Report to the Congress on Ocean Pollution, Overfishing, and Offshore Development

July 1973 through June 1974

Public Law 92-532, Title II, Section 202 (c)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
JANUARY 1975

Report to the Congress on Ocean Pollution, Overfishing, and Offshore Development

July 1973 through June 1974

Submitted in compliance with Section 202 (c),
Title II of the Marine Protection, Research,
and Sanctuaries Act of 1972
(Public Law 92-532)

January 1975

UNITED STATES
DEPARTMENT OF COMMERCE
Frederick B. Dent, Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

February 28, 1975

President of the Senate
Speaker of the House of Representatives

Sirs:

The program of the United States dealing with man's impact on the ocean environment was marked in FY 1974 by a number of sound accomplishments and new departures.

In the international area, U.S. leadership in several arenas produced significant contributions toward reducing man's impact on the oceans' living resources. At the June 1974 meetings of the International Whaling Commission (IWC), substantial reductions were made in the allowed catch of several whale species, and the principle of a selective moratorium to be applied to any stock which falls below optimum population levels was accepted. Within the International Commission for the North Atlantic Fisheries (ICNAF), the United States achieved agreement on a quota system which will gradually reduce fish catches and thereby allow for a rebuilding of valuable fisheries off our Atlantic coast.

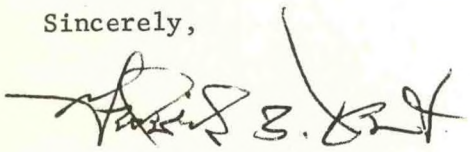
The proposed accelerated development of the oil and gas resources lying under the Outer Continental Shelf (OCS) and the need to carry out that activity with due regard for the marine environment has imposed new responsibilities on the part of the Federal Government to ensure that the decisions regarding OCS development are based on the best and most complete information possible. During the reporting period, the Council on Environmental Quality (CEQ) issued its detailed study of the environmental impact of OCS oil and gas development. In addition, the OCS environmental studies program of the Bureau of Land Management (BLM) got underway with field surveys in two areas - the Gulf of Mexico and the Gulf of Alaska.

There also have been technological advances that enhance our ability to deal with ocean pollutants. Methods have been developed and successfully applied to measure pollutants in extremely low concentrations. The Coast Guard has made considerable progress in developing a capability of matching spilled oil to the source of that oil. Also, scientists have developed more sophisticated bioassay techniques

that permit more realistic laboratory evaluation of the impact of pollutants on marine organisms.

These accomplishments and other aspects of U.S. marine research efforts directed at long-range effects of pollution, overfishing, and other man-induced changes of ocean ecosystems are described in detail in the annual report that I am transmitting today in accordance with the requirements of Title II of the Marine Protection, Research, and Sanctuaries Act.

Sincerely,



Secretary of Commerce

CONTENTS

CHAPTER I

MARINE ENVIRONMENTAL RESEARCH ACTIVITIES: AN OVERVIEW

Fiscal Year 1974 was a year of continued progress toward the long-term objective of improving our understanding of the ocean environment and the effects of man's activities thereon. The range of activities which impact the oceans and over which Congress expressed its concern by approving the research provisions of the Marine Protection, Research, and Sanctuaries Act of 1972 is broad. In the language of the legislation, it includes ocean pollution, overfishing, and other man-induced changes of ocean ecosystems. This last category encompasses the effects on the marine environment by the construction and operation of deepwater ports, offshore nuclear powerplants, offshore oil and gas platforms, and by ocean mining operations. This chapter provides a brief summary of marine environmental research efforts and findings during the previous fiscal year.

MARINE POLLUTION RESEARCH

Marine pollution research in this country has focused on petroleum hydrocarbons, heavy metals, and man-made (synthetic) hydrocarbons. The rationale for this is that these three classes of chemical compounds: (1) are already present, in widely varying concentrations, in the oceans of the world; (2) have or may have toxic effects on marine life; (3) may or may not have a relationship to human health and well-being; and (4) will continue to be introduced into the oceans more or less in direct relation to their production, transport, and use.

Petroleum Hydrocarbons

With respect to petroleum hydrocarbons in the oceans, one of the most difficult tasks has been to assess the problem in terms of how much is added to the oceans each year and by what pathways. A recently completed study by the Ocean Affairs Board of the National Academy of Sciences (NAS) estimated that the amount of petroleum hydrocarbons entering the world's oceans each year through man's activities is approximately 5.5 million metric tons (mmt).[1/] About 40 percent of that total is from oil tanker operations and accidents. The remainder is of nonmarine origin such as automotive waste oil, industrial waste oil, and other sources through river runoff and atmospheric transport and rainout. Petroleum additions to the oceans from natural seeps in the sea floor cannot be measured with any scientific certainty. The NAS estimate for this pathway was 0.6 mmt, giving an overall total of 6.1 mmt per year.

The Federal agencies conducting or sponsoring research on marine oil pollution include: the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), the Environmental Protection

Agency (EPA), the Bureau of Land Management (BLM) and the Geological Survey of the Department of the Interior, the Maritime Administration, the Navy, and the Coast Guard. Some States are sponsoring research efforts on the potential effects of oil pollution in their coastal waters. In the private sector, the NAS, the Ford Foundation, Battelle Memorial Institute, the American Petroleum Institute, and oil companies are among the organizations actively engaged in various aspects of marine oil pollution research.

NOAA research on oil pollution is centered on the west coast and in Alaska where its laboratories are investigating the acute and chronic effects of petroleum compounds on fish and shellfish. Researchers are attempting to measure the physiological and toxicological effects of water-soluble fractions of crude oil on marine species of fish and shellfish at various stages during their life cycles. Work is also underway to examine the effects of petroleum at the cellular and subcellular levels of marine organisms to determine the extent of long-term chronic effects which may be bringing about adverse changes in biochemical or physiological processes. In similar efforts, EPA continues its studies on the acute and chronic effects of pollutants, including petroleum and heavy metals, on marine organisms, in order to establish water quality standards for marine and estuarine waters.

The National Science Foundation (NSF) has sponsored, within its International Decade of Ocean Exploration (IDOE) program, research concerning the transfer and effects of pollutants, including oil, in the marine environment. In the Controlled Ecosystems Pollution Experiment (CEPEX), which started in 1973, natural marine communities contained in large plastic enclosures located offshore of British Columbia are subjected to low-level and long-term exposures of selected contaminants. The first CEPEX test involving petroleum was started in the summer of 1974. Preliminary results indicate that at very low concentrations of oil (approximately 80 ppb) there is an enhancement of primary productivity (plant plankton). The CEPEX effort is unique because it attempts to bridge the gap between laboratory results and field observations of the fates and effects of selected contaminants in a marine ecosystem.

Under the IDOE program, the NSF also sponsors research on baseline levels and pollutant transfer processes. In January 1974, NSF/IDOE conducted a Pollutant Transfer Workshop and later issued a report summarizing the results of the first 2 years of the project.2/ With regard to petroleum hydrocarbons, participants in this program are looking at such problems as intercalibration of instruments, standardization of results, atmospheric transport, and differentiation between natural and man-introduced sources.

The Maritime Administration (MarAd) and NOAA, with the assistance of the National Bureau of Standards (NBS), are jointly sponsoring a study of oil pollution baselines in the Pacific Ocean. This project is designed to determine the existing distribution of hydrocarbons along selected tanker routes in the Pacific Ocean, including transects along the marine leg of the Trans-Alaska Pipeline System (TAPS). Samples are being collected from tankers and from vessels participating in the Geochemical Oceans Sections Study (GEOSECS) sponsored by the National Science Foundation (NSF). This

Pacific Ocean survey is similar to that conducted in the Atlantic Ocean in the 1971-73 period. Preliminary results of the Pacific Ocean survey indicated that hydrocarbon concentrations were generally below 10 parts per billion (ppb) except for the San Francisco to Cook Inlet, Alaska tanker route, which was at the time of sampling in the 10-25 ppb range.

The Navy in FY 1974 sponsored research at various universities in biodegradation of petroleum residues, fate of petroleum residues in marine food chains, and biodegradation of petroleum in low-temperature marine and estuarine environments.

Coast Guard research and development work on the problem of oil pollution continued in FY 1974 to be directed at oil spill containment and surveillance. Development was completed and production began on a high seas oil containment barrier system capable of being transported and deployed by air. The Coast Guard also reported progress in developing a capability of identifying the source of spilled oil which has enhanced its effectiveness in the law enforcement area.

Heavy Metals

Heavy metals, when introduced into the marine environment in elevated concentrations, can kill organisms or contaminate them to an extent that they create a hazard to human health. It is necessary, therefore, to establish what levels of pollutants cause mortalities or interfere with growth, behavior, and reproduction. It also is important to know the long-term effects of exposure to sublethal concentrations of heavy metals.

NOAA has studies underway to determine the effects of heavy metals, such as arsenic, cadmium, copper, mercury, nickel, lead, zinc, and silver, on the normal life functions of certain marine species. Results indicate that some marine animals are extremely sensitive to minute amounts of heavy metals. Research also is progressing in assessing the physiological changes in various species of marine shellfish, crabs, lobsters, and fish that are common to the Atlantic coast. Work to date has indicated that the American oyster exhibits genetic damage from exposure to certain heavy metals.

NOAA is also conducting a major program to determine baseline levels of metals in seafood. This survey consists of measuring concentrations of trace metals and other chemical elements in the muscle and liver in some 200 species of marine fish and shellfish from the Atlantic, Gulf, and Pacific coasts, and from the Gulf of Alaska. Another aspect of the program will be to compare the consumer's intake of trace metals in seafood and the consumer's intake of trace metals from nonfishery food sources.

The National Science Foundation, in its Pollutant Transfer Program, has active research underway to: 1) determine the mechanisms that are important in the transfer of heavy metals into and within the marine environment; 2) determine important physical, chemical, and biological factors affecting pollutant transfer processes; and 3) identify principles governing transfer of heavy metals.

Synthetic Hydrocarbons

The major groups of synthetic hydrocarbons that are likely to have an impact on the marine environment are pesticides (such as insecticides and herbicides) and industrial compounds such as polychlorinated biphenyls (PCBs). Many of these compounds are toxic. Many resist chemical and biological degradation, and thus persist and accumulate in the environment.

The pesticide DDT, although no longer used in the United States except for restricted purposes that require special EPA permits, is still manufactured and used in other parts of the world for pest control. Therefore, it remains a global problem, although now somewhat reduced in magnitude. Recent research in this field has focused on other persistent chlorinated hydrocarbons such as endrin, dieldrin, chlordane, heptachlor, and toxaphene. Another class of toxic pesticides is the organophosphates, residues of which have been found in tissues of marine fishes from the Atlantic Coast and Gulf of Mexico. The large quantities of organophosphates now being applied and their many degraded forms (metabolites) which are biologically active make them an important subject of research. The mode of action of these compounds is to disrupt nerve-impulse transmissions in the nervous systems of animals by means of enzyme inhibition. Progress has been made in determining the effects of these enzyme-inhibiting pesticides on estuarine and marine organisms. Specific levels of brain enzyme inhibition associated with death in such organisms have been defined for many of the organophosphate insecticides.

Polychlorinated biphenyls (PCBs), an industrial compound used in a variety of ways, including heat transfer systems, electrical devices, plastics, and paints, are present in oceanic water, sediment, and biota. In the United States, about 40 million pounds of PCBs are produced each year. Studies show that all PCBs are toxic to certain estuarine marine animals and in tests of longer duration it was demonstrated that PCBs accumulate in liver and fatty tissues in amounts that can exceed 100,000 times the amount normally present in their environment.

Progress was reported in the development of more refined analytical techniques that permit measurement of concentration of pesticides in water and animals at the parts-per-trillion level. Also, egg-to-egg chronic bioassays that test toxicity of a chemical to all life stages of a marine species have been developed. The results from these improved research techniques, which were largely developed or refined by EPA's Gulf Breeze Environmental Research Laboratory, and from data gathered in the pesticide monitoring program conducted cooperatively by EPA, NOAA, States, and universities, have advanced our knowledge of how and where certain pesticides and PCBs accumulate in the marine environment.

REGIONAL STUDIES OF MARINE POLLUTION

At the present time, several oceanic areas are the subject of comprehensive environmental studies, including the New York Bight region, the North Sea, and the Baltic Sea.

In the 15,000 square-mile New York Bight region, most of the present effort of the NOAA Marine Ecosystems Analysis (MESA) program is directed at the immediate problem of dumping of wastes in the Bight, the results of which will be described in the annual report to the Congress on Section 201 of P.L. 92-532. However, work was begun in FY 1974 on another principal objective of the MESA project in the Bight--to determine the effects of existing and projected pollution loads from other (nondumping) sources, such as sewer outfalls, land runoff, rivers and atmospheric transport and rainout.

The North Sea is also the subject of a cooperative research effort by several European states on pollution and its effects on living resources and their exploitation. Data have been gathered on amounts and types of pollutants introduced into the North Sea by the bordering countries. In addition, background levels of selected heavy metals and synthetic hydrocarbons have been measured and determined to be generally below the minimum concentrations established by certain countries as standards for human consumption. In recent years, the study has turned its attention to the problems associated with rapid development of North Sea oil and gas production.

In addition to the North Sea project, the NATO Committee on the Challenges of Modern Society (CCMS) is directing a part of its resources toward oil spill problems. This effort, led by Belgium, is known as the North Sea Pollution Project. The current major tasks of this project include the development of a North Sea diagnostic model and encouraging member countries to conduct research on: (1) the fate and effects of oil pollution and (2) methods to control oil spills.

The Baltic Sea, because of its location adjacent to the most heavily populated and industrialized part of Europe, is seriously polluted. While the problems of the Baltic have been under continuous study by the bordering states for several decades, until recently no remedial action of any significance had materialized. In 1972 an effort was begun to draft an international convention to set forth principles of collaboration among the Baltic countries in halting pollution of the Baltic Sea. Such a convention was signed in Helsinki, Finland, in March 1974. When ratified, the convention will prohibit the dumping of solid wastes and chemicals into the Baltic and provide for the construction of sewage treatment facilities. The convention also establishes a Baltic Sea Commission which will enforce regulations established by and within the framework of the treaty.

In addition, other regional studies of a smaller scale have been carried out domestically in San Francisco Bay, Prince William Sound, Puget Sound, and the Great Lakes.

OVERFISHING

During FY 1974, the United States made significant contributions toward the reduction of man's impact upon fisheries resources through participation in international commissions concerned with the status and management of stocks. In large part, through the efforts of the United States, significant progress was made in many aspects of international whale conservation at the 26th Session of the International Whaling Commission held in London, England, during June 1974. A selective moratorium was established to be applied to any stock of whales that falls below optimum population levels; worldwide quotas for whale species of most concern were greatly reduced; whale stocks are to be managed by ocean areas; and factors, other than simple numbers of whales, which encompass the health of the total marine ecosystem are to be considered. The worldwide quotas established by the Commission at the meeting also provided substantial reductions in the allowed catch of several species.

There also is concern over heavy fishing pressures in the northern Pacific Ocean and the Bering Sea. Because of the lack of effective controls, there is a potential for rapid reductions in stock abundance. The stocks of fish off areas of the U.S. west coast which our scientists believe to be overfished or approaching a status of overfishing include most major groundfish stocks and herring in the Bering Sea, hake and perch off Oregon and Washington, perch and halibut in the Gulf of Alaska, and sardine and mackerel off California. For the collection of adequate data on distant-water fleets in the North Pacific and Bering Sea in response to the overfishing situation in these areas, observers have been routinely placed on foreign distant-water trawlers. This action and periodic surveys of the resources in these ocean areas are enhancing our ability to bring about reduction in the fishing effort.

Heavy fishing now taking place in the northwest Atlantic also is taking its toll on the stocks in that region. To reduce the fishing pressure on these stocks, the United States has been able to achieve a significant agreement to reduce the 1975 total allowable catch levels for 54 separate stocks in this region. At the instigation of the United States, a Special Meeting of the International Commission for the Northwest Atlantic Fisheries (ICNAF) was held in October 1973 to design a quota system that would reduce fish catches off the U.S. Atlantic coast over the next 3 years in order to halt the serious stock decline and allow for the rebuilding of valuable fishery resources. As a consequence of this meeting, the member nations of ICNAF agreed in June 1974 to a reduction in overall total quota from 924,000 metric tons in 1974 to 850,000 metric tons in 1975, with an agreement to set the overall quota in 1976 at a level consistent with maintaining the maximum sustainable yield.

The effects of overfishing in the ICNAF region are illustrated by the haddock fishery. In the period immediately preceding the early 1960s, the catch of haddock ranged close to the maximum sustainable yield of 50,000 metric tons. In 1965 foreign distant-water fleets started seeking haddock because of their apparent abundance as indicated in U.S. catches. This added fishing effort resulted in a haddock catch of 155,000 metric tons in

1965 which later caused a drastic reduction in the haddock population. As a result, ICNAF established catch limitations for haddock in 1970. Since these restrictions did not result in recovery of the stocks, a zero quota was established for 1974. In addition, on the basis of analyses of survey data, the U.S. delegation to the ICNAF Annual Meeting in June 1973 unsuccessfully proposed a 30-percent reduction in total fishing effort for the ICNAF region. This concern resulted in the meetings leading to the establishment of the reduced 1975 quotas.

While these steps have been taken, it is too early to evaluate the results of these conservation efforts. It will be several years before we can determine the rapidity with which these stocks are being restored.

OFFSHORE DEVELOPMENT

Section 202 of P.L. 92-532 refers to "other man-induced changes of ocean ecosystems". This phrase comprehends offshore development activities such as deepwater ports, nuclear powerplants, ocean mining, and outer continental shelf (OCS) oil and gas extraction.

Offshore Deepwater Ports

The question of whether or not the United States should permit construction of deepwater port facilities along its coasts has been the subject of intensive study and discussion. These offshore facilities would serve deep draft ships--vessels of 100,000 deadweight tons and over--that cannot now enter most U.S. ports. The environmental effects of such deepwater port development can be divided into: (a) the primary effects of the construction of the port and of oil spillage once the port becomes operational; and (b) the secondary effects of industrialization and development on the shore. The primary effects are in large measure related to the type of deepwater port facility and its location with respect to critical coastal environmental features. For example, a single point mooring (SPM) facility will require far less disruption of seabed than an artificial sea island. Also, the impact of oil spills or construction will vary according to the relative ecological vulnerability of any specific port location. According to a Coast Guard statistical projection prepared for the Council on Environmental Quality (CEQ), at an import level of 2 million barrels per day, spillage from tankers of 50,000 DWT size, using conventional port terminals, would be 10 times greater than from tankers of 250,000 DWT size, using deepwater ports.3/ This difference is primarily the result of the reduction in the number of tankers required, fewer unloading cycles, new technology at deepwater terminals, and the transfer of oil by pipeline.

With regard to onshore secondary effects, another study for CEQ, produced the following interim findings:4/

- Vulnerability to environmental damage is greatest at inshore sites, less at offshore sites, and least at far offshore sites.

- Major spills would have critical effects at inshore and offshore sites--potentially less critical at far offshore sites.

- Chronic, low-level oil spills may have critical effects at inshore sites--they are less likely to be damaging at offshore and far offshore sites.

- Impacts of operations (excluding oil spills) and terminal maintenance are important, but not critical at inshore sites--they are insignificant at offshore and far offshore sites.

The Congress approved and the President signed in January 1975 the Deepwater Port Act of 1974. This important legislation will be discussed in next year's report to the Congress.

Offshore Powerplants

The concept of locating nuclear powerplants in offshore waters continues to undergo careful study. The environmental implications of this approach are generally divided into two categories--those associated with the construction of the protective breakwater and those associated with operation of the plant. The massive breakwater required involves in each case a significant commitment of seabed area. Dredging and other construction activity will result in resuspension of sediment with uncertain effects on biotic communities. With respect to plant operation, the effects will be due to impingement, entrainment, thermal discharge, and chemical discharge. These problems have stimulated a number of conferences and reports concerning offshore nuclear power siting, including the AEC-sponsored workshop Offshore Nuclear Power Siting (1973)5/ and the AEC report A Survey of Unique Technical Features of the Floating Nuclear Power Plant Concept (1974).6/

These and other problems are discussed in considerable detail in (1) an environmental effects study7/ submitted to AEC by two private firms in support of an application to build a manufacturing facility for floating nuclear powerplants, and (2) the comprehensive CEQ report prepared in collaboration with NOAA, Atomic Energy Commission, Federal Power Commission, Environmental Protection Agency, Corps of Engineers, Department of the Interior and others. This latter report, which is now in the final review process, examines the environmental, legal, economic, and social issues attendant to the offshore powerplant concept.

Ocean Mining

Ocean mining, although not yet occurring on a significant scale, is another way in which man may cause changes in the marine environment. Ocean mining is carried out in both deep water and nearshore waters. Deepsea mining for manganese nodules, which contain commercially important concentrations of manganese, copper, nickel and cobalt, appears to be on the horizon. According to industry spokesmen, mining of manganese nodules could begin as early as 1978; however, certain international legal problems may delay the commencement of commercial mining. These issues are being taken up at the UN Law of the Sea (LOS) Conference.

The decreasing availability of economically suitable land deposits of sand and gravel, and the recent escalation of transportation and production costs for phosphate rock from onshore sites, makes offshore deposits an attractive source of these minerals. Concern, however, has been expressed over the possible adverse environmental effects of this type of mining and, as a result, there are at present actual and de facto moratoria at the Federal and State levels on offshore sand and gravel mining.

Both deep ocean and nearshore mining will require environmental studies prior to actual operations in order to determine baseline conditions and the potential effects on the surrounding biota. Toward this end, NOAA has initiated a Deep Ocean Mining Environmental Study (DOMES), a program to investigate the physical, chemical and biological, and geological properties of the water column and ocean bottom in a potential manganese nodule mining area. In the case of sand and gravel mining, there is no ongoing Federal research program designed to assess the environmental effects of commercial operations.

Offshore Oil and Gas Development

An important element of the Administration's program to achieve self-sufficiency in energy for the Nation is accelerated development of the extensive oil and gas reserves lying under the outer continental shelf. It is generally recognized, however, that the benefits accruing from an accelerated program of developing our offshore energy reserves may not be without some effect upon the marine environment. Sound management practice requires that we determine, insofar as possible, the costs and benefits associated with offshore oil and gas development in order that the decisions regarding this development be based on the best and most complete information. The Federal Government, in association with various State governments, universities, private firms, and other organizations, is now organizing to carry out multidisciplinary scientific studies of potential oil and gas lease areas. These include baseline assessments and field and laboratory investigations of both the chronic and immediate effects of petroleum hydrocarbons on the ocean environment and particularly on living resources.

During FY 1974, the CEQ issued its comprehensive study of the environmental impact of OCS oil and gas development. This report lays out a set of principles to guide governmental decisions in choosing OCS areas to lease and in administering environmentally safe offshore oil and gas operations.8/

There is agreement among the concerned Federal agencies, particularly the Bureau of Land Management, Fish and Wildlife Service, Geological Survey, EPA, and NOAA, on the importance of obtaining offshore environmental data prior to oil and gas exploration and development. The Bureau of Land Management has incorporated into its proposed leasing schedules provisions for the support of environmental studies in the regions where leasing of tracts on the OCS is anticipated. Studies commenced in FY 1974 in the coastal area off Mississippi, Alabama, and Florida and in the northeast Gulf of Alaska. Regions for which OCS environmental assessment studies are being planned for FY 1975 include: Baltimore Canyon Trough; Southern California; Bering Sea; South Texas; and the Beaufort Sea.

CHAPTER II

OCEAN POLLUTION

The oceans and seas receive polluting materials from a large variety of industrial, municipal, and agricultural sources. These materials enter the marine environment by means of barge dumping, direct discharge from outfalls or submerged pipes, polluted rivers and streams, runoff, and atmospheric transport from land. Most oceanic pollution occurs in the estuaries, semi-enclosed seas, and nearshore waters adjacent to industrialized nations. Pollution has reached severe proportions in certain regions, including the Baltic Sea, North Sea, and the New York Bight. These and other environmentally threatened parts of the ocean are the subject of intensive study and, in some cases, governmental regulation.

Although the serious problems of polluted waters near industrialized states have been the focus of attention in recent years, coastal or nearshore pollution is only part of the overall picture. Efforts have recently begun to measure the concentrations of petroleum hydrocarbons, heavy metals, and pesticides in the open ocean, including some of the most remote regions therein. These surveys show that pollutants are being introduced into the ocean on a global scale. The extent to which these substances have pervaded the world's oceans is not yet known.

A major concern is that concentrations of contaminants in remote corners of the world will, if historical trends continue, increase with time. The long-term implications of continued pollution of the oceans are unknown. The problem requires continuous and systematic study by all nations capable of making a contribution.

PETROLEUM HYDROCARBONS

With respect to petroleum hydrocarbons in the oceans, one of the most difficult tasks has been to assess the problem in terms of how much is added to the oceans each year and by what pathways. A recently completed study by the Ocean Affairs Board of the National Academy of Sciences (NAS) estimated that the amount of petroleum hydrocarbons entering the world's oceans each year through man's activities is approximately 5.5 million metric tons (mmt).9/ About 40 percent of that total is from oil tanker operations and accidents. The remainder is of nonmarine origin such as automotive waste oil, industrial waste oil, and other sources through river runoff and atmospheric transport and rainout. Petroleum additions to the oceans from natural seeps in the sea floor cannot be measured with any scientific certainty. The NAS estimate for this pathway was 0.6 mmt, giving an overall total of 6.1 mmt per year. Table 1 provides a more detailed breakdown of the sources and rates of impact of petroleum hydrocarbons as estimated by the NAS study.

Table 1.--Budget of petroleum hydrocarbons introduced into the oceans 10/

Source	Input rate (mta)[a] Best estimate	Probable range
Offshore production	0.08	0.08-0.15
Transportation		
LOT[b] tankers	0.31	0.15-0.4
Non-LOT tankers	0.77	0.65-1.0
Dry docking	0.25	0.2-0.3
Terminal operations	0.003	0.0015-0.005
Bilges, bunkering	0.5	0.4-0.7
Tanker accidents	0.2	0.12-0.25
Nontanker accidents	0.1	0.02-0.15
Coastal refineries	0.2	0.2-0.3
Atmospheric rainout[c]	0.6	0.4-0.8
Coastal municipal wastes	0.3	-
Coastal, nonrefining, industrial wastes	0.3	-
Urban runoff	0.3	0.1-0.5
River runoff	1.6	-
SUBTOTAL	5.513	
Natural seeps	0.6	0.2-1.0
TOTAL	6.113	

[a] mta, million metric tons annually.
[b] LOT is an abbreviation for "Load-on-top".
[c] Based upon assumed 10 percent return from the atmosphere.

Petroleum hydrocarbons are not evenly distributed over the surface of the oceans. They are more heavily concentrated in coastal areas, where land-originated petroleum and petroleum wastes enter the marine environment, where there is more vessel traffic, and where offshore drilling operations are conducted. The coastal regions are also the areas of greatest biological activity, thus oil pollution in these regions can result in greater ecological damage than if the same amount of oil occurred in a noncoastal area.

The major classes of hydrocarbon compounds in petroleum are alkanes, alkenes, and aromatics. Alkanes or aliphatics are also produced by life processes in the oceans and are found in all marine organisms. Aliphatics with few carbon atoms can cause, in low concentrations, anaesthesia and narcosis in marine organisms. The heavier aliphatics (more carbon atoms) are produced by marine life. Those of petroleum origin are normally not toxic to marine organisms. The alkenes are not found in crude oil, but are found in large quantities in the cracking process and are therefore

present in some refined products. Alkenes probably are more toxic than aliphatics, but less so than aromatics. The aromatic compounds are not found in nature and there are many unanswered questions about their fate and effects in the marine environment. Some polynuclear aromatics have been shown to cause cancer in laboratory test animals. One of the questions that will continue to be raised is whether the introduction of petroleum oils into the ocean environment is increasing the level of carcinogens in that environment.

In FY 1974 many research projects were carried out to investigate the interaction of petroleum hydrocarbons and the marine environment. Some of the more significant findings during that period are reviewed below.

Both field and laboratory studies indicate that marine plants are damaged by aliphatic compounds, probably due to interruption of the chlorophyll process. Whether this adverse effect occurs only when plants are coated with oil or whether it also occurs when water-soluble aliphatic compounds are present is not known. Aliphatics do not appear to be particularly toxic to animals unless exceedingly high levels are present, then some aliphatics possibly may have a narcotic effect. Some indications exist that this narcotic effect may be neutralized by the action of any aromatic compounds that are present.

Laboratory results suggest that the water-soluble fraction or emulsified oils may have an adverse respiratory effect at levels considerably below the levels that are toxic when taken internally through feeding. Experimental studies also indicate that molting crabs are adversely affected when exposed to sublethal concentrations of oil. Exposed crabs were observed to drop legs, indicating the possibility of neural responses. Low molecular weight aromatics such as benzene and its derivatives can affect the hatchability of eggs of freshwater fish under laboratory conditions.

Studies on uptake of petroleum hydrocarbons from water indicated that, when test animals were first exposed, a rapid uptake occurred to a maximum and then dropped off almost as rapidly. When 10 parts per million of radioactive aliphatic and aromatic compounds were fed to fish for a week, and then removed from the diet, the reactions of young coho salmon to the two classes of compounds were different. The aromatics disappeared from the fish in a few days, the time of retention being related to the molecular weight of the compounds. The aliphatics decreased more slowly, were metabolized in the liver, and appeared to be treated as an energy source. No obvious detrimental effects to the fish were noted during the few weeks of the experiment. This type of study must be carried out with longer exposure times and on flatfish and shellfish.

Significant progress was made during this period in analytical techniques to measure the low levels of petroleum hydrocarbon compounds and classes of compounds found in samples of biota and water. Concentrations of oil or petroleum hydrocarbons found in seawater are usually at the parts per billion or parts per trillion level. Methods are now available to extract and analyze quantitatively samples containing petroleum compounds in concentrations as low as the parts per trillion level. Detection and

quantitative analysis at the level are still an art but results are reproducible and good recovery of the compounds can be achieved. The earlier, less sensitive methods had been a serious deterrent, both in field work and in the laboratory, to the determination of the fate and effects of petroleum hydrocarbons in the marine environment.

Results from field surveys have not shown positive differences in the hydrocarbon content of animals from polluted waters and animals from unpolluted marine waters. Amounts of hydrocarbons in animals from a natural oil seep area were not significantly different from amounts of hydrocarbons in the same species of animals from unpolluted control sites. Experimental work is needed to determine whether this is due to: 1) adaptation of the animals living in a natural oil seep area; 2) lack of accumulation of the petroleum hydrocarbons by animals; 3) accumulation of the petroleum hydrocarbons in certain organs or tissues of the animals--an increase that is masked when the entire animal is analyzed; or 4) other unknown possible explanations.

Marine Oil Pollution Research Programs--FY 1974

A number of governmental agencies and private organizations are currently involved in research on oil pollution in the marine environment. Federal agencies that conduct or sponsor marine oil pollution research activities are: the National Science Foundation (NSF); the Environmental Protection Agency (EPA); the Bureau of Land Management (BLM); Fish and Wildlife Service (FWS) and the U.S. Geological Survey of the Department of the Interior; the National Oceanic and Atmospheric Administration (NOAA), the Maritime Administration (MarAd), and the National Bureau of Standards (NBS) of the Department of Commerce; the U.S. Coast Guard of the Department of Transportation; and the U.S. Navy of the Department of Defense. Many coastal states are conducting or sponsoring research on various aspects of marine oil pollution. In addition, the National Academy of Sciences (NAS), Ford Foundation, Battelle Memorial Institute, American Petroleum Institute (API), various oil companies and other organizations carried out during the FY 1974 period studies of the distribution, fate, or effects of oil in the ocean. The nature of research programs and activities by these public agencies and private organizations is briefly summarized.

National Science Foundation. As part of its IDOE program, NSF has sponsored research on the transfer and effects of pollutants, including oil, in the marine environment. In the Controlled Ecosystems Pollution Experiment (CEPEX), which started in 1973, natural marine communities contained in large plastic enclosures located offshore of British Columbia are subjected to low-level and long-term exposures of selected contaminants. The first CEPEX test involving petroleum was started in the summer of 1974. Preliminary results indicate that at very low concentrations of oil (approximately 80 ppb) there is an enhancement of primary productivity (plant plankton). The CEPEX effort is unique because it attempts to bridge the gap between laboratory results and field observations of the fates and effects of selected contaminants on marine organisms in their natural environment.

Also as part of its IDOE program, NSF initiated in 1972 the Pollutant Transfer Program. While NSF's earlier Baseline Program (1971-1972) indicated levels of contaminants in water, sediment, and biota, it did not provide information on the pathways or mechanisms controlling the rate of pollutant transfer from the source and within the ocean environment. The goals of the Pollutant Transfer Program are: 1) to identify important transfer pathways and mechanisms; 2) to evaluate major environmental factors that affect transfer processes; and 3) to develop principles governing transfer of pollutants.

During the first 2 years, primary research emphasis in the Pollutant Transfer Program has been on the transport of petroleum, as well as chlorinated hydrocarbons and trace metals, to the ocean via the atmosphere, rivers, sewage and industrial outfalls, and ocean dumping. Research also was begun on the chemical form and degradation of these pollutants in the marine environment. Biological studies were designed to investigate the mechanisms of pollutant uptake by organisms, to verify transfer through the food web, and to quantify the role of organisms in pollutant dispersion.

A workshop sponsored by NSF in January 1974 reviewed the findings of the program and presented recommendations for additional research on pollutant transfer. It was pointed out that little or no research attention was being directed toward pollutants other than the three major classes (petroleum hydrocarbons, heavy metals, and synthetic organics) and that this deficiency should be corrected. The workshop participants suggested that more work must be done to determine quantitative fluxes of the three major classes of pollutants. Also recommended was an analytical means to distinguish between natural and anthropogenic sources of heavy metals and petroleum hydrocarbons in the marine environment. The NSF published in 1974 a review of the initial 2-year research effort carried out under the Pollutant Transfer Program.11/

Environmental Protection Agency. Research programs on the effects of oil in the marine environment are carried out by EPA in partial response to Resolution 2 of the 1973 London Conference on Marine Pollution, which considered the need to establish water quality criteria for the protection of the marine environment. As a part of its mission to develop the scientific basis for the establishment of water quality criteria for marine and estuarine waters, EPA is conducting toxicological studies on the acute and chronic effects of pollutants, including petroleum and heavy metals. To date it has conducted original investigations to determine the acute toxicity of six petroleum products on four test organisms, determined physiochemical properties of water emulsions of the test oils, completed a thorough literature review on the relative effects of different refined fractions of crude oil, and developed acute toxicity bioassay procedures for oil and oil dispersants. EPA also cosponsored symposia on "Pollution and the Physiological Ecology of Estuarine and Coastal Water Organisms" in November 1973 and on "Identification and Transformation of Aquatic Pollutants" in April 1974, which considered petroleum hydrocarbons.

Department of the Interior. Within the U.S. Geological Survey there are ongoing studies of pollution by heavy metals and organic chemical compounds in rivers, and coastal, estuarine, and continental shelf waters. The input of pollutants from rivers has been measured at selected stations for many years. The general "state of pollution" in estuaries, has been studied in most west coast estuaries, some gulf coast estuaries, and one east coast estuary. Ongoing studies have been accelerated in outer continental shelf areas of potential leasing for oil and gas development. The field studies are complemented by laboratory studies that include organic and trace metal geochemistry, origin of petroleum hydrocarbons, pollution indexes, and fate and dispersion of contaminants. The effects of OCS activities on aquifers that extend seaward beyond the coast also are being studied by the Geological Survey.

The role of the Bureau of Land Management (BLM) in marine oil pollution research is in the context of the offshore oil and gas leasing program which that agency administers. BLM activities in this area are described in Chapter IV.

Department of Commerce. NOAA is currently conducting baseline environmental studies of Puget Sound, Wash., and Prince William Sound, Alaska, to establish natural oceanographic conditions and ambient pollution conditions. The focus is on these two areas because of the proposed Alaskan outer continental shelf oil and gas development and the anticipated increase in other energy-related activities.

In Puget Sound, studies have been completed that contribute to understanding recirculation patterns and establishing ambient concentrations of aliphatic hydrocarbons in intertidal organisms.

The 2-year Prince William Sound study, in cooperation with the National Bureau of Standards, will complement a study of Port Valdez completed in 1973 by the University of Alaska. Initial results suggest that Prince William Sound waters and marine life have unexpectedly low levels of low molecular weight aromatic hydrocarbons (approximately 1 part per billion). This is the case even in the waters off Port Valdez where the Prince William Sound earthquake of 1964 caused a large quantity of oil to spill into that coastal area.

Another baseline study provided a preliminary analysis of San Francisco Bay water for concentrations of low molecular weight hydrocarbons. Greatest concentrations of aromatics (benzene at 50 parts per billion) were found to occur near San Francisco airport.

In addition to baseline surveys, NOAA is conducting or sponsoring research to determine the effects of various marine pollutants, including petroleum hydrocarbons, on marine organisms and communities of organisms. In FY 1974, NOAA researchers continued to examine the effects of sublethal concentrations of oil on marine organisms. These are multidisciplinary efforts to determine the tolerance of marine organisms to low levels of oil and the limits of this tolerance. Studies have been carried out using crude oil, especially Prudhoe Bay oil, and selected aliphatic hydrocarbons, but

the principal emphasis to date has been on the sublethal effects of the water-soluble fraction and low molecular weight aromatics on larval forms of herring, anchovy, and crab; on shellfish, primarily shrimp and crab; and on young fish, primarily salmon, herring, striped bass, and flatfish. The work is being done in the waters of San Francisco Bay, Puget Sound, and Alaska.

The Sea Grant Program in FY 1974 sponsored university research in the dynamics of oil movement on the ocean surface and the chemical stress of long-term crude oil contamination in estuarine areas.

The Maritime Administration (MarAd) pollution abatement research and development program is developing vessel equipment and operating procedures and systems to enable U.S. vessels to operate within specified national and international discharge standards without undue economic penalty. Major R&D antipollution activities in FY 1974 included the development of on-board processing equipment, oil discharge control and monitoring systems, and improved tank cleaning procedures, segregated ballast designs, navigation equipment, shoreside reception facilities, and deepwater port equipment. Additionally, in cooperation with NOAA, MarAd is sponsoring studies on baseline concentrations of hydrocarbons along selected tanker routes in the Pacific Ocean, including transects along the marine leg of the Trans-Alaska Pipeline System (TAPS). The project involves collection of seawater samples from tankers and from ships that are also participating in the GEOSECS Program of NSF.

The National Bureau of Standards (NBS) is supporting NOAA in the Prince William Sound study by establishing analytical techniques to measure hydrocarbons in the parts per trillion range in sediments, biota, and water. NBS has also been working to improve sampling techniques in order to minimize or eliminate contamination of samples. Analytical techniques developed in the Prince William Sound study should be useful in future baseline surveys in other coastal areas.

Coast Guard. Research and development by the Coast Guard is directed to surveillance and containment of oil spills. Development was completed and production began in FY 1974 on a high-seas oil-containment barrier system capable of being transported and deployed by air. This system can contain oil at current speeds up to 1 knot in 4-foot waves and can survive in higher wave heights. Air-deliverable, high-volume pumping systems for off-loading liquid cargo from a stricken vessel were developed and delivered to Coast Guard Strike Forces. Work began on the development of systems that are capable of containing and recovering oil in ocean currents of up to speeds of 10 knots. Research continued on the feasibility of using inexpensive cotton wastes as a sorbent in oil spill situations.

The Coast Guard reports further progress in the development of surveillance systems that have the capability of all-weather detection of oil and other hazardous substances. A five-sensor prototype airborne surveillance system was developed and installed in a Coast Guard aircraft for test and evaluation. Work continued on a fixed-site harbor surveillance system and spot and scanning systems were developed to the prototype stage.

The Coast Guard completed work on the development of sample collection and transmittal techniques and made considerable progress in developing a capability of positively identifying the source of spilled oil. The latter effort utilizes four techniques based on differing scientific principles for matching spill samples to possible sources. These advances have enhanced the Coast Guard's effectiveness in the law enforcement area.

Several studies were continued to develop means to separate and monitor waste oil from bilge and ballast water discharged from ships. These efforts were closely coordinated with MarAd, EPA, and the Navy and were aimed at compliance with recommendations of the International Maritime Consultative Organization (IMCO). Results of this research were fed back into IMCO through Coast Guard participation in various IMCO working groups.

Studies and field tests were begun on the risks, fate, and effects of petroleum spills in the Arctic environment to support the need for developing the necessary response and cleanup capability.

The Coast Guard's Pollution Incident Report System (PIRS) continued to provide valuable statistical data on oil discharges into the navigable waters of the United States, the contiguous zone, and the high seas.

U.S. Navy. The Navy in FY 1974 sponsored a number of research projects that examine the phenomenon of microbial degradation of petroleum hydrocarbons. Work sponsored at universities included the biodegradation of aromatic petroleum products and the feasibility of accelerating biodegradation of oils by seeding with yeasts and other fungi.

The Navy also funded two research projects on the fate and effects of oil pollutants in cold marine environments. One study examined the interactions of microorganisms and Prudhoe Bay crude oil. The purpose was to identify a mixed culture capable of degrading all or at least most of the components of Prudhoe crude at low temperatures. Work at another university was directed at isolating microorganisms that degrade hydrocarbons in low-temperature marine environments and comparing the rates at which selected organisms can accomplish degradation at different temperatures.

The Naval Biomedical Research Laboratory at Oakland, Calif., is measuring petroleum hydrocarbon concentrations in the waters and organisms of San Francisco Bay to: (a) determine which types of residues, if any, accumulate in these organisms; (b) estimate potential hazards in human consumption of organisms containing petroleum residues (e.g. crabs); and (c) determine if the waste hydrocarbon content of selected species of marine invertebrates can be used as an indicator of environmental stress caused by hydrocarbons.

Private Sector Oil Pollution Research

A large number of companies and private research organizations are engaged in various facets of marine oil pollution research. Some of the more significant investigations carried out during the FY 1974 period are described.

The Ford Foundation, as part of its Energy Policy Project, published in 1974 a current review of the ecological and technological aspects of marine oil pollution.12/ The Ford Foundation document recommends that, because of the large knowledge gaps and conflicting opinion surrounding marine oil pollution, great caution be applied in making policy decisions involving oil and the marine environment. The report urges more and better research into the problem, particularly in the more neglected aspects, such as chronic pollution and sublethal effects.

The oil industry sponsors research on marine oil pollution through the American Petroleum Institute (API), individual companies, and regional consortia such as the Western Gas and Oil Association. Recent API-sponsored field and laboratory research includes: sorbent recovery systems; effects of oil and chemically dispersed oil on selected marine biota; testing of oil recovery equipment; waterfowl rehabilitation techniques; shoreline protection and restoration methods; toxicity studies; sublethal effects on marine organisms subjected to chronic exposure to oil; fate of oil in a water environment; and development and validation of techniques for the analysis of petroleum components in water, sediments, and marine animal tissues.13/

API has made a direct contribution to laboratory studies on oil in the marine environment by establishing four reference oils for use by their contractors. These four oils include a southern Louisiana crude, a Kuwait crude, a Bunker C and a #2 fuel oil. Limited amounts of these reference oils are available at cost for other research workers.

In the FY 1974 period, Battelle Memorial Institute conducted numerous studies relating to marine oil pollution for a variety of sponsors.

Battelle-Northwest completed for API a program on the effects of oil and chemically dispersed oil on marine biota, including evaluation of multicomponent flow-through bioassay methods for study of both lethal and sublethal concentrations as well as uptake and elimination. Battelle continued this research effort with in-house funds, further developing hydrocarbon analytical methodologies applicable to tissue.

Other work by Battelle-Northwest has concentrated on future petroleum developments in Alaska and has included operation of a laboratory for Alyeska Pipeline Service Company in Valdez, Alaska, to determine the acute and chronic effects of treated ballast water on selected biota of the area.

For the Coast Guard, Battelle-Northwest also completed a long-range projection and geographical analysis of oil pollution potential in Alaska arising from oil production and transportation systems.

Battelle Columbus Laboratories examined in a study for the Coast Guard the following aspects of maritime oil spills and their control:

1) Optimum transfer systems for use in oil recovery operations;

2) Availability of vessels suitable for oil recovery operations;

3) Methods and systems for the ultimate disposal of recovered oil; and

4) Projected patterns of oil transport traffic and likely areas of spill mishaps of U.S. coastal regions for 1975-1990.

The Western Gas and Oil Association is funding continuing studies at Santa Barbara and in Alaska. Gulf Coast Oil Producers are funding a number of studies on petroleum in the marine environment through the Gulf Universities Research Consortium. Both API and regional consortia sponsor symposia to review research results by their contractors. These symposia are open to other scientists who are involved in research on marine oil pollution, from the public and private sectors.

Exxon Corporation has been collecting and analyzing water samples along selected tanker routes since 1971. This activity, which is jointly sponsored with MarAd and NOAA, is designed to generate baseline data on the concentration and distribution of hydrocarbons in the open ocean. In the 1971-73 program, water samples were obtained from Exxon tankers and from oceanographic vessels and were analyzed. More than 1,050 samples were taken along four main tanker routes in the Atlantic Ocean and adjacent seas. Samples were taken from the top meter of the water column and at a depth of 10 meters. The results of the 1971-73 program indicate that the mean concentration of nonvolatile hydrocarbons was 4 parts per billion (ppb) with values from 1.3 ppb to 13 ppb falling within one standard deviation from the mean. These values include hydrocarbons produced by marine organisms. However, the higher values, according to the Exxon study, probably result from recent input of petroleum from shipping activity near the immediate sampling area.14/

The Atlantic Ocean survey is being followed by a comparable baseline study in the Pacific Ocean. This survey began in 1973 and will be completed in 1975. The Pacific Ocean program is jointly sponsored by NOAA and MarAd under contract with Exxon Research and Engineering Company. The Pacific sampling program differs from that in the Atlantic in that volatile hydrocarbons also are being measured.

Figures 1 and 2 show the data of most interest--nonvolatile hydrocarbons in surface water. In the South and North Atlantic, most surface water was found to contain <10 ppb of nonvolatile hydrocarbons. An occasional sample was found to contain 10-25 ppb. Some higher concentrations were found near ports in the northern part of the Mediterranean Sea and in the Indian Ocean near the Persian Gulf. Surface water in the Pacific was predominantly of <10 ppb hydrocarbon content. Only the northwest sector and, in particular, the San Francisco/Cook Inlet tanker route had hydrocarbon concentrations in the 10-25 ppb range. Tokyo harbor water had a measured concentration of 25 ppb.15/

The Exxon survey showed that in almost every case, the surface sample had a greater hydrocarbon content than the sample drawn from depths of 3 meters, 10 meters, or more. For example, of 36 pairs of samples in the Pacific, the surface sample contained more hydrocarbons in 34 cases.

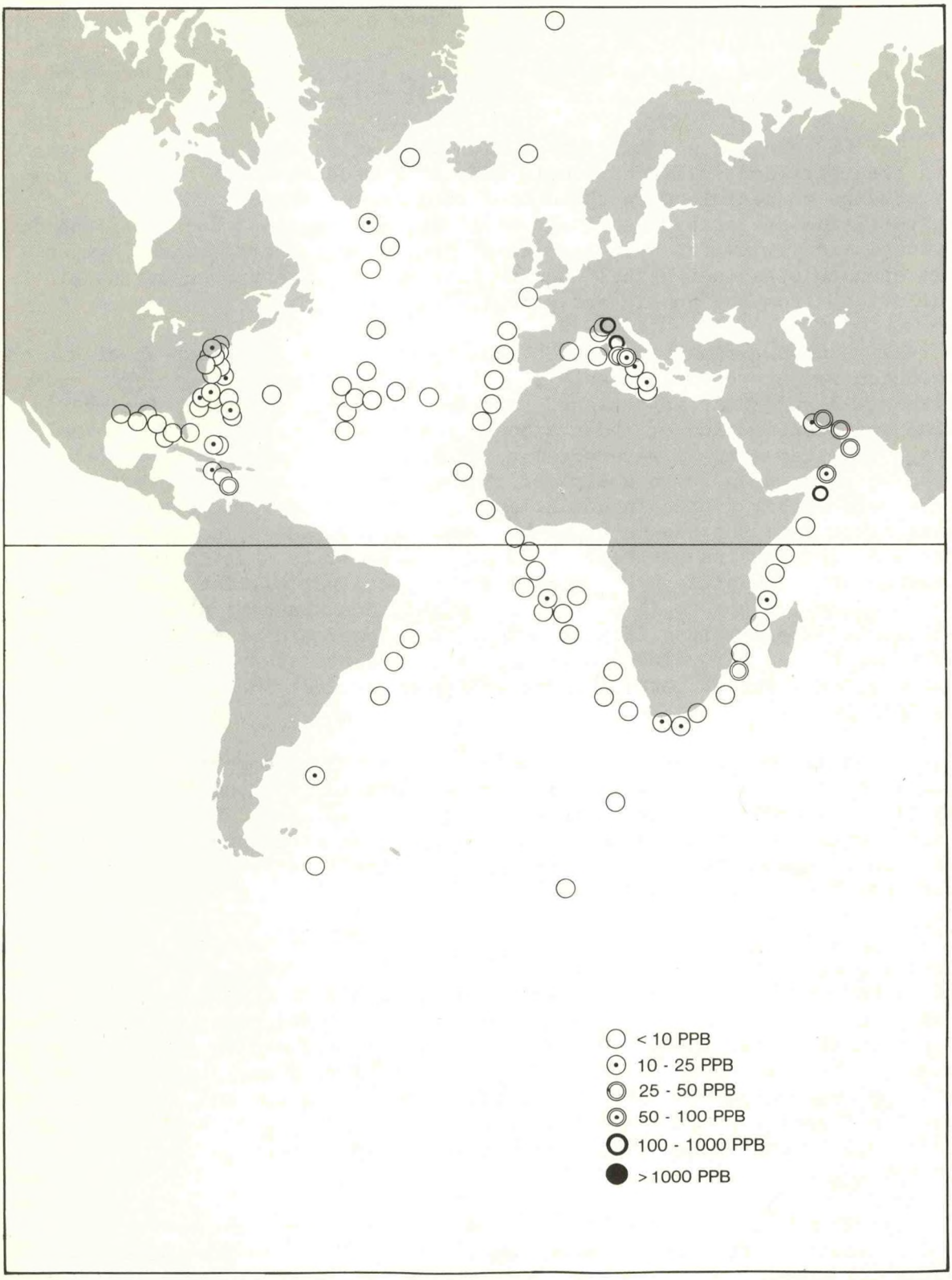


Figure 1.--Nonvolatile hydrocarbons in surface waters of Atlantic Ocean and nearby waters.

To identify the origin of the hydrocarbons, analyses are made of the sample's complex compositions. Such analyses frequently indicate the presence of one or more compounds that came from marine organisms. However, petroleum-type hydrocarbons appear to dominate, even in samples where hydrocarbons from marine organisms occur. Petroleum-derived hydrocarbon compounds can originate from natural seeps or man's activity. Further investigative work is needed to find a more definitive indication of hydrocarbons derived from these sources.

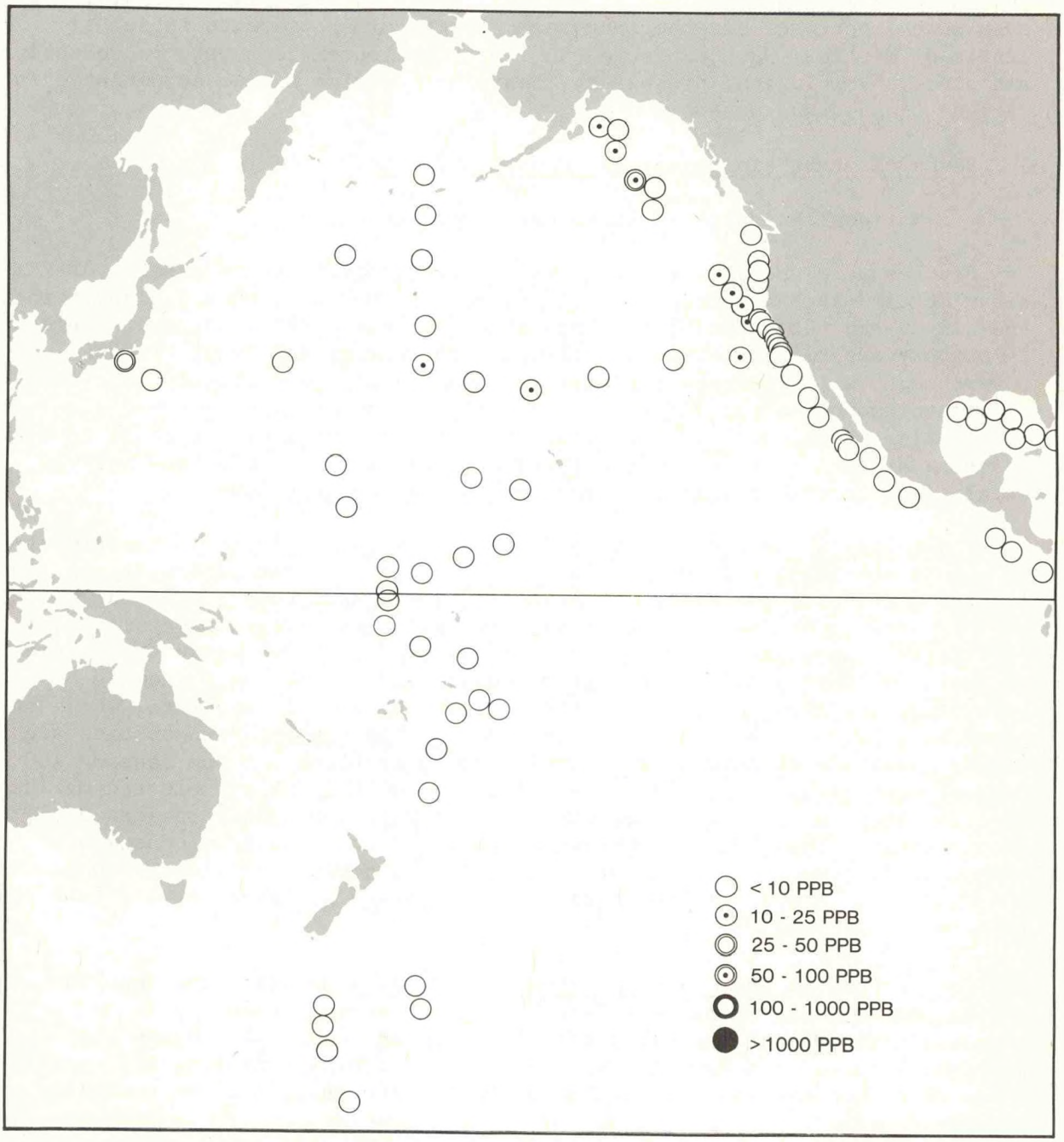


Figure 2.--Nonvolatile hydrocarbons in surface waters of Pacific Ocean.

Environmental stress caused by the introduction of heavy metals can alter the ecosystem and limit the recruitment, abundance, and distribution of living marine resources. Heavy metals can kill marine organisms or contaminate them to such extent that they create a hazatd to human health. To provide a basis for environmental management, it is necessary to establish precise levels of heavy metals that can cause mortalities and limit the responses of marine organisms at various stages in their life history. Of even more importance are the long-term effects of exposure to sublethal levels of metals. Such exposure can limit development, growth, reproduction, and other physiological processes. Heavy metals also can be accumulated in various tissues and organs.

Research on Physiological and Genetic Effects

National Oceanic and Atmospheric Administration

Studies were underway to determine in the laboratory the effects of heavy metals--such as arsenic, cadmium, copper, mercury, nickel, lead, zinc, and silver--on the normal life functions of certain marine species. These laboratory experiments, when correlated with contaminant levels in the environment, will indicate the marine animals that are extremely sensitive to minute amounts of metals and the animals or communities that are likely to flourish where specific metal contaminants are available at trace levels. A second area of research interest was the long-term effects that heavy metals (and certain pesticides) may have on marine organisms.

Physiological damage resulting from heavy metal pollution: Experiments to assess physiological changes in various species of marine shellfish, crabs, lobsters, and fish common to the Atlantic coast, have been conducted. Results of this work have shown, for example, that different metals have different effects on clam eggs compared to oyster eggs, even though these two species of shellfish have similar life cycle requirements. Clam eggs seem to be more sensitive than those of the oyster to zinc, nickel, and lead, while the opposite appears to be the case with silver. The eggs of both species are highly sensitive to mercury at very low concentrations - 8 ppb causing 100 percent mortality.16, 17/ Studies involving adult forms of selected marine species showed stress responses when subjected to low concentrations of heavy metals. These stress responses included altered oxygen consumption rates, deviations from normal behavior (silver, copper, cadmium, arsenic, and zinc), and a loss of the ability to maintain a proper internal fluid balance (copper).18, 19, 20/

Genetic damage resulting from heavy metal pollutants: Some important marine contaminants--heavy metals and certain pesticides--are able to induce genetic damage to cells, chromosomes, and genes. Years ago this was demonstrated in nonaquatic species of higher plants and animals. Recent research on the American oyster, a marine invertebrate, indicates similar genetic damage.

Three heavy metals studied to date (cadmium, lead, and silver) affected the early embryos of the oyster--almost invariably damaging the chromosomes and genes directly. Cadmium below 1.0 part per million and silver below 1.0 part per billion have been found to directly damage the chromosomes of spawned oyster eggs. Also, low levels of lead were shown to cause near-absolute genetic arrest of egg development in one species of clam. Mutations induced in fish and shellfish by chemical pollutants can lead to reduced fecundity, defective gametes, abnormally developed eggs, and dead larvae, thereby reducing recruitment into the fisheries. Also, mutations induced in developing embryonic cells not only permanently reduce the total reproductive potential of fish, but in more primitive invertebrates cause a greater amount of total energy to be utilized in reproduction, thereby diverting energy from overall growth. Based on general findings, it is expected that fish will be far more genetically resistant to mutagenic chemical contaminants than invertebrates such as the oyster. Experimental and field-oriented studies on the potential mutagenicity of widespread marine contaminants are being extended to groundfish and crustaceans.

Metals in Seafood and Sediments

Considerable efforts are being made by Federal agencies and university researchers to quantitate man's contributions of trace metals to the marine environment and to evaluate the potential threat of these metal additions to marine organisms and the people who consume them. A number of programs are being conducted to determine concentrations of trace metals in marine organisms. Some of these are monitoring programs and others are basic research efforts to understand the cycling and transfer processes of metals in the marine environment.

National Oceanic and Atmospheric Administration. The major Federal Government program presently underway to determine baseline levels of metals in seafood is being conducted by NOAA. This effort, known as the Resource Survey, has the following goals and objectives:

1. Define occurrences of microconstituents (trace metals) in marine fish and fishery products;

2. Assess significance of the extent of occurrence of metals in seafood in relation to human consumption;

3. Influence the establishment of sound regulation or guidelines; and

4. Establish an information base to assist other organizations with related responsibilities.

Initially, a preliminary resource survey was conducted to measure the concentrations of 15 elements (mercury, lead, cadmium, arsenic, selenium, silver, chromium, copper, zinc, nickel, molybdenum, vanadium, manganese, antimony, and tin) in muscle and liver in 204 species of marine fish and shellfish (85% finfish and 15% shellfish) from seven major geographical

areas. (North and Mid-Atlantic, South Atlantic, Gulf of Mexico, California, Pacific Northwest, Alaska, and Hawaii). Data from this survey will identify potential problems relative to certain trace metals in particular species and geographical areas. The second phase of the study--indepth surveys--has been initiated to confirm the extent and nature of potential problems. These detailed surveys will determine: (a) levels of trace metals; (b) their relationships to size and sex of organisms, season, and locale; and (c) if management of the problem is necessary or possible. The third phase of the program will be to relate consumer intake of trace metals in fish to consumer intake from other food sources.

The National Oceanic and Atmospheric Administration has sponsored a major study on heavy metal wastes in Long Island Sound to determine to what extent, if any, the region is a sink for these materials. The gross budgets of heavy metals in this ecosystem are being determined, as well as their sources, chemical interactions, and accumulation in biota and sediments. Heavy metal adsorption and subsequent release by suspended material and sediments also are being examined.21/

As part of the comprehensive study of the New York Bight, an investigation of the concentrations of five typical heavy metals in sediments around the sewage sludge dumping area are being carried out.22/ Concentrations of chromium, copper, lead, nickel, and zinc in superficial sediments in the New York Bight have been shown to be 10 to 100 times greater near waste disposal areas than in uncontaminated sediments. It was also indicated that some wastes are transported by currents northeast toward Long Island and southeast along the Hudson Submarine Valley.

Environmental Protection Agency. Studies were conducted by EPA to assess the impact of elevated environmental levels of metals of marine communities. Rates at which metals are leached from material dumped at disposal sites and possible accumulation by biota are being determined in the laboratory. Possible uptake patterns of metals, based on feeding relationships of benthic invertebrates, are being examined to establish biological monitors for tracing the movements of deposited materials away from areas of concentration and to determine their subsequent availability to biota. Changes in concentrations of metals in and around dump sites are being documented.

National Science Foundation. The NSF sponsored in FY 1974 various research projects on the transfer and effects of heavy metals in the marine environment. Most of this work was carried out as part of the International Decade of Ocean Exploration (IDOE) program that is described in the section of this chapter entitled, International Marine Pollution Research Activities.

The National Science Foundation also supports research related to trace metal contamination in marine organisms. This research is designed to understand and alleviate estuarine effects of waste discharges and dumping in the coastal zone and to determine the levels of toxic substances in the environment, assess the effects of these levels on animal (including man) and plant communities, and relate these findings to methods of control.

To date, some of the efforts in this program have been on the fate and effects of lead, mercury, molybdenum, arsenic, zinc, and cadmium in terrestrial, freshwater, and marine environments.

Atomic Energy Commission. The AEC has funded research related to the biogeochemical cycling of radionuclides in the marine environment. At the present time, the AEC supports about 60 marine contracts with university, Federal, and private research groups. Because knowledge of the chemical behavior of naturally occurring elements is needed from a radioecological point of view, the AEC is funding a number of projects dealing with accumulation of heavy metals in marine organisms.

National Shellfish Sanitation Program. This program, conducted by a group of Federal, State, and private sector research organizations, is sponsoring a Chemistry Task Force which is attempting to establish environmental levels of four trace metals (lead, copper, zinc, and cadmium) in approved shellfish growing beds along the Atlantic, Gulf, and Pacific coasts of the United States and Canada. This represents an attempt to determine background concentrations of these metals in different growing areas so that metal contaminated shellfish beds can be readily identified. Once this is known, efforts can be made by appropriate State and Federal agencies to identify and eliminate sources of unnatural inputs of these metals to these growing areas. Sample collection and analyses are being made by State agencies and the results will be reviewed periodically by the Chemistry Task Force.

SYNTHETIC HYDROCARBONS

The major groups of synthetic hydrocarbons that are likely to have an impact on the marine environment are pesticides (such as insecticides and herbicides) and industrial compounds such as polychlorinated biphenyls (PCBs). Many of these compounds are toxic. Many resist chemical and biological degradation, thus they persist and accumulate in the environment. Volatility of some of these compounds permits their escape into the atmosphere, where they are transported to the oceans by air currents.

Commonly, many synthetic hydrocarbons are translocated from land via runoff and sewage outfalls into rivers, then into estuaries and the oceans. Areas in which the less persistent chemicals are apt to exert the greatest unintended effect are estuaries and nearshore portions of oceans. These areas are of extreme biological importance because estuaries are nursery grounds for many species used as human food or as sources of valuable commercial products. Also, estuaries and nearshore waters are the marine areas in which such species encounter these toxicants earliest--at the most sensitive stage--in their life cycles and in greatest concentrations. At the same time, more persistent synthetic hydrocarbons are borne into oceans in the tissues of these migrating animals or in water currents. Passage of persistent synthetic hydrocarbons through marine food chains permits concentration of these toxicants to amounts that become harmful at higher

trophic levels to predators such as fishes, fish-eating birds, and man. Also, some species of oceanic plankton have proven to be more susceptible to synthetic hydrocarbons in water than are related coastal species.

Important Synthetic Hydrocarbon Pollutants

Chief toxicants in this category are (1) pesticides, such as the persistent halogenated compounds (DDT and others), herbicides, and esterase-inhibiting insecticides, and (2) industrial compounds, such as polychlorinated biphenyls (PCBs).

The pesticide DDT, although no longer used in the United States except for restricted purposes that require special permits, is still manufactured and used in other parts of the world primarily for human disease vector control. Therefore, it remains a global problem. In the United States, DDT was banned for general use in 1972. During the 5-year period prior to its ban, the use of DDT declined, a trend that was evidenced by decreasing levels of the pesticide measured in estuaries. Also, there has been a concomitant reduction of DDT in certain municipal sewage outfalls.

Decreased production and use of DDT should decrease its global significance; however, the effect of increases in the quantities of other chlorinated hydrocarbon, organophosphate, and carbamate insecticides on the marine environment is, at present, uncertain. It is on these chemicals, particularly other persistent chlorinated hydrocarbons such as endrin, dieldrin, chlordane, heptachlor, and toxaphene, that recent research has focused.

Highly toxic organophosphate and carbamate pesticides are now produced and applied in greater quantities than the chlorinated hydrocarbon pesticides. Monitoring for residues of the compounds in water has been rare, but residues of organophosphates have been found in tissues of marine fishes from the Atlantic Coast and Gulf of Mexico. These compounds are believed to be degraded more rapidly than are the chlorinated hydrocarbon pesticides that they are replacing, but effects can be caused by practically unmeasurable metabolites.

Recent research findings indicate that the presence of organophosphate and carbamate insecticides can often be detected by measuring reduction in activity of enzyme acetylcholinesterase in nervous systems of some marine animals. The mode of action of organophosphate and carbamate insecticides in vertebrates and arthropods is generally regarded as disruption of nerve-impulse transmission in the central and peripheral nervous systems by inhibition of the enzyme acetylcholinesterase.

Progress has been made in determining the effects of the anticholinesterase pesticides on estuarine and marine organisms. Laboratory studies have been made on the nature of the enzyme acetylcholinesterase in fishes and the relation of its inactivation to poisoning and deaths in the laboratory and in the field. Specific levels of brain enzyme inhibition associated with death in marine and estuarine fishes have been defined for many of the organophosphate insecticides, and research is in progress on some carbamate

compounds. Field studies have supported laboratory findings and show substantial effects of large-scale aerial application on marine organisms.

Use of herbicides is increasing, but very little is known about their potential effects in the marine environment. In bioassays of short duration, many herbicides can affect rooted plants and phytoplankton that provide food and shelter for commercially important marine animals. Also, herbicides are toxic to certain estuarine animals in short-term laboratory studies. Information is not available to assess long-term impact of herbicides on fragile marine ecosystems.

Polychlorinated biphenyls (PCBs) are present in oceanic water, sediment, and biota. PCBs are mixtures of biphenyls containing from one to 10 chlorine atoms on the biphenyl rings; 210 isomers are possible and each has its own chemical, physical, and possible biological properties. In the United States, about 40 million pounds of PCBs are produced per year. Several different types of PCBs are produced and each contains different kinds or amounts of the isomers.

The toxicity of PCBs to some marine organisms, including algae, protozoa, mollusks, arthropods, and fishes, has been investigated. Acute bioassays lasting 96 hours or less demonstrate that all PCBs are toxic to certain estuarine organisms. Tests of longer duration demonstrate that PCBs accumulate in the tissues of marine organisms, particularly in liver and fatty tissues, in amounts that can exceed 100,000 times the amount in their environment. These PCBs are retained even after the animal is placed in PCB-free water. The presence of PCBs in concentrations of 100 parts per trillion or more can be lethal to sensitive shrimps and fishes and can adversely affect communities of organisms. PCB-exposed organisms are sensitive to disease and changes in environmental conditions; the reproductive portion of the life cycle of fish is particularly sensitive.

Advances in Analytical Methods

Prior to FY 1974, research techniques available were limited essentially to (1) 96-hour or longer bioassays of single chemicals and single species and (2) a single life stage of an animal in static or flowing-water systems. Criteria of effect were usually death, loss of physiological function, or alteration of behavior, and bioaccumulation of the toxicant in the body of the test animals.

Now, a wider range of refined investigative techniques is available. These techniques permit more realistic laboratory evaluation of the impact of a toxic chemical in the marine environment. They include:

1. Use of the bioassays noted above in conjunction with repeatable, controlled conditions of salinity and temperature;

2. Short-term and long-term bioassays that test simultaneously interaction of test animals with two or more toxicants in flowing-water systems in which both salinity and temperature can be controlled;

3. Egg-to-egg chronic bioassays that test the toxicity of a chemical to all life stages of a marine species;

4. Experimental ecosystem studies that test the effect of a toxicant on development of communities of animals;

5. Studies of pathological changes induced at the organ, tissue, cellular and ultracellular levels that permit early recognition of interactions of animal, toxicant and infectious disease; and

6. Chemical analytical techniques that permit measurement of concentrations of pesticides and related toxicants present in water and biological samples at the parts-per-trillion level.

The results emanating from these research techniques have advanced our knowledge of how and where certain pesticides and PCBs accumulate in the marine environment, and have provided a firmer scientific basis for establishment of effluent guidelines and ocean dumping criteria to reduce pollution of the marine environment by synthetic hydrocarbons.

MAJOR REGIONAL STUDIES OF OCEAN POLLUTION

New York Bight

The New York Bight, a 15,000-square-mile area of the ocean extending from the tip of Long Island, N.Y., to Cape May, N.J., and out to the edge of the continental shelf, is the ultimate repository of about 4 million metric tons of industrial wastes and 5 million metric tons of sewage sludge annually from the New York/New Jersey metropolitan region. Although ocean dumping of industrial and municipal wastes accounts for a significant fraction of the contaminants entering the Bight, at least four other sources or pathways of pollutants are important. They are: sewer outfalls; land runoff; the Hudson River; and atmospheric transport.

In the early 1970s NOAA initiated the Marine Ecosystem Analysis (MESA) program, which consists of multidisciplinary investigations of the ecology of a given marine environment and the changes in that natural system which result from human activities and natural forces. In FY 1973 the New York Bight was selected as the first U.S. coastal area to undergo a comprehensive study under this program.

In FY 1974 most of the resources of the MESA New York Bight project were directed to an investigation of the immediate problem of dumping of wastes in the Bight. However, work was also initiated to: (1) determine the effects of existing and projected pollution loads from the other major sources; and (2) investigate the nearshore ocean processes such as currents, wave patterns, and sediment movement in order to improve coastal zone management and coastal engineering decisions.

The MESA effort in the New York Bight is obtaining useful information and data for other programs and activities of Federal environmental protection and resource development agencies, including the U.S. Army Corps of Engineers' construction, dredging, and disposal activities, and the Bureau of Land Management's leasing program for offshore oil and gas development.

Great Lakes Studies

The International Field Year for the Great Lakes (IFYGL) is a joint United States and Canada multiyear program that includes an intensive field study of Lake Ontario and its drainage basin. It also includes a program of coordinated research into the physical, chemical, and biological aspects of Lake Ontario and its basin, using the field study data. The findings will improve our understanding and lead to better management of Great Lakes resources.

The intensive 1-year data collection effort was completed March 31, 1973. Data on physical, chemical, and biological properties were collected from ships, buoys, towers, and aircraft by radars and rawinsondes and at meteorological and hydrologic stations.

The IFYGL studies are being conducted on both a whole-lake scale and on a fine scale for the nearshore and selected tributaries to determine distributions and variability in specific sections of the lake. The whole-lake scale studies provide information on the balances of physical, chemical, and biological properties in terms of input, output, and storage. The fine-scale studies provide information on the mechanisms by which effluents are transported and distributed. Studies of special features, such as the nearshore temperature and current structures, indicate that these play a major role in the transport and diffusion of both dissolved and particulate matter. Studies of harbors and embayments are providing information on the fate of effluents discharged into these waters as a function of the physical characteristics of the shore area and the lake.

The IFYGL data and analysis results will provide a basis for determining the distribution and fate of pollutants in Lake Ontario. Mathematical models are under development and test to simulate the important processes in determining the impact of man's activities on the lake's future state and its value as a resource for various uses. Much of the information collected during IFYGL may be applicable to the other Great Lakes. This includes the relationship of the lake's physical characteristics to external influences, the capacity of the lake as a dumping ground for various effluents, the biological and chemical process rates, and the interrelationships of the various trophic levels.

The IFYGL Water Movement Project is investigating the water movements and mixing processes involved in the distribution and variability of pollutants. These studies include analyses of physical properties, and the development of diagnostic and simulation models of the deep lake and coastal circulation, the effects of diffusion, and of internal and surface waves. Analyses of IFYGL data are yielding significant results on these physical parameters and the hydrodynamic models show promise of useful simulations.

The occurrence and accumulation of hazardous materials in the lake and the biotic system are being investigated through a series of transport pathway studies. Hazardous materials, such as radioactive materials, pesticides, organics, etc., were sampled on a limited basis to determine the magnitude of their input and very detailed mapping of chlorophyll a was undertaken on a weekly basis to measure the eutrophic status of the lake.

A fish survey was conducted during IFYGL as a first step in an ongoing program to guide management initiatives aimed at restoring the fish stocks of Lake Ontario and the other Great Lakes. Both nearshore and deep lake surveys were conducted to determine the species and distribution of fish still inhabiting Lake Ontario. A species distribution study has been completed and a long-period study of the relationships of the lake biota and the physical and chemical properties of the lake is underway.

Work is continuing on analysis of IFYGL data to provide descriptive summaries of the distributions and variability of measured parameters, statistical relationships of the parameters and processes observed, and simulation and prediction models of the physical, chemical and biological processes occurring in the lake. These products will have almost immediate utility in making decisions relative to use of the lakes as an effluent dumping ground, as a source of water for public and industrial use, as fish and wildlife habitat, and as a recreational resource. They also will increase our scientific understanding of the Great Lakes as a total system.

As a part of the 1972 Great Lakes Water Quality agreement between the United States and Canada, the International Joint Commission (IJC) was requested to conduct a study of water quality in Lake Huron and Lake Superior. This task was delegated to the IJC Water Quality Board which was established by the 1972 agreement. An international study plan was developed and work is underway to determine the degree of pollution in the upper lakes, to identify sources, and to consider remedial measures.

As a part of the Upper Great Lakes Study, water quality was assessed in the waterway connecting Lake Huron with Lake Erie which includes the St. Clair River, Lake St. Clair, and the Detroit River. Heavy concentration of population and industry exists on both shores of the waterway in the United States and Canada. Water quality in the waterway decreases gradually from very high in Lake Huron to highly polluted at the entrance to Lake Erie. The pollution load consists of treated wastes from larger municipalities and factories, and untreated wastes from smaller units.

During the period from May to November 1974, a comprehensive water sampling program was accomplished by NOAA. Samplings to determine time-spatial variations were made at 98 reference stations at predetermined geographical locations, which were visited 10 times to monitor variation of characteristics of the water and its immediate environment. Through these time-rate determinations, any station can reasonably be correlated with any other. The program has been planned to utilize and complement existing data. Channels in the two rivers and on the St. Clair River delta

were sampled in cross-section where the standard hydraulic sections have been established in order to develop volume discharge estimates of dissolved and solid constituents.

The first report of the Upper Great Lakes Study to the IJC is due in late 1975 or early 1976.

North Sea Studies

The International Council for the Exploration of the Sea (ICES) established in 1971 a working group for the study of North Sea pollution. This working group was formed to conduct an interdisciplinary study of the pollution of the North Sea and its effects on living resources and their exploitation. The group has endeavored to assess the input of various pollutants to the North Sea through (a) domestic sewage disposal, (b) industrial discharges both directly and via rivers, estuaries, and fjords, (c) dumping, and (d) atmospheric transport.

Quantitative data on amounts and types of pollutants that are introduced into the North Sea by each member country were gathered by the ICES. In addition, baseline concentrations of certain heavy metals and synthetic hydrocarbons in selected fish and shellfish were measured. Results showed that the level of metals (mercury, cadmium, copper, zinc, and lead), pesticide residues, and PCBs in the species investigated were below the lowest levels established by certain countries as standards for human consumption.

The ICES effort to date has concentrated on obtaining a synoptic view of present conditions in the water and has been concerned with the immediate problem of the hazard to human health from the consumption of contaminated fish and shellfish. In recent years the ICES has turned its attention to the rapid development of the North Sea oil production industry and its potential effects on living resources. Initial studies have been started in Norway and in the United Kingdom within the framework of the ICES study of Pollution of the North Sea.

Future work will involve an examination of the effects of contaminants on the biota of the North Sea. The working group has recommended to the Council that more complete data on pollution inputs be obtained and that work on the atmospheric pathway be initiated.

A detailed summary of the ICES North Sea pollution study was issued in May 1974.23/

In 1969 the North Atlantic Treaty Organization (NATO), accepting an initiative proposed by the United States, added a social dimension to its activities by establishing a Committee on the Challenges of Modern Society (CCMS). The North Atlantic Council directed CCMS to examine ways to improve the exchange of information among member countries relative to creating a better environment and to consider specific problems of modern society with the objective of stimulating action by member governments.

CCMS identified oil spills as a problem of urgent concern and therefore gave it early priority. CCMS activities are organized by individual member countries of NATO, each acting as a "pilot" for one or more activities. Belgium accepted the role of "pilot" on the problem of oil spills, as a first step in the broader project of coastal water pollution. In late 1970 the Belgium Government convened in Brussels an international conference on oil spills. A significant outcome of this conference was a resolution by the NATO Foreign Ministers committing their governments to work toward the elimination of intentional discharges of oil and oily wastes into the sea by 1975, if possible, but no later than the end of the decade. This NATO/CCMS resolution was adopted as the goal of the Inter-Governmental Maritime Consultative Organization (ICMO) International Conference on Marine Pollution held in London in October 1973.

Belgium, as "pilot country", together with the United Kingdom and the Netherlands, initiated a North Sea Pollution Project. The major effort in this project is development of a North Sea diagnostic model which should be available in early 1975. The basic CCMS North Sea model has also been modified for application in the estuarine of the Tagus River in Portugal and the Po River in Italy.

Baltic Sea Studies and Convention

The Baltic Sea covers a total area of 163,050 square miles and serves as the depository of drainage from a land area four times its size, including three major river systems. It receives the chemical and organic wastes from the most highly industrialized and populated region of northern Europe. Direct dumping, agricultural runoff, and rivers polluted with industrial wastes and largely untreated sewage from over 20 million people have produced over the years a most serious situation.

In addition to these stresses imposed on this ecosystem by man, the Baltic is a naturally fragile system with only a marginal capacity to support marine life. It is a shallow sea for its size with an average depth of only 180 feet. The Baltic is almost completely enclosed by land and thus receives limited infusions of cleaner waters from the Atlantic Ocean.

The Baltic Sea is one of the most thoroughly studied bodies of water in the world. Nevertheless, no serious cooperative effort was undertaken to examine the pollution problem until around 1968 when ICES established a Working Group on the Study of Pollution of the Baltic. The Working Group meets periodically to coordinate the various national efforts. The ICES is now conducting a comprehensive ecological study of the Baltic Sea. The study includes taking an inventory of available national laboratory facilities, achieving an intercalibration of instruments capability, and obtaining accurate and comparable data on the pollution contribution of the various Baltic countries.

While these cooperative research efforts were getting underway, a need was felt to provide an official treaty framework for future collaboration among the Baltic states on the problem of Baltic Sea pollution. Preparation for an international convention began about the time of the United Nations

Conference on the Human Environment (June 1972), when Finland circulated a questionnaire among the other Baltic Sea states about their willingness toward a joint action in restoring the quality of that body of water.

In September 1973 Finland proposed and offered to host a Baltic anti-pollution conference in early 1974. The conference resulted in an international Convention, signed in Helsinki in March 1974, that is one of the few agreements dealing with the comprehensive environmental protection of a major body of water. Representatives from the USSR, Poland, the Federal Republic of Germany, Denmark, Sweden, Finland, and the German Democratic Republic also agreed to establish a Commission which will enforce the anti-pollution regulations provided by the Convention. The Commission will be headquartered in Helsinki; its personnel will be drawn from the countries participating in drafting the Convention.

The new Convention sets forth basic principles for collaboration, forbids the dumping of solid wastes and of chemicals into the Baltic, and provides for the construction of sewage treatment facilities. The Baltic Sea Commission will enforce these regulations and will develop further measures, which, in addition to already existing laws, should prevent irreversible degradation of the Baltic Sea.24/

INTERNATIONAL MARINE POLLUTION RESEARCH ACTIVITIES

Three major international cooperative programs of marine research are reviewed. Among these are the International Decade of Ocean Exploration (IDOE) pollutant effects and pollutant transfer studies, including the Controlled Ecosystems Pollution Experiment (CEPEX) and the Geochemical Ocean Sections Study (GEOSECS). The section concludes with a description of FY 1974 activities of the Global Investigation of Pollution in the Marine Environment (GIPME) and the Integrated Global Ocean Station System (IGOSS).

International Decade of Ocean Exploration (IDOE)

The IDOE Environmental Quality Program of the National Science Foundation includes major research on the effects and transfer of pollutants in the marine environment and the use of analytical geochemical data in the study of diffusion, mixing, and large-scale ocean circulation.

Pollutant Effects Programs. In the Controlled Ecosystems Pollution Experiment (CEPEX), scientists from the United States, the United Kingdom, and Canada are studying the effects of specific pollutants on marine life. In this project natural marine communities, contained in large plastic enclosures located in Saanich Inlet, Victoria, British Columbia, are subjected to low-level and long-term exposure to petroleum, polychlorinated biphenyls, and heavy metals.

Initial experiments were carried out in 1973 using 1/4-scale cylindrical enclosures (8 ft x 52 ft) for the purpose of testing the engineering feasibility and scientific soundness of the approach. Test results were

encouraging and in 1974 a full scale model (33 ft x 96 ft) was deployed for engineering field tests which will run until early 1975.

As part of the engineering feasibility studies, experiments on the effects of selected pollutants on ecosystems were carried out. Plankton organisms trapped inside the enclosures went through an ecological sequence common to waters surrounding the enclosures. Experiments using the 1/4-scale enclosures included measuring the effects of low concentrations of copper and petroleum hydrocarbons. The results of the copper experiments showed that low concentrations (10 ppb) of copper cause an immediate mortality of zooplankton and phytoplankton species, followed by the development of a plankton population that is tolerant of low-level copper concentrations. The preliminary findings from the petroleum hydrocarbon experiments were even more striking than those of the copper experiments. At low concentrations of petroleum hydrocarbons (approximately 80 ppb) there was an enhancement of primary productivity among certain marine organisms. This enhanced photosynthesis stands in contrast to the photosynthetic inhibition which is generally reported for hydrocarbon concentrations greater than 1 ppm.

In addition to studies on the effects of pollutants on natural ecosystems, as represented by CEPEX, laboratory investigations were started to evaluate the effects of petroleum hydrocarbons, heavy metals, and synthetic organics on individual classes of organisms including bacteria, phytoplankton, zooplankton, and higher marine organisms.

Several pollutants which were acutely toxic to these organisms in the parts-per-million range have been examined. Results suggest that, in general, heavy metals, such as mercury, and chlorinated hydrocarbons (e.g., PCB-Aroclor 1254) were found to be more toxic than petroleum hydrocarbons to most test species. Larvae were more sensitive to pollutants than adults of the same species; and crude oils and Number 2 fuel oil were found to be toxic to microalgae at concentrations of 15-150 ppb as were their water soluble extracts. These acute toxicity studies were conducted to determine the sensitivity of various organisms to each of the major classes of pollutants, and to establish the concentration range with which subsequent sublethal studies should be conducted. It is the effect of sublethal concentrations of the pollutants which is of primary interest.

Pollutant Transfer Program. The National Science Foundation also is supporting research to determine the pathways or mechanics controlling the rate of pollutant transfer from the source to and within the ocean. To meet this research need, in 1972 NSF established the Pollutant Transfer Program. Goals of this program are to: (1) identify important transfer pathways and mechanics; (2) evaluate the major environmental factors that affect transfer processes; and (3) develop principles governing transfer of pollutants. Special attention is given to the concentration and dispersal of pollutants at the air-sea interface, movement of pollutants through estuaries to continental shelf waters, deposition of pollutants in sediments, and the chemical forms of each pollutant.25/

A major research area of interest is the role of the atmosphere as a route for the transfer of chlorinated and petroleum hydrocarbons and trace

metals to the ocean. Results of studies on the atmospheric transfer of trace metals suggest that, except for seawater-derived earth metals, most of the trace metals found in the atmosphere over the open ocean and Antarctica are from normal weathering of the Earth's crust. However, several trace metals (zinc, copper, antimony, lead, selenium, and cadmium are found in concentrations far in excess of those predicted as being of crustal origin.

Several investigators are studying the atmospheric transport of heavier chlorinated hydrocarbons to the oceans. For example, scientists studying PCB transport in the Southern California area have shown that transport of particulate chlorinated hydrocarbons is not a global phenomenon, but one where most residues are deposited within a radius of 100 kilometers of the source.

Studies also give indirect evidence for the atmospheric transport of PCB and DDT compounds from their observed distribution in the biota of the more remote marine environment. Both of these compounds are universally present in terrestrial and marine Arctic wildlife that live in areas where transport by other pathways is highly unlikely. The use of marine birds, principally fish-eating species such as cormorants and pelicans or surface feeders such as petrels and shearwaters, has permitted an assessment of the present contamination patterns in the Pacific. Highest DDT residues (which are the result of a single land source), occur in the Southern California Bight. Elsewhere, however, aerial dispersal and rainout appear to account for the majority of the residues.

The major routes for pollutant transfer to coastal areas are rivers and sewage and industrial outfalls. These sources subject estuarine ecosystems to the most severe man-induced stresses in the marine environment. At the Skidaway Institute of Oceanography, researchers are studying the fluxes of iron, manganese, copper, cadmium, and mercury through the salt marsh estuaries of the southeastern Atlantic coast to the adjacent continental shelf.

Other researchers have begun an extensive investigation of the input of lead to the Southern California Bight from storm runoff and sewage outfalls. They have found, in significant contrast to earlier investigations, that less than one percent of the waste effluent lead is dissolved while the rest is in particulate form. The isotopic composition of the dissolved lead was also considerably different from particulate lead, suggesting different sources for these forms of this metal. Extensive sampling of dissolved and particulate lead in the ocean in the vicinity of sewage outfalls as well as in rain and storm runoff is presently underway.

A survey of petroleum hydrocarbons has been made by scientists at the Woods Hole Oceanographic Institution and the University of Rhode Island. Effluent from the Fields Point Sewage Plant, which serves the cities of North Providence, Providence, and some industries in Cranston, R.I., was found to contain from 2.4 milligrams per liter total hydrocarbons on the 3 days it was sampled.

From the discharge rate and the concentrations of hydrocarbons in the effluent, it was estimated that the Field's Point plant discharged between 130 and 655 metric tons of hydrocarbons per year, if the concentrations found are representative of concentrations throughout the year. Approximately 30 billion liters of municipal wastes are discharged to U.S. coastal waters each day. If the concentration of hydrocarbons in these effluents are similar to those of the Field's Point effluent, then 28,000 to 140,000 metric tons of petroleum hydrocarbons are discharged each year by wastewater effluents to U.S. coastal waters. Based on available data, it is calculated that approximately 28,000 metric tons of oil were spilled into U.S. coastal waters during 1970. Thus, the estimated amount of petroleum discharged by wastewater effluents may be in the same range as the reported amount spilled in coastal areas.

Geochemical Ocean Sections Study (GEOSECS). Scientists in the GEOSECS program have obtained measurements of oceanic constituents at selected depths along Arctic-Antarctic sections in the Atlantic and Pacific Oceans, to provide, for the first time, a set of physical and chemical parameters measured on the same water samples. The major effort to date has been measure measurements at sea and collection of samples for study by the participating shore laboratories. The Atlantic transect was started on July 18, 1972, and completed on April 4, 1973, by personnel aboard the RV *Knorr*. The Pacific transect was completed by the RV *Melville* between August 22, 1973, and June 9, 1974. During the Atlantic and Pacific transects, more than 30,000 containers of sea water were shipped to shore-based laboratories for analysis and 200,000 measurements of dissolved oxygen, nutrients, argon, nitrogen, and alkalinity were made aboard ship. At most stations, continuous measurements were made of salinity, temperature, oxygen, and light scattering throughout the water column. These data are already providing the basis for quantitative studies of the stirring and mixing processes in the deep sea; the interchange of material between deep and surface waters; and the exchange of water and gases between the sea and atmosphere. The data also will serve as a baseline against which the addition of fission products and other pollutants to the sea can be measured.

Global Investigation of Pollution in the Marine Environment (GIPME)

Members of the Intergovernmental Oceanographic Commission's International Coordination Group for the Global Investigation of Pollution in the Marine Environment (GIPME) met at the United Nations headquarters in New York, July 15-19, 1974, and approved a comprehensive plan for GIPME which will be used as the foundation of an IOC program to study marine pollution and the scientific means to combat it. The ultimate objective of this comprehensive investigation is to provide a sound scientific basis for the assessment and regulation of the pollution problem, including carefully planned and implemented monitoring programs.

The GIPME Comprehensive Plan sets forth a framework within which national and regional programs on various aspects of marine pollution can be coordinated to improve our understanding of global pollution problems. A first priority will be a series of national or regional baseline studies.

These will be conducted within a similar framework to facilitate collection and comparison of the data. Interpretation of these data will be used to formulate statements on the health of the ocean.

Members of the IOC group foresaw an immediate need to assess the training and technical assistance requirements of development nations, a need that must be satisfied before such nations can participate effectively in the Comprehensive Plan. An ad hoc task team is being formed to look into this matter and to provide liaison with the IOC Working Committee on Training, Education, and Mutual Assistance.

The report of the group, including the Comprehensive Plan, will be submitted to a future session of the IOC Executive Council for approval and recommendations on implementation of priority items during 1975.

Integrated Global Ocean Station System (IGOSS)

The Marine Pollution Monitoring Pilot Project is part of the Integrated Global Ocean Station System (IGOSS) Program cosponsored by the United Nations' Intergovernmental Oceanographic Commission (IOC) of UNESCO and the World Meteorological Organization (WMO). The purpose of the Pilot Project is to bring together and coordinate the national activities of various countries, and to develop common methodology into a global organization on marine pollution monitoring. The forms of petroleum hydrocarbons that will be monitored include:

- Oil slicks and other floating pollutants,
- Floating particulate petroleum residues or tar balls,
- Tar on beaches, and
- Dissolved/dispersed petroleum hydrocarbons in the ocean surface waters.

The ocean areas to be monitored were chosen on the basis of existing national and regional programs, regions of offshore oil production, the main routes of oil transportation, and the major ocean currents. However, observations from all ocean areas are encouraged. Data collected by participating countries will be made available to a spectrum of ocean users.

Efforts are underway to coordinate and encourage the participation of U.S. Federal agencies, academic institutions, and private industries in the Pilot Project. To provide for U.S. participation in the project, and to ensure compatibility with ongoing activities and programs, the U.S. plan will be implemented in phases. The first phase, beginning in early 1975, will consist of developing reporting procedures for visually observable pollutants, obtaining sampling information from ongoing programs, and receiving, archiving, and disseminating data.

In May 1974 the Intergovernmental Oceanographic Commission (IOC-UNESCO), the World Meteorological Organization (WMO), and the Department of Commerce (MarAd, NBS, and NOAA) cosponsored the Marine Pollution Monitoring Symposium and Workshop. The objectives of the symposium and workshop were to develop working guidelines for the Pilot Project by: (1) providing scientific and

technical advice as to methodology to be used during the Pilot Project; and (2) recommending technical assistance programs and training assistance programs and training and education projects that would provide adequate support to enable developing countries to establish marine pollution monitoring activities. The report of the symposium and workshop is expected to be made available in early 1975.

CHAPTER III

OVERFISHING

The first report to the Congress described in general terms how overfishing and natural fluctuations in fish populations affect marine ecosystems. It told how serious long-term effects can result when even moderately heavy fishing is coupled with natural fluctuations in fish populations. This chapter summarizes activities relating to fisheries resources during fiscal year 1974--tuna in the eastern Pacific and central Atlantic and groundfish in the northeast Pacific, the eastern Bering Sea, and the northwest Atlantic. These resources, of special concern to the United States, have been subjected to ever-increasing fishing pressure since World War II, with a corresponding increase in the stress on the stocks fished as well as on the total biomass of associated living organisms.

The major part of this chapter describes the overfishing problems of a particular region of the ocean, in this case the northwest Atlantic, and the efforts of the United States to reduce by international action the fishing pressure on stocks in this area that are stressed or below optimum yields. In subsequent annual reports, other oceanic regions will be similarly examined.

OVERVIEW

The United States, as a party to 8 multilateral fisheries treaties and 12 bilateral agreements, has actively pursued its objective to conserve stocks of marine resources throughout the world.

Significant progress in international whale conservation was made at the 26th Session of the International Whaling Commission (IWC), June 24-28, 1974. Catch limits for fin and sei whales were reduced in both the North Pacific and the Antarctic and it was agreed that whale stocks would be managed by ocean areas rather than oceans as a whole. These lower catch limits and limits for smaller ocean areas will be in effect during the 1974/75 Antarctic season and the 1975 North Pacific season.

The increasing pressures on worldwide tuna stocks have been a major concern. In the eastern Pacific, the Inter-American Tropical Tuna Commission (IATTC) has continued its extensive research program, which resulted in management recommendations for the establishment of a catch quota beginning in 1966 for yellowfin tuna. So far, IATTC actions have been successful in maintaining the yellowfin

tuna resources of the eastern tropical Pacific at a relatively high level of abundance. The quota for 1974 was 175,000 short tons.

The International Commission for the Conservation of Atlantic Tunas (ICCAT) was formed in 1969. Although this commission has been primarily concerned with organization and administrative questions, it has embarked on a limited program of resource conservation. In 1972 the commission adopted a minimum landing size of 3.2 kg for yellowfin tuna. The United States has been particularly concerned with the apparent decline of Atlantic bluefin tuna stocks. At the next ICCAT meeting, the United States will raise the problem of possible overfishing with a view of a strong international conservation program.

In the meantime, the United States has worked informally with key Atlantic coastal States, commercial and recreational groups, and with Canada to begin a cooperative scientific study. The United States and Canada have further agreed to take all possible measures to limit the total annual catch for sale of Atlantic bluefin tuna by the two countries to a maximum of 2,500 short tons. The National Marine Fisheries Service, in cooperation with appropriate States, has instituted a voluntary management program in 1974 to limit the U.S. catch to 1,700 tons and to ensure that the size of bluefin tuna caught does not exceed 115 pounds in weight or is not less than 14 pounds in weight.

In the northeast Pacific Ocean and the eastern Bering Sea, it is difficult to pinpoint all the stocks being depleted because the buildup of foreign distant-water fleets in the past 10 years has sharply increased the fishing power that can be applied to any stock of fish. The potential for rapid reductions in abundance has increased proportionately in the absence of effective controls. This very point was raised recently by the United States in informing the Japanese, who are responsible for the major fishing effort in this area, that the accelerated growth of multinational fisheries has far outpaced our ability to produce timely evaluation of the total impact of exploitation on North Pacific resources. Nevertheless, stocks of fish off certain areas of the U.S. west coast which U.S. scientists believe to be overfished or approaching a status of overfishing include: (1) most major groundfish stocks and herring in the eastern Bering Sea (pollock, cod, shrimp, some flounders, black cod, and halibut); (2) Pacific ocean perch and halibut in the Gulf of Alaska; (3) hake and Pacific ocean perch off Oregon and Washington; and (4) California sardines and Pacific mackerel off California. In some circumstances, certain stocks may be down in an area of the northeastern Pacific or eastern Bering Sea due to factors not completely understood; e.g., environmental conditions rather than excessive fishing pressure.

The Northwest Fisheries Center of NOAA's National Marine Fisheries Service is responding to the overfishing situation in the northeast Pacific and the eastern Bering Sea. One of the most important problems is the collection of adequate data from distant-water fleets in the area. The Northwest Fisheries Center is routinely placing observers on foreign distant-water trawlers to obtain better estimates of their catches in directed fisheries and also of incidental catches. In addition, the Center is conducting routine surveys of the resources in these vast ocean regions to strengthen the sometimes incomplete statistics received from the distant-water fleets. The results of the surveys, combined with data taken by United States observers and the catch statistics received from the distant-water fleets, are being analyzed to clarify the effects of the distant-water fisheries and of environmental conditions on stocks of marine resources. The Center's assessment data on stocks in this area have helped to bring about some reduction in fishing effort.

At the 20th Annual Meeting of the International North Pacific Fisheries Commission (INPFC) in November 1973 and at the U.S.-Japan bilateral fisheries discussions, the United States called upon Japan to operate its 1974 salmon fishery with due concern for the Bristol Bay runs and urged that studies be undertaken to assess the proportion of western Alaskan chinook salmon vulnerable to Japan's high seas fishery. The working group to which the Commission assigned the task of recommending halibut conservation measures in the eastern Bering Sea could not reach agreement at the annual meeting, but laid the basis for agreement in early 1974 on conservation measures and the taking by Japan of certain domestic conservation measures, including provisions for seasonal and area closures on trawling in the eastern Bering Sea when juvenile halibut are especially vulnerable to capture. Agreement was reached at the annual meeting on the continuation of a U.S. observer program aboard Japanese trawlers to observe incidental catches of halibut and king and tanner crabs.

The national sections agreed in separate statements that all nations should exercise prudence in harvesting Pacific Ocean perch stocks in the northeastern Pacific. Canada noted that it would restrict development of the Canadian Pacific Ocean perch fishery in the Vancouver area. Japan announced that it would reduce its harvest of Pacific Ocean perch in the Vancouver area by nearly 50 percent of the 1972 level and would keep catches in the Columbia area to the 1969 level (nearly zero). Concerning crabs, Japan agreed to permit U.S. observers aboard its crab motherships. A U.S. proposal to expand the terms of reference of the Bering Sea Groundfish Subcommittee to cover all Bering Sea fishery resources was adopted by the INPFC.

NORTHWEST ATLANTIC--NEW ENGLAND FISHERIES

The continental shelf area off the northeastern United States is one of the Earth's richest ocean regions. Fish and shellfish in this area are a vital natural resource that has influenced the early development of our country. The early maritime industry of New England and of the Middle Atlantic States had its roots in fisheries. Salt cod was an early mainstay of the New England fisheries and the ports of Boston and Gloucester became the world's leading suppliers. Later, salt mackerel became important, as did fresh and frozen fillet products in recent years.

Recent History

Some 200 species of fish occur in the northwest Atlantic off the U.S. coast, about 36 of which are commercially important. Current fishing operations result in the harvest of all species to some degree. Some species, however, are discarded at sea for lack of markets.

While the northwest Atlantic has been fished by European fishermen since the 16th century, until the early 1960s it was fished primarily by fishermen from Canada and the United States who caught haddock, cod, whiting, and, in the inshore areas, Atlantic Ocean perch, several species of flounders, sea scallops, and sea herring (Maine sardines). The vessels were and still are mostly small trawlers, less than 300 gross tons. As with any coastal fishery, these vessels were developed to fish for short periods close to processing plants to which the fresh fish were delivered. Shortly after World War II, the distant-water fishing industry expanded and the number of stocks in the North Atlantic that have been fully exploited or overfished has increased. At first, fleets from the U.S.S.R., Spain, Poland, Federal Republic of Germany, German Democratic Republic, Japan, Bulgaria, Rumania, and other countries concentrated on cod and Atlantic Ocean perch in northern areas. In recent years they have also fished heavily off the New England coast.

Many vessels of these distant-water fishing fleets exceed 1,000 gross tons since they were designed to fish long distances from home port and to remain at sea for 6 to 9 months. The factory ships process the fish at sea into fish blocks, fillets, fish meal, and other assorted forms of processed seafood, depending on the home country's market.

The impact of this influx of fishing pressure can be demonstrated by harvest statistics which show that in 1963 470,000 metric tons of finfish and squid were harvested off New England

as compared to 1,161,000 metric tons in 1973. Such high harvests in recent years resulted in some stocks being overfished, that is, harvested to the point of reducing the population below the level which can produce the highest sustainable yield each year.

Initially, distant-water fleets off New England entered the herring and whiting fisheries in the Georges Bank area, fishing stocks which were larger and more concentrated, but in doing this a portion of all the other stocks of fish available to trawls were also taken. Some of these species were sought by other fishermen in directed fisheries, but their directed catch has been less than the incidental harvests. For example, 64 percent of the cod and 61 percent of the haddock catch are now taken in fisheries directed to other species (table 2).

Table 2.--Percentage of various species taken as incidental catch (bycatch) off the New England area in 1971*

Species caught	Percentage taken as bycatch
Cod	64
Haddock	61
Ocean perch (redfish)	39
Silver hake (whiting)	31
Flounders	31
Other groundfish	66
Other fish	86

*Source: ICNAF Redbook 1973, Part 1, Appendix I, Supp. Table 1.

The herring stock began to decrease sharply after initial heavy harvests by distant-water fleets from the two good year-classes of 1960 and 1961, and more and more fishing effort was applied to maintain high catches. This inhibited development of a coastal fishery for adult herring which could be economically more productive than the frozen herring produced by distant-water fisheries. Silver hake stocks also declined following this influx of heavy fishing.

However, declines in stocks were not only the result of efforts by distant-water fishermen for there were other examples of overfishing prior to those efforts. The sea scallop, fished solely by the United States and Canada, supported a fishery that developed rapidly during the 1960s, but soon began to show signs of overfishing. The average size decreased rapidly as older and larger individuals were caught; as a result many of the scallopers transferred their operations to groundfish and thereby put additional stress on other groundfish stocks.

Landings of Atlantic Ocean perch from the Gulf of Maine reached a peak of 60,000 tons in 1941 and then declined, after which the fishery moved farther north into waters off Canada. The yellowtail flounder fishery went through a period of increased catches into the late 1940s, but the stock and catch declined thereafter. Subsequent reduction in fishing effort allowed a recovery of the stock and the catch climbed again in the late 1960s to levels close to the maximum sustainable yield. However, because of the heavy directed fishing pressure and the incidental catch of yellowtail flounder, this species has again been severely depleted. Thus, in 1975, the directed fishery for yellowtail will be restricted to 20,000 tons in an attempt to build up the stocks to a level that will allow a sustainable yield of 34,000 tons.

The effects of overfishing can be graphically illustrated by a review of the haddock fishery. This valuable fish has long been sought by fishermen from Canada and the United States mainly to supply the fresh fish market. Because this species has been studied since the early 1900s, a considerable amount of data are available to document the impact of fishing and other factors.

Due to increased consumer demand in the late 1920s, fishing effort on haddock began to increase rapidly. Annual landings reached a peak of over 110,000 metric tons in 1929 (fig. 3), well in excess of the sustainable yield and due entirely from fishing pressure by the coastal fisheries, principally the United States. When the abundance of fish declined, fishing effort was reduced and the recovery of the stock occurred within a relatively short time. From 1935 to the early 1960s, the fishery produced annual catches close to the maximum sustainable yield of 50,000 metric tons. In 1965, a short-term diversion of effort by distant-water fleets from the herring and silver hake fisheries (because of the decline in abundance of those stocks) resulted in increased haddock catches of 150,000 metric tons in 1965 and 127,000 tons in 1966. Since the directed fishery for haddock was already

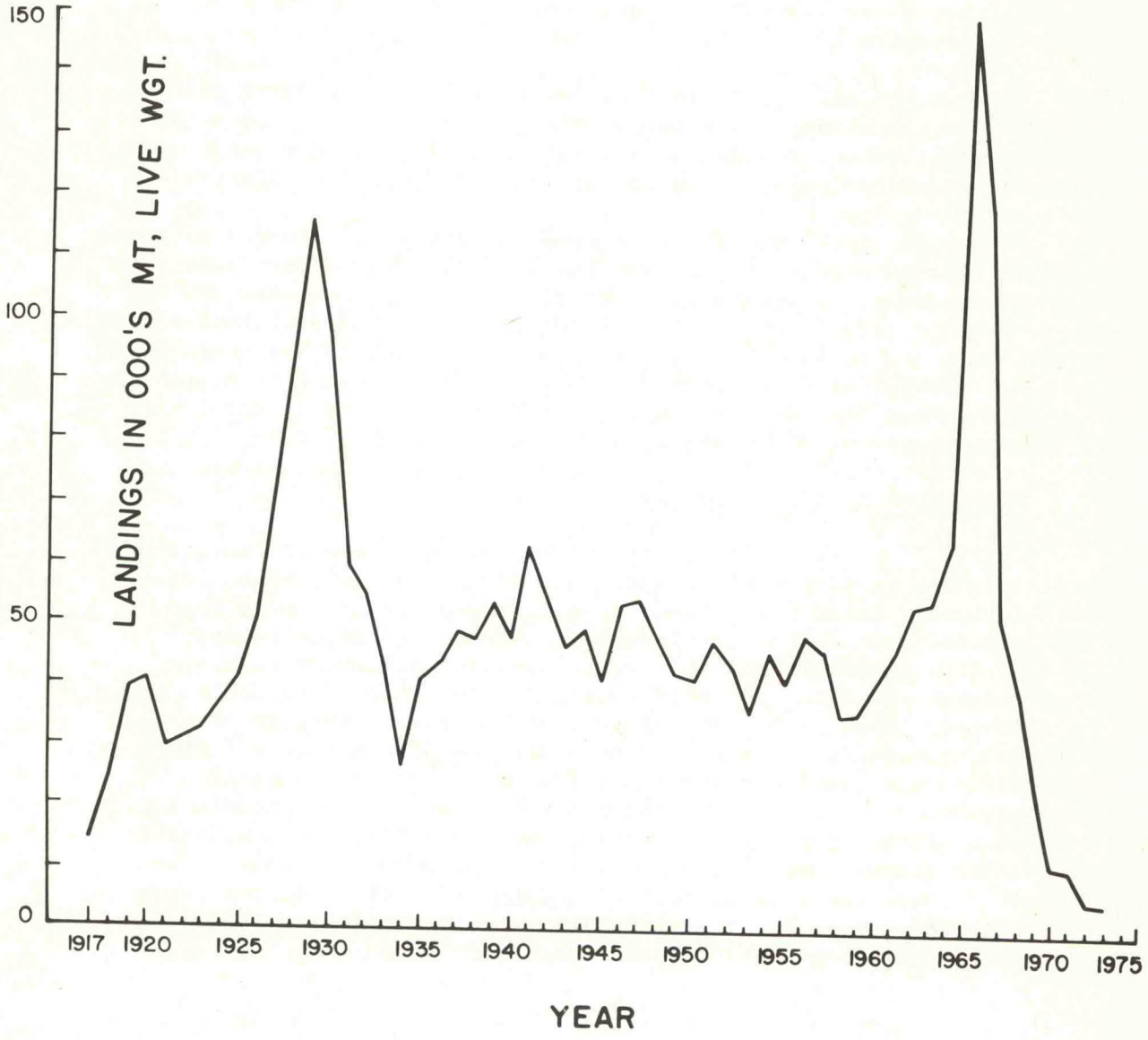


Figure 3.--Georges Bank haddock landings.

close to, or possibly exceeding, the maximum sustainable yield, these increased catches resulted in a drastic reduction in the haddock population, thereby creating serious economic problems for the directed fisheries for haddock. For example, the U.S. haddock fishery has declined from an average annual harvest of around 50,000 metric tons to a zero quota established in 1974 by the International Commission for the Northwest Atlantic Fisheries (ICNAF).

The reason for the zero quota is an attempt to bring the haddock stocks back to their maximum sustainable yield in the face of continued high incidental catches in other fisheries - which, in 1971, was about 7,300 metric tons, or 61 percent of the total haddock harvested in that year.

However, to attribute stock depletion only to excessive fishing effort is an over-simplification of the problem, since it does not take into consideration the effects of environment or the interactions with other species that may have either positive or negative effects.

For example, in 1963 there occurred a very high survival of young haddock because of factors not yet fully understood. When these fish became available to fishing gear in 1965, they attracted the distant-water trawl fleets which were suffering from a scarcity of herring and silver hake and looking for fish to meet their quota. There has been no major year-class produced since that time to provide the necessary recruits; thus, the haddock fishery continues to be in critical condition and in need of drastic conservation measures.

Management of the Resources

Concern for the health of the fisheries resources in the northwest Atlantic increased after World War II; and in 1949, 12 nations with fisheries interests in this area of the ocean agreed to form the International Commission for the Northwest Atlantic Fisheries (ICNAF) for the investigation, protection, and conservation of fisheries in the area, in order to maintain maximum sustainable catches from these fisheries. Regulatory proposals were to be based on scientific evidence. The Convention Area was established from West Greenland to southern New England (fig. 4). Initial regulatory measures to improve yields were based on the incorrect assumption that fishing effort would remain constant. Hence, the commission established minimum mesh sizes for nets catching cod and haddock. These regulations worked as long as stocks and areas were not fully harvested, a situation which ended in the early 1960s when the large distant-water trawl operations began.

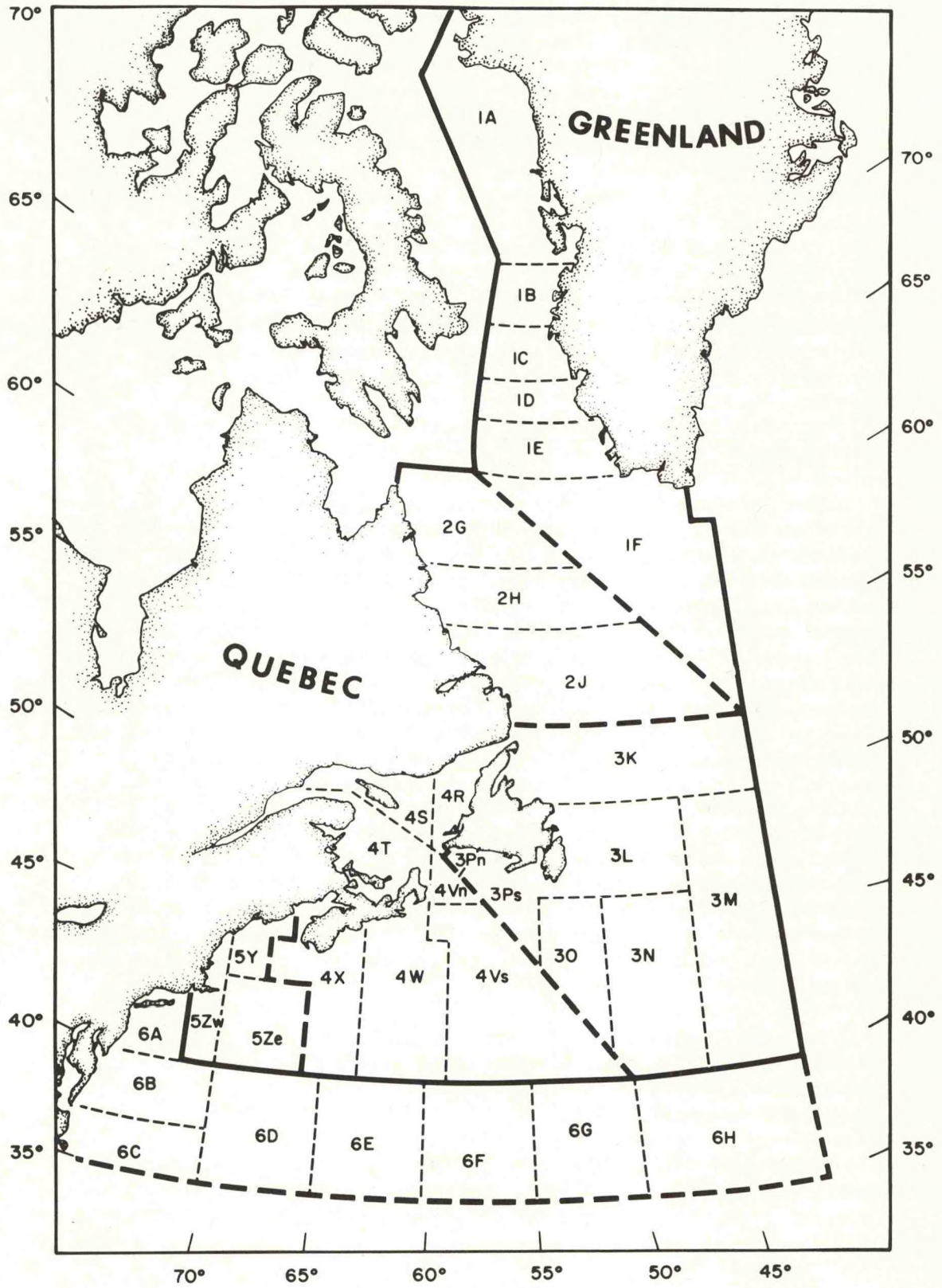


Figure 4.--ICNAF Statistical Area.

By the mid-1960s, it became evident that the conservation measures so far employed were not sufficient to control the ever-increasing effort. In addition, foreign fishing increased south of ICNAF Statistical Area 6, a region where the United States has no authority to regulate fishing activity. Consequently, bilateral negotiations were initiated with major fishing countries, first with the U.S.S.R. in 1967. These agreements established closed areas in the U.S. middle Atlantic region (not within the ICNAF Convention Area) for large fishing vessels in order to protect such resources as scup, fluke, butterfish, and hake while they are concentrated in deep water in the winter and before they move into shallow waters where they become available to the U.S. inshore commercial and sport fishing fleets. The benefits of existing bilateral agreements were lessened, however, by continuing new foreign entry into the fisheries.

The Role of Research in Preventing Overfishing in the Northwest Atlantic.

The Northeast Fisheries Center of NOAA's National Marine Fisheries Service has responded to these problems by changing its previous concentration on a few key species to conducting total biomass studies and seasonal synoptic MARMAP (Marine Resources Monitoring, Assessment, and Prediction) surveys encompassing the entire continental shelf area from Nova Scotia to Cape Hatteras (fig. 5). These surveys are being carried out in cooperation with other countries fishing in the area. Data on catch of all species, age and length samples, oceanographic observations, and plankton samples are routinely taken for several hundred stations during each cruise. Indices of abundance are estimated by analysis of the commercial catch and of the surveys for cod, haddock, flounder, whiting, etc. Special assessment studies are directed toward estimation of allowable removals from the stocks on a total biomass basis. This change in emphasis was designed to monitor the overall effects of increased fishing pressure and of the environment on the entire biomass, after it became evident by the mid-1960s that the conservation measures so far employed were not sufficient to control the ever-increasing fishing effort.

Bilateral agreements to substantially reduce fishing pressure, south of the ICNAF area, on stocks of special interest to recreational fishermen, such as scup and fluke, resulted from such survey and assessment data.

Through joint MARMAP surveys and analyses, the scientific committees of ICNAF have been striving to arrive at a common understanding with respect to standing stock and potential yield.

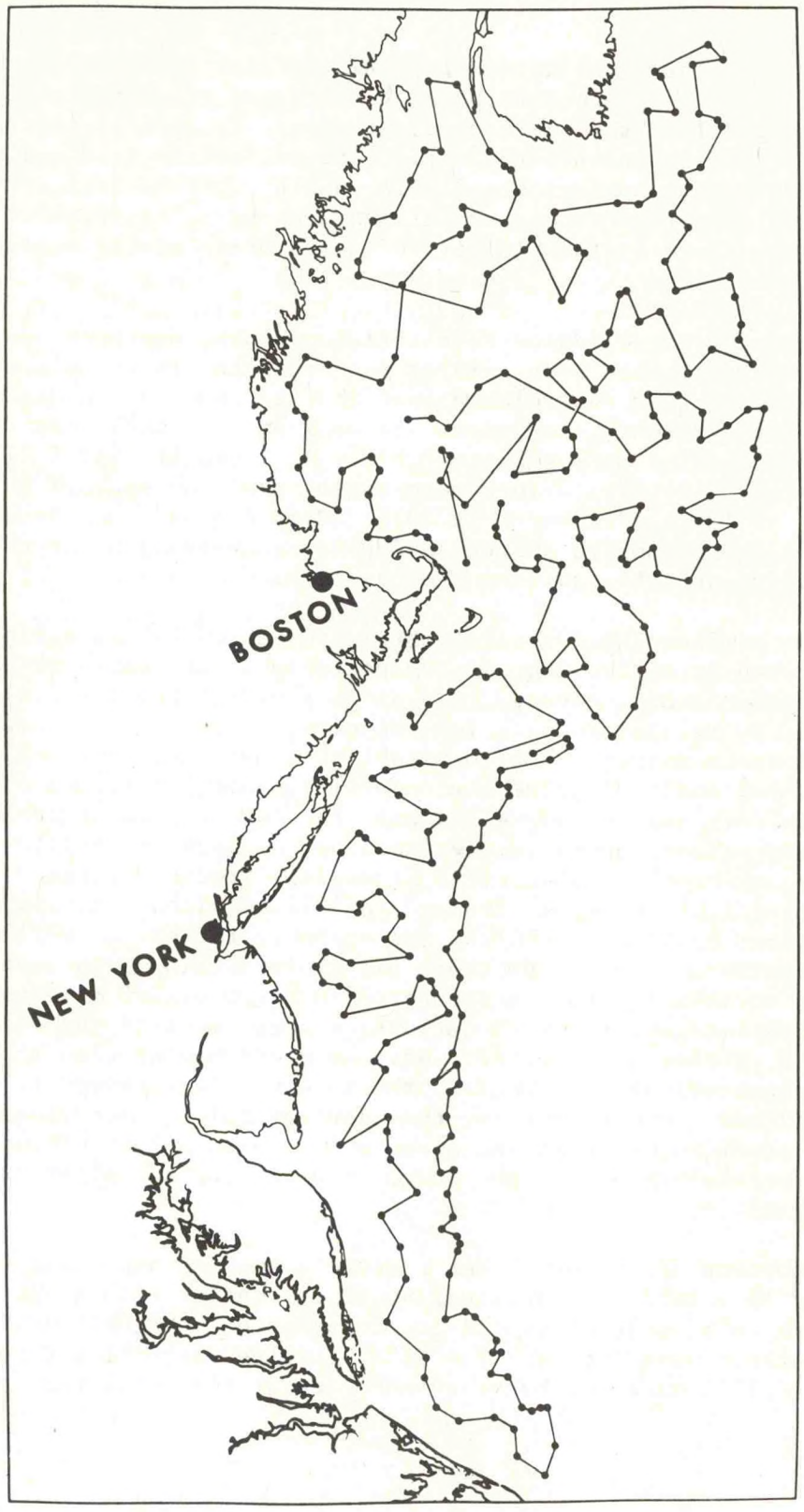


Figure 5.--Nova Scotia to Cape Hatteras continental shelf biomass studies and MARMAP surveys.

Such joint efforts are unique in international fisheries activities; they bring to the negotiations confidence and credibility in the data among all of the ICNAF commissioners. Success in this effort will continue to enhance the quality of scientific data and advice provided to the commission and will enable ICNAF to deal directly with problems of international allocation and policy without extensive debate on the validity of assessments of the status of the stocks.

This new consolidated scientific approach goes back only a few years but it has been a major factor in the recent successes of ICNAF to impose controls on overfishing. When stock depletion became more evident, the United States submitted more comprehensive conservation proposals to ICNAF. As a result, Total Allowable Catch (TAC) limitations were established for haddock in 1970 and for yellowtail flounder in 1971. Closed areas were established for certain seasons to protect offshore concentrations of red hake and whiting and the spawning grounds of haddock and cod.

The earlier ICNAF goal of obtaining maximum sustainable yield, established at a time when it was possible to increase the harvest, proved too narrow a concept. It did not permit regulations designed to regulate yields for the direct benefit of specific coastal state fisheries or to establish a national quota allocation system that would minimize the competition among national fleets. The TACs for haddock and yellowtail flounder had considerable utility, but their effectiveness was lessened by the lack of ability to control "bycatches" of these species in fisheries directed at other species. The protocol of ICNAF was changed in 1972 to allow establishment of regulations based on technical and economic factors as well as scientific considerations. This permitted, among other things, the establishment of national quotas, and ushered in a new era of international fisheries management. With national shares, much of the reluctance to limit catches disappeared. Nations could better plan their fishing operations. Meanwhile, the foreign fleets moved to the mackerel and squid resources, the last remaining underutilized resources of any significant size, and also to a host of smaller stocks heretofore not sought (e.g., dogfish sharks, argentines, goosefish).

Adoption of the new ICNAF protocols enabled a special Commission meeting to establish a national quota allocation within TACs in 1972 for three herring stocks in the areas off the United States and southern Nova Scotia. The TACs involved significant reductions over the 1971 catches; but they were set at the level necessary to

stabilize the stock size that would be reached by the end of 1972 and not low enough to permit recovery of stocks. A major principle of coastal state preference was tacitly accepted at this time. The United States and Canada were given quotas above previous catch levels to allow for development of coastal fisheries. Other countries accepted decreases. In June 1972, TACs and national quotas for 1973 were imposed on other species, establishing the principle of imposing preemptive quotas on stocks for which assessments were not adequate. These interim measures were designed to prevent overfishing and to control rates of fishery development until sufficient information is available to establish reliable quotas.

In the January 1973 special Commission meeting, the United States proposed a regulation limiting the total fishing effort in areas off its coast. This proposal included a 30-percent overall cut in fishing effort and was based on analyses by the NMFS Northeast Fisheries Center on fisheries catch and effort and survey data. The proposal failed to gain acceptance, as did an alternate proposal at a June 1973 meeting to reduce and limit the overall total catch of all species. At a special meeting in October 1973, an overall TAC was established, based on an analysis of the sustainable yield of the entire biomass, considering the effects of bycatch, and attempting to account for interrelationships among species; e.g., competition and predation. The overall TAC was set at 924,000 tons for 1974. This catch limit was designed to stop further declines in the resources. An overall TAC of 850,000 tons was established for 1975 to allow a further stabilization and potential for recovery of the resources. In June 1975, the 1976 overall TAC will be negotiated to set a level assuring recovery of the stocks. An additional step was taken in 1973 to limit large vessels from off-bottom trawling in certain areas. This was designed to minimize competition with the smaller coastal fleets and to reduce the bycatch on such species as haddock and yellowtail flounder.

While these developments have resulted from effective negotiations based on sound assessments of the status of the stocks, the length of time required to accomplish this has resulted in continued severe reductions in the stocks and adverse economic effects on the fisheries of all countries. Ways must be found to develop in a more timely manner adequate control measures to meet a given resource situation. Also, there is the related need to ensure that such control measures are actually implemented. Efforts along these lines have not progressed as far and as fast as development of the regulatory measures.

Problems of Fishery Management of a Total Fishery Resource Ecosystem

The increasing demand for full use of all fishery resources requires the continuing development of more refined regulations and control measures. One of the immediate needs is a solution of the incidental catch problem. Part of the answer lies with improving technology and selectivity of fishing gear and methods. It can be expected that after recovery, the resources of finfish and squid off New England will yield close to a million metric tons per year to be utilized in one form or another; e.g., for harvest by U.S. fleets or harvest by other fleets as an addition to the world food supply or for helping to supply the need for recreational outlets. Considerable effort is needed to improve fisheries statistics so that incidental catch can be fully considered in designing regulations and allocations. Management techniques should be refined to permit direct control of fishing effort. It is more effective to control fishing effort than to enforce quotas; therefore, the former is more suitable for achieving optimum yield. It is also critical that a better understanding be achieved of the interacting role of all species in the ecosystem and their relation to the environment.

Current Status of the Resources

The current condition of the stocks is a result of a decade of increasing fishing effort and catch. The total catch reached peaks of over 1,100,000 tons in 1972 and 1973. These catches were achieved by switching from one stock to another and expanding fisheries throughout the entire area. Fishing effort during the last decade increased by a factor of about six, exceeding by about 30 percent the effort estimated to maintain maximum sustainable yield. The reduction in the rate of increase of effort achieved by the regulations for 1974, and the further reductions in 1975 and beyond, can be expected to have only limited immediate effects on the stocks; it may take years for the stocks of many species to rebuild.

Currently, while the haddock stocks show a very minor improvement, they are still too low to allow more than incidental catches. It may take as long as 10 years for the haddock stock to recover fully and provide the optimum yield (about 10 times the present harvest). The yellowtail flounder, in some parts of its range, appears to be seriously depleted and will require extreme action to allow recovery. Herring are at similar low levels. Other stocks, in general, have declined by about 50 percent since the early 1960s. Of course, a decline of some magnitude inevitably would have occurred even with a controlled increase in fishing. The full effects of the recent regulations will not be seen until a few more years have passed; observations to date are sketchy. It does appear that overall

effective fishing effort has been reduced in 1974 and that decline in overall biomass should soon be significantly slowed, if not halted. It is anticipated that a yield level of 1 million metric tons can be achieved somewhere around 1980, provided that all member nations strictly adhere to regulations they have developed at recent ICNAF meetings.

CHAPTER IV

OFFSHORE DEVELOPMENT AND THE OCEAN ENVIRONMENT

New technology is making it possible to place large structures offshore and is increasing man's capability to remove minerals and fuels from the sea floor. Four major categories of offshore development are treated in this chapter: deepwater ports, nuclear powerplants, oil and gas structures, and ocean mining. The first three categories relate in some manner to the extraction, production, or transport of energy, and, as the Nation expands its search for additional sources of energy, each will involve the oceans to an increasing extent.

Large offshore structures and mining in both nearshore areas and in deep waters will change the local marine environment. The significance of these changes is now largely unknown. It is essential that both their immediate and long-range effects be understood and considered. The Federal and State governments, as well as the private sector, are responsible under various environmental protection laws, to assess and consider the potential environmental consequences of offshore development operations. This chapter describes some of the more significant research programs and activities carried out in this area during FY 1974.

OFFSHORE DEEPWATER TERMINALS

Economic and environmental factors underlie U.S. Government and industry studies to determine the need for construction of offshore, deepwater port facilities to accommodate large bulk oil carriers. The Maritime Administration and other public and private interests are intensively studying the need for these facilities, their environmental effects, their possible locations, their costs, their design and who should construct and pay for them. These issues surrounding deepwater ports involve many national priorities in addition to our domestic and foreign commerce and for this reason close coordination with all interested parties is essential in pursuing these study efforts.

The problem of accommodating supertankers in U.S. ports is accentuated by the fact that the 1,286 deep-draft ships of over 100,000 tons deadweight (DWT) in service, under construction, or on order throughout the world cannot enter U.S. ports. Of the 1,286 vessels, about 618 are now in service.

The economies of larger tanker and bulk carrier transportation have given rise to over 50 foreign port facilities that are either in operation, under construction, or planned and that have the capability to handle 200,000-ton bulk vessels and larger. The United States is the only major industrial nation that has no support facilities to handle these giant bulk carriers. Two existing port areas in the United States, Long Beach, Calif., and Puget Sound, Wash., are the only ones that can provide sufficient depth to accommodate vessels in the range of 120,000 to 250,000 DWT, but they still lack physical facilities.

Offshore Terminal Technology

As a result of studies by both industry and the Federal Government for the purpose of designing offshore terminals to receive crude oil from tankers of 200,000 DWT to 500,000 DWT, several types and configurations are being considered from an environmental and economic aspect. These include Single Point Mooring, Single Anchor Leg Mooring, Conventional Mooring Buoy, Single Pile Mooring Pier, Sea Island, and Artificial Island.

Single Point Mooring (SPM): These moorings, also called monobuoys, normally consist of a cylindrical buoy with its axis vertical and held in place with chains attached to anchors or to piles driven into the ocean floor. The primary characteristic of the SPM is that it is suitable for the open sea because the manner of mooring and oil transfer allows the ship to swing through 360 degrees and thereby to orient itself to minimize strain on the mooring lines in heavy weather. Oil transfer between the shore and ship is through the buoy by submarine line and flexible hoses.

SPMs are usually put far enough offshore and in deep enough water to obviate the need for dredging; however, if the buoy is too far from onshore storage/utilization facilities, it may be necessary to provide auxiliary pumps on a fixed platform near the buoy.

Units off the Atlantic and Gulf of Mexico would likely be in water 100 to 120 feet deep and, in most instances, would be 15 to 30 miles offshore.

The SPM system is now well developed and used throughout the world, with the exception of the United States. Since 1958 over 100 such systems have been installed and are operating. Seven of these installations, located in Japan, the Phillippines, Taiwan, and Vietnam, are owned by the U.S. armed forces.

Single Anchor Leg Mooring (SALM): This mooring system is a variation of the SPM system. The major difference is that the hose and swivel mechanism of the SALM system are on the seabed. The buoy floats on the water and is anchored to the bottom by a single chain. The octagonal steel doughnut base is filled with sand for ballast and anchored to the bottom by piles to prevent lateral movement. The onshore pipeline is connected to the base. The unloading hoses are connected to a fluid swivel assembly on top of the buoyancy chamber.

Resistance to damage by heavy seas and from ship action is a favorable characteristic of the SALM. Most of the system's principal elements are on the sea floor, and the tanker-to-mooring hoses can be lowered to the sea floor so that they are below the influence of waves. The mooring buoy is the only element of the system exposed at the surface.

The SALM system has been installed at two locations in depths of 85 and 140 feet. It can be designed for mooring tankers over 500,000 DWT. Mooring and berthing limitations of the SALM are similar to the SPM.

Conventional Mooring Buoy: The conventional mooring buoy uses multibuoy moorings to maintain the tanker in a given position and orientation, thereby avoiding the need for a 4,000-foot radius as required for SPMs. Because of this fixed orientation, sites are limited to where prevailing winds are longitudinal to the berth; or at least where strong winds are not expected broadside to the berth. Once the tanker is in place, crude oil is pumped through flexible hoses connected to a submarine pipeline leading onshore.

CMBs usually cannot be tended when waves greater than 4 feet approach the berth at a small angle off the bow or stern of the tanker. If the vessel is moored directly into the predominant direction of the waves, the berth may be tended when waves are more than 10 feet. Because mooring operations require the use of a launch and launch operations are generally precluded in 6- to 8-foot seas, berthing must be halted during rough seas. Although many of these berths have been in operation for years in all parts of the world, industry generally considers the 100,000 DWT tanker the maximum size for multibuoy moorings.

Single Pile Mooring Pier (SPMP): The single pile mooring pier consists of a pylon or tower fixed to the sea floor on which is mounted a long semi-submersible floating structure, supported by a swivel at the top of the tower at one end, and by a floating tower at the other. The tanker is moored at the bow, permitting it to feather into the wind, sea, and current to assume a line of least resistance. The oil moves from the vessel through a short hose connected to the semisubmersible floating structure into the submarine pipeline. The SPMP is about two to five times more expensive to install than a monobuoy. Also, the loading arm is vulnerable to certain sea conditions and to collision damage. On the other hand, it has a much higher capacity than the monobuoy. Single pile moorings also tend to eliminate the major disadvantages of monobuoys by replacing the more vulnerable flexible elements with solid or truss structures.

Sea Island: The sea island is a platform-type structure that can be permanently attached to pilings. Some platforms have berthing on one side only, but the sea island platform allows berthing on both sides. Submarine pipelines connect the platforms and the storage tanks onshore. The system can include a breakwater and ancillary platforms to support storage tanks, pumping equipment, or dock space for the offshore supply vessels.

The sea island keeps the ship restrained in position and orientation. It is suitable where the prevailing wind is parallel to the berth, or at least where strong winds are seldom broadside to the berth.

Operationally, this facility is generally preferred for oil transfer from large tankers. It permits the installation of several all-metal flexible, loading arms, through which oil can be transferred at high rates. Bunkering can be easily provided. Surveillance of the actual oil transfer can be carried out by trained personnel who otherwise would have to be aboard the tanker.

The sea island requires an area that is more sheltered from waves than SPMs. Because tugs are used to berth tankers safely at a sea island, any waves that preclude tug operations will prevent the berthing.

Artificial Island: This system is probably the most expensive type of deepwater port; however, such a facility has unlimited versatility. The island would be constructed by placing a rock-fill dike around the perimeter of the facility. Fill would then be pumped within the dike, to settle out and form the island. Simultaneous with the placement of the fill, a stone revetment would be built around the outside perimeter of the dike. The revetment would be reinforced with precast concrete units of required mass to remain stable during severe weather and seas. The size of the island would be determined for the types and amounts of material to be shipped through the facility. Attached to the island would be a marginal pier-type mooring structure on all four sides to handle the actual berthing of the ships. The island could be used for the unloading, storage, and transshipment of both liquids and solids.

Transshipment from an artificial island complex to mainland storage, processing, or distribution facilities can be made by smaller vessels, tug-barge systems, or pipelines.

Environmental Effects

Several Federal agencies have conducted or sponsored studies on the impact of deepwater ports. These studies were described in last year's report. The major study on the impact of deepwater ports on the marine environment was prepared in 1973 for the Council on Environmental Quality by the Office of Sea Grant of NOAA. Three Atlantic coast and two Gulf of Mexico sites were studied by five educational institutions under the Sea Grant program. The major study of potential onshore impact associated with deepwater ports was conducted for CEQ by Arthur D. Little, Inc. This study examined the economic and onshore environmental effects of deepwater ports on the same five coastal areas considered in the NOAA report.

These studies and earlier ones prepared for the Corps of Engineers and the Maritime Administration provided valuable guidance in the consideration of deepwater port legislation. The then Chairman of the Council on Environmental Quality, in his testimony before joint Senate committee hearings in July 1973, suggested that the environmental effects of deepwater port development can be divided into two broad categories: the primary effects of the construction of the port and of oil spill once the port becomes operational, and the secondary effects of industrialization and development on the shore which would be induced by the location of a deepwater port.

The primary effects are in large measure related to the type of deepwater port facility and its location with respect to critical coastal environmental features. For example, a single point mooring (SPM) facility will require far less disruption of seabed than an artificial sea island. Also, the impact of oil spills or construction will vary according to the relative ecological vulnerability of any specific port location.

With regard to onshore secondary effects, the Arthur D. Little study produced the following interim findings:

- Vulnerability to environmental damage is greatest at inshore sites, less at offshore sites, and least at far offshore sites.

- Major spills would have critical effects at inshore and offshore sites--potentially less critical at far offshore sites.

- Chronic, low-level oil spills may have critical effects at inshore sites--they are less likely to be damaging at offshore and far offshore sites.

- Impacts of operations (excluding oil spills) and terminal maintenance are important, but not critical at inshore sites--they are insignificant at offshore and far offshore sites.

According to a Coast Guard statistical projection prepared for CEQ, at an import level of 2 million barrels per day, spillage from tankers of 50,000 DWT size, using conventional port terminals, would be 10 times greater than from tankers of 250,000 DWT size, using deepwater ports. This difference is primarily the result of the reduction in the number of tankers required, fewer unloading cycles, new technology at deepwater terminals, and the transfer of oil by pipeline.

More studies are required to test the CEQ findings and their applicability to specific regions. It is necessary, further, to consider how environmentally sensitive areas react to the cumulative effects of hydrocarbons that are present because of chronic releases from transport of oil, barge traffic, and pipeline leakage. It is possible that efficient safeguards can keep spillage from deepwater port operations to a minimum; however, it is essential that our national programs and studies carefully examine potentially adverse effects under all conditions, including large accidental spills. Furthermore, ecological relationships in likely deepwater port areas must be understood, baseline conditions determined, and predictive models constructed. In this regard, the Maritime Administration, NOAA, and other Federal agencies are supporting programs that involve the determination of the fate and effects of oil discharges during offshore terminal operations. NOAA's work in the New York Bight area and information from studies in Puget Sound and Prince William Sound, as well as the Corps of Engineers study on dredge spoil disposal and its environmental effects, will provide an important data and information base for the assessment of the impacts of superport construction and operation on the marine environment. These assessments will be essential for future decisions on site locations, environmental safeguards, and monitoring requirements.

The Congress has been considering deepwater port legislation for the past few years. Both the House of Representatives and the Senate held extensive hearings on the subject during the period 1972-74. In 1974 each house approved a deepwater port bill. The differences between the two measures were worked out in joint conference during the closing days of the

93d Congress, and the President signed the compromise version on January 4, 1975. The Deepwater Port Act of 1974 authorizes the construction and operation of deepwater ports in U.S. coastal waters. The legislation will be administered by the Department of Transportation (Coast Guard). This important new law will be discussed in detail in next year's report to the Congress.

OFFSHORE NUCLEAR POWERPLANTS

It is projected that, as electrical power consumption grows, nuclear powerplants will be an increasingly important source of electricity. Some estimates indicate that by the turn of the century the electrical energy generated by nuclear powerplants will increase from the present 4 percent to over half of the total electrical energy produced in this country. This growth translates itself into a few hundred additional powerplants, 30 percent of which would service the eastern seaboard.26/

Many nuclear powerplant facilities have been built near or on the coast where water is readily available for cooling condensers. How such coastal operations affect the environment has been uppermost in the minds of many people. The construction of offshore powerplants appears to have many advantages: they can be mass-produced and towed to specific sites, these sites can be closer to areas of high demand, and proponents believe offshore facilities to be less controversial than land-based ones.

One design concept being considered for floating nuclear powerplants, and under review by the Atomic Energy Commission, consists of a barge-mounted nuclear facility fully assembled and tested at a shipyard, and then towed to a permanent offshore coastal site for installation in a basin enclosed by a massive breakwater. Should it be approved, the offshore plant would take advantage of the great heat assimilation capacity of the ocean as condenser cooling water. Offshore siting in this manner could, in some instances, provide an acceptable alternative to a powerplant near an estuary or a coastal marsh, which are highly productive but fragile ecosystems.

The offshore concept does have a number of potential advantages and opens up large areas of the ocean's surface for plant sites, but it also has a number of inherent environmental problems. In general, these problems can be divided into those associated with the construction of the protective breakwater and with actual operation of the plant. These issues have stimulated a number of conferences and reports concerning offshore nuclear power siting, including the AEC-sponsored workshop Offshore Nuclear Power Siting (1973)27/ and the AEC report A Survey of Unique Technical Features of the Floating Nuclear Power Plant Concept (1974).28/

These and other problems are discussed in detail in a report submitted to the AEC in May 1973 by Offshore Power Systems, an unincorporated joint venture of Westinghouse Electric Corporation and Tenneco Inc., to support an application for construction of a manufacturing facility for floating

nuclear powerplants.29/ A second comprehensive study of the environmental issues involved is a CEQ report, now in preparation, that includes contributions from NOAA, AEC, Federal Power Commission, EPA, Corps of Engineers, the Department of the Interior, and others. The CEQ report sets forth the environmental, legal, economic, and social issues associated with the offshore powerplant concept. It is currently in the final review process and will be discussed in detail in next year's report.

Construction of the breakwater required to protect the powerplant requires very large quantities of rock and stone. It also involves a significant commitment of seabed area. The breakwater would eliminate an area equivalent to 1/4 square mile of ocean bottom. The dredging necessary to bury the powerlines that extend to shore will, at least temporarily, disrupt the bottom with a 960-foot right-of-way for as much as 3 miles. Dredging and other construction related to powerplant construction could severely disrupt bottom sediments and adversely affect local communities of plants and animals. The large protective breakwater could affect current patterns and fish migration routes in nearshore areas. The breakwater will become an artificial reef and furnish habitat for those organisms that prefer reefs. Whether this beneficial aspect would lead to increased productivity would depend on how the organisms are affected by potential pollutants discharged from the normal operation of the plant.

The operation of floating nuclear powerplants probably will affect primarily the biota of the nearshore environment by impinging and entraining organisms and discharging heat and chemicals. Organisms are impinged when they can no longer swim against the intake current and usually die. They eventually are washed off the screen, along with other accumulated debris. Juvenile schooling fish are particularly susceptible to impingement, and mortality rates depend on intake flow velocities and position and design of intake structures. Organisms small enough to pass through intake screens will be entrained within the condenser system of the plant and subjected to a combination of rapid pressure differentials, thermal changes, biocides, and harmful discharge products.

Several Federal agencies have participated in the development and review of comprehensive reports, such as those being generated by CEQ and AEC, on the overall effects of offshore powerplant siting. Offshore powerplant development was also considered during the conference on "The Coastal Imperative: Developing a National Perspective for Coastal Decision Making," which NOAA sponsored at Charleston, S.C., in 1974.30/

Ongoing research will continue to supply baseline data on physical and ecological processes in selected coastal marine environments. To these will be added the evaluation of how construction, operation, possible accidents, and decommissioning of offshore powerplants affect marine ecosystems.

Additional research is necessary that will give information on the major problem areas associated with these powerplants. Some of the ongoing and proposed research include (1) the separate and combined effects of heat, chlorine, gas supersaturation, radionuclides, and trace elements on

individual marine organisms as well as on total communities; (2) larval transport and distribution patterns in nearshore areas; (3) current patterns in nearshore areas that are likely to be considered as powerplant sites; and (4) sediment characteristics and transport of surficial sediments in these same areas.

It is highly important to be able to predict beforehand the possible environmental consequences of these powerplants so as to be able to take prompt remedial action when necessary. Hence, it is vital that sufficient environmental information and data exist.

An important element in the choice of potential powerplant sites in the offshore environment will be the ability to predict environmental effects of their construction and operation. It will be necessary to develop regional environmental assessment studies to gage these impacts and establish prediction mechanisms. An obvious concern to the concept is weather-related hazards. Beyond this, however, offshore sites must be selected as much for their environmental suitability as their economic and technical considerations.

OCEAN MINING

Deep Ocean Mining

The only known hard minerals of potential economic importance on the deep ocean floors beyond the continental shelf are nodules and crusts of manganese. Although these nodules and crusts occur infrequently in some freshwater lakes and more often in some shelf areas, the highest quality and amount of these materials found to date are in the North Pacific Ocean at depths of 5,000 to 6,000 meters. These seafloor nodules have been known since at least 1875, when they were found at many stations during the *Challenger* Expedition. Since then, researchers have reported their widespread occurrence and abundance in the world oceans. Crusts of manganese were found on the Mid-Atlantic Ridge in 1973 by NOAA's research vessel *Discoverer*.

Five U.S. firms are actively developing equipment to mine nodules, and the metallurgical processing of the nodules is no longer a serious problem. Two U.S. companies have been operating pilot refining plants for several years. Industry spokesmen have stated that it may be technologically possible and economically practicable to begin mining as early as 1978; however, complex international legal problems may delay the actual start of commercial mining. Four of the five U.S. companies are reported to have foreign partners.

Manganese nodules contain commercially significant quantities of manganese, copper, nickel, and cobalt and the total estimated recoverable quantities of these materials represents a significant portion of known world resources. While the development of a viable U.S. deepsea mining industry would provide increased security of supply for these minerals, the principal benefits are economic.

A necessary step in developing a deepsea mining industry is a thorough evaluation of the effects of this activity on the marine environment. At the present time information on the immediate and long-term effects of manganese nodule recovery operations on open ocean ecosystems is limited. In addition, it is likely that in the near future either an international treaty governing the removal of minerals from the seabed will be negotiated in the Law of the Sea Conference or domestic legislation will be considered to govern the orderly development of deepsea mining by U.S. companies operating under the U.S. flag. In order to provide an adequate information base for developing the environmental impact statements required to pursue either alternative, the Deep Ocean Mining Environmental Study (DOMES) was initiated in 1974 with a survey cruise to the southeast central Pacific to gather baseline data. The overall objectives of DOMES, which will require approximately three years to complete, are as follows:

(a) Establishment of physical, chemical, biological, and geological baseline environmental conditions in potential mining areas;

(b) Documentation of changes induced in benthic and pelagic ecosystems by deepsea mining;

(c) Determination of the properties that should be monitored during deepsea mining to provide the information needed to evaluate the environmental impact of specific mining methods and to devise mitigating measures, if necessary; and

(d) Formulation of guidelines for future mining operations that will minimize environmental effects.

Present plans call for continuation of this deep ocean work in 1975.

Continental Shelf Mining

Because of the decreasing availability of economically suitable land deposits of sand and gravel, offshore deposits are an attractive potential for ocean mining on the U.S. continental shelf. There are now three areas of active interest: off New England, New York/New Jersey, and Southern California. Technology is available, and the economic aspects appear promising. In addition to sand and gravel, the offshore mining of phosphorite is becoming more attractive. Recent escalation of costs of transportation and production of phosphate rock mined on land has encouraged active interest in the recovery of this marine mineral. A significant barrier to development of large-scale commercial mining operations in offshore areas, however, has been uncertainty over the possible deleterious environmental side effects. The result has been actual and de facto moratoria on commercial mining at the Federal and State levels. This general situation continues; however, draft rules and regulations for the mining of hard minerals on the continental shelf have been proposed by the Department of the Interior and commercial mining offshore could begin within a few years.

Development of offshore mining of sand and gravel will require assessment of the environmental effects of such an activity. Destruction of

various species and removal of plant materials may affect significantly the marine ecosystem in the immediate area of the dredge site. Also, the effects of the turbidity plume on marine organisms are largely unknown and can be predicted only in a general way at present. Abnormally high levels of suspended materials can reduce both the rate of oxygen transfer across gill tissues and tissue glycogen (carbohydrate storage) levels. Moreover, mining of sand and gravel will cause cratering of the sea floor, thereby altering the character of the bottom habitat.

Although there is currently no commercial marine sand and gravel industry in this country, the experience gained in other countries which do engage in nearshore mining may be of benefit to the United States. For example, the marine sand and gravel industry of the United Kingdom is the largest and most advanced offshore mining operation of this type in the world. Environmental problems and restraints associated with commercial dredging of sand and gravel off the coast of the United Kingdom relate primarily to fisheries ecology, coastal erosion, and navigation. The major objections appear to be based largely on fears created by a lack of knowledge rather than on any scientific facts. Certain fishery impacts, coastal erosion problems, and navigational interferences are known to exist, but in the absence of adequate baseline data and related monitoring programs, it is not possible to determine which problems are due to natural causes and which have been caused by offshore mining. The lack of environmental monitoring in the United Kingdom highlights the need for consideration of a baseline and monitoring program in the United States in areas of potential offshore mining.

With the termination in 1973 of Project NOMES (New England Offshore Mining Environmental Study), as reported in last year's report to the Congress, there is now no ongoing Federal research program designed to assess the environmental effects of sand and gravel mining on the continental shelf. However, the Corps of Engineers' Dredged Material Research Program (1971-78), which is a comprehensive study of the problem of dredge spoil disposal, may produce data and information on environmental effects that would be applicable to commercial offshore mining. A research effort specifically addressed to the effects of offshore mining of sand and gravel may become necessary if commercial interest continues to grow. Environmental baseline data for proposed mining areas will be required as well as a program for monitoring of the actual mining.

OFFSHORE OIL AND GAS DEVELOPMENT

The Energy Situation in Brief

Energy consumption in the United States has increased from 33 quadrillion Btu's to 73 quadrillion Btu's in the past 25 years, with the rate of increase greatly accelerated from 1966 onward. Among the reasons for this phenomenal growth are population and industrial growth, the continued trend toward capital-intensive production processes, higher personal incomes, and, until recently, low-cost energy. The overall growth in energy demand throughout the world since 1947 is due generally to these same factors.

Except for large reserves of coal, the oil and gas resources under the U.S. continental shelf constitute the most important readily extractable source of new energy supplies needed to meet the Nation's requirements in the near term. Our objective is to realize an energy advantage by using our continental shelf resources in a manner that will eliminate or minimize chances of environmental damage.

The first offshore platform was erected off Santa Barbara in 1897. In 1947--50 years later--the first platform out of sight of land began operation off Louisiana. Since then the industry has grown dramatically and has advanced into deeper and deeper waters. Today, about 6,500 producing wells are in outer continental shelf waters. Technology has advanced to where wells can now be drilled in water depths from 1,200 to 1,500 feet, and some exploratory wells have been drilled in over 2,000 feet of water.

Federal supervision, until recently, was focused on volume of oil and gas production and lease sales. This changed rapidly beginning with the blowout of an offshore well near Santa Barbara in 1969, and since then a series of regulations have been developed and enforced. However, environmental concern has continued to be expressed not only over spills and oil washing up on the beaches, but also on the secondary effects of offshore oil and gas operations on the adjacent shoreline. The public is concerned about the associated tank farms, sea-to-shore pipelines, refineries, and other structures that will have economic and social implications for the shore communities. These matters are the subject of State planning efforts pursuant to the Coastal Zone Management Act of 1972.

The basic problem, therefore, is how to develop our offshore oil and gas resources, and do so in a manner that fully takes into account the potential risks of damage to the marine and coastal environments.

CEQ Oil and Gas Study

CEQ issued a report, OCS Oil and Gas - An Environmental Assessment, in April 1974.31/ The report is a comprehensive analysis of the environmental vulnerabilities of the Atlantic Outer Continental Shelf and the Gulf of Alaska to offshore drilling. It examines the technology involved, the offshore and onshore effects, and the institutional and legal mechanisms for managing OCS development. The report is timely in view of the planned accelerated leasing of acreage on the continental shelves by the Bureau of Land Management. Equally important, the study underscores the importance of environmental baseline information as the first step in preventing adverse impact in offshore areas and shoreside communities.

The CEQ study develops a set of principles to guide governmental decisions in choosing OCS areas to lease and in administering environmentally safe offshore operations. These principles are:

- "Exploration and development of the OCS must take place under a policy which puts very high priority on environmental protection.

- o "The location and phasing of OCS leasing should be designed to achieve the energy supply objectives of the leasing program at minimum environmental risk.

- o "The best commercially available technology must be used to minimize environmental risks in new OCS areas.

- o "Regulatory authorities available to Federal agencies must be fully implemented and requirements strictly enforced to minimize environmental risks in new OCS areas.

- o "Planning at all phases of OCS oil and gas operations must respect the dynamic relationship between initial Federal leasing decisions and subsequent State and local community action. The States and the communities affected must be given complete information as early as possible so that planning can precede and channel the inevitable development pressures. Experience must be continuously integrated into the management process.

- o "The interested public must be given the opportunity to participate and play a major advisory role in the Federal management and regulation of the OCS."

These principles, the report states, "if applied consistently by responsible government and industry decision makers at all stages of the development of new OCS areas for oil and gas, will provide the basis for policies and progress, that can significantly reduce risk to every element of the environment."32/

The study also recommends procedures and techniques for the safe extraction of OCS oil and gas. In addition, it provides a relative environmental risk analysis of major potential OCS geographic areas. According to the report, the southern Baltimore Canyon and the eastern Georges Bank off New England are low-risk areas, and portions of the Gulf of Alaska are relatively high-risk areas.

There is a national need for preparing to utilize our OCS resources. But there has also been unanimous and purposeful agreement among the Federal agencies, particularly between the Bureau of Land Management and NOAA, in the importance of obtaining offshore environmental data before oil and gas exploration. Programs are underway, described later in this section, to obtain this information. Only through careful planning beforehand can we assess the potential environmental impacts and consider risks and ways to minimize them effectively.

Environmental Studies Program

With the proposed accelerated development of offshore areas for oil and gas, a public concern has developed over the impact that offshore exploration and production activities may have upon the coastal environments of these regions. This concern has been recognized by BLM, which has

incorporated into proposed OCS planning documents provisions for the support of environmental studies in the regions where leasing is anticipated.

The objectives of the BLM Outer Continental Shelf Environmental Studies Program are to:

- Provide information about the OCS environment that will enable the Department of the Interior and BLM to make sound management decisions on the development of mineral resources.
- Provide a basis for predicting how oil and gas exploration and development will affect the marine environment.
- Provide data that may result in modification of leasing regulations, operating regulations, or operating orders.
- Establish a basis for predicting the impact of oil and gas activities in frontier areas.

The program of studies to be followed to meet the objectives described above involves: 1) the establishment of environmental baselines in selected OCS regions before oil/gas exploration, 2) monitoring the environment during oil and gas exploration and production to detect changes, and 3) special studies to provide the information needed to understand and predict the impact of development activities.

The BLM OCS Environmental Studies Program has four phases. These are:

Phase I - Summarize OCS environmental information available from previous studies made for other purposes. This information summary will: 1) assist in the identification of gaps in environmental information, 2) provide a basis for study program design, and 3) provide information for the development of an environmental impact statement (EIS).

Phase II - The purpose of this phase is the acquisition of environmental baseline data and information, including a comprehensive data base for establishment of predevelopment OCS conditions and prediction of potential environmental impacts.

Phase III - The emphasis of the studies during phase III is on special supporting studies. These will emphasize the processes, dynamics, and causal relationships to understand and enable prediction of environmental effects. Typical studies include determination of hydrocarbon toxicity on the biota, oil spill trajectories, food chain effects of selected pollutants, socio-economic impacts of offshore development, and studies and identification of unique environments.

Phase IV - The purpose of this phase is monitoring the effects of oil/gas operations, including, for example, such actions as the discharge of drilling muds, disposal of drill cuttings, chronic leakage of petroleum, discharge of other products from platforms and work boats, and platform

placement. Data gathered are compared with information from the three previous phases in order to determine the effects of explorations as well as operations.

Agency Roles

The conduct of environmental assessment studies related to OCS oil and gas development requires the coordinated efforts of many Federal, State, and private agencies. It is only through such coordination of effort that the expertise can be assembled for an adequate environmental assessment in each region.

The primary Federal agencies involved in these studies are: the Bureau of Land Management, U.S. Geological Survey, and Fish and Wildlife Service of the Department of the Interior; and the National Oceanic and Atmospheric Administration of the Department of Commerce. An abbreviated description of each agency's role in the development of OCS oil and gas resources follows:

o The Bureau of Land Management is responsible for the leasing objectives of the Outer Continental Shelf Lands Act of 1953, as amended. Activities include planning and preparing for leasing, making lease sales, collecting bonus revenues, and administering the leases. The Bureau of Land Management performs its leasing functions within the purview of three departmental leasing and management goals: (1) orderly and timely resource development, (2) protection of the environment, and (3) receipt of fair market value for the mineral resources. Implementation of OCS leasing objectives by BLM includes the preparation of Environmental Impact Statements in conformance with the National Environmental Policy Act of 1969, oversight of OCS environmental studies, and pre- and postsale analyses to ensure receipt of fair market value.

o The U.S. Geological Survey has responsibility for appraising geologic conditions and associated resources of the national domain, for classifying the energy and mineral resource potential of Federal OCS lands, in accordance with the USGS Organic Act of 1879 and the Outer Continental Shelf Lands Act of 1953. Activities include basic geologic investigations and mapping, general and detailed assessments of oil, gas, and mineral resource potentials; supervision of mineral exploration, development and exploitation; and collection of rentals, royalties, and related revenues. Emphasis is on the geologic environment and the conservation of associated resources in support of the leasing program to assure safe and efficient operations.

o The National Oceanic and Atmospheric Administration contributes to the development of oil and gas resources of the OCS by conducting marine environmental assessments with (1) field investigations of proposed lease areas, (2) laboratory studies of the effects of hydrocarbons on living marine organisms, (3) assistance in the preparation of Environmental Impact Statements, and (4) review and comment on completed environmental impact studies of other agencies. The field and laboratory studies contribute oceanographic

and biological information to decisions involving OCS oil and gas development. The various components of NOAA, together with its Sea Grant program, provide a broad range of expertise needed for carrying out marine assessment studies, particularly for research on the dynamics of sediment transport and in physical, chemical and biological oceanography. NOAA also produces bathymetric maps for use in planning environmental study programs and making environmental decisions, and its Environmental Data Service stores and makes available to all investigators data pertaining to the OCS. The Special Energy Research and Development Act of 1975, passed in June 1974, further provided for the reactivation of three NOAA vessels " . . . for the purpose of conducting surveys, investigations, and research connected with the environmental effects of offshore energy-related activities". These vessels will become operational in FY 1975.

o The Fish and Wildlife Service participates in the development of OCS energy-related activities by planning and executing biological programs to assess the impact of offshore oil and gas development on fish and wildlife resources and coastal ecosystems. Specifically, areas subject to OCS oil and gas exploration, production, and transport are studied to obtain information on potential environmental impact on fish and wildlife resources in order to provide guidance in the operation of the leasing program. Particular attention is directed toward aquatic birds and mammals, endangered species, and coastal ecosystems--beaches, estuaries, and marshes. Under a November 1972 Memorandum of Understanding between the Bureau of Land Management, the U.S. Geological Survey, and the Fish and Wildlife Service, and pursuant to a number of legislative authorities, the Service develops resources reports on OCS areas under consideration for leasing; participates in tract selection; provides input to and comment on environmental impact statements; participates in development of special lease stipulations; and reviews and comments on exploratory and development plans and placement of platforms, pipelines, and other structures. In FY 1974 the Fish and Wildlife Service was engaged in planning for participation in the accelerated OCS leasing program. The Service studies of coastal environments will contribute to the resolution of similar issues associated with proposed deepwater ports and offshore nuclear powerplants.

Current Environmental Assessment Studies

The outer continental shelf areas that are now under consideration for leasing and that either are now or may in the future be included in the BLM Environmental Studies Program are shown on figure 6. By the end of FY 1974 environmental assessment studies had been initiated in two areas: along the Mississippi, Alabama, and Florida (MAFLA) shelf and in the northeast Gulf of Alaska.

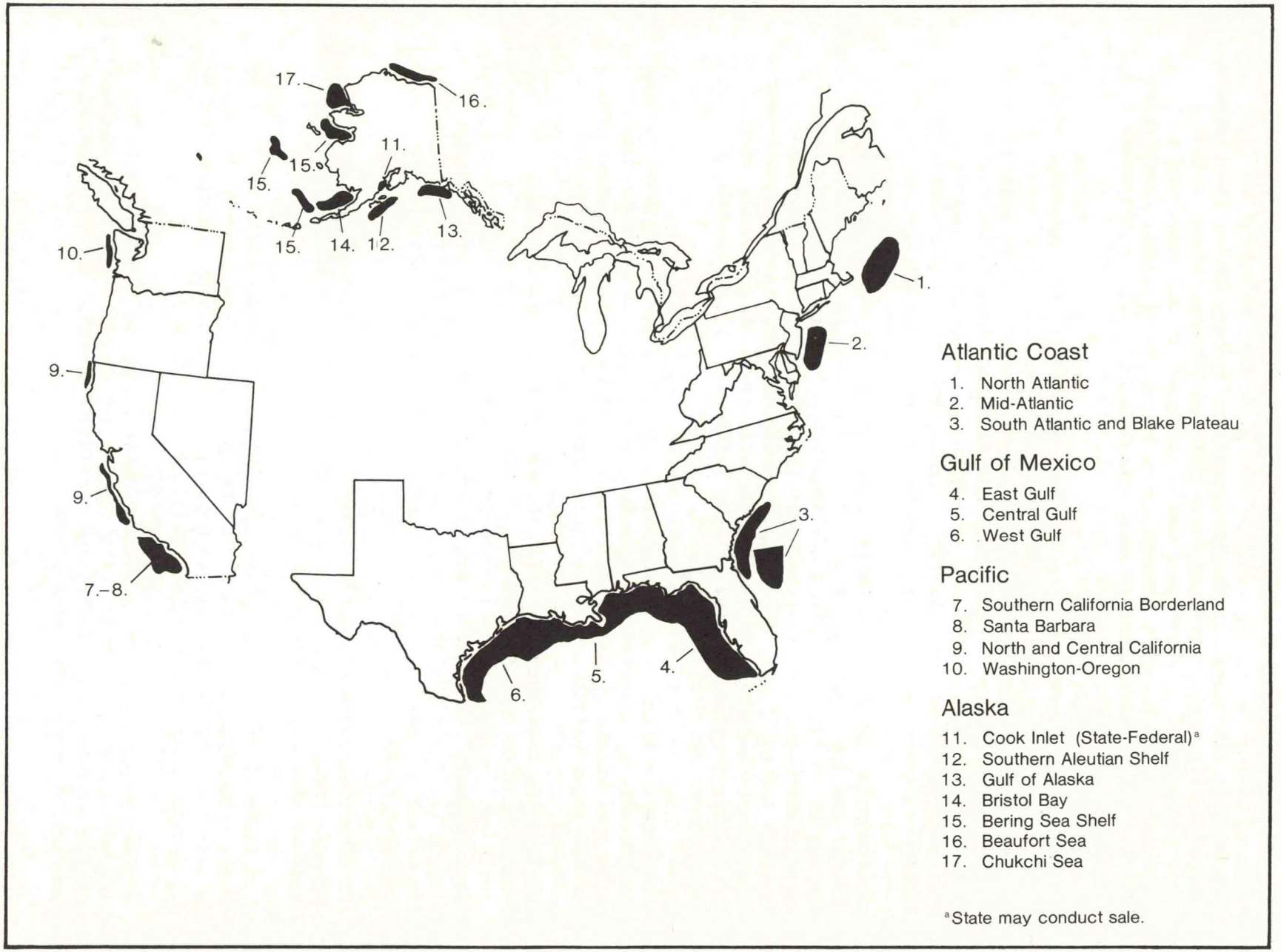


Figure 6.--Outer continental shelf areas under consideration for leasing.

Mississippi, Alabama, and Florida Shelf Region

The first study concerned the Mississippi, Alabama, and Florida (MAFLA) shelf region (fig. 7). Referred to as the MAFLA study, it began in May 1974 in response to numerous comments received by BLM regarding the Final Environmental Impact Statement for a Proposed 1973 Outer Continental Shelf (OCS) Oil and Gas General Lease Sale Offshore Mississippi, Alabama, and Florida (FEIS 73-60; October 17, 1973).

The MAFLA study is being funded by the Bureau of Land Management with overall program management being provided by Florida's State University System Institute of Oceanography (SUSIO). As manager, SUSIO is responsible for the design and conduct of a field sampling and analysis program for geological, biological, chemical, and physical oceanographic samples; establishment of analytical quality control procedures; and preparation of all progress reports as well as a comprehensive final report.

In accordance with the concepts previously stated for environmental assessment studies, the purpose of the field surveys in the MAFLA area during FYs 1974-75 is to establish a baseline of existing conditions for selected environmental parameters prior to preparation of each tract for rig emplacement and drilling. As designed, this environmental baseline should be suitable for comparing future measurements of samples from the same tracts in order to determine if changes follow OCS oil and gas exploration and development activities.

The sampling sites of the MAFLA study include locations within the lease tracts themselves, and stations outside the projected sphere of influence of activities within these tracts. These stations are located where they will facilitate the determination of the natural variability.

Sampling is designed to provide the necessary information to characterize each sampling site and includes:

1. A summary characterization of the differences and similarities of sampling sites including bathymetry, substrate characteristics, community characterization and relationships where possible, and identification of the dominant flora and fauna.

2. The collection of sediment samples. A portion of the sample is to be used for chemical analyses and the remainder for archiving for future analysis of sediment characteristics.

3. The collection of samples of benthic biota, zooplankton, and phytoplankton. (Quantitative estimates of the biomass and gradient analyses are being made, as well as statistical measures of variability and correlations of population parameters and nonbiological parameters.)

4. Analysis of samples of sediment, water, and selected biota. The samples are analyzed for hydrocarbons and heavy metals. Water samples are also being analyzed for salinity, pH, dissolved oxygen, and microconstituent concentrations within the water column.

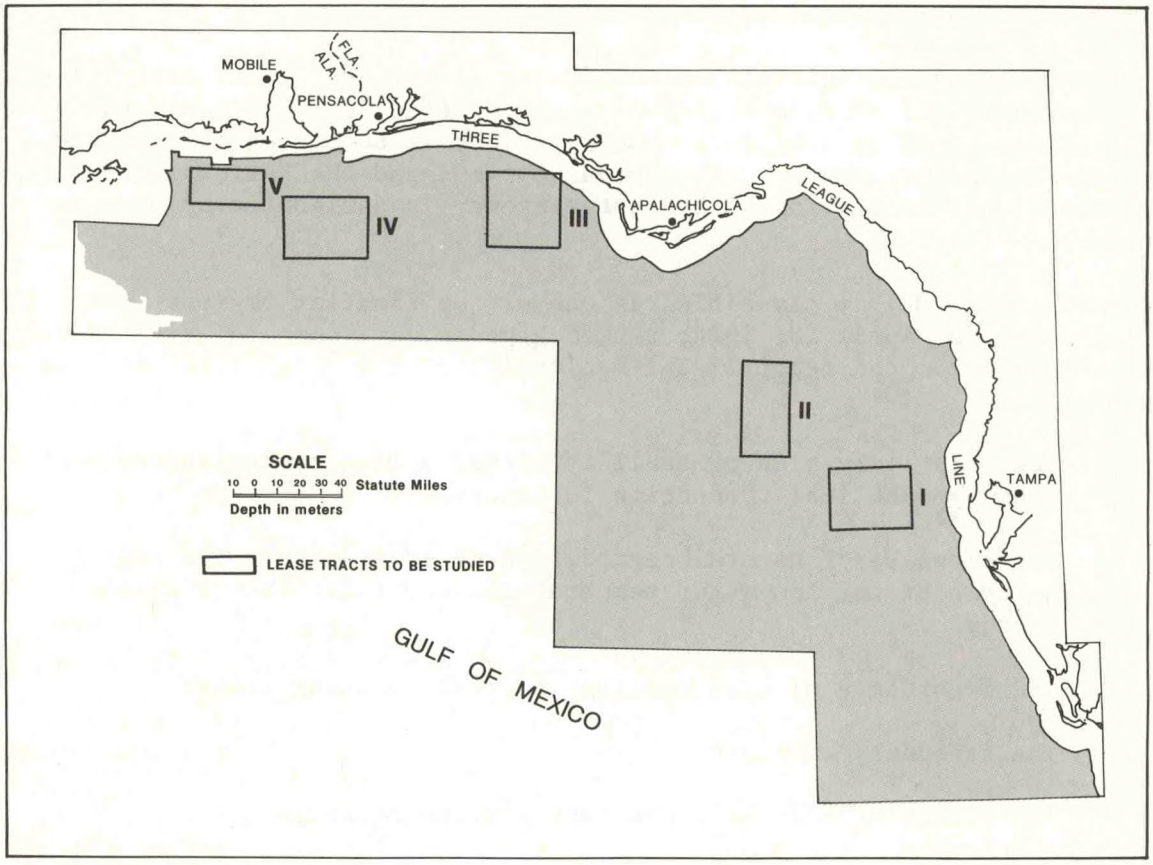


Figure 7.--Boundary of lease area--Mississippi, Alabama, and Florida (MAFLA).

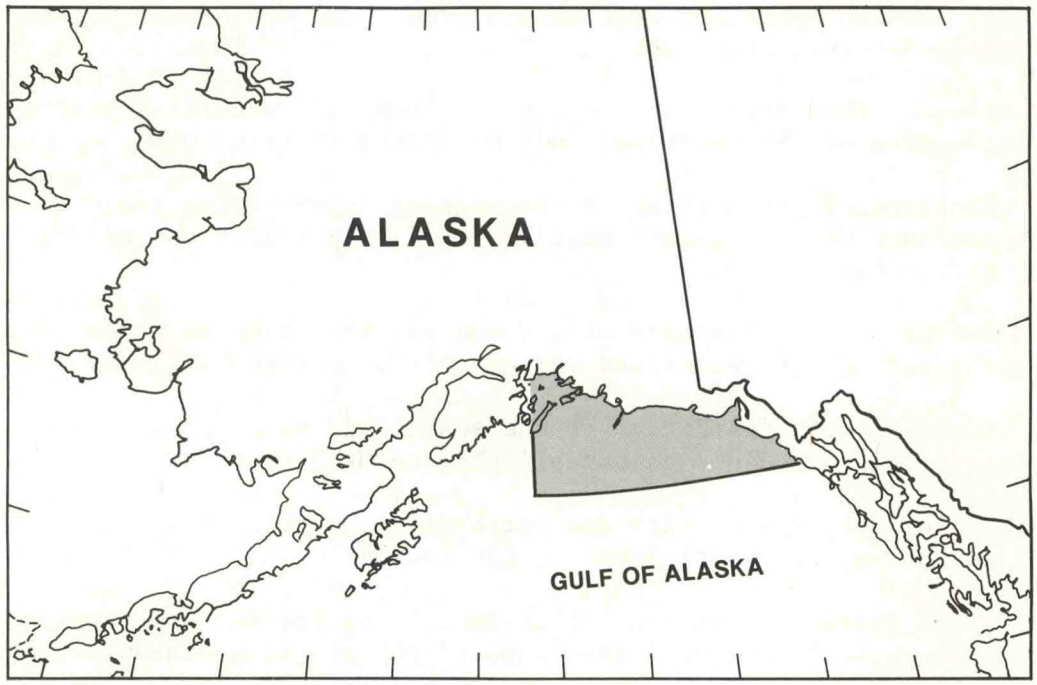


Figure 8.--Approximate boundary of lease area--northeast Gulf of Alaska (NEGOA).

Northeast Gulf of Alaska

Planning for the initial year of environmental assessment activities in the northeast Gulf of Alaska (NEGOA) was completed in FY 1974 and the field effort began in June 1974. This project is supported by the Bureau of Land Management, the U.S. Geological Survey, and the National Oceanic and Atmospheric Administration. The latter agency is designated as program manager.

NEGOA (fig. 8) is classified as one of the frontier regions, which CEQ, in its report of April 18, 1974, ranked high in environmental risk among the areas studied for the report. The rationale for the "high risk" ranking included:

- The relatively high probability of oil spills coming ashore from hypothetical production locations.
- The slowness of natural degradation of crude oil in the region because of the low water temperatures and relatively low solar energy.
- The importance of bird nesting and fish spawning areas.
- The frequency of storms.
- The potential effects of earthquakes and tsunamis.

The NEGOA program emphasizes quantitative assessment of each of the factors noted by CEQ and also provides a comprehensive environmental baseline for the study area. Participants in the study include the University of Alaska, Alaska Department of Fish and Game, U.S. Geological Survey, Fish and Wildlife Service, and NOAA.

As planned, the first year's study in NEGOA will provide a preliminary characterization of the northeast Gulf of Alaska in terms of:

- The general circulation of the region, interpreting the dominant driving forces involved in flow patterns and mixing processes.
- The geological features of the seabed, including an assessment of the earthquake hazard and delineation of natural oil seeps.
- Chemical characteristics of the seabed and water column, with particular emphasis on establishing natural hydrocarbon levels.
- Biological productivity and variability, with emphasis on the sensitive intertidal areas of the region.

In future years, additional OCS environmental studies are planned for the areas shown in figure 6. The proposed BLM planning schedule released

by the Department of the Interior indicates that in FY 1975 environmental assessment studies will also be in progress in the following OCS areas:

South Texas
Southern California
Mid-Atlantic (Baltimore Canyon Trough)
Bering Sea - St. George Basin/Outer Bristol Basin
Beaufort Sea

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TITLE II—COMPREHENSIVE RESEARCH ON OCEAN DUMPING

Report to Congress.

SEC. 201. The Secretary of Commerce, in coordination with the Secretary of the Department in which the Coast Guard is operating and with the Administrator** shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of material into ocean waters or other coastal waters where the tide ebbs and flows or into the Great Lakes or their connecting waters and shall report from time to time, not less frequently than annually, his findings (including an evaluation of the short-term ecological effects and the social and economic factors involved) to the Congress.

SEC. 202. (a) The Secretary of Commerce, in consultation with other appropriate Federal departments, agencies, and instrumentalities shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, overfishing, and man-induced changes of ocean ecosystems. In carrying out such research, the Secretary of Commerce shall take into account such factors as existing and proposed international policies affecting oceanic problems, economic considerations involved in both the protection and the use of the oceans, possible alternatives to existing programs, and ways in which the health of the oceans may best be preserved for the benefit of succeeding generations of mankind.

(b) In carrying out his responsibilities under this section, the Secretary of Commerce, under the foreign policy guidance of the President and pursuant to international agreements and treaties made by the President with the advice and consent of the Senate, may act alone or in conjunction with any other nation or group of nations, and shall make known the results of his activities by such channels of communication as may appear appropriate.

Annual report to Congress.

(c) In January of each year, the Secretary of Commerce shall report to the Congress on the results of activities undertaken by him pursuant to this section during the previous fiscal year.

(d) Each department, agency, and independent instrumentality of the Federal Government is authorized and directed to cooperate with the Secretary of Commerce in carrying out the purposes of this section and, to the extent permitted by law, to furnish such information as may be requested.

Inter-agency agreements.

(e) The Secretary of Commerce, in carrying out his responsibilities under this section, shall, to the extent feasible utilize the personnel, services, and facilities of other Federal departments, agencies, and instrumentalities (including those of the Coast Guard for monitoring purposes), and is authorized to enter into appropriate inter-agency agreements to accomplish this action.

Federal-State cooperation.

SEC. 203. The Secretary of Commerce shall conduct and encourage, cooperate with, and render financial and other assistance to appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and to promote the coordination of, research, investigations, experiments, training, demonstrations, surveys, and studies for the purpose of determining means of minimizing or ending all dumping of materials within five years of the effective date of this Act.

Appropriation.

SEC. 204. There are authorized to be appropriated for the first fiscal year after this Act is enacted and for the next two fiscal years thereafter such sums as may be necessary to carry out this title, but the sums appropriated for any such fiscal year may not exceed $6,000,000.

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*The "Marine Protection, Research, and Sanctuaries Act of 1972."

**Sec. 3(a): The Term "Administrator" means the Administrator of the Environmental Protection Agency.