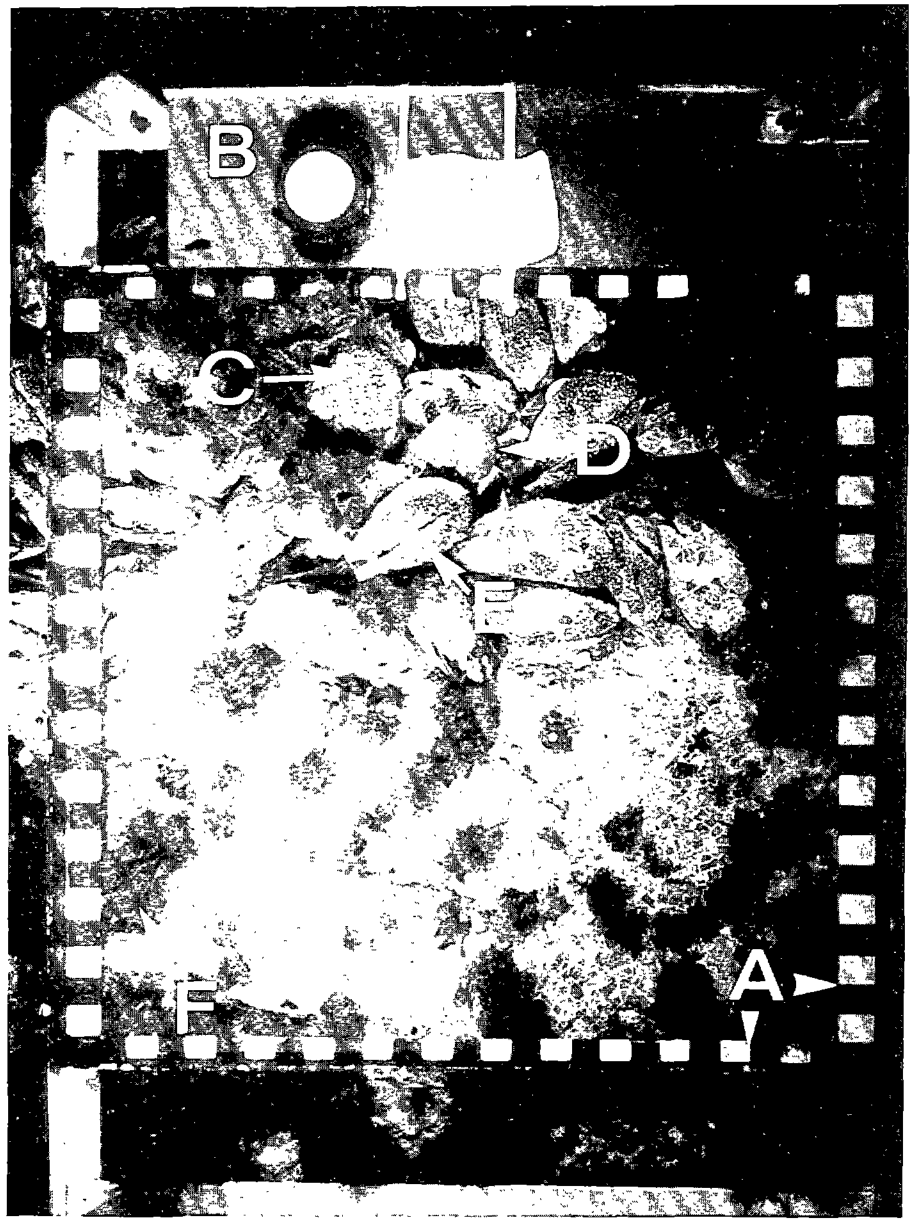
NOAA Technical Memorandum NMFS-F/NEC-20

Northeast Monitoring Program

Annual NEMP Report on the Health of the Northeast Coastal Waters of the United States, 1981

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

February 1983



An important part of the Northeast Monitoring Program is the in-situ documentation of the quality of benthic ecosystems, particularly those undergoing or scheduled to undergo human intervention (e.g., oil extraction, sewage disposal, industrial wastes, etc.). In-situ documentation—whether by using scuba gear or deepsea research submersibles—is essential for inaccessible habitats such as submarine canyons and hard-bottom habitats where conventional sampling gear is ineffective. It is also essential for resampling specific sites to reveal fine-scale changes from year to year.

Underwater color photography is an efficient way to conduct this in-situ documentation—less time is spent by analyzing photographs in an onshore lab than would be spent by collecting and measuring samples and recording data on the ocean floor; hence, the results are more quickly available.

The above photograph (seen here in black and white) was taken by Dr. Alan Hulbert of the Northeast Fisheries Center's Woods Hole (Massachusetts) Laboratory with a Nikonos II 35-mm camera, 15-mm wide-angle lens, and Kodachrome-64 film. It shows a 0.25-m^2 quadrat emplaced over a section of fixed transect at the Isles of Shoals station in the Gulf of Maine. Each contiguous 0.5-m length of the transect is photographically documented each year, revealing even subtle changes in species composition, abundance, size distribution, etc.

This photograph, taken at 18 m, is typical of hard-bottom habitats and communities between 18 and 30 m in the Gulf of Maine. (A=quadrat frame with 2-cm measuring bands; B=data panel with pressure-activated depth gauge; C=an asteroid, *Leptasterias* sp.; D=the northern whelk, *Buccinum undatum;* E=the northern horse mussel, *Modiolus modiolus,* covered with crustose coralline algae; and F=a deep-growing fleshy red alga, *Ptilota serrata*).

For more information on such in-situ documentation, see Section 3.3.2.1 of this issue, and *NOAA Technical Memorandum NMFS-F/NEC-14*—"Ecosystem Definition and Community Structure of the Macrobenthos of the NEMP Monitoring Station at Pigeon Hill in the Gulf of Maine."

BIBLIOGRAPHIC INFORMATION

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The Northeast Monitoring Program has again found that impacts of man's activities are clearly evident in the altered quality of the coastal and shelf environments of the northeast United States. The biological resources of this region have also been shown to have been stressed, especially in the New York Bight apex and other coastal areas near human population or industrial centers. Significant impacts have been detected for several years at sites where pollution inputs have been terminated. Extensive integrated data bases have been developed that have not existed before, and which will greatly enhance detection of future impacts, even subtle ones.

KEYWORDS: *Middle Atlantic Bight, *Water pollution, *New York Bight.

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Northeast Monitoring Program

Annual NEMP Report on the Health of the Northeast Coastal Waters of the United States, 1981

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U.S. DEPARTMENT OF COMMERCE
Malcolm Baldridge, Secretary
National Oceanic and Atmospheric Administration
John V. Byrne, Administrator
National Marine Fisheries Service
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Northeast Fisheries Center

Woods Hole, Massachusetts

February 1983

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1.0 EXECUTIVE SUMMARY

An interest in the health and use of the marine environment is a major media topic, nationally and internationally. For example, in 1981 there has been increasing concern in regard to the possible impacts of offshore oil exploration and development in or near productive fishering grounds. At the same time, municipalities have challenged legislated termination of ocean dumping of sewage sludge and various other wastes. The United States and other nations must face the problems associated with disposal of various radioactive wastes or by-products from the nucelar power industry.

Many scientists and managers believe that the oceans are capable of receiving and assimilating increased amounts of wastes and contaminants. Planning documents or feasibility studies are appearing which suggest the possibility of increased loading of marine waters; they also describe an urgent need for increased monitoring and research of ocean disposal of various wastes. Environmental managers, the public, and legislators must have the information from such studies if appropriate decisions are to be made. The need for long-term monitoring and research in regard to the effects of wastes and disposal activities has been recognized, especially in regard to effects on the living resources of the Continental Shelf waters and adjacent estuaries, and the production of foodstuffs from the sea.

Given the immediate nature of the foregoing, in October 1979, three principal NOAA organizational elements began to develop plans to combine their various research and monitoring activities into a single, unified monitoring program called the Northeast Monitoring Program (NEMP). The Ocean Pulse (OP) program, conducted since 1977 by the Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service (NMFS) formed the basis for the combined monitoring program. Planned activities conducted by the Office of Marine Pollution Assessment (OMPA) and the Oceanic and Atmospheric Services (OAS) were also to be included in the program.

A program development plan (PDP) and technical development plan (TDP) were completed in September 1980. During the planning phase, however, it was essential to combine monitoring activities. Numerous cruises and monitoring studies were initiated in 1980 and continued throughout 1981; these activities culminated in a series of reports which were submitted to the Program Manager by over two score principal investigators. While elements of NMFS, OMPA, and OAS were involved in the actual field monitoring efforts and ancillary studies, a considerable portion of the work was done through contracting with academic institutions, consulting firms, and other governmental agencies.

During 1981, the Northeast Monitoring Program (NEMP) continued to monitor and assess various components of the marine ecosystem of the coastal and shelf waters of the northeastern United States to provide a current appraisal of the health of these waters. The most recent monitoring observations and assessments are summarized in this, the second Annual NEMP Report. This summary highlights some of the more significant findings of interest to managers and scientists; for more details the reader is advised to review the body of this report or contact the program managers (see Introduction for names and addresses). Although this report involves activities for 1981, other projects within NEMP, which represent an ongoing continuum are also represented. The very nature of environmental monitoring dictates that most scientific work connected with the effort be undertaken on a routine basis at prescribed intervals. In this way, data collected in 1979, for example, may have been analyzed during the 1981-2 calendar year as part of a particular study which has been in place since the earlier date. The results of such analyses are also contained in this volume.

I. Most recent water quality monitoring has indicated:

- Data appear to indicate that there has been a shift in the phytoplankton community towards smaller diatoms and ultraplankton in the nearshore waters, especially at the mouths of major estuaries. These shifts may cause alterations to exisitng food webs supporting resource species.

- There is a suggestion that high nutrient inputs from the Hudson-Raritan estuary dominate nutrient distribution and utilization for the entire New York Bight.

- Sampling programs have shown that a consistent five-year pattern of phytoplankton biomass (Chl a) and primary production (C^{14}) on the northeast shelf, shows areas, e.g. N. Y. Bight apex, that have some of the highest production rates known.

- Much of the high spring primary production in the N. Y. Bight is not consumed by zooplankton or nekton feeders, but sinks to the bottom and thus influences summer oxygen levels.

- High concentrations of fecal bacteria are found off many estuaries and coastal areas, including species that are potentially pathogenic to both fish and man.

II. Sediment quality monitoring has shown that:

- Potentially toxic trace metals are found in high concentrations in the sediments of several coastal areas, e.g. N.Y. Bight apex, Buzzards Bay, Massachusetts Bay, Casco Bay, at the mouths of major estuaries and in a natural depositional area south of Martha's Vineyard.

- PCB distribution and levels generally follow the same pattern as trace metals with highest levels (144 ppb) in the N. Y. Bight apex and elevated levels in Buzzards Bay compared to measurements made in pristine areas.

- Distribution and levels of coprostanol, a fecal indicator, suggest the importance of sewage derived materials as a major source of PCB in the N. Y. Bight apex.

- Within the NEMP study area, levels of petroleum hydrocarbons were highest (31,000 ppb) in the N. Y. Bight apex, but traces of hydrocarbons were ubiquitous.

- Pesticide residues (kepone, heptaclore epoxide, lindane and aldrin) were present at a planned dumpsite off the mouth of Chesapeake Bay.

- Fecal bacteria were found at elevated levels at the mouths of many major estuaries, often associated with the potentially pathogenic protozoan acanthomoebae and associated pathogenic viruses.

III. The biological effects of the reduced environmental quality indicated by NEMP monitoring are:

- Physiologically stressed fish were detected in polluted western Long Island Sound, throughout the N. Y. Bight and off the Merrimack River, Massachusetts.

- Stressed sea scallops were present at several sites, e.g. south of Martha's Vineyard and off New Jersey.

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

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

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

- PCB concentrations in fish and shellfish tissues from several species taken from the Middle Atlantic Bight and Long Island Sound were generally below 5 ppm, the maximum acceptable level for human consumption.

- The benthic community in Portland Harbor, Maine, has low species richness and density which may be related to the high contaminant concentrations found there.

The Northeast Monitoring Program has again found that impacts of man's activities are clearly evident in the altered quality of the coastal and shelf environments of the northeast United States. The biological resources of this region have also been shown to have been stressed, especially in the New York Bight apex and other coastal areas near human population or industrial centers. Clear long-term trends are not yet evident, but significant impacts have been detected for several years at sites where pollution inputs have been terminated. Extensive integrated data bases have been developed that have not existed before, and which will greatly enhance detection of future impacts, even subtle ones. In the next year, greater cooperation with other monitoring groups, e.g. U. S. Environmental Protection Agency, U. S. Army Corps of Engineers and several States, is envisioned.

2.0 INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA), the nation's principle civilian ocean agency, is committed to determining and monitoring the effects of man's activities on offshore and coastal waters, the ecosystems contained therein and their living resources. Addressing this commitment, three groups within NOAA involved in marine pollution research: National Marine Fisheries Service (NMFS), National Ocean Survey (NOS), Office of Marine Pollution Assessment (OMPA) cooperatively developed the Northeast Monitoring Program (NEMP).

2.1 Goals and Objectives

The following goals and objectives were established for the Program. Comments on the results of the first two years of effort and recent program reviews indicate these goals and objectives should remain the principle focus of NEMP.

The Goals of NEMP are to:

1. Assess the health of the coastal and offshore ecosystems of the northeastern United States;
2. Provide information ensuring present and future protection of human health and wise management of the living marine resources of the Northeast; and
3. Develop a prototype monitoring program to determine cost-effectiveness, user requirements, and applicability of monitoring techniques to other U.S. coastal areas.

To attain these goals, NEMP management identified ten objectives:

1. Determine or confirm the existing levels, trends, and variations of contaminants in water, sediments, and biota and the effects of these substances on living resources.
2. Establish and maintain a data archive including information from NEMP and other local marine pollution monitoring programs in the Northeast to foster cooperation and coordination of environmental monitoring and research efforts off the Middle Atlantic and New England States.
3. Summarize, in collaboration with other responsible agencies, information on pollutant inputs to estuarine, coastal and offshore waters.
4. Provide timely data and information, for planning and management, to regulatory organizations and the general public.
5. Determine the effects of major activities such as offshore drilling and waste disposal on marine environments and living resources.
6. Detect and provide early warnings of severe or irreversible changes in the marine ecosystem and in living resources. This

element includes interactions with agencies responsible for coordination of both routine and crisis response activities (oil spills, harmful waste and toxic chemical discharges, etc.).

7. Determine marine pollution data users and their requirements.
8. Develop and apply standard methods to monitoring and for evaluating monitoring effectiveness.
9. Determine which elements of marine monitoring are most cost-effective.
10. Determine applicability of marine pollution monitoring methods to other United States marine regions.

2.2 Water Management Units

During the past year the National Marine Fisheries Service (NMFS) has been involved in developing Regional Action Plans (RAP) for the Northeast Region (Cape Hatteras to the Canadian border). These plans call for a coordinated effort in research, monitoring, assessment and impact evaluation.

The primary strategy of RAP is to redirect our activities from site specific assessments and individual permit requests to generic assessments that address issues in a broad zoogeographic context. Through this strategy, a more realistic perspective of the immediate, short-term (1 year) and long-term (5 years) impacts may be gained. In addition, describing and monitoring in a more general context provides a long-term basis for assessing environmental conditions and evaluating habitat-related decisions.

As part of this strategy, the northeastern region has been divided into six Water Management Units (WMUs), Figure 1. Each unit represents a relatively cohesive area, based on hydrography and biology, and provides a narrower context within which specific management decisions can be made. To establish the basis for decision making within the specific WMUs, a series of documents will be developed which describe and characterize the known biological, physical, and chemical parameters, as well as the integral ecosystems for each unit. These documents will be developed by NOAA personnel in cooperation with other government agencies based on the combined data bases and issue-related activities of associated programs.

A second aspect of the RAP is the development of regional position papers, staff studies and site characterizations that identify problems and options on projected critical environmental issues. Analyses of the critical issues, prepared in advance, will identify various options and provide a scientific basis for decisionmaking. Issues and problems will be identified and ranked by an evaluation of activities, associated threats, and projected or observed impact on habitats and living marine resources. To support NEMP and RAP planning and assessments, a report has been prepared summarizing the physical oceanographic processes and

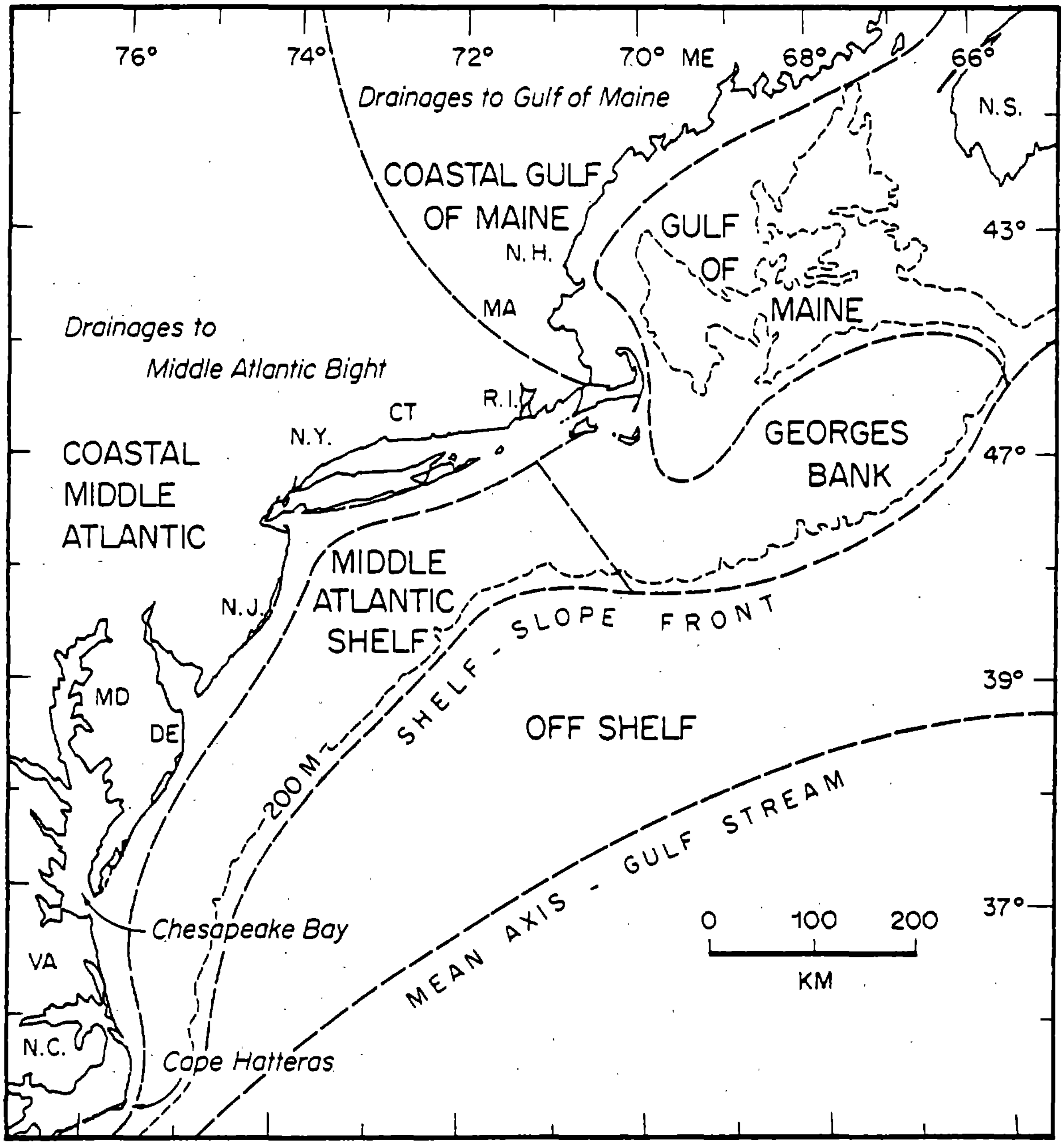

Figure 1. NOAA's Regional Action Plan (RAP) Water Management Unit areas.

features pertinent to pollution distribution in coastal and offshore waters of the Northeast. This report was edited by M.C. Ingham, NOAA, National Marine Fisheries Service, Atlantic Environmental Group, Narragansett, RI and is available upon request.

2.3 Environmental Issues and Events

In 1981 there were several significant issues or events which involved the NEMP area of interest. These included an increased public concern about the possibility that radioactive wastes that were dumped into a Massachusetts Bay disposal area might be escaping into the larger environment. Public concern was also raised by reports of PCB's discharge into the New Bedford Harbor area. The state of Massachusetts has closed certain areas in New Bedford Harbor and Buzzards Bay to lobster fishing. A number of scientists have indicated PCB's may have affected the well-being of lobsters and other resource species.

Plans for the expansion of port facilities in areas such as the Norfolk-Hampton Roads Harbor, lower Chesapeake Bay, have raised the issue of possible effects ocean disposal of dredged materials may have on these areas. Fishermen, in particular, have expressed a concern that offshore dumping of such materials might have an impact on fisheries outside the harbor areas and in Chesapeake Bay itself.

The continued energy crisis and need to develop offshore mineral deposits have resulted in increased oil exploration and potential development in the Middle Atlantic Bight and on Georges Bank. The Northeast Monitoring Program's protocol has been accepted and incorporated into regional monitoring programs that are funded by Department of Interior's Bureau of Land Management (BLM) but which will use data developed by NEMP.

Increased concern about effects of discharging sewage sludge, dredged materials, and industrial chemical wastes in inshore waters has led several agencies and the courts to evaluate the consequences of moving dumpsites from the New York Bight apex to offshore waters beyond the edge of the continental shelf. The results of past NOAA studies on ocean dumping in the New York Bight and recent NEMP data will be utilized to understand better the consequences of ocean dumping. Several cities are also considering returning to the sea to dispose of sewage sludge and other wastes.

2.4 Special Activities

In response to environmental events and developments during 1981, NEMP participated in special surveys and data or sample collections. For example, a major cruise was made to Massachusetts Bay, the site of radioactive waste dumping, where samples were collected and furnished to the US Environmental Protection Agency (EPA) for analysis of levels of radioactivity in sediments and biota. An extensive side-scan bathymetric survey was also made to determine areas of the dumping ground that may have resolvable accumulations of dumped material. The results of this survey will be used to define further a monitoring strategy for the Massachusetts Bay disposal area.

Ongoing monitoring in the New York Bight has produced a range of observations, sample collections and analyses. These results were incorporated into a summary of our findings for the New York Bight in 1981 with comparisons to earlier data. Considerable time was also spent in developing background material for the PCB's issue in New Bedford Harbor.

This year, several extensive standardized data bases were or are being assembled utilizing current NEMP data, National Oceanographic Data Center (NODC) files, and other historical or archived files. Two data bases, one dealing with over 75,000 chlorophyll measurements made between 1978 and 1982 and a second consisting of over 20,000 measurements of inorganic nutrients made between May 1979 and March 1980, were used to determine the natural boundaries between Georges Bank and surrounding waters. A benthic data file is being assembled that will include sediment and macrofaunal data from over 130 surveys that have occurred in the shelf and coastal waters of the Northeast. These archived files enable the program to bring together rapidly and thoroughly available data to address current issues.

In order to review and synthesize the various data sets developed by NEMP investigators in 1981, the first annual workshop of the Northeast Monitoring Program was held at Milford, CT from 24-26 February 1982. The workshop provided an opportunity for over 30 investigators to present and discuss summaries of their significant findings. The workshop was divided into three sessions and chaired by the following individuals:

1) Water Quality and Phytoplankton -
Dr. Merton Ingham
Atlantic Environmental Group, NMFS, NOAA
Narragansett, RI

2) Sediment Quality and Benthos -
Dr. Carlton Hunt
University of Rhode Island
Kingston, RI

and 3) Contaminant Burdens and Indicator Species Health -
Dr. Donald Miller
US EPA
Narragansett, RI

Representatives from other areas of NOAA, other agencies (EPA, FDA, COE), and the academic community attended and offered comments and suggestions on the program and its results, especially during an open forum near the conclusion of the workshop. These comments were considered in preparing this report, and many of their suggestions are being studied for incorporation into future monitoring efforts.

2.5 The Annual Report

This annual report presents an assessment of the health of the environment and valuable biological resources of the marine waters of northeastern United States (Cape Hatteras to Canadian border), based primarily on the results of NEMP monitoring and research. It is the second annual report by NEMP. The report is organized much like the first report, but because it is the product of an evolving and flexible program, contains some changes that hopefully will make it more useful, e.g., the summarizations by regions (Water Management Units). The program management welcomes comments on the utility of this report and on NEMP in general and suggestions for improvement (see below for the names and addresses of the management team). Anyone requesting additional copies of this or last year's report, or other information should contact members of the management team.

This report was compiled by a team of individuals who dedicated time and effort from otherwise busy schedules to make this information available in as timely a fashion as possible. Section 7 lists the contributors to the report.

This year special praise must go to Mr. Frank Steimle, Northeast Fisheries Center, Sandy Hook Laboratory, and Lt. Denise Hollomon who spent much of the spring and summer of 1982 editing and rewriting the various sections and contributions to this report. Without their dedication it would have been difficult to provide this report to the various users. They and CDR Carl Berman reviewed and edited the penultimate draft of the report prior to it being submitted for publication.

The following persons were responsible for overall mangement of the Northeast Monitoring Program as well as for specific contributions to this annual report:

Merton Ingham - Deputy Manager, Northeast Fisheries Center, October 1979 to March 1981.

Millington Lockwood - Deputy Manager, National Ocean Survey, March 1980 to present.

John B. Pearce - Program Manager, Northeast Fisheries Center, October 1979 to present.

Harold Stanford - Deputy Manager, Office of Marine Pollution Assessment, 1980 to present.

Ms. Dolores Toscano of the Northeast Office, Office of Marine Pollution Assessment, was responsible for typing the several drafts of the report, Michele Cox pf the Northeast Fisheries Center, Sandy Hook Laboratory, provided graphical support. Mrs. Virginia Boeckel of the Sandy Hook Laboratory provided additional clerical and secretarial assistance.

The final report was prepared through the efforts of Dolores Toscano (typing) and Michele Cox (graphics) and a diverse editorial team.

3.0 PROGRAM RESULTS

The results presented in this annual report are organized in four sections: Water Quality, Sediment Quality, Biological Effects and WMU regional summarizations.

3.1 Water Quality

A water quality monitoring element was established as part of NEMP to collect hydrographic and ecological data from the northeast continental shelf and slope waters over the area of Cape Hatteras to the Gulf of Maine. Concentration of effort occurs in the Middle Atlantic Bight, where contaminant concentrations or impacts are known or suspected to be a problem.

The objectives of water quality monitoring are to provide information on the extent of the annual cycle of pycnocline development, reduction of dissolved oxygen concentrations, distribution of inorganic nutrients, chlorophyll a concentrations, phytoplankton taxa and rates of primary production. Phytoplankton biomass, taxa and rates of production are important determinants of the quality of the marine environment, as phytoplankton represent a major source of energy, nutrition and contaminants to the food web.

Results from broad shelf-wide studies on phytoplankton abundance, species composition, production and nutrient-hydrographic factors are also presented here. The following summarizes the results of water quality monitoring in 1981:

3.1.1 Hydrography

Hydrographic conditions over the middle Atlantic Bight varied slightly in 1981 from 1980. Surface water temperatures varied ± 1-3°C from April to September, 1981, bottom temperatures were generally warmer (+1-5°C). A very intense thermocline (average vertical gradient of 2.5°C m^{-1}) developed by August, 1981, along the New Jersey coast, but disappeared by late September due to wind mixing. Surface salinities were approximately 0.5 o/oo higher in 1981 than in 1980 for the New York Bight, apparently resulting from drought conditions in the Northeast during 1980-81.

In the late summer when the water is highly stratified, dissolved oxygen concentrations decreased to lowest levels, 2 ml/l, in bottom waters near the New York Bight apex dumpsites and nearshore waters off New Jersey (Figure 2). Average dissolved oxygen levels for the New Jersey coastal region were, however, within the mean historical range (Armstrong 1979) except for June when they were slightly lower (Figure 3). The low dissolved oxygen that is frequently found north of Barnegat Inlet was not observed during the summer of 1981.

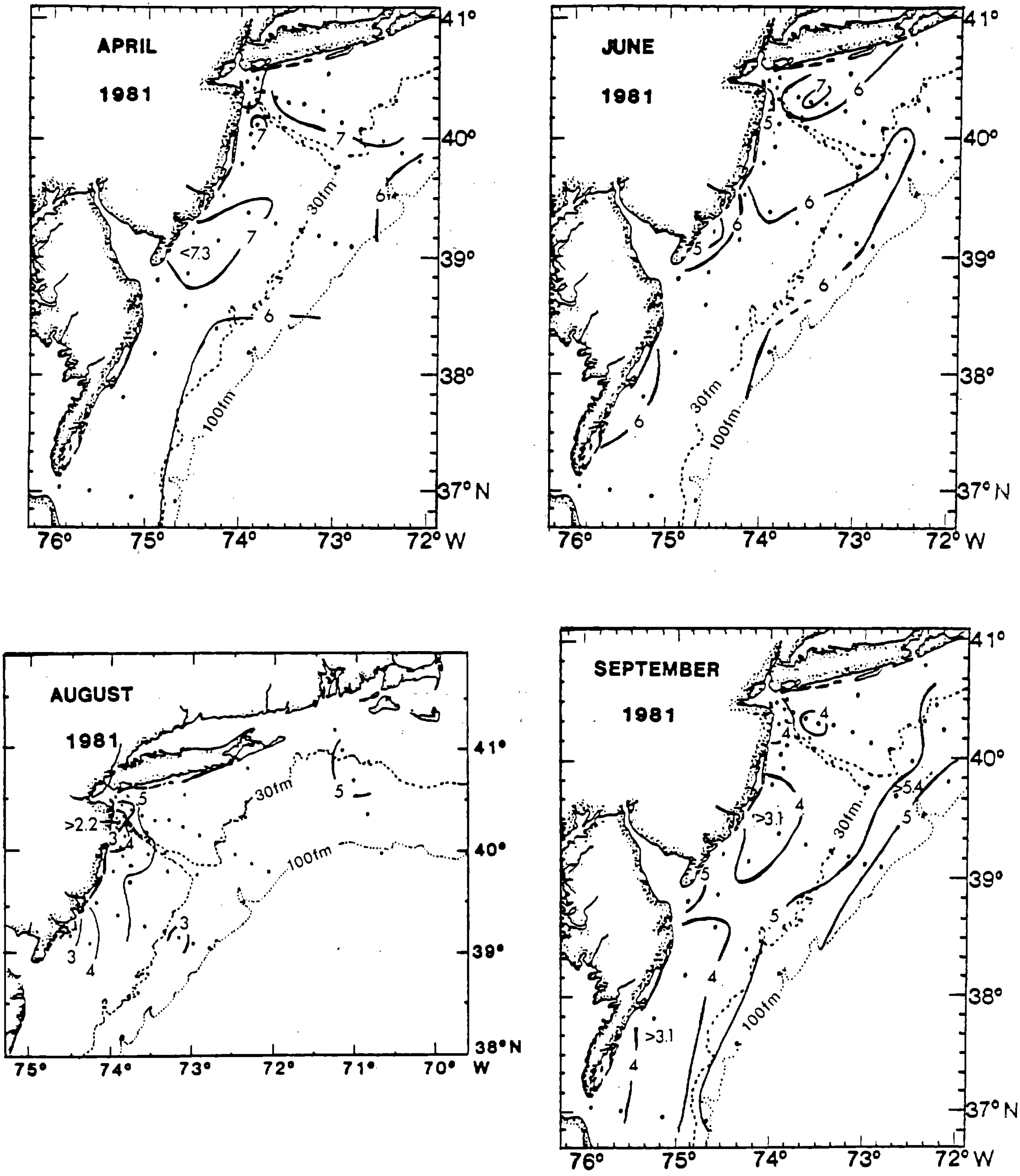

Figure 2. Distribution of dissolved oxygen (ml/l) in bottom water, April-September 1981, in the Middle Atlantic Bight.

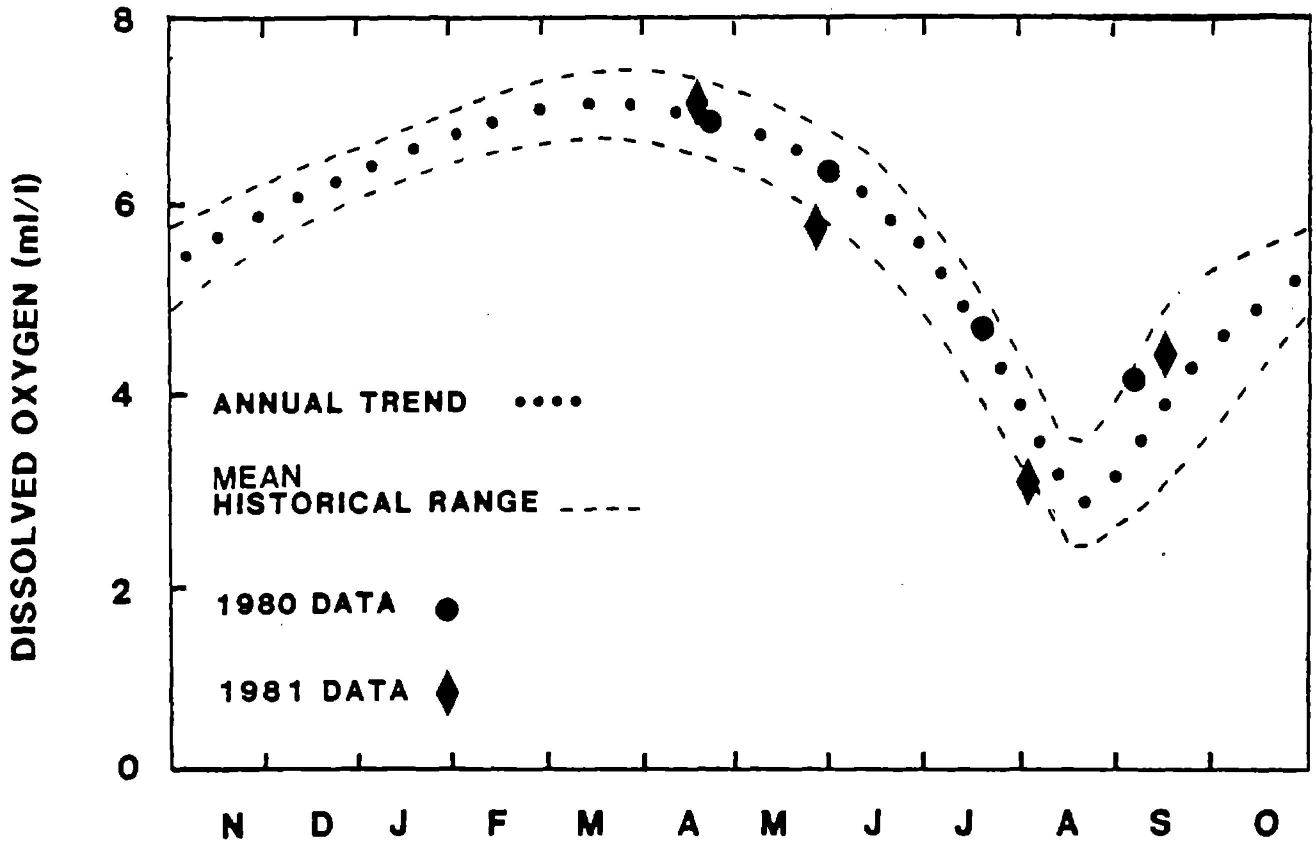

Figure 3. Historical seasonal trends in dissolved oxygen levels of the bottom waters of New Jersey shelf (based on Armstrong 1979) compared to recent data.

3.1.2 Nutrients

Analyses of 1979 and 1980 nutrient data indicate that as the seasons progress from spring to summer, the predominant form of nitrogen available to support phytoplankton growth on the shelf is recycled ammonium. Differences in the seasonal dominance of the ammonium fraction northeast and south of the New York Bight apex were evident. Ammonium nitrogen predominates the surface and bottom inshore waters south of the apex as early as March, compared with a June ammonium nitrogen dominance north of the apex, suggesting that the Hudson-Raritan estuary as being important as a forcing function for nitrogen distribution on the shelf.

Phosphate distribution in the New York Bight also showed an inshore maximum associated with the Hudson-Raritan plume and offshore maximum associated with the "cold pool". During the 1981 summer months, water above the pycnocline was gradually depleted of phosphate (<0.2 μg-at/l) while concentrations in subpycnocline water slowly increased (0.8 to 0.9 μg-at/l).

Analysis of nutrient data from central Georges Bank revealed a unique seasonal cycling of inorganic nitrogen compared to areas to the north (Gulf of Maine) and south (slope water). Following vertically uniform and higher winter nitrate levels (5-10 μg-at/l), intense depletion of nitrate by phytoplankton activity produces low concentrations throughout the water column over the shallow areas of the Bank. This depletion results in regenerated ammonium becoming the dominant form of inorganic nitrogen in the surface layer as well as the bottom. Upon destratification, the continued vertical mixing over the Bank appears to promote the introduction of nitrogen from the Gulf of Maine intermediate water, making the Bank relatively high in nitrate.

3.1.3 Phytoplankton Biomass

Initial analysis of phytoplankton data from 1980 revealed that highest biomass concentrations were often localized at the mouths of estuaries with decreasing gradients offshore. In April 1981, chlorophyll biomass concentrations were found to be highest at the surface of the mouth of the Hudson-Raritan estuary (9 mg Chl*a* m^{-3}). Values of 4-5 mg Chl*a* m^{-3} were observed near-bottom across most of the shelf. The offshore extent of high chlorophyll concentrations decreased from spring to summer. In a comparison of near bottom chlorophyll data for the Middle Atlantic Bight from 1981 and 1980, patterns and concentrations of chlorophyll were similar from April to August, but concentrations were much higher in September 1980 along both the Long Island and New Jersey shorelines. Since 1981 bottom water temperatures were warmer than those of 1980, the reduction in chlorophyll concentration may be the result of elevated *in situ* regeneration rates.

Chlorophyll a measurements made between 1977 and 1982 in the euphotic layer on Georges Bank show a pattern of higher concentration of biomass in the shallow areas of the Bank (<60m) with a decrease toward the periphery. Biomass concentrations ranged from 7.3 mg Chla m^{-3} at depths <60m to 0.5 mg Chla m^{-3} at greater depths. Average of all chlorophyll a (mg m^{-3}) measurements in the upper 27m of the water column, according to bathymetrically-defined subareas, are presented in Figure 4. The lowest average concentrations were found in slope water south of Georges Bank and in water entering the Gulf of Maine through the Northeast Channel. Gradients between Georges Bank and deeper water in total pigment concentrations were evident for most surveys, varying with survey and season of the year. In the Gulf of Maine, biomass concentrations were generally lowest toward the center of the Gulf and highest in coastal waters near Cape Cod Bay, Massachusetts Bay and Penobscot Bay.

In 1980 and early in 1981 there was a significant decrease in the amount of rainfall in the New York area. As stream flow decreased, effects could be expected on the shelf off the Hudson-Raritan estuary. No major differences in chlorophyll concentrations within 10 km of the Hudson-Raritan estuary were evident between late fall 1977, 1978, 1979, and 1980; data from this area will be reexamined to determine if effects of drought are noticeable as more 1981 data become analyzed in greater detail.

In spring and summer of 1981, chlorophyll concentrations were generally higher near the mouth of the Chesapeake Bay compared to the data collected during the previous year's record drought conditions. Along with increases in nutrient concentrations and suspended solids, these water quality changes reflect a higher level of stream runoff into the Bay during 1981 caused by increased rainfall.

In addition to regular monitoring of phytoplankton biomass, a special study on benthic accumulations of phytoplankton pigments was undertaken in 1981 to examine the relationship between the chlorophyll biomass of the spring bloom and summer dissolved oxygen levels. Along the coastal and seaward boundaries of the Middle Atlantic Bight, peaks in phytoplankton biomass are found during winter and early spring. These blooms apparently are not heavily grazed, and it has been hypothesized (Malone and Chervin 1979) that they are dissipated by sinking and lateral mixing across the shelf. If this occurs, it should be reflected in seasonal variations in phytoplankton pigments of the bottom water layer and sediment.

Vertical profiles and variations in the pigment content of sediments from March to April 1981 suggest that netplankton (diatoms) were slowly sinking into bottom water layers (Table 1). The concentration of pigments (chlorophyll a and phaeophorbide a) in the upper 1 cm of sediment ranged from 2 mg m^{-2} to 21 mg m^{-2}, with a mean of 7 mg m^{-2} in March. By April, the mean had increased to 32 mg m^{-2} as the

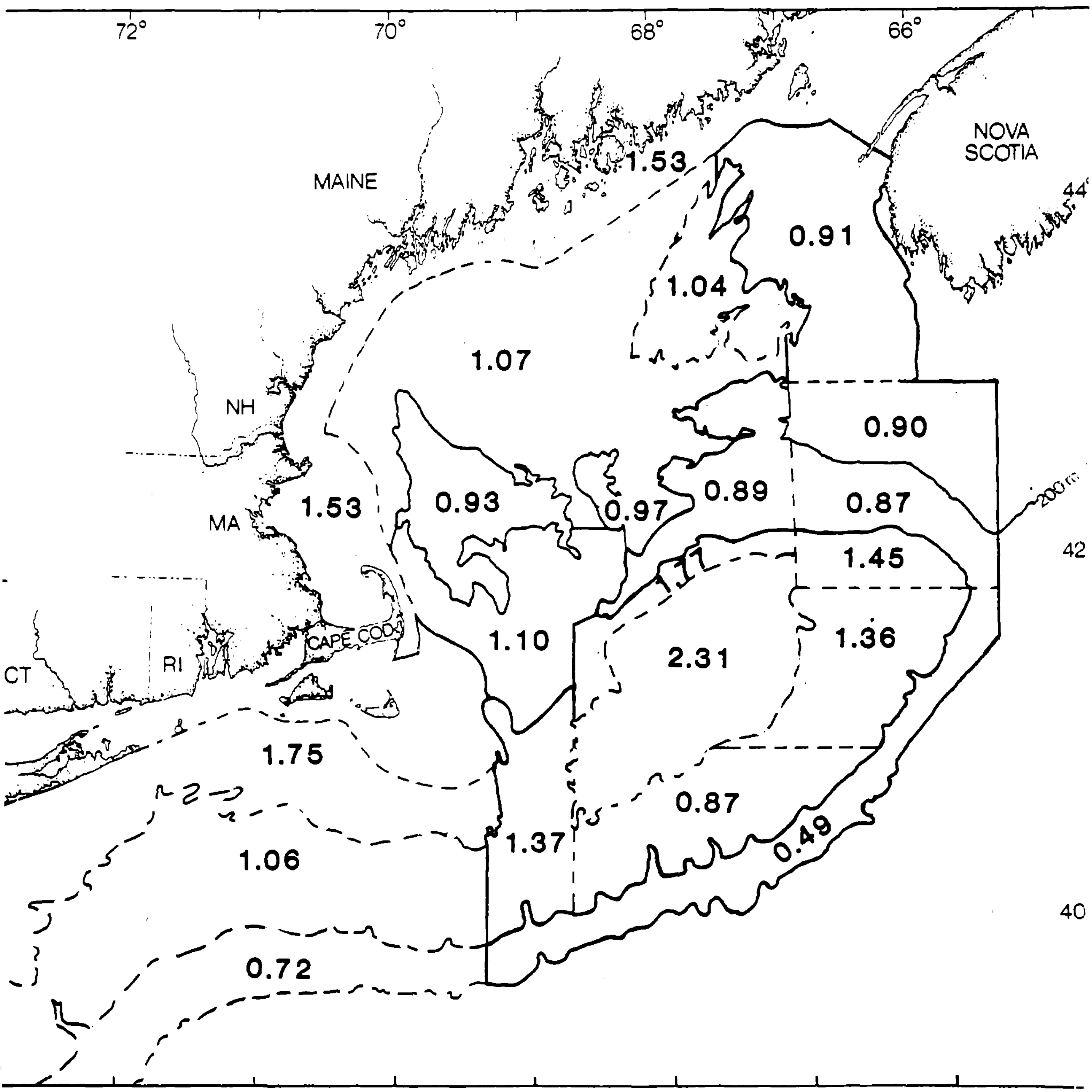

Figure 4. Average chlorophyll a (mg m^{-3}) in the upper 27 m of the water column, by subarea.

Table 1. Pigment content (chlorophyll *a* and phaeophorbide *a*) and percent phaeophorbide *a* in New York Bight sediments north of 39°N latitude.

Date	Pigment Content mg m^{-2}		%Phaeo.	
	Mean	Range	Mean	Range
7-18 March	7	2-21	40	2-88
15-20 April	32	6-78	54	5-90
9-15 Sept	34	4-99	76	58-91

proportion of phaeophorbide _a_ increased from 40% to 54%. This increase indicates a net flux of phytoplankton and phytodetritus into the sediments as well as a degradation of chlorophyll _a_.

Pigment content of sediments showed little increase between April and September while the proportion of phaeophorbide continued to increase. This constant level of benthic pigment suggests that the net flux of phytoplankton and phytodetritus into the benthos was small compared to the net flux from March to April.

Sediment pigment concentrations were generally highest in the region of the Hudson Shelf Valley system (Figure 5). South of this region shelf concentrations were uniformly low, with the exception of a single sample off the Delaware Bay estuary.

3.1.4 Primary Productivity

Baseline estimates of annual phytoplankton production for the NEMP shelf area as reported in the 1980 NEMP Annual Report (NEMP 1981) have been recalculated and revised (Figure 6). The present estimate of annual phytoplankton production (particulate and dissolved) in the 14 shelf regions ranged from 260 to 470 gC $m^{-2}y^{-1}$. The values still place this continental shelf system among the most productive shelf ecosystems in the world (Table 2).

High daily rates of phytoplankton production (1 gC $m^{-2}d^{-1}$) were observed during most of the year and were not limited to the spring bloom period. The highest rates of daily production of particulates and dissolved organic carbon consistently were found in the New York Bight apex. The highest value measured during the study (5.9 gC $m^{-2}d^{-1}$) was found in the Bight apex in early March. This value is high, particularly when compared to the theoretical maximum sustainable daily production for nearshore waters: 9 gC $m^{-2}d^{-1}$ (Takahashi and Parsons 1972).

The second-most productive region of the shelf is the area of Georges Bank less than 60 m in depth (470 gC $m^{-2}y^{-1}$); in waters with depths greater than 60 m, productivity is less (300 gC $m^{-2}y^{-1}$). The Gulf of Maine, the mid-shelf region off the coast of Long Island, the mid-shelf region off the Delaware-Maryland-Virginia coasts, and the slope between Georges Bank and Cape Hatteras are among the least productive regions monitored.

Size fractionation of ^{14}C-labeled particulate organic carbon revealed that netplankton (>20 μm) are major primary producers during the spring and fall blooms in the Middle Atlantic Bight, on Georges Bank and in the Gulf of Maine. The smaller nannoplankton (<20 μm) are, however, responsible for most of the annual photosynthetic production in the study area. Additionally, a progression of increasing nannoplankton contribution to particulate production from the shallow inshore areas of

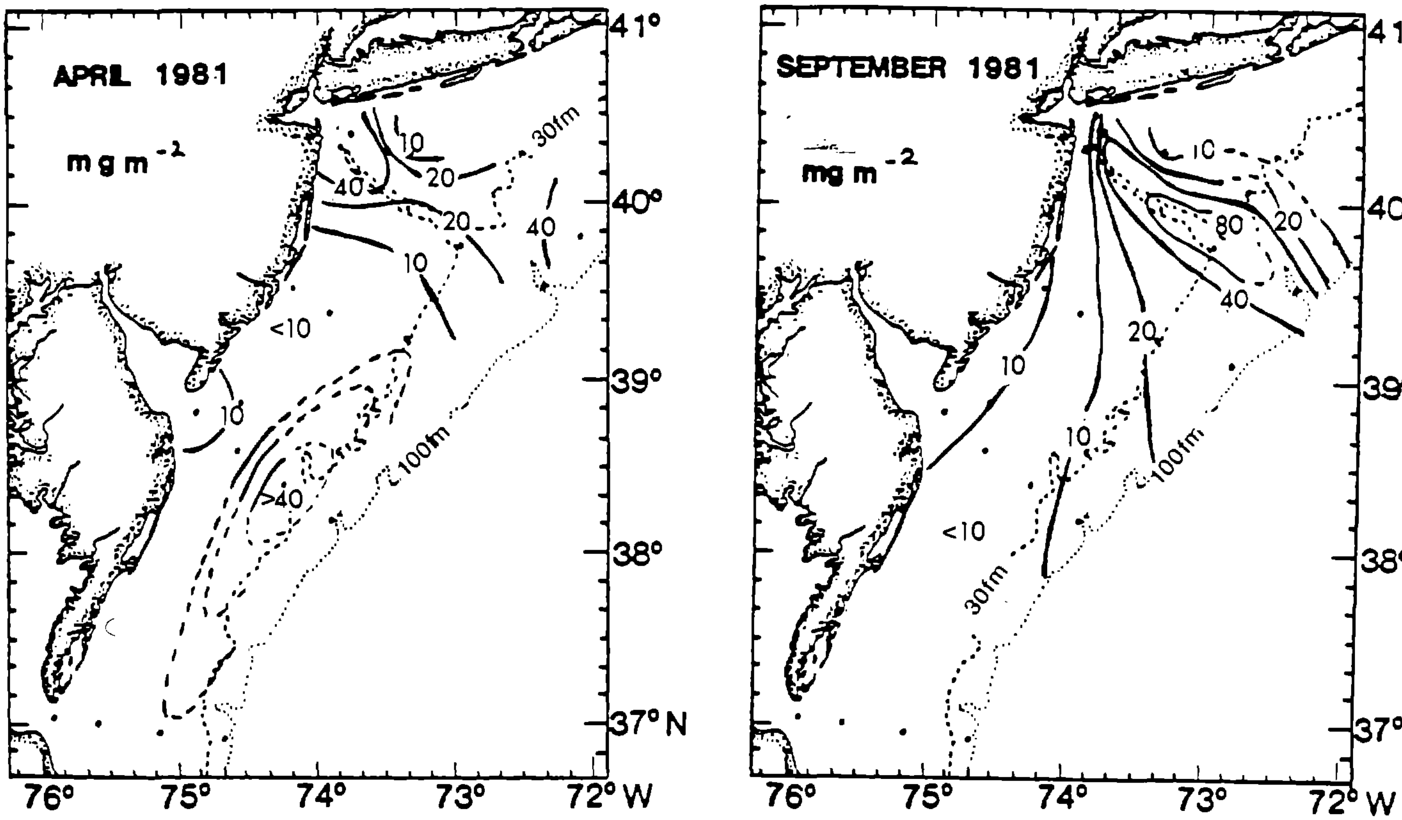

Figure 5. Distribution of phytoplankton pigments (chlorophyll a and phaeophorbide a) in the upper 1 cm of sediment, April and September 1981, on the Middle Atlantic Bight shelf.

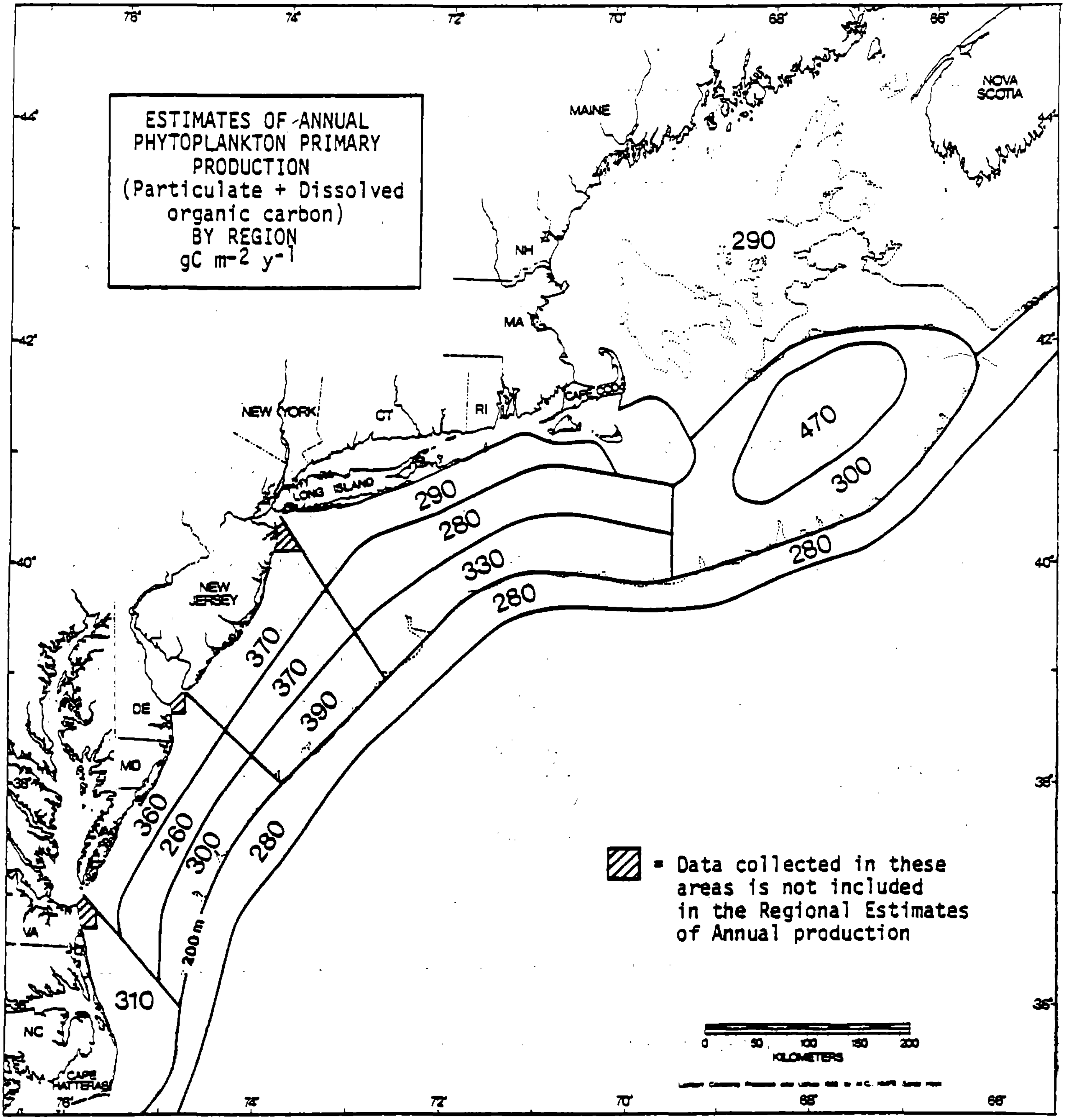

Figure 6. Estimates of annual phytoplankton production (particulate and dissolved organic carbon) by region, g C m^{-2} y^{-1}. Data collected from 1977 to 1980.

Table 2. Comparison of our estimates of annual primary production for Middle Atlantic Bight, Georges Bank, and Gulf of Maine shelf water with annual estimates for other systems.

Area	$g\ C\ m^{-2}\ y^{-1}$		Reference
Oceanic	55-70	P	Steeman-Nielsen and Jensen 1957
North Sea	90-100	P	Steele 1974
Coastal water, Japan	90	P	Hogetsu 1979
Northern Baltic	127	P	Wulff 1979
Eastern Scotian Shelf	102-128	P	Mills and Fournier 1979
Washington and Oregon coast, USA	60-152	P	Anderson 1964
New York Bight	100-160	P	Ryther and Yentsch 1958
Hanu Bight (Baltic proper)	154-194	P	Ackefors and Lindahl 1979
Georgia Bight, USA	134-285	P	Haines and Dunstan 1975
Off Long Island coast, 20 m	343	P	Mandelli et al. 1970
Coastal water off India	434	P	Quasim 1979
Gulf of Maine	260-470	T	
Georges Bank	225-415	P	This study
Middle Atlantic Bight			
New York Bight apex	370-480	P	Malone and Chervin 1979
Georgia coast off Altamaha River	547	P	Thomas 1966

P = particulate production

T = particulate and dissolved organic carbon production the Middle Atlantic Bight to the deeper outer shelf and slope waters is evident (Malone 1971). A similar bathymetric relationship exists over Georges Bank.

The contribution of netplankton to primary production over the shallower regions of Georges Bank (<60m) is greater than in the shallower areas of the Middle Atlantic Bight. This situation is probably due, in part, to the relatively high rate of vertical mixing in this area, which offsets the inherent advantages that small phytoplankters have over larger phytoplankters in obtaining nutrients and maintaining themselves in the euphotic layer (Munk and Riley 1952; Smayda 1970; Eppley et al. 1978).

3.1.5 Phytoplankton Community Structures

An extensive seasonal study of the composition and concentrations of phytoplankton for the northeastern shelf waters was conducted between October 1978 and 1981. A pattern of different levels of cell concentrations throughout each season has emerged from this study. Areas of highest cell concentrations were consistently associated with nearshore waters adjacent to major estuarine systems, with wide ranges of abundance, or patchiness, noted over the shelf.

Phytoplankton assemblages in October-November were dominated by large concentrations of smaller diatoms with an assortment of other diatoms, phytoflagellates and chlorophyceans. Large concentrations of a variety of ultraplankters (<10 μm) were often found at stations throughout the shelf, but in greatest numbers nearshore, over Georges Bank and at scattered sites in the Gulf of Maine. In general, diatoms were more abundant nearshore (<35 km from land), with a greater number of species inshore than at offshore stations.

The seasonal maximum of cell concentrations occurred during the December-March period; highest average counts were found at stations both near the coast and over the shelf toward the end of February. Samples were dominated by small chain-forming diatoms, e.g., *Skeletonema costatum*, *Leptocylindrus danicus*, *Thalassiosira nordenskioldii*, and *Asterionella glacialis*. A variety of ultraplankton-sized cells including coccolithophores, cryptomonads, cyanophyceans, and chlorophyceans was also common. The highest concentrations of cells occurred at coastal stations near the Hudson-Raritan estuary and off Delaware and Chesapeake Bays.

Phytoplankton assemblages in May, following the spring bloom, included a large representation of *Chaetoceros* spp. (a larger celled diatom), an assortment of smaller diatoms and an unspeciated ultraplankton component as most abundant. As in the fall and winter periods, the ultraplankton component was concentrated at the nearshore stations. Phytoplankton composition at offshore stations differed from that near the coast in having fewer species present, with dominance spread over a larger number of forms. The numbers of phytoflagellates and larger sized cells over the mid and outer shelf regions were significantly greater than those at the nearshore stations. Again, highest concentrations of cells were located at sites in the Gulf of Maine, over Georges Bank, south of Nantucket shoals and near the Hudson-Raritan estuary.

From May through August there was an increase in the average concentrations of phytoplankton over the shelf. Diatom species dominated both the coastal and offshore stations and, with few exceptions, none of the other groups were found in high concentrations. Patchy cell concentrations were observed, with greatest concentrations generally found at nearshore stations in the Gulf of Maine, southwest of Nantucket Shoals and at shelf sites along a transect beyond the entrance to Delaware Bay.

Areas with the greatest cell concentrations were generally associated with regions of nutrient enrichment and/or upwelling. Although increased nutrient enrichment may not necessarily increase total phytoplankton biomass, a change in the structure (species composition, size composition) of the phytoplankton community may result. Preliminary comparisons of recent phytoplankton distribution and composition patterns with data sets collected over a decade ago (Marshall 1976, 1978), indicate population shifts to smaller diatoms and ultraplankton in eutrophic nearshore waters.

In a comparison of grazing rates of the Atlantic menhaden as a function of particle size and concentration, a minimum size grazing threshold of between 13 and 16 μm was determined (Durbin and Durbin 1975). This suggests that shifts in population structure to smaller phytoplankton could have a detrimental effect on other filter feeders and thus on related food chain organisms associated with fish production.

3.1.6 Algal Assays

Algal assay studies were conducted to characterize the chemical water quality that regulates phytoplankton abundance in northeast coastal and shelf waters. The assays provide direct assessments of the relative availability of required nutrients and growth factors, and can also detect non-nutrient associated changes in water quality which may have profound influence on phytoplankton species composition, growth and succession. Non-nutrient associated changes can be caused by toxic contaminants or metabolites produced by certain phytoplankton which inhibit growth of other phytoplankton and may also be detected by assay.

The present assay sampling scheme includes a total of 28 stations between Chesapeake Bay and the Gulf of Maine. Water samples were divided into aliquots, which received various nutrient supplements, and were inoculated with the diatom, *Thalassiosira pseudonana*. Assay results were assessed on the basis of culture growth.

The results from an early fall, 1979, cruise (Figure 7) indicated the nutrients whose relative scarcity resulted in complete or partial growth limitation. Throughout the study area and in the water column, nitrogen was usually the nutrient limiting growth. Occasionally, nitrogen was the only limiting nutrient. Most frequently, phosphorus was secondarily limiting. In several instances phosphorus rivaled nitrogen in importance or was more limiting than nitrogen. Silicate and vitamin B_{12} were of secondary or tertiary importance in a few instances.

As in the fall cruise, results from an early spring cruise (1980) indicated that nitrogen was usually the most limiting nutrient, and occasionally, the only limiting nutrient. Again, there were particular depths at various stations where nitrogen was equaled or supplanted in importance by phosphorus. There were two instances where no apparent nutrient limitation was evident. One of the sites was in the New York Bight apex. The partial growth limitations caused by vitamin B_{12} and silicate seen in the fall cruise were not present.

In general, the results support a complex picture of sea water chemical fertility rather than the often repeated and mostly discredited idea of regulation of phytoplankton growth by a single nutrient. The assay results have not revealed any acute inhibition of phytoplankton growth which would be expected to result from a toxic contaminant intrusion.

A companion study to the assay work determined the effects of 12 trace metals in environmentally relevant concentrations on growth of *Olisthodiscus luteus*, an important phytoflagellate in several northeast coastal locales, particularly the New York Bight apex. Manganese, zinc, molybdenum, lithium, mercury and arsenic were not inhibitory to this species at any concentrations tested. Higher concentrations of iron, copper, cadmium, lead and nickel were particularly inhibitory. Addition of the chelating compound, EDTA, at 11.7 µM/l relieved the inhibition except for the highest concentrations of iron and nickel. In no instance were the metals algicidal. All cultures, including inhibited ones, contained live, active cells (75% or greater) at the end of the incubation term. Initial results suggest that the metal tolerance of *O. luteus* might contribute to its seasonal dominance and extensive blooms in local waters that attract yearly the attention of the public.

3.1.7 Microbial Indicators

During seasonal monitoring cruises, water samples were analyzed for *Clostridium perfringens* and the *Vibrio* group of bacteria. *Clostridium perfringens*, present in feces, can be used as an indicator of fecal pollution and is more stable in seawater than the standard coliforms. *Vibrio* spp. are widespread in the marine environment and include several

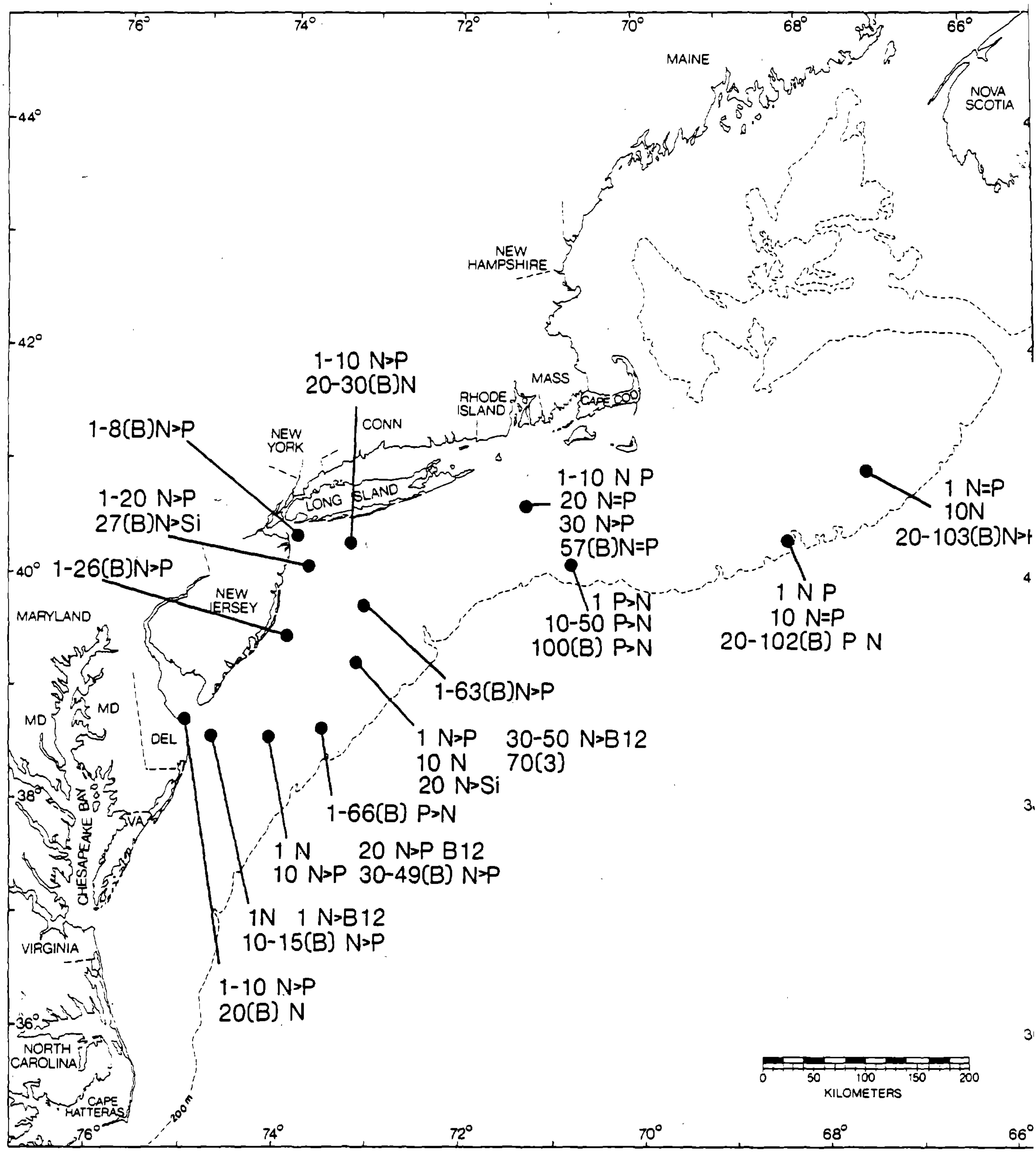

Figure 7. Algal assay results based on September 13-27, 1979 samples, expressed as nutrient growth limitation of the diatom Thalassiosira pseudonana arranged per sample depth. The results per sampling site are presented in this order: sample depth (m), B = bottom; nutrient limitation - N, only nitrogen; N>P, nitrogen most limiting, phosphorus secondarily; N=P, nitrogen and phosphorus equally limiting; P>N, phosphorus most limiting, nitrogen secondarily; $N>B_{12}$, nitrogen most limiting, vitamin B_{12} secondarily; N>Si, nitrogen most limiting, silicate secondarily limiting.

pathogenic species (e.g. V. parahaemolyticus and V. cholerae). Although the relationship of the vibrios to fecal pollution is still unclear, higher counts of both groups of bacteria, e.g. 1800 colonies/100 ml seawater for Clostridium and 10^3 colonies/100 ml for Vibrio, were observed in waters from estuary mouths, coastal areas and sewage disposal areas than in other regions of the shelf (<100 colonies/100 ml seawater).

3.1.8 Estuarine Plume Studies

A satellite imagery study to identify the extent of the Hudson-Raritan estuary plume was recently undertaken. This study can help identify sources of contaminants to the New York Bight apex. Fifty-eight cloud-free Landsat turbidity images from 1972 to 1981 and 16 cloud-free Heat Capacity Mapping Mission (HCMM) images from 1978 to 1979 were used. The summarized images indicate that plumes from Lower New York Bay into the Bight apex are lobate and remain close to the Bay mouth on ebb tide, advancing seaward and spreading laterally during the following flood tide. On the next ebb tide the plume fronts straighten and spread further seaward. As with the Chesapeake Bay plume, winds have the greatest influence on plume movement; seawardmost plume fronts occurred during westerly and northwesterly winds. Fifty-six percent of the plumes, visible in Landsat and HCMM imagery, entered or extended beyond the dredge spoils dumpsite. Of all turbid plumes visible in Landsat imagery, only 10% entered or extended beyond the sewage sludge dumpsite, while no thermal plumes visible in HCMM imagery reached the same site. No plumes found in either imagery reached the acid waste dumpsite. Landsat imagery also revealed 57 apparent plumes related to waste disposal (dumping) with the starting points of sharp (recent) disposal tracks concentrated along a line extending from the acid waste dumpsite toward the mouth of Lower New York Bay.

An additional remote sensing study analyzed satellite infrared imagery collected during the summer of 1981, to examine more closely the dynamics of the coastal boundary layer. Infrared imagery, in conjunction with in situ sampling of temperature and salinity, aided in the determination of the sources (estuarine or shelf) of the boundary layer water and sources of contaminants and/or biostimulants in the shelf system. The data show a rather rapid successive change in the waters along the coast. In June, a warm coastal boundary layer (20 km wide) developed as a result of outflow from the Chesapeake and Delaware Bays and the Hudson River. During July and August, a cold coastal boundary layer developed as a result of coastal upwelling and/or tidal mixing. However, the cold coastal boundary layer disappeared by early September, probably a result of mixing. Soon thereafter, a warm coastal boundary layer once again developed, apparently a result of outflow from the Chesapeake and Delaware Bays and the Hudson River. Since the source waters for the development of the warm and cold coastal boundary layers are different, these data indicate a potential for changes in the water quality in the coastal zone.

3.2 Sediment Quality

The monitoring of the quality of benthic environments or habitats is a critical element in NEMP. Many of the valuable food fish and shellfish that inhabit the coastal waters of the Northeast are demersal species; e.g. cod, haddock, the various flounders, lobsters, scallops and clams. These animals spend a major or critical portion of their life on the bottom, and use bottom organisms for food or have other essential linkages with the seabed. Unfortunately, the seabed is also where many contaminants, e.g. toxic trace metals and hydrocarbons, entering or discharged in the coastal or continental shelf waters, ultimately settle and concentrate. Obtaining information on levels of contaminants in sediments and monitoring to detect trends in contaminant concentrations are important because a decrease in the quality of the benthic habitat may seriously influence the quality and productivity of fishery resources. Monitoring detects trends before they become problems so that regulatory managers can take appropriate steps to halt or reduce the degradation of benthic habitats and protect resources.

The NEMP monitors a wide variety of variables to assess the quality of the benthic habitat. These include: a) chemical assessments for concentrations of toxic trace metals, petroleum hydrocarbons, PCB's, a fecal indicator - coprostanol, polynuclear aromatic hydrocarbons (PAHs), and organic carbon enrichment; and b) biological assessments for the presence of fecal or pathogenic bacteria (e.g. *Clostridum perfringens*), viruses, and protozoans.

The results of this year's assessment of the health of the benthic environment are summarized below:

3.2.1 Trace Metals

A. Silver - The highest concentrations of this metal (0.4-0.5 ppm) in sediments were found during a fall 1980 survey, in the New York Bight apex, Buzzards Bay and the "Mud Patch" south of Martha's Vineyard (Figure 8). Generally, levels in the other coastal areas were around 0.25-0.3 ppm, with continental shelf values below 0.25 ppm.

B. Chromium - The highest 1980 concentrations (>82 ppm) were found in sediments collected in the New York Bight apex. Concentrations >20 ppm were also found in the "Mud Patch", Buzzards Bay, Massachusetts Bay, Casco Bay and Portland Harbor (48 ppm). Concentrations between 10-20 ppm were found at the mouth of the Delaware Bay, in the Hudson Shelf Valley, Block Island Sound, Narragansett Bay mouth, and just outside of Casco Bay. Most other shelf and coastal sediments examined contained about 3-5 ppm of this metal.

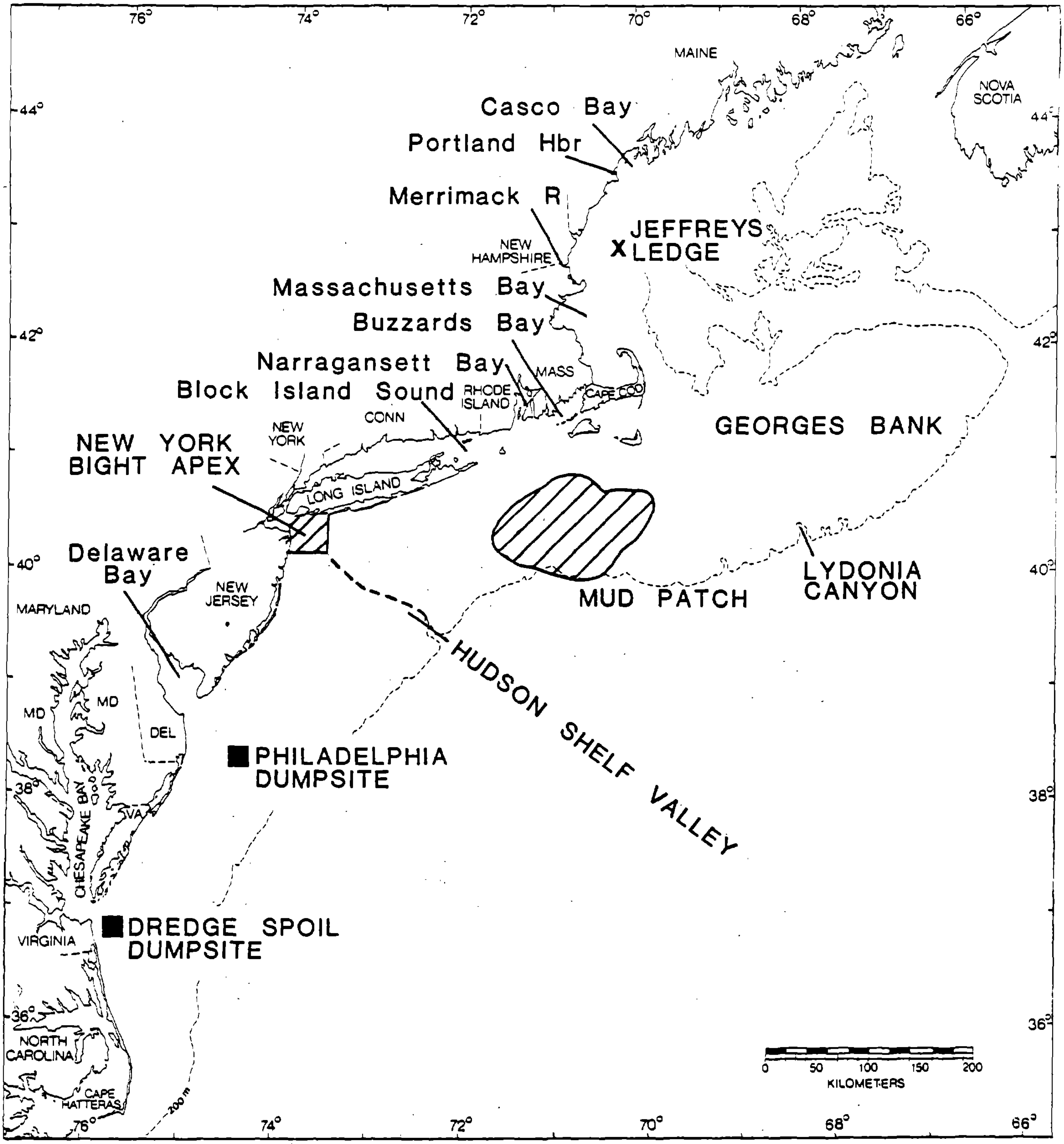

Figure 8. Location of specific areas discussed for sediment quality assessment.

C. Copper - Concentrations above 160 ppm were found in the New York Bight apex. Other areas with levels above 10 ppm were Buzzards Bay and the Casco Bay - Portland Harbor area, and Raritan Bay. Generally concentration levels were below 5 ppm elsewhere.

D. Nickel - The highest concentrations found for this metal were 21-22 ppm in Portland Harbor. Levels above 10 ppm were also found in Casco Bay, Buzzards Bay, the "Mud Patch" and the New York Bight apex. Elsewhere levels were generally below 5 ppm.

E. Lead - Concentrations exceeding 50 ppm were found in the New York Bight apex (182 ppm) and in Portland Harbor; levels greater than 10 ppm were found in Casco Bay area, Massachusetts Bay, Buzzards Bay, Narragansett Bay, Block Island Sound, the "Mud Patch", Hudson Shelf Valley and at the mouth of the Delaware Bay. Elsewhere levels were generally below 6 ppm.

F. Zinc - The highest concentrations of this metal (>75 ppm) were found in the New York Bight apex (285 ppm) and Portland Harbor. Sediments from several other areas contained concentrations above 25 ppm; these include Casco Bay, Massachusetts Bay, the "Mud Patch," Buzzards Bay, Narragansett Bay, Block Island Sound, Hudson Shelf Valley, and the mouths of Delaware and Chesapeake Bays.

G. Cadmium - The highest concentration of this metal, nearly 5 ppm, was found in the Christiaensen Basin of the New York Bight apex; levels above 0.5 ppm were only found there and in Portland Harbor. Generally, levels were below 0.25 ppm, although the "Mud Patch" had levels of 0.4 ppm and Buzzards Bay 0.3 ppm.

H. Mercury - This metal only was analyzed for at stations on the southern flank of Georges Bank, in the New York Bight and at Jeffreys Ledge. Of these areas, the highest concentrations (0.45 ppm) were found in the Christiaensen Basin of the New York Bight apex with elevated concentrations also at the dredge spoil site and west of the sewage sludge dumpsite.

In general, there is a close correlation of trace metals with increased or elevated organic matter in sediments as well as with finer sediments.

Higher metal levels can be expected in any depositional area, whether it be one of the major estuaries, the Block Island "Mud Patch", or a Gulf of Maine basin. What makes an area such as the Christiaensen Basin different from these other depositional areas is the amount of metals concentrated in the wastes which accumulate there. Comparing sediments of similar physical characteristics from the Christiaensen Basin with those from the "Mud Patch", for instance, shows up to a ten fold difference in metal levels.

Based on available data, the Christiaensen Basin and adjacent Hudson Shelf Valley are the most contaminated areas on the continental shelf between Cape Hatteras and Canada. Nearshore bodies of water that can also be considered contaminated are Massachusetts Bay, Buzzards Bay, Narragansett Bay, Raritan Bay and Portland Harbor.

3.2.2 Sediment Organics

The levels of total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) in sediments can be used to identify organic contamination and possible sources of this contamination, i.e. the ratio of TOC to TKN has been proposed for separating terrigenous (TOC:TKN <6) or marine (TOC:TKN >10) organic carbon sources (Walsh 1981).

TOC and TKN values obtained in 1981 are compared with values previously obtained from two 1980 surveys (Table 3). Concentrations are generally quite similar over the three surveys; a longer sequence of measurements will be required to determine trends. Discrepancies are apparent at benthic stations 35, 16C, 17 and 33 (see Figure 9 for locations).

3.2.3 Hydrocarbons

A. <u>Polychlorinated Biphenyls</u> - Concentrations of PCB's in nearshore sediments ranged from 144 ± 41 ppb at station 16B, the area of sludge accumulation in the Christiaensen Basin of the New York Bight apex, to 0.32 ± 0.24 ppb (station 3) on the shelf outside Chesapeake Bay (Figure 10). Concentrations of PCB's detected at the Buzzards Bay station were 12.8 ± 7.7 ppb. These concentrations were roughly equal to mean values at station 37, within the depositional "Mud Patch" south of Nantucket, and at station 33, in the mid-Hudson Shelf Valley, i.e. 8-9 ppb. However, there was a considerable range of values in the "Mud Patch" (0.6-30 ppb). Thus, the median value at the "Mud Patch" was 3.0 ppb and at station 33, 9.0 ppb.

Values for PCB's can be put into perspective when compared to previous coastal sediment data (Tables 4 and 5). For example, the PCB's levels for the New York Bight/Hudson Shelf Valley samples (stations 16B and 33) were 0.009-14 ppm and most other 1981 samples also fall within previous ranges. Thus, drastic changes in sediment concentrations of PCB's are not evident comparing available data.

Table 3. Comparison of current and historical total organic carbon (TOC), total Kjeldahl nitrogen (TKN) with TOC:TKN ratios in the Northeast.

STATION	TOC(mg/g)			TKN (ug/g)			TOC:TKN		
	AUG 81	JUL 80	DEC 80	AUG 81	JUL 80	DEC 80	AUG 81	JUL 80	DEC 80
3	2.3	1.4	1.6	276	260	190	10.0	5.4	8.4
7	1.4	0.9	1.1	128	180	100	10.9	5.0	11.0
8	1.0	-	1.1	110	-	60	9.1	-	18.3
9	2.0	-	2.5	249	-	240	8.0	-	10.4
11	1.9	-	1.4	197	-	110	9.6	-	12.7
12	1.4	-	2.3	214	-	190	6.7	-	12.1
18	4.7	6.8	5.6	623	940	620	7.5	7.2	9.0
19	3.7	4.1	4.7	461	590	780	8.0	6.9	6.0
20	14.3	-	-	1685	-	-	8.5	-	-
21	0.8	-	-	124	-	-	6.7	-	-
22	1.9	3.5	3.5	423	530	610	4.5	6.6	5.7
23	1.5	1.4	-	181	230	-	8.3	6.1	-
24	0.4	0.5	0.4	82	20	-	4.9	25.0	-
28	13.8	-	13.3	957	-	2540	14.4	-	5.2
34	7.1	-	-	729	-	-	9.7	-	-
35	4.0	11.0	6.5	341	1400	980	11.7	7.9	6.6
36	13.1	-	-	854	-	-	15.3	-	-
37	8.3	-	-	519	-	-	16.0	-	-
13	1.6	-	-	135	-	-	11.9	-	-
15A	0.7	-	-	138	-	-	3.8	-	-
16A	4.6	3.2	1.3	183	410	130	25.1	7.8	10.0
16B	23.5	12.0	3.0	962	1100	280	24.4	10.9	10.7
16C	1.00	10.0	1.1	85	1000	-	11.5	10.0	-
17	1.3	11.0	0.7	79	1500	-	15.9	7.3	-
31	1.6	-	-	211	-	-	7.6	-	-
32	1.3	0.6	0.7	122	90	50	10.7	6.7	14.0
33	-	1.8	8.1	-	290	970	-	6.2	8.4

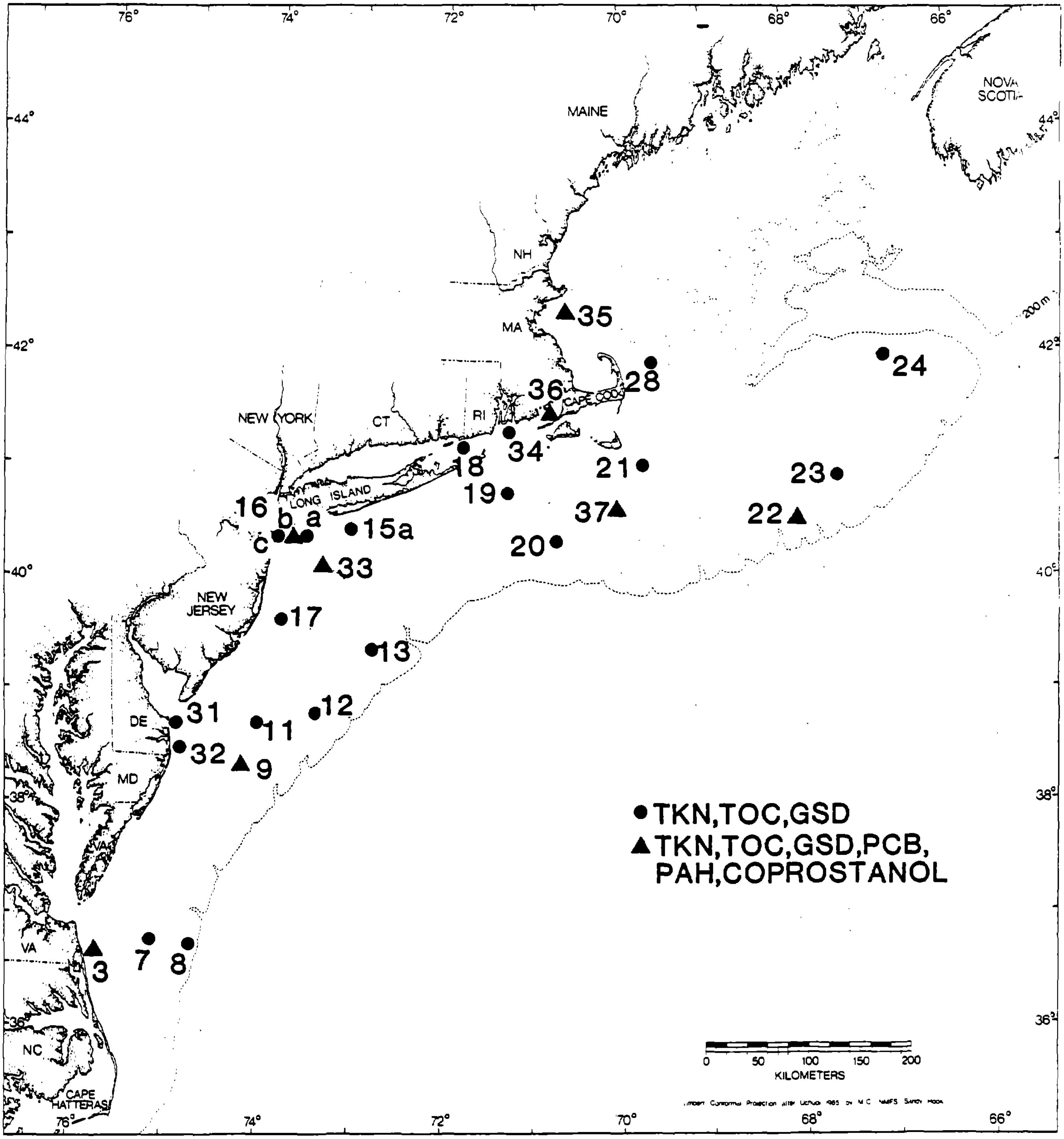

Figure 9. Sampling locations for sediment quality monitoring in 1981.

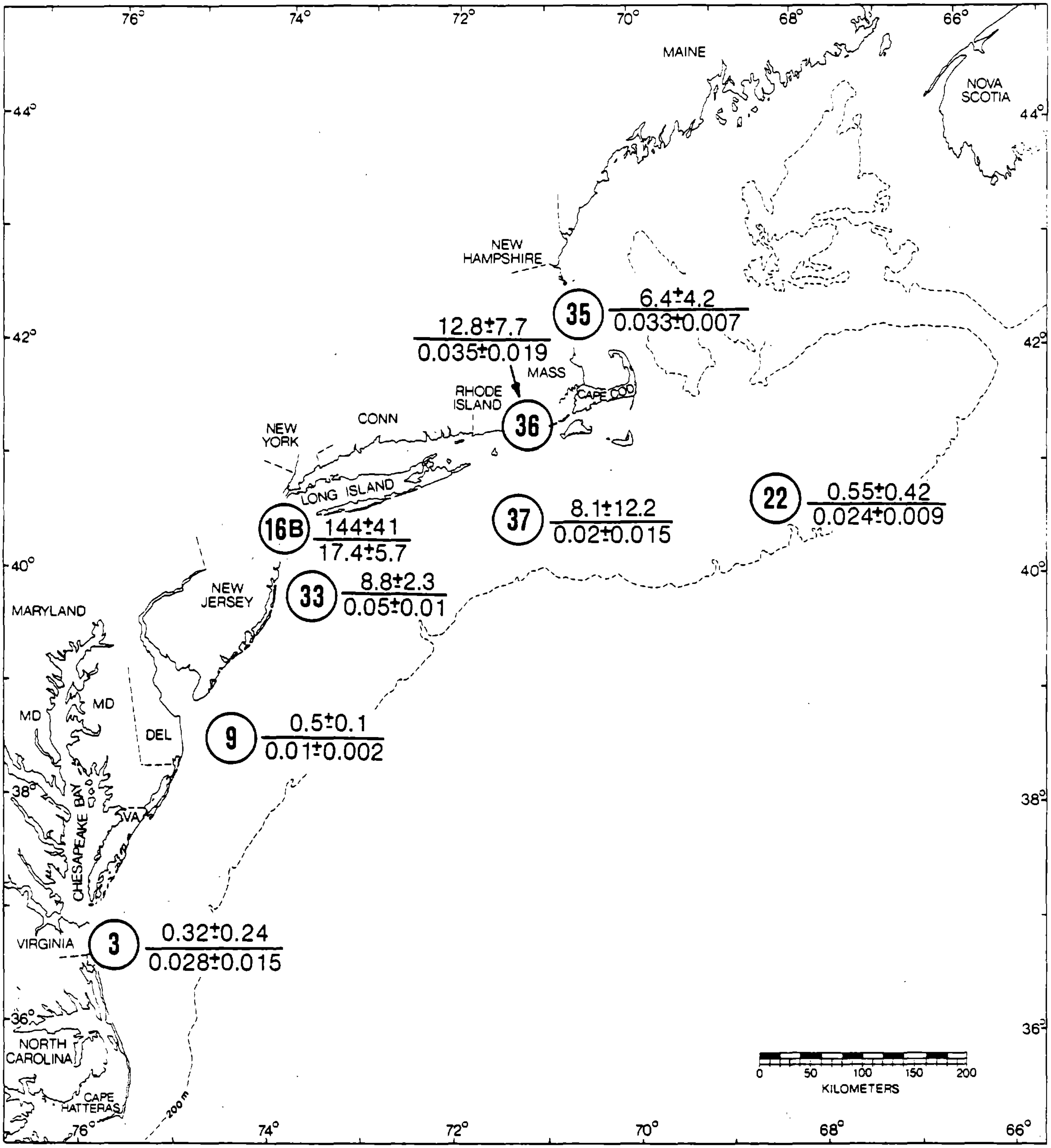

Figure 10. Sediment PCB (upper number - ppb) and coprostanol (lower number - ppm) levels with one Standard Deviation (means of five replicates) for 1981 sampling.

Table 4. Reported PCB concentrations in New York Bight sediments.

Location	Concentration (ppm)	Reference
Hudson River	0.5-140	Bopp et al. 1981
Upper Bay	0.13	MacLeod et al. 1981
	0.40	Boehm 1981b
Lower Bay	0.7	MacLeod et al. 1981
Newark Bay	1.6	Boehm 1981b
Arthur Kill Region	2-3	MacLeod et al. 1981
	0.32 (dredged area)-1.1	Boehm 1981b
Raritan Bay	0.4-0.5	MacLeod et al. 1981
	0.27	Boehm 1981b
Christiaensen Basin	1.3-1.5	MacLeod et al. 1981
	0.05-0.15	Boehm 1980
	0.1-0.3	West and Hatcher 1980
New York Bight (non-dumpsite)	ND-0.01	Boehm 1980
	0.002-0.01	West and Hatcher 1981
Dredge Spoils (Metropolitan N.Y.)	0.4-3.5	MacLeod et al. 1981
	3.7-6.9	Boehm and Fiest 1980
Sewage Sludge (Metropolitan N.Y.)	3.5	Bopp et al. 1981
	6.4	West and Hatcher 1980
Sewage Sludge Deposit (New York Bight)	0.4	Boehm 1982
	0.06-0.2	Boehm 1980
	1.5-2.2	West and Hatcher 1980
Dredge Spoil Deposit (New York Bight)	0.003-0.28	Boehm 1982
	0.03	Boehm 1980
	0.4	West and Hatcher 1980

ND = None detected.

Table 5. Reported PCB concentrations in U.S. marine sediments.

Location	Concentration (ppm)	Reference
New Bedford Harbor		
Inner Harbor	3-30	Mass. DEQE 1980 unpublished
Outer Harbor	0.3-78	US EPA 1980 unpublished WHOI 1980 unpublished
Buzzards Bay	0.08-0.54	SMU 1980 unpublished
Boston Harbor		
Sewage Solids (MDC)	20-30	New England Aquarium 1976
Massachusetts Bay		
Nearshore	0.015-0.030	New England Aquarium 1976
Offshore	0.001-0.020	New England Aquarium 1976
Chesapeake Bay	0.004-0.4	Sayler et al. 1978
Gulf of Mexico	0.0002-0.035	US EPA 1976
Escambia Bay (Fla.)	ND-8	US EPA 1976
Coastal California (depending on distance from Los Angeles discharges)	0.5-7	Young et al. 1977

ND - non detectable

The present sampling was not intensive enough spatially to uncover geochemical relationships governing pollutant distributions in sediment. The ratio of PCB's to TOC (Table 6) indicates that the areas considered unpolluted, e.g. stations 3, 9 and 22, have low (0.14×10^{-6} to 0.29×10^{-6}) PCB to TOC ratios. At stations impacted by PCB's, a greater proportion of the TOC is PCB material. Thus, PCB/TOC ratios at stations 36 and 37 are similar while they are much higher (6.1×10^{-6}) in the New York Bight samples. Stations 16B and 33 have been sampled previously (Boehm 1980) and at that time values for PCB's were determined to be 55 and 0.5 ppb respectively. The values reported here are significantly higher (144 and 9 ppb respectively), indicative, perhaps, of the inherent patchiness in the system.

No detectable levels of PCB were found for sediments collected from the Casco Bay region. One sample in Portland Harbor showed traces of PCB's (aroclor 1242 and 1254) below the 0.1 ppm level.

B. Coprostanol - Average values of the fecal steroid, coprostanol, in sediments, (Figure 10) ranged from 0.01 ppm to 17.4 ppm. Only at New York Bight station 16B, within the sewage sludge depositional area, does the coprostanol value (17.4 ppm) reflect gross sewage contamination. This value is quite similar to that determined previously for this station: 11 ppm (Boehm 1980). Similarly, values for station 33 for the two annual data sets are similar (0.07 and 0.05 ppm). At other stations coprostanol values of 0.01 ppm to 0.035 ppm are typical of values for New Jersey and Long Island shelf stations (not detectable to 0.06 ppm; Boehm 1980).

The influence of sewage-derived organic matter relative to non-sewage steroidal inputs can be understood better using the ratio of coprostanol to total steroids (Table 6). Only at station 16B, within the New York Bight, is sewage input to sediments high, based on finding coprostanol to total steroid ratios in the 0.05 to 0.6 range. A scale of 0 to 0.74 was established by Boehm (1980) to indicate the relative proportion of sewage-related compounds in marine sediment, with 0.74 indicating very high sewage inputs. Assumed sewage-associated pollutants are also found as low-level, ubiquitous components of offshore marine sediments.

Another parameter to assess sewage contamination is the ratio of coprostanol to PCB's. Although PCB's are abundant in sewage sludge, they are not limited to sewage-related sources. The coprostanol to PCB ratios near the sewage dumpsite in the New York Bight have been determined to be 150-200 (Boehm 1980). Boehm (1982) suggests that most PCB's found in

Table 6. Key organic contaminant parameter ratios.

Station-NEMP (NYB)	Copros / PCB	Copros / Total Steriods[a]	PCB/TOC (x 10^6)
3	108±58	0.02±0.009	0.14
9	21±4	0.01±0.002	0.25
22	58±55	0.03±0.01	0.29
35	6.3±4.9	0.017±0.005	1.6
36	3.7±2.1	0.045±0.028	0.98
37	5.2±4.0	0.010±0.008	0.98
16B	134±66	0.58±0.03	6.13
33	7.1±3.8	0.011±.0	-

[a]Sum of five steroids: coprostanol, cholesterol, cholestanol, stigmasterol, ß-sitosterol.

sediments with values in this range are probably sewage related. Elevated ratios are observed for station 16B, as expected, due to its location within the sewage sludge dumpsite. However, elevated ratios were also found at station 3 (below Chesapeake Bay), and at Georges Bank (station 22) and the Philadelphia dumpsite (station 9), indicating that PCB inputs to sediments from these stations have a significant sewage-related source.

C. Polynuclear Aromatic Hydrocarbons (PAH) - PAH compounds are ubiquitous constituents of marine sediments from the continental shelves of the world's oceans (Windsor and Hites 1979). PAHs were detected in nearly all sediments from the NEMP area, the exception being station 9, the Philadelphia Dumpsite. Concentrations of PAHs ranged from 1.0 ppb at station 22 on Georges Bank to 31,000 ppb in the New York Bight apex (Table 7). The "Mud Patch" depositional site also contained moderate PAH levels ($\sim$110 ppb), suggesting a pollutant depositional area. Massachusetts Bay station 35 contained 646 ppb of total PAHs. In the Casco Bay area, concentrations of PAHs were highest in Portland Harbor, with a maximum of 14,425 ppb, although traces, not less than 200 ppb, were found at all stations.

Sources of PAH compounds to the sediments are generally identified by the following criteria: 1) petroleum sources are indicated by high levels of alkylated (C_1, C_2, C_3 C_4) naphthalenes, phenanthrenes, fluorenes, and dibenzothiopenes relative to parent (unsubstituted) compounds (Youngblood and Blumer 1975); 2) combustion sources are indicated by an equal or larger amount of C_o compounds relative to C_1 and C_2 plus large relative quantities of the larger PAH compounds, fluoranthene and pyrene [4 rings], benzofluoranthene and the benzopyrenes [5 rings]. PAH sources to all stations, except New York Bight stations (16B), are of a combustion origin with 3-5 ring aromatics dominant. PAH sources to station 16B are a mixture of petroleum and combustion-derived materials. It is worth noting that the increase of PAH concentrations at station 16B, between 1980 and 1981 samplings (Table 7), is primarily in the naphthalene and dibenzothiopene compound series, indicating a petroleum-related increase.

D. Pesticide and Other Hydrocarbons at the Chesapeake Bay Dredge Spoil Site - Surveys at the Chesapeake Bay disposal site were designed to supplement previous trace metal studies in defining the degree of contamination of sediments at this disposal site. Summary data from the survey are presented in Table 8. The sites are listed according to quadrants moving clockwise from the northeast section of the disposal site. The sediments at most stations were sandy, although a visual

Table 7. Summary of PAH data
(mg/g dry wt.; mean of fine replicates).

	STATIONS									
	3	9	22	35	36	37	16B	16B (1980)[b]	33	(1980)[b]
(1) Total Naphthalenes (C_0-C_4)	nd	nd	nd	2.8	< 1	nd	6,575	790	10	12
(2) Total dibenzothiopenes (C_0-C_3)	nd	nd	nd	1.4	nd	nd	1,690	830	< 1	15
Phenanthrene (C_0)	7.7	nd	nd	60	6.8	12	1,290	820	110	16
(3) Total Phenanthrenes (C_0-C_4)	7.7	nd	nd	120	9.8	22	12,900	3,430	130	47
Fluoranthene (C_0)	3.0	nd	1.0	105	20	23	1,640	1,100	72	28
Pyrene (C_0)	1.0	nd	nd	96	38	14	1,370	1,200	55	25
(4) Total fluoranthenes and pyrenes (C_0-C_1)	4.0	nd	nd	270	58	43	3,810	-	140	-
Benzanthracene	nd	nd	nd	43	2.0	3.3	660	800	18	15
Chrysene	nd	nd	nd	61	7.3	8.5	840	600	32	20
(5) Total benzathracenes and chrysenes (C_0-C_1)	nd	nd	nd	136	9.3	20	2,390	-	87	-
Benz(a)pyrene (252)	nd	nd	nd	32	3.3	2.5	670	720	26	18
Benzofluoranthenes (252)	nd	nd	nd	39	4.3	9.5	1,300	1,300	45	90
Benzo(e)pyrene (252)	nd	nd	nd	33	3.3	11	1,010	590	40	22
Perlyene (252)	nd	nd	nd	12	< 1	5	380	180	15	10
(6) Σm/e 252	nd	nd	nd	116	10	29	3,360	2,790	126	140
ΣPAH (1-6)	11.7	nd	1.0	646	177	114	30,730	19,500	493	300

[a] Individual Isomer concentrations will appear in final report; nd = < 0.5 ng/g.

[b] From Boehm, 1980.

[c] C_0, C_1, C_2, C_3, C_4 = number of alkyl substituents on aromatic molecule.

Table 8. Chlorinated and aromatic hydrocarbons in sediment, mean concentration (ng/g) and (standard error), at the Chesapeake dredge spoil disposal area.

	Site	αBHC	Lindane	Aldrin	Heptachlor Epoxide	Kepone	ppDDT	opDDT	ppDDD	ppDDE	Aromatics
NE	15	0.59 (0.59)	bdl	0.44 (0.44)	0.20 (0.20)	bdl	bdl	bdl	bdl	bdl	16.74 (0.98)
	G5	bdl	bdl	bdl	0.28 (0.14)	2	bdl	bdl	bdl	bdl	9.25 (6.61)
	G11	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	4.7 (0.25)
	24	bdl	0.04 (0.04)	bdl	0.18 (0.18)	bdl	bdl	bdl	bdl	bdl	9.36 (5.40)
	11	bdl	bdl	bdl	0.31 (0.31)	bdl	bdl	bdl	bdl	bdl	4.7 (0.25)
SE	28	0.68 (0.68)	bdl	bdl	0.34 (0.34)	bdl	bdl	bdl	bdl	bdl	12.57 (9.21)
	8	1.13 (0.20)	bdl	0.37 (0.19)	0.35 (0.22)	bdl	bdl	bdl	bdl	bdl	1.08 (1.08)
	G24	1.36 (1.36)	1.39 (1.39)	bdl	bdl	bdl	bdl	bdl	bdl	bdl	11.4 (0.11)

Table 8. (cont.)

	Site	αBHC	Lindane	Aldrin	Heptachlor Epoxide	Kepone	ppDDT	opDDT	ppDDD	ppDDE	Aromatics
	G25	bdl	bdl	bdl	1.29 (1.29)	bdl	bdl	bdl	bdl	bdl	1.09 (1.09)
	26	1.85 (0.05)	bdl	0.42 (0.08)	0.38 (0.38)	bdl	bdl	bdl	bdl	bdl	bdl
	G16	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
	G14	0.23 (0.23)	0.05 (0.05)	bdl	bdl	bdl	bdl	bdl	bdl	0.19 (0.19)	12.82 (9.43)
	G6	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
NW	22	0.85 (0.15)	0.04 (0.04)	0.35 (0.11)	0.30 (0.18)	bdl	bdl	bdl	bdl	bdl	bdl
	5	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	9.25 (6.61)

Note 1: bdl - SW below detection limits.

Note 2: Significant amounts of Kepone detected. Confirmation and CC/MS analysis currently in progress.

inspection of the samples indicated that they ranged from fine sand/silt to coarse sand/shell hash in composition. Because of the importance of agricultural activities to the area, influenced by drainage from rivers and streams emptying into Chesapeake Bay, and because of known spills of pesticide (e.g. Kepone) into Bay tributaries, analysis of pesticide residues was included in the contaminant burden survey at this site.

As expected, pesticide levels in sandy sediments were extremely low (generally below the ppb range). Heptachlor epoxide and αBHC were detected in a number of samples, but at very low levels. Lindane and aldrin were also occasionally detected. One finding was significant levels (ppm range) of what appears to be Kepone in triplicate samples from one station. The Kepone peak from each sample was confirmed on two gas chromatograph columns, but additional confirmation extractions and a GC/MS analysis by an independent laboratory are being conducted currently on frozen aliquots to insure conclusive identification and quantitation of the compound.

Aromatic hydrocarbon levels in sandy sediments were also low (Table 8); concentrations generally in the low ppb range with no particular pattern apparent.

3.2.4 Microbiology

A. Fecal coliform - During the 1981 summer New York Bight sediment quality monitoring survey, 41 stations were sampled for fecal coliform contamination. Most Probable Number (MPN) analysis found high fecal coliform concentrations in and around the sewage sludge dumpsite (Figure 11). The values appeared slightly lower than those observed in the 1980 summer survey, but were all within the 95% confidence MPN level for the two sampling periods. Preliminary results of a fall 1981 cooperative survey with U.S. Food and Drug Administration (FDA) also found high MPN coliform counts in sediments near the mouth of the Merrimack River, MA and at the mouth of Delaware Bay. Moderate MPN coliform counts were observed at inshore stations off Race Pt. (Cape Cod), at the mouth of Narragansett Bay, in Block Island Sound, and in the upper Hudson Shelf Valley. Most offshore stations were negative for coliform bacterial indicator counts. Fecal bacteria were also found in surficial sediments near the former Philadelphia sludge dumpsites. Additional survey data are required to establish reproducibility against the many factors that can influence counts.

B. Clostridium perfringens - Counts for this bacterium, another indicator of fecal contamination, were elevated where fecal coliforms were also high. At a few stations, however, C.

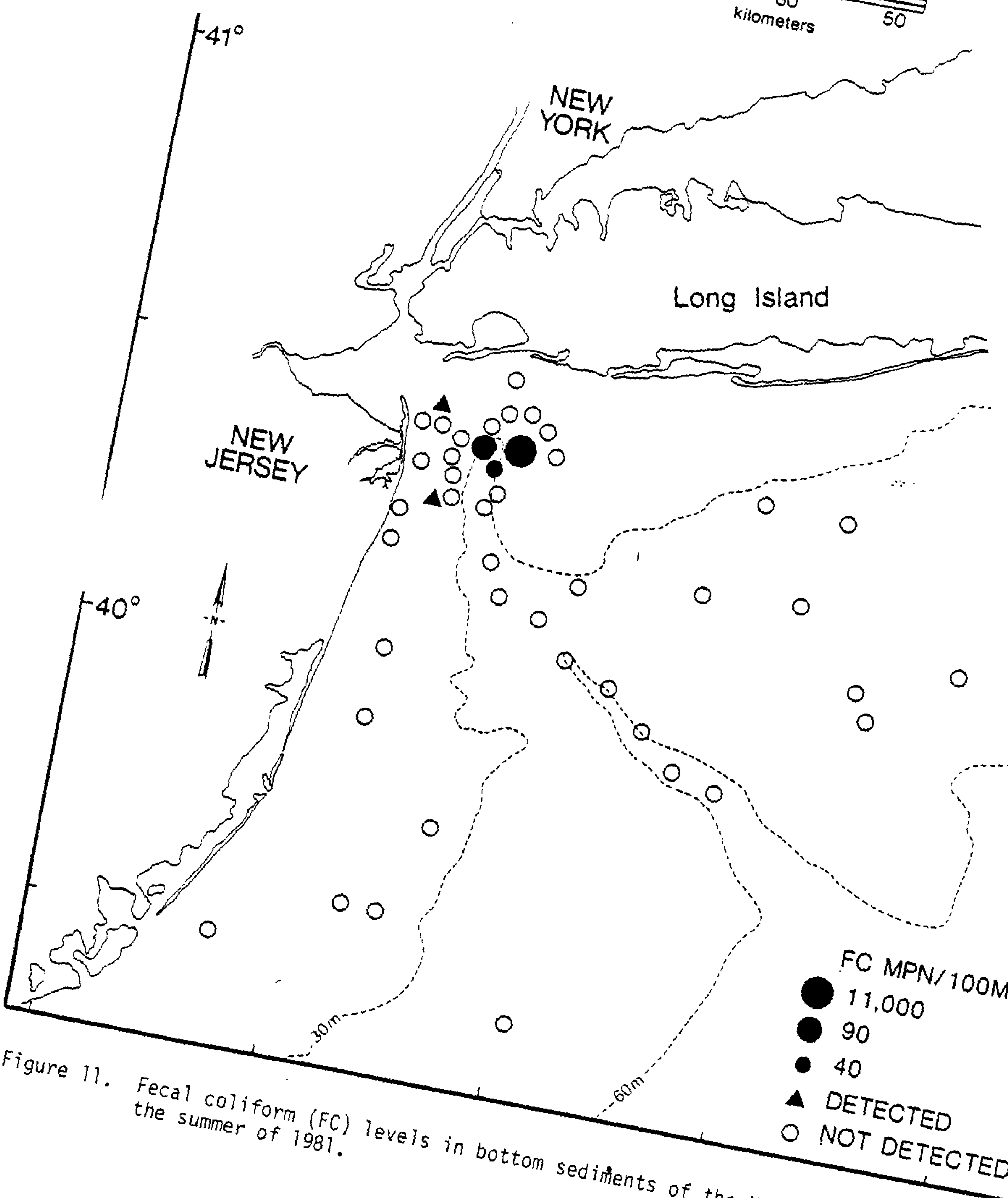

Figure 11. Fecal coliform (FC) levels in bottom sediments of the New York Bight during the summer of 1981.

perfringens counts were high where fecal coliform MPN values were lower or not detectable, possibly accounted for by the greater stability of Clostridium in marine waters. The C. perfringens counts were within the range of values observed in 1979 and 1980 surveys results from the same stations.

Clostridium perfringens spore counts were also high (although these counts are incomplete) in sediments in the "Mud Patch" south of Martha's Vineyard, and near the presently inactive Philadelphia dumpsite off Delaware. Elevated spore count values down the Hudson Shelf Valley suggest possible migration of material from the New York Bight sludge dumpsite towards the Hudson Canyon, as suspected from previous data.

C. Acanthomoebae - Samples were collected during fall 1981 for this protozoan, which is a potential human pathogen. Preliminary analysis of the samples indicate positive counts at Race Point (Cape Cod), Narragansett Bay mouth, mid-Hudson Shelf Valley, Delaware Bay mouth and the Philadelphia dumpsite stations. The higher frequency of this organism at inshore stations is not surprising because of its dependency on bacteria for food; these are more abundant at inshore stations. Such protozoans have persisted at the Philadelphia dumpsite a year after cessation of dumping.

D. Virus - Virological studies at the inactive Philadelphia dumpsite have resulted in the isolation of viruses of pathogenic significance from sediments in contaminated areas of the dumpsite. Enterovirus also were detected in 5 of 30 stations in the New York Bight in 1980 and 7 of 43 in 1981, during the summer sediment quality survey.

3.3 Biological Effects

This area of NEMP monitoring is concerned with measuring natural variability and anthropogenic effects on biological components of the ecosystem. Because of the complexity of even the simplest ecosystem, measurements are made at many levels of biological organization or function, from cellular to community. To assist in organizing the diverse measurements being reported, they have been grouped under two headings: 1) individual responses, including measurements made on individual organisms, species, or populations; and 2) community responses that concentrate on measurements of benthic communities. Planktonic communities were treated in the previous section on Water Quality.

3.3.1 Individual Responses

A number of techniques are being explored to detect the effects of pollution on individual organisms collected at specific stations throughout the NEMP area. Many of these techniques are still being refined so subtle effects of anthropogenic contaminants can be distinguished from natural stresses. The 1981 data establish further baselines for seasonally variable physiological conditions for selected marine species. When viewed collectively, the 1981 data point to pollution effects most often detected in the New York Bight, where the importance of anthropogenic stressors relative to natural stressors is greater than elsewhere in the Northeast. As laboratory protocols and field applications of these new techniques become more refined, we expect them to incorporate the sensitivity needed to distinguish anthropogenic effects from natural effects in regions outside the New York Bight. The results of monitoring individual species biological effects are:

3.3.1.1 Physiology and Biochemistry

The objectives of this element of NEMP are: (1) to determine baseline physiological conditions of selected marine species at 25 stations in the waters of New England and the Middle Atlantic, (2) to establish a seasonal collection of such data so that future effects of specific activities, including offshore drilling and waste dumping, can be evaluated, (3) to perform supportive laboratory studies to corroborate and aid in the interpretation of field observations and measurements, and (4) to develop additional techniques for measuring, in the field, the physiological condition or "health" of marine species.

In 1981, a large volume of data was added as a result of full participation in four NEMP cruises plus data collections on other cruises. Many of these data have been prepared for ADP entry and mapped for easier visual interpretation. Figure 12 is an example of some of the baseline data.

Six blood constituents in windowpane, yellowtail, and winter flounder were examined in specimens collected throughout the NEMP area. These constituents fluctuate seasonally and patterns have been established for windowpane flounder collected monthly from three stations in Long Island Sound (Figure 13). These patterns illustrate the necessity for considering normal seasonal variations when interpreting data. Four of the blood variables (hematocrit, sodium, calcium, and plasma osmolality) were significantly different in fish collected from the heavily polluted western end of the Sound when compared to fish from the "much cleaner" eastern end. Hence, there is considerable promise that these variables can be used as indicators of physiological stress. Other results point to physiologically stressed populations, across the New York Bight and off the Merrimack River, a river in Massachusetts.

In a concurrent study, the scallop <u>Placopecten magellanicus</u> was collected from NEMP stations, as well as from random sites during trawl surveys, and measurements of metabolic efficiency were made on adductor

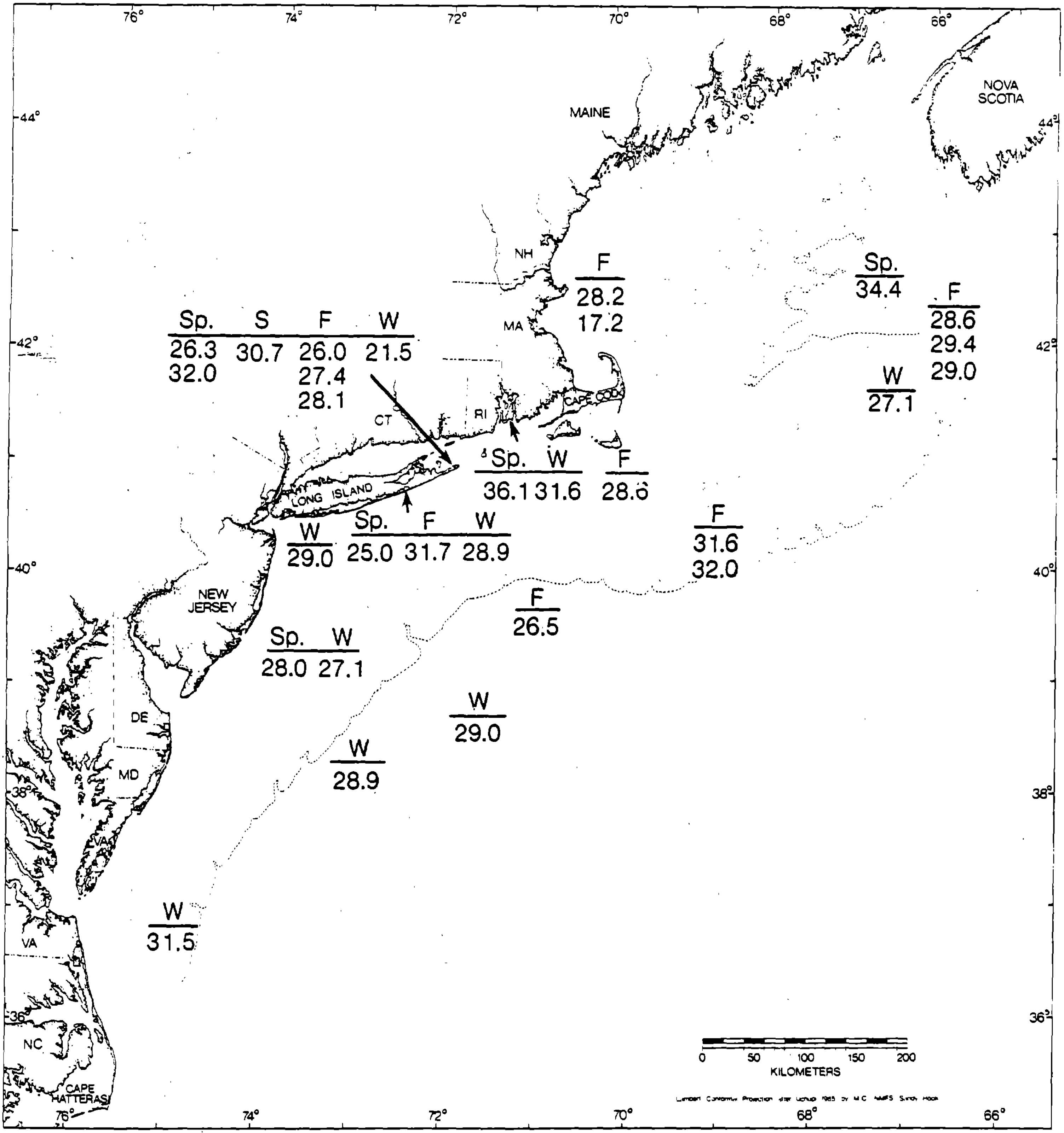

Figure 12. Distribution of hematocrit values in winter flounder, means of 10-20 animals during survey in various seasons (F = Fall, Sp = Spring, S = Summer and W = Winter).

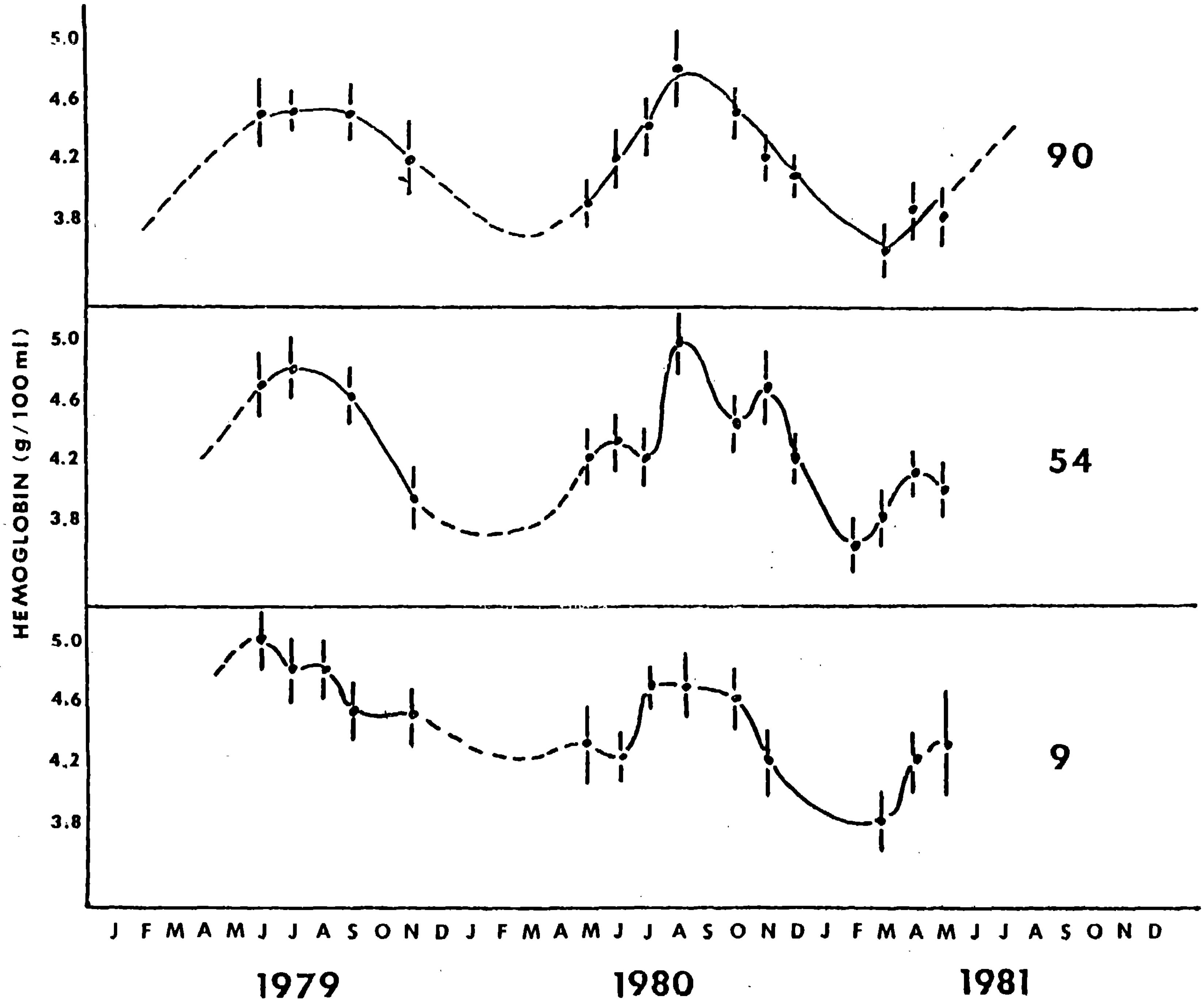

Figure 13. Hemoglobin concentrations in the blood of windowpane flounder from three stations in Long Island Sound during 1979-1981. Each point is the mean of 20 animals. Standard error is indicated by vertical lines.

muscle and on kidney tissue. Biochemical parameters included GDH (energy charge), glycogen reserves, PK (energy mobilization rate), MDH (redox activity), and, in kidney, GGPDH (biosynthetic activity). Stressed populations of sea scallops were found in deepwater sites in the Gulf of Maine (Table 9) where the scallops are nutritionally deficient and thought to be non-spawning, as well as in the area of the "Mud Patch" (Table 10). Scallops at the latter site showed metabolic stress, according to the biochemical parameters listed above. It was also possible to detect early signs of potential spawning failure in populations in the outer Hudson Valley shelf (Table 11) and incipient stress at the Baltimore Canyon Trough station and south central Georges Bank sites. Scallops from several of these same sites also show calcium deficiencies, a condition that has been linked to trace metal exposure in associated laboratory studies.

Other bivalve studies have demonstrated metabolic changes in blue mussels (*Mytilus edulis*) held along a pollutant gradient in Narragansett Bay. Figure 14 illustrates respiratory differences between mussels held at clean and polluted Bay stations. This study is part of a cooperative field and laboratory program sponsored by the National Marine Fisheries Service, Northeast Fisheries Center and the U.S. EPA Laboratory, Narragansett, Rhode Island.

The RNA-DNA ratio in larval and juvenile fish was used as an analog of growth rate and index of overall condition in several surveys in the NEMP area. Sand lance larvae were used as an indicator species because of their abundance, wide distribution, and use in other studies. Cod and haddock larvae were also monitored because of their commercial importance and the likelihood of expanded drilling operations on Georges Bank. The RNA-DNA ratios of specimens collected in 1981 were consistently high, indicating good condition and rapid growth. This was not unexpected, since the fish appeared upon visual examination to be robust and in excellent condition. Monitoring should continue to detect changes from these baseline conditions.

3.3.1.2 Genetics

Chromosomal mutation frequencies in blood erythrocytes of windowpane flounder were measured in Long Island Sound, New York Bight, New Jersey/Delaware coastal waters, and on Georges Bank. There were no site-related differences in the adults of this species, except at two contaminated Long Island Sound sites (Figures 15 and 16). At one of these sites, in Hempstead Bay, Long Island, mutation frequencies were three times those at sites elsewhere. Erythrocytes of larval red hake displayed high outlying incidence of mutations in a cluster of stations in New York Bight sites near dumpsites. In addition, blood from flounder taken in New York Bight waters showed high incidences of enhanced fragility of red blood cells, up to 25% of the fish at some sites.

Table 9. Selected biochemical parameters for phasic adductor muscle of sea scallops collected from 3 northern stations having different depths, temperatures, and food availability. All animals were taken during Ocean Pulse Cruise AL 80-09 (September 1980).

Station descriptor	Deepwater (DW) Gulf of Maine	Fippennies (FL) Gulf of Maine	P (df/t), DW vs FL	Central Georges
Depth (m)	155	68		65
Btm T (°C)	6.0	7.3		14.0
Sample N	18	18		18
Shell height (cm)	9.1	9.0		9.9
Glycogen	133 ± 24	407 ± 62	<0.001 (22/4.101)	694 ± 104
Endogenous cbh	164	160		160
GDH	109.4 ± 4.9	55.7 ± 6.1	<0.001 (34/6.852)	73.5 ± 4.8
PK	484 ± 17	574 ± 24	<0.005 (34/3.030)	672 ± 25
MDH	2703 ± 103	2052 ± 116	<0.001 (34/4.202)	2722 ± 169
Stress indices				
PK:GDH	4.5	11.5		9.0
MDH:PK	5.5	3.6		4.4
Glycogen:GDH	1.3	6.6		8.7

All biochemical data are expressed as arithmetic means ± standard error. Animal height is measured from umbo tip to largest diameter outer shell rim . Enzyme activities are expressed as μmoles substrate turn-over per min per mg biuret protein. Both glycogen and endogenous carbohydrate(cbh) are expressed as μg glucose per g wet wt tissue. Values for the ratios PK:GDH <5 and MDH:PK >6 are considered indicative of metabolic stress, and glycogen:GDH <3, of nutritional stress. These conventions are followed in Tables 10-11 also.

Table 10. Selected biochemical parameters for phasic adductor muscle of sea scallops collected from stations in the Middle Atlantic Bight, including Block Island Midshelf (BIMS), during Ocean Pulse Cruise DL 80-09 (December 1980). Mud Patch specimens were collected at station BIMS. Parenthetical data at that station are for the severely stressed scallop (see text), and at Outer Hudson Shelf Valley (OHV), for scallops showing marked stress. Statistical comparison is shown for the most significantly changed metabolic parameter, GDM.

Station descriptor	Southeast of Philadelphia dumpsite	Near Baltimore Canyon Trough	Outer Hudson Shelf Valley	Block Island Mid shelf
Depth (m)	57	64	77	58
Btm T (°C)	10.0	11.5	11.7	10.8
Sample <u>N</u>	8	18	17	5 (+1)
Shell height (cm)	12.2	9.7	8.8	12.2 (13.4)
Glycogen	1579±191	461±36	275±39 (0)	440±92 (126)
Endogenous cbh	136±24	142±23	183±25 (260)	146±22 (34)
GDH	66.2±5.8	96.9±5.1 3.3	99.9± (129.6)	124.6±7.4 (75.3)
<u>P</u> (df/t) for GDH, compared to BIMS	<0.001 (11/6.223)	<0.005 (21/3.796)	<0.05 (18/2.443)	
PK	740±34	642±30	680±36 (560)	503±17 (282)
MDH	3117±213	3412±146	3658±155 (5719)	3377±116 (2901)
<u>Stress indices</u>				
PK:GDH	11.7	6.8	7.0 (4.3)	4.0 (3.7)
MDH:PK	4.3	5.4	5.2 (9.3)	6.7 (10.3)
Glycogen:GDH	23.9	4.8	2.8 (0)	3.5 (1.7)

Table 11. Selected biochemical variables for phasic adductor muscle of sea scallops collected in random sampling from the outer Hudson Shelf Valley (OHV) - Philadelphia dumpsite transect during spring bottom-trawl Survey Cruise DL 81-02. These stations were sampled in mid-April, toward the end of the late winter-early spring phytoplankton blooms, during which the scallops normally lay down glycogen stores for gamete maturation. The two stations near OHV and Baltimore Canyon Trough had exceptionally low muscle glycogen, although the endogenous carbohydrate, PK, and GDH were all normal. These data indicate populations under no particular metabolic stress, but needing to build up glycogen reserves if they are to have a successful spawning season in late summer-early fall.

Station descriptor	75 km East of Chincoteaque, VA	Near Phila Dumpsite	Near Baltimore Canyon Trough (oil and gas drilling area)	Outer Hudson Shelf Valley
Depth (m)	59	62	73	128
Btm T (°C)	9.2	7.6	7.3	11.4
Sample N	7	8	10	4
Shell height (cm)	7.3	7.8	7.6	14.0
Glycogen	214±48	534±73	74±24	83±6
Endogenous cbh	320±15	341±19	305±19	278±23
GDH	22.9±1.5	27.4±2.1	18.8±1.4	39.1±2.8
PK	422±33	484±42	381±23	432±21
Stress indices				
PK:GDH	18.5	18.5	20.1	11.8
Glycogen:GDH	9.6	19.4	3.8	2.1

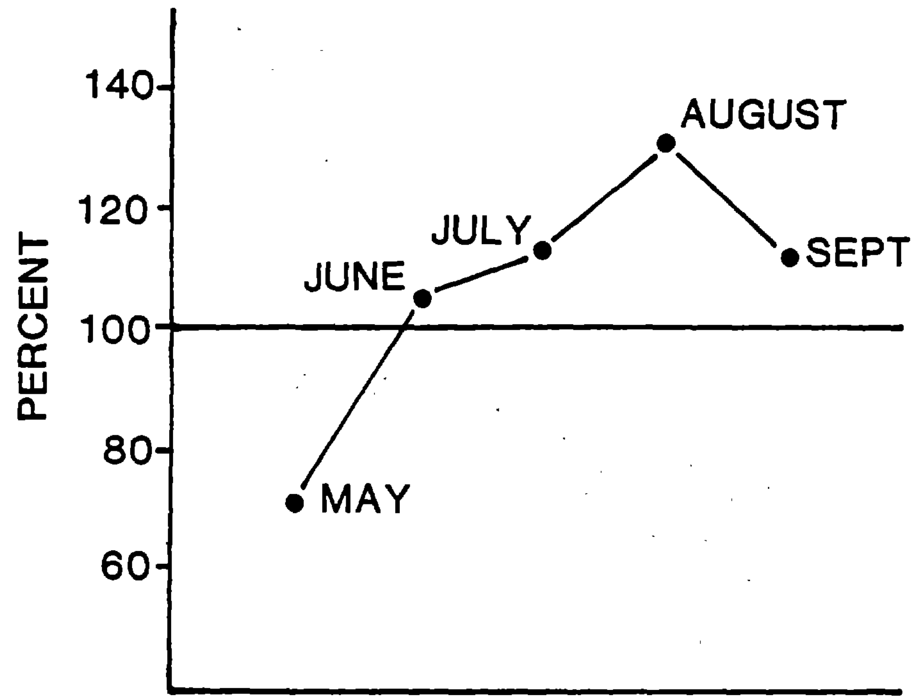

Figure 14. Oxygen consumption of blue mussel <u>Mytilus edulis</u> gill tissue sampled monthly at two stations in Narragansett Bay, R. I. The horozontal line at 100% represents data for animals from a relatively clean station (4), taken as unity. The connected monthly points represent data for animals from a polluted station (2), presented as percent of values at clean station.

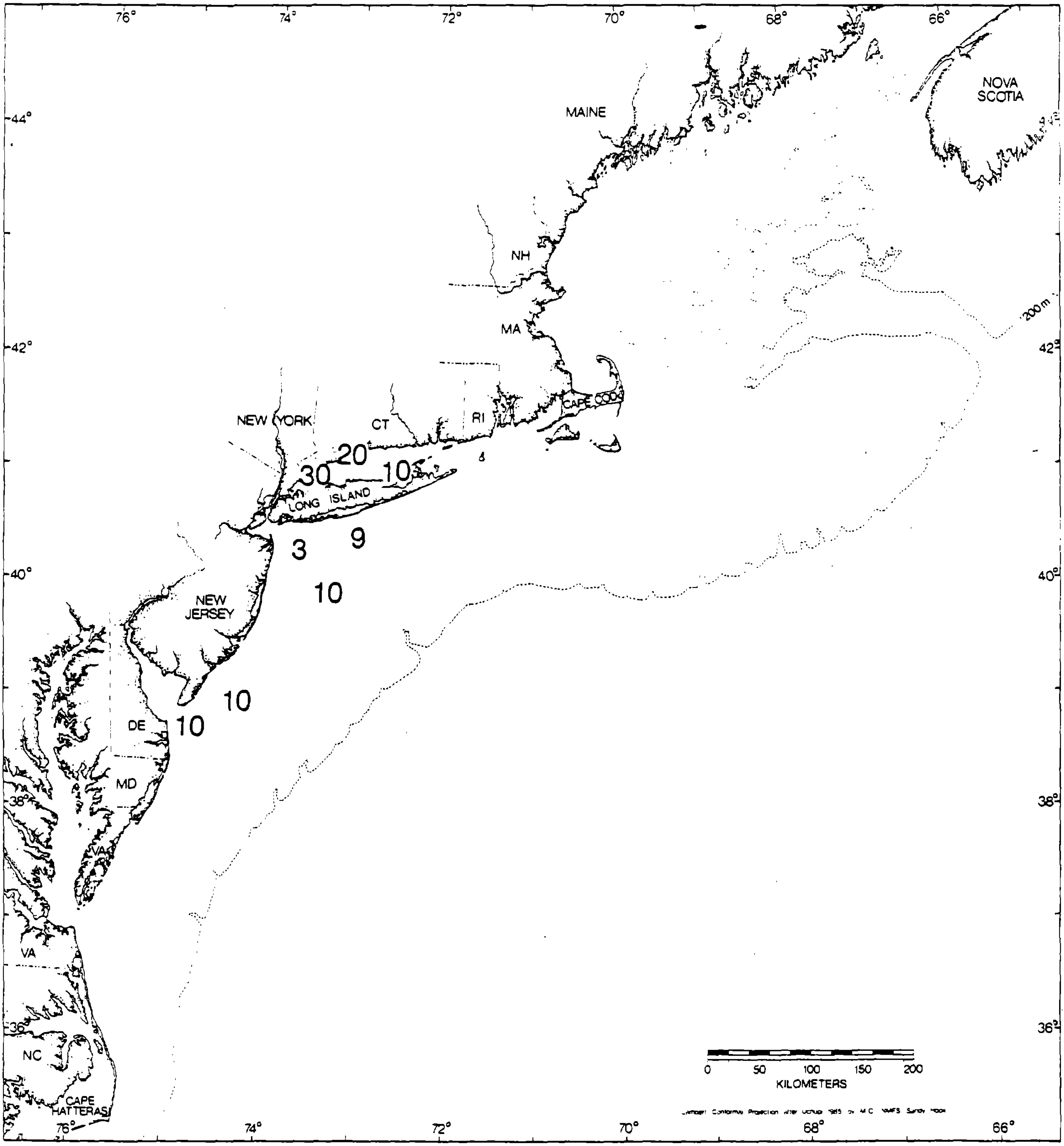

Figure 15. Mean incidence of micronuclei (chromosome mutation) per 10^5 mature red blood cells (erythrocytes) for windowpane flounder, 1980-81.

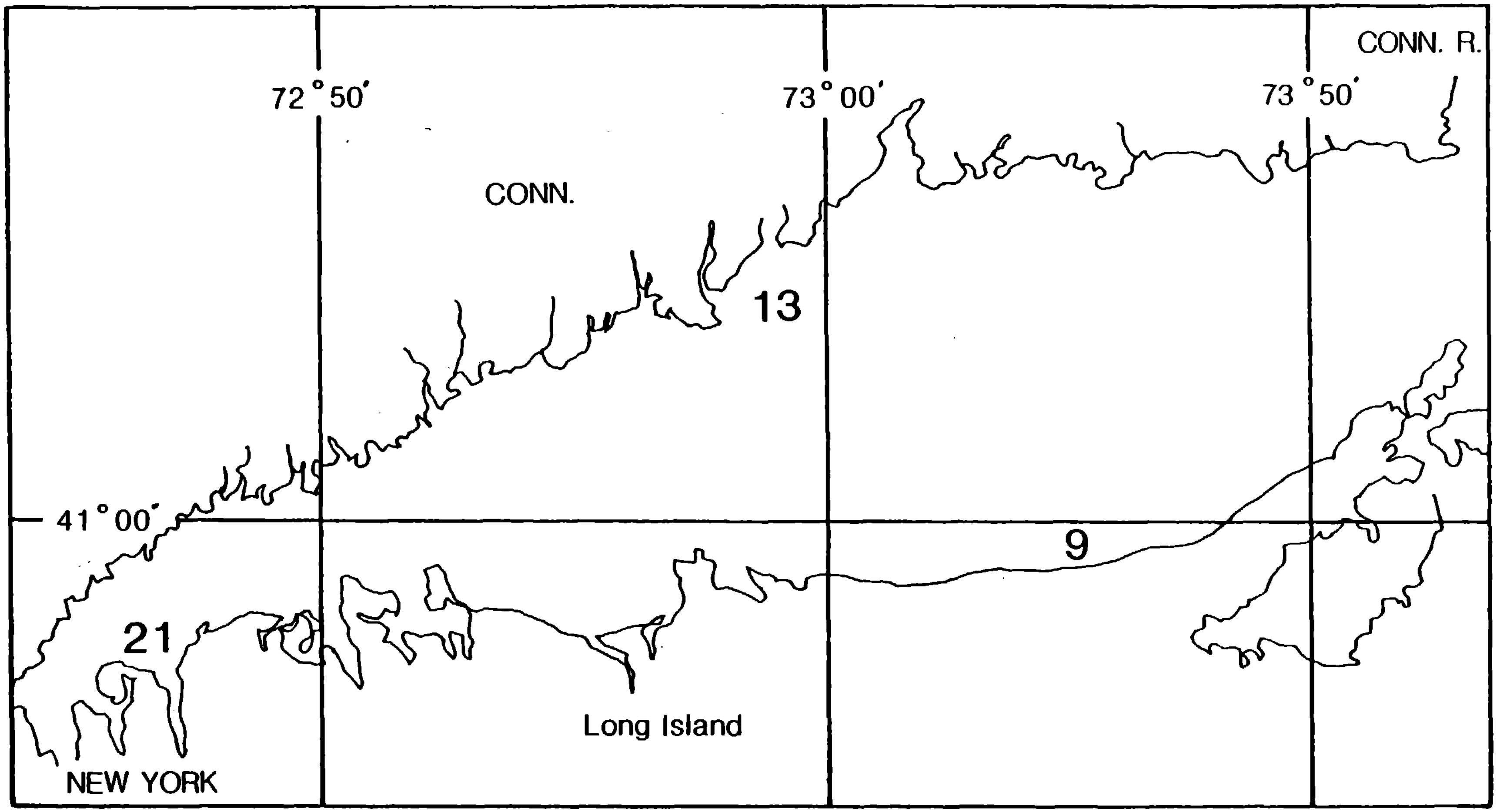

Figure 16. Mean incidence of micronuclei (chromosone mutation) per 1,000 immature red blood cells (erythrocytes) from the blood forming tissue of windowpane flounder kidney in 1981.

3.3.1.3 Pathology

A number of molluscs were monitored for a variety of diseases, tissue abnormalities, and parasites, at stations throughout the NEMP area. These measurements are useful for establishing regions of normal and stressed populations. Although abnormal specimens were present at many sites, nowhere did there appear to be areas of severe and widespread stress. There was evidence of copper accumulation and related pathological effects in oysters in Delaware, Raritan, and Buzzards Bays, and the Piscataqua River, NH, and it is possible that evidence of stress in other areas will surface as more data are accumulated in the future. Shell abnormalities, associated with predators, were observed in the sea scallop Placopecten magellanicus at the majority of stations. However, these effects appear to be natural, apparently not associated with environmental stress.

Abnormal and pathological conditions in several crustaceans were monitored. Gill melanization in some planktonic euphausids was noted in slope waters in and around the 106 mile dump site. There was a considerable difference in melanization incidence among the euphausid species, so that the distribution of melanization may depend on species distributions (Figure 17). There was a high percent association (25%) between occurrence of suctorian ciliates on gills and gill melanization, suggesting that the two conditions are related. Cuticular melanization was observed in 18% of the decapod, Crangon septemspinosa, specimens collected from the New York Bight. Crangon from the abandoned Philadelphia dumpsite also had signs of pathological melanization, suggesting poor environmental quality at that site. In contrast, no cuticular melanization was observed in Crangon collected from the cleaner Chincoteague Bay, VA.

Gill condition in rock crab, Cancer irroratus, was surveyed in the New York Bight apex. An average 4% of the specimens displayed gill blackening. However, the only area of possibly elevated incidence is a site just south of the dredge spoil and sewage sludge dumpsites, where 30% of the animals had black gill condition.

In a summer study at the New York sewage sludge dumpsite, winter flounder placed in cages in the dumpsite area showed a higher incidence of disease and rate of mortality than those caged in a control area. Summer flounder placed in the same locations at a later date showed 100% mortality in the dumpsite area. Several other abnormal conditions in fish were monitored in the NEMP area. Skeletal anomalies in the sand lance Ammodytes were observed with similar frequency in specimens of all sizes, indicating that the defect occurs early in the life cycle. Samples from inshore stations had a greater prevalence of abnormalities than those from offshore stations, especially sites associated with the outflow of major estuarine systems. Integumental lesions were also examined in a variety of ground fish collected at many NEMP stations. Finrot was the most frequently encountered lesion (0.35%), and winter

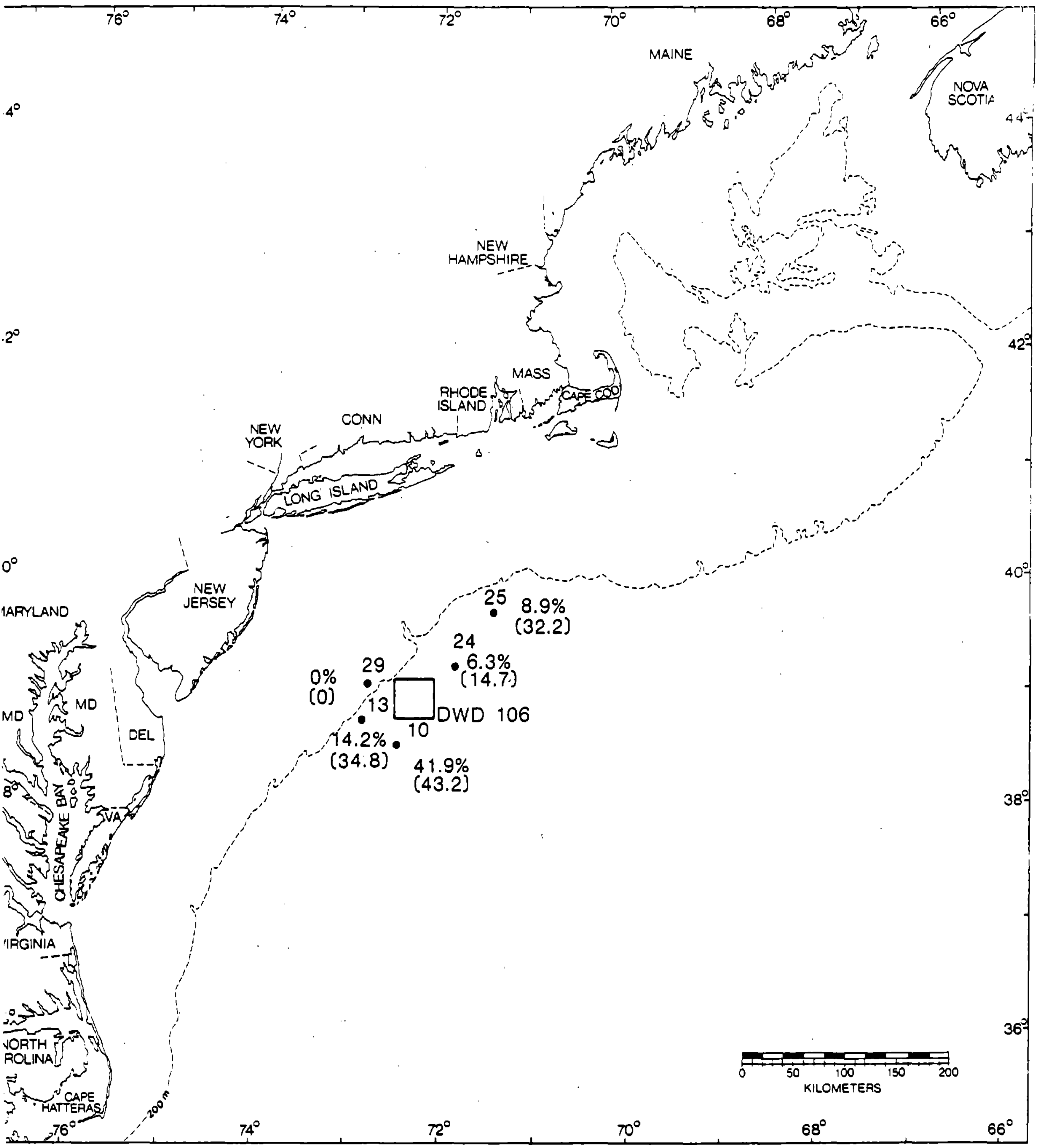

Figure 17. Station locations and prevalence of focal gill melanization in adult euphausids (Nematoscelis megalops, Euphausia krohnii and Meganyctiphanes morvegica). Values in parenthesis are prevalence when data for M. morvegica is omitted.

flounder, *Pseudopleuronectes americanus*, was the most frequently diseased species (2.5%). Overall, it appeared that groundfish in the NEMP area were not unduly diseased. This initial evaluation of fish health, using gross changes in the integument and skeleton, establishes present conditions against which future changes may be assessed.

In a corroborating laboratory study, examination of normal and copper-exposed fish larvae indicated that the olfactory organ may be involved in the acquisition of food. The sensory tissues of this organ developed lesions of varying severity when four-week old larvae were exposed to 500 ppb Cu^{++} for 18 hours, but not when they were exposed to 150 ppb for the same time.

3.3.1.4 Life History

Identification of factors limiting populations of the commercially valuable surf clam, *Spisula solidissima*, in the New York Bight apex are being undertaken. Laboratory and field experiments were used to supplement SCUBA observations and collections, and to attempt to determine causality of observed population dynamics phenomena. Larval settlement densities in 1981 ($\sim$250/m^2) were about the same as 1979 but an order of magnitude less than in 1980. Predation, mostly by crabs and less by moon snails, appears to eliminate nearly all juvenile clams in most years and is thus a major factor limiting surf clam abundance. One experiment indicated surf clams and other invertebrates set in numbers in contaminated as well as clean sediments in field-deployed trays. Further work is planned for summer 1982 to quantify any inhibition of setting or growth in contaminated trays. In both laboratory and field studies, adult clams burrowed as quickly into sands from the sewage sludge dumpsite as into clean sands, indicating that sludge contaminated sediments do not inhibit burrowing behavior of adults.

3.3.1.5 Contaminant Body Burdens

Data on trace metals, PCB's and PAHs in muscle tissue of six demersal fish and shellfish species are now available from a summer 1980 survey of the New York Bight and Long Island Sound.

All tissue concentrations of PCB's were well below the recommended maximum level of 5 ppm for human consumption, and were not consistently related to levels in sediments or to areas of contaminants. Statistically significant differences between inner and outer N.Y. Bight stations were found only for rock crab. Concentrations in inner Bight lobsters were higher than for a single outer Bight sample, but no statistical tests could be run due to limited data. The highest concentration measured in any species was 1.08 ppm in a composite lobster sample from the upper Hudson Shelf Valley. All other composites of target species had $\leq$0.63 ppm in muscle. Values in winter flounder ranged from 0.11-0.56 ppm, with the highest concentration found $\sim$21km off eastern Long Island. Windowpane flounder body burdens had a slightly greater range, from 0.06-0.63 ppm. All values for red hake were <0.1 ppm, except for 0.34 ppm at a mid-shelf station off eastern Long Island. PCB's in scallops were very low or undetectable, with all values ≤0.04 ppm.

The lack of a consistent pattern of higher body burdens in more contaminated areas may be related to the mobility of the species sampled. It is possible, though conjectural, that a large proportion of the measured body burdens is acquired in the inner NYB or other contaminated areas, but that the migratory nature of most megafauna (and/or of their prey) can account for the observed pattern of low body burdens across large areas of the shelf. Boehm (1980a), reporting results of a broader-scale survey of PCB's and petroleum hydrocarbons in shelf biota off the northeastern United States, similarly noted contamination throughout the region, but no values approaching the 5 ppm action level, in contaminated areas or elsewhere. Murray (1979) has also documented widespread presence of PCB's in areas remote from point-source contamination in England and Wales. Concentrations measured in the present survey were generally an order of magnitude higher than Boehm's (1980a) reported values, when the latter are converted from a dry to an approximate wet weight basis.

These values are in better agreement with those of MacLeod et al. (1981), which included more samples from the New York Bight apex than did Boehm's (1980a) analyses. Both the results of the MacLeod et al. survey and 1980 NEMP surveys indicate low concentrations of PCB's in scallops (<0.04 ppm). Values for rock crabs and windowpane flounder were about 1-2 times, winter flounder 1-5 times, and lobster 2-10 times the levels found by MacLeod et al. (1981).

Highest overall PAH values measured in the New York Bight-Long Island Sound survey were found in rock crabs, with a peak of 2.51 ppm wet weight (almost all phenanthrene) in mid-eastern Long Island Sound. Lobster had next highest residues, ranging from 0.14-0.53 ppm, followed by red hake. The only geographical trend noticed was a slight tendency for the total PAH (minus phenanthrene) for all species combined to be highest in and near Christiaensen Basin.

Table 12 lists overall ranges of values for metals in muscle tissue of the six demersal species collected over most of the Bight and in the western and mideastern Long Island Sound. Concentrations were generally highest in Long Island Sound, the Christiaensen Basin and in an area called the "Mud Hole", about 30 km SSE of the central Basin. Levels in flesh usually increased in the order scallop < fish < crustaceans. Highest levels of mercury (0.15 ppm) and lead (0.6 ppm) in lobsters were found in the "Mud Hole".

Additional information has become available on metals in biota from a region-wide sampling in summer 1979. These data (Table 13) include analyses of liver, gill, viscera and gonad of various species, as well

Table 12. Range of muscle tissue trace metal burdens (ppm - wet weight) in six species of fin- and shellfish from the New York Bight and Long Island Sound during 1980.

Species		PPM Wet Weight							
		Ag	Cd	Cr	Cu	Ni	Pb	Zn	Hg
Sea scallop	high	< 0.10	0.20	0.44	0.19	< 0.18	< 0.5	3.26	0.04
	low		< 0.09	0.16	0.08			0.85	0.02
Winter flounder	high	< 0.10	< 0.10	1.35	0.34	0.35	< 0.6	6.44	0.12
	low			0.12	0.14	< 0.16		1.42	0.03
Windowpane flounder	high	< 0.14	0.25	1.22	0.35	< 0.29	< 0.9	6.80	0.25
	low		< 0.14	< 0.20	0.15			1.42	0.02
Red hake	high	< 0.33	< 0.33	0.76	0.48	< 0.65	< 2.0	16.4	0.09
	low			0.10	0.10			0.77	0.03
Lobster	high	0.73	0.15	0.52	15.48	0.46	0.6	19.3	0.15
	low	0.10	< 0.07	< 0.10	2.27	0.08	< 0.5	5.75	0.04
Rock crab	high	0.81	< 0.27	1.34	10.04	0.64	< 1.6	59.3	0.16
	low	0.14		0.25	3.24	0.26		4.18	(1 sample

Table 13. Range of muscle tissue trace metal burdens (ppm - wet weight) in four species of fin- and shellfish from non-New York Bight NEMP sampling sites, 1979.

	N		PPM Wet Weight						
			Ag	Cd	Cr	Cu	Ni	Pb	Zn
Winter Flounder	3								
-muscle		High	< 0.11	< 0.11	0.19	0.34	< 1.2	< 0.6	3.02
		Low			0.15	0.19			1.91
-liver		High	< 0.54	1.26	< 1.07	15.6	< 1.07	< 3.2	31.2
		Low	0.21	0.13	0.34	8.0	< 0.20	< 0.6	24.3
Windowpane Flounder	3								
-muscle		High	< 0.13	< 0.13	0.30	0.32	< 0.25	< 0.8	2.75
		Low			0.20	0.16			1.56
-liver		High	< 0.72	0.33	< 1.74	6.5	< 1.44	< 1.0	25.0
		Low	< 0.12	< 0.16	< 0.23	5.1	< 0.23		14.7
Rock Crab	9								
-gill		High	3.04	1.79	2.52	33.4	0.91	9.2	38.5
		Low	0.34	0.88	< 0.20	12.4	0.41	0.7	19.5
Scallop	4								
-muscle		High	< 0.16	< 0.20	< 0.38	0.23	< 0.32	< 1.0	2.67
		Low	< 0.07	< 0.07	< 0.16	0.11	< 0.14	< 0.5	0.17
-viscera		High	2.55	78.1	< 1.36	10.7	2.08	< 4.8	24.9
		Low	0.87	33.3	< 1.07	5.06	< 1.19	< 1.5	9.82
-gonad		High	< 1.12	< 3.89	< 2.24	3.82	< 2.24	< 4.9	23.6
		Low	0.10	0.27	< 0.28	0.90	< 0.23	< 0.5	8.83

N = Number of stations sampled

as muscle analysis. The data show that levels of all metals increase in the order, muscle <gonad <liver < gill < viscera. Although no concentrations of either metals or organic contaminants have been found in edible flesh which exceed action limits for human health, it is still possible that the observed body burdens are affecting the organisms in question, especially since levels in accumulative organs, e.g. liver and kidneys, are often much higher than in muscle.

Concentrations of metals in lobster, Cancer crabs, and tilefish from Georges Bank were low and similar to 1980 values. PCB's were undetectable in these species collected on Georges Bank. The data provide a good baseline for assessing any increases due to oil-related activities. NEMP is also presently analyzing samples of the ocean quahog, *Arctica islandica*, from many sites on the northeast shelf to establish similar baselines for the entire NEMP region. Haddock from Georges Bank of two size groups (<30 cm young and >75 cm adults) have been analyzed by several compositing techniques to determine variability of analyses and most effective ways of making future determinations. The results of this analysis indicate that:

1. PCB and ΣDDT levels in adult haddock are greater than for young fish by a factor of 2-3,
2. Levels of saturated hydrocarbons in these samples are, however, the same in both adults and young,
3. The steady-state aromatic hydrocarbons levels in adults and juveniles are similar, and
4. The pooling of six individuals yields an analytical result adequate to describe pollutant levels in a given population of fish.

In a cooperative effort among several Federal groups (U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, NOAA), polychaete worms from selected areas of the New York Bight were collected for analysis of tissue PCB's. Results were provided to the Corps of Engineers for comparison with the "action level" (0.4 ppm) presently used in their 10-day solid-phase bioaccumulation test to determine whether dredged materials are acceptable for ocean dumping. Mean polychaete PCB's body burden in the Bight apex was 0.83 ppm (whole body, dry weight). This was at least twice as high as for any other vertebrate or invertebrate tissue examined except for whole body of one female lobster.

3.3.2 Community Responses (Benthic)

The benthic macrofauna is defined here as those small invertebrates living in or on the sediment, that can be retained on a 0.5 mm mesh sieve. The relative immobility of such organisms and their intimate association with sediment contaminant sinks make them good integrators of environmental conditions, and indicators of environmental health. The benthic macrofauna includes several species of direct economic interest to man and provides forage for other valuable species, for which the macrofauna can also serve as a vector for contaminants. The macrofauna is collected twice yearly at 28 sites on the northeastern continental shelf. More spatially intensive sampling was conducted at existing or potential problem areas in Casco Bay, ME and the New York Bight, as well as off Delaware Bay and Chesapeake Bay (Figure 18).

Benthic megafauna are larger, more motile species consisting mostly of echinoderms, fin- and shellfish. They include a number of commercially and recreationally valuable species. Some of the megafauna are also useful as environmental integrators. Most of the megafauna monitoring is done using *in situ* quantitative photographic techniques, and from submersible vehicles or via SCUBA diving. Surveys have concentrated on 1) areas near and downstream (Lydonia and Oceanographer Canyons) from potential oil production areas on Georges Bank; 2) Jeffreys Ledge and Isle of Shoals, Gulf of Maine; 3) Block Island and Rhode Island Sound (Figure 18). A summary of 1981 results for each survey is presented below:

3.3.2.1 Macrofauna

Analysis of data from the region-wide macrobenthic sampling concentrated on numbers of species and numbers of amphipods (small crustaceans), both of which have been reported to decrease with environmental stress. Trends in species composition were examined using cluster analysis and lists of dominant species at each station, over time.

Portions of the inner New York Bight continue to show the most severe and widest extent of impacts to the benthos of any NEMP sites. An impoverished fauna dominated by the polychaetes *Capitella* spp. (often used as indicators of organic pollution) covers 10 km^2 of bottom in an area of sewage sludge accumulation west of the sludge dumpsite. This most impacted area grades into an enriched zone containing dense populations of several species known to be pollution-tolerant. The enriched assemblage is present over much of the Christiaensen Basin and extends into the upper Hudson Shelf Valley. Based on abundances of over 1000 m^{-2} of the polychaete *Nephtys incisa*, this zone covered about 200 km^2 in summer 1980. It is not yet possible to separate completely impacts to macrofauna of the several dumpsites and the plume emanating from the Hudson-Raritan estuarine system, but there is general agreement with other assessments (e.g. Steimle et al. 1982) that the greatest alterations of the benthos appear most closely associated with sewage sludge disposal.

Data from long-term monitoring sites reveal no temporal trends in extent or severity of impacts to Bight macrobenthos. Examples of these data are given in Figure 19, which shows that numbers of species and numbers of amphipod crustaceans, both sensitive indicators of environmental stress, have been relatively stable since 1973 at the

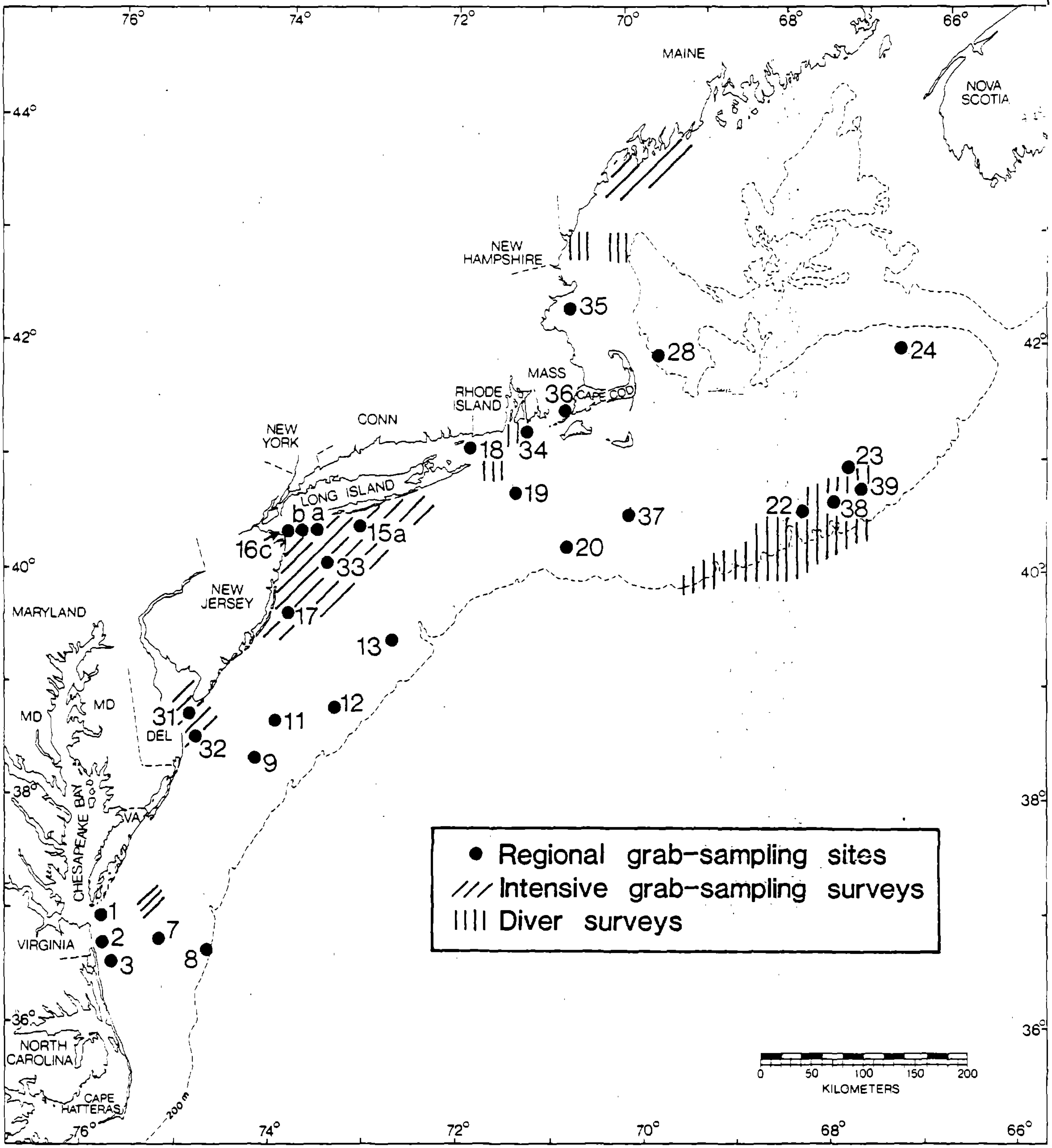

Figure 18. Sampling locations for benthic macrofauna.

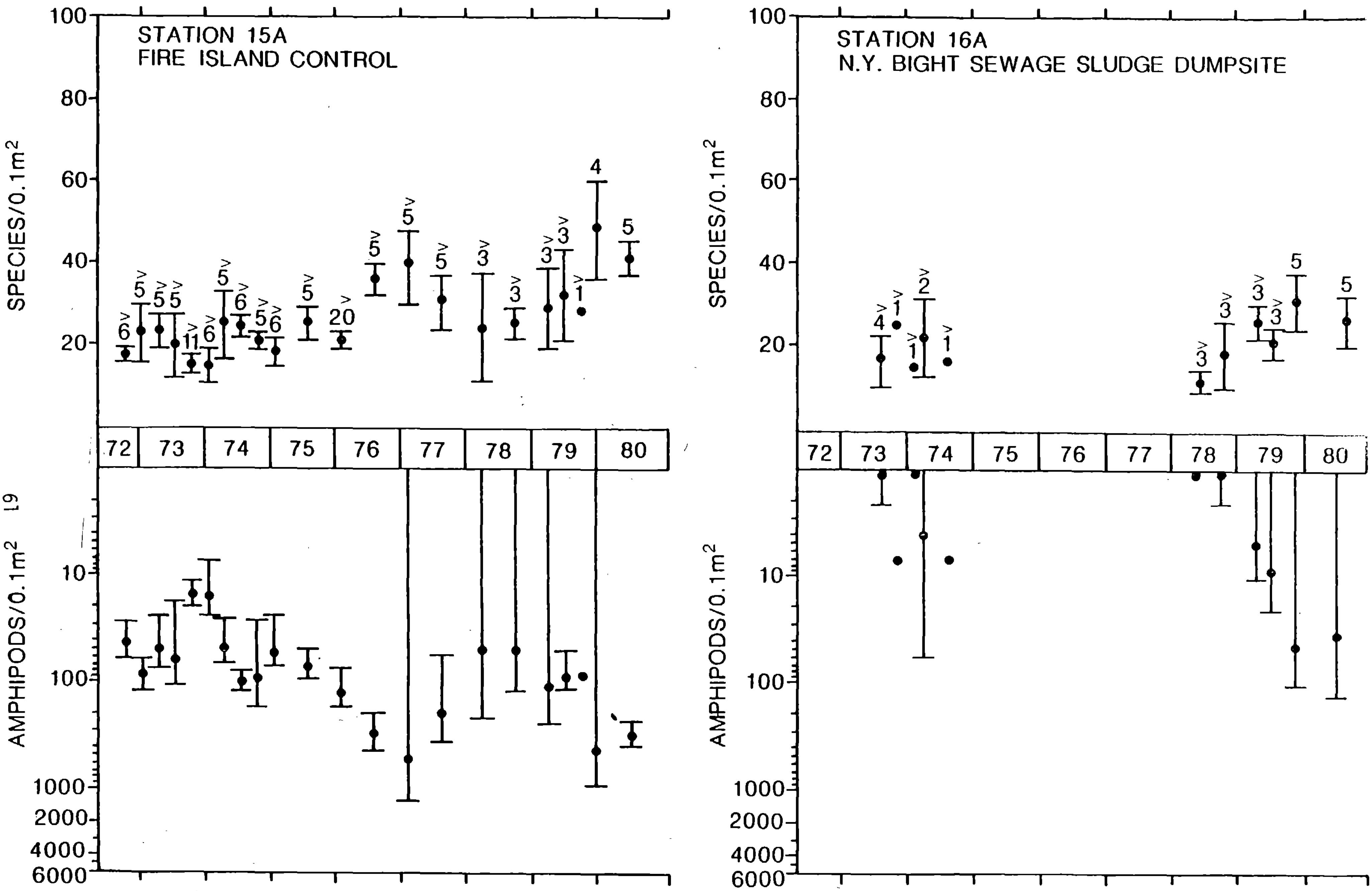

Figure 19. Means and 95% confidence limits for numbers of benthic macrofaunal species and amphipods at four New York Bight sites, 1972-1980. The number of replicates used are indicated above the ranges presented for species.

sludge accumulation area and since 1972 at a reference station off mid-Long Island.

Stations 1, 2 and 3 (at the mouth of Chesapeake Bay and 9 and 37 km to the south under the plume from the Bay) showed high similarity of species composition, and dominance by some of the same stress-tolerant species found in the inner New York Bight. This finding suggests that plume effects may be present and fairly similar for at least several km south from the Bay mouth. In the Baltimore Canyon Trough (station 13), numbers of species and numbers of the amphipod *Ampelisca agassizi* reached low values in July 1980 (although preliminary data indicate the *A. agassizi* population increasing again by December 1980), and cluster analysis revealed a unidirectional shift in species composition between 1978 and 1980. Though data interpretation does not point to new or increased environmental problems at station 13, information from other NEMP studies is being examined for similar patterns at these sites, as well as in the Chesapeake plume. No major trends in species richness, species composition or amphipod densities were seen at any other station.

Grab samples from 56 sites in Casco Bay, Maine were analyzed to describe benthic conditions and select monitoring sites for that area. Parts of the inner Bay, including Portland Harbor and the Fore River estuary, show clearly altered benthic communities associated with high levels of organic and inorganic contaminants in sediments (See Section 3.2). The benthos of the outer Bay displays no overt signs of stress.

The hard substrates monitored by divers at the inshore Isles of Shoals and offshore Jeffreys Ledge sites, in the western Gulf of Maine, are presently characterized by relatively pristine faunas (Hulbert et al. 1982). At both sites, there are large differences between the faunas of vertical and horizontal rock surfaces. The vertical surfaces are dominated by sponges, tunicates and brachiopods, while algae and worm tubes often cover most of the horizontal surfaces. A number of species have been identified whose size, abundance and feeding habits make them promising as indicators of contaminant fates and effects. Once *in situ* study areas such as these are established, photographic techniques permit rapid, inexpensive and nondestructive monitoring of a given fauna over time. In New England, it has been generally noted that sea urchin populations are increasing in many portions of the Gulf of Maine. This is perhaps due in part to overfishing of their predators, changes in recruitment, or variation in their food supply. Larger urchin populations can be expected to reduce macroalgae cover through grazing, which would lead to other ecosystem changes including further declines in lobster populations. This sequence has been documented for eastern Canadian waters (Wharton and Mann 1981). The Canadian urchin populations are now apparently being reduced by disease, so a natural control of the problem may be present. Nevertheless, the fluctuations could prove highly significant to the fishing industry, and should be monitored.

Manned submersibles are used for most *in situ* monitoring in the deep waters of southern Georges Bank and two adjacent submarine canyons, Lydonia and Oceanographer. The ocean floor environments and associated megabenthic fauna of these areas also appear unaltered, based on submersible observations, quantitative photography, and *in situ* collections of sediments and animal samples from within and downstream of oil and gas exploration areas. Special emphasis has been placed on the canyons because of the potential impact of oil and gas drilling operations on their unique habitats and abundant megabenthic fauna. It has been hypothesized that submarine canyons function as conduits for bottom currents and sinks for contaminants entrained in bottom waters.

Of the 30 or more megabenthic species that inhabit the Georges Bank canyons to depths of 350 meters, there are ten that represent likely candidates for long-term monitoring as key indicator species of possible impact from gas and oil operations. (Examples of the species and habitats monitored using submersibles are shown on the inside front and back covers of this report.) The population levels of these species appear to be relatively constant from 1980 to 1981 (summer assessments), with no evidence of population shifts, or habitat or behavioral changes.

At three stations arranged along a gradient in the Delaware Bay plume, the standard macrofauna community structure surveys are supplemented by a two year pilot study of secondary production of dominant benthic macrofauna. Such studies have been rare, and are necessary to assess better subtle impacts of pollution and understand links between forage species and production of fish and shellfish of interest to man. The first year estimates for annual production of all dominants are: station 29 (just inside the Bay mouth), 13.9 gC m^{-2} y^{-1}; station 31, (9 km south of Bay mouth), 20.6 gC m^{-2} y^{-1}; and station 32 (37 km south of Bay mouth), 3.8 gC $m^{-2}y^{-1}$. These estimates of production are within the range of secondary production estimates for other estuarine systems in the North Atlantic, 3.3 - 48.8 gC $m^{-2}y^{-1}$ (Steimle in prep.).

At the Philadelphia sewage sludge dumpsite (very near station 9 in Figure 18) surveys of sludge impacts have been conducted since 1973. The area's predominantly sandy sediments have a ridge and swale (hill and valley) topography. Impacts to the benthic macrofauna have been identified in a swale 5-10 km south of the dumpsite. The impacts were much less than those seen around the New York Bight sludge dumpsite; they centered on reductions in populations of the pollution-sensitive ampeliscid amphipods. Disposal at this site ended in November 1980, so continued monitoring affords a unique opportunity to measure benthic recovery rates at a former ocean sludge disposal site.

Three years of quarterly grab sampling data are now available for the macrobenthos of an area ~31 km east of the mouth of Chesapeake Bay where dumping of dredged material from the Norfolk area is planned. Seasonal benchmark densities have been established for species characteristic of various portions of the dumpsite to enable detection of any future impacts. The infauna comprise a highly diverse community typical of undisturbed areas on the Middle Atlantic inner shelf. Fairly high spatial-temporal variability has been found. The disposal site does not support any populations of commercially important benthic invertebrates.

3.3.2.2 Seabed Oxygen Consumption

Oxygen uptake by the seabed includes that which is chemically utilized by sediments as well as consumption by benthic microflora, and the meio-, and macrofauna. Seabed oxygen consumption (SOC) has been used to indicate the oxidation of organic matter and effects of contaminants and organic pollution on the benthic communities of the northeast continental shelf and associated estuaries. Seabed oxygen consumption measurements thus provide a link between the above data on sediment quality and the more specific studies on effects of that quality on individuals, populations and communities. For SOC analysis, the shelf has been divided into several strata based on depth, sediment type and geographical location (Figure 20).

Seabed oxygen consumption values for 1981 were similar to those of previous years in both magnitude and variability. Overall general trends (Figure 21) were: 1) higher rates in the coastal and inshore than the offshore strata, attributable to high, naturally fluctuating inputs of carbon from estuaries such as Chesapeake, Delaware, Raritan, Narragansett, and Buzzards Bays; and 2) larger seasonal changes inshore, because of the greater seasonal temperature differences in the bottom waters of the shallower strata.

The literature and experimental evidence indicate that elevated SOC rates reflect increased organic loading, but the nature and amount of the organic material the sediments receive will determine the magnitude of the rates. The SOC rates of the coastal and inshore strata receiving substantial inputs of carbon are of the same magnitude as those rates obtained from similar sediments in the Baltic Sea, which also receives large inputs of organic material. The sediments of the offshore strata, Georges Bank and the Gulf of Maine maintain SOC rates more comparable to those of other relatively pristine areas, e.g. S.E. Bering Sea, which was sampled cooperatively this year with researchers from Brookhaven National Laboratory.

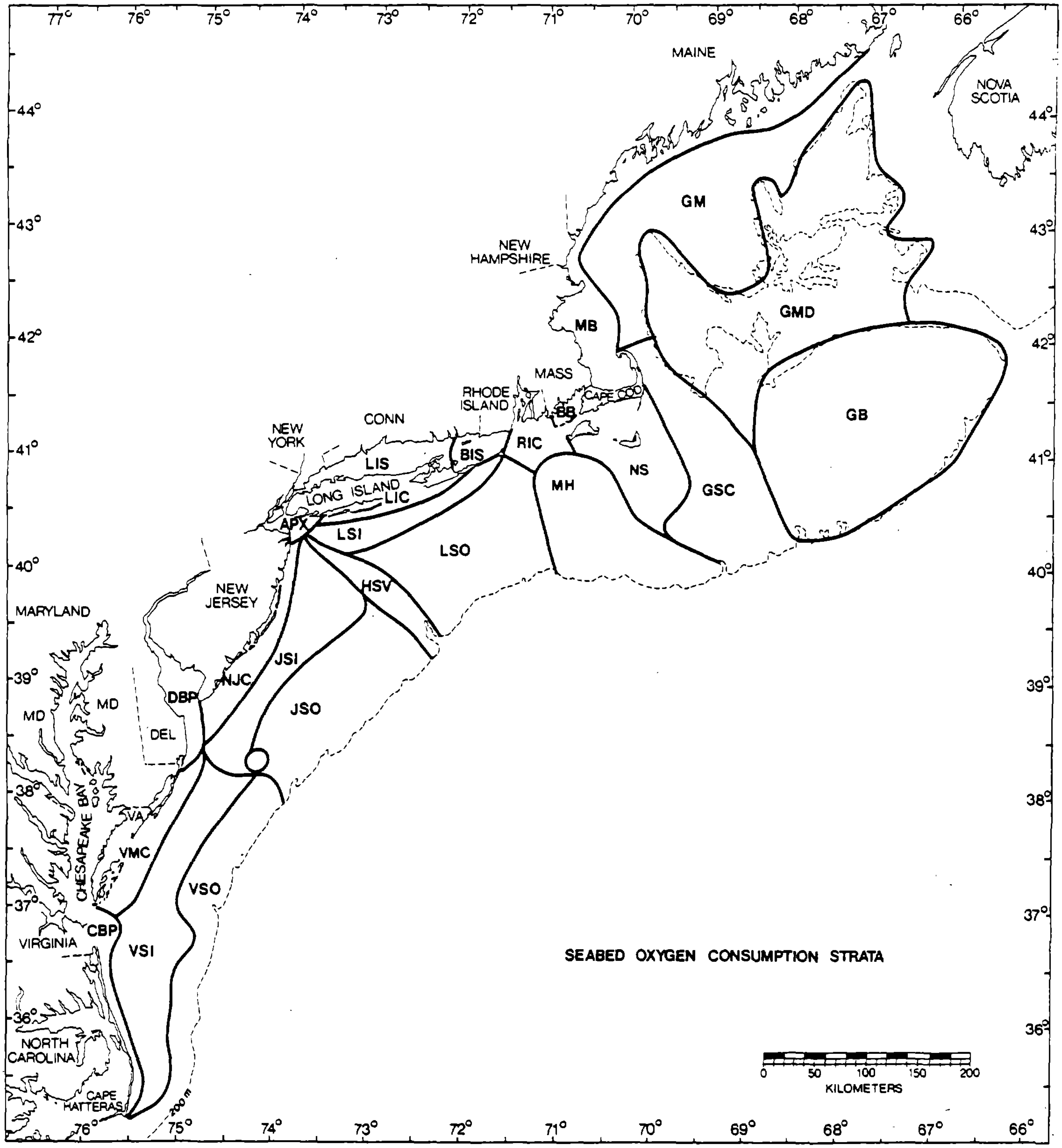

Figure 20. Seabed oxygen consumption (SOC) strata, based on distribution of similar rates.

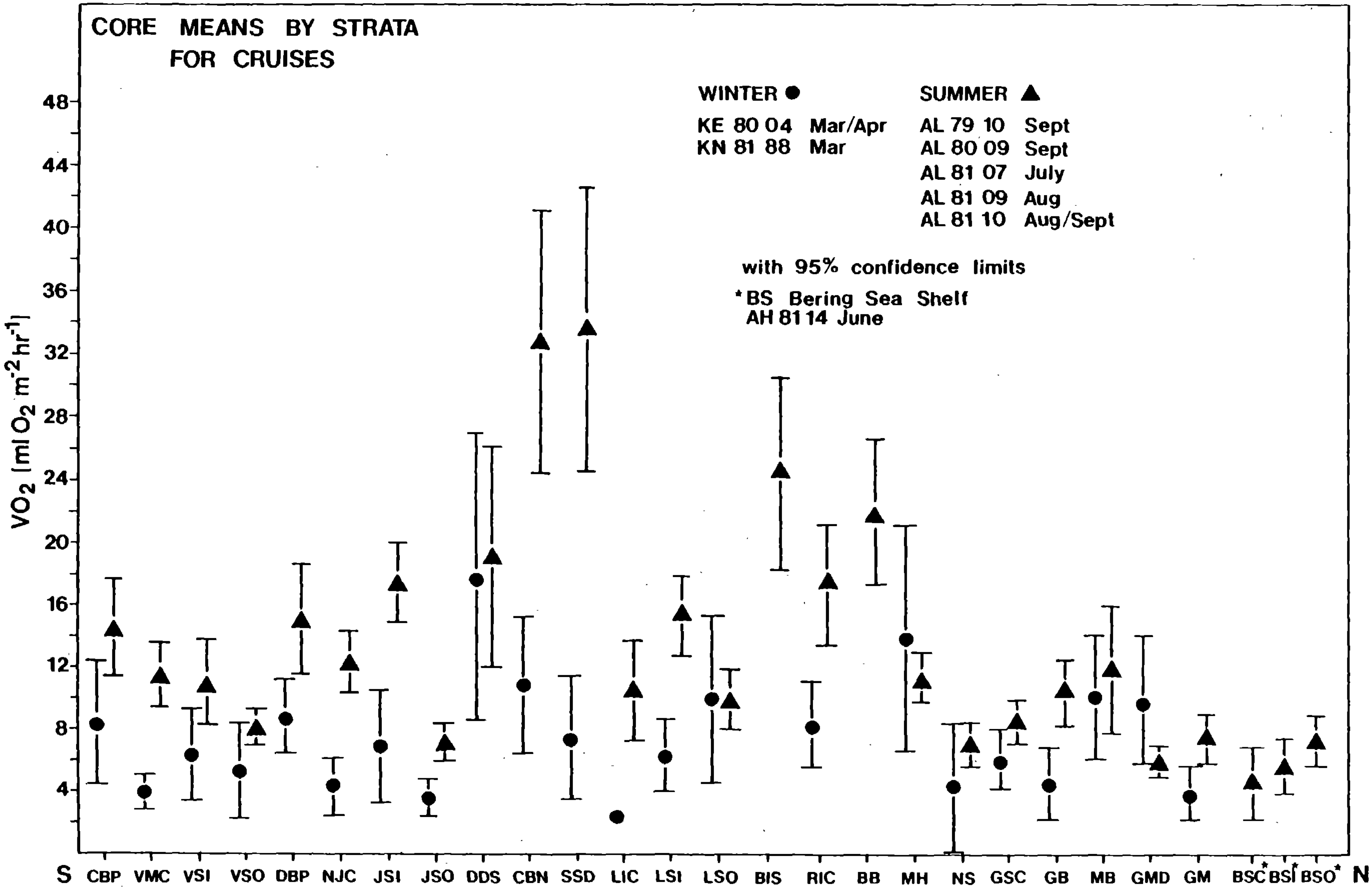

Figure 21. Spacial and temporal trends in seabed oxygen consumption rates.

4.0 RESULTS SUMMARIZED BY WATER MANAGEMENT UNITS (WMU)

This section discusses results compiled for the five WMU on the continental shelf (Figure 1) defined on the basis of similarity of oceanographic influences and biological communities:

4.1 Coastal Gulf of Maine

High concentrations of phytoplankton biomass (2 to 4 mg Chl*a* m^{-3}) have been observed in coastal waters near Cape Cod Bay, Massachusetts Bay, Cape Elizabeth, Penobscot Bay and the southwest coast of Nova Scotia. High phytoplankton cell concentrations have also been observed in the nearshore waters.

Sediments at two monitored sites in this WMU (Casco and Massachusetts Bay) were found to be moderately to highly contaminated. In Massachusetts Bay, relatively high concentrations of chromium, zinc and PAH were detected, with moderate concentrations of PCB's, although higher concentrations are known from Boston Harbor (New England Aquarium 1976). In Casco Bay, especially Portland Harbor, most of the measured trace metals and PAHs were present in relatively high concentrations. PCB's were detectable only at very low levels at one station.

A comparison of trace metal levels at other coastal Gulf of Maine and coastal southern New England areas (Table 14) suggested that three estuaries, Machias Bay, Cape Rosier and the Seabrook River estuary, show little increase in trace metal concentrations over the past decades and are probably representative of pre-industrial levels. Two other estuaries, the Saco and Kennebec, exhibit contaminant enrichment due to industrial and/or sewage inputs.

Elsewhere in this WMU, high fecal coliform MPN counts were detected south of the mouth of the Merrimac River, MA with moderate counts off Cape Cod's Race Point. *Acanthomoebae* were also detected at the Race Point station.

Biological effects monitoring has found that yellowtail flounder collected near the mouth of the Merrimac River, MA had very low blood hematocrits, evidence of physiological stress. There were also elevated levels of copper detected in oysters from the Piscataqua River, NH. Increases in sea urchin populations are reducing macroalgae cover in many areas, with possible deleterious effects on lobsters and other ecosystem components. A natural control of the urchins by disease may now be taking effect, however. Parts of inner Casco Bay, but not the outer Bay or the Isles of Shoals, show anthropogenic stresses. Seabed oxygen consumption rates were similar here to other coastal areas, except New York Bight.

4.2 Gulf of Maine

The center of the Gulf of Maine is an area of one of the lowest chlorophyll biomass concentrations and primary productivity rates on the

Table 14. Comparison of trace metal levels in sediments at several New England locations.

Site	Cd $\bar{x}$	Cd range	Cd S.D.	Cr $\bar{x}$	Cr range	Cr S.D.	Cu $\bar{x}$	Cu range	Cu S.D.
Casco Bay (this study)	0.47	0-0.90	0.23	34.5	5.8-55.0	13.4	15.5	2.4-44.5	8.0
Kennebec River Estuary, ME (Lyons et al. in press)				29	-	-	33	-	-
Saco River Estuary, ME (Lyons et al. in press)				274	-	-	15	-	-
Penobscot Bay, ME (Lyons et al. in press)				18	-	-	9	-	-
Machias Bay, ME (Lyons et al. in press)				16	-	-	9	-	-
Seabrook River Estuary, NH (Lyons et al. in press)				19	-	-	7	-	-
Great Bay Estuary, NH (Armstrong et al. 1976)				142	9.6-594	112	16.4	2.9-129	14.8
Jeffreys Basin (Lyons and Gaudette 1979)				56.3	20.1-83.7	-	16.4	2.4-35.1	-
Mystic River Estuary, CT[2] (Lyons and Fitzgerald 1980)	0.41	-	-				4.4	-	-
Branford Harbor, CT[2] (Lyons and Fitzgerald 1980)	1.16	-	-				34.5	-	-
Eastern Long Island Sound[3] (Greig et al. 1977)	2.7	-	1.0	57.7	-	56.7	20.0	-	26.4

Table 14 (cont.)

Site	Ni $\bar{x}$	Ni range	Ni S.D.	Pb $\bar{x}$	Pb range	Pb S.D.	Zn $\bar{x}$	Zn range	Zn S.D.
Casco Bay (this study)	17.6	4.5-32.0	6.7	26.8	9.0-61.4	13.1	65.4	20.8-100.5	20.5
Kennebec River Estuary, ME (Lyons et al. in press)				33	-	-	64	-	-
Saco River Estuary, ME (Lyons et al. in press)				36	-	-	47	-	-
Penobscot Bay, ME (Lyons et al. in press)				12	-	-	32	-	-
Machias Bay, ME (Lyons et al. in press)				13	-	-	35	-	-
Seabrook River Estuary, NH (Lyons et al. in press)				9	-	-	29	-	-
Great Bay Estuary, NH (Armstrong et al. 1976)				40.7	0.80-145	22.1	60.6	13.4-212	28.5
Jeffreys Basin (Lyons and Gaudette 1979)				31.2	9.5-58.6	-	75.4	30.7-102.4	-
Mystic River Estuary, CT[2] (Lyons and Fitzgerald 1980)				14.5	-	-	56.5	-	-
Branford Harbor, CT[2] (Lyons and Fitzgerald 1980)				265	-	-	54.5	-	-
Eastern Long Island Sound[3] (Greig et al. 1977)	7.6	-	6.6	16.2	-	14.5	48.0	-	43.7

[1] top centimeter; [2] top 4 centimeters; [3] stations 72-143

northeast shelf. A patchy distribution of phytoplankton cell concentration, with scattered areas of high concentrations, characterized the region.

A recent study by Lyons and Gaudette (1979) investigated trace metal concentrations in Jeffreys Basin, a fine-grain depositional area off the coast of southern Maine and New Hampshire. They concluded that the relatively high levels found there are the results of sediments (silty) exported from adjacent estuaries.

A population of sea scallops was found in the central Gulf of Maine which is thought to be stressed because of limited food supplies (primary production) in the area. The fauna of Jeffreys Ledge and of a single grab-sampled station in the southern Gulf of Maine appears normal. Seabed oxygen consumption rates here are among the lowest measured, suggesting that input and utilization of labile carbon is slow.

4.3 Georges Bank

The shallower regions of the Bank (<60m) are areas of high phytoplankton biomass and cell concentrations, with primary productivity rates among the highest in the ocean (470 gC m^{-2} y^{-1}). This production has been attributed partly to extensive mixing over the Bank and the possible supply of nutrients from deeper waters on both sides of the Bank (Maurer 1982). As a result of this mixing, netplankton plays a larger role in photosynthesis in the shallow water of Georges Bank than in any of the other regions studied.

Benthic sampling on the Bank has generally indicated an uncontaminated environment, except Lydonia Canyon, where trace levels of PAHs, PCB's and coprostanol were detected. The PCB/coprostanol ratio suggests sewage contamination as a source, although this must be examined further. The depositional "Mud Patch", south of Martha's Vineyard at the western edge of the Georges Bank WMU, as presently defined, contained sediments that had relatively high concentrations of silver, nickel, lead, zinc, cadmium and Clostridium spores. Moderate concentrations of PAHs and PCB's were found, but there was much variability and coprostanol levels were low. Overall this sampling supports the suggestion that the "Mud Patch" is a pollutant depositional area. A review report of Georges Bank benthic environment was recently prepared (Maurer 1982) and provides an extensive summary of earlier sediment quality work in this area.

Some sea scallops that exhibited incipient stress were collected at a site on south-central Georges Bank. PCB's were generally undetectable in several species of fin- and shellfish; however in a special study, levels in adult haddock, although low, were 2-3 times levels in young haddock. Trace metal tissue burdens were low and apparently stable since 1980.

Neither grab sampling nor *in situ* monitoring have revealed any significant trends in community structure that may be related to anthropogenic or natural alteration. Seabed oxygen consumption rates were also relatively low here.

4.4 Middle Atlantic Continental Shelf

Chlorophyll biomass concentrations over the shelf were generally intermediate between the highs of the coastal waters and the lows of the shelf-slope front. Mid-shelf regions (Delaware to Virginia and off Long Island) and the shelf-slope front from Georges Bank to Cape Hatteras were among the least productive regions of the study area. Nannoplankton were the main contributors to the annual primary production of the shelf.

Generally, the quality of the sediments in this WMU were good, with two exceptions: the central Hudson Shelf Valley (HSV) and the former Philadelphia dumpsite. In the central HSV, down valley from the New York Bight apex, discussed in the following WMU, relatively high concentrations of chromium, lead and zinc were found in sediments. Moderate concentrations of PCB and fecal coliforms were also present, as were *Acanthomoebae*. A gradient of *Clostridium* spore counts down the valley suggests a movement of sewage derived material into deeper waters. Traces of coprostanol were also detected. Sediments from the former Philadelphia dumpsite, unused since 1980, still contained moderate levels of fecal coliforms, *Clostridium* spores, and several trace metals. *Acanthomoebae* were detected, as were human pathogenic viruses. PCB and coprostanol concentrations were low with the PCB/coprostanol ratio indicating a sewage origin.

Stressed populations of sea scallops were found in the "Mud Patch" areas south of Martha's Vineyard as well as at a site south of the head of the Hudson Canyon in the outer continental shelf, near exploratory oil and gas drilling, although a cause and effect relationship cannot be proven. Cuticular melanization was observed in 18% of the mud shrimp *Crangon septemspinosa* collected in the New York Bight. *Crangon* from the former Philadelphia dumpsite off Delaware also showed evidence of pathological melanization. Samples of this species collected near Chincoteaque, VA, a clean control area, did not have any indication of cuticular melanization. PCB's were detected in several species of fin- and shellfish, although well below the 5 ppm action level set by FDA.

Relatively small effects (reduction in populations of some ampeliscid amphipods) have been detected at the Philadelphia sewage sludge dumpsite. The proposed Norfolk dumpsite presently has a normal fauna, and no unnatural stresses have been seen at other monitoring sites located in this WMU. Seabed oxygen consumption rates were uniformly low to moderate over this entire area.

4.5 Coastal Middle Atlantic

The coastal areas generally have higher phytoplankton biomass and cell concentrations than other regions of the shelf. Concentration peaks were often localized at the mouths of estuaries, indicating nutrient enrichment from estuarine sources. Areas of highest ammonia concentrations were associated with the mouths of the Hudson-Raritan and Delaware Bay estuaries. Phytoplankton communities were characterized by small diatoms and ultraplankters (<10 µm). Rates of primary productivity were highest near estuary mouths, and approached the theoretical maximum sustainable daily production for nearshore eutrophic waters in the New York Bight apex. Although primary productivity rates are comparable to those of Georges Bank, ultra and nannoplankton-based food chains have more trophic transfers (and associated energy losses) than the netplankton grazing scheme of the Bank.

Higher bacterial counts were associated with coastal waters, particularly the water near the New York Bight sewage sludge dumpsite. Satellite imagery indicates that the Hudson-Raritan plume may occasionally extend beyond the dredge-spoil and sewage sludge dumpsites. No conditions of widespread hypoxia were observed off the coast of New Jersey during the present period of monitoring. Most of the nine areas monitored in this WMU contained moderately to highly contaminated sediments. Starting in the north, Buzzards Bay sediments were high in silver, chromium, copper, nickel and cadmium, with moderate concentrations of lead, zinc and PCB's. A station at the mouth of Narragansett Bay had moderate concentrations of chromium, lead, zinc and fecal coliforms, with *Acanthomoebae* present. Block Island Sound sediments, thought to be a clean area, contained moderate concentrations of chromium, lead, and zinc and fecal coliform MPN counts. The sediments off Fire Island were relatively uncontaminated, as was the area off Barnegat (the New York Bight apex will be discussed separately below). The sediments at the mouth of Delaware Bay had high fecal coliform MPN counts, with *Acanthomoebae* present, and moderate concentrations of chromium, lead and zinc. Sediments at the mouth of Chesapeake Bay were relatively clean, although the proposed dredge spoil site a short distance offshore had trace levels of several pesticides (including Kepone) and PAH.

The New York Bight apex continues to have the most contaminated sediments. High levels of silver, chromium, copper, lead, zinc, cadmium, mercury, PCB's, coprostanol and PAH and high fecal coliform MPN counts were found in the Christiaensen Basin of the apex, with moderate levels of nickel. Enterovirus was found at approximately 18% of the stations examined in the inner New York Bight, which includes the apex, in both the 1980 and 1981 surveys. *Clostridium perfringens* spore counts were high in the Christiaensen Basin and a gradient was observed along the Long Island coast and down the Hudson Shelf Valley, to approximately 70 km offshore.

Six blood constituents in windowpane flounder varied seasonally in Long Island Sound; four of these constituents varied significantly between fish collected in the polluted western end of the Sound compared to fish from the cleaner eastern end. Chromosomal mutation the frequencies in the blood erythrocytes of windowpane flounder were also elevated only in western Long Island Sound, up to three times frequencies found at other sites in the eastern Sound or sites outside of the Sound. Erythrocytes of larval red hake displayed higher evidence of mutation in a cluster of New York Bight sites in the apex. Blood from flounder collected in coastal New York Bight waters showed high incidences of enhanced fragility of red blood cells (up to 25% of the fish at some sites). Metabolic changes in the blue mussel were noted along a pollution gradient in Narragansett Bay. There was evidence of increased copper accumulation and stress effects in oysters collected from Delaware, Raritan and Buzzards Bays. In the upper Hudson Shelf Valley, below the dredge spoil and sewage sludge dumpsites, 30% of the rock crab *Cancer irroratus* displayed gill blackening, elsewhere the incidence was less than 4%. Polychaetes collected in the New York Bight apex had very high body burdens of PCB's (0.83 ppm, whole body-dry wt.); these levels are higher than those found in any other organisms from the area, except a whole female lobster (1.08 ppm). PAH body burden levels were higher in the Christiaensen Basin of the apex than other coastal or non-coastal areas. Generally, trace metal body burdens in several species of fin- and shellfish were highest in Long Island Sound, Christiaensen Basin and upper Hudson Shelf Valley of the New York Bight. Crustacea generally had higher contaminant levels than fish or scallops.

The inner New York Bight continues to exhibit the most acute and spatially extensive alterations of all the benthic systems monitored by NEMP. No other major changes are evident for the inner Bight over that period. The plume of Chesapeake Bay may be exerting subtle effects on the fauna to at least 37 km south of the Bay mouth. Impacts have not been detected off Narragansett Bay or Delaware Bay, or at the other coastal sites being monitored. Summer seabed oxygen consumption rates in the vicinity of the New York Bight apex sewage disposal area are the highest measured in the northeast. Rates under the Chesapeake and Delaware Bay effluent plumes and nearshore Virginia to Long Island are similar to rates further offshore. Slightly higher rates have been determined for Block Island Sound and Buzzards Bay.

5.0 FUTURE PLANS AND RECOMMENDATIONS

Most of the monitoring studies indicated previously have continued in 1982 and are planned for 1983. These include the broad scale biological effects surveys, the New York Bight water and sediment quality surveys, the Chesapeake Bay dredge spoil disposal site monitoring, and diver and submersible monitoring in New England waters. In 1982, increased effort is being directed toward implementing and/or expanding monitoring studies in cooperation with other programs. The NEMP will have increased participation and cooperation on several types of Northeast Fisheries Center surveys: MARMAP I (plankton) and MARMAP II (ground fish and shellfish stock assessment). The Program's interaction with other agencies will increase, e.g. there are new cooperative efforts between NEMP and EPA Regions I, II and III in the New York Bight apex, in the areas of EPA's "mussel watch" program, and in water column and benthic quality assessment.

The EPA has also assisted NEMP in analyzing sediment and biota from the New York Bight for radionuclide levels. Several chemical analysis intercalibration exercises are also planned, or ongoing, between NEMP and EPA, Brookhaven National Laboratories and/or other research groups (national and international). Contaminant burden benchmarks are being developed for fishery resources; additional special samples of the ocean quahog and tilefish will be collected to supplement NEMP benchmarks for these species. In 1982 and beyond, NEMP activities in certain geographic areas, e.g. Buzzards and Massachusetts Bays, will be expanded in response to recent events or issues of public concern. Last year NEMP was requested to assist investigations in both of these areas by providing bathymetric and sidescan sonar data and sediment and biota samples from the Massachusetts foul grounds, where radioactive material had been dumped, and for current monitoring data for Buzzards Bay.

Table 15 lists most of the major cruise efforts planned to support the activities discussed above.

Table 15. A list of major cruises involving NEMP personnel in 1982.

Vessel	Dates	Chief Scientist or Project Representative	Activity
MT. MITCHELL S-D501-M-M1-82	18-19 Jan	Catherine Warsh NOS/OA	Chesapeake Bay Dredge[1] Spoil Dumpsite
ALBATROSS IV AL 82-01	25 Jan-12 Feb	Denise Hollomon NOS/OA, Sandy Hook	Biological Effects Survey[2]
ALBATROSS IV AL 82-02	16 Feb-25 Mar	John Sibunka NMFS, Sandy Hook	MARMAP-NEMP Coop.[3]
GLORIA MICHELLE	03-04 Mar 10 Mar	Richard Cooper NMFS, Woods Hole	Pigeon Hill and Southern New England Benthic Monitoring[4]
ALBATROSS IV AL 82-03	30 Mar-09 Apr	Denise Hollomon NOS/OA, Sandy Hook	Biological Effects Survey
LAIDLY	19-23 Apr	Michael Sagalow NOS/OA	Chesapeake Bay Dredge Spoil Dumpsite
CAPE HENLOPEN	19-26 Apr	Catherine Warsh NOS/OA	Water Quality Monitoring,[5] New York Bight
LAIDLY	17-19 May	Michael Sagalow NOS/OA	Chesapeake Bay Dredge Spoil Dumpsite
DELAWARE II DL 82-03	17 May-11 Jun	John Sibunka NMFS, Sandy Hook	MARMAP-NEMP Coop.
CAPE HENLOPEN	28 May-04 Jun	Catherine Warsh NOS/OA	Water Quality Monitoring, New York Bight
GLORIA MICHELLE	01-18 Jun	Richard Cooper NMFS, Woods Hole	Pigeon Hill and Southern New England Benthic Monitoring
ALBATROSS IV AL 82-06	02-10 Jun	Tom Azarovitz NMFS, Woods Hole	Scallop Survey - NEMP[6] Coop.
LAIDLY	28 Jun-02 Jul 19-21 Jul	Michael Sagalow NOS/OA	Chesapeake Bay Dredge Spoil Dumpsite
JOHNSON-SEALINK	10-22 Jul	Richard Cooper NMFS, Woods Hole	Submersible Monitoring[7] on Georges Bank

Table 15 (cont.)

Vessel	Dates	Chief Scientist or Project Representative	Activity
ALBATROSS IV AL 82-08	12 Jul-06 Aug	Tom Azarovitz NMFS, Woods Hole	Scallop Survey - NEMP Coop.
CAPE HENLOPEN	26 Jul-02 Aug	Catherine Warsh NOS/OA	Water and Sediment Quality Monitoring, New York Bight
LAIDLY	16-26 Aug	Michael Sagalow NOS/OA	Chesapeake Bay Dredge Spoil Dumpsite
LULU-ALVIN	23 Aug-01 Sep	Richard Cooper NMFS, Woods Hole	Submersible monitoring on Georges Bank and Continental Slope
ALBATROSS IV AL 82-10	23 Aug-04 Sep	Denise Hollomon NOS/OA, Sandy Hook	Biological Effects Survey
LAIDLY	07-09 Sep	Michael Sagalow NOS/OA	Chesapeake Bay Dredge Spoil Dumpsite
DELAWARE II DL 82-06	08-17 Sep	Robert Reid NOS/OA, Sandy Hook	New York Bight Benthic Survey
ALBATROSS IV AL 82-11	13 Sep-19 Oct	Tom Azarovitz NMFS, Woods Hole	Fall Bottom Trawl-MARMAP[8] NEMP Coop.
MT. MITCHELL	08-15 Sep	Catherine Warsh NOS/OA	Water Quality Monitoring, New York Bight
LAIDLY	04-08 Oct	Michael Sagalow NOS/OA	Chesapeake Bay Dredge Spoil Dumpsite
DELAWARE II	01-12 Nov	Marvin Grosslein NMFS, NOAA	Georges Bank Food Web studies
ALBATROSS IV AL 82-12	15 Nov-10 Dec	Denise Hollomon NOS/OA, Sandy Hook	Biological Effects Survey

[1] This survey type includes sediment and water column sampling as well as bioaccumulation and benthic community studies at the Chesapeake Bay dumpsite.

[2] This survey type generally includes benthic and trawl sampling as well as water column work at up to 80 sites from Cape Hatteras into the Gulf of Maine.

[3] This cooperative survey includes mostly water column sampling: hydrography, zooplankton, at approximately 290 sites on the continental shelf and slope from Cape Hatteras to Nova Scotia.

[4] This survey uses divers to conduct benthic community studies at Pigeon Hill, Block Island Sound and Brenton Reef.

[5] This survey monitors the hydrography and phytoplankton dynamics of the New York Bight to predict the threat of hypoxia.

[6] This cooperative effort involves examining scallop and yellowtail flounder samples for biological effects.

[7] This survey includes benthic community monitoring by submersibles at selected sites on Georges Bank and the continental slope.

[8] This cooperative effort involves examining finfish for biological effects.

6.0 REFERENCES

Ackefors, H. and O. Lindahl. 1979. Primary phytoplankton production in the Baltic proper, 1973-1976, in relation to secondary zooplankton production. ICES C.M. 1979/L:32. 13 pp.

Anderson, G.C. 1964. The seasonal geographic distribution of primary productivity off the Washington and Oregon coasts. Limnol. and Oceanogr. 9(3): 284-302.

Armstrong, P.B., E.M. Hanson and H.E. Gaudette. 1976. Minor elements in sediments of Great Bay Estuary, New Hampshire. Envir. Geol. 1:207-214.

Armstrong, R. 1979. Bottom oxygen and stratification in 1976 and previous years. In: NOAA Professional Paper 11, Eds. R.L. Swanson and C.J. Sindermann, pp. 137-148.

Boehm, P.D. 1980a. Gulf and Atlantic Survey (GASI); Cape Hatteras to Gulf of Maine Survey for selected organic pollutants in finfish and benthic animals. Final Report, NOAA Contract NA-80-FAC-00046, NOAA, NMFS, NEFC Sandy Hook Lab., Highlands, N.J. 55 pp.

Boehm, P.D. 1980b. New York Bight sampling survey: coprostanol, polychlorinated biphenyl and polynuclear aromatic hydrocarbons measurements in sediments. Final report, NOAA Contract NA-80-FAC-00038. NOAA, NMFS, NEFC Sandy Hook Lab., Highlands, N.J. 20 pp.

Boehm, P.D. 1981a. Petroleum in the marine environment - physical/chemical methods; Background paper for the National Academy of Sciences update of <u>Petroleum in the Marine Environment</u> (in press).

Boehm, P.D. 1981b. Investigations on pollutant organic chemical fluxes in the Hudson-Raritan estuarine and New York Bight coastal systems. Final Report, Grant No. NA-80-AAD-00062, NOAA/OMPA, Rockville Md.

Boehm, P.D. 1982. Investigations on estuarine/continental shelf and benthic/water column coupling of organic pollutant-bearing water column particulates in the New York Bight Region. Canadian Journal of Fisheries and Aquatic Sciences (in press).

Boehm, P.D. and D.L. Fiest. 1980. Ocean dumping of dredge material - organo-geochemical studies. In: Proceedings, Second International Ocean Dumping Symposium, April 15-18, 1980. Woods Hole, Ma. 20 pp.

Boehm, P.D., D.L. Fiest, and A. Elskus. 1981. Comparative weathering patterns of hydrocarbons from the Amoco Cadiz oil spill observed at a variety of coastal environments. In: Proceedings, Amoco Cadiz: Fate and Effects of the Oil Spill, 19-22 November, 1979, Centre Nationale pour l'Exploration des Oceans, COB, Brest, France.

Bopp, R.F., H.J. Simpson, C.R. Olsen, and N. Kostyk. 1981. Polychlorinated biphenyls in sediment of the tidal Hudson River, New York. Envir. Sci. Technol. 15:210-216.

Durbin, A.G. and E.G. Durbin. 1975. Grazing rates of the Atlantic menhaden Brevoortia tyrannus as a function of particle size and concentration. Mar. Biol. 33:265-277.

Eppley, R.W., P. Koeller and G.T. Wallace, Jr. 1978. Stirring influences the phytoplankton species composition within enclosed columns of coastal sea water. J. exp. mar. Biol. Ecol. 32:219-239.

Greig, R.A., R.N. Reid and D.R. Wenzloff. 1977. Trace metal concentrations in sediments from Long Island Sound. Mar. Poll. Bull. 8:183-188.

Haines, E.B. and W.M. Dunstan. 1975. The distribution and relation of particulate organic material and primary productivity in the Georgia Bight, 1973-1974. Estuar. and Coast. Mar. Sci. 3:431-441.

Hogetsu, K. 1979. Biological productivity of some coastal regions of Japan. In Marine Production Mechanisms, M.J. Dunbar (ed). Cambridge Univ. Press. 338 pp.

Hulbert, A.W., K.J. Pecci, J.D. Witman, L.G. Harris, J.R. Sears, and R.A. Cooper (1982). Ecosystem definition and community structure of the macrobenthos of the NEMP monitoring station at Pigeon Hill in the Gulf of Maine. NOAA Tech. Memo. NMFS-F/NEC14. 143 pp.

Ingham, M.C. [ed.], R.S. Armstrong, J.L. Chamberlin, S.K. Cook, D.G. Mountain, R.J. Schlirz, J.P. Thomas, J.J. Bisagni, J.F. Paul, and C.E. Warsh. 1982. Summary of the physical oceanographic processes and features pertinent to pollution distribution in the coastal and offshore waters of the Northeastern United States, Virginia to Maine. NEMP Oceanography Summary Report, November 10, 1982.

Lyons, W.B., P.B. Armstrong and H.E. Gaudette (in press). Sedimentary trace metal concentrations in northern New England estuaries. Sea Grant Publication, U.N.H. Durham, N.H. 14 pp.

Lyons, W.B. and W.F. Fitzgerald. 1980. Trace metal fluxes to nearshore Long Island Sound sediment. Mar. Poll. Bull. 11:157-161.

Lyons, W.B. and H.E. Gaudette. 1979. Sediment geochemistry of Jeffreys Basin, Gulf of Maine: inferred transport of trace metals. Oceanologica Acta 2:477-481.

MacLeod, W.D., L.S. Ramos, A.J. Friedman, D.G. Burrows, P.G. Prohaska, D.L. Fisher, and D.W. Brown. 1981. Analysis of residual chlorinated hydrocarbons, aromatic hydrocarbons and related compounds in selected sources, sinks and biota of New York Bight. NOAA Tech. Mem. OMPA-6.

Malone, T.C. 1971. The relative importance of nannoplankton and netplankton as primary producers in tropical oceanic and neritic phytoplankton communities. Limnol. and Oceanogr. 16(4):633-639.

Malone, T.C. and M. Chervin. 1979. The production and fate of phytoplankton size fractions in the plume of the Hudson River, New York Bight. Limnol. and Oceanogr. 24:683-696.

Mandelli, E.F., P.R. Burkholder, T.E. Doheny and R. Brody. 1970. Studies of primary productivity in coastal waters of southern Long Island, New York. Mar. Biol. 7:153-160.

Marshall, H.G. 1976. Phytoplankton distribution along the eastern coast of the USA I. Phytoplankton Composition. Mar. Biol. 38:81-89.

Marshall, H.G. 1978. Phytoplankton distribution along the eastern coast of the USA II. Seasonal assemblages north of Cape Hatteras, North Carolina. Mar. Biol. 45:203-208.

Maurer, D. 1982. Review of benthic invertebrates of Georges Bank in relation to gas and oil exploration with emphasis on management implications. Report to: NOAA, NMFS, NEFC, Woods Hole, Ma. 329 pp.

Mills, E.L. and R.O. Fournier. 1979. Fish production and the marine ecosystem of the Scotian shelf, eastern Canada. Mar. Biol. 54:101-108.

Munk, W.H. and G.A. Riley, 1952. Absorption of nutrients by aquatic plants. J. Mar. Res. 11(2):215-240.

Murray, A.J. 1979. Metals, organochlorine pesticides and PCB residue levels in fish and shellfish landed in England and Wales during 1974. Ministry of Agriculture, Fisheries and Food, England Aquatic Environment Monitoring Report No. 2., 11 pp. and appendices.

NEMP. 1981, Annual NEMP Report on the Health of the Northeastern Coastal Waters of the United States, 1980. NOAA Tech. Memo. NMFS-F/NEC-10. 79 pp. and appendices.

New England Aquarium. 1976. Distribution of polluted materials in Massachusetts Bay. Final report for Commonwealth of Massachusetts, Division of Water Pollution Control. New England Aquarium Corp., Boston, MA. 173 pp.

Quasim, S.Z. 1979. Primary productivity in some tropical environments. In: Marine Production Mechanisms, M.J. Dunbar (ed). Cambridge, Univ. Press. 338 pp.

Ryther, J.H. and C.S. Yentsch. 1958. Primary production of continental shelf waters off New York. Limnol. and Oceanogr. 3(3):327-414.

Sayler, G.S., R. Thomas, R.R. Colwell. 1978. Polychlorinated biphenyl (PCB) degrading bacteria and PCB in estuarine and marine environments. Estuar. Coast. Mar. Sci. 6, 553-567.

Smayda, T.J. 1970. The suspension and sinking of phytoplankton in the sea. Oceanogr. Mar. Biol. Annu. Rev. 8:353-414.

Steele, J.H. 1974. The Structure of Marine Ecosystems. Harvard Univ. Press. Cambridge, Ma. 128 pp.

Steeman-Nielsen, E. and E.A. Jensen. 1957. Primary oceanic production. The autotrophic production of organic matter in the ocean. Galathea Report Vol. 1. Copenhagen. 135 pp.

Steimle, F.W. Jr. Benthic production (meio-, macro- and mega fauna). Section 9.2, In: Georges Bank. MIT Press. (In preparation).

Steimle, F.W. Jr., J.V. Caracciola and J.B. Pearce. 1982. Impact of dumping on New York Bight apex benthos. In: Ecological Stress in the New York Bight: Science and Management. Est. Res. Soc.

Takahashi, M. and T.R. Parsons. 1972. Maximazation of the standing stock and primary productivity of marine phytoplankton under natural conditions. Indian J. Mar. Sci. 1:61-62.

Thomas, J.P. 1966. Influence of the Altamaha River on primary production beyond the mouth of the river. Masters Thesis, Univ. Georgia. Athens, GA. 46 pp.

U.S. Environmental Protection Agency. 1976. Review of PCB levels in the environment. Report No. EPA-560/7-76-001. Washington, D.C.: U.S. Environmental Protection Agency.

Walsh, J.J. 1981. Shelf-Sea Ecosystems, Chapter 6. In: A.R. Longhurst, (ed). Analysis of Marine Ecosystems, Academic Press, pp. 159-196.

West, R.H., and P.G. Hatcher. 1980. Polychlorinated biphenyls in sewage sludge and sediments of the New York bight. Mar. Poll. Bull. 11:126-129.

Wharton, W.G. and K.H. Mann. 1981. Relationship between destructive grazing by the sea urchin Strongylocentrotus droebachiensis and the abundance of American lobster Homarus americanus on the Atlantic Coast of Nova Scotia. Can. J. Fish. Aquat. Sci. 38:1339-1349.

Windsor, J.G. Jr., and Hites, R.A. 1979. Polycyclic aromatic hydrocarbons in Gulf of Maine sediments and Nova Scotia soils; Geochimica et Cosmochimica Acta 43:27-33.

Wulff, F. 1979. The effects of sampling frequency on estimates of the annual pelagic primary production in the Baltic. In: Cyclic Phenomena in Marine Plants and Animals, E. Naylor (ed). Pergamon Press. Oxford.

Young, D.R., D. McDermott-Ehrlich, and T.C. Heesen. 1977. Sediments as a source of DDT and PCB. Mar. Poll. Bull. 8:254-257.

Youngblood, W.W., and M. Blumer. 1975. Polycyclic aromatic hydrocarbons in the environment: homologous series in soils and recent marine sediments. Geochimica et Cosmochimica Acta 39:1303-1314.

7.0 APPENDIX

List of NEMP contributors to 1981 Annual Report by section and area of contribution, with addresses and phone numbers for further information.

I. Executive Summary and Introduction

Dr. John B. Pearce - NOAA, NMFS, NEFC, Highlands, NJ 07732 (201-872-0200, FTS 342-8206) - overall management

Frank Steimle - NOAA, NMFS, NEFC, Highlands, NJ 07732 (201-872-0200, FTS 342-8259) - overall management and coordination

Millington Lockwood - NOAA, NOS, OAS/C2x7, Rockville, MD 20852 (301-443-8241, FTS 443-8241) - overall management

Harold Stanford - NOAA, OMPA, Northeast Office, SUNY, Stony Brook, NY 11794 (516-751-7002, FTS 667-1805) - overall management

LTJG Denise Hollomon - NOAA, NOS, Highlands, NJ 07732 (201-872-0200, FTS 342-8278) - logistics, operations and field survey coordination.

II. Results

Water Quality

LTJG Denise Hollomon - see above - compilation and editing

Dr. R.W. Alden, III - Old Dominion University, Norfolk, VA 23508 (804-440-4196) - Chesapeake dredge spoil disposal site studies

Myra Cohn - See J. Pearce above - (FTS 342-8356) - Phytoplankton communities

Andrew Draxler, Ruth Waldhauer, Albert Matte - see J. Pearce above - (FTS 342-8254) - Nutrient concentrations and distributions

Dr. John Graikoski - NOAA, NMFS, NEFC, Milford CT 06460 (203-878-2459, FTS 642-5238) - Bacteriology

Dr. John Mahoney - see J. Pearce above - (FTS 342-8255) - Algal assays

Dr. Harold Marshall - see R. Alden above - (804-440-3594) - Phytoplankton communities

Dr. John Munday, Michael Fedosh - Virginia Institute of Marine Science, Gloucester Pt., VA 23062 (804-642-2111) - Satellite imagery of estuarine plumes

John O'Reilly - see J. Pearce above (FTS 342-8251) - Primary productivity

Dr. James Thomas - see J. Pearce - above (FTS 342-8246) - Remote sensing

Fred Vukovich - Research Triangle Institute, Research Triangle Park, NC 27709 (919-541-5813) - Coastal remote sensing

Catherine Warsh - see M. Lockwood - above - Mid-Atlantic Bight water quality monitoring

Dr. Terry Whitledge - Brookhaven National Laboratory, Upton, NY 11973 (516-282-2123, FTS 665-3100) - New York Bight phytoplankton dynamics

Christine Evans-Zetlin - see J. Pearce - above (FTS 342-8269) - Chlorophyll biomass.

Sediment Quality

Frank Steimle - see above - compilation and editing

Dr. Richard Cooper - NOAA, NMFS, NEFC, Woods Hole, MA 02543 (617-548-5123, FTS 840-1272) - Sediment quality on Georges Bank and Gulf of Maine

Dr. Donald Gadbois - NOAA, NMFS, NEFC, Gloucester, MA 01930 (617-281-3600, FTS 837-9286) - Organic chemistry (PCB, PAHs, DDT)

Dr. John Graikoski - see above - Bacteriology

Dr. Peter Larsen - Bigelow Laboratory, West Boothbay Harbor, ME 04575 (207-633-2173) - Sediment quality in Casco Bay, ME

Dr. Thomas Sawyer - NOAA, NMFS, NEFC, Oxford, MD 21654 (301-226-5193) - Rock Crab pathobiology and Acanthoamoeba

Vincent Zdanowicz - see J. Pearce - above (FTS 342-8232) - Trace metal chemistry

Biological Effects

Dr. Harris White - see M. Lockwood above - compilation and editing

Dr. R.W. Alden III and D.M. Dauer - see R. Alden above - Chesapeake dredge spoil disposal site studies

Dr. Lawrence Buckley - NOAA, NMFS, NEFC, Narragansett, RI 02882 (401-789-9326, FTS 838-7142) - RNA/DNA ratios

Dr. Richard Cooper - see above - Diver and submersible surveys in Georges Bank Canyon heads

Edith Gould - see J. Graikoski above (FTS 642-5222) - Fish and shellfish biochemistry

Dr. Larry Harris - University of New Hampshire, Durham, NH 03824 (603-862-2100) - Diver surveys on Jeffreys Ledge in the Gulf of Maine

Stavros Howe and Wayne Leathem - University of Delaware, College of Marine Studies, Lewes, DE 19958 (302-645-4304) - Benthic studies near Delaware Bay

Dr. Alan Hulbert - see R. Cooper above - Diver surveys in the Gulf of Maine and Southern New England

Dr. Phyllis Johnson - see T. Sawyer above - Benthic crustacean pathobiology

Dr. Frederick Kern and C.A. Farley - see T. Sawyer above - Benthic shellfish pathobiology

Dr. Peter Larsen - see above - Casco Bay benthic communities

Dr. Donald Lear - U.S. EPA, 839 Bestgate Rd., Annapolis, MD 21401 (301-224-2740, FTS 922-3752) - Benthic monitoring at the Philadelphia dumpsite

Dr. Arlene Longwell - see J. Graikoski above (FTS 642-5207) - Genetics

Clyde Mackenzie - see J. Pearce above (FTS 342-8258) - Surf clam habitat preference and survival experiments

Sharon A. Maclean - see T. Sawyer above - Pelagic crustacean pathobiology

Drs. Robert Murchelano and Martin Newman - see T. Sawyer above - Finfish pathobiology

William Phoel - see J. Pearce above (FTS 342-8215) - Seabed oxygen consumption

Robert Reid - see J. Pearce above (FTS 342-8220) - Benthic invertebrates community structure

Dr. Joanne Stolen - see J. Pearce above (FTS 342-8257) - Fish immunocompetence

Dr. Frederick Thurberg and Margaret Dawson - see J. Graikoski above (FTS 642-5244/42) - Fish and shellfish physiology

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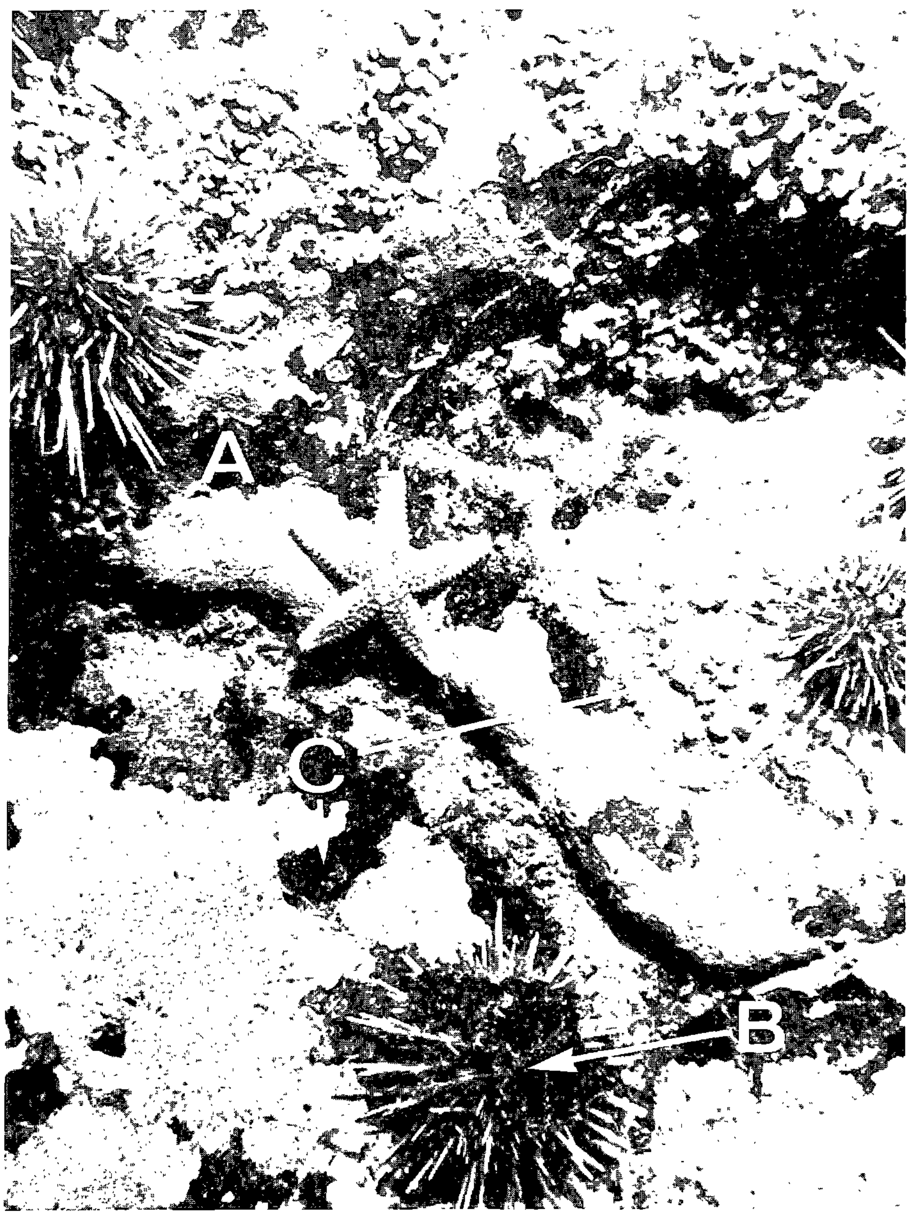

The above photograph (seen here in black and white) was taken by Dr. Alan Hulbert of the Northeast Fisheries Center's Woods Hole (Massachusetts) Laboratory with a Nikonos II 35-mm camera, 3.5:1 extension tube, and Kodachrome-64 film. It shows a section of the benthic community at 18 m at the Isles of Shoals station in the Gulf of Maine. It is typical of the hard-bottom habitats and communities between 18 and 40 m in the Gulf of Maine. (A=an asteroid, *Leptasterias* sp., a "key indicator species"; B=the northern sea urchin, *Strongylocentrotus droebachiensis;* and C=various crustose coralline algae.)

For more information on such habitats and communities, see the inside front cover, Section 3.3.2.1, and *NOAA Technical Memorandum NMFS-F/NEC-14*—"Ecosystem Definition and Community Structure of the Macrobenthos of the NEMP Monitoring Station at Pigeon Hill in the Gulf of Maine."

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