NOAA Technical Memorandum NMFS-F/NEC-44

NOAA's Northeast Monitoring Program (NEMP):
A Report on Progress of the First Five Years (1979-84) and a Plan for the Future

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts
May 1987

NOAA TECHNICAL MEMORANDUM NMFS-F/NEC

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29. ***Status of the Fishery Resources Off the Northeastern United States for 1983.*** By Resource Assessment Division, Northeast Fisheries Center; Emory D. Anderson, ed. July 1984. iii + 132 p., 44 figs., 48 tables. NTIS Access. No. PB85-106847.

30. ***Recent Estimates of Adult Spawning Stock Biomass Off the Northeastern United States from MARMAP Ichthyoplankton Surveys.*** By Peter Berrien, Wallace Morse, and Michael Pennington. July 1984. ix + 111 p., 25 figs., 25 tables. NTIS Access. No. PB85-108991.

31. ***Evidence of Nearshore Summer Upwelling Off Atlantic City, New Jersey.*** By Merton C. Ingham and James Eberwine. November 1984. iii + 10 p., 5 figs. NTIS Access. No. PB85-150290.

32. ***Secondary Production of Benthic Macrofauna at Three Stations of Delaware Bay and Coastal Delaware.*** By Stavros Howe and Wayne Leathem. November 1984. ix + 62 p., 6 figs., 19 tables. NTIS Access. No. PB85-145753/AS.

33. ***MARMAP Surveys of the Continental Shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1977-1983). Atlas No. 1. Summary of Operations.*** By John D. Sibunka and Myron J. Silverman. November 1984. vii + 306 p., 52 figs., 2 tables. NTIS Access. No. PB85-150985/AS.

(continued on inside back cover)

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May 1987

Since the completion of this report, budgetary constraints in NOAA have made it necessary to curtail many of the plans made for the next phase of the Northeast Monitoring Program (NEMP), and to formally discontinue its operation as such. The Northeast Fisheries Center will continue to conduct surveillance, monitoring, and research to evaluate the effects of anthropogenically-induced environmental degradation on the abundance, distribution and utilization of estuarine and coastal fishery resources. The activities planned will profit from the findings presented in the Report and will focus on habitats and species threatened by pollution and consequent habitat changes.

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ACKNOWLEDGMENTS

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SUMMARY

The Northeast Monitoring Program (NEMP) was initiated at the beginning of Fiscal Year (FY) 1980 (1 October 1979) by the National Oceanic and Atmospheric Administration (NOAA). The objective of the NEMP Program is to coordinate and focus monitoring and research activities of NOAA studies of the marine environment in coastal and offshore waters of the northeastern United States. The pilot phase of the NEMP was from FY 1980 through 1984. Operational monitoring was to begin in FY 1985. This document describes the program's background, results of the pilot phase and plans for the operational phase.

Information obtained from the pilot phase reveals a coastal marine environment generally free from high concentrations of pollutants, and from obvious biological effects of pollutants. However, in several small portions of the area there was evidence of pollution and related effects.

Major findings of the four program components (Water Quality, Sediments and Benthos, Trace Contaminants in Tissues, Biological Effects) are:

Water Quality

- Phytoplankton communities of the inner New York Bight are influenced by nutrient effluents discharged into the Hudson-Raritan estuary and the smaller estuaries of northern New Jersey. This infusion frequently promotes blooms of phytoplankton species not useful in the food web. Bottom waters become deficient in oxygen with decay of the blooms. Such phenomena are classically associated with eutrophication processes. (pp. 9-18)
- Hypoxia (oxygen concentrations less than 2.0 ml/l) occurred each summer in bottom waters of nearshore areas between Delaware Bay and Sandy Hook, New Jersey and western Long Island. The water quality of these areas was affected by the intrusion of nutrients and organic material from estuarine plumes, coastal sewage discharges, and ocean dumping of sewage sludge and dredged material. (Fig. W1 and p. 9)
- Conceptual and quantitative models have been developed for the seasonal (spring, summer, fall) cycle of oxygen decline and recovery. The models show the early part of the decline is fairly linear and biologically controlled, but midsummer and early fall changes are more erratic and are caused by meteorological processes and solar warming of the water. (pp. 12-14)
- Depth of the base of the regional pycnocline (steep density gradient), amounts of oxygen-demanding materials below the pycnocline, and estimated bottom flow velocity can be used to predict development of hypoxia. No significant trend in oxygen concentrations was detected during the pilot program or in comparison to earlier data extending back to 1969. (pp. 14-17)

Sediments and Bottom Organisms

° Bottom sediments around dumpsites and elsewhere in the inner New York Bight were analysed for concentrations of metals. Values were similar for the summers of 1980-82, and did not show major changes from levels found in 1973-74. The three standard NEMP stations in the inner Bight had the highest metal concentrations of all areas sampled. (p. 21)

° Surveys of metals in sediments of Casco and Penobscot bays, Maine, revealed concentrations (except for cadmium) above preindustrial levels. Concentrations of chromium, copper and lead were similar to those reported for other New England estuaries. Nickel and zinc values in Penobscot Bay sediments were the highest yet recorded for a New England estuary. (p. 23)

° Most stations on the shelf consistently had low concentrations of the metals analyzed. (p. 21)

° The highest concentrations of polychlorinated biphenyls (PCBs) were found near the New York Bight sewage sludge dumpsite (to 1.15 ppm). The second highest PCB levels were observed in Boston Harbor. The total mass of PCBs in Boston Harbor-Massachusetts Bay sediments was calculated to be five times that of the New York Bight. (p. 23)

° Concentrations of PCBs of Portland Harbor and Casco Bay in 1981-1983 were higher than those detected during baseline sampling in 1980. (p. 23).

° In 1984, four years after cessation of sewage sludge dumping at the Philadelphia dumpsite, no pathogenic protozoans were detected. Numbers of fecal coliform bacteria were also within acceptable limits; therefore, it was recommended that the site be reopened for shellfishing. (pp. 25-26)

° Distribution of spores of a sewage-indicator bacterium, <u>Clostridium perfringens</u>, on the northeast shelf changed little over five years. Highest spore counts were noted near the New York Bight sewage sludge dumpsite. (p. 25)

° Numbers of fecal coliform bacteria per gram of sediment in the Bight were similar in summers of 1980-83 and 1971-75. (p. 25)

° The inner New York Bight had the region's most altered assemblages of bottom-living invertebrates, dominated by a few pollution-tolerant species. However, between 1973 and 1984 there were no clear changes ascribable to contamination. (p. 26)

Trace Contaminants in Tissues

- Concentrations of inorganic and organic contaminants do not reveal large scale spatial and temporal trends. (p. 32-37)

- The concentrations of trace metals in biota were generally lower in muscle than in gonads and viscera. (pp. 32-36)

- Concentrations of PCBs in fish muscle were lower than the U.S. Food and Drug Administration (FDA) cautionary limit of 2 parts per million wet weight. In general, levels of other contaminants in flesh of fish species from the northeastern shelf were not elevated. [Species such as striped bass, bluefish and eel, for which contaminant values exceeding FDA limits have been reported elsewhere, were not analyzed.] (pp. 32-37)

- Differences were found in the concentrations of trace metals and organics between animals collected inshore and those collected offshore. Higher concentrations were usually found inshore. (pp. 32-37)

- Limited data are available for assessing temporal trends in concentrations of trace metals. Trace metal levels in tissues of sea scallops showed considerable intraannual variation. (p. 32)

- There was no correlation between concentrations in sediments and in polychaete worms for several organic contaminants (PCBs, polynuclear aromatic hydrocarbons [PAHs] and phthalate acid esters [PAEs]. (p. 37)

- Concentrations of PCBs and Σ DDTs in muscle of adult haddock were 2-3 times greater than in muscle of juveniles. The levels of petroleum hydrocarbons (PHCs) and aromatic hydrocarbons were the same in juveniles and adults. (p. 37)

- It was found that triplicate analyses of a six-individual composite of haddock muscle tissues provides adequate data to describe organic contaminant levels. (p. 37)

- Dioxin (TCDD) was detected in blue crab, winter flounder and tomcod collected from the Kill Van Kull in the Hudson-Raritan estuary. (p. 36)

Biological Effects

- Hematological analyses of four species of flounder showed that abnormal values were consistently characteristic of fish collected from inshore areas. Abnormal hematological values in flounders from Long Island Sound approximately matched the pollution gradient. Fish collected in the western, more polluted, end of the Sound had the most abnormal values. (p. 40)

- High levels of a stress-indicating flounder kidney enzyme were found in fish from polluted areas, including Buzzards Bay, the NY Bight Apex, Block Island Sound, lower Delaware Bay and the lower Merrimack River. Enzyme levels revert to normal in fish that move to cleaner waters (p. 41).

- Statistical evaluations of environmental data and data on cytogenetic abnormalities of mackerel eggs collected in the New York Bight showed significant correlations between abnormalities and pollutants, including aromatic hydrocarbons, heavy metals and chlorinated hydrocarbons. (pp. 41-42)

- Examinations of almost 85,000 fish revealed higher prevalences of pathological conditions in fish from nearshore zones. Fin erosion and liver neoplasms appear to be reliable indicators of effects of degraded environments on fish. (p. 42)

- More gill pathology was found in blue mussels from degraded habitats, such as Raritan Bay, NJ, Cape May, NJ and an oil-spill area near Searsport, ME, than other locations. Inflammation and ciliate infestations were found in mussels from these sites but were rare in the other coastal locations sampled. (p. 43)

- Sediments contaminated with crude oil caused unusual behavior in benthic organisms, which would increase their vulnerability to predation. (p. 43)

- Benthic polychaetes exposed to sediments contaminated with cadmium were unable to avoid contact with the contaminant and bioaccumulation resulted. (p. 45)

- An inverse correlation was observed between survival of laboratory-reared striped bass larvae and contaminant body burdens of female parents obtained from several rivers and hatcheries in the eastern U.S. (p. 41)

The five years of monitoring have also established baselines for water and sediment quality, abundance and diversity of infaunal benthos, body burdens and biological effects for fish and fish habitats, throughout the northeastern shelf region. The data will improve our ability to characterize fish and environmental quality on the shelf. If the same species and sites are later re-examined using comparable methods, comparison with data acquired during the pilot phase of the NEMP will aid in detecting changes.

1. INTRODUCTION

On 1 October 1979, the Deputy Administrator of NOAA released a decision memorandum creating the Northeast Monitoring Program (NEMP). The program was to be formed by integrating the monitoring and related research activities of three NOAA elements (National Marine Fisheries Service [NMFS], Oceanic and Atmospheric Services [OA], and Research and Development [RD]). These components were already operating in coastal waters of the northeastern United States. Initial efforts aimed at combining the experimental and field monitoring activities, and developing a Program Development Plan (PDP) and Technical Development Plan (TDP).

The NEMP was conceived as a two-phased program. The first, from fiscal year (FY) 1980 through FY 1984, was a series of evaluations of pollution-related monitoring and research for marine waters from the Canadian border to Cape Hatteras. (Figure 1 shows the overall study area , including major features discussed below; Figure 2 shows standard sampling locations.) This pilot phase of the NEMP emphasized marine over estuarine work, because it was felt estuaries were relatively well studied by states and academia, while there was a dearth of baseline and monitoring information on the "health" of marine waters. The second phase, operational monitoring, was to begin in FY 1985. In addition, the NEMP was to be the basis of a FY 1982 budget initiative for a national coastal and estuarine monitoring program. Although that particular initiative was not funded, later efforts resulted in such a national program.

The PDP and TDP have guided NEMP development. These documents include descriptions of NEMP goals and objectives, statements of scientific/technical procedures, indications of environmental problems and threats, information on environmental and administrative constraints and opportunities, and a definition of products designed to address particular audiences and to meet specific needs. During the pilot phase, the NEMP evolved to reflect program findings, developments in methodologies and approaches, changes in administrative makeup and policy, and emerging environmental problems.

The NEMP accomplished much during the pilot phase and met most program objectives. New information has been applied to problems in existence or those which emerged as the program evolved. Information and assessments of conditions have been provided to other NOAA components and other agencies, the public and environmental groups. Working relations, within and outside NOAA (government groups, academia, commercial firms, etc.), have been established and have grown, thereby enlarging program scope. Research findings have been applied to monitoring, and new monitoring techniques have been applied.

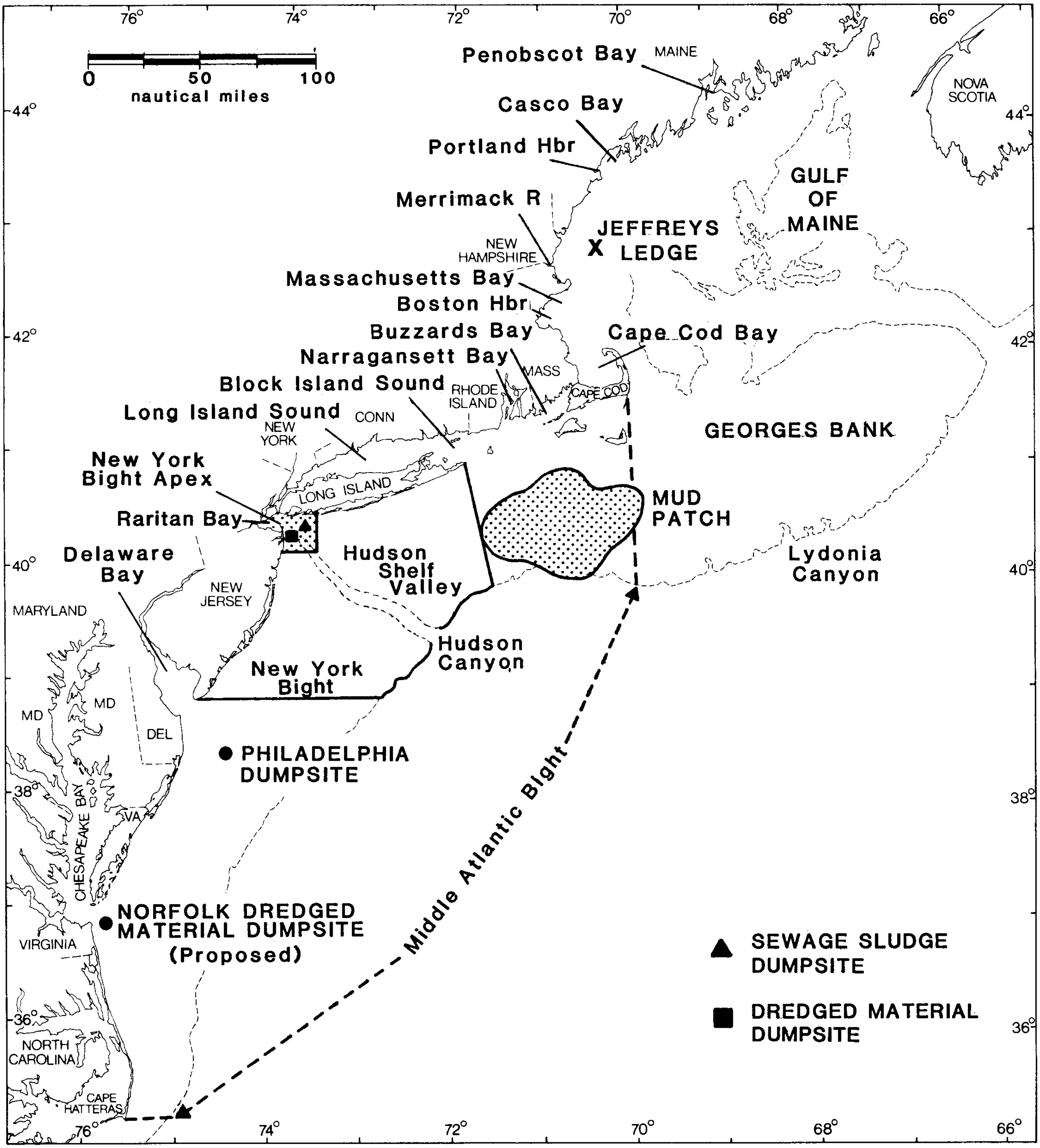

Figure 1. General area of NEMP studies, with features discussed in text.

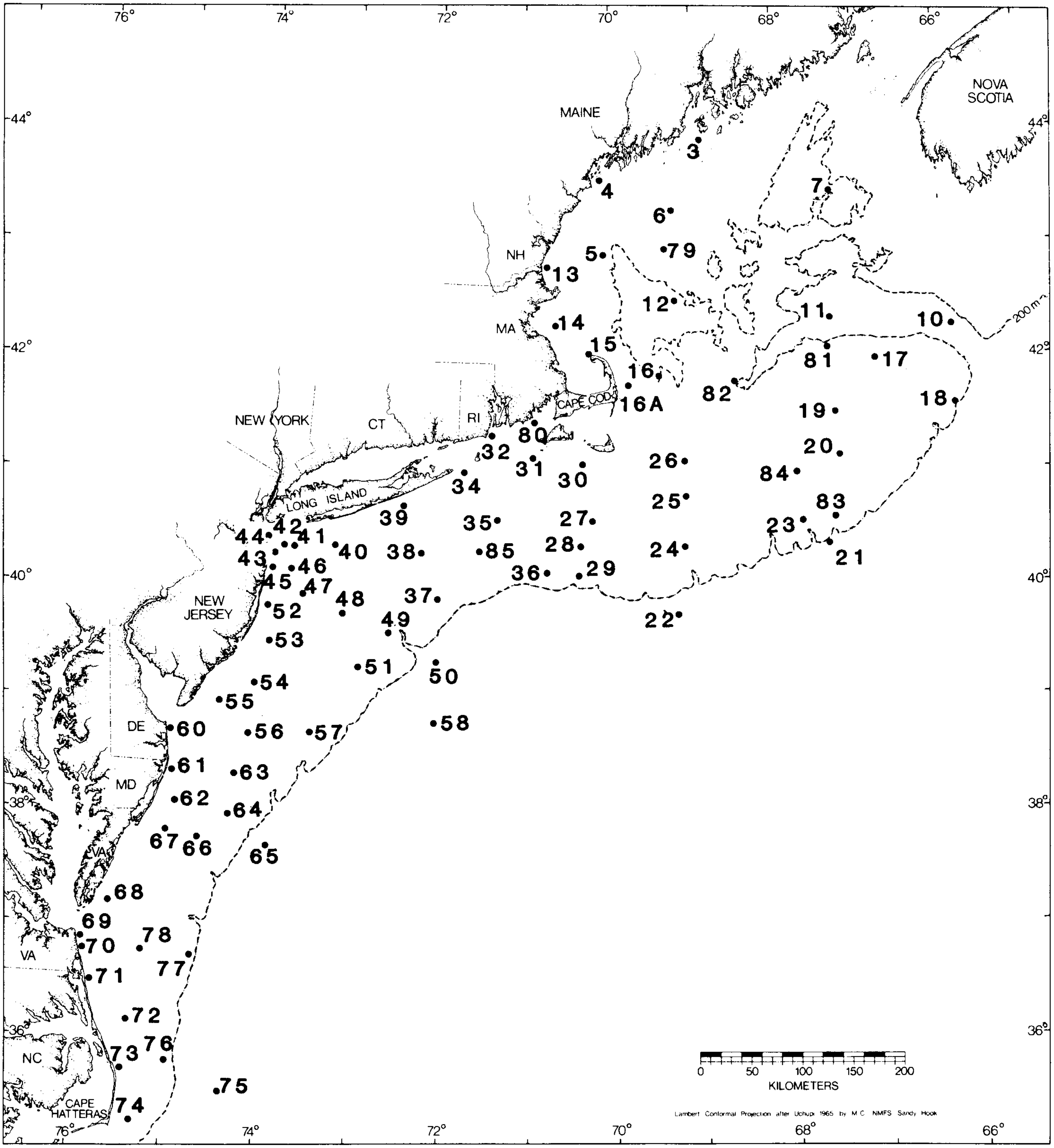

Figure 2. Locations of NEMP stations in the Northeast which were occupied in FY 1980 through 1984.

Marking the end of the pilot phase, this report is meant to:

- provide a succinct history of program development,
- document pilot program findings and accomplishments,
- describe the present program status,
- evaluate the effectiveness and utility of the program and its component parts,
- define changes in program scope and focus, and
- develop a plan for the future.

2. PROGRAM EVOLUTION

2.1 Organizational Background

In 1978, NMFS began monitoring the health of Northeast fisheries habitats under the "Ocean Pulse" (OP) Program. In early 1979, OA proposed an initiative for a national, integrated ocean pollution monitoring program, the "Pilot Monitoring Network", for FY 1981. Because this budget initiative appeared to duplicate parts of OP, and monitoring elements of OA's Ocean Dumping Program (OD) and RD's Marine EcoSystems Analysis (MESA) Program, NOAA management did not support it. Instead, a portion of the FY 1980 Funding Memorandum directed NOAA to initiate a five-year pilot monitoring program for coastal and estuarine waters of the Northeast by 1 January 1980. The program combined appropriate elements of the three existing programs into a coordinated effort called the NEMP.

In 1983, OD and MESA became part of the Ocean Assessments Division (OAD) of the National Ocean Service. The NEMP became a two-group effort, involving OP and the OAD, which continued to operate to the end of FY 1984.

During the second half of FY 1983 the OAD planned and initiated a national marine pollution monitoring program. This "National Status and Trends" (NS&T) Program became operational in FY 1984 and involves three NMFS Fisheries Centers, including the Northeast Center. Many results of the NEMP pilot phase helped form the NS&T Program, and the Program's activities in northeastern waters are considered part of the NEMP.

2.2 Goals

The PDP for NEMP, developed in 1980, contains the following goals:

1. Maintain an assessment of the health of the coastal ecosystem of the northeastern United States;

2. Provide information necessary to ensure present and future protection of human health and the safety and wise management of the living marine resources of the Northeast, and

3. Develop a pilot monitoring program to determine the cost-effectiveness, user requirements, and potential applicability of monitoring methodologies to other U.S. coastal areas.

2.3 Objectives

The PDP identifies the following ten objectives:

1. Determine or confirm the existing levels, trends, and variations of contaminants in water, sediments, and biota and their effects on living marine organisms.

2. Establish and maintain an interactive data archive resulting from other marine pollution monitoring programs in the northeast and foster cooperation and coordination of estuarine/shelf environmental monitoring and research efforts off the Middle Atlantic and New England States.

3. Summarize, in collaboration with other agencies, information on pollutant inputs to estuarine and coastal waters.

4. Provide data and relevant information to regulatory organizations and the general public, in a timely manner, for planning and management.

5. Determine effects of major activities such as offshore drilling, dumping, and toxic waste disposal on the coastal marine environment and its resources.

6. Detect and provide appropriate and early warning of severe or irreversible changes in the coastal marine ecosystem and its resources. This includes coordination with agencies responsible for routine and crisis response activities (oil spills, harmful waste and toxic chemical discharge, etc.).

7. Determine users' needs.

8. Develop and apply standard methodologies for monitoring and evaluate monitoring effectiveness.

9. Determine cost effectiveness of coastal monitoring elements.

10. Determine applicability of marine pollution monitoring methodologies to other United States coastal regions.

2.4 Environmental Issues and Statutory Mandates

In the northeastern United States, municipal and industrial wastes from the activities of 30 million people are discharged directly or indirectly into marine or estuarine waters. The NOAA and other organizations, before the NEMP, found that portions of the northeastern coastal environment had been degraded. Indicators of degradation of the Middle Atlantic Bight area included: a) stimulation of phytoplankton productivity by riverborne nutrients emerging from such drainages as the Hudson and the Delaware; b) possible increased frequency and intensity of algal blooms; c) abnormal depletion of dissolved oxygen concentrations; d) elevated levels of trace metals in surf clams, sediments and water; e) closures of clam beds because of bacterial contamination; f) closures of lobster and finfish fisheries because of PCBs; and g) significant differences in the prevalence of certain fish and crustacean diseases between polluted and cleaner areas.

It was evident that ecological and public health hazards off the northeast coast could result from multiple causes. It is often difficult to determine causes responsible for a given effect, making it difficult to solve specific problems. It seemed urgent to establish baselines and monitor biological effects, in order to take remedial actions before effects became irreversible or public health was affected. Traditional research alone was unlikely to detect long-term trends that would provide evidence of contaminant effects. However, research was seen as an active contributor to the monitoring program, by determining causal relationships and by testing and evaluating monitoring techniques. The NEMP Management Team ensured the interaction between monitoring and research, and the establishment of lines of communication throughout the NEMP and with other appropriate elements.

The regionally-oriented NEMP was seen as a means for providing information important for management decisions and useful to municipalities, states, Federal agencies, and conservation groups. Baseline information, lacking or inadequate in some areas, was required for decisions concerned with regulating contaminant sources. In the Northeast, where a preliminary data base existed, the NEMP has worked to expand this data base.

The majority of ocean pollution monitoring by the Federal government in the Northeast had been funded by agencies other than NOAA. This monitoring for the most part was specific to sites of waste input. Little if any effort monitored the cumulative, long-range effects of pollution over the region. Thus the NEMP provided NOAA with regional assessments of marine pollution problems.

NOAA's responsibility for the development of this program came from several mandates. The National Ocean Pollution Research and Development and Monitoring Planning Act of 1978 (P.L. 95-273) directed NOAA to "establish within the Administration (NOAA) a comprehensive, coordinated, and effective ocean pollution research and development and monitoring program.". The pilot monitoring program for the northeast coastal waters was a NOAA response to this mandate. Other mandates for NOAA's involvement in the region are found in the following statutes:

- The Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532)
- Fish and Wildlife Act of 1956 (P.L. 85-888)
- Fish and Wildlife Coordination Act of 1958 (P.L. 73-121)
- Sea Grant Improvement Act of 1976 (P.L. 94-461)
- Deepwater Port Act (P.L. 93-627)
- Migratory Game Fish Study Act of 1959 (P.L. 89-359)
- Anadromous Fish Conservation Act of 1965 (P.L. 89-304)

- Coastal Zone Management Act of 1972 (P.L. 92-583, as amended in 1976)
- Endangered Species Act of 1973 (P.L. 93-205)
- The National Environmental Policy Act of 1969 (P.L. 91-190)
- Federal Water Pollution Control Act of 1972 (P.L. 92-500, as amended by the Clean Water Act of 1977 [P.L. 95-217])

NOAA's responsibility for managing marine and estuarine natural resources and for assessing environmental impacts of activities associated with offshore oil and gas development was defined explicitly in P.L. 95-373, the OCS Lands Act, Title 3, Section 303(b) (3). This role was further defined in Executive Order 12123, 26 February 1979, (Federal Register 11199 1-1).

Public Law 95-273 designated NOAA as the lead Federal agency for preparing a comprehensive 5-year Federal plan for ocean pollution research, development and monitoring. The Northeast was identified in the "Federal Plan for Ocean Pollution Research, Development, and Monitoring for FY 1979-1980" as the area with the highest monitoring priority. The Northeast was also identified by an interagency subcommittee on ocean monitoring[1] as follows:

> "Coordination of regional plans and new monitoring activities, as the first phase of the National Ocean Pollution Monitoring Program, should be implemented in FY 1981. Because of the critical pollutant stress conditions, public and institutional support, and the existence of a sufficiently complete research base, the new monitoring efforts should be in the northeastern Atlantic coast and Great Lakes region".

2.5 Funding

The foundation of NEMP has been the OP program of the NEFC, and the largest share of NEMP funding has come from habitat conservation appropriations to the NEFC for OP. Other funding support has been contributed to NEMP by OAD (formerly part of OA). Direct funding levels, not including contributed ship time or in-house salaries, were relatively constant at about $2 million, with $1.3 million from NEFC/OP and $0.7 million from OAD. In FY 1984 the OAD contribution was reduced to $0.36 million.

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[1] Report of the Subcommittee on Ocean Pollution Monitoring, Interagency Committee on Ocean Pollution Research and Development and Monitoring, 4 May 1979.

3. PROGRAM ACCOMPLISHMENTS

3.1 Annual Highlights

Highlights of program findings for each year are compiled in Appendix 5.1. The findings from the first three years (1980, 1981, 1982) are from NEMP annual reports (individually cited in Appendix 5.1).

3.2 Five-Year Summary Findings and Trend Identification

3.2.1 Water Quality - Catherine Warsh, Coordinator

Introduction

The acute and persistent hypoxia (dissolved oxygen concentration below 2 ml/l, or about 2.86 ppm) which occurred over a wide area of the Middle Atlantic Bight in the summer of 1976 has sharpened the awareness of the potential for eutrophication and consequent effects in marine waters. More localized, generally less persistent and less severe episodes recur in the nearshore waters in this area (Figure W1) during summer months. Thus, questions have been raised concerning the predictability, causative factors, ecological effects, fisheries impacts, human health aspects and potential manageability of such events.

Oxygen depletion in coastal waters is now seen internationally as a paramount problem, and is a marine environment issue in the Middle Atlantic states. Greatest concern results from apprehension that widespread anoxia (zero concentrations of dissolved oxygen), as experienced in 1976, will recur, with the associated losses amounting to hundreds of millions of dollars.

Several research and monitoring programs have examined this and related phenomena in the last decade. The NEMP emphasized eutrophication and associated hypoxia in its coordinated water column monitoring during the first five years of the program and developed extensive data sets. To understand the processes which contribute to eutrophication and dissolved oxygen depletion, the following variables were monitored: light penetration, temperature, salinity, oxygen, nutrients (nitrate, nitrite, ammonium, phosphate and silicate), fluorescence, chlorophyll a and phytoplankton species composition. Data on wind speed and direction, precipitation, stream flow, sea surface temperature and chlorophyll a (the latter two from satellite imagery) were obtained from other NOAA and United States Geological Survey sources. Each variable is discussed in the NEMP 1982 annual report. Since 1982, sedimented phytoplankton (viable resting stages in bottom sediments) has been monitored, because it is a factor in summer oxygen depletion and is abundant in known hypoxic areas.

The field sampling program which evolved over the first five years includes two major components (Figure W2):

° Frequent occupation (weekly during April-October, monthly during November-March) of a transect of stations extending from the Long Branch (NJ) pier to the Hudson Shelf Valley.

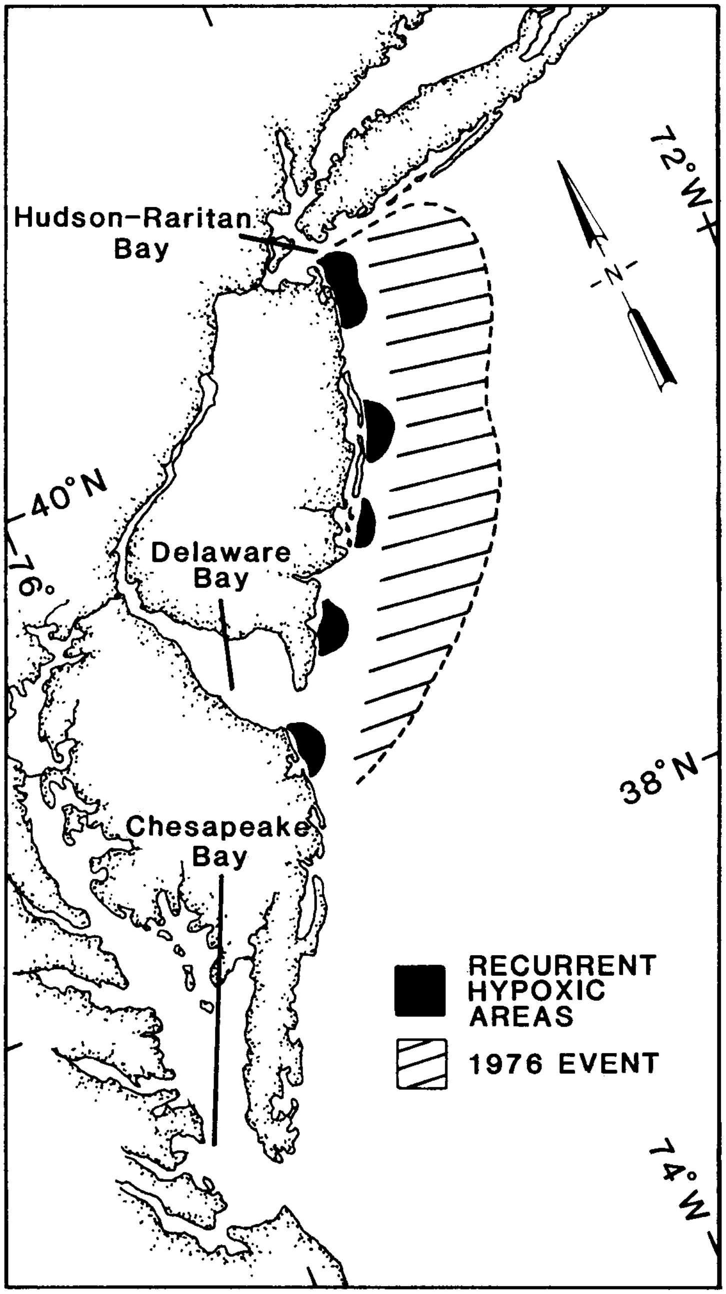

Figure W1. Recurrent areas of low dissolved oxygen (≤3 ml/l, or 4.3 ppm) in bottom waters along the Northeast coast.

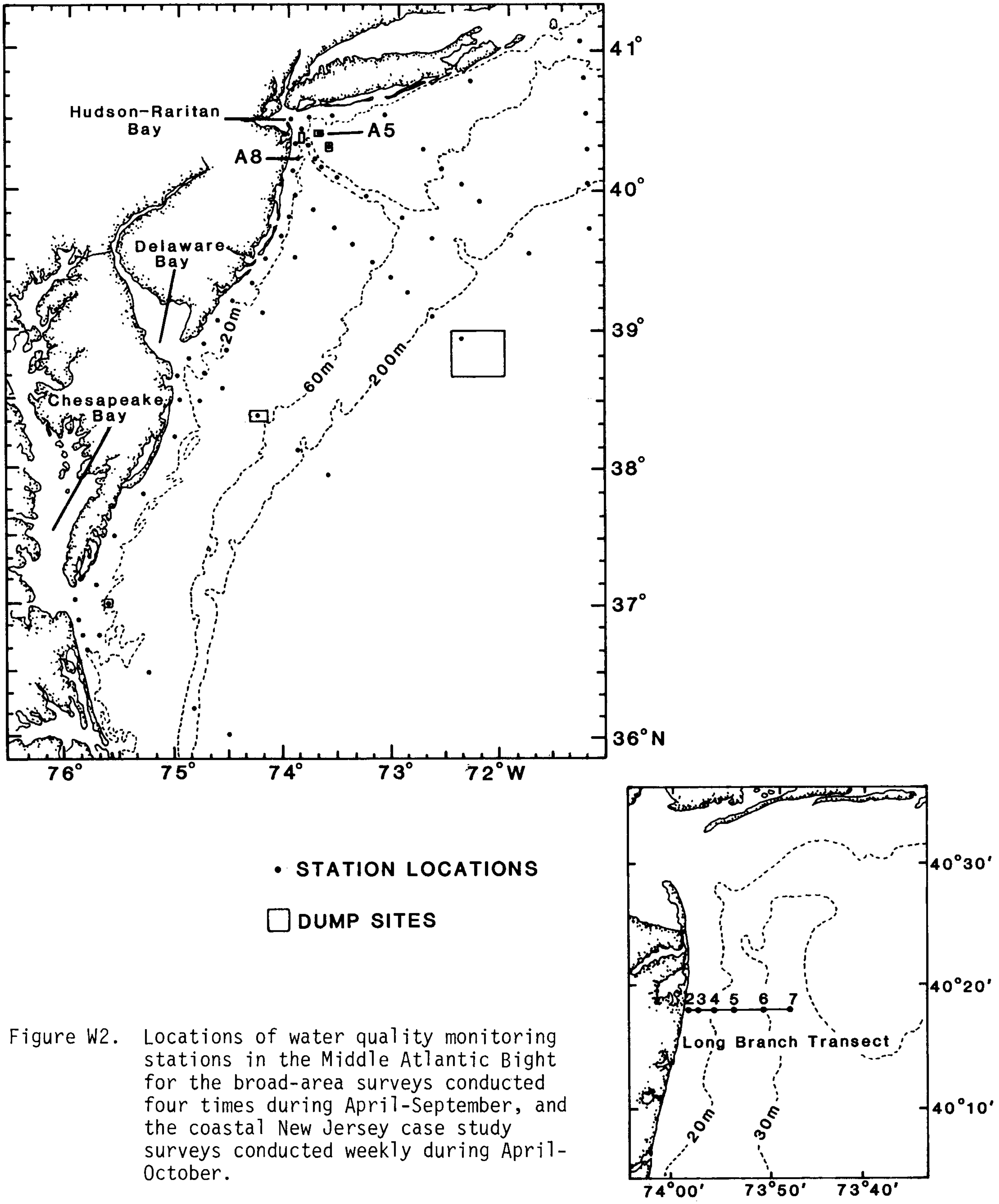

Figure W2. Locations of water quality monitoring stations in the Middle Atlantic Bight for the broad-area surveys conducted four times during April-September, and the coastal New Jersey case study surveys conducted weekly during April-October.

- ° Four surveys of the shelf and slope waters from Cape Hatteras to Block Island during April-September, monitoring development of hypoxic conditions and contributing factors during the season of water-column stratification.

Results

Oxygen depletion occurs in the lower part of the water column in the New York Bight during summer months. During this period an upper layer of warm, less saline, less dense water is separated from cool, more saline and denser water below by a sharp density gradient (pycnocline). Oxygen entering the surface is not readily available to bottom waters, because of greatly inhibited mixing across the density gradient, but oxygen consumption in the bottom water continues. The relative importance of the natural physical, chemical and biological processes and anthropogenic influences in oxygen depletion is not clear, and continues under study.

The most significant anthropogenic influence revealed in NEMP water quality studies is the nutrient loading of estuarine and nearshore waters from a variety of sources, both point and non-point. As a consequence of nutrient inputs, New Jersey nearshore waters and those in the New York Bight apex have the highest rates of primary productivity in the NEMP area. Greatest phytoplankton cell counts also were found in and near estuarine plumes extending into shelf water. Occasionally under such conditions phytoplankton "blooms" occur which exceed the grazing capacity of filter feeding herbivores. The ungrazed phytoplankton cells eventually settle to the bottom where they are consumed by benthic organisms including bacteria and reduce oxygen concentrations of bottom waters.

Monitoring the Long Branch transect during 1984 showed blooms of phytoplankton in the Hudson-Raritan estuarine plume caused deposition of surplus cells in nearshore sediments. The number of viable phytoplankton cells per ml of sediment, a useful index of recent deposition, varied widely at nearshore stations. Greatest concentration occurred at Station 3 (18 m depth) at the end of March. One sample contained over 3 million viable cells per ml, mostly a diatom which had recently "bloomed." During August at the same station cell densities of over 1 million per ml occurred, coincident with relatively high concentrations of nitrates, chlorophyll (phytoplankton) and dissolved oxygen in the surface waters. At the same time low concentrations of dissolved oxygen (0.66 ppm) in bottom water occurred off Manasquan, NJ, associated with a decaying mass of diatoms from a recent bloom.

At both locations conditions normalized within a week, reflecting the dynamic linkage of nutrients with phytoplankton blooms and oxygen depletion.

Analysis and Modeling

The transect (Figure W3) and survey cruise data were incorporated into a model of seasonal patterns of oxygen concentrations in bottom waters. The decline of bottom oxygen is rather steady during the first half of the season, extending from the onset of stratification in April-May until about July. During this period oxygen concentration is controlled by biological consumption processes and organic loading. From mid-July to fall the

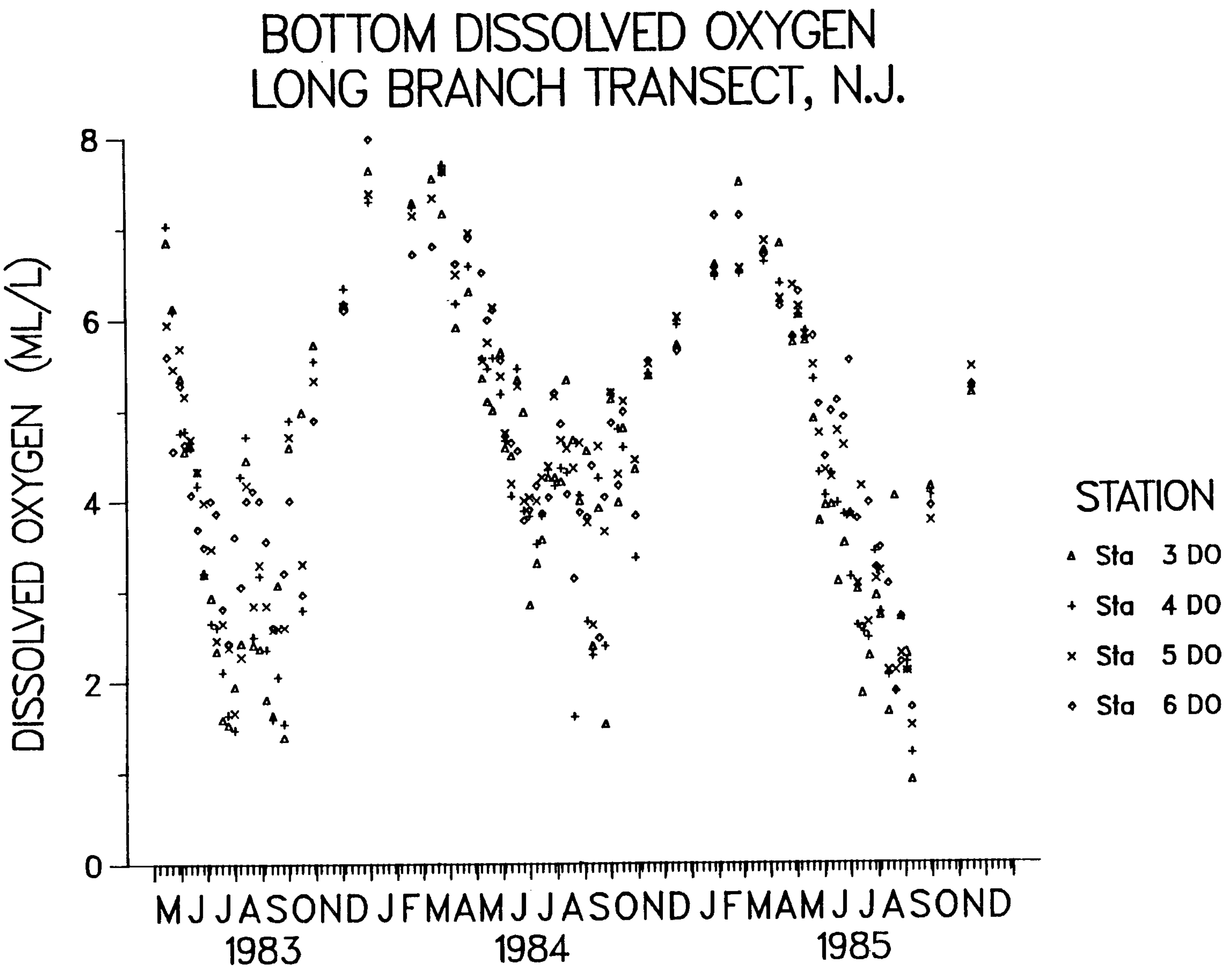

Figure W3. Concentrations of dissolved oxygen in bottom water along the Long Branch transect during 1983, 84 and 85.

concentration of dissolved oxygen in the bottom water varies irregularly, with large excursions caused by weather and solar influences. Changes in coastal wind stress may cause a near-bottom water mass, called the cold pool, to move onshore or off, which changes the dissolved oxygen concentration at the nearshore monitoring stations. Local storms or wind events may provide temporary relief of hypoxic conditions, but in a highly stratified water column the system can re-establish, preventing further mixing or aeration of bottom waters. Wind events also provide a mechanism to lessen the severity of hypoxia or to preclude worsening.

Since 1980, bottom dissolved oxygen levels have remained within the normal range. No severe problems have been encountered since the 1976 event, but local areas of hypoxic conditions have occurred annually. In 1983 low values (< 4.3 ppm) of dissolved oxygen were measured in the New York Bight apex and prevailed throughout the summer. The cold pool was nearshore, which, with local wind conditions, appeared to have confined the problem to the Apex.

Excessive runoff occurred during spring, 1984, as in 1976, but hypoxia did not develop. Consistent southwesterly winds in June and July caused onshore transport of bottom water, bringing in very cold water with higher oxygen concentrations from the mid-shelf region. From mid to late July upwelling of this water occurred along the coast from New York to Virginia. The bottom dissolved oxygen concentrations were found consistently to be around 5.7 ppm.

From the 1984 field season data we made a prognosis for dissolved oxygen levels in bottom waters for the Apex for the first two weeks of August. In conjunction with a circulation model, we considered a worst case and normal case for rates of oxygen utilization. The worst case (Figure W4, line a) assumed near stagnant circulation and highest respiration. The normal case (Figure W4, line b) corresponded to a local mean value for respiration without renewal events. In both cases, dissolved oxygen concentrations would not be predicted to fall below 4.3 ppm before mid-August (Hopkins unpublished). Neither worst nor normal conditions occurred and above-normal levels of dissolved oxygen were encountered during August, associated with high productivity periods. This exercise demonstrated the utility of the conceptual model, using real-time data for a short-term prediction.

In a study of past occurrences of hypoxic conditions in bottom waters in New York Bight and the physical factors that influenced those conditions, Swanson and Parker (1985) found:

- "The single most reliable estimator of the regional summertime minimum $[DO]_R$ (dissolved oxygen concentration beneath the pycnocline) is that of the depth of the base of the regional pycnocline ($r = 0.87$)."
- "River flow is important in establishing the depth of the base of the pycnocline ($r = 0.66$). Because of its relatively strong correlation with the depth of the pycnocline, it cannot be considered an independent variable when assessing the likelihood of low bottom [DO], if pycnocline depth is also used."

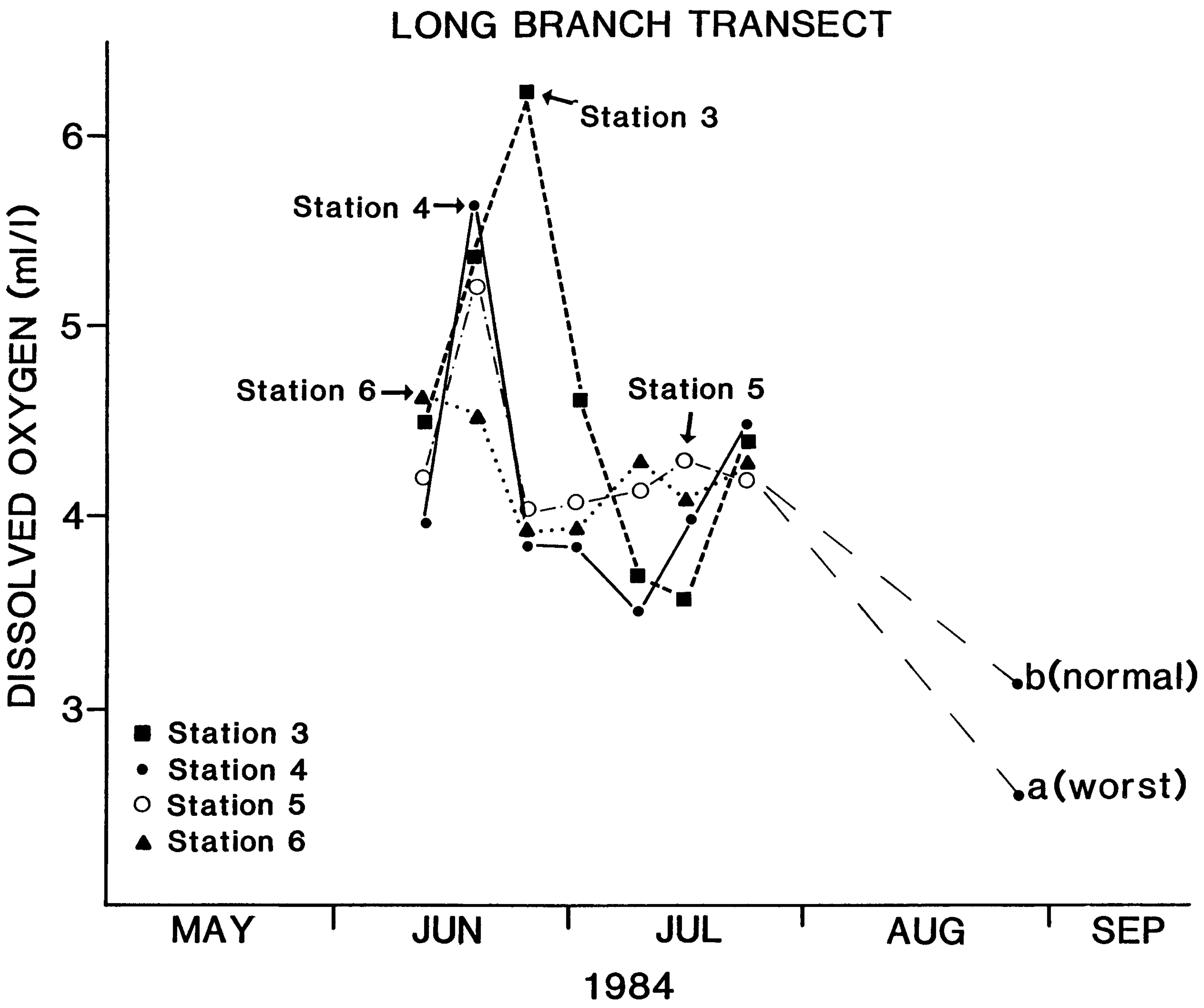

Figure W4. Bottom water concentrations of dissolved oxygen measured at three stations and predicted for the late summer period for one station. Line b portrays the predicted decline assuming average rates, and line a assuming "worst case" conditions.

- "Frequency of spring storms does not appear to play a significant role in alleviating stressed bottom [DO]. During the peak period of stratification, storms and the wind field provide instantaneous relief but following their passage, gravitational circulation quickly reestablishes stratification and its attendant oxygen stress. These brief periods of relief may be important in preventing severe hypoxia/anoxia."

- "Han (unpublished manuscript) and Mayer et al. (1979) have quantified a close relationship between subpycnocline flow and wind stress along the New Jersey coast. Strong, persistent southerly to southwesterly winds tend to retard the general tendency of bottom waters to flow to the southwest, parallel to the isobaths, and support coastal convergent material transport and coastal upwelling along New Jersey.

  Thus wind and current flow are highly correlated estimators of the potential of the bottom waters to be sluggish, and therefore slowing the advective renewal of oxygen to the area of concern.

  We selected the Han regression model to estimate bottom flow. Using this estimator, along with the depth of the regional pycnocline, we can account for 79% of the variance in the mean values of the July/August bottom $[DO]_R$. This is an incremental improvement of 3% over using only depth of the base of the regional pycnocline. While only a small improvement, it is nevertheless considered useful as an estimator variable. Bottom flow may be viewed as contributing the incremental amount of oxygen that is available for oxidative processes."

- "Based on the limited information at hand we can say that over thirteen years when estimates of the regional summer-minimum bottom $[DO]_R$ are available, two years have had less than 4.3 ppm, a probability of 0.15.

  It thus appears that at this point, there is not a long term decreasing trend in the regional mean summer-minimum bottom $[DO]_R$. Extreme oxygen depletion events such as experienced in 1976 are in fact unusual and the probability of such an event recurring is 0.1. Nevertheless, it is important to recognize that while there is little evidence to suggest that there is a regional problem, our studies confirm the recurrence of localized oxygen depletion in the Christiaensen Basin and in the very nearshore area along the New Jersey coast (perhaps up to 15 km offshore). There is insufficent evidence to state whether this is a growing problem."

° "We know that the Christiaensen Basin, the remnant Hudson River Valley, is a natural settling basin for materials. Under certain summertime conditions involving a deep and intense pycnocline and upvalley flow, material, natural or anthropogenic is essentially trapped in the basin. When this occurs, aeration from the surface and advective renewal are limited. The relatively small static oxygen pool is drawn down rapidly creating depleted conditions."

° "The recurring oxygen depletion problem along the New Jersey coast appears to be unrelated to the conditions of the Christiaensen Basin. The Hudson River plume preferentially hugs the New Jersey coastline, intensifying the pycnocline and transporting with it oxygen demanding materials from natural sources and from man's activities including wastes from agriculture, industry, and treated and untreated sewage."

Some 1.7 m^3 s^{-1} of effluent are discharged directly to nearshore waters along the New Jersey coast between Sandy Hook and Barnegat Inlet (Mueller et al., 1976). These discharges are mainly from primary and secondary municipal waste treatment. A small fraction is industrial wastes. O'Connor (1979) estimates that the nitrogen added all along the New Jersey coast may be equivalent to up to 20% of the anthropogenic nitrogenous load emanating from the Hudson-Raritan estuary".

An effort to develop a quantitative predictive and diagnostic model relating nearshore (less than 30 m depth) dynamics to the dispersion and fate of discharged wastes has produced useful early results. A detailed description of the modeling and results of test runs is in Hopkins and Dieterle (1983, 1984). They discuss a circulation model and a particle dispersion model. This effort was applied specifically to the New York Bight apex (Hopkins and Dieterle 1984), to simulate the distributions of various- sized particles dumped into the New York Bight or introduced from the Hudson-Raritan estuary. The models tracked approximately 43,000 particles of assigned sinking velocities and initial distribution over 8-day time periods under different assumed wind conditions. Runs were made to assess best and worst environmental conditions for dumping, estuarine effluent plumes, depositional sorting of particles and accumulation of particles on the pycnocline. All these factors complicate waste management decisions.

For example, one of the runs tracked neutrally buoyant particles introduced from the Hudson-Raritan estuary at the rate of 2700 particles every 12 hours for 8 days under southwesterly wind conditions. The 4- and 8-day distributions (Figure W5) show the eastward movement and dispersion of the particles. Divergent flow kept the plume south of Long Island and away from the coast, and upwelling caused by the wind kept the particles in the surface layer. The net result was the transport of the effluent particles to the midshelf north of the Hudson Shelf Valley.

Simulation runs of the models can be applied to the problem of bottom water hypoxia in the Bight apex by tracking oxygen-consuming particles with assigned sinking rates in specified velocity fields. Coupled with calculated rates of oxygen consumption, the particle dispersion maps (Figure W6) can be used to predict where hypoxia should occur and its severity.

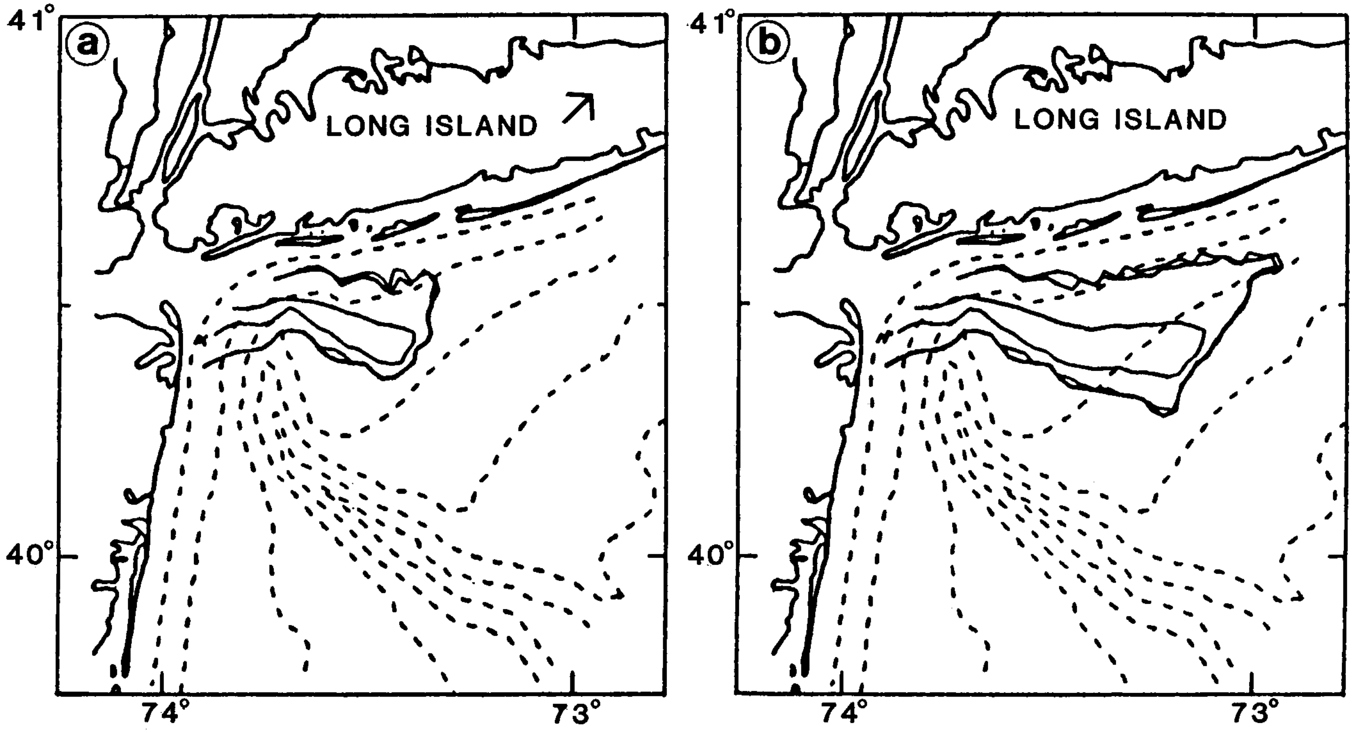

Figure W5. The particle distribution as neutrally buoyant effluent from the Hudson-Raritan estuary for the southwesterly wind case, a) the 0 to 5-m layer after 4 days b) the 0 to 5-m layer after 8 days.

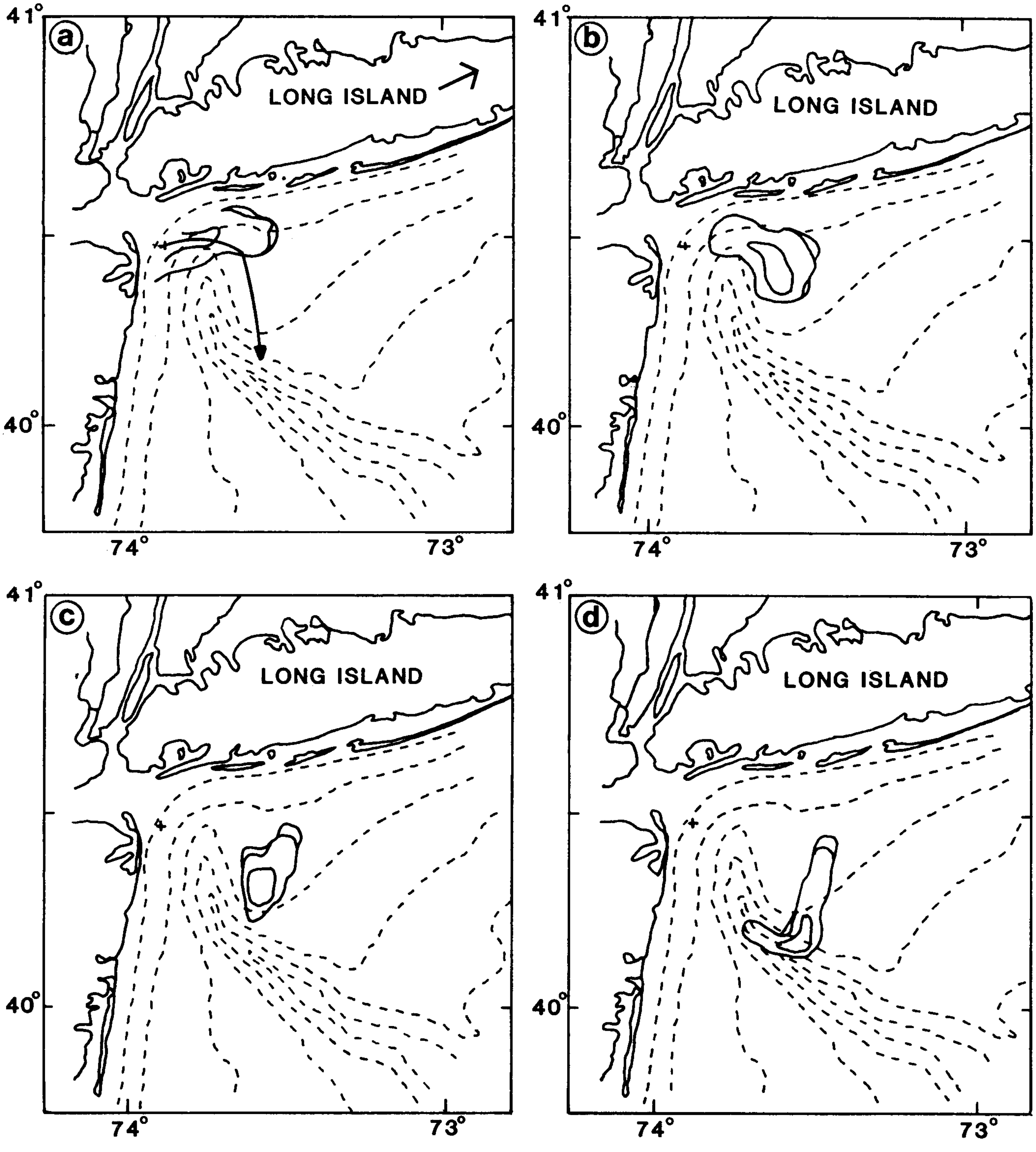

Figure W6. The particle distribution as effluent sinking at 3 m/d from the estuary after 8 days for the southwesterly wind case, a) the 0 to 5-m layer, b) the 5 to 10-m layer, c) the 10 to 15-m layer, and d) the 20 to 25-m layer.

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3.2.2 Sediments and Bottom Organisms - Robert Reid, Coordinator

Introduction

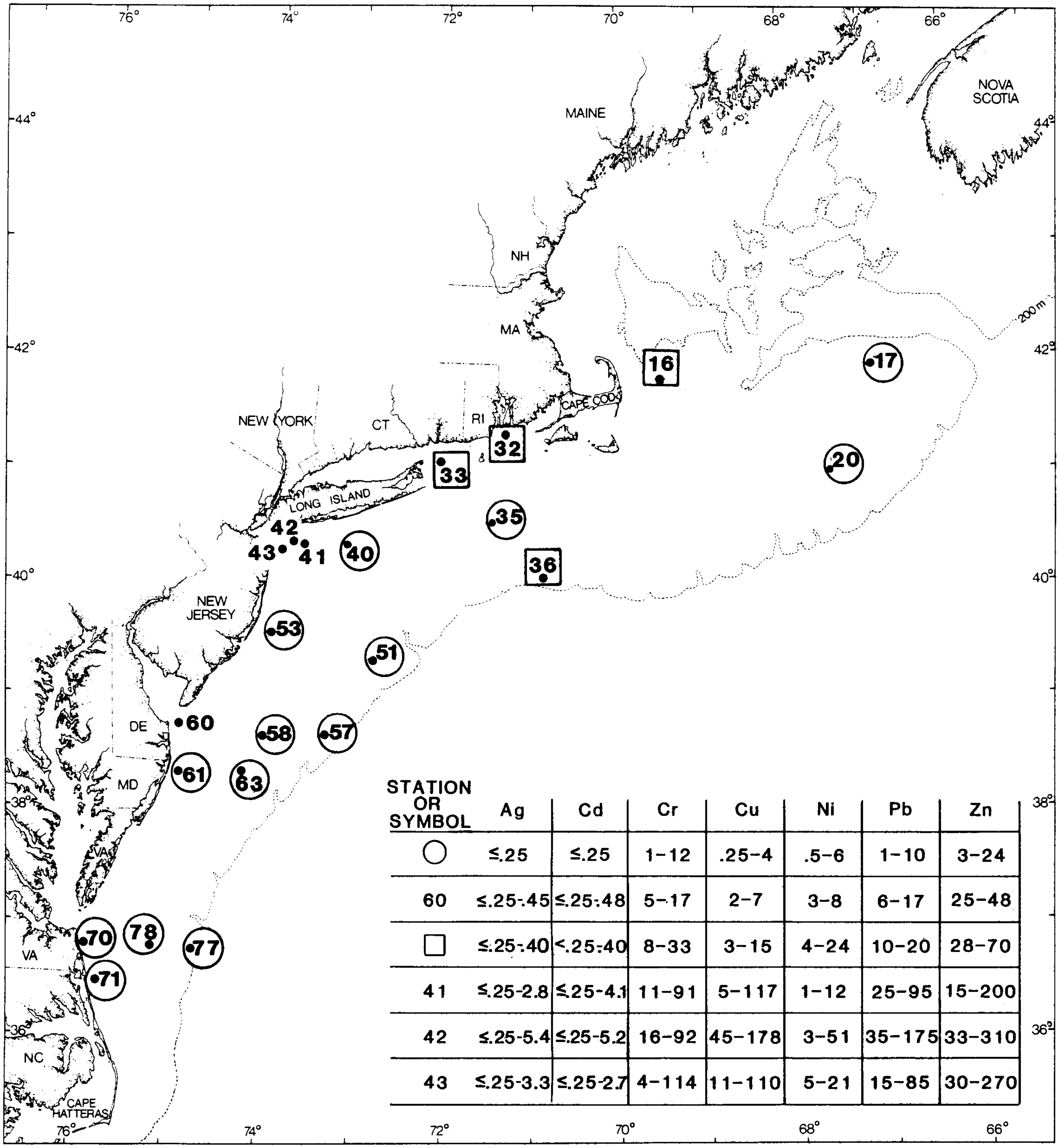
Sediments and associated bottom-living organisms (hereafter "benthos") are among the best indicators of fates and effects of contaminant inputs. We monitor sediments and benthos for several reasons. For example: 1) sediments, especially the finer sizes (silts and clays), are a "sink" which accumulate organic detritus, pathogenic and indicator microorganisms, and contaminants. Sediments sometimes hold over 99% of the total amount of a contaminant in an ecosystem (Renfro 1973). Sediment type also influences distribution and abundance of bottom fish, shellfish and smaller invertebrates. 2) Small benthic animals usually have limited mobility, so patterns of their abundance can integrate effects of contaminants in sediments and bottom waters over areas and time. The benthos can serve as an "early warning" of environmental degradation before it affects species of direct interest to man. 3) Many benthic species are important in diets of resource species. Changes in distribution and abundance of forage species may influence survival, growth and/or reproduction of harvestable fish and shellfish. 4) Finally, the benthos can concentrate contaminants (including pathogenic microorganisms) from the sediments, bottom waters and sediment pore waters. These contaminants then can pass up food webs to resource species (which may also take up contaminants directly from the sediment pore waters).

Sediment Trace Metals

We routinely determine concentrations of seven trace metals (cadmium, chromium, copper, lead, nickel, silver and zinc) in sediments. All these metals are potentially toxic to marine organisms and to man. Trace metals were sampled on 24 regional OP/NEMP cruises between 1978 and 1983. Data are available for the 1979-80 cruises and for New York Bight samples taken in 1981 and 1982, and are summarized in Figure S1. Most stations (circled in Figure S1) consistently had low concentrations of metals analysed. This is not surprising, since these stations are in areas remote from major metal inputs, and have low percentages of the fine sediments with which most contaminants are associated. Four stations (squares in Figure S1) in more depositional environments but not located near major sources of metals (except station 32, 3.5 n. mi. south of the mouth of Narragansett Bay), have finer sediments with slightly higher concentrations of all metals. The most contaminated locations sampled are the three stations (41-43) in the inner New York Bight.

Beginning in 1980, we have monitored metal contamination of sediments at 40 or more standard sites in the Bight each summer. Since 1982 the surveys included intensive sampling near dumpsites. This added effort was an attempt to separate influences of the major sources (sewage sludge and dredged material dumpsites, Hudson-Raritan plume) on contaminant concentrations and effects. At most of the standard Bight sampling sites, metal levels in surface sediments did not change appreciably among the summers of 1980, 1981, and 1982. We previously reported a lack of major changes in metal concentrations between 1973-74 and 1980 (Reid et al. 1982), so it now appears that the inner Bight has been in a "steady state" of metal contamination for at least a decade.

Baseline values for trace metals were also established for Casco and



STATION OR SYMBOL	Ag	Cd	Cr	Cu	Ni	Pb	Zn
○	≤.25	≤.25	1-12	.25-4	.5-6	1-10	3-24
60	≤.25-.45	≤.25-.48	5-17	2-7	3-8	6-17	25-48
□	≤.25-.40	<.25-.40	8-33	3-15	4-24	10-20	28-70
41	≤.25-2.8	≤.25-4.1	11-91	5-117	1-12	25-95	15-200
42	≤.25-5.4	≤.25-5.2	16-92	45-178	3-51	35-175	33-310
43	≤.25-3.3	≤.25-2.7	4-114	11-110	5-21	15-85	30-270

Figure S1. Ranges of metal concentrations (ppm, dry wt.) in the top 5 cm of surface sediments, from NEMP monitoring stations, 1979-1980 (1981 and 1982 data are included for stations 41-43).

Penobscot bays (Larsen 1985). The values were compared to existing data for other New England estuaries. Except for cadmium, trace metal concentrations in both bays were well above presumed preindustrial levels. Mean concentrations of chromium, copper and lead were similar to levels in other industrialized New England areas. Nickel and zinc levels in Penobscot Bay were the highest yet recorded for a New England estuary, contradicting a common perception that the estuaries of Maine have been little affected by industrialization.

Sediment Organic Contaminants

In addition to the toxic trace metals, there are numerous organic compounds which can be harmful to marine life and to man. Of these, the NEMP has concentrated on PCBs and PAHs, both of which are 1) relatively toxic and persistent in marine environments, 2) taken up and accumulated in food webs leading to man, and 3) carcinogenic, at least in laboratory animals.

The NEMP has collected considerable information on concentrations of PCBs in northeastern sediments. Ranges of values found for each area and sampling period are given in Table S1. Highest values (to 1150 ppb) were found near the sewage sludge dumpsite in the New York Bight. This concentration is lower than the maximum (2200 ppb) reported by West and Hatcher (1980) for the same area. Next highest values (to 450 ppb) were found in Boston Harbor.

Boehm et al. (1984) calculated that the total mass of PCBs in Boston Harbor-Massachusetts Bay sediments was greater than in the New York Bight by a factor of perhaps five, and PCB concentrations per km^2 were also much greater in Massachusetts Bay (the differences are not solely due to different quantities of input, but are also related to the greater amounts of contaminant-trapping fine sediments in Massachusetts Bay).

Maximum PCB concentrations of 100 ppb or more were also found in Casco Bay (with values to 340 ppb in Portland Harbor), Penobscot Bay and the deep Gulf of Maine. No concentrations as great as 100 ppb were found in limited sampling at the mouth of Chesapeake Bay, the Philadelphia Dumpsite, Hudson Shelf Valley, Hudson Canyon, the Mud Patch, outer Buzzards Bay, Cape Cod Bay and Georges Bank.

In the Portland Harbor-Casco Bay surveys, an increase in PCBs was noted for 1981-83 where sediments had been relatively free of PCB contamination during the 1980 baseline sampling. Several other areas listed in Table S1 also showed apparent changes in concentrations of PCBs over time. These differences may be related to slight variations in sampling locations, combined with effects from spatial "patchiness" of sediments and their contaminants.

Analyses of PAHs were completed for a subset of the samples in which PCBs were measured. Spatial trends in PAH contamination generally paralleled those for PCBs. As with PCBs, Boehm et al. (1984) reported the total mass of PAHs in Massachusetts Bay to be greater than in the New York Bight by about a factor of five, with elevated concentrations more widespread than in the Bight. Concentrations of PAHs per km^2 were not higher in the Bay than in the Bight, in contrast to the findings for PCBs. The highest concentration of

Table S1. NEMP measurements of total PCBs in sediments, 1980-83 (ppb, dry wt.). Data on first line are ranges of values found. (Numbers of stations sampled/replicates per station) are indicated on second line. ND=not detected.

LOCATION	YEAR			
	1980	1981	1982	1983
Penobscot Bay (Larsen 1985)			<100-200 (49/1)	
Casco Bay (Larsen 1985)	ND (29/1)	50 (1/1)	100 (1/1;Feb) 50 (1/1;Jul) 40-50 (1/2;Dec)	40-100 (1/6)
Portland Harbor (Larsen 1985)	ND (3/1)	210 (1/1)	250 (1/1;Feb) 340 (1/1;Jul) 80-110 (1/2;Dec)	110-320 (6/1-2;Aug) 80-200 (1/6;Sep)
Massachusetts Bay (1981, Jan 1982 from Boehm 1982a; Nov 1982 from ERCO 1983; 1983 from Boehm et al. 1984).		1-12 (1/5)	2.6-9.4 (1/5;Jan) 0.3-12.3 (1/5;Nov)	0.3-108 (12/5)
Boston Harbor (Boehm et al. 1984)				7.1-450 (7/5)
Cape Cod Bay (Boehm et al. 1984)				22.6-37.7 (2/5)
Deep Gulf of Maine (1981 from Boehm et al. 1984; 1983 from Larsen 1985)		1.4-11.0 (10/1)		<10-130 (19/6)
Georges Bank (1981, Jan. 1982 from Boehm 1982a; Nov. 1982 from ERCO 1983)		<0.1-1.1 (1/5)	<0.1-0.4 (1/5;Jan) <0.1-1.9 (1/5;Nov)	
Mud Patch (1981, Jan. 1982 from Boehm 1982a; Nov. 1982 from ERCO 1983)		0.6-30 (1/5)	0.6-7 (1/5;Jan) 2.3-4.6 (1/5;Nov)	
Buzzards Bay (1981, Jan. 1982 from Boehm 1982a; Aug.,Nov. 1982 from ERCO 1983; Sep. 1982 from Boehm 1983)		2-20 (1/5)	32-50 (1/5;Jan) 52-69 (1/5;Aug) <0.1-105 (3/5;Sep) 6.4-45 (1/5;Nov)	
Long Island Sound	9.5-52 (2/1)		139-450 (1/5;Jan)	
New York Bight (Inside 60 m) (1980 from ERCO 1980; 1981 from Boehm 1982b; 1982 from ERCO 1983; 1983 from Boehm et al. 1984)	<0.1-160 (35/1)	0.5-430 (39/1)	<1-1150 (6/5;Sep) 155-812 (1/5;Nov)	3.0-150 (6/1)
Hudson Shelf Valley (60-200 m) (1980 from ERCO 1980; 1981 from Boehm 1982a, 1982b and Boehm et al. 1984; 1982 from ERCO 1983; 1983 from Boehm et al. 1984)	<0.1-6.6 (3/1)	1.4-38 (15/1-5)	0.1-9.8 (1/5;Jan) 1.4-5.1 (1/5;Sep) 0.4-5.0 (1/5;Nov)	3.8 (1/1)
Hudson Canyon (Boehm et al. 1984)		2.9-13 (6/1)		
Philadelphia Dumpsite (1981, Jan. 1982 from Boehm 1982a; Aug., Nov. 1982 from ERCO 1983)		0.4-0.6 (1/5)	0.8-3.2 (1/5;Jan) 6.3-58 (1/5;Aug) 0.1-2.0 (1/5;Nov)	
Mouth of Chesapeake Bay (1981, Jan. 1982 from Boehm 1982a; Aug., Nov. 1982 from ERCO 1983)		0.1-0.7 (1/5)	<0.1-0.9 (1/5;Jan) 0.5-2.8 (1/5;Aug) 0.2-3.5 (1/5;Nov)	

PAHs found by Boehm et al. (1984), 880 ppm in Boston Harbor, is greater than all but one value (1791 ppm in the Severn Estuary, England) reported in Johnson et al.'s (1985) review of worldwide studies.

The NEMP also made the first PAH measurements for Casco and Penobscot bays (Johnson et al. 1985). Penobscot sediments had 0.1-5 ppm PAHs (wet weight), which is in the same range as most sediments from the New York Bight, Buzzards Bay and Massachusetts Bay. Some Casco Bay concentrations were much higher (to 232 ppm wet weight). Samples from the Gulf of Maine were toward the low end of concentrations of PAHs reported worldwide.

Sediment Microorganisms

We have monitored several groups of bacteria (total and fecal coliforms and an anerobic spore forming species, *Clostridium perfringens*[1]) which can indicate fates of sewage-related materials and presence of less easily detected microorganisms which may be pathogenic (*C. perfringens* itself can cause food poisoning and infections). Samples have also been analyzed for a type of marine bacillus bacteria (several species of which are known to be pathogenic to both marine animals and man), as well as for pathogenic viruses and *Acanthamoeba*, an amoeba (protozoan) which can be harmful to man.

Distribution of *Clostridium* on the northeast shelf was consistent over the first five years of NEMP sampling. Highest counts (100,000 or more per ml of sediment) occurred just west of the New York Bight sewage sludge dumpsite. Next highest levels were found in the upper Hudson Shelf Valley, indicating a migration of sludge to that area, agreeing with our earlier results and those of Cabelli and Pedersen (1982). High counts were also recorded in Massachusetts Bay and, surprisingly, off the New Hampshire estuaries, reflecting waste inputs to coastal waters there.

Fecal coliform abundances in surface sediments of the New York Bight have also had a consistent pattern, in summer surveys from 1980-83 and as compared to 1971-75 abundances (Reid et al. 1982). The several years of coliform and *Clostridium* data, like the sediment metals data, indicate little recent change in contamination of the inner Bight.

The various marine bacillus species have been detected only in low concentrations. Highest densities were at the mouths of estuaries, followed by other inshore areas.

The NEMP has monitored microorganisms at the Philadelphia sewage sludge dumpsite (about 40 n mi east of the Delaware-Maryland border) before and after dumping stopped there in November 1980. Cooperative annual surveys with EPA and FDA showed that by June 1983, sediments in and near the dumpsite either were negative for sewage-associated bacteria, or had densities within acceptable limits for shellfish harvesting. The potentially pathogenic amoeba species was found in sediments at 35% of 23 stations sampled during summer 1980. Occurrence dropped to 6% by summer 1983, and in summer 1984 samples from 44 stations revealed no specimens. Based on the bacteria and amoeba

[1] The text uses only common names for all species except microorganisms. Appendix 5.6 lists common and scientific names of all species discussed.

data, we concluded that pathogens no longer were a significant health threat at the site, and FDA recommended that the site be reopened to shellfishing. The findings have generic applicability, i.e., if like quantities of similar quality sludge were dumped at other sandy midshelf sites, recovery could be expected within three to four years after disposal ceased.

Benthic Macrofauna Community Structure

The NEMP, and the earlier OP program, have monitored bottom-dwelling invertebrate communities at 25 sites on the northeast shelf at least twice a year from 1978 through 1984. Earlier data are available for several stations, e.g. the baseline extends from 1955 for the Buzzards Bay station. The annual New York Bight surveys since 1980 have also included benthic macrofauna sampling. We have concentrated on analyzing 1) patterns in numbers of species and of amphipod crustaceans (both of which usually decrease with increasing pollution stress over space and time); 2) abundances of the 10 numerically dominant species for each station and sampling; and 3) overall composition of the benthic community, using classification (cluster) analysis.

Mean numbers of species and amphipods have been stable at offshore monitoring stations. Figure S2a shows consistent mean values during 1974-83 for a swale (trough between two sand ridges) about 60 n. mi east of southern New Jersey (a scarcity of amphipods in July 1979 is thought to be due to missing the swale during sampling, because a dense population was found again two months later). This station is in the Baltimore Canyon Trough, an oil exploration area on the outer shelf. Although far from most direct contaminant inputs, the BCT station is considered "transitional" or "early warning" because it is in a swale and thus has a greater tendency to accumulate fine sediments and associated contaminants. There are several other "transitional" stations in the regional sampling pattern: in the mid-Hudson Shelf Valley; off Fire Island, Long Island; in the "Mud Patch" south of Nantucket; and in a depression just east of Long Island Sound. Species richness, amphipod densities, and cluster analysis have not shown major changes or contaminant effects at these stations over the time for which data are available. Since effects have not been seen at the "transitional" stations, they are not expected in the other offshore areas we monitor, and, in fact, none were evident in the species richness, amphipod or cluster data.

Contaminant and/or enrichment effects have been most apparent in the inner New York Bight, where we have consistently found lowest numbers of species and a scarcity of the relatively sensitive Crustacea. This is illustrated in Figure S2b, which shows numbers of species and amphipods over time for a station at the northwest corner of the sewage sludge dumpsite. Most sludge dumped in this area is carried into deeper waters. The fauna of the dumpsite is thus exposed to high contaminant concentrations but not major physical alteration of the sediments (though there may be storm-related sediment movement). Faunal conditions at the dumpsite are therefore undoubtedly related to the contamination of the site. The lack of clear trends in numbers of species and amphipods at the dumpsite from 1973 to 1984 agrees with the above findings for sediment metals and bacteria. All these data indicate the inner New York Bight has been in an equilibrium state of degradation for at least the past decade.

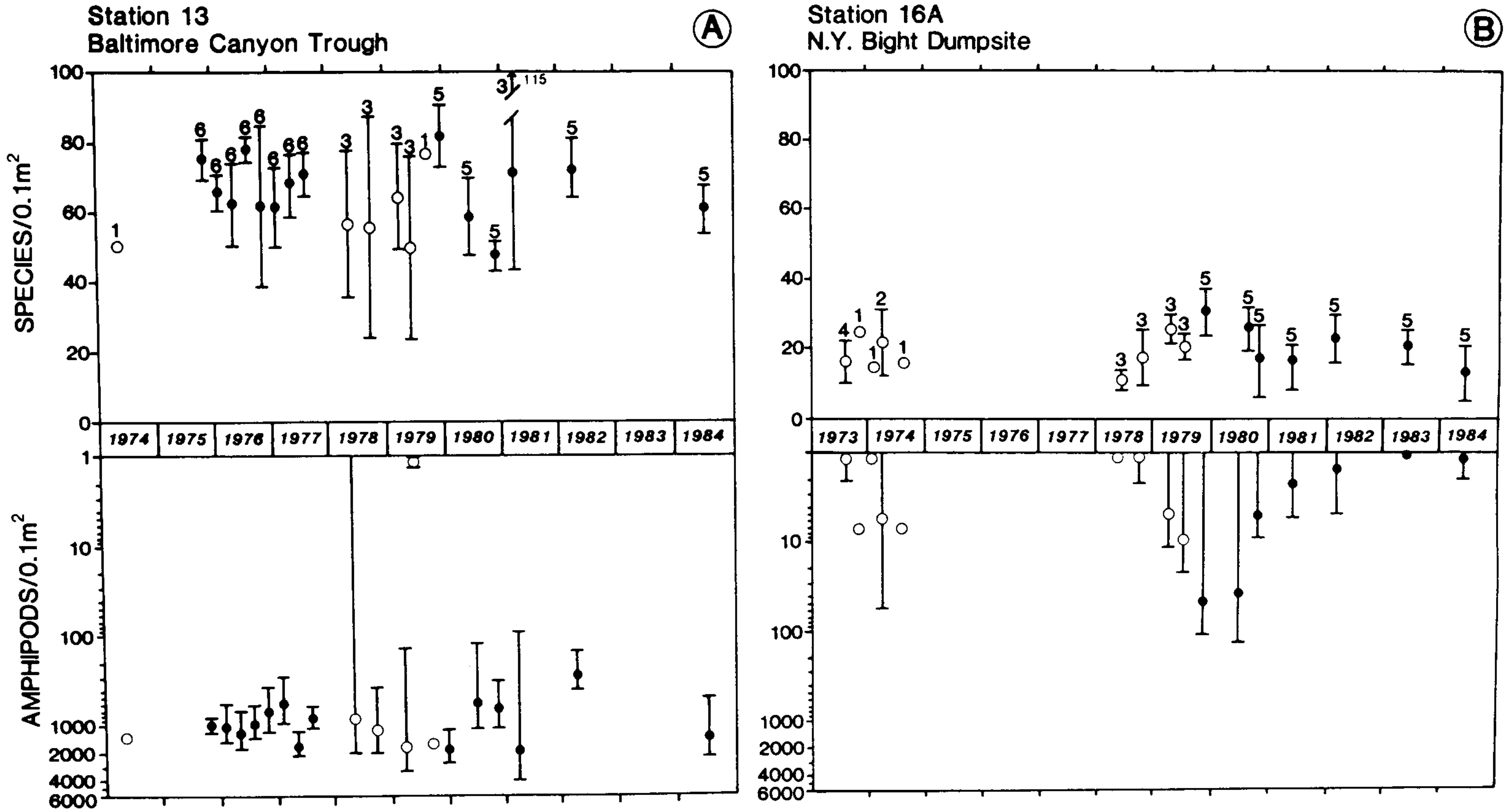


Figure S2. Means and confidence limits for numbers of species (upper graphs) and amphipods (lower) collected at NEMP stations in the Baltimore Canyon Trough (A) and at the New York Bight sewage sludge dumpsite (B). Numbers of samples analysed are indicated above the confidence limits for species richness. Open circles indicate 1 mm sieves used; otherwise sieves were 0.5 mm.

In addition to the regional and New York Bight surveys, the NEMP has used intensive sampling to establish macrofauna baselines in the following areas:

Area	Dates	Methods and Comments
Penobscot Bay, ME	1982-1984	Standard[2] semiannual sampling at 2 stations after preliminary single-grab survey of 50 stations
Casco Bay, ME	1980-1984	Standard semiannual sampling at 2-6 stations after preliminary single-grab survey of 56 stations.
Deep Gulf of Maine	1983-1984	Standard; 31 stations sampled once (samples archived)
Pigeon Hill, on Jeffreys Ledge (deep Gulf of Maine)	1977-1983	SCUBA - annual sampling and photography at 108 and 138 ft. depths.
Isles of Shoals, New Hampshire (shallow Gulf of Maine)	1975-1983	SCUBA - monthly to semiannual sampling and photography at 25, 60 and 100 ft.
Massachusetts Bay	1983	Standard one-time sampling at 20 stations.
Submarine Canyons south of Georges Bank	1972-84	Submersible observations, annually or more frequent, and photography, mostly in Lydonia, Oceanographer and Veach canyons.
Block Island, NY	1981-83	SCUBA - annual sampling and photography at two permanent and variable numbers of random transects.
"Norfolk" Dumpsite (17 mi east of mouth of Chesapeake Bay)	1979-83	Standard sampling (except using Shipek grab or box corer) at 5 stations, 4-5 times/year.

[2] "Standard" methods: Smith McIntyre sampler, 0.5 mm sieve, 5 replicate grabs/station.

If the above areas are resampled using the same methods, comparisons with existing data will aid in detecting trends in the effects of natural and man-induced environmental changes over time.

Seabed Oxygen Consumption

Sediment cores were incubated aboard ship at ambient bottom water temperatures to determine rates of oxygen uptake by the sediments and associated organisms. Such measurements integrate all chemical and biological responses of the seabed to changes in organic loading and other contamination. Measurements for the New York Bight were begun in 1974, for Georges Bank in 1977, and for other parts of the northeastern shelf in 1979.

Comparison of 1974-75 oxygen consumption rates for the inner Bight with 1982-83 data has revealed good agreement between changes in dumping volume (+89% at the sludge dumpsite and -63% at the dredged material dumpsite) and oxygen consumption (+57% and -36% respectively). We are now sampling the standard inner Bight stations every two months. This sampling, together with continued annual monitoring of sediments, contaminants and benthos, will help determine the rate and extent of the recovery process as dumping is phased out at the sewage sludge site. Such data can be used to model effects of any new dumping activities in similar waters.

Surf Clam Ecology

The surf clam is the most important shellfish species in the Middle Atlantic Bight in terms of value of annual harvests. We have been conducting field observations and experiments on the ecology of surf clam beds, to assess potential growth of clam populations and factors limiting that growth. Trays of sediments with various grain sizes and contaminant loads are placed on the bottom in the inner Bight, and effects on settlement of larval clams and other invertebrates are recorded. Early results indicate that settling surf clams avoid fine sediments but not coarse ones in which high sulfide-low oxygen conditions have been experimentally created. Surf clams and most other invertebrates had low densities of settling larvae in sediments with domestic sewage sludge or domestic sludge with industrial wastes added.

Several years of observations have also documented the significance of predation on surf clam populations. We estimate at least 99% of all surf clams which set are consumed, especially by rock crabs and calico crabs. The increased understanding of recruitment dynamics can improve clam management by facilitating predictions of future stock sizes. The studies may suggest new management techniques to increase clam abundance, such as control of predators and contaminants.

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3.2.3 Trace Contaminants in Tissues - Adriana Cantillo, Coordinator

Introduction

One of the goals of the NEMP is to determine and/or confirm the existing levels, trends and variations in the concentrations of contaminants in biota, and the effects of these substances on living resources. Body burdens of contaminants can be relevant because of possible effects on the well-being or survival of marine organisms, and on human consumers of seafood containing contaminants. The contaminants of principal concern in the NEMP body burden studies are a suite of trace metals, petroleum hydrocarbons (PHCs), particularly PAHs, and chlorinated hydrocarbons, especially PCBs.

Description of data sets and results

During the past 5 years, extensive surveys of the levels of toxic trace metals and trace organics in various species of fish and shellfish collected in northeast U.S. waters have been undertaken by the NEMP. At this writing, many of the biological samples collected are yet to be analyzed. A summary of trace metal and trace organic concentrations found in the tissues of various species, and the data sources, is given in Appendices 5.7 and 5.8.

Prior to the NEMP, Greig et al. (1978) determined Ag, Cd, Cu, Hg, Ni, Pb and Zn in scallops collected in the northeast. Geographical trends were not evident; differences in the level of Cd and Zn were related to sex. Some of these results are confirmed by data from a monthly scallop survey during 1981 (Zdanowicz unpublished data) sampling the same scallop population, located about 10 miles east of Asbury Park, NJ, on the southern side of the Hudson Shelf Valley. Trace metal concentrations increased in the order: muscle < (less than) gonad < gill < viscera (Figure C1). The temporal variations of Ag, Cd, Cr, Cu, Ni and Pb in gonad and viscera are shown in Figure C2. Cadmium levels in gonad decreased over the summer, reaching a minimum in September, while Cd levels in viscera increased. There may be other relationships in the data, such as an inverse covariance between gonadal Ni and Cu.

The concentrations of Ag, Cd, Cr, Cu, Hg, Ni, Pb and Zn in the tissues of windowpane flounder, winter flounder, sea scallop and rock crab collected in the Northeast during various NEMP cruises were reported by Zdanowicz and Ruiz (1981). Levels of all the metals increased in the order muscle < gonad, liver << (much less than) scallop viscera. Comparison of tissue trace metal levels was possible for four species collected in four areas of the Northeast. These were : a) winter flounder, windowpane flounder, rock crab and sea scallop from the New York Bight; b) winter and windowpane flounder from Rhode Island Sound and Georges Bank; c) rock crab from Long Island and the Delaware shelf; and d) sea scallops from the New Jersey and Long Island shelf areas. The authors found no geographical correlations. In a similar study reported in Zdanowicz and Bruno (1982a), correlations between Ag and Cu, and Zn and Cu, were observed.

Ocean quahogs collected in the Northeast were analyzed for PCBs, PAHs, PHCs, Ag, Cd, Cr, Cu, Ni, Pb and Zn (Steimle et al. in press). Observed levels of PCBs ranged from 2 to 30 ppb wet weight. Ocean quahogs from Georges Bank and Nova Scotia were minimally contaminated (2-5 ppb wet weight). Ocean quahogs from nearshore in the New York Bight, Rhode Island Sound and Buzzards

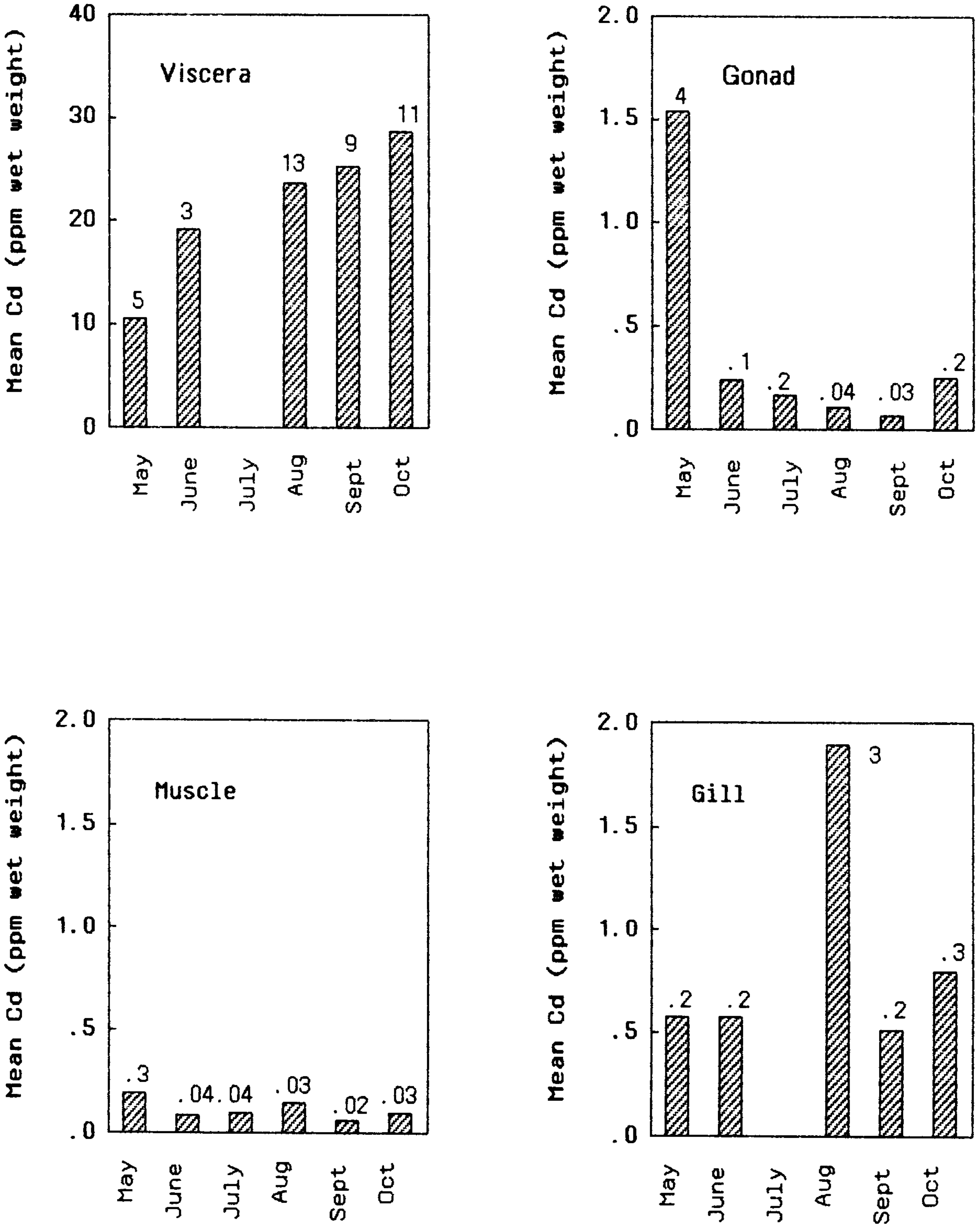

Figure C1. Mean Cd (ppm wet weight) in viscera, gonad, muscle and gill of sea scallops collected during cruises of the R/V KYMA in 1981 [Value above bar is the standard deviation] (Zdanowicz unpublished).

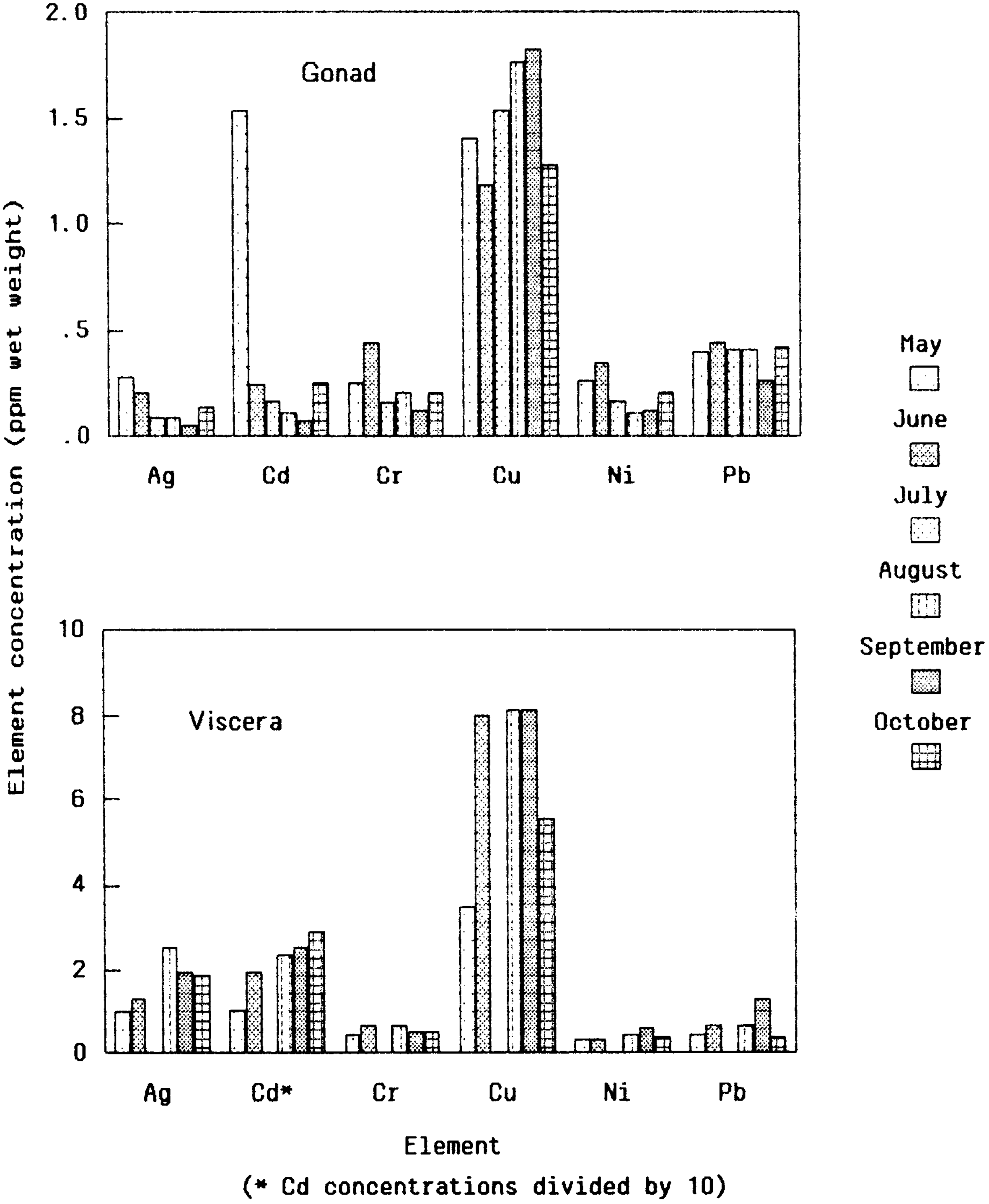

Figure C2. Trace element concentrations in gonad and viscera of sea scallop (Zdanowicz unpublished).

Bay were more contaminated, with values up to 25 ppb wet weight, although still well below the U.S. Food and Drug Administration (FDA) "action level" of 2 ppm. Levels of PCBs were relatively uniform, ranging only over one order of magnitude. There was also homogeneity of PHCs and PAHs, with concentrations ranging from 0.8 to 7.3 ppm wet weight and <1 to 55 ppb wet weight, respectively. The mean PAH value measured over the Northeast was 16.7 ± 12.0 ppb wet weight. The composition of the PAHs, however, varied considerably, ranging from 0 to 81% "petroleum" PAHs (as contrasted to PAHs from combustion sources). PCBs also showed differences in abundances of congeners (similar molecules in different configurations). The highest mean Ag, Cr, Cu and Pb concentrations were in the New York Bight, with Ni and Zn highest in the "Mud Patch", and highest Cd values off Delaware. Lowest concentrations were at mid-shelf stations off New Jersey and Maryland (except at stations near dumpsites).

Concentrations of Cd, Cu and PCBs were determined in mussels collected from the mouths of various rivers and inshore areas along the Connecticut shoreline of Long Island Sound (Greig and Sennefelder 1985). The levels of PCBs in mussels from all ten stations sampled were low, with means ranging from 0.05 to 0.12 ppm wet weight. The concentrations at the upper end of the range, 0.08 to 0.12 ppm, were found at only four stations. All these concentrations are well below the 2 ppm FDA limit. The Cu levels in mussels were low, with means ranging from 1.0 to 2.3 ppm wet weight. The Cd levels were also low, ranging from 0.41 to 1.3 ppm, except for Bridgeport, CT, where the mussels had a mean Cd level of 5.1 ppm wet weight. The FDA does not have action limits for Cu and Cd. Mackay et al. (1975) report a recommended maximum level of 2 ppm Cd for seafood in Australia. Thus the mussels from Bridgeport exceeded the Australian Cd limit.

In a related study, the stomach contents and livers of windowpane flounder were collected at various times of the year in Long Island Sound and analyzed for PCBs, Ag, Cd, Cu and Pb (Greig et al. 1983). The PCB levels ranged from 0.88 to 2.3 ppm wet weight in livers, and from 0.03 to 0.45 ppm wet weight in stomach contents. Levels of PCBs in liver varied little with season. There was no clear trend in the levels found in stomach contents. There were differences in mean levels of the trace metals among the three stations sampled in the Sound. Variation in fish from the same station, however, was too great to allow firm conclusions regarding either differences between stations or seasonal variability.

Soft clams from New Bedford Harbor were analyzed for PHCs, specific PAHs and PCBs (ERCO 1983a). The PCB concentrations were high, ranging from 0.75-13.7 ppm wet weight, compared with concentrations in other areas (Appendix 5.8). Saturated hydrocarbons ranged from 34-362 ppm wet weight, and PAHs from 5.3-73 ppm wet weight. These concentrations are also high compared to other areas.

Body burdens of PCBs were determined as part of a comprehensive survey of PCBs, PAHs and coprostanol in Boston Harbor, Massachusetts Bay and Cape Cod Bay (Boehm et al. 1984). Rock crab, winter flounder and American dab were analyzed. The levels of PCBs were greatest in crabs and lowest in dabs. The PCB levels of crabs from Boston Harbor were about four times those from Massachusetts Bay and about twice those in Cape Cod Bay. All these PCB concentrations were at least one order of magnitude below the FDA action limit. These samples were also analyzed for PAHs and elevated levels were only in the crabs, which ranged from 28-1840 ppb wet weight. The highest levels were in crabs from Boston Harbor.

Selected finfish and benthic epifaunal samples were collected as part of the Gulf and Atlantic Survey and analyzed for PHCs, PCBs, DDTs and PAHs in edible flesh (Boehm and Hirtzer 1982). Most silver hake samples contained detectable PHCs, with levels from 6 to 90 ppm wet weight. The high incidence of PHC contamination (86% of the samples collected) was unique among the species analyzed. PHC concentrations in silver hake increased with decreasing distance from the New York Bight Apex, indicating a potential gradient from pollutant sources. A similar pattern was observed for PCBs. These patterns were not observed in red hake or in any other species sampled. Other finfish samples contained very low levels of the chemicals. Of the benthic epifauna sampled, only lobsters and rock crabs contained elevated amounts of PCBs and DDE (a product of DDT breakdown).

Two benthic species from Buzzards Bay, the false quahog clam and the American lobster, were analyzed for PCBs (Boehm 1983). Our findings indicated that little of the contamination from the heavily impacted New Bedford Harbor/Acushnet River region enters the fauna of Buzzards Bay proper. The PCB levels in clams ranged from 0.021-0.05 ppm wet weight, and in lobsters from 0.02-0.09 ppm wet weight. The PCB composition varied between species, probably a result of feeding behavior and metabolic transformations. The clams contained a range of PCB compounds similar to those in surface sediments, but also trichlorobiphenyls and tetrachlorobiphenyls. Lobsters contained primarily hexachlorobiphenyls.

Several fish species and a crab species from the Hudson-Raritan estuary were analyzed for PCBs and dioxin (Boehm and Steinhauer 1984). Samples were collected at the Manhattan piers, Kill Van Kull and the north shore of Raritan Bay. The PCB concentrations ranged from 0.07 to 0.25 ppm wet weight. No distinct geographical trends were apparent. The concentrations found in winter flounder tissue were greater than in fourspot flounder from the same area. Dioxin (2,3,7,8-TCDD) was detected only in samples from Kill Van Kull where the concentrations ranged from undetectable to 3.1 parts per trillion wet weight.

Gadbois (1982) determined the concentrations of PCBs and PAHs in the edible tissues of several finfish and shellfish species. The PCB concentrations were low and remained fairly constant between species and stations. In flounders, liver tissue had higher PCB levels than muscle tissue. The fourspot flounder had the lowest concentrations, followed by windowpane flounder and winter flounder. The total PAH concentrations in muscle ranged from 2 to 45 ppb wet weight for finfish and 13 to 282 ppb wet weight for shellfish. No dominant PAH was found. Sand lance from Stellwagen Bank contained <0.1 ppm PCBs, and PAH concentrations were also low.

Gadbois (1983) determined PCBs and PAHs in Atlantic mackerel collected from near Point Pleasant, NJ, and other northern and southern areas of the New York Bight. The Point Pleasant fish were also used for physiological studies at the NMFS Milford Laboratory. Full data interpretation as related to possible physiological variations has not been completed, but analysis of the northern and southern mackerel showed that liver samples contained the largest concentrations of PCBs, followed by the ovaries, kidneys and muscle. The northern group had slightly higher levels than the southern group.

As part of a two-year study, Boehm (1982b) analyzed nut clams and two species of worms (red-lined and flabelligerid) for PCBs, PAHs and PAEs (phthalate acid esters). The ratio of PCBs in worm tissue to PCBs in sediment on a wet basis was 0.4 when the concentration of PCBs in sediments was less than approximately 1 ppm. This bioconcentration factor (BCF) decreased with increasing sediment PCB level, indicating no direct relationship between bulk sediment level and tissue level. The tissue levels appear to be controlled by transport of PCBs from sediments to interstitial waters. The BCF of various PCB isomer groupings varied from station to station. The BCF for DDT in worms was approximately equal to that for PCBs. The BCF for PAHs increased slightly with increasing size of PAH molecule, but was less than predicted from octanol-water partition studies. PAEs were bioconcentrated only marginally less than PCBs, with a much greater BCF than expected. The BCF for PCBs for the clams was generally low, in spite of high levels of PCBs in sediments. Clams bioconcentrated PAHs much more than worms did, with the heavier PAH molecules being bioconcentrated to a much larger extent.

Boehm (1982a) analyzed haddock from Georges Bank for PHCs (including specific alkanes), PCBs and DDTs. Both individual fish and poolings of different numbers (6, 12 and 30) of adult and juvenile fish were used. PCB and *S*DDT levels in adult haddock were greater than in juveniles by a factor of 2-3. The levels of PHCs were the same in juveniles and adults. The data on PCBs, *S*DDT, PHCs and PAHs show the mean of triplicate analyses of tissue poolings from 6 individuals yields a valid baseline data point for chemical body burdens in fish. This conclusion may not be valid for highly polluted scenarios such as spills and discharges. It is also unclear whether these results can be extrapolated to benthic species.

The data on the concentrations of trace metals and trace organics in tissues of animals collected in the Middle Atlantic Bight have not been fully examined for temporal and spatial trends and correlations with other NEMP studies. Some of the samples collected are unanalyzed so integration of the various data sets is incomplete. Greig et al. (1978), Steimle et al. (in press) and others have begun to compare trace organic and trace metal body burden data collected by NEMP. Such comparisons of NEMP data sets will add to understanding of the interrelation of chemical and biological processes.

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3.2.4 Biological Effects - Edith Gould, Coordinator

Introduction

The primary purpose of NEMP's biological-effects monitoring effort is to detect and measure pollutant effects in key marine resource species. The intent is to identify present and potential "trouble spots" in coastal and offshore waters. From a manager's viewpoint, pollutant effects can diminish a fishery stock through mortality and loss of reproductive efficiency, which can lead to its collapse. From the fishery industry's standpoint, pollutants can reduce marketability of seafood through tainting and accumulation of contaminant concentrations thought to be hazardous to consumers. The NEMP monitoring effort, therefore, emphasizes the collection of data from animals in the field, supported by carefully designed field studies and by controlled, relevant laboratory studies to aid in interpreting field data.

This five-year Summary of NEMP's monitoring is divided into four main categories: 1) The impact of pollutants on animal metabolism and how this may affect health, survival and ability to reproduce (Physiology and Biochemistry); 2) the frequency of mutational defects, and how this could affect stock recruitment (Genetics); 3) the occurrence and frequency of disease, and measures of resistance capacity (Pathology and Immunology); and 4) the general response of selected animals to a contaminated environment, and response effect on survival (Behavior).

Physiology and Biochemistry

Four flounder species (winter, summer, yellowtail, windowpane) have been collected seasonally over the past five years at 25 NEMP stations from the Gulf of Maine to Cape Hatteras. From these samplings, we have amassed baseline data on flounder hematology. Early observations, confirmed in subsequent years, established that abnormal blood values are most consistent in flounders from inshore stations (e. g. Plum Island, off northern Massachusetts; Massachusetts Bay; Long Island Sound). Windowpane flounder taken for the past three years along a pollutant gradient in Long Island Sound corroborated the NEMP broad-scale cruise results. Fish from the most polluted, western part of Long Island Sound differed most from those collected at a "clean" station. Concurrent laboratory metal-exposure studies provided data on metal effects for use in interpreting field observations.

Potentially useful tools for monitoring were found in a simple, established technique and in a new one. Work with blue mussels deployed at dumpsites (central Long Island Sound, New York Bight Apex) and along pollutant gradients (Narragansett Bay) showed gill tissue respiration paralleled the more labor-intensive scope-for-growth measurements. The former technique thus proved its usefulness as a rapid screening tool. Lobsters held in cages at a dredged material dumpsite near New Haven had a stronger and more frequent rate of backflushing their gills, or "coughing", than lobsters at control sites. This new technique can assess relative pollutant levels in water and sediments.

Activity of a flounder kidney enzyme called G6PDH serves as another indicator of pollutant stress in these fish. High values (> 80) indicate a stimulatory response to sublethal toxicant stress which was found in flounder (winter and windowpane) taken in Buzzards Bay, the NY Bight Apex and Block Island Sound, and at the mouth of Delaware Bay. The condition is reversible in fish that move to cleaner waters.

Monitoring offshore populations of sea scallops for the past 5 years has produced two separate conclusions. The first is that nutritionally deficient scallops at deepwater (135-200 m) sites in the Gulf of Maine lack glycogen reserves necessary for successful spawning. Muscle glycogen remains low throughout the year except for a slight increase in winter that suggests gamete resorption. This observation has been made repeatedly since 1980, and we have concluded that such populations do not reproduce themselves.

The second, first seen in 1981, has since been confirmed by sporadic collections at NEMP stations. Biochemical stress parameters (muscle glycogen and marker enzyme GDH; kidney marker enzymes G6PDH, IDH, MDH) indicate most offshore marine habitats are healthy, but a few scallop populations may not support a commercial fishery without endangering recruitment.

A continuing study of laboratory metal exposures has shown that copper (20 ppb, 7 wk) strongly inhibits the reproductive process in sea scallops, and indeed reverses it, simultaneously producing lethal effects in the kidney. A similar cadmium exposure produced neither effect.

Preliminary work with another biochemical parameter, the adenylate energy charge (AEC) in the soft-shelled clam, found AEC values in clams caged in Raritan Bay and Arthur Kill significantly lower than in clams held at a control station (Mt. Sinai Harbor, L.I.). Results suggest a long-term adaptive response for natural clam populations in Raritan Bay. Lipid values remained fairly constant throughout the study, but glycogen concentrations varied seasonally, possibly related to gamete production.

A general model was developed for relationships among temperature, RNA-DNA ratios, and growth rates of temperate marine fish larvae. With a better understanding of factors affecting the RNA-DNA ratios, the ratios may be useful in assessing larval health and predicting growth and survival.

An inverse correlation existed between survival of striped bass larvae reared in the laboratory and body burdens of a wide variety of organic contaminants in female parents taken from several rivers (including the Hudson, Nanticoke and Choptank) and hatcheries of the eastern U.S. Differences in the condition indices of juvenile (age-0) striped bass from the same rivers and hatcheries included swimming stamina, relative liver weight, tissue chemical composition, backbone mechanical properties, and histopathology. Symptoms of poor condition in Hudson River fish were consistent with exposure to stress, possibly contaminant-induced.

Genetics

Field studies on embryo cytopathology and on mutations in embryo, juvenile, and adult resource fish suggest that present levels of coastal pollution can adversely influence recruitment. Studies of reproduction in these fish should not be conducted without some consideration of the pollution factor. Mitotic spindle effects and abnormal division of the chromosomes more frequently account for the higher incidences of chromosome mutation found in some areas than does any increase in chromosome breakage.

Multivariate statistical analysis was performed on cytogenetic, biological, chemical, and physical oceanographic data sets for eggs of Atlantic mackerel taken from 20 variously polluted or clean sites in the New York Bight over the past several years. Aromatic hydrocarbon pollutants and salinity together were associated with adverse conditions in all stages of embryo development: mortality, gross anatomical abnormality, developmental delay, and mitotic chromosomal abnormality. Trace metals were associated with malformation of the mid-states of embryo development. Non-PCB chlorinated hydrocarbons and PCBs, with temperature, were associated with adverse effects at later stages of embryo development. Other, related studies on petroleum spills point further to the vulnerability of fish embryos floating near the sea surface.

Pathobiology and Immunology

Five years of data have been obtained from radiograph analysis of 7400 sand lance from the northwest Atlantic. These data indicate that vertebral anomalies occurring in this species may be correlated with the quality of the fish's habitat. These were statistically significant differences ($P<.05$) in prevalence of these anomalies between mid-Atlantic coastal areas and the deeper offshore waters of New England. Extensive sampling of inshore New England waters is needed to test further the usefulness of this monitoring tool.

Since 1979, about 135,000 fish in ten of the most uniformly distributed species were examined for six disease conditions. Peak prevalences for any particular condition occurred inshore, reflecting the greater degradation of these areas compared to oceanic areas. For instance, 2.1% of cod inshore had fin erosion compared to 0.4% of offshore cod. Fin erosion (and liver neoplasms) appear to be reliable indicators of stress to fish populations associated with degraded environments.

Ocean mollusks (sea scallops, ocean quahogs, and surf clams) were examined histologically for parasites and pathology. Pathological responses considered indicators of site specific stress were not observed at any of 33 monitoring stations. Bacterial and other microbial infections that have seriously affected inshore sea scallops were not a problem in offshore populations.

The persistence of gill darkening in rock crabs serves as an excellent indicator of active sludge disposal, and of recovery of sea bottoms at a discontinued disposal site. The prevalence of gill darkening in rock crabs from deep waters of the Hudson Shelf Valley remained consistently high (6-19%) since 1981. In contrast, the progressive decline (17% to 0%) of black gills at the Philadelphia - Camden dumpsite is associated with the "recovery" of the site since sludge disposal ceased in 1980.

Blue mussels collected from coastal Maine to Virginia exhibited increased gill pathology (inflamation, adenohyperplasia, and ciliate infestations) at locations considered degraded (i.e. Raritan Bay, NJ; Cape May, NJ; and Searsport, ME). These gill lesions were rare or absent in mussels from all other coastal locations. Histochemical tests for copper (Cu^{++}) were negative in mussels and positive for oysters collected simultaneously from Raritan Bay, indicating that species differ as indicators of some contaminants.

During five years of using immunological methods (antibody profiles) in monitoring, bacteria isolated from the New York Bight sewage dumpsite were used as a test antigen (Stolen 1983). Fish kept in cages near the dumpsite and at cleaner locations were compared for antibody levels. As indicated by immunological competency, the condition of the dumpsite fish worsened from 1982 to 1984.

Prerecruit winter flounder experimentally infected with the protozoan Glugea stephani had high mortality. This implies a major loss to any infected flounder populations (Cali et al. 1986). The prevalence of this parasite in field-collected winter flounder remained relatively constant in the New York-New Jersey Lower Bay complex from 1981-1984 (ca. 8% annual), with a seasonal range of 3-28% (Takvorian and Cali 1984). Between 1982 and 1984, there were indications of localized high-prevalence areas along the northeast coastal areas of Massachusetts (12% on Nantucket Shoals, 38% in Cape Cod Bay, 52% in Massachusetts Bay) (Cali and Takvorian 1983).

Behavior

During the first five years of the NEMP, behavioral research was directed toward developing predictive capabilities for detecting and assessing the effects of environmental perturbations on marine and estuarine ecosystems. This included establishing normal baselines on the behavior, life habits, and habitat requirements of selected marine fishes and invertebrates, and determining how sublethal contaminant levels affect survival of the organism (Olla et al. 1980). Such effects may be reflected at the population and ecosystem levels (Figure B1). The underlying principle has been that changes in behavior of an organism would follow environmental alterations, especially those caused by man.

Blue and Dungeness crabs detected water soluble fractions of crude oil. Avoidance of oiled sediment was highly variable and apparently related to factors characteristic of the species, the oil, and the environment (Olla 1981; Olla et al. 1981; Pearson et al. 1980, 1981a). Exposure of Dungeness crabs to crude oil impaired chemosensory detection of food cues, although the competency returned after exposure to clean water.

In sediments contaminated with sublethal levels of crude oil, aberrant burying behavior and/or emergence of selected benthic organisms, e.g. hard clams, littleneck clams, sandworms, bloodworms and sand lance, increased their vulnerability to predation, which would lead to decreased survival (Olla 1981; Olla et al. 1983, 1984; Pearson et al. 1981b, 1983).

Juvenile red hake exhibited limited escape responses to introduced drilling fluids, but under prolonged exposure, their consumption of prey decreased, resulting in reduced growth rates (Olla et al. 1982).

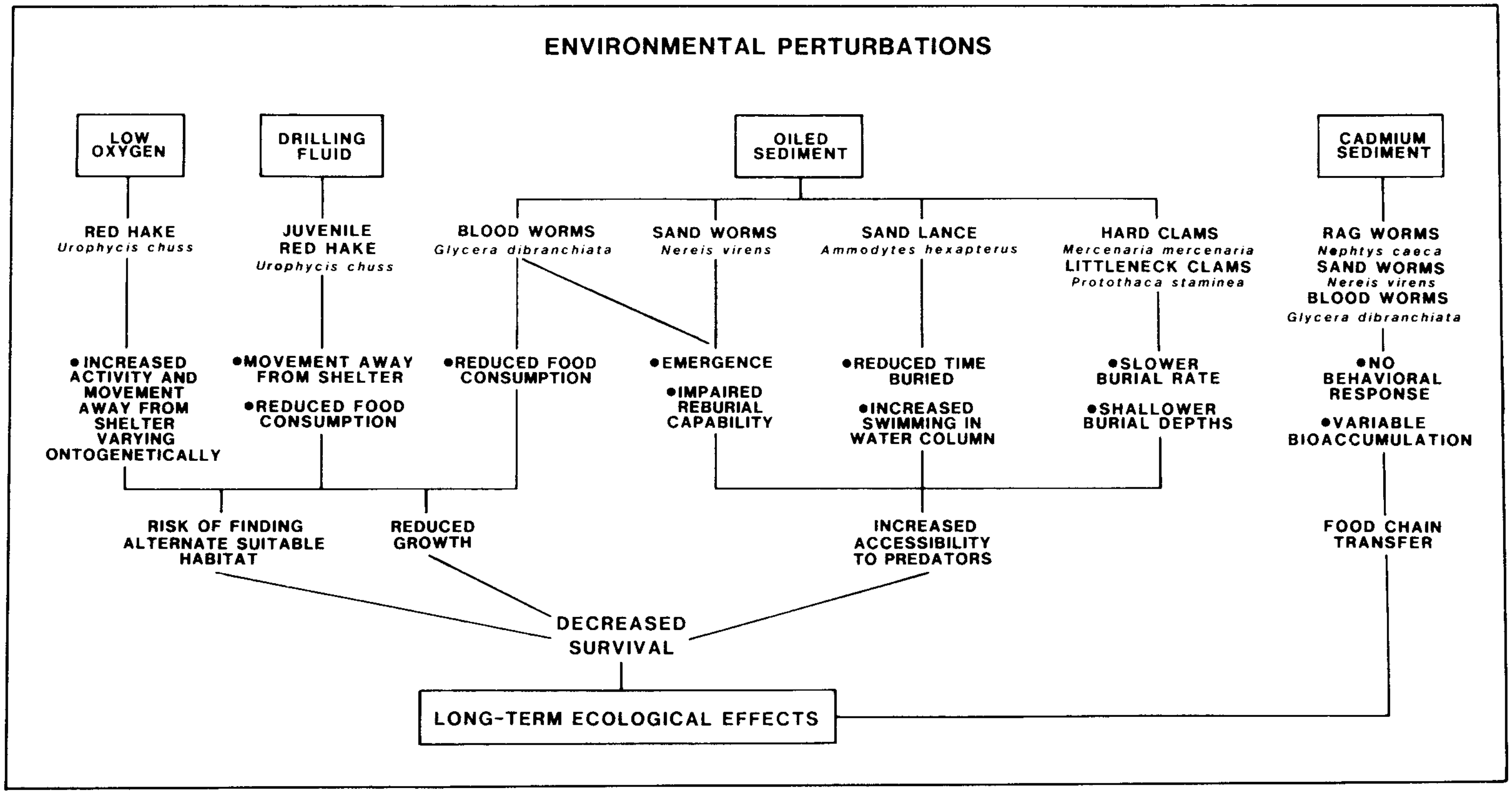

Figure B1. Comparative behavioral responses of marine fishes and invertebrates to selected environmental perturbations.

Under simulated hypoxia, red hake exhibited increases in activity indicative of avoidance, but the nature and magnitude of the response differed by age or stage of development.

Inability to avoid or mitigate behaviorally exposure to cadmium-contaminated sediment resulted in variable bioaccumulation for selected benthic polychaetes, i.e. sandworms, bloodworms, and ragworms. This poses a threat to higher trophic levels through food web transfer.

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3.3 Progress Toward Meeting Program Objectives

1. "Determine or confirm the existing levels, trends, and variations of contaminants in water, sediments, and biota and their effects on living marine organisms."

   There has been substantial progress toward determining the existing levels of trace metals and organic contaminants in sediments and biota. Measurements have been made in representative habitats over the entire Northeast continental shelf, from Cape Hatteras to Canada. Establishing trends and variations is a slower process. Data acquired can reveal only portions of longer cycles of events and changes. While the number of years of monitoring required to establish such patterns cannot yet be stated accurately, each year of data increases the likelihood of detecting and measuring important changes.

   Nutrients and other materials involved in eutrophication processes also have been monitored regularly throughout the NEMP region. These measurements, along with assessments of primary production and chlorophyll biomass, are the first sets of data in which these conditions have been studied over a broad geographic area and on a regular schedule at frequencies ranging from seasonal to monthly.

   Gradients in a series of biological effects measurements were also found. These included deleterious changes in chromosome structure, changes in biochemical and physiological responses, changes in clinical measurements of blood which suggest anemia in response to various stresses, and changes in benthic community structure associated with elevated levels of contaminants. Again, this is the first time, anywhere in the world, that such a wide range of biological effects measurements has been used in a field monitoring program.

2. "Establish and maintain an interactive archive of data resulting from other marine pollution monitoring programs in the northeast and foster coordination of estuarine/shelf environmental monitoring and research efforts off the Middle Atlantic and New England states."

   A NEMP data management system is being implemented at the NEFC, Sandy Hook Laboratory. The primary purpose of the system is to handle the internal requirements of NEMP. A secondary objective is to develop cooperation and coordination with other organizations that gather monitoring-type data in Northeast coastal region. The data system has acquired NEMP-derived plankton and benthic data. Water quality data from EPA, FDA, and the City of New York also are being added.

   An interactive data retrieval system started in November 1981. The system has grown as data sets have been added. By early FY 1985 the system provided access to hydrographic and dissolved oxygen data collected in the Middle Atlantic Bight since the early 1950s. Major sources of the data entered into the unified hydrographic data base were NMFS (OP and Long Branch Transect, as well as the Marine Monitoring, Assessment and Prediction, or MARMAP, program), National Ocean Service, National Oceanographic Center, and Brookhaven National Laboratory.

Coordination of monitoring has included integration of New York Bight water column monitoring with complementary efforts of the Federal EPA, states of New Jersey and New York, and BNL. Other coordinated activities have been joint sediment-benthos cruises to the Bight with EPA and joint regional water column sampling with the NMFS MARMAP program and with contractors.

3. "Summarize, in collaboration with other responsible agencies, information on pollutant inputs to estuarine and coastal waters."

There has been only a limited effort in NEMP to gather information on point and non-point source inputs to estuarine and coastal waters, since this is also an objective of EPA-funded studies and is being addressed separately by OAD. The positions of major estuarine plumes, which introduce pollutants to coastal waters, have been detected in remote sensing data, and are proving valuable to the understanding of such phenomena.

We have worked with the US EPA Environmental Research Laboratories, Narragansett, Rhode Island, to develop syntheses and site characterizations which include information on pollutant inputs to specific water management units. The site-characterization studies include extensive reviews of what is known about oceanographic features and processes in the target areas.

4. "Provide real-time data and information to regulatory organizations and the general public for planning and management."

Some of the remote sensing and water quality studies are now producing near real-time data, whereas most sediment, benthos and biological effects data are not available until weeks or longer after a given cruise. Data reports are released as they are completed throughout the year. The NEMP Annual Reports for 1980, 1981 and 1982 have been distributed to users including planning, management, and regulatory groups and the general public. The NEMP office receives numerous requests for additional information regarding statements contained in the annual report as well as for copies of principal investigators' reports. Workshops and meetings are other methods through which NEMP results have been provided to regulatory agencies and the general public.

5. "Determine the effects of major activities such as offshore drilling, dumping, and toxic waste disposal on the coastal marine environment and its resources."

Studies in the vicinity of such activities have provided information concerning the effects of ocean disposal at the 12-mile sewage sludge disposal site in New York Bight, and have established baselines for a proposed dredge spoil disposal site off Chesapeake

Bay. Several stations located on Georges Bank, and observations from submersibles in the nearby submarine canyons, may provide useful information concerning the effect of oil and gas exploration. However, the basic intent of a monitoring program is to collect time-series information, to enable observations to be made concerning trends and variations in pollutant levels and effects. The NEMP has produced a series of benchmark data which provides information on distributions and concentrations of contaminants and will be useful in assessing the effects of various polluting activities, many of which may not yet be clearly identified.

Continuing efforts have also furthered understanding of seasonal and annual variations in the distribution of contaminants in places such as the New York Bight Apex. Indications of stress in organisms, such as sea scallops collected near the Mud Patch south of Nantucket Shoals, and winter flounder in Long Island Sound, have been documented.

6. "Detect, and provide appropriate and early warnings of, severe or irreversible changes in the coastal marine ecosystem and in its resources. This would include interaction with agencies responsible for coordination of both routine and crisis response activities (oil spills, harmful waste, and toxic chemical discharge, etc.)."

Analysis of monitoring data collected by the NEMP can provide early warnings of moderate to large changes in the coastal marine ecosystem. For example, studying the data collected on spring and summer water column cruises in New York Bight has increased the ability to forecast the severity of late summer oxygen depletion in bottom waters in the Bight Apex and off northern New Jersey.

While the program has not formulated specific contingency plans for dealing with other forms of severe change, contacts with the appropriate regulatory agencies have been established, and will be used should significant degradations be detected.

7. "Determine users and their needs."

A user community has actively followed the program since it began producing data and information in 1980. At present, this community includes NOAA components, other Federal agencies, area Congressional delegates and staffs, state resource and environmental agencies and commissions, regional and municipal commissions and offices, universities and colleges, environmental consulting firms, industrial firms, recreational fishing interest groups, public environmental conservation interest groups, and foreign marine science research institutions and agencies. A partial list of specific users in these categories is given in Appendix 5.4.

8. "Determine and apply standard methods for monitoring and for evaluating monitoring effectiveness."

The program has used both standard and innovative techniques for determining the degree of habitat contamination and for monitoring biological effects. In several instances (see Item 9) the monitoring techniques did not prove effective. In other cases chemical analyses and methods of sample collection have lent themselves to standardization.

Building on the earlier activities of the NEMP, other NOAA programs have developed quality assurance activities that have lead to standardization of measurements within the NEMP and with the other NOAA groups. The standard activities have included field monitoring efforts conducted by NOAA personnel as well as field activities accomplished by a range of academic and industrial personnel. Descriptions of the quality assurance efforts of NOAA have been released in reports provided to several national and international meetings.

9. "Determine which elements of monitoring are the most cost-effective."

A continuing process of evaluating the effectiveness and cost of the various monitoring tactics undertaken in the first five years of the program was brought to a focus in late 1984, when the NEMP Management Team members each rated the extant and candidate monitoring activities.

The highest-rated half of the activities (with highest listed first) were those involved with: eutrophication and low dissolved oxygen levels in the inner New York Bight; body burdens of pollutants in fish tissue; lesions and deformities in fish; benthic community structure; organic and inorganic pollutants in sediments; cytogenetic aberrations in fish; and organic and inorganic pollutants in benthic organisms.

The lowest-rated half of the activities (highest again ranked first) involved: incidence of black gill and pathogens; chlorophyll concentrations and primary productivity; benthic bacteria and protozoa; fish immunology; modeling of the inner New York Bight nutrient/oxygen system, hydrography and circulation; physiological responses to stress; seabed oxygen demand; variation in phytoplankton species composition and distribution of resting spores; behavioral responses to pollution; and RNA/DNA ratios in fish larvae.

It should be emphasized that these rankings were related to the readiness or suitability of activities for routine monitoring and not related to their research or development value. Some of the low-rated activities merely were not ready for use in a monitoring effort yet or were too difficult or costly for routine shipboard use.

10. "Determine applicability of ocean pollution monitoring to other coastal areas."

Many of the biological effects and contaminant monitoring techniques used within the NEMP have been applied in other national and international programs. For example, the NEMP studies of relationships between sediment contamination and body burdens and diseases in resource species were adopted by the NOAA NS&T Program. Whereas the NEMP was oriented particularly towards habitat conservation issues of the Northwest Atlantic, NS&T is a national effort which includes coverage of the southeastern, Gulf and Pacific coasts.

Several of the NEMP monitoring techniques have been applied to programs being conducted in the North Sea and other European waters. These activities were based on papers submitted to the International Council for the Exploration of the Seas (ICES).

4. PRESENT STATUS AND DIRECTION OF THE PROGRAM

4.1 Program Evolution and Factors Which Led to Present Status and Direction

The original goals and objectives of NEMP were developed just as NOAA was beginning to accept the concept that monitoring and research should be conducted in a manner that would allow for identification of the sources, fates, and effects of contaminants. Moreover, the NEMP PDP was developed because of increased concern over multiple uses of coastal marine waters. Early plans for long-term environmental monitoring and research in the marine habitat tended to be related to specific activities such as ocean dumping, offshore petroleum exploration and development, point-source discharges, dredging and dredged material disposal, and similar identifiable activities. Subsequently, society and government have realized that most instances of deterioration of marine habitat quality have been caused by a multiplicity of activities. In addition, regional and national concerns have grown with regard to non-point-source contamination, and the interactions between it and point-source activities such as dredging and dredged material disposal. Thus, continued monitoring and concurrent research must take into consideration the multiple uses which will tend to degrade marine habitats (including estuaries, coastal waters, and offshore shelf habitats).

In recent years, there have been reductions in major vessel time available to the NEMP. Also, total funding in the sense of real dollars available to the program has been decreased by inflation and by reduction in funds available through OAD. Also, because of hiring and staffing limitations and reorganizations, the number of people at work in the program has also diminished.

The trend of reduced funding and staffing has been coupled with a trend for increased demands on the program to deal with an ever-widening range of acute and chronic issues. For example, the matter of ocean dumping and redesignation of dumpsites has consumed a significant amount of time and effort for drafting documents concerned with those issues. Situations such as the discovery of large amounts of PCBs in New Bedford Harbor sediments and resource species have required effort that was formerly dedicated to field, laboratory, and management activities within the program. Outer continental shelf petroleum exploration and development activities have also required the involvement of program personnel. Requests for large data sets by other agencies, such as the Department of Interior, Minerals Management Service, necessitated allocations of human and fiscal resources. Finally, the development of new activities in the NMFS, such as the Regional Action Plan (RAP), has resulted in the diversion of program effort to the development of planning documents and strategies to expedite these activities.

4.2 The Present Program

At the conclusion of the program's first five years, it was evident that the NEMP must undergo adjustments which would result in operational and programmatic economies. A major adjustment has been to focus the program's efforts in those geographic areas which seem to be most severely degraded by man's activities. This has included a new emphasis on monitoring the status and trends of selected contaminants and organisms in estuaries and coastal waters (NOS/OAD NS&T Program). Special attention is now being given to documenting habitat and fishery resource problems in urbanized and industrialized areas. At the same time earlier shelf-wide monitoring activities have been reduced and previously collected data are being analyzed to reveal levels and trends of contaminants and effects.

We also have begun to synthesize information obtained during the earlier years of the program. The syntheses have included a major technical report on conditions in areas potentially affected by dumping at the 106-Mile Disposal Site. We are now preparing Water Management Unit descriptions, which are habitat quality portrayals essential to the development of hazard assessments within unique zoogeographic regimes.

Program personnel also have attempted to identify key issues and problem areas around which "case studies" are being developed. The case studies may focus on the effects of pollution on particular resource species important to commercial or recreational exploitation.

These changes are leading to a program more commensurate with resources available and tailored to address specific issues. The adjustments will provide products that will be more immediately useful in managing marine fisheries habitats.

In making programmatic adjustments, emphasis on new research into and development of additional biological effects monitoring techniques has been reduced. Greater attention is now being paid to using certain selected, tested techniques for monitoring responses of individuals and populations to contaminant loadings and physical degradation.

4.3 Outlook for the Second Five-Year Period (1985-1989)

There is need for scientists and managers working with marine habitat quality problems to be precise in identifying those issues which warrant extensive and expensive monitoring or research. Major concerns identified by NOAA (action memo from John V. Byrne, NOAA Administrator, dated June 14, 1984) are the effects of 1) pathogens, 2) synthetic organic compounds and petroleum hydrocarbons, 3) eutrophication from nutrient loading, and 4) physical modification of habitats by dredging, filling and other construction activities on living marine resources. In general, these concerns are similar to those identified by the Northeast Region of NMFS, and also by the U. S. Environmental Protection Agency in their estuarine strategies.

In dealing with these principal concerns, quantitative evaluations of habitat quality and assessment of the hazards imposed by habitat degradation are required. Hazard assessments should be based on knowledge of: 1) inputs and fates of contaminants in the environment, 2) effects of specific contaminants on living marine resources, and 3) status of the resources at risk. The development of hazard assessments in the Northeast requires that NEMP scientists focus on specific case studies involving particular areas or species at risk. For example, the NS&T monitoring program in the northeast is being conducted in selected estuaries, with winter flounder as one target species.

In the second five years (1985-89) the NEMP will deal with some of the following issues (as budgets and overall priorities permit):

- Evaluating the effects of eutrophication/hypoxia on resource species,
- Determining body burdens of organic pollutants in fish and shellfish tissues and the environment,
- Quantifying pollution-related diseases in fish and shellfish,
- Evaluating reproductive capacity, survival, and recruitment in resource species affected by contaminants,
- Documenting the recovery of polluted areas and affected fishery resources,
- Surveillance and evaluation of habitat quality in degraded areas, with particular relevance to effects on important resource species,
- Evaluation of habitat and resource effects in newly designated dumpsites.

To address these issues, emphasis in monitoring and research will be redirected geographically and temporally, to include some or all of the following (again dependent on available resources):

- Focusing monitoring efforts on coastal and estuarine habitats.
- Continuing studies of eutrophication and hypoxia in the inner New York Bight, with particular reference to resource effects.
- Surveying organic contaminants in fish and shellfish, emphasizing problem areas or species.
- Monitoring disease in fish, focusing on larval and juvenile stages but continuing efforts with adult stages.
- Monitoring recovery of the New York Bight sewage sludge dumpsite (12-mile site) as its use is discontinued.
- Continuing monitoring and research along the contaminant gradient in Long Island Sound, to evaluate effects on resource species.
- Conducting infrequent broad-area surveillance of continental shelf and slope/habitats and resource species.
- Conducting case studies of problem areas, important resource species or biological effects.

4.4 Revised Program Goals and Objectives

In response to changing needs of NOAA and society, and from knowledge gained in the pilot phase of the NEMP, the original goals and objectives (pp. 5-6) have been modified to the following:

Goal 1. Monitoring: Implement a program to monitor the health of coastal/estuarine ecosystems of the northeastern United States.

Objective A. Measure the status and trends of sediment contamination, and contamination and pathology of demersal resource species, in northeastern estuaries.

Objective B. Monitor eutrophication, oxygen depletion and contaminant fates and effects in the NEMP area of interest, emphasizing the inner New York Bight.

Objective C. Monitor recovery of the benthic environment in the vicinity of the 12-mile dumpsite as its use is phased out.

Objective D. Repeat sampling of selected mid- and outer-shelf stations occupied during the pilot phase of the program, at reduced frequencies, to determine trends in habitat conditions and effects on resources.

Objective E. Repeat sampling of selected stations in problem areas of nearshore waters to establish rates of variation of habitat conditions and effects on resources.

Goal 2. Research: Determine processes controlling impacts of natural and anthropogenic habitat alteration on important components of marine and estuarine ecosystems.

Objective A. Conduct "case studies" of species and areas deserving detailed attention, such as determining effects of habitat alteration on populations of winter flounder and other species in 1) Long Island Sound, 2) Narrangasett Bay, 3) Buzzards Bay, 4) Massachusetts Bay/Boston Harbor, and 5) Raritan Bay.

Goal 3. Information: Provide data and information needed to develop and implement hazard assessments necessary for conservation and management of resource species and their habitats.

Objective A. Develop further and maintain an interactive archive of data resulting from the NEMP and other marine pollution monitoring programs in the northeast.

Objective B. Support EPA and NOAA initiatives in developing information on pollutant inputs to estuarine and coastal waters, and incorporate data in an interactive archive.

Objective C. Complete report synthesizing results of the program's first five-year operational phase (FY 85-89) and assessing impacts of habitat alterations on resource species and their ecosystems.

Objective D. Provide relevant information, including hazard assessments, to resource agencies, the scientific community, regulatory organizations, the general public and other users in a manner timely for planning and management.

5. APPENDICES

5.1 Annual Highlights

5.1.1 1980 Findings

Highlights of interim findings by year and discipline are listed below. The highlights are taken from the respective NEMP annual reports as well as from annual reports of principal investigators. See those reports for more details.

5.1.1.1 Water Quality

- Evidence pointed to coastal eutrophication in the Middle Atlantic Bight. Plumes from the Hudson-Raritan estuary, Delaware Bay and Chesapeake Bay had high concentrations of inorganic and organic nutrients, particulates, organic carbon and pollutants. High levels of phytoplankton production and biomass were recorded consistently in inshore waters from northern New Jersey to south of the Cheaspeake Bay mouth. Higher incidence of blue-green algae was in the estuarine plumes, suggesting excessive nutrient enrichment.

- During the year there was no recurrence of a widespread hypoxic water mass off the coast of New Jersey even though concentrations of *Ceratium tripos*, a dinoflagellate thought to be important to the catastrophic 1976 low oxygen episode, occurred in relatively high numbers in March. No severely depressed oxygen levels were detected in the plumes downstream from any of the estuaries, despite the evidence for eutrophication and unusual oxygen demand noted.

- The possibility for contamination of foodfish by chemical wastes at the 106-Mile dumpsite was realized and a procedure for reducing the chances by directing the dumping away from shelf water occasionally present was proposed.

- Microbial indicators of fecal pollution (bacillus bacteria) and the anaerobic spore-forming *Clostridium perfringens*, were found in some inshore waters and in the vicinity of the New York Bight sewage dumpsite. These organisms are indicators of sewage pollution and potentially pathogenic to humans and fish. It was suggested their distribution and abundance be monitored on a continuing basis.

5.1.1.2 Sediments and Benthos

- Elevated concentrations of trace metals in sediments were generally in four areas: the New York Bight Apex, Buzzards Bay, the "Mud Patch" southwest of Nantucket, Buzzards Bay, and the mouth of Portland Harbor.

- Concentrations of sediment trace metals in the Bight Apex in 1980 were similar to levels measured in 1973-74.

- Maximum concentrations of sediment PCBs (to 100-160 ppb) in the Bight were within three nautical miles of the sludge and dredged material dumpsites. Levels were undetectable over most of the surrounding shelf, and in the Hudson Shelf Valley within 20 miles seaward of the dumpsites.

- Concentrations of polynuclear aromatic hydrocarbons (PAHs) in sediments were highest (19.5 ppm) in an area of apparent sludge accumulation within three n. mi. to the west of the sludge dumpsite and undetectable in the mid-Shelf Valley and in coarser sediments outside the Christiaensen Basin.

- *Clostridium perfringens* was most abundant ($>10^6$ colonies per ml of sediment) in the same sludge accumulation area. Counts of 10^5/ml came from the sludge and dredged material dumpsites.

- Other high counts of the same bacterium (but 3-4 orders of magnitude lower than the New York Bight maximum) were within five miles of Chesapeake Bay, Delaware Bay, and the Rhode Island and New Hampshire coasts.

- A pathogenic amoeboid protozoan, *Acanthamoeba*, which flourishes on bacteria and sewage in sediments decreased seaward from upper Narragansett Bay to open coastal waters. This amoeba also occurred in sediments near the Philadelphia Sewage Sludge Dumpsite.

- Seabed oxygen consumption increased generally between Delaware Bay and Cape Cod, with highest rates (means of 20-23 ml $O_2/M^2/hr$) in Block Island Sound and near the New York Bight dumpsites.

- The Christiaensen Basin in the New York Bight Apex had the greatest apparent alterations in benthic macrofauna communities, based on species richness, species composition, dominant species, and amphipod populations. The Basin benthos showed little change from 1973-74 to 1980.

- Species with low dispersal abilities, such as amphipods, required at least 2-3 years to repopulate the center of the area affected by anoxia off New Jersey in 1976.

- The benthos in parts of Portland Harbor (Maine), especially at a station 12 km downstream from a pulp mill, had an altered faunal composition and depressed species richness.

5.1.1.3 Trace Contaminants in Tissues

- A definitive review of heavy metals in fish and shellfish of the New York Bight was prepared. Principal findings were that highest concentrations of metals were in fish from the New York Bight Apex, with levels decreasing with increasing distance from this area. Metal levels in crustaceans, molluscs, and samples of whole fish were higher than in samples of fish flesh. Variations in heavy metals between species were marked, with highest burdens of seven selected metals in ocean pout, cod, and rock crabs.

- PCB and DDE compounds were widespread in animal tissues throughout the sampling area, more so than PHCs. PCB and DDE compounds were present at low levels and varied from station to station independently of PHC distributions for most species. The highest PCB levels in any of the major epifaunal species were found in lobsters (0.15 ppm).

- PHCs in fish from the Northeast shelf varied with species, but were within ranges previously reported for the region. Levels in some species were high compared with some other coastal areas. PHC concentrations were low, however (6-9 ppm), in the most important species analysed (cod, haddock, winter flounder). Rock crab, the only epibenthic species analysed for PHCs, had a higher concentration (65.4 ppm wet weight) than any in fish.

- The geographic distributions of PCB and PHC compounds indicated no regional point source, despite high sediment levels near dumpsites.

5.1.1.4 Biological Effects

- There was a higher incidence of skeletal deformities, mutagenic aberrations, and various shell or skin lesions in organisms collected inshore and in and around dumpsites, an indication of adverse effects of ocean dumping and coastal discharge.

- Laboratory exposure of Dungeness crabs to crude oil impaired chemosensory detection of food; the capability returned after the crabs were placed in clean water.

- Predation by Dungeness crabs on littleneck clams was higher in oiled sediment than in clean because of shallower burrowing by clams in oiled sediment.

5.1.2 1981

5.1.2.1 Water Quality

- Bight-wide hypoxia did not occur in 1981. Lowest values were 2.9 ppm near the New York Bight dumpsites and New Jersey coast. The depressed oxygen levels typically found north of Barnegat Inlet in summer were not detected in 1981.

- Data indicate shifts in the phytoplankton community toward smaller diatoms and ultraplankton in nearshore waters, especially at the mouths of major estuaries. Such shifts may alter existing food webs supporting resource species.

- High nutrient input from the Hudson-Raritan estuary may dominate nutrient distribution and utilization for the entire New York Bight.

- There was a consistent (five-year) pattern of phytoplankton biomass (chlorophyll *a*) and primary production (C^{14}) on the northeast shelf. Portions of the shelf, e.g. the New York Bight Apex, have some of the highest production rates known.

o Much of the high spring primary production in the New York Bight was not consumed by zooplankton or nekton feeders, but sank to the sea floor and influenced summer oxygen levels.

o High concentrations of Clostridium perfringens occurred in New York Bight Apex, Buzzards Bay, Massachusetts Bay and Casco Bay, Maine, at the mouths of major estuaries and in the natural depositional area (Mud Patch) south of Martha's Vineyard.

5.1.2.2. Sediments and Benthos

o Highest concentrations of sediment trace metals were in the same areas as in FY 80 (Bight Apex, Mud Patch, Buzzards Bay, Casco Bay), and also in Massachusetts Bay and at the mouths of major estuaries.

o Sediment PCBs followed the same pattern as trace metals, with highest level (144 ppb) in the Bight Apex, and with elevated concentrations in Buzzards Bay.

o Very high concentrations of sediment PAHs (to 31,000 ppb) were found in the Bight Apex; PAHs were detected at all but one of 48 Bight stations.

o Low concentrations of pesticide residues (up to 2.0 ppb Kepone, 4.5 ppb aldrin, and 6.4 ppb heptaclor epoxide) were present at the proposed Norfolk dredged material dumpsite (14.6 n. mi. off Chesapeake Bay) where no dumping has yet taken place.

o Densities up to 5 x 10^3/ml sediment of Clostridium perfringens were at the mouths of several estuaries. Pathogenic bacteria, viruses and Acanthamoeba were also detected there.

o An intensive survey of the New York Bight indicated (in agreement with earlier studies) a highly altered benthic community of about 10 km^2 centered just west of the sewage sludge dumpsite, and an "enriched" area with high densities of several macrofauna species over about 200 km^2 of the Christiaensen Basin and upper Hudson Shelf Valley.

o SCUBA techniques were used to develop baselines for benthic fauna of the inshore Isles of Shoals and offshore Jeffreys Ledge in the Gulf of Maine. Macro- and megafauna of Georges Bank and two canyons to its south (Lydonia and Oceanographer) were characterised via observations, photography and sampling from submersibles.

o The first year's estimates for three stations in and near Delaware Bay indicated annual benthos production ranged from 3.8 to 20.6 grams of carbon per m^2 per year.

5.1.2.3 Trace Contaminants in Tissues

- All concentrations of PCBs in demersal fish tissues were well below the 5 ppm recommended maximum level for human consumption, and were not consistently related to levels in sediments or to contaminated areas.

- Statistically significant differences in PCB concentrations between the inner and outer New York Bight existed for rock crab, but not lobster, scallop, windowpane and winter flounder, or red and silver hake.

5.1.2.4 Biological Effects

- Physiologically stressed flounders (winter, windowpane, yellowtail) were found in polluted western Long Island Sound, throughout the New York Bight Apex, and off the Merrimack River, Massachusetts.

- Nutritionally stressed sea scallops were found at deepwater sites in the Gulf of Maine. These deepwater populations probably do not spawn sucessfully.

- Scallops in poor metabolic condition were collected from an area abutting the Mud Patch southwest of Martha's Vineyard.

- Chromosomal mutation frequencies in red blood cells of adult flounder from polluted western Long Island Sound were three times those of fish sampled elsewhere; red blood cell mutations in larval red hake were highest near the New York Bight dumpsites.

- There was evidence of copper accumulation and related pathological effects in oysters from Delaware, Raritan, and Buzzards bays, and in the Piscataqua River, New Hampshire.

- Samples of adult sand lance, an important forage for fish and whales, had a greater prevalence of skeletal abnormalities at inshore stations than offshore, especially near plumes from major estuaries.

- More bacterial infections, as measured by the amebocyte lysate test, were in fish caged at the New York Bight sludge dumpsite than in fish caged at a control station.

- Juvenile red hake exhibited escape responses to drilling fluids introduced into an experimental holding tank. Such responses could increase the risk of predation in fish forced to leave preferred habitats.

5.1.3 1982 Findings

5.1.3.1 Water Quality

- Low dissolved oxygen in bottom water over the New Jersey shelf did not occur. The lowest recorded values along the bottom were found in September and exceeded 5.0 ppm, well above stress levels for most species.

- The Hudson River plume was a significant source of nitrogen in April and September. Replenishment of depleted sources came from subeuphotic depths on the inner shelf from April through September, returning about half the nitrogen used by productivity processes during the spring bloom.

- Phytoplankton populations were monitored over the northeastern continental shelf; seasonal composition and distribution patterns for the shelf and population centers associated with major bay systems, Georges Bank, and sites along the outer shelf were defined. Several stations over the shelf contained high levels of species associated with bloom conditions (e.g. *Ceratium* spp.).

- Data from the Coastal Zone Color Scanner on the Nimbus-7 satellite were used to examine temporal patterns of sea surface temperature and phytoplankton pigments in the Gulf of Maine-Georges Bank region of the northwestern Atlantic Ocean. Subareas were classified into three ecologically distinct regimes: (a) vertically mixed, relatively cold, and rich in pigment; (b) seasonally stratified, relatively cold, and pigment-poor; and (c) weakly to mostly stratified, relatively warm, and pigment-poor. Colder waters, except for the Scotian Shelf and Gulf of Maine, were subject to greater vertical turbulence and nutrient replenishment. Persistently high pigment concentrations were associated with turbulent waters less than 60 m in depth.

- Waste dispersion modelling of particles with different sinking velocities was initiated to demonstrate variability in depositional patterns under mean westerly wind conditions. This effort was made to demonstrate the utility of tracking oxygen demanding particles emanating from the estuaries and settling along the bottom.

5.1.3.2 Sediments and Benthos

- An area of elevated concentrations of several trace metals, often to half of their highest concentrations in the New York Bight Apex, was found beyond 200 m depths in Hudson Canyon (the extension of the Hudson Shelf Valley, which runs from the Apex to the shelf edge). This indicates the Shelf Valley acts as a seaward conduit for contaminants introduced in the inner Bight.

- Trace metal levels in Penobscot Bay, Maine were (as previously reported for Casco Bay) comparable to other, more industrialized New England embayments.

- Statistically significant increases in sediment PCB concentrations between 1981 and 1982 were detected off Delaware Bay, (mean concentration in Summer 1982 was 40x Summer 1981) in the New York Bight Apex (4.6x) and in Buzzards Bay, Massachusetts (4.6x). However, mean values in November 1982 were again statistically similar to summer 1981 values off Delaware Bay and in Buzzards Bay. This illustrates the spatial and/or temporal patchiness of PCBs. Concentrations at other stations changed little from 1981.

- PAHs were again in nearly all sediments analyzed. Except for the New York Bight Apex, analyses indicated the PAHs generally came from combustion sources rather than from liquid petroleum. Mean concentrations in Casco and Penobscot bays (up to 14.4 ppm) exceeded all others we have measured in the NEMP Region except the New York Bight Apex. Distributions in Penobscot Bay suggest contemporary, anthropogenic sources rather than long-term natural phenomena.

- Incidences of *Acanthamoeba* at the Philadelphia sewage sludge dumpsite in June 1982 were unchanged from incidences found before sludge disposal ended in November 1980. Numbers of coliform bacteria diminished.

- Preliminary estimates indicated productivity of the anthropogenically stressed Bight Apex benthic macrofauna was similar to that of unpolluted Georges Bank within comparable bathymetric zones.

- NEMP and other groups studied the continued destruction of kelp beds off Maine and New Hampshire by grazing sea urchins. Increases in urchin populations were attributed, in part, to reduced predation by diminished lobster stocks. Kelp provides shelter for lobsters, and its removal may further reduce lobster populations.

- NEMP submersible observations and grab-sampling revealed no major short-term changes in contaminant concentrations or biological effects due to oil exploration on Georges Bank, in agreement with studies by other groups. In the demersal species analyzed, petroleum hydrocarbons occurred at low levels before drilling.

- Larval surf clams and amphipods had significantly lower setting and/or survival in sediment trays with sewage sludge added, compared to trays of uncontaminated sediment, deployed off the southern Long Island coast.

5.1.3.3 Trace Contaminants in Tissues

- Concentrations of Cd in the livers of winter flounder from the New York Bight appeared related to concentrations of Cd in the sediments from collection sites.

- In general, clams and lobsters from Buzzards Bay contained PCB concentrations below the FDA "action level". The most contaminated specimens were found at stations closest to New Bedford. Soft clams from New Bedford had very high levels (to 13.7 ppm wet wt.). Clams contained a range of PCBs, whereas lobsters contained primarily hexachlorobiphenyls.

- Bacteria indicative of human wastes, and pathogenic bacillus bacteria, were found in several fish and shellfish species.

- A comprehensive survey of PCBs in ocean quahogs from the Gulf of Maine, the Scotian Shelf, Georges Bank, and south to the Delmarva Peninsula was completed. PCBs were low in all samples (maximum 30 ppb wet wt.).

5.1.3.4 Biological Effects

- Monitoring growth and condition of larval fish using the ratio of ribonucleic acid to deoxyribonucleic acid (RNA-DNA ratio) showed 17% of the the larval sand lance analyzed were in poor condition. Low hepatic DNA and muscle protein levels occurred in juvenile striped bass from the Hudson River.

- Collections of deepwater (130-190 m) scallops made throughout the year on both NEMP and Resource Assessment cruises showed consistently low muscle glycogen, indicating a lack of the necessary energy reserves for gamete maturation. Bottom temperatures of these sites rarely rose to 10°C, the temperature at which spawning is generally initiated.

- Anemic flounder were collected from coastal waters between Boston and Cape Cod and from the Block Island midshelf station near the Mud Patch; other abnormal blood profiles were found in flounder off Narragansett Bay. Offshore populations appeared to have normal blood chemistry.

- Mutation frequencies in winter flounder were most common in specimens from the New York Bight and near-coastal areas, particularly the western end of Long Island Sound and along the New Jersey coast. Frequencies were sometimes three times that of fish from cleaner areas.

- Data were gathered on the antibodies to human pathogens in summer flounder and tautog. Experimentally, these fish formed antibodies to human bacteria isolated from the sewage sludge dumpsite. These antibodies in fish blood are specific for bacteria to which the fish have been exposed. The antibody titer can be used to determine whether exposures detrimental to the health of either the fish or the human consumer occurred.

- The incidences of "black gill disease", tissue pathology, and microbial fouling of gills of the rock crab were monitored in specimens from the New York Bight Apex, the former Philadelphia sewage disposal site, and the Sheepscot River, Maine. Black gills were observed in some specimens from all areas except Maine.

- Three species of ocean bivalves (sea scallops, surf clams, and ocean quahogs) were examined for specific parasites and histopathology. There were no significant differences between animals from different stations, and all were within the range of "healthy" individuals.

- Prevalences of integumental and skeletal fish diseases were monitored in commercially important bottom fishes from the northeastern shelf. Except for fin rot and lymphocystis, diseases (ulcers, skeletal anomalies and ambicoloration) were randomly distributed. Overall disease prevalence in 105,042 fishes was 0.99%.

- Numbers of vertebral anomalies of 5000 sand lance were tabulated and their geographical locations plotted. A high prevalence of anomalies was associated with nearshore, shallow water environments and with major estuaries.

- Parasites and pathological conditions in benthic amphipods collected on one NEMP cruise from 1981 and three from 1982 were studied grossly and through histological sections. The data provided adequate baseline information on kinds and prevalences of common parasites in the populations studied. Two parasites - a microsporidian from an ampeliscid amphipod, and a dinoflagellate from several species -- were seen. During 1982, none of the amphipod populations examined exhibited changes from pollution stress.

- Evidence was found that concentrations of organochlorine components in field-collected female striped bass may be related to increased larval mortality. Also, juvenile striped bass from the Hudson River had poor swimming stamina and a high prevalence of parasitic infestation and liver necrosis compared to striped bass from other areas.

- There were correlations between numbers of Vibrio in sediments, waters, and animals from the same areas. The distribution of this bacterium was not alwyas related to sewage pollution.

- Hard clams exposed to sublethal levels of oiled sediment burrowed more slowly and to a significantly shallower depth than clams in unoiled sediment. Sand lance decreased the amount of time spent buried in oil-contaminated sediment, thus increasing predation risk.

5.1.4 1983 Findings

5.1.4.1 Water Quality

- Hypoxia appeared confined to the New York Bight Apex and the head of the Hudson Shelf Valley. Dissolved oxygen measurements ranged between 1.4 and 2.9 ppm, with intermittent increases from mid July through September. Local storms mixing the water column probably prevented the Apex from becoming anoxic. Wind mixing moved the thermocline deeper, to just above the bottom, in September.

- Freshets in the Hudson River plume from June until early July carried high concentrations of phytoplankton.
- The hypoxic area increased in size from August to September, decreasing vertically and spreading horizontally, and moved deeper into the Hudson Shelf Valley. Higher ammonia values were associated with hypoxic areas.
- The rate of decline of oxygen decreased from nearshore (10 m) to offshore.
- The movement of local hypoxic areas in response to wind events was tracked from nearshore to offshore.
- Precipitation of 5.7 inches above normal fell in May. This resulted in low salinities at the mouths of estuaries in June, particularly the Hudson-Raritan and Chesapeake.
- The Hudson-Raritan, Delaware, and Chesapeake estuaries all contribute dissolved silicates to surface waters of the Middle Atlantic Bight, providing enrichment of this nutrient for diatom growth.
- Patches of high silicate concentrations were found in areas of high chlorophyll *a*. These possibly are due to regeneration of silicate by bacteria and zooplankton.
- The Hudson-Raritan system is a major source of nitrate and ammonia for the Middle Atlantic Bight in April through June. By August the primary nitrate source is from offshore, deeper waters. Bottom concentrations of ammonium increase in the nearshore from spring through fall.
- Phytoplankton spores in sediments are accumulating at the head of the Hudson Shelf Valley compared with similar shelf depths. Large numbers were at the sewage sludge dumpsite, particularly during low concentrations of dissolved oxygen in August and September.

5.1.4.2 Sediments and Benthos

- Trace metal concentrations in New York Bight sediments did not change appreciably between samplings in the summers of 1980, 1981 and 1982. Since earlier analyses had shown no gross changes between 1973-74 and 1980, the inner Bight has been in a "steady state" of metal contamination for at least a decade.
- Portland Harbor sediments were contaminated with PCBs (80-340 ppb). This contrasts with a 1980 survey of 32 stations in the harbor and Casco Bay, which had not revealed PCB contamination. Traces of PCBs were also found at a station at the mouth of the bay earlier considered uncontaminated.

- Traces (much less than 100 ppb) of PCBs were found at all but two of 49 stations sampled in a summer 1982 baseline survey of Penobscot Bay. A station outside Searsport Harbor had 200 ppb, and one in Rockland Harbor had 120 ppb.

- The Penobscot Bay survey revealed PAHs at every station, with distinct gradients of increasing concentration toward the inner (northern) end of the bay and toward urban areas (Camden, Rockland) bordering the southwest part of the bay. Values exceeding 5.9 ppm dry wt. (similar to moderately contaminated parts of the inner New York Bight) were found in all these areas.

- By June 1983, sediments in and near the deactivated Philadelphia sewage sludge dumpsite had low occurrences of pathogenic amoebae (found at 6% of stations sampled) compared to densities while dumping was ongoing and shortly afterward (35% of stations). The surveys were cooperative with FDA and EPA, who also reported substantial decreases in densities of fecal coliform bacteria. Based on these data, FDA recommended reopening the site to shellfishing.

- *Clostridium perfringens* was again most abundant (to 10^5 or more per ml of sediment) just west of the New York Bight's sewage sludge dumpsite. *Clostridium* and fecal coliform densities in the Bight in summer 1983 were similar to those found 1980-82 and in the early 1970s. This reinforces the conclusion from the trace metals data that the Bight has been in an approximate equilibrium state of contamination since at least the early 1970s, when surveys began.

- The benthic macrofauna of the Bight Apex likewise changed little from the early 1970s to the early 1980s. The macrofauna of the region-wide sampling sites was consistent over the (generally shorter) periods for which data were available. There were no apparent contaminant effects outside the Bight.

- Benthic biomass (127-344 g/m^2 wet weight) and production (201-383 $Kcal/m^2/yr$) in the inner Bight were equal to or greater than most reported values for North Atlantic waters. Several of the dominant benthic species were common in stomach contents of the area's demersal fish and lobsters.

- Several years of observations on inner Bight surf clam beds indicated that over 99% of all clam set is consumed by predators, especially rock crabs (*Cancer* spp.), and calico crabs (*Ovalipes ocellatus*). In continuing tray experiments, sediments contaminated with domestic sewage sludge alone were avoided by settling surf clams (and most other invertebrates) nearly as much as domestic sludge with industrial wastes.

- There were significant changes in seabed oxygen consumption at the New York Bight sewage sludge dumpsite (+ 57%) and dredged material dumpsite (- 36%) between 1974-75 and 1982-83, paralleling changes in amounts of wastes dumped at those sites.

- Baseline characterization of the proposed dumpsite off Norfolk, Virginia was completed after five years of quarterly sampling. Results indicated faunal consistency similar to that of the regional monitoring. The fauna of the area was diverse and typical of uncontaminated areas on the inner shelf. No populations of commercially important benthic invertebrates were present.

- Continued submersible work in depths between 150 and 700 m in the canyons south of Georges Bank led to the description of five bottom habitat types, each with a distinct faunal assemblage. The canyons provided nursery grounds for about 20 species, and shelter for adults of some 25 species, including lobster and tilefish.

5.1.4.3 Biological Effects

Physiology and Biochemistry:

- A field study of a dumpsite in central Long Island Sound provided evidence of physiological stress in lobsters held in cages near the site. Spoils from maintenance dredging of a Bridgeport harbor had been dumped there as part of a study by the U.S. Army Corps of Engineers and EPA on long-term effects of dredging operations. The dredge spoils were heavily contaminated with petroleum hydrocarbons, heavy metals, and bacteria. Measured by relative counts of Clostridium perfringens in sediments, dispersion of the spoils material followed patterns of currents in the area, extending 500 meters east and west of the dumpsite.

- Baseline information on seasonal metabolic patterns in sea scallops was applied to the interpretation of field observations. Muscle glycogen levels differ from year to year primarily with respect to available nutrients in the spring. Seasonal flux of glycogen provided an estimate of relative potential for reproductive success in different scallop populations. Kidney G6PDH activity (a marker for biosynthetic activity) was used to judge overall scallop health. Biochemical data from deepwater (>130 m) scallops again showed that their metabolic reserves are too low for successful spawning.

- Monitoring of larval fish was expanded to include juveniles and additional species. Differences were found in RNA/DNA ratios and growth of haddock larvae collected at three sites on southern Georges Bank. Differences were associated with food availability and the presence of a thermocline. Mackerel were spawned and reared through metamorphosis, and their growth and RNA/DNA ratios recorded. The relationships between temperature, RNA/DNA ratios, and growth of temperate marine fish were modeled. Cooperative studies with EPA began on the effects of contaminants on early life stages of marine fish.

- Preliminary work with measures of the adenylate energy charge (AEC) in the soft-shelled clam, showed significant differences between clams caged in Raritan Bay and Arthur Kill and clams caged at a Long Island Sound control station.

Genetics:

- Winter and windowpane flounders and Atlantic mackerel from coastal mid-Atlantic waters have statistically higher frequencies of red blood cell (RBC) chromosome mutation than fish from offshore. No significant relationship has been found between these frequencies and any natural variables that might influence mutation rates.

- Field studies on embryo cytopathology and on mutations in embryo, juvenile, and adult resource fish suggest that present levels of coastal pollution may adversely influence recruitment. Mitotic spindle effects and abnormal division of chromosomes account for the higher incidences of chromosome mutation found in some areas, more than does any increase in chromosome breakage.

Pathobiology and Immunology:

- A high percentage of summer and winter flounder taken from coastal areas had antibody titers indicating they had been exposed to *Aeromonas hydrophila*, a bacterial species, isolated from the New York Bight sludge dumpsite. Windowpane flounder had antibodies predominantly to *E. coli*. Large numbers of red hake had antibody titers to *E. coli* in March, May, and August. In November, however, 60% of red hake collected had titers to *A. hydrophila*, coinciding with reports of an outbreak of red-sore disease in the hake. Caged tautog near the sludge dump had depressed immune states, compared with fish held at the same sites in 1982. Laboratory testing showed that exposure to PCB lowered the immune response in summer flounder.

- Field monitoring for the occurrence of a protozoan parasite, *Glugea stephani*, in winter flounder showed that prevalence varied with site: in Massachusetts Bay, 52% of the fish were infected; 38% in Cape Cod Bay; and at Nantucket Shoal, only 12%. Along the coastal mid-Atlantic Bight, incidence of cysts of the parasite generally reflected the condition of the inshore waters where the flounder spawn, with higher incidence at higher water temperatures.

- A survey of the incidence of parasites and general pathology of sea scallops, surf clams, and ocean quahogs throughout the NEMP monitoring areas showed all to be in good health. No abnormal incidence of infections or parasites was observed.

Behavior:

- In sediments contaminated with sublethal concentrations (74-5222 ppm) of crude oil, initial burrowing of sand worms did not differ from worms in unoiled sediments. Sand worms buried in unoiled sediments, however, did not emerge, whereas emergence of exposed worms was related to the oil concentration and to the extent of weathering of the oiled sediment. Such oil-induced behavioral aberrations may increase vulnerability to predation. This work corroborates similar studies with hard clams, sand lance, and three life stages of red hake.

5.1.5 1984 Findings

5.1.5.1 Water Quality

- While continuing the long-term monitoring of water quality elements, the Water Quality Group recognized the need for a unified data base to document the occurrence and extent of hypoxic areas, changes in phytoplankton species, increases in nutrient loadings, changes in rates of productivity, and variability in physical conditions. This activity was begun during Summer 1984.

- Episodic events of phytoplankton blooms occurred throughout the summer with associated reductions in dissolved oxygen at depths. In August, surface dissolved oxygen values of 15.7 ppm were found in the Hudson-Raritan plume while near-bottom water downstream of this area had 1.6 ppm. Cell counts deposited in the sediments numbered over 10^6 cells/cm^3 of sediment. During the spring bloom fall-out the sedimented cell count measured 3 x 10^6/cm^3.

- The residues of the phytoplankton blooms seen in the bottom nearshore (10 m) appeared to be transient where fine-grained sand sediment indicated a physically dynamic area. In contrast, at the head of the Hudson Shelf Valley (60 m), in fine black mud, the viable cell counts were more constant and with lower numbers except for 10^5 cells/cm^3 in July.

- Persistent low dissolved oxygen in bottom waters did not occur in 1984. Episodic events occurred, and critical values were recorded, but were not area-wide or long-lasting. Lobster mortalities in pots off Manasquan Inlet, associated with large numbers of decaying phytoplankton cells and low dissolved oxygen (0.04 ppm).

- Persistent upwelling occurred from late June through July along the coast from the New York Bight Apex to Chesapeake Bay, with a temperature anomaly of about -2°C. By August the upwelling wind stress decreased and the nearshore water (< 20 m) was nearly isothermal. Upwelling transports sedimented phytoplankton to the photic zone, where they may contribute to bloom conditions. The blooms experienced in August may have resulted from these physical conditions. Upwelling also brings nutrient-rich bottom waters to the surface.

- The rates of decline of lower water mass dissolved oxygen during summer were less in 1984 than 1983.

- Low dissolved oxygen (1.4 ppm) and elevated sulfide (4 micromoles/liter) concentrations were found in the near bottom waters of the Christiaensen Basin in 1983 and 1984. The condition is associated with reducing sediments which develop seasonally as the result of the accumulation of organic material from the nearby sewage sludge dumpsite.

- Lowest salinities since 1980 were encountered in April and June off estuaries (17 $^{o}/oo$ from the Hudson-Raritan system and Chesapeake Bay).

- Counts of Clostridium perfringens were higher in surface waters near estuaries and river mouths. This may be attributable to surface runoff, especially in early spring.

- Concentrations of ammonium found in outer shelf bottom layers in April reflected decomposition of the spring bloom.

- Ammonium concentrations inshore at the head of the Hudson Shelf Valley in August suggested reduced amounts of organic material in the bottom water layer offshore.

- High ammonium concentrations found in August on the inner and middle shelf south of the Shelf Valley probably were related to production of the Hudson-Raritan estuary or inner shelf region.

- Bottom chlorophyll distributions (an indicator of organic loading) were high in April, particularly over the shelf north of Delaware Bay and south of Chesapeake Bay. Chlorophyll concentrations in August were relatively high at the mouths of the Hudson-Raritan and Delaware estuaries and lower along the Delmarva Peninsula.

5.1.5.2 Sediments and Benthos

- An extensive survey of PCBs and PAHs in sediments and selected biota confirmed the heavy pollution of Boston Harbor sediments, and identified sewage discharges and storm water runoff as the dominant sources. Massachusetts Bay sediments landward of Stellwagen Bank also had elevated levels of sediment PCBs (to 84.2 ppb) and PAHs (to 33.3 ppm), whereas levels were lower in Cape Cod Bay and the deep Gulf of Maine.

- Analyses of samples from 19 stations in the deep Gulf of Maine provided baseline information on sediment PCBs there. Concentrations ranged from traces (<0.01 ppm dry weight) to 0.13 ppm; the latter value is similar to maximum concentrations found in an earlier NEMP survey of the New York Bight (0.16 ppm) and Long Island Sound (0.05 ppm).

- In August 1984, spores of Clostridium perfringens (300/ml) occurred to approximately 53 n. mi. seaward of the inner Bight dumpsites down the Hudson Shelf Valley. Densities increased fairly uniformly to a maximum of 1.8 x 10^5/ml 3 n. mi. west of the sewage sludge dumpsite. That value is typical of densities found during past sampling in the same area.

- Samples from 44 stations in the vicinity of the Philadelphia Dumpsite revealed no pathogenic amoebae. Collaborators from EPA and FDA concurrently documented the continued decline in numbers of fecal coliform bacteria. Within four years after cessation of waste disposal, the site completely recovered with respect to human enteric pathogens.

- Links between abundances of sea urchins, kelp and lobsters have been demonstrated conclusively at Cape Neddick, Maine, where increases in urchin populations began creating areas barren of kelp about 10 years ago. Divers have removed all urchins from two large rocks for the past five years. The removal site now has a small but healthy kelp bed with lobster abundance three times that of the adjacent urchin-infested areas.

5.1.5.3 Trace Contaminants in Tissues

- The PCB-PAH survey of Massachusetts Bay revealed only low levels of these contaminants in biota. The highest PCB concentrations measured were in Jonah crabs, and were about a tenth of the 2 ppm action level. Winter flounder and American dab had roughly an order of magnitude fewer PCBs than the crabs.

- Concentrations of PCBs in fish from the lower Hudson-Raritan estuary were at least 10 times lower than the FDA cautionary limit of 2 ppm. Winter flounder contained the highest quantities of PCBs, followed closely by American eel. No spatial trends were apparent in the PCB concentrations.

- Dioxin (TCDD) levels were determined in winter flounder, fluke, blue crab, tomcod, tautog and American eel from in the Hudson-Raritan estuary. Levels were below the limit of detection except at Kill Van Kull where the values ranged from not detectable to 3.8 parts per trillion.

Physiology and Biochemistry:

- Field sampling and laboratory exposures were used to differentiate normal seasonal changes from pollutant-related changes in the blood chemistry of winter and windowpane flounders. Windowpane flounder were collected from 3 stations along a pollutant gradient in Long Island Sound, sampled at monthly intervals over a period of three years. Three blood parameters (osmolality, hematocrit, hemoglobin) differed from the most polluted station compared with the cleanest. In supportive laboratory work, windowpane flounder exposed to mercury (10 ppb, 2 mo.) had altered plasma sodium and calcium, whereas exposure to 10 ppb cadmium or 20 ppb copper produced no such changes in blood chemistry.

- Winter and windowpane flounder collected from sites subject to contaminant loading (NY Bight Apex, Buzzards Bay, Block Island Sound, mouth of Delaware Bay) showed signs of early metabolic stress (high kidney G6PDH, a marker enzyme for biosynthetic activity). Flounder from cleaner stations did not. High values (>95) indicate a stimulatory response to sublethal toxicant stress, and the condition is usually transient in fish that move away from contaminated habitats.

- Information on the sea scallop from Resource Assessment and NEMP/OP monitoring cruises corroborates earlier findings indicating that deepwater populations in the Gulf of Maine are probably unsuccessful at spawning. Most other populations apparently are in good health. Some stressed scallops were found in the area of the Mud Patch, and along the transect from the outer Hudson Shelf Valley south to the Baltimore Canyon Trough station.

- Copper (20 ppb, 7 wk exposure) produced strongly inhibitory effects in the reproductive system and lethal effects in the kidney of experimentally exposed sea scallops. Cadmium (20 ppb, 7 wk), on the other hand, almost entirely sequestered and immobilized in the kidneys, produced little observable effect other than to stimulate an earlier-than-normal gamete maturation.

- Lobsters held in cages at a dredged material dumpsite in central Long Island Sound showed physiological stress, evidenced by a "cough" rate (gill flushing) stronger and more frequent (greater than twofold) than in lobsters held at a control site.

- Enrichment cultures for anaerobes on gills of blue crabs and butterfish taken from Chesapeake Bay were toxic to mice, and appeared to be a type of botulinum. Pathogenic bacteria associated with gill tissue from the same animals appeared in other enrichment cultures.

Genetics:

- Multivariate analysis was performed on cytogenetic, biological, chemical, and physical oceanographic data for eggs of Atlantic mackerel from 20 polluted or clean sites in the NY Bight. Aromatic hydrocarbon pollutants and salinity were co-associated with adverse conditions in all stages of embryo development -- mortality, gross anatomical abnormality, developmental delay, and mitotic chromosomal abnormality. Trace heavy metals were associated with malformation of the mid-states of embryo development. PCBs and other chlorinated hydrocarbons, with temperature, were associated with adverse effects at later stages of embryo development.

Pathobiology and Immunology

- We added 800 specimens and 18 stations to the data base for skeletal anomalies in sand lance. The entire area sampled was divided into 9 sub-areas (6 inshore, 3 offshore) to test for differences between clean and degraded areas. Preliminary analysis indicates some significant differences.

- An infectious sarcoma was discovered in 50% of Chesapeake Bay soft clams. This disease was not present in Chesapeake populations before 1978. In both laboratory and field studies, high mortality rates were associated with the disease.

- Four years after dumping stopped at the Philadelphia disposal site, rock crabs caught there show no evidence of black gill disease. Crabs caught near the New York dump site continued to show evidence of black gill disease in 10-20% of samples. Accumulations of black sand and silt from dumpsite sediment account for a high prevalence of gill blackening in rock crabs.

- No abnormally high parasite burdens or pathology levels were observed in molluscs examined from 33 NEMP stations. Icelandic scallops from the Great South Channel are being examined in light of increased commercial interest.

- The fish-pathology data base was expanded by NMFS Resource Assessment cruises on the shelf in winter, spring, and fall, and by Massachusetts Division of Marine Fisheries cruises in spring and fall. Ulcerated red hake occurred in the Boston area during the fall. Collections near New Haven in Long Island Sound had high prevalences of severe fin erosion in winter flounder, but not in windowpane or summer flounder. Spring prevalences in winter flounder were 17% (N=133) ranging from 13-30%. At Bridgeport, tomcod had a 2% (N=39) prevalence or hepatoma during the spring.

- A wide variety of fish species from the Northeast coastal region were shown to have antibodies indicating exposure to human enteric bacteria. The most prevalent antibody in fish blood tested, however, was to a bacterium indicative of sewage sludge. Cage studies showed evidence of increasingly stressful conditions for fish life at the New York sewage sludge dumpsite. For the first time in three years of study, tautog were unable to survive in cages there.

Behavior:

- After exposure to oil-contaminated sediments, both sandworms and bloodworms burrowed less effectively than control worms and had impaired feeding responses. Shallow burrowing increases predation risk for these important commercial baits for sportfishing.

- Three species of marine polychaetes (sandworms, bloodworms and rag worms) concentrated substantial quantities of cadmium after burial in cadmium-contaminated sediment. This poses a probable threat to predators in terms of food-chain transfer.

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5.3 Data Bases Developed by NEMP Participants

DATA TYPE	TIME PERIOD - CRUISE	SAMPLING LOCATIONS	CUSTODIAN DATA BASE
Amphipods species, parasites, pathology	8-29 Jul 1980 - AL 8007	NEMP Area	P. T. Johnson, NMFS, Oxford Lab.
	4-17 Sep 1980 - AL 8009		
	8-21 Jul 1981 - AL 8107		
	27 Aug-16 Sep - AL 8110		
	26 Jan-11 Feb - AL 8201		
	2-18 Dec 1980 - DL 8009		
	16-20 Nov 1981- DL 8107		
	24 Apr-8 May - KE 8104		
Fish & Scallop physiology, blood data	Fall 1878 - AL 7812	NEMP Area	F. Thurberg, NMFS, Milford Lab.
	Spring 1978 - RE 7804		
	Fall 1979 - KE 7910/11		
	Winter 1979 - DE 7911		
	Summer 1979 - AL 7907		
	Spring 1979 - AD 7901		
	Spring 1980 - KE 8004		
	Summer 1980 - AL 8007		
	Winter 1980 - DE 8009		
	Fall 1980 - AL 8009		
	Spring 1981- KE 8104/05		
	Fall 1881 - AL 8110		
	Summer 1981 - AL 8107		
	Winter 1981 - DE 8107		
	Jan 1982 - AL 8201		
	Apr 1982 - AL 8203		
	Oct 1982 - AL 8211		
	Jul 1982 - AL 8208		
	Aug-Sep 1982 - AL 8210		
	Nov 1982 - AL 8212		
	Spring 1983 - AL 8202		
	Fall 1983 - AL 8308		
	Nov-Dec 1983 - AL 8309		
	Jul 1983 - AL 8305		
	Spring 1984 - AL 8402		
	Summer 1984 - AL 8406		
Fish & Scallop energy metabolism data	Spring 1978 - RE 7804	NEMP Area	E. Gould, NMFS, Milford Lab.
	Fall 1978 - AL 7812		
	Spring 1979 - AD 7901		
	Summer 1979 - AL 7907		
	Fall 1979 - KE 7910/11		
	- KE 8001		
	- DE 8002/Al 8003		
	Spring 1980 - KE 8003/04		
	Summer 1980 - AL 8007		
	- DE 8007		
	Fall 1980 - AL 8009		
	Winter 1980 - DE 8009		

DATA TYPE	TIME PERIOD - CRUISE	SAMPLE LOCATIONS	CUSTODIAN-DATA BASE
Continued	Winter 1980 - DE 8101		
	- DE 8102		
	- DE 8104		
	Spring 1981 - KE 8104/05		
	- KE 1806		
	- AL 8106		
	Winter 1981 - DE 8107		
	Fall 1981 - AL 8110		
	- AL 8113		
	Jan 1983 - AL 8201		
	- DE 8202		
	Apr 1982 - AL 8203		
	- AL 8206		
	Jul 1982 - AL 8208		
	Aug-Sep 1982 - AL 8210		
	Nov 1982 - AL 8212		
	- AL 8302		
	- AL 8305		
	- AL 8307		
	Fall 1983 - AL 8308		
	Spring 1984 - AL 8402		
	Summer 1984 - AL 8406		
	- AL 8407		
Bacteria in sediments, water, animal tissues	Fall 1978 - AL 7812	NEMP Area	J. Graikoski, NMFS, Milford Lab.
	- DE 7802		
	- DE 7902		
	Summer 1979 - AL 7907		
	Fall 1979 - KE 7910		
	Spring 1980 - KE 8003/04		
	Summer 1980 - AL 8007		
	- KE 8011		
	- KE 8007/08		
	- DE 8007		
	- AL 8109		
	- DE 8206		
	Jan 1982 - AL 8201		
	Apr 1982 - AL 8203		
	Aug-Sep 1982 - AL 8210		
	Jul 1983 - AL 8305		
	- AL 8306		
	Nov-Dec 1983 - AL 8309		
	Summer 1984 - AL 8406		
	- AL 8401		
Algal assay of water quality for phytoplankton	Sep 1979 - AL 7910	Del. Bay-Geo. Bank	J. Mahoney, NMFS, Sandy Hook Lab.
	Dec 1979 - DL 7911	Ches. Bay-Geo. Bank	
	Mar-1980 - KE 8003/04		
	Jul 1980 - AL 8007		
	Sep 1980 - AL 8009		

DATA TYPE	TIME PERIOD - CRUISE	SAMPLING LOCATIONS	CUSTODIAN-DATA BASE
Surf clam, ocean quahog, sea scallop pathology	Summer 1980 - DL 8001	NEMP Area	F. Kern, NMFS, Oxford Lab.
	- AL 8006		
	- DL 8006		
	Summer 1981 - DL 8105		
	- AL 8106		
	Summer 1982 - DL 8202		
	- AL 8206		
	- DL 8205		
	Fall 1982 - AL 8212		
	Summer 1983 - AL 8307		
	- DL 8307		
	Summer 1984 - DL 8405		
	- AL 8407		
Planktonic crustaceans, pathology	May 1980 - KE-80	DWD-106 Area	S. MacLean, NMFS, Oxford Lab.
	Jul 1980 - AL 8007	NEMP Area	
	Dec 1980 - DL 8009		
Yellowtail EM-Blood samples	Fall 1981 - DL 8107	NEMP Area	J. Bodammer, NMFS, Oxford Lab.
	Spring 1982 - AL 8203		
Phytoplankton species composition	Oct-Nov 1978 - BE 7803	Nova Scotia Cape Hatteras	M. Cohn, NMFS, Sandy Hook Lab.
	Nov 1978 - BE 7804		
	Feb.-Mar 1979 - DL 7903		
	May 1979 - DL 7904/05		
	Jun-Jul 1979 - AL 7906		
	Aug-Sep 1979 - BE 7901		
	Dec 1979 - DE 7911		
	Feb-Apr 1980 - AL 8002		
	Feb-Mar 1980 - AL 8101		
	Mar-Apr 1980 - KE 8103		
	Apr-May 1980 - EV 8001		
	May-Jun 1980 - DE 8103		
Remote sensing	Nov 79-Jun 81 (weekly) Sea surface temperature	NEMP Area+	W. Phoel, NMFS, Sandy Hook Lab.
	Nov 79-Feb 80 (weekly) Sea Current Charts		
	May 78-Jun 80 (monthly) Surface Isotherm Chart		
	Aug 82-Aug 84 (9 days) Sea Surface Thermal Analy.		

DATA TYPE	TIME PERIOD - CRUISE	SAMPLING LOCATIONS	CUSTODIAN-DATA BASE
Continued	Nov 79 - Present (weekly) Ocean Frontal Analy.		
	Sep 83 - Present (3 days) Thermal Gradients		
	Jul 84 - Present (monthly) Sea Surface Temp.		
	Feb 84 - Present (daily) Sea Surface Temp. Fixed Buoy Data		
	Jun 84 - Present (weekly) Sea Surface Temp. Analy.		
	Jun 84 - Present (15 day mean bimonthly) Sea Surface Temp. Anomalies (incl. SST-Mean & Anomaly)		
	Jun 83 - Present (monthly) Oceanogr. Monthly Summary		
	May 80-Aug 83 (every 2 days) Ocean Frontal Analy. Gulf Stream Analysis		
	May 82 - Present (every 2 days) GOES EAST Satellite Cloud Coverage		
	May 82 - Present (daily) AVHRR (IR) Satellite Images		
	Misc. Dates 1982-83 NOAA 7 Thermal Imagery (photos)		
	Sep 78-Dec 78 LANDSAT EAST CHARM Satellite Images		
	Jan 78 Present (daily) GOES EAST Images		
	Nov 79 - Present (weekly) Sea Surface Temp.		
	May 83 - Present (daily) NOAA AVHRR Inventory Images (IR)		

DATA TYPE	TIME PERIOD - CRUISE	SAMPLING LOCATIONS	CUSTODIAN-DATA BASE
Fish serum antibody profile	Nov 1981 - DE 8107	NEMP Area	J. Stolen, Drew Univ., Madison, NJ
	Aug.-Sep 1981 - AL 8201		
	Jan-Feb 1982 - AL 8201		
	Mar-Apr 1982 - AL 8203		
	Aug-Sep 1982 - AL 8210		
	Nov-Dec 1982 - AL 8212		
	Jul 1983 - AL 8305		
	Aug 1983 - AN 8301	NY Bight & Estuaries	
	Nov 1983 - AL 8309	NEMP Area	
	Jul 1984 - AL 8406		
	Dec 1984 - AL 8409		
	May 1981 - Aug 1984 70 day cruises	NY Bight & Estuaries	
Primary production, nutrient, chlorophyll, trace metals, hydrography	27 Feb-5 Apr - AL 8002	NEMP Area	J. O'Reilly, NMFS, Sandy Hook Lab.
	8-24 Jul - AL 8007		
	3-18 Sep - AL 8009		
	24 Sep-30 Oct - AL 8010		
	17 Nov-23 Dec - AL 8012		
	17 Feb-26 Mar - AL 8101		
	7-21 Jul - AL 8107		
	31 Jul-7 Aug - AL 8108	NY Bight	
	26 Aug-17 Sep - AL 8110	NEMP Area	
	22 Sep-6 Oct - AL 8111	Warm Core Ring Cruise	
	12-23 Oct - AL 8112		
	16 Nov-22 Dec - AL 8201	NEMP Area	
	25 Jan-12 Feb - AL 8201		
	16 Feb-25 Mar - AL 8202		
	30 Mar-9 Arp - AL 8203		
	19 Apr-4 May - AL 8204	Warm Core Ring Cruise	
	17 Jun-2 Jul - AL 8207		
	9-20 Aug 1982 - AL 8209		
	23 Aug-3 Sep - AL 8210	NEMP Area	
	23 May-3 Jun - AL 8304		
	1-15 Jul 1983 - AL 8305		
	22 Aug-7 Sep - AN 8301	NY Bight	
	21 May-23 Jun - DL 8003	NEMP Area	
	24-30 Jun 1980- DL 8004		
	2-19 Dec 1980 - DL 8009		
	20 May-18 Jun - DL 8103		
	17 May-11 Jun - DL 8203		
	8-28 Sep 1982 - DL 8206	Warm Core Ring Cruise	
	15 Nov-22 Dec - DL 8209	NEMP Area	
	17 Jan-11 Feb - DL 8301		
	14 Nov-21 Dec - DL 8309		
	9 Jan-10 Feb - DL 8401		
	5-6 Aug 1980 - EG 8002	Mid-Atl. Bight	
	14 Apr-15 May - EV 8001	NEMP Area	
	16-29 May 1980- EV 8002	Geo. Bank	
	14 Jul-11 Aug - EV 8006	NEMP Area	

DATA TYPE	TIME PERIOD - CRUISE	SAMPLING LOCATIONS	CUSTODIAN-DATA BASE
Continued	24 Mar-10 Apr - KE 8004	NEMP area	
	28 Jul-5 Aug - KE 8011		
	28 Oct-6 Nov - KE 8103		
	18-27 Mar 1981- KE 8104		
	31 Mar-8 Apr - KE 8104		
	May 1983 - Present (weekly) Long Branch Transect	Long Branch, NJ	
	11 Feb-11 Mar - WI 8002	NEMP Area	
	29 Oct-7 Dec - DL 8409		
	21 Jan-8 Feb - DL 8501		
	21-31 Aug 1984- AN 8401	NY Bight	
	7 May-3 Jun - AL 8403	NEMP Area	
Conductivity, Salinity, Temperature, Dissolved O_2, pH*, Meteorological Observations	21-25 Apr 1980- KE 8001	Mid-Atlantic Bight	C. Warsh. NOS/Ocean Assmts. Div., Rockville, MD
	2-6 Jun 1980 - KE 8002		
	14-18 Jul 1980- KE 8003		
	2-6 Sep 1980 - KE 8004		
	15-20 Apr 1981- KE 8005*		
	3-9 Jun 1981 - KE 8006		
	1-7 Aug 1981 - AL 8107		
	9-15 Sep 1981 - MM 8108		
	19-26 Apr 1982- CH 8209		
	28 May-4 Jun - CH 8210		
	26 Jul-2 Aug - CH 8211		
	8-15 Sep 1982 - MM 8212		
	8-15 Apr 1983 - CH 8314		
	31 May-7 Jun - CH 8315		
	30 Jul-6 Aug - CH 8316		
	15-22 Sep 1983- MM 8317		
	16-24 Apr 1984- CH 8419		
	2-9 Jun 1984 - CH 8420		
	14-22 Aug 1984- CH 8422		
	22-31 Oct 1984- MM 8423		
Conductivity, Salinity, Temperature, Dissolved O_2	8-9 Feb 1983 - PI 8313	Norfolk/Dam Neck Dump-site Area	C. Warsh, NOS/ Ocean Assmts. Div., Rockville, MD
	1-2 Feb 1984 - WI 8418		
	28 Feb-1 Mar - PI 8524		
	25-26 Jul 1984- CH 8421	Delaware Shelf	
Chlorophyll *a*	21-25 Apr 1980- KE 8001	Mid-Atlantic Bight	T. Whitledge, Brookhaven Natl. Laboratory, Upton, NY

* pH measurements were collected on this cruise only.

DATA TYPE	TIME PERIOD - CRUISE	SAMPLING LOCATIONS	CUSTODIAN-DATA BASE
Phytoplankton: Identification, Enumeration Nutrients: Ammonium, Nitrate, Nitrite, Phosphate, Silicate	2-6 Jun 1980 - KE 8002		
	14-18 Jul 1980- KE 8003		
	2-6 Sep 1980 - KE 8004		
	15-20 Apr 1981- KE 8105		
	3-9 Jun 1981 - KE 8106		
	1-7 Aug 1981 - AL 8107		
	9-15 Sep 1981 - MM 8108		
	19-26 Apr 1982- CH 8209		**Dr. H. Marshall Old Dominion Univ., Norfolk, VA (phytoplankton only)
	28 May-4 Jun - CH 8210		
	26 Jul-2 Aug - CH 8211		
	8-15 Sep 1982 - MM 8212		
	8-15 Apr 1983 - CH 8314		
	31 May-7 Jun - CH 8315		
	30 Jul-6 Aug - CH 8316		
	15-22 Sep 1983- MM 8317		
	16-24 Apr 1984- CH 8419		
	2-9 Jun 1984 - CH 8420		
	14-22 Aug 1984- CH 8422		
	22-31 Oct 1984- MM 8423		
	25-26 Jul 1984- CH 8421*	Delaware Shelf	T. Whitledge, Brookhaven Natl. Laboratory, Upton, NY
Sediment Grab: phytoplankton identification, C:H:N ratios, chlorophyll a, $N_{14}/15$ ratios, diatom resting spores	21-25 Apr 1980- KE 8001	Mid-Atlantic Bight	T. Whitledge BNL
	2-6 Jun 1980 - KE 8002		
	19-26 Apr 1982- CH 8209		
	28 May-4 Jun - CH 8210		***E. Cosper State Univ. of New York, Stony Brook, NY
	26 Jul-2 Aug - CH 8211		
	8-15 Sep 1982 - MM 8212		
	8-15 Apr 1983 - CH 8314		
	31 May-7 Jun - CH 8315		
	30 Jul-6 Aug - CH 8316		
	15-22 Sep 1983- MM 8317		
	16-24 Apr 1984- CH 8419		
	2-9 Jun 1984 - CH 8420		
	14-22 Aug 1984- CH 8422		
	22-31 Oct 1984- MM 8423		

* Nutrient data only

** Dr. Marshall and T. Whitledge both contributed phytoplankton data beginning in 1982.

*** Beginning in 1982, E. Cosper contributed diatom resting spore data.

5.4 Partial List of NEMP Data and Information Users

Within NOAA

Northeast and Southeast Center and Regional Offices, NMFS
Ocean Assessments Division, National Ocean Service
Estuarine Programs Office
National Undersea Research Center
National Sea Grant

Other Federal Agencies

Environmental Protection Agency
  Environmental Research Laboratories, Narragansett, R.I.; Gulf Breeze, FL; Corvallis, OR
  Region I, II, III Offices

Army Corps of Engineers
  New England Division
  New York Division

Department of Energy

Brookhaven National Laboratory
Argonne National Laboratory
Oak Ridge National Laboratory
Nuclear Regulatory Commission

Department of Interior

  U. S. Fish and Wildlife Service - Boston, MA; Cortland, NY; Newton, PA; Washington, D.C.; LaCrosse, WI; Columbia, MO
  Minerals Management Service - Washington, D.C.; New York, NY

U. S. Navy

  Naval Undersea Research Center - Hawaii
  Naval Underwater Systems Center - New London, CT

U. S. Department of Agriculture

  Bureau of Reclamation - Denver, CO

Smithsonian Tropical Research Inst.
Smithsonian Museum of Natural History

National Academy of Sciences - Washington, DC

New England and Mid-Atlantic Fishery Management Councils

Congressional Offices

Senator Edward Kennedy
Representative James Howard
Office of Technology Assessment

Port Authority of New York and New Jersey

State Agencies or Offices

Massachusetts Division of Marine Fisheries
Massachusetts Coastal Zone Management
Connecticut Department of Environmental Protection
New Jersey Department of Environmental Protection
Louisiana Department of Wildlife and Fisheries
Maryland Department of Natural Resources
Florida Department of Natural Resources
New York Department of Environmental Conservation
Maryland Fisheries Administration
New York Public Service Commission
Florida Department of Environmental Regulation
Oregon Department of Fish and Wildlife
North Carolina Division of Marine Fisheries

Universities and Colleges (U.S.)

- Rutgers University
- Florida Atlantic University
- University of South Carolina
- Univ. of Southern Mississippi
- University of Washington
- University of Connecticut
- SUNY - Stony Brook
- Humboldt State University
- Florida State University
- North Texas State University
- Utah State University
- Oregon State University
- Univ. of California, Santa Barbara
- Virginia Inst. of Marine Science
- Boston University
- Univ. of North Carolina
- Johns Hopkins University
- Long Island University
- Louisiana State University
- Univ. of New England
- College of Charleston
- Mississippi State University
- Texas A&M University
- Univ. of Puerto Rico
- Univ. of Rhode Island
- City College of New York
- University of Miami
- University of West Florida
- University of Massachusetts
- Portland State University, Oregon
- Duke University
- Monmouth College
- T. H. Morgan School of Biol. Science
- University of Illinois
- Adelphi University
- University of Maryland
- Winthrop College
- Calif. State U., Long Beach
- Clemson University
- University of Pennsylvania
- Northern Illinois University
- University of Hawaii
- University of Georgia
- E. Stroudsburg State College
- Southern Calif. Ocean Studies Consortium
- Old Dominion University
- University of Alaska
- University of Arizona
- North Carolina State University
- University of Michigan
- Columbia University
- Virginia Polytechnic Institute and State University
- University of Maryland
- University of Texas
- University of Maine
- University of Vermont
- Colorado State University
- Skidway Institute of Oceanography
- California State College, Fullerton
- Harvard University
- Franklin and Marshall College
- University of Minnesota
- University of Wisconsin
- Fairleigh Dickinson University
- Roanoke College
- Montana State University
- Pennsylvania State University
- Herbert H. Lehman College
- Brown University
- Southeastern Mass. University
- Stanford University
- Southern Conn. State College
- Tulane University
- University of West Florida
- Univ. of Maryland Eastern Shore
- Princeton University
- Cornell University
- Stockton State College
- Va. Commonwealth University
- Miami University
- University of Cincinnati
- Jacksonville University
- West Virginia University
- Michigan State University
- University of Virginia
- University of Delaware
- Lehigh University
- Tufts University
- Manhattan College

Universities and Colleges (Foreign)

Academy of Scientific Research and Technology, Cairo, Egypt
University of Stockholm
University of Montreal
University of Tokyo
Univ. of Sao Paolo, Brazil
Univ. of Sar es Salaam, Tanzania
University of Lund, Sweden
Univ. of Queensland, Australia
University of Oslo
Brock University
Trent University
Queens University
University of Glasgow
Univ. of Rio Grande, Brazil
University of Guelph
University of Pisa
University of Dakar
University of Quebec
The New University of Ulster
University of Algiers
University of Umea, Sweden
University of Bergen, Norway
University of Trieste
Ruhr-Universitat Bochum, Germany
University of Aberdeen
Dalhousie University
University of Alberta
Univ. Autonoma de Barcelona
Mount Allison University
Memorial Univ. of Newfoundland
University of Haifa
University of Nigeria
University of Trondheim
University of Auckland
University of Uppsala, Sweden
University College, Galway, Ireland
University of Pisa, Italy
University of West Ontaria
University of Karachi, Pakistan
University of Southampton
Adam Mickiewicy University, Poland
McGill University
University of Tunis
University of St. Andrews
University of Nice
Unvi. of Juvaskyla, Finland
University of Calgary
University of Victoria
Univ. of Rajastban, India
Univ. Claude Bernard
University of Malaysia
University of Cordoba
Madras University
University of Lancaster
Queen Mary College
Universite Sainte Ursule
University of North Bengal
Kyushu University
University of Hohenheim
Pacharyappa's College
University of Edinburgh
University of Lima
University of Sydney
University of Liverpool
The Chinese University of Hong Kong
University of Salzburg
Univ. of Santiago, Spain
University of York
Jiwaji University, India
University of Dundee
University of Jodhpur, India
The Hebrew University
Ecole Normale Superieure, Paris

Public or Private Institutions

- Center for Energy & Environmental Research - San Juan, PR
- International Council for the Exploration of the Sea - Copenhagen
- Pacific Gamefish Foundation
- Marine Environmental Sciences Consortium - Dauphin Is., Alabama
- Worcester Foundation for Experimental Biology
- Max Planck Institute
- Harbor Branch Foundation
- New York Aquarium
- Academy of Natural Sciences of Philadelphia
- The Nature Conservancy
- New England Aquarium
- Mystic Aquarium
- Mote Marine Science Center
- New Jersey Marine Sciences Consortium

Environmental Consulting and Industrial Firms

- Battelle Laboratories, Columbus, OH; Duxbury, MA; Sequim, WA
- Dames and Moore - Los Angeles, CA
- SEAMocean - Wheaton, MD
- Ecological Analysts - Sparks, MD
- Camp, Dresser and McKee - New York
- TETRA TECH - Bellevue, WA
- Metcalf & Eddy - Woburn, MA
- Goldberg Zoino Assoc. - Newton, MA
- Science Applications, Inc. - Newport, RI; Oak Ridge, TN; La Jolla, CA
- Boston Edison
- NASA Slidell Company
- Atlantic Oceanics Co., LTD.
- Steimle and Associates, Inc.
- Shell International Research
- Woodward-Clyde Consultants
- Dalton-Dalton, Newport
- Hawaiian Electric Co., Inc.
- Carolina Power and Light Co.
- Lockheed Center for Marine Research
- Yankee Atomic Electrical Co.
- Water Resources Engineers
- Wapora, Inc.
- Texas Instruments, Inc.
- Bionomics
- Bechtel Corporation
- ESE Environmental Science and Engineering, Inc.
- Applied Biology, Inc.
- L.G.L. Limited
- Garden State Seafood
- EG&G - Waltham, MA
- Henry Ford Hospital
- Normandeau Associates, Inc.

Recreational Fishing Interest Groups

International Game Fish Association - Ft. Lauderdale, FL

Public Environmental Conservation Groups

Monmouth County Friends of Clearwater, Inc.
American Littoral Society
Clean Ocean Action
Conservation Law Foundation
National Wildlife Federation

Media

New York Times
Cape Cod Times
Palm Beach Post
Long Island Newsday
Asbury Park (NH) Press
Shrewsbury (NJ) Register
Newark (NJ) Star Ledger
National Geographic
National Fisherman Magazine
The Long Island Fisherman

Foreign Marine Science Research Institutions and Agencies

Ministry of Agriculture, Fisheries and Food - England
Swedish Salmon Research Institute
Institute of Applied Zoology, Poland
Scottish Marine Biological Assoc.
Fisheries Research Board of Canada
Nederlands Institute voor Hersenonderzoek
Institut Europeen d' Ecologie
Marine Biological Laboratory, India
National Institute for the Investigation of Fishes - Portugal
Rkysinstituit voor Visserijondezoek
Hydrometeorological Services of the USSR
National Agency of Environmental Protection, Denmark
Southeast Asian Fisheries Development Center - Philippines
Oceanographical Museum and Sea Aquarium, Poland
Dept. Fisheries and Fauna - Australia
Inland Fisheries Institute, Poland
Natural Environment Research Council, Scotland
Turkish Ministry of Agriculture and Forestry
Fisheries Research Branch - St. Johns, NF, Canada
Vetinary Hygiene Research Station, Gdansk, Poland

5.5 Glossary of Abbreviations and Acronyms

BCF	Bioconcentration factor (here the ratio of concentrations in organisms to concentrations in sediments)
BNL	Brookhaven National Laboratory of Department of Energy
FY	Fiscal Year (1 October through 30 September)
MARMAP	Marine Resources Monitoring, Assessment and Prediction Program of NOAA
MESA	Marine Ecosystems Analysis Program of NOAA
NEFC	Northeast Fisheries Center, NMFS
NEMP	Northeast Monitoring Program of NOAA
NMFS	National Marine Fisheries Service of NOAA
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center of NOAA
NOS	National Ocean Service of NOAA
NS&T	National Status and Trends Program of OAD and NMFS
OA	Oceanic and Atmospheric Services of NOAA (prior to 1983)
OAD	Ocean Assessments Division of NOAA (1983 - present; formerly OA)
OD	Ocean Dumping Program of AO, NOAA
PAE	phthalate acid ester
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDP	Program Development Plan
PHC	petroleum hydrocarbon
RAP	Regional Action Plan of the Northeast Region and Center of NMFS
RD	Research and Development of NOAA
TDP	Technical Development Plan

5.6 Common and Scientific Names of Species Discussed in Text

COMMON NAME	SCIENTIFIC NAME
American dab	*Hippoglossoides plattesoides*
American eel	*Anguilla rostrata*
ampeliscid amphipod	*Ampelisca agassizi*
anaerobic spore-forming bacterium	*Clostridium perfringens*
Atlantic mackerel	*Scomber scombrus*
blood worm	*Glycera dibranchiata*
blue crab	*Callinectes sapidus*
blue mussel	*Mytilus edulis*
butterfish	*Peprilus triacanthus*
calico crab	*Ovalipes ocellatus*
ceriantharian anemone	*Ceriantheopsis americanus*
diatom	*Skeletonema costatum*
Dungeness crab	*Cancer magister*
false quahog	*Pitar morrhuana*
flabelligerid worm	*Pherusa affinis*
fourspot flounder	*Paralichthys oblongus*
haddock	*Melanogrammus aeglefinus*
hard clam (quahog)	*Mercenaria mercenaria*
Jonah crab	*Cancer borealis*
little neck clam	*Protothaca staminea*
little skate	*Raja erinacea*
lobster	*Homarus americanus*
lumbrinerid thread worm	*Lumbrineris fragilis*
marine bacillus bacterium	*Vibrio* spp.
nut clam	*Nucula proxima*
ocean quahog	*Arctica islandica*
pathogenic amoeba	*Acanthamoeba* sp.
protozoan flatfish parasite	*Glugea stephani*
rag worm	*Nephtys caeca*
red hake	*Urophycis chuss*
red-lined worm	*Nephtys incisa*
rock crab	*Cancer irroratus*
sand lance	*Ammodytes americanus* or *A. dubius*
sand worm	*Nereis virens*
sea scallop	*Placopecten magellanicus*
silver hake	*Merluccius bilinearis*
sludge-indicating bacterium	*Aeromonas hydrophila*
sludge-indicating coliform bacterium	*Escherichia coli*
soft clam	*Mya arenaria*
striped bass	*Morone saxatilis*
summer flounder	*Paralichthys dentatus*
surf clam	*Spisula solidissima*
tautog	*Tautoga onitis*
tomcod	*Microgadus tomcod*
windowpane flounder	*Scophthalmus aquosus*
winter flounder	*Pseudopleuronectes americanus*
yellowtail flounder	*Limanda ferruginea*

Appendix 5.7. Trace Metal Body Burdens for Species Measured in the Northeast as Part of the NEMP.

Notations for "Number of samples and types of values", and abbreviations, are encoded as follows:

12c (3-5) = 12 composites of 3-5 individuals each
9m (1-6) = 9 mean values calculated from 1-6 individual measurements each
12 = individual analyses
NYB = New York Bight
NA = Not available

Ag (ppm wet weight)

Area	Matrix	Number of samples and type of values	Mean	Range	Source/ Cruise
Crab, rock (*Cancer irroratus*)					
NYB	Muscle	12c (3-5)	-	.27- .81	KE8007
NYB	Gill	9m (1-6)	-	.34-3.04	AL7907
NYB	Diverticula	12m (4-5)	-	.93-2.56	AL8109
Flounder, four spot (*Paralichthys oblongus*)					
NYB	Liver	9m (3-5)	-	<.10- .12	AL8109
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	12c (1-4)	-	<.08-<.14	KE8007
NYB	Muscle	3m (6-11)		<.10-<.13	AL7907
NYB	Liver	3m (1-9)	-	<.12-<.72	AL7907
NYB	Liver	11m (4-11)	-	<.10- .29	AL8109
NYB	Muscle	13m (4-16)	-	.02- .16	GR83
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c (2-5)	-	<.05-<.1	KE8007
NYB	Muscle	3m (3-12)	-	NA-<.11	AL7907
NYB	Liver	3m (2-10)	-	<.54- .21	AL7907
NYB	Liver	9m (3-16)	-	.20- .69	AL8109
Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	-	<.04-<.33	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8c (2-3)	.44	.10- .73	KE8007
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	12	.04	.03- .05	KY8101
Off New Jersey	Viscera	12	.96	.22-2.11	KY8101
Off New Jersey	Gonad	12	.28	.13- .73	KY8101
Off New Jersey	Gills	12	.24	.13- .36	KY8101
Off New Jersey	Muscle	8	.03	.02- .05	KY8102
Off New Jersey	Viscera	11	1.28	.35-2.48	KY8102
Off New Jersey	Gonad	10	.21	.09- .37	KY8102
Off New Jersey	Gills	11	.10	.06- .21	KY8102

Off New Jersey	Gonad	13	.09	.04- .19	KY8103
Off New Jersey	Muscle	12	.04	.02- .05	KY8104
Off New Jersey	Viscera	12	2.52	.25-8.35	KY8104
Off New Jersey	Gonad	12	.09	.04- .19	KY8104
Off New Jersey	Gills	12	1.89	.53-12.7	KY8104
Off New Jersey	Muscle	12	.02	.01- .03	KY8105
Off New Jersey	Viscera	12	1.94	.27-3.83	KY8105
Off New Jersey	Gonad	12	.05	.03- .08	KY8105
Off New Jersey	Gills	9	.06	.02- .10	KY8105
Off New Jersey	Muscle	11	.04	.01- .13	KY8106
Off New Jersey	Viscera	12	1.89	.39-6.86	KY8106
Off New Jersey	Gonad	11	.14	.03- .67	KY8106
Off New Jersey	Gills	12	.09	.04- .16	KY8106
NYB	Muscle	6c (3-5)	-	<.04-<.1	KE8007
NYB	Muscle	4m (10-11)	-	<.07-<.16	AL7907
NYB	Viscera	4m (9-11)	-	.87-2.55	AL7907
NYB	Gonad	4m (9-11)	-	.10-<1.12	AL7907
NYB Apex	Whole	5m (5-6)	-	.11- .19	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	.13- .29	DL8105,8205
Georges Bank	Whole	1m (5-6)	.07	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	.09- .45	DL8105,8205
NE shelf	Whole	6m (5-6)	-	.11- .40	DL8105,8205
Gulf of Maine	Muscle	9	-	<.18-<1.39	AL8007
Gulf of Maine	Viscera	9	-	4.93-15.4	AL8007
Gulf of Maine	Gonad	9	-	<.27-2.32	AL8007
Gulf of Maine	Gill	9	-	.23-<.79	AL8007
Shelf off Cape Cod	Muscle	9	-	<.18-<.39	AL8007
Shelf off Cape Cod	Viscera	9	-	6.60-19.3	AL8007
Shelf off Cape Cod	Gonad	9	-	<.23-<1.14	AL8007
Shelf off Cape Cod	Gill	10	-	<.24-<.96	AL8007

Cd (ppm dry weight)

Crab, rock (Cancer irroratus)					
NYB	Muscle	12c (3-5)	-	<.06-<.27	KE8007
NYB	Gill	9m (1-6)	-	.88-1.79	AL7907
NYB	Diverticula	12m (4-5)	-	.80-4.65	AL8109
Flounder, four spot (Paralichthys oblongus)					
NYB	Liver	9m (3-5)	-	.06- .43	AL8109
Flounder, windowpane (Scophthalmus aquosus)					
NYB	Muscle	12c (1-4)	-	<.08- .25	KE8007
NYB	Muscle	3m (6-11)	-	<.10-<.13	AL7907
NYB	Liver	3m (1-9)	-	<.16- .33	AL7907
NYB	Liver	11m (4-11)	-	.03- .37	AL8109
NYB	Muscle	13m (4-16)	-	.10- .68	GR83
Flounder, winter (Pseudopleuronectes americanus)					
NYB	Muscle	13c (2-5)	-	<.06-<.10	KE8007
NYB	Muscle	3m (6-11)	-	<.08-<.11	AL7907
NYB	Liver	3m (1-9)	-	.13-1.26	AL7907
NYB	Liver	9m (5-16)	-	.03- .13	AL8109

Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	-	<.04-<.33	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8c (2-3)	6.6	<.07- .15	KE8007
Mussel (*Mytilus edilus*)					
Long Island Sound	Whole	10 (10)	1.3	.41-5.1	GR85
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	12	.19	.06-1.09	KY8101
Off New Jersey	Viscera	12	10.6	.63-18.3	KY8101
Off New Jersey	Gonad	12	1.54	.19-15.3	KY8101
Off New Jersey	Gills	12	.58	.26-1.03	KY8101
Off New Jersey	Muscle	9	.09	.05-.18	KY8102
Off New Jersey	Viscera	11	19.0	14.3-24.1	KY8102
Off New Jersey	Gonad	9	.24	.13- .38	KY8102
Off New Jersey	Gills	11	.58	.36-1.03	KY8102
Off New Jersey	Muscle	12	.10	.06- .18	KY8103
Off New Jersey	Gonad	13	.17	.08- .58	KY8103
Off New Jersey	Muscle	12	.15	.12- .22	KY8104
Off New Jersey	Viscera	12	23.6	.78-4 .6	KY8104
Off New Jersey	Gonad	12	.11	.06- .18	KY8104
Off New Jersey	Gills	12	1.89	.53-12.7	KY8104
Off New Jersey	Muscle	12	.07	.05- .09	KY8105
Off New Jersey	Viscera	12	25.4	15.5-44.8	KY8105
Off New Jersey	Gonad	12	.08	.04- .14	KY8105
Off New Jersey	Gills	11	.51	.11- .95	KY8105
Off New Jersey	Muscle	12	.10	.06- .19	KY8106
Off New Jersey	Viscera	12	28.7	15.8-44.6	KY8106
Off New Jersey	Gonad	12	.26	.06- .73	KY8106
Off New Jersey	Gills	12	.80	.50-1.39	KY8106
NYB	Muscle	6c (3-5)	-	<.09- .20	KE8007
NYB	Muscle	4m (10-11)	-	<.07-<.20	AL7907
NYB	Viscera	4m (9-11)	-	33.3-78.1	AL7907
NYB	Gonad	4m (9-11)	-	<.27-<3.99	AL7907
NYB Apex	Whole	5m (5-6)	-	.16- .32	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	.18- .22	DL8105,8205
Georges Bank	Whole	1m (5-6)	.43	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	.29- .59	DL8105,8205
NE shelf	Whole	6m (5-6)	-	.26- .46	DL8105,8205
Gulf of Maine	Muscle	9	-	<.18-<1.39	AL8007
Gulf of Maine	Viscera	9	-	120-236	AL8007
Gulf of Maine	Gonad	9	-	<.27-<1.00	AL8007
Gulf of Maine	Gill	9	-	.26- .88	AL8007
Shelf off Cape Cod	Muscle	9	-	<.15-<.39	AL8007
Shelf off Cape Cod	Viscera	9	-	69.2-242	AL8007
Shelf off Cape Cod	Gonad	9	-	<.23-<1.14	AL8007
Shelf off Cape Cod	Gill	10	-	<.31-2.31	AL8007

Cr (ppm wet weight)

Crab, rock (*Cancer irroratus*)					
NYB	Muscle	12c (3-5)	6.5	.25-1.39	KE8007
NYB	Gill	9m (1-6)	-	<.20-2.52	AL7907

Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	12c (1-4)	-	<.20-1.22	KE8007
NYB	Muscle	3m (6-11)	-	.20- .30	AL7907
NYB	Liver	3m (1-9)	-	<.174-<.23	AL7907
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c (2-5)	-	<.13-1.35	KE8007
NYB	Muscle	3m (3-12)	-	.5- .19	AL7907
NYB	Liver	3m (2-10)	-	.34-<1.07	AL7907
Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	.25	.10- .76	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8c (2-3)	-	<.10- .52	KE8007
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	12	.12	.07- .15	KY8101
Off New Jersey	Viscera	12	.43	.14- .60	KY8101
Off New Jersey	Gonad	12	.26	.15- .47	KY8101
Off New Jersey	Gills	12	.14	.09- .22	KY8101
Off New Jersey	Muscle	9	.16	.08- .23	KY8102
Off New Jersey	Viscera	11	.68	.47- .99	KY8102
Off New Jersey	Gonad	8	.44	.17- .74	KY8102
Off New Jersey	Gills	11	.22	.12- .29	KY8102
Off New Jersey	Muscle	12	.15	.09- .42	KY8103
Off New Jersey	Gonad	13	.16	.09- .23	KY8103
Off New Jersey	Muscle	12	.12	.09- .14	KY8104
Off New Jersey	Viscera	12	.66	.30-1.00	KY8104
Off New Jersey	Gonad	12	.21	.12- .32	KY8104
Off New Jersey	Gills	10	.23	.13- .36	KY8104
Off New Jersey	Muscle	10	.10	.08- .15	KY8105
Off New Jersey	Viscera	10	.53	.27- .69	KY8105
Off New Jersey	Gonad	11	.13	.09- .24	KY8105
Off New Jersey	Muscle	8	.17	.07- .39	KY8106
Off New Jersey	Viscera	11	.52	.20- .77	KY8106
Off New Jersey	Gonad	4	.21	.17- .29	KY8106
Off New Jersey	Gills	3	.19	.08- .38	KY8106
NYB	Muscle	6c (3-5)	.26	.16- .44	KE8007
NYB	Muscle	4m (10-11)	-	<.16-<.38	AL7907
NYB	Viscera	4m (9-11)	-	<1.07-<1.36	AL7907
NYB	Gonad	4m (9-11)	-	<.28-<2.24	AL7907
NYB Apex	Whole	5m (5-6)	-	.16-1.06	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	.49- .73	DL8105,8205
Georges Bank	Whole	1m (5-6)	.30	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	.31- .64	DL8105,8205
NE shelf	Whole	6m (5-6)	-	.27- .65	DL8105,8205
Gulf of Maine	Muscle	9	-	.25-<2.78	AL8007
Gulf of Maine	Viscera	9	-	.99-3.00	AL8007
Gulf of Maine	Gonad	9	-	<.54-2.60	AL8007
Gulf of Maine	Gill	9	-	<.46-<2.14	AL8007
Shelf off Cape Cod	Muscle	9	-	<.30-<.78	AL8007
Shelf off Cape Cod	Viscera	9	-	<1.17-<2.14	AL8007
Shelf off Cape Cod	Gonad	9	-	<.45-<2.27	AL8007
Shelf off Cape Cod	Gill	10	-	<.47-<1.92	AL8007

Cu (ppm wet weight)

Crab, rock (*Cancer irroratus*)					
NYB	Muscle	12c (3-5)	-	3.24-10.0	KE8007
NYB	Gill	9m (1-6)	-	12.4-33.4	AL7907
NYB	Diverticula	12m (4-5)	-	20.5-56.3	AL8109
Flounder, four spot (*Paralichthys oblongus*)					
NYB	Liver	9m (3-5)	-	2.73-6.71	AL8109
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	12c (1-4)	-	.15- .35	KE8007
NYB	Muscle	3m (6-11)	-	.16- .32	AL7907
NYB	Liver	3m (1-9)	-	5.1-6.5	AL7907
NYB	Liver	11m (4-11)	.23	3.23-9.11	AL8109
NYB	Muscle	13m (4-16)	-	2.8-9.1	GR83
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c (2-5)	.23	.14- .34	KE8007
NYB	Muscle	3m (2-10)	-	.19- .34	AL7907
NYB	Liver	3m (2-10)	-	8.0-15.6	AL7907
NYB	Liver	9m (4-15)	-	4.62-26.3	AL8109
Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	-	.10- .48	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8c (2-3)	-	2.27-15.5	KE8007
Mussel (*Mytilus edilus*)					
Long Island Sound	Whole	10m (10)	1.8	1.0-2.3	GR85
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	12	.17	.12- .29	KY8101
Off New Jersey	Viscera	12	3.49	1.42-5.37	KY8101
Off New Jersey	Gonad	12	1.41	.47-4.86	KY8101
Off New Jersey	Gills	12	.69	.54- .80	KY8101
Off New Jersey	Muscle	9	.19	.11- .23	KY8102
Off New Jersey	Viscera	11	7.98	4.74-11.0	KY8102
Off New Jersey	Gonad	8	1.18	.75- 1.86	KY8102
Off New Jersey	Gills	11	.76	.57- .91	KY8102
Off New Jersey	Muscle	12	.17	.12- .28	KY8103
Off New Jersey	Gonad	13	1.54	.14- 2.34	KY8103
Off New Jersey	Muscle	12	.22	.17- .24	KY8104
Off New Jersey	Viscera	12	8.08	3.57-10.9	KY8104
Off New Jersey	Gonad	12	1.76	.90-2.85	KY8104
Off New Jersey	Gills	12	.91	.73-1.07	KY8104
Off New Jersey	Muscle	12	.17	.13- .20	KY8105
Off New Jersey	Viscera	12	8.07	4.73-11.5	KY8105
Off New Jersey	Gonad	12	1.82	.78-3.28	KY8105
Off New Jersey	Gills	11	.51	.31- .65	KY8105
Off New Jersey	Muscle	12	.21	.14- .47	KY8106
Off New Jersey	Viscera	12	5.52	2.83-8.44	KY8106
Off New Jersey	Gonad	12	1.28	.57-2.76	KY8106
Off New Jersey	Gills	12	.72	.40- .94	KY8106

NYB	Muscle	6c (3-5)	.12	.08- .19	KE8007
NYB	Muscle	4	-	.11- .23	AL7907
NYB	Viscera	4	-	5.06-10.7	AL7907
NYB	Gonad	4	-	.90-3.82	AL7907
NYB Apex	Whole	5m (5-6)	-	1.52-3.10	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	1.65-2.30	DL8105,8205
Georges Bank	Whole	1m (5-6)	1.02	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	.86-1.27	DL8105,8205
NE shelf	Whole	6m (5-6)	-	1.08-1.86	DL8105,8205
Gulf of Maine	Muscle	9	-	.20-1.11	AL8007
Gulf of Maine	Viscera	9	-	23.8-42.4	AL8007
Gulf of Maine	Gonad	9	-	1.94-6.43	AL8007
Gulf of Maine	Gill	9	-	1.03-21.4	AL8007
Shelf off Cape Cod	Muscle	9	-	.12- .41	AL8007
Shelf off Cape Cod	Viscera	9	-	13.0-35.3	AL8007
Shelf off Cape Cod	Gonad	9	-	1.63-6.57	AL8007
Shelf off Cape Cod	Gill	10	-	1.35-2.08	AL8007

Hg (ppm wet weight)

Crab, rock (*Cancer irroratus*)					
NYB	Muscle	1	.16	-	KE8007
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	10	-	.02- .25	KE8007
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	7	-	<.04- .12	KE8007
Hake, red (*Urophycis chuss*)					
NYB	Muscle	7	-	.03- .09	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8	.09	.04- .15	KE8007
Scallop, sea (*Placopecten magellanicus*)					
NYB	Muscle	6	-	<.02-<.04	KE8007

Ni (ppm wet weight)

Crab, rock (*Cancer irroratus*)					
NYB	Muscle	12c (3-5)	-	.26- .64	KE8007
NYB	Gill	9m (1-6)	-	.41- .91	AL7907
NYB	Diverticula	12m (4-5)	-	.15-1.38	AL8109
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	12c (1-4)	-	<.15-<.29	KE8007
NYB	Muscle	3m (6-11)	-	NA-<.25	AL7907
NYB	Liver	3m (1-9)	-	<.23-<1.44	AL7907
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c (2-5)	-	<.16- .35	KE8007
NYB	Muscle	3m (3-12)	-	<.16-<.25	AL7907
NYB	Liver	3m (2-10)	-	<.20-<1.07	AL7907

Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	-	<.09-<.65	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	7c (1-5)	.22	.08- .46	KE8007
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	5	.09	.06- .12	KY8101
Off New Jersey	Viscera	9	.30	.20- .41	KY8101
Off New Jersey	Gonad	4	.27	.21- .34	KY8101
Off New Jersey	Gills	4	.24	.18-32	KY8101
Off New Jersey	Muscle	3	.08	.08- .09	KY8102
Off New Jersey	Viscera	9	.35	.25- .44	KY8102
Off New Jersey	Gills	3	.16	.12- .21	KY8102
Off New Jersey	Muscle	12	.12	.06- .16	KY8103
Off New Jersey	Gonad	11	.17	.08- .43	KY8103
Off New Jersey	Muscle	12	.11	.09- .13	KY8104
Off New Jersey	Viscera	11	.45	.23-.64	KY8104
Off New Jersey	Gonad	8	.11	.02- .15	KY8104
Off New Jersey	Gills	9	.17	.11- .22	KY8104
Off New Jersey	Muscle	1	.10	-	KY8105
Off New Jersey	Viscera	5	.62	.38- .91	KY8105
Off New Jersey	Gonad	3	.13	.09- .19	KY8105
Off New Jersey	Gills	3	.35	.26- .43	KY8106
Off New Jersey	Muscle	4	.08	.07- .09	KY8106
Off New Jersey	Viscera	5	.36	.22- .47	KY8106
Off New Jersey	Gonad	1	.21	-	KY8106
Off New Jersey	Gills	2	.13	.12- .13	KY8106
NYB	Muscle	6c (3-5)	-	<.09-<.18	KE8007
NYB	Muscle	4m (10-11)	-	<.14-<.32	AL7907
NYB	Viscera	4m (9-11)	-	<1.19-2.08	AL7907
NYB	Gonad	4m (9-11)	-	<.23-<2.24	AL7907
NYB Apex	Whole	5m (5-6)	-	1.06-2.53	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	.56-1.07	DL8105,8205
Georges Bank	Whole	1m (5-6)	.97	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	1.71-2.83	DL8105,8205
NE shelf	Whole	6m (5-6)	-	.84-3.91	DL8105,8205
Gulf of Maine	Muscle	9	-	<.35-<2.78	AL8007
Gulf of Maine	Viscera	9	-	2.43-3.43	AL8007
Gulf of Maine	Gonad	9	-	.50-<2.00	AL8007
Gulf of Maine	Gill	9	-	<.52-<1.58	AL8007
Shelf off Cape Cod	Muscle	9	-	<.30-<.58	AL8007
Shelf off Cape Cod	Viscera	9	-	1.35-3.43	AL8007
Shelf off Cape Cod	Gonad	9	-	<.45-<2.27	AL8007
Shelf off Cape Cod	Gill	10	-	<.47-<1.96	AL8007

Pb (ppm wet weight)

Crab, rock (*Cancer irroratus*)					
NYB	Muscle	12c (3-5)	-	<.3-<1.6	KE8007
NYB	Gill	9m (1-6)	-	.7-9.2	AL7907

Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	12c (1-4)	-	<.4-<.9	KE8007
NYB	Muscle	3m (6-11)	-	<.6-<.8	AL7907
NYB	Liver	2m (1-2)	-	<.7-<1.0	AL7907
NYB	Muscle	13m (4-16)	-	<.4- .8	GR83
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c (2-5)	3.8	<.3-<.6	KE8007
NYB	Muscle	3m (6-11)	-	<.5-<.6	AL7907
NYB	Liver	3m (1-9)	-	<.6-<.32	AL7907
NYB	Liver	9m (2-10)	-	.30-1.09	AL8109
Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	-	.3-<2.0	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8c (2-3)	-	<.3- .6	KE8007
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	4	.19	.10- .32	KY8101
Off New Jersey	Viscera	3	.45	.34- .51	KY8101
Off New Jersey	Gonad	1	.40	-	KY8101
Off New Jersey	Muscle	4	.26	.16- .46	KY8102
Off New Jersey	Viscera	5	.69	.32-1.76	KY8102
Off New Jersey	Gonad	1	.45	-	KY8102
Off New Jersey	Gills	3	.23	.17- .34	KY8102
Off New Jersey	Muscle	9	.25	.12- .38	KY8103
Off New Jersey	Gonad	8	.41	.12- .77	KY8103
Off New Jersey	Muscle	12	.32	.25- .38	KY8104
Off New Jersey	Viscera	11	.70	.24-1.29	KY8104
Off New Jersey	Gonad	12	.41	.28- .54	KY8104
Off New Jersey	Gills	11	.53	.30- .76	KY8104
Off New Jersey	Muscle	3	.30	.11- .55	KY8105
Off New Jersey	Viscera	2	1.26	.74-1.78	KY8105
Off New Jersey	Gonad	5	.27	.19- .40	KY8105
Off New Jersey	Gills	4	.66	.50- .87	KY8105
Off New Jersey	Muscle	4	.23	.17- .29	KY8106
Off New Jersey	Viscera	3	.41	.35- .46	KY8106
Off New Jersey	Gonad	2	.42	.37- .46	KY8106
Off New Jersey	Gills	2	.28	.23- .32	KY8106
NYB	Muscle	6c (3-5)	-	.2-< .5	KE8007
NYB	Muscle	4m (10-11)	-	<.5-<1.0	AL7907
NYB	Viscera	4m (9-11)	-	<1.5-<4.8	AL7907
NYB	Gonads	4m (9-11)	-	<.5-<4.9	AL7907
NYB Apex	Whole	5m (5-6)	-	.51-2.23	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	.66- .97	DL8105,8205
Georges Bank	Whole	1m (5-6)	.57	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	.66-1.18	DL8105,8205
NE shelf	Whole	6m (5-6)	-	.56-1.44	DL8105,8205
Gulf of Maine	Muscle	9	-	<1.1-5.6	AL8007
Gulf of Maine	Viscera	9	-	4.2-12.9	AL8007
Gulf of Maine	Gonad	9	-	1.1-<6.0	AL8007
Gulf of Maine	Gill	9	-	<1.4-3.3	AL8007
Shelf off Cape Cod	Muscle	9	-	1.2-3.9	AL8007

Shelf off Cape Cod	Viscera	9	-	4.0-29.5	AL8007
Shelf off Cape Cod	Gonad	9	-	.9-14.1	AL8007
Shelf off Cape Cod	Gill	10	-	1.0-7.2	AL8007

Zn (ppm wet weight)

Crab, rock (*Cancer irroratus*)					
NYB	Muscle	12c (3-5)	39	4.18-59.3	KE8007
NYB	Gill	9m (1-6)	-	19.5-38.5	AL7907
NYB	Diverticula	12m (4-5)	-	18.7-35.0	AL8109
Flounder, four spot (*Paralichthys oblongus*)					
NYB	Liver	9m (3-5)	-	41.1-77.8	AL8109
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	12c (1-4)	3.82	1.42-6.80	KE8007
NYB	Muscle	3m (6-11)	-	1.56-2.75	AL7907
NYB	Liver	3m (1-9)	-	14.7-25.0	AL7907
NYB	Liver	11m (4-11)	-	25.2-35.4	AL8109
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c (2-5)	-	1.42-6.44	KE8007
NYB	Muscle	3m (3-12)	-	1.91-3.02	AL7907
NYB	Liver	3m (2-10)	-	24.3-31.2	AL7907
NYB	Liver	9m (3-16)	-	26.7-56.7	AL8109
Hake, red (*Urophycis chuss*)					
NYB	Muscle	7c (1-5)	4.08	.77-16.4	KE8007
Lobster (*Homarus americanus*)					
NYB	Tail meat	8c (2-3)	14	5.75-19.3	KE8007
Scallop, sea (*Placopecten magellanicus*)					
Off New Jersey	Muscle	12	8.57	6.74-11.0	KY8101
Off New Jersey	Viscera	12	17.2	6.08-47.7	KY8101
Off New Jersey	Gonad	12	23.2	8.26-53.4	KY8101
Off New Jersey	Gills	12	13.6	8.49-33.9	KY8101
Off New Jersey	Muscle	9	9.27	8.32-10.8	KY8102
Off New Jersey	Viscera	11	20.2	16.5-26.0	KY8102
Off New Jersey	Gonad	11	29.6	11.4-62.9	KY8102
Off New Jersey	Gills	11	11.2	5.18-15.2	KY8102
Off New Jersey	Muscle	12	8.80	7.34-12.9	KY8103
Off New Jersey	Gonad	13	38.3	5.25-71.1	KY8103
Off New Jersey	Muscle	12	10.6	8.84-12.7	KY8104
Off New Jersey	Viscera	12	21.3	13.10-27.9	KY8104
Off New Jersey	Gonad	12	37.0	7.18-69.9	KY8104
Off New Jersey	Gills	12	10.7	7.70-13.7	KY8104
Off New Jersey	Muscle	12	8.64	7.51-9.96	KY8105
Off New Jersey	Viscera	12	17.1	12.4-30.4	KY8105
Off New Jersey	Gonad	12	32.0	3.71-69.9	KY8105
Off New Jersey	Gills	11	6.77	4.73-10.3	KY8105
Off New Jersey	Muscle	12	12.0	8.00-30.1	KY8106
Off New Jersey	Viscera	12	18.3	9.82-24.6	KY8106
Off New Jersey	Gonad	12	19.7	6.12-41.1	KY8106
Off New Jersey	Gills	12	8.89	6.23-12.0	KY8106

NYB	Muscle	6c (3-5)	1.9	.85-3.26	KE8007
NYB	Muscle	4m (10-11)	-	.17-2.67	AL7907
NYB	Viscera	4m (9-11)	-	9.82-24.9	AL7907
NYB	Gonad	4m (9-11)	-	8.83-23.6	AL7907
NYB Apex	Whole	5m (5-6)	-	12.2-22.4	DL8105,8205
Narragansett Bay	Whole	3m (5-6)	-	9.98-23.2	DL8105,8205
Georges Bank	Whole	1m (5-6)	14.2	-	DL8105,8205
Shelf off Delaware	Whole	9m (5-6)	-	11.2-17.4	DL8105,8205
NE shelf	Whole	6m (5-6)	-	13.0-26.1	DL8105,8205
Gulf of Maine	Muscle	9	-	2.50-18.1	AL8007
Gulf of Maine	Viscera	9	-	28.9-55.7	AL8007
Gulf of Maine	Gonad	9	-	6.93-111.	AL8007
Gulf of Maine	Gill	9	-	3.22-20.5	AL8007
Shelf off Cape Cod	Muscle	9	-	2.47-12.1	AL8007
Shelf off Cape Cod	Viscera	9	-	17.6-43.7	AL8007
Shelf off Cape Cod	Gonad	9	-	6.15-67.1	AL8007
Shelf off Cape Cod	Gill	10	-	5.23-14.1	AL8007

Source/Cruise (for complete citations see Literature Cited for Section 3.2.3, Trace Contaminants in Tissues):

AL8109 - R/V ALBATROSS IV survey, August 1981 (Zdanowicz and Bruno 1982a)
AL8007 - R/V ALBATROSS IV survey, September 1980 (Zdanowicz and Ruiz 1981)
AL7907 - R/V ALBATROSS IV survey, September 1979 (Zdanowicz and Ruiz 1981)
KE8007 - R/V KELEZ survey, August 1980 (Zdanowicz and Ruiz 1981; Reid et al. 1982)
DL8105, 8205 - R/V DELAWARE surveys, August 1981 and July-September 1982 (Zdanowicz and Bruno 1982b)
KY8101 - R/V KYMA survey, May 1981 (Zdanowicz unpublished data)
KY8102 - R/V KYMA survey, June 1981 (Zdanowicz unpublished data)
KY8103 - R/V KYMA survey, July 1981 (Zdanowicz unpublished data)
KY8104 - R/V KYMA survey, August 1981 (Zdanowicz unpublished data)
KY8105 - R/V KYMA survey, September 1981 (Zdanowicz unpublished data)
KY8106 - R/V KYMA survey, October 1981 (Zdanowicz unpublished data)
GR 83 - Greig et al. 1983.
GR 85 - Greig and Sennefelder (1985)

Appendix 5.8. Summary of Trace Organic Concentrations in Tissues of Species Collected in the Northeast as Part of the NEMP.

Notations for "Number of samples and types of values," and other symbols and abbreviations, are encoded as follows:

5c(3-6) = 5 composites of 3-6 individuals each
6 = 6 individual analyses
NYB = New York Bight
NA = Not Available
ND = Not Detectable
* = Number of composites/individuals is estimated

Area	Matrix	Number of samples and type of values	Mean	Range	Source
PCBs (ppm wet weight)					
Clam (*Pitar morrhuana*)					
Buzzards Bay	Whole	3c(5)	.032	.021-.045	B083
Clam (*Nucula proxima*)					
NYB Apex	Whole	7c(*)	-	.099-17.1	B082b
Clam, soft (*Mya arenaria*)					
New Bedford	Whole	24c(1-8)	4.7	.75-14	ER83a
Cod, Atlantic (*Gadus morhua*)					
NYB	Whole	5c(3-6)	.001	.0004-.0036	B082c
Crab, Jonah (*Cancer irroratus*)					
Boston Harbor	Soft tissues	3c(>3)	.252	.235-.279	B084b
Massachusetts Bay	Soft tissues	1c(>3)	.065	-	B084b
Cape Cod Bay	Soft tissues	2c(>3)	.141	.140-.143	B084b
Georges Bank	Muscle	1c(4)	.0004	-	B082c
NYB	Soft tissues	10c(5*)	.04	.02-.06	GA82
Crab, blue (*Callinectes sapidus*)					
Kill Van Kull	Muscle	1c*(3)	.076	-	B084a
Crab rock (*Cancer irroratus*)					
NYB	Muscle	1c(12)	.0086	-	B082c
Dab, American (*Hippoglossoides plattesoides*)					
Massachusetts Bay	Muscle	6c(>3)	.024	.010-.034	B084b
Cape Cod Bay	Muscle	1c(>3)	.019	-	B084b
NYB	Muscle	4c(2-9)	.0008	.0002-.0048	B082c
Eel, American (*Anguilla rostrata*)					
Manhattan Piers	Muscle	1c*(5)	.156	-	B084a
Flounder, four spot (*Paralichthys oblongus*)					
Manhattan Piers	Muscle	1c*(5)	.068	-	B084a
Kill Van Kull	Muscle	1c*(5)	.066	-	B084a
NYB	Muscle	9c(5*)	.02	.01-.04	GA82

NYB	Liver	6c(5*)	.81	.61-1.22	GA82
NYB	Muscle	4c(1-10)	.001	.0008-0016	BO82c
Flounder, summer (*Paralichthys dentatus*)					
NYB	Muscle	1c(2)	.0028	-	BO82c
Flounder, windowpane (*Scophthalmus aquosus*)					
Long Island Sound	Liver	16c(3-14)	-	.88-2.3	GR83
Long Island Sound	Stomach	12c(2-14)	-	.03-.45	GR83
NYB	Muscle	9c(5*)	.04	.02-.14	GA82
NYB	Liver	9c(5*)	1.70	1.04-2.18	GA82
NYB	Muscle	8c(2-9)	.004	.0008-.017	BO82c
Flounder, winter (*Pseudopleuronectes americanus*)					
Boston Harbor	Muscle	4c(>3)	.103	.090-.135	BO84b
Massachusetts Bay	Muscle	1c(>3)	.065	-	BO84b
Manhattan Piers	Muscle	1c*(5)	.25	-	BO84a
Kill Van Kull	Muscle	1c*(3)	.178	-	BO84a
NYB	Muscle	13c(5*)	.03	.01-.09	GA82
NYB	Liver	13c(5*)	2.59	.36-4.14	GA82
NYB	Muscle	13c(1-8*)	-	ND-.0062	BO82c
Flounder, yellowtail (*Limanda ferruginea*)					
NYB	Muscle	16c(2-8*)	-	ND-.0078	BO82c
Haddock (*Melanogrammus aeglefinus*)					
Adult					
Georges Bank	Muscle	6	.0197	.0132-.0317	BO82a
Georges Bank	Muscle	3c(6)	.0323	.0301-.0356	BO82a
Georges Bank	Muscle	3c(12)	.0404	.0383-.0555	BO82a
Georges Bank	Muscle	3c(30)	.0291	.0285-.0341	BO82a
NYB	Muscle	7c(1-11)	.0012	.0002-.0052	BO82c
Juvenile					
Georges Bank	Muscle	6	.0082	.0062-.0099	BO82a
Georges Bank	Muscle	3c(6)	.0116	.0105-.0125	BO82a
Georges Bank	Muscle	3c(12)	.0120	.0108-.0136	BO82a
Georges Bank	Muscle	3c(30)	.0140	.0123-.0150	BO82a
Hake, red (*Urophycis chuss*)					
NYB	Muscle	10c(5*)	-	ND-.03	GA82
NYB	Muscle	14c(3-15)	-	ND-.0084	BO82c
Hake, silver (*Merluccius bilinearis*)					
NYB	Muscle	6c(5*)	.04	.02-.08	GA82
NYB	Muscle	14c(3-12)	.03	.0034-.091	BO82c
Lobster (*Homarus americanus*)					
Buzzards Bay	Tail meat	4c(2-3)	.049	.024-.088	BO83
NYB	Muscle	2c(3-6)	.024	.019-.03	BO82c
NYB	Tail meat	3c(5*)	.04	.03-.05	GA82
Mackerel, Atlantic (*Scomber scombrus*)					
Pt. Pleasant	Gonads	47	-	<.1-.4	GA83
NYB (northern)	Liver	6	1.12	.55-2.63	GA83
NYB (northern)	Ovary	6	.12	.06-.19	GA83
NYB (northern)	Muscle	1c(6)	.32	-	GA83

NYB (northern)	Kidney	1c(6)	.37	-	GA83
NYB (southern)	Liver	6	.78	.54-1.08	GA83
NYB (southern)	Ovary	6	.47	.11-1.46	GA83
NYB (southern)	Muscle	1c(6)	.17	-	GA83
NYB (southern)	Head kidney	1c(29)	.10	-	GA83
Mussels (*Mytilus edilus*)					
Long Island Sound	Whole	10c(10)	.055	.049-.115	GR85 (in press)
Quahog, ocean (*Arctica islandica*)					
Narragansett Bay	Whole	3c(6)	.014	.007-.0232	ER83b
Buzzards Bay	Whole	1c(6)	.0201	-	ER83b
Georges Bank	Whole	1c(6)	.0038	-	ER83b
Off Nova Scotia	Whole	3c(6)	.0029	.0022-.0042	ER83b
East Long Island	Whole	4c(6)	.011	.0017-.0204	ER83b
NYB, inner shelf	Whole	5c(6)	.016	.0015-.0268	ER83b
NYB, outer shelf	Whole	8c(6)	.0096	.0019-.0164	ER83b
Sand lance (*Ammodytes americanus* or *dubius*)					
Stellwagen Bank	Whole	3c(29)	.07	.06-.08	GA82
Scallop, sea (*Placopecten magellanicus*)					
NYB	Muscle	1c(5)	.0002	-	B082c
Skate, little (*Raja erinacea*)					
NYB	Muscle	2c(2-9)	.0003	.0004-.0024	B082c
Tautog (*Tautoga onitis*)					
Raritan Bay	Whole	1c(3)	.105	-	B084a
Tomcod (*Microgadus tomcod*)					
Kill Van Kull	Muscle	1c*(2)	.053	-	B084a
Worms (*Nephtys incisa* and *Pherusa affinis*)					
NYB Apex	Whole	10c(*)	1.93	.099-17.1	B082b
PAHs (ppb wet weight)					
Clam, soft (*Mya arenaria*)					
New Bedford	Whole	24c(1-8)	36	5.3-73	ER83a
Crab, Jonah (*Cancer irroratus*)					
Boston Harbor	Soft tissues	3c(>3)	952	444-1828	B084b
Massachusetts Bay	Soft tissues	1c(>3)	244	-	B084b
Cape Cod Bay	Soft tissues	2c(>3)	44	28-64	B084b
Crab, rock (*Cancer irroratus*)					
NYB	Soft tissues	10c(5*)	23	13-62	GA82
Dab, American (*Hippoglossoides plattesoides*)					
Massachusetts Bay	Muscle	6c(>3)	-	ND-48	B084b
Flounder, four spot (*Paralichthys oblongus*)					
NYB	Muscle	9c(5*)	14	2-19	GA82

Flounder, windowpane (Scophthalmus aquosus)					
NYB	Muscle	9c(5*)	18	11-22	GA82
Flounder, winter (Pseudopleuronectes americanus)					
NYB	Muscle	13c(5*)	10	3-19	GA82
Boston Harbor	Muscle	5c(>3)	-	ND-20	BO84b
Massachusetts Bay	Muscle	1c(>3)	40	-	BO84b
Hake, red (Urophycis chuss)					
NYB	Muscle	10c(5*)	25	11-45	GA82
Hake, silver (Merluccius bilinearis)					
NYB	Muscle	6c(5*)	18	12-31	GA82
Quahog, ocean (Arctica islandica)					
Narragansett Bay	Whole	3c(6)	12	7.0-16	ER83b
Buzzards Bay	Whole	1c(6)	2.5	-	ER83b
Georges Bank	Whole	1c(6)	<1	-	ER83b
Off Nova Scotia	Whole	3c(6)	-	ND-18	ER83b
East Long Island	Whole	4c(6)	17	6.1-29	ER83b
NYB, inner shelf	Whole	5c(6)	25	3.3-55	ER83b
NYB, outer shelf	Whole	8c(6)	18	4.2-26	ER83b
Sand lance (Ammodytes americanus or dubius)					
Stellwagen Bank	Whole	3c(29)	41	36-50	GA82
Worms (Nephtys incisa and Pherusa affinis)					
NYB Apex	Whole	10c*	21	.3-42.6	BO82b
Phenanthrene (ppb wet weight)					
Haddock (Melanogrammus aeglefinus)					
Adult					
Georges Bank	Muscle	6	NA	-	BO82a
Georges Bank	Muscle	3c(6)	3.2	1.3-5.0	BO82a
Georges Bank	Muscle	3c(12)	3.8	1.0-6.4	BO82a
Georges Bank	Muscle	3c(30)	2.6	.6-5.2	BO82a
Juvenile					
Georges Bank	Muscle	6	NA	-	BO82a
Georges Bank	Muscle	3c(6)	3.0	1.0-5.5	BO82a
Georges Bank	Muscle	3c(12)	5.4	5.1-6.3	BO82a
Georges Bank	Muscle	3c(30)	2.9	1.9-3.7	BO82a
Fluoranthene (ppb wet weight)					
Haddock (Melanogrammus aeglefinus)					
Adult					
Georges Bank	Muscle	6	NA	-	BO82a
Georges Bank	Muscle	3c(6)	ND	-	BO82a
Georges Bank	Muscle	3c(12)	ND	-	BO82a
Georges Bank	Muscle	3c(30)	ND	-	BO82a

Juvenile					
Georges Bank	Muscle	6	NA	-	B082a
Georges Bank	Muscle	3c(6)	ND	-	B082a
Georges Bank	Muscle	3c(12)	ND	-	B082a
Georges Bank	Muscle	3c(30)	ND	-	B082a
Pyrene (ppb wet weight)					
Haddock (*Melanogrammus aeglefinus*)					
Adult					
Georges Bank	Muscle	6	NA	-	B082a
Georges Bank	Muscle	3c(6)	3.2	1.0-7.5	B082a
Georges Bank	Muscle	3c(12)	2.7	1.0-6.1	B082a
Georges Bank	Muscle	3c(30)	2.2	.5-4.3	B082a
Juvenile					
Georges Bank	Muscle	6	NA	-	B082a
Georges Bank	Muscle	3c(6)	ND	-	B082a
Georges Bank	Muscle	3c(12)	1.2	1.0-1.5	B082a
Georges Bank	Muscle	3c(30)	ND	-	B082a
PHCs (ppm wet weight)					
Clam, soft (*Mya arenaria*)					
New Bedford	Whole	24c(1-8)	153	34-362	ER83a
Crab, rock (*Cancer irroratus*)					
NYB	Muscle	1c(12)	65.4	-	B082c
Dab, American (*Hippoglossoides plattesoides*)					
NYB	Muscle	1c(5)	.3	-	B082c
Flounder, four spot (*Paralichthys oblongus*)					
NYB	Muscle	2c(1-10)	.74	.36-1.14	B082c
Flounder, yellowtail (*Limanda ferruginea*)					
NYB	Muscle	5c(2-7)	.8	.42-1.3	B082c
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	3c(2-8)	.84	.34-1.3	B082c
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	2c(4-8)	1.1	1.2-1.7	B082c
Haddock (*Melanogrammus aeglefinus*)					
NYB	Muscle	2c(4-11)	.3	.2-.4	B082c
Hake, red (*Urophycis chuss*)					
NYB	Muscle	4c(6-12)	2.0	.2-1.08	B082c
Hake, silver (*Merluccius bilinearis*)					
NYB	Muscle	12c(5-12)	5.4	.6-19	B082c

Quahog, ocean (Arctica islandica)					
Narragansett Bay	Whole	3c(6)	3.9	3.7-4.0	ER83b
Buzzards Bay	Whole	1c(6)	3.7	-	ER83b
Georges Bank	Whole	1c(6)	1.9	-	ER83b
Off Nova Scotia	Whole	3c(6)	.8	.8-.9	ER83b
East Long Island	Whole	4c(6)	2.1	.9-3.5	ER83b
NYB, inner shelf	Whole	5c(6)	3.6	1.1-73	ER83b
NYB, outer shelf	Whole	8c(6)	1.7	.2-4.6	ER83b

n-Alkanes (ppb wet weight)

Haddock (Melanogrammus aeglefinus)					
Adult					
Georges Bank	Muscle	6	123	63-190	B082a
Georges Bank	Muscle	3c(6)	370	330-410	B082a
Georges Bank	Muscle	2c(12)	610	590-630	B082a
Georges Bank	Muscle	3c(30)	370	210-360	B082a
Juvenile					
Georges Bank	Muscle	6	167	140-200	B082a
Georges Bank	Muscle	3c(6)	380	210-520	B082a
Georges Bank	Muscle	3c(12)	460	410-520	B082a
Georges Bank	Muscle	3c(30)	470	240-790	B082a

Pristane

Haddock (Melanogrammus aeglefinus)					
Adult					
Georges Bank	Muscle	6	204	30-460	B082a
Georges Bank	Muscle	3c(6)	150	140-160	B082a
Georges Bank	Muscle	3c(12)	262	260-270	B082a
Georges Bank	Muscle	3c(30)	180	110-240	B082a
Juvenile					
Georges Bank	Muscle	6	148	80-210	B082a
Georges Bank	Muscle	3c(6)	310	270-370	B082a
Georges Bank	Muscle	3c(12)	364	360-370	B082a
Georges Bank	Muscle	3c(30)	340	290-390	B082a

DDT (ppb wet weight)

Cod, Atlantic (Gadus morhua)					
NYB	Muscle	5c(3-6)	-	ND-.001	B082c
Crab, Jonah (Cancer borealis)					
Georges Bank	Muscle	1c(4)	ND	-	B082c
Crab, rock (Cancer irroratus)					
NYB	Muscle	1c(12)	.025	-	B082c
Dab, American (Hippoglossoides plattesoides)					
NYB	Muscle	4c(2-9)	.0004	.0002-.0006	B082c

Flounder, four spot (*Paralichthys oblongus*)					
NYB	Muscle	4c(1-10)	-	ND-.0004	B082c
Flounder, summer (*Paralichthys dentatus*)					
NYB	Muscle	1c(2)	.0006	-	B082c
Flounder, windowpane (*Scophthalmus aquosus*)					
NYB	Muscle	8c(2-9)	-	ND-.0066	B082c
Flounder, winter (*Pseudopleuronectes americanus*)					
NYB	Muscle	13c(1-8*)	-	ND-.0014	B082c
Flounder, yellowtail (*Limanda ferruginea*)					
NYB	Muscle	16c(2-8*)	-	ND-.0078	B082c
Haddock (*Melanogrammus aeglefinus*)					
NYB	Muscle	7c(1-11)	-	ND-.0004	B082c
Hake, red (*Urophycis chuss*)					
NYB	Muscle	14c(3-15)	-	ND-.0046	B082c
Hake, silver (*Merluccius bilinearis*)					
NYB	Muscle	14c(3-12)	.0062	.0004-.015	B082c
Haddock (*Melanogrammus aeglefinus*)					
Adult					
Georges Bank	Muscle	6	.21	.07-.57	B082a
Georges Bank	Muscle	3c(6)	.37	.33-.40	B082a
Georges Bank	Muscle	3c(12)	.35	.28-.42	B082a
Georges Bank	Muscle	3c(30)	.34	.28-.41	B082a
Juvenile					
Georges Bank	Muscle	6	.08	.04-.13	B082a
Georges Bank	Muscle	3c(6)	.14	.12-.15	B082a
Georges Bank	Muscle	3c(12)	.11	<.01-.18	B082a
Georges Bank	Muscle	3c(30)	.17	.14-.19	B082a
Lobster, American (*Homarus americanus*)					
NYB	Muscle	2c(3-6)	.0074	.005-.01	B082c
Scallop, sea (*Placopecten magellanicus*)					
NYB	Muscle	1c(5)	ND	-	B082c
Skate, little (*Raja erinacea*)					
NYB	Muscle	2c(2-9)	-	ND-.0004	B082c

Dioxin (pptr wet weight) [2,3,7,8 tetrachloro- -dibenzodioxin (TCDD)]

Crab, blue (*Callinectes sapidus*)					
Kill Van Kull	Muscle	8c(2-5)	3.8	-	B084a
Eel, American (*Anguilla rostrata*)					
Manhattan Piers	Muscle	8c(2-5)	<1	-	B084a

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(continued from inside front cover)

34. ***Oceanology: Biology of the Ocean. Volume 2. Biological Productivity of the Ocean.*** By M.E. Vinogradov, editor in chief. First printed by Nauka Press, Moscow, 1977. Translated from the Russian by Albert L. Peabody. January 1985. x + 518 p., 81 figs., 59 tables. NTIS Access. No. PB85-204683/AS.

35. ***Annual NEMP Report on the Health of the Northeast Coastal Waters, 1982.*** By John B. Pearce, Carl R. Berman, and Marlene R. Rosen, eds., and Robert N. Reid (benthos), Catherine E. Warsh (water quality), and Edith Gould (biological effects), topic coords. January 1985. xi + 68 p., 29 figs., 5 tables. NTIS Access. No. PB85-219129/AS.

36. ***Growth and Survival of Larval Fishes in Relation to the Trophodynamics of Georges Bank Cod and Haddock.*** By Geoffrey C. Laurence and R. Gregory Lough. January 1985. xvi + 150 p., 67 figs., 15 tables, 1 app. NTIS Access. No. PB85-220093/AS.

37. ***Regional Action Plan: Northeast Regional Office and Northeast Fisheries Center.*** By Bruce E. Higgins, Ruth Rehfus, John B. Pearce, Robert J. Pawlowski, Robert L. Lippson, Timothy Goodger, Susan Mello Roe, and Douglas W. Beach. April 1985. ix + 84 p., 4 figs., 6 tables, 9 app. NTIS Access. No. PB85-219962/AS.

38. ***The Shelf/Slope Front South of Nantucket Shoals and Georges Bank as Delineated by Satellite Infrared Imagery and Shipboard Hydrographic and Plankton Observations.*** By J. B. Colton, Jr., J. L. Anderson, J. E. O'Reilly, C. A. Evans-Zetlin, and H. G. Marshall. May 1985. vi + 22 p., 14 figs. NTIS Access. No. PB85-221083/AS.

39. ***USA Historical Catch Data, 1904-82, for Major Georges Bank Fisheries.*** By Anne M. T. Lange and Joan E. Palmer. May 1985. iii + 21 p., 12 figs., 2 tables. NTIS Access. No. PB85-233948/AS.

40. ***Indexing the Economic Health of the U.S. Fishing Industry's Harvesting Sector.*** By Virgil J. Norton, Morton M. Miller, and Elizabeth Kenney. May 1985. v + 42 p., 44 figs., 25 tables, 1 app. NTIS Access. No. PB85-217958/AS.

41. ***Calculation of Standing Stocks and Energetic Requirements of the Cetaceans of the Northeast United States Outer Continental Shelf.*** By Robert D. Kenney, Martin A. M. Hyman, and Howard E. Winn. May 1985. iv + 99 p., 1 fig., 5 tables, 1 app. NTIS Access. No. PB85-239937/AS.

42. ***Status of the Fishery Resources Off the Northeastern United States for 1985.*** By Conservation & Utilization Division, Northeast Fisheries Center. August 1985. iii + 137 p., 46 figs., 49 tables. NTIS Access. No. PB86-125473/AS.

43. ***Status of the Fishery Resources Off the Northeastern United States for 1986.*** By Conservation & Utilization Division, Northeast Fisheries Center. September 1986. iii + 130 p., 45 figs., 48 tables. NTIS Acces. No. PB87-122115/AS.

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