Report to the Congress on Ocean Dumping Monitoring and Research

January through December 1980

July 1982

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

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

July 1982

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary
National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

JUL 26 1982

President of the Senate
Speaker of the House of Representatives

Dear Sirs:

It is my honor to transmit to the Congress this eighth annual report on ocean dumping monitoring and research.

Under Section 201 of the Marine Protection, Research, and Sanctuaries Act of 1972, Congress assigned the responsibility to the Department of Commerce for a comprehensive program of monitoring and research to improve our understanding of the effects of dumping wastes into the ocean. This Act also requires that the Secretary report at least once a year to Congress on the findings of this monitoring and research.

This report describes ocean dumping investigations carried out by the National Oceanic and Atmospheric Administration (NOAA) during calendar year 1980. It focuses on three major categories of pollutants: sewage sludge, industrial wastes, and dredged materials.

Scientists who worked with NOAA made substantial progress during the year in expanding the general understanding of the basic environmental effects of dumping waste materials into the ocean. These scientists have also developed chemical, physical, and biological techniques for monitoring dispersal patterns of dumped wastes. These advances were achieved as a result of a series of field experiments performed in unison with laboratory studies of the chemical and physical nature and biological impacts of the wastes.

The Department of Commerce will continue to fulfill its responsibilities under the law for carrying out monitoring and research on the effects of ocean disposal of wastes. The work will improve our scientific understanding of the environmental implications of ocean dumping.

Sincerely,

Malcolm Baldrige

Secretary of Commerce

Enclosure

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EXECUTIVE SUMMARY

As mandated by the Marine Protection Research and Sanctuaries Act (P.L. 92-532) the results of NOAA research on ocean dumping are annually reported to Congress. That research is designed to develop information upon which to base decisions on safe use of the ocean for waste disposal. Individual projects during 1980 focused on key processes determining contaminant distributions and biological responses at deep ocean dumpsites, in the heavily used New York Bight and at a recently abandoned sewage sludge dumpsite off the mid-Atlantic coast.

Wastes dumped at deep ocean sites are extensively diluted in the dumping process. Waste concentrations, except in relatively fresh plumes, are below those which laboratory tests indicate could affect marine organisms. Changes in phytoplankton populations and losses of zooplankton reproductive potential have been observed in waste plumes but not in other areas. The rate of flushing of these sites therefore appears adequate to prevent an accumulation of waste from repeated dumping events to levels of biological consequence. The site north of Puerto Rico is less dispersive than the other deep ocean site off the east coast. It also receives the most toxic waste but the volume it receives seems low enough relative to the flushing capacity to prevent effects except in isolated plumes.

Studies in the New York Bight centered on defining spacial limits to water column contamination due to discharges into the Hudson River and waste dumping in the Bight. The contamination was found to extend only to about 20 miles offshore. Also, dumped dredged material in the New York Bight was found to be a source of contamination to overlying waters. Pathogenic viruses, ameoba, and bacteria have been found in sediments surrounding the dumpsite used by Philadelphia for sewage sludge disposal until November 1980. These are only indicators of contamination so long as human exposure to the sediments or raw shellfish from them is avoided. The rates of change of concentrations of these microbes will be followed now that the site is no longer used.

These and other findings indicate that the long-term and cumulative impacts of waste disposal in the ocean should be the primary consideration in future management decisions. NOAA's program will contribute to these decisions by supporting studies of oceanic processes, experimental and modelling studies of waste behavior and empirical studies at waste disposal sites.

An additional important facet of NOAA's program is communication of results to the scientific community and to waste management decision-makers. Communication is fulfilled by encouraging investigators to present results at meetings and in the open scientific literature and through the NOAA-sponsored International Symposium Series on Ocean Waste Disposal. This latter series has attracted increasing national and international interest and provides a focal point for scientific assessment of ocean waste disposal.

CHAPTER I

INTRODUCTION

Background

The proper use of coastal and marine resources requires a judicious balance among production, protection, and consumption of both renewable and non-renewable assets. For decades, however, we have viewed the ocean as an essentially boundless source of food and minerals, and as an avenue of transportation and recreation. At the same time, we have used it as a dump for the many and often highly toxic waste materials our civilization produces. These wastes include sewage sludge, industrial wastes, and dredged materials that may be contaminated heavily with pollutants.

Even the oceans, however, have a limited capacity to absorb wastes, dilute them, and carry them away. We now know that unregulated dumping of wastes into the oceans could jeopardize our future use of the ocean resources.

Recognizing these concerns, Congress passed a series of laws aimed at protecting and conserving marine resouces. Beginning with the Fish and Wildlife Coordination Act of 1958, these include the National Environmental Policy Act of 1969, the Coastal Zone Management Act of 1972, the Marine Protection, Research, and Sanctuaries Act of 1972, the Clean Water Act of 1972, the Endangered Species Act of 1973, the Fishery Conservation and Management Act of 1976, and the National Ocean Pollution Planning Act of 1978.

Each of these laws gives the National Oceanic and Atmospheric Administration (NOAA), along with other U.S. Government agencies, certain responsibilities for managing and protecting our marine resources. In particular, the Marine Protection, Research, and Sanctuaries Act (P.L. 92-532) authorizes the Secretary of Commerce, acting through NOAA, to assess the effects of ocean dumping on marine ecosystems. The National Ocean Pollution Planning Act (P.L. 95-273) requires NOAA in cooperation with other Federal Agencies to prepare a 5-year plan for Federal ocean pollution, development, and monitoring efforts.

The Marine Protection, Research, and Sanctuaries Act of 1972 is organized into three titles. Title I deals with the regulatory aspects of ocean dumping, assigning that authority to the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (COE), and the U.S. Coast Guard (USCG). Title II deals principally with monitoring and research on the effects of pollution and other man-induced changes in the oceans. The monitoring and research responsibilities described in Title II are assigned to the Department of Commerce (NOAA). Title III, also administered by NOAA, provides for the designation of marine sanctuaries.

Section 201 of Title II assigns responsibility to the Secretary of Commerce for a comprehensive and continuing program of monitoring and research regarding the effects of dumping material into the oceans, coastal waters, and the Great Lakes. It also directs the Secretary of Commerce to report to the Congress at least once a year the findings from the monitoring and research programs.

NOAA established the Ocean Dumping Program in October 1976 in response to Section 201. Now operating as part of NOAA's Office of Marine Pollution Assessment (OMPA), the Ocean Dumping Program monitors and, through scientific research conducted both within and outside of the Federal Government, assesses the consequences of waste disposal in the oceans. Its goal is to provide information on marine waste management to aid policy-makers in Congress, other Federal agencies, state and local governments, industry, and the public.

Specifically, NOAA's Ocean Dumping Program seeks to:

- Determine the ways in which ocean disposal affects marine ecosystems.
- Assess the risks to human health posed by ocean dumping.
- Improve our understanding of the inputs, distribution, transfer, and overall balance of materials dumped in the oceans.
- Evaluate the environmental effects of past and present dumping by studying specific dumpsites and relating the knowledge gained there to broader regional and national problems.
- Investigate the basic natural processes involved in ocean dumping to improve our understanding of the biological effects of waste disposal in the oceans.
- Develop monitoring procedures to measure the effects of continuing, stopping, increasing, or decreasing waste disposal at specific sites.
- Monitor different types of wastes dumped at specific sites to determine the degree of risk associated with each type and to determine the capacity of each site to assimilate those wastes.
- Study possible alternative marine disposal procedures and techniques to determine the environmental and human health risks that each poses, and to predict the consequences of waste disposal over time.

The Ocean Dumping Program accomplishes these goals by managing and sponsoring research performed by scientists and technicians from NOAA laboratories, other Federal agencies, state and local governments, industry, and academic and research institutions. Investigations are drawn from such fields as the physical, biological, and biomedical sciences, marine sciences and oceanography, mathematics and statistics, and engineering.

Scope of the Report

This is the eighth annual ocean dumping report. In addition to the Section 201 research of NOAA, the first three annual reports described ocean dumping research by EPA, COE, and USCG in support of their respective regulatory responsibilities. Since 1976, those agencies have been required to submit their respective annual reports directly to Congress. This report, therefore, covers only NOAA monitoring and research on ocean dumping during calendar year 1980.

NOAA-funded waste-disposal studies began in 1973 at the sewage sludge dumpsite in the New York Bight. A year later, NOAA began monitoring the industrial disposal site located 198 km (106 nautical miles) southeast of New York Harbor (the so-called "106-Mile Site"). The locations of the dumpsites on the eastern U.S. coast are given in Figure 1. These early studies examined the impact of ocean dumping and provided a baseline of data for future scientific research. Since then, NOAA has conducted a series of systematic studies of the effects of ocean dumping in the following areas: the 106-Mile Site, New York Bight, Delaware Bay, the Philadelphia Site, Chesapeake Bay, the Puerto Rico Site, and the Gulf of Mexico.

Intra-agency Coordination

The Ocean Dumping Program (ODP) works closely with other NOAA programs, particularly those within the Office of Marine Pollution Assessment (OMPA), Ocean Monitoring Program of the National Ocean Survey (NOS), and the National Marine Fisheries Service (NMFS). The program also coordinates its work with ocean dumping offices in the Environmental Protection Agency, the Corps of Engineers, and the Coast Guard.

In October of 1979 (i.e., beginning of FY 1980), the Administrator of NOAA established a new NOAA program titled the Northeast Monitoring Program (NEMP). The purpose of this program was, inter alia, to provide a focus for NOAA monitoring activities in the coastal waters of the Northeastern United States. The program comprised elements of National Marine Fisheries Service--Northeast Fisheries Center, the Office of Marine Pollution Assessment, and the Ocean Dumping Program located in the National Ocean Survey. While the main emphasis of the program has been on monitoring the overall condition of the coastal waters from Maine to Cape Hatteras, a significant amount of effort has gone into determining conditions at or near ocean disposal sites. Approximately 30 percent of the program could be construed as relating directly to NOAA's responsibilities under Title II - Section 201 of the Ocean Dumping Act.

Although scientists from many NOAA components were involved in ocean dumping research during 1980, most of the work by NOAA during the year was planned, sponsored, and managed by the Ocean Dumping Program located in Rockville, Maryland, or by the Marine Ecosystems Analysis (MESA) Project Office in Stony Brook, New York. The MESA Project sponsored and managed work relating to sewage sludge dumping in the New York Bight and cosponsored, with the Ocean Dumping Program, research on dredged material disposal in the same region. Work related to other topics and geographic areas discussed in this report was sponsored by the Ocean Dumping Program.

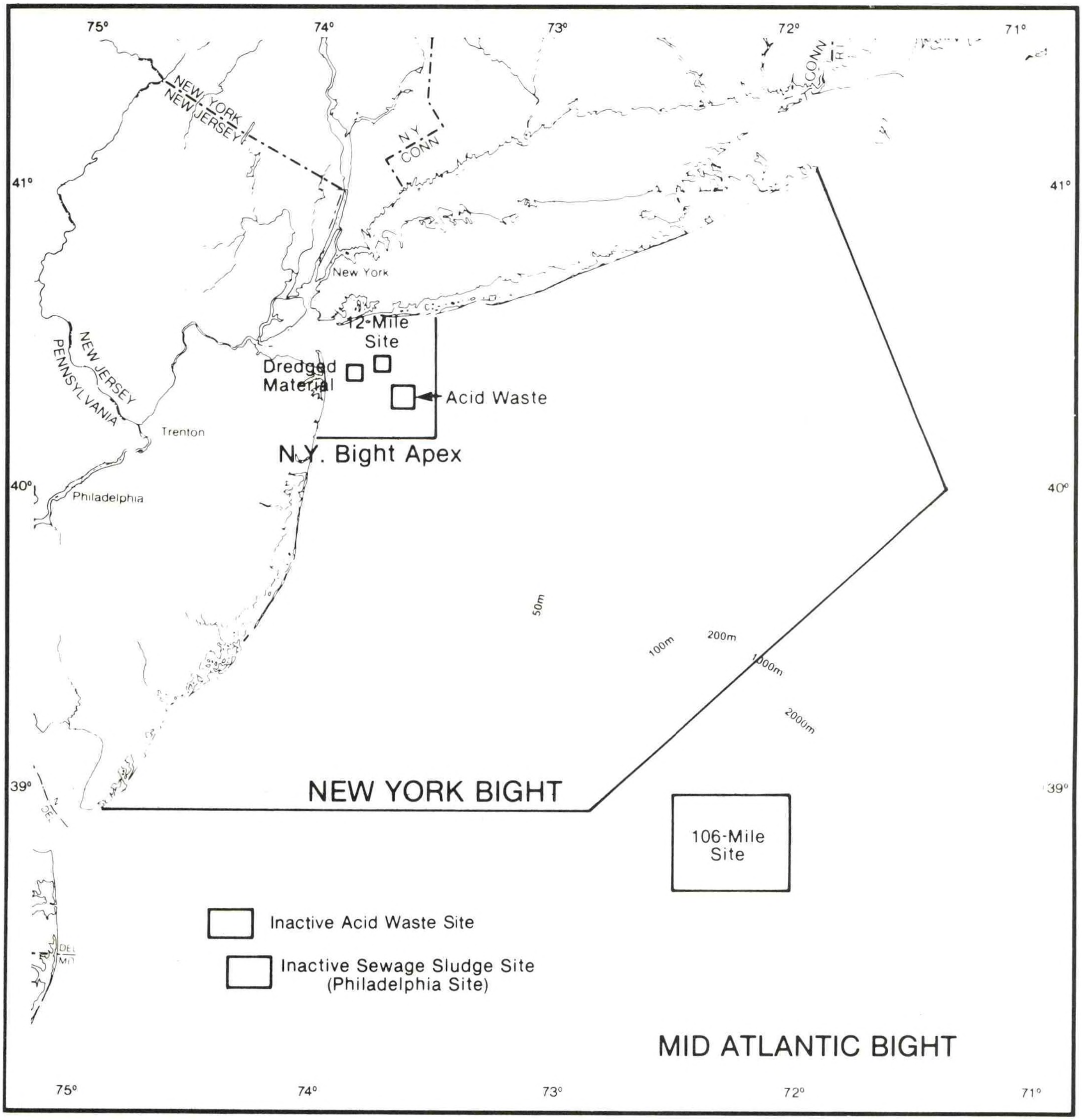

Figure 1. Location of east coast dumpsites

A second International Ocean Dumping Symposium, held in April 1980 at Woods Hole, Massachusetts, brought together researchers from all over the world to present and review their findings. Subsequently, three volumes from this second symposium will be published by Wiley Interscience. The first volume from the first symposium, with 32 papers, was published by Plenum Press in March 1981.

During 1980, the Ocean Dumping Program was transferred to the Office of Marine Pollution Assessment (OMPA) from the National Ocean Survey (NOS). This change placed responsibility for Section 201 and 202 within the NOAA Office of Research and Development.

Organization and Administration

The Ocean Dumping Program operates with a staff of four scientists, including one resident scholar (a university professor on Intergovernmental Personnel Act appointment to NOAA). The staff develops research priorities, selects projects and scientific teams to conduct the research, oversees the efforts to ensure that the results relate to the program's goals, and disseminates findings to aid decision makers and the public. Each research project focuses on a specific physical, chemical, or biological process or aspect of disposal technology (engineering).

To conduct this work, NOAA budgeted $2.9 million in FY 1980 for ocean dumping research and monitoring. Of the $2.9 million, $2.5 million directly supports research sponsored by the Ocean Dumping Program and its administration. The remaining $0.4 million supports the Ocean Pollution Monitoring Program in the National Ocean Survey. Additional ocean dumping-related research was funded through the MESA New York Bight Project, the Long-Range Effects Program (P.L. 92-532, Section 202) and the Financial Assistance Program (P.L. 95-273, Section 6). Summaries of NOAA-funded ocean dumping research projects are available upon request from NOAA's Ocean Dumping Program, Rockville, Maryland 20852.

CHAPTER II

THE WHAT AND WHERE OF OCEAN DUMPING

Four general classes of wastes are dumped into the oceans: dredged material, municipal wastes (sewage sludge), industrial wastes (including acid wastes, pharmaceutical wastes, coal ash, and seafood processing wastes), and radioactive wastes. In addition, a new waste disposal process -- ocean incineration -- has come into use in recent years to destroy highly toxic organic chemicals at sea.

Dredged Material

About 90 percent by weight of all wastes annually dumped in the ocean consists of material dredged from rivers, ship channels, and harbor bottoms. The percentage of material varies as maintenance dredging varies. During 1979, almost 84 million tonnes* (56 million cubic meters) were discharged into open oceanic waters, a 38 percent increase from 1978. Most of the increase was related to dredging required as a result of heavy storms within the Mississippi River basin during 1978. Increased sedimentation required extensive dredging in the lower portion of the river between the Head of Passes and the Gulf of Mexico.

Dredged material is disposed of at sea by bottom-dump scows, split-hulled barges, and/or by self-propelled hopper dredges. In some cases, dredged materials are a major source of sediments deposited on the ocean bottom. In the New York Bight, for example, eight times more dredged material now reaches the ocean floor than coastal- or river-deposited sediment.

The Corps of Engineers maintained 127 ocean disposal sites for dredged material in 1980. About 40 percent of those sites are located along the Gulf of Mexico, off the coasts of Mississippi, Louisiana, and Texas. In Louisiana coastal waters, the Gulf is quite shallow and is often buffeted by high winds. The sediments there are most often fine-grained, which, along with the mixing of fresh and salt water at the mouth of the Mississippi River, affects the way in which dredged material settles to the bottom. Mixing processes also determine whether dredged material is distributed over a wider area than the actual dumpsite.

NOAA began research in 1979 on a possible future ocean dumping site for dredged material disposal in the Atlantic Ocean. The site is located about 30 km (18 miles) due east of the mouth of the Chesapeake Bay. The Corps of Engineers is examining the possibility of dumping material there from dredging in the Elizabeth River at Norfolk, Virginia. The Chesapeake Bay Site would replace Norfolk's Craney Island, which is filling up after 40 years of use.

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*Tonne (metric ton) is equivalent to 2,205 U.S. pounds

About one-third of all dredged material is considered contaminated. Most pollution comes from municipal and industrial discharges and runoff that settle into the bottom sediments of rivers, streams, and harbors, and are taken up when channels are dredged. These pollutants include organic compounds such as polychlorinated biphenyls (PCBs), Kepone, and pesticide residues, trace quantities of toxic metals, viruses and bacteria from untreated sewage, and plant nutrients such as ammonia, nitrate, and phosphate.

Municipal Sewage Sludge

Since almost 67 percent of all Americans in the continental United States live in coastal states, it is not surprising that municipal wastes are disposed of at sea. Municipal wastes usually reach the oceans as discharged effluent through pipe outfalls that empty into rivers, harbors, or the ocean itself.

The second source of ocean-disposed sewage comes from sludge produced by municipal wastewater treatment plants. The sludge is collected and dumped into the sea from barges or discharged by offshore pipelines. Some 1.3 million tonnes of sludge are discharged into the oceans annually: 720,000 tonnes through sewage outfalls and 576,000 tonnes by barges. As of 1978, about 15 percent of all sewage sludge produced in the United States was ocean dumped.

Sewage discharges through outfall pipes are regulated by EPA under Sections 301, 403, and 405 of the Clean Water Act (P.L. 92-500). Those discharged by ocean-going vessels are regulated by Section 102 of the Marine Protection, Research, and Sanctuaries Act (P.L. 92-532). In either case, NOAA-sponsored research is concerned with the effects of excess nutrients, metals, viruses and bacteria, and other pollutants on marine ecosystems.

One sewage sludge site of interest to NOAA's Ocean Dumping Program is the so-called "Philadelphia Site," located in the Atlantic Ocean about 70 km (43 nautical miles) east of Ocean City, Maryland. The cities of Philadelphia, Pennsylvania, and Camden, New Jersey, began dumping sludge there in 1973. Camden stopped ocean dumping in 1978 and Philadelphia ceased using the site in 1980. Research at the dumpsite was conducted by the Environmental Protection Agency until 1979. Anticipating cessation of dumping, NOAA began to study the Philadelphia Site in January 1979. Supported by NOAA funds, EPA research staff based at Annapolis, Maryland, and scientists from other agencies and academic institutions continue to study the Philadelphia Site. The research effort now focuses on how well a marine environment can recover once ocean dumping of sewage sludge has ceased.

Studies in the New York Bight centered on evaluating the relative effects of the Hudson River discharge, dredged material disposal at the mud dumpsite, and sewage sludge dumping at the 12-Mile Site on the distribution of contaminants within the Bight Apex.

Industrial Wastes

As of 1980, ocean dumping of U.S. industrial wastes occurred at two deep ocean sites and in the New York Bight. The deep sites are located in the Atlantic Ocean: one is 170 km (106 nautical miles) southeast of New York Harbor, and the other is 74 km (46 nautical miles) north of Arecibo, Puerto Rico.

The 106-Mile Site received 620,000 tonnes of wastes, primarily liquids, in 1980. Thirty-eight percent (238,000 tonnes) of the total was so-called "acid-iron" waste from the manufacture of titanium dioxide at the duPont plant in Edgemoor, Delaware. Titanium dioxide is a chemically stable, non-toxic, white pigment used in paper products, paints, plastics, drugs, and ceramics. Almost two million metric tonnes of a similar waste, from NL Industries, were dumped at the acid-iron waste site in the New York Bight.

Of the other wastes dumped at the 106-Mile Site, 38 percent (238,000 tonnes) was an alkaline solution from chemical production at the duPont Grasselli plant in Linden, New Jersey, 11 percent (68,000 tonnes) was organic wastes from the American Cyanamid chemical plant in Linden, 8 percent (52,000 tonnes) came from cleaning out sewage sludge digesters in the New York and New Jersey area, and 4 percent (23,000 tonnes) was from a Merck pharmaceutical plant in New Jersey. Also, 1,400 tonnes of coal wastes (fly and bottom ash) were dumped under a research permit issued to Consolidated Edison of New York.

Until 1977, acid-iron wastes were dumped both at the 106-Mile Site and at another site about 50 km (31 nautical miles) east of Delaware Bay. At that time, however, duPont shifted all of its waste disposal to the 106-Mile Site where dumping is done by specially designed barges. Their hulls are lined with rubber and they are equipped with pipes that release the wastes below the water surface. The wastes are dumped gradually over a period of up to 6 hours and over a distance of 14 to 19 km (9 to 12 nautical miles).

A different sort of industrial waste is dumped in the Atlantic Ocean north of Arecibo, Puerto Rico. Figure 2 gives the location of the dumpsite. There, wastes from seven pharmaceutical plants, principally organic materials, are mixed in a holding tank and dumped together.

After 8 years of planning and construction, a land-based sewage treatment plant in Puerto Rico (which discharges wastes through an outfall) has been modified to treat the pharmaceutical wastes that are now dumped in the ocean. Ocean dumping of pharmaceutical wastes will cease in the fall of 1981 (see Section IV for a discussion of future research needs that this change entails).

Coal fly ash is recovered from mechanical and electrostatic dust collectors (the so-called "flue scrubbers") located in the exhaust systems of coal-fired electric generating plants. Bottom ash is collected from furnaces. The mixed ash is characterized by trace amounts of metals and finely divided particles.

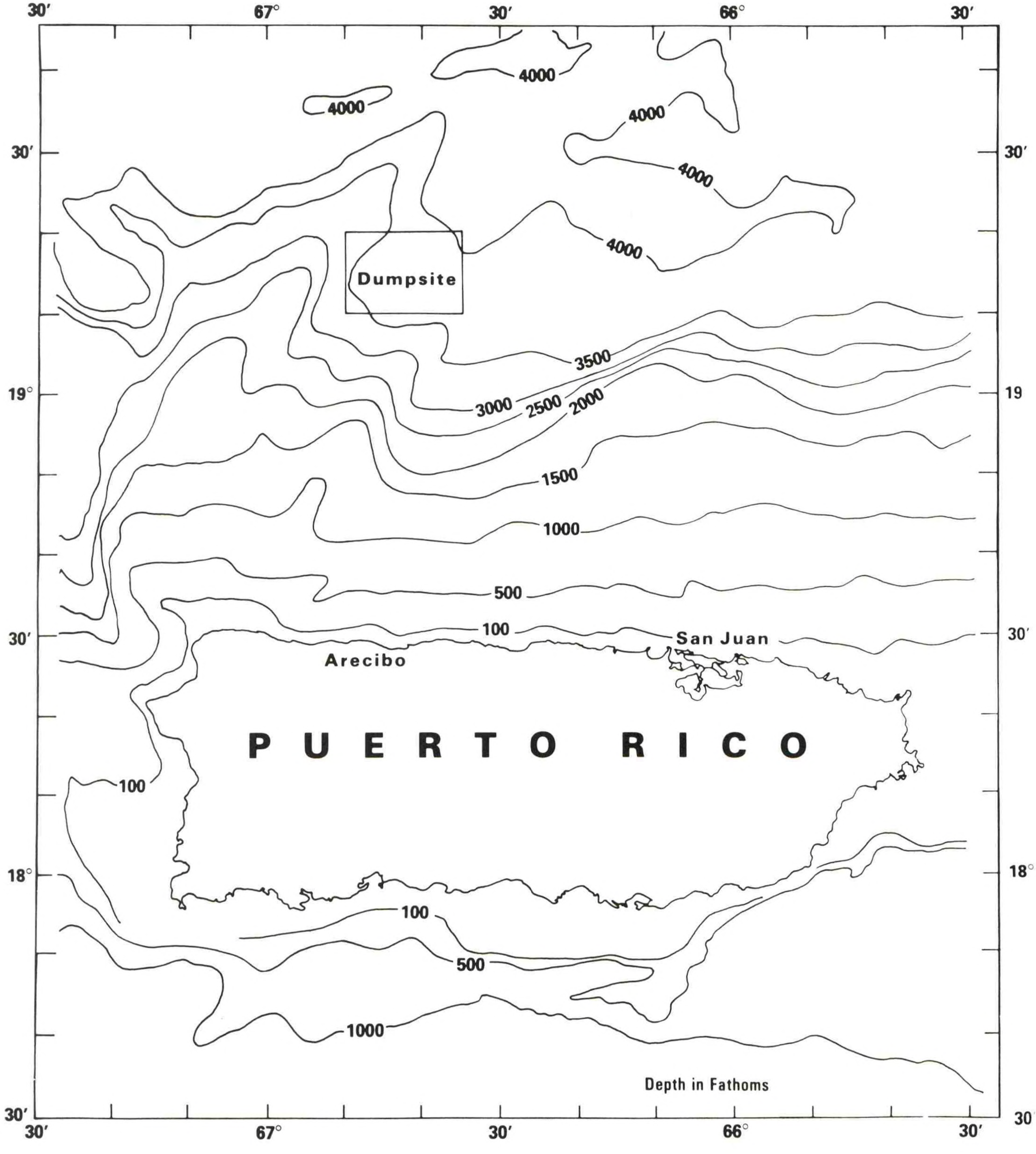


Figure 2. Puerto Rico Site

In recent years, a process has been developed to combine fly ash with scrubber sludge to produce concrete-like blocks. Scrubber sludge consisting principally of calcium sulfate and calcium sulfite is produced when power plant fumes are "scrubbed" of their sulfur. When dumped into the ocean, these blocks appear to have no adverse environmental effect, and may serve as fish habitats (Figure 3).

As petroleum continues to become more costly and as nuclear power's future remains uncertain, more and more electric utilities are expected to return to coal. According to a report by the Congressional Office of Technology Assessment, utilities will have to discard 65 million tonnes of fly and bottom ash combined, and 15 million tonnes of scrubber sludge would be produced annually by 1985. NOAA will continue to scrutinize the effect arising from the disposal of coal wastes into the oceans.

Seafood Processing Wastes

Currently, seafood processing wastes can be dumped in the ocean without a permit if they contain no additives or preservatives. Also, the culling of fish catches at sea by commercial fishermen is not considered to be ocean dumping. Fish wastes in American Samoa are now dumped under an EPA permit in the Pacific Ocean at a deep ocean dumpsite. Fish wastes are also dumped into the ocean in Alaska, in the Gulf of Mexico off Louisiana, and in the Atlantic Ocean off Puerto Rico under the non-permit needed status. A permit is pending for disposal off the California coast.

Seafood wastes are high in fats, proteins, and other organic materials. These wastes include uneaten fish parts, culls, and inedible species (Figure 4). While ocean dumping avoids the hordes of flies and scavenging seagulls of on-land disposal, it can reduce the dissolved oxygen available for marine life. Seafood wastes can create a surface slick and turbidity plume, and attract unwanted predators such as sharks.

The oxygen that fish wastes consume during decomposition is of particular concern. Too little oxygen may be left in the water to support zooplankton populations that are vital to the marine food chain. Studies of decomposition processes of fish wastes in the ocean will help determine the capacity of the ocean to assimilate such naturally occurring organic materials.

Radioactive Wastes

Recently, suggestions have been made that high-level radioactive wastes from nuclear power plants be buried under the ocean floor. At present, some European countries discharge low-level radioactive wastes into the oceans through pipe outfalls and by ships at a designated dumpsite in the northeast Atlantic. Before high-level radioactive wastes can be buried in deepsea sediments, we need to know more about their effects on the marine environment. Therefore, the major concern is the food-chain transfer of radioactive materials to man and subsequent radiation exposure. To date, however, no comprehensive field tests have been conducted.

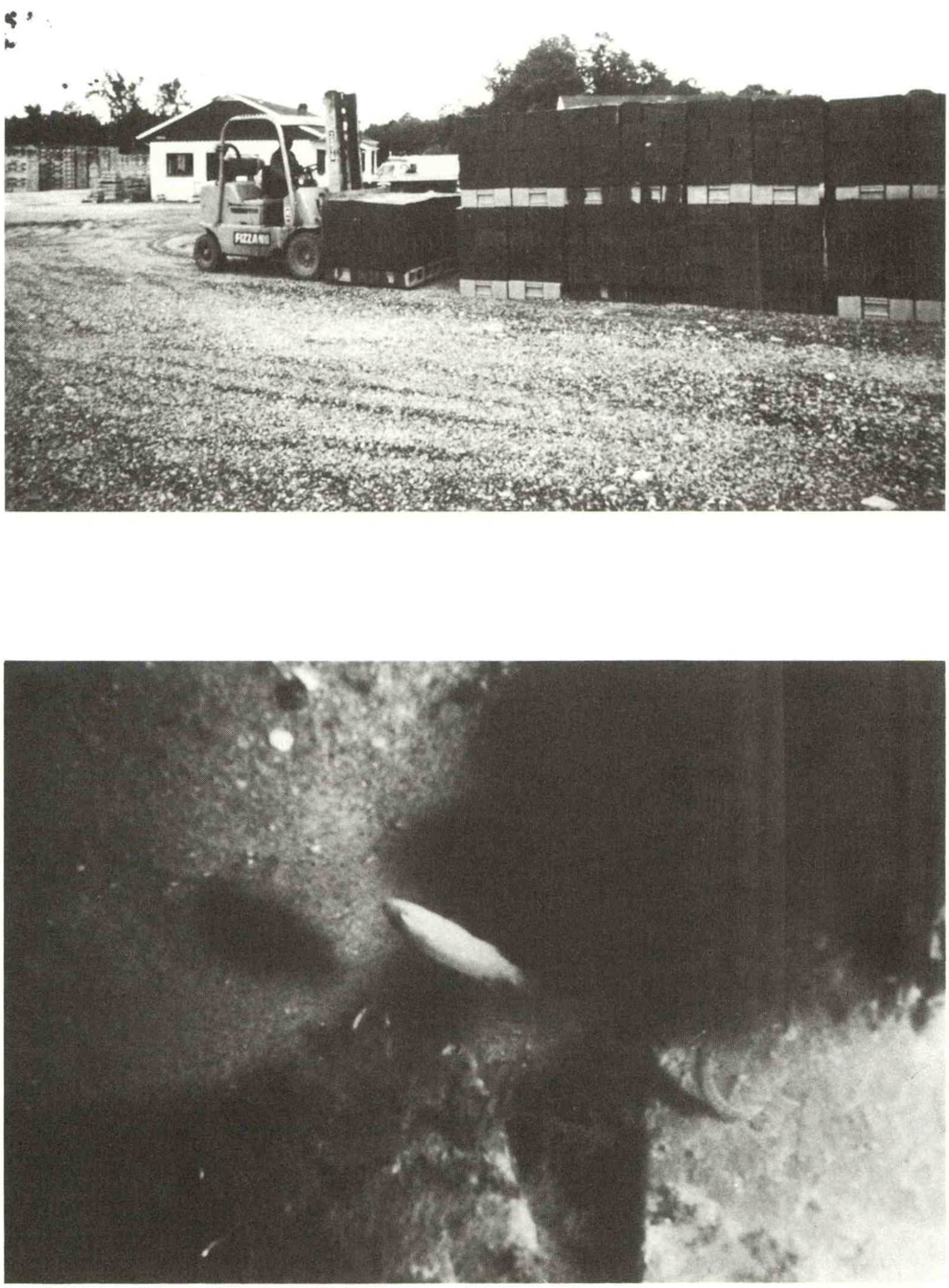
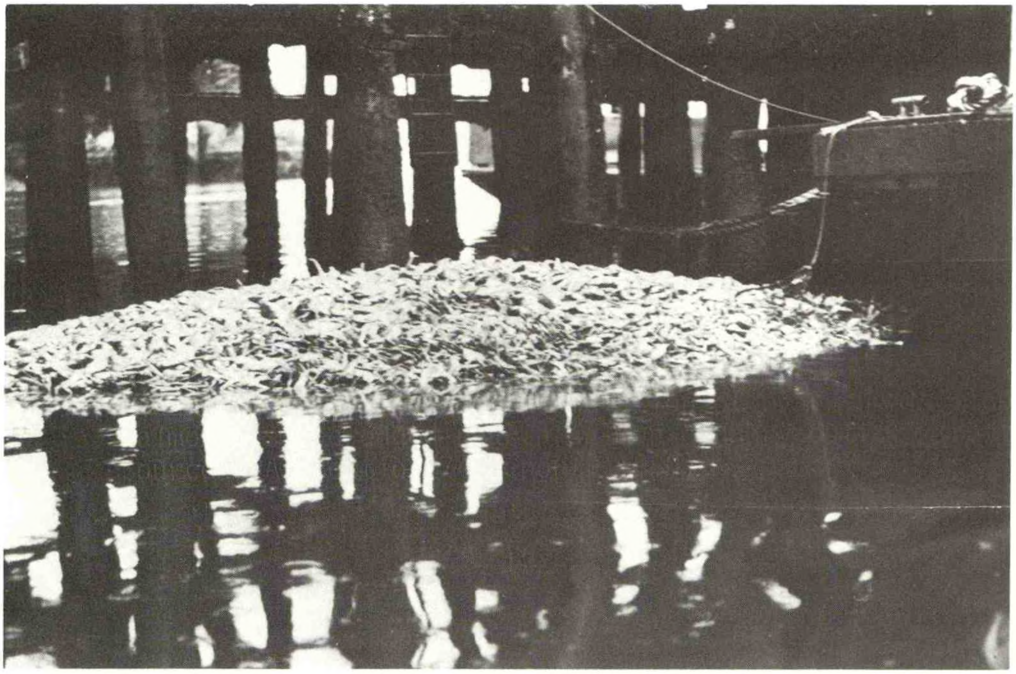


Figure 3. Coal waste blocks (top). Following ocean disposal, the blocks are colonized by marine organisms (bottom). Photographs from I. W. Duedall and J. Parker, State University of New York, Stony Brook.



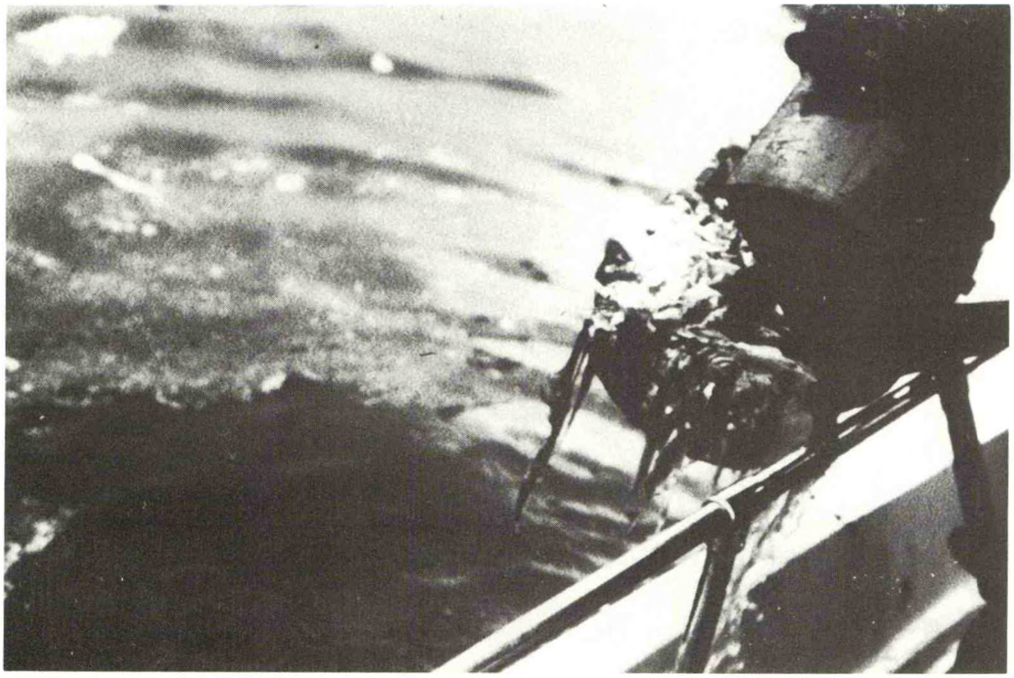


Figure 4. Fish wastes in Alaska. Accumulation of crab shells (top). Salmon waste dredged near a salmon cannery outfall (bottom). Source EPA (Section 74 Report, 1980).

Ocean Incineration

While various wastes have been dumped in the oceans for many years, only recently have some toxic wastes been destroyed by incinerating them at sea. Ocean incineration may replace dumping or on-land burning of highly toxic wastes, particularly pesticides and organic chlorides.

Ocean incineration uses tankers with specially designed incinerators capable of reaching temperatures in excess of 1,370 degrees Celsius (2,500 degrees Fahrenheit). Tests in Europe in the early 1970s showed ocean incineration to be effective and safe. Following those tests chlorinated organic compounds, principally trichloropropane, trichloroethane, and dichloroethane were burned on the incineration ship *Vulcanus* in the Gulf of Mexico in 1974 and 1975, and again in 1977. In each case, more than 99.9 percent of the wastes were destroyed with no significant adverse environmental effects.

Also in 1977, more than 10,000 tonnes of Agent Orange were burned in the Pacific Ocean near Johnston Atoll. Agent Orange was a mixture of the herbicides 2,4,5-T and 2,4-D that also contained the extremely toxic contaminant, dioxin (TCDD). Again, more than 99.9 percent of the wastes were destroyed in the burn.

So far, ocean incineration is a seldom-used, experimental method for disposing of highly toxic chemicals. But because of the efficiencies achieved and the ability to burn the wastes away from populated areas, it may take on increased importance in the future.

CHAPTER III

OCEAN DUMPING RESEARCH

The major objective of NOAA-sponsored research is to learn more about the processes which govern the distribution of dumped wastes in the oceans and the ocean's chemical and biological response to these wastes. For example, studies of the short-term behavior of single waste plumes have yielded results that are independent of specific dumping locations. These studies also have shown that open ocean plankton are more sensitive to contamination than are marine organisms in heavily used coastal waters.

Studies of the effects of discarding certain wastes at particular sites form part of a generic research program on the use of the oceans for waste disposal, but the approach also includes detailed evaluation of actual dumpsites. Some oceanographic studies have been specifically aimed at a particular dumpsite. These studies have been concerned with how long wastes remain at dumpsites, the path they take away from the dumpsites, and the flow of water available to dilute wastes.

Research findings from deep ocean dumpsite studies discussed in the 1978 and 1979 annual reports considered the chemical and physical characteristics of individual wastes, dilution of waste plumes, and laboratory studies of individual waste toxicity. This report emphasizes the extent of biological effects from existing practices as determined in the ocean, the capacity of dumpsites to dilute wastes, possible future uses of the dumpsites, and further research needs in the context of those uses.

As described in previous reports, dumping over the deep ocean tends to produce relatively narrow, discolored ribbons of contamination. Over a day's time, these ribbons grow to about 1 km (0.6 nautical miles) wide and up to 50 km (27 nautical miles) long. Also, within a day of a dump, wastes extend downward to the first major density gradient in the water column, or about 20 m (65 feet), during summer conditions. The waste concentration typically ranges from 1 to 10 parts of waste per million parts of seawater (ppm).

Deep Ocean Sites: Biological Effects

Plankton are the small, usually microscopic, plant and animal organisms in water that form the base for freshwater and marine food chains. Phytoplankton are the plant members of the plankton community; zooplankton are the animals. Previous laboratory tests have shown that phytoplankton are not affected by present wastes dumped at concentrations of 10 ppm or less. NOAA-sponsored researchers hypothesized, however, that within phytoplankton communities the exact numbers of individuals of each species would change even at low waste concentrations. No species would die out, the researchers thought, but some might thrive upon, or be less sensitive to, contamination than others. This has been demonstrated to occur at the Puerto Rico Site where, within new waste plumes, a shift toward smaller size species occurred within the phytoplankton community.

This response, if widespread, could significantly alter food chains. The conversion of sunlight into biomass or food, phytoplankton's role in the sea, would not change, but the plankton might be too small-sized for zooplankton, the next step in the food chain, to eat them efficiently. However, the change in the phytoplankton community off Puerto Rico could be demonstrated only within fresh waste plumes. Away from the plumes, even though the surrounding waters of the Puerto Rico Site usually contained some wastes, the plankton community structure appeared normal.

Sampling at the 106-Mile Site has so far produced no evidence of a similar effect on the phytoplankton community. The presence of community modification at the Puerto Rico Site may be because the pharmaceutical wastes (presently ocean dumped) are, by laboratory tests, the most toxic to plankton of ocean dumped industrial wastes.

Laboratory tests also have shown that concentrations up to 20 ppm of the wastes currently ocean dumped at the 106-Mile Site do not kill zooplankton. Nevertheless, organisms have shown evidence of decreased feeding, respiration rates, and egg production. Such response, if widespread in the ocean, would result in a decrease of biomass at the second level of the marine food chain. If so, that could affect commercially or recreationally valuable fish stocks.

Species of zooplankton collected in fresh waste plumes at both the 106-Mile and Puerto Rico Sites were found to have decreased metabolic and reproduction rates. As with the phytoplankton community, the observed effects were limited to zooplankton collected within 1 day of individual dumps. Affected zooplankton did not recover when placed in clean seawater, but their eggs that were also exposed since they are carried externally did survive.

Thus far, our observations have shown that the consequences to plankton of dumping wastes are evident only on the small scale of relatively fresh waste plumes and do not appear to affect subsequent generations. Corroborating evidence comes from a recent analysis of additional zooplankton collections made north of Puerto Rico in 1976 which revealed no abnormalities in the numbers or kinds of organisms.

In another biological finding, a relatively high number (15 percent) of euphausiids, shrimp-like large zooplankton, suffer from gill melanization or black spots at the 106-Mile Site, but not at the Puerto Rico Site. Gill melanization may be naturally prevalent in deep ocean waters off the northeast coast; however, it is less prevalent in coastal waters. The differences in its occurence, once thought to be related to disposal of specific wastes, now appear to be related to the distribution of particular species of euphausiids.

Some species, no matter where collected, display uniformly high or low frequencies of gill melanization. Deep ocean waters contain a lower percentage of susceptible species. In explaining this phenomenon, and in seeking responses to waste, scientists have looked for changes in animal tissues. Even though causes of observed conditions cannot be identified precisely, the distribution of abnormalities must be investigated to differentiate natural from contaminant-induced effects.

At the Puerto Rico Site, bacterial populations may have been altered by waste dumping. As with euphausiids, natural distributions must be considered first. More than half of the marine bacterial populations there are dominated by species that usually number about 10 percent of the total. Also, terrestial bacteria common in pharmaceutical wastes, but not usually in the ocean, have been found off Puerto Rico. The terrestrial bacteria are found primarily near the dumpsite, indicating that they have limited lifetimes in the ocean or that water circulation has limited their dispersion.

The altered marine bacterial communities and waste chemicals have been found over a large area surrounding the Puerto Rico Site. However, they have no obvious consequence for valuable marine life. Also, the shift in oceanic bacterial communities to include pathogenic terrestial bacteria has not caused a public health hazard because the site is far from shore.

Even if the directly affected marine organisms suffer no apparent harm from wastes, scientists are concerned that chemicals could accumulate in fish. The ultimate effect of such bioaccumulation could be upon people who eat contaminated fish. However, this is unlikely to occur from wastes dumped in the deep ocean, because neither deep ocean dumpsite is in a major commercial or recreational fishing region, and because fish are transient in the dumpsite regions.

Zooplankton collected near the dumpsites have not shown clear evidence of being contaminated. The waste chemicals do not have large bioaccumulation ratios and zooplankton are not continuously exposed to high waste concentrations. Even if waste chemicals do accumulate in zooplankton living in concentrated waste zones, as ambient concentrations decrease, the chemicals tend to return to the water through excreted zooplankton fecal material.

In summary, studies indicate that biological responses to present ocean dumping practices are limited in time and space, that they occur within discrete waste plumes, and that they disappear within a day of individual dumps. Long-term and widespread effects have not been observed. But as more and more wastes are ocean disposed the total loading rather than individual dumps become the concern.

Deep Ocean Sites: Physical Oceanography

The lack of observed biological effects, except in fresh plumes, is due in part to the rapid dilution of wastes that takes place in moving water. Wastes can be altered chemically by sunlight (photochemical reactions), volatilization (loss of organic compounds to the atmosphere), oxidation, hydrolysis (reaction with water under normal seawater conditions), formation of complex chemicals between waste metals and naturally occuring substances, other non-biological transformations, and by biologically-mediated decay.

Except possibly for fast oxidation, hydrolysis, or complex-forming reactions, which may occur immediately upon mixing wastes with seawater, special treatments of waste/seawater mixtures have not reduced their toxicity. Bubbling air through mixtures of selected wastes with seawater to purge them of volatile compounds has not decreased their toxicity. Wastes exposed to sunlight or stored for long periods of time have not shown decreased toxicity. However, none of these tests was definitive because laboratory conditions, such as waste concentration, were not identical to those in the ocean.

On the other hand, initial toxicity levels do decrease as a substance becomes diluted. Further, waste concentrations decrease with time and distance from the actual dumpsite. In addition, biological effects have not been observed except in fresh waste plumes. Therefore, it is primarily, if not solely, through dilution that effects of wastes are diminished at deep ocean dumpsites.

Ocean disposal makes use of the physical process of dilution to discard wastes safely. The discharge procedure and the amount of wastes dumped are the two manageable aspects of disposal available to exploit the ocean's diluting capacities. The aim should be to discharge wastes so as to dilute them as much as possible initially and to limit the amount of wastes (more precisely, the amount per unit of time, or flux, of wastes) to that which can be accommodated safely in the available volume of seawater.

Deep ocean dumping is done slowly, with typically 4,000 m^3 (1,000,000 gallons) of wastes discharged over distances of 40 to 50 km (22 to 27 nautical miles). As described in previous reports, this slow dumping achieves initial waste dilutions by a factor of about 5,000. Within 1 day of a dump, the waste concentration is diluted by a factor of 100,000. Storms can dilute wastes rapidly by stirring up the water and breaking plumes into pieces. Other natural mechanisms also effectively dilute wastes since no waste plume has ever been successfully followed for more than 3 days.

It is important to note, however, that the amount of wastes dumped over time should not exceed the capacity of any deep ocean dumpsite to dilute these wastes. If the amount is excessive, new waste plumes simply will be mixed into already contaminated water.

The capacity for waste dilution at a given dumpsite depends on the rate of replacement of water within that region. Therefore, regional consideration is important, not the specific geographic coordinates of the dumpsites. Rates of water replacement would not be significantly altered if dumpsites were in different locations within the same region or if the sites were of different sizes.

Even within major ocean current systems such as the Gulf Stream, oceanic waters do not move uniformly in one direction. Depending on the region, the waters may move periodically in one direction and then reverse course, so that the net movement of water, and therefore of wastes, out of the region can be very slow. Alternatively, the flow may be gyre-like with water returning to a point in a region after moving through a more-or-less circular path. What should be determined in assessing the value of a site for waste disposal is the area of the region over which wastes can mix, how long water stays within that region, and the bottom depth of the site.

As discussed in previous reports, water is not readily replaced at the Puerto Rico Site. Wastes have been detected over a wide area surrounding the site. Physical oceanographic measurements in October 1979 implied that the site is within a gyre system. Water was projected to flow southward on the western side of the site, then turn eastward along the island of Puerto Rico, finally flow northward and westward to complete a gyre about 100 km (62 nautical miles) in diameter. Such a gyre is consistent with observations of widespread wastes.

Clusters of drogues, submerged funnel-shaped devices attached to surface floats that are used to trace current flows, were cast adrift in the dumpsite and tracked by radio for about 2 weeks during October 1979 and again in March and August 1980. The drogues behaved differently each time and indicated a nonuniform flushing pattern at the dumpsite. The periodic oscillations, which varied in speed and direction, were consistent with a gyre-like circulation.

A fourth drogue was released at the dumpsite in October 1980 and tracked by satellite for 6 months. It, too, indicated a gyre, but on a larger scale than did the previous drogues. This time, the drogue moved southward from the dumpsite, then eastward along the north coast of the island, moved northward for about 300 km (180 nautical miles), and then turned southwestward and passed through the dumpsite about 100 days after having been released. It then moved southward again, but this time it passed through the Mona Passage west of Puerto Rico and into the Caribbean Sea.

Thus, no two assessments of the flow regime north of Puerto Rico have yielded the same results. The satellite-tracked drogue moved away from the site twice, taking a different path each time. The radio-tracked drogues followed three different, short-term routes indicating a wide range of variability in circulation patterns. All measurements, though, are consistent with a sluggish rate of water replacement; a result that was not expected on the basis of historical data indicating westward-flowing Antilles Current in the region.

If the site were to receive continued use, additional wastes, or more toxic wastes, it would be important to better define the region's circulation patterns. On the basis of biological observations showing effects on plankton only in fresh waste plumes and terrestrial bacteria existing only near the actual dumpsite, the circulation, even though sluggish, seems to be sufficient to prevent long-term adverse environmental consequences from present levels of dumping.

At the 106-Mile Site off the Delaware coast, water-flow data have been collected through the extensive use of satellite- and radio-tracked drogues (which yield shorter-term and less reliable data than at the Puerto Rico Site because of the greater distance from shore-based radio stations) and through satellite imagery of oceanic temperatures. This work has revealed a frontal zone between waters over the continental shelf and those overlying the deeper continental slope, as well as the migration of warm-core Gulf Stream eddies (see reports to Congress for 1978 and 1979).

The circulation pattern at the 106-Mile Site is better understood than at the Puerto Rico Site. At the former site, water flows at an average speed of 10 cm/sec (0.2 nautical miles/hour) in a southwest direction along the contour of the edge of the continental shelf. Satellite-tracked drogues have always followed this path and have become incorporated into the Gulf Stream about 500 km (270 nautical miles) southwest of the site within 1 to 2 months of having passed through the dumpsite.

There are fluctuations in this average, however. Radio-tracked buoys, drogued at 10 to 30 m, have moved westward over the continental shelf under conditions where, presumably, near surface shelf water is moving seaward. In one case in which a warm core eddy near the site influenced the current, the drogues moved northeastward. These fluctuations show a large-scale mixing mechanism by which seawater is exchanged between the coastal and open oceans. It is part of the mixing process to which wastes also are subjected.

Dilution available at the 106-Mile Site is now more than adequate to handle currently dumped wastes, but if the site were also used to dispose of sewage sludge and/or coal ash, as has been proposed, the volume of waste dumped there could increase more than ten times. Better information would be needed to better define flow fluctuations, mixing mechanisms, and subsurface flows. Researchers should also consider the likelihood of a large gyre system which would return wastes to the dumpsite over long periods rather than sweeping them into the Gulf Stream where they would be further diluted and dispersed.

The Philadelphia Site

Unlike the 106-Mile and Puerto Rico Sites, both of which are over the deep ocean, the Philadelphia Site lies over the continental shelf in waters that average 40 to 60 m deep.

Research at the Philadelphia Site began in 1973 before sewage sludge was dumped. Thus, baseline data exist with which to compare later findings. Since 1973, research there has focused on tracking the movement of sewage sludge in the water and along the bottom, and its effects on marine ecosystems. Studies have concentrated on surveys of marine organisms and sediments, and on comparisons of the organisms inhabiting the disposal site with those from relatively uncontaminated areas nearby.

Following cessation of all sewage sludge dumping at the Philadelphia Site in November 1980, NOAA aimed its research efforts at learning how the marine environment recovers from dumping. Research projects study pathogenic protozoans (minute, single-cell animals), pollution-related diseases in crabs, and the distribution and cycling of viruses that inhabit the human gastro-intestinal tract.

Researchers studying the Philadelphia Site in 1980 found species of amoebas belonging to the genus *Acanthamoeba* that feed on bacteria. Some of these amoebas are human pathogens. Their presence at the dumpsite is thought to be directly related to contamination of marine environments by municipal sewage sludge. Indeed, scientists found the amoebas' distribution to coincide with that of fecal bacteria. Ongoing studies at the site are expected to document whether these amoebas have declined now that sewage sludge is no longer dumped there. This work is part of a broader study by NOAA's National Marine Fisheries Service to survey _Acanthamoeba_ in the mid-Atlantic and New York Bight dumpsites.

In another study, scientists found that rock crabs near the Philadelphia Site show a high incidence of gill melanization or black spots. The disease is apparently caused by pollutants contained in sewage sludge. The pollutants become trapped in the crustaceans' gills but are periodically discarded with their old exoskeleton when the animals molt.

Still other studies in 1980 showed that sewage sludge particles can harbor viruses that inhabit the human gastro-intestinal tract. Research at the Philadelphia and New York Bight Sites sought to learn if those viruses could become a hazard to human health. Sampling of bottom sediments and analysis of the viruses in the laboratory will continue in 1981.

Finally, scientific teams from EPA and NOAA made several cruises to the Philadelphia Site in 1980 to gather data. The teams monitored mortality levels in bottom-dwelling species, levels of heavy metals and other pollutants in sediments and marine organisms, and changes in the water's oxygen content that might be related to sewage dumping.

As a result, scientists found that there are increased levels of metals and PCBs in marine organisms and bottom sediments at the site. They also found changes in the abundance of different marine species, increased mortality in one clam species (_Arctica islandica_, the so-called "ocean quahog"), and appearances of sludge beds, sewage bacteria, pathogenic protozoans, and crab diseases.

Although the degree of overall pollution remains unclear, it appears to be low. The Ocean Dumping Program will continue to measure long-term trends and the effects of municipal wastes on the marine ecosystems at the Philadelphia Site. In the end, these efforts will produce a continuum of data from pre-dumping in 1973 through the years of disposal of municipal wastes and into the current period in which dumping has ceased.

Chesapeake Bay (Dredged Material Research)

Similar to the Philadelphia Site, the Chesapeake Bay Site is in relatively shallow water over the continental shelf. Here, NOAA-sponsored research aims to evaluate the area as a possible disposal site for dredged materials and to develop criteria for monitoring the site if disposal begins. The site is located about 30 km (18 nautical miles) due east of the mouth of Chesapeake Bay (Figure 5).

Ten cruises were made to the site in 1980 to take samples of the sediment and marine organisms for laboratory study. A study was also conducted of the liver enzyme systems in three fish species -- American sole (_Trinecthes_

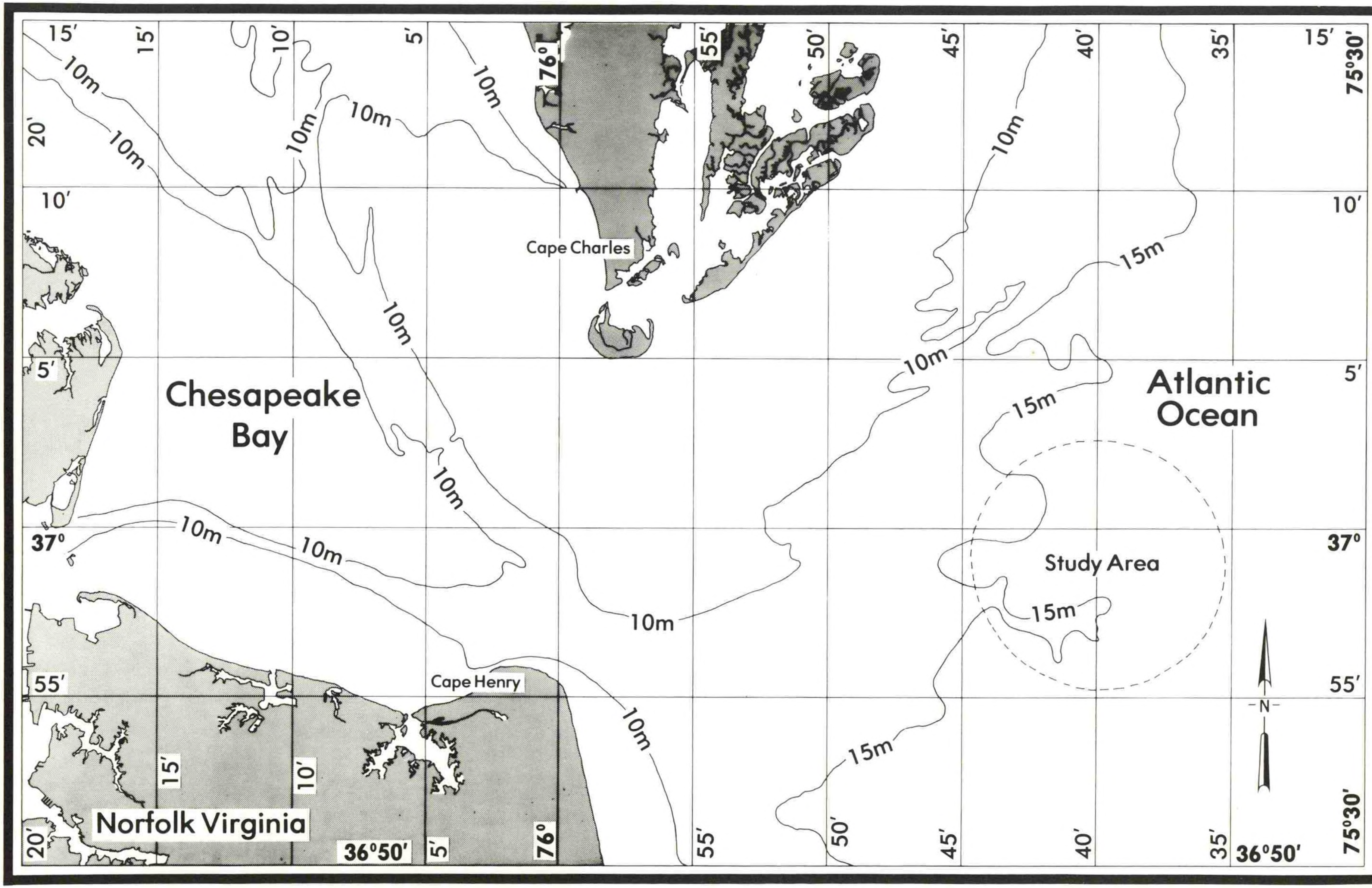


Figure 5. Chesapeake Bay disposal study area

maculatus), spot (Leiostomus xanthurus), and menhaden (Brevoortia tyrannus). Through these studies of liver enzymes, we hope to learn how fish react to sublethal stress caused by contaminants.

Research in 1980 showed that the bottom organisms at the Chesapeake Bay Site were similar to those of surrounding waters. They also showed very low levels of metals compared with those found in the Norfolk port area, the source of the dredged material that may be dumped at the site.

Material from selected current dredging sites in the Norfolk area did not produce toxic effects to Chesapeake Bay marine organisms. Lethal effects were mainly associated with materials from the most highly industrialized areas. Bioaccumulation studies likewise indicated little effect. Overall environmental impact of these dredged sediments thus appears to be low, although the effects of pollutants on individual communities of organisms are still being analyzed. Experimental trays that were filled with Elizabeth River sediment and placed at the proposed dumpsite were scoured clean of that sediment in less than a month, indicating that most material disposed of would be dispersed subsequently.

New York Bight Dumpsites

Through its Marine Ecosystems Analysis (MESA) Program, NOAA has sponsored research in the New York Bight since 1973. During 1980, there were no major pollution-related incidents in the New York Bight. Consequently, MESA's efforts in the Bight were directed towards accomplishing its planned and projected research and monitoring. This was MESA's third year of data synthesis and the seventh year of an 8-year study. This year marked a continuation of that shift in emphasis from field research, which was essentially completed in 1979, to data synthesizing. It was also marked by two symposia convened by MESA to assist with synthesizing research results into forms that will help guide regulatory and planning agencies and the public.

The program looks at regional problems, including those resulting from dumping dredged material, sewage sludge, and other wastes into the Bight. Figure 1 presents the dumpsite locations. A mound of sediment has built up in the mud dumpsite, and the dredged material is a major source of toxic metals and organic contaminants to the Bight. It is not known whether these contaminants are taken up by any of the marine organisms there. The dredged material has little effect on the amount of oxygen available to marine organisms, especially for bottom dwellers.

Dredged material will be a point source of contamination to the New York Bight if chemicals are released from the dredged material mound. Current practices require that the contaminated dredged material dumped at the site be covered with a layer of "clean" sand "capping". The "capping" layer, which is the subject of ongoing research, is intended to prevent mobilization of chemicals from the underlying ocean dumped dredged material.

Studies of water quality changes occurring during dumping events were made in 1979. Metals and organic chemical concentrations were seen to be elevated near the seafloor (top of dredged material mound) within 15 minutes of a dump but not at later times. The question arose as to whether the background concentrations themselves were elevated by a continuous chemical migration from the dredged material mound.

A 1980 survey included chemical measurements in the water over the dredged material mound (in the absence of dumping events). The purpose was to establish horizontal and vertical gradients in chemical concentrations from New York Harbor to the 106-Mile Site. The final results are not yet available, although preliminary data are available for particulate metal concentrations, particulate polychlorinated biphenyl (PCB), and polyaromatic hydrocarbon (PAH) concentrations. These show that both the dredge mound and sewage sludge deposits appear to be sources of bottom-water cadmium, copper, iron, and lead, but not high molecular weight organics. There is a decrease in concentrations of all anthropogenically introduced chemicals in a seaward direction, but the two waste deposits have uniquely high concentrations in bottom waters above them.

The sediments of Lower Bay and the Christiaensen Basin appear to be depositories for large quantities of PAHs and chlorinated hydrocarbons. The data suggest that New York Harbor sediments, dredged and dumped in the Bight, contribute about three times as much PCBs to the Bight as does dumped sewage sludge.

The areas of greatest environmental and biotic contamination are the Hudson-Raritan Estuary and the Christiaensen Basin. While the likelihood of people obtaining significant doses of organic toxicants via marine foods is very low, these analyses do suggest the importance of assessing the public health implications of contaminated fish and shellfish. Also, several ecological effects documented elsewhere in the world are consistent with the high concentrations of toxic organics found in the Estuary and inner Bight. These chemical analyses indicate the importance of determining the extent to which these toxic organics contribute to significant ecological degradation, and in applying necessary practical management measures.

There is no microbiological or epidemiological evidence that the disposal of municipal sludge at the existing dumpsite has caused deterioration of water quality or swimming-associated illness at New York or New Jersey coastal beaches. However, sewage sludge dumping has reduced water quality in nearby shellfish growing areas. It must be assumed that consumption of these shellfish carries with it a significant risk of diseases. Consequently, the Food and Drug Administration has forbidden shellfish harvesting within a distance of 6 nautical miles about the center of the dumpsites, plus additional areas extending to the Long Island and New Jersey beaches.

Some municipal wastewaters are discharged directly into the Bight. Among them are those emerging from the Upper Bay and the confluence of the Raritan River and Arthur Kill, and discharges entering embayments along the Long Island and New Jersey coasts. These have deteriorated water quality at nearby beaches. Furthermore, it is now clear from the results of an epidemiological/microbiological program and a study conducted at New York City beaches that this deterioration carries with it a measurable risk of swimming-associated gastroenteritis.

The findings also suggest that sporadic cases of gastroenteritis probably are occurring via shellfish consumption. A model is being developed for predicting the number of cases of gastroenteritis per season which occur at bathing beaches along the Bight.

The estimated percentage of the total PCB input to the New York Bight Apex from ocean dumped sewage sludge is 30 percent and dredged material contributes 70 percent. Wastewater discharges upstream contribute approximately 25 percent of the PCBs in the dredged material, with the remainder from upstream industrial contaminated bottom sediments carried downstream. Estimates for other organic contaminants, especially PAHs, are not possible since data on concentrations in the water column and on suspended particulates are not available. Nevertheless, dumping of dredged material and sewage sludge probably contributes most of the annual load of PCBs entering the Bight Apex.

The quantities of PCBs available to marine organisms due to ocean dumping of sewage sludge and dredged materials have not been determined. In general, PCBs in sewage sludge probably remain for some time in the water column, associated primarily with suspended solids, since sewage sludge does not settle rapidly and disperses widely. Much of the PCBs in dredged material, on the other hand, is likely to remain with the settleable fraction of dredged material which forms a mound at the dumpsite.

The presence of PCBs in the water column or in deposited sediments does not define their availability to organisms. Ongoing research in several laboratories is aimed at defining rates and routes of PCB uptake from dredged materials. Preliminary results from these studies show that the presence of suspended solids decreases bioconcentration of PCBs from water. Uptake of particle-bound PCBs from deposited sediments is apparently very low. Both these results support the observation that, in general, organisms in the New York Bight contain low levels of PCBs despite rather high concentrations in the environment.

Sediment cores carefully retrieved by divers from the dredged material site have been subjected to chemical studies. These cores fortuitously consisted of a 10 cm thick layer of sand overlying mud. This sand cap is either natural or an artifact of past dumping; it is not a deliberately created cap. Studies of changes in water overlying these cores have shown the sediment to be a source of cadmium and copper. Thus the sand cap did not prevent chemicals in the dredged material from affecting bottom water. Further analysis of chemical data from the New York Bight and the Hudson River Estuary may indicate whether chemical releases from the dredged material mound have significantly affected overall Bight water quality.

The cores also show that the polyaromatic hydrocarbon distribution is distinctly different between dredged material and sewage sludge. The sludge contains primarily lighter compounds, indicating a petroleum source, while the dredged material contains primarily heavier compounds derived from combustion of fossil fuels. These findings may allow scientists to sort the various sources of New York Bight contamination.

In 1980, MESA New York Bight Project collaborated with NOAA's National Ocean Survey and the Northeast Fisheries Center's Sandy Hook Laboratory, the U.S. Environmental Protection Agency, the American Littoral Society, and selected state and local agencies in the Northeast Monitoring Program (NEMP). Four cruises were conducted in 1980 along a grid of stations selected by MESA on the basis of an earlier research sampling grid. These cruises were designed to understand better how sewage discharges and sludge affect oxygen concentrations in the New York Bight. This is a continuation of monitoring conducted from 1977 to 1979 to assess Bight water quality. During 1980, dissolved oxygen values over bottom sediments along the New Jersey shelf were within the normal range. Trends during the year can be characterized as healthy. The lowest observed values occurred during September along the southern New Jersey coast. Values ranged from 1.3 millimoles (4.0 ppm) near the New Jersey shore, to between 1.6 and 2.3 millimoles (5.2 and 7.3 ppm) across the remainder of the shelf. Serious oxygen depletion did not develop during 1980 (NEMP Annual Report, 1980).

MESA received two reports in 1980 on experiments tracking sewage sludge in the New York Bight. The experiment tracked the fate of sludge dumped by different techniques. Shortly after a "spot dump", the sludge components (both dissolved and particulate) in the water column were found most concentrated at about 5 m deep. Shortly after a "line dump", in which more extensive turbulence is produced in the wake of the dumping barge, the sludge components were more rapidly mixed.

After dumping, suspended solids were found to be enriched in silver, chromium, and lead. Scanning electron microscopy and X-ray fluorescence spectroscopy of individual particles showed the presence of larger sludge particles (50-125 μm), amorphous in appearance and containing relatively low concentrations of trace elements. The smaller particles (<50 μm), appearing mostly as either spheres or crystalline flakes, were enriched in trace elements such as chromium and titanium. Biological decomposition of sludge, as inferred from adenosine triphosphate (ATP) production in dialysis bag experiments, did not occur for about 48 hours after dumping.

During 1980, bioassay results demonstrated that bioaccumulation of PCBs from test sediments (to be dredged) is occurring in levels that exceed the permit criteria. Therefore, permits for dredging at two locations in New York Harbor were denied. An intergovernmental task force was established to evaluate existing field data to guide the interpretation of laboratory-derived levels of PCB bioaccumulation. NOAA has been assisting by providing field data relative to dredged materials and interpretive guidance. Interim evaluation criteria, using a matrix, were developed and are being used in concert with a sand-capping procedure until new criteria are promulgated.

MESA also received a final report in 1980 that analyzed the short-term chemical findings associated with the Dredged Materials Tracking Experiment (DREMATREX) during June 1979. There appeared to be little short-term change in the chemical, hydrographic, and biological parameters associated with individual dredged material dumps. Within minutes after dredged sediments were dispersed, most parameters returned to a level that was indistinguishable from the background conditions.

The absence of a chemical modification of the water column after a dump of dredged material indicates either that there is no effect on the water column from a dump or that other sources of particulate matter in the New York Bight are so large that the effect of a dump is obscured. The sampling plan was designed to obtain the most information possible from the acoustic backscattering measurements. Consequently, there was no opportunity to determine the importance of particulate matter sources other than the dredged material disposal. A comparison report on the acoustical findings was published in January 1982.

Complementary Research

Some Ocean Dumping Program resources are devoted to basic studies on the interaction of contaminants with organisms. These are designed to reveal how marine organisms respond to toxic metallic elements as functions of oceanic area and relative changes in metal concentrations. Recent data have shown that metal concentrations in the sea are generally in the parts per trillion range, not the previously believed range of parts per billion. Therefore, the possibility that metals could significantly alter natural systems is increased. Moreover, metals in the parts per trillion range affect marine organisms. For example, variations among metal concentrations in this range may control the size and species composition of phytoplankton communities.

Open ocean phytoplankton are more sensitive to metal additions than those living in coastal waters. This occurs because open ocean waters contain lower levels of substances capable of combining with metals, thus lowering their bioavailability, and because open ocean organisms are not adapted to higher metal concentrations. There appears to be a process occurring at outer membranes of cell surfaces by which needed iron is assimilated via a light-induced photo reduction of iron from seawater; trace metals other than iron may interfere with this process. This mechanism of trace metal toxicity would indicate, as is the case, that iron additions can mediate negative effects of other metals.

The sensitivity of cell membranes to various metals may explain the relative effectiveness among metals and may explain the observation that ratios of metal concentrations rather than single concentrations are the important consideration. Long-term adaptability of phytoplankton to metal additions may be due to modifications of membrane proteins to metal contamination. Survival of phytoplankton from short-term metal increases may be due to the cell membrane process being able to essentially stop until conditions of the external medium return to normal. It is known that effects of metals are reversible unless exposures are too long or metal concentration increases too high.

Future Considerations

Beginning in the fall of 1981, an on-land wastewater treatment plant is scheduled to replace deep ocean disposal for pharmaceutical wastes in Puerto Rico (see Section III). The plant will discharge treated waste effluent into the Atlantic Ocean about 1 km (0.6 miles) north of Arecibo, Puerto Rico.

If the effluent contains the same organic compounds as the raw waste, the result will be a replacement of the highly efficient mixing induced by barge dumping with the less extensive initial dilution that occurs with pipeline discharge. Also, it will occur much nearer to shore. The wastes would be dispersed only by the same sluggish circulation that characterizes the movement of ocean water at the present dumpsite.

However, because treated waste may be less toxic than the raw waste now being dumped, the environment may benefit from changing the disposal methods. On the other hand, the discharge will be chlorinated to eliminate bacteria. Most chemicals in pharmaceutical wastes are organic solvents and may form organo-chlorine compounds. If these organic compounds are not removed by secondary treatment, their chlorinated analogs (a chemical compound structurally similar to those that have been altered) will be present in the discharge. These compounds are inherently more toxic than those in the original wastes.

Chemical and biological samples have been collected from around the discharge pipe to compare with samples that will be taken after pharmaceutical wastes begin going to the treatment plant. Also, with ocean dumping about to cease in the deep ocean, an opportunity will exist to examine bacteria at the former dumpsite in the absence of waste-induced effects.

In addition to continuing work at Puerto Rico, several other research areas need to be explored. For example, mixing of waste has been studied primarily in the upper mixed layer of ocean water. Estimates of long-term dilution have not taken into account the immense volume of water available below the upper mixed layer. Two major mechanisms for descent of wastes deserve consideration: the ingestion of waste components by zooplankton and the incorporation of wastes into fecal matter that settles to the bottom rather rapidly.

Rates of pelletization of wastes in the deep ocean need to be quantified. Particulate wastes may sink via the process of flocculation, in which small and essentially non-sinking particles coalesce with one another to form larger and faster settling matter. This process is important in the case of hydrous iron oxides produced from acid-iron wastes. It also will be important in determining whether sewage sludge and coal ash can be dumped safely at deep ocean dumpsites.

Methods also are being developed to better assess the consequences of the contamination of plankton. Current methods of analyzing the response of plankton to wastes are time consuming and inefficient. Better methods that would allow faster and wider observations of sublethal responses to contamination are being developed.

CHAPTER IV

PROGRAM EMPHASIS FY 1981-86

The scope of the ODP in FY 1981-86 will combine the continuation of process studies with increasing attention to ocean waste disposal options arising from development of overall waste management strategies. Research emphasis will be on ocean use for waste disposal with a major focus on contaminant loading and capacity of deep ocean disposal sites for municipal and industrial wastes. Program emphasis will compare and contrast different waste disposal methods, e.g., pipeline outfalls to barge disposal of sewage sludge, both relative to one another and in terms of impact on the ecosystem.

New wastes, such as radioactive waste disposal, seafood wastes, and coal ash wastes, may require specific laboratory or field studies. At present, each of these situations is being reviewed to determine its importance and the extent of the role being played by other agencies. It is planned to review each of these waste disposal situations and develop preliminary assessment reports for each and to develop field and/or laboratory research programs, if appropriate.

Other present and possible waste disposal problems, such as manganese nodule mining and processing wastes and drilling and cutting needs, are being dealt with adequately by other agencies or other components of NOAA. The ODP will review these situations periodically and will contribute expertise and assistance as requested.

Disposal of sewage sludge at the Philadelphia Site ended in November 1980. However, at least two annual cruises will be made to the site to record changes in contaminant distributions resulting from the cessation of dumping. Specific studies focusing on indicator organisms and effects of sludge disposal will continue. Those will include surveys of human viruses in organisms occupying polluted areas and pathological studies of crabs in and out of polluted areas. A comprehensive assessment report on the Philadelphia Site will be prepared.

Studies in the New York and Southern California Bights have been carried out by the MESA New York Bight Project and by the Southern California Coastal Water Research Project, respectively. The ODP will continuously review the status of knowledge relative to these major municipal waste disposal areas in order to guide future municipal waste studies. If necessary, the ODP will undertake cooperative analytical studies of high-priority disposal situations. Evaluations will be made of the relative effects and impacts of shallow water disposal, deep water disposal, dumping, outfalls, and indirect input of municipal wastes to the ocean.

An overall synthesis of ocean disposal of municipal waste is needed. Conceptual and observational mass balance models need to be developed. Information on relative and absolute effects and risks from various forms of barge and outfall disposal is required. Comprehensive recommendations need to be developed pertaining to the use of the ocean for municipal waste disposal. These could include predictive studies for deep ocean dumpsites, if the dumping at the 12-Mile Site were shifted to the 106-Mile Site.

Ocean disposal of dredged material is permitted by law at over 120 designated sites. The ODP will only be able to address specific process studies in a generic sense. The most important specific regions have been proposed for study, i.e., New York Bight, but emphasis will be placed on specific capping studies or generic problems that relate to ocean disposal of dredged material such as bioaccumulation.

Assessment reports on alternative disposal mechanisms and long-term effects will be issued. Based on these assessments, selected studies of longer-term mass balance, effects, and risks will be implemented. An overall synthesis report on ocean disposal of dredged material is necessary.

ODP studies of the two active industrial waste sites will continue. The studies will emphasize field and laboratory studies with major emphasis on biological processes and long-term contaminant distribution and transfer mechanisms. A study will be made of contaminant distributions near the Puerto Rico outfall location, which is scheduled to replace ocean dumping in 1982. A major synthesis report on deep ocean disposal of industrial wastes will be prepared. This report will include evaluation of the suitability of deep ocean sites for various forms of waste disposal, including sewage sludge and dredged material. Comparative assessments will be made of ocean versus outfall disposal of pharmaceutical wastes in Puerto Rico, and on the impact of decreased disposal at the 106-Mile Site.

Process Studies

The impact of a waste on the environment depends on a number of specific factors, such as the disposal method, distribution processes in the marine environment, and biological responses. However, many of the most important waste disposal problems are concerned with the general mechanisms by which wastes interact with the environment. These involve the manner in which contaminants are transferred between ecosystem components and the mechanisms by which organisms respond to contaminant inputs. These need to be known before any given waste situation can be evaluated. Moreover, they need to be understood in general before they can be applied to a specific case. A major 1981-86 effort, therefore, will be to develop basic information on transformation processes and on biological response mechanisms.

Transfers and transformation occur between sediments and the water column, and among particulate, dissolved and biotic states. The ODP will consider how and to what extent dispersed material on the bottom becomes a source of dissolved and particulate contamination to the water column. The extent to which the natural complex-forming capacity of water constituents decreases the biological effects of disposed metals is being addressed. Transfer processes for deep ocean disposal wastes will be studied to determine how the wastes are initially partitioned among dissolved, particulate, and biotic states, and what long-term processes determine the eventual fate of the wastes.

Biological response mechanism studies will range from investigations of bioaccumulation to studies of mechanisms by which organisms rid themselves of contaminants (natural detoxification processes). A broad range of effects studies will examine the factors which influence uptake and accumulation to determine how actual phytoplankton communities in situ are affected by wastes.

Comprehensive reports will be issued by the ODP on process-oriented studies as significant results are achieved. Assessments will be prepared on long-term transfers and transformation processes for ocean disposed wastes, and on the relative utility of various field and laboratory techniques for predicting biological effects.

The study of specific waste disposal problems, and even the study of the key processes determining waste disposal impact, will not of themselves lead to a strategy for managing waste disposal. The development of a strategy requires an ability to rationally evaluate various waste disposal options in terms of the ecological situation which exists.

Waste management studies by the ODP in 1981-86 will have four main components:

1. Studies of assimilative capacity of the ocean for specific wastes.

2. Development of risk assessment methodology for marine wastes.

3. Establishment of a waste-disposal-oriented marine pollution index.

4. Development of a management strategy for marine wastes.

CHAPTER V

PUBLICATIONS FROM OCEAN DUMPING PROGRAM RESEARCH FUNDING OR SUPPORT

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APPENDIX I. SUMMARY OF OCEAN DUMPING PROGRAM FUNDING

AREA	ODP FUNDING (in thousands of dollars) YEAR		
	1978	1979	1980
106-Mile Site and New York Bight	920	889	820
Puerto Rico Site	630	547	240
Gulf of Mexico Site	320	-	-
Philadelphia Site	-	75	184
Dredged Material Sites	-	335	180
Complementary Research	-	425	425

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