITE

Characteristic	New York City Sludge †	American Cyanamid	DuPont Edge Moor	DuPont Grasselli	Merck
Specific gravity	1.009	1.028	1.135 (1.085 - 1.218)	1.109 (1.036 - 1.222)	1.28
pH	ND	2.7 - 8.3	0.1 - 1.0	12.4 - 13.6	5 - 7
Suspended Solids (mg/l)	25,000	300 (60 - 21,000)	2,000	800 (5 - 15,090)	1,000
Oil and Grease (mg/l)	4,900	900 (10 - 6,214)	4 (1 - 24)	17 (0.8 - 108)	80
Arsenic (ug/l)	1,000	600 (20 - 2,600)	ND	ND	200
Cadmium (ug/l)	2,700	4 (1 - 50)	300 (20 - 900)	200 (3 - 700)	50
Chromium (ug/l)	59,000	600 (45 - 4,900)	270,000 (52,600 - 900,000)	300 (10 - 3,500)	500
Copper (ug/l)	82,000	400 (1 - 4,100)	3,000	3,000 (25 - 154,700)	400
Iron (mg/l)	ND	ND	33,000 (14,500 - 54,800)	ND	ND
Lead (ug/l)	66,000	100	41,000 (2,700 - 76,000)	900 (10 - 4,900)	1,500
Mercury (ug/l)	800	30 (1 - 200)	30 (1 - 200)	7 (1 - 20)	50
Nickel (ug/l)	17,000	1,000 (145 - 6,400)	29,000 (200 - 65,000)	700 (30 - 2,000)	2,600
Vanadium (ug/l)	2,000	ND	120,000 (80 - 250)	ND	1,000
Zinc (ug/l)	160,000	600 (7 - 5,160)	101,000	500 (30 - 2,700)	400
96-hr LC_{50} Atlantic silversides (*M. Menidia*) (mg/kg)	7,200 - 16,000	0.24 - 2,900	5,000*	1.8 - 6,950*	650 - 100,000*
Diatom (*S. costatum*) (mg/kg)	39 - 1,000	10 - 1,900	712 - 3,450	29 - 8,600	65 - 12,000

* Data from Mueller et al., 1976.
† Aerated

TABLE 5-3. ESTIMATED AMOUNTS OF SEWAGE SLUDGE TO BE DUMPED IN THE NEW YORK BIGHT 1979 TO 1981

Waste Generator	Amount in Thousands of Metric Tons (Thousands of Tons)					
	1979		1980		1981	
Middletown Sewerage Authority	36	(40)	42	(46)	48	(53)
Passaic Valley Sewerage Commissioners	767	(844)	1,007	(1,108)	1,007	(1,108)
City of Long Beach	9	(10)	9	(10)	9	(10)
Middlesex County Sewerage Authority	767	(844)	915	(1,007)	926	(1,019)
City of New York	4,364	(4,800)	4,634	(5,097)	5,904	(6,494)
Modern Transportation Co.	108	(119)				
Bergen County Utilities Authority	230	(253)	234	(257)	239	(263)
Linden-Roselle & Rahway Valley Sewerage Authorities	252	(277)	261	(287)	270	(297)
Joint Meeting of Essex and Union Counties	334	(367)	334	(367)	334	(367)
Nassau County	418	(460)	435	(479)	453	(498)
Westchester County	533	(586)	683	(751)	703	(773)
City of Glen Cove	13	(14)	13	(14)	13	(14)
General Marine Transport Corp.	11	(12)				
TOTAL	7,842	(8,626)	8,567	(9,423)	9,906	(10,896)

ENVIRONMENTAL ACCEPTABILITY

Camden's relatively brief use of the 106-Mile Site provided little chance to study the impacts of sewage sludge disposal there. In lieu of adequate experimental data from the Site, projections of the effects of potential future sludge disposal there must be based on data from studies of other wastes at the Site and on data obtained from studies at other sewage sludge ocean disposal sites.

Use of an off-Shelf site for sludge disposal can have several environmental advantages over disposal at a Shelf site: (1) Except in an area of upwelling, biological productivity is much lower in off-Shelf waters than in Shelf waters because of colder temperatures and the reduced supply of nutrients. (2) In a site located far from shore, wastes are diluted before they can impact coastal fisheries or shorelines. (3) Bottom impacts are less likely at a site located in sufficiently deep water because sinking particles undergo rapid horizontal dispersion as they slowly descend, ensuring that very little material reaches the bottom. (4) Any material that does eventually reach bottom, will be so widely dispersed that a substantial build-up of elevated concentrations is highly unlikely.

Several concerns with the potential effects of 106-Mile Site sludge disposal were voiced at the Toms River Hearing:

- Accumulation of materials which could ultimately float up undecayed to contaminate seas and beaches.
- Development of deep-sea anaerobic environments.
- Damage to organisms that are adapted to the stable conditions of the deep ocean environment.
- Long-range adverse effects on marine biota that are undetectible until irreversible.
- Persistence of pathogens for long periods of time.

These issues and others are addressed in this section. Based on the present knowledge of the physical characteristics of the 106-Mile Site, and the characteristics of the sludge proposed for disposal at the Site, no significant adverse impacts are anticipated.

FATE OF SEWAGE SLUDGE

The fate of dumped sludge in the water column at the Site is important for understanding of the chemical and biological effects of sludge disposal.

DILUTION AND DISPERSION

The nature of impact from a dumped material is determined in large part by the waste's life history in the water mass. The material may sink directly to the bottom, as does dense, course construction material or dredged materials or it may remain in the water mass for long times, dispersing slowly or rapidly throughout all or a portion of the water column. Shallow water makes the likelihood of bottom contact in a relatively short time more probable. Deep water offers a lower probability of bottom deposition due, in part, to complex changes in the environmental conditions through the vertical water column.

The 106-Mile Site is a dynamically complex region not amenable to assumptions of stationarity or steady state. This natural complexity limits the predictability of events that may ensue from waste disposal.

The focus of attention must be the interaction of the environment and the dumped sludge. The best evidence of the mechanical settling and dispersion is from direct observation of the sludge after it is released from a barge. Orr (1977b) had the opportunity to track the early stages of a Camden sludge dump via acoustic means. From his observations, the points most cogent to the influence of environment on the dumped material are the movement of material to only about 60 meters depth and the evidence of a strong vertical shear at about 28 meters that rapidly spread the upper and lower portions of the dumped material over large horizontal areas. It should be noted that Camden's sludge received only primary treatment, so particles were heavier than those in sludge from secondary treatment. Thus, secondary sludge would be even more rapidly dispersed.

Sixty meters is about the depth of the seasonal pycnocline in the offshore area, forming a density surface that acts as a restriction to settling of near neutrally buoyant material such as sludge. The depth and intensity of this pycnocline varies with season and with storm activity, but is quite pervasive, extending over the several water masses (although perhaps not well developed in Gulf Stream eddies). A permanent pycnocline, found to start at 250 meters (on average), will act as another barrier to settling material. While neither density surface is impenetrable, the retardation of settling will act to keep the dumped material in the upper surface waters for longer periods of time. The dynamic activity of surface waves, internal waves, shears, and small-scale turbulence enhance this suspended state. Where a variety of water masses interact, fronts and shear lines are commonplace and represent regions of spatially varying speeds and increased turbulence. These conditions act to increase dispersion of the material in both the vertical and horizontal, again reducing the rate of settling. This could be viewed as an anisotropic dispersion (Ichiye, 1965), where horizontal dispersion rates exceed those of the vertical by as much as two orders of magnitude.

With increased residence time in the surface waters, the material is subject to transport by near-surface currents which normally sustain higher speeds than currents at greater depths. Woods Hole Oceanographic Institution, records of currents measured at Site D, about 110 nautical miles east-northeast of the Site, furnish a proximal description of conditions at the Site. Two hundred and sixty-one days of record in the surface waters to depths of 150 meters shows an average vector of movement to the west and north of 6 to 11 cm/sec. On a larger scale, this means an average of about 5 to 10 km (3 to 5 nmi miles) per day of translational movement with brief periods of faster and slower speeds. Warsh (1975) suggests the currents follow the bathymetry, and move to the south and west at the 106-Mile Site.

A typical sludge settling rate in oceanic conditions may be taken from Calloway et al. (1976) who monitored dispersion of sludge dumped in the shoal waters of the New York Bight Apex. Nonflocculated particles which comprised most of the dumped material had settling velocities of 0.01 to 0.30 cm/sec or less. If the material is dispersed throughout the upper 60 meters of the water column, this settling rate provides a mean time to the 60-meter density interface of 10,000 to 300,000 seconds (or 4 hours to 7 days) in which time it could be transported a maximum of 56 to 93 km (30 to 50 nmi). In that time, this waste fraction is assumed to have reached the density interface at 60 meters where it may accumulate for some unknown time. It should eventually pass through, settling to the next interface at 250 meters (or thereabouts). Assuming a linear descent to that interface, the range of time is about 8 hours to 72 days. In the longer time frame, at the mean speed of 5 to 10 km (3 to 5 nmi) per day, the finer fractions could have traveled a total of about 740 km (400 nmi) from the Site.

Values used here for the purpose of discussion may vary significantly without detracting from the observation that the waste material will spend long times in the water column undergoing dispersion and transport and degradation by chemical and biological processes. Orr (1977b) is presently analyzing data on the horizontal dispersion acting on the sludge during a 32-hour experiment in which the sludge had, at the end of the experiment, dispersed along several density interfaces within 45 meters of the surface but did not penetrate the 60-meter depth. This experiment adds credibility to the use of a time interval greater than three days for settling to 60 meters and to a long residency in surface waters.

A worst-case estimate for areas of the bottom where particles may fall is based on approximation techniques of Callaway et al. (1976). Assuming a point source dump (with no associated turbulent diffusion as from a discharge in the wake of a moving barge), a 6 cm/sec horizontal current (U), and a particle settling velocity (W_s) of 0.1 cm/sec the size of the settling area at the 106-Mile Site will be proportional to the depth change of the existing disposal site (depth = H = 22 m) to the 106-Mile Site. Particles will settle over the length $L = UH/W_s$. The 106-Mile Site has an average depth of about 2,000 meters. Solving the equation for L yields 120 km. If a circular settling patch is assumed, the 106-Mile Site yields 45,216 sq km. Assuming an even distribution of solids within the computed area, the accompanying decrease in solids per unit area relative to the New York Bight Sludge Site is by a factor of 3,000, resulting in a bottom accumulation of 0.6 microns based on current sludge volumes--an infinitessimal amount. Therefore, disallowing horizontal and vertical dispersion, density gradients, or degradative processes normal to the 106-Mile Site, and assuming an unrestricted fall of sludge particles from surface to bottom, shows that insignificant amounts of sludge would be deposited on the bottom under the worst conditions.

EFFECTS ON WATER CHEMISTRY

Sewage sludge produced by secondary treatment contains low concentrations of organic materials. Anaerobic digestion reduces these concentrations even further. The only organic materials that resist these treatment processes are recalcitrant and not easily degraded, consisting primarily of proteins, amino acids, lipids, and cellulose. These materials will be rapidly dispersed in the surface layer above the thermocline and will not accumulate at the Site. They will eventually be degraded by organisms in the water column such as proteolytic, lipolytic, and cellulytic bacteria. Based on the low sludge concentrations of organic material requiring degradation and the highly dispersive environment at the 106-Mile Site previously discussed, accumulations of large amounts of undecayed matter at the disposal site are likely. Formation of deep-sea anaerobic environments will also be avoided since insignificant amounts of material requiring oxygen for degradation will sink to depths where oxygen is limited.

Sludge disposal at the 106-Mile Site will introduce heavy metals, inorganic nutrients, suspended solids, and chlorinated hydrocarbons to the water column. However, since the waste will be introduced in the barge wake, rapid initial dilution will occur, and further dilution and dispersion will result as material sinks and the water mass acts on the material.

The following discussion is based in part on the projections made by Raytheon (1976) on the effects of sludge disposal at the Alternate Sewage Sludge Site in the New York Bight. The potential effects on water chemistry at the 106-Mile Site and the Alternate Sludge Site are comparable. Bottom chemistry effects are not discussed since, as indicated earlier, the sludge is not expected to reach the bottom in significant proportions.

Most of the heavy metals introduced by sludge will occur in the particulate fraction. In Table 5-4 the present metal content of sewage sludge has been applied to a worst-case model of nondispersive, nondiluting physical conditions at the Site with sludge dumped in the water column contained within an areal quadrant to a depth of 15 meters over 22 days. In such strict conditions, the concentrations of some metals will almost double over the low background levels. However, in observed typical conditions, with the thermocline located near 60 meters and water flushing through the quadrant in 3 days at the rate of 11 cm/sec, the percent metal loading within the quadrant that is due to sludge dumping is a small fraction of the worst-case value. This suggests that any future sludge disposal at the Site should occur under the most dispersive conditions to avoid elevated concentrations in the water column. In addition, amounts of sludge dumped can be regulated to permit adequate dilution and dispersion so that concentrations with the Site not remain elevated.

TABLE 5-4. WORST-CASE PROJECTIONS OF METAL LOADING DUE TO SEWAGE SLUDGE DISPOSAL IN A QUADRANT OF THE 106-MILE SITE

Metal Load	Cadmium	Copper	Lead	Mercury	Zinc
Average background metal Concentration (ug/l)*	0.37	0.9	2.9	0.72	8.0
Total amount of metal (g) in 7.7×10^{12} l†	2.8×10^{6}	6.9×10^{6}	2.2×10^{7}	5.5×10^{6}	6.2×10^{7}
Estimated metal input (g) in 1981**	3×10^{7}	8.9×10^{8}	6.6×10^{8}	8×10^{6}	1.6×10^{9}
Estimated input in 22 days††	1.8×10^{6}	5.4×10^{7}	4.0×10^{7}	4.8×10^{5}	9.6×10^{7}
% Total metal due to sludge during 22 days	64	78	182	9	155

* From Hausknecht, 1977

† Volume based on one-fourth of the total area of the Site and a minimum seasonal thermocline of 15 meters

** Based on sludge metal concentrations from Mueller et al., (1976) and EPA (1978) volume estimates

†† The maximum length of time an Gulf Stream eddy has been observed at the Site.

Chlorinated hydrocarbons, PCBs, and other toxic organics in sludge will be introduced to the Site in association with particulates in the sludge. However, the concentrations of these materials in the sludge are relatively low and are, therefore, not expected to significantly increase levels at the Site as long as their inputs to the sludge are controlled.

Nutrients in the form of inorganic nitrogen (NO_3^-, NO_2^-, and NH_3^+) and inorganic phosphorus (PO_4^-) would be introduced to the Site by sludge disposal. Table 5-5 presents an evaluation of worst-case conditions. Only phosphate is added in significant proportions. Since most primary production in the ocean is limited by the amount of inorganic nitrogen in the water, and even in the worst case, sludge would introduce insignificant amounts of nitrate, dumping sludge at the Site would not significantly increase productivity or support plankton blooms like those that occur in coastal waters.

TABLE 5-5. WORST-CASE PROJECTIONS OF INORGANIC NUTRIENT LOADING IN A QUADRANT OF THE 106-MILE SITE DUE TO SEWAGE SLUDGE DISPOSAL

	Nitrite and Nitrate	Phosphate
Background Concentration* (ug/l)	19.2	114
Total amount in 7.7×10^{12} l** (g)	$1/5 \times 10^8$	9×10^8
Estimated input during 1981 (g)	4.0 x 107	4.0 x 109
Estimated input in 22 days (g)	2.3×10^6	2.4×10^8
% total nutrient load due to sludge	2.0	30

* From Peterson (1975). Concentrations at 15 meters.
** Volume of a quadrant of the Site to 15 meters.

The heavier particles in the suspended solid fraction are fairly inert, consisting of silt and sand that wash into the sewage treatment plants. These particles would be expected to act as sites for biological growth and will sink fairly rapidly. Finer particles, such as clays, will remain in the water column for long periods of time providing charged sites for bonding with ionic species (like heavy metals) in solution and for bacterial growth, which can also remove ionic species from solution.

INTERACTIONS WITH INDUSTRIAL WASTE

Whenever chemically diverse materials are mixed, a potential for interaction exists. For example, combining sludge with strong acids can cause heavy metals to deadsorb from sludge particles. Conversely, the particles in sludge can provide a nucleus for adsorption of contaminants in chemical wastes.

The potential for interaction of chemical wastes and sludge dumped at the 106-Mile Site is slight. EPA imposes simultaneous disposal in separate quadrants of the Site, each quadrant large enough (150 nmi^2) to significantly dilute the material within its boundaries. So sludge and chemical wastes at the Site would be separated by a sufficient distance to prevent the materials from mixing. Sludge at the New York Bight Sludge Site is presently dumped only 5 km from the New York Bight Acid Site. No interactions between these materials have ever been recorded.

EFFECTS ON ORGANISMS

Many components of sewage sludge can have an adverse effect on organisms. Some of these constituents, like nutrients and heavy metals, are necessary to sustain marine life, but are toxic at the high concentrations found in undiluted sludge. However, rapid dilution and dispersion of the sludge will mitigate all but short-term, acute effects on organisms inhabiting the upper water column at the Site. Because of the extreme vertical dilution of waste through the water column, benthic organisms in the vicinity should not be affected.

NOAA's studies to date at the 106-Mile Site have demonstrated no impact on populations of water column organisms at the Site from disposal of industrial wastes. Although sewage sludge shares few chemical, physical, or biological characteristics with the present chemical wastes dumped at the site, bioassays indicate that sludge is less toxic to the Atlantic silversides (Menidia menidia) than the industrial wastes and about as toxic to diatoms (Skeletonema costatum). Therefore, sludge is not expected to affect the site organisms to any greater degree than the present industrial wastes if discharged at compatible rates. Since no adverse effects of industrial waste dumping have been demonstrated at the site, no demonstrable adverse effects are anticipated from sludge disposal assuming the limiting permissible concentration is met.

Only one biological study (Longwell, 1977) has been conducted during a sludge disposal operation at the 106-Mile Site. Fish eggs were collected from inside and outside of the sewage sludge plume for the study of effects on developing fish embryos. The fish embryos were examined for cell and chromosome damage. Although too few fish eggs were collected to permit quantitative comparisons, sewage sludge appears to be toxic to fish eggs in the early developmental stages as evidenced by adverse effects on the chromosome and mitotic apparatus of embryos undergoing cell division. No effects of any waste, either industrial or municipal, have been demonstrated on fish populations because of the high natural variability of these populations. In addition, most populations of fish that are taken commercially in the Mid-Atlantic spawn over the Continental Shelf, rather than in Off-Shelf water such as that at the 106-Mile Site. Therefore, although sewage sludge may cause short-term effects on early stages of fish embryos, measurable long-term effects on fish populations are unlikely.

SURVIVAL OF PATHOGENS

Sewage sludge contains many pathogenic (disease-causing) organisms. These may be classified into four groups: bacteria, viruses, protozoa, and helminths (parasitic worms). Secondary treatment removes or inactivates many of these organisms but die-off is highly variable (Akin et al, 1977). Anaerobic digestion further reduces the pathogens in sludge, but some persistent viruses and parasite eggs can survive. However, the ocean possesses bactericidal properties that can effectively deactivate sludge microorganisms through two basic mechanisms: (1) toxic properties of seawater, and (2) biological predation.

There is little information on the survival of sludge pathogens at the 106-Mile Site. One study conducted during a Camden sludge disposal operation, collected surface and subsurface water samples from a stationary ship for total and fecal coliform bacteria analysis (Vaccaro and Dennett, 1977). In the first hour of sampling within the waste plume, surface samples yielded positive results for both total and fecal coliforms. No positive results from either test were obtained from any of the subsurface samples.

Sewage microorganisms normally tend to die off quickly in the water column; whereas pathogens that are sequestered in bottom sediments can live considerably longer. Since accumulations of sludge particles on the bottom are unlikely at the 106-Mile Site pathogenic contamination of sediments is not a real issue from sludge disposal at this Site. Numerous investigators have reported conflicting observations on the effects of seawater, sunlight, pressure, or exposure on the survival of sewage microorganisms in the water. However, most agree that the survival of sludge organisms dumped at an oceanic site far from shore are relatively unknown. If the 106-Mile Site is used for future sewage sludge disposal, the monitoring program accompanying the disposal must address these unknowns.

ENVIRONMENTAL MONITORING

The feasibility of monitoring for impacts of sewage sludge disposal at the 106-Mile Site was addressed in the Toms River Hearing. Although opinions expressed at the hearing varied on monitoring feasibility, all agreed that monitoring the 106-Mile Site, so as to detect and control short and long-range impacts of sludge dumping, would be most difficult (some felt it would be impossible). NOAA stated that such a program would be technically possible, but also very expensive:

> **The techniques required for a monitoring program are available. It is, however, more time-consuming and thus more expensive to monitor a site which is 100 miles from shore and**

> **2,000 meters deep than one which is nearshore and shallow. An effective monitoring program would be built upon our existing knowledge. Initial work directed specifically at sewage sludge would be to define the volume of water through which the sludge settles, the area of the bottom accepting the waste, the rate of water renewal, and rates of deep-sea sludge oxidation. The effects of sludge on deep-sea biota would be addressed through field sampling and by application of specialized techniques for observation at low temperature and high pressure. It is estimated that such a program would require about $2.5 million for each of its first two years and, thereafter, about $1.0 million per annum (Martineau, 1977). [All of the New York Bight monitoring currently costs about $1 million.]**

Considering the dispersion data from the Site, which indicate that the major potential effects of sludge dumping there would occur in the water column above the thermoclines (seasonal or permanent), monitoring could be simpler than originally thought because extremely deep sampling would be unnecessary. However, because of the wider dispersion of materials in the upper water column, monitoring over a larger area would be necessary.

SURVEILLANCE

Although a site far from land requires additional surveillance effort compared to a nearshore site, surveillance of sludge disposal operations at the 106-Mile Site is clearly feasible based on testimony at the Toms River Hearing (Mullen, 1977).

ECONOMICS

EPA (1978) presents a thorough overview of the economic issues imposed by using the 106-Mile Site for sewage sludge disposal. The salient points of that discussion are presented herein.

The most severe economic drawback to transferring all sludge disposal operations from the existing New York Bight Sludge Site to the 106-Mile Site lies in the size of the existing fleet of sludge dump vessels. The increased cost of using the 106-Mile Site rather than a nearshore site lies in two areas: (1) transport to the 106-Mile Site takes so much longer that additional vessels are necessary to carry the same amount of material; and (2) the time required for discharge will increase because the rate will be based on the LPC rather than the uniform rate of 5 hours currently imposed by USCG on dumpers at the New York Bight Sludge Site for safety. Because of the increased transit time to the 106-Mile Site over the existing site, the 12 vessels which now comprise the fleet would be inadequate to handle the sludge volumes, therefore, additional vessels would be necessary.

With equal discharge rates, the cost of using the 106-Mile Site would be about twice the cost of using the Alternate Sewage Sludge Site and six to eight times the cost of continuing to use the existing New York Bight Sludge Site. By 1981, the estimated cost to municipal permittees for transporting sludge to the 106-Mile Site is estimated to be within a range of \$124 million to \$154 million. Many present at the Toms River Hearing felt that such a prohibitive expense to the municipal dumpers would divert funds for implementing land-based disposal alternatives into ocean disposal, thus perpetuating this means of disposal (NOAA, 1977; Forsythe, 1977; Kamlet, 1977).

The projected cost of monitoring sludge disposal was discussed in a previous section. Since a portion of the monitoring cost would be passed on to the permittees, their economic burden would increase even further. In addition, the cost to federal agencies monitoring the Site would be substantial.

Surveillance costs would also be high if this site were utilized for sludge disposal. The USCG monitors sludge disposal operations at the New York Bight Sludge Site with helicopters and patrol vessels. Since the 106-Mile Site is far outside of the range of this equipment, shipriders would be required, at an additional expense to the USCG.

LOGISTICS

Use of the 106-Mile Site for sludge disposal would be logistically feasible although initial delays of several months primarily for obtaining suitable vessels, would probably be necessary for implementation. Increased traffic at the site would present additional navigational hazards; however, dumping in quadrants of the site would tend to mitigate many of the hazards.

SUMMARY

Use of the 106-Mile Site for sewage sludge disposal would be environmentally acceptable under carefully controlled conditions, and accompanied by a comprehensive monitoring program. However, substitution of this Site for the existing New York Sewage Sludge Site or the Alternate Site would impose severe economic burden, surveillance and monitoring difficulties, and logistical problems. Therefore, the following recommendations are made.

RECOMMENDATIONS

It is recommended that use of the Site for sewage sludge disposal be decided by EPA case-by-case, on the basis of severity of need. Any permit issued should include provisions for adequate monitoring and surveillance to ensure against significant adverse impacts resulting from disposal. Sludge disposal should be allowed at the Site only under the following conditions:

- The existing New York Bight Sewage Sludge Site cannot safely accommodate more sludge disposal without endangering public health, severely degrading the marine environment, or degrading coastal water quality.
- Independent surveillance by the U.S. Coast Guard or USCG Auxiliary (the latter at the permittee's expense) be conducted.
- Monitoring for short- and long-term impacts be accomplished by federal agencies and environmental contractors (the latter at the permittee's expense). This monitoring must include studies of the fate of solids and sludge microorganisms, both inside and outside of the Site, in addition to a comprehensive analysis of environmental effects.
- Vessels discharge the sludge into the wake so that maximum turbulent dispersion occurs.
- Vessels discharging sludge be separated from vessels discharging chemical wastes so that the two types of wastes do not mix.
- Key constituents of the sludge be routinely analyzed in barge samples at a frequency to be determined by EPA on a case-by-case basis, but sufficient to accurately evaluate mass loading at the Site.
- Routine bioassays be performed on sludge samples using appropriate sensitive marine organisms.

Chapter 6

LIST OF PREPARERS

Preparation of this EIS was a joint effort employing many members of the Interstate Electronics Corporation scientific and technical staff and EPA Region II. This chapter summarizes the background and qualifications of the primary preparers of the document.

KATHLEEN M. KING

Ms. King is the principal author of the EIS. She is a marine biologist and Manager of the Biological Sciences Branch within the contractor's Oceanic Engineering Division. She possesses a B.S. in Biological Sciences from the University of California and an M.A. in Biology (with emphasis on marine biology) from California State University, Long Beach.

Ms. King has been working in the area of ocean disposal impact assessment for several years. Her initial work on this subject was done under a grant from EPA to develop standard cultures of polychaetes to be used for bioassays testing waste toxicity. She later worked under a contract from EPA Region III, dealing with the effects of waste disposal at the Delaware Bay (DuPont) Acid and Philadelphia Sewage Sludge Disposal Sites.

For the past two years, she has been involved in planning, organizing, and managing the production of ocean disposal site designation EIS's being prepared under contract to EPA Headquarters. In addition, she has participated extensively in the planning of disposal site surveys for impact assessment and site characterization.

Ms. King prepared Chapters 1, 2, 4, and 5 of this EIS. As the Coordinator of the entire document, she directed writing efforts on other sections of the EIS, edited all chapters, and maintained liaison with EPA Headquarters and Region II.

JOHN R. DONAT

Mr. Donat received his B.S. in Chemical Oceanography from Humboldt State University in 1978 and is presently continuing study in preparation for an advanced degree in chemical oceanography. He has three years experience in instrumental and wet chemical analysis of seawater in addition to other aspects of oceanography, including the planning of and participation in numerous oceanographic surveys off Northern California aboard the R/V CATALYST, the collection and processing of physical and chemical oceanographic data, and sedimentological analyses.

Mr. Donat's work as an Associate Oceanographer at Interstate Electronics has included extraction and assessment of oceanographic data for the evaluation of the environmental impacts of ocean waste disposal, preparation of disposal site characterizations, and determination of necessary parameters for impact detection at dredged material disposal sites. He is presently responsible for characterizing wastes dumped at various East Coast sewage sludge and industrial chemical waste disposal sites, and co-authoring an EIS on dredged material disposal in Hawaii.

Mr. Donat authored Appendix B and several sections in Appendix A of the 106-Mile Site EIS.

WILLIAM DUNSTAN

Dr. Dunstan is a biologist with 13 years of experience in biological oceanography. He holds a B.S. in Engineering from Yale University, an M.S. in Marine Biology from Florida State University, and a Ph.D. in Biology from Florida State. For ten years he has conducted research on effects of sewage effluent trace metals and nutrients on marine organisms.

At Interstate Electronics Corporation, Dr. Dunstan is the Deputy Program Manager for the EPA program on ocean disposal site designation. In addition to maintaining liaison between the Program Office in Anaheim and the Project Office at EPA Headquarters, he maintains contact with other Federal groups and the scientific community involved in assessments of ocean disposal impacts.

Dr. Dunstan prepared Appendix C and conducted extensive initial editing of the other Chapters and Appendices.

MARSHALL HOLSTROM

Mr. Holstrom received his B.A. and M.A. in Biology from Stanford University. In addition, he has completed several years of graduate work in Marine Biology at the University of Southern California. At Interstate Electronics Corporation, Mr. Holstrom has participated in projects with EPA Region III, U.S. Army Corps of Engineers, EPA Headquarters, and BLM. He has been extensively involved in assessments of environmental impacts of ocean waste disposal and is one of the principal staff EIS coordinators, with several EIS's in preparation.

Mr. Holstrom authored sections in Chapters 2 and 4 of the EIS.

RANDY McGLADE

Mr. McGlade received his B.S. and M.A. in Marine Biology from California State University, Long Beach. He has five years experience in marine environmental surveying, taxonomic consulting, and bioassay work. He was Assistant Director of the University of Southern California's Harbor Research Laboratory where he designed, managed, and reported results of various studies of the effects of industrial/municipal wastes and dredged materials on the Los Angeles Harbor marine environment. He is presently an Associate Oceanographer at Interstate Electronics Corporation, involved in writing Environmental Impact Statements on several sites.

Mr. McGlade prepared Chapters 3 and 6 of this EIS, and participated in the preparation of Appendix A.

STEPHEN M. SULLIVAN

Mr. Sullivan, a Biological Oceanographer at Interstate Electronics, obtained his B.S. in Oceanography from Humboldt State University in 1977 and has since completed graduate courses at Scripps Institute of Oceanography and California State University, Fullerton. As a participant on numerous oceanographic cruises off the Northern California Coast, he obtained experience in oceanographic data collection and survey design.

His work at Interstate Electronics has included descriptions of the plankton ecology of potential sites for Ocean Thermal Energy Conversion (OTEC) power plants, and assessments of the ecological impacts of impingement, entrainment, and toxic substance release associated with plant operations. In addition, he has participated in data collection and report-writing for the ocean disposal EIS program.

Mr. Sullivan prepared the biology sections of Appendix A.

Chapter 7

GLOSSARY AND REFERENCES

GLOSSARY

Abundance	Relative degree of plentifulness
Abyssal	Pertaining to the great depths of the ocean beyond the limits of the Continental Shelf, generally below 1,000 meters.
Acute Effect	The death or incapacitation of an organism caused by a substance within a short time (normally 96 hours).
Adsorb	To adhere in an extremely thin layer of molecules to the surface of solid bodies.
Aesthetics	Pertaining to the natural beauty or attractiveness of an object or location.
Ambient	Pertaining to the undisturbed or unaffected conditions of the surrounding environment.
Amphipods	A large group of usually marine crustaceans, ranging from minute, planktonic forms to benthic, tube-dwelling forms, which have a laterally compressed body.
Anaerobic digestion	Digestion of organic matter by bacterical action in the absence of oxygen.
Anthropogenic	Relating to the effects or impacts of man on nature.
Anticyclonic	Clockwise rotation around a high pressure zone (winds) or around a cold core (ocean currents) in the northern hemisphere.
Anticyclonic eddies	Mesoscale (50 to 100 km) features of oceanic circulation in which water flows in a circular (clockwise) pattern around cold core waters.
Apex	See New York Bight Apex.
Appropriate sensitive benthic marine organisms	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.
Appropriate sensitive marine organisms	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.
Aqueous	Similar to, containing, or dissolved in water.
Assemblage	A group of organisms sharing a common habitat.
Background level	The naturally occuring level of a substance within an environment.
Baseline data	Data collected prior to beginning actions which have potential of altering an existing environment.
Baseline surveys	Surveys conducted to collect information prior to beginning an action which has the potential of altering an existing environment.
Benthos	All marine organisms (plant or animal) living on or in the bottom; also, the floor or deepest part of the ocean.
Bight	A slight indentation in the shore line of an open coast or of a bay, usually crescent shaped.
Bioaccumulate	The uptake and assimilation of materials, such as heavy metals, leading to an elevated concentration of the substance within an organism's tissue, blood, or body fluid.
Bioassay	Determination of the strength (potency) of a substance by its effect (on growth or survival) on an organism--plant or animal.
Biochemical Oxygen Demand (BOD)	The amount of oxygen required to oxidize a substance or waste.

Biomass	The amount (weight) of living organisms expressed in terms of an area or volume of the habitat.
Biota	Collectively, plants and animals of a region.
Biotic groups	Organisms which are ecologically, structurally, or taxonomically grouped.
BLM	Bureau of Land Management
Bloom	An enormous concentration of plankton in an area resulting from their rapid growth and reproduction.
Boreal	Pertaining to the higher northern latitudes, as opposed to tropical.
°C	Degrees Celsius
C/N	Carbon/Nitrogen Ratio
Carcinogen	A substance or agent producing cancer.
CE	U.S. Army Corps of Engineers
Cephalopods	Squid, octopus, or cuttlefish. Members of the phylum Mollusca.
CFR	Code of Federal Regulations
Chaetognaths	A phylum of small, elongate, transparent, wormlike invertebrates, also known as arrow-worms, which are important carnivores in the zooplankton community.
Chlorophyll	A group of green plant pigments which receive the light energy used in photosynthesis.
Chlorophyll _a_	A specific green plant pigment used in photosynthesis and used to measure phytoplankton biomass.
Chronic effect	A sublethal effect of a substance on an organism which reduces the survivorship of that organism over a long period of time.
cm	Centimeter(s)
cm/sec	Centimeters per second

Coccolithophorid — Ultra-microscopic planktonic algae, the cells of which are surrounded by an envelope of small calcareous discs.

Coelenterate — A animal phylum which includes hydroids, sea anemones, jellyfish, and corals.

Compensation depth — The depth at which photosynthetic oxygen production equals oxygen consumed by plant respiration during a 24-hour period.

Continental Margin — The zone between the shoreline and the deep ocean floor; generally consists of the continental shelf, continental slope, and the continental rise.

Continental Rise — A transitional portion between the Continental Slope and the ocean floor which is less steeply sloped than the Continental Slope.

Continental Shelf — The Continental Margin extending seaward from the coast to a variable depth, generally 200 meters.

Continental Slope — The steeply descending slope lying between the Continental Shelf and the Continental Rise.

Contour line — A chart line connecting points of equal elevation above or below a reference plane, such as sea level.

Copepod — A large group of usually small crustaceans; they are an important link in the oceanic food chain.

Coriolis effect — An apparent force acting on moving particles resulting from the earth's rotation. In the northern hemisphere moving particles are deflected to the right.

Crustaceans — Animals with jointed appendages and a segmented external skeleton composed of a hard shell (chitin). The group includes barnacles, crabs, shrimps, and lobsters.

Ctenophores — An animal phylum superficially resembling jellyfish, ranging from less than 2 cm to about 1 m in length. These

	planktonic organisms are commonly referred to as comb jellies or sea walnuts.
Current meter	Any device for measuring and indicating speed or direction (often both) of flowing water.
Current shear	The measure of the spatial rate of change of current velocity with units of $cm\text{-}sec^{-1}m^{-1}$
Decapod	The largest order of crustaceans in which the animals have five sets of locomotory appendages, each joined to a segment of the thorax. Includes crabs, lobsters, and shrimp.
Demersal	Living at or near the bottom of the sea.
Density	The mass per unit volume of a substance.
Diatom	A microscopic, planktonic plant with a cell wall of silica. Abundant world wide.
Diffusion	The process whereby particles in a liquid intermingle spontaneously; net motion is from an area of higher concentration to an area of lower concentration.
Dinoflagellate	Marine, planktonic organisms with flagella, which are an important part of marine food chains.
Discharge plume	The region of fluid affected by a discharge of waste which can be distinguished from the surrounding water.
Dispersion	The movement of discharged material over large areas by the natural processes of turbulence and currents.
Dissolved oxygen	The quantity of oxygen dissolved in a unit volume of water; usually expressed in ml/liter.
Dissolved solids	The dissipation of solid matter in solution, such as salt dissolved in water.

Diversity	A measure that usually takes into account the number of species and the relative abundance of individuals in an area.
Dominance	A species or group of species which largely control the energy flow and strongly effect the environment within a community.
Dry weight	The weight of a sample of organisms after all water has been removed; a measure of biomass.
EC_{50}	In bioassay studies, the concentration of a substance which causes a 50 percent reduction in the growth rate of the test organisms (usually phytoplankton) during a unit time (usually 96 hours).
Echinoderms	A phylum of benthic marine animals having calcareous plates and spines forming a rigid articulated skeleton or plates with spines embedded in the skin. This group includes starfish, sea urchins, sea lillies and sea-cucumbers.
Economic resource zone	The oceanic area within 200 nautical miles from shore in which the adjacent coastal state possesses exclusive rights to the living and non-living marine resources.
Ecosystem	A functional system which includes the organisms of a natural community or assemblage together with their physical environment.
Eddy	A water current moving contrary to the direction of the main current, especially in a circular motion.
EIS	Environmental impact statement
Endemic	Restricted or peculiar to a locality or region.
EPA	U.S. Environmental Protection Agency
EPA Headquarters	U.S. Environmental Protection Agency Headquarters, Washington, D.C.
EPA Region II	U.S. Environmental Protection Agency, Region II, New York, N.Y.

Epifauna	Animals which live on the surface of the sea bottom.
Epipelagic	Ocean zone extending from the surface to 200 meters in depth.
Estuary	A semienclosed coastal body of water, which has a free connection to the sea and within which the sea water is measurably diluted with fresh water.
Euphausiids	Shrimp-like, planktonic crustaceans which are widely distributed in oceanic waters. These organisms, also known as krill, may grow to 8 cm in length and are a very important link in the oceanic food chain.
°F	Degrees Fahrenheit
Fauna	The animal life of a particular location, region, or period.
FDA	Food and Drug Administration
Flocculate	The process of aggregating a number of small, suspended particles into small masses.
Flora	The plant life of a particular location, region, or period.
FWPCA	Federal Water Pollution Control Act
g/cm^3	Grams per cubic centimeter
Gastropods	Mollusks that possess a distinct head (generally with eyes and tentacles) and a broad, flat foot, and which usually have a spiral shell.
Geostrophic current	A current resulting from the balance between gravitational forces and the Coriolis effect.
Gulf Stream	A relatively warm, swift, northward flowing ocean current which flows through the Carribbean, Gulf of Mexico and up the North American East Coast.
Heavy metals or elements	Elements which posses a specific gravity of 5.0 or greater.

High-level radioactive waste	The aqueous or solid waste resulting from the reprocessing of irradiated fuel from nuclear power reactors.
Histopathology	The study of tissue changes associated with disease.
Hydrography	The measurement and description of the physical features of bodies of water.
Ichthyoplankton	Fish eggs and weakly motile fish larvae.
IEC	Interstate Electronics Corporation
Indigenous	Having originated in and being produced, grown, or naturally occurring in a particular region or environment.
Infauna	Animals who live buried in soft substrata.
In situ	(Latin) in the original or natural setting.
Insolation	Solar radiation received at the earth's surface.
Invertebrates	Animals without backbones.
ISC	Interstate Sanitation Commission
Isobath	A line on a marine chart joining points of equal depth below sea level.
kg	Kilogram(s)
kg/day	Kilograms per day
km	Kilometer(s)
LC_{50} (Lethal concentration 50)	In bioassay studies, the concentration of a substance which causes 50 percent mortality in the population of the test organisms during a unit time (usually 96 hours).
Limiting permissible concentration (LPC)	A concentration of a waste substance which after intial mixing, does not exceed marine water quality criteria or cause acute or chronic toxicity.
LORAN C	Long Range Aid to Navigation
m	Meter(s)

m^3	Cubic meters
m/sec	Meters per second
u	Micron(s)
ug/kg	Micrograms per kilogram, or millionth gram per kilogram.
ug/l	Milligrams per liter, or millionth gram per liter
Macrozooplankton	Planktonic animals which can be recognized by the unaided eye.
Marine	Pertaining to the sea.
Mesopelagic	Relating to depths of 200 to 1,000 meters below the ocean surface.
mg	Milligram(s), or thousandth gram
mg/l	Milligrams per liter
mi	Mile(s)
Microorganisms	Microscopic organisms including bacteria, protozoans, and some algae.
Mid-Atlantic Bight	The continental shelf extending from Cape Cod, MA. to Cape Hatteras, NC.
Mixed layer	The upper layer of the ocean which is well mixed by wind and wave activity.
ml	Milliliter(s), or thousandth liter
$ml/m^2/hr$	Milliliters per square meter per hour
mm	Millimeter(s), or thousandth meter
Monitoring	As used here, to observe environmental effects of disposal operations through biological and chemical data collection and analyses.
mph	Miles per hour
MPRSA	Marine Protection, Research, and Sanctuaries Act
Mutagen	A substance which increases the frequency or extent of mutations.

Myctophids — A group of small mesopelagic fish which posses light emitting organs and undergo large-scale vertical (deep to near-surface) migrations daily.

Nannoplankton — Minute planktonic plants and animals which are 50 microns or less in size. Individuals of this size will pass through most plankton nets and are therefore usually collected by centrifuging water samples.

NAS — National Academy of Science

NASA — National Aeronautics and Space Administration

Nekton — Free swimming animals which move independent of water currents.

NEPA — National Environmental Policy Act of 1969

Neritic — Pertaining to the region of shallow water adjoining the seacoast and extending from low-tide mark to 200 meters depth.

Neuston — A community of planktonic organisms which are associated with the surface film of water; mainly composed of certain copepods and the eggs and larvae of fish.

New York Bight — The continental shelf which extends from Montauk Point, Long Island to Cape May, New Jersey.

New York Bight Apex — A portion of the New York Bight bounded at the south by latitude 40°10' and at the east by longitude 73°30'.

NJDEP — New Jersey Department of Environmental Protection

n mi — Nautical mile(s)

NOAA — National Oceanic and Atmospheric Administration

NOAA-MESA — National Oceanic and Atmospheric Administration-Marine Ecosystems Analysis

NOAA-NMFS	National Oceanic and Atmospheric Administration-National Marine Fisheries Service
NSF	National Science Foundation
Nuisance species	Organisms which have no commercial value yet out compete or harm commercially important species.
Nutrient	Any substance which promotes growth or provides energy for biological processes.
OCS	Outer Continental Shelf
ODSS	Ocean Dumping Surveillance System
Organophosphate Pesticides	A phosphorus-containing organic pesticide, such parathion or malathion.
Ortho-phosphate	One of the possible salts of orthophosphoric acid; an essential nutrient for marine plant growth.
Oxygen minimum layer	The depth in the water column where the lowest concentration of dissolved oxygen naturally occurs.
Parameters	Any of a set of physical properties whose values determine the characteristics or behavior of something; a characteristic element.
Particulates	Fine solid particles which are individually dispersed in water.
Parts per thousand (ppt; o/ooò)	A unit of concentration of a mixture indicating the number of parts of a constituent contained per thousand parts of the entire mixture.
Pathogen	Producing or capable of producing disease.
PCB	Polychlorinated bi-phenols
Pelagic	Pertaining to water of the open ocean beyond the shore and above the abyssal zone.
Perturbation	A disturbance of a natural or regular system.

pH	A term used to describe the hydrogen ion activity; 0-7 is acid, 7 is neutral, 7-14 is alkaline.
Photic Zone	The layer in the ocean from the surface to the depth where light is reduced to one percent of its surface value.
Phytoplankton	Planktonic plants; the base of most oceanic food chains.
Plankton	Organisms whose movements are determined by the currents and not by their own locomotive abilities.
Polychaetes	The largest class of the phylum Annelida (segmented worms) distinguished by paired, lateral, fleshy appendages provided with setae on most segments.
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
Precipitate	A solid separating from a solution or suspension by chemical or physical change.
Predator	An animal which uses other animals as a source of food.
Primary Production	The amount of organic matter synthesized by plants from inorganic substances per unit time per unit area or volume. The plant's respiration may (net productivity) or may not (gross productivity) be subtracted.
Protozoan	Microscopic, single-celled organisms which have very diverse characteristics.
Quantitative	Pertaining to the numerical measurement of a parameter.
Recruitment	Addition to a population of organisms by reproduction or immigration of new individuals.
Release zone	An area 100 meters on either side of the disposal vessel extending from the first waste release point to the end of the release.

Runoff — The portion of the precipitation on the land that ultimately reaches streams or the ocean.

Salinity — The amount of dissolved salts in seawater measured in parts per thousand.

Sea state — The numerical or written description of ocean roughness. Often used to include both sea and swell.

sec — Second(s)

Shelf water — Water which originates or can be traced to the Continental Shelf. It has special temperature and salinity characteristics which permit its identification.

Shellfish — Any aquatic invertebrate having a shell or exoskeleton, especially any edible mollusk or crustacean.

Shiprider — An onboard observer assigned by the Coast Guard to assure that ocean disposal operations are conducted according to the permit specifications.

Short dumping — The discharge of waste from a vessel prior to reaching a designated disposal site. This may occur legally under emergency circumstances, or illegally if done to avoid hauling to a designated site.

Significant wave height — The average height of the one-third highest waves in a given wave group.

Slope water — Water which originates from, occurs at, or can be traced to the Continental Slope. It has special temperature and salinity characteristics which permit identification.

Sludge — A precipitated solid matter produced by sewage and chemical waste treatment processes.

Species — A group of individuals which closely resemble each other structurally and physiologically and interbreed in nature, producing fertile offspring.

Specific Gravity	The ratio of the density of a substance relative to the density of pure water at 4°C.
SPM	Suspended particulate matter
sq	Square
SS	Suspended solids
Standing Stock	The biomass or abundance of living material per unit volume or area of water.
Stressed	A stimulus or series of stimuli which disrupt the normal ecological functioning of an area.
Surfactants	An agent which lowers surface tension, as soap, bile and certain detergents.
Surveillance	Systematic observation of an area by visual, electronic, photographic, or other means for the purpose of ensuring compliance with applicable laws, regulations and permits.
Suspended Solids	Finely divided particles of a solid temporarily suspended in a liquid, such as soil particles in water.
Synergism	The interaction between two or more agents which produces a total effect greater than the sum of the independent effects.
Taxon (pl. Taxa)	A taxonomic group or entity sufficiently distinct to be distinguished by name and to be ranked in a definite category.
TCH	Total carbohydrate content
Temporal distribution	The distribution of a parameter over time.
Teratogen	A chemical agent which causes developmental malformations and monstrosities.
Terrigenous sediments	Shallow marine sedimentary deposits composed of eroded terrestrial material.

Thermocline	A sharp temperature gradient which separates a warmer surface water layer from a cooler subsurface layer and is most pronounced during summer months.
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon
Trace metal or element	An element found in the environment in extremely small quantities.
Trend Assessment Surveys	Surveys conducted non-seasonal over long time periods to detect shifts in environmental conditions within a region
Trophic level	A feeding level in the food chain of an ecosystem through which the passage of energy proceeds.
Turbidity	A reduction in transparency which, in seawater, maybe caused by suspended sediments or plankton growth.
Turnover rate	The time necessary to replace the entire standing stock of a population; generation time.
U.S.	United States of America
USCG	U.S. Coast Guard
Water mass	A body of water usually identified by its temperature, salinity and chemical content and containing a mixture of water types.
Water type	Water defined by a narrow range of temperature and salinity.
Wet weight	The weight of organisms before drying them to remove the internal water.
yd^3	Cubic yard(s)
Zooplankton	Usually small, weakly swimming animals which are unable to resist water current movements.

UNITS OF MEASURE (ENGLISH EQUIVALENTS OF METRIC UNITS)

Metric	English
centimeter (cm)	0.4 inches (in)
meter (m)	1.1 yards (yds)
kilometer (km)	0.6 statute miles (mi)
	0.54 nautical miles (n mi)
square meter (sq m; m^2)	1.2 square yards (sq yd; yd^3)
square kilometer (sq km; km^2)	0.29 square nautical miles (sq nmi; n mi^2)
gram (g)	0.035 ounces (oz)
kilogram (kg)	2.2 pounds (lb)
metric ton	1.1 short tons (2,000 lbs)
liter (l)	0.26 gallons (gal)
cubic meter (cu m; m^3)	1.3 cubic yards (cu yd; yd^3)
centimeters/second (cm/sec)	0.39 inches/second (in/sec)
kilometers/hour (km/hr)	0.54 knots (kt), nautical miles/hour
Celsius (°C)	9/5 °C + 32 Fahrenheit (°F)

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APPENDIX A

CONTENTS

ILLUSTRATIONS

APPENDIX A CONTENTS (continued)

TABLES

Appendix A

ENVIRONMENTAL CHARACTERISTICS OF THE 106-MILE CHEMICAL WASTES DISPOSAL SITE

METEOROLOGY

The New York Bight receives air from several regions, but air from the tropical Atlantic or Gulf of Mexico predominates during most of the year. The Bight often receives storms which are pushed eastward by the "prevailing westerlies" from midwest areas where polar and tropical air masses meet. However, due to the influence of several physical factors, the Bight possesses a more uniform climate than continental areas in the same latitude.

The seasonal location of the Bermuda high is a primary determinant of general weather conditions in the Bight. When the Bermuda high is centered over the eastern seaboard, as in summer and early autumn, the Bight experiences its longest periods of stable weather conditions. During winter, spring, and late autumn the absence of this high pressure zone allows storms from northeastern and southern regions to move into the Bight, causing extreme weather conditions. However, even in the presence of the Bermuda high, tropical storms and hurricanes move northward through the Bight during late summer and early autumn.

Warm air from the Gulf Stream region is advected toward coastal regions throughout the year. In the Bight, the air is quickly cooled by Shelf Water, which results in muggy summer conditions and persistent fog during both warm and cold months.

AIR TEMPERATURE

Marine surface air temperatures in the area of the Bight are buffered throughout the year by the influence of the underlying Atlantic waters. Summer temperatures are lower and winter temperatures are higher in the Bight than on adjacent coastal land masses.

At the 106-Mile Site, air temperature data from 1949 to 1973 (Brower, 1977) show that the mean maximum temperature ranged between 16.2°C in February to 29.9°C in July (Table A-1). The annual mean maximum temperature was 22.6°C. The mean minimum temperatures for the same period ranged between -4.0°C in February to 18.6°C in August. The annual mean minimum temperature was 5.7°C.

WINDS AND STORMS

Northwesterly winds prevail over the 106-Mile Site from October to March, with average speeds approaching 19 knots. From April to September the prevailing winds are southwesterly and reach an average speed of 11 knots. The percentage of winds greater than 33 knots increases seaward beyond the frictional influence of the land throughout the year. At the dumpsite, there is a maximum frequency greater than 5 percent from November through April, with a peak of 8.5 percent in February; it is less than 1 percent from May through August, with a minimum of 0.2 percent in June. These infrequent summer wind speeds are due to disturbances by tropical cyclones and severe thunderstorms. Return values of maximum sustained winds are presented in Table A-2.

The storms sweeping over the New York Bight and the 106-Mile Site are of two general classifications: extratropical cyclones, which form outside of the tropic regions in marine or continental areas, and tropical cyclones, which form in tropical waters such as the Gulf of Mexico and the Caribbean Sea.

TABLE A-1. AIR TEMPERATURE AND WIND DATA FOR THE 106-MILE CHEMICAL WASTE DISPOSAL SITE (Adapted from Brower, 1977)

PARAMETER	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
AIR TEMPERATURE												
No. of observations	436	308	403	516	426	520	410	421	526	427	529	438
Maximum Temp (°C)	17.3	16.2	16.6	20.1	21.9	26.8	29.9	29.4	27.9	25.8	21.6	18.2
Minimum Temp (°C)	-3.5	-4.0	-1.6	3.3	7.2	12.2	18.2	18.6	14.7	10.1	3.7	-0.3
Mean Temp (°C)	7.0	6.4	7.5	10.5	14.1	19.6	23.5	24.0	21.6	18.3	13.5	9.2
SURFACE WINDS												
No. of observations	440	309	409	514	427	521	410	423	528	430	529	444
Percent Frequency _ 10 Knots	23.5	22.3	25.7	34.3	50.6	54.9	54.1	51.3	46.4	39.4	28.8	26.1
Percent Frequency _ 34 Knots	7.9	8.5	5.0	4.3	0.9	0.2	0.5	1.2	2.0	2.9	5.9	6.5
Mean Wind Speed (Knots) From All Directions	18.3	18.9	18.0	14.6	12.0	11.2	10.9	11.2	12.4	14.7	16.9	17.8
Prevailing Direction	NW	NW	NW	SW	SW	SW	SW	SW	NE	NW	NW	NW
Mean Wind Speed (knots) From Prevailing Direction	20.9	21.7	19.2	13.0	12.5	12.2	12.6	12.4	15.7	17.1	19.5	20.1

TABLE A-2. RETURN PERIOD OF MAXIMUM SUSTAINED WINDS
AT THE 106-MILE CHEMICAL WASTE SITE
(Brower, 1977)

Return Period (Years)	Maximum Sustained Winds (Knots)
5	72
10	79
25	90
50	99
100	111
*Period of Record: 1949-1973	

Prevailing winds and weather in the area of the New York Bight are quickly altered by invading extratropical cyclones. "Strong winds, sometimes of hurricane force, accompany the storms and many bring heavy rain or snow" (Brower, 1977). Exceptionally cold northwesterly winds are also characteristic of these storms. Nearly 600 such storms were observed within the Bight region from May 1965 to April 1974.

"Tropical cyclones are infrequent in comparison with extratropical cyclones, but they have a record of destruction for exceeding that of any other type of storm" (Brower, 1977). Wind speeds of tropical cyclones range from less than 34 knots to greater than 63 knots. From 1871 to 1976, 114 tropical cyclones entered the New York Bight, although the force of several of these storms had been reduced to the level of an extratropical storm by the time they reached the Bight. The greatest frequency of tropical cyclones in the New York Bight occurs during late summer and early autumn. "There has been an average of one tropical cyclone per year within the Bight area over the past 106 years" (Brower, 1977).

PHYSICAL CHARACTERISTICS

WATER MASSES

A water mass may be defined as a seawater parcel having unique properties (temperature, salinity, oxygen content) or a unique relationship between these properties. Each water mass thus defined is given a name which qualitatively describes its location or place of origin. Water masses are produced in their source areas by either or both of two methods: (1) alteration of their temperature and/or salinity through air-sea interchange, and (2) mixing of two or more water types. After formation, the water masses spread at a depth determined by their density relative to the vertical density gradient of the surrounding water.

Since a water mass possesses unique properties, physical oceanographers have found it possible to represent a water mass by plotting data with two of above parameters as coordinates. In most cases, a temperature-salinity (T-S) diagram is sufficient for the identification of a water mass. To construct such a diagram, water samples are generally taken from several depths at an oceanographic station, and the temperature and salinity values for each sample are determined. These values are plotted and a smooth curve is drawn through each point, in order of depth. The water mass may appear as the entire curve or as an area of the T-S diagram. In cases of exceptionally homogeneous water, a single point on the plot identifies the parcel, which is then termed a "water type".

NOAA has characterized the physical oceanographic environment at the 106-Mile Site as being extremely complex and variable in all but near-bottom water (NOAA, 1977). Normally, the surface layer of the site is slope water, which lies between fresher shelf water to the west and more saline Gulf Stream water to the east. However, conditions often change, periodically allowing shelf water to enter the site from the west or permitting Gulf Stream water, in the form of southward moving Gulf Stream eddies, to be present about 20 percent of the time. Below is a description of the water masses and water types commonly encountered at the 106-Mile Site.

Shelf Waters

The waters lying over the Continental Shelf of the Mid-Atlantic Bight are of three general types: Hudson River plume water, surface Shelf water, and bottom Shelf water (Hollman, 1971; Bowman and Wunderlich, 1977). Hudson River plume water results from the combined discharge of the Hudson, Raritan, and various other rivers into the northwest corner of the Bight Apex. This low-density water floats over the Shelf waters as it moves into the Bight. During episodes of high runoff, the plume may spread over large areas of the Bight producing large vertical and horizontal gradients of salinity. This water type persists throughout the year, but its extent and depth are highly dependent on flow rates of the Hudson and Raritan Rivers (McLaughlin et al., 1975). Generally, the plume flows southward between the New Jersey coastline and the axis of the Hudson Shelf Valley. Bowman and Wunderlich (1976) have found that the plume direction is sensitive to wind stress and reversals in the residual flow. Consequently, the plume may flow eastward between the New Jersey Coastline and the axis of the Hudson Shelf Valley, or may occasionally split and flow both eastward and southward.

With the onset of heavy river discharge in the spring, surface salinities in the Bight decrease, and, initially, a moderate, haline-maintained (i.e., maintained by salinity differences) stratification occurs, separating the coastal waters into an upper and lower layer. These two layers are the surface Shelf water and the bottom Shelf water. Decreasing winds and increasing insolation solar radiation increase the strength of the stratification and cause it to undergo a rapid transition (usually within a month) from a haline-maintained to a thermal-maintained (i.e., maintained by temperature differences) condition (Charnell and Hansen, 1974). This two-layer system becomes fully developed and reaches maximum strength by August.

Surface Shelf water is characterized by moderate salinity and high temperature. During the winter the water column is essentially vertically homogenous over most of the Bight Shelf. With the rapid formation of the surface Shelf water layer during the spring, the bottom waters become isolated until sufficient mixing takes place the next winter. Bigelow (1933) found that the "cool cell" (having temperature typically less than 10°C) of the bottom Shelf water layer extended from south of Long Island to the opening of Chesapeake Bay and seaward, nearly to the shelf edge. This cold water persists even after the surface layers have reached the summer temperature maximum. Bigelow (1933) also found that this "cool cell" was surrounded on all sides by warmer water.

The upper layer of this bottom Shelf water is usually found between 30 and 100 meters depth during the summer (Bowman and Wunderlich, 1977). Seaward, near the Shelf edge, strong temperature, salinity, and density gradients occur which limit large-scale mixing between the Shelf waters and the waters found over the Continental Slope. The mechanism by which bottom Shelf water is replenished is currently under study.

Slope Waters

The Slope water mass is a highly complex, dynamic body of water which represents an area of mixing between Shelf waters, which bound it on the north and west, and the Gulf Stream, which forms its southern boundary (Figure A-1). These boundaries (frontal zones) are not stationary but migrate seaward and landward.

The Gulf Stream frequently migrates in such a way that anticyclonic (clockwise) loops of current are formed. Occasionally, these loops detach and form separate entities known as eddies. The eddies are rings of Gulf Stream water surrounding a core of warm Sargasso Sea Water which originates to the east of the Gulf Stream. Large amounts of this water may be advected to depths as great as 800 to 1000 meters (NOAA, 1977). After detachment, these eddies may migrate into the slope water region, usually in a southwesterly direction. The eddies may, in addition, interact with Shelf water causing considerable disturbance in the water column within the 106-Mile Site (Figure A-1). While there appears to be no seasonal pattern in the occurence of these eddies, Bisagni (1976) found that, based on the trajectories of 13 eddies between 1975 and 1976, the 106-Mile Site was wholly or partially occupied 20 percent of the time by these eddies. The eddies either dissipate or are reabsorbed by the Gulf Stream, usually in the region of Cape Hatteras.

Periodically, a seaward migration of the Shelf/Slope water boundary brings highly variable Shelf water into the upper waters of the disposal site, thereby producing a very complex vertical structure consisting of thin layers of cool, low-salinity Shelf water interspersed with warm, high-salinity Slope water.

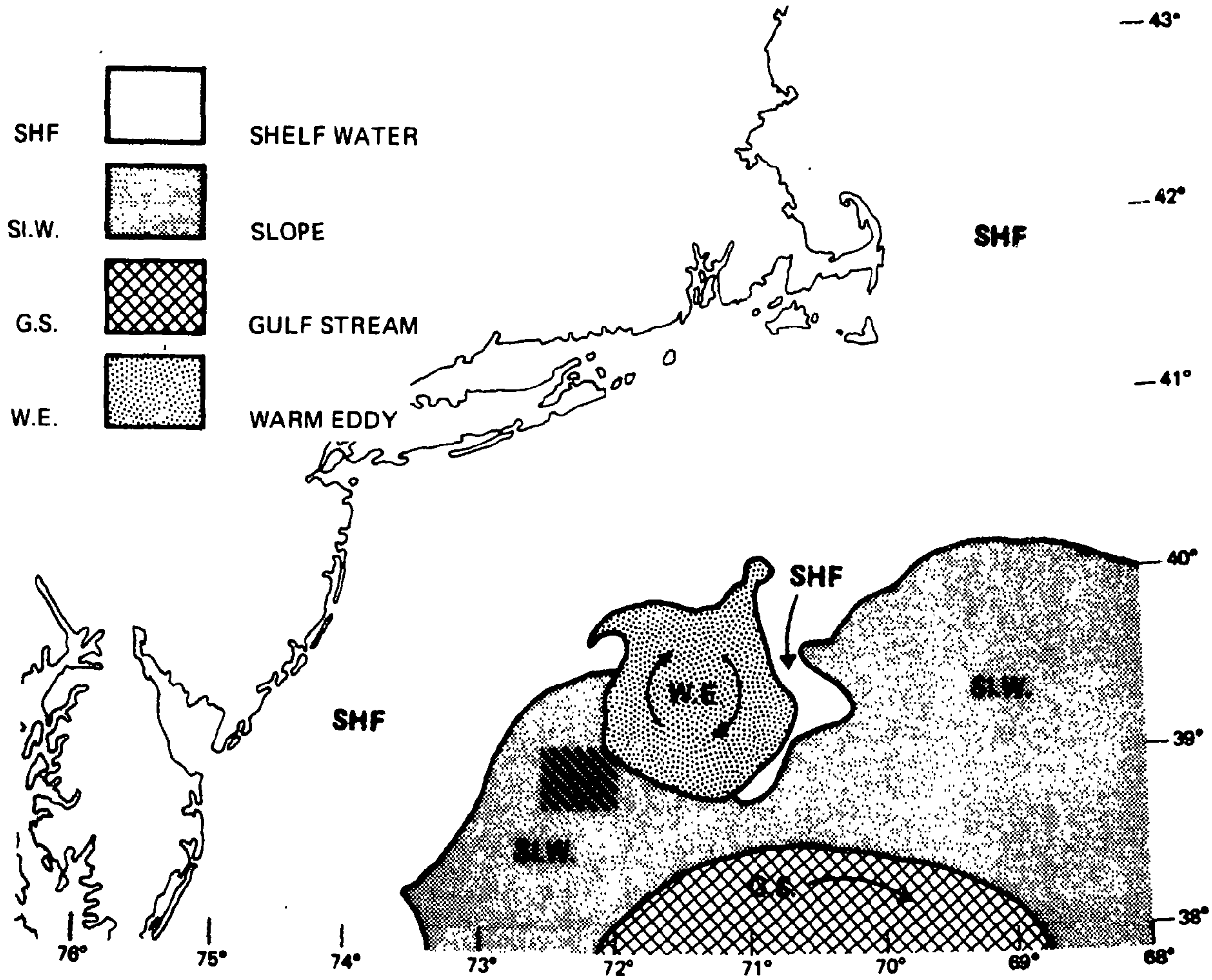


Figure A-1. NOAA National Environmental Satellite Service Observations of Shelf, Slope, and Gulf Stream Waters Surrounding the 106-Mile Site in May 1974 (Warsh, 1975a)

Marcus (1973) found the Shelf/Slope front to be located over the200-meter isobath during summer, and north and west of this isobath during fall. The winter and spring positions of this front have been reported by Warsh (1975b) as ranging from the Shelf break to 130 km south and east of the Shelf break. The surface waters of the Shelf are cooler than those of the Slope except during the summer months when the well-defined thermal front disappears. Fisher (1972) has observed Shelf water overlying Slope water as far as 100 km seaward of the 200-meter isobath. He and others (Boicourt, 1973; Boicourt and Hacker, 1976) suggest that wind driven advection may be responsible for these migrations. The onshore movement at lower depths of more saline Slope water is frequently associated with the offshore movement of low-salinity Shelf water.

The combined effects of mixing, boundary migration, and the usual seasonal distribution of river runoff and rain produce a multitude of different water types resulting in a confused, interlayered water column. Figure A-2 displays a stylized representation of this complex arrangement.

Like many deep water sites, the water column of the Slope water mass can be divided into three general layers: the upper or surface layer where variability is great, the thermocline region where temperature changes rapidly with depth, and the deep water where seasonal variability is small.

For Slope water in general, stratification forms in the upper water column early in May and persists until mid or late fall when cooling and storm activity destroy it. The permanent thermocline is located at a depth of 100 to 200 meters. During the period when the surface layers are stratified, a seasonal thermocline forms which reduces the mixed-layer depth to between the surface and 30 to 40 meters. From fall through early spring, the water column is isothermal to between 100 to 200 meters depth. At this time, inversions are observed where low-salinity, cool Shelf water flows under warmer, high-salinity Slope water.

The upper layer of the Slope water mass is termed surface Slope water. It extends from the sea surface to a depth of about 200 meters. Because the Shelf water extends seaward to the 200-meter isobath, its vertical extent at the Shelf/Slope interface is the same as that of the surface Slope water mass. Consequently, the seaward boundary of the Shelf water mass borders only the surface Slope water mass; direct mixing between Shelf water and the waters of the permanent thermocline, which are located below the surface Slope water mass, does not usually occur. However, mixing of waters across the Shelf water/Slope water front may be caused by the strong circulation of eddies or meanders from the Gulf Stream (NOAA, 1977).

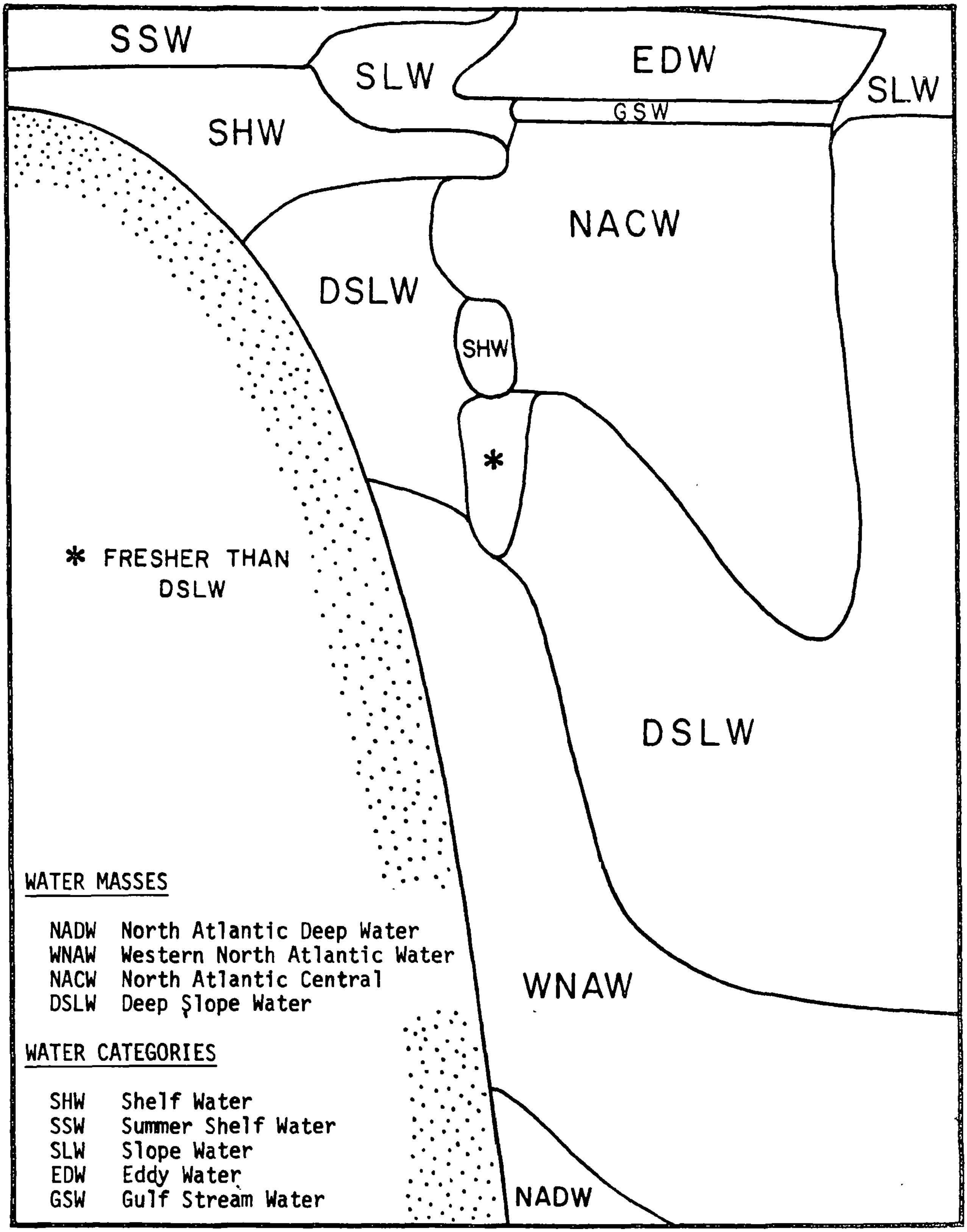


Figure A-2. Stylized Section from the Continental Shelf through the Dumpsite Eddy, Showing Surface Water Categories and Deeper Water Masses (Goulet and Hausknecht, 1977)

The spillage of cooler Shelf water into the relatively warm surface Slope water has been documented by numerous researchers (Bowman and Weyl, 1972; Wright, 1976b; Bigelow, 1933). Wright (1976a) suggests that significant interchange of Shelf and Slope water may ccur via this mechanism. Beardsley et al. (1975) report that this process of cool water spillage or "calving" may be related to the occurrence of anticyclonic Gulf Stream eddies and their subsequent migration along the Shelf edge. Based on an aerial survey of the formation and subsequent behavior of an anticyclonic eddy, Saunders (1971) found that bottom Shelf water may have been pulled off the Shelf and displaced at least 150 km southward to the eastern edge of the eddy. The amount of Shelf/Slope water mixing promoted by this process and the frequency of occurrence of this type of induced mixing is unknown (Beardsley et al., 1975). However, estimates range from 300 km^3/year to 8,000 km^3/year (Stommel, 1960; Fisher, 1972; Beardsley et al, 1975).

CURRENT REGIMES

Surface

There are no major, well-defined circulation patterns in the surface layers of the Slope water region (Wright, 1976a). Few long-term current records and large natural variability limit the usefulness of any estimates of the mean current for this region. The westward-flowing Labrador Current loses its distinctness somewhere west of the Grand Banks. Current measurements have been made by several researchers using neutrally buoyant floats, parachute drogues, and moored current meters in the region of the Shelf break and Slope south of New England (Webster, 1969; Voorhis et al., 1976; Beardsley and Flagg, 1976). The mean currents in this area are generally on the order of 10 to 20 cm/sec westward, following the bottom contours. This direction is similar to the direction taken by currents over the Continental Shelf.

Wright (1976a) indicates that along the northern boundary, Slope waters flow slowly to the southwest, following the bathmetry to Cape Hatteras, where they turn and flow seaward into the Gulf Stream. Evidence of a slow northeastward flow along the Gulf Stream, in the southern part of the Slope water region, was also found. Wright (1976a) suggests that the Gulf Stream and the Shelf water form a cul-de-sac near Cape Hatteras, and, while some interchange of water occurs across these boundaries, most of the water entering the Slope water region from the east probably exists along the same path.

Beardsley et al. (1975) have studied the kinetic energy spectrum from several sites located over the Continental Shelf and Continental Slope. They found that the considerable variance of kinetic energy in the Slope water currents was due to inertial periods of motion. This fraction of the variance in the kinetic energy increased significantly as one moved onto the Shelf. From the long term records obtained at a site 204 km northeast (39°20'N, 70°W) of the dumpsite, Beardsley et al. (1975) found that at 100 meters depth much of the observed variance in kinetic energy is due to motions recurring at 30-day intervals.

The Oceanographer of the Navy (1972) reported a mean surface current speed of about 25 cm/sec for a region near the 106-Mile Site. The direction of the flow was either east-northeast or south-southwest. No other current estimates for the 106-Mile Site have been reported in the literature.

WAVES

Brower (1977) has compiled wave data for the New York Bight coastal region, the disposal site, and adjacent waters. The data are taken from the MESA New York Bight Atlas Monograph 7, Marine Climatology (December 1976) and from published and unpublished data for the New York and Middle Atlantic Bights. Reported observations for the period 1949 to 1974 are discussed below.

Wave heights increase with distance from shore throughout the year and the differences in height are smaller during summer. The average frequency of observations reporting hazardous waves (wave heights greater than or equal to 3.5 meters) is 5 percent to 6 percent from December through March. While the frequency of hazardous waves at two light stations near the New Jersey coast varies from less than 0.5 percent in summer to approximately 1 percent to 2 percent in winter, the frequency seaward at the dumpsite area varies from about 1 percent in summer to more than 10 percent from November through March, with a peak of 13 percent in January and February (Table A-3). The frequency tends to increase northwest to southeast across the Bight throughout the year.

TABLE A-3. MONTHLY WAVE HEIGHT FREQUENCY FOR THE 106-MILE SITE (Brower, 1977)

WAVE HT	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
No. Obs.	355	243	329	392	314	382	274	290	401	337	409	377
WH <1.5 m	33.5	36.2	38.8	48.7	68.2	75.9	78.6	66.3	60.0	50.2	39.8	38.5
WH <2.5 m	70.7	68.1	75.3	82.7	90.1	95.3	95.0	97.6	89.5	80.2	79.2	78.5
WH ≥3.5 m	12.7	13.1	11.0	6.6	1.9	1.0	0.9	0.7	3.5	5.3	10.1	10.3

WAVE HT
NO. OBS. Number of observations
WH <1.5 M Percent frequency of wave height <1.5 m
WH <2.5 M Percent frequency of wave height <2.5 m
WH ≥3.5 M Percent frequency of wave height ≥3.5 m

Mean return periods (recurrence intervals) for maximum significant and extreme waves; i.e., the wave value is that height which will be equalled or exceeded, on the average at least once during the period.

The frequency of waves less than 1.5 meters in height follows the same pattern. Near shore, the frequency ranges from 70 percent in winter to 90 percent in summer. Offshore, at the dumpsite, the frequency of occurrence ranges from 35 percent to 40 percent in winter to nearly 80 percent in early summer.

Table A-4 lists the mean return periods (recurence intervals) for maximum significant wave height and the extreme wave height in the disposal site. The maximum significant wave height is the average height of the highest one-third of the waves in a given wave group. Thus, Table A-4 shows that, for example, there will be a maximum significant wave height of 69 feet within the Site area at least once in every 100 years. Similarly, an extreme wave height of 124 feet will occur at the Site at least once every 100 years.

TABLE A-4. RETURN PERIODS FOR HIGH WAVES AT THE 106-MILE SITE (Brower, 1977)

Return Period (Years)	Maximum Significant Wave (Feet)	Extreme Wave (Feet)
5	41	74
10	47	84
25	55	98
50	62	111
100	69	124

TEMPERATURE STRUCTURE

The waters in and around the 106-Mile Site are subject to the sudden changes in temperature that may occur between Shelf and Slope water. Shelf water is always much colder than Slope water during the winter months, but during the warmer months of the year, peak surface temperatures of Shelf water exceed those of Slope water. The horizontal temperature gradient between the two water masses becomes less marked only during periods of warming and cooling. The water masses are then best distinguished by salinity differences (Warsh, 1975b).

Warsh (1975a) summarized hydrographic data collected by the USCG and the NOAA Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program. These data were taken during all seasons over an area encompassing the Mid-Atlantic Bight and the Continental Slope, including the disposal site region. Monthly summaries from Marsden Square 116, subsquares 81, 82, and 91 (Figure A-3) are discussed below. Table A-5 gives the ranges of temperatures for each subsquare. These areas, while differing in the month of minimum temperature, had the same month of maximum temperature. Surface temperatures ranged between 5.1°C (February-subsquare 82) and 25.0°C (August-subsquare 82). Figure A-4 illustrates the average monthly sea surface temperatures for each subsquare.

In the upper 50 meters of the water column, a seasonal thermocline develops in late spring (May) and is usually present through mid-autumn (October). However, remnants of the thermocline may be present as late as November. By December, the water is essentially isothermal to a depth of 100 meters, but temperature inversions have been observed near 30 meters. These inversions may persist through April or May. The permanent thermocline is usually found between 100 and 500 meters. The temperature ranges between 100 and 500 meters for each subsquare are listed in Table A-6.

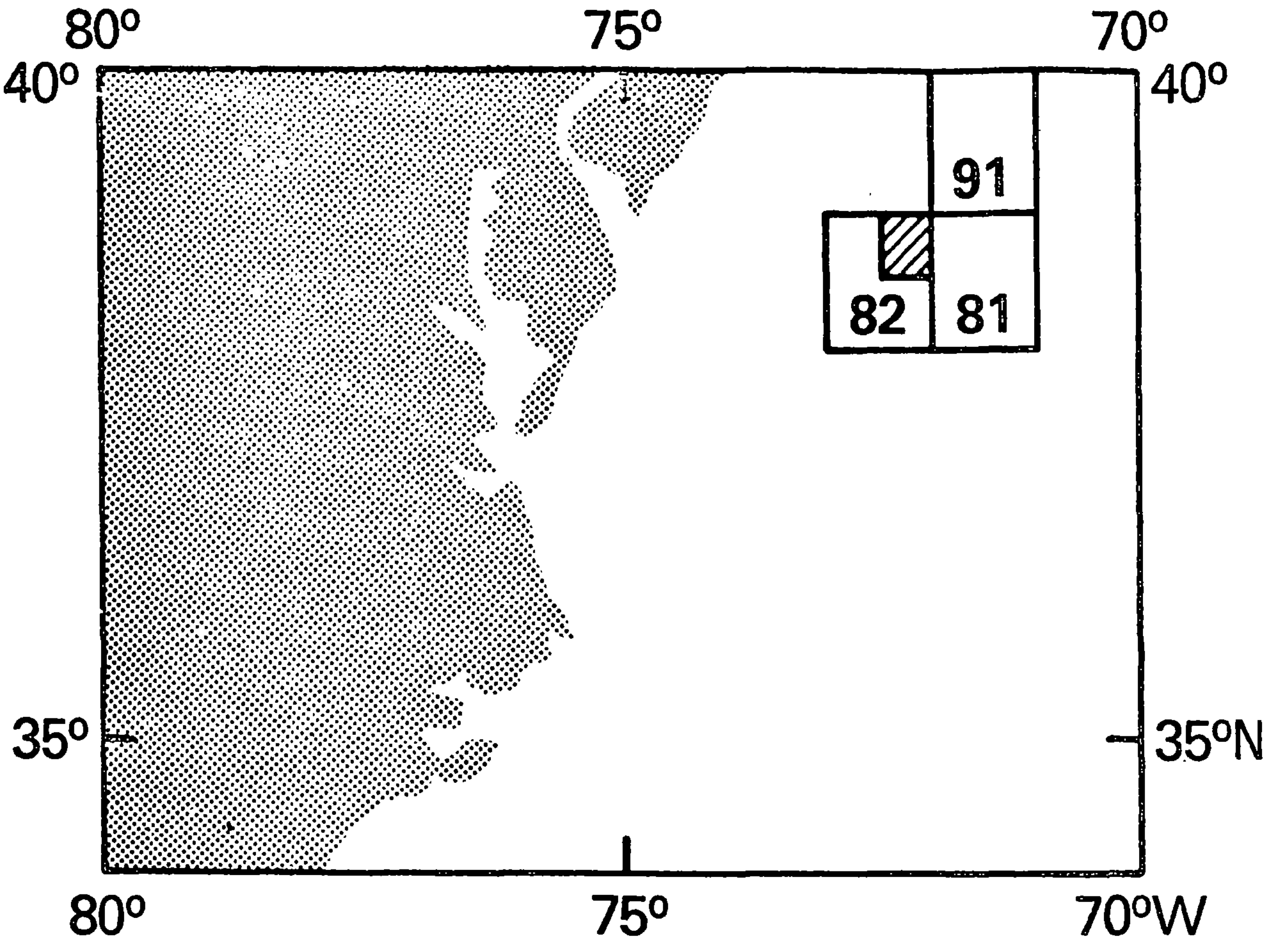


Figure A-3. Marsden Square 116; Subsquares 81, 82, and 91; and the 106-Mile Site (Diagonal Lines in Subsquare 82) (Warsh, 1975b)

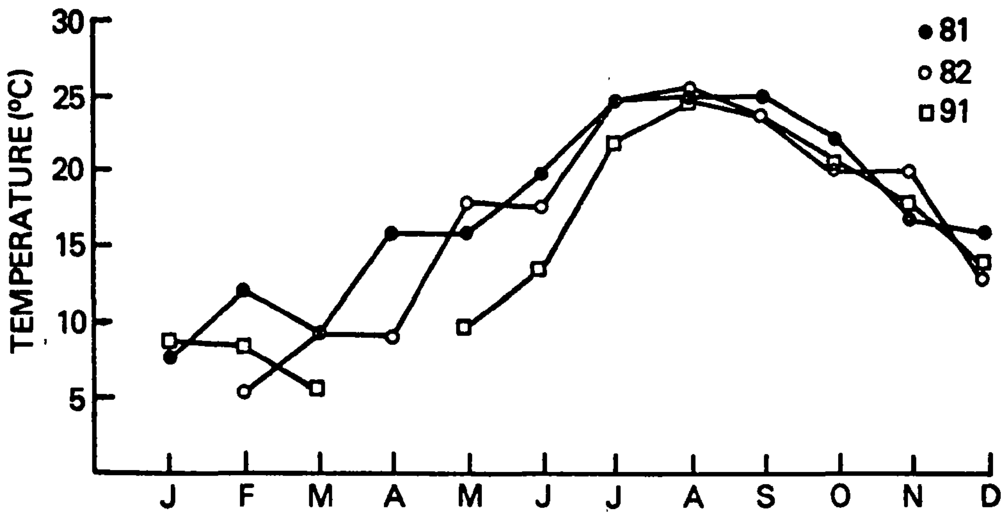


Figure A-4. Average Monthly Sea-Surface Temperatures for Subsquares 81, 82, and 91 in Marsden Square 116. (Warsh, 1975b)

TABLE A-5. AVERAGE SURFACE TEMPERATURE RANGES AND MONTHS OF MINIMUM AND MAXIMUM TEMPERATURES FOR SUBSQUARES 81, 82, AND 91 IN MARSDEN SQUARE 116 (Warsh, 1975b)

Subsquare	Month of Minimum Temperature	Average Surface Temperature Range (°C)	Month of Maximum Temperature
81	January	7.8 - 24.9	August
82	February	5.2 - 25.0	August
91	March	5.4 - 24.5	August

TABLE A-6. AVERAGE TEMPERATURE RANGES BETWEEN 100 AND 500 M FOR SUBSQUARES 81, 82, AND 91 IN MARSDEN SQUARE 116 (WARSH, 1975b)

Subsquare	Average Temperature Ranges (°C) From 100 to 500 m
81	5.0 - 14.4
82	4.8 - 15.8
91	5.0 - 14.6

From 500 to 1,000 meters the temperature range decreases to between 4°C and 6°C. Below 1,000 meters, the temperature ranges from 2°C to 4°C. Figures A-5, A-6 and A-7 display the monthly temperature profiles for each subsquare.

SALINITY STRUCTURE

The waters in and surrounding the 106-Mile Site are subject to the sudden changes in salinity that may occur between Shelf and Slope waters. Shelf water is always fresher than Slope water during the winter months. During the warmer months of the year, the two water masses are best distinguished by temperature differences. During periods of warming and cooling, the water masses are best distinguished by salinity differences (Warsh, 1975b).

Table A-7 gives the ranges of salinity for each subsquare. The range of surface salinity was quite variable, and was dependent on the water mass present (Shelf, Slope, or Gulf Stream) within each square. The values ranged from 32.70 ppt (parts per thousand) in June (subsquare 82) to 35.75 ppt in April (subsquare 81). Figure A-8 illustrates the average monthly sea-surface salinities for each area.

TABLE A-7. AVERAGE SURFACE SALINITY RANGES AND MONTH OF MINIMUM AND MAXIMUM SALINITY FOR SUBSQUARES 81, 82, AND 91 IN MARSDEN SQUARE 116 (WARSH, 1975b)

Subsquare	Month of Minimum Salinity	Average Surface Salinity Range (ppt)	Month of Maximum Salinity
81	January	33.05 - 35.75	April
82	June	32.70 - 35.45	November
91	May	32.85 - 34.90	November

Salinity generally increased to depths of 100 to 150 meters, where the maximum salinities are encountered. Values at these depths average approximately 35.75 ppt. Salinity then decreases with depth to about 400 meters where the minimum average salinity of 34.95 ppt exists. Below 400 meters, the water column is nearly isohaline, and salinity values may range between 34.90 ppt and 35.05 ppt. Figures A-9, A-10, and A-11 display the monthly salinity profiles for each subsquare.

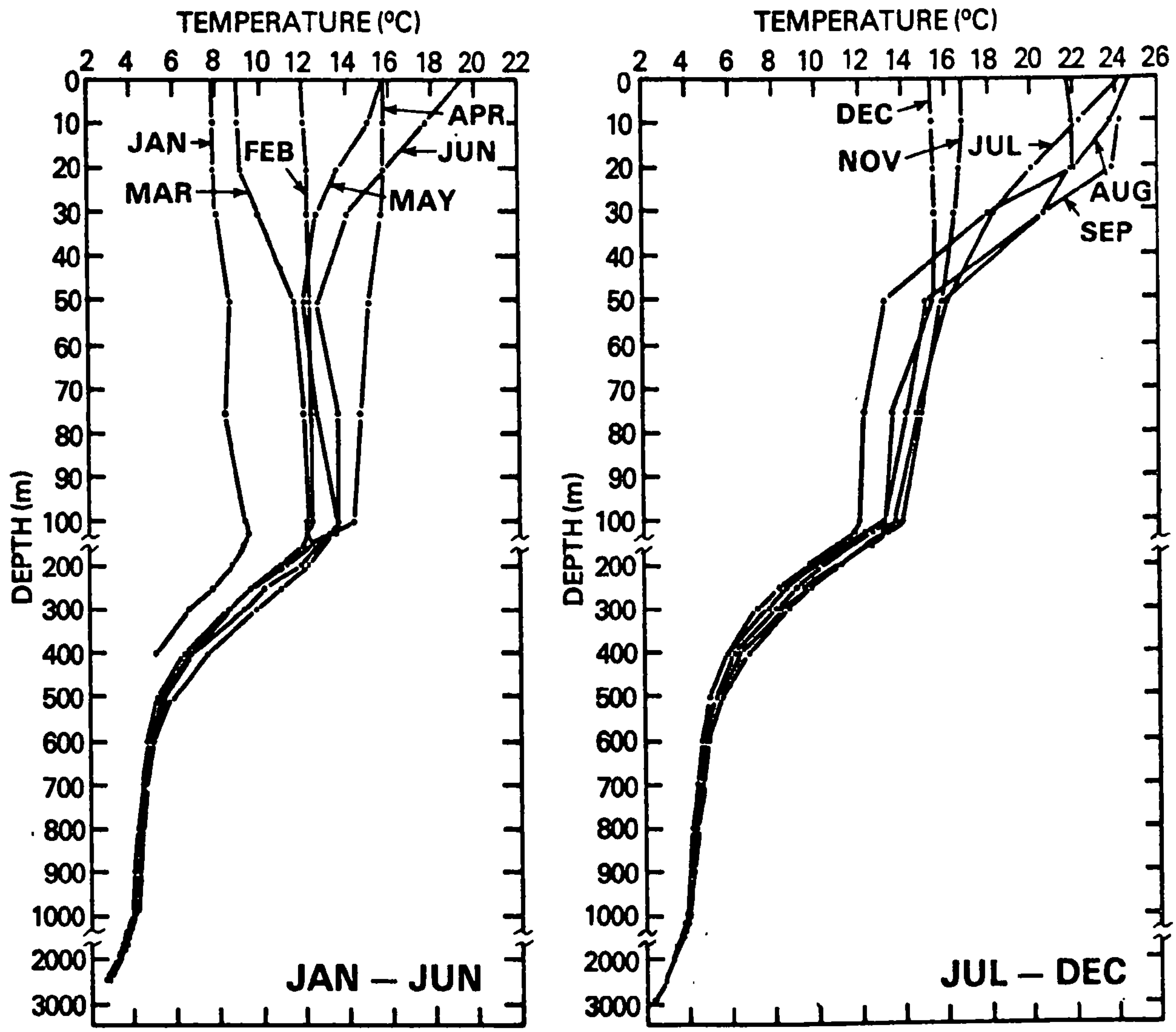


Figure A-5. Temperature Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 81 (Warsh, 1975b)

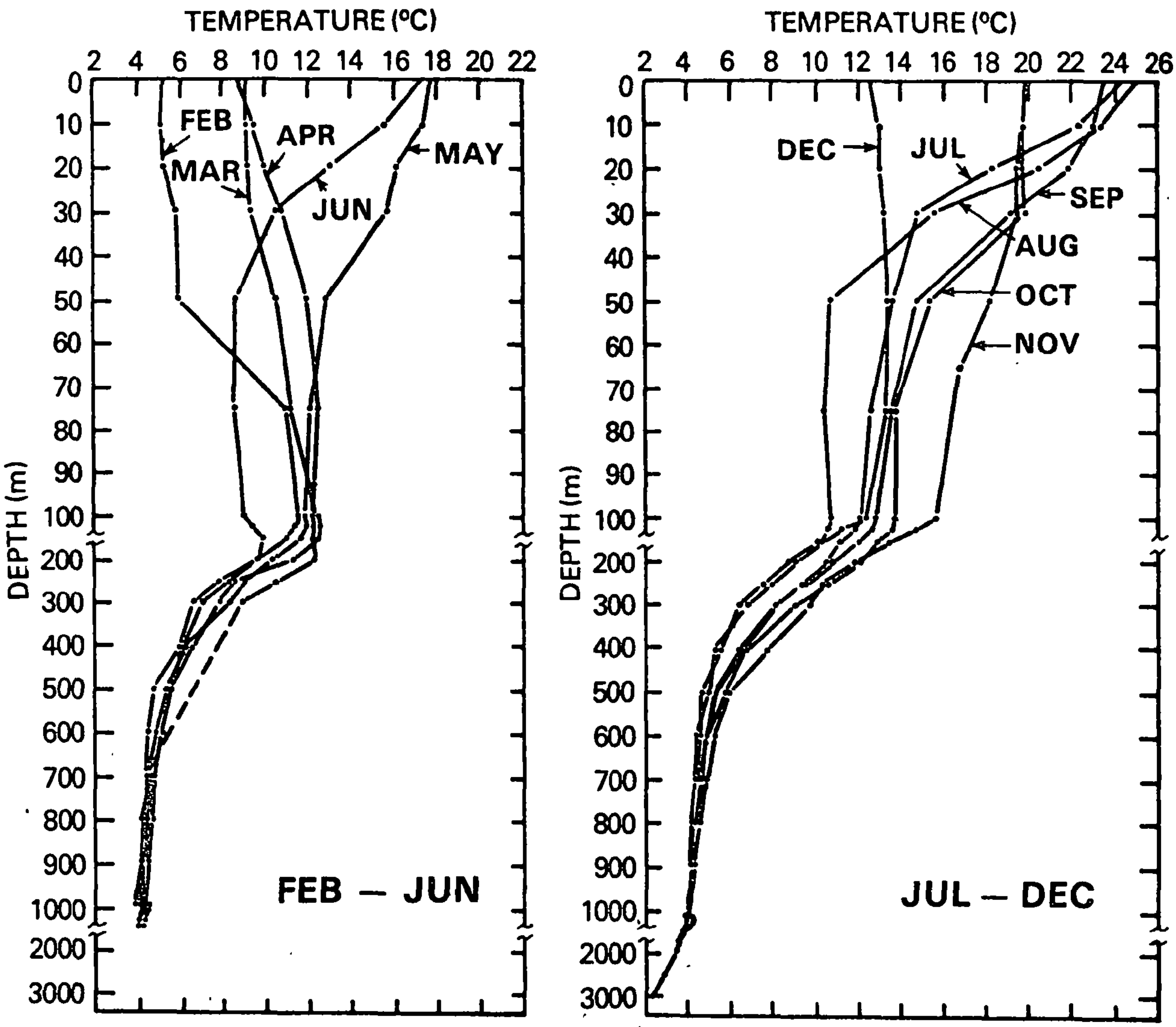


Figure A-6. Temperature Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 82 (Warsh, 1975b)

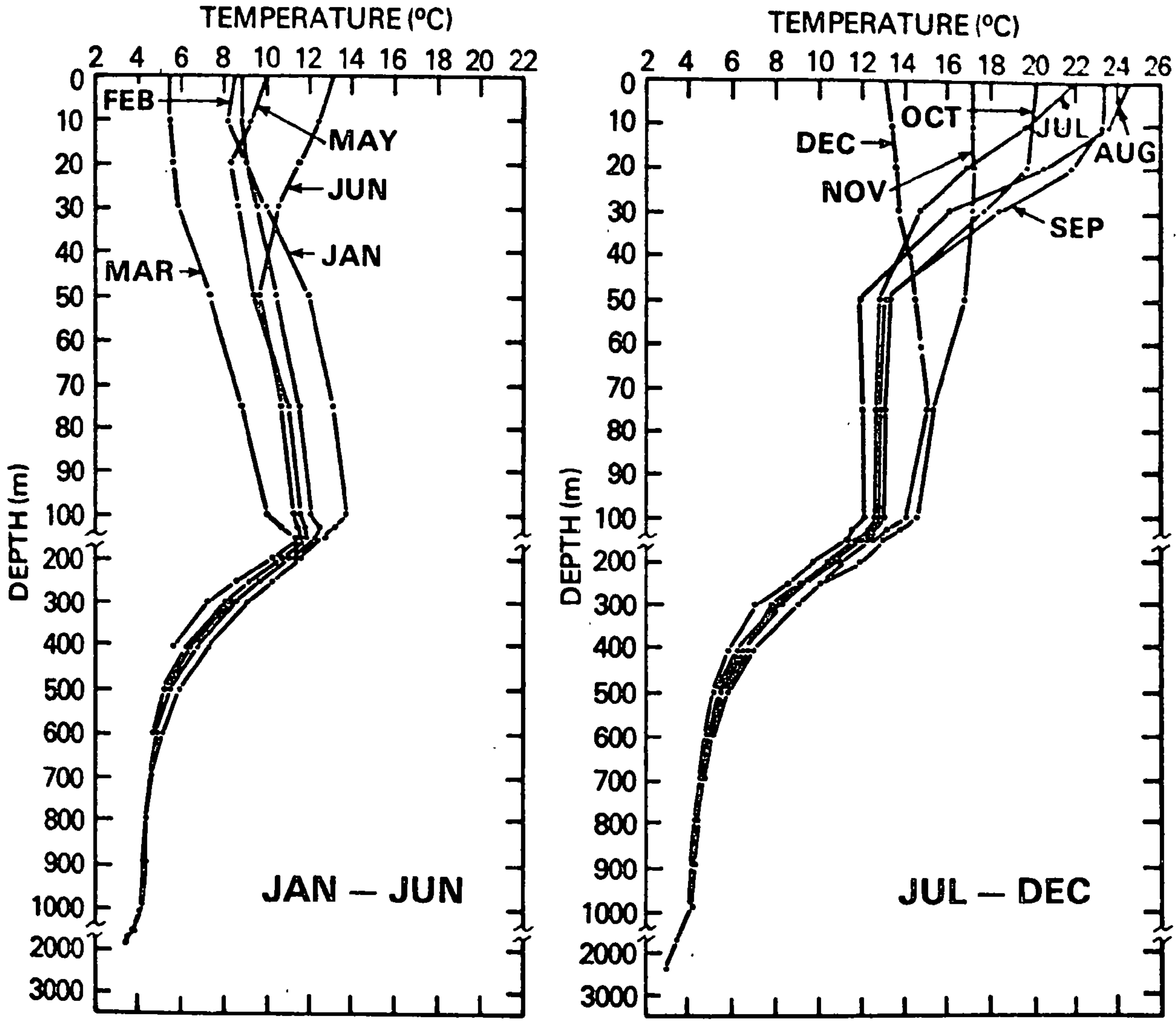


Figure A-7. Temperature Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 91 (Warsh, 1975b)

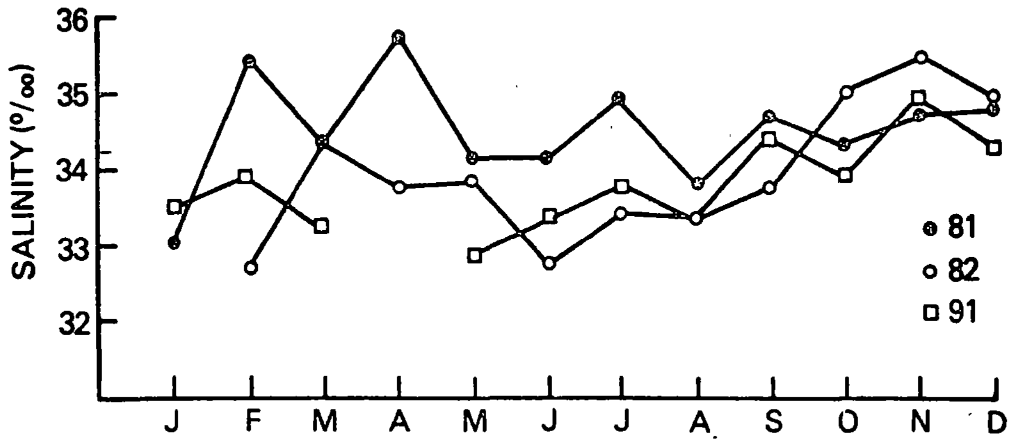


Figure A-8. Average Monthly Sea-Surface Salinities for Subsquares 81, 82, and 91 in Marsden Square 116. (Warsh, 1975b)

GEOLOGICAL CHARACTERISTICS

The 106-Mile Site covers portions of the Continental Slope and Continental Rise (Figure A-12). Water depths within the Site range from 1,500 meters in the northwest corner to approximately 2,725 meters in the southeast corner. The Continental Slope portion of the Site experiences a 4 percent grade, whereas the grade of the Continental Rise portion is 1 percent (Bisagni, 1977a).

Four submarine canyons incise the Continental Slope within the Site: Mey, Hendrickson, Toms, and Toms Middle Canyon. In addition, numerous smaller canyons exist in the Slope region west of the Site. Sixty kilometers north of the Site is the massive Hudson Canyon system, which extends from the New York Bight Apex to the edge of the Continental Slope.

Although the Middle Atlantic Bight is one of the best studied continental margins in the world, few studies have concentrated on the Continental Slope region of the Bight. Emery and Uchupi (1972) suggest that marine geologists may have found the numerous submarine canyons which incise the Slope to be geologically more interesting than the more featureless region of the Slope.

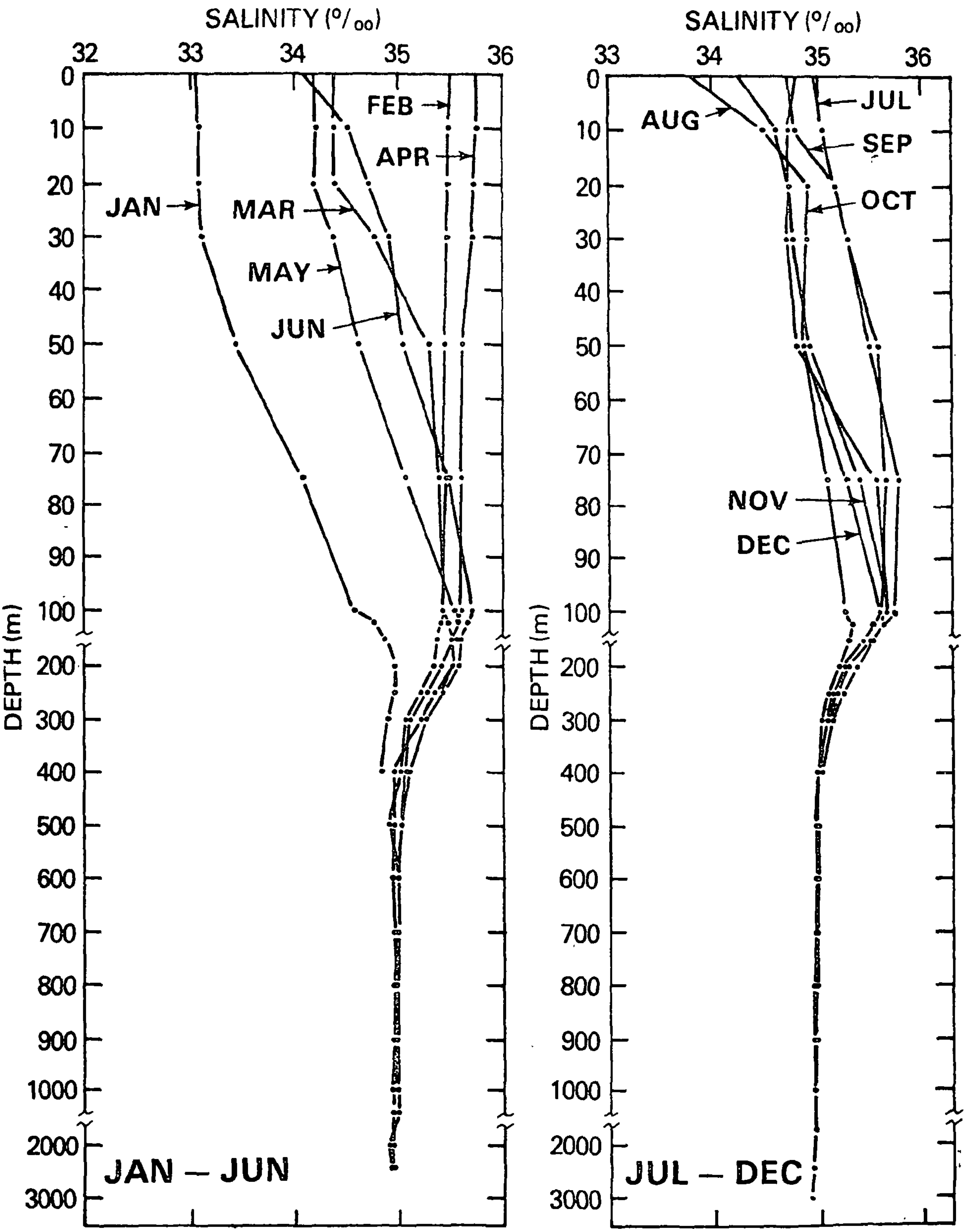


Figure A-9. Salinity Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 81 (Warsh, 1975b)

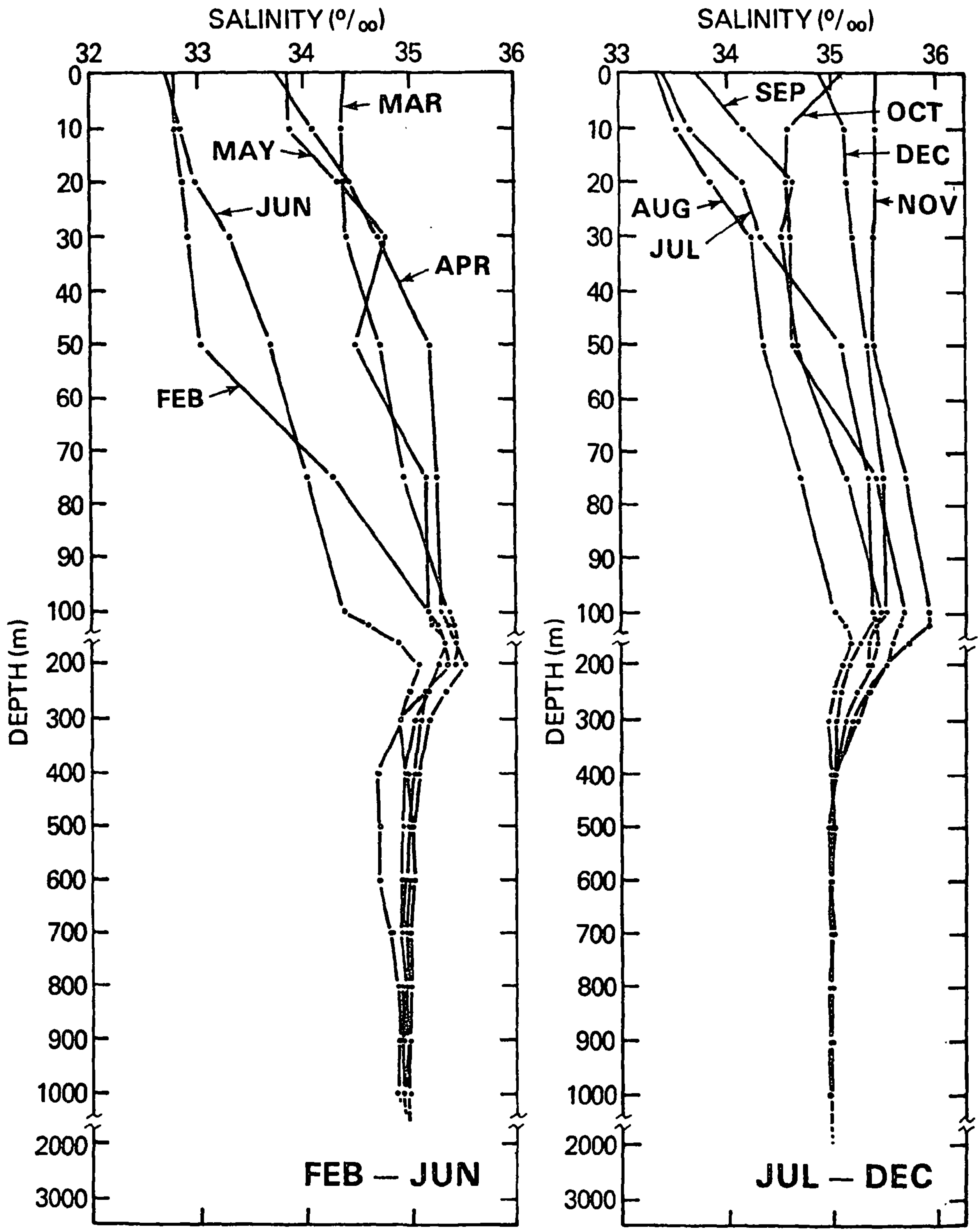


Figure A-10. Salinity Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 82 (Warsh, 1975b)

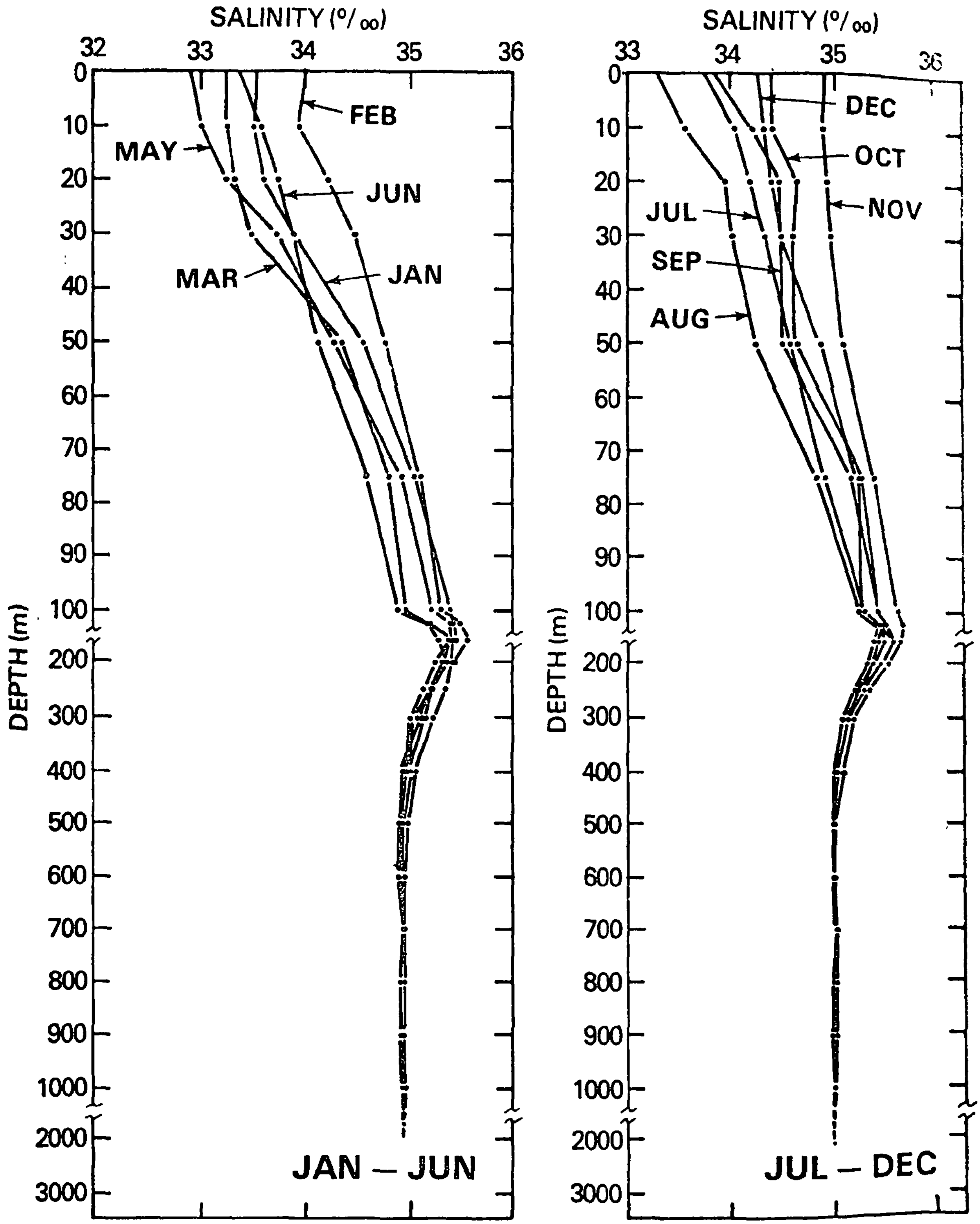


Figure A-11. Salinity Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 91 (Warsh, 1975b)

Based on interpretation of bottom photographs, seismic reflection profiling, and data from the Deep Sea Drilling Project, Heezen (1975) concluded that the upper Continental Rise is a tranquil area of nearly uniform sedimentation that has existed for at least 1,000 years. The sediments are characterized as a wedge of Mesozoic and Cenozoic sediment, up to 13 km thick near the Baltimore Canyon (Shenton, 1976).

A narrow transition zone of recent high erosion separates the upper Continental Rise from the lower Slope area. Sediment cores and seismic reflection profiling in this area of the Continental Slope have shown that "recent sediments along with Pliocene or Holocene deposits were totally absent in the area," apparently removed by current action since 1975 (Bisagni, 1977a). Prior to that time, photographs showed that the bottom was covered by a soft sediment of hemipelagic ooze and that significant currents were absent (Heezen, 1975).

The lower Slope and Rise, which lies below 3,500 meters depth, exhibits numerous current-induced bedforms, formed by the southwestward-flowing Western Atlantic Undercurrent (Heezen, 1975). The lower Slope and Rise may be thick prisms of deep sea turbidites, clays, and slump deposits (Drake et al., 1968).

The recent sediments deposited on the Continental Slope and Rise are primarily silt and clay (Milliman, 1973). Most of the sand in this region is biogenic in origin, although patches of terrigenous sand occur in the axes of some canyons (Hathaway, 1971; Keller et al, 1973). The sediments on the Slope tend to be olive or brown in color (Milliman, 1973), which may be a function of the high oxygen content of the Slope water and iron staining. Calcium carbonate is a major component of Slope sediments, making up as much as 75 percent of the sediments in some areas. The carbonate grains are chiefly the tests of planktonic foraminifera, benthonic foraminifera, and echinoid plates. Coccoliths are often common components, but are seldom abundant (Milliman, 1973).

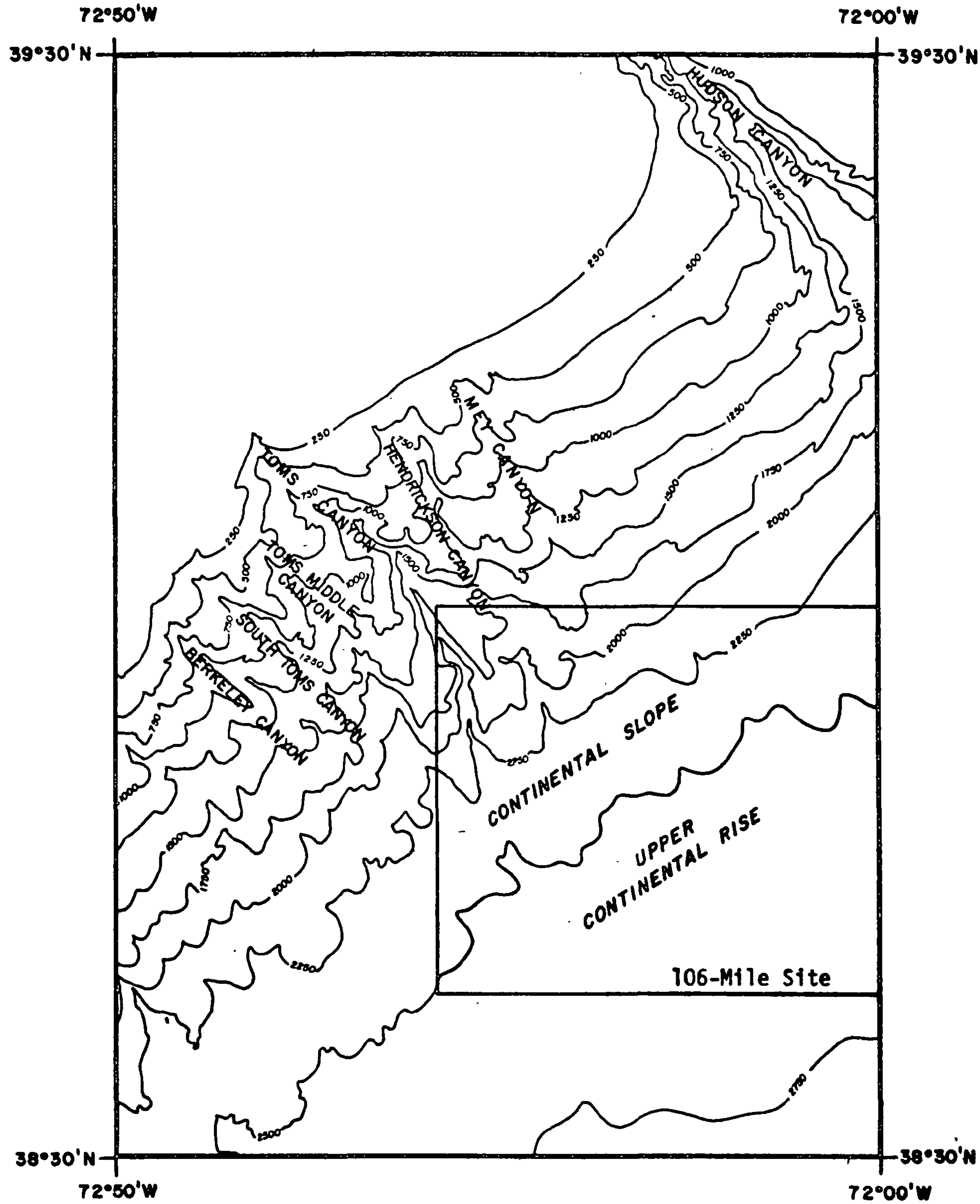


Figure A-12. Bathymetry in the Vicinity of the 106-Mile Site (Bisagni, 1977a)

Heavy minerals in the sand-sized fraction average less than two percent in the slope sediments. Amphiboles represent 31 to 45 percent of the heavy mineral fraction; epidote represents less than 10 percent (Milliman, 1973). The light minerals are mostly quartz, feldspar and glauconite. The clay minerals, which are more prevalent on the Slope than across the Shelf, are chiefly illite and montmorillonite (Emery and Uchupi, 1972). Milliman (1973) reports illite fractions which range from 30 to 40 percent, chlorite fractions of 10 to 20 percent, and kaolinite fractions ranging from 20 to 30 percent.

CHEMICAL OCEANOGRAPHY

WATER COLUMN CHEMISTRY

Dissolved Oxygen

Oxygen is a fundamental requirement for marine life. It is produced by photosynthesis in the photic (i.e., sunlit) zone usually less than 100 meters in depth) and is used by animals in respiration and in the decomposition of organic matter.

The contrasting processes of photosynthesis and respiration are the main causes of in situ changes in the concentrations of dissolved oxygen. In the photic zone, photosynthesis by phytoplankton may predominate and lead to the liberation of oxygen. Under optimum conditions, this will lead to the development of an "oxygen maximum layer" in the surface waters. Below this layer, respiration and decomposition predominate and oxygen values diminish steadily with depth. Another layer, where dissolved oxygen concentrations are at a minimum, will form at depths varying between 150 and 1,000 meters.

The ability of a water parcel to maintain certain minimal concentrations of oxygen determines the survival of life in that parcel. The saturation level (i.e., maximum solubility) of dissolved oxygen in seawater is dependent on the temperature, salinity, and pressure. In general, the solubility of oxygen in seawater decreases as the temperature and salinity increase. Within the normal range of oceanic salinity (30 to 40 ppt), temperature is the dominant factor determining oxygen solubility.

At all depths, seawater is saturated with atmospheric gases with the exception of those, such as oxygen, that are involved in life processes. Values of oxygen below the saturation level suggest that bacterial activity is removing oxygen faster than it is being replenished by mixing or other processes.

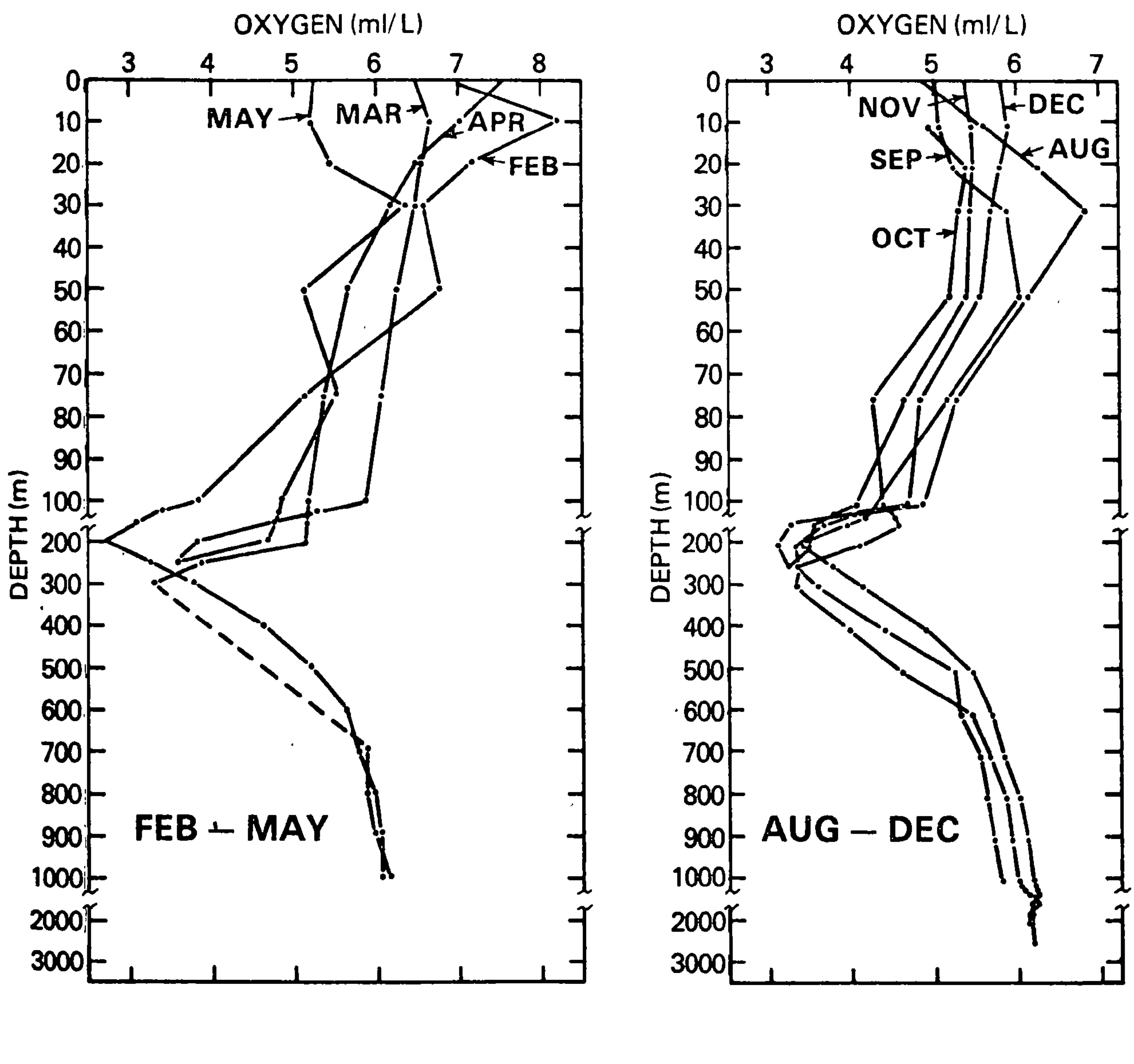


Figure A-13. Monthly Averages of Oxygen Concentration Versus Depth at the 106-Mile Site (Warsh, 1975b)

Dissolved oxygen concentrations are generally higher during the winter months because of increased mixing in the water column. Increased plankton populations during the spring result in a high fallout of dead organisms, and, consequently, a higher oxygen demand in deeper water, due to microbial decomposition of organic matter. As a result, bottom waters tend to have lower dissolved oxygen levels at this time of year.

Warsh (1975b) summarized historical data for the water column within and adjacent to the 106-Mile Site. Within the Site, monthly average oxygen values at the surface range from 4.9 mg/l (approximately 104 percent saturation) in August to 7.5 mg/l (approximately 113 percent saturation) in April (Figure A-13). The oxygen minimum zone is between 200 and 300 meters and the oxygen values there range between 2.8 mg/l (approximately 43 percent saturation in February) and 3.5 mg/l (approximately 57 percent saturation) in September. The historical data for the site show the development of a subsurface oxygen maximum zone during several months. Values varied from 7.0 mg/l at 30 meters during August to 8.2 mg/l at 10 meters during February.

Monthly average oxygen values for surface waters adjacent to the 106-Mile Site range from 4.5 mg/l (approximately 92 percent saturation) in October to 7.5 mg/l (approximately 106 percent saturation) in March. The oxygen minimum zone in waters adjacent to the Site occurs between 200 and 300 meters. Oxygen values in this zone show approximately the same range as the waters within the 106-Mile Site.

A baseline investigation of the 106-Mile Site during May, 1974 (NOAA, 1975) found concentrations of dissolved oxygen at the surface ranging from 4.36 mg/l to 6.94 mg/l. The highest values occurred in areas over the Continental Shelf and generally decreased seaward. An oxygen minimum layer occurred between 200 and 400 meters. Most of the values recorded for this layer were about 3.2 mg/l. The lowest value recorded for the minimum layer was 3.12 mg/l at approximately 300 meters. At depths below the oxygen minimum layer, values increased to slightly above 6 mg/l. From 1200 meters to the bottom, the amount of dissolved oxygen fluctuated between 6.2 and 5.3 mg/l. Hausknecht and Kester (1976a) reported oxygen values at the 106-Mile Site taken during

July 1976. Surface values averaged 5.3 mg/l while concentrations at the oxygen minimum layer (300 meters) averaged approximately 3.5 mg/l.

pH and Alkalinity

pH is a measure of the acidity or alkalinity of a solution. The pH scale ranges from 1 to 14, with a neutral solution having a pH of 7.0. Acidic solutions have pH values lower than 7, whereas alkaline solutions have ph values higher than 7. Seawater pH ranges from 7.8 to 8.4 with an average of 8.2. This narrow range is maintained by buffering from chemical systems such as the carbon dioxide-bicarbonate-carbonate complex. The buffering capacity or alkalinity of seawater results from the presence of acid-neutralizing bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. Alkalinity is important for fish and other aquatic life because it buffers pH changes that occur naturally as a result of photosynthetic activity. Components of alkalinity (carbonate and bicarbonate) have been shown to complex some toxic heavy metals and reduce their toxicity markedly. Alkalinity is increased by the dissolution of calcium carbonate already present in seawater and that which enters by runoff. Decomposition of organic matter in seawater consumes oxygen and produces carbon dioxide which, in turn, reacts with water to form carbonic acid and lowers the pH. Thus, pH and oxygen profiles in the sea generally parallel one another since the pH is lowered as the oxygen concentrations decrease.

Hausknecht and Kester (1976a, 1976b) reported pH values for samples taken during the summer at the 106-Mile Site. At the surface, the average pH was 7.9, while below 300 meters, the pH decreased to an average of 7.6.

Trace Metals

Trace metals are present in seawater in minute quantities. The significance of a trace metal introduced by ocean disposal depends on its relationship to the biota; that is, the concentration of the metal, the form in which it exists, and how these two factors affect an organism. It is common practice to use the term "heavy metal" and "light metal" when discussing trace metals. Both terms originated from systems used to subclassify the known metals. Heavy metals have densities greater than 5 grams per cubic centimeter--5 times the density of water. Metals with densities less than 5 are properly classified light metals.

The heavy metals (vanadium, chromium, manganese, iron, copper, etc.) are usually incorporated into proteins, some of which serve as enzymes, or biological catalysts. The light metals (sodium, maganesium, potassium, and calcium) readily form ions in solution, and, in this form, help maintain the electrical neutrality of body fluids and cells. They also help maintain the proper liquid volume of the blood and other fluid systems (Stoker and Segar, 1976).

The environmental persistence of metals is a serious problem. Unlike organic compounds, metals, being elements, cannot be degraded biologically or chemically in nature. The toxicity of metal-containing compounds can be altered by chemical reaction and/or complexation with other compounds, but the undesirable metals are still present. In some cases, such reactions result in more toxic forms of the metal. The stability of metals also allows them to be transported for considerable distances in the ocean.

One of the most serious results of metal persistence is the potential for biomagnification of metal concentrations in the food chains. Biomagnification of metals occurs as small organisms containing metals in their tissues are eaten by larger organisms which in turn are eaten by still larger animals. As a result of this process, the metals in the higher levels of the food chain can reach concentrations many times higher than those found in air or water. Thus, biomagnification can cause some fish and shellfish to become health hazards when used as food.

Metal pollution is complicated by the fact that some toxic metals are needed in trace amounts by all plants and animals and a balance must be reached between too little and too much of these essential metals. However, in seawater, insufficient amounts of these micronutrients is not normally a problem. In addition, certain trace metals (such as arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, zinc) are important because of their potential toxicity and/or carcinogenic properties. The chemical behavior and the toxicity of a metal in the aquatic environment depends on the form (complexed, absorbed, or ionized) in which it exists, and whether the metal is present in solution or in colloidal or particulate phases. For example, the toxicity of copper to some marine organisms is controlled by the formation of copper organic complexes. Mercury, which is toxic in sufficient amounts of any of its forms (except the metallic), is especially toxic when methylated by organisms.

Hausknecht (1977) reported metal concentrations from studies conducted at the 106-Mile Site during May 1974 and February and August 1976. The average metal concentrations for all samples taken during these cruises are presented in Table A-8. For comparison, average metal concentrations for the New York Bight Apex and Northwest Atlantic Ocean are also included.

The cadmium concentrations in samples taken during May 1974 and February, 1976 cruises were relatively unchanged; however, these cadmium values are an order of magnitude greater than those found during the August 1976 cruise and the cadmium values listed for the Shelf, Slope, and open waters of the Northwest Atlantic. In comparison to the New York Bight Apex values for summer, the 106-Mile Site values for cadmium are as much as two orders of magnitude lower. The copper values for the three studies at the disposal site show a small range, and all fall within the same order of magnitude. These values are comparable to the values found by Bewers et al. (1975) for the Northwest Atlantic. The 106-Mile Site copper concentrations are one or two orders of magnitude less than those given for the New York Bight Apex.

Lead concentrations at the site show a range of as much as two orders of magnitude for the 1974 and 1976 values. As with cadmium and copper, lead values at the Site are much lower than the concentrations found in the New York Bight Apex. Mercury concentrations at the Site varied slightly between 1974 and 1976 and are significantly higher than mercury values listed for the Slope and open waters of the Northwest Atlantic. Concentrations of the metal are, however, comparable to those reported for the Continental Shelf.

Zinc concentrations for the 106-Mile Site showed remarkable consistency between 1974 and 1976. The values are higher than the Northwest Atlantic values but an order of magnitude less than zinc concentrations in the New York Bight Apex.

TABLE A-8. AVERAGE CONCENTRATIONS OF FIVE TRACE METALS IN WATERS OF THE NORTHEAST ATLANTIC OCEAN

AREA	CADMIUM (mg/1)	COPPER (mg/1)	LEAD (mg/1)	MERCURY (mg/1)	ZINC (mg/1)
106-Mile Site:					
May 1974*	0.30	0.70	3.10	0.63	6.8
February 1976*	0.46	0.40	0.70	0.17	6.9
August 1976*	0.035	0.23	0.07	-	-
New York Bight Apex:					
Summer**	3.1	80.0	140.0	-	11.0
Fall†	0.1	5.6	3.0	0.008	19.0
Open Ocean††	0.044	0.39	-	0.008	1.07
Continental Slope††	0.034	0.24	-	0.041	0.72
Continental Shelf††	0.036	0.56	-	0.122	1.11

* Hausknecht (1977)
** Klein et al. (1974)
† Alexander et al. (1974)
†† Bewers et al. (1975)

Nutrients

In addition to the conservative elements (which are not involved in biological processes--sodium, chlorine, bromine, strontium, fluorine, etc.) and the trace metals, nutrients in seawater are important for the growth of marine phytoplankton. The major nutrients are inorganic phosphate, nitrate, nitrite, ammonium, and hydrated silicate. Nutrients are consumed by phytoplankton only in the upper layers of the ocean where light conditions permit photosynthesis and growth. Inorganic phosphorus and nitrogen are generated primarily by bacterial decomposition of organic debris and soluble organics. Silicate is generated by the dissolution of the siliceous shells of diatoms, radiolaria, and silicoflagellates.

Nitrogen exists in the sea in combination with other elements: in ammonia (NH_3) and as oxides of nitrogen in the nitrite ion (NO_2^-) and nitrate ion (NO_3^-). Nitrogen enters into the composition of all living things and is one of the nutrients used by plants to form the complex protein molecules from which animals derive nitrogen. However, because not all forms of nitrogen can be used by plants, the complex nitrogenous compounds found in both plants and animals must be decomposed to chemically simpler compounds after the organism dies. Bacteria are mainly responsible for this decomposition.

Phosphorus also has a biologically-activated cycle involving alternation of organic and inorganic phases. This cycle is similar to that of nitrogen, except that only one inorganic form, phosphate, is known to occur. Phosphorus can be found in organisms, in particulate and dissolved organic compounds, and as phosphate. Phosphate is probably the only form utilized by plants.

The nitrogen-phosphorus ratio in the sea is approximately 15:1. Nitrogen and phosphorus are extracted from seawater by phytoplankton but phosphorus is regenerated more rapidly than nitrogen, causing nitrogen to be the nutrient which limits phytoplankton growth. A phytoplankton population will cease growing when nitrogen is depleted. However, in coastal waters, land run-off and sewage effluents may provide excess nitrogen to the system. When this situation occurs, phosphate becomes the growth-limiting factor. Silicate is used by some phytoplankton and zooplankton in building shells and skeletons, but it is never a growth-limiting nutrient in the marine environment.

The phosphate and nitrate content of Continental Shelf and Slope waters of the Mid-Atlantic Bight varies seasonally. The Shelf and Slope waters are vertically mixed during the winter. Consequently, phosphate and nitrate concentrations are fairly uniform from the surface to the bottom. In spring, mixing is reduced and the water column stratifies. Phosphate and nitrate concentrations decrease in the surface layers due to increased biological activity and lack of replenishment by mixing with nutrient-rich deeper layers. By the end of summer, nitrate in the upper waters is depleted and phosphate is present in very low concentrations. Vertical mixing of the water column begins in the fall and nutrients are transferred from subsurface to the surface layer (Kester and Courant, 1973).

Peterson (1975) reported vertical profiles for phosphate, nitrate, silicate, and ammonia compiled for samples taken during May 1974 at the 106-Mile Site (Table A-9). Average concentrations of phosphate generally increased with depth ranging from 0.1 mg/l in the upper 15 meters to 0.2 mg/l at 500 meters depth. Average nitrate concentrations also increased with depth, ranging from 0.01 mg/l in the upper 15 meters to 1.22 mg/l at 500 meters depth. Silicate was observed to follow the same profile as phosphate and nitrate. Concentrations ranged from 0.09 mg/l at the surface to 1.28 mg/l at 500 meters depth. Ammonia concentrations were quite uniform throughout the water column, ranging only from 0.0071 mg/l at the surface to 0.0068 mg/l at 500 meters depth.

TABLE A-9. AVERAGE CONCENTRATIONS (mg/l) OF NUTRIENTS AT VARIOUS DEPTHS IN THE 106-MILE SITE (Adapted from Peterson, 1975).

Depth (meters)	Phosphate	Nitrate	Silicate	Ammonia
Upper 15	0.10	0.01	0.09	0.0071
100	0.13	0.60	0.39	0.0066
500	0.20	1.22	1.28	0.0063
Below 1,000	0.19	1.09	1.28	0.0070

Organic Compounds

Organic compounds are numerous and diverse with varying physical, chemical, and toxological properties. Organic compounds occur naturally in the marine environment, resulting either from chemical/biological processes or oil seeps. However, anthropogenic sources such as oil spills, urban run-off, or disposal operations provide the major oceanic inputs of organic compounds. Field work and laboratory experiments have demonstrated both acutely lethal and chronic (sublethal) effects of organic compounds on marine organisms.

One of the largest groups of organic compounds is the hydrocarbons, or those which contain only the elements hydrogen and carbon. Tens of thousands of such compounds are known to exist. They are found in all 3 physical states (gas, liquid, solid) at room temperatures. The physical state characteristic of each is related to the molecular structure and particularly to the number of carbon atoms making up the molecule. In general, the tendency to exist as a solid increases with increasing number of carbon atoms. Hydrocarbons may be classified as "aliphatic" or "aromatic" on the basis of their molecular structures. An aromatic hydrocarbon contains, as a structural unit, one or more 6-membered carbon rings. Aliphatic hydrocarbons lack this characteristic ring structure.

Crude petroleum is a complex mixture containing hundreds of different compounds, most of which are aliphatic hydrocarbons. The estimated total direct petroleum hydrocarbon losses to the marine environment, including ocean disposal, is 3,245,000 tons per year (Stoker and Segar, 1976). Waste oil and grease from industrial and automotive sources make a significant contribution of 25 percent (825,000 tons) to the annual total. Another 24 percent (805,000 tons) results from normal oil tanker operations (ballasting, tank cleaning). The normal operation of ships other than oil tankers amounts to 22 percent (705,000 tons) of yearly volume. Discharges from oil refineries and petrochemical plants account for 14 percent (450,000 tons) annually. Accidental spills may amount to as much as 9 percent (300,000 tons) and the routine procedures associated with offshore oil production constitute approximately 5 percent (160,000 tons).

Oil pollution may be viewed as having short-term (acute) and long-term (subacute or chronic) effects. Short-term effects fall into two categories: those caused by coating and asphyxiation, and those resulting from the toxicity of oil. The long-term effects of oil components on living systems are not as apparent as short-term effects. Some of the possible areas now being studied are:

- The effects of increased concentrations of organic compounds on certain life processes which depend on the concentrations of organic chemical messengers in the sea.

- The possibililty of biomagnification of stable organic compounds.

- The possibility that oil may serve as a concentration medium for fat-soluble poisons such as organohalogens.

Smith et al. (1977) reported levels of dissolved and particulate aliphatic hydrocarbons in the waters of the outer Mid-Atlantic Bight just northwest of the 106-Mile Site. Mean concentrations during winter were the highest with a value of 7.6 ug/l, while in summer, the mean hydrocarbon concentration was at a low of 0.22 ug/l. The mean concentration reported for spring was 0.53 ug/l.

Chlorinated hydrocarbons are basically composed of carbon-hydrogen skeletons to which chlorine atoms are attached. The polychlorinated biphenyls (PCB's) are one type of chlorinated hydrocarbon compound and have properties similar to chlorinated hydrocarbon pesticides. Theoretically, 210 different PCB compounds can be formed by varying the number and position of the chlorine constituents. Some of the compounds are more common than others. Commerical mixtures, which generally contain many types of PCB's are usually in the form of liquids or resins.

The PCB's are stable at high temperatures (up to 800°C), resistant to acids, bases, and oxidation, and are only slightly soluble in water. These properties make them quite adaptable to various uses, such as (1) heat transfer fluids in industrial heat exchangers, (2) insulators in large capacitors and transformers required by electrical power companies, (3) hydraulic fluids, and (4) plasticizers in polymer films. They have also been used as a constituent of brake linings, paints, gasket sealers, adhesives, carbonless carbon paper, and fluorescent lamp ballasts.

PCB's were first identified in 1881, and have been used widely since the 1930's. The first environmental contamination was found in 1966, when PCB residues were identified in fish. It is now apparent that PCB's are distributed throughout the environment.

Most PCB's are introduced into the environment accidentally. Available evidence indicates that the physiological effects of the PCB's are similar to those of DDT. As with DDT, long-term chronic effects appear to be more of a problem than acute toxicity. The PCB's appear to be more effective enzyme inhibitors than DDT. It is now believed that some eggshell thinning previously blamed on DDT may be caused by PCB's or synergistic PCB-DDT combinations.

Harvey et al. (1974) measured PCB's in North Atlantic waters over the Continental Shelf and Slope off the northeastern United States. Their data show a widespread distribution in the North Atlantic, with an average PCB concentration of 35 parts per trillion in the surface waters and 10 parts per trillion at 200 meters. A wide range of concentrations (1 to 150 parts per trillion) was found, with extreme concentrations occurring only several kilometers apart. No apparent relationship between PCB concentrations and the proximity to land was observed, and it was suggested that the high variation may be due to localized slicks, rainfall, or ship discharge.

SEDIMENT CHEMISTRY

Most of the geological data collected at the Site are derived from photographs and a few grab samples (Pearce et al., 1975). Sediments within the disposal site are mainly sand and silt, with silt predominating. Heezen (1977) reported that the Continental Slope around the 106-Mile Site may have a transitory blanket of hemipelagic ooze which, depending on the strength of the bottom current, is either deposited or swept away.

The grade of the Continental Slope within the Site is approximately four percent, while the grade of the upper continental rise is less than one percent (Bisagni, 1977). The upper Rise is an area of tranquil deposition and the lower Rise an area of shifting deposition. Erosional areas exist between these two provinces (Heezen, 1975).

Trace Metals

Trace metals are conservative elements in sediments. Their distribution and accumulation in the sediments is thought to delineate the benthic area that is affected by the disposal of waste. Recommendations have been made to use either the individual metal concentration or the metal-to-metal concentration ratios to trace a particular type of waste and separate it from other wastes disposed nearby.

Pearce et al. (1975) noted that the heavy metal content of sediment samples taken in the vicinity of the 106-Mile Site appeared elevated relative to uncontaminated Shelf sediments. Since the stations at which these elevated levels occurred are located near the Hudson Canyon outfall, the investigators suggested that materials having an elevated heavy metal content and originating inshore were tranported seaward via the Shelf valley and canyon.

Greig and Wenzloff (1977) reported that heavy metal values in deepwater sediments collected in 1976 in and near the 106-Mile Site were generally similar (Table A-10) to those reported for collections made in 1974 (Pearce et al., 1975). Greig and Pearce (1975) reported concentrations for cadmium, chromium, copper, nickel, lead, and zinc in waters of the outer Mid-Atlantic Bight. Cadmium, chromium, and copper were rarely detectable in sediments; nickel and zinc were usually measurable, but were present in very small amounts relative to their abundance in Bight Apex sediments. Lead varied somewhat but was often not detectable. The values obtained were generally less than those previously reported for sediments collected from the New York Bight Apex (Carmody et al., 1973; Greig et al., 1974). The concentrations found by Greig and Pearce were also somewhat less than those reported for stations near the 106-Mile Site.

Harris et al. (1977) analyzed sediment samples from the mid-Atlantic Continental Shelf for barium, cadmium, chromium, copper, iron, nickel, lead, vanadium, and zinc. They found that concentrations of iron, zinc, nickel and lead, total organic carbon content, and the percent silt-clay generally increased seaward across the Shelf. These increases correlated with a decrease in the average particle size of sediment grains across the Shelf. Metal concentrations, percent silt-clay, and total organic carbon showed a general consistency from season to season.

Organics

Hydrocarbon (C_{15+}) concentrations in and near the 106-Mile Site were found to be similar to those of Continental Shelf sediments from the Northern and Southern Areas assumed to be uncontaminated (Greig and Wenzloff, 1977). The amounts (approximately 20 ppm) of C_{15+} hydrocarbons in sediments from the area near the 106-Mile Site were much less than those found in sediments at other disposal sites located in relatively shallow coastal water: 6,530 ppm at the Dredged Material Site and 1,568 to 3,588 ppm at the 12-Mile Sewage Sludge Disposal Site in the New York Bight Apex.

TABLE A-10. AVERAGE CONCENTRATIONS (PPM, DRY WEIGHT) OF SIX TRACE METALS IN THE TOP 4 CM OF SEDIMENTS

Date \ Metal	Cadmium	Chromium	Copper	Nickel	Lead	Zinc
May 1974 Pearce et al. (1975)	-	25.90	27.60	25.23	28.67	60.17
February 1976 Greig & Wenzloff (1977)	1.38	25.82	27.02	31.46	13.20	50.46

Smith et al. (1977) reported levels of both total aliphatic and aromatic hydrocarbons in sediments of the mid-Atlantic Continental Shelf to be generally less than 1 ug/g (1 ppm). These concentrations strongly correlated with the amount of silt-clay in sediments. This suggests that, whether their inputs are general or localized, hydrocarbons accumulate primarily in locations where fine-grained sediments are deposited.

BIOLOGICAL CHEMISTRY

General observations on trace metal concentrations in phytoplankton can be made despite the lack of specific data. The uptake of contaminants and their incorporation into the phytoplankton may have no apparent effect on the organisms or on primary production; however, as the phytoplankton are consumed, the contaminants are transferred to and concentrated in consumers at the next higher trophic level (biomagnification). The end result of this accumulation through the food chain is that higher trophic levels (and, eventually, man) may exhibit concentrations of contaminants far in excess of ambient levels in the environment. This is considered to be a far less important problem in the deep ocean than in nearshore waters since the dispersed distribution and wide-ranging horizontal migrations of the epipelagic nekton tend to retard the accumulation of contaminants in oceanic nekton populations (Pequegnat and Smith, 1977). In addition, other existing evidence suggests that, aside from mercury and cadmium, few, if any, of the trace metals are irreversibly accumulated by nektonic species.

Windom et al. (1973a), reporting on zooplankton samples collected between Cape Cod and Cape Hatteras, found nearshore samples to be higher in mercury than offshore samples. Species composition of these samples varied considerably, although a general copepod dominance was maintained. However, the high mercury concentrations measured did not seem as strongly correlated with species composition as with sampling distance from shore.

Windom et al. (1973b) provide information on the cadmium, copper, and zinc content (expressed as ppm dry weight) of various organs in 35 species of fish obtained from waters of the North Atlantic. Cadmium concentrations in liver tissue were generally less than 1.7 ppm, although one sample contained 5 ppm cadmium. Cadmium levels in other organs and whole fish were usually less than 1 ppm; however, some species had values as high as 2.6 ppm. Copper levels in the fish tissues sampled were, in most cases, less than 10 ppm. Zinc levels were reported to be in the range of 10 to 80 ppm; however, a zinc level of 397 ppm was obtained for the bay anchovy (Anchoa mitchilli).

Pearce et al. (1975) reported that the levels of silver, cadmium, and chromium did not vary greatly in most of the finfish and invertebrates collected in and adjacent to the 106-Mile Site. Their results did show, however, that copper, zinc, and lead varied significantly, with lead showing the greatest variation of all the metals. Liver tissues from the deep-sea slickhead (Alepocephalus agassizi) had the highest levels of silver, cadmium, copper, and zinc. The values for these metals were several orders of magnitude greater than the metal concentrations found in windowpane flounder (Scopthalmus aquosus) taken from the sewage sludge and dredged material disposal sites in the New York Bight Apex. The levels of the metals (as wet weight) in liver tissues from the slickhead were: cadmium, 13.9 ppm; copper, 28.6 pm; silver, 1.2 ppm; and zinc, 271.0 ppm. The copper concentrations in other species of fish obtained were similar to the copper levels in fish examined by Windom et al. (1973b).

Greig and Wenzloff (1977) found uniform metal concentrations in three species of mid-water fish (Gonostoma elongatum, Hygophum hygomi, and Monaconthus [=Stephanolepis] hispidus) during spring 1974, 1975, and 1976 studies near the 106-Mile Site; however, copper concentrations were highest in fish taken in 1976. In Apex predators, such as sharks, cadmium concentrations were generally less than 0.12 ppm in muscle tissue, but levels in the liver were consistently higher, ranging from 0.28 to 7.2 ppm. Lancetfish, oilfish, and dusky shark had similar cadmium concentrations.

Copper and manganese concentrations were low in the muscle of the sharks and other fishes examined; levels were mostly below 1.5 ppm for copper and below 0.5 ppm for manganese. With the exception of lancetfish, almost all samples of fish muscle examined had concentrations of mercury that exceeded the 0.5 ppm action level set by the Food and Drug Administration. Mercury levels in lancetfish were most often below 9.23 ppm. Lead concentrations were below the detection limit (about 0.6 to 0.8 ppm) of the method employed for both the muscle and liver of the fishes examined. Zinc concentrations in the muscles of fishes examined were several orders of magnitude greater than the cadmium, copper, manganese, and lead levels. Zinc levels ranged from 1.0 to 6.9 ppm and were about the same magnitude as those found in the muscle of several finfish obtained from the New York Bight.

In another study, Greig et al. (1976) determined the concentration of nine metals in four demersal fish species and three epipelagic fish species from the Outer Bight in water depths of 1550 to 2750 meters. They found that mercury concentrations in deepwater fish muscle averaged three times higher than muscle concentrations reported by Greig et al. (1975) from offshore Continental Shelf finfish.

BIOLOGICAL CHARACTERISTICS

WATER COLUMN

The biota at the 106-Mile Site exhibit complex diurnal, seasonal, and longer term cycles of species composition and abundance. Several factors contribute to these cycles: the influence of various water masses, each with its characteristic biota; the location of the site relative to the boreal fauna found to the north and the temperate to subtropical fauna found to the south; and the effects of unusual or non-periodic physical conditions.

The Mid-Atlantic Bight is biologically heterogeneous; this section, however, discusses only the environmental aspects of the region which are directly relevant to the specific conditions at the 106-Mile Site. The water column is described first, then the benthic biota are characterized. For the benthos, the discussion is confined to organisms characteristic of a fine silt and clay bottom at abyssal depths. A discussion of the biota typical of other sediment types and other depths in the mid-Atlantic is not pertinent to this EIS.

Phytoplankton

Phytoplankton are free-floating algae which produce some of the organic matter upon which the rest of the marine food chain is built. Phytoplankton consists of autotrophic algae that have representatives from six taxonomic groups: Bacillariophyta, Pyrrophyta, Cyanophyta, Coccolithophorida, Chlorophyta, and Euglenophyta. The algal cells are commonly found in combinations of single, filamentous, or colonial units of varying size in the euphotic zone (upper 100 meters) and require sunlight, nutrients, and certain conditions of temperature and salinity in order to synthesize organic matter. The various combinations of these factors in the euphotic zone dictate the floral characteristics of the waters at any particular time or place.

Very few phytoplankton investigations have been performed at the 106-Mile Site, and the available data indicate summer as the only season in which sampling was performed. Hulburt and Jones (1977) found the phytoplankton abundance at the 106-Mile Site to vary with depth from 100 to 100,000 cells/liter, with the phytoplankton much more abundant in the upper 20 meters than at 25 to 50 meters. Abundance was greatly reduced at greater depths. The dominant species of phytoplankton was a group of unidentifiable naked cells. Phytoplankton populations at the 106-Mile Site were found to be composed of a mixture of coastal and oceanic species, due to the Site's location in a transitional area between coastal and oceanic waters and in the path of meandering Gulf Stream eddies.

Data from Hopkins et al. (1973) indicate the summer chlorophyll values at the 106-Mile Site are highest at or near the surface, decrease to very low levels at 100 meters, and then slowly rise to a second maximum (much smaller than the first) at depths greater than 1,000 meters. Steele and Yentsch (1960) observed these chlorophyll concentrations at great depths and attributed these higher concentrations to the sinking of hytoplankton until their density equals that of the surrounding water. The subsurface accumulation of chlorophyll occurs at depths where water density, which is inversely related to temperature, is increasing most rapidly. This phenomenon becomes more apparent as the summer progresses and is most distinct in slope waters. This midwater accumulation of chlorophyll disappears with the destruction of stratification of the water column in fall.

More data exist on phytoplankton in mid-Atlantic Continental Shelf and Continental Slope waters than exist for the 106-Mile Site. The locations of the stations from which phytoplankton samples have been taken are shown in Figure A-14. The available information indicates that the phytoplankton population in the mid-Atlantic is comprised mainly of diatoms during most of the year. Hulburt (1963, 1966, 1970) described 33 abundant phytoplankton species, of which 27 were diatoms, 4 were dinoflagellates, and 2 were nannoflagellates. Hulburt (1963, 1966, 1970) and Hulburt and Rodman (1963) found that *Rhizosolena alata* dominates during summer, and *Thalassionema nitzschioides*, *Skeletonema costatum*, *Asterionella japonica*, and *Chaetoceros socialis* dominate during winter. Spring dominants include *Chaetoceros* spp. and *Nitzschia seriata*. *Thalassionema nitzschioides* dominates in fall.

In several studies, phytoplankton densities ranged between 10^3 and 10^6 cells/liter, generally decreasing with distance from land (Hulburt, 1963, 1966, 1970). Major pulses in phytoplankton abundance were due to four neritic diatom species: Skeletonema costatum, Asterionella japonica, Chaetoceros socialis, and Leptocylindrus danicus (Hulburt, 1963, 1966, 1970; Malone, 1977). Uniform distributions were exhibited by Rhizosolena alata in summer and Thalassionema nitzschioides in winter. The flagellates Chilomonas marina, C. gracilis, Ceratium lineatum, Katodinium rotundatum, Oxytoxum variabile, and Prorocentrum micans were locally abundant, but rarely dominant during summer. Maximum cell densities were observed in December, and minimum densities in July (Malone, 1977).

Major changes in species composition occur inshore to offshore. Dominant coastal species are primarily chain-forming centric diatoms (Smayda, 1973), which require relatively high nutrients to sustain high bloom populations and are subject to wide seasonal variations in abundance and diversity. Of secondary importance in coastal waters are the dinoflagellates and other flagellated groups. In contract, oceanic waters under some influence of the Gulf Stream carry a phytoplankton community characterized by dominance of coccolilthophorids, diatoms, dinoflagellates, and other mixed flagellates (Hulburt et al., 1960; Hulburt, 1963), all of which require somewhat lower nutrients and are subject to reduced or dampened seasonal variations in abundance.

Riley (1939) showed the vertical distribution of phytoplankton from a Slope water station adjacent to the Continental Shelf and a station near the outer boundary (Figure A-15). The inner station is characteristic of Shelf waters having higher surface abundance (2.5 ug chlorophyll a per m^3) with the phytoplankton disappearing at about 100 meters. The outer Slope station has relatively fewer surface phytoplankton (0.9 ug chlorophyll a per m^3) but cells are found at a greater depth (200 meters). This illustrates the transition, in terms of vertical abundance, between coastal and open ocean characteristics within the Slope water (Chenoweth, 1976b).

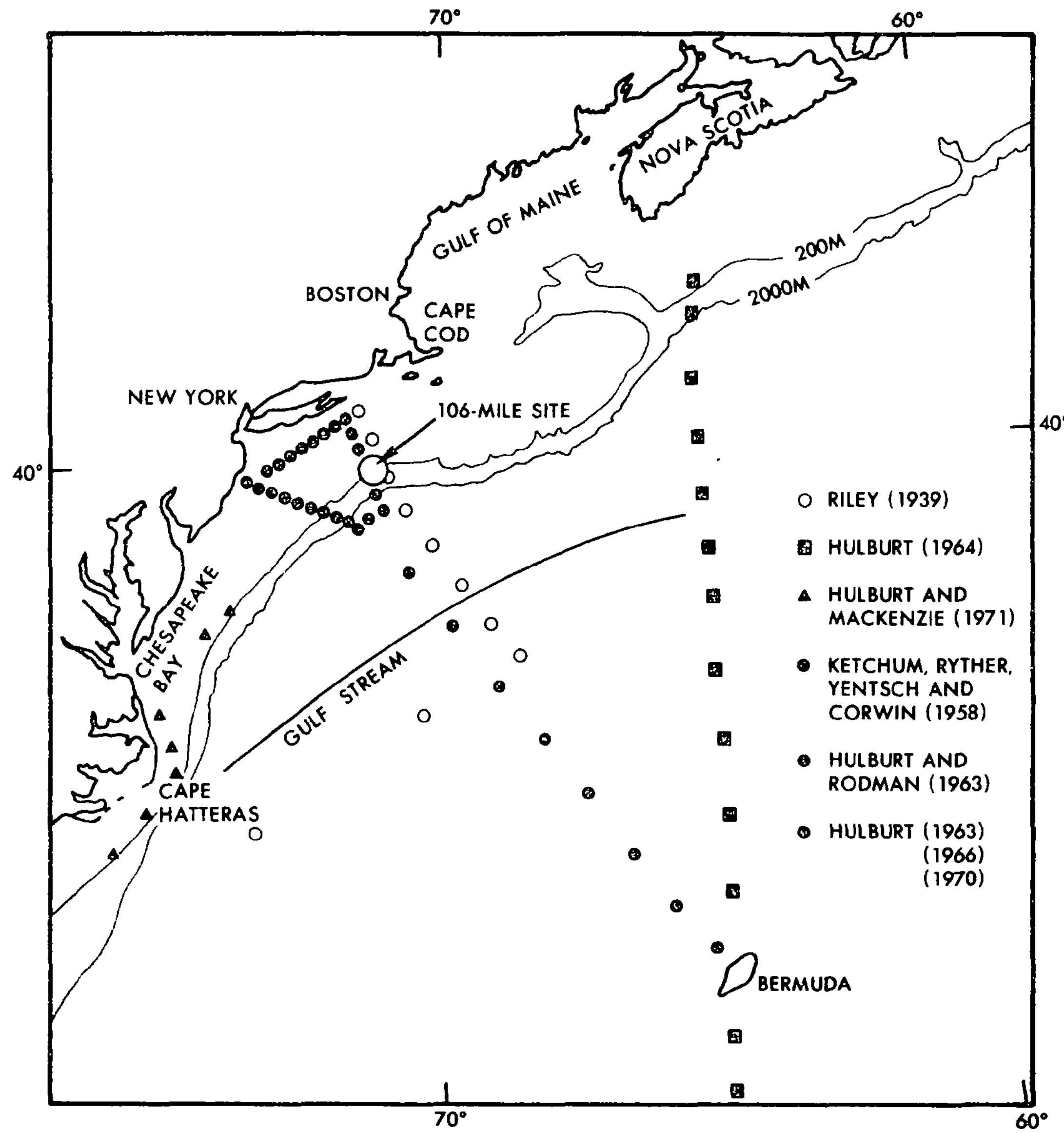


Figure A-14. Station Locations of Major Phytoplankton Studies in the Northeastern Atlantic (Chenoweth, 1976b)

Seasonality - Mid-Atlantic Bight waters are well mixed during winter and strongly stratified during summer. This sharp seasonal distinction is reflected in the seasonal changes in phytoplankton abundance. During summer, diversity is high, while at other times, when growth conditions are more favorable, diversity is lowered. In Slope waters, the seasonal cycle is characterized by two equally intense pulses of chlorophyll--the spring and fall blooms (Yentsch, 1977). In Shelf waters, the fall bloom is the most intense feature of the seasonal cycle. Chlorophyll concentrations vary regionally and seasonally from less than 0.5 mg/l to about 6 mg/l (Smayda, 1973). The seasonal variations in mean chlorophyll content for the inshore (less than 50 meters) and offshore (greater than 1,000 meters) stations are given in Figure A-16A. The annual range in primary production (Figure A-16B) does not differ appreciably between inshore (0.20 to 0.85 gC/m^2/day) offshore (0.10 to 1.10 gC/m^2/day) (Ryther and Yentsch, 1958). However, the total annual production differs over the Shelf and Slope, with an annual production of 160 gC/m^2 at the inshore stations (less than 50 meters) decreasing progressively seaward to 135 gC/m^2 at the intermediate locations (100 to 200 meters), and 100 gC/m^2 at the offshore stations (greater than 1,000 meters). Ketchum et al. (1958a) indicated that the nutrient-impoverished offshore areas (Slope water) result in physiological differences between inshore and offshore phytoplankton. Results of their light and dark bottle experiments (Figure A-17) show differences in the ratio of net to gross photosynthesis; high ratios in September and February indicated healthy, growing populations while lower ratios in December and March indicated less healthy populations. Geographically, the low ratio of offshore populations indicated poorer physiological conditons. Ketchum et al. (1958a) suggested that this variation of net gross photosynthesis ratios may be the result of nutrient deficiencies, particularly in the offshore waters.

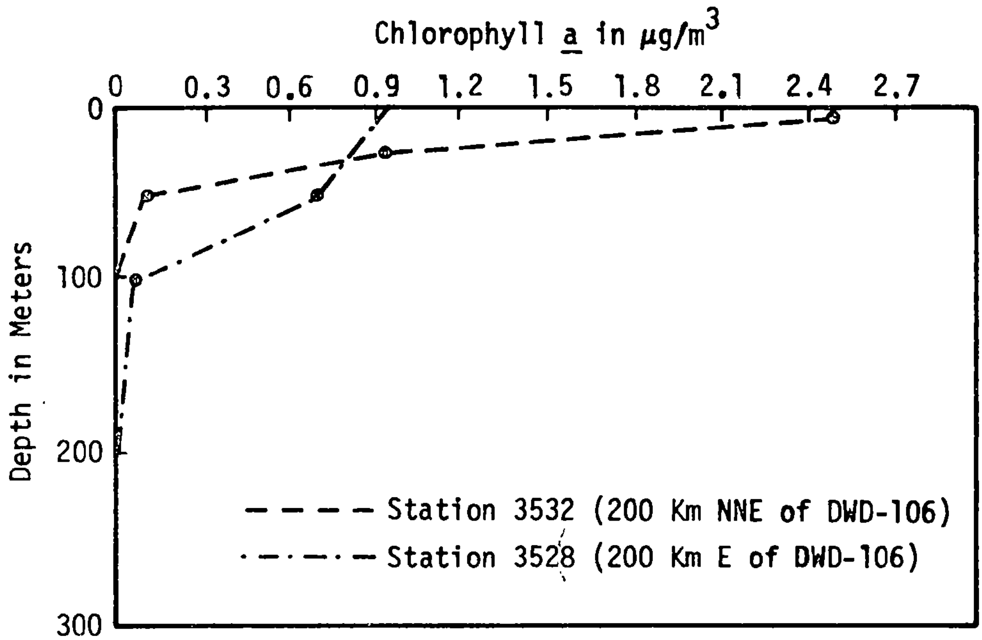


Figure A-15. Vertical Distribution of Chlorophyll a (Riley, 1939)

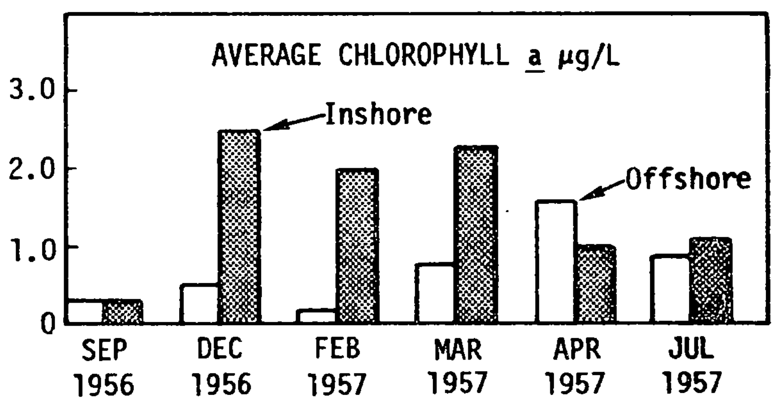


Figure A-16A. Summary of the Average Chlorophyll a Content at Inshore (less than 50 meters) and Offshore (greater than 1,000 meters) Sites in the Mid-Atlantic Bight (Ryther and Yentsch, 1958; Yentsch, 1963)

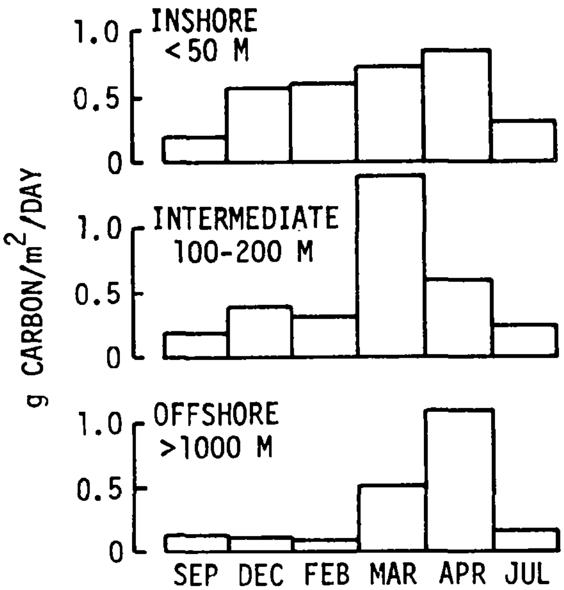


Figure A-16B. Summary of Mean Daily Primary Production per Square Meter of Sea Surface at Inshore (less than 50 meters), Intermediate (100 to 200 meters), and Offshore (greater than 1,000 meters) Sites in the Mid-Atlantic Bight (Ryther and Yentsch, 1958; Yentsch, 1963).

The critical depth, the depth to which plants can be mixed and at which the total photosynthesis for the water column is equal to the total respiration (of primary producers), accounts for the low total annual production in the offshore waters. Although compensation depth and the critical depth for Mid-Atlantic Bight waters are not precisely known, Yentsch (1977) estimates them to be between 25 and 40 meters and at 150 meters, respectively. If this estimate is at all accurate, it means that critical depths are not encountered on the Shelf, since the average water depth is about 50 meters. Beginning in fall, extensive vertical mixing occurs with the cooling of surface waters and an increase in wind velocity. Since Shelf waters are mixed to the bottom during fall and winter, the average plant cell within the water column receives adequate light for production. In addition, the plants have access to the nutrients dissolved within the entire water column, and, since production is limited by light only, production can proceed at a moderately high level.

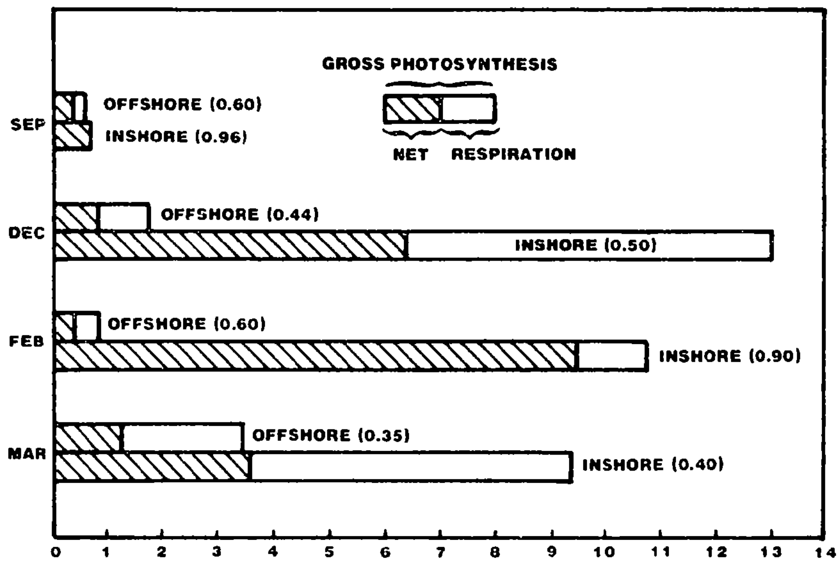


Figure A-17. Comparison of Gross and Net Photosynthesis Between Inshore and Offshore Stations (Chenoweth, 1976b)

Concentrations of chlorophyll decrease during fall and winter, moving from the shelf to the slope (Yentsch, 1977). As winter conditions intensify, Slope chlorophyll concentrations become much lower than Shelf water concentrations. This is due to Slope waters being deep enough for critical depth conditions to occur, since these waters are mixed to a depth of 200 meters or more. Therefore, although daily photosynthesis may equal or exceed that of Shelf waters (Ryther and Yentsch, 1958), the average plant cell within the Slope water column does not receive sufficient light to grow and production proceeds at a low level.

In the spring, vertical mixing is impaired first in shallow waters and then progessively seaward into deeper waters (Yentsch, 1977). Following the development of the thermocline, there is a brief period of high production, since the average cell above the thermocline is now exposed to much greater radiation. Therefore, the spring bloom begins, and then is impaired, first on the shelf and then progressively seaward to the Slope. The spring bloom is of greater magnitude in Slope waters than in Shelf waters, since the nutrients have not been depleted by growth during the winter. Oligotrophic conditions prevail in Shelf and Slope waters during the summer until the cooling and mixing processes of fall destroy the thermocline. The fall bloom occurs during the transition from a stratified to a mixed water column.

Zooplankton

Zooplankton are the passively swimming animals of the water column and contain members of nearly every phylum. Zooplankton represent the second trophic level of the food chain, since the group is dominated by herbivorous crustacea (copepods, euphausiids, amphipods, and decapods) that graze on the phytoplankton. The zooplankton studies performed at the 106-Mile Site (Austin, 1975; Sherman et al., 1977; Harbison et al., 1977) have confirmed the variable and transient nature of water masses in the area of the Site. The composition of the zooplankton population was found to be the result of mixing of the Shelf, Slope, and Gulf Stream water masses. Even within areas for which the water mass could be identified, Sherman et al. (1977) could not differentiate species characteristic for the area. However, the contour of diversity indices was such that a differentiation could be made between Shelf and Slope water (Chenoweth, 1976c). Copepod populations in Shelf waters were dominated by boreal assemblages characterized by high abundance and few species, while the Slope waters contained a mixture of subtropical and boreal assemblages that resulted in lower abundance of individuals and a greater number of species.

The seasonal zooplankton biomass range was 7.7 to 1780 ml/1000 m^3 in summer and 5.5 to 550 ml/1000 m^3 in winter. The displacement volumes are comparable with literature values for shelf and slope waters. The dominant zooplankton species found at or near the 106-Mile Site during various seasons of the year are listed in Table A-11. The most common copepod genera were *Centropages*, *Calanus*, *Oithona*, *Euaugaptilus*, *Rhincalanus*, and *Pleuromamma*. *Centropages* and *Calanus* predominated in the shelf and also in areas where Shelf water intrusions occurred in the Slope water. *Calanus* was least abundant in the offshore areas where water column stability suggested an oceanic origin. Mixing of waters was demonstrated by the presence of Gulf Stream water in the

TABLE A-11. DOMINANT ZOOPLANKTON SPECIES IN THE VICINITY OF THE 106-MILE SITE (NUMBER OF SAMPLES IN WHICH THE SPECIES COMPRISED 50 PERCENT OR MORE OF THE INDIVIDUALS OF THAT GROUP/NUMBER OF STATIONS SAMPLED) (Austin, 1975)

GROUP	SPECIES	Summer 1972	Winter 1973	Spring 1974	Winter 1976
Copepods	Centropages spp.			3/22	
	C. typicus	3/18			2/22
	Clausocalanus arcuicornis	2/18			
	Oithona similis				1/22
	O. spinirostris	4/18			
	Pleuromamma borealis			1/22	
	P. gracilis	5/18	4/16		10/22
	Pseudocalanus minutus		5/16		1/22
	Rhincalanus cornutus			1/22	
	Temora longicornis	1/18			
Euphausiids	Euphausia americana			2/21	
	Meganyctiphanes norvegica	1/16			
	Nyctiphane couchii			7/21	
	Stylocheiron elongatum			4/21	
	Thysanoessa gregaria				2/21
Chaetognaths	Sagitta enflata	4/16			
	S. serratodentata		1/17		
	S. spp.	2/16			2/21
Pteropods	Limacina helicina			1/21	3/21
	L. retroversa				3/21
	L. trochiformis		4/17		
	L. sp. (Juveniles)	1/16	4/17		

center of the disposal site study area as evidenced by the abundance of Rhincalanus, Euaugaptilus, Oithona, and Pleuromamma. A copepod common to deep waters of the northwestern Atlantic, Euchirella rostrata, was also found at all the stations.

The chaetognaths were dominated by Sagitta species and were most abundant over the Shelf (greater then $23/m^3$) and least abundant beyond the Shelf break (less then $10/m^3$). The euphausiids found at the 106-Mile Site were a mixture of boreal-arctic and subtropical species which were dominated by Nyctiphanes couchii, a cold-water form. Warm water species of the Euphausia and Stylocheiron genera were also dominant. Pteropods were dominated by species of Limacina.

Neuston organisms associated with the air-sea interface were sampled at the disposal site during various seasons. The results are summarized in Table A-12.

The zooplankton from Cape Cod to Hatteras have been studied more or less continuously for the past 50 years and the station locations of these studies are shown in Figure A-18. However, many of these studies do not compare well with one another due to the use of different techniques for sampling and the varied ways of expressing such parameters as abundance and biomass. Jeffries and Johnson (1973) point out that most of the studies were, at best, of only a few years' duration. Therefore, since few of them overlapped, the literature is spotty. The data clearly show, however, that fluctuations occur not only in the total mass of zooplankton, but also in the abundance of some of the more common species.

The most striking feature of the Mid-Atlantic Bight zooplankton is the near-complete dominance of calanoid copepods, both numerically and volumetrically (Grice and Hart, 1962; Falk et al., 1974). Copepods also tend to show greater diversity than any of the other zooplankton groups (Falk et al., 1974). Nine species of copepods have been found to dominate the zooplankton at various times. These include Centropages typicus, Metridia lucens, Paracalanus parvus, Pseudocalanus minutus, Oithona similis, Acartia tonsa, Temora longicornis, Clausocalanus furcatus, and Calanus finmarchicus. In addition, the ctenophore Pleurobrachia pileus and the pelagic tunicate Salpa fusiformis occasionally dominate.

TABLE A-12. DOMINANT NEUSTON SPECIES IN THE VICINITY OF THE 106-MILE SITE (NUMBER OF SAMPLES IN WHICH THE SPECIES COMPRISED 50 PERCENT OR MORE OF THE INDIVUDALS OF THAT GROUP/NUMBER OF STATIONS SAMPLED). (Austin, 1975)

GROUP	SPECIES	Summer 1972	Winter 1973	Spring 1974	Winter 1976
Copepods	Anomalocera patersoni	3/18	3/15		
	Calanus finmarchicus		3/15		
	Candacia armata	1/18			
	Centropages typicus	5/18			1/18
	Clausocalanus arcuicornis	1/18			1/18
	Labidocera acutifrons	4/18			
	Metridia lucens		1/15		
	Oithona similis		1/15		
	Pleuromamma gracilis		2/15		12/18
	P. robusta				1/18
	Rhincalanus nasutus		1/15		
Euphausiids	Eukrohnia hamata				1/14
	Euphausia brevis	1/13			
	E. krohnii		1/15		
	E. spp.				1/14
	Meganyctiphanes norvegica				2/14
	Nematoscelis megalops		1/15		
	Nyctiphanes couchii			4/12	
	Stylocheiron robustum			5/12	
Chaetognaths	Sagitta enflata	7/13			
	S. serratodentata	1/13	1/15		2/14
	S. spp.	1/13	1/15		3/14
Pteropods	Cavolina uncinata			1/12	
	Creseis virgula conica			1/12	
	Limacina helicina		2/15		
	L. retroversa		1/15		
	L. sp. (Juveniles)	1/13	4/15		

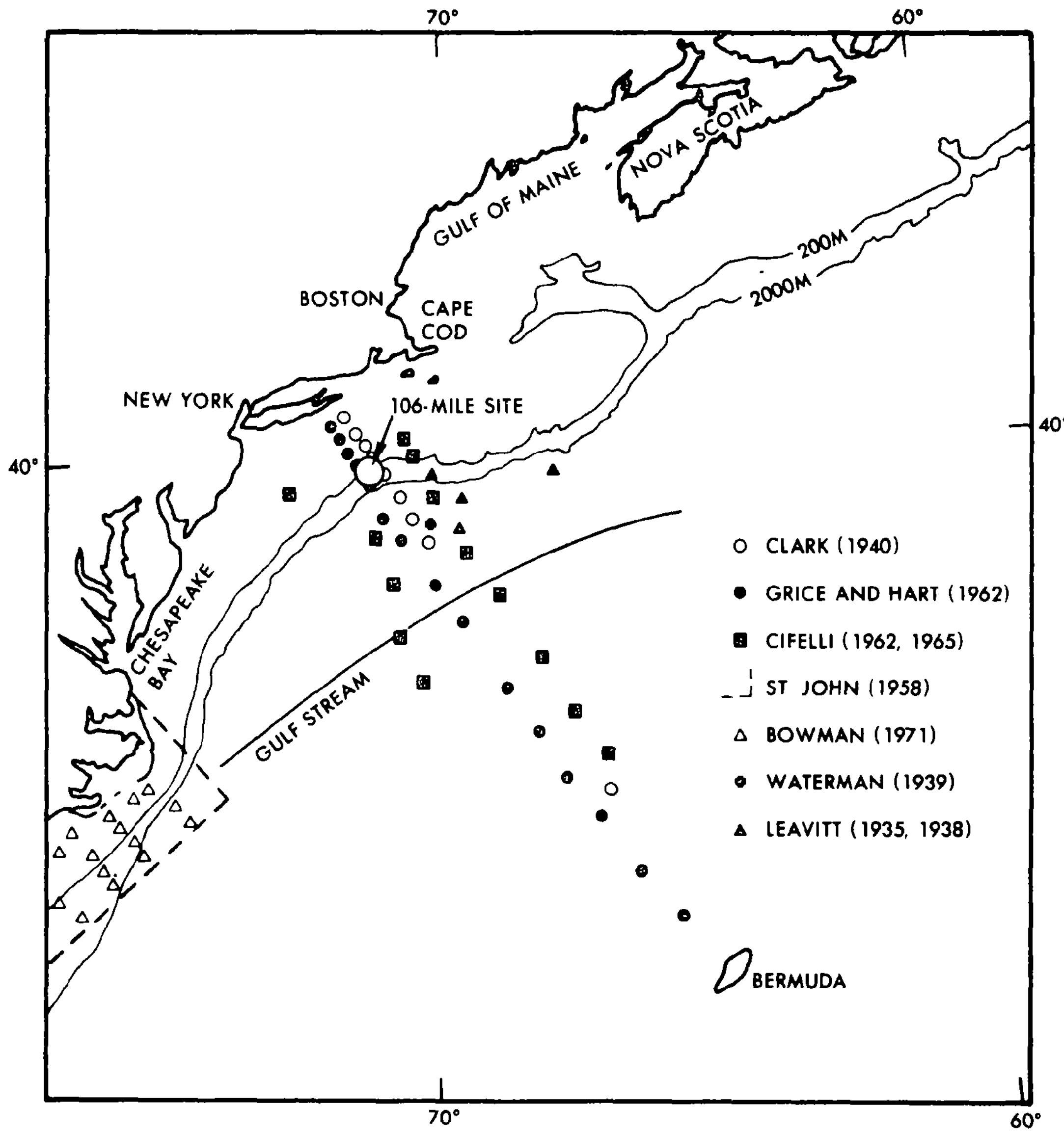


Figure A-18. Station Locations of Major Zooplankton Studies in the Northeastern Atlantic (Chenoweth, 1976c)

The following information on the less abundant members of the zooplankton was reported by Chenoweth (1976c):

> Chaetognaths were the second most abundant numerically and volumetrically in Grice and Hart's (1962) transect study. In the four regions studied (shelf, slope, Gulf Stream, Sargasso Sea), chaetognath concentrations were highest in the shelf waters and lowest in the slope waters. The twelve species of chaetognaths found in the slope water were of three distributional types: shelf species, Gulf Stream-Sargasso Sea species, and endemic slope water species. Sagitta elegans was the most abundant form in both the slope and shelf water. The two species endemic to the slope water (Sagitta maxima and Eukrohnia hamata) were found at a number of stations, mostly in March. They were cold-water forms that have been reported at a number of cold, (approximately 7.4°C) deepwater slope areas along the East Coast. Grice and Hart (1962) concluded that these species were indicative of cold waters in general and slope waters in particular.
>
> The foraminifera are more closely associated with the hydrographic characteristics of water masses than any other zooplankton group and therefore, are often used as indicators of water mass mixing. The faunal composition of foraminifera included twenty recognizable species. The shelf and inner slope was characteristically temperate throughout the year and was dominated by species of Globigerina. Important species were Globigerina bulloides, G. pachyderma incompta, G. inflata, and G. aff. quinqueloba. Towards the Gulf Stream, the temperate fauna was gradually replaced by a diverse southern group dominated by Globigerinoides ruber, G. triloba, Globigerinella aequilateralis, Globorotalia truncatuli, and Pulleniatina obliquiloculata. The slope water yielded the highest abundance of foraminifera all year with the seasonal peak in the fall and the spring. The poorest concentration was found in the summer.
>
> Euphausiids were not an important part of the total zooplankton collection of Grice and Hart, ranking fifth in mean displacement volume. However, they were a relatively important component in the slope waters (8.3 percent of the zooplankton volume with an average numerical abundance of $2.2/m^3$). A succession of species indicated seasonal changes in the euphausiid population. September and December collections were characterized by a large number of diverse forms. Of the eleven species recorded, 6 were most typical of warmer Gulf Stream and Sargasso Sea water and indicated a mixing of these warmer waters in the slope area (Euphausia tenera, Stylocheiron abbreviatum, S. affine, S. carinatum, S. submii, and Nematoscelis microps). Two species were from neritic waters (Meganyctiphanes norvegica and Thysanoessa gregaria). Three species were practically endemic to the

slope area (Nematoscelis megalops, Euphausia krohnii, and Euphausia pseudogibba). N. megalops was found to be breeding at most of the stations during March. The March and July samples produced few species and lower abundance. In March, the colder waters probably prevented the 6 warm-water species from occurring, and in July, large collections of salps may have affected euphausiid abundance.

Grice and Hart (1962) show that although the amphipods represented relatively low volumes and numbers, they were second only to the copepods in the number of species present. The number of species increased seaward with 8 recorded for the shelf, 15 for the slope water, 26 for the Gulf Stream, and 46 for Sargasso Sea. They were, however, relatively more abundant in the shelf waters than offshore. The most frequently occurring shelf and slope species were Parathemisto gaudichaudii and P. gracilipes. These were seasonally augmented by the occurrence of Gulf Stream and Sargasso Sea species.

Siphonophores were found to have more representation offshore than inshore. Of the 30 species recorded by Grice and Hart (1962), 17 were found in slope waters and only 4 in shelf waters. Volumetrically, they were more important in the Gulf Stream and Sargasso Sea. The molluscs are represented pelagically by the pteropods and heteropods. Grice and Hart (1962) reported 10 heteropod and 19 pteropod species from their transect, with very few found in the neritic environment. Of the cephalopods, squid larvae were a widely-distributed group of the oceanic component. However, their abundance never exceeded 6.2 per 1000 m^3.

Early investigators found that certain species of zooplankton were indicative of the continental region from which the samples were collected (Bigelow and Sears, 1939; Clarke, 1940). Grant (1977), utilizing cluster analysis, examined these "indicator" species and found that 3 distinct communities are present throughout much of the year: a coastal community, a central Shelf community, and a Slope boundary (oceanic) community. Grant found that the coastal community is identified in all seasons except spring by the great abundance of the copepod, Acartia tonsa. During spring, the coastal community is characterized by the simultaneous occurrence of Centropages hamatus and Tortanus discaudatus. Typical inhabitants of the central Shelf community include Centropages typicus, Calanus finmarchicus, Sagitta elegans, S. tasmanica, Nannocalanus minor, and Parathemisto gaudichaudii. C. typicus is the dominant organism, and, along with C. finmarchicus and S. elegans, is an indicator of this central Shelf community. A distinct faunal boundry exists at the Shelf break (200-meter contour), with the organisms occurring offshore of this boundary being oceanic in nature. Useful indicators of this offshore water type include Metridia lucens, Pleuromamma gracilis, Euphausia krohnii, Meganyctiphanes norvegica, and Sagitta hexaptera. M. lucens has an extended distribution over the Shelf during winter and spring, as does M. norvegica in spring (Grant 1977); however, other oceanic species are seldom found more than 16 to 24 km inside the 200-meter contour (Sears and Clarke, 1940). Occasionally, Shelf waters become temporarily "overridden" with an oceanic species (i.e., Salpa fusiformis) which reproduces rapidly, but this is due to local propagation and is not an indication of an unusually large mixture of Slope water with Shelf water, since other oceanic species occur only as traces (Sears and Clarke, 1940).

Although information is lacking, a preliminary description of the zooplankton seasonal cycle can be given. Grice and Hart (1962) noted that maximum displacement volume occurred in July (0.76 ml per m^3) and a minimum displacement in December (0.04 ml per m^3), a twenty-fold difference. Clarke (1940) reported a ten-fold seasonal difference; however, Grice and Hart (1962) considered their December values low because of a missing station and felt that it should be closer to 10 mi per m^3, which would be comparable to Clarke's value. The Shelf water exhibited a much greater seasonal fluctuation (20- to 40-fold) while the Sargasso Sea volumes showed little seasonal variation. Likewise, the numerical abundance of zooplankton varied seasonally in the Slope water but with lesser magnitude than neritic areas. Maximum average values (571 per m^3) occurred in September and minimum values (36 per m^3) in July. The March average (504 per m^3) was similar to that of the shelf waters (585 per m^3).

The available biomass data for the Mid-Atlantic Bight is summarized in Table A-13. Grice and Hart (1962) determined that the mean zooplankton standing crop in the Shelf waters was about three times greater than in the Slope waters, and in the Slope water, it was three to four times greater than that of Gulf Stream and Sargasso Sea areas. If salps were included in the measurements, the Slope zooplankton were four times less abundant than those of the Shelf and nine to ten times more abundant than the zooplankton of the oceanic areas. This compares with Clarke's (1940) estimates (salps included) of the Slope water zooplankton: four times less abundant than the Shelf zooplankton and four times more than oceanic areas. Examination of the numerical abundance as well as the displacement volumes of each taxonomic group indicates that this difference between Shelf and Slope waters is not due to the disappearance or decline of any one group of organisms but apparently to the general reduction of zooplankton in Slope waters (Grice and Hart, 1962).

Several authors have noted that the most productive area for zooplankton seems to be near the edge of the Continental Shelf. Grice and Hart's (1962) data show the most consistent peaks of either biomass or numbers to be at the outer Shelf or inner Slope stations (Figure A-19). During March, quantities for the inner Slope exceeded (in biomass and abundance) that of any other area. Riley et al. (1949) also noted from their summary of existing data that the water at the edge of the shelf was unusually rich in zooplankton.

The published biomass and abundance relationships from coastal to oceanic areas apply only to the surface zone since most surveys had a maximum sampling depth of less than 275 meters. Examination of the vertical distribution and diurnal migration of zooplankton in the Slope waters indicates that a significant number of organisms reside below the surface zone (Leavitt, 1935, 1938; Waterman et al., 1939). Leavitt's data (Figure A-20) show a series of peaks down to 2,000 meters--the largest occurring at 600 to 800 meters. He determined that between 40 and 90 percent of the animals were in depths less than 800 meters; however, only one-half to one-fifth of the total volume occurred above 200 meters. Waterman et al. (1939) determined that the malacostracan crustacea of the Slope water migrated 200 to 600 meters vertically in response to light stimulus. This implies that there is a large number of zooplankton unacounted for by the surface surveys. Leavitt (1938) concluded that the deep water zooplankton maximum was not due to the occurrence of a well-developed bathypelagic fauna, but was comprised of species such as <u>Calanus finmarchicus</u> and <u>Metridia longa</u> that are abundant in boreal surface waters. He suggested that the deepest maximum resulted from the intrusion of water masses that originated in shallow waters of higher latitudes.

TABLE A-13. ZOOPLANKTON BIOMASS IN THE MID-ATLANTIC BIGHT

Region	Displ. Vol. ml/1000m^3	Wet wt. mg/m^3	Net Mesh mm	Depth Range m	Reference
Western North Atlantic					
Coastal	8100		0.158	0-25	Riley (1939)
Slope Water (spring)	4300		0.158	0-50	Riley (1939)
Slope Water (summer)		430-1600	0.158	0-400	Riley & Gorgy (1948)
Coastal (yearly mean)	540		10 strands/cm	0-85	Clarke (1940)
Offshore (yearly mean)	400		10 strands/cm	0-85	Clarke (1940)
Cape Cod-Chesapeake Bay					
Coastal					
(summer)	700-800			Variable	Bigelow & Sears (1939)
(winter)	400			Variable	Bigelow & Sears (1939)
Continental Slope 38°-41° N (fall)	328		0.170	0-200	Yashnov (1961)
New York-Bermuda				or less	
Coastal Water (yearly means)	1070		0.230	0-200	Grice & Hart (1962)
Slope Water (yearly mean)	270		0.230	0-200	Grice & Hart (1962)

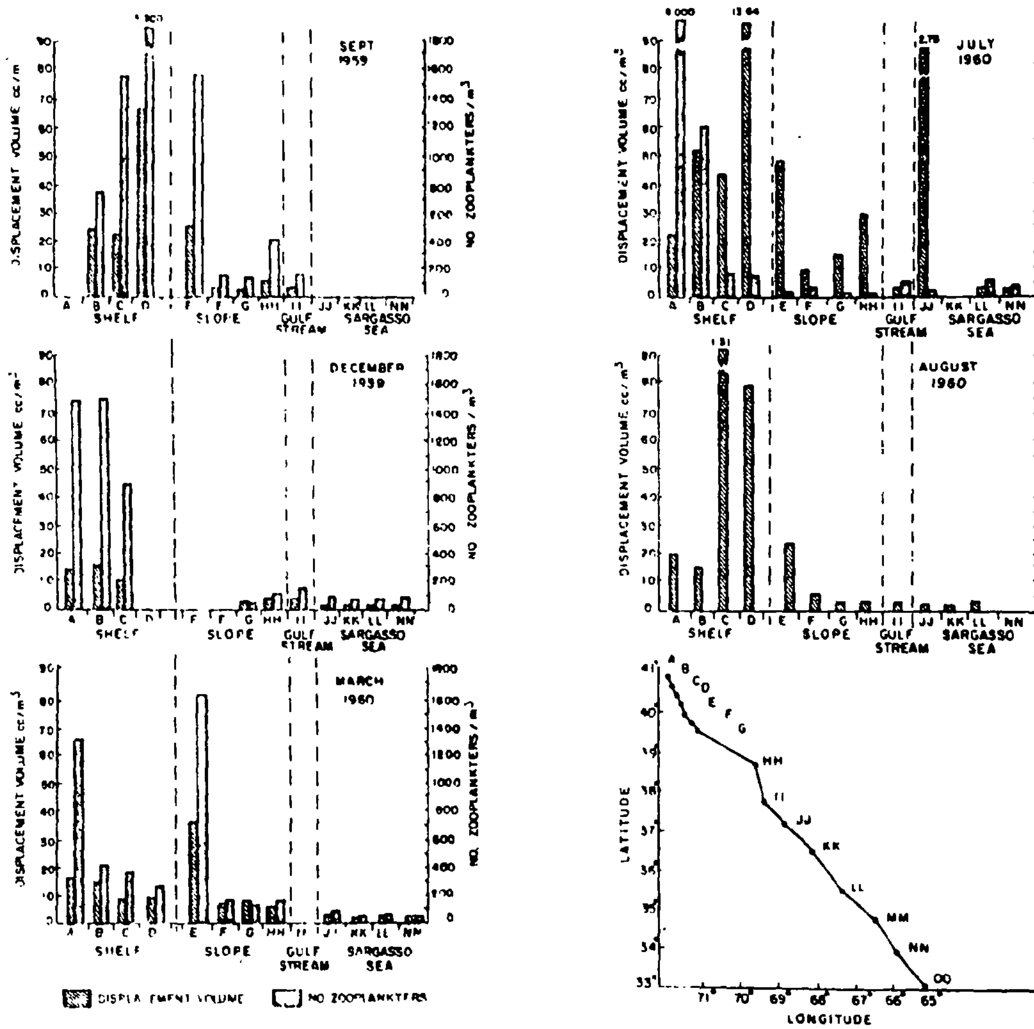


Figure A-19. Biomass and Density of Zooplankton from Transects Across the Northeast Atlantic (Grice and Hart, 1962)

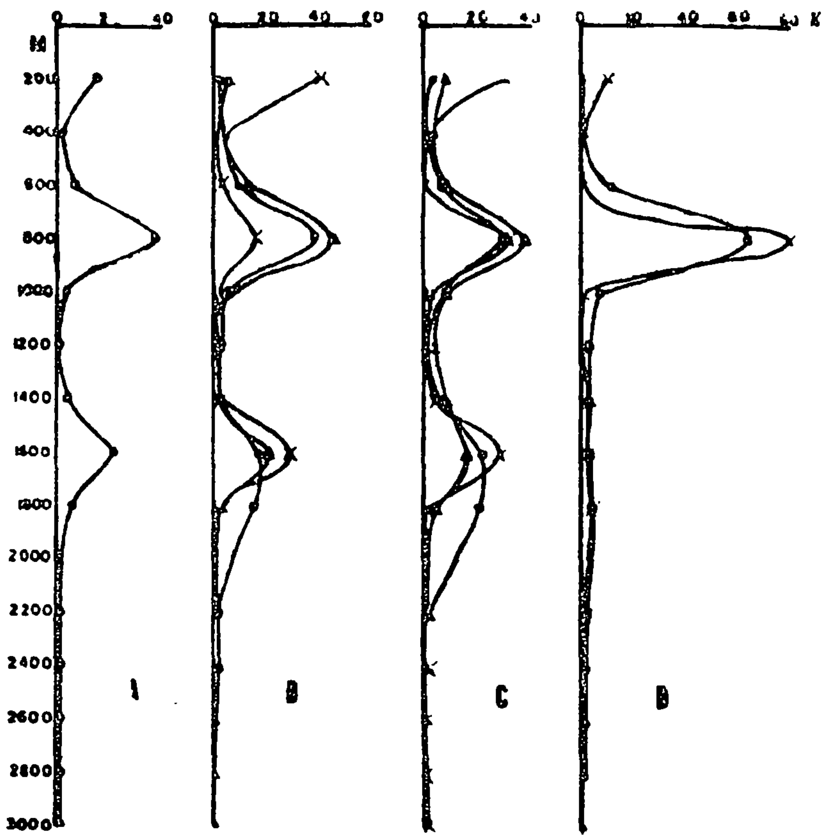


Figure A-20. Vertical Distribution of Zooplankton in Slope Water (Leavitt, 1938)

The neuston (organisms associated with the air-sea interface) of the mid-Atlantic compose a unique faunal assemblage quite different from subsurface populations. The neuston is dominated during the day by the early life stages of fish, which are joined at night by the zoea and megalopae stages of decapod crustacea, primarily <u>Cancer</u> sp., that vertically migrate into the neuston (Grant, 1977). The euneuston (organisms that spend their entire life cycle in the surface layer) is usually less abundant than the "facultative" neuston (organisms that spend only part of their life cycle in the surface layer). The euneuston is dominated by pontellid copepods and the isopod <u>Idotea metallica</u>.

Nekton

Nekton are marine organisms such as fish, cephalopods, and marine mammals that have sufficient swimming abilities to maintain their position and move against local currents. Nekton can be subdivided into 3 groups: micronekton, demersal nekton, and pelagic nekton. Micronekton consist of weakly-swimming nekton, such as mesopelagic fish and squid, that are commonly collected in an Isaac-Kidd Midwater Trawl. Demersal nekton are the extremely motile members of the nekton that are associated with the bottom, while pelagic nekton inhabit the overlying waters. Since nekton schools are highly mobile, migrate over long distances, and have unknown depth ranges, information on these organisms is limited and qualitative.

Investigations of midwater nekton at the 106-Mile Site by Krueger et al. (1975, 1977) have shown the community to be dominated by micronekton, gonostomatid, and myctophid fishes. During the day, most fishes are found at considerable depths (greater than 200 meters), while at night, large numbers of the population migrate to the upper layers of the water column. During the day, between 50 percent and 80 percent of the catch in the upper 800 meters was composed of *Cyclothone* species (family Gonostomatidae), while lanternfish (family Myctophidae) made up 14 percent to 35 percent. *Cyclothone* species remain at depths greater than 200 meters both day and night, while lanternfish migrate upward at night, at which time they account for 95 percent of the catch in the upper 200 meters. Above 800 meters at night, the proportion of the population made up of *Cyclothone* species decreases with a concomitant increase in the lanternfish portion, probably as a result of lanternfish migrating from below 800 meters and becoming more catchable at night. An estimated 20 percent of the population of lanternfish migrate from below 400 meters during the day to the upper 200 meters at night; one-third to two-thirds of these reach the upper 100 meters (Krueger et al., 1977).

Most of the *Cyclothone* catch at the 106-Mile Site was attributable to *C. microdon* and *C. braueri*, the first and third most abundant species for all areas and seasons. *C. microdon* is most abundant below 500 meters, while *C. braueri* predominates above 600 meters. Both species appear to occur generally shallower in winter than in summer. Of the fifty species of lanternfish captured, only four were abundant. Krueger et al. (1977) reported *Ceratoscopelus maderensis* as the second most abundant species overall, but only by virtue of a single extremely large sample. Otherwise, this species was only moderately abundant during winter, and rare or absent during summer. *Hygophum hygomi* and *Lobianchia dofleini* were moderately abundant during summer but were virtually absent during winter. Adult *Benthosema glaciale* were abundant during winter, but during summer, the species was only moderately abundant and composed primarily of juveniles. *Cyclothone* and lanternfish contributed between 25 percent and 70 percent of the total biomass in the upper 800 meters depending upon area and diel period. Therefore, small numbers of larger species contribute greatly to the total fish biomass. Krueger et al., (1977) found that the larger fish inhabit depths greater than 300 meters and speculated that these fish concentrate toxic materials as a result of feeding on smaller fishes and larger zooplankton. Only five species, *Benthosema glaciale*, *Lepidophanes guentheri*, *Cyclothone pallida*, *C. braueri*, and *C. microdon* were taken in all areas and seasons.

Krueger et al. (1977) concluded that the 106-Mile Site, both in summer and winter, was characterized by a Slope water fish fauna, upon which a Northern Sargasso Sea fauna, presumably transpor ed to the disposal site by warm-core eddies, was superimposed. The Sargasso Sea species that were present in summer were less abundant in winter, suggesting that their presence and abundance are dependent upon eddy size, age, and/or core temperature.

The most common pelagic nekton in the 106-Mile Site include the tunas, bluefin (*Thunnus thynnus*), yellowfin (*T. albacores*), big eye (*T. obesus*), and albacore (*T. alalunga*) as well as the swordfish (*Xiphias gladius*), lancetfish (*Alepisaurus* spp.), blue shark (*Prionace glauca*), mako shark (*Isurus oxyrinchus*), and dusky shark (*Carcharhinus obscurus*). All of these species are seasonal migrants north of Cape Hatteras and feed on a variety of prey organisms (Casey and Hoenig, 1977). Approximately 50 percent and 30 percent of the tuna's diet consist of fish and cephalopods, respectively. Crustaceans and miscellaneous organisms comprise the remainder of their diet. Swordfish feed on surface fish, such as menhaden, mackerel, and herring, as well as a variety of deepwater fish and cephalopods. Lancetfish feed on small fish and zooplankton. The blue and mako sharks feed mostly on small fish and cephalopods, while other sharks feed mainly on teleosts.

A considerable amount of information is available for nekton in the Mid-Atlantic Bight. The dominant micronekton groups are the (1) mesopelagic fish: myctophids, gonostomatids, sternoptychids; (2) crustaceans: penaeid and caridean shrimps, euphausiids, mysids; (3) cephalopods; and (4) coelenterates: medusae and siphonophores. These organisms form one of the major links in the pelagic food chain, since they provide forage for the animals of higher trophic levels. The mesopelagic fish occur in large schools that are continually changing depths. Characteristically, these fish are in the surface layers at night and at great depths (1,200 meters) during the day. The general faunal composition of mesopelagic fishes in the Western North Atlantic consist of a few abundant and many rare species (Backus, 1970). Dominant, in terms of numbers of species and individuals, are the fishes from the families Myctophidae and Gonostomatidae.

The long-finned squid (Loligo pealei) and the short-finned squid (Illex illecebrosus) are two of the most abundant cephalopod species found in the MidAtlantic Bight. The former belongs to the family Loliginidae, which are primarily continental shelf species, while the latter is a member of the family, Ommastrephidae, which are oceanic squids. The long-finned squid migrates into shallow water in April to spawn. In October and November, as temperatures decrease in inshore areas, the long-finned squid moves offshore to the edge of the Continental Shelf. The short-finned squid spends January through April in rather dense aggregations along the outer Continental Shelf and Slope where the water temperatures are relatively warm. In the spring (April to May), when Shelf waters begin warming, short-finned squid migrate shoreward. During the summer, fall, and early winter, they are widespread throughout the entire Mid-Atlantic Continental Shelf. In November and December, they begin moving to deeper, warmer, offshore waters. Short-finned squid range throughout the water column to depths of at least 700 meters.

The pelagic nekton include the large, oceanic fishes which are representatives of the family Scombridae (mackerels and tunas), Xiphiidae (swordfish), and Istiophoridae (marlins and sailfishes). The bluefin tuna, Thunnus thynnus, and the white marlin, Tetrapterus albidus, are the dominant species in the Slope waters of the Mid-Atlantic Bight (Chenoweth et al., 1976). Other common species include the swordfish, Xiphias gladius, albacore, Thynnus alalunga, and the skipjack tuna, Euthynnus pelamis.

The bluefin tuna is a highly migratory species that utilizes the waters of the New York Bight during critical periods of its life cycle. Giant bluefin (over 125 kg) annually pass northward through the Straits of Florida in May and June during or just after spawning. They follow the Gulf Stream northward and usually appear in the Mid-Atlantic Bight in June and July. Medium sizes (35 to 125 kg), which are believed to have spawned in the Mid-Atlantic Bight, normally move inshore in June. All sizes have historically left these inshore feeding areas with the coming of autumn storms. In winter, the species has generally been taken only by long-line fisheries over wide areas of the North Atlantic.

The movement of the white marlin follows a pattern similar to that of tunas, in that they move up the Florida current and Gulf Stream and into the mid-Atlantic Shelf and Slope waters in the summer, then return to the Lesser Antilles through the open ocean in the fall. The greatest summer abundance is off the New Jersey to Maryland Coast to about 1800 meters (Chenoweth et al., 1976). These fish enter the area from the south about June and July, concentrate in the area during August, and then move directly offshore in September and October. The concentration of white marlin in summer is probably related to feeding, since spawning occurs in the Caribbean.

Swordfish range along the Shelf and Slope waters of the middle Atlantic coast during the summer months. In winter, the fish are confined to the waters of the Gulf Stream where surface temperatures exceed 15°C. In warmer months, they range over a much wider area as a result of following the northern movement of the 15°C isotherm. There is a relationship between temperature and several components of the swordfish population. Females and larger, older individuals seem better able to tolerate cooler waters than males or small individuals. Swordfish populations at the edge of the Continental Shelf are, therefore, likely to consist primarily of large females.

The cetaceans (whales and dolphins) are wide-ranging marine mammals which utilize the slope waters of the Mid-Atlantic Bight. There is, however, very little data on what species are found in the slope water and the role this region plays in their life history. The species of cetaceans found in the mid-Atlantic, along with their range, distribution and estimated abundance are summarized in Table A-14. From the data available on cetaceans in offshore waters, it appears that the Slope waters serve as a migratory route between northern summering grounds and southern wintering grounds (Chenoweth et al., 1976). The proximity of rich feeding grounds along a north-south migration route would make the Slope waters an extremely attractive region to the cetaceans. The 200-meter isobath appears to be the inshore boundary for the distribution of some of the larger species.

Five species of sea turtles are known to be associated with coastal and Slope waters in the Mid-Atlantic Bight (Table A-15). Three of the species (hawksbill, leatherback, and Atlantic ridley) are endangered, and the remaining two (green and loggerhead) are expected to be classified as endangered soon. Leatherbacks (Dermo chelvy coriacea), loggerheads (Caretta caretta), ridleys (Lepidochelys kempi), and green turtles (Chelonia mydas) are regular migrants in East Coast waters, usually most numerous from July through October, at which time, the turtles follow their primary food (jellyfish) inshore. The exact migration route used by these organisms in not known.

The main components of the demersal nekton are flatfish (flounders, halibut, plaice, and sole), cartilaginous fishes (skates, rays, and torpedoes), and "roundfish" (cod, haddock, hake, and cusk). The diet of these groups consists mainly of bottom-dwelling animals such as crustaceans, mollusks, echinoderms, and worms, although a number of the "roundfish" are predaceous on other fish and shrimp. Spawning activity generally occurs near the bottom, but in some cases the eggs, and in many instances the larvae, are pelagic.

TABLE A-14. SPECIES SUMMARY OF CETACEANS (From Chenoweth et al. 1976)

Family	Common Name(s)	Species Name	Western Atlantic Range and Distribution	Habitat	Estimated Abundance in Western North Atlantic
Balaenidae*	Right whale	Eubalaena glacialis	New England to Gulf of St. Lawrence; Possibly found as far south as Florida	Pelagic and coastal; not normally inshore	200-1000
Balaenopteridae*	Blue whale	Balaenoptera musculus	Gulf of St. Lawrence to Davis Strait: routinely sighted on banks fringing outer Gulf of Maine; Population much reduced from original number of about 1,100 in western N. Atlantic	Pelagic, deep ocean; however occasionally approaches land in deep water regions, e.g. the Laurentian Channel of the St. Lawrence River	Generally not common; some sightings expected in offshore regions; no estimates.
Balaenopteridae*	Sei whale	Balaenoptera borealis	New England to Arctic Ocean	Pelagic, does not usually approach coast	1,570 off Nova Scotia
Balaenopteridae*	Finback whale	Balaenoptera physalus	Population centered between 41°21'N and 57°00'N and from coast to 2000 m contour	Pelagic but enter bays and inshore waters in late summer	7,200
Balaenopteridae	Minke whale	Balaenoptera acutorostrata	Chesapeake Bay to Baffin Island in summer, eastern Gulf of Mexico, northeast Florida and Bahamas in winter	Pelagic, but may stay nearer to shore than other rorquals (except humpback)	No estimates
Balaenopteridae*	Humpback whale	Megaptera novaeangliae	Common near land but can be found in deep ocean	Approaches land more closely and commonly than other large whales; also found in deep ocean	800 - 1,500
Delphinidae	Killer whale	Orcinus orca	Tropics to Greenland, Spitzbergen Baffin Bay	Mainly pelagic and oceanic, however they do commonly approach coast	No estimates apparently not seen as commonly as in more northerly areas

TABLE A-14. (continued)

Family	Common Name	Species Name	Western Atlantic Range and Distribution	Habitat	Estimated Abundance in Western North Atlantic
Delphinidae	**Saddleback** dolphin	Delphinis delphis	Caribbean Sea to Newfoundland; very wide ranging; may be most widespread and abundant delphinid in world	Seldom found inside 100 m contour, but does frequent seamounts. esearpments, and other off shore features	Poorly known; probably more common than available records indicate; may be more common in Massachusetts Bay no estimates
Delphinidae	**Atlantic Pilot whale**	Globicephala melaena	New York to Greenland; Especially common in Newfoundland	Pelagic (winter) & coastal (summer)	No estimates; Most common whale seen in Cape Cod Bay; Schools of up to 300 on Georges Bank
Delphinidae	Bottle-nosed dolphin	Tursiops truncatus	Argentina to Greenland, but most common from Florida, West Indies, & Caribbean to New England	Usually close to shore & near islands; enters bays lagoons, rivers	Rare, especially in inshore regions; no estimates
Delphinidae	**Grampus;** Grey grampus, Risso's dolphin	Grampus griseus	Ranges south from Massachusetts	Coastal waters; habitat poorly known	Uncommon, but possibly not rare; no estimates
Physeteridae*	Sperm whale	Physeter catadon	Equator to 50°N (females & juveniles) or Davis Strait (males).	Pelagic, deep ocean	Estimated 22,000 inhabit North Atlantic Ocean
Physeteridae	Pygmy sperm whale	Kogia breviceps	Tropics to Nova Scotia	Pelagic in warm ocean waters	Very rare; only one record
Ziphiidae	Bottle-nosed whale	Hyperoodon ampullatus	Rhode Island to Davis Strait	Pelagic; cold temperate and subarctic waters	Poorly known; between 260-700 taken annually in North Atlantic Ocean, 1968-70
Ziphiidae	True's beaked whale	Mesoplodon mirus	Northern Florida to Nova Scotia	Nothing is known	Extremely rare; poorly known
Ziphiidae	Dense-beaked whale	Mesoplodon densirostris	Tropics to Nova Scotia	Probably pelagic in tropical and warm waters	Extremely rare: stray visitor

* Endangered Species

TABLE A-15. THREATENED AND ENDANGERED TURTLES FOUND IN THE SLOPE WATERS OF THE MID-ATLANTIC BIGHT (Chenoweth et al., 1976)

Common Name	Species Name	Geographic-Bathymetric Range	Habitat	Reason for Decline
+Hawksbill turtle	Eretmochelys imbricata	tropical waters, rare in New England waters, nests on Carribean shores and along Atlantic coast to Brazil on undisturbed beaches.	deep ocean	heavily exploited for shell
+Leatherback turtle	Dermochelvy coriacea	New England waters summer-autumn. Closely associated with slope waters during migration	highly pelagic, feeds on pelagic jellyfish	some slaughter by fishermen, eggs collection on breeding grounds
*Loggerhead turtle	Caretta caretta	New England waters summer-autumn. Migrate Atlantic coast to/from Sargasso Sea	frequently sighted in coastal waters, more littoral than leather-back or hawks-bill	predation by racoons and people, egg destruction of breeding beaches due to coastal development
*Green turtle	Chelonia mydas	occasionally seen in New England waters in summer. Tropical oceans. Rare north of Cape Cod.	deep slope waters between Gulf Stream and littoral feeding grounds	reduction of breeding grounds and commercial exploitation
+Atlantic ridley	Lepidochelys kempi	New England waters during summer months, breeds on more tropical beaches	more littoral than leather-back or hawks-bill	eggs plundered on breeding beaches

*proposed threatened status +endangered species

Markle and Musick (1974) found 29 species and 17 families of benthic fishes in the Slope waters of the region between Nantucket and Cape Hatteras. They also reported the dominant demersal fish in the Mid-Atlantic Bight to be the synaphobranchid eel (*Synaphobranchus kaupi*), the macrourids (*Mezumia* spp.), the long-finned hake (*Phycis chesteri*), and the flatfish (*Glyptocephalus cynoglossus*). Schroeder (1955) found that numbers and weights of fish caught increased between 400 and 1,000 meters. Slope levels below 1,000 meters were regions of reduced abundance, biomass, and diversity, with the 1,000 meter isobath being the point at which a significant change occurs. The most significant species of demersal fish found in Slope waters, along with their average abundance, are listed in Table A-16. Generally, the deeper water forms, such as the macrourids (grenadiers), offshore hakes, batfish, and stomiatoids are found in low quantities scattered throughout the area. These species are probably never as abundant as the shallower water forms that are found in the upper Slope levels.

The Mid-Atlantic Continental Shelf contains very few permanent residents. It is composed primarily of continuously shifting populations that move north, many into the Gulf of Maine, during the warm months, and revtreat south during the cold months (Larsen and Chenoweth, 1976). During the spring, along the Shelf edge and upper Slope, the weight and numbers of fishes are far greater than they are in the fall. This is particularly true of highly migratory forms such as silver hake (*Merluccius bilinearis*), spiny dogfish (*Squalus acanthias*), and red hake (*Urophycis tenuis*). The overall average of numbers of fish caught and their weight in the spring were 684 and 819 kg, respectively, as opposed to 374 and 140 kg in the fall.

BENTHOS

The benthos of the 106-Mile Site lies at abyssal depths on the lower mid-Atlantic Continental Slope and Continental Rise. Research on the faunal assemblages of the Continental Slope was begun only recently, and has centered around the contributions of comparitively few people. This accounts for the sparse amount of data concerning Continental Slope benthic populations, particularly at the 106-Mile Site. There is substantial evidence, however,

TABLE A-16. AVERAGE NUMBER AND WEIGHT PER TOW OF DEMERSAL FISH TAKEN AT SHELF EDGE AND SLOPE DURING FALL AND SPRING TRAWL SURVEYS, 1969 - 1974 (Larsen and Chenoweth, 1976)

		Shelf Break				Slope			
		Fall		Spring		Fall		Spring	
Common Name	Species Name	Av. No.	Av. Wt. (kg)	Av. No.	Av. Wt. (kg)	Av. No.	Av. Wt. (kg)	Av. No.	Av. Wt. (kg)
Silver Hake	*Merluccius bilinearis*	12.75	3	30.33	25	8.11	5	75.89	66
Offshore Hake	*M. albidus*	0.09	1	0.06	1	2.97	3	5.60	8
Red Hake	*Urophycis chuss*	1.73	2	7.20	9	0.98	1	36.45	32
White Hake	*U. tenuis*	0.18	1	0.40	1	0.65	2	2.33	16
Spiny Dogfish	*Squalus acanthias*	0.85	1	69.00	350	0.04	1	79.50	468
Mackerel	*Scomber scombrus*	0.42	1	98.98	158	0.07	1	4.84	8
Butterfish	*Poronotus triacanthus*	262.62	67	129.87	57	14.03	3	57.46	18
American Goosefish	*Lophius americanus*	1.70	3	0.55	12	2.14	14	1.99	44
Witch Flounder	*Glyptocephalus cynoglossus*	0.06	1	0.14	1	0.44	1	3.08	3
Black Bellied Redfish	*Helicolenus dactylopterus*	2.45	1	0.80	1	13.01	3	13.42	3
Northern Sea Robin	*Prionotus carolinus*								
Striped Sea Robin	*P. evolans*	0.33	1	169.01	67	0.60	1	1.78	1
Armored Sea Robin	*Peristedion miniatum*								
Batfish	*Ogcocephalus vespertilio*								
Pearlsides	*Maurolicus* spp.	186.69	1	2.62	1	24.37	1	7.38	1
Greeneye	*Chloropthalmus agassizii*								

that the major components of faunal assemblages at various Slope depths do not change significantly throughout the Mid-Atlantic and neighboring areas (Larsen and Chenoweth, 1976; Rowe et al., 1977; Pearce et al., 1977a). It is possible, then, to use faunal data from adjacent areas in order to enhance the data and interpretations associated with the disposal site fauna.

Variation in sediment type is generally recognized as the primary factor influencing benthic faunal distributions on the mid-Atlantic Shelf. This factor, however, is of doubtful importance in influencing benthic faunal distributions in the 106-Mile Site Slope area, due to only slight sediment variations within similar areas (Rowe and Menzies, 1969). Temperature can be discounted as being an important factor as no seasonal changes or variations with depth occur below 1,000 meters (Larsen and Chenoweth, 1976; Rowe and Menzies, 1969). It has not been determined to what extent species interaction within the Site determines the faunal composition and zonation, but competitive exclusion may be a critical factor (Sanders and Hessler, 1969).

Deep sea nutrition is probably the most important factor influencing benthic faunal distributions in the Site vicinity. Larsen and Chenoweth (1976) believe that the lower levels of available organic carbon at greater depths are a key factor determining faunal biomass and density in the deep benthos. The importance of competitive exclusion, mentioned above, relates directly to the abundance and distribution of nutrients.

The food materials utilized by the benthic fauna of the 106-Mile Site and the associated food sources and transport mechanisms are incompletely known. Several dominant species of fish in the Site are known to feed strictly on the epibenthic and infaunal invertebrates, while other fish feed primarily on pelagic items'(Cohen and Pawson, 1977; Musick et al., 1975). Most of these pelagic items were diurnal migrants which correlated with the views of Sanders and Hessler (1969) regarding the importance of these migrants in efficient transport of food from the euphotic zone to deeper layers. The majority of fish at the Site are probably generalized feeders, since this is characteristic of the fish of deeper depths (Haedrich et al., 1975) and many generalized feeding fish have been found at the Site (Musick et al., 1975).

The dominant epibenthic and infaunal invertebrates of the Site are deposit feeders whose abundance and distribution would depend upon the availability of detrital food items (Jones and Haedrich, 1977; Pearce, 1974). It is generally recognized that the food supply of the benthos originates from shallower areas, particularly the euphotic zone (Sanders and Hessler, 1969), but the primary mechanism by which the food is transported to the deeper layers is uncertain. The most important mechanism transporting detritus to the benthos of the site is probably the passive sinking of potential food items. Turbidity currents may also play some part but their role has been discounted (Sanders and Hessler, 1969).

Many authors have recognized distinct quantitative and qualitative zones of distribution for the benthic fauna of Continental Slope areas of the Mid-Atlantic. The number and demarcation of zones may vary between authors but they all center their zones on an axis horizontal or vertical to the Slope. Cohen and Pawson (1977) mention a horizontal distribution pattern of benthic fish and invertebrates in the Site. They observed great variance in the abundance of the four most commonly seen epibenthic invertebrates from one site area to the next but were hesitant to label this distribution as patchy.

Vertical distributions are more commonly recognized in the Site, the general trend being one of decreasing numbers of taxa and individuals with increasing depth (Cohen and Pawson, 1977; Pearce et al., 1977; Musick et al., 1975). This trend is typical for Slope and deep sea areas (Haedrick et al., 1975; Rowe and Menzies, 1969; MacDonald, 1975). Musick et al. (1975) recognize the shelf-slope break above the Site as an area of increased diversity, species richness and biomass of benthic fish populations. This pattern remained stable down to the 2,200-meter depth of the site, where it rapidly declined. Haedrich et al. (1975) also recognized these two zones in an area northeast of the Site.

Surveys of the benthos in the Site have found no species of present commercial importance and only a few of potential importance. The shellfish commonly harvested on the adjacent shelf, including the surf clam, sea scallop, and southern quahog, do not extend their range onto the Continental Slope. The lobster, presently fished in canyon and shelf areas above the Site, is not found in the site (Pratt, 1973). The red crab, Geryon quinquidens, is a potential commercial species of the mid-Atlantic but is found only in Slope areas shallower then the Site (Musick et al., 1975; Pratt, 1973).

No demersal fishes of commercial importance are presently being harvested from the Site vicinity and only a few potential species have been found there. Two dominant Site species, Coryphaenoides cupestris and Alepocephalus agassizii, have been experimentally harvested by the Russian and British fishing industries from areas outside the Site. The Site also serves as a nursing ground for Glyptocephalus cynoglossus, the adults of which support a fishery elsewhere (Musick et al., 1975).

Epibenthos

Musick et al. (1975) reported 48 species of demersal fishes from 12 trawl stations in and around the 106-Mile Site. They described the diversity of the fish community as being higher than that of estuarine and Shelf communities. The dominant species of fishes was different at each deeper station within the site: Synaphobranchus kaupi at shallower depths; Nezumia bairdii and Antimora rostrata at mid-depths; predominantly Coryphaenoides armatus at the deepest stations. At increasing depths, the smaller species decreased in number while the larger species increased in number. This resulted in the steady level of biomass observed throughout the Site, as mentioned above, but with an increasingly smaller number of fish making up the biomass at each depth.

Cohen and Pawson (1977) observed 55 species of fishes during 9 dives in the deep sea research vessel (DSRV) ALVIN. They described the overall distribution as patchy and noted that most of the species were rarely encountered. The six most common fishes included two of the dominant species in the above study: the eel, Synaphobranchus kaupi, and the morid, Antimora rostrata. The other four species were the rattails, Nematonurus armatus and Lionurus carapinus, the halosaur, Halosauropsis macrochir, and the lizard fish, Bathysaurus ferox. Densities of fishes in two depth zones were estimated by counting fish along six transects. There was a relative abundance of fish, showing patchy distribution, from 1720 to 1819 meters. The range of densities for this depth zone was 5.7 to 32.8 fishes per 1000 m^2. The density from 2417 to 2545 meters was lower, ranging from 1.83 fishes per 1000 m^2, and the fishes were distributed more evenly. The dominant species listed above are common dominants of the Mid-Atlantic Bight (Larsen and Chenoweth, 1976).

The epibenthic invertebrates of the 106-Mile Site have been described in two studies by Cohen and Pawson (1977) and Rowe et al. (1977), both of which are based on visual and photographic observations from the DSRV ALVIN. These studies were limited by the observers' abilities in detecting in situ epibenthic invertebrates from the vantage point of the ALVIN'S viewports and in photographs. Animals which avoid submersibles will be consistently missed by both methods. This is assumably what caused the "selectivity" of the former study; Cohen and Pawson do not indicate if other detectable invertebrates were selectively omitted from the report. Although it is unknown how many species may be missing, the authors' results most likely include all the dominant species and major contributors to the total biomass of epibenthic invertebrates in the site.

According to Cohen and Pawson (1977), the four most abundant invertebrates, in decreasing order and their peak densities per 1000 m^2 were, Ophiomusium (brittle star), 2445; Cerianthus sp. (tube anemone), 813; Echinus affinus (sea urchin) 259; and Euphronides (holothurian), 101. Rowe et al. (1977) reported identical results for numerical dominance with the exception of the substitution of Phormosoma placenta (sea urchin) for Euphronides. The average number of species was 2.36 per m^2 within a range of 0.25 to 5.15 per m^2. In studies of similar areas to the north of the Site (Jones and Haedrich, 1977; Haedrich et al., 1975), Ophiomusium was consistently found to be the most numerically abundant species, with Echinus affinus as a major contributor. Also, the major contributor to the biomass in each study was always one of the numerically dominant species common to each site.

It may be concluded, therefore, that there is little difference between the major epibenthic invertebrate faunal components of the site and those of other mid-Atlantic Continental Slope areas of similar depth (Jones and Haedrich, 1977; Haedrich et al., 1975). In general, echinoderms are always the most important faunal component of these areas.

Infauna

The infaunal assemblage of the 106-Mile Site is typical for the mid-Atlantic Slope (Pearce et al., 1977a). Diversity and density decrease with increasing depth, and polychaetes are the dominant species, followed by bivalves, nematodes, and peracarida. Pearce et al. (1977a) reported a range of densities for 22 stations in the site vicinity of 0 to 119 organisms per 0.1 m^2. The number of taxa ranged from 0 to 34 per 0.1 m^2. The peak valves for these ranges are higher than in a previous study by the author (Pearce, 1974).

APPENDIX B

CONTENTS

ILLUSTRATIONS

TABLES

Appendix B

CONTAMINANT INPUTS TO THE 106-MILE CHEMICAL WASTE SITE

HISTORICAL USAGE (1973-1978)

The 106-Mile Chemical Waste Disposal Site was proposed for use in 1965 by the U.S. Fish and Wildlife Service as an alternative to the inland discharge of industrial chemical wastes that might contaminate potable water supplies. However, some chemical wastes were disposed at the Site during 1961, 1962, and 1963. From 1961 to 1978, approximately 5.1 million metric tons of chemical wastes, 102 metric tons of sewage sludge, and 287,000 metric tons of sewage sludge digester cleanout residue were dumped at this site.

When ocean waste disposal came under EPA regulation in 1973, there were 66 permittees at the Site. Since 1973, the number of permittees has steadily declined until, as of mid-February 1979, only four permittees remained: American Cyanamid (Linden, N.J.), E.I. duPont de Nemours and Co., Inc. Edge Moor Plant (Edge Moor, Del.) and Grasselli Plant (Linden, N.J.), and Merck & Co. (Rahway, N.J.). Despite the decline in the number of permittees, the volume of waste increased 134 percent from 341,000 metric tons in 1973 to 797,000 metric tons in 1978. The increase in volume was primarily the result of the relocation of industrial waste generators from the New York Bight Sewage Sludge Site in 1974, DuPont-Grasselli from the New York Bight Acid Wastes Site in 1974, and DuPont-Edge Moor from the Delaware Bay Acid Waste Site in 1977. This latter DuPont plant alone discharged 380,000 metric tons or 50 percent of total waste released in 1977, as compared to the previous year's total volume of 375,000 metric tons for all permittees. In addition, the City of Camden, New Jersey, was relocated by court action to the Site in the same year. However, Camden contributed only six percent of the annual total or 48,000 metric tons. In 1978, the volume of dumped waste totalled 797,000 metric tons representing a four percent decrease from the high volume in 1977. Overall, approximately 75 percent of the waste discharged from 1973 to 1978 was from three industrial sources: American Cyanamid, DuPont-Edge Moor, and DuPont-Grasselli.

Figure B-1 illustrates the dumping trends at the 106-Mile Site from 1973 to 1978. The actual dumping volumes and percent contribution of each permittee appear in Table B-1.

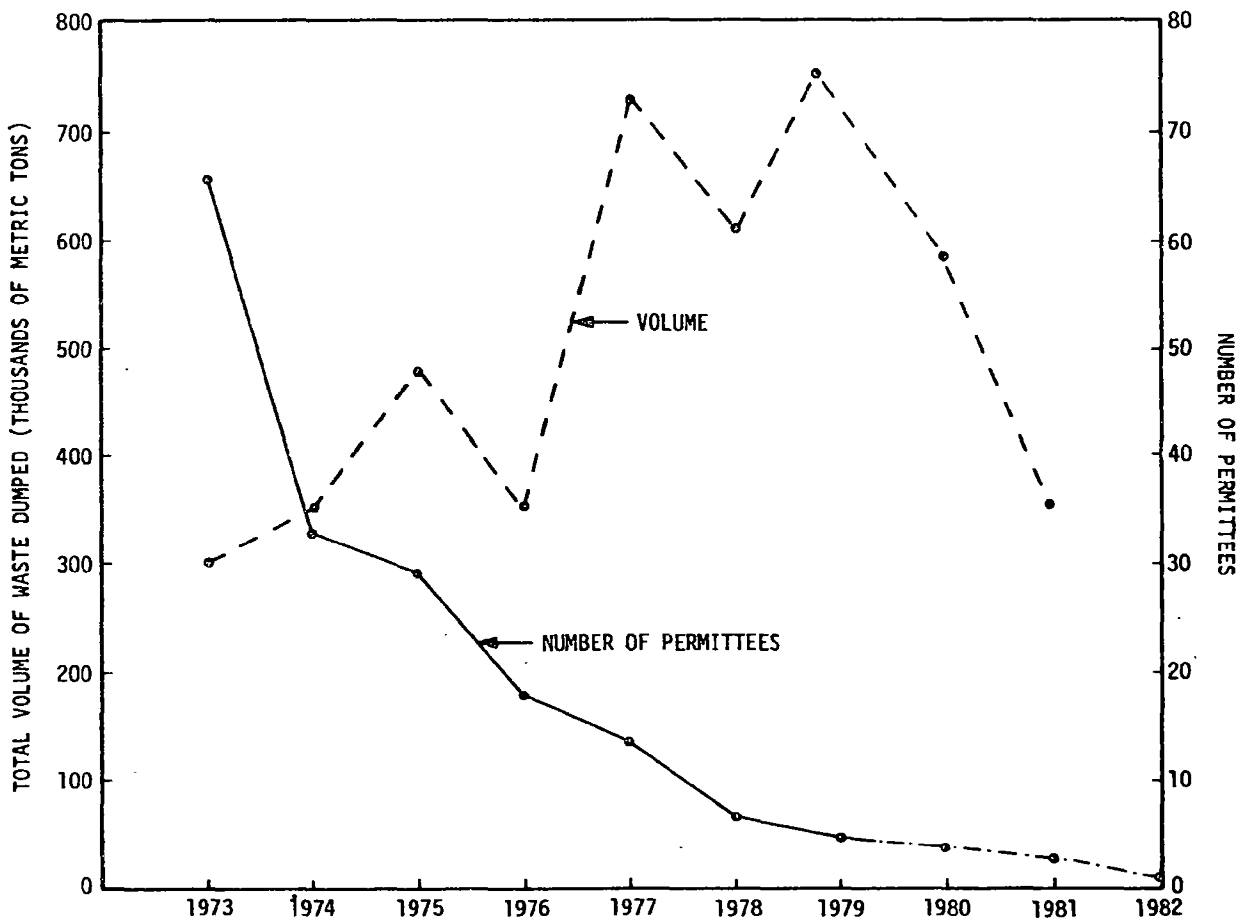


Figure B-1. Historical and Projected Dumping Activity at 106-Mile Site

TABLE B-1. DUMPING VOLUMES AT THE 106-MILE SITE FROM 1973 TO 1978[*]

(THOUSANDS OF METRIC TONS)

Permittee	1973	1974	1975	1976	1977	1978	Totals
American Cyanamid Co.	118 (35)	137 (31)	116 (26)	119 (32)	130 (17)	111 (14)	731 (22)
Camden, N.J.	--	--	--	--	48 (6)	54 (7)	102 (3)
Chevron Oil Co.	25 (7)	26 (6)	22 (5)	--	--	--	73 (2)
DuPont-Edge Moor	--	--	--	--	380 (50)	372 (47)	752 (23)
DuPont-Grasselli	116 (34)	155 (35)	264 (59)	164 (44)	107 (14)	172 (22)	978 (30)
Hess Oil Co.	7 (2)	--	--	--	--	--	7 (0.2)
Mixed Industries[**]	34 (10)	35 (8)	78 (17)	67 (18)	85 (11)	72 (9)	371 (11)
Mixed Municipalities[†]	41 (12)	93 (21)	96 (22)	25 (7)	16 (2)	16 (2)	287 (9)
Totals	341	446	576	375	766	797	3,301

* Permittee's percentage of annual total appears in parentheses.
** Crompton and Knowles, Merck and Co., and Reheis Chemical Co.
† Permittees using New York Bight Sewage Sludge Site (sewage sludge digester cleanout residue).

Over the years, DuPont-Grasselli has been the largest contributor of waste to the Site, releasing 978,000 metric tons or approximately 30 percent of the total volume for 1973 to 1978. The volumes ranged from 107,000 metric tons in 1977 to 264,000 metric tons in 1975, averaging 163,000 metric tons annually. DuPont-Grasselli disposes of its waste seven to nine times per month.

DuPont-Edge Moor, the second major waste contributor, moved its dumping operation from the Delaware Bay Acid Waste Disposal Site to the 106-Mile Site in March 1977. Although DuPont-Edge Moor has been dumping at the site for only 2 years, they have released approximately 752,000 metric tons or 23 percent of the total volume of waste dumped between 1973 and 1978. DuPont-Edge Moor barges its waste to the Site an average of seven times per month.

From 1973 to 1978, American Cyanamid disposed of approximately 731,000 metric tons of chemical waste, averaging 122,000 metric tons per year. American Cyanamid's volume constituted approximately 22 percent of the waste which was dumped at the Site during that period. The volumes ranged from 111,000 metric tons in 1978 to 137,000 metric tons in 1974. American Cyanamid has its waste barged out to the Site an average of seven times per month.

The mixed waste of a number of industries has been barged to the Site. In 1973, 61 industrial permittees (besides the three already discussed) were dumping at the Site, but now only Merck and Co remains. From 1973 to 1978, approximately 371,000 metric tons of mixed industrial wastes were dumped, comprising 11 percent of the total volume released during that period. The mixed input ranged from 34,000 metric tons in 1973 to 85,000 metric tons in 1977, averaging 62,000 metric tons per year. Depending on the barge used and the volume of waste, Merck's waste is dumped once or twice per month.

In addition to industrial waste, sewage sludge has been dumped at the Site. The City of Camden relocated its municipal sewage sludge disposal operation to the Site in 1977. Camden discharged 102,000 metric tons or seven percent of the waste dumped during 1977 and 1978. Camden's waste volume represented three percent of the total waste dumped at the Site from 1973 to 1978. Camden ceased ocean dumping on June 15, 1978.

Sewage sludge digester cleanout residue from many New York/New Jersey area municipal wastewater treatment plants was also released at the Site from 1973 to 1978. Approximately 287,000 metric tons were dumped, comprising nine percent of the total dumped during this period.

PROJECTED INPUTS

Table B-2 summarizes the projected dumping volumes and scheduled phaseout dates for the current permittees at the 106-Mile Site.

TABLE B-2. PROJECTED VOLUMES, 1979-1980, AT THE 106-MILE SITE

(Thousands of Metric Tons)

Permittee	Scheduled Phaseout Date	Year		
		1979	1980	1981
American Cyanamid	April 1981	123	123	30
DuPont-Edge Moor	May 1980	299	136	0
DuPont-Grasselli	--	295	295	295
Merck	April 1981	36	36	10
Yearly Totals		753	590	335

DuPont-Grasselli has investigated several land-based alternatives, two in detail: biological treatment and incineration. These alternatives do not comply with state and/or Federal environmental regulations and, therefore, have been rejected in favor of ocean disposal. Although the waste has been demonstrated to meet EPA's marine environmental impact criteria, both EPA and the New Jersey Department of Environmental Protection (NJDEP) have recommended further detailed investigations of alternatives by DuPont. DuPont-Grasselli has projected that its annual waste volumes will not exceed 295,000 metric tons. DuPont-Grasselli's current permit expires January 14, 1981. It will be eligible for renewal at that time, assuming that DuPont continues to demonstrate compliance with EPA's need and environmental impact criteria.

DuPont-Edge Moor is currently complying with an EPA-imposed schedule to cease ocean dumping by May 1980 in favor of other alternatives. The iron chloride in the waste will be converted to ferric chloride and marketed as a water treatment chemical. In addition, the company is constructing facilities which will allow DuPont to recycle hydrochloric acid, a major component of the waste. The concept has been tested in the laboratory and at a pilot plant and is expected to be fully operational in 1980 (Kane, 1977).

American Cyanamid will continue to ocean dump according to its compliance schedule until April 1981, when the land-based alternative is operational. The land-based alternative waste disposal method selected by Cyanamid basically consists of on-site carbon treatment and off-site thermal oxidation of the balance of the wastes. Whether or not these alternative treatment technologies can meet environmental regulations has not been determined at present.

Merck has determined that two feasible modifications of present ocean disposal methods can be implemented: (1) on-site pre-treatment of existing wastes followed by discharge to a municipal treatment plant, and (2) manufacturing process changes that would produce wastes which could be discharged directly to a municipal treatment plant. Merck is complying with an EPA-imposed schedule to cease dumping by April 1981.

WASTE CHARACTERISTICS

The characteristics of wastes dumped at the Site since 1973 are summarized in Tables B-3 through B-9. The future waste characteristics of the four remaining permittees are expected to follow historical trends. Merck waste, previously undifferentiated from the mixed industrial waste analyses, is characterized separately as data permit.

TABLE B-3. ANNUAL ESTIMATED MASS LOADING FOR SUSPENDED SOLIDS, PETROLEUM HYDROCARBONS, AND OIL AND GREASE AT THE 106-MILE SITE, 1973-1978
(Metric Tons)

Constituent \ Year	1973	1974	1975	1976	1977	1978
Suspended Solids	1,182	397	2,340	10,372	2,467	4,298
Petroleum Hydrocarbons	5	27	642	29	202	47
Oil and Grease	217	210	141	174	745	115

DUPONT-GRASSELLI

The principal process generating the DuPont-Grasselli waste is the production of DMHA (N,O-dimethylhydroxylamine) and Anisole. The Grasselli plant is authorized to dispose of approximately 295,000 metric tons annually (Table B-2). Disposal is accomplished by subsurface release of the waste at a rate not exceeding 196,820 liters (52,000 gallons) per nautical mile. This rate permits complete offloading of an average barge load of 1.5 million liters in approximately 70 minutes (assuming a barge speed of 6 knots), over a linear distance of approximately 7.4 nautical miles.

The major trace metals present in Grasselli waste, ranked in decreasing order of input volume are: copper, lead, nickel, zinc, chromium, and mercury.

In addition to the broad categories or organic materials identified in Tables B-3 and B-4, the organic phase of the Grasselli waste is composed of sodium methyl sulfate (up to 50 percent of the organic phase), methanol (20 percent) and N,O-dimethylhydroxylamine (DMHA) plus other amines (1 percent). The remainder is in the form of phenols, Anisole, and other compounds.

TABLE B-4. CONCENTRATIONS OF SUSPENDED SOLIDS, PETROLEUM HYDROCARBONS, AND OIL AND GREASE IN INDUSTRIAL WASTE DUMPED AT THE 106-MILE SITE

(mg/l)

Permittee	Suspended Solids		Petroleum Hydrocarbons		Oil and Grease	
	Mean	Range	Mean	Range	Mean	Range
American Cyanamid	312	2-2,375	314	5-5,270	872	10-6,214
Dupont-Edge Moor	2,192	60-21,000	<0.3	--	4	1-24
DuPont-Grasselli	760	5-15,090	16	1-108	17	1-108
Mixed Industries	81,000	12-771,000	1,361	1-57,600	1,088	6-4,850

DMHA has been monitored in the Grasselli waste since 1975. The concentrations have ranged from 20 mg/l t 364 mg/l, averaging approximately 115 mg/l. Annual inputs average 17,320 kg annually, ranging from 10,170 kg in 1978 to 27,800 kg in 1977. Since the first report of volumes of the compound in 1975, DuPont-Grasselli has released 69,266 kg of DMHA at the 106-Mile Site.

Monitoring of Anisole also began in 1975 and the concentrations in the Grasselli waste have ranged from 1 mg/l to 14 mg/l, averaging approximately 5 mg/l. Annual volumes have ranged from 619 kg in 1978 to 1656 kg in 1975. The average annual input is 918 kg. Since 1975, the Grasselli plant has released 3,052 kg of Anisole at the 106-Mile Site. DuPont-Grasselli is the only known source of Anisole at this site.

Phenols have been monitored in the Grasselli waste since 1973 and the concentrations have shown a range from 0.2 mg/l to 3,550 mg/l, averaging 209 mg/l. Yearly inputs have ranged from 245 kg in 1978 to 204,010 kg in 1975. The average annual input of phenols by Grasselli is 45,182 kg. Since 1973, DuPont-Grasselli has disposed of 225,572 kg of phenols at the 106-Mile Site.

TABLE B-5. SUSPENDED SOLIDS, PETROLEUM HYDROCARBONS, AND OIL AND GREASE RELEASED AT THE 106-MILE SITE, 1973-1978

(Metric Tons)

Permittee and Year	Total Suspended Solids		Petroleum Hydrocarbons		Oil and Grease	
	Amount Dumped	Permittee's Percent of Annual Total Dumped	Amount Dumped	Permittee's Percent of Annual Total Dumped	Amount Dumped	Permittee's Percent of Annual Total Dumped
American Cyanamid						
1978	97	2	34	73	75	65
1977	39	1	100	49	223	30
1976	27	1	15	51	74	43
1975	19	1	55	--	17	12
1974	60	15	18	--	97	46
1973	19	2	NR	--	NR	--
DuPont-Edge Moor						
1978	1,100	25	0.1	<1	1.6	2
1977	68	3	0.1	1	0.9	1
DuPont-Grasselli						
1978	53	1	0.6	1	2	2
1977	19	1	1	1	3	1
1976	45	1	2	6	2	1
1975	607	26	NR	--	6	4
1974	97	24	NR	--	2	1
1973	49	4	NR	--	NR	--
Mixed Industries*						
1978	3,048	72	12	26	36	31
1977	527	21	9	4	13	2
1976	10,300	99	12	43	98	56
1975	168	72	551	--	97	69
1974	226	57	7	--	108	51
1973	1,100	93	5	--	0.2	--
Camden, N.J.						
1977	1,815	74	93	46	505	68
Chevron Oil Co.						
1975	34	1	35	--	22	15
1974	14	4	2	--	3	1
1973	14	1	NR	--	2	--
Hess Oil Co.						
1973	0.3	1	--	--	214	--

NR - Not reported
* Crompton and Knowles, Merck and Co., and Reheis Chemical Co.

TABLE B-6. ESTIMATED ANNUAL INDUSTRIAL TRACE METAL MASS LOADING

Year/Volume Trace Metal/ Permittee	1973		1974		1975		1976		1977		1978	
	Volume Dumped (kg)	Total Dumped (%)	Volume Dumped (kg)	Total Dumped (%)	Volume Dumped (kg)	Total Dumped (%)	Volume Dumped (kg)	Total Dumped (%)	Volume Dumped (kg)	Total Dumped (%)	Volume Dumped (kg)	Total Dumped (%)
Cadmium												
American Cyanamid	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	2
DuPont-Edge Moor	--	--	--	--	--	--	--	--	185	23	107	64
DuPont-Grasselli	12	6	29	1	72	1	33	15	8	<1	25	15
Mixed Industries	197	93	5,484	99	19,430	99	180	84	529	65	33	19
Chevron Oil	1	<1	3	<1	1	<1	--	--	--	--	--	--
Hess Oil	<1	<1	--	--	--	--	--	--	--	--	--	--
TOTAL	211		5,516		19,503		213		812		168	
Chromium												
American Cyanamid	156	23	46	7	58	8	50	23	56	<1	23	1
DuPont-Edge Moor	--	--	--	--	--	--	--	--	69,208	94	98,982	99
DuPont-Grasselli	33	5	87	13	89	13	19	9	64	<1	21	1
Mixed Industries	483	71	552	79	557	79	146	68	3,909	5	934	1
Chevron Oil	1	<1	11	1	1	<1	--	--	--	--	--	--
Hess Oil	4	<1	--	--	--	--	--	--	--	--	--	--
TOTAL	677		696		705		215		73,845		99,960	
Copper												
American Cyanamid	11	1	5	1	5	<1	13	2	14	<1	156	8
DuPont-Edge Moor	--	--	--	--	--	--	--	--	827	22	1,221	65
DuPont-Grasselli	35	3	64	11	73	9	41	8	2,069	56	220	12
Mixed Industries	954	94	509	84	733	89	481	90	87	2	266	15
Chevron Oil	8	1	25	4	15	2	--	--	--	--	--	--
Hess Oil	3	1	--	--	--	--	--	--	--	--	--	--
TOTAL	1,011		603		826		535		3,695		1,863	
Lead												
American Cyanamid	47	19	6	<1	13	1	2	<1	2	<1	8	<1
DuPont-Edge Moor	--	--	--	--	--	--	--	--	13,663	89	12,573	97
DuPont-Grasselli	54	22	115	12	386	36	104	11	38	<1	229	2
Mixed Industries	142	57	759	81	674	62	822	89	96	<1	200	1
Chevron Oil	4	1	53	6	12	1	--	--	--	--	--	--
Hess Oil	4	1	--	--	--	--	--	--	--	--	--	--
TOTAL	251		933		1,085		928		15,336		13,010	
Mercury												
American Cyanamid	11	24	2	14	1	1	3	<1	1	10	3	27
DuPont-Edge Moor	--	--	--	--	--	--	--	--	4	40	6	55
DuPont-Grasselli	1	2	2	14	2	1	1	<1	<1	5	1	9
Mixed Industries	22	49	9	64	1,622	98	960	99	<1	5	1	9
Chevron Oil	9	20	1	8	1	1	--	--	--	--	--	--
Hess Oil	2	5	--	--	--	--	--	--	--	--	--	--
TOTAL	45		14		1,626		964		10		11	
Nickel												
American Cyanamid	217	52	83	23	366	21	129	23	138	2	40	1
DuPont-Edge Moor	--	--	--	--	--	--	--	--	7,315	91	11,119	96
DuPont-Grasselli	83	20	114	32	199	25	110	19	59	1	133	1
Mixed Industries	100	24	142	40	418	53	332	58	413	5	287	2
Chevron Oil	18	4	16	4	2	1	--	--	--	--	--	--
Hess Oil	2	<1	--	--	--	--	--	--	--	--	--	--
TOTAL	420		355		785		571		8,009		11,579	
Zinc												
American Cyanamid	82	1	32	<1	18	<1	25	1	163	<1	77	<1
DuPont-Edge Moor	--	--	--	--	--	--	--	--	20,796	89	51,800	98
DuPont-Grasselli	49	1	154	1	141	2	41	1	27	<1	83	<1
Mixed Industries	11,985	99	15,549	98	7,087	97	3,165	98	133	<1	580	1
Chevron Oil	4	1	68	<1	33	<1	--	--	--	--	--	--
Hess Oil	5	1	--	--	--	--	--	--	--	--	--	--
TOTAL	12,125		15,803		7,279		3,231		23,382		52,540	

TABLE B-7. AVERAGE METAL CONCENTRATIONS FOR WASTES AT 106-MILE SITE (ug/l)

Metal	Seawater Concentration	Reference	American Cyanamid		DuPont-Edge Moor		DuPont-Grasselli		Mixed Industries	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range
Arsenic	2-3	Kopp, 1969	620	20-2,600	140	5-525	7	1-30	30	1-130
Cadmium	0.15	Fleischer et al., 1974	4	1-150	320	20-900	170	3-700	3,200	20-15,600
Chromium	1	EPA, 1976	550	45-4,900	270,200	52,600-900,000	330	10-3,500	21,170	4-170,000
Copper	3.0	Mero, 1964	350	1-4,100	3,250	4-7,400	3,150	25-154,700	10,900	1-115,000
Lead	0.03	Horne, 1969	120	1-1,000	40,540	2,700-76,000	900	10-4,900	8,840	8-62,000
Mercury	0.05-0.19	Robertson et al., 1972	30	1-200	30	< 1-500	7	< 1-20	300	21-3,830
Nickel	5-7	NAS, 1974	1,100	145-6,400	29,060	200-65,000	730	30-2,000	4,900	20-31,500
Zinc	10	EPA, 1976	560	7-5,150	100,960	110-530,000	540	30-2,700	163,800	15-1,400,000

TABLE B-8. pH, SPECIFIC GRAVITY, AND PERCENT SOLIDS IN INDUSTRIAL WASTE DUMPED AT THE 106-MILE SITE

Permittee	pH		Specific Gravity		Percent Solids
	Mean	Range	Mean	Range	
American Cyanamid	5.0	2.7 - 8.3	1.028	1.015 - 1.055	0.03
DuPont-Edge Moor	0.6	0.1 - 1.0	1.135	1.085 - 1.218	0.16
DuPont-Grasselli	12.9	12.4 - 13.6	1.109	1.036 - 1.222	0.07
Merck		5 - 7	1.28	-	0.08

TABLE B-9. CHARACTERISTICS OF TYPICAL SEWAGE SLUDGE DIGESTER CLEANOUT RESIDUE*

Specific gravity	1.016
Total solids (mg/l)	52,400
Volatile solids (mg/l)	38,500
Petroleum hydrocarbons (mg/l)	16
Liquid cadmium (mg/l)	0.2
Solid cadmium (mg/kg)	45
Liquid mercury (mg/l)	0.002
Solid mercury (mg/kg)	0.39

* From Nassau County Department of Public Works. Dumped 10/26/78.

Toxicity

Results of bioassay tests, which were conducted between 1973 and 1977, show that the toxicity of Grasselli waste to brine shrimp (*Artemia salina*) has varied between 48-hour TL_{50} values of 3,250 to 100,000 ppm. This variation may be due primarily to a change from non-aeration to aeration of the samples rather than large changes in the toxicity of the material. Bioassays conducted since 1977 with Atlantic silversides (*Menidia menidia*) yield 96-hour TL_{50} values that range between 1.8 ppm and 6,950 ppm for aerated tests and between 1.65 ppm and 6,170 ppm for nonaerated tests. Bioassays on diatoms (Skeletonema costatum) produce 96-hour EC_{50} values between 29 ppm and 8,600 ppm. Tests with copepods (Acartia tonsa) give 96-hour TL_{50} values ranging between 57 ppm and 238 ppm. Notwithstanding the changes in required testing procedures, some of the observed variation may be due to the differences in the character of the individual barge loads, even though they come from the same waste source.

In 1976, DuPont sponsored an extensive series of studies to describe the in-situ dispersion characteristics and biological effects of ocean-disposed waste waters from its Grasselli plant (Falk and Gibson, 1977). The study was prompted by DuPont's desire to demonstrate to the EPA the validity of the time-toxicity concept, i.e., determining the maximum length of time in which wastes would remain at a sufficiently high concentration to cause acute toxic effects by taking into consideration both wastewater dispersion and wastewater toxicity as a function of time. The results of these studies show that:

(1) Under oceanographic conditions least likely to enhance dispersion, the peak wastewater concentration in the barge wake is, initially, about 450 ppm (v/v) one minute after release.

(2) Wastewater concentrations decline to a peak of about 80 ppm within 4 hours after release, and to about 60 ppm after 12 hours.

(3) In 178-day chronic toxicity tests, the no effect level for opossum shrimp (Mysidopsis bahia) and sheepshead minnow (Cyprinodon variegatus) was found to be 750 ppm.

(4) The wastewaters are not selectively toxic to a particular life stage of Cyprinodon or Mysidopsis.

(5) There is little difference in the toxicity of the wastewater to several species of marine organisms.

These results supported the discharge of Grasselli waste into the Site over a 5-hour period, at a barge speed of 5 knots, without adverse impact.

Dilution and Dispersion

Mixing of waste with seawater is a function of prevailing meteorological and oceanographic conditions. Following discharge from the barge, initial mixing (within the first 15 minutes) occurs primarily as a result of barge-generated turbulence. After the initial mixing, wind, waves, currents, and density stratification components dictate the rate and direction of dispersion and dilution.

Bisagni (1977) studied the behavior of DuPont-Grasselli wasted dumped at the 106-Mile Site in June, 1976, using Rhodamine-WT dye mixed with the waste as a tracer. Water column profiles showed the surface mixed layer extended down to a depth of 20 meters. Below the surface mixed layer, a seasonal thermocline was found between 20 and 50 meters. The permanent thermocline was located between 200 and 350 meters. The waste remained in the upper 60 meters of the water column.

The initial concentration of the undiluted waste within 15 minutes after release was 19.3 ppm. Water samples collected within an hour of commencement of dumping indicated that the dilution ranged from 18,000:1 to 4,600:1. After 70 hours, dilution was estimated to range from 210,000:1 to 45,000:1. During a second dilution study performed in June, minimum factors of 54:1 to 100:1 occurred within 10 minutes after the dumping had begun. After 30 hours, a dilution of about 110,000:1 was estimated.

Orr (1977a) tracked the precipitate formed by the Grasselli waste during June and September, 1976, using a multifrequency acoustic backscattering system. In June, a sharp density gradient in the water column was located at a depth of 10 meters. The data indicated that the particulates separated into two components: a lighter phase which is trapped in the upper 10 to 20 meters of the water column, and a heavier phase which sinks to the base of the mixed layer. These phases were observed to behave in two different ways: collecting in a thin layer on an isopycnal surface (i.e. a plane surface of equal density) or appearing as a diffuse cloud within patches of water which have nearly constant density.

The study conducted in September, 1976, by Orr (1977a) used an acoustic system with improved sensitivity. In this study, both acoustic and dye measurements were collected simultaneously. The waste was observed to spread over an area of 13.7 square kilometers by both methods. The results from this study show that the residence time of the suspended matter can exceed 24 hours. The particulates were heavily concentrated in the upper 15 meters of the water column. The waste settled from an initial uniform distribution to collections of particles in dense layers. The particles that were trapped in the seasonal thermocline outlined the associated isopycnal surfaces and were from 15 cm to 5 meters in thickness. In at least one instance, the particulates associated with the seasonal thermocline were observed to have penetrated it and appeared as a diffuse cloud extending down to a depth of nearly 80 meters. The data also indicated that the particles which penetrated the seasonal thermocline and were trapped at the base of the mixed layer spread horizontally much facter than did the particles trapped by the seasonal thermocline.

Kohn and Rowe (1976) studied the dilution and dispersion of DuPont-Grasselli waste during September, 1976, using Rhodamine-WT dye as a tracer. The dispersion of the waste was monitored by means of two fluorometers, one drawing water from a depth of 5 meters and the other drawing from a depth of 10 meters. Data were gathered for a period of 19 hours following the start of discharge. The initial dilution of the waste was 4250:1 at 5 meters while after 17 hours the dilution was 12,500:1. The waste plume movements following the dump were estimated on the basis of the movements of "window shade" current drogues and from fluorometer readings. In general, the plume moved in a semicircular path, returning to the starting position after about 20 hours. The DuPont waste was found to pass through the upper 5 meters of the water column and stabilize between a 10 meter depth and the top of the thermocline.

Falk and Gibson (1977) described a dye dispersion study conducted by EG&G on the Grasselli waste in September, 1976, during a time when ambient conditions at the 106-Mile Site were least conducive to waste dispersion (i.e., calm seas, light winds, strong thermocline present). The results of the survey indicated that the waste material was limited to the surface mixed layer by the strong thermocline. The horizontal extent of the waste ranged from 35 meters in width initially, to 300 meters after 2 hours, to 600 meters after 8 hours, and to 1,000 meters after 11 hours. Minimum waste dilutions were 5,000:1 initially, 15,000:1 after 2 hours, and 15,000 to 30,000:1 after 11 hours. The average waste dilutions were 10,000:1 initially, 20,000 to 40,000:1 after 2 hours, and 30,000 to 80,000:1 after 11 hours.

Hydroscience (1978c, 1978d, and 1979d) monitored dumps of Grasselli waste in May, July, and October 1978. In all surveys, the wastewater concentration after 4 hours was well below the chronic no-effect level for appropriate sensitive marine organisms of 750 ppm, a dilution of 1,300:1.

DUPONT-EDGE MOOR

DuPont-Edge Moor waste is generated by the manufacture of titanium dioxide using the chloride process. The waste consists principally of an aqueous solution of iron and miscellaneous chlorides, and hydrochloric acid. DuPont-Edge Moor is authorized to dump approximately 299,000 metric tons during 1979 and 136,000 metric tons during 1980 (Table B-2). Disposal of the waste is accomplished by subsurface release at a rate not exceeding 140,045 liters (37,000 gallons) per nautical mile. This rate permits complete offloading of an average barge load of 3.8×10^6 liters of waste in approximately 4.5 hours (assuming a barge speed of 6 knots), over a linear distance of approximately 27 nautical miles.

Ten trace metals are usually reported in the analyses of DuPont-Edge Moor waste. These are, ranked by decreasing input volume: iron, titanium, chromium, vanadium, zinc, lead, nickel, copper, cadmium, and mercury. The organic components of Edge Moor waste (Table B-4) comprise a very slight portion of the waste constituents.

Toxicity

Bioassays conducted since 1977 with Atlantic silversides (*Menidia menidia*) yield 96-hour TL_{50} values greater than 5,000 ppm for aerated tests and between 5,000 ppm and 14,400 ppm for nonaerated tests. Bioassays on diatoms (*Skeletonema costatum*) produce 96 hour EC_{50} values between 712 ppm and 3,450 ppm.

In 1976, DuPont sponsored an extensive series of studies to describe the in situ dispersion characteristics and biological effects of ocean disposed waste waters from its Edge Moor plant (Falk and Phillips, 1977). The dispersion studies were conducted at the Delaware Bay Acid Waste Disposal Site.

A series of laboratory toxicity experiments conducted with the DuPont-Edge Moor wastes gave the following results:

1. In 200-day chronic toxicity tests, the no-effect level for opposum shrimp (*Mysidopsis bahia*) and sheepshead minnow (*Cyprinidon variegatus*) was found to be in the range of 25 to 50 ppm.

2. pH-adjusted waste (as will occur in seawater) produces mortalities only at concentrations several orders of magnitude above the unaltered waste.

3. Pulsed exposure of grass shrimp (*Palaemonetes pugio*) to initial wastewater concentrations of 250 ppm (v/v) followed by dilution slower than that observed in the barge wake produced no mortalities.

4. Maximum waste concentrations in the barge wake were calculated to be approximately 150 ppm within 2 hours, and about 5 ppm within eight hours. The two-hour calculated wake concentrations is well below the acute LC_{50} value range of 240-320 ppm and the eight-hour wake concentration is well below the calculated chronic no-effect level of 25 to 50 ppm for unaltered waste.

Based on these results, Falk and Phillips (1977) reached the conclusion that the Edge Moor wastewaters can be discharged into the marine environment over a 5-hour period, at a barge speed of 6 knots, without adverse impact, and without violating the requirements of Section 227.8 of the EPA Ocean Dumping regulations.

Dilution and Dispersion

In September 1976, EG&G conducted a dispersion study of Edge Moor wastewater at the Delaware Bay Acid Waste Site (EG&G, 1977). A well-defined thermocline was present at a depth of 20 meters, winds were blowing at 8 to 12 m/sec, and waves were 1 to 2 meters. The waste concentration was monitored over 8 hours using pH and iron concentrations. Minimum dilutions were 7,000:1 within 2 hours and 200,000:1 within 8 hours. The 2-hour concentration was well below acute LC_{50} values reported for the organisms tested, and the 8-hour concentration was well below the chronic no-effect level of 25 to 50 ppm (dilutions of 40,000:1 and 20,000:1, respectively).

In May 1978, Hydroscience, Inc. (1978a) studied the dilution and dispersion of the DuPont-Edge Moor waste following its release at the Site. A weak thermocline was present at a depth of 13 meters. Based upon a comparison of undiluted and post-dumping (after 4 hours) seawater concentrations of particulate iron, minimum dilutions were estimated at 75,000:1. Measurements indicated that the DuPont-Edge Moor waste did not significantly penetrate the seasonal thermocline and the waste was diluted and dispersed only within the upper 13 meters of the water column. Surveys conducted during July and October did not yield dilution values; however, the waste was estimated to have been diluted below the chronic no-effect level (Hydroscience, 1978b, 1979a). These observations are compatible with observations made at the Delaware Bay Acid Waste Site while Edge Moor was still dumping its waste there. (Falk and Phillips, 1977).

AMERICAN CYANAMID

American Cyanamid produces industrial wastes which are generated by the manufacture of approximately 30 different organic and inorganic compounds. The broad categories that comprise the waste are approximately 25 percent chemical, 35 percent equipment and floor wash, 25 percent vacuum jet condensate and 15 percent from overhead and bottom distillate units. The chemical products manufactured include rubber, mining, and paper chemicals, nonpersistent organophosphorus insecticides, surfactants and various intermediates.

American Cyanamid is authorized to dispose of approximately 123,000 metric tons annually (Table B-2). Disposal is accomplished by subsurface release of waste through automatic and/or manual vent valves at a rate not exceeding 113,500 liters (30,000 gallons) per nautical mile. This rate permits complete offloading of an average barge load of 1.5 million liters of waste in approximately 2 hours (assuming a towing speed of 6 knots), over a linear distance of approximately 13.5 nautical miles.

American Cyanamid waste is routinely analyzed for trace metals. In order of decreasing input volume, they are: nickel, arsenic, chromium, zinc, lead, copper, mercury, and cadmium.

Because of the complexity of the American Cyanamid waste mixture, it is extremely difficult to characterize all of the organic compounds present in any industrial waste. Thus, the organic content of American Cyanamid waste is known only in general terms. Table B-10 lists the various non-persistent organophosphorus insecticides released by American Cyanamid since 1973.

Toxicity

Results of bioassays that have been conducted since 1977 show that the toxicity of the waste to Atlantic silversides (*Menidia menidia*) has varied between 96-hour TL_{50} values of 0.24 ppm to 2,900 ppm for aerated tests and between 0.10 ppm to 2900 ppm for non-aerated tests. Bioassays conducted from 1973 to 1977 with brine shrimp (*Artemia salina*) yielded 48-hour TL_{50} values of 670 ppm to 21,000 ppm. Bioassays on diatoms (*Skeletonema costatum*) gave 96-hour EC_{50} results that varied between 10 ppm and to 1,900 ppm. Additional tests with copepods (*Acartia tonsa*) gave 96-hour TL_{50} values that varied between 19.5 ppm and 3,500 ppm. This variation may be due to the differences in the toxicity of the individual barge loads, even those from the same waste source. However, such variation is not outside the limits of variability that can be applied to bioassay results of this type.

Dilution and Dispersion

In August, 1976, Kohn and Rowe (1976) studied the dilution and dispersion of the American Cyanamid waste following its release at the Site. Enough Rhodamine-WT fluorescent dye was added to the waste in a barge to yield an undiluted dye concentration of 9.36 ppm. For 17 hours following the start of the waste discharge from the barge, a continuous flow of water was pumped from a depth of 5 meters into an onboard fluorometer. The initial dilution of the American Cyanamid waste was 115:1 while the dilution after 17 hours was 2,500:1.

TABLE B-10. NON-PERSISTENT ORGANPHOSPHORUS INSECTICIDES RELEASED BY AMERICAN CYANAMID, 1973-1978, AT THE 106-MILE SITE

(Metric Tons)

Constituent	Description	1973	1974	1975	1976	1977	1978
Malathion	General Insecticide	188	183	13	39	117	10
Thimet®	Systemic Insecticide	92	133	12	34	73	11
Counter®	Soil Insecticide	0	0	2	37	28	3
Abate®	Manufacturing Concentrate Insecticide	0	0	0	0	14	0
Cytrolane®	Technical Systemic Insecticide	15	9	0	18	3	3
Cygon®	Systemic Insecticide	73	54	12	0	2	0
Cyolane®	Technical Systemic Insecticide	0	0	0	0	0	1

The waste plume movements following the dump were estimated from the movements of "window shade" current drogues and from the fluorometer readings. In general, the plume moved in a semicircular path, returning to the starting position after about 20 hours. American Cyanamid waste remained in the upper few meters of the water column.

Hydroscience, Inc. (1978e, 1978f, 1979c) studied the dilution of the American Cyanamid waste in several seasonal surveys. Comparison of undiluted waste concentrations and post-dump concentrations 4 hours following the dump indicated minimum dilutions of approximately 25,000:1 in May, 14,000:1 in July, and 9,200:1 in October. Hydroscience (1978f) also studied the dispersion of the waste in July 1978, using Rhodamine WT dye. The maximum distance that the plume traveled from the dump location was 675 meters within 4 hours. At this point, the concentration of the waste was near detection limits.

MERCK AND COMPANY

Merck's aqueous waste is generated in the manufacture of thiabendazole, a pharmaceutical product. Previous discussion in this Appendix included Merck among the mixed industrial wastes permittees.

Merck is authorized to dispose of approximately 36,288 metric tons annually. Disposal is accomplished by subsurface release of the waste at a rate not exceeding 378,000 liters (100,000 gallons) per nautical mile. This rate permits complete offloading of an average barge load of 5.7 million liters in approximately 6 hours (assuming a towing speed of 6 knots), over a linear distance of approximately 38 nautical miles.

The six major trace metals present in the Merck waste are, in order of decreasing input volume: nickel, lead, vanadium, beryllium, chromium and cadmium.

Toxicity

Bioassay tests which have been conducted on mixed industrial wastes between 1973 and 1977 with brine shrimp (*Artemia salina*) yielded 48-hour TL_{50} values of 1,525 ppm to 100,000 ppm. Bioassays conducted since 1977 with Atlantic silversides (*Menidia menidia*) give 96-hour TL_{50} values that range between 650 ppm and 100,000 ppm for aerated tests, and between 150 ppm and 100,000 ppm for non-aerated tests. Bioassays on diatoms (*Skeletonema costatum*) produce 96-hour EC_{50} values between 65 ppm and 12,000 ppm. Tests with copepods (*Acartia tonsa*) yield 96-hour TL_{50} bioassay values that vary between 29.7 ppm and 5,300 ppm. Some of the observed variation may be due to the differences in the character of the individual barge loads.

Dilution and Dispersion

Hydroscience, Inc. (1978g) performed the dilution study in May 1978 for the mixed industrial waste generated by Merck and Reheis Chemical. Based on comparisons between the concentrations of aluminum and carbon in the barge wastes and the concentrations of these same parameters found in the seawater samples collected after 4 hours following the disposal, minimum dilution factors of 20,000:1 and 52,000:1 were observed. A July 1978 survey yielded a minimum dilution at 4 hours of 150,000:1; the plume was barely detectable at 1,000 m from the site of release. An October survey also yielded a minimum dilution of 150,000:1 after 4 hours (Hydroscience, 1979d).

APPENDIX C

CONTENTS

TABLES

Appendix C

MONITORING

The Final EPA Ocean Dumping Regulations and Criteria (40 CFR 220 to 229) discusses monitoring requirements (Section 228.9):

(a) The monitoring program, if deemed necessary by the Regional Administrator or the District Engineer, as appropriate, may include baseline or trend assessment surveys by EPA, NOAA, other Federal agencies, or contractors, special studies by permittees, and the analysis and interpretation of data from remote or automatic sampling and/or sensing devices. The primary purpose of the monitoring program is to evaluate the impact of disposal on the marine environment by referencing the monitoring results to a set of baseline conditions. When disposal sites are being used on a continuing basis, such programs may consist of the following components;

(1) Trend assessment surveys conducted at intervals frequent enough to assess the extent and trends of environmental impact. Until survey data or other information are adequate to show that changes in frequency or scope are necessary or desirable, trend assessment and baseline surveys should generally conform to the applicable requirements of Section 228.13. These surveys shall be the responsibility of the Federal government.

(2) Special studies conducted by the permittee to identify immediate and short-term impacts of disposal operations.

(b) These surveys may be supplemented, where feasible and useful, by data collected from the use of automatic sampling buoys, satellites or in situ platforms, and from experimental programs.

(c) EPA will require the full participation of other Federal and State and local agencies in the development and implementation of disposal site monitoring programs. The monitoring and research programs presently supported by permittees may be incorporated into the overall monitoring program insofar as feasible.

Further in Section 228.10, the Ocean Dumping Regulations delineate specific types of effects upon which monitoring programs must be built:

(a) Movement of materials into estuaries or marine sanctuaries, or into oceanfront beaches, or shorelines;

(b) Movement of materials toward productive fishery or shellfishery areas;

(c) Absence from the disposal site of pollution-sensitive biota characteristic of the general area;

(d) Progressive, non-seasonal, changes in water quality or sediment composition at the disposal site, when these changes are attributable to materials disposed of at the site;

(e) Progressive, non-seasonal, changes in composition or numbers of pelagic, demersal, or benthic biota at or near the disposal site, when these changes can be attributed to the effects of materials disposed of at the site;

(f) Accumulation of material constituents (including without limitation, human pathogens) in marine biota at or near the site.

Thus, the regulations identify two broad areas which must be taken into account in monitoring:

(a) Short-term or acute effects immediately observable and monitored at the time of disposal and before disposal for the waste itself.

(b) Long-term or progressive effects measurable only over a period of years and indicated by subtle changes in selected characteristics over time.

SHORT-TERM MONITORING

The permit program administered by EPA Region II has provided the means for monitoring immediate effects of disposal. The program acts as an important check on the variable chemical characteristics of the waste, the biological influence as measured by bioassays and the cumulative totals of known potential toxicants (See Appendix B, Tables B-5, B-6, and B-7.) This program provides information about the environment at the time of disposal and the dispersion and dilution of the wastes under varying oceanographic conditions. Table D-1 summarizes the parameters measured at sea for each permittee.

In 1978, three seasonal surveys were made at the Site:

- May - no upper thermocline
- July - strong upper thermocline (28 m)
- October - weak upper thermocline (68 m)

A dye dispersion study was made for each waste type during the July survey (see Appendix B, page B-13, for results). For each survey a drogue was set at the thermocline, in the waste plume, where the wastes are expected to accumulate. Samples were taken at 4-, 6-, 8-, and 10-hour intervals at various depths (Table C-1). Two stations were sampled immediately prior to the waste release to establish the background levels. Samples from the barge were also analyzed for the same parameters so that minimum dilution factors could be calculated.

This program will be continued as one of the permit requirements. The sampling program is the minimum design sufficient to detect changes resulting from the disposal of these chemical wastes. The effects documented at the Site are transitory (see Appendix B), and have not caused long-term measurable damage to populations of organisms indigenous to the Site or adjacent areas. This sampling program periodically confirms that the wastes are diluted well below the chronic "no effect" concentrations (as determined by the monthly bioassays) within the allowable short period of initial mixing.

The physical and chemical variables monitored were chosen based on the composition of the wastes and the possible effects of waste discharge. Water column sampling is adequate to detect unusual, adverse effects of disposal; benthic samples are not required since the wastes apparently do not penetrate the thermocline and would not reach the bottom in measurable amounts at this deep site. Therefore, no changes to the existing permittee monitoring program are recommended.

TABLE C-1. SHORT-TERM MONITORING REQUIREMENTS

Permittee	Parameter to be Monitored
General	
All Dumpers	Temperature Dissolved oxygen to 100 m Conductivity pH Chlorophyll a Total mercury 1, 15, 30 m Total cadmium Total organic carbon Secchi disk to extinction point
Special	
Merck	Sulfonate
DuPont-Grasselli	Phenol Total Kjeldahl nitrogen
DuPont-Edge Moor	Total iron Total vanadium
American Cyanamid	Pesticides in the waste at the time of the dump

LONG-TERM MONITORING

As discussed in Chapter 3 and Appendix B, an extensive research effort has been directed at determining the fate of wastes released at the 106-Mile Site. Yet, there are many aspects of waste disposal at this site which are poorly understood and which must be refined before a meaningful trend assessment and long-term monitoring program can be finalized. Studies must provide further information on the following factors:

- The penetration of seasonal and permanent thermoclines by different wastes.
- The fractionation of wastes in the water column and the association of potentially toxic substances with different fractions.

- The fate of wastes related to Gulf Stream eddies and general current patterns.
- The refinement and selection as monitoring tools of acoustical tracking, dye or trace metal dispersion data, and organic markers (methyl sulfate).

Studies on these and other important aspects of monitoring at the 106-Mile Site are part of a continuing effort of NOAA's Ocean Dumping Program (National Ocean Survey), supplemented by permittee-supported work.

Further impetus to a formal monitoring program has been given by the passage of PL 95-273, which calls for NOAA to develop a five-year plan for ocean pollution resea ch and monitoring. On a broader scale of time and space, the "Ocean Pulse" program of the National Marine Fisheries Service should also provide valuable monitoring data. Thus, long range monitoring and trend assessment of waste disposal in complex deep oceanic regions like the 106-Mile Site are feasible only through the combined resources of several agencies under the upcoming NOAA five-year plan.

APPENDIX D

CONTENTS

Appendix D

CHAPTER III, FINAL EIS ON OCEAN DUMPING OF SEWAGE SLUDGE IN THE NEW YORK BIGHT

This Appendix is Chapter III of the Final Environmental Impact Statement on sewage sludge dumping in the New York Bight (EPA, 1978).

It is reproduced here to document the earlier considerations of using the 106-Mile Site as an alternate sewage sludge site. Included are discussions on land-based alternatives to ocean dumping of sewage sludge.

ALTERNATIVES TO THE PROPOSED ACTION

Alternatives to the proposed action considered in this EIS fall into two categories. other ocean-dumping alternatives (short-term) and land-based sludge disposal alternatives (long-term).

Since implementation of land-based disposal methods in the metropolitan area is still some years off, a suitable interim ocean dumping alternative is needed. In addition to the proposed action, the ocean-dumping alternatives are.

— Continued use of the existing dump site (No Action or Phased Action),
— Use of an alternate dump site other than the Northern or Southern Area, including sites off the continental shelf, and
— Modification of dumping methods to mitigate potential marine and shoreward impacts.

The land-based sludge disposal alternatives are:

— Direct land application,
— Incineration,
— Pyrolysis, and
— Use as a soil conditioner.

These land-based alternatives have been studied by the Interstate Sanitation Commission (ISC) under a grant from EPA. The ISC sludge disposal management program was issued in October 1976. Since that time, EPA has awarded grants to most of the ocean dumping permittees for specific studies of land-based sludge management alternatives within their geographic areas. The EPA has also placed a condition on the ocean dumping permits issued in August 1976, requiring that ocean dumping be phased out by December 31, 1981. This phase-out date was legislatively mandated in November 1977, by amendment to the Marine Protection Research and Sanctuaries Act of 1972.

Alternatives to the proposed action are discussed in Chapter III.

CHAPTER III

ALTERNATIVES TO THE PROPOSED ACTION

Generally, sewage sludge can be either dumped in the ocean or disposed of by land-based methods. The latter constitute the only legitimate long-range solution to the New York-New Jersey metropolitan area's sludge disposal problem, and they will have to be implemented as ocean dumping is phased out. The background studies for land-based sludge disposal management in the metropolitan area were completed by ISC in 1976. The testing and implementation phases have begun. Current predictions are that land-based sludge disposal methods can be implemented in time to meet the December 31, 1981 deadline for phasing out ocean dumping of sewage sludge.

Until this full-scale, land-based sludge disposal program can be implemented, however, ocean dumping will continue to be the only practical method of disposing of the volumes of sludge produced in the metropolitan area. Within the ocean-dumping alternative, options are available with regard to where the sludge is dumped and how it is dumped. The proposed action, immediate designation and use of an alternate dump site in either the Northern or Southern Area is described in detail in Chapter IV. Chapter III discusses the other ocean-dumping alternatives and summarizes the results of the ISC studies of land-based sludge disposal methods.

OCEAN-DUMPING ALTERNATIVES

In addition to the proposed action, the ocean-dumping alternatives considered in this EIS are: 1) continued use of the existing dump site (No Action and Phased Action), 2) use of an alternate dump site other than the Northern or Southern Area, and 3) modification of dumping methods to mitigate potential marine and shoreward impacts. The phasing out of ocean dumping by the end of 1981 would not be compromised under any of these alternatives.

Continued Use of the Existing Dump Site

The No Action alternative involves continued use of the existing dump site until land-based methods of sludge disposal can be implemented. Under this alternative, the existing dump site would have to accommodate in 1981 more than one and a half times the volume of sludge dumped in 1977; moreover, the site would have to accommodate the increased volume without endangering public health or the marine environment. The primary argument for the No Action alternative is that it limits environmental impacts to the existing site rather than spreading them to another area of the marine environment.

The original argument for moving the sewage sludge dump site was that greatly increased volumes of sludge might impair the recreational quality of Long Island and New Jersey's beaches. As discussed below, current studies tend to show that this argument is largely invalid, lending support to the No Action alternative.

A variation on the No Action alternative is the Phased Action alternative, under which sewage sludge would continue to be dumped at the existing site until a comprehensive monitoring program indicated an impending hazard to public health or damage to recreational water quality. Under the phased alternative, an alternate dump site would have to be designated and held in reserve for possible future use. Since this alternative would maximize use of the existing dump site, adverse impacts on an alternate dump site would be minimized, and sludge hauling costs would not be increased unnecessarily.

This was the alternative recommended in the draft EIS. However, when the fish kill and beach closure incidents discussed in Chapter II occurred, doubts were raised about the acceptability of continuing to use the existing dump site. Studies of the fish kill and beach closure incidents found that sludge dumping was at most a minor contributing factor. Those findings were reconfirmed at a public hearing held in Toms River, New Jersey, on May 31 and June 1, 1977, to consider possible relocation of the New York and Philadelphia sewage sludge dump sites. On the basis of the evidence presented, the hearing officer recommended that neither dump site be moved.

With specific reference to sludge dumping in the New York-New Jersey metropolitan area, the hearing officer also recommended. 1) strict enforcement of existing phase-out schedules and deadlines, 2) inclusion in the sludge dumping EIS being prepared by EPA-Region II of specific criteria for determining the need for relocation of the dump site, 3) intensified monitoring of the existing dump site, and 4) immediate designation of the alternate 60-mile site (this would be the site in the Northern Area recommended in the draft EIS). The report of the Toms River hearing officer, which was issued on September 22, 1977, is presented in Appendix C

On March 1, 1978, the EPA's Assistant Administrator for Water and Hazardous Materials issued his decision on proposals to relocate the New York and Philadelphia sewage sludge dump sites. The decision report is presented in Appendix D. In all important respects, the Assistant Administrator's decision is in agreement with the findings, conclusions, and recommendations of the Toms River hearing officer:

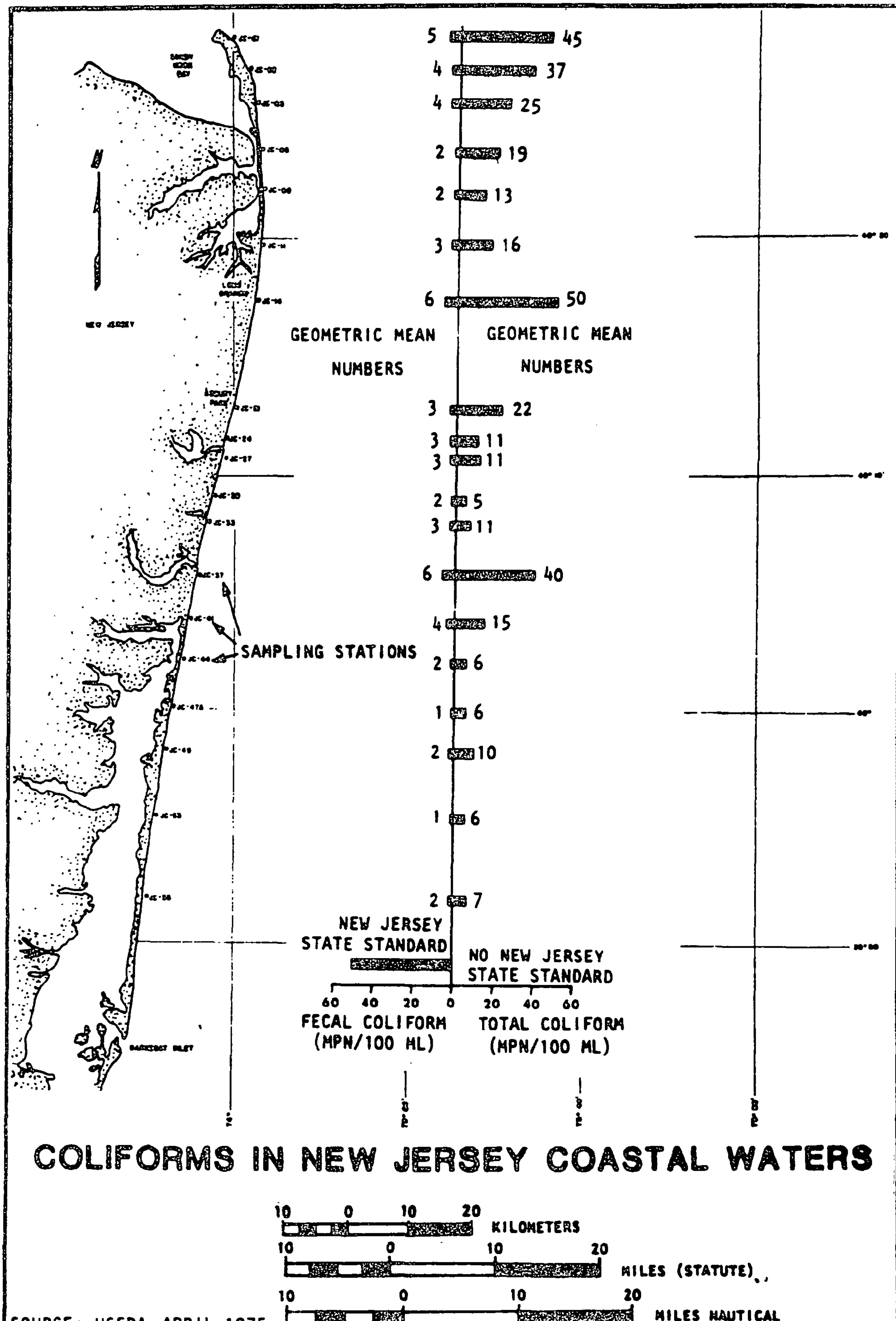
> It is my determination that sewage sludge dumping by these municipalities [in the New York-New Jersey metropolitan area] should not be relocated at the present time; however, efforts should begin immediately to designate the 60-mile site for the disposal of New York/New Jersey sewage sludge in the event such sludge cannot be dumped at the New York Bight site for public health reasons prior to December 31, 1981

In accordance with this decision, EPA intends to designate the existing site for continued use, as well as the 60-mile site in the Northern Area for possible future use. An intensified monitoring program has already been implemented; it is described in detail in the Monitoring and Surveillance section of Chapter XI. Criteria that can be used to determine whether public health reasons require moving sludge dumping operations from the existing to the alternate site at any time between now and December 31, 1981 have been drawn up by EPA-Region II, and are presented in Appendix E. Finally, a Regional Enforcement Strategy, designed to insure that ocean dumping of sewage sludge is replaced by environmentally acceptable land-based disposal methods by the legislatively mandated deadline of December 31, 1981, has been developed by EPA-Region II, and is presented in Appendix F.

EPA Monitoring Studies. In April 1974, EPA initiated a program to investigate the quality of the water and bottom sediments in the New York Bight and along the Long Island and New Jersey beaches (USEPA, July 1974, April 1975) Data from the surf and near-shore waters indicate that water quality remains excellent in terms of total and fecal coliform density, and that it is acceptable for contact recreation (Figures 8 and 9) Although the data show a few random elevated coliform counts, no violation of state standards is indicated nor does there appear to be any systematic degradation of water quality. Sediment data indicate slightly elevated bacterial counts at certain near-shore sampling stations, but these can be attributed to inland runoff or to wastewater outfalls.

Sampling is continuing along transects between the existing dump site and the following points: the Long Island shore, the entrance to New York Harbor, and the New Jersey shore. Results to date indicate that a clean water and sediment zone, about 10 to 11 km (5.5 to 6 n mi) wide, separates the area affected by sludge from the Long Island coast. As a supplement to the sampling program, EPA has expanded the monitoring and review process to insure protection of public health and welfare and prevention of coastal water quality degradation (see the Monitoring and Surveillance section of Chapter XI).

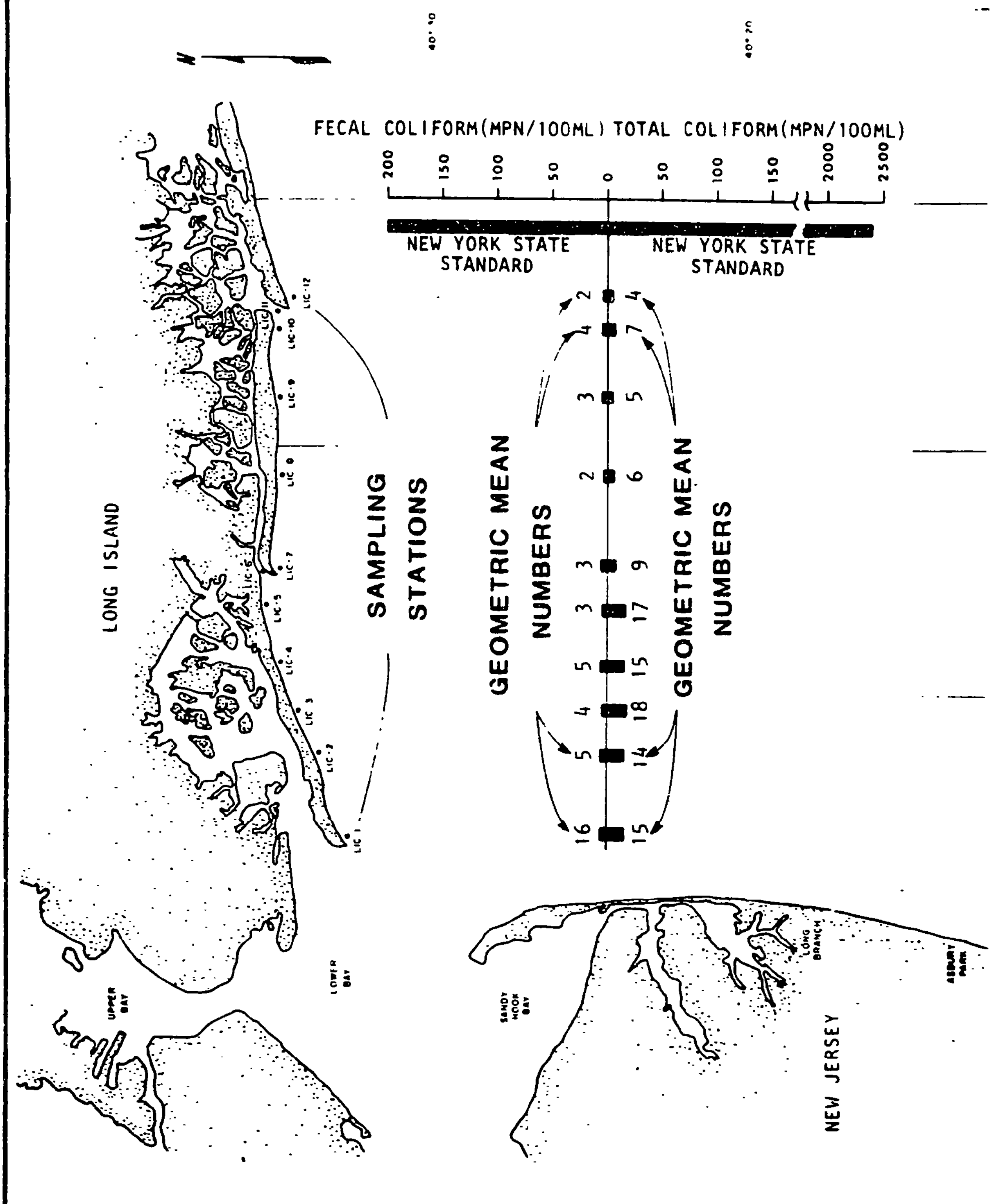
NOAA-MESA Studies. On the basis of two comprehensive reports prepared by NOAA-MESA (March 1975, February 1976), there seems to be no significant accumulation of sewage sludge at the existing dump site, although some sludge particles may be mixing with natural fines in the Christiansen Basin, northwest of



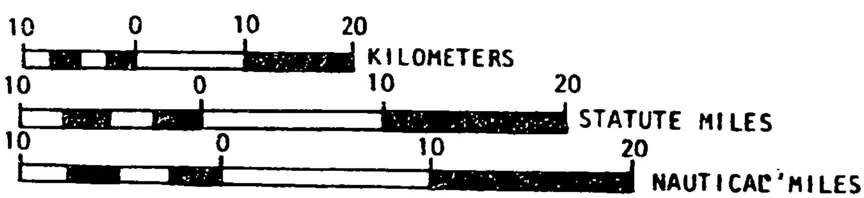
COLIFORMS IN NEW JERSEY COASTAL WATERS

SOURCE: USEPA, APRIL 1975.

FIGURE 8



COLIFORMS IN LONG ISLAND COASTAL WATERS



SOURCE: USEPA, APRIL 1975.

FIGURE 9

the site. Both reports also note that the general ecological effects of sewage sludge dumping are indistinguishable from those associated with other sources of pollutants in the Bight Apex (the dumping of dredged material and acid wastes, contaminants from the plume of the Hudson estuary, shore-zone pollutant contributions, and atmospheric fallout of contaminants).

However, sludge dumping does exert significant local effects. The catch of groundfish appears to be reduced in areas with high-carbon sediments, such as the area of the existing sludge dump site. Furthermore, it is apparent that very few surf clams reach commercial size within the area now impacted by sludge dumping. Although some fish in the Bight Apex are afflicted with fin rot, this disease is not thought to be attributable solely or even primarily to sludge dumping.

The NOAA-MESA reports do not indicate any shoreward movement of coliform contamination as a result of sludge dumping at the existing site, but they do note the apparent persistence of coliform bacteria in the vicinity, especially in bottom sediments There is no evidence that under current FDA regulations the cessation of sewage sludge dumping at the existing site would permit reopening of the immediate area to shellfishing. The complete text of NOAA-MESA's conclusions and recommendations from the February 1976 report is presented in Appendix G.

At the Toms River hearing in 1977, NOAA concurred with EPA's recommendation of continued use of the existing dump site based on the fact that there is no demonstrated need for relocation (see Appendix C)

Related Studies. The most recent study of the area (Mueller *et al.*, 1976) indicates that sludge dumping accounts for 0.04 to 11 percent, at most, of the total pollutant loading in the Bight Apex; pollutant loadings from non-dumping sources (wastewater discharges, runoff, and atmospheric fallout) far outweigh those from all current ocean-dumping sources (sewage sludge, dredged material, acid wastes, and cellar dirt).

A study by the Town of Hempstead (1974) supports the conclusion that sewage sludge dumped at the existing site does not significantly affect the quality of the waters or beaches of Long Island.

Use of an Alternate Dump Site Other Than the Northern or Southern Area

Besides the Northern and Southern Areas, possible locations for an alternate sewage sludge dump site include: the other existing dump sites in the Bight Apex (the dredged material, acid wastes, cellar dirt, and wreck sites); other areas in the New York Bight; and areas off the continental shelf, notably the chemical wastes dump site. These locations are discussed below

Other Existing Dump Sites in the Bight Apex. Dumping sewage sludge at one of the other existing sites in the Bight Apex (the dredged material, acid wastes, cellar dirt, or wreck site) would violate the original concept of segregating wastes by dump site It would be extremely difficult to isolate the true cause of adverse environmental effects at a site where two or more types of wastes were dumped The end result would probably be several seriously contaminated dump sites in the Bight Apex, instead of the two that now exist (the sewage sludge and dredged material sites) Use of the existing dredged material site for sludge dumping would be particularly ill-advised because the site is only about 9 km (5 n mi) from the New Jersey shore; the existing sludge dump site is about 20 km (11 n mi) offshore.

Other Areas in the New York Bight. Solely in terms of minimizing potential environmental impacts, a site located offshore, 148 to 158 km (80 to 85 n mi) from the Sandy Hook-Rockaway Point transect, and within the depression of the Long Island Shelf Valley, about 80 m (264 ft) deep, would be preferable. In this area, the tendency is towards bottom transport off the continental shelf, which would minimize the potential for sludge transport to adjacent biological resource areas, including the Hudson Shelf Valley and near-shore shellfisheries. In addition, the greater depth would provide maximum dilution and dispersion of the sludge, minimizing any adverse effects.

The one major drawback to use of this area is that it is beyond the maximum 120 km (65 n mi) range of the existing barge fleet. It would be difficult to justify the greatly increased costs of transportation and possible fleet capitalization in terms of concomitant benefits. Benefits to public health would not increase proportionally with distance. Both the Northern and Southern Areas appear to be far enough from the Long

Island and New Jersey coasts, and in deep enough water, to minimize potential impacts on public health and marine life.

Areas Off the Continental Shelf. In the draft EIS, the alternative of dumping sewage sludge in areas off the continental shelf, such as at the existing chemical wastes dump site, was quickly dismissed because of the prohibitive transportation costs and because of the unknown effects of dumping sewage sludge in those waters. Developments since that time, the 1976 fish kill and beach closure incidents (see Chapter II) and the 1977 public hearing on possible relocation of sludge dump sites (see Appendices C and D), have indicated the need for a more extensive evaluation of this alternative.

The decision report issued by EPA-Headquarters on proposals to relocate the New York and Philadelphia sewage sludge dump sites specifies six major factors that must be considered in determining the feasibility of using an off-the-shelf site for sewage sludge disposal: known environmental acceptability, ability to monitor impact, surveillance of dumping activities, economic burden, logistics, and the effect of utilizing such a site on the ability of dumpers to meet the December 31, 1981 deadline for the termination of harmful sewage sludge dumping (Appendix D). Briefly, the chemical wastes site does not appear favorable on any of these six counts. The environmental acceptability of dumping sewage sludge there is unknown, and scientific opinion by and large recommends against use of this site for sludge dumping. Monitoring and surveillance capabilities are substantially reduced, primarily because of the great distance to the chemical wastes site. Distance is also the primary factor in making the chemical wastes site economically and logistically disadvantageous. The prohibitive cost in turn diminishes the ability of dumpers to meet the 1981 deadline by diverting the available economic resources from the development of acceptable land-based disposal methods. Each of these factors is explored in more detail below.

Environmental Acceptability – Although the MPRSA recommends that the dumping of wastes be done in areas off the continental shelf, *wherever feasible*, the limited information available on this area suggests otherwise. At a 1971 ocean disposal conference, cosponsored by the Woods Hole Oceanographic Institution (WHOI) and the COE, the panel on biological effects stated:

> Disposal should not occur in the deep sea, i.e beyond the continental shelf. A fundamental reason for this suggestion is the following. The deep sea is an area where biological decomposition rates are apparently very low in comparison with other ocean regions. It is an area of great constancy with respect to the physical-chemical environment and it is thought that the fauna living there is finely tuned to small environmental changes. Thus, the fauna may be quite susceptible to large environmental perturbations such as might be expected with the introduction of dredge spoils. If deleterious effects occur in the deep sea, the opportunities to alter the course of events is [sic] minimal. We therefore suggest that the deep sea should be off limits for disposal activities at least until other information is brought to bear which would render the possible dangers non-existent. (WHOI, 1971).

A similar view was expressed at a 1974 workshop at Woods Hole, sponsored by the National Academy of Sciences (NAS):

> Data for the evaluation of the deep sea as a disposal site are inadequate. This is due to: difficulties in conducting bioassays; slow rates of mixing and diffusion potentially resulting in anaerobic conditions; slow organic degradation; and narrow tolerance ranges for sensitive assemblages of organisms. Although the area is relatively stable in comparison to the shelf and nearshore, the much greater scientific uncertainty, and consequently increased risk associated with off-shelf disposal, dictate that any but the most innocuous use of the area should be approached with extreme caution. (NAS, 1976).

In 1974, NOAA, in cooperation with EPA and with several academic/research institutions, began gathering background information on conditions at the chemical wastes site. Three baseline survey cruises (1974, 1975, and 1976) and several field studies (February, June, August, and September 1976; July 1977; and February and April 1978) have been conducted. A report on the baseline survey cruises has been published (NOAA, June 1977); the Introduction and Summary from that report, which deals with the chemical wastes site's physical, biological, and chemical characteristics and its contaminant inputs, are presented in Appendix H.

The chemical wastes site has been in use since 1965. Therefore, at the time of NOAA's first baseline survey cruise, the site had been in use for about nine years, making it impossible for NOAA to obtain a pure pre-dumping baseline. Most of the data gathered by NOAA concern chemical wastes dumping by American Cyanamid and by DuPont's Grasselli Plant since these two companies accounted for 80 percent of the total volume of material dumped at the chemical wastes site. The applicability of these data to an assessment of sewage sludge dumping at the chemical wastes site is limited because particulate sewage sludge bears little resemblance to dissolved chemical wastes.

After EPA authorized the dumping of sewage sludge from Camden, New Jersey, at the chemical wastes site in early 1977, NOAA began making plans to study the possible effects. That opportunity to study the possible effects of sewage sludge dumping at the chemical wastes site ended on June 12, 1978, when Camden terminated its ocean dumping operations, a few days short of the expiration of its permit. Camden now disposes of its sludge through a composting process that is described later in this chapter (see the section on Land-Based Alternatives).

While Camden was using the chemical wastes site, NOAA conducted a coliform test and a tracking study. Although data collection and analysis are in a preliminary stage, some information on sludge dumping at the chemical wastes site has been furnished by NOAA.

In June 1977, researchers from WHOI collected samples of seawater during, and for some time after, the release of primary sewage sludge from Camden, New Jersey. The samples were tested for the presence of total and fecal coliform bacteria:

> Positive results were limited to the first hour of surface sampling from within the plume area. Regarding total coliforms, 75 percent of the samples collected proved positive and gave a most probable number range of 1-240 total cells per 100 ml. Measurements on these same samples for fecal coliforms were positive at the 25 percent level and provided a range of 1-120 cells per 100 ml.
>
> No positive results from either test were obtained from any of the subsurface samples. Possibly these results might have differed given the opportunity for continuous sampling over the entire plume. However, the necessary gear was not available at this time and we had to rely on a stationary ship to acquire water samples from beneath the surface.
>
> There are strong indications that the bacterial population associated with sewage sludge is rapidly dispersed by the turbulence and sinking associated with sludge release. Most of the bacterial load appears to remain associated with solid material which rapidly descends to the deeper portions of the water column where a positive sampling becomes highly dubious (Vaccaro and Dennet, 1977).

In July 1977, sewage sludge released at the chemical wastes site was acoustically monitored to determine its qualitative dispersion characteristics. Preliminary results of the tracking study show a slow, wide distribution of the waste material:

> A sharp thermal gradient ($\approx$1°C/m) existed between 18 and 24 m. The waste field on either side of the dump axis was observed to be distributed through the first 18 m of the water column. On the dump axis, the waste was observed to penetrate to a depth of 60 m. The deeper penetration was of limited horizontal extent, conical in shape (apex at the point of deepest penetration), and was distributed continuously from near the surface to the 60 m depth. The heaviest particle concentration appeared to be in the first 40 m of the water column. A shear with a velocity maximum between 15 and 20 m advected the waste field in the horizontal. Thus, the waste was slowly distributed over an increasing area as material sank from the mixed layer to the seasonal thermocline. During the 32 hr experimental period, the particle field became distributed over the first 45 m of the water column. The distribution was not uniform. Heavy concentrations of backscattering, hence particles were found to be associated with one or two strong thermal gradients [sic]. The thickness of the heavy scattering areas ranged from 5 to 10 m. The layers were periodically displaced by as much as 15 m by the internal wave field. The horizontal distribution of the waste field will be determined as our data reduction progresses. The column of material which penetrated to 60 m was observed several hours after the dump. There appeared to be little change in its depth of penetration or size. (Orr, unpub.).

Although increased dilution and dispersion are generally considered to be positive aspects of dumping in deeper waters, there are serious drawbacks as well. In testimony at the Toms River hearing in 1977, Dr. Carol Litchfield, a marine microbiologist, cautioned that moving the dump site to deeper waters would significantly increase the time required for sludge decomposition:

> The very factor which is appealing to many people in moving and relocation of the dump site in the deeper waters is the very factor which is going to assure that there will be a longer residence time of the sludge and a greater accumulation of the material that is dumped
>
> Another concern. .is what happens to the organisms that are introduced along with the sewage sludge.
>
> Unfortunately, there is very little information on the survival of coliforms in deeper waters.
>
> It has been repeatedly shown, however, that decreased temperatures aid the survival of coliform bacteria in the increased salinities and slightly increased pressures that they would encounter at the deeper dump site, therefore, automatically assuming that deeper waters will "take care of" potential pathogens more efficiently than that which occurs at the present location, could lead to a very false sense of security.
>
> In summary, based solely upon the scientific data available through numerous other studies we know that only about ten percent of the problem would be relieved by moving of the dump site.
>
> This would probably have little positive effect on decreasing the survival of potentially pathogenic micro-organisms, and would definitely result in slower decomposition, and hence, greater accumulation of the dumped organic matters (in USEPA, June 1, 1977; see also Appendix C).

Another point that must be considered is the unknown consequences of dumping sewage sludge and chemical wastes at the same site. As previously mentioned, combining different types of wastes at one dump site makes it extremely difficult to isolate the true cause of any adverse environmental effects. This would be an especially difficult problem at the chemical wastes site because the effects of chemical wastes dumping alone are not yet well understood:

> The chemical behavior of the substances discharged at DWD-106 [the chemical wastes site] and their impact on the marine environment are unknown A research group consisting of investigators from Woods Hole Oceanographic Institution, University of Rhode Island, National Marine Fisheries Service, and the Smithsonian Institution have developed a multidisciplinary oceanographic study at DWD-106 to consider the physical, biological, and chemical factors associated with dumping of chemical wastes The primary chemical questions to be considered in this program are:
>
> 1. Does the discharge of wastes at DWD-106 produce elevated concentrations of potentially toxic metals in the seawater?
> 2. What are the horizontal and vertical extents of chemical impact at the dumpsite?
> 3. What are the chemical forms of metals which may be toxic to marine organisms?
> 4. To what extent are the metals discharged at DWD-106 taken up by organisms, suspended particles, and seafloor sediments?
>
> Answers to these questions will provide a basis for evaluating the consequences of chemical waste disposal at DWD-106 and for designing a future monitoring program to assure that this ocean dumping does not materially degrade the quality of the marine environment. (Hausknecht and Kester, December 1976).

Despite the limited information available on the chemical wastes site, it has been suggested as an alternate sewage sludge dump site. The hope of avoiding a recurrence of the fish kill and beach closure incidents discussed in Chapter II is the reason most often cited for this suggested move. However, as reported in Chapter II, results of the studies of the fish kill and beach closures have shown that both incidents were basically the result of atypical atmospheric and hydrographic conditions, and that sludge dumping was at most a minor contributing factor. Therefore, moving the sludge dumping operations to the chemical wastes site would have no value as a preventive measure.

During its investigation of the fish kill and beach closures, EPA-Region II sought the opinion of other federal and state agencies about the relationship of sludge dumping to these incidents. Specifically, EPA-Region II asked NOAA, the USCG, FDA, ISC, the Fish and Wildlife Service, the New York State Department of Environmental Conservation (NYSDEC), and NJDEP whether they thought sludge dumping was responsible for the incidents and whether they would recommend relocation of the dump site:

> In that during this past spring and summer, there have been several environmental episodes, mainly the wash-up of floatables and trash on Long Island and New Jersey beaches, an extensive kill of benthic organisms in the New York Bight, and considerable press and political pressure to associate dumping practices as a direct cause of these episodes, we would appreciate your comments regarding the following:
>
> 1. Does your Agency believe that dumping is the direct cause of these episodes? If so, do you have any technical evidence to support this claim?
>
> 2. Do you maintain, as you have indicated in the past, the position that sludge dumping at the existing site should be continued? If not, what would be your position on moving to either of the two sites studied by NOAA and located roughly 60 miles offshore? What would be your opinion of moving the dump site off the Continental Shelf to the present chemical wastes site? If you believe that the dump site, on the basis of the recent incidents, should be relocated, what environmental factors do you consider appropriate in that decision? (See Appendix I.)

In general, there was a lack of enthusiasm for any move from the existing dump site. Only one agency, NJDEP, favored relocation; it recommended a gradual shift to the chemical wastes dump site, but only after a thorough evaluation of the potential impacts in accordance with NEPA. Copies of the individual responses can be found in Appendix I.

At the Toms River hearing in 1977, NJDEP restated its recommendation for a gradual shift to the chemical wastes site after a thorough environmental assessment of the consequences. At the same time, NOAA slightly modified its position. In general, NOAA continues to strongly recommend against any move from the existing dump site based on the fact that there is no demonstrated need for such a move. Nevertheless, if an alternate site must be chosen, NOAA would prefer the chemical wastes site to a site in either the Northern or Southern Area. However, NOAA's acceptance of the chemical wastes site as an alternate sludge dump site is conditioned on the demonstration that "the net adverse environmental effects are (or are likely to be) less as a result of dumping the material at DWD-106 [the chemical wastes site] than at the original dump site." (in USEPA, May 31, 1977).

After reviewing all of the testimony submitted at the Toms River hearing in 1977, the hearing officer briefly recounted the reasons why sludge dumping at the chemical wastes site would be environmentally unacceptable:

> The preponderance of informed scientific opinion urges extreme caution in dumping wastes in the deep ocean, particularly wastes containing solid materials, because of the many unknowns about this part of the environment. There is a strong feeling among marine scientists that it would be possible to start long-range trends which would be undetectable until it was too late to take corrective measures
>
> Specific concerns with the dumping of sewage sludge in the deep ocean are the possible persistence of pathogens for long periods of time, the accumulation of biodegradable materials which could ultimately float up undecayed to contaminate seas and beaches, the development of anaerobic deep sea environments, and the damage to deep sea organisms which are used to extremely stable conditions.
>
> Based on this informed scientific opinion, it is concluded that dumping of sewage sludge at the 106-mile site [the chemical wastes site] has a potential for irreversible, long-range, and therefore unreasonable degradation of the marine environment, and that the use of this site for this purpose would be contrary to the intent of the Act [the MPRSA] and the Convention [the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter]. (See Appendix C.)

Monitoring and Surveillance – Although precise information is not available, indications are that both monitoring and surveillance of sewage sludge dumping at the chemical wastes site would be more difficult, far more expensive, and perhaps less reliable than at the existing site. As NOAA observed in its baseline survey report on the chemical wastes site, monitoring is far more complicated at off-the-shelf sites:

> The environmental effects of disposal in deeper waters are. .more difficult to measure and, hence, to predict. This is due to factors such as greater depths of water and distances from shore and also to the general paucity of environmental and biological information in off-the-shelf areas. In the case of DWD-106 [the chemical wastes site] this situation is further complicated by the interactions of major water masses, Shelf Water, Slope Water, and Gulf Stream eddies. The DWD-106 is a complex oceanographic area in which to assess natural environmental conditions and the impact of man's activities upon those conditions (NOAA, June 1977; see Appendix H).

In testimony at the Toms River hearing, Kenneth Kamlet, representing the National Wildlife Federation, expressed serious doubts about the feasibility of monitoring sludge dumping operations at the chemical wastes site:

> Relocation of sludge dumping to the 106-site [the chemical wastes site] would essentially deny the opportunity to monitor the situation and render it vitually impossible to alter the course of events should corrective action be necessary.
>
> This is a frequently cited concern. For example, at the EPA workshop on "Evaluation of Ocean Dumping Criteria" convened at Airlie House, August 31 - September 1, 1973, a group chaired by Dr. Edward D. Goldberg, and including among others, Drs. Dean F. Bumpus, Gilbert T. Rowe, and David Menzel, concluded that, although off-Shelf dumpsite locations "would be amenable to mixing of liquids, it is not possible to predict the effect and fate of solids at great depths and it would be difficult to monitor their effects." Dr. Holger Jannasch has pointed out that "the feasibility of short-term studies (on deep-sea biodegradation) is very limited," and that, for this and other reasons, "it will probably be difficult or impossible "to show" — not because there will be no harm.. " (but because) (s)cientific evidence for or against such an effect will be very difficult to obtain" (in USEPA, May 31, 1977).

In connection with the Toms River hearing, NOAA was asked by the hearing officer to provide information on the feasibility of developing a program to monitor the effects of sludge dumping at the chemical wastes site. In reply, NOAA stated that such a program would be possible but also very expensive:

> The techniques required for a monitoring program are available. It is, however, more time-consuming and thus more expensive to monitor a site which is 100 miles from shore and 2,000 meters deep than one which is nearshore and shallow.
>
> An effective monitoring program would be built upon our existing knowledge Initial work directed specifically at sewage sludge would be to define the volume of water through which the sludge settles, the area of the bottom accepting the waste, the rate of water renewal, and rates of deep-sea sludge oxidation The effects of sludge on deep-sea biota would be addressed through field sampling and by application of specialized techniques for observation at low temperature and high pressure.
>
> It is estimated that such a program would require about $2.5 million for each of its first two years and, thereafter, about $1.0 million per annum (Martineau, October 11, 1977).

After evaluating all of the information presented at the Toms River hearing, the hearing Officer concluded that it would not be feasible to design an effective monitoring program for sewage sludge dumping at the chemical wastes site (see Appendix C).

Similar problems arise in terms of surveillance at the chemical wastes site. As previously reported, the USCG has responsibility under the MPRSA for surveillance and other appropriate enforcement activity with regard to ocean dumping, and the USCG - Third District is responsible for surveillance of ocean dumping in the New York Bight.

At the Toms River hearing, Commander Mullen, representing the Third Coast Guard District, testified about the difficulties of conducting a thorough surveillance program if sludge dumping is moved from the existing site to either the 60-mile site or the chemical wastes site:

Surveillance of sewage sludge disposal operations at the New York Bight Site (11-mile site) is conducted by four Coast Guard vessels which are of the 82 foot and 95 foot classes. These are relatively small vessels.

An average of four vessel patrols per week are conducted at this site. The patrols occur both daytime and nighttime and are intended primarily to detect and to deter dumping outside of the dumpsites, although other EPA requirements, affecting rate of discharge, discharge of floatables, and so forth are also monitored.

In addition, a daily schedule of multi-mission helicopter patrols by Coast Guard Air Station Brooklyn is also conducted which in part, monitor the same activities.... [The helicopters used in this program] are of the type HH-52A, with an operational limitation of approximately 25 miles from shore.

Surveillance at the Industrial Waste Site [the chemical wastes site] is conducted by shiprider.

Currently, five petty officers at New York and two at Philadelphia are involved. It should be noted at this point that the departure times of the vessels and barges are subject to substantial changes as a result of mechanical failures or weather and tidal conditions.

As a result, shipriders are often tied up for considerable periods of time awaiting departure for a particular disposal trip.

Considerable time is also involved in transporting the shiprider to the barge, which requires a vehicle and an additional man.

Coast Guard National Policy is to provide 75% surveillance of toxic chemical dumps which are disposed of at the Industrial Waste Site. With regard to surveillance of sewage sludge and other material ocean dumped, Coast Guard policy is to provide 10% surveillance.

Now let us consider the feasibility of surveillance at each of the alternative sewage sludge disposal sites.

As I mentioned earlier, surveillance at the 106-mile site [the chemical wastes site] is conducted entirely by shipriders. Disposal of all the area's sewage sludge at the 106-mile site would cause a dramatic increase in the number of dumps occurring there.

In order to provide the 10% level of surveillance presently maintained over sewage sludge, Coast Guard shipriders would have to be utilized for these additional missions.

This would require the allocation of new personnel at the Captain of the Port offices and extensive use of reserve petty officers.

The use of reserve petty officers as shipriders is a concept that has recently been tested by the Captain of the Port, Philadelphia. Some of the problems encountered included a lack of expertise with all types of navigational equipment.

The reservists generally have to be provided with refresher training in the use of Loran A, Omega, dead reckoning etc. Delays in vessel and barge departures due to weather and mechanical failure caused the reservist to spend considerable time in stand-by status.

This tends to be a serious problem in terms of manpower utilization due to the short active duty period of each reservist.

Helicopters would have the capacity to check vessels in transit to the 106-mile site, but surveillance at the dump site is beyond the capabilities of the shore based HH052A [sic].

In the near future, we hope to implement an automated ocean dumping surveillance system.

This system is presently being field tested. Such a system would greatly facilitate our ability to monitor dumps at any of the dump sites far offshore.

It is anticipated that regulations requiring installation of ODSS will be issued within six months.

Three modes of surveillance are being considered for the 60-mile site [in the Northern or Southern Area], should sludge dumping be moved there. Shipriders could be utilized as at the Industrial Waste Site and essentially the same problems would be encountered.

Although the time required to complete a mission would be less, the departure delays and time required to transport the shiprider to and from the vessel would still exist.

In considering use of the 95 and 82 foot patrol boats for surveillance at the 60-mile site, new problems arise that do not exist for surveillance at the present sludge dump.

The 82 and 95 foot class vessels are ill adapted to cruising during rough waters encountered on the high seas.

Larger class vessels have been committed to offshore fisheries patrol and are fully utilized while assigned to that program. While the possibility exists that the larger vessels used on fisheries patrol could occasionally pass in the vicinity of the 60-mile dump site, it is unlikely that the frequency of this happening could result in an effective surveillance program.

The proximity of the 11-mile site [the existing sewage sludge dump site] to Groups Sandy Hook and Rockaway allows for easy access to the site and keeps the 82 and 95 foot patrol boats "close to home" in an excellent position to respond to other missions most importantly search and rescue.

It is important to note, that the 82 and 95 foot patrol boats are the primary SAR [search and rescue] boats for Coast Guard Surveillance goal of 10% [sic].

As mentioned earlier, Coast Guard safety policy is to utilize the HH-52A helicopter up to 25 miles from shore.

The proposed 60-mile site is 33 miles from Long Island, 8 miles beyond the aircraft's normal range. In other words, the HH-52As could be used for occasional surveillance of barges and vessels in transit to the 60-mile site, but actual surveillance of disposal operations at the site would by necessity be limited

The Automated Ocean Dumping Surveillance System (ODSS) once available, would provide an additional alternative to monitoring at the 60 mile site

In conclusion, the resulting surveillance programs for sewage sludge dumped at either the 60 mile site or the 106 mile mile site would not be as effective as they are presently, unless sufficient lead time were available to acquire additional shipriders, or unless implementation of the automated ocean dumping surveillance system were to first take place.

In the interim period, while attempts are being made to obtain additional resources, it is recommended that a requirement be added to all permits issued for the 60 or 106 mile site for daytime and nighttime that the master of the ocean dumping vessel prepare at the time of occurrence a navigational overlay of the dumping vessel's trackline during the dumping operation, indicating the times and positions at entry and exit of dumpsite and beginning and end of dump.

It is our intention to make every effort to acquire the needed extra persons as soon as any decision is made to move the sludge site, but the extent of lead time needed to actually obtain the needed resources is not known at this time (in USEPA, May 31, 1977)

In summary, Commander Mullen's assessment was that there would be no insurmountable technological problems associated with providing the standard 10 percent surveillance of sewage sludge dumping, at the chemical wastes site. However, until the electronic surveillance device being tested by the USCG is approved and installed on vessels engaged in ocean dumping, an effective surveillance program would be economically and logistically burdensome, requiring substantial increases in equipment and personnel as well as the lead time to acquire the needed equipment and to adequately train Coast Guard reservists in its use.

In his report on the Toms River hearing, the hearing officer acknowledged the difficulties pointed out by Commander Mullen, but concluded, "there is no indication that surveillance of dumping at the 106-mile site [the chemical wastes site] would not be feasible" (see Appendix C).

Logistics and Economics – Even if there were enough data to determine the potential effects on the marine environment of dumping sewage sludge at the chemical wastes site, and even if those effects were found to be acceptable, the logistical and economic drawbacks associated with the distance to the chemical wastes site would probably preclude this alternative At its closest point, the chemical wastes site is 210 km (115 n mi) from the Sandy Hook-Rockaway Point transect. The limitations of the existing fleet are such that a maximum distance of 120 km (65 n mi) was made one of the criteria for selecting an alternate sewage sludge dump site. Transporting sludge to the chemical wastes site or to some other area off the continental shelf would necessitate upgrading and expansion of the existing fleet.

As shown in Table 7, only twelve vessels are actually in use in the New York Bight, and one of those, the barge *Westco I*, is not seaworthy for use beyond the existing sludge dump site. This reduces the total fleet to eleven and the total carrying capacity to 41,374 cu m (54,112 cu yd) or about 91 percent of the carrying capacity of the full thirteen-vessel fleet.

At an average speed of 13 km/hr (7 knots), a tanker would take approximately 54 hours to make a round trip to the chemical wastes site (see Table 29). At an average speed of 9 km/hr (5 knots), a barge would take approximately 72 hours. These time estimates include 10 hours per trip for docking and loading and 5 hours per trip for discharging the sludge. The 5-hour discharge limitation was imposed by the USCG for safety reasons at the existing dump site. It is used here to facilitate time comparisons between the existing dump site and the chemical wastes site. If the chemical wastes site were actually to be used, the time required for discharge would be substantially greater because the USCG safety limit would not apply and the discharge rate would have to be established in accordance with section 227.8 of the current ocean dumping regulations (see Appendix B). Thus, the round trip time to the chemical wastes site would be 54 hours plus for a tanker and 72 hours plus for a barge. A round trip to the existing sewage sludge dump site takes about 26 hours for a tanker and 30 hours for a barge.

Given the time constraints associated with the chemical wastes site and assuming that necessary overhauls would put each vessel out of service for about one month per year, the maximum number of annual trips to the site would be 147 for each tanker and 111 for each barge. It is most unlikely that the maximum number of trips could actually be made, however, because this would require that each vessel be in round-the-clock service for the other eleven months of the year.

Even if optimum conditions prevailed, the total volume of sludge that could be transported to the chemical wastes site by the available eleven-vessel fleet (six tankers and five barges) would be 5.0 million cu m (6.6 million cu yd) per year. Almost 4.0 million cu m (5.3 million cu yd) of sludge were dumped at the existing site in 1977, and over 6.0 million cu m (7.9 million cu yd) are projected to be dumped in 1978 (see Tables 6 and 9).

The situation could be improved somewhat by the addition of the *Liquid Waste No. 1*, which is now in use in Puerto Rico. This would bring the number of vessels to twelve (six tankers and six barges) and the total hauling capacity to about 5.3 million cu m (7.0 million cu yd) per year. However, since this volume will probably be surpassed in 1978, fleet augmentation cannot be avoided if a site off the continental shelf is chosen for sludge dumping.

The sludge dumping fleet could be enlarged either by hiring or by constructing the needed vessels. Both of these options would be prohibitively expensive, and the latter would also be infeasible considering the time required to construct the needed vessels and the scheduled phase out of ocean dumping in 1981.

Expanding the fleet of dumping vessels and increasing the travel time for each vessel in order to make use of the chemical wastes site would dramatically raise the cost of sludge dumping for those municipalities that now hold ocean dumping permits (see Table 6):

Dump Site	Cost per Wet Ton	Cost per cu m	Cost per cu yd
Existing	$1.25	$1.95	$1.47
Northern or Southern Area	4.00 to 5.00	6.30 to 7.80	4.70 to 5.90
Chemical Wastes	8.00 to 10.00	12.50 to 15.60	9.40 to 11.80

Thus, the cost of using the chemical wastes site would be twice the cost of using a dump site in the Northern or Southern Area, and six to eight times the cost of continuing to use the existing sewage sludge dump site. Had the chemical wastes site been used for sludge dumping in 1977, it would have cost the municipal permittees somewhere between $49.0 million and $61.0 million instead of the $7.6 million that it cost to use the existing site. By 1981, use of the chemical wastes site for sludge dumping would cost the municipal permittees somewhere between $124.0 million and $154.0 million. The cost to New York City alone could be as much as $64.0 million; currently, sewage sludge dumping at the existing site costs the city $2.2 million per year (Samowitz, June 14, 1977).

Other costs would rise as well, including the cost of monitoring the dump site and the cost of the USCG's surveillance operations.

Its dubious environmental acceptability and its extreme cost are the major but not the only drawbacks to dumping sewage sludge at the chemical wastes site. Greater navigation hazards would result from the dumping vessels' increased travel time on the open ocean. Short dumping, including emergency dumping, would almost certainly increase. Added to this is the fact that using the chemical wastes site for sludge dumping would be of negligible benefit to the water quality of the Bight Apex. Of all of the pollutant sources in the Bight Apex, sludge dumping is hardly the most significant, and its removal to the chemical wastes site could not by itself effect a substantial change in water quality.

Effect of Using the Chemical Wastes Site on the Ability of Dumpers to Meet the December 31, 1981 Deadline - The prohibitive cost associated with using the chemical wastes site for sewage sludge disposal would threaten the ultimate objective of terminating sludge dumping by December 31, 1981. The economic resources of the communities involved are finite, and if they are spent on transporting sludge to the chemical wastes site, they will not be available for implementing land-based disposal methods. This particular aspect of using the chemical wastes site is a matter of concern not only to the communities that would have to bear the cost, but to federal agencies, to environmental groups, and to some of the Congressmen who were instrumental in amending the MPRSA to specify the 1981 deadline (see Appendices C and D)

Although NOAA would prefer that the chemical wastes site rather than a site in the Northern or Southern Area be used in an emergency between now and 1981, NOAA opposes summarily moving sludge dumping from the existing site to the chemical wastes site:

> NOAA is not in agreement with the proposal to move the sludge dump site which serves the New York-New Jersey metropolitan area from the Apex to the deep water site at 106 miles [the chemical wastes site].
>
> Our position is that no need has been established to require moving the existing dump site, and that all sewage sludge dumping should be halted by 1981.
>
> We are concerned that an open door policy of sewage sludge could ultimately lead to the situation in which most or substantial amounts of east coast municipal and industrial waste dumping is carried out at that site.
>
> *Such a policy would seriously undermine efforts to encourage ocean dumpers to seek land based alternatives to ocean dumping* [emphasis added] (in USEPA, May 31, 1977).

A similar view was expressed by Kenneth Kamlet, representing the National Wildlife Federation, at the Toms River hearing in 1977. In responding to the argument that the increased cost of using the chemical wastes site would make land-based disposal more cost-competitive with ocean dumping and therefore more attractive to the municipalities involved, Mr. Kamlet stated:

> In the first place, any significant increment between now and the end of 1981 (the deadline for completing the phase-out of sewage sludge ocean dumping) in the cost of sewage sludge disposal could as easily discourage as encourage the expedited phase-out of sludge dumping, *if it had the effect of diverting into continued ocean dumping limited funds which would otherwise be available to implement a dumping phase-out* [emphasis added].
>
> In the second place, if the cost increment for relocating the dumpsite were not substantial enough to jeopardize the implementation of land based alternatives, chances are they would also not be substantial enough to provide much if any incentive to accelerate a dumping phase-out (in USEPA, May 31, 1977).

Congressman Edwin Forsythe, the ranking minority member of the House Subcommittee on Oceanography, also testified against moving sludge dumping to an alternate site, particularly the chemical wastes site:

> A decision regarding the location of municipal sewage sludge dumping is a critical resource management problem. Since the environmental and fiscal resources at stake are extremely valuable, our decision-making must be based on rationality. Attempts to sensationalize the issue, and politically expedient pressure to move the problem "out of sight", "out of mind", must be resisted.
>
> The net effects at present of a dumpsite move would be the following: a new site would be contaminated, with little recovery of existing dumpsites.
>
> *Municipalities will exhaust their financial resources on increased transportation costs and ocean dumping barge construction while alternative treatment methods go unfunded* [emphasis added]. The government will investigate and monitor new dumpsites at the time when Congress has reaffirmed its unequivocal intent to end ocean dumping of sewage sludge by 1981.
>
> Finally, responsible parties seeking permanent solutions to the region's waste disposal problem will have their efforts diffused if a quick-fix, "out-of-sight", "out-of-mind" non-solution is adopted.
>
> I am particularly concerned about the possiblity of dumping sewage sludge at Deepwater dumpsite 106 [the chemical wastes site].
>
> The sensitivity of biota, the likely impact on fisheries, the difficulty of policing, the high probability of short dumps, and the impossible task of thoroughly monitoring adverse impacts at the site clearly indicate that dumping at the 106-site could be an environmental nightmare (in USEPA, May 31, 1977)

Congressman Forsythe and the Chairman of the House Subcommittee on Oceanography later reiterated these same concerns during EPA's 1978 ocean dumping authorization hearings (see Appendix D).

The estimated cost to municipalities of using the chemical wastes site for sludge dumping is shown in Table 30. An increase of 641 to 800 percent over the cost of using the existing dump site between 1978 and 1981 is projected. This large an increase would almost certainly detract from the search for alternative land-based disposal methods. As the hearing officer's report for the Toms River hearing concludes:

> None of the municipalities stated that they could not meet the added costs, but they did point out that there would be difficulties in funding, and that *these costs might have to come from funds presently allocated for implementing alternatives* [emphasis added] (See Appendix C.)

Modification of Dumping Methods

Current sludge dumping procedures, as set forth in each ocean dumping permit, require that the sludge be discharged within the designated dump site, at a uniform rate of 15,500 gallons per n mi (27,441 liters per km) and a speed of at least 3 knots (5 km/hr). Vessel traverses must be at least 0.5 n mi (1 km) apart. These requirements have been stipulated by the USCG for safety reasons in this heavily trafficked area. They would not be applicable if sludge dumping were moved to a site outside the Bight Apex.

Methods of sludge release considered in this EIS include simple overboard dumping, jet discharge, and discharge in the vessel's wake (the present method).

Overboard Dumping. This method consists of simply releasing the sludge from the vessel; the material descends by its own momentum. Since its vertical motion is affected by buoyancy, the initial distribution is mainly within the surface water layers.

Jet Discharge. This method involves pumping the sludge from the vessel through an opening beneath the surface. It is effective in passing the material through the surface layers, but it results in a more confined initial distribution, usually at the depth of neutral buoyancy of the sludge.

Discharge in the Vessel's Wake (Present Method). This method results in high initial mixing and dilution, but the sludge's vertical motion is still dependent on density differences between it and the receiving waters.

Considering the 30 to 60 m (100 to 200 ft) depths and the flow patterns in the Northern and Southern Areas, the present dispersive method of sludge dumping should be continued at an alternate dump site for the following reasons:

— Sewage sludge dumped at or near the surface will settle over a wide area because of its low bulk density, 1.01 g/cu cm.

— Differences in the thermohaline (temperature and salinity) density structure of the ocean would probably slow the settling of sludge under stratified conditions and would negate the effectiveness of a pumped subsurface discharge.

— Dispersion at either the Northern or Southern Area is primarily a function of sea state, depth, and water mass movements. As such, it is not likely to be improved by altering the present dumping technique.

— Given the volumes of dumped sludge projected through 1981 and the limitations of the present fleet, use of sophisticated dumping techniques would probably be both technically impossible and economically prohibitive. Moreover, such techniques would be of little value in improving dispersion patterns.

— Monitoring of the dump site would be facilitated if dumping were limited to a specific surface area.

LAND-BASED ALTERNATIVES

Although an immediate changeover to land-based disposal of sewage sludge in the New York-New Jersey metropolitan area is not feasible, current predictions are that land-based methods can be implemented in time to meet the December 31, 1981 deadline for phasing out ocean dumping of sewage sludge.

In June 1975 and June 1976, ISC issued reports on Phases 1 and 2, respectively, of a three-phase sludge management study funded by EPA. In October 1976, the study was completed with the publication of ISC's sludge disposal management plan for the New York-New Jersey metropolitan area. The study's purpose was to describe the feasible land-based alternatives for sludge disposal and methods of implementing them. As the study progressed and more information was gathered, ISC modified its recommendations accordingly; the final report, published in October 1976, sets forth ISC's current position on the question of sludge management in the metropolitan area.

ISC Phase 1 Report

The Phase 1 report was primarily concerned with the following land-based methods of sewage sludge disposal: direct land application, incineration, pyrolysis, and use as a soil conditioner or fertilizer.

Direct Land Application Sewage sludge in its liquid form can sometimes be applied to the land as a soil conditioner or fertilizer. Those characteristics of sludge that affect its suitability for direct land application include the organic matter content, the available nutrients (nitrogen, phosphorous, potassium, and trace elements), the quantities of heavy metals, and the toxic organics (especially chlorinated hydrocarbons). In general, three factors limit the immediate implementation of direct land application of metropolitan area sludge.

First, the sludge generated by metropolitan wastewater treatment facilities contains high concentrations of heavy metals (cadmium, chromium, copper, lead, mercury, nickel, and zinc) and significant quantities of toxic organics (chlordane, dieldrin, endrin, heptachlor, lindane, and mirex). If these substances leached into the soils underlying a land-application site, they would be harmful to adjacent streams and groundwater aquifers.

Second, metropolitan area sludge is low in nutrients (as are most domestic sewage sludges) in comparison with commercial fertilizers.

Finally, land is not available in the metropolitan area for a large-scale land-application program. The cost of transporting large quantities of sludge to suitable sites outside the metropolitan area appears to be prohibitive.

Incineration Sewage sludge incineration results in waste gases, particulates, and a relatively small quantity of sterile ash that retains most of the heavy metals originally present. Air pollution controls, such as wet scrubbers, are necessary to remove the particulates, odors, nitrogen oxides, sulfur oxides, volatile toxic organics, and airborne heavy metals (cadmium, lead, and mercury). Multiple-hearth incineration has the least potential for air pollution; it can burn without auxiliary fuel (gas, oil, or coal), and it is compatible with a phased change-over to pyrolysis. The ash, of course, which contains heavy metals, must ultimately be disposed of in an environmentally acceptable manner.

To burn without auxiliary fuel, sludge must generally be dewatered, that is, the liquid content must be reduced from its usual range of 93 to 97 percent to less than 65 percent.

Although the air pollution problems posed by this method of sludge disposal could be minimized by incinerating the material on ships or offshore platforms, the costs cannot be justified since other, more economical, methods of sludge disposal are available.

Pyrolysis. Destructive distillation, or pyrolysis, is the process of breaking down organic matter, such as sewage sludge, by heating it in the absence of oxygen. The resulting by-products are a number of gases, a carbon/ash char, and a liquid waste containing a wide variety of organic compounds. Pyrolysis is generally cheaper than incineration because it produces fewer particulates and thus requires less in the way of air pollution controls. The by-products, char and gases, can be used as fuels. To date; however, no large-scale pyrolysis tests have been conducted on sewage sludge alone, so prior to implementation of this alternative, a pilot demonstration plant would have to be built and successfully operated.

Use as a Soil Conditioner. Problems with the use of sewage sludge as a soil conditioner or fertilizer are much the same as those with direct land application: the high concentrations of heavy metals and toxic organic compounds must be removed or reduced. In addition, the sludge must be dried to 5 or 10 percent moisture content and fortified with nutrients before it can be used as a fertilizer. Finally, there is the problem of promoting consumer acceptance.

Conclusions and Recommendations. The ISC Phase 1 report (1975) drew the following conclusions regarding land-based sludge disposal methods for the metropolitan area and the eventual, phased implementation of those methods.

The most feasible alternative to ocean dumping would be pyrolysis (the sludge having been dewatered with filter presses). This conclusion was based on considerations of environmental impact, economic feasibility, and energy recovery. Pyrolysis has the least potential for negative impacts on water, air, or land resources. It could be implemented within ten years.

Multiple-hearth incineration could be implemented sooner than pyrolysis, and the incinerators could be converted to pyrolysis units once that process was demonstrated to be successful. Incinerators, however, would face more difficult siting problems because of their potential for air pollution and because of the possibility of local community resistance. The incinerators needed to handle the volumes of sludge projected for the year 2000 would cost on the order of $400 to $500 million (in 1975 dollars).

Direct land application could be implemented only in fringe areas (outside the metropolitan area), where population density is low and large tracts of land are available, and where agricultural enterprises would provide a market for sludge-based fertilizers and soil conditioners.

A small-scale pilot study should be undertaken immediately with the aid of an equipment manufacturer who is familiar with both pyrolysis technololgy and multiple-hearth furnace construction. The purpose would be to identify and define the required engineering parameters prior to full-scale demonstration plant construction.

The complete text of the Phase 1 report's conclusions and recommendations is presented as part of Appendix J.

ISC Phase 2 Report

The object of the Phase 2 report (ISC, 1976a) was to develop and recommend a specific, coordinated disposal program based on the technical findings of the Phase 1 report (ISC, 1975). In sum, the Phase 2 report recommends the construction of regional pyrolysis plants at six separate locations in the metropolitan area and only limited land application of sludge.

Incineration and Pyrolysis. To date, pyrolysis of sludge alone has been studied only in pilot-scale tests; large-scale demonstrations have utilized solid wastes. The ISC's Phase 1 report indicated that multiple-hearth furnaces could be built by 1981, initially operated as incinerators, and then converted to pyrolysis units as that technology developed. Between the publication of the Phase 1 and Phase 2 reports, it was learned that such furnaces could be designed and constructed as pyrolysis units directly during the same time span; incineration was therefore not considered further.

The ISC evaluated the retention of anaerobic digestion capabilities at individual plants because a number of operating wastewater treatment plants have, or plan to construct, these digesters. It was found that maintenance of existing anaerobic digesters was cost-effective, but that new digesters should not be built if sludge was to be pyrolyzed.

Land Application, Composting, and Landfilling. Land application and composting are feasible sludge disposal alternatives for outlying plants in the metropolitan area. These plants could form regional groups for direct land application or for sludge composting.

Landfilling of stabilized, dewatered sludge is cost-effective only for the smaller suburban wastewater treatment facilities, and only if landfill sites are available. Landfilling, however, should be considered a short-term solution, to be used while long-term direct land application or composting programs are instituted. In addition, landfilling was found not to be feasible for sludges produced by treatment plants in highly urbanized portions of the metropolitan area because of the larger quantities of sludge produced and the limited lifespans of available landfill sites.

Sludge Management. The plan recommended in ISC's Phase 2 report calls for pyrolysis of sludge produced in urban treatment plants and land application or composting of sludge produced in outlying plants. The recommended pyrolysis sites and areas to be served are:

1. Port Newark (New Jersey regional), serving Bergen, Hudson, and Union counties, and the Passaic Valley Sewerage Commissioners.
2. Sayreville, serving the Middlesex County Sewerage Authority.
3. Cedar Creek, serving Nassau County.
4. Twenty-Sixth Ward, serving Coney Island, Jamaica, Rockaway, and Twenty-Sixth Ward.
5. Hunts Point, serving Bowery Bay, Hunts Point, Tallmans Island, and Wards Island.
6. Fresh Kills (New York regional), serving Newtown Creek, North River, Owls Head, and Port Richmond.

Conclusions and Recommendations. Pyrolysis is favored as a particularly promising means of disposing of the large volume of municipal sewage sludge expected to be produced by the year 2000. The ISC Phase 2 report concludes that if future federal policies prohibit or significantly curtail the ocean dumping of sludge, pyrolysis is the best alternative for its disposal The report also recommends the construction of six regional pyrolysis facilities (listed above). Only limited amounts of sludge are seen as suitable for direct land application.

The ISC concludes that direct land application of either treated or untreated sludge in quantities sufficient to dispose of the expected volumes would be dangerous because of the large heavy metal and toxic organic content, and the threat of surface and groundwater contamination. Pyrolysis is also preferred to incineration because units could be more easily decentralized. While pyrolysis equipment capable of reducing sludge is not yet in commercial operation, recent technological advances make it appear that the method could be in practical use by the early 1980s.

While the ISC acknowledges the urgent need for the cessation of ocean dumping, it considers EPA's phase-out date of December 31, 1981 to be somewhat optimistic.

The complete text of the Phase 2 report's summary chapter is presented as part of Appendix J.

ISC Sludge Disposal Management Program

The latest ISC report (1976b) presents ISC's plan for sewage sludge management in the New York-New Jersey metropolitan area. It combines the Phase 1 and Phase 2 reports with an examination of legal-institutional implementation problems.

In general, the sludge management plan currently recommended by ISC is very similar to the one recommended in the Phase 2 report. The major difference, is that ISC now places a greater emphasis on composting followed by land spreading. The sludges produced by several treatment plants in the metropolitan area are now suitable for composting and land spreading. Other sludges are still unsuitable, primarily because of their heavy metal and synthetic organics content However, pretreatment of industrial wastewaters could resolve these problems.

Relative to pyrolysis, the ISC recommends five facility sites rather than the six given in the Phase 2 report:

1. Port Newark (New Jersey regional), serving Bergen, Hudson, and Union counties, and the Passaic Valley Sewerage Commissioners.
2. Sayreville, serving the Middlesex County Sewerage Authority.
3. Cedar Creek, serving Nassau County.
4. Twenty-Sixth Ward, serving Newtown Creek, Owls Head, Coney Island, Jamaica, Rockaway, and Twenty-Sixth Ward.
5. Hunts Point, serving Bowery Bay, Hunts Point, Tallmans Island, and Wards Island.

The ISC makes no recommendation relative to the North River or Red Hook treatment plants that are being constructed in New York City; both plants are scheduled to go into operation in the mid-1980's.

The complete text of the summary chapter of the October 1976 report is presented as part of Appendix J.

Testing and Implementation

As noted at the start of this chapter, the testing and implementation phases of the sludge disposal management program have begun. Since no large-scale pyrolysis test had been conducted on sewage sludge alone, ISC recommended, in its Phase 1 Report, that a pilot demonstration plant be built and successfully operated. In 1976, EPA funded such a pilot test. Nichols Engineering and Research Corporation was contracted to test sludge pyrolysis at its Belle Mead, New Jersey, research facility. Sludges from several treatment plants were chemically conditioned, dewatered, and pyrolyzed under various design conditions in a Nichols Herreshoff Multiple Hearth Furnace. Nichols has reported that pyrolysis can be used as a commercially feasible and cost effective thermal destruction method for sludge disposal without using fuel, including afterburning at 759°C (1400°F) (ISC, 1978).

In December 1976, a sludge composting project in Camden, New Jersey, was funded by EPA and NJDEP This project uses a technique developed by the U S Department of Agriculture's experimental sludge composting station in Beltsville, Maryland. During the process, which takes a total of thirty days, dewatered sludge is mixed with a bulking agent, such as wood chips, corn cobs, or waste paper, and stacked in piles. The piles are blanketed with an inert material, and air is drawn through the piles. Aerobic biological degradation increases temperatures within the piles to 82°C (180°F), thus destroying most pathogenic bacteria.

The Camden composting facility, which was dedicated in June 1978, established several major environmental precedents. It is the largest composting operation of its type in the United States. It is also the first such municipal undertaking in the New York-New Jersey area. Most important, it is the first instance of cessation of ocean dumping by a large municipal sewage treatment plant (58,118 cu m or 76,471 cu yd per year).

All municipal permittees in EPA-Region II are required by permit condition to select and implement an environmentally acceptable alternative to ocean dumping on or before December 31, 1981. Each permittee has been given a final phase-out date based upon the individual permit implementation schedule Each of the permittees is on a strict implementation schedule, and is closely monitored by EPA-Region II. All permittees are afforded the opportunity to comply with this condition using federal funds available through the FWPCA (the Clean Water Act), and most have chosen this path. Examples of the technologies being considered or currently being implemented are:

Camden Middletown Township Northeast Monmouth Linden-Roselle	Composting

Nassau County	
Bergen County	Composting of sludge and use as landfill cover as an interim solution; co-recovery with solid wastes as a long-term solution
Joint Meeting of Essex and Union Counties Rahway Valley Wayne Township Lincoln Park Pequannock Township Pompton Plains Oakland	Incineration
Middlesex County	Multiple hearth incineration or starved air combustion
Glen Cove	Co-incineration with solid wastes
New York City	Composting or landfilling of digested dewatered sludge as an interim solution; utilization of other technology (pyrolysis, co-recovery, etc.) or shipment out of the city area for composting as a long-term solution
Westchester County	Use of existing excess capacity in solid waste incinerators and composting of remainder

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