OFFICE OF MARINE POLLUTION ASSESSMENT

ANNUAL REPORT FY 1981

R. Lawrence Swanson, Director

January 1982

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

Office of Research and Development
Ferris Webster, Assistant Administrator

OFFICE OF MARINE POLLUTION ASSESSMENT

ANNUAL REPORT FY 1981

R. Lawrence Swanson, Director

Boulder, Colorado
January 1982

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Office of Marine Pollution Assessment

DISCLAIMER

Mention of a commercial company or product does not constitute an endorsement by National Oceanic and Atmospheric Administration. Use for publicity or advertising purposes of information from this publication concerning proprietary products or the tests of such products is not authorized.

Table of Contents

FIGURES

TABLES

I. EXECUTIVE SUMMARY

Background

The Office of Marine Pollution Assessment (OMPA) was established by NOAA's Assistant Administrator for Research and Development (RD) to (1) serve as a focal point within RD for all activities that are directly responsive and supportive of the National Ocean Pollution Planning Act, P.L. 95-273, and (2) to provide coordination within NOAA for the development and implementation of integrated marine pollution research, development, and monitoring programs in response to national needs and priorities identified in the five-year National Marine Pollution Program Plan. OMPA's primary goal is to provide scientific information that will guide public policy decisions on marine pollution issues. The purpose of providing scientific information will be to anticipate and to minimize the adverse consequences attributable to the various facets of ocean-use.

OMPA FY 1981 Activities and Accomplishments

The research summaries of OMPA's program follow the categories of concern developed in the Federal Plan for Ocean Pollution Research, Development, and Monitoring for FY 1981-85. These categories are: marine waste disposal, marine mining, marine energy, marine transportation, accidental discharge of oil and hazardous materials, coastal land-use, and ocean pollution assessment and management of cumulative effects.

A. Marine Waste Disposal

The management of wastes is a problem of growing importance. In addition to dredged sediments being routinely disposed of in the ocean, sewage sludge and toxic industrial wastes also have been dumped into the marine environment. The OMPA program on waste disposal research addressed the following issues:

a. determine the ways in which wastes are transported and transformed in marine systems,

b. evaluate the biological effects associated with specific waste components and waste disposal practices, and

c. develop strategies for managing marine waste disposal.

The objective of OMPA's waste disposal research is to obtain information upon which to base resource management decisions.

In FY 1981, OMPA examined the impact of industrial waste disposal at two deep-ocean dumpsites. The studies emphasized how the wastes disperse and change physically and chemically after dumping, and the effects of the wastes on selected marine organisms.

Two assessment reports were published summarizing technical results and analyzing overall dumping impact at (1) the 106-Mile Site and (2) a discontinued dumping site in the Western Gulf of Mexico. Both reports found that short-term impacts were transitory and minor, but that information is not available to determine the long-term impacts.

Another deep-ocean dumpsite studied was the Puerto Rico Site. (see Figure 5, page 14). The FY 1981 studies show that the wastes may not be swept away from the dumpsite as previously believed and may persist for days or weeks at measurable concentrations. The long-term consequences of chronic exposure to low waste concentration on reproductive potential are currently being investigated. Generally, dumping impact is most severe when the circulation is slow, marine populations are long-lived, and dumping takes place into a small region.

A 10-year study of man's impact on the New York Bight ecosystem was concluded in FY 1981. The main sources of contaminants to New York Bight waters (stormwater runoff, combined sewer overflow discharges, sewage treatment plant outfalls, industrial outfalls, and sewage sludge and dredged materials dumping) have two major health implications: (1) contamination of swimming waters and food organisms with pathogenic organisms and (2) the contamination of food organisms with toxic metals and organic compounds.

FY 1981 was a year of transition for work in Puget Sound; the focus decreased on field work and increased on identifying contaminants of concern and gaining understanding of their biological effects. The list of chemicals of concern in the Puget Sound region contains 17 substances or chemical groups (8 halogenated hydrocarbons, 2 nonhalogenated hydrocarbons, and 7 trace elements). In addition to identifying chemicals of concern, chemicals were listed that are <u>not</u> of concern in terms of their distribution and toxicity.

The unknown quantity of chemicals remaining at a former chemical dumpsite in Commencement Bay near Tacoma prompted an analyses of sediments in that region. The result of these studies contributed directly to the designation of Commencement Bay as the highest priority marine problem on the Environmental Protection Agency's priority listing of hazardous dumpsites.

OMPA also investigated the mechanisms and factors controlling biological accumulation and associated physiological effects of trace metals in seawater. Results indicate that the susceptibility of organisms to poisoning by certain metals may be greater if the organisms are deficient in another metal.

Ocean dumping work will continue with in-depth studies of specific ocean disposal problems, but will increasingly emphasize process-oriented and predictive studies dealing with distribution, transfers and transformation, and biological effects. Non-site-specific studies will focus on the following three categories of wastes in priority order:

a. municipal and industrial wastes (from sludges, effluents, and spills)

b. urban and agricultural runoff (from non-point and riverine sources).

c. dredged material (from maintenance and channel deepening)

B. Marine Mining

Outer Continental Shelf (OCS) activities which are likely to contribute to marine pollution are oil and gas extraction; sand, gravel, and shell mining; and deep-sea mining. Of these, oil and gas extraction has received the most attention with concern focused on these three factors:

a. The potential impact of OCS development in coastal areas (e.g., increased populations, marine transport, and facilities and construction siting).

b. The effects of OCS exploration and production activities on the marine environment (i.e., chronic spillage of contaminants, structures, noise, people, etc.).

c. The likelihood of accidental spills or well blowouts and their potential impact on marine resources.

Within OMPA, the bulk of the OCS oil and gas-related research has been focused on the Puget Sound and Alaska regions. The primary goal of the Alaskan program is to provide scientific information in a timely manner for management decisions relating to OCS oil and gas leasing on the Alaskan continental shelf. Five generic tasks (contaminant baselines, environmental hazards, pollutant transport and fate, living resources, and effects) are the core of this program. The Bureau of Land Management's leasing schedule determines the geographic area to be emphasized each year. FY 1981 was largely devoted to the completion of ongoing research in the Gulf of Alaska. Other areas studied in FY 1981 were the Bering Sea and the Arctic Ocean.

Arctic Ocean oil and gas-related studies are in many ways distinctive from those in the Bering Sea or the Gulf of Alaska. Current research in the Arctic places emphasis on ice and permafrost studies. A major accomplishment in FY 1981 was the completion of a detailed statistical analysis of ice gouges in the seafloor. This will enable the design depths for subsea pipelines in the Beaufort Sea to be developed on a sound probabilistic basis.

Laboratory investigations of the lethal and sublethal effects of exposure to oil and oil components on marine organisms have been conducted for several years. Research activities in FY 1981 were concentrated in four areas: (1) disease resistance, (2) behavior, (3) metabolism, and (4) physiology (growth).

As noted earlier, the Alaska program determines the geographic study area according to the needs of BLM's leasing schedule. In FY 1982, research will emphasize the Bering Sea and the Arctic Ocean lease areas.

C. Marine Energy

The increased costs of imported and domestic oil and gas exploration and development have caused the oceans to receive attention as a potential source of energy. Limited research and development have focused on ocean winds, currents, tides, waves, salinity and temperature gradients, and biomass conversion.

In FY 1981, OMPA had no activities that directly responded to pollution caused by use of the oceans for alternative energy sources. However, it is recognized that this will be a growing concern and the extent of needed study will be examined in FY 1982.

D. Marine Transportation

Pollution resulting from marine transportation can enter the environment either intentionally as a result of routine operational discharges, or unintentionally as a result of accidental spills. The National Marine Pollution Program Plan separates discussion of these two causes of pollution and addresses unintentional spills under the section entitled Accidental Discharges of Oil and Hazardous Materials. Based on this division of issues, OMPA had no activities in FY 1981 that directly responded to pollution caused by marine transportation. However, OMPA does address marine pollution resulting from marine transportation in a peripheral sense through its OCSEA program, as discussed in Section III-E (page 33).

E. Accidental Discharges of Oil and Hazardous Materials

Substantial amounts of oil and hazardous materials enter the marine environment as a result of accidental spills. In the past, the focus has been on the cleanup and mitigation of spilled oil. Now, national interest is shifting toward hazardous materials as the cause of immediate concern.

OMPA, representing NOAA within the Department of Commerce, currently has eight members on Regional Response Teams (RRT). These RRT members are primarily responsible for development of NOAA's regional response contingency plans, stating NOAA's concerns and policies during response activities and requesting additional participation from other main line components (e.g., National Marine Fisheries Service) during spill emergencies. The management of OMPA's RRT responsibilities has been assigned to OMPA's Hazardous Materials Response Project (HMRP).

OMPA's activities relating to accidental discharges is categorized into (1) spill response, (2) damage assessment, and (3) pollutant transport, weathering, and transformation. During spill incidents, the HMRP Scientific Support Coordinator serves as the liaison between the On-Scene Coordinator and the scientific community. The listing of

OMPA's response to accidents involving ship collisions or groundings is given in Table 1 (page 39) of this report; Table 2 (page 41) lists OMPA's response to accidents involving hazardous chemical releases.

OMPA's activities in damage assessment have been to document changes in the chemical composition of oil, define the extent of the impact area, define the retention time of oil in the sediments, and study the benthic infauna for changes in abundance, community structure, and species diversity. The pollutant transport, weathering, and transformation studies have been conducted by the OCSEA program. These studies are designed to: (1) provide data that can be used to minimize risks to environmentally sensitive areas during the various stages of oil and gas development, (2) determine probable trajectories and landfalls in the event of an accidental release of contaminants, and (3) provide information for cleanup operations in coastal and nearshore areas.

F. Coastal Land-Use

Many land-based human activities require access or proximity to marine or estuarine waters. Pollution problems of greatest concern that are associated with such land-use activities are:

- Siting, Construction, and Operation of Coastal Facilities
- Non-point Source Pollution

The loss and alteration of critical habitats are the most important concerns associated with the construction and operation of coastal facilities.

Non-point source pollution discharges into surface waters in a diffuse way, for example, by land runoff. Therefore, non-point-source pollution accounts for a major portion of the contaminants that enter coastal waters. During FY 1981, OMPA's coastal land-use assessment focused principally on the Hudson-Raritan Estuary and the adjoining New York Bight, where a significant part of the total contaminant inputs are introduced via runoff and riverine flows. Studies emphasized characterization of the sources and transport of contaminants and the determination of marine environmental effects related to coastal land-use.

In addition to the efforts in the Hudson-Raritan Estuary, OMPA supported complementary research on the factors contributing to the pollutant composition of runoff in two other areas. In one study, the movement of pollutants and related material through Sandusky Bay into Lake Erie was examined during periods of intense runoff from major storms and at times when the river was at low flow. The second study characterized sources, transport, form, and flux of petroleum hydrocarbons in urban runoff and combined sewage overflows into Narragansett Bay.

G. Ocean Pollution Assessment and Management of Cumulative Effects

Coastal regions characterized by excessive pollution usually are impacted by multiple ocean-use activities. One of the more challenging

problems is linking the environmental effects of pollutants to specific sources. Another problem is defining the risk to humans and marine organisms that are the ultimate receptors of pollutant insults.

OMPA's studies provide information on basic environmental processes, environmental effects of pollutants, and ecosystem recovery. OMPA's efforts address pollution issues of national concern. Field research and development efforts are focused in selected "model" study areas, especially in the New York Bight and the adjacent Hudson-Raritan Estuary, the Great Lakes, and Puget Sound. Additionally, OMPA supports an extensive non-site-specific program, with individual studies focusing on specific environmental processes and effects that must be understood in order to assess and manage the cumulative environmental effects of contaminants.

Collecting and Using Information

OMPA has two specific management tools that directly pertain to collecting and using information. The first, data and information management, has three major roles: (1) translating data and information into forms useful to decision makers, (2) aiding the OMPA program in its management and coordination functions through the better use and organization of existing data and information, and (3) organizing and storing environmental data in a retrievable form. The second tool, marine pollution monitoring, uses collection of data to warn against unacceptable impacts of human activities and to provide a long-term data base that can be used for evaluating and forecasting natural changes in marine ecosystems and superimposed impacts of human activities.

Program Emphasis for FY 1982-85

The OMPA program will place its major emphasis in FY 1982-85 on addressing marine pollution problems related to marine waste disposal. However, other major ocean-use problems will also be addressed. NOAA identified six agency-wide marine pollution goals in the January 1982 NOAA Marine Pollution Program Plan. OMPA's role in each of the goals is outlined in Section V of this report.

II. DESCRIPTION OF THE OFFICE OF MARINE POLLUTION ASSESSMENT (OMPA)

The Office of Marine Pollution Assessment (OMPA) was established in NOAA in response to the National Ocean Pollution Planning Act of 1978 (P.L. 95-273). Congress passed this act in order to give a unified Federal focus to marine pollution problems. OMPA is charged with the responsibility for coordinating NOAA's activities in marine pollution research, development, and monitoring. The OMPA Marine Pollution Program's primary goal is to provide scientific information that will guide public policy decisions on marine pollution issues. A complete description of applicable legislation and overall responsibilities and a comprehensive list of programmatic goals and objectives appears in OMPA's Plan for 1982-86. A description of OMPA's organization is given in Appendix A.

This report summarizes OMPA's achievements in FY 1981 and, also, OMPA's plans for FY 1982 and following years. The research summaries follow the categories of concern developed in the Federal Plan for Ocean Pollution Research Development and Monitoring for Fiscal Years 1981-85. These categories are being approached conceptually through an ocean-use management model shown in Figure 1. This model links man's activities with environmental and ecological consequences as deduced through scientific research and couples those to judgmental processes leading to management decisions. Previously, our major emphasis has been on scientific findings and recommendations; this is reflected in the descriptions of Chapter III. However, the ocean-use management model will be explicitly incorporated into our future programs, as reflected in our program emphasis for FY 1982-85 (Chapter V).

The model specifically emphasizes the judgmental process, which involves not only the scientific understanding of the consequences of man's activities, but also the economic and social realities which, in fact, play the key role in today's decision processes. One such reality is that today we are using the oceans for waste-disposal, even though we know that these activities may cause certain undesirable impacts on the marine environment.

The model recognizes that our scientific endeavors must be directed toward understanding the consequences of man's activities, and that this requires understanding the ecological and environmental processes. The knowledge of the specific effects of specific polluting activities is the fundamental information necessary for the effective control of marine pollution.

Scientific information, to be relevant to real-life situations, must incorporate understanding of the options available for ocean-use and pollution control. OMPA's program will evaluate not only current marine pollution problems, but also anticipate the options available for ocean-use and pollution control and consider sociological and economic implications in the development of ocean-use alternatives. The model highlights this aspect of the ocean-use management process, and also the feed-back from the decisions to man's activites. In this latter part of the loop, the role of science is to assist management to verify or

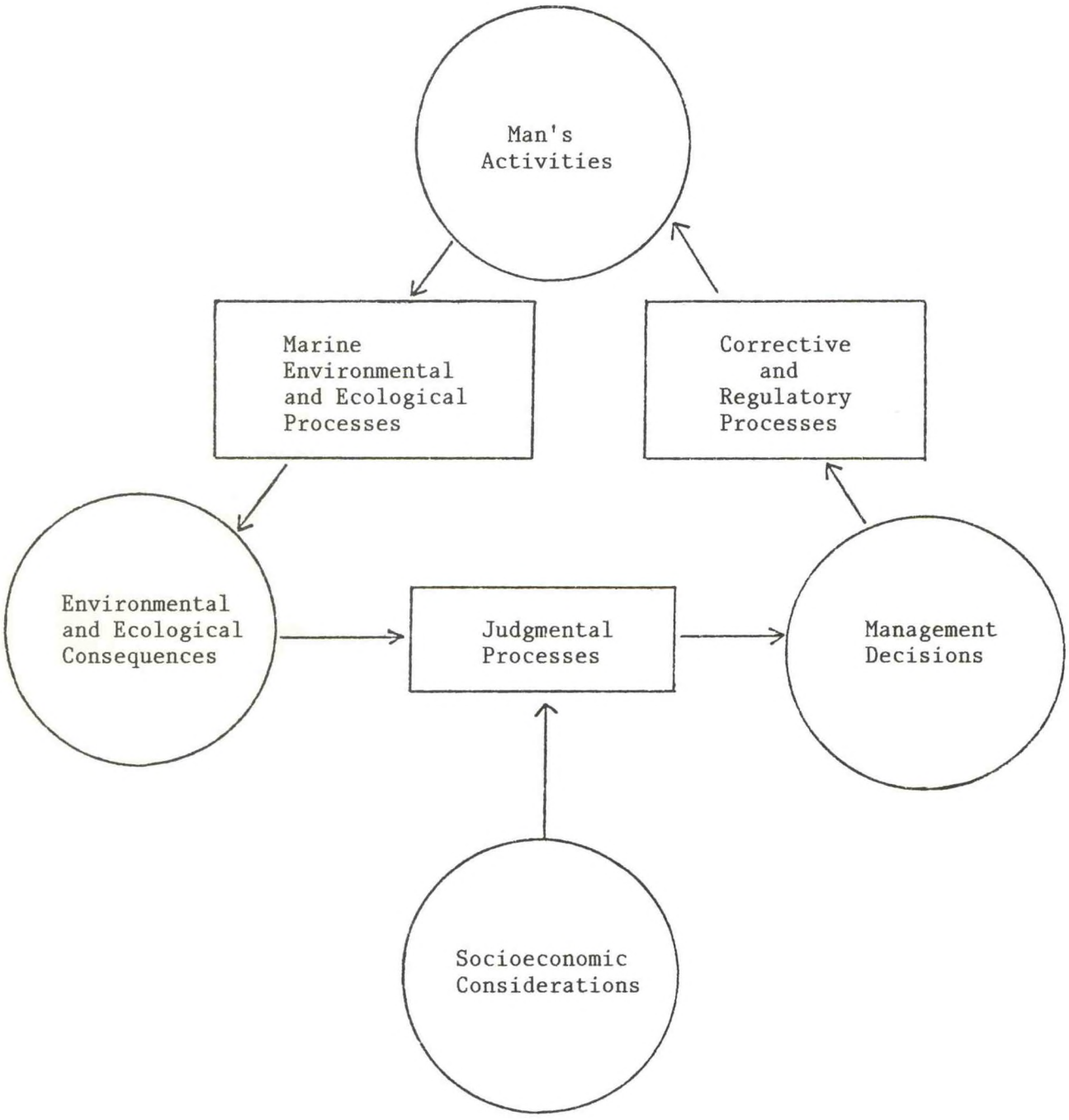


Figure 1. Ocean-use Management Model

refute the effectiveness of the corrective control measures that were implemented to reduce adverse ocean-use impacts.

The OMPA program, based on the ocean-use management model, advocates a strategy whereby all elements of the ocean-use decision process are considered. The purpose for providing scientific information will be to anticipate and minimize the adverse consequences attributable to the various facets of ocean-use.

III. OMPA FY 1981 ACTIVITIES AND ACCOMPLISHMENTS

The following sections describe OMPA programs according to the priority categories identified in the Federal Plan. These categories identify man's ocean-use activities that are the primary causes of marine pollution: marine waste disposal, marine mining, marine energy, marine transportation, accidental discharge of oil and hazardous materials, coastal land-use, and ocean pollution assessment and management of cumulative effects. However, the programs in marine pollution often do not fall into these district categories. For example, much of the waste disposal research is also closely connected with problems of coastal land-use. Also, results from specific geographical regions will be used as much as possible to guide ocean-use research and management in other regions and in general.

A. MARINE WASTE DISPOSAL

1. Introduction

The problem of waste management in the United States is growing in importance. Some materials, such as dredged sediments, are routinely disposed of in the ocean, and such disposal is expected to continue for the foreseeable future. Other materials, such as sewage sludge and toxic industrial wastes, have also been disposed of in the ocean, but strenuous efforts have been made in recent years to find other means of disposal. In the recent Special Report to the President and Congress, however, NACOA (National Advisory Committee on Oceans and Atmosphere) strongly recommended expanding or continuing the role of the ocean in the development and implementation of a U.S. National Waste Management Policy. Marine waste disposal will therefore remain controversial. Continued research is required to evaluate the economic and environmental costs of ocean-disposal practices as part of the development of overall management strategies for particular and general waste disposal problems.

The OMPA program has addressed problems of marine waste disposal through several approaches. We have determined the specific environmental, social, and economic consequences of marine waste disposal at several selected ocean dumpsites. In the New York Bight/Hudson-Raritan Estuary and Puget Sound, we have dealt with all forms of waste disposal from a regional perspective. Finally, we have sponsored numerous

research projects addressing specific environmental processes and mechanisms of impact that relate to marine waste disposal.

The objective of waste disposal research in OMPA is to obtain information upon which to base resource management decisions, both generically and at specific waste disposal sites. The issues addressed by waste disposal research are:

a) to determine the ways in which wastes are transported and transformed in marine systems;

b) to evaluate the biological effects associated with specific waste components and waste disposal practices; and

c) to develop strategies for managing marine waste disposal

2. Priority Activities

The largest OMPA priority in ocean dumping research through FY 1981 was studying the impact of industrial waste disposal at two deep ocean dumpsites. One, the 106-mile site, is about 106 miles southeast of the entrance to New York Harbor; the other is about 40 miles north of Arecibo, Puerto Rico. We have emphasized those sites because of the perceived potential for serious impact on the deep ocean ecosystem from very toxic wastes. Lesser efforts were directed toward (1) the dredged material disposal site in the New York Bight and (2) documenting changes that have occurred at the Philadelphia Sewage Sludge dumpsite since dumping ended in November 1980. The assessment techniques developed for these sites will be tested and applied at additional sites in the future. The results from all these studies will be used to develop an overall management strategy for marine waste disposal.

Our FY 1981 program related to deep ocean sites emphasized field studies of how the wastes disperse after dumping, field and laboratory studies of how the wastes change physically and chemically after they are dumped, and field and laboratory studies of the effects of the wastes on selected marine organisms. The ways in which wastes are distributed and assimilated has been approached through selected modeling studies. These studies have examined the dispersion and dilution of wastes under various conditions, and evaluated the relative importance of several environmental factors in determining waste impact. The factors which determine the biological effects of waste metals have been extensively examined in the laboratory. The experiments have studied the relative impact of metals in many different concentrations, combinations, and states, as well as examining the uptake and transfer of zinc within an experimental marine food chain. To facilitate development of management strategies for ocean dumping, we have emphasized the development of technical reviews and assessment reports summarizing scientific findings and management recommendations for specific ocean dumping problems. The program has also developed and sponsored a series of International Ocean Dumping Symposia, as a forum for the presentation and discussion of ocean dumping issues in the United States and other countries.

OMPA's regional studies in the New York Bight concluded in FY 1981, completing a comprehensive 10-year study of man's impact on the Bight ecosystem with the synthesis of findings on potential health hazards due to waste disposal and other factors. The main sources of environmental contaminants to New York Bight waters (stormwater runoff, combined sewer overflow discharges, sewage treatment plant outfalls, industrial outfalls, and sewage sludge and dredged materials dumping) have two major health implications: (1) contamination of swimming waters and food organisms with pathogenic organisms, and (2) the contamination of food organisms with toxic metals and organic compounds.

Emphasis was focused in FY 1981 on completing a thorough compilation, review, and interpretation of existing information on the Hudson-Raritan Estuary, including effects of waste disposal. We have encouraged and supported expansion of New York Bight work that related to problems and effects of waste disposal so that the most significant scientific and management issues in the Hudson-Raritan Estuary can be identified and addressed.

FY 1981 research priorities in Puget Sound derived from several pollution issues. Sediments in waterways and bays of Tacoma and Seattle contain high concentrations of metals, chlorinated hydrocarbons, petroleum compounds, and often potentially hazardous chemicals from a variety of sources, including direct disposal. The amount of chemicals remaining at a former chemical dumpsite in Commencement Bay near Tacoma is unknown. In FY 1981, we analyzed sediments in those regions to determine present contamination and to assess potential hazards from dredging the waterways. Since fishes, crabs, and shrimp taken from waterways of Commencement Bay and Elliott Bay showed significantly higher frequency of some internal lesions than those taken elsewhere in Puget Sound, we studied to see if these indicated significant ecological problems. Investigations were also made of the structure and diversity of benthic invertebrate communities, which are significantly different in waterways and shoreline sites in Commencement and Elliott Bays than at remote sites, to determine whether chemical contaminants are causing the changes. The project also analyzed the impact of a proposed diversion considered by the Municipality of Metropolitan Seattle of a large flow of sewage from an inland plant directly into Puget Sound.

Progress was also made in FY 1981 in developing an understanding of the fate and effects of marine waste disposal through numerical modeling and supporting field studies. Through grants awarded in FY 1981, we addressed research dealing with the refinement of a numerical model of sediment quality near an ocean outfall and with improvement of a model to estimate near-field initial dilution obtained by ocean wastewater discharges from multiple port diffusers.

3. FY 1981 Program Accomplishments

A large number of scientific studies of marine waste disposal were completed in FY 1981 and numerous reports on important issues were prepared. The program made important determinations about the physical characteristics of disposal sites and practices and about the chemical characteristics and behavior of the wastes, in addition to making

progress toward determining biological effects through numerous field and laboratory studies. Findings were developed from dump-site-specific studies, regional studies, and process-specific studies about conditions under which wastes could pose a hazard to humans or organisms. Modeling studies have given us general information about how wastes disperse and under what conditions serious biological consequences might be expected. Several studies considered trace metals as a class of important contaminants, and determined conditions under which toxicity due to high concentrations of these metals might be mitigated or enhanced. Several assessments and reports, as well as symposium proceedings, were published and summarized findings on problems of industrial wastes, municipal wastes, and seafood wastes. Major synthesis efforts are summarized below, followed by brief reports of the progress and results of particular projects at each principal study site.

Two assessment reports summarized technical results and analyzed overall dumping impact for the 106-mile site and for a discontinued site in the Gulf of Mexico. Both reports found that dumping was taking place in an environmentally acceptable manner, and that short-term impacts were transitory and minor. Further studies were recommended, however, if dumping conditions changed, or continued over a long period of time. Information is not yet available to evaluate long-term impacts, or to predict the impact of new kinds or greater amounts of wastes.

Several reviews of particular ocean dumping problems were published during FY 1981. These articles included reviews of deep ocean dumping of industrial waste, a global review of ocean dumping of sewage sludge, and a management analysis of ocean dumping of seafood wastes.

The proceedings of the first International Ocean Dumping Symposium were published during FY 1981 and included articles on the historical and international development of ocean dumping research and future prospects of ocean dumping by program staff, as well as, a wide selection of scientific and policy articles. The Proceedings of the Second International Symposium are being edited. Final preparations were made for the Third Symposium, to be held October 12-16, 1981.

During this fiscal year, OMPA personnel assisted in developing a NOAA Ocean Dumping Policy. This effort has investigated the relative merits of disposal options and the environmental and ecological impacts of ocean dumping at three dumpsites in the Middle Atlantic Bight (12-, 65-, and 106-mile) each with different ambient characteristics.

106-Mile Dumpsite

Studies in earlier years have shown that the 106-mile site (Figure 2) is occupied predominantly by southwest-setting water which remains over the continental slope and rise, but that periodically, intrusions of lower-salinity water from the continental shelf and southwest-migrating warm eddies from the Gulf Stream are also present. Further studies of this complex structure were made in FY 1981 and important information was developed on the probable long-term movement of waste. A number of drogues were tracked for several months, and after drifting to the southwest for 30-50 days, were caught up in the northward flowing Gulf Stream when they reached Cape Hatteras. One

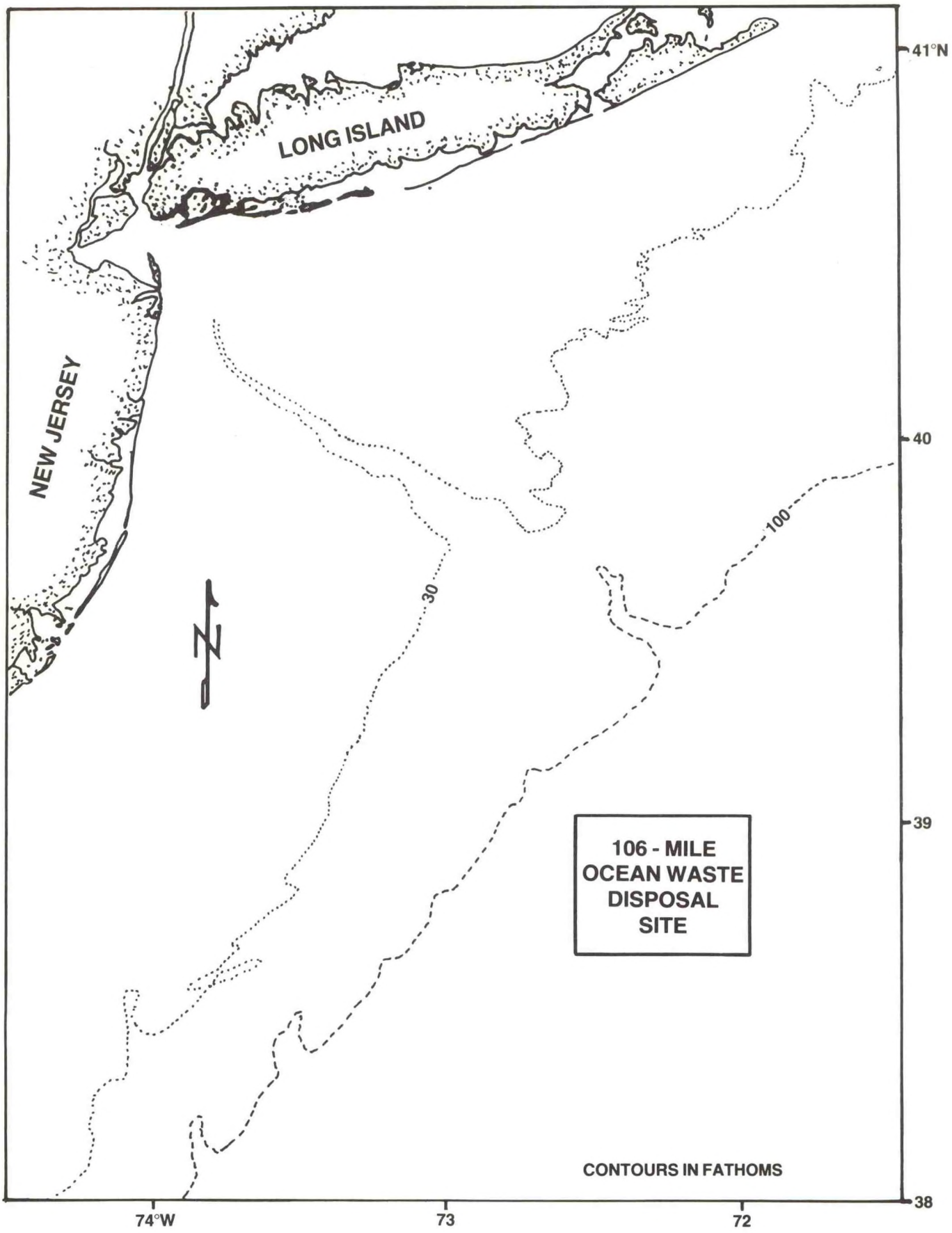


Figure 2. 106-Mile Chemical Waste Disposal Site

drogue, however, migrated onto the continental shelf and another moved directly to the northeast. This confirms the earlier report that both the short- and long-term fate of waste may depend on the characteristics of the water mass that it is dumped into, rather than on the geographical location of the dump.

In a study at the 106-mile site during a period of strong mixing and dispersion, wastes were detected only in fresh plumes, and the volatile organics could not be used as an effective tracer. This may have been due to the rapid but irregular flushing of the site caused by the presence of a Gulf Stream eddy.

Studies continued on the movement, transformation, and dispersion of ocean-dumped acid iron waste at the 106-mile site. After dumping, this waste forms iron-rich precipitates that can be used as an effective tracer. It was determined that nearly all of the iron in the waste is associated with the particulate phase, rather than being dissolved in solution. Such knowledge is essential in assessing the final fate and effect of waste constituents. Concentration measurements confirmed earlier general notions about waste dilutions. Wastes are diluted by a factor of 10^4 in a few minutes, but subsequent dilution to 10^5 requires about a day, and 10^6 may require several weeks in the absence of strong mixing events. The field results are presently being correlated with experiments in a large tank, using a stratified water column and controlled additions of waste.

Laboratory experiments on zooplankton using wastes dumped at the 106-mile site have detected acute toxic effects at concentrations of 5-100 ppm, depending on the particular waste. Lower concentrations of waste reduce feeding, metabolic, and egg production rates. In the field, zooplankton collected from a waste plume showed a similar response, and sublethal effects were not reduced when animals were transferred to clean water. Progeny of the animals, however, did not show these effects. Because only a small percentage of the zooplankton within the dumpsite region are exposed to these short-term dumping events, the long-term consequences appear to be minimal.

Extensive collections of shrimp were made from the 106-mile site region and from stations farther to the north. These collections show a much greater incidence of gill blackening from dumpsite collections than from northern collections. This blackening results from biochemical reactions associated with cellular responses to injury caused by various organic chemicals, heavy metals, and parasitic infections. Species composition may be important, but laboratory studies will be needed to test this, as well as any relationship to waste materials.

New York Bight

Program emphasis related to waste disposal in the New York Bight (Figure 3) for FY 1981 was focused primarily on summarizing the conclusions and findings of previous research efforts. These findings dealt with possible health implications from pathogenic organisms, toxic metals, and organic compounds.

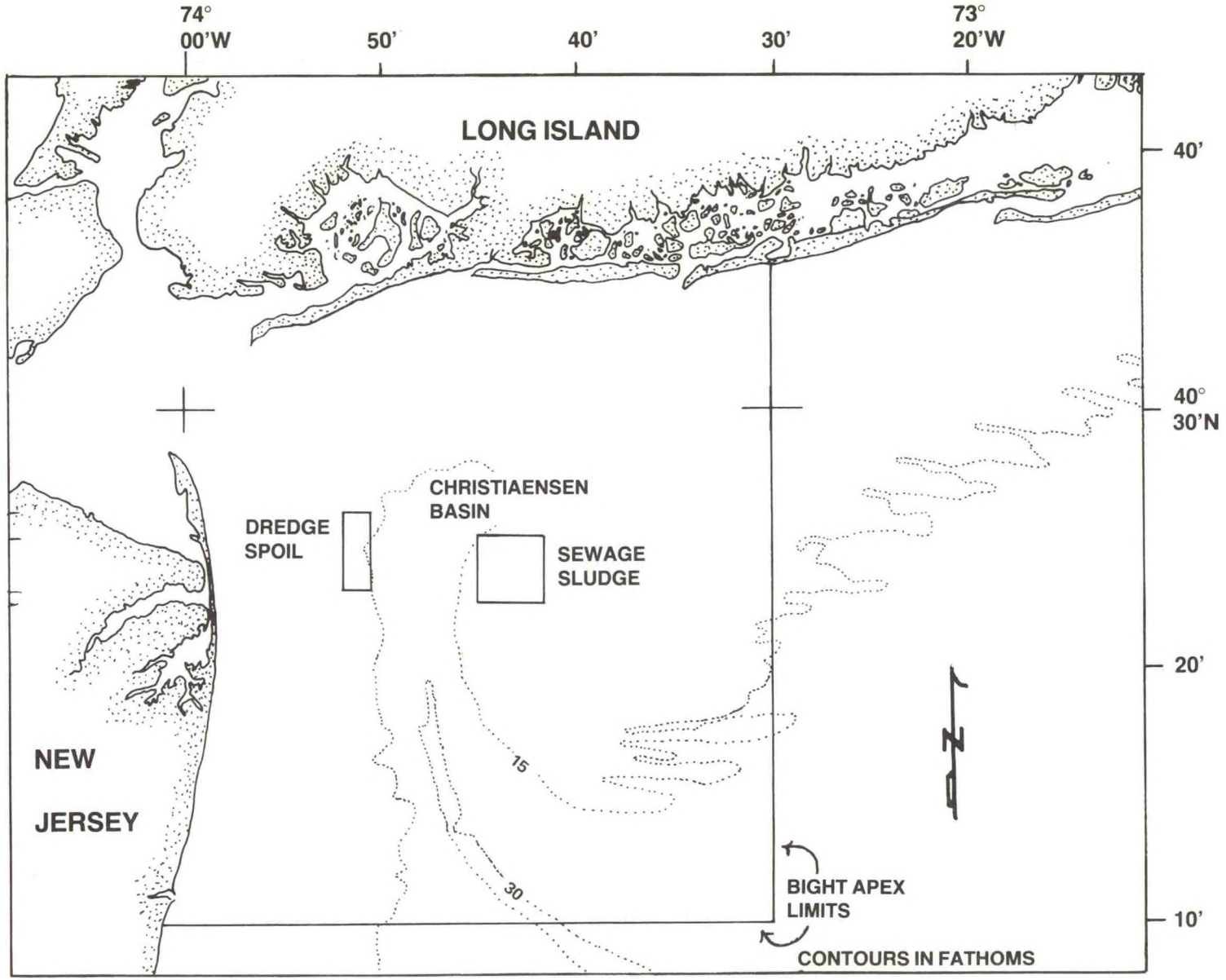


Figure 3. New York Bight Sewage Sludge Dumpsite

The potential for infectious disease among individuals using the New York Bight as sources of recreation and food stems from municipal wastewaters and combined sewer overflow discharges. There is no microbiological or epidemiological evidence that the disposal of municipal sludge at the existing sewage sludge dumpsite has been responsible for deterioration of water quality or swimming-associated illness at New York and New Jersey coastal beaches. However, sewage sludge dumping has reduced the quality of the water at nearby shellfish growing areas.

Some municipal wastewater discharges into the Bight, not only those emerging from the Upper Bay and the confluence of the Raritan River and Arthur Kill, but also those entering embayments along the Long Island and New Jersey coasts, have resulted in deterioration of water quality at nearby beaches. There is a measurable increase of gastroenteritis associated with swimming in these waters even though mean enterococcus densities are very low. This suggests that sporadic cases of gastroenteritis may also occur via shellfish consumption.

Metal loadings to the Bight have been estimated by various investigators in order to assess the importance of contaminant inputs due to offshore dumping of wastes relative to the Hudson estuary discharge. For copper, chromium, lead, and cadmium, the largest single source of metal loading to the Bight is dredged material dumping. A lesser source quantitatively, though possibly important, is the sewage sludge which is also dumped in the New York Bight Apex. Other sources of trace metals are wastewaters, runoff, shelf transport, and atmospheric input.

It seems likely that the trace metal concentrations in the New York Bight Apex are increased by pollution. Within the New York Bight Apex, there are areas with especially high concentrations of acid leachable trace metals: the dredged material dumpsite in the New York Bight Apex, the Christiaensen Basin, and to a lesser extent the Hudson Shelf Valley. The Christiaensen Basin is immediately adjacent to the dredged material and sewage sludge dumpsites. It may be that fine-grained polluted sediment is transferred from those dumpsites to the Basin either by slumping or suspension and redeposition. There is no trace metal excess anomaly in the area where the sewage sludge is dumped. Part of this may be due to inaccurate dumping by the barges, but more likely it reflects that most of the sewage sludge does not get to the sediment when it is dumped due to its very low density. It is ultimately deposited elsewhere within the Bight.

A final report on the extent of remobilization and subsequent release of heavy metals at the dredged material dumpsite using coring and seismic profiling has indicated that the spatial distributions of heavy metals such as lead, copper, silver, mercury, cadmium, iron, and manganese in the dredged material deposit exhibit highly variable and considerably elevated concentrations over those observed in sediment outside the deposit and in underlying natural sediment. Compared to metal enrichments reported for other coastal deposits, the degree of metal enrichment observed in dredged material sediments are orders of magnitude greater.

Another study has shown that there appears to be little short-term change in the chemical, hydrographic, and biological parameters which could be associated with individual dredged material dumps. The absence of a chemical modification of the water column after a dump of dredged material indicates either that there is no effect on the water column from a dump or that other sources of particulate matter in the New York Bight are so large that the effect of a dump is obscured.

For organic contaminants, only crude estimates of the relative contribution of river discharge and dumping have been made. The estimated contribution of PCBs to the Bight from Hudson River discharge may range from 5 to 10 percent of the mass discharged by dumping of sewage sludge. In all cases, estimates are small relative to that contributed by dumping.

PCBs in sewage sludge remain for some time in the water column, associated primarily with suspended solids, since sewage sludge settles slowly and disperses widely. Much of the PCBs in dredged material, on the other hand, is likely to remain with the settleable fraction of dredge spoil, which has formed a detectable mound at the dumpsite.

Dumping of Harbor dredged material in the New York Bight constitutes a major transport mechanism for PCBs and pesticides. Disposal of sewage sludge in the Bight appears to be less important for PCBs, but is still a significant source of these compounds to the coastal environment.

Studies of dredged material disposal in the New York Bight in conjunction with the Corps of Engineers have focused on the extent to which this disposal contributes to increased concentrations of toxic materials in regional waters, and whether capping the contaminated material with clean sand can diminish these concentrations. Analysis of experimental results indicate that chemical modifications to the water column from a single dredged material dump lasted less than 30 minutes. Concentrations of toxic constituents at the dumpsite were about 10 times higher than offshore, but could be partly due to Hudson River plume effects. Analysis of sediment cores indicated a significant flux of ammonia and cadmium out of the sediment, sufficient to produce increased water column concentrations in about a week. Fluxes of other materials were less significant or absent. Studies are continuing to determine how much of increased toxic metal concentrations in the water column are due to dredged material disposal, and how much to sewage sludge or the Hudson River plume. Field work was completed in July 1981 and processing of the data should be completed early in 1982.

Philadelphia Dumpsite

An extensive sampling for the presence of pathogenic amoebae has been made at the Philadelphia site (Figure 4) and selected other clean and contaminated locations. These amoebae serve as sensitive and long-surviving indicators of sewage sludge contamination. Amoebae have been recovered from 20 to 40 percent of sewage site stations regardless of ambient conditions, and correlated well with the distribution of fecal bacteria. The amoebae are recovered from only 0 to 5 percent of test stations in healthy environments. Work is continuing on the isolation

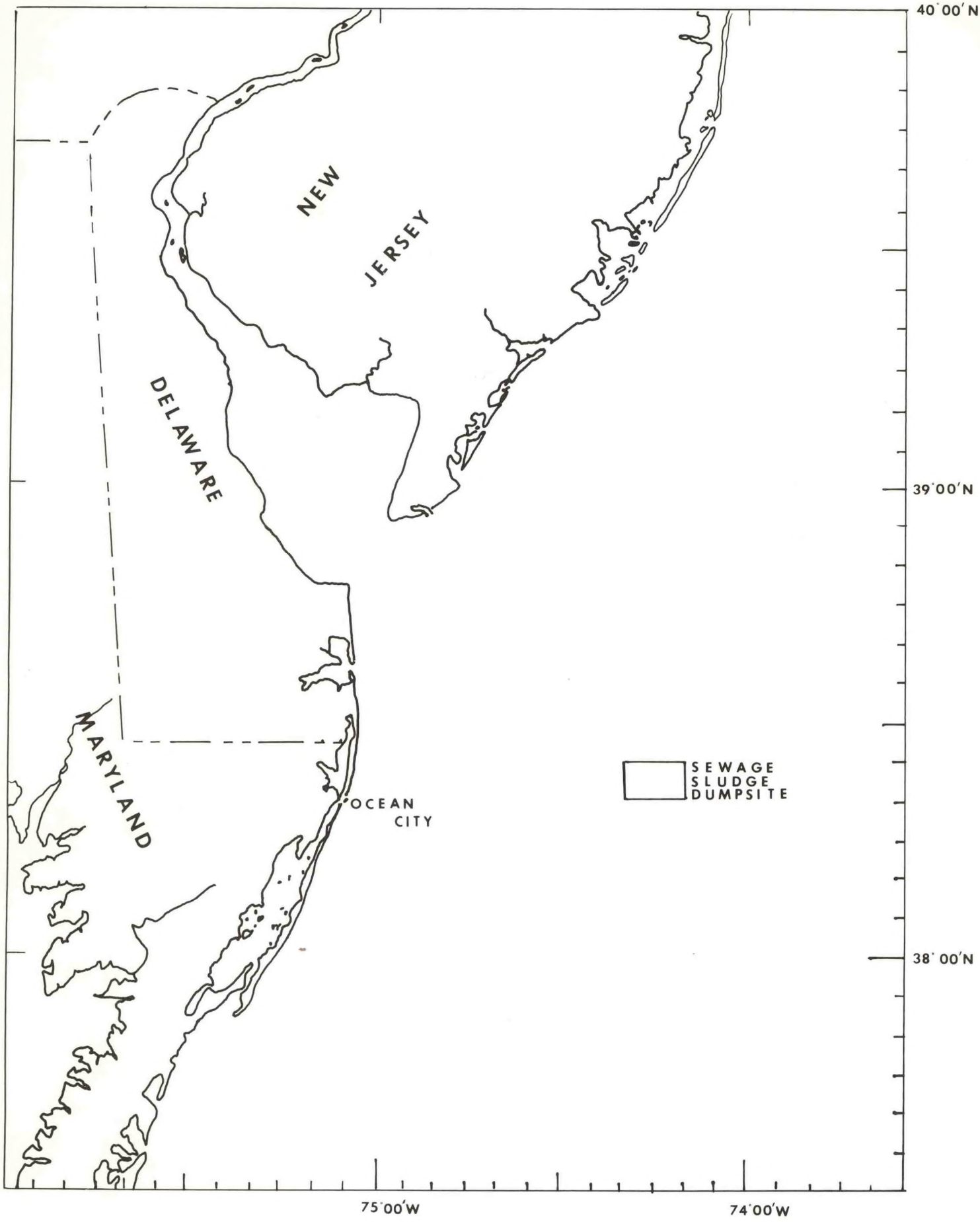


Figure 4. Philadelphia Sewage Sludge Dumpsite

of both pathogenic and nonpathogenic amoebae, in order to develop a reliable test system for monitoring active and abandoned dumpsites.

Intensive investigations of gill disease and tissue pathology in rock crabs over a wide variety of Atlantic coastal waters have shown that blackening of the gills of the crabs is a striking and immediately visible effect of accumulated sludge deposits. This decrease does not occur at all in healthy waters, but is observed in up to 10 percent of samples in the New York and Philadelphia sewage sludge sites. Work is underway to determine whether metal levels in the gill tissues of the crabs increase with gill blackening.

Sampling for the presence of selected human viruses has been made at the Philadelphia and New York dumpsites as part of a program to study the impact of sewage sludge disposal on the distribution and cycling of human viruses. The viruses were present in five of 42 sediment samples and one of ten waste samples. Viruses were isolated in some cases even where fecal indicator bacteria were not detectable, showing that these bacteria may not be adequate for predicting the virological quality of water or sediment. Isolation of larger numbers of viruses from sediment than from water indicates that sediment may act as a reservoir of human viruses at dumpsite locations.

Studies of the chemistry and geology of sediments at the Philadelphia site continued. Contamination of surficial sediments by toxic heavy metals, particularly lead, has been associated with dumping activity both by absolute concentrations and by concentration ratios. Topographical factors and sediment size continue to be closely correlated with chemical and biological parameters, with accumulations concentrating in topographic depressions.

Puerto Rico Dumpsite

Two projects have developed new information about the surface circulation patterns at the Puerto Rico dumpsite (Figure 5). Prior to our studies, it was thought that the dumpsite was in the region of a steady westward flowing Antilles current. Drogue and drifter tracking, hydrographic studies, and fluorometric measurements (performed or analyzed in FY 1981) show that this is often not the case. For long periods of time, the near surface circulation may be predominantly north-south, with an eastward zonal component. Some evidence indicates an intermittent gyral structure, which may result in little net surface water movement over periods of weeks. At other times, the currents have a predominantly westward set, but with considerable irregularity. Therefore, waste may not be generally swept away from the dumpsite after disposal, but may sometimes persist for days or weeks at measurable concentrations. No biological consequences of this persistence are apparent at this time, but detailed knowledge of the physical environment is needed wherever ocean waste disposal takes place.

Low-molecular-weight, volatile organic material constitutes the major non-aqueous portion of Puerto Rico wastes. This material can be detected at very low concentrations in the ocean, and is therefore very useful as a waste tracer. An extensive program of measurement confirmed the indication that wastes often are not effectively flushed away from

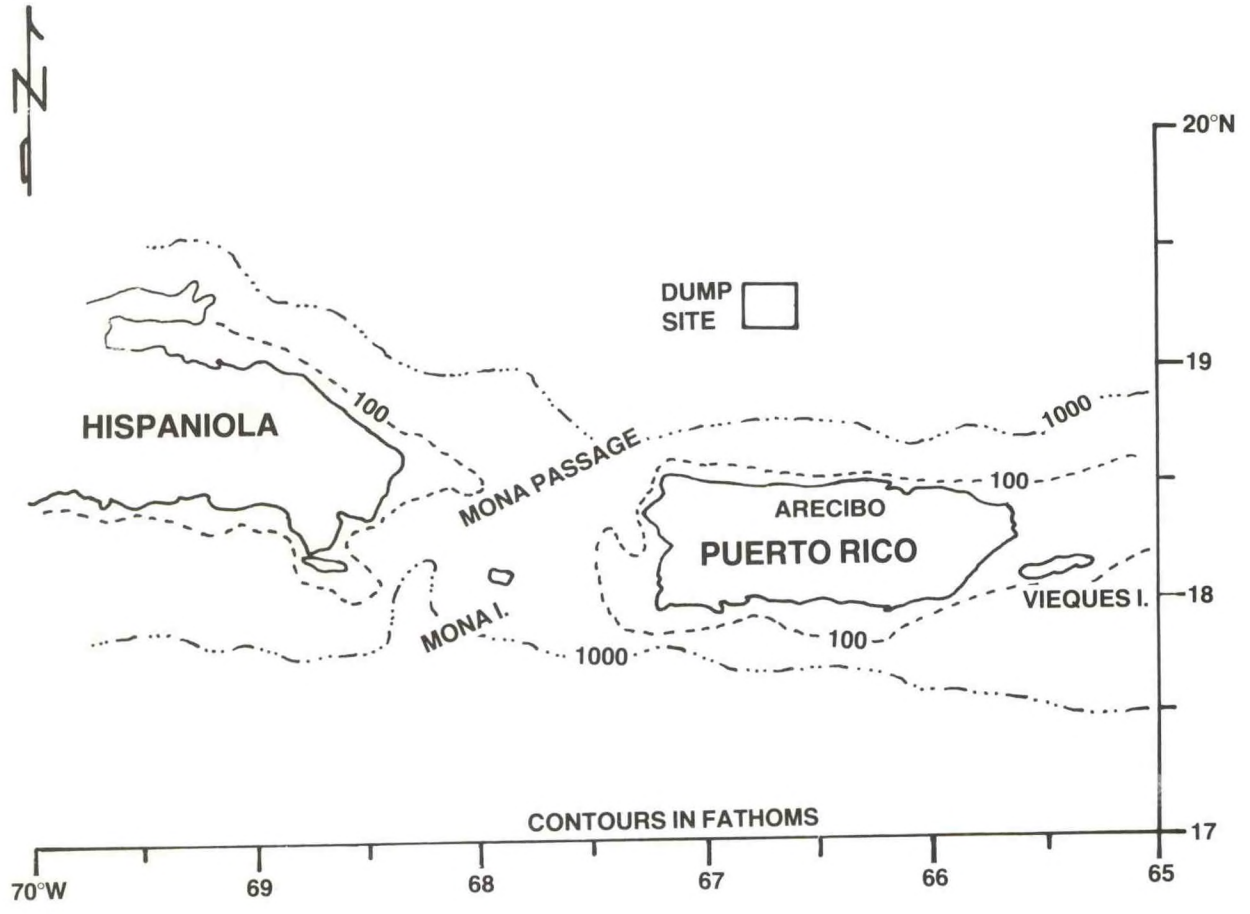


Figure 5. Puerto Rico Site

the dumpsite. They were found distributed over a 23,000 km^2 area around the dumpsite on one occasion when north-south water movement dominated, but were much more scattered or absent at other times when currents set strongly westward. Depth penetration to 200 m was found, indicating that these light waste constituents may be transported downward by attachment to denser particulate material.

Phytoplankton community structure was analyzed before and after several Puerto Rico waste dumps, in order to test and extend laboratory findings that some species of phytoplankton are significantly more resistent to wastes than others. Although considerable variability was present, significant short-term changes in population structure were found, with some species increasing while others decreased. Some species, in fact, seem to be very resistent to the wastes. Long-term widespread effects have not been found. Work is in progress on developing a measurement for determining the physiological state of natural communities.

Laboratory experiments using Puerto Rico pharmaceutical wastes show acute toxic effects at concentrations above 10 ppm. There are indications of significant sublethal effects as well. Zooplankton collected in the field one and 24 hours after waste dump showed significant reduction in metabolic activity and sluggish swimming behavior. They did not recover when transferred to clean water. The long-term consequences of chronic exposure to low waste concentrations on reproductive potential is currently being investigated. This is particularly important because of the documented persistence of detectable waste concentrations around the Puerto Rico site. Work is also in progress on accumulation and removal of toxic trace metals by feeding and fecal pellet production.

Another study shows that bacterial populations in the surface waters of the Puerto Rico dumpsite region appear to have been altered in a way which can be associated with dumping activity. Normal marine species occur with a frequency of less than 10 percent while other species occur with unexpectedly high frequency. Laboratory studies have confirmed that the structure of the bacterial community can be altered by waste additions of 100-1000 ppm. Such shifts in structure may be useful as indicators in monitoring schemes.

Puget Sound

FY 1981 was a year of transition for work in Puget Sound (Figure 6), with less focus on field work and more on identifying contaminants of concern and gaining understanding of their biological effects. Surveys were undertaken to identify and describe the occurrence of contaminants of special concern within manageable areas of Puget Sound. The list of chemicals of concern in the Puget Sound region contains 17 substances or chemical groups, including eight kinds of halogenated hydrocarbons, two nonhalogenated groups of hydrocarbons, and seven trace elements. The five of most concern are: chlorinated dibenzo furans (PCDFs), chlorinated butadienes, chlorinated and brominated naphthalenes, several kinds of PAHs, and arsenic. Of these, actual concentrations of PCDFs and chlorinated and brominated naphthalenes have not been determined, although peaks have been

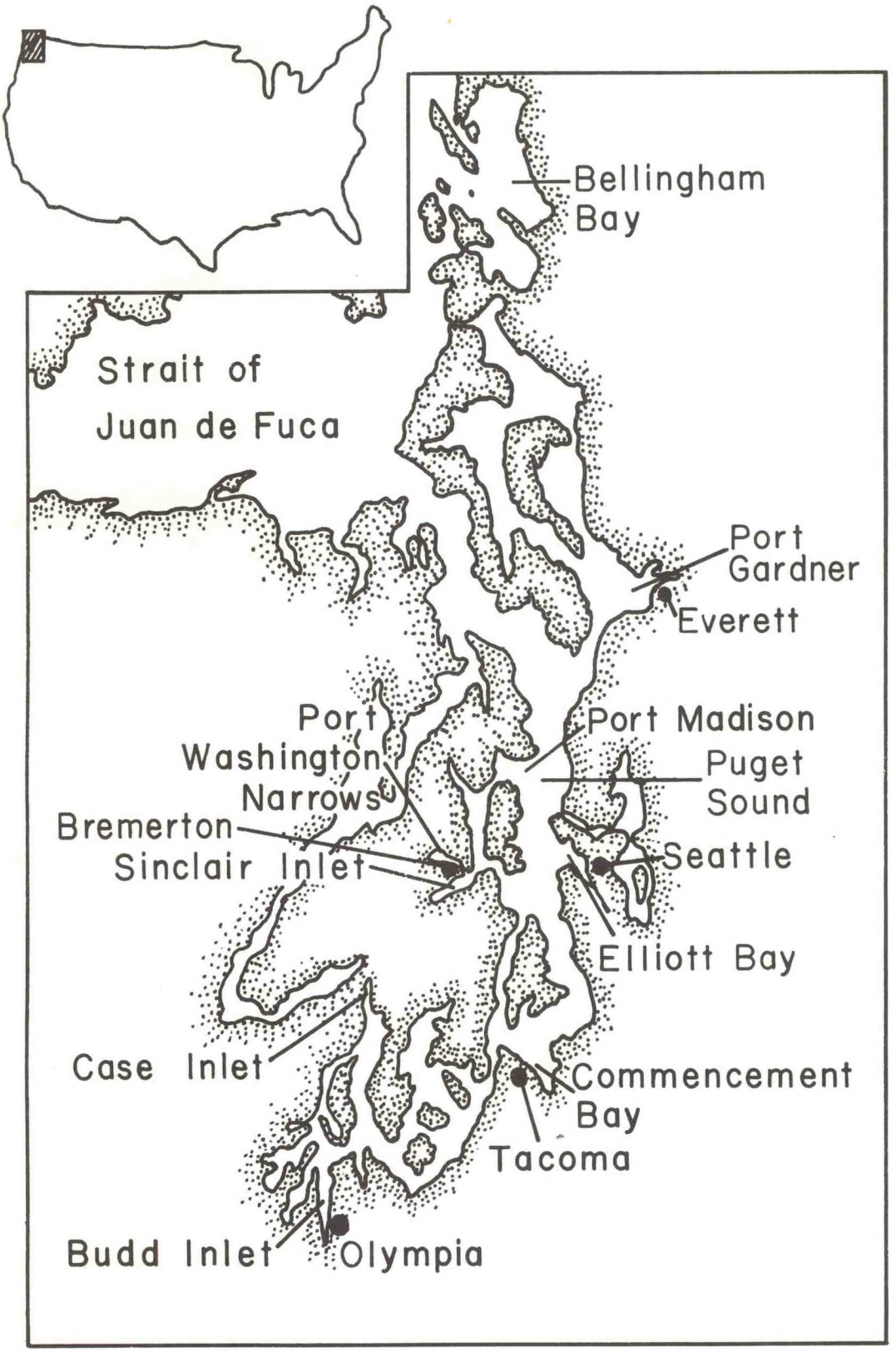


Figure 6. Area Map of Puget Sound

identified. In addition,the synthesis resulted in a list of chemicals that are not of concern in terms of their distribution and toxicity.

Results of surveys and literature reviews indicate that sediments in waterways of Commencement Bay and Elliott Bay contain generally higher concentrations of trace elements, chlorinated hydrocarbons, and petroleum hydrocarbons than elsewhere in Puget Sound. In addition, sediments from these waterways contain hundreds of unidentified hydrocarbons. Relative to organisms from rural areas, polychaetes, clams, shrimp, and crabs from these waterways also contain increased concentrations of trace elements. Two popular sport fish groups, salmon and cod, contain measurable concentrations of PCBs and hexachlorobutadienes; bottomfish contain levels of PCBs that approach within 20 percent of the U.S.F.D.A. guidelines for human consumption. As a result of these findings, local agencies have posted warnings to fishermen in Tacoma.

During FY 1979-81, researchers collected samples of sediments and selected bottom-dwelling fish and invertebrates at regular intervals from urban embayments and non-urban reference areas throughout Puget Sound. Sediment and tissue samples were analyzed for a large number of organic and inorganic chemicals. The findings indicate that hundreds of potentially toxic chemicals are present in Puget Sound sediments from as far north as Bellingham Bay to as far south as Budd Inlet, or virtually all of the Sound and the eastern end of the Strait of Juan de Fuca. Many of the chemicals are also found in a variety of benthic and pelagic organisms. The threat posed to these organisms, or to the consumer, is not known and can only be determined through further research.

Non-Site-Specific/Generic Studies

Modeling studies have been performed to show what effect dumping patterns, biological populations and environmental conditions have on dumping impact. In one model, biologically degradable wastes are dumped into a recirculating gyre at various rates. If a critical waste concentration in the gyre is not exceeded, biological decay of waste will maintain the vitality of gyre waters. However, if biologically induced waste decay is significant, the population can decrease drastically if dumping increases above a critical level. Generally, dumping impact is found to be most severe when the circulation is slow, populations are long-lived, and dumping takes place into a small region. Other kinematic studies show that pollutants ahead of or near a moving eddy can be displaced hundreds of kilometers by the passage of the eddy. These findings may have important implications for the fate of wastes dumped at sites with current regimes similar to the 106-mile site.

A numerical model has been developed to predict the dispersion of suspended and particulate waste. It has been applied to the dispersion of acid iron waste at the 106-mile site, but could be used for any waste dumped into the deep ocean. The model shows that vertical current shear coupled with vertical diffusion is more important for dilution than direct horizontal mixing. Under favorable conditions, dilution to background level occurs in a minimum of 15 days.

Two projects developed a numerical model of sediment quality near an ocean outfall, and developed a model to estimate near field initial

dilution in ocean wastewater discharges from multiple port diffusers. The sediment quality model considered the importance of individual resedimentation episodes showing that resuspension flux depends largely on the probability that bottom currents exceed local resuspension velocity. Observed drogue movements can be explained by mean flux and acceleration and by diurnal and semidiurnal tide fluctuations.

An extensive experimental program to compare the effects of trace metals on a representative selection of marine phytoplankton has shown a great variability in species sensitivities. This leads to the expectation that the major impact of metal pollution in marine waters may be a shift in dominant phytoplankon species. Decreases in primary productivity were found to be reversible after rather prolonged exposure to moderately toxic concentrations. This suggests that gradual dilution of waste material in the ocean will often allow planktonic communities to recover from a transient toxic episode. The iron content of wastes has been found to be important for two reasons. It adsorbs toxic metals and reduces their activity. Also, increased iron concentrations lessen the effects of other metals, since the toxic action of other metals is to decrease an organism's ability to assimilate necessary iron. These factors all mitigate the likely impact of metal toxicity in marine waters. There is no effective toxicity inhibition or reversal, however, at very high toxic metal activities.

Another investigation studied the mechanisms and factors controlling biological accumulation and associated physiological effects of trace metals in seawater. Results indicate that the susceptibility of organisms to poisoning by certain metals may be greater if the organisms are deficient in another metal. Therefore, not only the concentration and chemical form of single trace metal ions, but also various trace metal ion ratios may have to be known to predict toxicity. Experiments with zinc toxicity in a model food chain indicate that fish take up increasing amounts of zinc from water in comparison with that taken up by consuming other organisms when zinc levels are high. Therefore, even though fish do not have their primary normal source of zinc in water, zinc toxicity to fish may be significant when zinc levels are elevated in water.

4. Conclusions and Plans

Ocean dumping work will continue with in-depth studies of specific ocean disposal problems, but will increasingly emphasize process-oriented studies dealing with distributions, transfers and transformations, and biological effects. The products from all of our scientific studies will be used to assist in the development of waste management strategies by both the in-house program staff and through grants and contracts.

Outfall disposal is scheduled to replace deep ocean dumping of pharmaceutical wastes in Puerto Rico by 1982; a major study will be made of the impact of this change. Our dredged material studies will include some efforts at specific important locations such as the New York Bight, but will emphasize broader problems such as contaminant transfer mechanisms and bioaccumulation. Municipal waste impact studies at the

Philadelphia Site will be concluded, and a report will be issued on the cumulative impact of dumping on the region. We will also study two potentially important problems. One is the impact which would result if New York sewage sludge were disposed of at the 106-mile site. This possibility is currently being considered. Another is the impact of the discharge of Orange County, California, sewage sludge through a proposed ten-mile-long pipe terminating at a depth of 300 m. We will continue studies in Puget Sound, focusing on determination of the physical, chemical, and biological processes influencing the transport, fate, and transformation of contaminants in Puget Sound, and on characterization of the biological effects of contaminants of special concern. Special emphasis will be placed on development of the capability to predict and hindcast the movement and fate of contaminants of concern in Puget Sound.

Non-site-specific studies will focus on the following three categories of wastes in priority order:

a) municipal and industrial wastes (from sludges, effluents, and spills)

b) urban and agricultural runoff (from non-point and riverine sources).

c) dredged materials (from maintenance and channel deepening)

Contaminants of priority concern contained in these wastes are synthetic organic compounds, processed petroleum products, biologically active toxic metals, and excess nutrients. Studies related to these wastes will primarily be supported in coastal water bodies and the Great Lakes where flushing rates are low, and in open waters where contaminants are released in concentrated forms (for example, ocean dumping sites and non-estuarine river mouths).

Several major synthesis efforts will be completed during 1982. A comprehensive assessment of the effects of pharmaceutical waste dumping at the Puerto Rico dumpsite will be issued as a special dumpsite evaluation report. The proceedings of the Second International Ocean Dumping Symposium, held in March 1980, will be published by Wiley-Interscience. A Comprehensive Ocean Dumping Bibliography will be completed and published during 1982. In addition, we will complete a comprehensive analysis of the distribution of cycling of carbon, oxygen, and nitrogen in the New York Bight including the influence of waste disposal and other human related and natural factors. We will also publish a bibliography on pollution aspects of the Hudson-Raritan Estuary and reports on contaminant inputs and water quality in the Estuary.

B. MARINE MINING

1. Introduction

Oil and gas extraction, sand, gravel, and shell mining, and deep-sea mining are Outer Continental Shelf (OCS) activities which cause

concern with regard to marine pollution. Of these activities, oil and gas extraction has received the most attention and research effort within the Federal Government. In addition to public concerns about oil spills, research has been prompted by the National Environmental Policy Act (NEPA) and OCS Lands Act (OCSLA). Most of the concern has been focused on three topical areas:

a) The potential impact of OCS development in coastal areas (e.g., increased populations, marine transport, and facilities and construction siting).

b) The effects of OCS exploration and production activities on the marine environment (i.e., chronic spillage of contaminants, structures, noise, people, etc.).

c) The likelihood of accidental spills or well blowouts and their potential impacts on marine resources.

Within OMPA, the bulk of the OCS oil and gas-related research has been focused on the Puget Sound and Alaska regions. During FY 1975-79, the MESA Puget Sound project conducted a five-year environmental assessment of northern Puget Sound and the Strait of Juan de Fuca. EPA provided funds for the work, which addressed concerns about increased petroleum transfer and refining activities in the region. Although the work is complete, some of the reports and data are still being prepared for publication.

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) was established in 1974 by a basic agreement between the Bureau of Land Management (BLM) and NOAA to conduct a program of environmental research for Alaskan OCS areas identified for potential oil and gas development. BLM continues to provide funding for the NOAA-managed program, which was initially part of NOAA's Environmental Research Laboratories (ERL), but became part of OMPA in 1978. In addition to its management role, NOAA has continually contributed a significant amount of logistical support for OCSEAP in the form of vessels and aircraft. OCSEAP is managed by OMPA's Alaska Office located in Juneau.

The primary goal of the Alaska program is to provide scientific information in a timely manner for management decisions relating to OCS oil and gas leasing on the Alaskan continental shelf. The proposed lease areas, extending from the Northeastern Gulf of Alaska in the south to the Beaufort Sea in the north, are shown in Figure 7. To achieve this goal, information must be available on those aspects of the environment that might be impacted by OCS oil and gas exploration and development; a basis for predictions of impacts must be established; and impact data influencing leasing stipulations, operating regulations, and OCS operating orders must be acquired. Five generic tasks--contaminant baselines, environmental hazards, pollutant transport and fate, living resources, and effects--form the core of the program. Research units are determined annually for each lease area in collaboration with BLM and according to special information needs and timing requirements for specific leasing decisions.

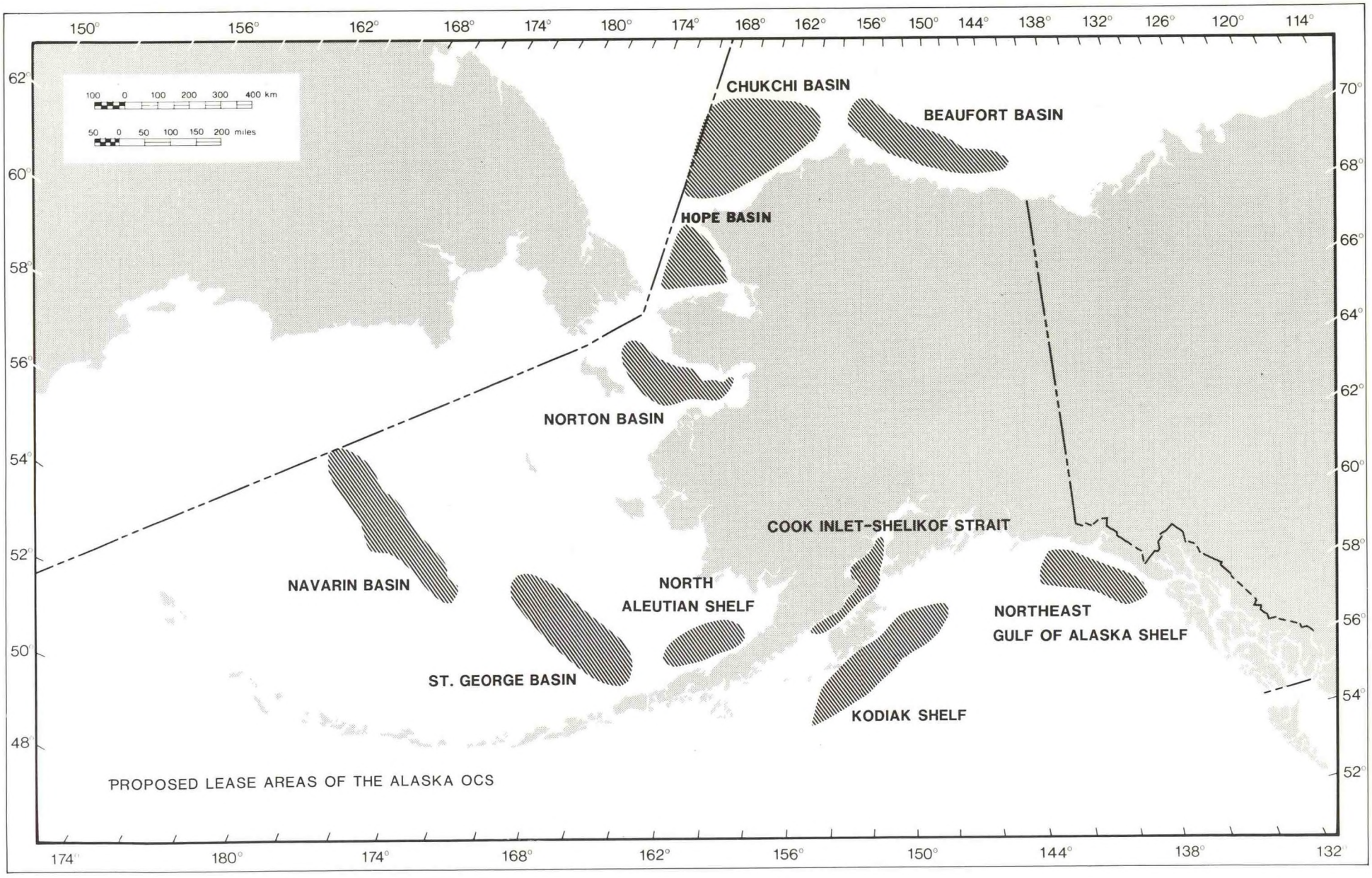


Figure 7. Proposed Lease Areas of the Alaskan Outer Continental Shelf

2. Priority Activities

Significant program changes and adjustments to the Alaska program occurred in FY 1981 as a result of policy decisions by BLM and funding availability. Environmental studies in the Gulf of Alaska were concluded, with monies allocated only to complete the remaining few projects. The level of research activity in the Bering Sea in FY 1981 was relatively high in anticipation of information needs for a number of decision points in the near future, especially those related to the proposed lease sales in the St. George Basin, Northern Aleutian Shelf, and Navarin Basin. Also, a policy decision by the Department of the Interior to discontinue geological studies brought about the conclusion or abrogation of such work in all Alaskan areas. (Three research units will be funded in FY 1982 for the completion of activities). The latest proposed accelerated OCS leasing schedule (Figure 8), which offers more sales, larger acreages of individual sales, and a streamlined leasing policy, has forced a reevaluation of study plans and priorities. New areas are being offered and lead times before sale decision points are much shorter, thus necessitating a less focused study approach and emphasizing acquisition of information that addresses exploratory stage issues. In parallel with such broad-scale reconnaissance studies, some long-term investigations directed toward the resolution of more generic issues, such as the weathering and fate of petroleum and effects of contaminants on organisms, are being pursued.

3. FY 1981 Accomplishments

Gulf of Alaska

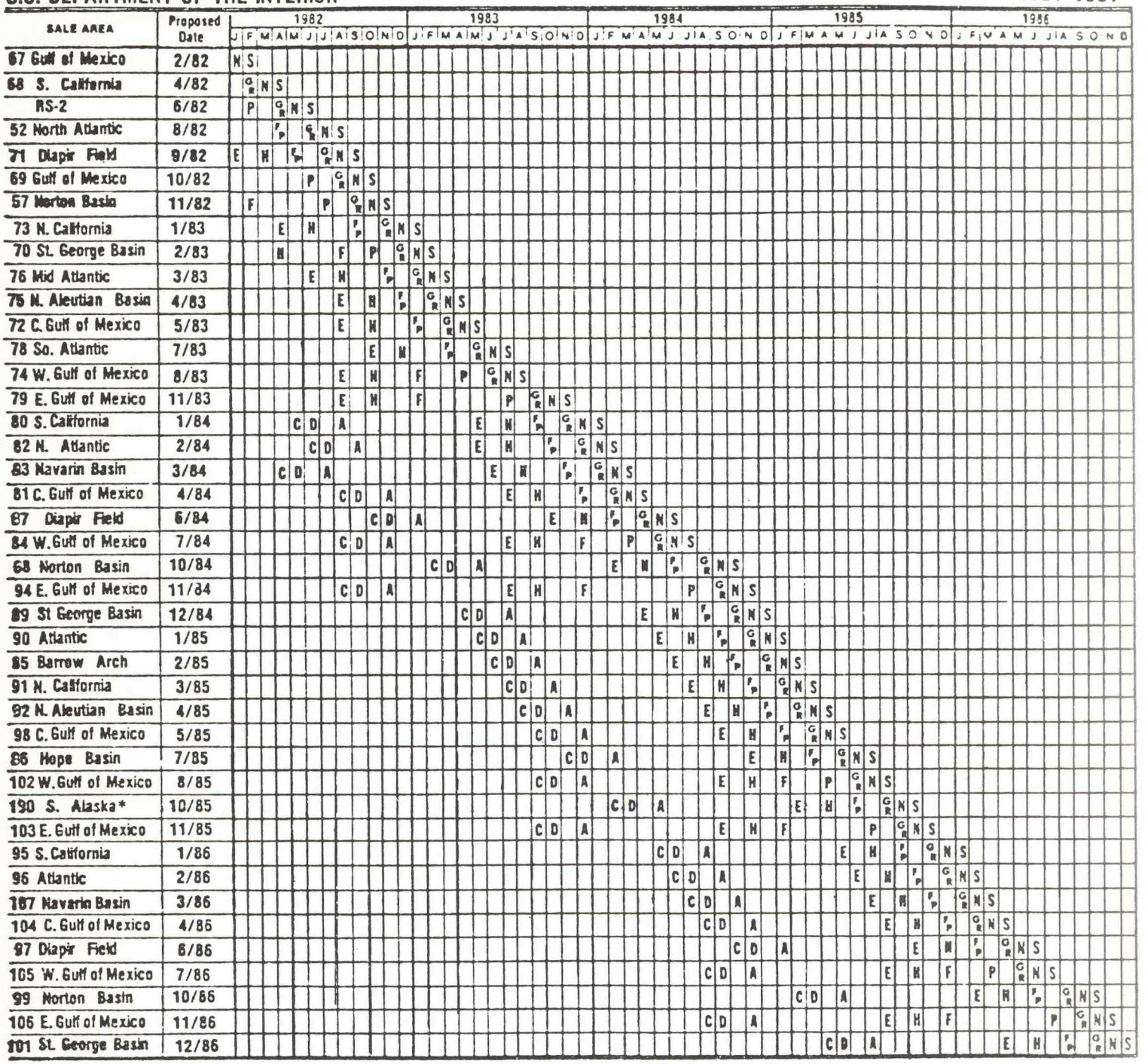
As noted above, FY 1981 was largely devoted to the completion of ongoing research in the Gulf of Alaska. Contaminant baseline studies were concluded with the receipt of two final reports that document the generally pristine nature of the waters and surficial sediments of the Gulf of Alaska with respect to petroleum hydrocarbon loads.

Environmental hazards research that has focused on seismicity, volcanism, faulting, and unstable sediments in this geologically very active region is now in a wind-down mode. The three seismic networks supported by the Alaska program continued monitoring, but the investigators are reducing their activities in anticipation of termination in FY 1982. A major effort in the Gulf involves the development of a seismic risk model and its application to the region. The state-of-the-art model employs a combination of Poisson and semi-Markov statistical procedures to characterize earthquake activity. The development of the model required considerable involvement of other investigators studying the regional seismicity. The initial application of the software to the Gulf of Alaska was nearing completion at the end of FY 1981.

Reconnaissance studies of volcanoes on the eastern end of the Alaska Peninsula were conducted in summer 1981. The results of this work will be reported in FY 1982, as will the results of monitoring of volcanoes on the western end of the peninsula.

PROPOSED 5-YEAR OCS OIL AND GAS LEASING SCHEDULE

U.S. DEPARTMENT OF THE INTERIOR — **JULY 1981**



C - Call for Information
D - Information Due
A - Area Identification
E - NEPA Document
H - Public Hearing
F - NEPA Document
P - Proposed Notice of Sale
G - Governors' Comments Due
R - DOE Review
N - Notice of Sale
S - Sale

* includes Cook Inlet, Shumagin, Kodiak, Gulf of Alaska

Figure 8. Leasing Schedule

Reconnaissance surveys of faulting and unstable sediments in Gulf of Alaska lease areas were completed in 1980, and 1981 activities emphasized analyses of the data. Final reports on results of work in Shelikof Strait and the Yakutat area are currently in preparation, as are reports on the geotechnical properties of sediment cores obtained in those areas.

The only pollutant transport investigation in the Gulf of Alaska in FY 1981 was in the Yakutat area, where nearshore sampling was conducted in fall 1980 and spring 1981. Initial results of this work suggest no persistent inshore current comparable to those in the northern Gulf is present in fall, likely due to the absence of large amounts of freshwater runoff. Major flow events coincided with the passage of strong storms. A final report on circulation and water masses in the Gulf of Alaska, presenting results of work done in 1980, concludes that coastal freshwater discharge for southeast and south coast Alaska is slightly greater than that from the Mississippi River. Because the discharge is many small streams, its magnitude has been overlooked as a major freshwater source. The freshwater discharge is speculated to be an important influence on the circulation of the Alaska current.

A major oil weathering study involving field and laboratory experiments to aid in the development of algorithms for a functional predictive model continued at the NOAA Kasitsna Bay facility in lower Cook Inlet. The experiments in progress are intended to evaluate residence times of oil in intertidal sediments, microbial degradation of oil, and long-term oil slick weathering under ambient conditions. An associated investigation in a low energy, subtidal environment in lower Cook Inlet concluded that sediment supplemented with 50 ppt fresh or weathered crude oil showed no measureable microbial activity or removal of petroleum hydrocarbons after one year and that spills delivering more than 1 ppt to the benthos in such environments will be detectable for more than one year. An investigation of marine algae-oil interactions showed that certain marine diatom species collected from Kachemak Bay can oxidize napthalene and that the capacity for oxidation of aromatic hydrocarbons is a general feature of the microalgae.

Two studies on the fate and effects of drilling muds and cuttings, initiated in response to a suit brought against the Department of Interior by the English Bay Native Corporation, concluded that the likelihood of significant impacts to commercial shellfish species from muds and cuttings discharges into lower Cook Inlet is remote, due to the prevailing high energy hydrodynamic regime of the inlet which would cause rapid dispersion, the relatively low chemical and physical toxicity of the muds, and the brief exposure time of larvae to significant concentrations.

A number of results of avian studies in the Gulf region were reported in FY 1981. A feasibility study of the use of Fork-tailed Storm Petrels as regional indicators of petroleum contamination demonstrated that the analyses developed to detect petroleum hydrocarbons in regurgitations are practical and unequivocal and that the field data obtained indicate a correlation between the timing and magnitude of oil slicks in the study area and the frequency of petroleum hydrocarbons in

the samples. A one-year investigation of seasonal bird use of coastal habitats adjacent to the Yakutat lease area was completed. In regard to avifauna, the Yakutat Forelands have a number of unique and significant qualities, including perhaps the world's largest Aleutian Tern colony, one of North America's largest concentrations of bald eagles in late winter, and the seasonal presence of a major fraction of the Alaskan Trumpeter Swan population. A comprehensive final report on seasonal density distributions, critical habitats, migratory routes, and breeding locales of marine birds in littoral and estuarine habitats of south-central Alaska was submitted. The results of 33 aerial surveys conducted in 1975-78 are presented in the report, which encompasses the entire Gulf of Alaska region and the southern Bering Sea coastline north to Cape Newenham. Also received in FY 1981 were a final report on the winter feeding ecology of seabirds in Kachemak Bay, lower Cook Inlet, and a doctoral thesis on the ecology of Southern Hemisphere shearwaters, which are the most abundant marine birds in Alaskan waters from spring through autumn.

The sole endangered species investigation active in the Gulf in FY 1981 involved analysis of data on whale distributions collected during the summer of 1980. Humpback and fin whales were found to be sparsely distributed throughout the shelf waters of the Gulf, with some minor aggregations observed in Yakutat Bay, around Middleton Island, in Prince William Sound, and around the Barren Islands. Total population estimates for humpback and fin whales in the survey area were 306 and 159 animals, respectively.

Two critical habitats and ecosystems-related investigations concluded work in FY 1981. A final report was received on the environmental sensitivity of coastal habitats in the Shelikof Strait region encompassing the recent OCS lease sale. Also submitted was a literature and data review of Alaskan corals. It appears that the commercially valuable Primnoa species are largely restricted to the Gulf of Alaska and that their habitat requirements are such that they are unlikely to be adversely affected by OCS oil and gas activities.

Bering Sea

As with the Gulf, the two now completed hydrocarbon baseline studies in the Bering indicate that the region is in essence, pristine.

In addition to geologic hazards studies, sea ice investigations comprise an element of the environmental hazards investigations in the Bering Sea. Sea ice investigations have been conducted by both remote sensing and field surveys. Recent results of satellite imagery analyses of ice velocity vector fields showed many occasions when average ice velocities were in the range of 30-50 cm/sec, thus indicating that the mode of brittle compressive failure between sea ice and any offshore structure should be taken as the limiting applicable design case in the Bering Sea. Ice thicknesses of as much as 10 m were reported for grounded annual ridges north of St. Lawrence Island, and such ridges may be expected to be carried into the Norton Sound region during breakup. Although the degree of consolidation of annual ice ridges in the Bering Sea has not been examined on a statistical basis, it appears that multiple rafted and consolidated thicknesses may be 3 m or more. Of

particular interest is Fairway Rock; this island is located in 50 m water depth in Bering Strait. An ice foot of maximum height 14.7 m was observed around the island, which is 350 m in diameter. The ice foot was believed to be grounded on the seafloor. Also, thick glaze ice attributable to spray extended to a height of 40 m above sea level on the rock face of the island, thus implying similar accumulations of spray ice can be expected to occur on structures or vessels in the northern Bering Sea. An analysis of the ice forces against Fairway Rock indicates maximum ice pressures of 3000 kPa (crushing) and 414 kPa (flexural), with the latter being the most likely failure mode.

Geologic hazards investigations in the Bering are comprised of seismic monitoring and reconnaissance surveys of seafloor faulting and unstable sediments. Seismograph networks in the Norton Sound--Kotzebue Sound region and in the southeastern Bering Sea reported no major earthquakes, although the former network identified clusters of epicenters running parallel to mapped structural trends that may be indicative of active faults. A second field season of geological-geophysical surveys was completed in the Navarin Basin area. Preliminary results suggest the Navarin Basin is relatively aseismic, although there may be some active faulting. Other potential hazards identified include submarine slides, sediment waves and gas-charged sediments.

Pollutant transport investigations are at a relatively mature stage in the eastern Bering Sea. Relatively little work is of a reconnaissance nature; the bulk of the Alaska program efforts are concentrated in process studies and circulation modeling. The North Aleutian Shelf Transport (NAST) study, an interdisciplinary study of pollutant transport mechanisms in the southeastern Bering Sea, completed all field work. A comprehensive final report is in preparation. The general circulation model, previously encompassing the southeastern Bering Sea and Norton Sound areas, was reconfigured to include the Navarin Basin and the Chukchi Sea and, in addition, now can incorporate ice cover. The results of several field studies were reported. Preliminary current meter data from the Navarin Basin during the winter period of ice cover confirms the presence of flow parallel to the shelf break there and the generally weak flow found in the southeastern Bering Sea. In the latter area, near-surface currents in the nearshore zone along the Alaska Peninsula were found to be southwesterly for long periods, contrary to the usual notion that they are generally northeasterly.

Due to the importance of winds as driving forces of spilled oil, studies in the Bering Sea have continued to refine this information base. Historic pressure records have been adequate sources of wind statistics except near certain coastlines and near the ice edge. A significant field effort in March 1981 was devoted to resolving the uncertainties about forecasting winds near the ice edge; the resultant data will increase the precision of such forecasts.

Three major final reports on seabird research were completed in FY 1981. One presented a comprehensive overview of a multiple-year study of the reproductive ecology, productivity, growth rates of young, food habits, and foraging areas of seabirds nesting on the Pribilof

Islands. Another statistically evaluated the seasonal pelagic distributions of dominant seabird species in the eastern Bering Sea and presented estimates of probability of encounter with spilled oil. High risk areas were Unimak Pass, along and inshore of the 50 m isobath in Bristol Bay, along the shelf break, and near the major colonies. Also pertinent was a coastal bird usage study (mentioned in the Gulf of Alaska section), which highlighted the importance of the northern Alaska Peninsula for a number of species of gulls, geese, shearwaters, seaducks, and shorebirds.

Field studies on walrus yielded three significant findings: (1) the major function of the St. Lawrence Island and Bristol-Kuskokwim Bay concentrations is mating; (2) the end of the breeding season was identified as early March; and (3) a decline in the physical condition of the walrus population since the early 1970s was documented as attributable to increased population and reduced food supply.

The characterization of the environmental sensitivity of coastal habitats in the Norton Sound/Yukon Delta regions, the Pribilof Islands, and Bristol Bay was a FY 1981 activity. A final report was submitted on the first two areas, while field work was performed in the Bristol Bay area.

Arctic Ocean

Arctic Ocean oil and gas-related studies are in many ways distinctive from those in the Bering Sea. Current research in the region places heavy emphasis on ice and permafrost studies and is more geographically restricted to the coastal fast ice zone than is the case in the more temperate Bering.

A number of significant results of sea ice investigations were reported in FY 1981. A major accomplishment was the completion of a detailed statistical analysis of ice gouges in the seafloor, enabling the design depths for subsea pipelines in the Beaufort Sea to be accomplished on a sound probabilistic basis. Fall storms and the formation of frazil ice have been clearly indicated as the cause of sediment-laden ice. The sediment-laden ice is significant as it greatly reduces sunlight penetration and, concommitantly, photosynthesis under the ice; it also is a significant mechanism of sediment transport and alters the sea ice melting rate the following spring. Grounded ice has been found to act passively to intensify current flow, resulting in scour depressions up to 3 meters deep and tens of meters across. Ice pounding in a seaway at the frequency of wave periods generates oscillatory currents which also produce such features. It has been determined that the rich biological communities associated with boulders in Camden Bay are the result of the protection from ice afforded the habitat by barrier spits and bars and sufficient water depth. Efforts during FY 1981 on the mechanical properties of ice were mainly analytical. Draft reports on the fracture toughness of sea ice and a method for strain measurements were completed.

The permafrost program is nearing conclusion. Field measurements have been obtained from a number of locations in the Beaufort and Chukchi Seas, as well as Norton Sound. In the Harrison Bay (Sale 71)

area, bonded permafrost is generally deeper than 40 m and probably extends at least 25 km from shore. Studies of permafrost on offshore islands indicated that those which are former land remnants are underlain by continuous ice-bonded permafrost. Some islands appear to be composed of sediments containing ice, but fall short of being ice-bonded and do not have high seismic velocity. Ice-bonded permafrost near the sediment-water interface in fine-grained soils was detected in the Beaufort Sea near Lonely, while in the Chukchi Sea near Icy Cape, ice-bonded materials are indicated at several locations within a few hundred meters of shore in water depths of 5 m or less. Sediment temperature measurements at several locations in Norton Sound and the presence of positive temperature gradients indicate that subsea permafrost is absent over most of Norton Sound. Data taken near Barrow and at several Chukchi Sea locations indicated secular seabed warming; the presence of ice-bearing material is uncertain in these areas.

A model for sea level history in the Sale 71 area was developed based on fossil foraminifera and ostracodes obtained from offshore borehole samples. In the eastern Beaufort, data developed from a number of studies indicate that the area between Camden and Pokok Bays is undergoing active uplift and that shorelines about 80,000 to 120,000 years old have been uplifted at least several meters and probably much more. On the shores of Camden Bay the deepest and presumably oldest peak is about 9,500 years old; this sets the upper limit on the age of the land-derived organic detritus available to detritivores.

Pollutant transport studies in the Arctic in FY 1981 included a mix of field and modeling investigations. Seasonal data on wind fields in the Harrison Bay (Sale 71) area showed mesoscale correlations at several stations around the Bay and, with the exception of sea breezes on some days, excellent correspondence between the surface winds and geostrophic winds. The results imply a high degree of confidence can be placed in the wind fields used as input for coastal current trajectory determinations. Weather stations were installed in the Chukchi Sea in FY 1981 to obtain data for similar applications in that region.

Shelf circulation investigations in the Harrison Bay area in summer 1980 showed that under prevailing easterly winds a variable current structure with generally westward drift dominates. A two-layer system, with warm, brackish Colville River water overlying cold, more saline oceanic water along the 6 m isobath, is formed. However, under strong westerly storm conditions, the vertical structure is destroyed and Colville River water becomes trapped in Harrison Bay, resulting in considerably lower salinity, if the westerly winds persist. Oil spill scenarios were generated and modeling of summer oil spills accomplished for the Harrison Bay area.

A series of twelve oil spill scenarios based on hypothetical oil spills in the Prudhoe Bay area was generated. The study indicated that oil spilled in winter in the Prudhoe Bay area will be trapped by under-ice relief and quickly encapsulated. Release to the water and significant transport will occur during spring breakup.

A final report was completed on the results of field measurements obtained in 1975-80 from depths of 27 to 225 m on the Beaufort Sea shelf. The influx during summer of warm Bering Sea water eastward at least as far as Barter Island was noted. Upwelling events from offshore depths of 200 m or more were also observed. The results of this work indicate the water of the Beaufort Shelf must be considered part of a global circulation including the Bering Sea, Arctic Ocean, and North Atlantic Ocean when considered over time intervals of a month or more.

A recent focus of fisheries-related studies in the Arctic has been on the arctic cisco, a species for which a small commercial fishery exists on the Colville River and which also is used for subsistence by arctic residents. Investigations are underway to determine the cause of a large decline in the apparent abundance of the species since 1976 and concurrently to locate the cisco's spawning grounds. Temperature preference experiments conducted in 1981 suggest the spawning fish may seek warm water seeps in the upper reaches of streams emptying into the Colville. A further study on arctic and least ciscos evaluated the potential barrier effect of the 2.9 km long ARCO Causeway on fish migration along the coast. Tag return data suggested no disruption of migration occurred.

A significant effort was directed toward ringed seal studies in the Beaufort region. In the Harrison Bay-Prudhoe area, summer trophics investigations showed that the seals were not distributed in response to local abundance of nektonic crustaceans, but rather were preying almost exclusively on arctic cod. A similar finding resulted from sampling in the Beaufort Lagoon area near the Canada/U.S. border. During the late winter-spring period, investigations of the response of ringed seals to seismic testing were conducted to obtain definitive data on possible displacement of the seals from areas where such activity occurs.

A seabird-ice interaction investigation conducted over the past few years in the offshore Beaufort has produced an important conclusion. Apparently biological events in the Beaufort are correlated with intrusions of Bering Sea surface waters. When the waters turned eastward at Point Barrow, increased feeding by seabirds and improved reproductive success at western Beaufort colonies occurred. These intrusions probably determine and explain a number of other variable phenomena including marine mammal distributions and zooplankton densities.

The Steffansson Sound "boulder patch" has been a focal point of a multidisciplinary research effort involving biologists, geologists, and oceanographers for several years. Numerous findings have resulted from the investigations. Growth rate measurements of the brown alga, Laminaria solidungula, demonstrated that this kelp accomplishes 90 percent of its linear growth during the darkness of late winter under the ice by mobilizing carbohydrate reserves stored in older blades during the light period of the previous summer. Recolonization experiments show (after three years) none of the indigenous brown algal species has successfully reestablished itself on the experimentally denuded substrates. Evidence is now becoming more persuasive that the boulder-based macrophytes contribute to a locally important food web

with the preliminary finding that kelp-fixed carbon is mobile to at least the stage of mysid shrimp, as reflected by the animal's carbon isotope signature, which is similar to that of Laminaria.

Non-Site-Specific Studies

Laboratory investigations of the lethal and sublethal effects of exposure to oil and oil components on marine organisms have been conducted for several years. A considerable amount of information has been accumulated. Research activities in FY 1981 were concentrated in four areas:

1) Disease Resistance. Juvenile flat fish exposed to crude oil-impacted sediments for periods up to six weeks showed no change in disease resistance as measured by laboratory challenge with a pathogenic bacterium.

2) Behavior. Exposure of chum salmon fry to the seawater soluble fraction of crude oil altered consumption of the oil-exposed prey by coho predators. Exposure of the coho salmon predators consistently reduced the number of prey consumed. Preliminary results suggest that it was not the parent petroleum hydrocarbons that were primarily affecting the coho's predatory behavior, but rather metabolites of these hydrocarbons.

3) Metabolism. Flatfish exposed to benzo[a]pyrene (B[a]P) in oil-contaminated sediment take up and readily metabolize the hydrocarbon. A number of mutagenic and carcinogenic metabolites were identified in the liver; some of the toxic compounds were bound to cellular macromolecules (e.g., DNA and protein). Also, B[a]P tends to remain largely unconverted in sediment and thus can be available for continued uptake by benthic organisms. Continued uptake, greater retention, and more extensive metabolism of B[a]P than naphthalene (NPH) by benthic fish indicate that, although B[a]P is a minor component of petroleum, its derivatives can be bioconcentrated in tissues of demersal organisms. The substantial bioconversion of B[a]P in fish liver probably explains why B[a]P is usually not detected in fish tissues even when considerable concentrations of B[a]P are detected in the environment of the fish.

4) Physiology (Growth). Embryos and larvae of chum salmon, pink salmon, English sole, sand sole, and surf smelt were exposed to seawater soluble fractions of crude oil in laboratory regimes which were designed to simulate natural conditions. Concentrations of 100 to 500 ppb of oil typically induced high mortalities, abnormalities, and pathologies in the exposed fish, indicating that the ability of these organisms to survive similar oil exposure in the natural environment would be severly reduced.

4. Conclusions and Plans

The management and organization of OMPA's Alaska Office were adjusted in late FY 1981 in anticipaton of further reductions in the OCSEAP budget in FY 1982 and of changes in the OCS studies program. The role of the Arctic Office was also significantly altered. Managerial responsibilities were considerably reduced and emphasis placed on provision of scientific expertise and technical support in the form of consultation in the areas of ice physics and engineering, sea ice distribution, hazards associated with permafrost, and technical guidance to the program's principal investigators. Responsibility for all Arctic logistics was given to the Juneau Office; the Fairbanks logistics staff position will be terminated February 1, 1982.

As noted earlier, in FY 1982 the Alaska program will emphasize research in the Bering Sea and Arctic Ocean to meet the needs of the proposed leasing schedule (see Figure 8). Four Bering areas will be studied: Norton Sound (Sale 57), St. George Basin (Sale 70), North Aleutian Shelf (Sale 75), and Navarin Basin (Sale 83). A number of FY 1982 projects will span many or all of these lease areas, either geographically or in generic applicability. Among these are new studies on endangered whales, ongoing belukha whale and walrus investigations, circulation and pollutant transport modeling work, the oil weathering investigation, new effects studies on waterfowl and commercial shellfish species, and finally, sea ice research.

Relatively little research will occur in the Norton Basin in FY 1982, as the information base for that area is fairly good and the Draft Environmental Impact Statement (DEIS) has been published. The aforementioned field studies of belukhas, walrus, and sea ice will be active; however, most of the other work will rely on existing data. In the St. George Basin, further work on oil transport will take place and new studies on benthic ecosystems are planned. FY 1982 will be the final year of geological hazards studies (as in the other Alaskan areas). The North Aleutian Shelf area is a recent addition to the leasing schedule; therefore, the available data base is not adequate. In FY 1982, the pollutant transport research of the interdisciplinary NAST study will be concluded. It is anticipated that the results of this study together with spilled oil trajectory predictions and oil weathering data will adequately describe probable landfalls and fate of oil in this extremely important and controversial lease area. A new investigation will use the sea otter as a focus for the characterization of nearshore habitats at selected sites along the Alaska Peninsula. In the huge Navarin Basin lease area, existing environmental data are few and scattered. In addition to the inter-area walrus, whale, ice, and transport studies mentioned above, limited field efforts will be directed toward seabirds in the basin in FY 1982. The planned pollutant transport predictions are notable because they will incorporate seasonal ice cover and the unique hydrographic conditions associated with the marginal ice zone.

OCSEAP Arctic research in FY 1982 revolves around five areas: the joint Federal/State lease areas (Bf, sold December 1979); the Beaufort Sale 71 area (scheduled for September 1982); the Chukchi Sea (Sale 85,

scheduled for February 1985); Hope Basin (Sale 86, scheduled for July 1985); and an as-yet-undesignated eastern Beaufort Sea region adjacent to the Canadian/U.S. border.

A modest level of effort will continue in the Bf sale area near Prudhoe Bay; it consists of studies of seismic disturbance of ringed seals, final analysis of winter ecological processes, and assessment of risks to the Steffansson Sound "live bottom" community. These studies have applicability to other arctic lease regions. In FY 1982, the focus of research in the Sale 71 area will be in Harrison Bay, just west of Prudhoe, and will consist of filling some information gaps via additional work on sea ice, ice-inhabiting biota, permafrost, oceanography, and trajectory modeling.

The Chukchi Sea (Sale 85) environment is relatively unknown. Little was done there by the OCSEAP until FY 1981. FY 1982 is the last full year of studies that can be used for input to the DEIS for Sale 85. Planned field studies consist of permafrost investigations, selected ice hazards assessments addressing shore processes and ridging, nearshore and offshore transport studies, and biological investigations of walrus, belukha whales, and anadromous fishes.

The Hope Basin (Sale 86) area is better known than the Chukchi area. However, little work has been done there since FY 1978 and most of the available information is of a reconnaissance nature. Limited research efforts are proposed for the region in FY 1982; field work will be directed toward belukha whales and walrus, as well as some effort on pollutant transport and ice hazards in the area.

The most recent OCS leasing schedule and five-year leasing plan imply that the eastern Beaufort Sea will soon be proposed for leasing, especially in view of the high estimates of petroleum and industry interest in the region. Therefore, the Alaska Office and BLM have planned an integrated research project focused on the vicinity of Beaufort Lagoon in anticipation of the need for environmental information from that region in the near future. The project's content and objectives, developed at an Arctic Systems Workshop held near Fairbanks in autumn 1981, includes a number of physical, biological, and ecological components.

C. MARINE ENERGY

Over the past few years, costs of imported and domestic oil and gas exploration and development have increased. As a result, alternative energy technologies in the oceans have received considerable attention as a potential energy source. Among these, Ocean Thermal Energy Conversion (OTEC) has the greatest potential for producing usable amounts of energy in the foreseeable future. Research and development in other ocean energy technologies have focused on ocean winds, currents, tides, waves, salinity gradients, and biomass conversion; however, these efforts have been limited.

In FY 1981, OMPA had no activities that directly responded to pollution caused by use of the oceans for alternative energy sources.

However, it is recognized that this will be a growing concern. Therefore, OMPA will review the OTEC environmental issues on a case-by-case basis and, if appropriate, will conduct studies to be useful for OTEC management requirements.

D. MARINE TRANSPORTATION

Pollution resulting from marine transportation can enter the environment in two ways: (1) intentionally as a result of routine operational discharges, and (2) unintentionally as the result of accidental spills. The National Marine Pollution Plan divides discussion of these two causes of pollution and addresses 2 above, unintentional spills, under the section entitled Accidental Discharges of Oil and Hazardous Materials. Based on this division of issues, OMPA had no activities in FY 1981 that directly responded to pollution caused by marine transportation. However, OMPA does address marine pollution resulting from marine transportation in a peripheral sense through its OCSEA program by providing scientific information for management decisions necessary to protect the Alaskan marine environment from excessive adverse impacts during oil and gas exploration and development. OCSEAP studies relating to marine transportation fall into two categories: (1) pollutant transport, weathering, and transformation occurring as a result of accidental petroleum spills, and (2) a series of environmental sensitivity indices which focus on the physical and biological responses of coastal environments to spilled oil. Many of the results from these studies are directly applicable to operational discharges. These studies are described in Section III-B, Marine Mining.

E. ACCIDENTAL DISCHARGES OF OIL AND HAZARDOUS MATERIALS

1. Introduction

Substantial amounts of oil and hazardous materials enter the marine environment as a result of accidental spills. Although the focus in the past has been on the cleanup and mitigation of spilled oil, national interest has been shifting toward hazardous materials as the cause of most immediate concern. Much has been learned in the past ten years about how to respond to oil spills; far less is known for spills of hazardous materials. Unlike oil, whose properties are fairly uniform, hazardous materials have a wide variety of physical and chemical forms, complicating and making much more difficult the response necessary for their cleanup and disposal.

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the principal Federal mechanism for operations pertaining to the identification, prevention, containment, and cleanup of oil and hazardous substance releases. Three principal operational components are identified in the NCP: the National Response Team (NRT), the Regional Response Team (RRT), and the On-Scene Coordinator (OSC). The NCP establishes national and regional response policy, organization, structure, and responsibilities of Federal agencies and other response organizations. Major responsibilities are given to the Environmental

Protection Agency and the Departments of Transportation, Commerce, Interior, and Defense.

NOAA represents the Department of Commerce on the RRT, and, within NOAA, OMPA has the responsibility of providing members for each coastal team. Four OMPA scientists and one from the Great Lakes Environmental Research Laboratory currently represent NOAA on eight RRTs. These RRT members are primarily responsible for development of NOAA's regional response contingency plans, stating NOAA's concerns and policies during response activities and requesting additional participation from other main line components (i.e., National Marine Fisheries Service) during spill emergencies.

The management of OMPA's RRT responsibilities has been assigned to OMPA's Hazardous Materials Response Project (HMRP). In coordination with EPA and DOI, HMRP has established six regional Scientific Support Coordinators (SSC) who can provide scientific and technical assistance both during spills and non-spill situations.

The major objective of the SSC is to increase the Federal Government's ability to respond to a spill by improving coordination, planning, and execution of the scientific response effort. SSCs provide close interaction among Federal On-Scene Coordinators (OSCs) and regional and national scientific resources. Such interaction can be critical in the protection of the environment when decisions are made concerning the containment of a pollutant, the strategy and method of cleanup, and the timing of operational activities.

As part of the spill response process, OMPA's HMRP provides for outside scientists to undertake in situ research on a non-interference basis with operational activities. Knowledge gained through studies of the behavior and effect of a pollutant, while perhaps not of immediate benefit in a given incident, increases the ability to improve the effectiveness of the measures taken to mitigate environmental impact in subsequent spills.

During non-spill periods, SSC efforts are directed toward preparing regional contingency plans, identifying vulnerable natural resources, and establishing contacts with the local scientific community.

In addition to OMPA's spill response activities, OMPA's OCSEA program addresses the transport and transformation of accidental or regulated discharges of contaminants associated with OCS oil and gas development. The potential for a large oil spill is considered the most detrimental aspect of petroleum development to the regional environment. There are definitive probabilities of spills from tanker accidents, pipeline rupture and spillage, well blowouts and other operational mishaps. In addition, various types of effluents and emissions associated with normal operations, if not dissipated or advected quickly, degrade regional air and water quality and may have harmful effects on the biota.

OMPA's activities relating to accidental discharges therefore fall into three categories: (1) spill response, (2) damage assessment, and

(3) pollutant transport, weathering and transformation. The following discussion describes OMPA's activities in these three categories. Additional information on OCSEAP's overall program can be found in Section III-B, Marine Mining.

2. Priority Activities

a. Spill Response

During spill incidents, the Scientific Support Coordinator (SSC) serves as the liaison between the OSC and the scientific community. The following describes the priority activities provided by SSCs at each spill event:

Trajectory analysis: The Modeling and Simulation Studies (MASS) group of OMPA provides forecasts of pollutant transport, dispersion, and dilution. On-scene observations and measurements of current movement and pollutant location are made to support the forecast effort.

Chemical hazard assessment: The University of New Orleans, under OMPA contract, coordinates an effort to provide interpretation and synthesis of toxicological, environmental, and analytical chemical information. This information is used to evaluate the fate of chemicals in the environment and the human and biological risks associated with their release.

Environmental sensitivity analysis: The Research Planning Institute, Columbia, South Carolina, under OMPA contract, provides advice on environmental sensitivity and recommends measures to mitigate spill effects based on geophysical and biological assessment of the region of impact. These assessments involve the ranking of resource sensitivity and the establishment of containment strategies designed to minimize overall environmental damage. Post impact evaluations are undertaken to determine the extent of damage to particular habitats and resources. Figure 9 illustrates an example of environmental sensitivity index mapping for San Miguel and Santa Rosa Islands, California. These maps are color coded to designate relative degrees of sensitivity to oil pollution.

b. Damage Assessment

During and after spill events, OMPA has been involved with damage assessment activities at EPA's request. (EPA is primarily responsible for damage assessment under the National Contingency Plan.)

OMPA's priority activities in damage assessment have been to document changes in the chemical composition of oil, define the extent of the impact area, define the retention time of oil in the sediments and study the benthic infauna for changes in abundance, community structure, and species diversity.

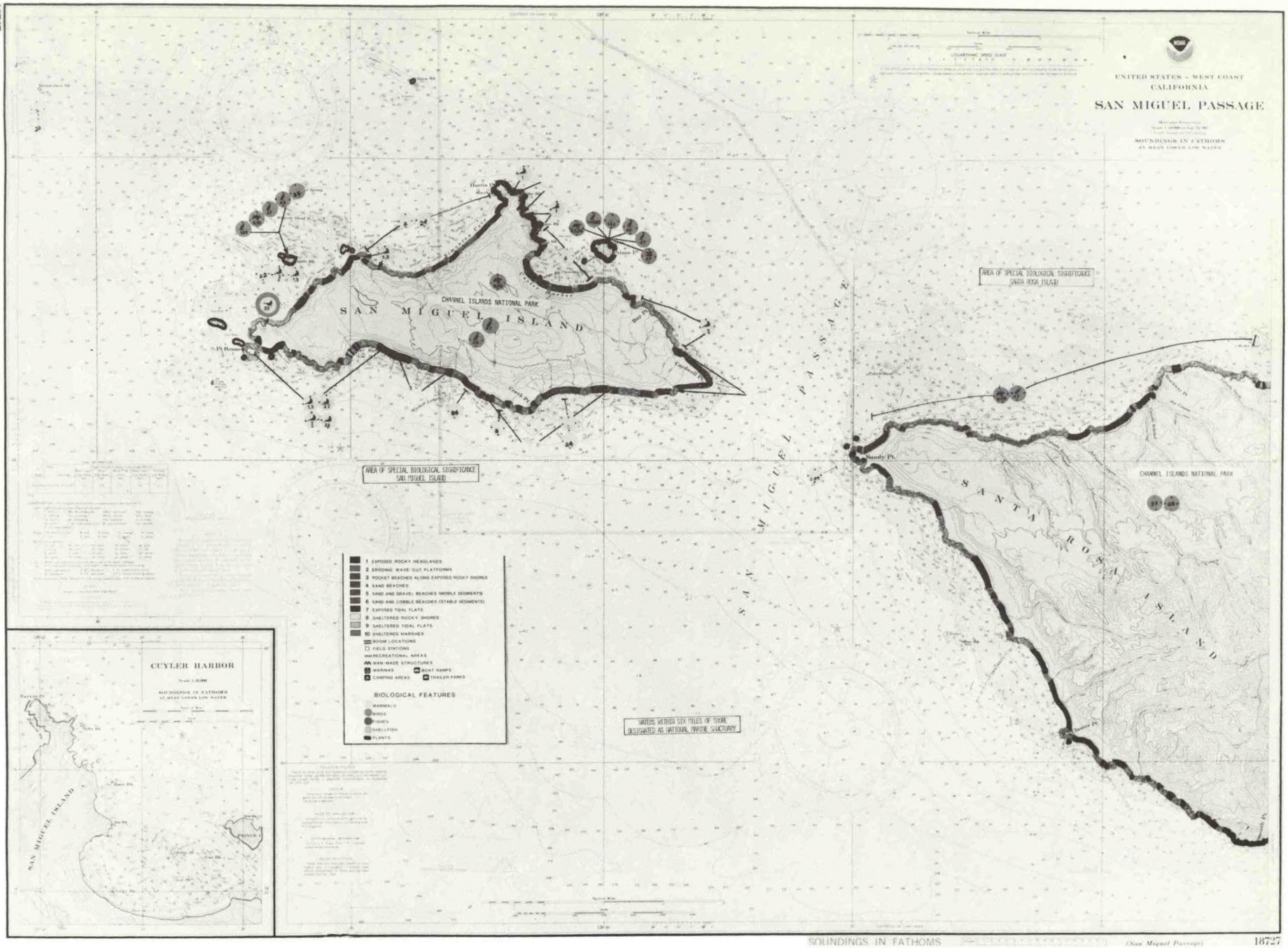


Figure 9. Example of an Environmental Sensitivity Index Map

c. Pollution Transport, Weathering, and Transformation

Planning of OCSEAP's priority activities on contaminant transport correspond to the three oceanic regions of the State of Alaska: Gulf of Alaska, Bering Sea, and Arctic Ocean. OCSEAP studies on pollutant transport in these regions are designed to: 1) provide data that can be used to minimize risks to environmentally sensitive areas during the various stages of oil and gas development; 2) determine probable trajectories and landfalls in the event of an accidental release of contaminants; and 3) provide information for cleanup operations in coastal and nearshore areas. The specific elements of these studies included literature of current meter data, drift buoy trajectories, interpretations of satellite imagery data, and meteorology. The study needs for these regions differ; therefore, they are grouped according to the priorities of each region, as follows:

Gulf of Alaska

Much of the study program on the continental shelf is now complete and the resulting information has been incorporated in circulation and contaminant trajectory models for the three lease areas in the Gulf. The primary purpose of these models is to describe, synthesize, and communicate observational and theoretical studies on the distribution and movement of contaminants in the sea. These models are in different stages of completion and reflect the amount and resolution of input data incorporated so far.

Bering Sea

The relationship of winds, currents, and ice that act to disperse pollutants both vertically and horizontally and chemical and biological processes that degrade and transform the pollutant are priority concerns in the Bering. Because of the shallow nature of much of the Bering Sea and because of the presence of rich and valuable benthic communities, transport of pollutants to the sediments is a major concern. Weathering rates and transformation products must be determined to evaluate persistence and toxicity of spilled petroleum. Nearshore circulation, storm surges, local meteorology, and sediment transport are important factors in transporting pollutants in the nearshore areas of the Bering.

Arctic

Major environmental issues in the Arctic concern technology to predict the behavior and transport of oil in ice, check oil spills, and clean up a spill. All of these are difficult undertakings even under the relatively benign, ice-free conditions in the Gulf of Mexico, but are very difficult if not impossible in the Arctic. It will be difficult to stop a blowout from either a drill ship or a gravel island. If ice conditions are unfavorable for the drilling of a relief well (by preventing a ship from operating in the area, or inhibiting construction of a gravel island), spills could continue unchecked for several months. If spilled oil is entrapped under ice, or in an ice matrix, detailed information on ice topography, characteristics, and dynamics is needed in order to

predict where the oil will go. Finally, moving, ridged ice is an effective barrier to cleanup once a spill has occurred. It may be possible to recover spilled oil from under shore-fast ice in winter, but oil cleanup in moving pack ice is presently not possible. Considerable ice research as well as oil spill cleanup engineering efforts will be required over the next few years in order to cope with oil spills in ice.

3. FY 1981 Program Accomplishments

a. Spill Response

During FY 1981, OMPA's Hazardous Materials Response Project (HMRP) responded to two types of accidental discharges: 1) those involving ship collisions or groundings or other sea-released discharges; and 2) those involving hazardous chemical releases from shore-based facilities. The HMRP responded to 10 accidents in the first category (see Table 1). The HMRP activities listed in this table are typical for these types of discharges. Three of the spills are summarized below.

Hellenic Carrier/Lash Atlantico collision - Virginia/North Carolina:
This collision, occuring in May 1981, resulted in a substantial oil release which threatened beaches in the Kitty Hawk - Nags Head, North Carolina region during a period of intense tourist usage. Trajectory forecasts prepared by the response team provided U.S. Coast Guard and local forces with a three-day period in which to prepare for land-fall of the spill. With this advance warning, beaches in the region were temporarily closed to the public to avoid undue tourist inconvenience. Drawing on experience obtained during the Amoco Cadiz incident in 1978, the HMRP derived methods by which the beach might be cleaned rapidly with minimal ecological damage. These methods were implemented by the U.S. Coast Guard and the beach was rapidly returned to active usage.

M/V Eastern Mariner - Bermuda
In February 1981, the Project responded to a request from the Government of Bermuda and the National Response Team to assess the damage that could result from the possible breakup of a disabled vessel moored in a major lagoon system near the coast of Bermuda. Based on the Project assessment that the breakup of the vessel would result in severe ecological damage over a 100 km^2 area, offloading was terminated, and the vessel was towed to deep water and sunk.

Dae Rim grounding - Alaska:
In March 1981, the Korean vessel Dae Rim grounded on the Alaskan Coast near Attur resulting in the threatened release of a considerable quantity of fuel oil. The Project forecast the likely impact on the coast should the vessel break up at various times throughout the year. Based on a Project recommendation, the vessel's hull was ruptured by U.S. Navy and U.S. Coast Guard

Table 1. OMPA Response to Accidents Involving Ship Collisions or Groundings

Jan. - T/V Concho - New York: Provided consultation in the area of oil-ice interactions, trajectory analysis.

Jan. - M/V Tucon Wickliff p-xylene spill - Houston ship channel: Provided chemical information and trajectory analysis.

Feb. - M/V Aihaterini oil spill - Virginia: Provided information on resources at risk, trajectory analysis.

Feb. - M/V Eastern Mariner ammonium phosphate spill - Bermuda: Provided chemical and trajectory assistance to the Government of Bermuda; recommended relocation and sinking of the vessel.

Mar. - Dae Rim grounding - Alaska: Evaluated resources at risk, advised environmental impact.

Apr. - M/V Kuniang grounding - Florida: Prepared trajectory analyses and environmental sensitivity assessments to support routing of disabled vessel from Florida to Chesapeake Bay.

May - Hellenic Carrier/Lash Atlantico collision - Virginia/North Carolina: Provided trajectory analysis and assistance in impact assessment and beach cleanup requirements.

Oct. - M/V Prinsedam fire - Alaska: Supported USCG effort along a route which would minimize coastal oil pollution.

Nov. - USNS Redstone - Florida: Disposal of contaminated ballast water.

Nov. - M/V Christian Reinauer oil spill - Virginia: Provided trajectory forecast.

demolition teams in order to release the remaining fuel when overall ecological damage would be minimized.

In each of these responses, as well as others throughout the year, the HMRP relied heavily on data provided by the National Marine Fisheries Service, the National Weather Service, and a number of other Federal and state agencies. An information and computational system is maintained by HRMP to enable rapid collection, synthesis, and dissemination of information that is critical to operational response actions.

To better prepare for future incidents, extensive contingency planning activities were undertaken during the year. Especially significant in this area, work continued on before-the-fact determination of regions highly susceptible to damage from transportation-related accidents. Regions carefully examined had a combination of high traffic density and environmental sensitivity. These assessments, together with formulation of preplanned response actions, were undertaken (in collaboration with the U.S. Coast Guard, industry, and several state agencies) for coastal areas in California, North Carolina, Maryland, Virginia, and Massachusetts.

Considerable progress was also made in improving technology associated with trajectory analysis, chemical hazard assessment, and remote sensing.

In addition to transportation-related actions discussed above, the HMRP responded to 11 incidents involving hazardous chemical releases from shore-based facilities (Table 2). Typical of these responses were the following:

Bayou Bonfuca Creosote Site - Louisiana

The HMRP provided an extensive field assessment of the extent and nature of the chemical hazard at an abandoned creosote plant within the city limits of Slidell, Louisiana. The site presents a substantial human health hazard and a number of cleanup alternatives were evaluated.

Ferric Chloride Spill - California

In February 1981, the HMRP responded to a major spill of ferric chloride on the coast of California, providing environmental and chemical information and recommending measures that might be taken to assess environmental damage.

During the year, the HMRP staff worked extensively with EPA and the U.S. Coast Guard to revise the National Contingency Plan and develop procedures for implementing the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In connection with expanded responsibilities under CERCLA, additional training was undertaken related to field operations associated with hazardous materials incidents.

Environmental sensitivity mapping was conducted in several segments of the Bering Sea and Gulf of Alaska coastlines. This work includes literature reviews and field programs of concommitant observations and

Table 2. OMPA Response to Accidents Involving Hazardous Chemical Releases

Nov. - St. Marks River oil spill - Florida: Provided field assessment of the extent of marsh damage, recommended against cleanup.

Jan. - Tignin Sulfonic Acid spill - Washington: Provided information on the nature of the chemical hazard, resources at risk.

Feb. - Pesticide, fertilizer spill - Alaska: Provided information on the nature of the chemical hazard.

Feb. - Nitric acid spill - Washington: Provided information on the nature of the chemical hazard.

Feb. - Ferric chloride spill - California: Provided chemical and environmental information; suggested mitigation measures to be taken.

Feb. - Bayou Bonfuca creosote dumpsite - Louisiana: Provided extensive support in assessing the extent and nature of contamination; evaluated a variety of disposal options.

Apr. - Elizabeth River Creosote dumpsite - Virginia: Conducted preliminary site assessment.

Apr. - Diethlene trimine, triethylene tetramine spill - Oregon: Provided assessment of the nature of the chemical hazard.

Apr. - Florida Keys oil spill - Provided trajectory analysis.

May - Para-Xylene spill - Texas: Provided information on the nature of the chemical hazard.

June - Cape Fear River oil spill - North Carolina: Provided trajectory analysis.

sampling for both physical and biological characteristics at representative intertidal study sites. In the Bering Sea, field work was performed between Cape Vancouver and Unimak Pass (including Nunivak Island) and a draft report was completed on the previous year's efforts in Norton Sound.

b. Damage Assessment

The limited IXTOC I Damage Assessment Program that was developed through NOAA and BLM funds in FY 1981 consisted of three studies:

1) "Investigation of Biological Effects from IXTOC I Oil Reefs in the Intertidal Zone of South Texas Gulf Beaches" by Dr. R. Warren Flint, University of Texas, Marine Science Institute, Port Aransas, Texas.

2) "IXTOC Oil: Weathering Experiments" by Patrick L. Parker, University of Texas, Marine Science Institute, Port Aransas, Texas.

3) "IXTOC Oil Spill Assessment" by Paul D. Boehm, Energy Resources Company, Inc. (ERCO), Cambridge, Massachusetts.

These studies were initiated to provide information on the following:

1) changes in the intertidal infauna community structure in relation to oil reefs;

2) chemical characterization with time of the weathering process for IXTOC oil on the sea surface and in beach environments; and

3) examination and quantification of the chemical impact of the IXTOC and BURMAH AGATE spills on the offshore benthic environment and biological community.

The oil reef study has been completed and has shown that a considerable amount of invertebrate biomass was eliminated from the intertidal beaches of Padre Island by the 1979 oiling of IXTOC I oil. Much of this biomass was not allowed to reestablish because of the persistence of the intertidal tar reefs which changed the geochemical structure of underlying sediment, thus affecting the quality of habitat space (oxygenated sediment) available to benthic species. Approximately 10 percent of the Padre Island coastline was affected by these oil reefs.

The weathering (#2) and the offshore (#3) studies will be completed in FY 1982.

Papers on the "Damage Assessment Plan, its Concept, Development, and Preliminary Results," were presented at the Coastal Zone 80 Symposium in Miami, Florida (November 16-20, 1980)

and the 1981 Oil Spill Conference in Atlanta, Georgia (March 2-6, 1981).

c. Pollutant Transport, Weathering, and Transformation

In FY 1981, results in pollutant transport weathering and fate included the development of a functional predictive model describing the physical-chemical alterations of spilled oil and its component residues. This model is being developed and advanced through an experimental program that includes laboratory experiments in La Jolla, California, and field experiments under actual subarctic conditions at Kasitsna Bay, lower Cook Inlet, Alaska. The latter work is described in Section III-B. Specific objectives for FY 1981 were:

1) To provide a predictive model for evaporation/dissolution processes.

2) To formulate a preliminary predictive model for oil-in-water dispersions and mousse formation and recommendations to improve the predictive capabilities of these models.

3) To collect data from real ocean spills and laboratory analyses on sedimentation and absorption rates. To put this data in the form of mathematical equations and to couple this with the dissolution model to describe the total water-column organic loading.

4) To experimentally determine the relative importance of slick surface area, available nutrients, and dissolved oxygen temperature, to the microbial degradation of oil and to use these data to form equations predicting carbon loss from an oil slick.

The investigators participated in the Duwamish II intercalibration exercise coordinated by NOAA's National Analytical Facility (NAF). The data set submitted was very similar to that produced by the NAF. The spring and summer field seasons at Kasitsna Bay were successfully completed and no problem is anticipated in meeting the schedule of deliverables. Objectives 1 and 2 should be completed by December 1981, when these will be submitted along with preliminary assessments of objectives 3 and 4.

Bering Sea

An interdisciplinary study of pollutant transport mechanisms in the southeastern Bering Sea, entitled the North Aleutian Shelf Transport (NAST) study, completed its field work in FY 1981. The data from the NAST Study was incorporated into a summary report at OCSEAP's St. George Synthesis meeting and then was used to assess the possible impacts of an oil spill.

Except at very low speeds, winds constitute the most important direct influence on the direction and speed of transport of oil

slicks. As a consequence, studies have continued to refine the information base from which winds are derived for oil spill trajectory models. The historic pressure field record for the Bering Sea has been an adequate source of wind statistics except near certain coastlines and near the ice edge, where the discontinuity in topography and temperature causes deviations in the wind field. A significant field effort during March 1981 was devoted to resolving the uncertainty in forecasting winds over ice near the ice edge. The data obtained will increase the precision of oil spill risk analysis near the marginal ice zone and may be very useful in forecasting local winds over production platforms or loading facilities under ice-dominated conditions.

Specific accomplishments of the RAND modeling study include oil spill trajectory calculations in the Norton Sound and St. George Basin lease areas. These calculations were in turn directly supported by analyses of field and theoretical data by other research projects conducted in this area. The general circulation model now incorporates effects of ice cover. Final verification of that model as used in Norton Sound and St. George Basin was accomplished by detailed analysis of buoy data obtained during FY 1981 in those areas, and by reference to current and density data obtained earlier. In addition to incorporation of ice-cover, the model was reconfigured to include the Navarin Basin and the Chukchi Sea. Results of the reconfigured model agree with the field data for such major features as the currents through Bering Strait, the location of tidal co-phase and co-amplitude lines, and the movement of ice.

Discussions during the St. George synthesis meeting revealed that oil spill trajectories calculated with a uniform wind field are not equivalent to those calculated with a non-uniform field containing a time sequence of circular patterns. This occurs even though the statistics in the two cases may be alike at any geographic point. In Bristol Bay, the application of a uniform wind field causes a slight southerly bias in trajectory direction compared to a trajectory calculated from revolving wind fields. This finding will, if confirmed, cause us to reconfigure the oil spill trajectory model to include non-uniform circular winds and alternatively to apply an empirical correction to directions of motion.

It is anticipated that the oil weathering model being developed will be coupled with the oil spill trajectory model for a general model capable of predicting the fate of spilled oil when used in conjunction with site-specific information such as circulation patterns and the characteristics, sources, sinks, and fluxes of suspended particulate matter.

Arctic

A major accomplishment in FY 1981 was the modeling of summer oil transport and generation of oil spill scenarios for Harrison Bay. Ice motion in the Chukchi Sea was studied in detail, using an ice dynamics model. Weather conditions which cause ice transport

southward from the Chukchi to the Bering Sea, an infrequent occurrence, were included.

The major contribution of these studies was the generation of twelve oil spill scenarios based on hypothetical spills in the Prudhoe Bay area. In that area, oil spilled in winter will be trapped by the under-ice relief and become encapsulated quickly. Release to the water and significant transport will occur during spring breakup. Trajectories for oil release in Prudhoe Bay and in Harrison Bay were generated. A field deployment of satellite-telemetered position buoys was made in Norton Sound to help validate the existing model for oil transport for that part of the Bering Sea.

In addition, the Baffin Island Oil Spill (BIOS) project completed its second field season. In cooperation with Canada and Norway, this project is designed to address the problem of whether dispersants should be used in nearshore environments, based on the severity of the effects of chemically-dispersed oil compared to those of untreated oil. Three small bays, on the north coast of Baffin Island in the Canadian arctic, are being used in this experiment: one as a control; one was treated with dispersed oil; and one was treated with non-dispersed oil.

The first field season, 1980, was designed to collect sufficient baseline physical, chemical, and biological data to allow the selection of three similar bays. The second field season, 1981, included a round of pre-spill sampling, the spills themselves, and a round of post-spill sampling. The pre-spill sampling in 1981 and the field work in 1980 provide a two-year data base of conditions prior to the spill. The post-spill sampling coupled with the sampling anticipated in 1982 will provide a two-year data base after the spill. Preliminary results include the visual evaluation of "stress" in the benthic organisms from the bay treated with dispersed oil but not in the bay treated with non-dispersed oil and the failure of *in situ* combustion as a shoreline cleanup technique.

4. Conclusions and Plans

a. Spill Response

In FY 1982, the Hazardous Materials Response Project, in addition to operational response activities, will emphasize the following programmatic functions:

1) Preparation for implementation of NOAA responsibilities under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). --The Project will undertake a major training, medical surveillance, and safety program in FY 1982 directed at improving NOAA's capability to deal with hazardous substance spills and uncontrolled waste sites. During the year, 10 individuals will be prepared and equipped to provide on-scene assistance during hazardous substance incidents.

2) Decentralization of the Scientific Support Coordinator (SSC) function. --In order to respond to program deficiencies cited by the National Response Team, additional SSCs are currently being recruited from within the NOAA Commissioned Officer Corps who, when trained in response techniques, will be assigned to coastal regions to supplement the NOAA and contract staff currently performing this function.

3) Expanded contingency planning activities, particularly in the area of environmental sensitivity mapping. --Contingency planning efforts will be extended to encompass several regions along the U.S. coast for which coverage has been inadequate to date. Particular emphasis will be placed on Southern Puget Sound, Chesapeake Bay, Delaware Bay, and the region adjacent to Portland, Maine.

b. Damage Assessment

NOAA's future responsibility in the assessment of damage from spills of oil and hazardous materials to both socio-economic and environmental factors is being developed through negotiations in the NRT with EPA and DOI.

c. Pollutant Transport, Weathering, and Tranformation

It is anticipated that the oil weathering model being developed in the Gulf of Alaska will be coupled with the circulation model, which currently can generate oil spill trajectories, to create and generate a model capable of predicting the fate of spilled oil when used in conjunction with information such as circulation patterns, and the characteristics, sources, sinks, and fluxes of suspended particulate matter.

Bering Sea

Important data gaps in the Bering Sea still remain in the realms of subsurface transport within the water column, the rate of transport to the sediments, and rate of transport of oiled sediments (or re-suspension). Future field studies on circulation should be necessary only in the verification of the oil spill trajectory and circulation models. This forecast does not include consideration of site-specific data if circulation and oil spill risk analysis are required on a much smaller scale than presently possible nor does this forecast include consideration of future perceptions of need to study circulation and processes unrelated to risk assessment or realtime oil spill tracking.

Arctic

In the Arctic, FY 1982's pollution transport activities will center on the completion of a final synthesis and analysis of nearshore circulation, storm surges, local meteorology, and sediment transport. All of these contribute to the understanding of pollutant transport in the nearshore areas of the Arctic, particularly,

in the sale area where no studies of this kind have been performed prior to FY 1980. A full synthesis of nearshore oceanographic information cannot be generated prior to the DEIS, however. Pollution trajectories can be calculated, but the bulk of the oceanographic information will not be available until immediately before the scheduled sale in October 1982. Offshore circulation was studied by OCSEAP adjacent to the sale area prior to FY 1982 and a final synthesis of this information is expected in early FY 1982.

In the Chukchi Sea, pollution transport studies started in FY 1981. No nearshore circulation, local meteorology, and ice transport of pollutants started in FY 1981 and are therefore proposed for FY 1982. FY 1982 work will be devoted to field studies, FY 1983 to data analysis.

F. COASTAL LAND-USE

1. Introduction

Many land-based human activities require access or proximity to marine or estuarine waters. Facilities associated with these activities tend to be concentrated in coastal areas because they are dependent on maritime transport, large volumes of cooling water, living marine resources, or use of the oceans for waste disposal.

Many pollution problems are associated with such land-use activities. Those of greatest concern are related to:

- Siting, Construction, and Operation of Coastal Facilities
- Non-point Source Pollution

The loss and alteration of critical habitats are the most important concerns associated with the construction and operation of coastal facilities. Estuarine and coastal habitats such as grass beds, marshes, mangrove swamps, and shallow areas serve as breeding and nursery grounds for the majority of recreational and commercial marine species. The construction of coastal facilities frequently requires filling or draining wetlands and dredging shallow areas to create channels. The normal salinity regime of an estuary may be altered by withdrawal of upstream freshwater for irrigation or human consumption, channel dredging, locks and dams, and land-use patterns, with direct and indirect effects on the health of commercial or recreational species within the estuary. Such physical effects that alter but do not destroy a critical habitat are very difficult to monitor and assess. Additionally, the presence of coastal facilities can increase the non-point-source pollution as well as create chronic unintentional discharges of harmful substances into coastal waters.

In most regions, non-point-source pollution accounts for a major portion of the contaminants that enter coastal waters. Point sources discharge into surface waters through a discrete pipe, outfall, or ditch; non-point sources generally discharge in a more diffuse way, for

example, land runoff and inputs to the sea-surface from the atmosphere. Urban runoff occurs in areas of relatively high populaton density that are largely impervious to water because of the large area covered by roads, sidewalks, parking lots, and buildings. Nonurban runoff occurs in all other land areas, such as agricultural lands, animal feedlots, pasture land, and forest land. The effect of non-point sources on water quality can be significant, depending on the hydrologic cycle and the type of land uses within a region.

During FY 1981, OMPA's coastal land-use assessment efforts focused principally on the Hudson-Raritan Estuary and the adjoining New York Bight, where a significant part of the total contaminant inputs are introduced via runoff and riverine flows. Studies have emphasized characterization of the sources and transport of contaminants and the determination of marine environmental effects related to coastal land use. The results of these studies are summarized briefly in the next sections.

2. Priority Activities

Priorities for coastal land-use activities reflect the information needs for the three concerns above. They are:

- Additional information on the extent and rate of habitat modification, and on its significance to commercial and recreational species and environmental quality in general.

- Reliable and comprehensive information on the extent and nature of non-point source pollution entering coastal marine areas. More specifically, mass loadings, major transport pathways, sinks, and chemical derivatives of key pollutants need to be identified. This information will aid in developing better strategies to control non-point sources, and also to provide a quantitative estimate of background levels for better management of point sources and for assessing the assimilative capacity of coastal and estuarine waters.

- Information on potential problems associated with increased coal use. These include the assessment of disposal methodologies for coal wastes and ash, the environmental effects of the various disposal options, the primary and secondary effects of coal transport, export, and handling in coastal areas (including harbor improvement projects), and assessments of coal power plant emissions. At this stage, efforts are focused on developing an effective interagency approach to this problem.

3. FY 1981 Program Accomplishments

During FY 1981, we emphasized synthesis of previous research results on the New York Bight. We are preparing a series of Special Reports to meet the needs of managers, planners, and decision-makers. Several of these reports will appear in a volume entitled "Perspectives

on the New York Bight", including the following topics that deal with coastal land use:

- Consequences of Continued Industrialization/Urbanization on the New York Bight Ecosystem.
- Urban Discharges to the New York Bight.
- Coastal Paradox: Change and Stability on the Barrier Islands.
- Economic Development.

In a draft report we have outlined the major plans and regulatory activities that influence the use of the Hudson-Raritan Estuary. These include plans and regulations in solid waste management, land development activities of public authorities, energy, water resources planning in general, flood plain management, waste water facility planning on both an areawide and project-specific basis, and coastal zone management. The report is essentially a resource document that focuses on land development problems and conflicts and will aid policymakers and planners in resource management decisions.

Two synthesis reports address other environmental management information about the Hudson-Raritan Estuary. One report on contaminant inputs updates a similar study conducted during the MESA New York Bight Project. The report summarizes the contaminants by source (wastewater, tributary, urban runoff, landfill leachates, accidental spills, and atmospheric). The second report summarizing the water quality of the Hudson-Raritan Estuary is nearing completion. Water quality is being assessed for possible recent improvement by comparing data sets from 1974 with data sets from 1979-80. The conclusions will provide a discussion of water quality conditions related to various water uses for environmental managers.

In a series of interrelated studies, we have researched the principal transport processes by which contaminants are moved about and through the Hudson-Raritan Estuary and by which they become available to organisms in the Estuary. These studies, designed to quantify the marine environmental impacts of coastal land-use practices, are summarized below.

In cooperation with the National Ocean Survey (NOS), we have obtained and analyzed basic circulatory survey data (measurements of currents, sea level, water density, and meteorology) for New York Harbor during summer/fall of 1980 and spring of 1981. The data are being processed for validations and sensitivity testing of a state-of-the-art, three-dimensional hydrodynamic model, being done in conjunction with the New Jersey Sea Grant. The basic work of fitting the model to the geometry of the Hudson-Raritan Estuary is complete, and test runs on the simpler two-dimensional components of the model have been performed successfully using tidal and riverine forcing. Refinement of the model is being emphasized to help understand dispersion and transport of pollutants and dissolved oxygen declines within the Estuary.

Also in conjunction with the New Jersey Sea Grant, we are investigating the modes of heavy metal transport, release, and mobilization. Analysis of mid-estuary and freshwater river samples shows that Cd, Cr, Co, Cu, Mn, and Ni are carried predominantly in solution; whereas, Al, Fe, and Pb are incorporated mainly in crystalline material, and Zn is transported mostly as adsorbed material. Low dissolved concentrations of Fe and Al in the estuarine samples may be explained by flocculation caused by seawater infiltration and a nearly-neutral pH.

Work on organic pollution in the Hudson-Raritan Estuary and adjacent nearshore systems addressed the objective of estimating rates and modes of transport of PCB species and of pesticides with similar chemical properties. Important conclusions are summarized as follows:

- Fine-grained sediments sequester radionuclides and a variety of organic pollutants, including PCBs and pesticides. Analyses of fine-grained sediments can provide both a chronology and a budget for many important anthropogenic substances in the system.

- Response times of the system to pollution events can be gauged by studying the sediment chronology of various substances. For example, sediment concentrations of ^{137}Cs and $^{239,240}Pu$ (which resulted from weapons-testing fallout) have been found to decrease, with a half-time of approximately six years. This half-time is similar to that of DDT-related compounds, which peaked in the mid 1960s. In contrast, the system responds on a considerably shorter time scale to direct pulses of pollution discharged to the Estuary, such as the Indian Point radionuclide release in 1971 and peak PCB sediment levels in 1973 associated with the removal of Fort Edward Dam. The half-times observed after these events are on the order of two years.

- The reduction in sediment pollutant concentration after pollution events is related closely to average sediment accumulation rates. A number of important organic pollutants (including PCBs, chlordane, dieldrin, DDD, and oxychlordane) show no evidence of degradation in anoxic sediment, even over a few decades. Decreases in sediment pollutant concentrations in the Hudson-Raritan appears to be dominated by two major processes: (a) dredging, which takes place mostly in New York Harbor, and involves translocation of contaminants to the New York Bight by ocean dumping, and (b) sediment accumulation, which basically buries contaminated sediment with "unpolluted" sediment. Sediment mixing rates determine the depth to which sediment must be buried before it ceases to influence overlying waters. Sediment/water diffusional processes can be ignored as important mechanisms of transport for these toxic organic compounds.

- Recent Hudson River sediments contain a record of gross PCB contamination, as a result of discharges from two General Electric plants north of Albany, between the early 1950s and

1976. The Indian Point nuclear power plant effluent supplies ^{60}Co and ^{134}Cs to the system. Both contaminant groups provide valuable tracers for Hudson-Raritan Estuary material transported to nearby systems.

- Dumping of Harbor-dredged material in the New York Bight constitutes a major transport mechanism for PCBs and pesticides. Disposal of sewage sludge in the Bight appears to be less important for PCBs, but is still a significant source of these compounds to the coastal environment.

- Most of Raritan Bay has little or no accumulation of recent fine-grained sediments. Preliminary indications show that recent sediments in the eastern part of Raritan Bay contain higher levels of PCBs. This indicates a larger fraction of Hudson River-borne sediments than in cores from the western Bay.

Research was sponsored to help determine the nature of sediment distribution and transport, and fine-grained suspended sediment load, which control partitioning of associated contaminants in the Estuary. The change of natural particle size and form of the suspended sediment with season along the length of the Estuary have been examined. Definite trends have been found, relative to spatial variation. Transport patterns appear to be related to current velocity regimes, which are controlled by local variations in channel characteristics: the faster the current, the greater the size and amount of particles that can be carried in suspension. Two modes of aggregation, electrostatic flocculation and biological agglomeration, appear to control the character of the suspended sediment load at different times of the year. Agglomeration dominates during intense biological activity (in summer and probably in the fall); large suspended sediment levels promote extensive flocculation, especially during spring in the region of well-developed turbidity maximum.

The ecology of the Hudson-Raritan Estuary has been described from a pollution-related perspective. Species lists and a sediment-type distribution map have been prepared. The 15 most abundant species of fishes are discussed in relation to sediment type and other variables. Plankton tows were analyzed for abundance of ichthyoplankton species. Historical changes in abundance for six species are discussed, from mid-1800 to present. Seasonal abundance and spawning are discussed for existing Hudson River fisheries.

Species composition and abundance in the Lower Bay Complex was compared with that of three other estuaries (Delaware Bay, Great Bay-Mullica River estuary of New Jersey, and Narragansett Bay). Fish density and number of species did not appear to differ substantially among the estuaries. However, abundance of particular species differed among estuaries. The clupeids (blueback herring, alewife, menhaden, and shad) were about ten times more abundant in Lower Bay than in any of the other areas. Bluefish were also about ten times as numerous in Lower Bay. Several species were absent from Lower Bay trawls, but ranked among the 15 most abundant in one of the three other estuaries. More

than half the species absent from Lower Bay trawls are bottom feeders. This may reflect the physiochemical environment or the depauperate nature of the bottom community. The densities of other species found in Lower Bay seem to be similar to those of one or more of the other estuaries.

In addition to the primary efforts in Hudson-Raritan Estuary, OMPA has supported complementary research on the factors contributing to the pollutant composition of runoff in two other areas. In one study, the movement of pollutants and related material through Sandusky Bay into Lake Erie was examined during periods of intense runoff from major storms and at times when the river was at low flow. More than half the total annual export of phosphorous, sediments, and sediment-related pollutants occurred during two storm runoffs. The runoff is characterized by low conductivity and high turbidity, with the dominant suspended matter being sediment. Storms do cause nitrate to be washed out of the soil, but the quantities and rates depend on the rainfall history.

A second study characterized sources, transport, form, and flux of petroleum hydrocarbons in urban runoff and combined sewage overflows into Narragansett Bay. The flux of suspended solids and petroleum hydrocarbons in urban runoff varies widely with storm progress; the total flux is correlated to total rainfall. Petroleum hydrocarbons are associated with particles; 63 percent of them were associated with settleable solids. The hydrocarbon flux depends on land-use: the highest being associated with highway and industrial use, intermediate with commercial use, and the lowest with residential use. The hydrocarbons were found to comprise crankcase oil (major component), auto exhaust, and plant waxes.

4. Conclusions and Plans

During FY 1982, the OMPA efforts related to coastal land-use will focus on synthesizing existing information, with emphasis on two categories of wastes:

- Municipal and industrial wastes (from sludges and effluent discharges.
- Urban and agricultural runoff (from non-point and riverine sources).

We will continue to focus on the Hudson-Raritan Estuary, where land-use practices strongly influence the nature and magnitude of contaminant impacts to the marine system. Studies will emphasize the distribution and fate of key contaminants, introduced all or in part via runoff, within the Hudson-Raritan Estuary, and their flux to the New York Bight and western Long Island Sound. The assessment technology developed in this region will be applied and tested in other locations, to document the validity of the approach. During FY 1982, we expect to publish the following reports:

- Contaminant inputs to the Hudson-Raritan Estuary
- Water quality of the Hudson-Raritan Estuary
- Ecology of the Hudson-Raritan Estuary

G. OCEAN POLLUTION ASSESSMENT AND MANAGEMENT OF CUMULATIVE EFFECTS

1. Introduction

Coastal regions characterized by excessive pollution usually are impacted by multiple ocean-use activities. One of the more challenging problems is the linking of environmental effects of pollutants to specific sources. Also, in cases of low-level pollution from multiple point and non-point sources, the chronic, interactive effects are very difficult to determine. Other problems include defining the risk to humans and marine organisms that are the ultimate receptors of pollutant insults.

Studies of ocean pollution assessment and management of cumulative effects provide generic information applicable to a wide variety of ocean uses. OMPA's studies provide information on basic environmental processes, environmental effects of pollutants, and ecosystem recovery, which taken together lead to development of pollution assessment techniques and management strategies. OMPA's efforts have strong regional orientation, with emphasis on problems in New York Bight and the adjacent Hudson-Raritan Estuary, the Great Lakes, and Puget Sound. In addition, however, OMPA supports an extensive non-site-specific program, with individual studies that focus on specific environmental processes and effects that must be understood in order to assess and manage the cumulative environmental effects of contaminants. The FY 1981 accomplishments and results are presented for each of these principal areas of attention.

2. Priority Activities

- Criteria based on the biological effects of contaminants should be developed for normal and unsafe levels of contamination in the three key ecosystem components -- organisms, sediments, and water. These criteria are likely to vary by geographic area.
- Sources of pollution to the marine environment should be identified for coastal areas of primary concern.
- Predictive capability should be developed for the fates and the physical, chemical, and biological behavior of pollutants as they move through marine ecosystems.
- Predictive capability should be developed for the biological and ecological effects associated with particular contaminant distributions and concentrations.

- Natural environmental conditions and processes in coastal areas and ecosystems should be understood and modeled so that natural variability can be described, trends can be identified and monitored, and ecosystem stress predicted at its earliest stages.

3. FY 1981 Program Accomplishments

New York Bight and Hudson-Raritan Estuary

In 1979, a series of broad scan analyses for many organic compounds was completed on samples from the New York region. Additional samples were collected and analyzed during 1980, bringing the total to more than 250 samples of sediment, sewage sludge, dredged material, fish eggs, plankton, water, and several species of fish and shellfish. These samples were analyzed for a wide variety of petroleum hydrocarbons, chlorinated hydrocarbons, and other synthetic organic compounds. The data analyses and interpretations are being published as reports or articles. As a consequence of excessive PCB bioaccumulation by test organisms exposed to New York Harbor dredged sediments, a Joint Interagency Technical Committee was established to define interim revisions criteria for ocean dumping of dredged materials. The extensive MESA data set on concentrations of organic compounds in the environment and biota was the major data source for this Committee, and OMPA personnel are working with interagency groups to redefine the EPA criteria for contaminated dredged material handling.

A study completed by Manhattan College evaluated potential engineering solutions, such as nutrient control, for existing water quality problems related to dissolved oxygen levels. A number of loading strategies for the Bight Apex and inner shelf region off New Jersey were run in an engineering model of carbon-oxygen-nitrogen cycling for the years 1974 (characterized by local, moderately anoxic conditions) and 1976 (a period of severe shelf wide anoxia). Horizontal transport, phytoplankton blooms, and upwelling were identified as codominant processes involved in the anoxia phenomenon. Although urban nutrient discharge contributes to the dissolved oxygen decline cycle in the inner Bight, a nutrient removal program in the region would assure significant reductions in the recurrence probability of significant anoxic incidents. The investigators point to major uncertainties in the amount of nutrients and carbon exported to the Bight from New York Harbor.

A draft final report on "The Fate of Trace Metals in the Sediments of the New York Bight" emphasizes the major contaminant elements (Zn, Cu, Pb, Cr and Ni) and especially Cd and Hg which are considered the greatest toxic threat to humans through the marine food supply. The raw data include more than 8,000 determinations of 16 elements from 1,000 stations in the New York Bight. Where available, additional data such as grain size, total organic carbon (TOC) and loss on ignition (LOI) were also assembled. This study concludes that except for Mn, no significant amounts of dissolved trace metals are transported into the Bight. Any metals introduced in solution would most likely be removed rapidly onto particles and sequestered in the sediments. Thus the most

important processes for the movement of trace metals in the Bight appear to be particle transport processes.

The concentration of trace metals in the silt and clay fraction of the sediment was calculated and maps of this fraction were plotted. Significant trace metal pollution occurs throughout the area, even in areas mainly covered with sand. The highest concentrations of trace metals in this fraction were found at the dredged material dumpsite, to the west and northwest of that site, adjacent to the sewage sludge dumpsite, and in the Christiaensen Basin. Attempts have been made to ascertain if this excess is due to pollution from decomposing sewage sludge or resuspended dredge spoil particles. It could also have a significant input from airborne particulate matter. The trace metal flux from dredged material dumping, though large, probably remains localized at the dumpsite; whereas, sewage sludge and atmospheric inputs are available for homogenization and deposition throughout the New York Bight Apex.

Through another study we have synthesized shelf sediment transport and waste dispersal in the New York Bight. The report estimates the sediment budget in the New York Bight and assesses its role in pollutant dispersal. Although not yet complete, several important conclusions can be made:

- The concept that the New York Bight is a highly dispersive system has been reinforced.
- The net flux of suspended material across the Sandy Hook-Rockaway Point transect is into the lower harbor at a rate of 380,000 tonnes/year.
- The flux of suspended material is difficult to measure along the coasts (an estimate of a 2KK tonnes/year is given).

Work on indicators of environmental quality is using protozoa, nematodes, and bacteria as assay organisms to determine the toxicity of sediments in the Hudson-Raritan Estuary. Antagonistic pairs of phytoplankters are also being compared, one for polluted waters and one for clean waters, to see which is advantaged or disadvantaged. The nematodes appear to be the most useful indicator organisms. Preliminary findings from both investigations show that the Kill Van Kull sediments are not as toxic as originally suspected.

Puget Sound

Two major synthesis reports on the Puget Sound region are currently under review. The first summarizes the status of knowledge and presents a conceptual representation of the distribution, transport, fate, and apparent field effects of trace contaminants in Puget Sound. In this synthesis, trace metal data were normalized to sediment particle size distributions, revealing that fewer stations were contaminated than previously thought, and, unexpectedly, shoreline erosion was concluded to be a major factor contributing trace elements and solids to Puget Sound. The second report summarizes much of the existing scientific knowledge concerning the bioavailability, bioaccumulation, and

laboratory effects of the contaminants found to date in Puget Sound. This report resulted in identification of 17 chemicals which are of major concern because of their regional concentrations and distributions, potential effects, and physiochemical properties.

A separate study was supported to quantify routes of polynuclear aromatic hydrocarbon (PAH) transport to sediments and the potential for accumulation in benthic food chains. Results indicate that high PAH levels are entering Puget Sound and being deposited in bottom sediments.

With support from OMPA, the NMFS Northwest and Alaska Fisheries Center has continued their studies on pollution in Puget Sound and its effects on marine biota. These studies have resulted in the identification of significant relationships between diseases in fish and shellfish and the occurrence of some of the chemical contaminants of concern.

The highest concentrations of PCBs, chlorinated pesticides, other chlorinated organic compounds, petroleum hydrocarbons, and some metals (e.g., arsenic and lead) in sediments were in samples from the waterways of Commencement Bay; the Duwamish Waterway, Seattle Waterfront, and West Point areas of Elliott Bay; and from Point Herron in Sinclair Inlet. Sediments from reference embayments, Case Inlet and Port Madison, also contained many of these chemicals, but most were present in lower concentrations. Highest concentrations of many of the chlorinated organic compounds, including hexachlorabutadiene which has been implicated as a carcinogen, were in sediment samples from Commencement Bay and its adjacent waterways.

Tissue samples generally had concentrations of organic contaminants which reflected the chemical composition of sediment in the subarea from which the organisms were obtained. Generally, chlorinated organic compounds were present in higher concentrations in fish and crustacean tissues than in associated sediments. The reverse relationship was generally true for petroleum hydrocarbons. Petroleum hydrocarbons, PCBs, chlorinated pesticides, hexachlorobenzene, and hexachlorobutadiene were detected in various concentrations in several types of organisms from both urban and nonurban sites. Typically, highest concentrations of these chemicals were found in animals from Elliott and Commencement Bays.

The incidence of liver lesions in English sole, rock sole, Pacific tomcod, and staghorn sculpin was generally highest in fish from areas with the highest levels of sediment-associated contaminants within Commencement and Elliott Bays. Tumor-bearing sole were found only in Elliott Bay's Duwamish Waterway, along the Seattle Waterfront, Commencement Bay's Hylebos and other waterways, and the southwest portion of Commencement Bay. Fish with the other types of liver lesions tended to be more widely distributed in Puget Sound.

Community characteristics of infaunal invertebrates (i.e., invertebrates living within the sediment) were measured according to numerical abundance, the Infaunal Trophic Index (a method based on feeding strategies of benthic invertebrates), and species richness (the number of species in a sediment sample). Of these three indices, species

richness values were found to correlate best with concentrations of certain sediment-associated toxic chemicals. Consistently low species richness values were found in the Duwamish Waterway.

Great Lakes

OMPA's program in this region, conducted primarily by NOAA's Great Lakes Environmental Research Laboratories, has emphasized the environmental cycling of synthetic organic contaminants: where they are, their residence time, their decomposition rates and products, where they will reside after long-term leakage or high concentration loading. So far, an equilibrium distribution model for toxic organics is complete; the most extensive analysis was done with DDT, DDD, and DDE. The model shows that a two order of magnitude change in solubility, or vapor pressure, has very little impact on concentrations of contaminant in sediments and biota. A second simplified model is complete where all transformations are first order with respect to contaminant concentration. This model gives reasonable DDT levels as compared to those reported in Lake Erie. A time dependent vertically segmented model to describe fate and decomposition pathways of toxic contaminants is complete. Based on carbon flow through three particulate pools (phytoplankton, zooplankton, and detritus), material transfer between dissolved and particulate pools is calculated by a bilinear sorption model.

Sediments in nearshore Lake Erie were homogenous in PAH levels (530-770 ppb) near a coal-fired power plant, although river and nearshore concentrations reached nearly 4 ppm. Oligochaetes and chironomids were near equilibrium with local sediments except for enhanced concentrations in nearshore midges; infaunal worms and offshore midges appear not to bioconcentrate individual PAH compounds. The activity of cesium-137 is constant over the upper few centimeters of sediment and increases to a maximum at about seven centimeters. Observed concentrations of ^{137}Cs in surface sediments are far higher than expected from present atmospheric fallout rates. The observed distribution is explained by sediment mixing by bottom dwelling organisms which brings into the surface sediments the ^{137}Cs deposited earlier during more intensive nuclear testing (at this location the residence time of a particle, assuming mixing, is nine years).

There is a definite enrichment of PCBs in the surface microlayer compared to subsurface Lake Erie water which averaged 1.8-6.07 ppt; the particulate portion of microlayer samples generally represented more than half of the total measured PCB. In subsurface water, however, only 17 to 38 percent of the total PCBs are on particles. The solid-water partition coefficients for PCBs in the microlayer imply that particles in the microlayer sorb PCBs more strongly than those in the subsurface.

A study was conducted to investigate the pattern of recovery of infaunal benthos of Lake Erie from anthropogenic disturbances and to examine the effects of colonizing benthos on the chemical structure of the sediment, the flux of hazardous materials across the sediment-water interface, and the transport of particulate matter by waves and currents. Findings to date indicate that oligochaetes are the most important early colonizers. After four months, trays of contaminated

sediment contained eight species compared to 32 present in natural bottom sediments. The sediment grain size distribution changed little when trays were defaunated, and there was no change in water content. Observed decreases in biogeochemically cycled substances, such as organic nitrogen, with depth are caused both by related diagenetic reaction and increases in depositional flux resulting from dredging and other human activities.

Non-Site-Specific Studies

A substantial part of OMPA's research effort on cumulative effects is generic in character, oriented towards understanding specific processes of transport and transformation of contaminants and the mechanisms and significance of contaminant effects on organisms. Studies are conducted in specific areas, and focus on specific contaminants or contaminant groups, but the results are expected to be applicable to related problems in other areas. In 1980, OMPA's non-site-specific studies emphasized transport, transformations, bioavailability and effects of contaminants, especially hydrocarbons and heavy metals.

A study was also initiated to determine the fates of several oil spills in coastal and offshore waters and to calculate a mass balance denoting major pathways for dispersion of the spilled oil generally. The work to date documents that a common problem for all spills is the lack of accurate data on how much oil was lost, how much went onshore, and evaporation data at the spill site. Common models include evaporation plus photo-oxidation, surface dispersion plus emulsification, incorporation into the water column, adsorption, biodegradation, and shoreline stranding.

The rate of transfer of oil components from the oil-like phase to the aqueous phase is diffusion controlled and diffusion coefficients are similar for all compounds tested. Increased mixing decreases the diffusion layer thickness and flux rate. The diffusion layer thicknesses under oil spills may be much greater than expected and dissolution rates of hydrocarbons from oil may be lower than previously believed.

The effects of sublethal concentrations of crude oil on the feeding behavior and reproductive success of marine zooplankton (crustacea, copepoda) have been studied in laboratory continuous flow systems. The results suggest three to five days of exposure to less than 300 ppb of crude oil has marked effects on the feeding and egg production of copepods. Swimming behavior is also affected; exposed copepods are more sluggish and have different feeding behavior than those which were not exposed. However, following several hours of depuration in "clean" water, normal swimming and feeding behavior return.

A study was conducted to determine the lowest concentrations of petroleum under cold temperature conditions which could affect continued survival of marine species in Alaska. The results show that mussels are very tolerant of oil water soluble fractions, with no mortalities in the first 21 days of exposure. Mussel byssal thread extrusion was stopped or slowed at sublethal exposures of only one to two days.

A study measured the persistence of oil in the intertidal zone of the Strait of Juan de Fuca and the effects of oil on recovery of that ecosystem. The work documented that both #2 fuel and residual oil are retained in sediment to the same degree. The residual oil lost lighter and aromatic compounds while up to 70 percent of the #2 fuel oil remained in sediment. The #2 fuel oil had more serious effects than residual oil on the species density of benthic macrofauna. Two species found to be good pollution indicators were: crustacean (Leptochelia dubia) and polychaeta (Exogene lourie).

Another oil study examined the persistence of oil from the Metula oil spill in the Straits of Magellan. On beaches with moderate wave energy and mixed sand and gravel, some oil is still buried along the upper beach face after 6.5 years of weathering. On beaches with low wave energy, a thick pavement of asphalt of up to 100-meters wide rests on the low tide terrace. Only minor growth of grass is occurring on the tidal flats. Oil will persist there for more than 100 years. The "do nothing" approach to oil spills will not work.

A study was undertaken in the Gulf of Mexico to understand the importance of trace metal interactions and transformation in the development and maintenance of a viable near oceanic food web that includes larval forms of important commercial fishery species. The findings indicate that fulvic acids strongly interact with zinc, but not with cadmium or copper. The zinc-fulvic acid interaction probably occurs as part of a steady state cycle of less than 40 hours; this duration is controlled both by photo-oxidation and bacterial processes. There appears to be a gradient from extreme sensitivity (in the Gulf loop) to virtual insensitivity (at the Mississippi) in the extent of copper inhibition to phytoplankton at a given concentration. The Mississippi plume is highly productive and turbid, while the underlying water is unproductive and clear. Transient advective and meteorological events caused a three-fold increase in primary productivity during a midwinter cruise. Fulvic acids do not significantly detoxify copper for bacteria (no appreciable copper bonding occurred). However, there are indications that both copper and zinc toxicity is reduced by humic acids. Dissolved copper is more highly complexed in productive waters than in less productive waters which affects toxicity of copper to natural bacteria. The natural communities of bacteria and phytoplankton are extremely sensitive to copper, more so than to cadmium or zinc, and low production communities are more sensitive than high production communities (because of both chemical and biological reasons). Phytoplankton are highly sensitive to zinc (more so for low production communities). This sensitivity could be reversed by additions of manganese, but not by iron. The differences in sensitivity may result from differences in manganese concentrations. Concentration and speciation of metals may exert very rapid natural controls on phytoplankton species composition and primary productivity. Trace metal effects on phytoplankton may affect subsequent productivity of zooplankton, especially larval fish through specific food-chain dependencies. Thus, we are examining the specific food habits of larval fish and attempting to establish criteria for deleterious effects on larval fish. Age-specific growth rates and orphometrics may be useful indicators for the health of fish larvae at sea.

A study to investigate effects of common contaminants on microbial viability and selected microbial activities in estuarine and salt marsh sediments shows that exposure to Hg increased the rate of C_2H_2 reduction continually over the exposure period. Levels of Hg caused no reduction in nitrogenase activity. Both levels of Hg stimulated methanogenesis (perhaps due to a differential inhibition of microbiota). Removal of plant matter also stimulated methanogenesis. The highest microbial activity occurred in the upper 3 cm of sediments. Much of the nitrogen fixation is associated with SO_4-respiring bacteria.

In another study, we examined the physiological and biochemical processes which organisms use to accumulate and detoxify trace metals and how these processes affect survival of organisms and cycling of trace metals. The work has documented that excessive metal exposure may interfere with the normal processes of metal interaction and detoxification by hemocyanins, which may lead to respiratory problems in crabs. Zinc partitioning is affected by cadmium accumulation in oysters. Oysters were found to have copper binding proteins with a molecular weight of about 7400.

A study was funded to determine if exposure to copper, a representative heavy metal, predisposes striped bass, an important commercial and recreational fish, to infection with bacterial pathogens. The findings indicate no evidence that copper was predisposing fish to either of the bacterial pathogens tested. A sensitive methodology was developed for following immune response of striped bass.

Another study examined the probable interactions among factors of water diversion, pollution, parasitism, and other variables which appear to be reducing both quality and quantity of striped bass in San Francisco Bay. Examinations of striped bass showed parasitic infections, lesions, and other abnormalities, including tissue damage to the liver and gonads. Declines in population may be attributable to decreases in reproduction and fecundity with increases in pollution, interacting with water diversion and low outflow years to increase the mortality of eggs and larvae. Mortality of juveniles is probably from parasitically induced lesions, while the increased mortality of adults is probably from stress of interaction of pollutants and parasites with spawning stress. Striped bass larvae appear to bioaccumulate benzene/metabolites continually through uptake from water and food until death occurs.

An experiment was conducted to test the hypothesis that organic enrichment can influence fish communities indirectly through effects on benthic invertebrate communities. Some of the findings indicate that organic enrichment is the most important sediment variable in explaining differences between demersal fish communities. Before these differences become substantial, organic enrichment must attain both a critical degree and scale. The responses of demersal fish are mediated through the effect of enrichment on benthic invertebrates. Variations occurring between sampling during day or night must be taken into consideration.

A study evaluating the effects of increased doses of nutrients to the functioning and stability of an estuary found evidence that

secondary productivity increases at low nutrient doses; these increases are not proportional to increases in available chlorophyll a. Food quality is an important variable in zooplankton production models. Higher nutrient levels caused lower water pH values, while very high nutrients caused changes in zooplankton species composition.

We have tested the usefulness of coral skeletons as an ecological monitor by examining growth and the storage of past chemical pollutants. Studies revealed differences in linear skeleton growth, mass, and density which may be linked to pollution. The skeletons can be used to date dredging events through aluminum and cadmium deposits with a precision of ± 2 years. The elements which can be utilized for monitoring have been determined. Skeletal pore water in corals may prove to be a very useful tool for reconstructing the environment's chemical history.

A study to develop marine fish cell test systems to assess toxic effects has shown it is possible to use cell cultures for direct toxicity studies. Five classes of mutagenic compounds were found to induce anaphase abberations in fish cells. Hexachlorobutadienes are toxic but probably not mutagenic.

4. Conclusions and Plans

During FY 1982, OMPA will continue to focus on synthesizing existing information with emphasis on the following:

- The persistence, partitioning, transformation, and bioaccumulation of toxic organic and metal bearing dredged material and of PCB, PAH, and toxic metal bearing sewage sludge and industrial wastes dumped at sea.

- Relationships among PCB, pathogen, and contaminated sewage sludge, industrial waste, dredged material, and the incidence of seafood contamination and human disease.

- Consequences of synthetic organic compounds and toxic metals to commercial fishery habitats, particularly along the Atlantic and Gulf coasts.

- Assimilative capacity of ecosystems; develop criteria for defining limits of acceptable contaminant concentration; apply and test assimilative capacity techniques.

- Assessment of resources threatened by accidental and chronic discharges of hazardous materials, and fishery habitats threatened by municipal and industrial wastes.

- Environmental quality indices and effects acceptability criteria for the New York Bight, Southern California Bight, and the Great Lakes.

- Disposal alternatives for sewage sludge, dredged material, and coal combustion residues for the New York Bight.

- Produce case studies of successes and failures in the use of environmental assessments in regulatory proceedings for the New York Bight, San Diego Bay, Puget Sound, and Lake Michigan.

Major publications in 1982 will include:

- The book Ecological Stress and the New York Bight: Science and Management.

- "The Monitoring Plan for the New York Bight".

IV. COLLECTING AND USING INFORMATION

A. INTRODUCTION

OMPA has two specific management tools that directly pertain to collecting and using information. The first is its data and information activity. This activity has three major roles: (1) translating data and information into forms useful to decision-makers; (2) aiding the OMPA program in its management and coordination functions through the better use and organization of existing data and information, and (3) organizing and storing environmental data in a retrievable form. The second tool, marine pollution monitoring, uses collection of data to warn against unacceptable impacts of human activities and to provide a long-term data base that can be used for evaluating and forecasting natural changes in marine ecosystems and the superimposed impacts of human activities. The following discussion summarizes OMPA's activities relating to these two management tools.

B. DATA AND INFORMATION MANAGEMENT

The data and information management activity is an integral part of OMPA management and therefore is performed at various levels of the program. To ensure that the maximum benefit is derived from this activity, however, OMPA established a Data and Information Management Group (D&IMG) to aid its management and coordination functions through better use of data and information tools.

Evaluation of needs by this activity leads to three sets of requirements:

- First, OMPA's marine pollution information must be available in a timely manner and in a useful form. In terms of ocean-use management, the results, findings, and information in "useful form" represents interpretive results and synthesis products. A major emphasis of OMPA's program is devoted to identifying urgent ocean-use management issues, and the development of synthesis products to address these issues.

- Second, management information, is required by OMPA managers to assure that projects are properly run, goals and objectives are met, efforts are not duplicative, and results are available in the shortest possible time. This requires that all OMPA projects submit project information at the earliest possible stage in the planning process and update this information throughout the life of the project. Management information is included on completed and ongoing work, such as type of research activity, geographical area of investigation, performing agency, principal investigator, and project goals.

- Third is data and information generated as a result of research programs. Significant gains in the utility of marine pollution data and information can be achieved through centralized storage of this information. The intent of this

centralized accumulation of information is twofold. Initially, the primary usefulness will be the availability of all results and findings from one source. The second benefit is using the information in the system to determine whether additional projects of research, development, and monitoring should be supported.

1. Synthesis and Interpretive Results

The information and data collected by OMPA's program has been extensively used in scientific analyses of a particular ocean pollution problem. However, these analyses must be presented to ocean-use managers in an interpretive context, crossing disciplinary and regional lines. This translational process, involving multi-source synthesis and presentation of scientific results in a useful form, is a major task of OMPA. The results of OMPA's work must be presented not only to the public, but also to managers so that informed decisions can be made.

OMPA's program has directed significant effort to the identification of urgent ocean-use management issues that require this synthesis and interpretation process. Development of synthesis products to address these issues has been an ongoing process throughout OMPA. Specific synthesis or interpretive results have been referenced in Section III of this report; the following discussion describes the major OMPA synthesis or interpretive processes that were ongoing in FY 1981.

a. Science/Management Interactions

A major process in OMPA's synthesis and interpretive results activities has been to seek input from the users of these results to define urgent ocean-use issues so that products can be developed to address these issues. In some cases this has been accomplished by conducting symposia or meetings to pool information, perspectives, and ideas. The following briefly describes the major meetings or symposia, their purpose, and their accomplishments.

Alaska Outer Continental Shelf Environmental Assessment Synthesis Meetings and Users' Panel Meetings

Synthesis meetings are a major vehicle employed by OMPA's Alaska Office to furnish BLM timely information for the generation of Environmental Impact Statements for Alaskan lease sales; these meetings are usually held about six months prior to the publication of a given document. The meetings involve OMPA program managers and their Principal Investigators, BLM staff, and other knowledgeable persons, such as petroleum industry representatives and those from state and Federal regulatory agencies.

Synthesis meetings are typically structured around several core questions or issues, which are addressed by working groups. Usually the unifying theme of the meeting is a series of development or oil spill scenarios which serve as a starting point for the groups' discussion of consequences. The scenarios and issues evolve from consultation between BLM and the Alaska Office, through

the "scoping" meetings with citizens of the affected regions and through Users' Panel meetings.

BLM staff are thus afforded the opportunity to interact with a broad spectrum of interests and expertise, thereby gaining up-to-date perspectives on the existing scientific knowledge of a lease area and receiving informed evaluations of likely impacts from the various development and oil spill scenarios. The meetings subsequently are documented in the form of reports which present the substantive results of the working groups and wrap-up session. Three synthesis meetings were held in FY 1981: the Norton Sound meeting (Sale 57 area), October 28-30, 1980; the Beaufort Sea meeting (Sale 71 area), April 20-22, 1981; and the St. George meeting (Sale 70), April 28-30, 1981.

Users' Panel meetings are designed to make potential users aware of the data and information base collected by OCSEAP and BLM in Alaska. In addition to environmental data, socioeconomic study results are presented. The meetings also serve as a forum for the exchange of views and concerns about OCS oil and gas activities and are attended by Federal and state agencies, the petroleum industry, conservation groups, and local citizens. Summary reports on such meetings are prepared by the Alaska Office. The annual Users' Panel meeting was held in Dillingham, Alaska, on May 19-21, 1981; it focused on the Southern Bering Sea, including the St. George Basin and North Aleutian Shelf lease areas. Workshop issues considered were (1) potential petroleum-fishing conflicts, (2) impacts of spilled oil on the region, and (3) competition for facilities and space between local industries and petroleum interests.

Perspectives on the New York Bight

An interdisciplinary symposium entitled "Perspectives on the New York Bight" was held in FY 1979. Synthesis writings resulting from this symposia are proceeding slowly. A book, now entitled Ten Years in a Quandary - The Story of Ocean Dumping in the New York Bight, and a series of 15 Special Reports will comprise the symposium output. Seven management issues of particular concern to the Bight will constitute the core of the book. The scientific and technical framework of each issue will be followed by analyses of the issue's importance, alternative management responses, and discussions of likely implications of the responses. Additional parts of the book will treat historical trends, case histories of environmental problems in the Bight and other regions, broad perspectives on recreation and aesthetics, human health, resources and ecosystem well-being, economic development, and future outlooks for the Bight.

b. Issue/Policy Papers, Major Publications, and Reports

The science/management meetings and interactions described above often define the need for specific products. The following summarizes the major OMPA products that have been developed in direct response to these identified needs:

- Policy Statement on Ocean Dumping of Sewage Sludge

How we should dispose of sewage sludge is a mixed political and scientific decision. However, the fact is that sewage sludge must be disposed of. In doing so, we must consider the disposal of sewage sludge in the marine environment. Based on this issue, NOAA, through OMPA, defined its responsibility and expertise to provide scientific information to address this issue by developing a NOAA policy statement on ocean dumping of sewage sludge. The following list summarizes the major points of this policy paper.

1) NOAA is the lead Federal agency for the ocean, marine fisheries, and the atmosphere; it has the responsibility to manage oceanic resources for the United States.

2) NOAA has the responsibility to predict and determine the fate and effects of proposed and ongoing sewage sludge disposal into the oceans by applying its scientific and technical competency.

3) NOAA has the responsibility to elucidate the natural oceanic processes of dilution, dispersion, and assimilation that may be used for safe disposal of municipal sewage sludge. The information on ocean disposal must be compared with non-marine disposal options. EPA has the ultimate decision-making power on choosing the sludge disposal method.

4) If EPA continues to permit ocean dumping in the New York/New Jersey region, NOAA recommends the 12-mile site for sludge dumping instead of the alternate 65-mile site or the deepwater 106-mile site. NOAA investigations have revealed that the present degradation at the 12-mile site is not expanding; the 65-mile site is a pristine, productive fishing ground; and the 106-mile site is economically expensive for sludge transportation. NOAA will continue to update its findings; therefore, data will be available to determine if any changes in disposal practices are necessary.

- Ocean Dumping of Industrial Wastes

This book presents a wealth of previously unpublished material. An introductory section considers the regulatory aspects of ocean dumping, the international agreements concerning waste disposal in the ocean, and a summary of recent ocean dumping practices in the United States. Three subsequent sections contain new data and interpretations related to the physical, chemical, and biological aspects of industral waste dumping. Specific chapters highlight hydrographic features and dispersion characteristics of wastes at U.S. dumpsites, new techniques applied to the problems of waste disposal, laboratory bioassay studies, an examination of field specimens for biological abnormalities, and behavioral and metabolic studies of fish response to industrial wastes.

The volume concludes with an inspection of the future prospects of ocean dumping.

- The Eastern Bering Sea Shelf: Oceanography and Resources (Volumes I and II)

  The primary purpose of this publication was to present the available knowledge about the natural science of the Eastern Bering Sea Shelf. These volumes were aimed at compiling basic information on the Bering Sea Shelf to be used by the Bureau of Land Management in its primary responsibility for implementing most of the pre-sale oil and gas objectives. An even greater long-term value will be the protection of the Bering Sea as a system. Only by understanding how this ocean functions will we be able to predict the impact of human activities on specific parts or the whole of this unusually productive environment.

- The Bight of the Big Apple
  by Donald F. Squires

  The first of the Perspectives on the New York Bight Special Reports to be published, this document deals with historical trends in the Bight beginning with a description of New York Harbor by Florentine Giovanni de Verrazano in 1524. The book discusses growth and development of the region through four centuries focusing on ocean resources and waterborne transport. Ideally, the book hopes to stimulate public action to undo some of the damage residents and users of the Bight have heaped on that 15,000 square mile area of coastal ocean.

- The Water Link: A History of Puget Sound as a Resource
  by Daniel Jack Chasan

  The first of 14 volumes in the Puget Sound Publication Series was published at the end of the fiscal year. This series of books, edited and published by the Washington Sea Grant Program, is designed to provide useful information about Puget Sound: its physical properties and biological aspects and man's uses of the Sound.

- "Compendium of Current Marine Studies in the Pacific Northwest"

  The Oceanographic Institute of Washington compiled and published this report describing ongoing environmental studies in the marine waters of this region. OMPA was one of five sponsors of this project; the objective was to provide researchers and administrators with sufficient information to effectively promote interagency communication and minimize duplication of effort.

c. Synthesis in Support of the OMPA Program

OMPA faced the task of accumulating and organizing existing information on the Hudson-Raritan Estuary (HRE) in order to formulate its marine pollution program activities in this area.

This information existed as unorganized data in scattered locations and unrecorded observations of scientists and environmental managers. To compile this information, OMPA conducted a series of seminars summarizing the relevant knowledge of experienced investigators and environmental managers and issued individual grants/contracts on land use/planning, economics, geology, water quality, and ecology to summarize information. One of the earliest of these contracts was an annotated bibliography focusing on the period between 1978 and 1980. More than 2,000 citations were identified consisting of published literature, institutional "grey" literature, and masters and doctoral dissertations. The bibliography contains a subject index developed from key words, identified in the abstracts of the citations. This effort has helped to minimize the duplication of planned research as well as form a sound data and information base for a well-conceived field program.

Another early effort involved a series of discussions with management agencies to define management information needs and help direct HRE planning and priorities. Parallel meetings with scientists reviewed the status of scientific knowledge and helped shape HRE research objectives and strategies. The scientific meetings, being less than conclusive, led to the realization that a more deliberate and comprehensive planning exercise was warranted. Through a State University of New York contract, an attempt was made to improve the match between management expectations and scientific achievement for HRE. A report prepared in 1980, summarized agency interests in the Hudson-Raritan Estuary, and proposed management strategies for potential research in the Estuary. These have assisted in redefining the HRE Program Goal and Objectives for FY 1982. A second report, now in preparation, will assess the appropriateness of identified scientific questions, and describe their tractability. Much of the material in the second report has been used in redefining the Goal and Objectives.

2. Management Information

The design and development of an OMPA management information system (MIS), called the Program Tracking System (PTS), was the largest and most time-consuming task in this category in FY 1981. The purpose of the PTS was to allow OMPA management to track different types of programmatic information quickly and easily.

Specific PTS applications developed by the end of FY 1981 by OMPA/D&IMG are:

- Proposal inventory - a system to track incoming proposals for studies through the receipt, review, and decision process.

- Funding summary - an internal inventory of all funded studies in all OMPA projects, and generally what types of problems the studies address.

- Reference bibliography - a file of citations, presently of oil dispersant information; eventually this will incorporate all publications from research studies funded by OMPA.

- Data tracking - a system to track all deliverables (e.g., digital or analog data, reports, products) from all OCSEAP investigators. Items are tracked from data collection through submission, processing, and availability to outside users.

- Equipment tracking - a file to keep account of various equipment purchased by contractors and investigators. It is also used to record response equipment and their locations and availability for the Hazardous Materials Response teams.

- Financial applications - two applications: one to track travel expenditures, and the other to track full-time equivalency (FTE) hours worked. Each application was designed for special reporting requirements now in effect.

- Financial tracking - a specialized system to track OCSEAP's financial expenditures and research units. This was designed to meet OCSEAP's particular requirements for reporting to the Bureau of Land Management.

- Mailing list - an automated mailing list allowing selective sorting and producing formatted mailing labels.

- Action item listing - a method of notifying individual users or groups of users of upcoming events, deadlines, or actions needed.

- Electronic mail - an extensive system of communication between users for sending messages, requests, or reports. It also has text editing and processing available for formatted reports and output.

Several other, more generic tasks were also performed by the D&IMG. These were not specific to certain MIS products, but related to overall system considerations. Examples are:

- Procurement of terminal and communication equipment for each office.

- Training of individuals and groups on system use.

- Documentation of specific applications and other system features.

- Examination of potential interfaces between word processing systems in each office and the PTS.

Through these and other related tasks, the D&IMG facilitated the use of the PTS for OMPA. The D&IMG also investigated expanding the system's capabilities through statistical packages, graphics terminals and software, and letter-quality printers for document output. These

types of tasks will continue in FY 1982 as needs change and the data processing market changes with new developments.

Overall, the Program Tracking System has been highly successful in providing the needed information in a useful form. The flexible file management system and input/output capabilities of the PTS have made it easy to use and responsive to change. The programming support has been excellent and helped the D&IMG provide the needed applications on time. The success of the PTS effort in a few particular applications has demonstrated the validity of the system concept and also the system's usefulness to management.

3. Data and Information Storage

OMPA's major effort in data and information storage has been through OMPA's OCSEAP data management program. A major goal of this program has been to build a quality data base containing information relevant and useful to the BLM for environmental assessment activities. In FY 1981, there were several significant accomplishments but some failures as well. Some FY 1981 highlights are noted below.

Data Quality Control and Products

During the initial stages of OCSEAP, the policy was established to store data in a digitized form, if sufficient quantity existed. All other sources of data, such as maps and photographs, are retained by the scientist concerned and selections are sent to various data centers as determined by the OCSEAP data manager.

The Environmental Data and Information Service (EDIS) in Washington, D.C., under contract with OCSEAP, maintains a digital data base with satellite centers for microbial data at the National Institutes of Health (NIH) in Washington, D.C. and for geophysical data at the National Geophysical and Solar-Terrestrial Data Center (NGSDC) in Boulder, Colorado. OCSEAP scientific results maintained in these data bases include oceanographic, chemical, microbial, bird, marine mammal, geologic, plankton, benthic, and fisheries data.

Increasing attention is being given to generation of data products from the the OCSEAP digital data base, the primary reason the data base was established. Preliminary products have been produced for the North Aleutian Shelf area by the University of Rhode Island and delivered to the BLM Alaska OCS Office. OCSEAP will maintain direct liaison contact with the BLM's Environmental Assessment staff for digital data products. If the North Aleutian Shelf products prove to be useful, we will produce similar products for other areas on the BLM's leasing schedule.

A major problem in digitizing data in OCSEAP involved initial submissions of data. These often did not comply with specified formats and codes. This problem was attacked in two ways. The first was an attempt to obtain clean data from the investigators by providing assistance in data entry and processing. The second solution was to "crunch" the data submitted through a series of error-checking programs. When errors were found, the investigator was contacted for corrections and the changes were made in the data set. These types of errors included

miscoded data, values outside of reasonable ranges, and improper record sequencing within a file.

Two additional parts of the OCSEAP data management effort address quality control aspects of the data being collected. One is a quality assurance program conducted by the National Analytical Facility for trace petroleum component analysis. This program had two objectives: (1) to improve analytical technique for petroleum hydrocarbons and their metabolites, and (2) to coordinate and conduct an analytical quality assurance program for hydrocarbon data collected by OCSEAP and other BLM-funded programs. Both phases of the intercalibration exercise have been completed and the second phase is being executed. Preliminary results show comparability of data from participating labs.

OCSEAP's second quality control activity is the voucher specimen archive maintained by the California Academy of Science (CAS). Over 8000 lots of specimens have been submitted to the archive since it was established. The specimens, maintained as a separate collection for five years, will be integrated into the main collections of the CAS. This archive addresses BLM's legal requirements for sample storage and provides authenticated data and a record of methodology in case the validity of BLM's studies are challenged.

Other than OCSEAP's data and information storage activities, very little of OMPA's D&IMG effort was directed toward strictly data base tasks in FY 1981. A major area of concern for the future is an inventory or directory of data collected by pollution related studies, both within the project and with outside agencies. This inventory would identify what data types are collected in a particular region, or what data can be used to address problems in other parts of the country than the one in which it was originally collected. In either case, the need to interrelate studies of different agencies on the same area or problem requires a complete inventory of data that has been collected, its location and format, and the collecting agency. This kind of inventory has been informally maintained by most regional projects for studies in their area, but a more formal inventory is needed, especially in areas not presently studied by OMPA projects. This will become a major FY 1982 undertaking of the D&IMG.

4. Conclusions and Plans

The Data and Information Management Group will address several specific areas during FY 1982. The first objective of continuing the development of the management information system will focus on three main tasks:

- Design and development of a comprehensive internal financial tracking system. This system will not replace the NOAA FIMA or the ERL PMIR system in their present uses inside OMPA. It will give more real-time information to be exchanged among the scattered OMPA offices and allow more fiscal control within the OMPA management structure.

- Integration of the various applications already developed into a single tracking and information system.

- Extensive training in all offices and documentation of the system, both for users and system developers.

The overall objective will address financial and reporting standardization within OMPA. This will allow management to more effectively evaluate the programmatic balance and control the direction of OMPA's efforts.

A second objective, environmental data analysis activities, will become a major effort during FY 1982. Longer-term planning will be needed to support OMPA's future assessment role. Three main tasks in this area will be addressed:

- Planning to support OMPA's future assessment and synthesis effort to generate information products for management and other users.

- Planning and design of a data inventory of studies funded by OMPA projects first, then of related studies by other agencies.

- Continued support to project staff members and investigators on data analysis tasks, as needed.

In addition, the D&IMG will play a more active role in NOAA's P.L. 95-273, Section 8 - Dissemination of Information responsibilities. Increased interaction between OMPA's marine pollution studies and EDIS's information storage and dissemination activities will lead to more useful products and more timely availability. The D&IM Group will be involved in EDIS's OPDIN (Ocean Pollution Data and Information Network) development and provide OMPA's interface to these activities.

C. MARINE POLLUTION MONITORING

During the development of the second Federal Plan for Ocean Pollution Research and Development and Monitoring, we realized that marine pollution monitoring needs and priorities should be addressed separately from those of research and development. Accordingly, a series of regional workshops addressing marine pollution monitoring needs was planned. Participants were drawn from both technical and managerial communities directly involved with obtaining and using marine pollution monitoring data.

OMPA's principal marine pollution monitoring activity has centered around these of regional marine pollution workshops held between September 1980 and February 1981. The locations for these workshops were: Northeast--Stony Brook, New York; Southwest--Pasadena, California; Western Gulf--New Orleans, Louisiana; Northwest--Seattle, Washington; Southeastern--Atlanta, Georgia; and Great Lakes--Ann Arbor, Michigan.

Invitees to the workshops were selected to achieve a balance:

a) among Federal, state, and local government, and industry,

b) between technical experts and managers, and

c) among the states within a given region, and also to include representation by public interest groups.

The workshops were intended to address broad objectives concerning the development of guidelines, strategies, and approaches for interrelating operational ocean pollution monitoring programs and findings in order to improve overall effectiveness and minimize costs. The workshops proposed to generate descriptions and assessments of existing monitoring programs and a definition of additional monitoring needs.

The report entitled "An Assessment of Great Lakes and Ocean Pollution Monitoring in the United States" summarizes findings of the six regional workshops in relation to the national marine pollution goals set forth by Congress in P.L. 95-273 and other legislation. Results of each regional workshop are summarized in individual reports which contain details not included in this national overview.

The following highlights the major findings of these workshops:

Coordination

The most critical deficiency in marine monitoring programs is the lack of coordination among the many individual programs. Needs were identified as follows:

1) An appropriate mechanism should be established to ensure that marine pollution monitoring programs are coordinated within each region and among the various regions.

2) Information should be made available concerning the essential characteristics of all marine monitoring programs. Information should be targeted primarily at local, state, and industrial interests who need to effectively assess the availability of existing data and information, and the need for additional monitoring data and/or information to address specific local problems.

3) Marine pollution monitoring planning and coordination should be achieved primarily on a regional basis, since the characteristics of marine ecosystems and the pollution problems affecting them differ widely from region to region. Monitoring program design should take into account considerations of the nature of local and regional ecology, pollution inputs, and other impacting activities.

Data, Information, and Quality Assurance

In each regional workshop, participants stated that it is difficult to obtain data from other monitoring programs in useful form. They also stated that information concerning the quality assurance of data and information products summarizing marine pollution monitoring knowledge are in general not available. The following needs were identified:

1) Acquisition, storage, and dissemination of marine pollution monitoring data should be improved. Access to data bases should be simplified, and mechanisms established which would actively produce awareness of the data that are available and facilitate access to the data by users, particularly occasional users unskilled in marine pollution data acquisition.

2) Monitoring data quality should ensure that data from all monitoring programs can be compared. The most critical needs are for publication of a compilation of approved methods and standard reference methods, for the inclusion of quality assurance information in marine pollution data bases, and for standardization of measurement units used for data reporting.

3) Information gained from assessment of marine monitoring data should be available to managers in a form suitable for use in making decisions. A hierarchy of information products is needed because of the wide variation in the degree of complexity of marine pollution problems and in the technical expertise available to these decision makers.

4) Access should be improved to those in-house monitoring publications and reports which are not published in a widely disseminated form.

Synthesis

While syntheses of marine pollution data addressing major national marine pollution issues are routinely formed by Federal agencies with programmatic responsibilities in the area of interest, no adequate mechanism exists for them to be performed concerning local and individual marine pollution problems. Throughout each of the regional workshops, state and local managers consistently remarked on the lack of synthesis products which were useful in their decision-making process.

The following synthesis needs were identified:

Existing and new marine pollution monitoring data need to be analyzed and assessed on a continuing basis for their application to current and projected marine pollution problems. Mechanisms are needed through which such evaluation is performed on a continuing basis with respect to broad regional problems. Mechanisms are also needed so that evaluations can be performed concerning individual marine pollution problems, especially those problems of a local nature where the management group has limited technical expertise.

Program Evaluation

Many regional workshops participants felt that marine pollution monitoring program design was inadequate, in part because the effectiveness of existing program designs has not been studied.

All types of pollution monitoring programs should be critically assessed on a continuing basis to establish their effectiveness in meeting stated objectives. The results of these assessments should be used to redesign existing and future monitoring programs.

Compliance Monitoring

Regional workshop participants, especially municipal and industrial representatives, voiced much dissatisfaction with the value of compliance monitoring in meeting national management objectives.

The following needs for improvement of compliance monitoring were identified:

1) Compliance monitoring requirements should be continuously reviewed and reduced to the minimum necessary to satisfy management objectives.

2) A study should be made of the monitoring strategies that can improve the efficiency and effectiveness of compliance monitoring, particularly that compliance monitoring which takes place in response to legislative and regulatory requirements which limit the extent of ecological change occurring in the affected ecosystem.

Ecosystem Research

Workshop participants in all regions strongly expressed the need for additional research on marine pollution problems affecting their region.

Region-wide multi-disciplinary ecosystem research programs are needed in pollution impacted coastal regions where no such efforts have previously taken place. In regions where multi-disciplinary region-wide ecosystem research programs have existed in recent years or are currently underway, these efforts need to continue at an appropriate level to identify and research new and emerging pollution problems that should be monitored, to aid interpretation of information gained from monitoring, and to aid development of more efficient and effective monitoring strategies and techniques.

Trend Assessment Monitoring

Existing trend assessment monitoring programs are structured to address a variety of concerns, including marine pollution issues. Therefore, the results of these programs are not often integrated effectively into overall marine pollution management considerations.

With regard to marine pollutant concentration trend monitoring, the following needs were identified:

1) Alternative strategies for monitoring the trend of marine pollutant concentration should be studied. The purpose of these studies should be to determine the most efficient and effective strategy for providing sufficient information to determine the concentrations of pollutants in critical components of the ecosystem, either directly or by modeling. Alternative strategies would include close examination of the sentinel organism approach, better use of recreational and commercial fishing data, research into the chemical indicators of pollutant stress, and methods to identify natural variability as a causative agent in ecological changes.

2) Data and information from all marine ecological trend monitoring programs, including those taking place in response to management needs other than marine pollution, should be reviewed on a continuing basis. Information concerning observed trends should be available for use in marine pollution management, and in the design of marine pollution monitoring and research programs.

Technology Development

Rather than suggesting needs for new technology with which to make more sophisticated environmental measurements, workshop participants expressed concern that the existing sampling and analysis technologies suffered operational problems which compromised the efficiency of marine monitoring programs. These operational problems include: unreliability, difficulty of operation, high cost, and lack of adequate operator training programs.

National Marine Pollution Monitoring Program Planning

Workshop participants felt that a national program should provide the framework for integration of the hierarchy of existing marine pollution and other marine monitoring programs, and should operate on a regional basis. In addition, since in most regions the hierarchy of programs is incomplete, the national program should seek to ensure that these information gaps are filled.

Workshop participants proposed that the national marine pollution monitoring program should be the sum of a number of regionally planned and coordinated programs. It should ensure the availability of data from all marine monitoring programs, and that these data are integrated in a manner leading to useful syntheses and interpretations. It should also ensure that useful information products are produced and disseminated to users. The national program should identify gaps in the hierarchy of monitoring programs and should find means to fill these gaps.

V. PROGRAM EMPHASIS FOR FY 1982-85

In FY 1982-85, the OMPA program will place its major emphasis on addressing marine pollution problems related to marine waste disposal. Other major ocean-use problems will also be addressed; however, the uncertain budget climate will play a major role in determining both the issues that can be studied and the accomplishments in terms of substantial progress or resolution of the issues. This section assumes that funds will be available to do the work identified and, therefore, defines program priorities (emphases) based on established priorities and OMPA program responsibilities. The criteria used for defining the OMPA priorities are recommended for the use of the definition of priorities of the subactivities as well. These are summarized at the beginning of this section.

A. CRITERIA FOR SETTING PRIORITIES

In addition to the general guidance provided by the legislative and assigned responsibilities, and the goals and objectives of the NOAA marine pollution program, criteria must be established to aid the selection of the specific program focus. The following were prescribed in the Federal Plan and are used by OMPA to determine priorities:

- Immediacy of pollution threat
- Value of the polluting activity to the nation
- Intensity and extent of the polluting activity, including future anticipated problems caused by the activity
- Value of the resources at risk
- Amount of useful information already available
- Timeframe in which information is required for decision-making
- Utility of information in preventing future pollution pollution problems

B. OMPA MARINE POLLUTION ROLES AND OBJECTIVES FOR FY 1982-85

Six agency-wide marine pollution goals are identified in the January 1982 NOAA Marine Pollution Program Plan. The following highlights the specific roles and objectives that OMPA will be responsible for in relation to these NOAA marine pollution goals:

NOAA Goal 1: To guide national policy decisions on marine pollution issues based upon scientific information.

OMPA ROLE:

OMPA, in conjunction with other MPE's as appropriate, will coordinate efforts to guide national pollution policy decisions by providing assessments of past, ongoing, and proposed ocean-use activities. It will develop strategies to predict and determine the environmental effects of proposed and ongoing ocean-uses by applying its scientific and technical competency. In this process, recommendations will be made on specific ocean-uses, including methods, place, and timing of ocean-use and alternative ocean-use practices.

OMPA OBJECTIVES - FY 1982-86:

1. Prepare draft NOAA policy document for major ocean-use issues.

2. Conduct analyses of the existing marine pollution regulatory framework and its application to specific ocean waste disposal activites.

3. Prepare assessment reports at selected sites describing impacts resulting from past, ongoing, and proposed ocean dumping activities.

4. Recommend alternative source control or disposal strategies based on knowledge of cumulative pollutant impacts and comparative assessment of risks for selected regions.

5. Develop site selection guidelines for disposal of waste materials in marine waters.

6. Prepare a comprehensive synthesis and evaluation report on the documentable environmental impacts from OCS oil and gas development using appropriate areas (Alaska, North Sea, Gulf of Mexico, Southern California) as case histories.

7. Prepare assessment reports on the impacts resulting from disposal of contaminated dredged material and evaluate alternative disposal practices.

8. Define the efforts and concerns associated with ocean disposal of nuclear wastes.

NOAA GOAL 2: To provide leadership in planning and coordinating Federal marine pollution research, development, and monitoring activities; in preparing and synthesizing results; and in disseminating information in a timely manner and in useful formats to all relevant users.

OMPA ROLE:

OMPA will assist the office delegated the responsibility for coordinating the Federal marine pollution program by organizing and actively participating in planning, information exchange, and review activities relating to all NOAA's marine pollution activities. In addition, OMPA will manage the marine pollution program information system for NOAA, which will become a direct input to the analysis of the Federal program.

OMPA will promote synthesis of information that has been obtained not only by OMPA and NOAA, but also by other Federal agencies and deals with national pollution issues.

OMPA OBJECTIVES - FY 1982-86:

1. Coordinate the preparation of an updated NOAA Marine Pollution Program Plan.

2. Prepare marine pollution sections of an Atmosphere and Marine Quality Assessment Plan.

3. Prepare an updated OMPA Program Plan for comprehensive coordinated program on high priority marine pollution issues.

4. Obtain regional input and prepare regional issue analysis reports.

NOAA GOAL 3: To develop sufficient understanding of marine ecosystems to provide a sound evaluation of the impacts of the marine environment as a source of renewable and non-renewable resources.

OMPA ROLE:

OMPA will conduct studies to understand critical ecosystems, their natural variations, and the short- and long-term effects of polluting activities on the environment. OMPA will evaluate various uses of the ocean and predict their associated risks in terms of social, ecologic, and economic costs and benefits. Existing risk assessment techniques will be adapted and new ones developed, as needed, so that OMPA can evaluate ocean uses and alternatives and make scientifically sound recommendations to management and regulatory authorities. This risk assessment approach will be applied to regions of the coastline for which critical ocean use decisions must be made over the next few years. Prototype studies can identify ocean resource use compatibilities and conflicts, develop multiple use management strategies, formulate cost-benefit analyses for the various management options, and recommend optimal strategies to ocean use managers.

OMPA OBJECTIVES - FY 1982-86:

1. Develop understanding of fundamental ecosystem processes which will enable NOAA to:

   a. Prepare interim indices of unacceptable ecological impacts resulting from introduction of contaminants.

   b. Define recovery rates following reduction of contaminant input or removal of existing contaminant reservoirs.

   c. Prepare a comprehensive conceptual model of physical processes and their interaction with contaminants.

   d. Prepare reports on specific, key environmental processes controlling contaminant distribution and impact.

2. Prepare and test prototype assessment strategies for predicting biological effects with consequences at the population level from selected ocean waste disposal strategies.

3. Develop an accurate method for determining sources and levels of pathogenic organisms in coastal environments with emphasis on safety for human consumption of seafood.

NOAA GOAL 4: To support efforts to prevent, or mitigate, the effects of and assess damages resulting from accidental releases of oil and hazardous materials into the marine environments.

OMPA ROLE:

An active OMPA program of scientific study and spill response increases protection of the coastal zones from spills of oil and other hazardous materials. This scientific program aids the response effort by identifying environmental resources which warrant extraordinary protective efforts, determining the potential of a pollutant to cause damage, forecasting the pollutant's distribution and composition with time, recommending alternative cleanup, mitigation, and containment strategies, and assessing the damages resulting from such an incident. These efforts will provide information that is pertinent to decisions regarding marine transportation and offshore development and which is critical in reducing regulations of commercial activity which have resulted from an effort to compensate for lack of knowledge.

OMPA OBJECTIVES - FY 1982-86

1. Achieve total spill response readiness.

2. Establish Scientific Support Coordinators in areas corresponding to U.S. Coast Guard Districts.

3. Complete Environmental Sensitivity Index maps for high risk regions of U.S. coast.

4. Provide on-scene assistance at spills of oil, other hazardous substances, and designated uncontrolled waste sites.

5. Provide DOC/NOAA representation on Regional Response Teams.

6. Develop simplified damage assessment procedures that will determine long- and short-term impacts, replacement value, use value, and ability of ecosystems or resources to recover.

7. Carry out applicable provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

NOAA GOAL 5: To protect the integrity, productivity, and aesthetic quality of the marine, estuarine, and Great Lakes systems from unacceptable ocean use practices and to enhance already degraded systems by recommending possible mitigatory and/or restorative actions.

OMPA ROLE:

OMPA will seek to understand the effects, both short- and long-term, of polluting activities on impacted ecosystems. OMPA programs are coordinated with other NOAA and Federal agency programs, and a special effort will be made to present multiple-use alternatives to decision-makers.

OMPA will also develop ocean-use alternatives leading to the enhancement of degraded environments. Whether the impacts occurred through lack of understanding, neglect, or necessity, it is in the best interest of the nation to upgrade these ecosystems, if possible. Through research efforts, OMPA will recommend action to alleviate some of the stress upon the ecosystem.

OMPA OBJECTIVES - FY 1982-86:

1. Predict and test in appropriate selected areas the effects on valuable living resources that will result from remedial action in demonstrably contaminated areas.

2. Develop effective regional monitoring approaches which will detect unacceptable impacts and indicate causative contaminants and sources and which will lead to development of management strategies.

NOAA GOAL 6: To document and evaluate the status and trends of source loadings, ambient levels, and biological accumulations of critical pollutants and the probable effects of these pollutants on the ecosystem and on human welfare.

OMPA ROLE:

OMPA will identify the pollutants of greatest concern and determine the concentrations at which these pollutants and their transformation products cause unacceptable environmental effects. Regulatory decisions on permissible exposure levels for the ecosystem can be made when the acute, chronic, bioaccumulative and synergistic effects are documented for various pollutants. OMPA synthesis of these research and monitoring efforts will result in assessments which will warn ocean use managers of imminent harmful impacts and will provide a long-term data base for impact evaluation and forecast.

Aspects of these efforts (compliance monitoring, trend assessments, effects studies, etc.) currently are conducted in NOAA and other agencies. These programs and studies generate information geared toward impact assessment. OMPA will evaluate these data to determine the status of ecosystem understanding and to determine where additional data are required. OMPA will analyse and synthesize data from existing Federal, state, and local programs and develop improved techniques to be recommended for trend-assessment monitoring. OMPA will also actively participate in the planning, coordination, synthesis, and information dissemination activities of regional monitoring programs.

APPENDIX A

OMPA ORGANIZATION

1. Organizational Structure

On May 14-15, 1981, OMPA held a management meeting to examine its organizational structure and to recommend means to improve program integration and effectiveness. Based on that meeting, a modest restructuring and realignment was proposed. These recommendations were initiated in FY 1981; therefore, OMPA is currently in transition from independent organizational elements related to marine pollution to an integrated program concept. This will permit a better use of personnel, more effective use of resources, easier definition of research needs, gaps, and overlaps, better communications, and the establishment of a comprehensive, coordinated, and effective marine pollution program within OMPA.

The new organizational structure (Figure A - 1) will be implemented gradually. All elements will be established by the end of FY 1982.

2. Responsibilities and Interactions

- The Office of the Director will perform or oversee the full range of OMPA responsibilities. The Director is the conduit for official communication with higher management and other NOAA MPEs. He is the final authority on organizational assignments, resource allocation, and personnel policy within OMPA.

- The Program Planning and Evaluation Office will perform the following functions:

  a) Develop and recommend long-range planning for comprehensive, integrated, and continuing programs for research, development, monitoring, and assessment related to marine pollution and people-induced changes in marine ecosystems.

  b) Coordinate the review and evaluation of OMPA and other NOAA marine pollution programs for responsiveness to national needs and priorities.

  c) Evaluate results and products by examining the program synthesis and assessment efforts of program activities.

  d) Maintain overview and coordination with OMPA programs, other MLCs, and non-NOAA marine pollution programs, and serve as a point-of-contact on technical and management aspects of these programs.

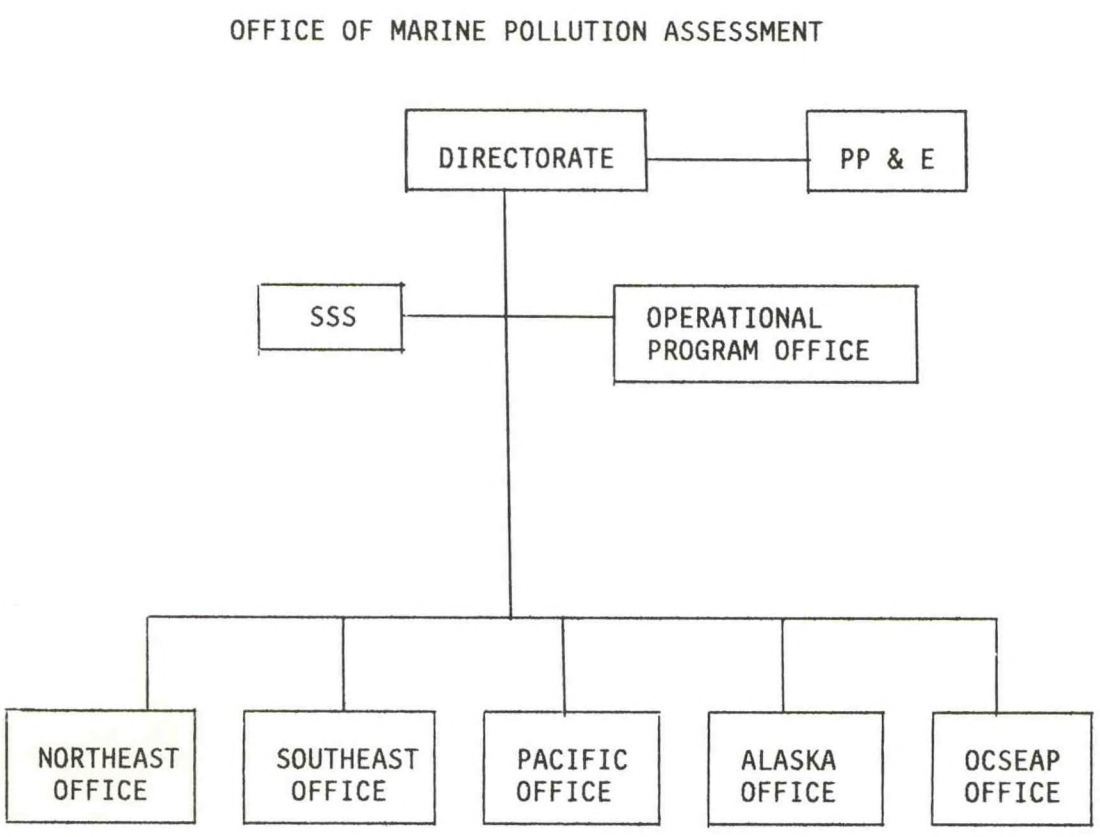


Figure A-1. Organizational Structure

e) Serve the OMPA Director by conducting special studies, performing tasks in support of the Director's Office, and providing information on a variety of technical and management issues involving OMPA, NOAA, and other marine pollution programs.

° The Scientific Support Services Office will provide technical and administrative support necessary to facilitate the OMPA mission. This includes, but is not limited to, budgetary, procurement, personnel, publication, and information management services.

° The Northeast, Pacific, Southeast, and Alaska Offices will each have the following responsibilities:

a) Maintain cognizance of research and monitoring related to marine pollution conducted within the region by all organizations, including NOAA, other Federal organizations, state agencies, and universities.

b) Provide assessments and syntheses of available data and information to address present or potential problems of regional interest.

c) Develop and maintain a broad understanding of regional marine pollution affairs for use in responding to policy inquiries by NOAA, requests for inputs to required reports or testimony to Congress, comments on Environmental Impact Statements, and inquiries by decision-makers or the general public.

d) Provide the DOC/NOAA representative to Regional Response Teams for spills of oil or hazardous materials; make NOAA input to contingency plans.

e) Identify and define regional needs and priorities for marine pollution information for OMPA research, investigation by other NOAA organizations, and input to the Five-Year Federal Plan.

° The Office of Operational Programs will manage all of OMPA's research, development, and monitoring projects. Commencing in FY 1982, it will assume management of the Ocean Dumping, Long-Range Effects, Financial Assistance, and Hazardous Materials Response Programs, and oversight and integration responsibilities for the MESA programs.

The Operational Programs Office will integrate the short-term planning, program execution, and information synthesis of the operational program components so that a complementary, coordinated program is oriented toward national needs. While OMPA's operational programs are to be centrally managed, the development of needs and the assignment of priorities remains a function of OMPA as a whole. PP&E and the regional offices will play a dominant

role in the long-term development of OMPA's research, development, and monitoring activities.

° The Outer Continental Shelf Environmental Assessment Program (OCSEAP) is established by a basic agreement between the National Oceanic and Atmospheric Administration and the Bureau of Land Management to conduct a program of environmental research for Alaskan outer continental shelf areas identified by BLM for potential oil and gas development. The primary goals of the OCSEA Program is to provide scientific information for management decisions necessary to protect the Alaskan marine environment from excessive adverse impacts during oil and gas exploration and development.

APPENDIX B

FY 1981 Bibliography of Publications, Papers, Books, and Articles Written by Principal Investigators on OMPA Funded Projects

Aagaard, Knut et al. 1981. On the halocline of the Arctic Ocean. Deep Sea Research, 28(6):529-545.

Anderson, M. A. 1981. The influence of aqueous iron chemistry on the uptake of iron by the coastal diatom Thalassiosira weissflogii. Ph.D. Dissertation. MIT, Cambridge, MA.

Atlas, R. M. et al. 1981. Distribution of hydrocarbons and microbial populations related to sedimentation processes in Cook Inlet and Norton Sound, Alaska. Oregon Agricultural Experiment Station Technical Paper No. --. 38 pp.

Barnes, P. W., E. Reimnitz, and D. Fox. (In Press). Ice rafting of fine-grained sediment, A new process, Beaufort Sea, Alaska. (No information is available on journal to which this article was submitted.) 25 pp.

Barnes, P. and C. R. Ross. (In press). Ice-pushed boulder pile, Camden Bay, Alaska. (No information is available on journal to which this article was submitted.) 22 pp.

Bates, H. F. and L. H. Shapiro. 1980. Breaking ice with gravity waves. Journal of Energy Resources Technology, 102, 148-153.

Bates, H. F. and L. H. Shapiro. 1980. Long period gravity waves in ice-covered sea. Journal of Geophysical Research, 85(C2): 1095-1100.

Bisagni, J. J. 1981. Physical oceanographic studies at 106-Mile site, July 1977. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report. 81-1. pp 233-242.

Bisagni, J. J. 1981. Physical variability at an east coast United States offshore dumpsite. In: Ketchum, Kester, and Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press, New York, NY. pp 89-108.

Bodammer, J. E. and T. K. Sawyer. 1981. Aufwuchs protozoa and bacteria on the gills of the rock crab, Cancer irroratus Say: A survey by light and electron microscopy. J. Protozoology 28(1):35-46.

Boehm, P. D. 1981. 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.

Boucher, G., E. Reimnitz, and E. Kempena. 1981. Seismic evidence for an extensive gas-bearing layer at shallow depth, offshore from Prudhoe Bay, Alaska. Cold Regions Science and Technology, 4:63-71.

Brown, D. W., A. J. Friedman, P. G. Prohaska, and W. D. MacLeod, Jr. 1981. Investigation of petroleum in the marine environs of the Strait of Juan de Fuca and northern Puget Sound. Part II NOAA Technical Memorandum OMPA-7, Office of Marine Pollution Assessment, Boulder, CO. 35 pp.

Burrows, D. G., W. D. MacLeod, Jr., L. S. Ramos, D. W. Brown. 1981. Mass spectral identification of chlorinated organic compounds from sediments collected near an industrial area. 29th Annual Conference on Mass Spectrometry and Allied Topics, Abstracts 1981, American Society for Mass Spectrometry, Minneapolis, MN pp. 615-616.

Capriulo, G. M. and E. J. Carpenter. 1980. Grazing by 35 to 202 m micro-zooplankton in Long Island Sound. Marine Biology 56:319-326.

Carey, A. G. and P. A. Montagna. (In press). An Arctic Sea ice faunal assemblage: A first approach to the description and the source of the under-ice meiofauna. Submitted to Marine Ecology - Progress Series. 25 pp.

Carnes, M. 1981. The critical and experimental studies of the Langmuir circulation. Ph.D. dissertation. Texas A&M University, College Station, TX.

Cerniglia, C. E. et al. (In Press). Aromatic hydrocarbon oxidation by diatoms isolated from the Kachemak Bay Region of Alaska. (No information is available on journal to which this article was submitted.) 12 pp.

Champ, M. A. and P. K. Park. 1981. Ocean dumping of sewage sludge: A global review. Sea Technology. 22(2):18-24.

Champ, M. A., T. P. O'Connor, and P. K. Park. 1981. Ocean dumping of seafood wastes as a waste management alternative. Seafood Waste Management in the 1980s, Conference Proceedings. Florida Sea Grant. Report No. 40, pp 103-115.

Champ, M. A., T. P. O'Connor, and P. K. Park. 1981. Ocean dumping of seafood wastes in the United States. Marine Pollution Bulletin (UK). 12(7):241-244.

Champ, Michael A., T. P. O'Connor, and P. K. Park. (In Press). Factors controlling the capacity of ocean dumpsite for municipal and industrial wastes. To be published in the Proceedings of the SCOPE Workshop on Assimilative Capacity of the Oceans for Man's Wastes. National Taiwan University, Taipei, Republic of China.

Champ, Michael A. and J. Frank Hebard. (In Press). Legislative history of national marine pollution strategies. To be published in the Proceedings of the Engineering Committee on Oceanic Resources International Conference: The Management of Oceanic Resources--The Way Ahead. April 7-9, 1981. London.

Chasan, D. J. 1981. The Water Link: A history of Puget Sound as a resource. Puget Sound Books, A Washington Sea Grant Publication distributed by the University of Washington Press, Seattle, WA. 180 pp.

Chervin, M., T. C. Malone, and P. J. Neale. 1981. Interactions between suspended organic matter and copepod grazing in the plume of the Hudson River. Estuarine, Coastal and Shelf Science, Academic Press Inc. (London) Ltd., pp 169-184.

Clearwater Consultants, Inc. 1981. Monitoring program for the Puerto Rico Industrial Waste Dumpsite: Ocean Drifter Experiment (October 2, 1980 - April 15, 1981). Clearwater Consultants, Inc., Mt. Vernon Street, Boston, MA 02108.

Clearwater Consultants, Inc. 1981. Ocean drifter experiment: Data report (December 1, 1980 - February 28, 1981). Clearwater Consultants, Inc., 33 Mt. Vernon Street, Boston, MA 02108.

Colwell, R. R., F. L. Singleton, and E. L. Elliott. 1981. Bacteriological analysis of fish collected during the 1980 fish-kill near Puerto Rico. Report to NOAA, Office of Ocean Dumping, Rockville, MD.

Colwell, R. R., J. W. Deming, E. R. Peele, F. L. Singleton, B. Cavari, and D. Popkin. 1980. Characterization of microbial communities in surface waters of the Puerto Rico dumpsite. Special Session of Dumping, Amer. Soc. of Limnol. and Oceanog. Abstracts of Annual Meeting, Knoxville, TN.

Cox, J. M., C. C. Ebbesmeyer, C. A. Coomes, L. R. Hinchey, J. M. Helseth, G. A. Cannon, and C. A. Barnes. 1981. Index to observations of currents in Puget Sound, Washington, from 1908-1980. NOAA Technical Memorandum OMPA-5, Office of Marine Pollution Assessment, Boulder, CO. 51 pp.

Cox, J. C. and L. A. Shultz. 1981. The containment of oil spilled under rough ice. Paper 022 presented at the 1981 Oil Spill Conference. 23 pp.

Craig, P. C. (In Press). Fish passage around a causeway in Prudhoe Bay, Alaska. (Submitted to Arctic). 15 pp.

Craig, P. C. et al. 1981. Ecological studies of arctic cod (Boreogadus saida) in Beaufort Sea Coastal Waters, Alaska. (Submitted to Can. J. Fish. Aquat. Sci.) 41 pp.

Cross, J. N. 1981. Structure of a rocky intertidal fish assemblage. Ph.D. Dissertation. College of Fisheries, University of Washington, Seattle, WA. 259 pp.

Dayal, R., M. G. Heaton, M. Fuhrmann, and I. W. Duedall. 1981. A geochemical and sedimentological study of the dredged spoil deposit in the New York bight. NOAA Technical Memorandum OMPA-3, 174 pp.

Devine, M., E. R. Meyer, and T. O'Connor. 1981. NOS Assessment: Project Background, Technical Summary and Assessment and Recommendations. Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 3-29.

Dick, M. H. and I. M. Warner. (In Press). A contribution to the biology of the pacific sand lance, Ammodytes hexapterus, from the Kodiak Archipelago, Alaska. Syesis. 19 pp.

Fay, F. H. (In Press). Nasal mites (Acari halarachridae) in the spotted seal, Phoca largha. Journal of Wildlife Diseases.

Fay, F. H. and B. P. Kelly. 1980. Mass natural mortality of walruses (Odobenus rosmarus) at St. Lawrence Island, Bering Sea, Autumn 1978. Arctic, 33(2):226-245.

Fedorak, P. M. and D. W. S. Westlake. 1981. Microbial degradation of aromatics and saturates in Prudhoe Bay crude oil as determined by glass capillary gas chromatography. Canadian Journal of Microbiology, 27(4):432-443.

Fish, W. and F. M. M. Morel. In prep. Production of metal chelating agents by Daphnia magnia.

Flierl, G. R. 1980. Modelling the effects of wastes dumped in deep ocean gyres. Report to NOAA.

Freeland, G. L., D. I. Stanley, D. J. P. Swift, D. N. Lambert. 1981. Hudson shelf valley, North American Atlantic Shelf: Its role in modern shelf sediment transport. Marine Geology, 42:399-427.

Frisch, A. S., J. Holbrook, and A. B. Ages. 1981. Observations of a summertime reversal in circulation in the Strait of Juan de Fuca. Journal of Geophysical Research, 86(C3):2044-2048.

Frisch, A. S. and B. L. Weber. 1981. Circulation and trajectory calculations in the eastern Strait of Juan de Fuca using a CODAR system. DOC/EPA Interagency Energy/Environment R&D Program Report EPA-600/ 7-81-089, U.S. Environmental Protection Agency, Washington, DC. 19 pp.

Frost, K. J. 1981. Descriptive key to the otoliths of gadid fishes of the Bering, Chukchi, and Beaufort Seas. Arctic, 34(1):55-59.

Frost, K. J. and L. F. Lowry. 1980. Feeding of ribbon seals (Phoco Fasciata) in the Bering Sea in spring. Can. J. Zool. 58(9)1601-1607.

Frost, K. J. and L. F. Lowry. 1981. Trophic importance of some marine gadids in Northern Alaska and their body-otolith size relationships. Fishery Bulletin, 79(1):187-192.

Frost, K. J., L. F. Lowry, and J. J. Burns. (In Press). Feeding and trophic interactions of ringed seals (Phoco hispida) in the Alaska Beaufort Sea. Arctic.

Galt, J. F. 1980. A finite-element solution procedure for the interpolation of current data in complex regions. Journal of Physical Oceanography, 10(12):1984-1997.

Garside, C. 1981. Nitrate and ammonia uptake in the apex of the New York Bight. Limnol. Oceanogr., 26(4):731-739.

Griffiths, R. P. 1981. Field observations on the acute effect of crude oil on glucose and glutamate uptake in samples collected from Arctic and subarctic waters. Applied and Environmental Microbiology, pp. 1400-1406.

Griffiths, R. P. et al. 1981. The long-term effects of crude oil on uptake and respiration of glucose and glutamate in Arctic and sub-arctic marine sediments. Technical Paper No. --; Oregon Agricultural Experiment Station. 35 pp.

Gunnerson, C. G. 1981. The New York Bight ecosystem. Marine Environmental Pollution, 2. Dumping and Mining. Elsevier Scientific Publ. Co. (Amsterdam). pp 313-378.

Guzman, Juan. 1981. The wintering of sooty and short-tailed shearwaters (genus Puffinus) in the North Pacific. Masters thesis. Department of Biology, The University of Calgary, Calgary, Alberta. 510 pp.

Hazelworth, J. B. and G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise. (XWCC-17), NOAA Ship GEORGE B. KELEZ, April 1978. NOAA Data Report OMPA-3, 200 pp.

Hazelworth, J. B., T. M. Niedrauer, G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise (XWCC-18), NOAA Ship GEORGE B. KELEZ, June 1978. NOAA Data Report OMPA-4, 22 pp.

Hazelworth, J. B. and G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise. (XWCC-19), NOAA Ship GEORGE B. KELEZ, July 1978. NOAA Data Report OMPA-5, 240 pp.

Hazelworth, J. B., and G. A. Berberian. 1981. MESA New York Bight Project, Expanded Water Column Characterization Cruise (XWCC-20), NOAA Ship GEORGE B. KELEZ, July-August 1978. NOAA Data Report OMPA-6, 240 pp.

Hazelworth, J. B. and G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise. (XWCC-21), NOAA Ship GEORGE B. KELEZ, April 1979. NOAA Data Report OMPA-7, 221 pp.

Hazelworth, J. B. and G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise. (XWCC-22), NOAA Ship GEORGE B. KELEZ, May-June 1979. NOAA Data Report OMPA-8, 219 pp.

Hazelworth, J. B. and G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise. (XWCC-23), NOAA Ship GEORGE B. KELEZ, July 1979. NOAA Data Report OMPA-9, 271 pp.

Hazelworth, J. B. and G. A. Berberian. 1981. MESA New York Bight Project Expanded Water Column Characterization Cruise. (XWCC-24), NOAA Ship GEORGE B. KELEZ, August 1979. NOAA Data Report OMPA-10, 285 pp.

Hebard, J. F., and M. A. Champ. 1981. Legislative history and philosophy of the development of the U.S. national marine pollution strategy. Workshop Proceedings-Toward a National Marine Pollution Policy. Center for Ocean Management Studies, University of Rhode Island. pp 11-34.

Hooper, C. (ed). 1981. The Ixtoc I Oil Spill: The federal scientific response. National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment, Boulder, CO.

Horner, R. A. (In Press). Ecology and productivity of Arctic Sea ice diatoms. (No information is available on journal to which this article was submitted.) 9 pp.

Ichiye, T., and M. Carnes. 1980/81. Application of aerial photography to the study of small-scale upper ocean phenomena, Pure and Applied Geophys. (PAGEOPH) 119, Basel, 1-15.

Johnson, S. R. and W. J. Richardson. (In Press). Waterbird migration near the Yukon and Alaskan Coast of the Beaufort Sea. II. Moult migration of seaducks. Arctic.

Kester, D. R., B. H. Ketchum, and Park. 1981. Future prospects of ocean dumping. In: B. H. Ketchum. D. R. Kester, and P. K. Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press, N.Y. pp. 505-519.

Kester, D. A., and K. A. Hausknecht. Transition and heavy metal chemistry associated with 106-Mile site. pp 39-80.

Kester, D. A., R, C. Hittinger, R. Mukherji, and R. A. Hausknecht. 1981. Metal Studies at 106-Mile Site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 81-130.

Kohn, B. and G. T. Rowe. 1981. Dispersion of two liquid industrial wastes dumped at 106-Mile site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 133-156.

Kopenski, R. P. and E. R. Long. 1981. An environmental assessment of northern Puget Sound and the Strait of Juan de Fuca: A summary. Office of Marine Pollution Assessment, Boulder, CO. 32 pp.

Kovacs, Austin. 1980. Recent ice observations in the Alaskan Beaufort Sea federal-state lease area. The Northern Engineer, 10(3):7-12.

Kozo, T. L. and F. Wu. 1981. Air-sea interaction along the Alaskan Arctic coast. Special Report by Tetra Tech. TC-3403. 78 pp.

Krahn, M. M., T. K. Collier, and D. C. Malins. (In Press). Aromatic hydrocarbon metabolites in fish: Automated extraction and high-performance liquid chromatographic separation into conjugate and nonconjugate fractions. (No information is available on journal to which this article was submitted.) 19 pp.

Lear, D. W., M. L. O'Malley, and S. K. Smith. 1981. Effects of ocean dumping on a temperate midshelf environment. In: B. H. Ketchum, Kester, and P. K. Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press, N.Y. pp 485-502.

Lee, W. Y. and J. A. C. Nicol. 1981. Toxicity of biosludge and pharmaceutical wastes to marine invertebrates. In: Ketchum, Kester, and Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press, N.Y. pp 439-454.

Lee, W. Y., A. Morris, and J. A. C. Nicol. 1980. Toxicity of ocean-dumped pharmaceutical wastes to marine copepods and ichthyoplankton Final Report to NOAA/ODMP. 32 pp.

Lesht, B. M., T. L. Clarke, G. L. Freeland, D. J. P. Swift, and R. A. Young. 1981. Empirical relationship between the concentration of resuspended sediment and near bottom wave orbital velocity. Geophys. Res. Ltrs., 7:1049-1052.

Litchfield, C. D. 1980. Heterotrophic studies: A comparison of four ways of calculating kinetic parameters. Microbiology. pp. 366-369.

Liu, S. K. and J. J. Leendertse. (In Press). A three-dimensional model of Norton Sound under ice cover. POAC 1981 Meeting in Canada. 11 pp.

Liu, S. K. and J. J. Leendertse. (In Press). A 3-D oil spill model with and without ice cover. Presented at the International Symposium on Mechanics of Oil Slicks on September 8, 1981, Paris, France. 16 pp.

Lowry, L. F. and J. J. Burns. 1980. Foods utilized by bowhead whales near Barter Island, Alaska, autumn 1979. Marine Fisheries Review, Sept.-Oct. pp. 88-91.

Lowry, L. F. and K. J. Frost. 1981. Distribution, growth and foods of arctic cod (Boreogadus saida) in the Bering, Chukchi, and Beaufort Seas. Canadian Field - Naturalist. 95(2):186-191.

Lowry, L. F., K. J. Frost, and J. J. Burns. 1980. Variability in the ringed seal diet, Alaska. Journal of Fisheries and Aquatic Science, 37(12):2254-2261.

MacLeod, W. D. et al. (In Press). Interlaboratory comparisons of selected trace hydrocarbons from marine sediments. (No information is available on journal to which this article was submitted.) 16 pp.

Mann, R. G. 1980. Suspended particulate matter, temperature and salinity data, New York Bight, 1979. NOAA Data Report OMPA-1, 41 pp.

Mason, D. T. 1981. Arctic saltmarsh lakes. Verh. Internat. Verein Limnol., 21:1171-1177.

Matthews, J. B. 1981. Observations of Surface and Bottom Currents in the Beaufort Sea Near Prudhoe Bay, Alaska. Journal of Geophysical Research, 86(C7):6653-6660.

Matthews, J. B. 1981. Preface to observations of under-ice circulation in a shallow lagoon in the Alaskan Beaufort Sea. Ocean Management, 6:85-86.

Matthews, J. B. 1981. Observations of under-ice circulation in a shallow lagoon in the Alaskan Beaufort Sea. Ocean Management, 6:223-234.

Maynard, D. J. and D. D. Weber. 1981. Avoidance reactions of juvenile coho salmon (Oncorhynchus kisutch) to monocyclic aromatics. Canadian Journal of Fisheries and Aquatic Science, 38(7):772-778.

Maynard, N. G. (In Press). Dispersants a view from the field. Presented at the 1981 Oil Spill Conference (Prevention, Behavior, Control, Cleanup). Atlanta, GA. March 1981.

Maynard, N. G. (In Press). Techniques for the optimization of scientific spill response - Tested at the BURMAH AGATE oil spill. Proceedings of the 1981 Arctic Marine Oil Spill Program (AMOP). Edmonton, Alberta. June 16-18, 1981.

Maynard, N. G. (In Press). National perspectives on oil spill dispersant use. Presented at the American Association for the Advancement of Science, Alaska Division, 32nd Alaska Science Conference 1981. Fairbanks, AK. August 25-27, 1981.

Maynard, N. G. 1981. Pentachlorophenol in the Mississippi River Gulf outlet--Problems and implications. Proceedings of OCEANS 81 Conference. Boston, MA. Sept. 16-18, 1981.

Mendez, A. and G. Berberian. 1981. MESA New York Bight Project: Winkler oxygen data. NOAA OMPA Data Report-2, 260 pp.

MESA Puget Sound Project. FY80-81 Technical Development Plan. Office of Marine Pollution Assessment, Seattle, WA. 87 pp.

Mizcuko, D. and J. L. Chamberlain. Gulf Stream Anticyclonic Eddies and Shelf Water at 106-Mile Site During 1977. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 207-232.

Montagna, P. 1980. A new species and new genus of Cerviniidae (Copepoda: Harpacticoida) from the Beaufort Sea, with a revision of the family. Proceedings of the Biological Society of Washington, 93(4):1204-1219.

Montagna, Paul A. 1980. Two new bathyal species of Pseudotachidius (Copepoda: Harpacticoida) from the Beaufort Sea (Alaska, U.S.A.). Journal of Natural History, 14:567-578.

Murphy, L. S. and P. R. Hoar. 1981. Effect of pollutants on marine phytoplankton at 106-Mile site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 309-319.

Murray, T. E. 1981. Summary of Waste Inputs to 106-Mile Site During 1976 and 1977. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 33-38.

Neave, K. G., P. V. Sellmann, and A. Delaney. 1981. Hyperbolic reflections on Beaufort Sea seismic records. CCRREL Report 81-2. 16 pp.

Niebauer, H. J., J. Roberts, and T. C. Royer. (In Press). Shelf break circulation in the Northern Gulf of Alaska. Journal of Geophysical Research.

Niedoroda, A. W. 1980. Shoreface - surf zone sediment exchange processes and shoreface dynamics. NOAA Technical Memorandum. OMPA-1, 89 pp.

Niedrauer, T. 1981. MESA New York Bight Project graphic presentation of T. S. Sigma-t and transmissivity data from the 1975-1977 XWCC cruises. NOAA Technical Memorandum OMPA-9, 257 pp.

O'Connor, T. P., Akira Okubo, M. W. Champ, and P. K. Park. (In Press). Deep ocean dumping of sewage sludge. Can. Jour. Aquat. and Fish. Sci.

O'Donnell, R. et al. (In Press). Growth characteristics of diatoms isolated from Lower Cook Inlet, Alaska.. Journal of Phycology. 10 pp.

Orr, M. H. and C. L. Winget. 1981. A six-port underway water sampling system. Marine Technology Society Journal, 15. pp 26-30.

Orr, M. H. 1981. Acoustic detection of the particulate phase of industrial chemical wastes released at 106-Mile site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 157-202.

Orr, M. H. 1981. Quantitative dispersion characteristics of the particulate phase of Du Pont Edge Moor Plant. Acid iron waste and Grassell: Plant wastes for summer and winter. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 203-204.

Orr, M. H. 1981. Qualitative characteristics of sewage sludge released in the presence of a shallow seasonal thermocline. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 205-206.

Ortner, P. B. and L. S. Murphy. 1981. Biological effects of a dump at 106-Mile site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 245-256.

Park, P. K. and T. P. O'Connor. 1981. Ocean dumping research: Historical and international development. In: B. H. Ketchum D. R. Kester, and P. K. Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press, NY. pp 3-24.

Pathobiology Division, Northeast Fisheries Center, NMFS. 1981. Histopathology of organisms sampled at and near 106-Mile site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 277-294.

Pavia, R., W. D. Ernst, E. R. Gundlach, L. Thebeau, and J. Sadd. (In Press). Sensitivity of coastal environments to spilled oil - Southern California. National Oceanic and Atmospheric Administration, Office of Marine Assessment, Boulder, CO. 41 pp.

Pearce, J., D. J. Radosh, J. V. Carracciolo, and F. W. Steimle. 1981. Benthic fauna. MESA New York Bight Atlas Monograph 14. MESA New York Bight Project and New York Sea Grant Institute. 79 pp.

Peele, E. R., F. L. Singleton, J. W. Deming, B. Cavari, and R. R. Colwell. 1981. Effects of pharmaceutical waste on the microbial populations in surface waters at the Puerto Rico dumpsite. Appl. Environ. Microbiol. 41:873-879.

Pitcher, K. W. 1980. Stomach contents and feces as indicators of harbor seal, Phoca vitulina, Foods in the Gulf of Alaska. Fishery Bulletin, 78(3):797-798.

Presley, B. J., J. S. Schofield, and J. H. Trefry. 1981. Waste material behavior and inorganic geochemistry at the Puerto Rico dumpsite. In: B. H. Ketchum, D. R. Kester, and P. H. Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press, NY. pp 233-246.

Reed, R. K. et al. 1981. On coastal flow in the Northeast Gulf of Alaska Near Yakutat. Atmosphere-Ocean. 19(1):47-53.

Reimer, R. W., J. C. Schedvin, and R. S. Pritchard. 1980. Ice motion in the Chukchi Sea. Flow Research Report. No. 168.

Reimnitz, E. and E. Kempena. (In Press). Large potholes of the Arctic nearshore - A dynamic bedform. (No information is available on journal to which this article was submitted.) 15 pp.

Richardson, W. J. and S. R. Johnson. (In Press). Waterbird migration near the Yukon and Alaska Coast of the Beaufort Sea, I. Timing, routes, and numbers in spring. Arctic.

Riehle, J. R. et al. (In Press). Lahars in Crescent River Valley, Lower Cook Inlet, Alaska. Alaska Geological and Geophysical Survey Geologic Report 53. 10 pp.

Rueter, J. G., Jr., S. W. Chisholm, and F. M. M. Morel. 1981. The interaction between zinc deficiency and copper toxicity as it affects silicic acid uptake in Thalassiosira pseudonana. Limnol. Oceanogr. 26:67.

Sackinger, W. M. and R. D. Nelson. 1980. Measurements of sea-ice stresses near grounded obstacles. Journal of Energy Resources Technology, 102:177-147.

Schandelmeier, L. and V. Alexander. (In Press). Oceanography of the eastern Bering Sea ice edge zone in spring: Part III - An analysis of the phytoplankton populations. Limnol and Oceanog.

Schrader, G. C., R. A. Horner, and G. F. Smith. (In Press). An improved chamber for in situ measurement of primary productivity of Arctic Sea ice algae. (No information is available on journal to which this article was submitted.) 9 pp.

Schwab, C. R., T. C. Sauer, Jr., G. F. Hubbard, H.ABD El-Reheim, and J. M. Brooks. 1981. Chemical and biological aspects of ocean dumping at the Puerto Rico dumpsite. In: Ketchum, Kester, and Park (eds). Ocean Dumping of the Industrial Wastes, Plenum Press, NY. pp 247-273.

Sillcox, R. L., W. R. Geyer, and G. A. Cannon. 1981. Physical transport processes and circulation in Elliott Bay. NOAA Technical Memorandum OMPA-8, Office of Marine Pollution Assessment, Boulder, CO. 45 pp.

Simpson, Duane C., T. P. O'Connor and P. K. Park. 1981. Deep Ocean Dumping of Industrial Wastes. In: R. A. Geyer (ed), Marine Environmental Pollution, II Dumping and Mining. Elsevier Scientific Publishing Co. N.Y. pp 379-402.

Squires, D. F. 1981. The Bight of the Big Apple. New York Sea Grant Institute, Albany, NY. 84 pp.

Stepein, J. C., T. C. Malone and M. B. Chervin. 1981. Copepod communities in the estuary and coastal plume of the Hudson River. Estuarine, Coastal and Shelf Science, Academic Press Inc. (London) Ltd., pp 185-195.

Stringer, W. J. (In Press). Interaction of Bering Sea and Norton Sound Pack Ice. Arctic and Alpine Research. 16 pp.

Stringer, W. J. (In Press). Nearshore ice characteristics in the Eastern Bering Sea. (No information is available on journal to which this article was submitted.) 32 pp.

Stringer, W. J. 1980. The role of sea ice as a physical hazard and a pollutant transport mechanism in the Bering Sea. Geophysical Institute, U. of Alaska, Fairbanks. 26 pp.

Stringer, W. J., M. E. Bauman, and L. J. Roberts. (In Press). Summertime ice concentration in the Harrison and Prudhoe Bay vicinities of the Beaufort Sea. (No information is available on journal to which this article was submitted.) 35 pp.

Stringer, W. J. and R. D. Henzler. (In Press). The frequency and percent coverage of sea ice in the St. George Basin. (No information is available on journal to which this article was submitted.) 6 pp.

Stringer, W. J. and R. D. Henzler. (In Press). Ice displacement vectors measured in Norton Sound and the adjacent Bering Sea, 1973-1979. (No information is available on journal to which this article was submitted.) 37 pp.

Stringer, W. J. and G. Weller. (In Press). Studies of the behavior of oil in ice, conducted by OCSEAP. (No information is available on journal to which this article was submitted.) 17 pp.

Stromberg, Pamela T., Marsha L. Landolt, and Richard M. Kocan. 1981. Alterations in the frequency of sister chromatid exchanges in flatfish from Puget Sound, Washington, following experimental and natural exposure to mutagenic chemicals. 52 pp.

Swanson, R. L., M. A. Champ, T. O. O'Connor, P. K. Park, J. O'Connor, G Mayer, H. Stanford, R. Erdheim, and J. L. Verber. (In Press). Sewage sludge dumping in the New York Bight: The pros and cons of the 12-Mile, 65-Mile, and 106-Mile sites. In: Duedall, Ketchum, Park, and Kester (eds), Ocean Dumping of Municipal Wastes. John Wiley and Sons, Inc., New York, NY.

Swanson, R. L., C. A. Parker, M. C. Meyer, and M. A. Champ. (In Press). Is the East River, New York, a river or Long Island an island? Jour. International Hydrographic Review. 45 pp.

Taylor, R. J. 1981. Shoreline vegetation of the arctic Alaska Coast. Arctic, 34(1):37-42.

TerEco Corporation. 1981. Ocean dumping of dredged material and subsequent environmental monitoring of possible effects at the Barataria Bay disposal site in the region of the Mississippi Delta. A report to the National Oceanic and Atmospheric Administration Ocean Dumping and Monitoring Division prepared by TerEco Corp. under Grant No. NA80AA-D-00042. 100 pp.

Thompson, E. P., T. D. Kana, and R. Pavia. (In Press). Burmah Agate - Chronology and containment operations. Proceedings of the 1981 Oil Spill Conference (Prevention, Behavior, Control, Cleanup). Atlanta, GA. March 1981.

Tucker, W. B. and J. W. Govoni. (In Press). Morphological investigations of first-year sea ice pressure ridge sails. Cold Regions Science and Technology.

Vaccaro, R. F. and M. R. Dennett. 1981. Environmental response of marine bacteria to waste disposal activities at 106-Mile site. In: Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site. NOAA Dumpsite Evaluation Report 81-1. pp 295-308.

Vaccaro, R. F., and M. R. Dennett. 1981. The bacterial bioassay and laboratory assessments of waste disposal activities at DWD-106. In: Ketchum, Kester, and Park (eds), Ocean Dumping of Industrial Wastes. Plenum Press. NY. pp 399-410.

Vaccaro, R. F., J. M. Capuzzo, and N. H. Marcus. 1981. The oceans and U.S. sewage sludge disposal strategy. Oceanus. 24(1):55-59.

Vanderhorst, J. R., J. W. Blaylock, P. Wilkinson, M. Wilkinson, and G. Fellingham. 1981. Effects of experimental oiling on recovery of Strait of Juan de Fuca intertidal habitats. DOC/EPA Interagency Energy/Environment R&D Program Report EPA-600/7-181-088, U.S. Environmental Protection Agency, Washington, DC. 129 pp.

Vincent, C. E., D. J. P. Swift, and B. Hillard. 1981. Sediment transport in the New York Bight, North American Atlantic Shelf. Marine Geology. 42:369-398.

Wahl, T. R., S. M. Speich, D. A. Manuwal, K. V. Hirsch, and C. Miller. 1981. Marine bird populations of the Strait of Juan de Fuca, Strait of Georgia and adjacent waters in 1978 and 1979. DOC/EPA Interagency Energy/Environment R&D Program Report EPA-600/7-81-156, U.S. Environmental Protection Agency, Washington, DC. 789 pp. (including 514 microfiche appendices).

Webber, H. H. 1981. Growth rates of benthic algae and invertebrates in Puget Sound: I. Literature review, and II. Field studies on Laminaria and Nereocystis. NOAA Technical Memorandum OMPA-4, Office of Marine Pollution Assessment, Boulder, CO. 45 pp.

Weber, D. D. et al. 1981. Avoidance reactions of migrating adult salmon to petroleum hydrocarbons. Can. Jour. Fish. and Aquat. Sci. 38(7):779-781.

Weller, Gunter. 1980. Oil pollution in ice-covered Arctic waters. In: R. A. Geyer (ed), Marine Environmental Pollution, 1. Hydrocarbons Elsevier Scientific Publishing Co., Amsterdam, The Netherlands. pp 353-369.

White, Harris H. and Michael A. Champ. (In Press). The great bioassay hoax, and alternatives. To be published in the Proceedings of the Second Annual Symposium on Testing of Hazardous and Industrial Solid Wastes. American Society of Testing and Materials. Philadelphia, PA.

Wigley, R. L. and R. B. Theroux. 1981. Atlantic continental shelf and slope of the United States - Macrobenthic invertebrate fauna of the Middle Atlantic bight region - Faunal composition and quantitative distribution. Geological Survey Professional Paper 529-N, 198 pp.

Williams, W. G. 1981. Meridional displacements of surface water north of Puerto Rico. Trans. Amer-Geophys. U. 62(17):305.

Young, R. A., T. L. Clarke, R. Mann, and D. J. P. Swift. 1981. Temporal variability of suspended particulate concentrations in the New York Bight. Journal of Sedimentary Petrology, 51:0293-0306.

Zeh, J. E., J. P. Houghton, and D. C. Lees. 1981. Evaluation of existing marine intertidal and shallow subtidal biologic data. DOC/EPA Interagency Energy/Environment R&D Program Report EPA-600/7-81-036, U.S. Environmental Protection Agency, Washington, DC. 262 pp.

Zimmer, R. D. 1980. Ocean Dumping: Where will we dispose of our wastes after 1981. The Jersey Shoreline, 2(5):1-3.

Zimmer, R. D. 1981. Protecting the public: Fish contaminants. The Jersey Shoreline, 4(4):5-6.

Zimmer, R. D. (ed.). 1981. Ocean Dumping: Issues and Answers Concerning Sewage Sludge Disposal. New Jersey Marine Sciences Consortium, Fort Hancock, NJ. 51 pp.

☆U.S. GOVERNMENT PRINTING OFFICE:1982—576-043 / 3