Report to the Congress on Ocean Dumping Research

January through December 1974

Public Law 92-532, Title II, Section 201

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
JUNE 1975

Report to the Congress on Ocean Dumping Research
January through December 1974

Submitted in compliance with Section 201,
Title II of the Marine Protection, Research,
and Sanctuaries Act of 1972
(Public Law 92-532)

June 1975

UNITED STATES
DEPARTMENT OF COMMERCE
Rogers C.B. Morton, Secretary

U.S. NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

July 28, 1975

President of the Senate
Speaker of the House of Representatives

Sirs:

It is my privilege to submit to the Congress this second annual report of federally sponsored research on the effects of ocean dumping.

Under Title II of the Marine Protection, Research, and Sanctuaries Act of 1972, the Congress assigned to the Department of Commerce a responsibility to initiate a program of monitoring and research in order to improve our understanding of the effects of dumping wastes into the ocean and the Great Lakes. This report is in response to Section 201 of the Act, which specifies that an annual report be made to the Congress on the findings of such research.

During 1974, approximately 130 million tons of waste materials were dumped in U.S. coastal waters. These materials, transported from coastal ports aboard barges or ships, included dredged material, municipal wastes, construction and demolition debris, and industrial wastes. The impact of these materials on our Nation's coastal waters is a matter of national concern, and the Federal agencies charged with responsibilities for assessing and regulating such dumping have initiated research programs to provide the understanding necessary for the proper management of our coastal waters.

I am pleased to report that by the end of 1974 the Federal research effort related to ocean dumping had made substantial headway in addressing the critical research needs outlined in *Ocean Dumping - A National Policy*, the 1970 report of the Council on Environmental Quality, and also expressed by the Congress through Title II of the Marine Protection, Research, and Sanctuaries Act of 1972.

A major marine ecological research project was initiated in the New York Bight in 1973 by the National Oceanic and Atmospheric Administration--the Marine Ecosystems Analysis (MESA) New York Bight Project. The project is an interdisciplinary investigation of the impact of ocean dumping of both dredged and nondredged materials upon the waters adjacent to the heavily populated and industrialized New York - New Jersey metropolitan area. Though

still in its initial phase, results from this investigation already have proven invaluable in assessing the local impacts of sewage sludge dumping.

In regard to the disposal of dredged material, the Dredged Material Research Program (DMRP), a major effort also initiated in 1973 by the Army Corps of Engineers, has moved steadily forward. By the end of 1974 the Corps has completed planning and other preliminary work for comprehensive studies of the effects of open-water disposal of dredged materials on aquatic organisms at four regionally representative disposal sites in Ohio, Oregon, New York, and Texas.

These major efforts are being further complemented by research programs of the Environmental Protection Agency (EPA) in direct support of its permit system pursuant to Title I of the Act. A more detailed description of this work is provided in the EPA annual report to the Congress under Section 112 of the Act.

Finally, one of the major concerns of the Congress and the Executive Branch relative to the ocean dumping problem is the development of alternatives to present ocean dumping practices. In response to these concerns, this report includes a summary of research directed toward developing economically and environmentally sound alternatives.

This federally sponsored research on ocean dumping is an important step in the preservation of our Nation's vital national resources.

Sincerely,

Secretary of Commerce

PREFACE

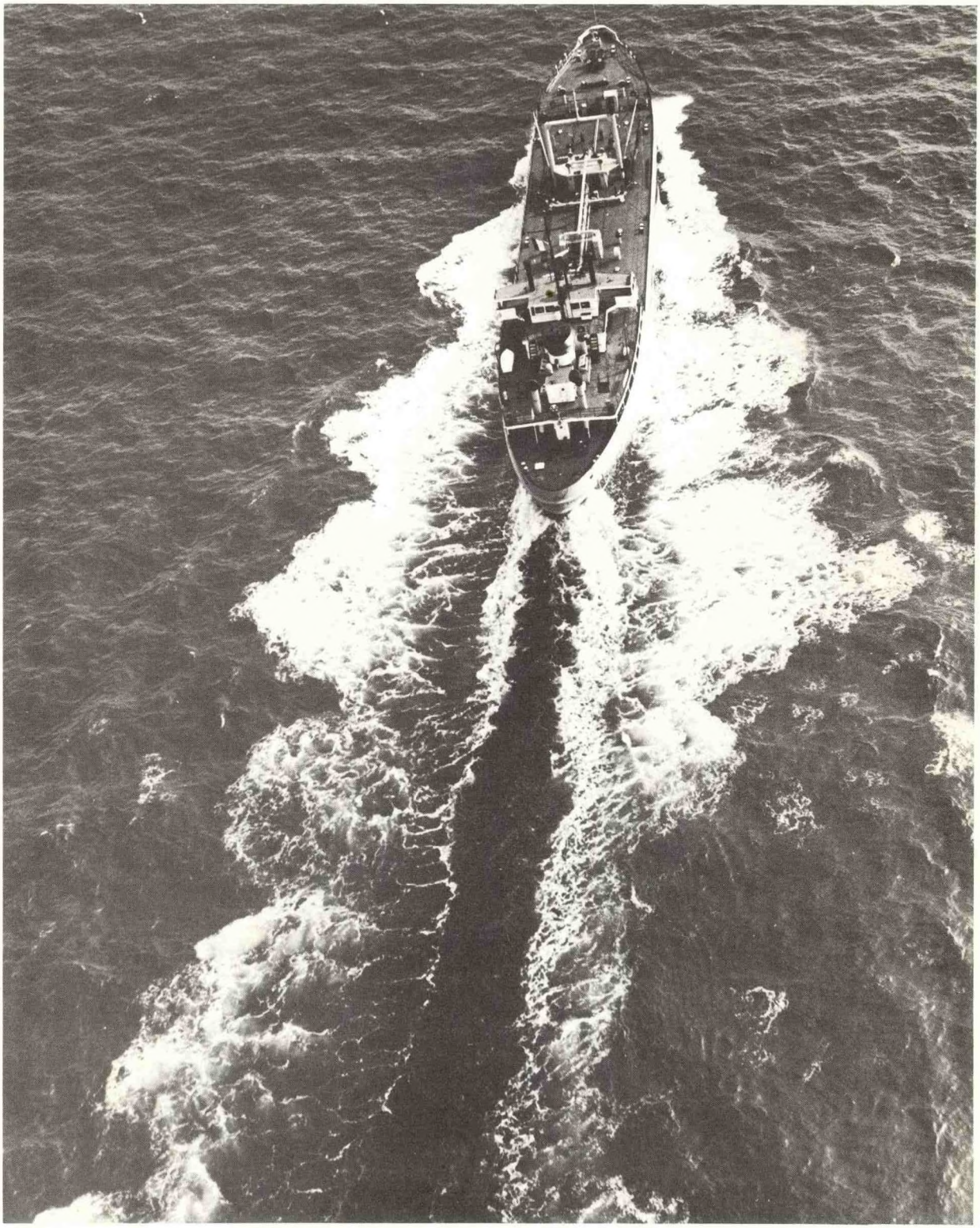
The Marine Protection, Research, and Sanctuaries Act (P.L. 92-532), enacted on October 23, 1972, provides for the regulation of ocean dumping, research on ocean dumping and other activities of man that cause changes to ocean ecosystems, and the designation, acquisition, and administration of marine sanctuaries. Title II of the Act assigned to the Department of Commerce (NOAA) significant responsibilities for initiating or promoting research related to ocean dumping and other man-induced changes to ocean ecosystems. Title II contains three operative sections as well as a section authorizing funds to carry out the purposes of the Title.

Section 201 provides for a comprehensive and continuing program of monitoring and research on the short-term ecological effects of ocean dumping.

Section 202 calls for a comprehensive and continuing program of research on the possible long-range effects that pollution, overfishing, offshore development, and other activities have on ocean ecosystems.

Section 203 states that the Secretary of Commerce shall conduct and encourage research and other activities to determine and demonstrate means of minimizing or ending all dumping of materials within 5 years of the effective date of the Act.

This is the second annual report to the Congress on ocean dumping research, as required under Section 201. The report describes significant Federal research programs and activities carried out in 1974. A separate report on Section 202 was sent to the Congress early this year. Although not specifically required by the legislation, this report includes a summary of 1974 studies relative to the requirements of Section 203.



Vessel discharging sewage sludge in New York Bight. Courtesy: EPA Region II.

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CHAPTER I

INTRODUCTION

AGENCY ROLES AND AUTHORITIES

The Federal effort in ocean dumping research is carried out by the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the U.S. Army Corps of Engineers.

The National Oceanic and Atmospheric Administration (NOAA) conducts research on ocean dumping in response to Section 201 of the Marine Protection, Research, and Sanctuaries Act, which directs the Secretary of Commerce, in coordination with the Coast Guard and the Environmental Protection Agency, to initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of material into ocean waters or other coastal waters or into the Great Lakes. NOAA research activities are focused on the Marine Ecosystems Analysis (MESA) Project in the New York Bight, on selected dumpsite investigations, and on studies by Sea Grant institutions on the environmental effects of ocean dumping. The MESA New York Bight Project, initiated in 1973, is an 8-year interdisciplinary investigation of the coastal area adjacent to the New York-New Jersey metropolitan area. The current research emphasis of the project includes: delineating stressed areas, identifying and quantifying the major pollutants, characterizing existing dumpsites, and investigating alternate dumpsite areas. The MESA New York Bight Project and other field studies of the effects of ocean dumping are supported by the laboratories and centers of NOAA's major line components.

The Environmental Protection Agency (EPA) conducts research on the effects of marine pollution pursuant to Section 104 n (estuarine research) and Section 403 (ocean discharge criteria) of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) and Section 102 (EPA ocean discharge permit program) of P.L. 92-532.

The overall objectives of EPA's marine research programs are to: (1) provide scientifically sound and legally defensible water quality criteria for estuaries and coastal waters; (2) provide information to assess damage to estuarine/marine environments resulting from both acute and long-term pollution; (3) develop criteria for ocean dumping and ocean outfalls; (4) provide technical assistance to EPA regional and program offices in terms of short-term studies, consultation, and expert testimony in legal proceedings; and (5) predict the long-term effects of pollutants (pesticides and toxic substances) on species, community structure, and total estuarine and marine ecosystems.

The U.S. Army Corps of Engineers is authorized, by the River and Harbor Act of 1970 (P.L. 91-611), to undertake a comprehensive, nationwide research effort on the problem of dredged material disposal. The problem is a large one in that annual U.S. dredging volumes now exceed 400 million cubic yards, of which approximately 100 million cubic yards, or roughly 118 million tons, are disposed of in the ocean. In May 1971, the Army Engineer, Waterways Experiment Station at Vicksburg, Mississippi, was assigned the task of defining and assessing the dredged material disposal problem and developing a research program. A 5-year Dredged Material Research Program (DMRP) was established in order to provide definitive information on the environmental impact of dredging and dredged material disposal operations and to develop technically satisfactory, environmentally sound, and economically feasible disposal alternatives. Execution of the DMRP was assigned to the Waterways Experiment Station and research was initiated in March 1973.

The U.S. Coast Guard is developing various equipment to be used in its ocean dumping surveillance and enforcement roles as defined by Section 107(c) of P.L. 92-532.

SUMMARY OF CURRENT OCEAN DUMPING PROBLEM

In the context of the legislation, ocean dumping means the disposal in ocean waters of waste materials transported from U.S. coastal ports aboard barges or ships. The types of waste materials include (but are not limited to): dredged material, solid waste, incinerator residue, garbage, sewage sludge, chemical wastes, discarded military equipment and munitions, excavation debris, and other industrial, municipal, and agricultural wastes. It does not include oil within the meaning of Section 311 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), sewage from vessels within the meaning of Section 312 of the Act, or the discharge of effluent from any outfall structure to the extent that such disposal is regulated under the provisions of P.L. 92-500 or other applicable laws.

During 1974 approximately 130 million tons of material were dumped in U.S. coastal waters. The types and amounts of materials dumped and the general locations where these materials were dumped are shown in figure 1. Dredged material accounted for 118 million tons, or over 90 percent of the total tonnage dumped in 1974. This amount was twice the dredged material deposited in the ocean in 1973. The increase was due to extensive flooding and silting in the Mississippi River basin in recent years. Dredged material is an environmental concern because of the large quantities involved and the fact that some dredged materials contain contaminated sediments. In data supplied to the Council on Environmental Quality (CEQ) in 1970, the Corps of Engineers estimated that, in 1968, an average of 34 percent of the dredged material dumped in the ocean was polluted. 1, 2/

The ocean disposal of wastes other than dredged materials occurs mainly in the New York Bight (Fig. 1). For example, the bulk of industrial waste dumping is in the Bight. Some industrial waste is dumped in the

Gulf of Mexico, but the amount of this dumping has diminished, from 1.4 million tons in 1973 to 950,000 tons in 1974, as industry responds to EPA's ocean disposal permit program. Further substantial reductions are expected in 1975.

Industrial waste dumped in New York Bight in 1974 was 3.0 million tons, a slight decrease from the 1973 total of 3.2 million tons. About 90 percent of the dumped material was some form of acid waste. The acid waste dumpsite is centered at 40°18'N-73°38'W where the depth is about 90 feet. Waste acids have been dumped at this location since 1948. An additional 0.6 million tons of waste acids are dumped each year at a dumpsite 35 miles east of the Delaware coast.

Construction and demolition debris are dumped only by the city of New York. The principal reason is lack of available space for disposal onshore. These wastes are usually inert, consisting typically of stone, tile, brick, concrete, masonry material, pipe, wood, and dirt. In 1974, 2.4 million tons were disposed at the cellar dirt dumpsite at 40°23'N-73°49'W. Yearly quantities vary considerably, depending on New York City construction activity. The cellar dirt dumpsite has been used for more than 33 years.

Sewage sludge is dumped in the New York Bight (4.1 million tons) and at a dumpsite about 40 miles east of Ocean City, Maryland, where the city of Philadelphia dumps sewage sludge (0.6 million tons).

The sewage sludge introduced into the Bight, whether from direct dumping or from outfalls and sewage-laden harbor waters, is one of the most serious environmental problems confronting the citizens of the New York-New Jersey metropolitan area.

The sewage sludge dumpsite was selected in 1924. Its center is 40°25'N-73°45'W in 90 feet of water. Criteria for selection of the site were apparently based on the need to avoid endangering navigation and to avoid sewage sludge contamination on Long Island and New Jersey beach areas. In 1974, approximately 4.1 million tons of sewage sludge were discharged at or near this site. The problem of sludge disposal will intensify in the coming years as population and industrialization expand and as higher levels of municipal and industrial wastewater treatment are achieved.

The dumped sewage sludge is roughly 5 percent solids, consisting of two major fractions. One, composed of heavier solids, sinks to the bottom in the vicinity of the dumpsite. The second fraction is composed of dissolved and suspended solids in the water column, and floatable materials. It remains in the water column for varying periods of time after dumping, depending on its composition and on conditions affecting water circulation in the general area. Both fractions contain toxic heavy metals and pathogenic materials.

The ocean disposal of sewage sludge is not the major source of domestic wastes entering the Bight. Other sources include harbor waters of New York City, industrial plant outfalls, ship discharges, sewage outfalls, storm

water runoff, and municipal treatment plant overflows. An understanding of the total pollution load from these sources and from ocean dumping is one of the goals of the Federal research effort.

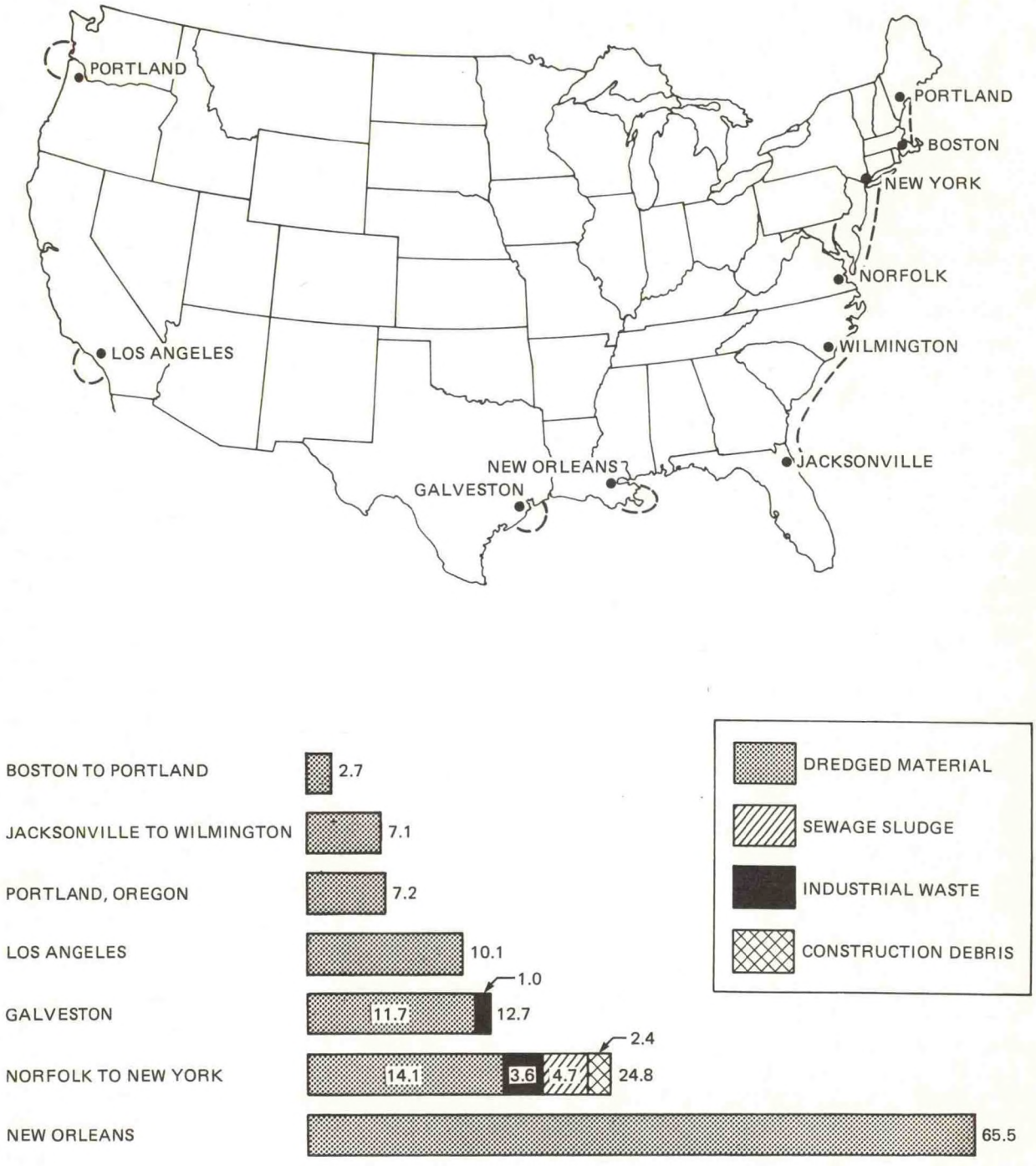

Figure 1.--Ocean waste disposal by category, 1974 (millions of short tons).

CHAPTER II

OCEAN DUMPING RESEARCH - CY 1974

The Council on Environmental Quality, in its 1970 report *Ocean Dumping - A National Policy* 3/, recommended a comprehensive national policy on ocean dumping of wastes to ban unregulated ocean dumping of all materials and strictly limit ocean disposal of any materials harmful to the marine environment. This national policy was adopted by the Congress when it approved the Marine Protection, Research, and Sanctuaries Act of 1972. In the same report the Council pointed out that in implementing such a policy certain information deficiencies would have to be overcome and identified seven major areas of needed research on ocean dumping. These included:

- Ecological research on pathways of waste materials in marine ecosystems--studies of the origin and fate of pollutants in the oceans, how pollutants pass through the food chain from microscopic plants and animals to ultimate predators, how pollutants accumulate and are concentrated in the food chain, and effects of this concentration on the marine environment and upon man.

- Preservation and study of representative marine ecosystems--these will serve as ecological reference points, baselines, and indices by which man-induced changes can be evaluated.

- Oceanographic studies of physical and chemical processes, with special emphasis on estuaries and coastal waters.

- Identification of toxic materials and investigation of their lethal, sublethal, and chronic long-term effects on marine life--studies of persistence of toxic substances, how pollutants are biologically and chemically degraded, how radioactive materials affect the marine environment and man, and the capacity of coastal and ocean waters to assimilate waste materials.

- Identification of pathogens in marine ecosystems--how they are transported, what risks to public health are involved, and what improvements can be made in measuring dangers to public health.

- Development of alternatives to ocean dumping, including research on the recycling of wastes and study of the social, institutional, and economic aspects of waste management.

- Development of effective national and international pollution monitoring systems, including studies to improve methods and technology to detect pollutants and alterations in the marine environment and to eliminate duplication of efforts in gathering, processing, and publishing the data.

By the end of 1974, the Federal research effort on ocean dumping had made substantial headway in addressing these critical research needs. A broad-based ecological research project to quantify the structure and function of the New York Bight ecosystem, including man's impacts on it was launched by NOAA in the New York Bight in 1973. Complementary research on the transfer of ocean-dumped pollutants through the marine food chain is being carried out by NOAA, EPA, the Corps of Engineers, and the National Science Foundation. These same agencies are also conducting studies on the immediate and long-term effects of toxic substances on marine organisms. Initial studies on the potential public health risks from ocean pollution were carried out in the New York Bight; additional work is scheduled for FY 1976. The Corps of Engineers and EPA are the lead agencies for developing alternatives to ocean dumping. Both agencies have extensive programs underway to identify feasible recycling technology and alternative waste disposal methods.

In terms of volume (Fig. 1), the disposal of dredged material presents the greatest number of problems. With regard to nondredged waste materials, the major problem is in the New York Bight. Research activities and accomplishments of 1974 follow.

RESEARCH ON OCEAN DISPOSAL OF NONDREDGED MATERIAL

New York Bight

The New York Bight includes the coastal waters between the eastern tip of Long Island, New York, and Cape May, New Jersey, and extends seaward to the edge of the continental shelf, an area of approximately 15,000 square miles (Fig. 2). The Bight is adjacent to the heavily populated and industrialized New York-New Jersey metropolitan area. Vessel traffic, waste disposal operations, commercial fishing, and recreational and other activities make the Bight the Nation's most complex and intensively used coastal area. By the end of 1974, about 5/6 of all nondredged waste material dumped in U.S. coastal waters went into the waters of the New York Bight. As the ultimate repository for most waterborne and airborne wastes from the Nation's largest metropolitan complex, the Bight waters, particularly in the area referred to in this report as the Apex (Fig. 2), have declined in quality over the years.

The need for better information on the effects of ocean dumping, as well as on other environmental problems in the New York Bight, led to the initiation in 1973 of a major NOAA investigation--the Marine Ecosystems Analysis (MESA) New York Bight Project. The MESA Project is an intensive, multiyear (1973-80), interdisciplinary investigation of: (1) the environmental stresses on the Bight, particularly those resulting from ocean dumping; and (2) the entire Bight ecosystem. The Project involves a number of NOAA organizational elements and contractors and is carried out in close cooperation with many other Federal, State, county, and municipal agencies.

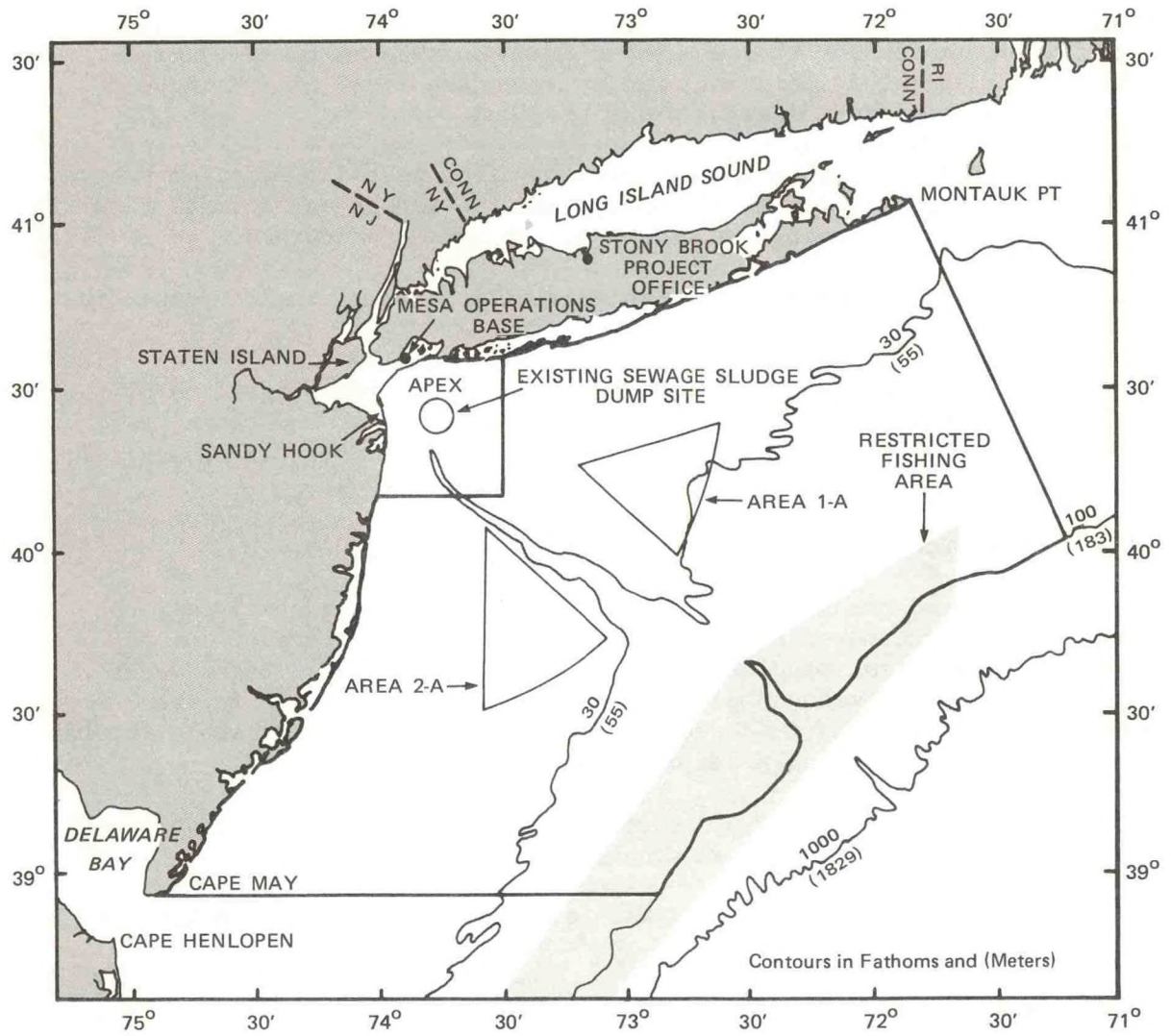

Figure 2.--Limits of New York Bight and Bight Apex. Existing sewage sludge dumpsite and proposed areas 1-A and 2-A for an alternative dumpsite for sewage sludge.

The MESA Project has developed a multiphased program to determine the fate and effects of pollutants in the New York Bight ecosystem:

Phase 1. Describing the marine environment in the vicinity of present and proposed dumpsite areas in the New York Bight Apex;

Phase 2. Assessing the impacts of ocean dumping in the New York Bight to date and predicting consequences of continued or modified disposal practices; and

Phase 3. Designing an environmental monitoring and prediction program to identify future changes in the marine environment resulting from dumping and other waste disposal practices.

Efforts through the end of 1974 were primarily directed toward completing Phase 1.

Existing information has been studied and field investigations of the Bight's ecosystem, and effects of ocean dumping on that ecosystem, were well underway in 1974. A summary of MESA field activities in geological, physical, chemical, and biological oceanography follows.

Geological Oceanography

To better understand the nature of the substrate and how it may be affected by dumped materials, or how it may affect the fate of dumped materials, geological studies are being made in and around Bight areas currently used for ocean dumping. Additionally, other areas in the Bight are being studied to determine their suitability as possible future dumpsites. The following types of observations are being made:

- Detailed bathymetry by conventional sonic techniques and micro-topography by side-scan sonar;
- Sediment composition and grain size by analysis of grab samples and core samples;
- Subsurface structure and stratigraphy by seismic reflection profiling and vibracoring;
- Sand transport by radioisotope tracing techniques and current measurements; and
- Bottom features by photography and submersible diving.

Topography of the 80- to 100-nautical-mile-wide continental shelf of the New York Bight is simple. Gently curving isobaths roughly parallel the coastlines of Long Island and New Jersey. The most notable topographic feature is the Hudson Shelf Valley, which begins near New York Harbor, deepens as it crosses the shelf, and becomes the Hudson Canyon at the continental slope.

In the fall of 1973, radioisotope sand tracing (RIST) experiments were begun to study the movements of bottom sediments (sand) in selected areas of the Bight. In RIST I (Fig. 3), the dispersal of sand tagged with gold-98 was measured and showed a slight movement north-northwest. A second experiment was carried out in the spring of 1974 near the Long Island shore. In RIST II the dumped material was tagged with ruthenium-103. Monitoring surveys were made over a 3-month period. There was limited dispersal of material after 20 days of exposure to currents of up to 0.8 knot. A subsequent monitoring study in the RIST II area in November 1974 showed sediment movement of 1,200 feet during a single storm. The general direction of sand transport in RIST II was east-west with oval-shaped spreading.

Data on substrate characteristics are obtained by a quarterly sampling program (substrate monitoring program--SUMP). Variability of grain size in the top centimeter of sediment is measured along two transects in the Bight Apex (Fig. 3). Sample analyses indicate that grain-size distribution along the two transects remains relatively stable with time.

Other experiments use side-scan sonar to measure changes in the micro-topography (substrate variability--SUVAR). The measurements suggest that current-produced bedforms develop during the winter months in response to wave and current action generated by frequent high-energy storm events. During summer months, when the time between high-energy storm events is much greater, the bedforms become degraded. Small bedforms, such as sand waves, sand ribbons, and ripple marks, undergo frequent change. Material accumulated at the dredged material dumpsite over the past 33 years indicates the stability of larger bathymetric features.

Dumped sewage sludge does not appear to have altered the bathymetry. Fine particles from the sludge, and probably from dredged materials, have had an effect on the grain size distribution of bottom sediments in Christiaensen Basin, north of the sludge dumpsite (Fig. 3).

Concentrations of suspended solids, including organic remains and mineral particles, are naturally high and quite variable within 5.5 nautical miles of the Long Island and New Jersey shores. These are supplied by the Hudson River estuary, by inner shelf currents moving westward along Long Island and northward along the northern New Jersey coast, by tidal exchange with shallow lagoons behind Long Island's barrier islands, and by plankton production. Microscopic analysis shows that suspended solids at all water depths within 8 nautical miles of Long Island during the fall of 1973 contained only trace amounts of processed cellulose (assumed to be disintegrated toilet paper) and black soot particles which are characteristic of samples of suspended solids collected from near-bottom waters at the sewage sludge dumpsite. It is clear that any sewage particles that move in suspension during transport northward toward Long Island are diluted by natural particles.

Concentrations of suspended solids in the lower third of the water column surrounding the dredged material and sewage sludge dumpsites are 30 to 50 percent greater than at locations in the same area not used

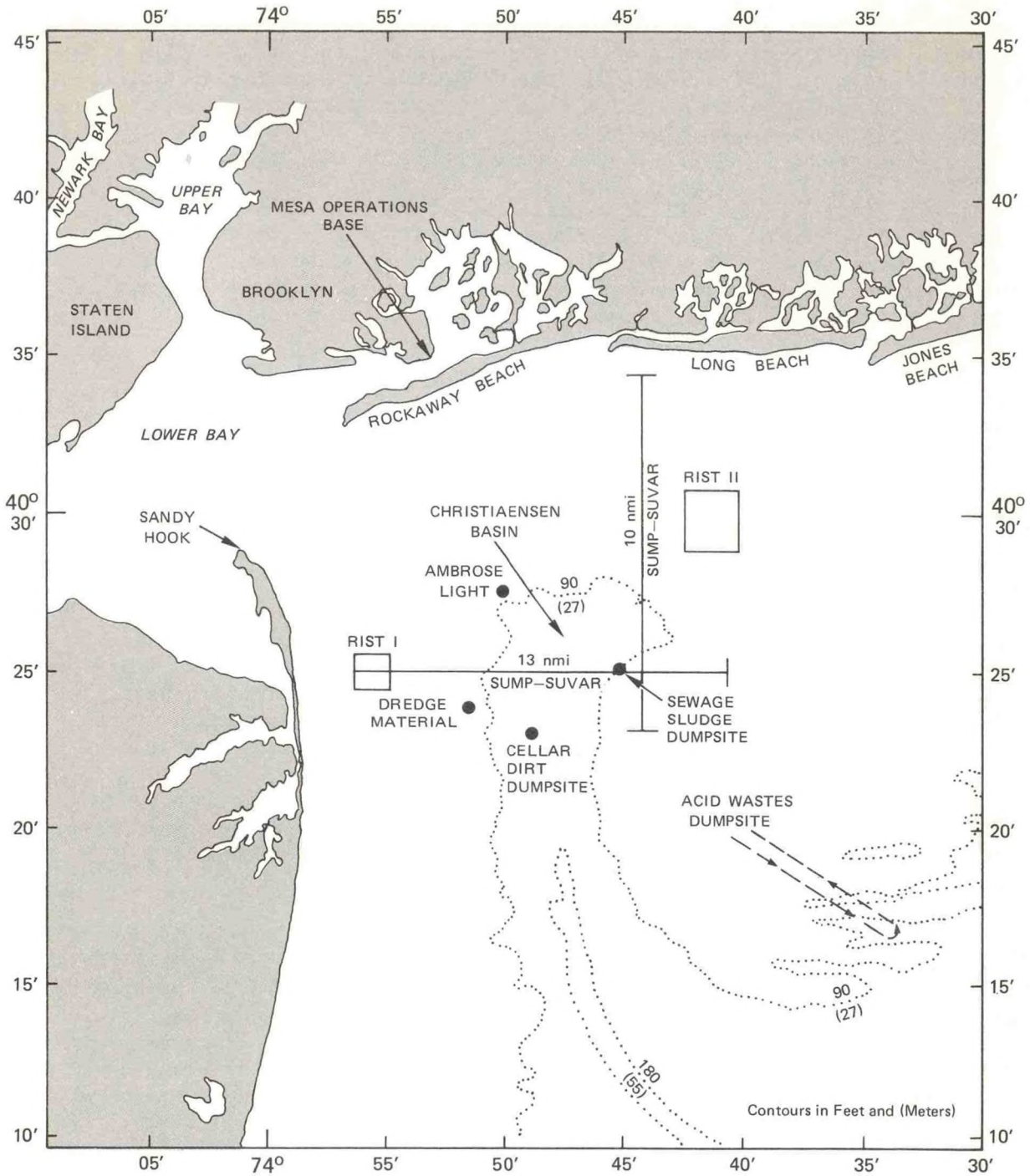

Figure 3.--Major dumpsites in New York Bight Apex: RIST I and II areas of radioisotope sand tracing experiments; and SUMP-SUVAR (substrate monitoring program - substrate variability experiments) transects along 40°25'N and 73°44'W.

for dumping. However, geological methods to date have not permitted investigators to separate quantitatively the dredged material, sewage sludge, and natural suspended material. Geochemical methods of identifying these components are being tested. Similar difficulties have been encountered in identifying the component sources of muds, which occur as isolated, thin, small patches on the bottom of the nearshore zone between the Long Island beaches and present dumpsites. Geochemical studies based on heavy metal ratios, organic compound ratios, and other chemical labels are being made to determine if the mud patches are of natural origin.

Two alternative areas have been studied for their suitability as ocean dumpsites (Fig. 2). Both have sand bottom. The absence of mud can be caused by a paucity of source material, or by strong currents that either remove or prevent deposition of mud-sized particles. Small bedforms indicate that storms periodically bring about changes in the microrelief and substrate and move sediments to the southwest. This suggests that sewage sludge, if dumped at either site, would be flushed to the southwest during severe storms, particularly in winter. Fractions of sewage sludge that settled to the sea floor would be actively reworked with sediment and have a net transport to the southwest. During extended periods of calm sea conditions, particularly in summer, sewage sludge might accumulate in small basins. However, permanent accumulation would result only if the supply of dumped materials exceeded the potential of the currents to remove deposited materials. If the northern alternative dumpsite (Area 1-A) is used, some sludge probably will reach the Hudson Shelf Valley, where it can be transported within the valley and incorporated into the muds. If the southern alternative dumpsite (Area 2-A) is used, its downcurrent position from the Hudson Shelf Valley will increase the probability of dispersal of dumped materials. Bathymetry and bedforms in this area also suggest the probability of greater dispersal of dumped materials.

Physical Oceanography

The study of the physical characteristics of the Bight, including winds, currents, circulation patterns, density gradients and other forces, is necessary to provide a more complete understanding of the transport and dispersal of dumped materials. This information is needed to help answer such questions as:

- Do wastes introduced into the Bight Apex tend to accumulate there?
- What is the probability of waste material reaching the beaches or waters used directly or indirectly by man?
- If the dumpsite were farther offshore, would the material remain seaward of an observed gyre?

Water temperatures over the shelf vary seasonally as do temperatures of the nearshore waters. Seasonal temperature changes in waters over the shelf lag by a few weeks the changes in nearshore waters. Salinities are variable over the shelf and particularly in nearshore areas affected by runoff. In the fall, cooling of surface waters and mixing by wind produce a vertically homogeneous water structure in the Bight Apex and over the shelf. In spring and summer, solar heating produces a warm upper layer. Over the shelf the warm surface waters are separated by a strong thermocline from the colder lower water layer. Throughout the year there is subsurface (at a depth of about 30 feet) evidence of slope waters near the shelf/slope boundary. Waters over the shelf flow southwesterly, generally parallel to the shore, but the circulation pattern is affected by tidal currents and variable meteorological conditions.

Available data on currents in the Bight Apex permit preliminary assessment of circulation patterns. Wind readily moves surface waters about with a fairly rapid response to changing wind direction; during non-stratified conditions, even bottom waters respond although to a lesser degree. However, during stratified conditions, bottom water response is inhibited. When the water is not stratified, surface winds, which are not great enough to contribute significantly to net transport of water, can cause suspension of bottom materials and mixing in the water column.

Drifter studies conducted in 1969 by the Sandy Hook Laboratory (now the Middle Atlantic Coastal Fisheries Center of NOAA), and more recently by the MESA New York Bight Project indicate that: (1) waters in the bottom return flow appear to come mostly from the head of the Hudson Shelf Valley; and (2) bottom transport does not extend under the Hudson River plume to reach the coast of New Jersey.

Solid wastes when dumped into New York Bight separate into floating, suspended, and bottom materials that are transported by surface, mid-depth, and bottom currents, respectively. Some solid materials go into solution and some suspended solids aggregate and settle to the bottom. Outflow from the Hudson and Raritan estuaries moves through the Bight Apex and along the shore to the south. Seaward a clockwise gyral circulation is modified by tidal and wind-driven currents and by the large-scale circulation over the shelf. The sewage sludge dumpsite is located within the western northerly moving portion of the gyre.

The possible existence of a clockwise gyral circulation of bottom waters came out of the 1969 drifter study. Further measurements were made during the fall of 1973 to confirm the presence of a clockwise gyral circulation of bottom waters in the area included in the Bight Apex. Studies indicate a northerly flow along the Hudson Shelf Valley toward the Christiaensen Basin. This flow appears to split, a portion feeding the Hudson estuary bottom return flow, and the remainder participating in an easterly flow at the northern extremity of the gyre.

Analysis of spring and summer current monitoring and other data will help to define the details and permanence of these circulation features of the Bight Apex.

Chemical Oceanography

Chemistry studies of Bight waters and suspended sediments are required to delineate the effects of ocean dumping on the water column and sea floor and to aid in identifying the extent, concentration, and movement of the dumped materials.

Chemical characteristics of the water and sediments of the New York Bight, especially near dumpsites, are a complex result of natural and man-made processes. Dredged material, sewage sludge, and acid wastes are dumped directly into the Bight at designated sites relatively close to each other. Dredged material contains natural organic matter from the drainage basin and organics in sewage discharged into the estuaries from which the dredged material is removed. Sewage sludge and dredged material also contain substantial amounts of trace metals, as do acid wastes. Areal or nonpoint pollutant sources include runoff from Long Island and New Jersey coasts and atmospheric fallout. Point sources include outflow from rivers through the Sandy Hook-Rockaway section, outfalls, ditches, and vessels. All these sources provide substantial amounts of trace metals. Runoff also contains large quantities of organic materials, especially hydrocarbons. Hydrocarbons also enter the Bight via oil spills and discarded waste oil. These contaminants accumulate or disperse, interact with organisms, dissolve, solidify, become buried or exposed, and are transported from the Bight. The same processes act upon natural materials that enter or occur in the Bight.

Several investigators have studied the distributions of trace metals in New York Bight sediments. 4, 5/ Higher concentrations were observed at and near the sewage sludge and dredge material dumpsites. Concentrations were observed to decrease with increasing distance from dumpsites. Klein et al. (1974) 6/ and Duedall et al. 7/ documented high and variable trace metal concentrations in sewage sludge from various treatment plants in the New York area. The MESA New York Bight Project has extended studies of trace metals in Bight sediments. Sediment samples collected in 1973 and 1974 have been analyzed for heavy metals.

Sediment samples at designated stations in the Bight Apex have been collected on a quarterly basis and analyzed for copper, chromium, lead, zinc, and nickel. High concentrations of the five metals are found north and west of the sewage sludge and dredge material dumpsites and to the south in the Hudson Shelf Valley. These high concentrations and similar distribution patterns indicate that some portion of sewage sludge and/or dredged material moves southward and seaward to the Hudson Shelf Valley.

Dumped dredge material and sewage sludge increase the oxygen demand of near-bottom waters around dumpsites and areas of natural deposition. These oxygen-deficient waters are restored to near-saturation values by mixing with waters of higher oxygen content, particularly with reaerated surface waters during the season of vertical mixing--at the time the water column is not stratified. The low oxygen content of water near the beaches is not necessarily an indication that the water has been in contact with sewage-derived or other organic materials. Seawater in equilibrium with

the atmosphere contains less than 5 milliliters per liter (ml/l) of oxygen at a temperature of 25°C and a salinity of 30 parts per thousand, which is common near the beach in summer.

Between the end of August 1973 and the end of September 1974, 11 cruises were conducted in the Bight Apex to study the chemical characteristics of the water column and their seasonal change. Measurements also were made of the nutrients--nitrate, nitrite, silicate, and phosphate. Nutrient concentration, as exemplified by silicate and nitrate, were, as expected, higher in bottom waters in the immediate vicinity of the sewage sludge and dredged material dumpsite areas. Concentrations were diminished when the Bight waters became nonstratified in the fall.

It is concluded that most nutrients in the Bight come from the Hudson River outflow and that the effects of dredged material and sewage sludge dumping on nutrient concentrations are relatively small and localized. There is no chemical evidence for movement of sewage sludge from the dumpsite toward Long Island beaches. There is evidence that some sludge and dredged material moves from the dumpsite seaward via the Hudson Shelf Valley. Pockets of mud near the beaches are a common natural occurrence and contain mainly natural materials, with small admixtures of sewage material derived from local outfalls, the sewage sludge dumpsite, or other sources.

Biological Oceanography

Biological studies and surveys are underway to determine the impact of ocean dumping on marine life in the Bight--the abundance, distribution, and composition of organisms, the condition of stocks, and the immediate and long-term effects on living resources.

Man's impact on the marine environment and its life forms is difficult to detect because of the magnitude of natural changes that affect marine populations. Most studies of plankton, benthos, and fish in the New York Bight have been directed to the effects of massive ocean dumping. Identification of these effects, versus those produced by natural events, is difficult.

Two studies of phytoplankton nutrients and productivity 9, 10/, three studies of net zooplankton 11, 12, 13/, and two studies of planktonic protozoa 14, 15/, show that impacts of dumping are localized and imperceptible relative to planktonic composition and productivity in the Bight Apex.

Benthic invertebrates are in direct contact for long periods with sediments that generally have higher concentrations of metal contaminants than do the overlying waters. Benthic organisms are better indicators of chronic pollution than plankton or free-swimming fish (nekton). They are an essential food source for many sport and food fishes in New York Bight. They also accumulate high concentrations of contaminants, such as heavy metals and organic chemicals. At present there is no evidence of widespread

decline or change in species composition of benthic invertebrates in the Bight as a whole, but in the Bight Apex there are changes that agree with an earlier report.

Amoebae and ciliated protozoa, important components of the plankton, also are significant benthic organisms. Over 150 samples of these small organisms in sediments are being analyzed to learn how their distribution is influenced by the dumping.

The high incidence of fin-rot disease in several species of fishes in the Bight may be an indication of environmental stress. The disease is characterized by a progressive erosion of the fin rays and overlying epidermis. The erosion begins at the outer edges of fins and progresses to the base. Figure 4 is a photograph of a fish with substantial erosion of dorsal and anal fins. Of the 22 species of fishes in the Bight that have fin-rot, the winter flounder is much more susceptible than any other species. However, in the past other species have had higher incidences of fin-rot than winter flounder. Monthly trawl samples have been taken inshore from Sandy Hook and Raritan Bays, and Great Bay, New Jersey. A significantly higher incidence of fin-rot in winter flounder is found in samples from the more polluted Sandy Hook-Raritan Bay (7.6%) than from Great Bay (1.9%). 16/

While the prevalence of fin-rot in winter flounder is clearly greater in the inner areas of the New York Bight, its precise causes are still unknown. Recent work concluded that fin-rot of winter flounder from Narragansett Bay, Rhode Island, was caused by the bacterium *Vibrio anguillarum*. 17/ Studies of several Pacific coast fishes having fin-rot disease indicate that some species have evidence of microbial infection whereas others do not. Extensive histological examinations of winter flounder from the Bight with fin-rot failed to show any in-situ bacteria.

It is known that shellfish near the sewage sludge and dredged material dumpsites contain high concentrations of coliform bacteria. A study of possible movements of bacteria from the sewage sludge dumpsite to Long Island beaches shows that all monitored beaches had acceptable bacteriological water quality. 18, 19, 20, 21/ Analyses of beach waters off Long Island for pathogenic bacteria did not reveal contamination. 22/

A circular area with a 6-nautical-mile radius around the sewage sludge dumpsite was closed to shellfishing in 1970 by the Food and Drug Administration (FDA). In May 1974, FDA expanded this closure area, because of bacterial contamination from ocean sewage outfalls and seaward flow from Lower Bay and other bays.

Coliform bacteria that have developed a genetic resistance to heavy metals and to a broad spectrum of antibiotics have been found in the New York Bight. 23/ Studies that have been conducted over the years have shown that a form of resistance called the "R factor," can be genetically transmitted to different genera and species of bacteria. Coliform bacteria, ordinarily viewed as a harmless indicator of pollution, have been found to transmit the "R factor." These bacteria can also serve as a reservoir

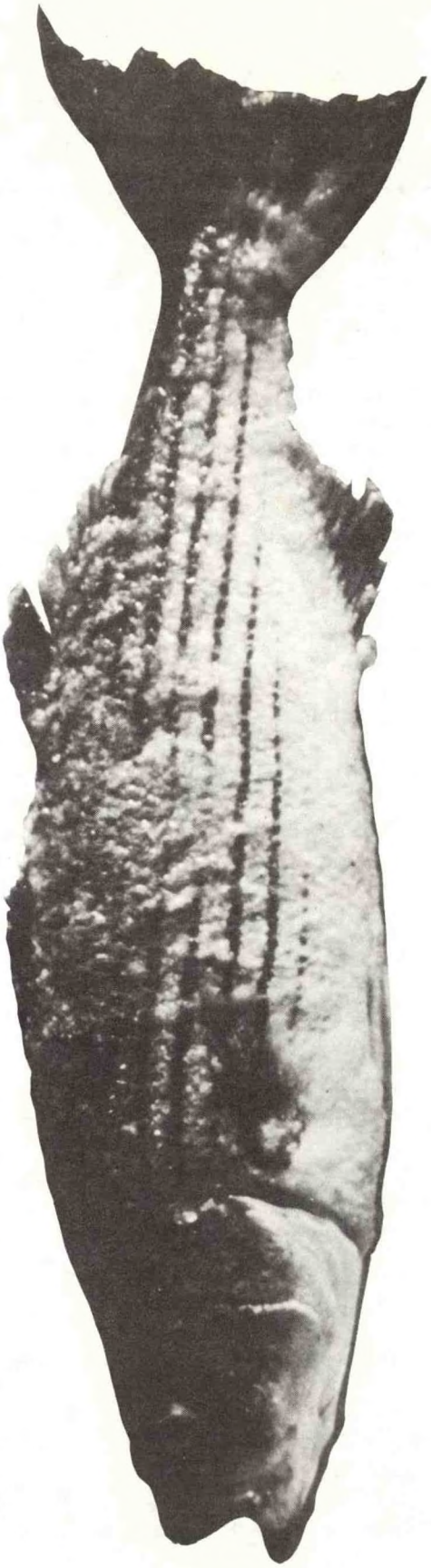

Figure 4.--Striped bass with fin-rot.

from which other bacteria, including human pathogens, are immunized against the effects of antibiotics or other substances normally toxic to bacteria, such as heavy metals. The public health implications of these resistant strains are unknown. Additional MESA resources will be made available for further research into this phenomenon.

Dumpsite Relocation

In early 1974 EPA requested NOAA's assistance in selecting areas within the Bight to be investigated as possible alternative sewage sludge dumpsites. This task was assumed by the MESA Project office. The alternative dumpsite investigation is described in this chapter under the title "Dumpsite Characterizations."

Findings and Recommendations

Studies of the present sewage sludge dumpsite have been undertaken by investigators over the past several years. Based on evaluation of these studies and on MESA investigations, it can be stated that there is no evidence of a massive general movement of sewage sludge toward Long Island beaches. On the contrary, evidence suggests that natural discharges and over 40 years of dumping sewage sludge have produced a well-established, rather stable distribution of organic-rich muds in the New York Bight. The distribution patterns of these muds are not likely to change appreciably with time.

Bacteriological effects of ocean dumping have resulted in closing the area around the sludge dumping site to shellfishing. There is concern that Long Island beaches are threatened by bacteriological contamination from sludge dumping. Additional study is needed to determine the probable level of contamination from dumping the larger future quantities of sludge at either present or alternative sites. These studies are underway, including assessment of resistance factors in coliform and pathogenic bacteria from the sludge.

The hazards of dumping sewage sludge and dredged material containing trace metals and other toxic industrial waste materials into the New York Bight are not well-known.

The higher than normal incidence of fin-rot in fish taken in the Bight Apex requires additional investigation.

The consequences of interaction of much of the dumped material, such as sewage sludge, with the marine environment are unknown at this time. Consequently, research on the fractionation, modification, and ultimate fate and effect of material dumped in the ocean is important.

New dumpsites should not be generated unnecessarily or without a thorough understanding of the environmental consequences. The ultimate impact of moving an existing dumpsite could result in more environmental damage than its continued use.

Chesapeake Bight

In 1974 EPA Region III sponsored additional surveys of the ocean area off the coasts of Maryland and Delaware where dumping is currently practiced. One dumpsite lies about 40 miles east of Ocean City, where the city of Philadelphia is dumping approximately 640,000 tons of sewage sludge each year (Fig. 5). Dumping at the other site, 38 miles east-southeast of Cape Henlopen, Delaware, was begun in May 1973, following a baseline study. This dumpsite has been used by the DuPont Company since 1968 for the disposal of ferrous sulfate and sulphuric acid wastes. About 20 million gallons of these wastes are dumped each month from barges; an amount approximately equivalent to 590,000 tons per year. The effects of this acid waste dumping have been under continuous study by DuPont and by government agencies.

In 1973 EPA conducted a survey called "Operation Quicksilver" to assess the environment at the municipal sewage sludge dumpsite prior to the disposal of sludge. Another cruise, "Operation Fetch," was undertaken later that year to evaluate, and possibly discriminate, the effects of both dumpsites. It became apparent from these cruises that the affected area, as indicated by metals in the benthic environment, was of greater extent than the area surveyed.

In 1974, two additional field surveys were conducted off the coasts of Maryland and Delaware to determine the extent of the area affected by ocean dumping. The March survey, "Operation Ides," gathered data in order to have a statistical basis for the evaluation of contaminant distributions and to evaluate the forces responsible for the observed distribution. This cruise was followed in August by "Operation Deep Six" which continued the investigation of the extent of materials dispersal, the causes thereof, and accumulation of contaminant materials in the biota.

Scientists and personnel from EPA, Geological Survey, Coast Guard, NOAA, and various private institutions took part in the surveys. Operation Deep Six was run nearly concurrently with a joint NOAA-EPA cruise using a two-man submersible vehicle to directly observe conditions in the water column and benthos.

The findings of both Operation Ides and Operation Deep Six showed no detectable concentrations of total coliforms or fecal coliforms (less than 3 organisms per 100 ml of sample at the 95 percent confidence limit) at the sewage sludge dumpsite. This was taken as evidence of no major buildup of coliform bacteria in the bottom waters or sediments. 24/

The distribution of metals in bottom sediments and organisms indicates these potentially toxic materials persist in bottom materials, and are apparently translocated as a result of hydrographic forces. This increases their potential toxicity to a relatively great area, with its indigenous biota. There was evidence of accumulation in benthic organisms, notably the mahogany clam, *Arctica islandica*, and the scallop, *Placopecten magellanicus*. Of 13 metals examined, 11 were observed to accumulate in

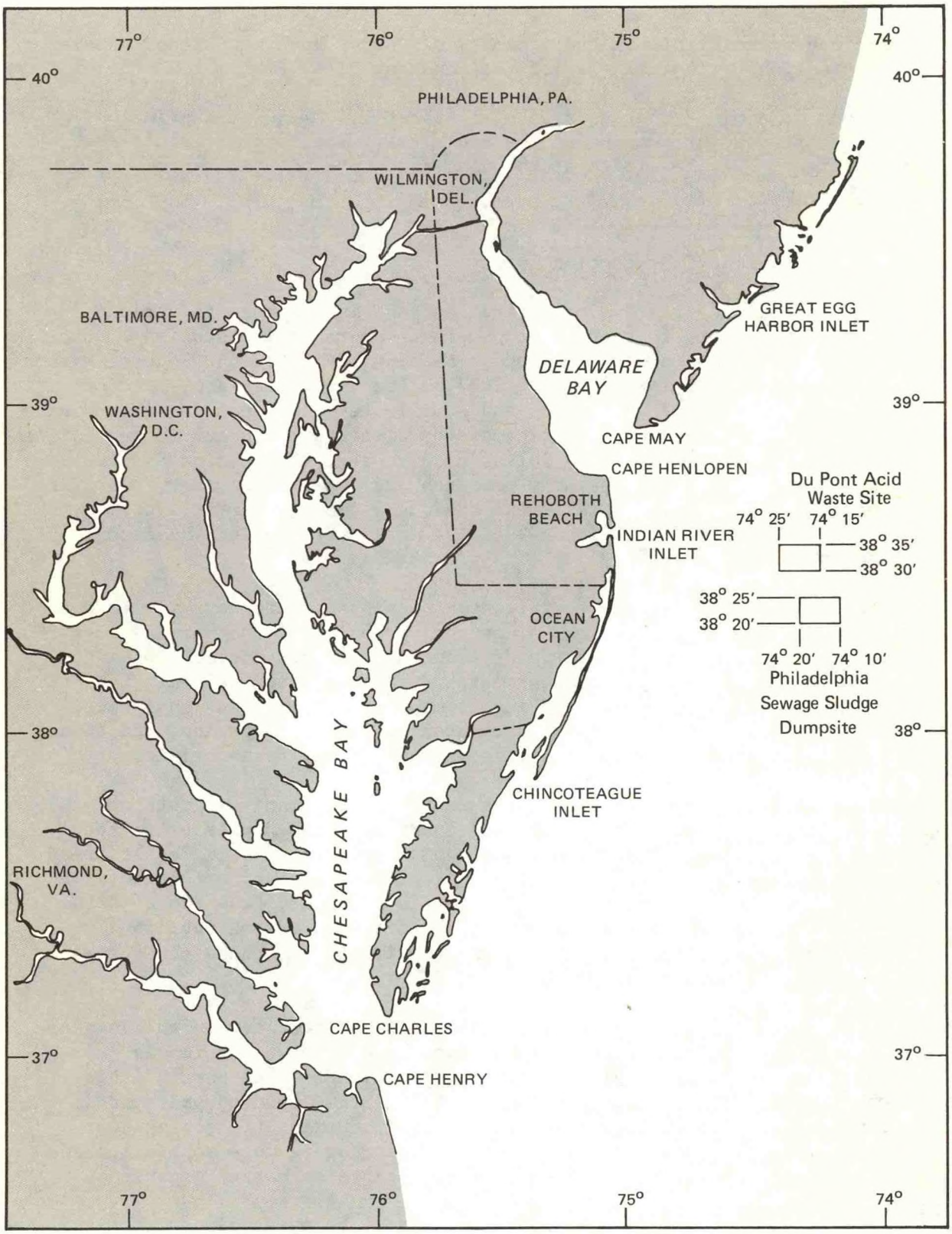

Figure 5.--Chesapeake Bight dumpsites.

animals and/or sediments in the vicinity of one or both dumpsites. There were indications of mortalities of the mahogany clam.

It was determined that an area of at least 1,000 square nautical miles was affected by dumping at the two sites. The total area affected may be larger, but the limits of the dispersion are not yet known.

Other Related Research

Environmental Protection Agency

EPA carries out programs of marine research in response to various legislative authority to conduct and support comprehensive studies of the effects of pollution in estuaries under Section 104(a) of the Federal Water Pollution Control Act Amendments of 1972. Also under that Act, EPA conducts research in order to develop and promulgate guidelines for determining the degradation of coastal waters caused by discharges subject to regulation under Section 402, the National Pollutant Discharge Elimination System. Finally, EPA conducts and sponsors research and baseline studies to provide the information it needs to implement the ocean dumping permit system established pursuant to Section 102 of the Marine Protection, Research, and Sanctuaries Act.

Research efforts related to the ocean dumping permit program within EPA have been focused in three areas since the inception of the permit program in 1973. These are: (1) criteria development, (2) methods development, and (3) environmental impact assessment. Highest initial priority has been given to the development and improvement of criteria and analytical methodology, and as these efforts have brought positive results, additional resources have been directed toward assessment of environmental impact.

Of particular concern to EPA has been the development of acute and chronic toxicity levels for mercury and cadmium in ocean waters and the application of these values to ocean disposal criteria. As a result of an EPA-sponsored review of water quality criteria by the National Academy of Sciences, together with recent findings of in-house EPA research efforts, information is now available to support modification of the published criteria for mercury and cadmium. Revised criteria for these constituents will be proposed in the near future.

Initial efforts on analytical methodology have resulted in the development of an interim Ocean Dumping Analytical Methods Manual which is currently in use by EPA regions and permit applicants. As part of this effort, a manual of standard bioassay techniques has been compiled and revised as the state of knowledge has advanced. During the coming year the bioassay techniques will be revised to incorporate more sophisticated methods of detecting chronic effects of pollutants on marine organisms.

The environmental impact of ocean dumping is being studied directly by in-house EPA activities as well as through grants and contracts. These efforts are being concentrated in two general areas: trace metal impacts and modeling techniques to predict impacts.

The following studies have been conducted on the movement and impact of trace metals in marine waters. Although most of these studies deal primarily with estuarine situations, the results can, in most cases, be extrapolated to ocean dumping situations:

1. An industrial waste dumpsite and a sewage sludge dumpsite are being used to test the concept of analytically "fingerprinting" a waste material by trace metals analysis. Research efforts have attempted to follow the fate of each waste by following particular metal "tags." Results to date indicate an increase in trace metals in benthic invertebrates at and around the dumpsites. Future efforts will extend the sampling areas in an effort to delineate the total area of effect of the dumping activities.

2. At a dredged material disposal site in Rhode Island Sound, where material containing high concentrations of heavy metals has been deposited, a clear demonstration of deleterious ecological impact is developing. Preliminary data indicate high cadmium and zinc concentrations in the water directly over the deposited material. Histological examinations of tissues from the clam *Arctica islandica* have revealed kidney-damaging concretions in clams found as far as 5 miles from the site. Tissue damage was greater in clams found closer to the site. Concentrations of selected metals in clam tissues have been shown to be very high relative to uncontaminated controls. Crabs caught on the dredged material showed abnormally eroded and discolored carapaces.

3. An extensive field sampling program to evaluate the effects of metals on benthic animals has been conducted in lower Narragansett Bay, Rhode Island. This study was designed to develop techniques for evaluating the ecological impact of a typical industrial discharge containing large quantities of heavy metals. Metal contamination of benthos has been demonstrated.

4. A study of the movement of trace materials from sewage sludge into marine biota is being performed. While prime emphasis is on metal transport and uptake, consideration is also being given to investigations of the ecological behavior of chlorinated hydrocarbons.

5. A study entitled "Dredge Spoils and Sewage Sludge in the Trace Metal Budget of Estuarine and Coastal Waters" will develop field methods for assessing metal fluxes from natural sediments. The study will attempt to develop correlations between concentrations of metals in the water column and in the sediment in the Hudson River estuary and the New York Bight.

6. A mathematical model to assess the effects of time-dependent and time-independent sewage sludge stress on marine plankton systems is under development.

7. A grant entitled "Influence of Dredged Spoils and Sediment Pollution on Trace Metal Assimilation by Organisms" will use controlled laboratory experiments simulating ocean dumpsites to assess metal fluxes between sediments and overlying water.

EPA is also investigating the feasibility of using mathematical modeling techniques to predict the fate of ocean-dumped pollutants in the marine environment and to assess their effects on marine ecosystems.

1. An in-house study of ocean dumping impact in the New York Bight will provide information essential to proper management of ocean disposal sites. The purpose of the project is to develop a predictive capability to describe the fate of sewage sludge discharged from moving barges into that nearshore ocean environment. Mathematical models have been devised to predict the time-spatial distribution of sewage sludge particulates originating from barge disposal. Work is being performed to field verify this model.

2. Another in-house study is developing biological assessment techniques to determine the health of marine ecosystems by using biological indices. This approach can be used to assess the impact of stresses such as ocean dumping and outfall discharges upon community structure and population dynamics of locally residing biota in polluted and nonpolluted marine environments.

3. The usefulness of currently available analytical techniques for objective and quantitative evaluation of species, populations, and community responses to environmental changes will be the focus of a grant entitled "Quantitative Response Characteristics of Coastal Fish and Benthic Invertebrate Communities."

4. A numerical hydrodynamical model study for the pollutant flushing in Prudhoe Bay, Alaska, is being carried out in-house. A limited field investigation will be undertaken during the ice-free season this summer.

5. A study entitled "Biological Analysis of Primary Productivity and Related Processes in New York Harbor as Reflective of Changing Water Quality" is investigating those processes and factors which might contribute to massive algal blooms. This study will provide information relevant to the kinds of treatment required for municipal waste discharges. In addition, the study will investigate whether the water quality of the New York harbor region is being affected by materials flowing into the area from offshore sludge dumping sites.

NOAA Sea Grant

The National Oceanic and Atmospheric Administration Office of Sea Grant has sponsored university research projects related to ocean dumping and the disposal of dredged material. Projects underway in 1974--by project title, principal investigator, and organizational affiliation--are:

- Economics of Waste Disposal in Marine Environment, James McFarland, Department of Resource Economics, University of Rhode Island.

- Technical Aspects of Ocean Dumping of Industrial Wastes, Roy W. Hann, Jr., Department of Civil Engineering, Texas A&M University.

- o Regeneration of Marshes on Dredge Spoil, E. D. Seneca, Departments of Biology and Soil Science, University of North Carolina.

- o Effect of Dredge Spoil Disposal on Benthic Animals, Saul B. Saila, Graduate School of Oceanography, University of Rhode Island.

RESEARCH ON THE OCEAN DISPOSAL OF DREDGED MATERIAL

Dredged Material Research Program

The River and Harbor Act of 1970 (P.L. 91-611) authorized the Chief of Engineers, under the direction of the Secretary of the Army, to conduct a comprehensive program of research, study, and experimentation relating to dredged material. In May 1971, the U.S. Army Engineer, Waterways Experiment Station (WES) at Vicksburg, Mississippi, was assigned the task of defining and assessing the problem and developing a research program.

A 5-year Dredged Material Research Program (DMRP) was conceived to provide definitive information on the environmental impact of dredging and dredged material disposal operations and to develop technically satisfactory, environmentally compatible, and economically feasible dredging and disposal alternatives, including consideration of dredged material as a natural resource. Execution of the program was assigned to WES and research was initiated in March 1973. The Corps estimates that DMRP will cost $30 million and will be completed in FY 1978.

In July 1974 a reorganization placed DMRP within the Environmental Effects Laboratory (EEL), the newest WES laboratory. Under this realignment, the identity, importance, mode of conduct, and management of DMRP are unchanged while the new organizational structure can provide additional planning, technical, and management support.

DMRP is divided into four projects--each directed by a full-time project manager and each with its own support staff.

- o Aquatic Disposal Research Project
- o Habitat Development Research Project
- o Disposal Operations Research Project
- o Productive Uses Research Project

Aquatic Disposal Research Project

Significant work units completed during 1974 included: planning and other preliminary work for comprehensive studies of the effects of open-water disposal of dredged materials on aquatic organisms at four regionally representative disposal sites located in Ohio, Oregon, New York, and Texas; development of models and other techniques for determining the spatial and temporal distribution of dredged materials discharged into various hydrologic regimes; assessment of aesthetic and ecological significance of turbidity in various aquatic environments; and design and establishment of estuarine ecosystem simulations.

Habitat Development Research Project

Major work units completed during 1974 were: development of a methodology for assessing the social, economic, and environmental effects of dredged material disposal in marsh and upland areas; collection and assessment of data on land disposal sites, selection of initial test sites, and design of basic field investigation programs; study of the identification of relevant criteria and survey of potential application sites for artificial habitat creation; design and establishment of salt marsh ecosystem simulations; and review and examination of disposal area filling techniques and rates to identify alternatives amenable to greater wildlife use of disposal areas.

Disposal Operations Research Project

Among the work units completed in 1974 were: an evaluation of promising species of vegetation for slurry filtering, pollutant removal, and dredged material desiccation; identification of the nature and distribution of objectionable environmental conditions in confined disposal areas; development of guidelines for containment facility design; development of methods for dewatering or densifying dredged material; development of viable concepts for improving the physical properties of dredged materials; identification of ways to promote the use of dredged material as a marketable resource; and laboratory studies to determine the amenability of polluted dredged materials to chemical, physical, and biological treatment processes.

Productive Uses Research Project

During the reporting period, studies were completed on: the feasibility of using existing and proposed pits of dredged material disposal, and the feasibility of lawn sod production and related activities in dredged material disposal sites.

Preliminary Findings

Some of the more significant findings of the Dredged Material Research Program as related to aquatic disposal are summarized as follows: 26/

o As a result of comprehensive baseline studies preliminary to experimental disposal at the Eatons Neck (Long Island Sound) field site, it was found that the historical disposal (75 years) at the site does not appear to have had a detrimental water-quality and biological impact on Long Island Sound. Fishing is excellent in the area, and bottom biota are representative of central Long Island Sound.

o The physical impact of the historical dumping in Long Island Sound has resulted in piles or mounds on the bottom. This has enhanced lobster habitat.

o The historical dumping in the Pacific Ocean site off the mouth of the Columbia River (another experimental test site) does not appear to have had a chemical or water-quality impact on the surrounding area.

o The bottom-dwelling biota in the Pacific Ocean site appear to be enriched by the accumulation of fine-grained sediments on the bottom.

o The physical impact of dumping at the Pacific Ocean site appears minimal.

o Laboratory studies are indicating that toxic heavy metals and organic pesticides do not appear to be released and are apparently very stable in sediments.

o Aerobic (oxygen-rich) conditions in disposal site water retard the release of some nutrients (such as phosphate), while others are unaffected.

o Anoxic (oxygen-depleted) conditions in disposal site water enhance the release of some nutrients (such as nitrogen and phosphate) and a few nontoxic heavy metals (such as iron and manganese).

o Most chemicals do not appear to be released from underwater dredged material deposits in quantities greater than release from natural sediments. Ammonium and manganese are released to overlying water but are rapidly lost to the aquatic system.

o Open-water disposal does not appear to have an acute or chronic effect on water quality either during disposal or after sedimentation.

o Results of one field investigation have shown that 86 percent of the biota was physically removed from the dredging site; 1-1/2 to 2-1/2 years were required for stable, predredge conditions to return.

o The field study also showed that at the disposal site ("clean dredged material") 2-1/2 years were required for stable conditions and 3-1/2 years to reach predredging conditions.

o Laboratory results indicate that 2 percent of sorbed pesticides are taken up by bottom-feeding organisms.

o Bulk criteria used to characterize the pollution potential of dredged material are totally inadequate. This approach is based on the assumption that all forms of chemical constituent in a sediment have an identical impact on water quality. This is technically unsound and yields uninterpretable data that are not implementable.

o The interim criteria (based on an "elutriate test") adequately predict the acute or short-term water column effect of aquatic disposal over a wide range of chemical constituents. The evaluations suggested that the test can predict the mobile concentrations of some constituents from the underwater disposal mound.

o Virtually nothing is known about existing subaqueous sand and gravel borrow pits as potential disposal sites in any part of the United States.

o Several activities, particularly exploitation of underwater sand resources for beach nourishment, will result in a slow, steady increase in the number of pits created.

o With supplemental navigation aids and proper vessel handling, disposal into borrow pits is feasible with present dredge plant, especially hopper dredges.

o While this alternative exists, the value to be derived by thus confining the material or covering it with inert material remains open to question. Other DMRP research results will help clarify this issue.

Dumping of Dredged Material in New York Bight

The center of the dredged material (mud) dumping ground in the New York Bight is located at 40°24'N-73°51'W, about midway between Sandy Hook, New Jersey, and the sewage sludge dumpsite. The present site has been used since about 1940. The dredged materials deposited at this location are from navigation channels, vessel, berths, and anchorage grounds in the New York Harbor complex. The materials are composed primarily of silt, and with clay materials making up the remainder of the solids. Admixed with these fractions are portions of sewage and industrial wastes that remain in the estuaries and bays and are subsequently dredged. Clean earth and fly-ash from conventional electric power generating stations are also disposed at the dredged material dumpsite. Between 1965 and 1970 an average 260 million cubic feet (about 11.6 million tons) of dredged material were dumped each year. This volume is expected to increase as harbor facilities continue to expand. Enough has been dumped to cause shoaling of some 30 feet. The dredged material is contaminated by organic materials and heavy metals.

The MESA New York Bight Project has conducted field investigations at this dumpsite and has analyzed samples in the laboratory as part of the overall MESA effort.

During summer 1973 MESA sponsored a substrate inventory profiling survey of the Bight Apex. One product of the survey data was a bathymetric contour map, which, when compared with data gathered in the 1930s, indicated less than 6 feet of net bathymetric change over the entire Apex, with one exception. The area in the vicinity of the present dredged material dumpsite has shoaled as much as 30 feet (Fig. 6). Changes in bathymetry at the dredged material dumpsite have been announced, and a chartlet has been published in Notice to Mariners No. 31, dated August 3, 1974. The finished version of the bathymetric map of the Apex is to be published in mid-1975.

During grab sampling surveys, initiated in summer 1972 and continued through summer 1974, surficial sediment samples were taken on a sampling interval of approximately 0.5 nautical miles in the Bight Apex. Special attention was given to the dredged dumpsite and its surrounding area. These samples were supplemented by grab samples obtained during quarterly benthic sampling cruises conducted as part of the MESA biology effort.

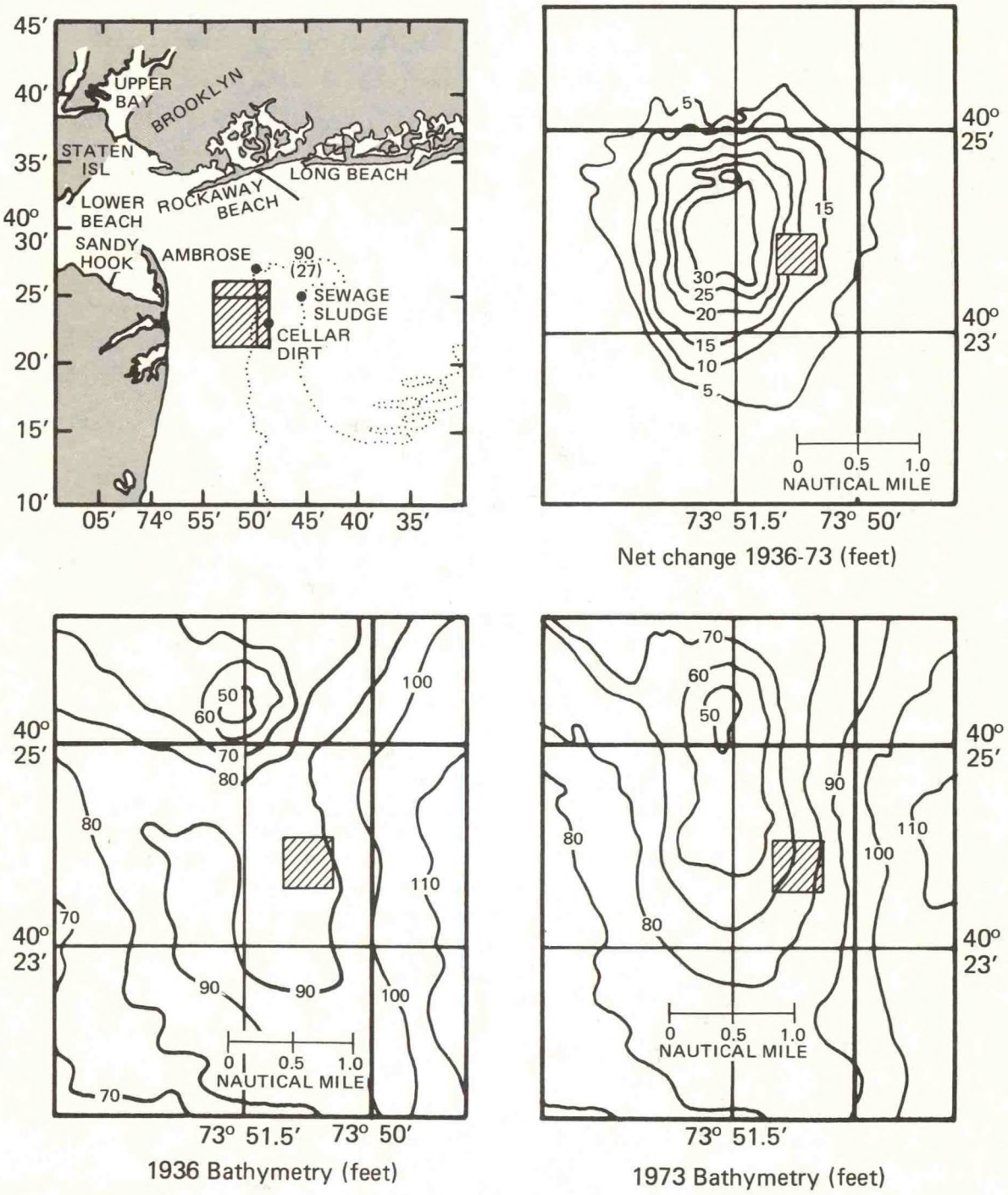

Figure 6.--Bathymetric change at the dredged material (mud) dumpsite.

Based on visual examination of samples the surficial sediment type at an near the dredged material dumpsite is mud; further from the dumpsite the surficial sediment is fine-medium sands. Several long cores were taken around the dredged material dumpsite during the bathymetry survey, and during spring and summer 1974, using a vibracoring technique.

During FY 1974, and extending into the first quarter of FY 1975, field activities were carried out to monitor noncohesive sediment (sand) fluxes along the 40°25'N transect, just north of the dredged material dumpsite (Fig. 3). Bottom samples, collected on a quarterly basis, were examined as part of the substrate monitoring program (SUMP) to determine storm-driven fluxes, and rates and areal extent of erosion and deposition.

In addition, in November 1973, a radioisotope sand tracing (RIST) experiment was conducted in an area between the dredged material dumpsite and the New Jersey shore. Four surveys of the tagged sand were conducted over a 10-day period to detect dispersal. A bottom-mounted current meter was deployed at the site to measure bottom currents acting on the substrate.

The results of these experiments suggest that the bedform patterns found are probably responses to storm-generated, high-intensity flow fields rather than fair-weather flow fields. The high-intensity flow fields are also probably responsible for the sediment distribution found around the dredged material dumpsite and the remainder of the Bight Apex. Coarse sediment transport is storm-driven, and its pattern differs markedly from fine sediment transport. Peak current velocities measured there were of the order of 35 cm/sec, just sufficient to initiate sand transport, but insufficient to move appreciable quantities.

As another effort to gain a better understanding of the fate of transportable materials (with particular emphasis on dredged material and sewage sludge), MESA supplemented a drifter study, ongoing at the State University of New York at Stony Brook. The resultant field operations consisted of 12 aircraft flights to release approximately 26,000 surface and 5,000 bottom drifters at selected locations during the period January - August 1974. Analysis of data from this effort is projected for early 1975.

Measured long-term mean flow in the water column at stations near and somewhat shoreward of the dredged material dumpsite show that flow is generally northward and slightly to the east.

In 1974, MESA chemistry efforts have included extensive sampling and analysis of Bight Apex sediments, mainly for the purpose of delineating the extent and fate of dumped dredged material and sewage sludge. Analysis of nutrient distributions (nitrate, nitrite, phosphate, and silicate) indicates that the water column in the New York Bight Apex is influenced more by the outflow of water from Lower Bay than by contamination from other sources, including dredged material and sewage sludge. These two specific sources do, however, contribute to somewhat higher levels at and in the local areas surrounding the dumpsites.

Five major cruises at quarterly intervals have been taken since August 1973 in the Apex, with primary emphasis upon sampling benthic organisms. Five replicate grab samples were taken at each of 103 stations, including stations immediately around the dredged material dumpsite. In addition to these quarterly cruises, benthic samples have also been taken in conjunction with the geologically oriented substrate monitoring program along the 40°25'N transect just north of the dredged material dumpsite. The time-consuming nature of identifying benthic invertebrates has precluded analysis of enough samples to allow definition of distribution at this time.

Six cruises have been made throughout the Bight to assess the distribution and abundance of bottom fishes (groundfish). A series of monthly cruises, along transects across the continental shelf, were initiated in June 1974 to supplement the major groundfish assessment cruises. The results of these cruises will be an evaluation of the groundfish resources in the Bight Apex, in general, and at the dumpsites in particular.

Two other MESA-sponsored studies are directly applicable to the dredged material disposal problem in the Bight Apex. Both were initiated in June 1974, and are designed to obtain estimates of the magnitude of contaminant inputs. The first is a quantification of the relative importance of point sources (dredged material, sewage sludge, outfalls, river and estuarine outflows, etc.) and nonpoint sources (ground runoff, groundwater seepage, petrochemical releases, atmospheric aerosol fallout, etc.). The final report, covering major categories of contaminants, such as solids, nutrients, and toxicants, is due the second half of 1975. The second study is designed to determine the effects of sediment accumulation rates and sediment stability on contaminant release to, or takeup from, the water column. The actions of currents, bioturbation, and episodic storms on sediments are being examined. The final report for this project is due the first quarter of FY 1976.

DUMPSITE CHARACTERIZATIONS

Alternative Sewage Sludge Dumpsite Investigations

In early 1974, the Environmental Protection Agency, Region II, requested NOAA's assistance in selecting areas within the New York Bight to be investigated as possible alternative sewage sludge dumpsite locations. The need was to identify appropriate areas, based on investigations to date, for relocating the sewage sludge dumpsite, should the present site prove to be adversely affecting the quality of the nearshore waters and the beaches. NOAA proposed two areas for consideration (Fig. 2).

Area 1-A lies northeast of the Hudson Shelf Valley. Its northern boundary is a line roughly parallel to and 25 nautical miles from the Long Island coast (this boundary is seaward of the 20-fm curve). Its southern boundary is a line roughly parallel to and 10 nautical miles north of the axis of the Hudson Shelf Valley; and its eastern boundary is described as an arc of

a circle with a radius of 65 nautical miles centered at the midpoint of the Sandy Hook, New Jersey-Rockaway Point, New York transect.

Area 2-A lies southwest of the Hudson Shelf Valley. Its northern boundary is a line roughly parallel to and 10 nautical miles south of the axis of the Hudson Shelf Valley. Its western boundary is an approximation of the 20-fm curve; and its southern boundary is an arc of a circle with a radius of 65 nautical miles centered at the midpoint of the Sandy Hook-Rockaway Point transect.

Selection of the two areas proposed was based on three requirements:

- o The location should minimize the chance of contamination reaching shorelines and beaches; and
- o The location should minimize, to the extent possible, adverse effects upon living marine resources; and
- o The location should be within 65 nautical miles of the harbor entrance.

A substantial amount of the MESA project's funds and efforts for FY 1975 was devoted to assessing the adequacy of the proposed areas. Water circulation patterns, interaction of the waters with bottom topography, and biological phenomena have been examined in these two areas. The location of the Hudson Shelf Valley itself imposes some restrictions on locating an alternative dumpsite. The clockwise circulation gyre in the Apex appears to have its western edge aligned with the Hudson Shelf Valley. There are indications of deposition and erosion, and transport both up and down the Shelf Valley. Additionally, the Shelf Valley area:

- o Serves as a migration route for certain fishes and shellfish;
- o Supports active fisheries; and
- o Serves as a winter aggregation zone for some fishes.

The areas most intensively fished for surf clams were also avoided in proposing the two areas. These areas are generally shoreward of the 20-fm contour along New Jersey and Long Island, with the greatest concentrations between the 10- and 20-fm contour.

Evidence available does not indicate that an interim change in the New York Bight sewage sludge dumpsite is required. However, in view of the projected increased quantity of sewage sludge to be dumped in the Bight over the next few years, plans should be made now to change the dumpsite should future conditions warrant.

Not addressed in the recommendations, however, is the problem of what to do about the dredged material dumpsite. There is a potential hazard to navigation at the dredged material site due to the buildup of dredged materials. Consideration might be given to combining the sewage sludge and dredged material dumpsites when an alternative site is designated by

EPA. Due to the pollutants contained in these dredged materials, there may be little benefit from moving only one of these two sources of contamination in the Bight Apex. However, because of the difference in the sediment characteristics of sewage sludge and dredged material, there might be little benefit derived by an extensive relocation of the dredged material dumpsite. The problem definitely requires more investigation.

By August 1975 NOAA plans to complete the assessment of the proposed areas. A compelling reason for an adequate yet speedy evaluation was the EPA announcement in October 1974 that use of the present sewage sludge dumpsite will not be permitted as of July 1, 1976, and that a new interim dumpsite would be selected in one of the two areas identified by NOAA. EPA is now preparing an Environmental Impact Statement for relocation of the site. The early announcement was made to provide permittees sufficient time to plan for the change.

Deepwater Dumpsite Investigations

In May 1974, NOAA conducted a baseline investigation of the "Deepwater Dumpsite," located 106 nautical miles southeast of Ambrose light. This survey was the first of three seasonal baselines scheduled to be obtained in the area. The second survey, a summer baseline, will be conducted during July-August 1975 and the winter baseline in February 1976. The 1975 survey will include the use of a submersible research vessel to carry out in-situ observations at the dumpsite.

The site is currently used by over 30 dumpers in the New York-New Jersey area for the disposal of chemical wastes. In 1974, a total of 120 million gallons of liquid waste were dumped in the area. The wastes are dumped or ejected from barges at a point just below the water surface. Typical wastes disposed of at the site include: sludge from galvanizing and plating processes, textile manufacturing byproducts, inorganic salts, etching and photographic acids, and similar materials.

The May 1974 survey was conducted by the NOAA ships *Albatross IV* and *Delaware II*, with participation by several laboratories and universities. The occurrence and relative abundance of nutrients, zooplankton, and other marine forms were mapped and described. Deepwater Dumpsite 106 is affected by any of three (3) major water masses: shelf water, slope water, and Gulf Stream water. The extent of mixing is not well known for this area, and circulation is complex and difficult to describe and predict.

The chief accomplishment of the May 1974 deepwater dumpsite survey was establishment of a spring season baseline of biological, chemical, geological, and physical oceanographic data for the area. This baseline, together with baselines for other seasons to be obtained in future surveys of the deepwater dumpsite, will serve as a data standard against which the effects of dumping can be measured.

COAST GUARD R&D FOR OCEAN DUMPING SURVEILLANCE AND ENFORCEMENT

Research and development by the Coast Guard in response to the Marine Protection, Research, and Sanctuaries Act of 1972 have been directed toward improving its program of ocean dumping surveillance and enforcement. Surveillance has been conducted by Coast Guard vessels, aircraft, shipriders, and land-based radar. These methods are limited by such factors as darkness, weather, and proximity to dumping activities, and by the number of observers and platforms. To satisfy the Coast Guard's minimum surveillance and enforcement goals, supplementary means were deemed necessary to ensure that ocean dumpers would dump only as directed by their permits.

During 1974, development of the Ocean Dumping Surveillance System (ODSS) continued. Preliminary studies were completed, and two prototype systems were assembled and bench-tested. The prototype systems consist of a low-cost, dual-channel LORAN-C receiver, and two data recorders. The prototype will record time versus position data for both manual (printed tape) and computer (punched tape) confirmation of the vessel's track by the Coast Guard. The ultimate system is expected to have only the computer-compatible punched tape recording.

The ODSS is designed to be a sealed, tamper-proof unit. It will be installed in the dumping vessel and the record it provides will help the Coast Guard in its surveillance mission. The system also will assist the dumper. The LORAN (LOng Range Aid to Navigation) receivers will continually indicate signals from two LORAN stations, giving the dumper an accurate two-line navigation fix as often as desired. One of the prototypes will include a "LORAN-C Loran Assistance Device" (C-LAD) that will indicate a constant range and bearing to any destination set into the device, as well as show distance to the left or right of the charted trackline.

An effort has been made to reduce the cost of the system as much as possible, so that the dumpers may be required to procure and maintain their own systems. As presently configured, the system (including C-LAD) should cost less than $10,000.

These prototypes are to be treated and evaluated on selected dumping vessels in the New York area during 1975.

Other related R&D efforts were begun during 1974. The Coast Guard initiated a contract for a study of dumping vessels to determine the feasibility of a dump sensor (another sealed unit to indicate when the dump doors or valves are opened and closed to function as an ODSS subsystem). Studies were commenced on dye and other marking or tagging materials that would enhance visual or remote sensor detection of dumped wastes. Studies also were conducted on legal aspects of enforcing Title I of the Act.

DREDGED MATERIAL DISPOSAL IN THE GREAT LAKES

Dredging operations in the Great Lakes remove and redeposit each year an average of 14.0 million cubic yards (16.9 million tons) of bottom materials from the Lakes and their connecting channels. Canadian dredgers remove about 20 percent of the total, U.S. dredgers about 80 percent (Table 1).

In recent years, Canadian and U.S. dredging activities have been less than forecast. This is so because delays were imposed to allow for environmental assessment and modification of many proposed projects. Lake levels remained above normal during this period and the delays have not resulted in significant loss of draft to navigation. However, this deferral of much of the normal annual maintenance dredging is only temporary.

Canadian and United States Dredging Activities

Of the Canadian Great Lakes dredging operations, 60 percent of navigational dredging and 30 percent of sand and gravel mining is in Lake Ontario. The harbors at Hamilton and Toronto account for over 94 percent of Canada's Lake Ontario navigational dredging. Canadian dredging in Lakes Erie and Huron, and their connecting channels, is fairly evenly distributed geographically, but in Lake Superior dredging at Thunder Bay accounts for almost all Canadian activity. Over 80 percent of this Canadian dredging is navigational dredging of approach channels and basins in commercial harbors. Mining of sand and gravel from lake beds represents about 17 percent. Land reclamation accounts for approximately 1 percent. Dredging for recreational purposes and fishery ports, although widespread through the Lakes, is a minor portion of the total activity.

In Canada, most of the dredged material has been redeposited in open-lake sites. The locations of the former disposal sites have not been precisely defined, rendering an accurate assessment of the environmental impact difficult. Today, however, site locations are more accurately located so that subsequent monitoring is possible. Diked disposal has been selected in relatively few cases. This method is used when either the land thus created was valuable or the polluted character of the material made open-lake disposal unacceptable. Economic considerations place severe constraints on land disposal in Canada as well as in the United States.

Of the U.S. Great Lakes dredging operations, the greatest activity is in Lake Erie, which accounts for 59 percent of the total. The harbors at Cleveland, Toledo, Buffalo, and Sandusky account for nearly half of the navigational dredging on Lake Erie. Over 75 percent of U.S. dredging on the Lakes is done in support of navigation at the many harbors and connecting channels throughout the Lakes. This includes a small amount of dredging of recreation harbors, harbors of refuge, and fishing harbors. Sand and gravel mining from the lake bed accounts for the remaining 25 percent of the total U.S. dredging on the Lakes.

Table 1.--Average annual quantities of dredged materials removed from the Great Lakes and connecting channels by the United States and Canada.*
(thousands of short tons)

Water body	Canada			United States		
	Commercial Navigation	Recreation & fishing	Mining	Commercial Navigation	Recreation & fishing	Mining
Lake Ontario	1,688	2	168	534	8	-
Welland Canal	259	-	-	-	-	-
Lake Erie	353	25	313	5,782	12	2,177
Detroit River and St. Clair River	62	10	-	1,217	-	-
Lake Michigan	-	-	-	1,908	148	-
Lake Huron	35	35	-	710	20	700
Lake Superior	346	-	93	194	80	-
Subtotals	2,743	72	574	10,345	268	2,877
Totals		3,389			13,490	

* Source: International Working Group on the Abatement and Control of Pollution From Dredging Activities. Based on dredging activities during the period 1966-1972, except for sand and gravel mining based on the period 1970-1972. Conversion factor of 1 cubic yard = 1.2 short tons used.

Prior to 1970, the Corps of Engineers and its contractors redeposited nearly all of the dredged materials in the open lakes. With the passage of the River and Harbor Act of 1970 (P.L. 91-611) which requires the Corps to provide diked disposal areas for polluted dredged material, the amounts being dredged on the U.S. side have declined considerably.

In fulfilling the requirements of P.L. 91-611, the Corps of Engineers must provide diked disposal areas for 71 navigation projects which have polluted materials to be dredged. Each site must provide sufficient capacity to accommodate all dredging, both private work and navigation channel dredging, for a period of 10 years. Several features of this law have caused some delay in getting the projects to the construction stage. Local interests must provide the site (in public ownership) and agree to maintain the filled area upon completion of the program. Additionally, local interests must contribute 25 percent of the construction costs unless the local region is in compliance with water quality improvement plans. If approval of such plans is obtained from the Environmental Protection Agency, a waiver of the requirement for a cash contribution can be made and construction is at full federal cost. The construction cost of this diked disposal area program is expected to be about $250,000,000.

International Action

An International Working Group on the Abatement and Control of Pollution From Dredging Activities--established pursuant to the Agreement between the United States and Canada on Great Lakes Water Quality, signed in Ottawa on April 15, 1972--is reviewing existing dredging practices, programs, laws, and regulations with the objective of developing (1) compatible criteria for the characterization of polluted dredged material and (2) compatible programs to govern disposal of polluted dredged material in open water. Pending the development of compatible criteria and programs:

(a) Dredged material found by the appropriate regulatory agencies to be polluted is to be disposed of in confined areas when they are available; and

(b) Responsible agencies are to continue efforts to develop sites for confined areas.

The Working Group is completing its assigned task of developing a procedure for the review of dredging projects within the Great Lakes that is compatible with both countries. The report to the two governments is in the final stages of editing, and signature by the twelve members of the Working Group is scheduled for the end of May 1975 in Ottawa.

Research - 1974

United States

The major U.S. research effort on dredged material disposal is the Dredged Material Research Program of the Corps of Engineers, which has already been described. Much of the work being done by that program will have applicability to the dredged material disposal problem in the Great Lakes. The Corps has selected a site near Ashtabula, Ohio, as one of four openwater dredged material disposal sites selected for 3-year field evaluations.

Other significant research underway or completed during 1974 included: (1) a study at Northwestern University on the engineering properties of dredged material in a confined disposal area in the Great Lakes, including an analysis of effluent water quality; (2) a study at the University of Michigan to delineate the nature and functional mechanisms of the release of pollutants to the aqueous environment during sediment dredging and disposal activities; and (3) a Corps-sponsored study at Michigan Technological University and the University of Minnesota to assess the environmental impact of dredged material disposal in Lake Superior.

Canada

The Federal Government and the Province of Ontario funded during 1974 several important research projects relating to the problems of lake dredging and dredged material disposal.

The Department of Public Works, Canada, sponsored a project to study the feasibility of using artificial islands for the disposal of contaminated dredged materials. The study is expected to indicate appropriate operating procedures for filling such an island; determine the extent of contamination in the displaced and supernatant water; develop necessary treatment methods where required; determine the quantities of contaminants leaving the island with the outflow of water through dikes of different cross section, and through atmospheric release; and to test various methods of controlling these releases.

A study was carried out at Queen's University, Kingston, Ontario, to investigate methods of retaining mercury-contaminated dredged material inside earth dikes. The purpose of this laboratory study was to obtain a correlation between laboratory experiments and the full-scale study of the artificial island concept.

A research and development effort was completed by Techwest (Vancouver) to design, construct, and test a bank of six or eight columns, approximately 1 m diameter and 4.5 m high to be used for studies simulating various natural lake processes, including sediment/water exchange and biotic systems.

The Canada Centre for Inland Waters (CCIW) sponsored a study to assess the effects of dredging and dumping activities on a before, during,

and after basis in selected areas within the Great Lakes. Studies have been designed to look at the physical and hydrographic aspects of the sites, the geochemistry of the sediments, and the related benthic communities. CCIW also is reviewing all experimental and field data available at CCIW on the subject of dredging and dredged material disposal in the Great Lakes, and is compiling and preparing this information for incorporation in the final report of the International Working Group on the Abatement and Control of Pollution From Dredging Activities to be released in 1975.

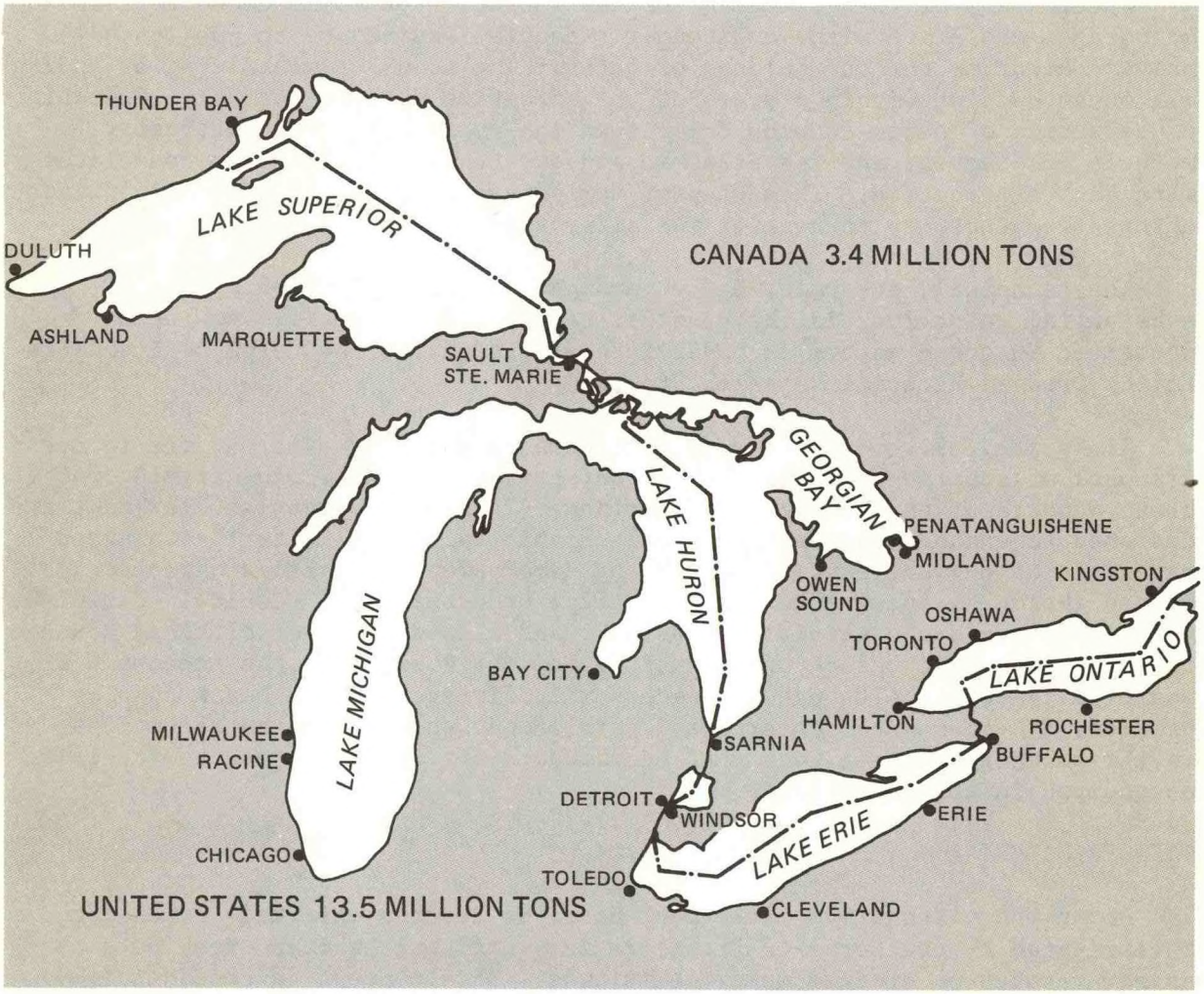

Figure 7.--Average annual quantities of dredged materials removed from the Great Lakes by the United States and Canada.

CHAPTER III

RESEARCH ON ALTERNATIVES TO OCEAN DUMPING

Section 203 of the Act calls for the Secretary of Commerce to conduct and encourage, cooperate with, and render financial assistance to public and private agencies for the purpose of determining means of minimizing or ending all ocean dumping within 5 years of the effective date of the Act. Reduction or cessation of ocean dumping depends on the availability of alternative methods of disposal and the economic and environmental tradeoffs associated with each alternative. This chapter summarizes some of the more significant efforts now underway to examine the alternatives to ocean waste disposal.

The technical, economic, and environmental feasibility of making substantial reductions in the quantities of dredged materials now being deposited in ocean waters is under intensive study by the Corps of Engineers in its Dredged Material Research Program.

The principal government effort to develop workable alternatives to ocean disposal of nondredged materials is that provided by EPA. In carrying out its broad mandate of environmental protection, EPA supports many studies that are designed to enhance our technological capability to deal with the unwanted materials of our society. Research and development activities directed toward improved, less wasteful, industrial processes will result in diminished volumes of residuals requiring transport and disposal. Technological advances can be expected to reduce the quantities of residuals from the treatment of municipal wastes. Although not necessarily directed at the ocean dumping problem, EPA-sponsored research and development should lead to reductions in the amounts of waste that must be disposed of, including waste materials now dumped in coastal waters.

DREDGED MATERIAL

Among the alternative methods of handling dredged materials now being investigated by the Corps of Engineers is artificial habitat creation such as new marshes or dredged material islands. This concept is considered by the Corps as one of the most attractive potential uses of dredged material. After a study of relevant criteria, involving social, economic, operational, and technical aspects, several potential test sites have been identified for comprehensive evaluation, including marshes in Texas and Connecticut. Studies also are underway to examine nutrient and metal cycling and metabolism of sediment and detritus in salt marsh communities affected by dredged material. Considerable research is being directed toward the engineering problems of containing dredged material in a given marsh site or artificial island. Still another concept of habitat creation is establishing vegetation on existing sandy, barren deposits of dredged material in order to support birds and other wildlife.

Confined dredged material disposal facilities can be viable alternatives for reducing the environmental impacts of disposal operations, such as when contaminated sediments could adversely affect water quality or aquatic organisms or when wetlands would be destroyed by the spread of unconfined material. However, research is badly needed, and is underway, to improve the integrity and effectiveness of dikes and weirs and to develop facility operations and management techniques to prevent these areas from being environmentally degrading.

A basic purpose for confining dredged material is to create quiescent conditions in which suspended solids in the slurry will precipitate, thereby improving the quality of the effluent. Vegetation in disposal facilities is known to be highly effective in promoting this process. Consequently, field tests are in progress to evaluate the relative effectiveness of various plants suitable for propagation in disposal sites that can promote filtering. The ability of various plants to desiccate and consolidate dredged material is being determined through field experiments.

MUNICIPAL SEWAGE SLUDGE

Overview

Whereas the Corps of Engineers is the lead agency for exploring alternatives to offshore disposal of dredged material, the Environmental Protection Agency fills a similar role with respect to nondredged materials, including municipal sewage sludge and industrial wastes. This section describes current EPA research on the problem of sewage sludge disposal.

EPA, through its Washington Headquarters, field centers, and regional offices, has carried out in recent years a continuous program of in-house and contract research into new methods of handling the many waste products of our society, including those that are currently being disposed of in coastal waters. Studies on municipal sewage sludge have focused on ways to encourage land application as well as incineration and recycling.

There are three basic alternatives to ocean dumping of sewage sludge. These are: (1) disposal on land; (2) recycling; and (3) treatment. Land disposal considerations include: (1) availability of reasonably priced land, especially in metropolitan areas; (2) transportation costs; and (3) local citizen acceptance. Recycling technology presently exists to recycle or treat practically any waste now being disposed of at sea. However, the application of many of these new recycling techniques on a plant scale and at reasonable cost has not been demonstrated. The passing of the era of low-cost energy has imposed another serious limiting factor on the development of economically reasonable alternatives to ocean dumping. Sophisticated recycling and treatment processes, by and large, require large amounts of energy.

The principal disposal methods most widely used at the present time include: (1) application to the land (60%), (2) incineration (25%), and (3) ocean dumping (15%). In terms of volume, there should be no major problem in absorbing into land-based disposal methods the 15 percent of the Nation's sludge currently being dumped in the ocean. There are, however, environmental factors that place constraints on available methods.

There are unresolved issues relative to land application. Leachate from landfills can contaminate surface and groundwaters. Health effects of land spreading, whether the land is used for agricultural purposes or not, is a current major issue. Largely unknown are the effects of nitrate contamination on groundwaters; contaminated runoff to surface waters; and impact of virus, bacteria, spores, and intestinal parasites, particularly when food crops are involved. Also largely undetermined is how trace metals contained in sludge affect the human food chain. Trenching appears viable, but requires further study for resolution of the same issues as for other land application techniques. Socio-economic problems are also affecting the use of land application methods.

Incineration is commonly used, but is under criticism now due to issues raised concerning air pollution. Again, trace metals are a potential problem and particulate control is needed. Some major metropolitan areas appear to be moving away from incineration because it is an energy-intensive method and because of air pollution considerations.

Potential alternatives which can be identified at the present time include pyrolysis, wet-oxidation, and co-incineration with municipal solid wastes. Technical studies and demonstration for pyrolysis and co-incineration are in the early stages.

Research completed during the reporting period included: disposal of sewage sludge into a sanitary landfill; a study of pesticide disposal in a sewage sludge incinerator; an investigation to utilize organic residues to improve sludge dewatering characteristics and to produce unstable fuel; evaluation of use of physical-chemical sludges on land; and design, development, and evaluation of a lime-stabilization system to prepare municipal sewage sludge for land disposal.

Other significant ongoing research includes: determination of agricultural benefits and environmental changes from the use of digested sludge on field crops, transportation of digested sludge by pipeline and utilization of remote strip-mined land, a review of techniques for incineration of sewage sludge with solid waste, and disposal of stabilized municipal and industrial sludge in the forest environment.

Finally, a major step forward made in 1974 was the preparation of EPA's "Process Design Manual for Sludge Treatment and Disposal." This manual is a comprehensive presentation of the latest techniques available for the treatment and handling of sludge materials. 27/

Study of Alternatives for the
New York-New Jersey Metropolitan Region

In 1974, EPA Region II funded a 2-year three-phase study program by the Interstate Sanitation Commission (ISC) of New York and New Jersey to develop a viable and coordinated system for the disposal of sewage sludge for the metropolitan area by June 1976.

The program consists of three phases: Phase 1, a state-of-the-art investigation of alternatives to ocean disposal of sludge; and the recommendation of a limited number of the most feasible alternatives for in-depth investigation in Phase 2. These alternatives will then be compared with controlled ocean disposal. Concurrently with these two phases, a legal-institutional Phase 3 investigation is being undertaken to determine the requirements for the administration of a coordinated sludge management system for the region.

The Phase 1 study defines the problem in terms of the present and projected sources and volumes of sludges produced and their chemical, physical, and biological properties. It includes sludges presently barged to sea and sludges now disposed of by other methods with identification of how each of the public waste treatment systems in the area now disposes of its sludge. The ISC will identify the entire spectrum of feasible alternatives and make preliminary estimates of disposal costs and environmental impact of each. Each of the methods is to be analyzed from the point of view of efficacy and desirability or undesirability. Each of the methods is also to be compared with each of the others. Among the factors to be considered will be environmental impact; energy conservation; convenience; and cost of collection, treatment, transportation and disposal either as a waste or as usable or marketable products. This phase is to include but is not limited to investigation of the following disposal techniques:

(1) Land disposal alternatives: (a) sanitary landfill, (b) spreading as soil conditioner and fertilizer, (c) various sludge solidification processes, and (d) drying and selling for fertilizer and soil conditioner.

(2) Disposal by combustion (incineration): (a) incineration of raw sludge, (b) incineration in combination with solid wastes, and (c) incineration to include power or steam generation.

(3) Disposal as a salable product: (a) activated carbon, (b) oil, (c) natural gas, each of the above through pyrolysis, and (d) building products.

Phase 2 of the program is scheduled to begin in July of 1975 and will conclude in June 1976. The in-depth study will include:

(1) Cost estimates,

(2) Thorough assessment of the environmental impact, and

(3) Recommendations relative to New York-New Jersey Metropolitan Sludge Management Plan.

The Commission will have available for its use preliminary results of the MESA Project and other input on the environmental consequences of

ocean disposal so that a comparison can be made between controlled ocean disposal, taking into account economic and environmental impact and the in-depth study of the alternatives investigated in Phase 2.

Phase 3 is an in-house investigation of legal and institutional requirements. It includes:

(1) Analyses of New York and New Jersey environmental control statutes and administrative regulations and examination of relative statutory and operational authorizations and responsibilities to existing State and local agencies and governments in New York and New Jersey;

(2) An examination of sludge collection disposal as a State level function in New York and New Jersey; and

(3) Drafting of sample statutes and/or interlocal and interstate agreements and contracts needed to implement the recommended legal and institutional approach to the problem.

A contractor was selected for the Phase 1 study and work commenced in July 1974. The Phase 3 work on the legal-administrative investigation of regional sludge management possibilities in the New York-New Jersey metropolitan area began in July 1974. This study is being conducted by the Commission itself. The effort through the end of 1974 consisted largely of research and analysis of the statutes of New Jersey and New York relating to water quality management and relevant aspects of intergovernmental relations. The purpose has been to provide a basis for determining what legal authority now exists for sludge management, either by the separate jurisdictions or on a regional or subregional basis. These preliminary analyses, now completed, show that the legal bases for interlocal cooperation on liquid waste treatment in the two States are substantially different New York has a State-level agency (the Environmental Facilities Corporation) which can assist, and under some circumstances operate or manage, municipal or county waste treatment and collection systems, while New Jersey has no counterpart agency. Consequently, sludge management on an interjurisdictional basis, except by the existing district systems, would require additional legal basis. When the study is further along, a detailed examination will be made of what could be done on the New Jersey side short of legislation, but preliminary study indicates that additional legislation might be desirable, if not absolutely necessary. No work has yet been done on Connecticut statutes.

INDUSTRIAL WASTES

Industrial wastes pose a special problem due to the very large number of compounds involved and the concomitant need to develop specific treatment methods for many classes of these substances. Most of the industrial materials now being dumped in ocean waters are acid wastes. These substances can be treated by neutralization techniques or by some biological-oxidation method such a trickling filters, activated sludge, or lagooning.

The primary method of treatment of acid wastes, however, is neutralization by means of an upflow limestone bed or a similar process. Another method used by oil refineries to dispose of sulphuric acid wastes is spraying the acid into a hot combustion chamber followed by an indirect combustion step.

Ocean incineration of toxic industrial wastes was carried out in the Gulf of Mexico during October 1974-January 1975. A specially designed incinerator ship capable of burning 4,200 metric tons of chemical wastes per mission incinerated organic chloride wastes with greater than 99.9 percent efficiency at a site 135 miles south of Galveston, Texas. Incineration converted these wastes to hydrogen chloride and carbon dioxide in quantities innocuous to the oceans and the atmosphere. This first ocean incineration in the United States was authorized initially under research permits for two shiploads of waste. EPA and the Shell Chemical Company cooperated in conducting thorough tests of burning efficiency, plume dispersal in the atmosphere, and effects on the marine environment. EPA provided scientific personnel for marine and aerial monitoring and to make tests to determine the effects on the environment. The marine monitoring utilized a NOAA research vessel with an EPA scientific party. The Coast Guard and NASA Goddard personnel also provided valuable aid in this monitoring effort. After two research burns EPA felt that enough information had been accumulated on the conditions of the incineration to allow disposal of the remainder of this particular waste under an interim permit. A full technical report of this operation is being prepared which will help in evaluating the viability of ocean incineration of organic chemical wastes as an alternative to dumping.

Other research completed or in progress during 1974 on hazardous substances by EPA included:

- A grant to the State of Louisiana/Gulf South Research Institute to develop control technology to treat biorefractories. Five treatment techniques are now being evaluated to remove these biorefractories: ozonation, carbon adsorption, solvent extraction, anaerobic/aerobic treatment, and air stripping.

- Through various R&D activities, a process of exhaustive chlorination has been developed to convert hazardous/toxic chlorohydrocarbon wastes into useful and marketable commodities. The process, referred to as chlorolysis, has been demonstrated by Hoechst AG, Frankfurt, Federal Republic of Germany, in a project supported by EPA. This method is appropriate for treatment of the residues produced during the manufacture of high-volume chemicals such as ethylene dichloride, vinyl chloride, vinylidene chloride, chlorinated solvents, etc., and also of chlorinated hydrocarbon-based pesticide residues. The conversion scheme is completely closed-loop, with minimal environmental risk as contrasted to the presently employed disposal techniques of land assimilation, deep-well, or land-based incineration.

- A grant to the Velsicol Chemical Corp. to demonstrate two processes for treatment of heptachlor-endrin wastewaters from Velsicol's Memphis, Tennessee, plant. The processes of choice are macroreticular resin adsorption and in-situ metal-bimetal catalytic reduction (dechlorination).

- A contract to Envirogenics Systems to develop and demonstrate through the bench scale (1.5 gpm) chemical degradation treatment processes for DDT, toxaphene, and chlordane aqueous pesticide manufacturing and processing wastes.

- A study with the U.S. Army to obtain data on hazardous and toxic waste detoxification techniques in order to determine which techniques are most effective in rendering hazardous materials nondetrimental to human health.

- A grant to Worcester Polytechnic Institute to develop catalytic techniques to be used to detoxify noxious, hazardous, and toxic organic pesticides.

- A grant to the University of Dayton to examine 34 different pesticides to determine the combustion temperatures and residence times required to effectively destroy pesticide compounds.

- A contract with Midwest Research Institute to study representatives of each class of organic pesticides to determine the thermal conditions necessary to degrade the pesticides. The data will be used to develop guidelines to describe specifically the required incinerator operating conditions.

- A contract with the University of California to study the volatilization and vapor transport of hexachlorobenzene from industrial wastes deposited on land. The objective is to obtain information about the vapor phase transport of hexachlorobenzene in order to specify the conditions under which it is safe to store or dispose of such wastes on land.

- A contract to Fenix & Scisson, Inc. to provide EPA with an evaluation and assessment of the capability and adequacy of salt openings and deposits and hard-core mines for use as sites for the storage and management of hazardous wastes.

- A contract to Louis R. Reeder & Associates to provide EPA with an evaluation of the available data regarding deep-well disposal and an assessment regarding the adequacy of the technology for managing wastes in an environmentally acceptable manner.

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TITLE II—COMPREHENSIVE RESEARCH ON OCEAN DUMPING

Report to Congress.

SEC. 201. The Secretary of Commerce, in coordination with the Secretary of the Department in which the Coast Guard is operating and with the Administrator** shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of material into ocean waters or other coastal waters where the tide ebbs and flows or into the Great Lakes or their connecting waters and shall report from time to time, not less frequently than annually, his findings (including an evaluation of the short-term ecological effects and the social and economic factors involved) to the Congress.

SEC. 202. (a) The Secretary of Commerce, in consultation with other appropriate Federal departments, agencies, and instrumentalities shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, overfishing, and man-induced changes of ocean ecosystems. In carrying out such research, the Secretary of Commerce shall take into account such factors as existing and proposed international policies affecting oceanic problems, economic considerations involved in both the protection and the use of the oceans, possible alternatives to existing programs, and ways in which the health of the oceans may best be preserved for the benefit of succeeding generations of mankind.

(b) In carrying out his responsibilities under this section, the Secretary of Commerce, under the foreign policy guidance of the President and pursuant to international agreements and treaties made by the President with the advice and consent of the Senate, may act alone or in conjunction with any other nation or group of nations, and shall make known the results of his activities by such channels of communication as may appear appropriate.

Annual report to Congress.

(c) In January of each year, the Secretary of Commerce shall report to the Congress on the results of activities undertaken by him pursuant to this section during the previous fiscal year.

(d) Each department, agency, and independent instrumentality of the Federal Government is authorized and directed to cooperate with the Secretary of Commerce in carrying out the purposes of this section and, to the extent permitted by law, to furnish such information as may be requested.

Inter-agency agreements.

(e) The Secretary of Commerce, in carrying out his responsibilities under this section, shall, to the extent feasible utilize the personnel, services, and facilities of other Federal departments, agencies, and instrumentalities (including those of the Coast Guard for monitoring purposes), and is authorized to enter into appropriate inter-agency agreements to accomplish this action.

Federal-State cooperation.

SEC. 203. The Secretary of Commerce shall conduct and encourage, cooperate with, and render financial and other assistance to appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and to promote the coordination of, research, investigations, experiments, training, demonstrations, surveys, and studies for the purpose of determining means of minimizing or ending all dumping of materials within five years of the effective date of this Act.

Appropriation.

SEC. 204. There are authorized to be appropriated for the first fiscal year after this Act is enacted and for the next two fiscal years thereafter such sums as may be necessary to carry out this title, but the sums appropriated for any such fiscal year may not exceed $6,000,000.

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*The "Marine Protection, Research, and Sanctuaries Act of 1972."

**Sec. 3(a): The Term "Administrator" means the Administrator of the Environmental Protection Agency.