Report to the Congress on Ocean Dumping Monitoring and Research

January through December 1979

October 1981

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)

October 1981

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

22 OCT 1981

President of the Senate
Speaker of the House of Representatives

Dear Sirs:

I hereby transmit to the Congress this seventh annual report on ocean dumping monitoring and research.

Under Section 201 of the Marine Protection, Research, and Sanctuaries Act of 1972, the Congress assigned to the Department of Commerce a responsibility to initiate 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 the ocean dumping investigations that the National Oceanic and Atmospheric Administration (NOAA) carried out during calendar year 1979. It focuses upon three major categories of pollutant materials: sewage sludge, industrial wastes, and dredged materials. Research scientists completed field and laboratory studies of these pollutants in several different marine areas. They investigated the effects of dumping industrial wastes into deep waters in the Atlantic Ocean off New Jersey and at a site north of Puerto Rico. They studied the environmental effects of sewage sludge and dredged material disposal in the New York Bight, the mid-Atlantic Bight, and along the Louisiana coast.

The NOAA's ocean dumping research scientists made substantial progress during the year in expanding our understanding of the environmental effects of dumping waste materials into the ocean. These scientists have developed the application of remote-sensing techniques for monitoring dispersal patterns of dumped wastes. They achieved these advances during a series of field waste-tracking experiments performed in unison with laboratory studies of the chemical and physical nature and biological impacts of the same 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,

Mac Baldrige

Secretary of Commerce

Enclosure

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EXECUTIVE SUMMARY

This report is a summary of the results of 1979 National Oceanic and Atmospheric Administration (NOAA) monitoring and research efforts under Section 201, Title II, of the Marine Protection, Research and Sanctuaries Act of 1972 (PL 92-532). The areas studied during 1979 were two deepwater industrial waste dumping sites, two sewage sludge disposal sites, and three dredged material dumping areas. Emphasis during the year was placed upon movements of dumped wastes at and around disposal areas, and upon the response of the ocean and its living resources to waste dumping. Knowledge of those responses will be crucial when comparing the environmental consequences of ocean dumping to those of other waste disposal technologies to establish long-term waste management strategies.

The industrial waste dumping sites studied during the year are located roughly 170 km east of Delaware Bay (the 106-Mile Site), and about 75 km north of Arecibo, Puerto Rico. Both sites lie in sections of the ocean more than 1500 m deep. Wastes from chemical factories are discharged at the 106-Mile Site, and pharmaceutical wastes are released at the Puerto Rico Site. Study emphasis in both areas focused upon rates of dilution of wastes released at the sites, patterns of movement of wastes away from the sites after dumping events, and upon laboratory observations of biological impacts of the waste materials. Results of the investigations indicate the short-term biological and ecological impacts of releasing the wastes at sea to be negligible. Wastes discharged at the Puerto Rico Site were found to remain in the vicinity of the Site in detectable concentration for relatively long periods of time; hence, a potential for long-term ecosystem change exists in that area. Wastes discharged at the 106-Mile Site move and dissipate to the southeast, but it is not possible at this time to estimate the exact nature of their ecosystem impacts. The magnitude of the impacts, however, appears to be small.

The two sewage sludge disposal site studies were located in the apex of the New York Bight and about 70 km east of Delaware Bay. The work applied to these sewage sludge dumping sites consisted of environmental quality monitoring to detect ecological change or deterioration. Although sewage sludge dumping appears to have only a minor impact upon the quality of the New York Bight at large, the activity seems to have initiated a trend of degradation of environmental quality at the Philadelphia Site.

NOAA assumed responsibility for conducting research and monitoring at the Philadelphia Site during October 1979. Before that, monitoring at the Site was the responsibility of the EPA Region III Office in Philadelphia.

The research at the New York Bight dredged material dumping site consisted of an acoustical and chemical plume tracking experiment conducted at the site during June. The purpose of the experiment was to determine the chemical and physical dynamics of sediments released there. At the site outside the mouth of Chesapeake Bay, a biological, physical and chemical site characterization program was initiated to assess the suitability of the area to receive dumped dredged sediments. The program is sponsored cooperatively with the Army Corps of Engineers in Norfolk and will be completed during 1980. Another dredged material dumping study site was along the north central coast of the Gulf of Mexico. The program was designed to summarize the state of knowledge about coastal sediment dynamics along the Louisiana shore as a means of understanding potential chemical and ecological effects of dredging in the area. The purpose of the dredging studies is to generate scientific data for use in selecting environmentally safe disposal areas for dredged sediments.

A Complementary Research Program began during 1979 to investigate generic pollution problems common to ocean dumping. The program, which will continue into 1980, focuses upon the environmental impacts of toxic heavy metals introduced to estuaries and the ocean through waste dumping.

An agreement was completed during 1979 between NOAA and the Army Corps of Engineers North Atlantic Division, New York, New York. Through the agreement, NOAA will provide scientific information to the Corps of Engineers for use in regulating dredged material disposal in the North Atlantic area, and the Corps will provide support to NOAA in generating the information.

CHAPTER I

INTRODUCTION

Background

The Marine Protection, Research, and Sanctuaries Act (MPRSA) was enacted October 23, 1972. This legislation resulted from concern on the part of Congress, the Executive Branch, and the public over the potential harmful effects of unregulated ocean waste disposal. The Council on Environmental Quality (CEQ) reviewed the problems of ocean dumping. The CEQ report recommended a comprehensive national policy on ocean dumping of wastes to end unregulated dumping and to prohibit ocean disposal of all materials harmful to the marine environment. Specific recommendations on the three major categories of dumped waste materials were as follows:

- Dredged material: "Ocean dumping of polluted dredged spoils should be phased out as soon as alternatives can be employed. In the interim, dumping should minimize ecological damage. The current policy of the Corps of Engineers on dredging highly polluted areas only when absolutely necessary should be continued, and, even then, navigational benefits should be weighed carefully against damages."

- Sewage sludge: "Ocean dumping of undigested sewage sludge should be stopped as soon as possible and no new sources allowed. Ocean dumping of digested or other stabilized sludge should be phased out and no new sources allowed. In cases in which substantial facilities and/or significant commitments exist, continued ocean dumping may be necessary until alternatives can be developed and implemented. But continued dumping should be considered an interim measure."

- Industrial waste: "Ocean dumping of industrial wastes should be stopped as soon as possible. Ocean dumping of toxic wastes should be terminated immediately, except in those cases in which no alternative offers less harm to man or the environment."

Passage of the Marine Protection, Research, and Sanctuaries Act of 1972 committed the United States on a national basis for the first time to:

> ". . . regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare of amenities, or marine environment, ecological systems, or economic potentialities."

Agency Roles and Responsibilities

The Marine Protection, Research, and Sanctuaries Act of 1972 is organized into three titles. Title I deals with regulatory aspects of ocean dumping. The Act assigns regulatory authority to the Environmental Protection Agency (EPA), the Corps of Engineers (COE), and the Coast Guard (USCG). Title II of the Act deals principally with monitoring and research aspects of the effects of ocean pollution and man-induced changes in the ocean ecosystem. The monitoring and research responsibilities described in Title II are assigned to the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), in consultation and coordination with other Federal agencies. Title III of the Act provides for the designation of marine sanctuaries. NOAA also administers this title in cooperation with other Federal departments and agencies.

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

Scope of the Report

This is the seventh annual report to Congress by the Department of Commerce pursuant to Section 201 of the legislation. In addition to the Section 201 research of NOAA, the first three annual reports by the Department of Commerce described research activities of EPA, COE, and USCG carried out in support of their respective regulatory responsibilities under Title I of MPRSA. Amending legislation in 1976 (Public Law 94-326) directed that those agencies submit to Congress separate annual reports on their administration of Title I. This report, therefore, covers only NOAA monitoring and research on ocean dumping during calendar year 1979.

Intra-agency Coordination

Although scientists from many NOAA components were involved in ocean dumping research during 1979, all work completed by NOAA during the year was sponsored and managed by two agency program offices. These offices are the Marine Ecosystems Analysis (MESA) Project Office in Stony Brook, New York, and the National Ocean Survey (NOS) Ocean Dumping and Monitoring Division (ODMD) in Rockville, Maryland. The MESA group sponsored and managed all work relating to sewage sludge dumping in the New York Bight, and cosponsored with ODMD the effort applied to dredged material disposal in the same region. All work applying to other topics and geographic areas discussed in this report were sponsored by and the responsibility of NOS/ODMD.

During 1979, there were no major pollution-related incidents in the New York Bight. Consequently, efforts of the MESA program in the Bight were directed towards accomplishing the planned and projected research and monitoring outlined in the program's Project Development and Technical Development Plans. The MESA Project's last year of field activities, 1979, was the sixth year of an eight-year study. Emphasis has shifted from research to synthesis since 1978. This year marked a continuation of that shift in emphasis with two symposia convened to assist MESA in developing research results into forms that will provide guidance to regulatory and planning agencies and to the public. This is best reflected in that approximately 20-30 percent of the project funds in 1979 were directed to understanding environmental impacts of ocean dumping.

CHAPTER II

NOAA OCEAN DUMPING MONITORING AND RESEARCH - 1979

Industrial Waste Dumping Sites

Two ocean dumping sites, sanctioned for use by the Environmental Protection Agency, are beyond the edges of continental shelves. The first is the 1425 km^2 106-Mile Chemical Waste Disposal Site, (Figure 1), 106 nmi SE of New York Harbor overlying 1800 to 2200 m of water. The other is a 450 km^2 site 40 nmi N of Arecibo, Puerto Rico (Figure 2), overlying depths of 6000 to 8000 m. During 1979, the 106-Mile Site received 550 million liters of waste, 93 percent of which came from three major sources (51 percent from the DuPont plant in Edge Moor, Delaware, 26 percent from the DuPont-Grasselli plant in Linden, New Jersey, and 16 percent from the American Cyanamid Warners plant, also in Linden). The Puerto Rico Site received 310 million liters of waste from seven pharmaceutical plants. Six of those wastes are mixed together prior to being loaded onto an ocean dumping barge. The seventh (2 percent of the total) is dumped separately from a tank on the same barge. The wastes were described in the 1978 Report to Congress.[1] Table 1 summarizes the recent history of dumping at these sites.

This report considers space and time scales of contamination at the dumpsites, and biological responses to the contamination. The scales depend on rates of dilution of individual waste plumes and on rates of flow of pollutants through the dumpsites. The method of dumping and oceanic mixing processes determine the dilution rates; therefore, these rates are independent of waste type. The capacity of the Puerto Rico Site to disperse waste plumes appears to be less than that of the 106-Mile Site since flow through the Puerto Rico Site is more sluggish. Based on laboratory toxicity studies, the biological consequence of dumping pharmaceutical wastes at the Puerto Rico Site should be small. However, the actual response cannot be determined solely from laboratory studies; some field observations may indicate waste-induced effects.

Dilution

During dumping at 106-Mile Site, the industrial wastes are quickly diluted by a factor of 5000. This is due to barge generated turbulence and the fact that wastes are discharged over about a 10 km distance per 10^6 liters of waste. Initial waste plumes are about 35 m wide, 15 m deep and 45 km long for 4 x 10^6 liter dumps typical at the 106-Mile Site, and 30 km long for 2.5 x 10^6 liter dumps employed at the Puerto Rico Site.

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[1] The 1978 Report to Congress is hereinafter referred to as "the previous report."

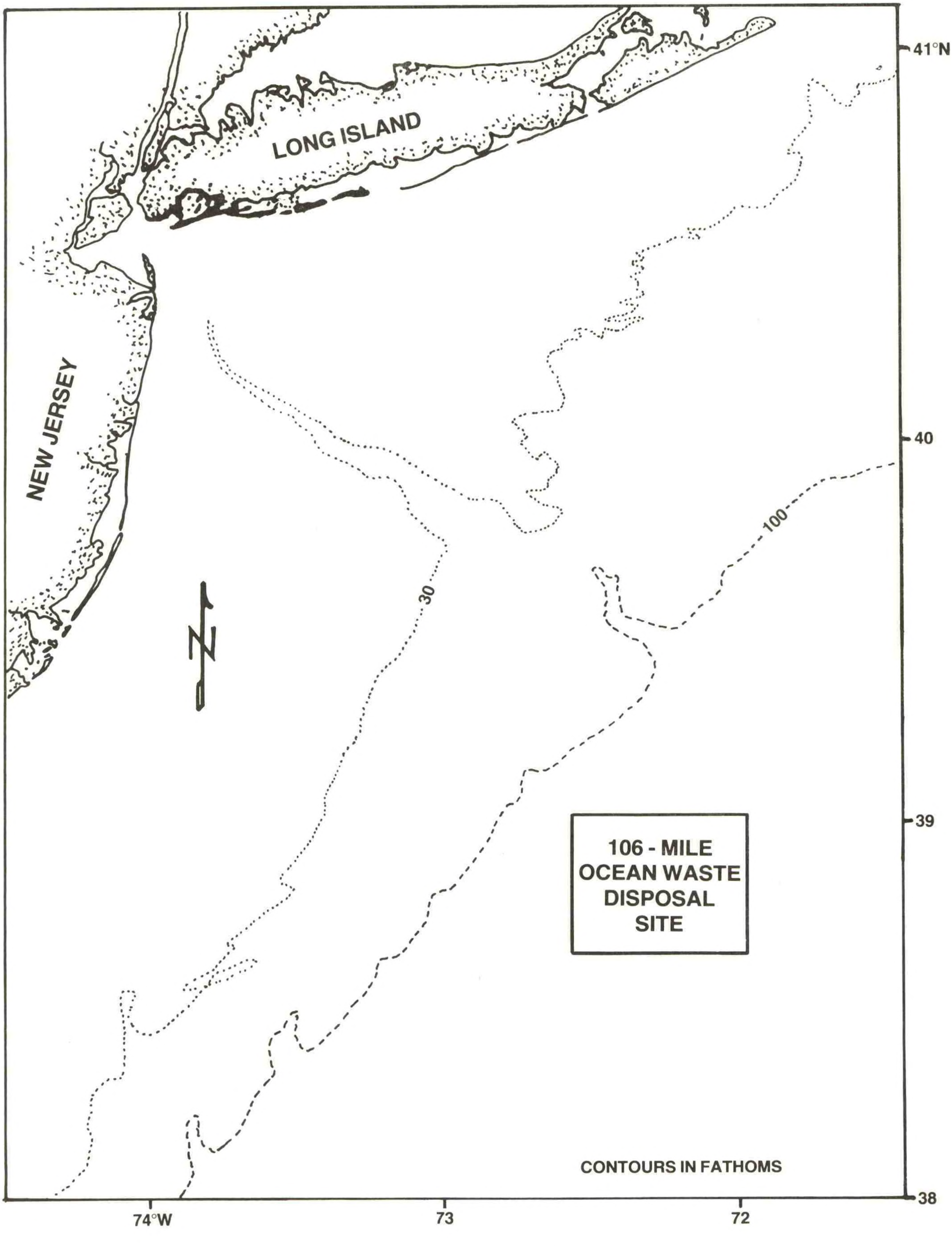

Figure 1. 106-Mile Chemical Waste Disposal Site

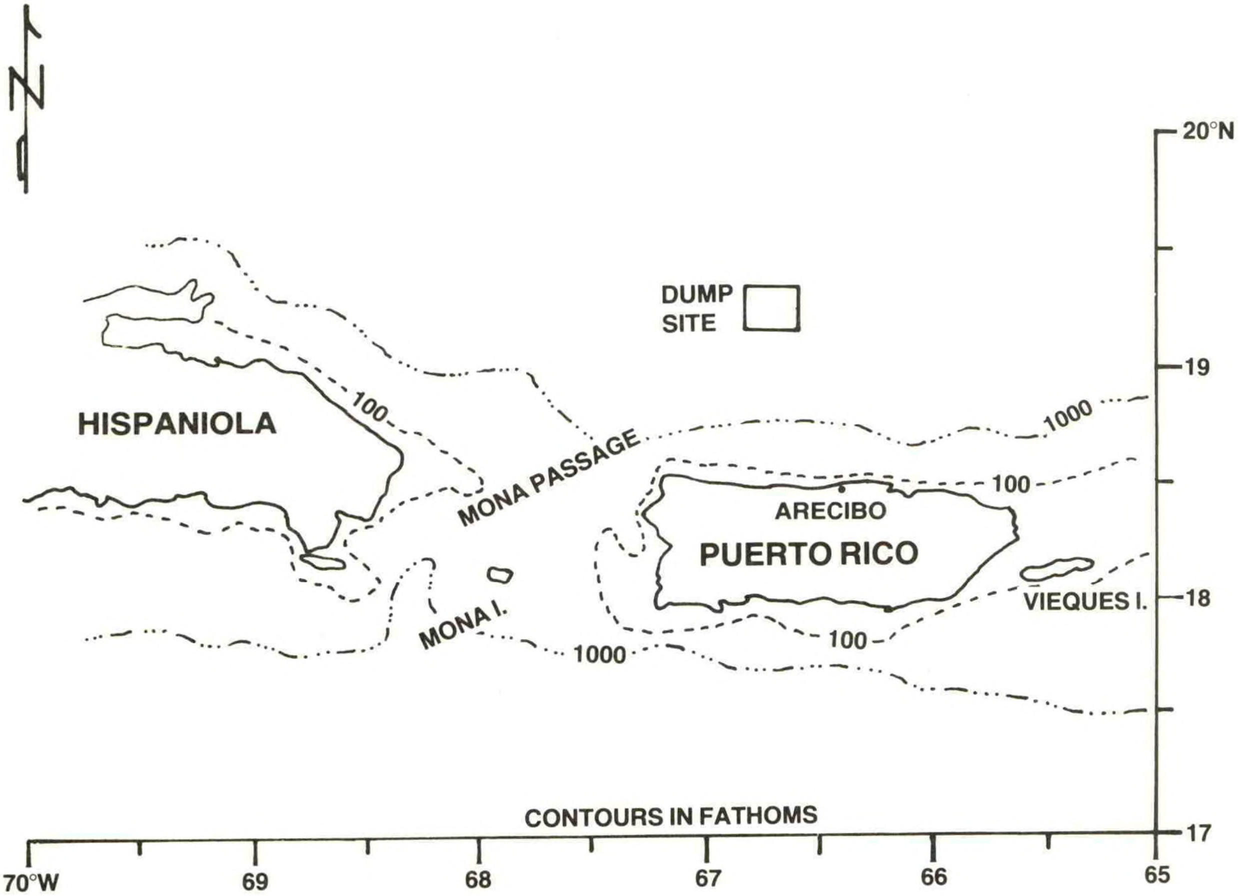

Figure 2. Puerto Rico Site

Table 1

Waste Input to Deepwater Dumpsites since 1976
(inputs in thousands of metric tons)[1]

106-Mile Site

Source	1976	1977	1978	1979
DuPont-Edge Moor	[2]	416	407	279
DuPont-Grasselli	180	117	188	142
American Cyanamid	130	142	121	91
Modern Transportation[3]	69	91	79	40
Camden, New Jersey	[2]	53	59	0
General Marine[3]	5	1	0	0

Puerto Rico Site

Source	1976	1977	1978	1979
Pharmaceutical waste	306	267	306	310
Petrochemical waste[4]	54	47	54	0

[1] Inputs are reported by dumpers in terms of metric tons. Assuming a specific gravity for all wastes of 1.0, one thousand metric tons can be considered equal to one million liters. Actual specific gravities vary from 1.02 to 1.16.

[2] Prior to 1977, DuPont-Edge Moor waste and Camden, N.J. municipal waste were dumped at sites over the continental shelf, not at the 106-Mile Site.

[3] Modern Transportation and General Marine have dumped waste at the 106-Mile Site for a variety of industrial waste producers.

[4] Until 1979, about 15 percent of the total waste dumped at the Puerto Rico Site was an alkaline sulfide solution from a hydrocarbon refining company. It was dumped separately from pharmaceutical waste.

This extensive initial dilution eliminates density differences which may have existed between wastes and seawater, and subsequent dilution is due to oceanic mixing processes. As described in the previous report, dumped industrial wastes remain in the surface waters. This limited depth penetration applies to dissolved waste components and to light particles contained in wastes. The wastes do not easily penetrate the pycnocline - the thermal density gradient that separates upper and lower ocean waters. Although the pycnocline is not an absolute limit of waste mixing, it is a zone of very slow mixing so that over a 2- to 3-day period it serves as a lower mixing boundary. The great depths of the deep ocean sites, together with the fact that density gradients within the water column inhibit vertical mixing, prevent wastes from reaching and accumulating on the ocean floor at and around the deepwater dumping sites.

Given the limited depth of waste penetration, mixing with ambient seawater occurs primarily along plume edges. Plumes grow in one direction, laterally. Wastes are diluted by a factor of about 10^5 within 4 to 6 hours of a dump, with further increases in dilution occurring rather slowly.

Observations of waste plumes made in 1979 are in agreement with this pattern. Although data are still being analyzed, it appears that an average plume widens at a rate of 1 cm/sec or 35 m/hr. It is not a fundamental characteristic of the ocean that plumes must widen at that rate, nor does the rate appear to remain constant over the life of a given plume. Until there is a better understanding of processes which control mixing rates, however, this value will serve as a reasonable average.

In addition to the width of the plume, the concentration of the waste at the plume center is calculated. This is according to the volume of waste per million volumes of seawater (ppm). Using the rate of 1 cm/sec with a shallow pycnocline prohibiting initial penetration of the plume below 15 m, a plume initially 35 m wide grows to nearly 200 in 5 hours and has a concentration of 40 ppm. In 50 hours this plume will grow to 1800 m and have a concentration of 4 ppm.

Application of the 1 cm/sec rate over longer periods of time indicates that 20 days are required for a plume to become 18 km wide and for waste concentrations to be reduced to about 0.1 ppm. Though no plume has been followed beyond 2.5 days, this 20-day period is probably an overestimate. It is known from large scale oceanographic measurements that diffusion rates tend to increase as plume size increases. More importantly, a storm may break a plume into pieces and accelerate diffusion. The minimum strength and duration of storm necessary to accelerate diffusion is not known since it has not been possible to detect and follow plumes during storms. The dilution history of a single plume can be divided into three phases: (1) extensive initial dilution caused by dumping, (2) slow subsequent dilution under relatively calm conditions, and (3) accelerated diffusion induced by storms. In terms of orders of magnitude and plume widths, the space and time history of a plume released in surface waters over a 40 km track can be approximated as follows:

Time Since Dump	Mixing Mechanism	Maximum Concentration (ppm)	Plume Width (km)	Plume Area (km^2)
minutes	dumping induced turbulence	100	0.035	1.4
5 hours	passive diffusion*	10	0.2	10
2 days	passive diffusion*	1	2.0	100
20 days	passive diffusion*	0.1	20	1000
hours	storm induced diffusion	0.1	20	1000

*Under relatively calm conditions

As a point of reference, concentrations of 10 ppm or less can be considered "long-term" since they may last longer than a day. Plume areas larger than 5000 km^2 may be considered "wide-scale" since that area is comparable to the areas of the dumpsites.

Advection

The scales of contamination relate not only to the diffusion of individual plumes but to the rate at which water and plumes flow away from the dumpsites. That rate relative to the frequency of dumping determines the likelihood of plumes mixing with one another and thus increasing the concentration of wastes to which local organisms are exposed. It appears that this "flushing" rate is lower at the Puerto Rico Site than at the 106-Mile Site.

In October 1979, organic chemical analyses were made over a 22,000 km^2 grid surrounding the Puerto Rico Site. Low waste concentrations were present at all but one of 36 stations in the grid, and also at one station 150 km NE of the site. This sampling was done because previous analysis at a few stations east of the site had also indicated the presence of waste. It is therefore apparent that wastes are not continuously flushed away in waters north of Puerto Rico.

On the basis of historical current data from the area, continuous flushing, like a river flow, was expected. The dumpsite lies in the Antilles Current which, on current charts, is described as flowing WNW at a speed of 0.5 to 1.0 knots. In a study predating the

ODMD program, a drogue placed in waters north of the Antilles Current and tracked by satellite flowed into the area of the Current. Instead of proceeding WNW, the drogue circumscribed a series of four 100-km diameter circles, and slowly progressed to the west in a spiral pattern. Under the 1979 ODMD program, a series of radio trackable drogues have been and are being deployed in the Puerto Rico dumpsite. Preliminary data from the deployment of October 1979 indicate a flow at that time to the east, then to the south and then to the west. Using organic chemistry to define the spatial and temporal scale of contamination relative to known times of waste dumping, together with tracking of drogues and observations of water density structure over a wide station grid, the ODMD will refine the knowledge of currents north of Puerto Rico.

In the previous report, the flow of water through the 106-Mile Site was estimated to be towards the SW at about 0.2 knots, the direction conforming to the contour of the continental shelf. During 1979, three satellite-tracked drogues deployed in Georges Bank, under a program related to oil exploration in that area, left the Bank to the south and crossed over the continental shelf into deep water. They then flowed along the contour of the shelf and passed through or near the 106-Mile Site at a speed of 0.2 to 0.4 knots. One drogue was retrieved near the dumpsite; the other two reached the vicinity of Cape Hatteras, North Carolina, where they were entrained into the Gulf Stream and moved with it to the ENE at about 2 knots.

On the basis of those drogues, together with earlier appraisals of flow rates, it can be estimated that waste from the 106-Mile Site will move to the SW and be entrained in the Gulf Stream in about a month. There should then be a path of low-level waste between the 106-Mile Site and Cape Hatteras. This hypothesis has been tested once. In November 1978, low levels of organic waste were found within 32 km SW of the site. Within the site and slightly to the north and west of the site, waste was also detected even though dumping had not occurred for 5 days prior to sampling. If flow was continuously to the SW, the site itself should have been free of waste. However, during the sampling period there was a warm-core Gulf Stream eddy (see previous report) just NE of the site. This could have affected the short-term movement of water within the site. More organic chemical and drogue studies are planned for the 106-Mile Site area. It appears that this area is flushed much more readily than the Puerto Rico Site.

In addition to analysis of the advective regimes and their effect on waste dispersion of the deep ocean sites, work is needed on the vertical penetration of wastes. There are some tentative observations of wastes in deep water north of Puerto Rico. If, as seems to be the case, wastes remain for long periods in surface waters north of the island, slow vertical mixing mechanisms may have time to cause deep penetration of waste at the site.

Biological Effects

Studies on waste dispersion, plume histories, advection through sites and vertical mixing rates apply to any waste at any deepwater site. They define the space and time scales of contamination, and sizes of contaminated zones. Separate chemical studies, in progress, are specific for particular wastes and are designed to indicate if there is significant degradation of waste components. With the major exceptions that inorganic wastes may be diluted to the point where their individual elemental concentrations become equivalent to normal seawater concentrations, that some organic compounds may decay to natural or innocuous components of the marine system, and that some compounds may be lost through volatization into the atmosphere, the response of the marine biological community is a response to dilutions of the dumped wastes. These reponses are not only specific to given wastes, they are specific to individual organisms and species within the contaminated zones.

The ODMD approach to measuring the biological consequences of dumping at the deep ocean sites has been two-fold. Laboratory studies have been made under controlled conditions on organisms exposed to a range of waste concentrations. Field studies have been made to test hypotheses based on laboratory results or to discover effects which may occur but which cannot be observed under laboratory conditions. These studies have been applied predominantly to planktonic organisms because these types of organisms will be exposed to wastes released at sea.

Laboratory studies of effects of wastes upon phytoplankton growth have shown that for a single species and a given waste, the response depends strongly on the area from which a particular clone of that species was isolated. For example, the decrease in growth of the diatom Thalassiosira pseudonanna exposed to mixed pharmaceutical waste at a 100 ppm concentration, ranged from 0 percent (no decrease) to 85 percent among 11 clones of the species. The most sensitive species were isolated from the surface of the deep ocean and from coastal areas free of anthropogenic stresses. The most tolerant species were isolated from heavily used and polluted coastal areas. It is likely that organisms endemic to stressed areas develop a resistance to contamination. It is also the case that if waste dumping is going to affect phytoplankton communities, the effect is more likely to occur at deep ocean dumpsites than in coastal areas.

The phytoplankton response to waste is so dependent on the tested organism, that relative toxicities of waste cannot be known unless wastes are tested against the same clone of the same organism. This has been done with the four major deep ocean dumped wastes. Using data obtained from the most sensitive clone of T. pseudonanna it can be noted that 1) at 1000 ppm there was no growth in the presence of any waste except for that from Dupont-Grasselli where the growth was 10 percent of the control value 2) at 100 ppm waste the growth rates relative to control were 16 percent for mixed pharmaceutical waste, 57 percent for American Cyanamid waste, 73 percent for DuPont-Grasselli, and 230 percent (growth stimulation) for DuPont-Edge Moor waste and 3) at 10 ppm there was no inhibition of growth for any waste and slight growth stimulations in the presence of some.

It cannot be unequivocally stated that the decreasing order of toxicity among the four wastes is mixed pharmaceutical, American Cyanamid, DuPont Grasselli, DuPont Edge Moor because there is some rearrangement of the order as tested concentrations are varied. More importantly, there is variation in toxicity of waste as a function of waste lot. Nevertheless the toxicity of mixed pharmaceutical waste is generally greater than that of the others, which is in contradiction to the previous report. That report was written with less data available and did not recognize the importance of basing comparisons on identical clones of the same species.

The importance of the clonal effect has affected the results of monthly toxicity analyses done under contract by the Puerto Rico dumping permittees. During 1978 the concentration needed to effect a 50 percent decrease in growth of the diatom Skeletonema costatum averaged 6300 ppm. Since December 1978, the average has been 50 ppm. Tests on a blue-green phytoplankton species, however, done in 1978 and 1979 under the ODMD program showed about the same response in each year. The permittee contractor obtained a new strain of S. costatum late in 1978. If changing the source of the test organism was the cause of the difference in reported toxicities, the method of routine toxicity testing to assess waste hazard potential must be reevaluated.

Laboratory toxicity studies can estimate relative toxicities of wastes. They have been used by the ODMD for the work just described, and for comparisons among the seven wastes making up the mixed pharmaceutical waste. It is of interest that the most sensitive clones tested did not exhibit a toxic effect at 10 ppm, the maximum "long-term" concentration of contaminants in plumes. It should not be assumed, however, that the absence of a laboratory response confirms an absence of effects in the ocean.

The phytoplankton communities in the areas where waste plumes are created may be affected by waste at concentrations below 10 ppm. This cannot be tested in the laboratory because most of the relevant species cannot be cultured in the laboratory and, moreover, all species cannot be tested. While it is known that low concentrations are not toxic to sensitive clones, it is also known the response varies widely within tested species. It has been demonstrated in large-scale experiments that the consequence of contaminants on phytoplankton communities is not necessarily a decrease in total population growth or in total primary productivity, but rather a rearrangement of the community structure. The presence of contamination can cause sensitive species in the natural population to decrease their rate of growth while more tolerant species are unaffected or undergo a stimulation of growth.

The hypothesis that ocean dumped wastes can yield changes in phytoplankton community structure is being tested by collecting samples within plumes over 2- to 3-day periods. These experiments will yield positive results if waste at concentrations in the 1- to 10-ppm range are effective and if 2 to 3 days is enough time for the population to change sufficiently for it to be measurably different from the population outside the plume. If there is a demonstrable change in phytoplankton populations within discrete plumes, it would be a consequence of dumping. If the change does not persist as the plume is diluted further (and the plume grows by entraining surrounding water with its normal population), the consequence would be a short-term one of no lasting consequence to the state of the oceanic biological system at large.

Laboratory tests exposing zooplankton to both DuPont wastes (other wastes not yet tested) indicate a lethal effect in the 1- to 10-ppm range. However, the effect is small, only 3 to 10 percent more deaths than in controls. A larger effect at those concentrations appears in fecundity which was decreased by 20 to 50 percent. It is not known if zooplankton at the dumpsites would be more sensitive than the organisms tests in the laboratory. It would be difficult to measure a 10 percent lethal effect in the ocean because of the wide natural variation in population structure. It would also be difficult to measure a change in population dynamics, assuming a range of species' responses as with phytoplankton. Because of the relatively long growth periods for zooplankton, 2 or 3 days in a discrete plume is not long enough to even expect an observable population shift. It may be possible however to collect individuals and test them for reproductive potential. This again, if it proved positive, would be a demonstrated effect of dumping. However, it has been demonstrated that the progeny of affected individuals in the laboratory do not themselves suffer reduced fecundity. Therefore the long-term consequences would appear to be small.

For both phytoplankton and zooplankton the possible oceanic effects have been postulated on the basis of discrete plumes being different from the surrounding water. Depending on the flushing time at the site and the dumping frequency, surrounding waters may not be free of contamination. This is known to be the case at the Puerto Rico Site. It is the case that if wastes at concentrations of 0.1 ppm exert biological effects, the effects will be widespread. Not only does a single plume at that concentration cover over 1000 km^2 but subsequent plumes will also blend into it and enlarge the polluted area. There is no laboratory evidence that any waste at 0.1 ppm is of biological consequence, but two observations made over wide areas demonstrate the possibility of effects at such low concentrations.

On four occasions since 1977 euphasiids, shrimp-like zooplankton, have been collected within and near the 106-Mile Site. At some of the collection sites water samples were also taken for organic chemical analysis to confirm the presence of dumped wastes. On all occasions the proportions of individuals showing gill melanization, black spots on the gills, was more than 60 percent. Euphasiids collected by others in coastal areas had a less than 10 percent frequency of this condition. It must be determined whether this condition is a normal one for oceanic as opposed to coastal species, and whether or not the occurrence is related to the presence of waste.

The marine bacterial community is being investigated at the Puerto Rico Site. One hypothesis was that there would be a change in species composition within plumes. However, it became evident that waste was very widespread in the waters surrounding the site and present in all samples, discrete plume or not. There was an almost complete absence of bacteria of the genus Pseudomonas. This absence may be a response to contamination, or it may be typical of tropical waters. Until waste-free water is identified and bacterially analyzed, it will not be known if this bacterial observation is related to waste dumping or not.

Two of the pharmaceutical wastes are derived from fermentation processes and are thus sources of bacteria to the marine environment. Unexpectedly high numbers of gram-positive bacteria, primarily Staphylococcus spp., have been collected in the vicinity of the dumpsite. Not all have been found in specific samples of waste. One species, not identified in specifically examined industrial waste samples, is the pathogenic form Staphylococcus aureus which has been found in low concentrations near the dumpsite. Part of the ongoing work is addressing the lifetime of the gram positive forms in the marine environment.

Research Needs

The task of the ODMD with regard to deepwater dumpsites is to define the space and time scales of contamination by dumping, and to measure the biological consequences of those scales.

Organic chemical analyses of water samples gathered during dumping events will be used to obtain knowledge about patterns and time scales of long-term waste dispersion. This will be augmented by physical oceanographic studies on the flow regimes at the dumpsites.

The chemical fate of wastes is not controlled solely by physical mixing processes. Rates of degradation of organic compounds in the marine environment are being studied. Biological uptake of organic waste components is being investigated through analysis of plankton collected in the vicinities of dumpsites. Such uptake can be a major part of the mixing of wastes into the deep ocean if the chemicals are incorporated into the sinking fecal pellets or tests (shells) of dead animals or are carried into deep water by vertically migrating organisms.

The overall biological responses on the marine community will be difficult to estimate because most of the effects detected to date are subtle rather than dramatic and not easily measured. Field sampling will continue along the lines suggested above. Laboratory work will be used to determine the permanence of induced effects. The effects measured to date would not persist if dumping ceased and if there is no long-term accumulation of wastes at the deepwater site. It is useful to know that the biological effects of dumping appear to be reversible. This will be addressed with laboratory studies which include observations after organisms are no longer exposed to waste.

Sewage Sludge Investigations

New York Bight Area

The location of the New York Bight sewage sludge dumpsite is shown in Figure 3.

Sewage sludge dumped in the New York Bight contains substantial quantities of contaminants that are potentially harmful to the Bight ecosystem. These include organic matter, petroleum hydrocarbons (particularly polynuclear aromatic hydrocarbons), halogenated hydrocarbons (particularly polychlorinated biphenyls [PCB]), toxic metals, and pathogens.

Large volumes of sewage sludge are dumped at the site; 6 million metric tons of sewage sludge are dumped there each year. Regional sewage sludge generation is projected to increase to 7.5 million tons by 1981, when the ban on dumping is scheduled to go into effect. A recent estimate suggests that sewage sludge dumping now accounts for 5 to 15 percent of the total pollution load on the Bight. In terms of volume, the single largest pollutant contributed by sewage sludge is organic matter. This class of material encompasses a very large range of natural organic substances. The particulate materials are of special concern.

Approximately 5 percent of sewage sludge consists of solid materials, some of which are organic in nature. When sludge is dumped in the Bight, a portion of the solids sink to the bottom while the remainder are suspended in the water column for varying periods. Recent acoustical tracking experiments suggest that detectable effects of a dump may persist for at least 6 to 8 hours. While in the water column, particulate material may scavenge dissolved pollutants, such as heavy metals and toxic organic compounds, and carry them to the bottom or to other areas of the Bight. When on the bottom, particulate organic materials may alter benthic productivity and respiration and, if excessive, exert a heavy oxygen demand.

It has long been known that domestic wastes represent a source of halogenated compounds such as DDT. However, of particular concern

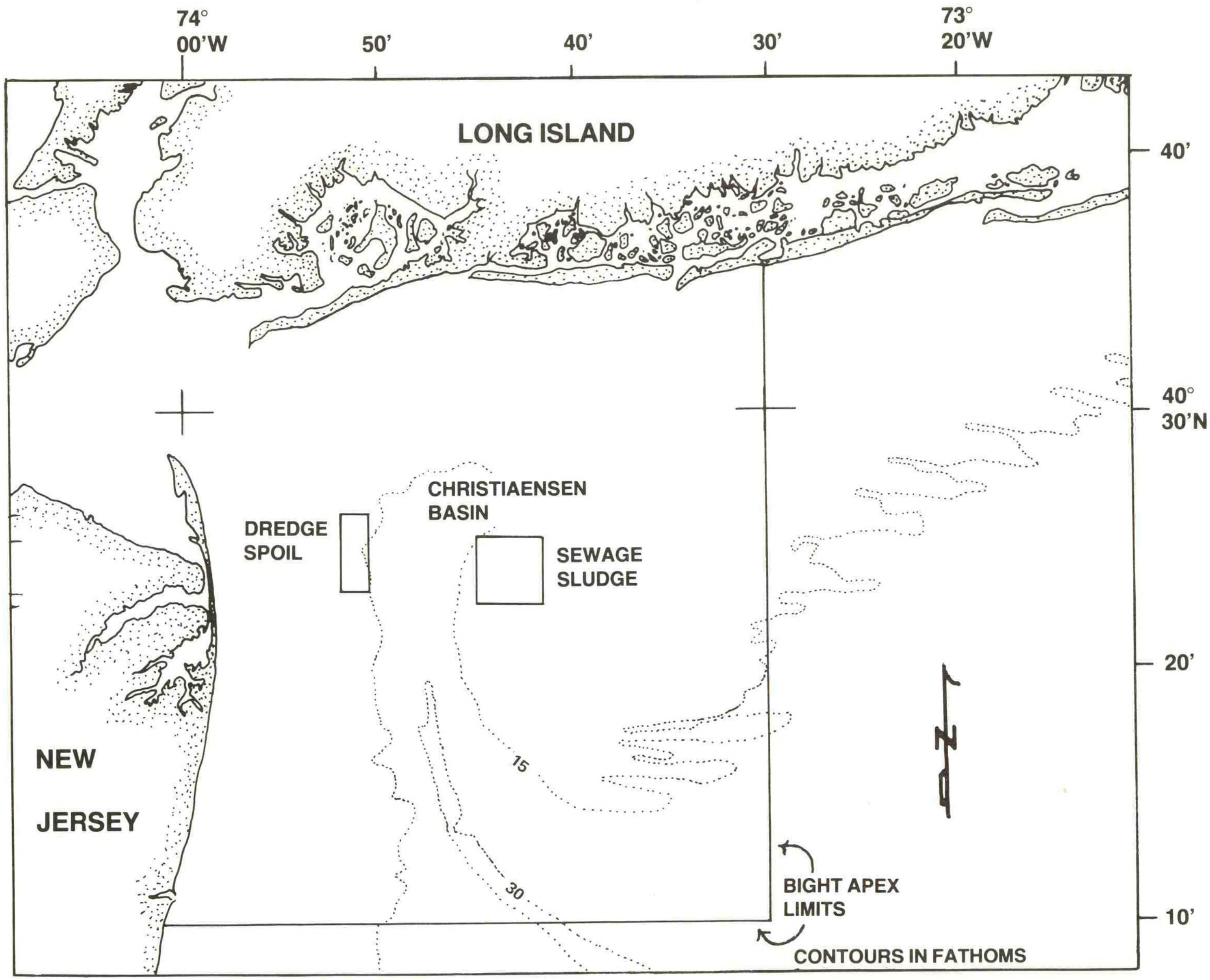

Figure 3. New York Bight Sewage Sludge Dumpsite

in New York Bight are additions of PCBs. These toxic substances have been found in significant concentrations in the sediments of the Christiaensen Basin (2200 ppb dry weight). PCB concentrations on fringes of the Basin were found to drop to about 100 ppb. This distribution of PCBs closely resembles that of trace metals, total organic carbon, and coprostanol, suggesting that sewage sludge is in part responsible for the elevated levels in the sediments. Approximately 90 percent of all PCBs in the Bight appear to lie within the general vicinity of the Christiaensen Basin.

In recent years, while no serious diseases have been traced to pathogens from the Bight. Concentrations of pathogenic viruses and bacteria by shellfish is sufficient reason for vigilance against such serious diseases as polio and hepatitis. Bacteria and protozoa implicated in diseases of both humans and marine organisms have been isolated from the Bight Apex.

In this regard, recent investigations conducted jointly by the National Marine Fisheries Service (NMFS), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA) have isolated specimens of the pathogenic protozoan genus Acanthamoeba from the vicinity of the sewage sludge dumpsite and from stations between the site and the shoreline to the north. Studies undertaken in other areas have indicated that this amoeba may be responsible for disease or death in humans, and domestic and wild animals. One species (A. culbertson) has been isolated from sewage-associated sediments off New York. Although it has not been demonstrated whether sewage-related materials are the source of the Acanthamoeba that infest the dumpsite and adjacent sewage-impacted areas, it is apparent that such amoebae are potential residents of ocean sediments where bacteria, including those of the coliform group, are available as food.

In addition to the problems caused by specific contaminants and pathogens, there are other ecologic effects in the New York Bight which, though apparent, are not fully understood. Several fish and shellfish diseases are common in the Bight and may in part be associated with pollutants in sewage sludge. The year 1979 was devoted to consolidation and final summarization of information gathered over the past six years on fish and shellfish diseases of the New York Bight. New York Bight Project studies have determined that:

- Fin rot affects many species of Bight fishes but is most prevalent in bottom-dwelling flatfishes. Because the greatest incidence of disease appears in fishes from the most polluted part of the Bight, it probably is related to depressed environmental quality. No specific cause for fin rot has been determined; however, it appears to be associated with the exposure of susceptible species to contaminated sediments. Fin rot appears to be a chronic disease that may cause mortality or decrease survival depending upon the availability of food or the abundance of predators. Causes for an observed decline in the incidence of fin rot in the Apex since 1974 are not understood.

- o Shell disease caused by bacteria and fungi affects Bight crabs, lobsters, and shrimp. This exoskeleton disease may be the invertebrate counterpart of fin rot. The disease usually is not fatal because the exoskeleton is shed periodically.

- o Black gill aptly describes a disease of crabs and lobsters in which the gills and the affected animals are blackened through changes in cell and tissue structure and the accumulation of microorganisms and sediments. The disease is prevalent in the most contaminated areas of the Bight, in the general vicinity of the sewage sludge dumpsite. Although crabs and lobsters periodically renew their gills, severely fouled gills may impair respiration and affect survival, since stressed crabs and lobsters are likely to be consumed by predators in larger numbers than unstressed organisms.

In 1979 MESA sponsored a symposium on Ecological Effects of Environmental Stress to summarize the program data and studies conducted over the past six years. It involved joint efforts of scientists, environmental managers, regulatory agencies, engineers, lawyers, and economists in examining the effects of contaminants on the Bight and adjacent bodies of water, and in exploring alternative pollution source control methods for reducing the volume of contaminants entering the region's marine waters.

Scientists addressing the ecological effects of pollutant loadings in the Bight and lower Hudson estuary agreed that portions of the New York Bight and adjacent estuarine systems represent highly stressed environments. However, in most cases it has not proved possible to lay the blame for specific effects on individual pollutants. Except in the cases of spills of toxic materials and localized anoxic incidents associated with anthropogenic carbon loadings, individual contaminants cannot be implicated in mortalities of specific organisms. Instead, pollutant effects are manifested as sublethal alterations in the physiological state of individual plants and animals (e.g., lowered resistance to disease, reduced fecundity, impaired senses, or subtle alterations in the internal chemistry and tissue structure) and as changes in ecosystem structure. Effects observed at given times are the results of cumulative interactions between many contaminants.

Despite the complexity of the Bight and estuarine situation, it is clear that contaminant concentrations in the more heavily impacted portions of the region are often at levels causing effects in laboratory studies and field studies conducted in other systems. In this regard:

- The composition and distribution patterns of phytoplankton assemblages in New York Harbor and adjacent estuaries are consistent with those induced by exposure to low concentrations of copper (10 μg/l), mercury (5 μg/l), or PCBs (1-10 μg/l).

- PCB and other chlorinated hydrocarbon levels are high enough in the inner New York Bight Apex to cause significant effects on the function of reproductive organs in fish.

- Mortality and reduced viability of planktonic fish eggs in the Bight appear to have a direct relationship with concentrations of toxic metals and hydrocarbons in the surface layer of the water.

- Dumping of sewage sludge and dredged material appears responsible for major changes in the quality and abundance of bottom marine life over an area of about 50 km^2 in the Bight Apex.

- Nitrogen and carbon from domestic waste water are responsible for excessive phytoplankton production in the Hudson-Raritan Estuary and the Apex. These loadings contribute substantially to annual oxygen declines in the lower Hudson-Raritan Estuary and add to the oxygen demand upon New York Bight waters.

- Pollutants in the New York Bight region are of both ecological and public health concern. Of particular note are heavy metals, chlorinated pesticides, polychlorinated biphenyls and other halogenated hydrocarbons, polynuclear aromatic hydrocarbons and other petroleum constituents, chlorophenols, nitrophenols, and a variety of other organic compounds.

Discussions of the management implications of pollution considered four types of sources: domestic wastes, industrial wastes, dredged material, and non-point sources. Several points of consensus emerged:

- Considerable improvement in the quality of wastes entering the marine ecosystem can be achieved without the application of new waste treatment technologies. Improvement in the management and operation of existing production and waste handling facilities, construction of more modern or additional facilities, institution of better enforcement procedures, and application of "institutional" solutions (e.g., economic incentives and more insightful planning) will lessen many impacts of domestic wastes, industrial wastes, and wastes from non-point sources.

- o Industrial pretreatment of effluents will improve the quality of wastes from all sources. Pretreatment and recycling of industrial wastes could be the most cost-effective, long-term means for reducing levels of toxic metals and organic compounds entering sewage treatment plants and sediments which must be dredged.

- o Effective management of pollution is limited more by economic constraints than by a lack of treatment technologies. This is dramatically illustrated by the controversy over the scheduled 1981 ocean dumping deadline for sewage sludge. The committee on domestic wastes pointed out that, "While elimination of sludge dumping is a readily attainable step in controlling pollution in the Bight, uncertainties as to its cost-effectiveness relative to those of alternatives have led to proposals for extending the timing or rate of compliance."

A point emerging from both the scientific and management discussions was the need for a better understanding of the behavior of specific contaminants in the coastal environment, and in the Hudson-Raritan Estuary in particular. Better data on fluxes, budgets, and compartmentalization of contaminants in the estuarine ecosystem is essential if enlightened and effective decisions regarding waste management in the region are to be made. This conclusion agrees with independent observations made by the MESA staff, which led to the proposal of a Hudson-Raritan Estuary Project (HREP). Conclusions and recommendations made by the Ecological Effects Symposium are being incorporated in HREP planning.

In 1979, a series of broad scan analysis for organic compounds was conducted on samples from the New York region. Analyses were completed for 153 samples of sediments, sewage sludge, dredged material, fish eggs, plankton, water, and several species of fish and shellfish. These samples were analyzed for a variety of petroleum hydrocarbons, chlorinated hydrocarbons, and other synthetic organic compounds. Modifications of standard analytical techniques were developed and implemented by NOAA's National Analytical Facility, Seattle, Washington, which carried out the analyses for the Project. The modifications increased extraction efficiency and enhanced the sensitivity of detection procedures. An interdisciplinary working group of scientists and agency representatives is preparing a short interpretation of the significance of these organic concentrations on human health and ecosystem well-being.

The Philadelphia Sewage Sludge Dumpsite

The Philadelphia sewage sludge dumping site (Figure 4) is a 172 km^2 area located about 70 km east of Ocean City, Maryland, at roughly 38°20' N, 74°15' W. The site lies over the continental shelf in waters 40-60 m deep. The area has been used for sewage disposal

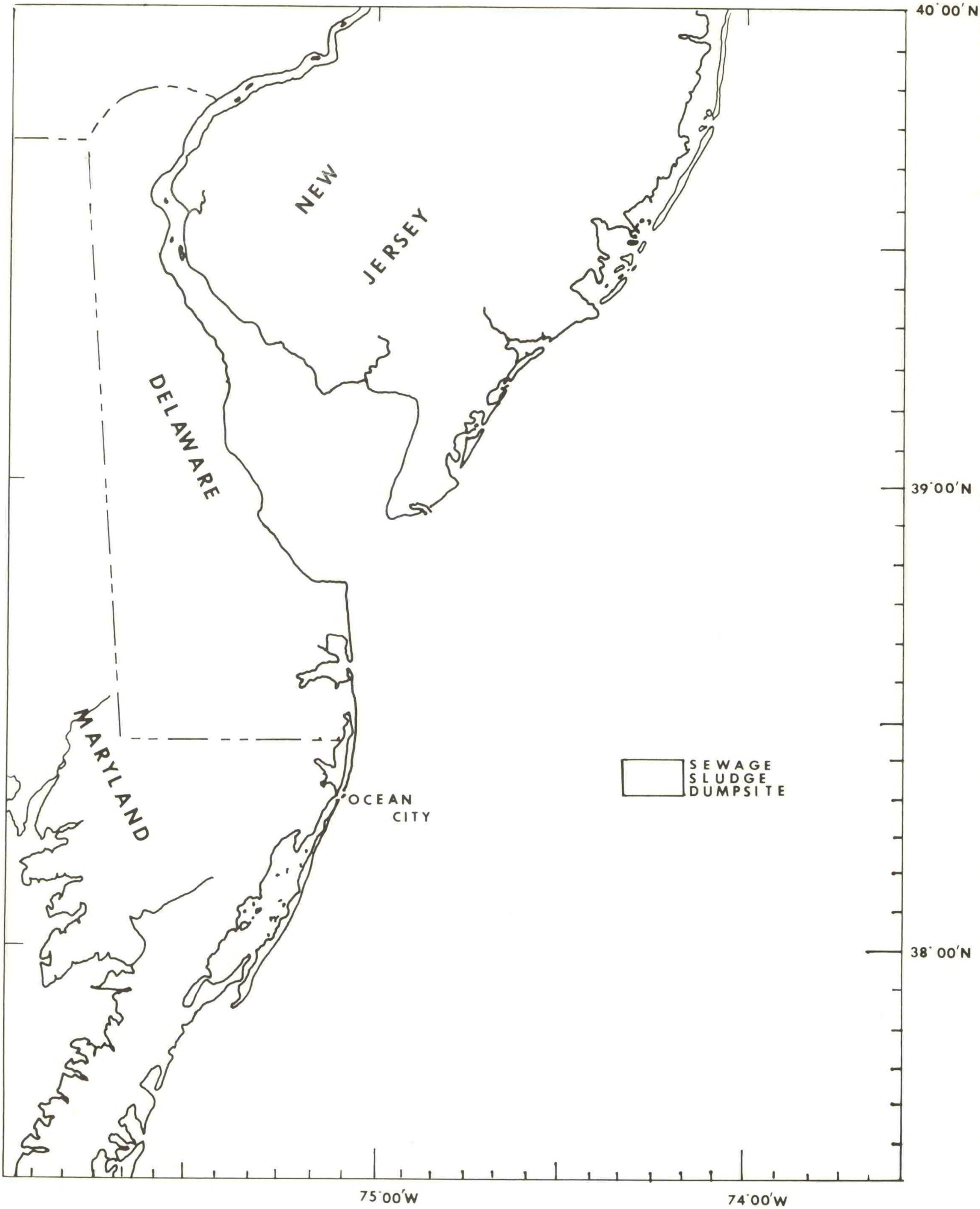

Figure 4. Philadelphia Sewage Sludge Dumpsite

since May 1973, when the EPA Region III Office in Philadelphia determined that sludge from the city of Philadelphia should be released there. Between 1973 and 1977, more than 2.8 billion kg of sludge was released in the disposal area. Sludge dumping at the Philadelphia Site is scheduled to end in 1980.

Waste dumping at the Philadelphia Site is regulated by the EPA Region III Office, and during 1973 the regional office initiated an intensive field research and monitoring program to measure the short- and long-term environmental effects of discharging sludge at the site. Through October 1979, the program was managed - and in large part conducted - by scientific personnel at the EPA Region III, Field Laboratory in Annapolis, Maryland.

Research to date at the site has included a short-term waste tracking experiment to demonstrate dispersion characteristics of sludge dumps, and a long-term impact assessment and monitoring effort designed to illustrate trends of ecological change associated with sludge dumping. The latter effort was initiated during 1973, prior to dumping at the site, with a baseline environmental assessment of the then pristine disposal area. Since 1973, ecological studies applying to the site have included: faunal surveys, physical and chemical water mass characterizations, heavy metal contamination studies of animals and sediments, and pathological and comparisons of animals inhabiting the disposal region to animals from relatively uncontaminated surrounding areas.

NOAA became involved in the ongoing work at the Philadelphia Site during January 1979 and assumed full responsibility for management and support of the program during October 1979, the beginning of FY 1980. At that time, an agreement with the EPA Region Office was completed to document the change of program authority. The agreement also specifies that the EPA scientific personnel at the Annapolis Field Laboratory will continue working on the dumpsite assessment under financial support, including salaries, from NOAA.

It is the intent of NOAA to continue monitoring activities at the Philadelphia Site subsequent to the end of dumping in 1981. The purpose of this will be to determine environmental recovery patterns that develop at the site following the cessation of dumping.

The work completed at the dumpsite during 1979 included continuation of the ongoing EPA monitoring effort and initiation of three new projects by ODMD. The new projects consisted of a stratigraphic survey of bottom sediments in the contaminated region, investigations of distributions of pathogenic protozoans, and appearances of pollution related diseases in crabs.

The purpose of the stratigraphic survey of bottom sediments is to demonstrate distribution patterns of sludge accumulations in the region contaminated by dumping. The study centers around laboratory analyses of sediment cores collected in and around the sludge dumping area. Products of the effort will include bathymetric maps showing extent and depth of sludge beds, and physical and chemical analyses of the sediments making up the sludge beds.

The purpose of the study dealing with protozoans in the dumping area is to survey distributions and abundances of the sewage-related genus *Acanthamoeba*. The organism is quite toxic to humans, is related directly to contamination of marine environments by municipal wastes, and promises to offer an accurate means of estimating the overall degree of pollution of the disposal area by sludge. The effort applying to the Philadelphia dumpsite is a component of a broader NMFS attempt to survey *Acanthamoeba* distributions throughout the polluted areas of the mid-Atlantic and New York Bights.

The investigation of sewage-related diseases in the rock crab (*Cancer irroratus*) is also a portion of a broader NMFS study of the northeast Atlantic region at large. The effort supported by ODMD at the Philadelphia Site is designed to survey the incidence of gill and shell disorders that are known to be related to different pollutants - including heavy metals - that are contained in sewage sludge.

The continuing efforts by the EPA Annapolis Laboratory at the Philadelphia Site during 1979 consists of seasonal cruises to the disposal area to gather data describing trends in environmental quality as related to sewage pollution. The variables monitored include mortality in important benthic species, levels of contamination by pollutants such as heavy metals and coprostanol in organism and sediments, and gross indicators of changes in water quality such as oxygen content, pH, salinity, and temperature. The data generated by these efforts provide a continuing body of scientific information describing trends of change in environmental quality.

The results to date of the Philadelphia dumpsite program have revealed several trends in environmental quality at the site that seem to be related directly to introduction of sludge in the area. The site was in pristine condition at the advent of sludge dumping, and the environmental changes that have appeared since then seem limited to the ocean bottom community. The trends of change have included increasing concentrations of metals and other toxic materials in organisms and sediments, changes in community structure, changes in abundances of different species, increased rates of mortality in a clam species (*Arctica islandica* - the ocean quahog), and appearances of sludge beds, sewage bacteria, pathogenic protozoans, and diseases in crabs. Although the overall degree of pollution in the disposal area remains unclear, it appears to be low. A long-term trend of general change and degradation of environmental quality in the polluted area, however, appears to be in early stages of development. The purpose of the NOAA program at this site during 1979 was to measure and monitor these trends.

Dredging Site Investigations

Gulf of Mexico Program

About 40 percent of the dredged-material disposal sites in the United States (including Alaska and Hawaii) are located along the Gulf of Mexico coastline from Mississippi to Texas. This fact is not surprising in light of recent estimates indicating that 78 percent of the water-borne sediment in the continental United States washes into the Gulf of Mexico, and a substantial quantity of this sediment must be removed from harbors and channels by dredging.

Many of the sites along the coast of Louisiana, such as those in Atchafalaya Bay, are not single disposal mounds but rather consist of extensive networks of sediment piles 5-15 km long. The Louisiana dredged sediment disposal sites are unique in that fine-grained sediments predominate, tide range is low (0.50 m), and wind effects are pronounced. The restricted depths of disposal sites and proximity to the shoreline ensure that frictional effects play a major role in determining the currents and hence the advection and dispersal of dredge spoil released at most sites. Their location inside the brackish sediment-charged coastal area likewise indicates that the local distribution of density (salinity) exerts important controls on currents and their capacity to transport dredged sediment.

The coastal waters of Louisiana are clearly dominated by the massive influx of fresh water provided by the Mississippi River and the numerous coastal bays along the shoreline. The density gradients and buoyancy effects brought on by the mixing of these fresh and brackish waters drained from the land with the saline waters of the Gulf of Mexico must be considered in understanding the mechanics controlling circulation and sediment transport along this coast. Wind stresses are especially important on the buoyant near-surface layer, while tides and semi-permanent water slopes affect the total water column to a lesser extent. In the immediate nearshore zone, wave-driven currents will control the circulation and beach drift, while buoyancy spreading and gravitational convection will assume important roles at tidal passes and estuary mouths. Large-scale topographic controls will also determine magnitude and directional properties of the coastal current field. This is especially true in the western bight of the Mississippi River, in which important dredge disposal sites are located, where a large trapped vortex frequently controls the local current pattern. All of these factors must be considered in designing a measurement program that will determine the annual variability of currents at dredge disposal sites, shed light on the driving mechanisms that control the spatial and temporal variability of the currents, and ultimately lead to an understanding of the dynamics and kinematics producing the movement and dispersion of dredged materials.

In consideration of this problem and future information needs, during 1979 NOAA initiated a review of all available data relating to sediment disposal in the Gulf. The purpose of the review is to summarize all pertinent data and to plan strategies and techniques for monitoring the fates and effects of dredged sediment discharged along the Louisiana coast.

The Louisiana coastal study has two components. The first consists of preparation of an assessment of all published environmental research applying to Louisiana estuarine and coastal waters. The second consists of a planning effort to outline what must be done in the future to monitor the effects of sediment dumping in the area.

The project has three major goals:

1. To produce a summary of the state of knowledge about coastal and sediment dynamics along the Louisiana shore and their importance to understanding chemical and biological effects of dredging.

2. To identify both geographic and disciplinary areas for which little or no data are available.

3. To identify and determine the priority of future research efforts necessary to monitor the effects of dredge spoil disposal.

Chesapeake Bay Mouth Program

In response to a request from the COE Norfolk District, during 1979 NOAA initiated a multidisciplinary environmental program applying to a dredged sediment dumping site just east of the mouth of Chesapeake Bay. The site is not in use at present, but it is likely that dumping of sediments will begin there within the next ten years. Permits for the dredging operations will be issued by the Norfolk COE District.

The site designated for study has a radius of about 4 km and is located 17 nmi due east of the mouth of Chesapeake Bay (Figure 5) at roughly 36°59' N, 75°39' W. The sediments likely to be dumped there will be dredged from ship channels in Hampton Roads, the lower Elizabeth River, and lower sections of Chesapeake Bay. The purpose of the site evaluation is to provide a predumping environmental characterization of the tentative dumping area, and to apply the COE/EPA sediment evaluation criteria bioassays to the materials scheduled to be dredged and discharged at the site. The latter effort was one component of an attempt to estimate the degree of both short- and long-term toxicity of the sediments to be dumped.

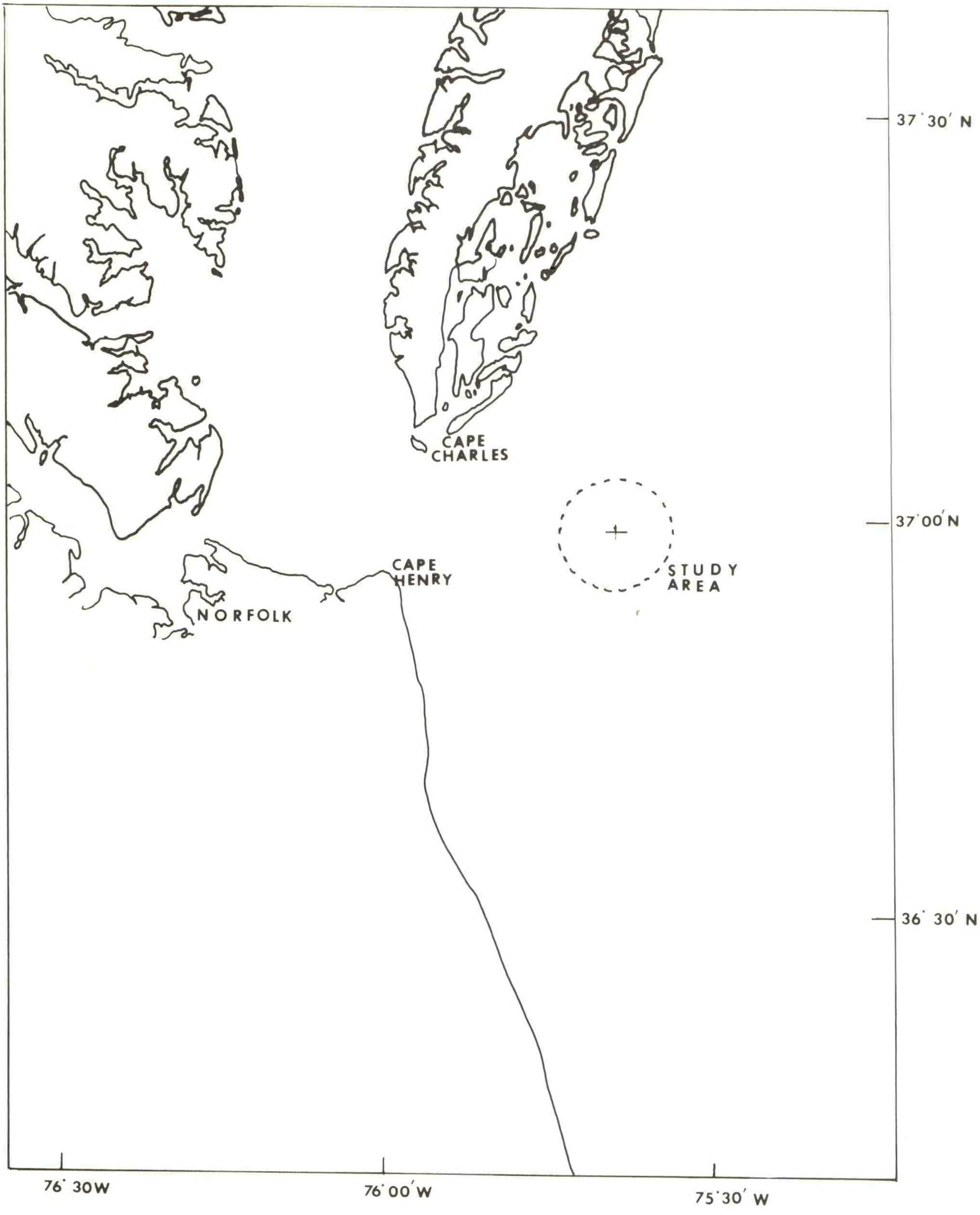

Figure 5. Chesapeake Bay Mouth Dumpsite

The objectives of the Chesapeake Bay Mouth Program are:

- To describe the water mass characteristics of the dumpsite, with emphasis upon circulation patterns,

- To provide biological and geological characterizations of the dumpsite, with emphasis on seasonal ecological changes and population dynamics of ecologically and economically important species,

- To provide a geological characterization of the sediments to be dumped in the disposal area, and

- To estimate the toxicity of the sediments to be dredged on native lower Chesapeake Bay fishes and to estimate the degree of sublethal stress upon fishes of dredging and dumping the sediments.

The program has both field and laboratory components. The laboratory work includes bioassays, physical and chemical sediment analyses, and analyses of faunal samples from the dredging and dumping sites. The field component consists of seasonal cruises to the dredging and dumping areas to collect sediment, water, and faunal samples for laboratory examination and to deploy current meters to measure water circulation patterns.

In addition to providing estimates of toxicity of sediments, the investigation dealing with fishes was also designed to measure the value of activity levels of a fish liver enzyme system - the aryl hydrocarbon hydroxylase system - as a means of monitoring sublethal stress upon fishes occupying polluted areas. Lower Chesapeake Bay fish species examined during the year included American sole (Trinecthes maculatus), spot (Leiostomus xanthurus), and menhaden (Brevoortia tyrannus).

All components of the Chesapeake Bay Mouth Program initiated during 1979 are well underway, and it is anticipated that draft reports summarizing their results and findings will be available during 1980. Although the results to date remain in preliminary form, several preliminary findings of the overall program are listed below:

- Almost two hundred species of bottom-dwelling marine invertebrates occupy the disposal site. The bottom fauna is very similar to that of surrounding waters. The dumping area is not a unique ecological area, appears to be in good environmental health, and is not occupied by significant numbers of commercially and recreationally important species.

- Seasonal water circulation in the disposal area is such that sediments released there are not likely to move towards shore or into Chesapeake Bay.

- Although sediments from the areas to be dredged all contained small amounts of a variety of pollutants - including metals and chlorinated hydrocarbons such as Kepone and DDT - the sediments did not appear to be particularly harmful to test organisms employed for the toxicity bioassays. The test organisms included the grass shrimp (*Paleomonetes pugio*), the blue crab (*Callinectes sapidus*), a mysid (*Neomysis americana*), and the mud snail (*Nassanus obsoletus*).

New York Bight Dredged Material Program

Since 1973, the MESA New York Bight Project has been evaluating the environmental effects of dumping dredged material into the New York Bight. Location at the dumpsite is shown in Figure 3. The major findings of the effort are listed below:

- A 10-meter high sediment mound at the dumpsite, accumulated over the period 1936 to 1973, increased as much as three meters during the period 1973-1978 in at least one place.

- Dumping of dredged material provides the largest source of trace metals to the New York Bight; however, the bioavailability of the metals is not documented.

- The oxygen demand of the dredged material has little effect upon summer depletion of bottom water of the New York Bight at large.

During 1978, the NOAA research effort at the New York Bight dredged material dumpsite focused upon the composition of sediments at the dumpsite as sampled by long cores. The coring work was sponsored by the MESA program. During 1979, NOAA studied the physical and chemical processes acting at the dumpsite during and immediately after dumping. The study was sponsored jointly by the MESA program and the ODMD. The field portion of the investigation was completed during June on a cruise to the dumpsite aboard the NOAA Ship KELEZ.

The Dredged Material Experiment had three research components: acoustical sediment plume tracking, inorganic chemical plume and water column analysis, and organic chemical analysis of plume sediment fractions. Acoustic signals were transmitted into the water column from a towed transducer immediately after dumping. Part of this signal was reflected from the descending plume of dumped dredged material. The distribution of suspended sediments were displayed on a graphic recorder. Water samples were taken simultaneously and analyzed for metals and organic compounds to correlate the acoustic signals with actual chemical analyses. Preliminary chemical findings indicate consistent increases in particulate copper, iron, lead, and cadmium within seven meters of the seafloor in all samples collected during dumping episodes. However, these findings have not yet been correlated with the acoustic data; conclusions regarding short-term processes at the dumpsite must await a final integrated report.

It appears probable from other studies, however, that contaminated fine-grained particles are preferentially dispersed compared to heavier sand and mineral grains, and that a significant portion of the contaminants would not be retained within the dumpsite mound.

Preliminary findings from the 1978 sediment coring research at the dumpsite showed elevated concentrations of metals in the accumulated dredged materials. Concentrations of dissolved metals in pore waters were also measured. Preliminary pore water data indicate a movement of dissolved iron and manganese to overlying waters. Cadmium and mercury were below detection limits (2 ppb and 1 ppb, respectively). Iron ranged from 0 to 90 ppm, and manganese from 0.3 to 6.9 ppm. Because concentrations of iron and manganese in overlying waters were in the ppb range, post-depositional benthic movement of these metals is possible. However, post-depositional movement would be small compared to the amounts put in from dredged material dumping.

Complementary Research

During 1979, the NOS/ODMD initiated a Complementary Research Program (CRP) to investigate generic pollution problems common to ocean dumping as well as to other types of pollution inputs to the ocean. While all other programs sponsored by ODMD during 1979 were site-specific, applying to particular waste disposal sites and specific waste materials, the CRP was of a more generic nature. The purpose of the program is to provide a continuing body of scientific information about pollution problems common to many types of wastes released in a variety of estuarine and oceanic situations. A major portion of this effort was applied to the question of dynamics of heavy metals in seawater and in marine food chains, and three of the four projects supported through the CRP centered around reactions of metals in the marine environment. The remaining project studied the potential use of chemical activity levels of liver enzyme systems in fish as a means of measuring and monitoring responses to marine pollution from urban and industrial sources.

Research on planktonic responses to metal stems from the observation that response varies not with total metal concentrations but with that fraction of the concentration which is in the free or uncomplex form. The research results so far concern relative toxicities of metals, reversibility of effects, adaptation to increased metal levels, synergistic effects, mechanisms through which effects are exerted, mechanisms through which organisms may excrete complex-forming chemicals and thus detoxify their surroundings, use of planktonic responses to measure a water body's capacity to form complexes with metals and thus accept metals without biological change, and the interaction of marine chemistry without bioavailability or uptake of metals.

For a range of phytoplankton species representing all major marine phyla, the elements nickel, cobalt, manganese, and lead did not alter growth rates when free-ion concentrations were below levels which solubility limits allow. The elements copper, cadmium, and in some cases, zinc were effective at concentrations close to those normally found in seawater. Therefore, for these three metals, the possibility of man-induced changes in concentration altering biological communities is strong. The effects of cadmium and copper appear to be reversible. Additions of complex-forming chemicals to systems containing either metal resulted in a return to normal growth on the part of test organisms. The time required for recovery was long if exposure to noncomplex metals occurred over an extended time.

Phytoplankton and other marine organisms have been shown to exude complex-forming chemicals when exposed to high levels of copper. This detoxifying process has been shown to occur for both a copper-tolerant and copper-sensitive clone of the same algal species and is therefore not a defense mechanism unique to the tolerant form. Neither is the effect of copper on chlorophyll production unique to a sensitive or tolerant form. Thus the mechanism through which some clones are demonstrably more tolerant of metals than others remains unknown. One mechanism which has been shown to be responsible for decreased growth in the presence of high levels of copper or cadmium is alteration of enzymes. Enzymes needed for nutrient metabolism by phytoplankton normally involve zinc. If free-ion concentrations of copper or cadmium are in too great excess over zinc, these metals will replace zinc in enzyme molecules and thereby inactivate nutrient metabolism.

Waste induced changes on phytoplankton communities are changes in the basic food source of marine ecosystems. Thus effects on phytoplankton could lead, indirectly, to effects on higher organisms. Metals, however, may also affect zooplankton, fish, and other organisms directly. CRP research with zooplankton is examining the correlation of free-metal ion concentrations with lethal and sublethal responses and with rates of metal uptake. As indicated above, liver enzyme systems in fish are being investigated as indicators of responses to metals.

Seawater contains naturally complex-forming chemicals derived from land runoff and developed in situ by plankton. These organic chemicals, depending on their concentration, will allow certain amounts of metals to be added without corresponding biological response. A method is needed to measure the complex-forming capacity of a given seawater sample. With such a method, it would be possible to evaluate the capacity for waters in a given region to accept inorganic wastes. Two techniques are being developed with the CRP to address this need. One is a chemical procedure based on assessing the capacity of natural complex-forming agents to compete with an added and measurable complex-forming chemical. The other uses the rate of glucose mineralization of marine bacteria as a measure of free-metal ion concentration. Metal is added, incrementally, to the point where bacterial activity dramatically decreases. This is the point also where the added metal has exhausted the complex-forming capacity of the seawater sample.

CHAPTER III

INTERAGENCY AGREEMENTS

In addition to the agreement between NOAA and EPA Region III described above assigning lead responsibility for research and monitoring at the Phildelphia sludge dumping site to NOAA/NOS/ODMD, a second interagency agreement related to ocean dumping was completed by NOAA during 1979. The latter agreement was completed during July between NOAA/NOS and the U.S. Army Corps of Engineers North Atlantic Division, New York, New York. The agreement assigns to NOS a responsibility for providing monitoring and research information to assist COE in regulating ocean disposal of dredged sediments within waters falling under North Atlantic Division authority.

The purpose of the agreement is to ensure that the NOAA Ocean Dumping Program, while fulfilling NOAA's mandate under Title II of P.L. 92-532, also provides information required by COE to meet EPA requirements for sediment dumping site selection, evaluation, and management. The information generated by NOAA will also be used by COE when issuing permits for dumping dredged materials.

The scope of the agreement is outlined below:

A. The COE will develop and provide NOAA with a schedule of priorities for areas to be dredged and disposal sites to be used.

B. The COE will provide information on the chemical composition and volumes of dredged materials being dumped or proposed for dumping. NOAA will provide detailed dumping site environmental assessment study plans to COE, and conduct the necessary studies. Funding will be handled independently by each agency. If funding is to be handled jointly, an additional agreement will be made stating the terms to the satisfaction of both agencies.

C. Where COE imposes monitoring requirements on permittees, the requirements will be developed in consultation with NOAA to reduce the possibility of duplication of effort and ensure the standardization of equipment, methodologies, and data quality control.