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

October 1976 through September 1977

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

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

November 1978

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

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Stock No. 003-017-00432-5

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

November 20, 1978

Dear Sirs:

It is my honor to submit to the Congress this fifth annual report on scientific research concerned with the potential long term effects of man's activities upon the oceans.

The report summarizes the findings of those programs conducted by the National Oceanic and Atmospheric Administration (NOAA) in response to Section 202, Title II, of the Marine Protection, Research, and Sanctuaries Act of 1972.

Long term effects research carried out by NOAA in fiscal year 1977 continued along the same general lines as in previous years, with emphasis on petroleum hydrocarbons, heavy metals, fishery stock assessments, ocean mining, and oil and gas development on the Alaskan Outer Continental Shelf. These investigations are providing the data and information required to make more definitive evaluations of the effects of human activities on the ocean environment.

Enactment this year of the National Ocean Pollution Research and Development and Monitoring Planning Act (P.L. 95-273) will have significant implications for all Federal agencies involved in marine environmental programs. This legislation requires the preparation of a comprehensive 5-year plan for the overall Federal effort in this area, and also directs the NOAA Administrator to establish within NOAA a comprehensive, coordinated, and effective ocean pollution research and development and monitoring program. The Section 202 activities will form an integral part of the comprehensive program now being established by NOAA.

All of NOAA's marine environmental programs are now undergoing intensive review in compliance with the new legislation. Future reports in this series may differ both in form and substance from this and previous reports.

Sincerely,

Juanita M. Kreps

Secretary of Commerce

President of the Senate
Speaker of the House of Representatives

CONTENTS

CHAPTER I

OCEAN POLLUTION

Oceanic waters receive polluting materials from a large number of point and nonpoint sources. Materials are introduced into the marine environment from polluted rivers and streams, land runoff, barge and other vessel dumping, discharges of shoreline outfalls, wastes discharged from submerged pipes, vessel casualties, deballasting and bilge pumping and other shipping operations, and atmospheric transport.

Most oceanic pollution occurs in the estuaries, semienclosed seas, and waters adjacent to industrialized nations. The open sea, while relatively insulated from the myriad sources of pollutants affecting estuaries and the nearshore areas, is beginning to show signs of man's impact. In the mid-oceans there is evidence of elevated levels of petroleum hydrocarbons, particularly along heavily traveled tanker routes, and elevated concentrations of heavy metals and synthetic hydrocarbons, carried to remote oceanic regions through the atmosphere. Oceanic currents also play a role in transporting polluting materials from nearshore regions to deeper waters. In recent years efforts have been underway to measure the concentrations of petroleum hydrocarbons, heavy metals, and pesticides in the open ocean, including some of its most remote regions. These surveys show that pollutants are being introduced into the ocean on a global scale.

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 able to make a contribution.

For both the nearshore and deepwater regions, the basic informational needs are essentially the same. These include: (1) sources and quantities of man-made materials reaching the marine environment; (2) pathways of such materials into and through the food chain; (3) toxicity of the materials to marine organisms and to man through the consumption of seafood; and (4) the persistence of the pollutants in the marine environment. In addition, research must be focused on both the acute or immediate effects as well as the longer term or chronic effects on marine organisms. Many investigations are in progress in this country and others; the task ahead is immense and the present state of knowledge in many of the fundamental areas of research is far from adequate.

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 affect 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

Petroleum hydrocarbons (PHCs) are introduced into the oceans as the result of offshore oil production activities, oil tanker operations, vessel casualties, coastal refinery operations, atmospheric transport, shoreline discharges of municipal and industrial wastes, land runoff, and natural submarine seeps. As stated in the FY 1974 report of this series, the problem of estimating input and flux of PHCs in the marine environment has proven to be most difficult. The 1975 National Academy of Sciences (NAS) report entitled Petroleum in the Marine Environment 1/ provides a "best estimate" of 5.5 million tonnes annually (mta) to the oceans for man's activities. 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 mta, giving an overall total of 6.1 mta.

Research on petroleum hydrocarbons is carried out in four general areas: inputs; analytical methods; fate of PHCs (physical, chemical, and biological); and effects of PHCs. Many activities are in progress in all these areas, yet the state of knowledge with respect to oil in the ocean environment is still quite incomplete. For example, information is lacking on such basic problems as how much oil enters the marine environment and from what sources, how to distinguish between PHCs and biogenic hydrocarbons, and how to assess oil spills in an adequate manner.

Effects of Petroleum on Marine Organisms

NOAA studies of the effects of petroleum on marine organisms are primarily at the National Marine Fisheries Service (NMFS) Northwest and Alaska Fisheries Center with projects conducted in laboratories at Auke Bay, Alaska (near Juneau), and at Seattle, Washington. Studies were also made at the Southeast Fisheries Center (Tiburon, California, Laboratory) and at the Northeast Fisheries Center (Narragansett, Rhode Island, Laboratory). The studies include a cooperative effort between NOAA's NMFS and its Environmental Research Laboratories (ERL) involving the NMFS Environmental Investigations Program, ERL's Marine Ecosystems Analysis Program (with partial funding from the Environmental Protection Agency), and the Outer Continental Shelf Environmental Assessment Program (with funding from the Department of the Interior's Bureau of Land Management).

During earlier studies, data on the nature of changes in marine organisms caused by exposure to petroleum were limited and considerable effort was expended in simply identifying petroleum-related changes. This earlier work increased our understanding of the nature of biological changes and their tendencies to occur in the organisms. The focus of much of the current effort is to identify biological alterations on a concentration/exposure, time-dependent basis. We have been able to relate various types of petroleum exposure to alterations in the life processes of key subarctic and arctic organisms. Moreover, the studies have provided substantial evidence to show that petroleum ingested by most marine organisms is rapidly and extensively transformed to metabolic products of potentially high toxicity.

This discussion reports a number of findings and interpretations from research on the effect of petroleum on marine organisms.

Invertebrates. Results indicate that many marine invertebrates, and especially their larvae, are highly susceptible to petroleum pollution. Research on the biological fate of aromatic hydrocarbons in larval invertebrates has shown that these developmental stages concentrate aromatic hydrocarbons from the water column. Naphthalene, one of the principal aromatic compounds examined, not only was concentrated in larval tissues but also underwent significant metabolic transformations. Preliminary data indicate that concentrations of parts per billion (ppb) of waterborne naphthalene induce a number of morphological changes in immature forms of invertebrates. These changes may be associated with the formation of metabolites in the organisms.

The feeding and reproductive behavior of shrimp and nudibranchiates and the embryonic development of nudibranchiates appear to be particularly sensitive to low levels of petroleum hydrocarbons in seawater. Exposure to low concentrations (ppb) of water-soluble petroleum fractions inhibited feeding activity of spot shrimp in the laboratory. It is likely that a similar effect would occur under natural conditions.

Larval shrimp and crabs are most sensitive to exposure to oil during molting and, again, larvae are more sensitive to exposure than adults. Macoma clams did not appear to exhibit toxic effects after exposure to oil, but their behavior (burying activity) was changed.

Vertebrates. Studies have shown that in certain instances exposures of fish to high concentrations of petroleum have little effect on physiology; whereas, in other instances, severe effects may result from light-to-moderate exposures to petroleum. In studies of the effect of oil on trout reproduction, and disease resistance of salmon and trout, high doses of crude oil in diets induced little or no detectable physiological impairment.

The effects produced by petroleum on marine species are influenced by an array of environmental factors. Present data show that sublethal exposure to petroleum, under certain circumstances but not in others, may result in physiological and/or behavioral changes that are inimical to the well-being of marine and anadromous species. It is still not possible to predict whether a particular species in a given area will be damaged by exposure to the large number of compounds present in petroleum. As knowledge concerning effects and interactions increases, so will interpretive and predictive capabilities.

Data obtained thus far on the pelagic and demersal fish species show that these organisms are able to concentrate water-soluble aromatic hydrocarbons in key tissues in short periods of time. Starry flounder, a demersal species, concentrates complex mixtures of water-soluble petroleum hydrocarbons in key tissues in short periods of time. This tendency of the starry flounder to concentrate alkyl-substituted naphthalenes from the water column is so pronounced that virtually imperceptible concentrations in the water-soluble fraction become major components in key tissues such as liver. Thus, demersal species may well be able to accumulate readily detectable levels of water-soluble aromatic hydrocarbons from marine environments that contain these compounds below the detectable limits of our most sophisticated analytical techniques. When we attempt to relate point sources of petroleum pollution to hydrocarbon profiles in the tissues of pelagic or demersal species, the effort is hampered because these patterns are altered through metabolism and selective retention and excretion. Thus, comparison of hydrocarbon profiles from animals with those from the original oil is not a valid method of monitoring petroleum contamination.

The finding that both pelagic and demersal species retain aromatic hydrocarbons in direct relation to molecular weight and alkyl substitution is important. The starry flounder, which appears to accumulate preferentially water-soluble aromatics associated with sediment, may be particularly susceptible to retaining relatively high proportions of alkyl-substituted benzenes and napthalenes present in this system. Moreover, both pelagic and demersal species may be expected to retain dietary aromatic hydrocarbons of multiple-ring structure for relatively long periods of time. The higher molecular weight aromatics might be presented to the organisms (e.g., through the food-web) in association with particulate matter, through tar formation, or as microdroplets. Although the low-molecular weight, acutely toxic hydrocarbon fraction of crude oil may be lost by evaporation, the higher molecular weight compounds may be of particular concern because of their longer retention time in the organisms.

We have accumulated a significant body of evidence indicating that aromatic hydrocarbons are rapidly and progressively converted to metabolites in the pelagic and demersal fishes and in larval invertebrates. Several cases have been documented in which the concentrations of metabolites exceed the concentrations of the parent hydrocarbons in tissues, with liver and skin identified as major sites for preferential accumulation of metabolites over hydrocarbons in marine fish. Our studies with marine fish and invertebrate larvae show that the hydrocarbons are readily depurated in clean seawater, but the metabolites are retained for relatively long periods of time. We cannot, at present, assess the possible toxic effects from the retention of metabolites. However, it seems likely that such effects can occur since arene oxides occur as intermediates, and the literature on mammalian systems indicates that extremely low levels of arene oxides are damaging to biological systems in many ways.

To pinpoint petroleum pollution in marine organisms the best places to look are skin, liver, dark muscle, gall bladder, and mucus of fish and thoracic segments of the invertebrates. This fact is especially helpful when hydrocarbon accumulations in marine organisms are being determined. Moreover, it emphasizes that petroleum contaminants may be overlooked when whole animal tissues are used in analyses of field samples, and thus, lead to errors in judgment about the nature and degree of petroleum contamination of marine organisms.

Investigations of the biological fate of petroleum in subarctic and arctic marine organisms have shown that aromatic hydrocarbons are particularly accumulated in certain organs and tissues. These locations include mucus, brain, skin, liver, gall bladder, and dark muscle of fish and thoracic segments of postlarval invertebrates. Each site, with the exception of the invertebrate thoracic segments that have not been studied with respect to bioconversions, has thus far been identified as a prominent site for metabolite accumulation. Mucus was identified as an important route of hydrocarbon excretion. This route must now be considered in the recycling of hydrocarbons and metabolites together with other elimination routes via the gills, gall bladder, and kidney.

Flatfish and salmon--examples of subarctic demersal and pelagic species, respectively--experience distinctly different levels of risk from petroleum in the marine environment. Thus far, we have not demonstrated that exposure of salmonid fishes to low-to-moderate levels of petroleum compounds results in significant pathological changes. Only certain parameters have been investigated thus far, however, and all studies relating to salmonid species are not yet complete (see work on salmon homing below). Results have provided strong indications that petroleum and other persistent marine contaminants may have a substantial impact on some demersal fish. Flatfish markedly concentrate petroleum from the water column and have a high capacity for converting aromatic hydrocarbons to metabolites, which are stored in amounts often far exceeding the hydrocarbons themselves. Notable metabolite storage in flatfish occurs in the liver and skin, both of which are known to undergo various pathological changes. In fact, we and others have found that skin tumors of flatfish are widely prevalent in certain areas although there is no clear relation between the incidence of these lesions and pollution, and the causes of these tumors are, in fact, unknown. We have found, however, that a high percentage ($\simeq$90%) of certain species of flatfish taken from a polluted estuary near Seattle exhibited substantial pathological changes (hepatomas, fin erosion), which were either nonexistent or uncommon in the same species in waters adjacent to less urban areas. In our studies in which English sole were held in oil-contaminated sediment for up to five months, pathological changes including loss of weight, and liver abnormalities occurred in the exposed fish. Hydrocarbons in sediments have been shown to reach very high levels after oil contamination resulting from long-term discharges into the environment thereby providing the possibility for severe exposures which may lead to the kinds of biochemical, physiological, and pathological alterations we have observed. The energy level of contaminated beaches, however, (i.e., ranging from high-energy beaches with active surf to low energy beaches within sheltered bays), will affect the levels of hydrocarbons in the sediment and the length of time they persist. The species of flatfish near a spill may not all develop the same pathological conditions in response to oil. Also, the degree of weathering of oil may be an important factor in its ability to induce pathology in marine animals.

Nevertheless, the best available knowledge suggests that English sole, and probably most of its relatives, exposed to levels of petroleum hydrocarbons of 500 ppm, or higher, in the sediments of a low-energy beach for several months, will develop abnormalities similar to those observed in the above-mentioned laboratory experiments.

Structural changes. When animals are exposed to contaminants such as petroleum, early physical changes are monitored by electron microscopy to detect changes at the cellular level. Work to date has shown definite changes in eye lenses of salmonids and in the livers of both salmonids and flatfish. Napthalene, a component of petroleum, has long been known as a causative agent in cataract formation in rabbits.

Homing of salmon. Salmon upstream migration was disrupted by introducing petroleum hydrocarbons into the "home stream" water. Although there was no effect on the homing behavior of salmon when hydrocarbons were present at concentrations of 0.2 ppm, concentrations of 1 ppm changed the salmon homing response. The implications from those results are that 1 ppm of petroleum in spawning streams and estuaries could, at least, delay spawning migrations and, at worst, seriously disrupt them.

Interactions among contaminants. Animals in the natural environment are exposed to multiple contaminants. This fact is important when conclusions are to be made about the impact of environmental contaminants on the animals. Consequently, studies are underway to obtain data on the effects of other contaminants on the biological changes that occur from exposure to petroleum compounds. For example, results show that exposure to lead alters metabolism, and disposition of hydrocarbons in fish. Furthermore, compounds such as chlorobiphenyls (PCBs) change the rate of transformations of petroleum aromatic hydrocarbons in exposed fish. This circumstance occurs as a result of altered responses of some liver enzyme systems in salmonids to contaminant exposure. Moreover, morphological changes occur in salmon as a result of food-path exposures of chlorobiphenyls and hydrocarbons; the changes appear more severe when both chemical classes are administered to the fish. Importantly, synergistic action by the two types of chemicals was apparent in both morphological changes and increased activities of the liver enzyme systems that permit metabolic changes in the compounds.

HEAVY METALS

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 an extent that they create a hazard 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 Biochemical Effects

Studies are continuing at the NOAA, National Marine Fisheries Service laboratory in Milford, Connecticut, to determine how heavy metals - such as cadmium, copper, mercury, zinc, and silver - affect the normal life functions of certain marine animals. These experiments, when correlated with contaminant levels in the environment, will indicate which marine animals are extremely sensitive to minute amounts of metals and also which animals or communities are likely to flourish where traces of specific metal contaminants are present. Along with this, studies are being performed to determine whether natural environmental fluctuations, such as changes in salinity and temperature, enhance metal toxicity to marine animals, especially their embryonic and larval stages.

Experiments are still in progress to measure survival of embryos of the American oyster, Crassostrea virginica, exposed to heavy metals singly, in combination, and in concert with various temperature and/or salinity regimes. The acute toxicity of the heavy metals (copper, mercury, silver, and zinc) added individually to embryos of the American oyster in natural seawater was studied at 20°, 25° and 30°C. The toxicity of copper-zinc and mercury-silver mixtures to oyster embryos at the above temperatures was also determined. All of these metals, added either individually or in combination, were less toxic at 25°C than at either 20° or 30°C, suggesting that oyster embryos are more susceptible to metal toxicity at either 20° or 30°C than at 25°C. Less than additive effects were observed at 20° and 25°C with mercury and silver in combination. Simple additive effects were noted at 30°C for the mercury-silver mixture and at 20°, 25°, and 30°C for the copper-zinc mixture.

Other studies have been performed to determine physiological and biochemical responses of marine animals, such as the striped bass (Morone saxatilis) and winter flounder (Pseudopleuronectes americanus) to sublethal levels of the metals silver, mercury, and cadmium for periods of time varying from two to five months. Parameters examined were changes in blood ionic balance and hematology, and changes in various enzyme systems in various organs and tissues of these exposed animals.

Winter flounder (Pseudopleuronectes americanus) were exposed to mercury as the chloride for 60 days and subsequently allowed to recover for 15 or 60 days in clean water. Some changes in blood parameters were noted after 60 days of exposure, with no recovery after 15 days and almost complete recovery after 60 days. Winter flounder and striped bass (Monrone saxatilis) were exposed to silver as the nitrate for 60 days. For winter flounder, there were no significant differences between control and exposed groups, while differences did occur in striped bass.

Enzyme activity was measured in winter flounder following exposure to cadmium as the chloride for either two or five months. A number of differences occurred which indicated a cadmium-induced weakening of the metabolic flexibility necessary for adaptation to and survival under changing environmental conditions.

Studies of this sort are being continued to further define the role of heavy-metal pollutants in the marine environment. Further studies to be performed are those not only with sublethal levels of metals in combination, but also of metals combined with other environmental challenges, such as varying salinity and/or temperatures.

CHAPTER II

OVERFISHING

This is the fifth report in this series, and the first since the full implementation of the Fishery Conservation and Management Act of 1976 (P. L. 94-265). Last year's report described in detail the intent and provisions of the Act. The most immediate effect of the Act has been a substantial decline in foreign fishing under quotas set by Preliminary Fishery Management Plans adopted by the Secretary of Commerce. The 1977 foreign catch of 1.7 million tonnes (t) was about 1 million t less than the 1976 catch and should allow stocks that were depleted by foreign fishing to begin rebuilding. The eight Regional Fishery Management Councils established under the Act are developing Fishery Management Plans that will supplant the Preliminary Fishery Plans promulgated by the Secretary of Commerce and that will regulate domestic as well as foreign fishing. Those plans should eventually give all depleted stocks the opportunity to rebuild to former levels of abundance; however, the condition of the stocks now remains about the same as reported earlier.

The largest number of species that have been depleted by domestic and foreign fishing is off New England. This report for FY 1977, after a summary of marine mammal conservation, is devoted to a history of fishing in the Northwest Atlantic from 1960 to the present and our past and present attempts to manage and conserve those stocks. This year's report is more technical than previous ones, but we feel it is important to document the efforts by the U. S. Government to assess and conserve the stocks on one of the most productive fishing grounds in the world.

WHALE CONSERVATION

At its 29th Meeting in June 1977 and at its Special Meeting in December 1977, the International Whaling Commission (IWC) continued to establish catch limits for commercial whaling based on recommendations of its Scientific Committee. The new management procedure was followed without modification. The result of both meetings was a 4,530-whale reduction in the total allowable catch from the previous year.

The Scientific Committee placed major emphasis on protecting Southern Hemisphere sei whales. They recommended that all but two stocks should be protected, and the Commission reduced the catch allowed from the previous year by 58.5 percent.

The recommendations of the Scientific Committee adopted by IWC in June 1978 reduced the allowed catch of 7,200 North Pacific sperm whales in the 1977 season to 763 North Pacific sperm whales in the 1978 season. This decision was reviewed at special meetings of the Scientific Committee and IWC in November and December. As a result, the allowable catch limit was raised to 6,444 North Pacific sperm whales for the 1978 season.

At the 29th Meeting, IWC decided, on the basis of a Scientific Committee recommendation, to prohibit the taking of right whales, including bowheads, by aboriginal people. After the possibility of a special IWC meeting on North Pacific sperm whales had been established at the June meeting and other issues had been added to the agenda, the United States requested IWC to reconsider its June position on the bowhead whale. The Commission agreed that, in 1978, Alaska Eskimos may kill 12 or strike 18 bowhead whales, whichever occurs first, as long as no calves or females with calves are taken.

Most regulations adopted by IWC encouraged nonmember whaling nations to become members of IWC. Resolutions seeking cooperation from Chile, Peru, Portugal, Republic of Korea, and Spain were adopted and sent to these nations. Other resolutions stated that IWC member nations should (1) prevent transfer of vessels or gear to nonmember nations, (2) discourage dissemination by their citizens of expertise and assistance necessary for nonmember nations to conduct whaling, and (3) prevent import of whale products from nonmember whaling nations.

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 vital natural resources that have 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. 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 harvest all species to some degree; however, some species are discharded at sea for lack of markets.

Northwest Atlantic Fisheries, 1960-72

In the early 1960s the Northwest Atlantic Ocean [ICNAF Subareas 5 and 6 (SA 5 and 6), fig. 1] became the fishing grounds for the newly developed distant-water fishing fleet of the Union of Soviet Socialist Republics. Soviet fleets entered the grounds in search of Atlantic herring and silver hake and used drift gill nets and otter trawls to take 68,000 t of herring in 1961. In 1962 the USSR had more fishing vessels in the area than ever before or since, and took 209,000 t of predominantly herring. Poland and Norway soon joined their efforts.

From the arrival of the distant-water fleets in the early 1960s, the catch quadrupled by 1972 (table 1), and the target species of the 15 countries that fished during the period changed with the varying abundance of the various species. Some stocks have not yet recovered from the high level of fishing mortality exerted upon them during that period. Examples are Georges Bank haddock and Southern New England yellowtail flounder. Of the 200 species in the area, those species, unfortunately, were among the

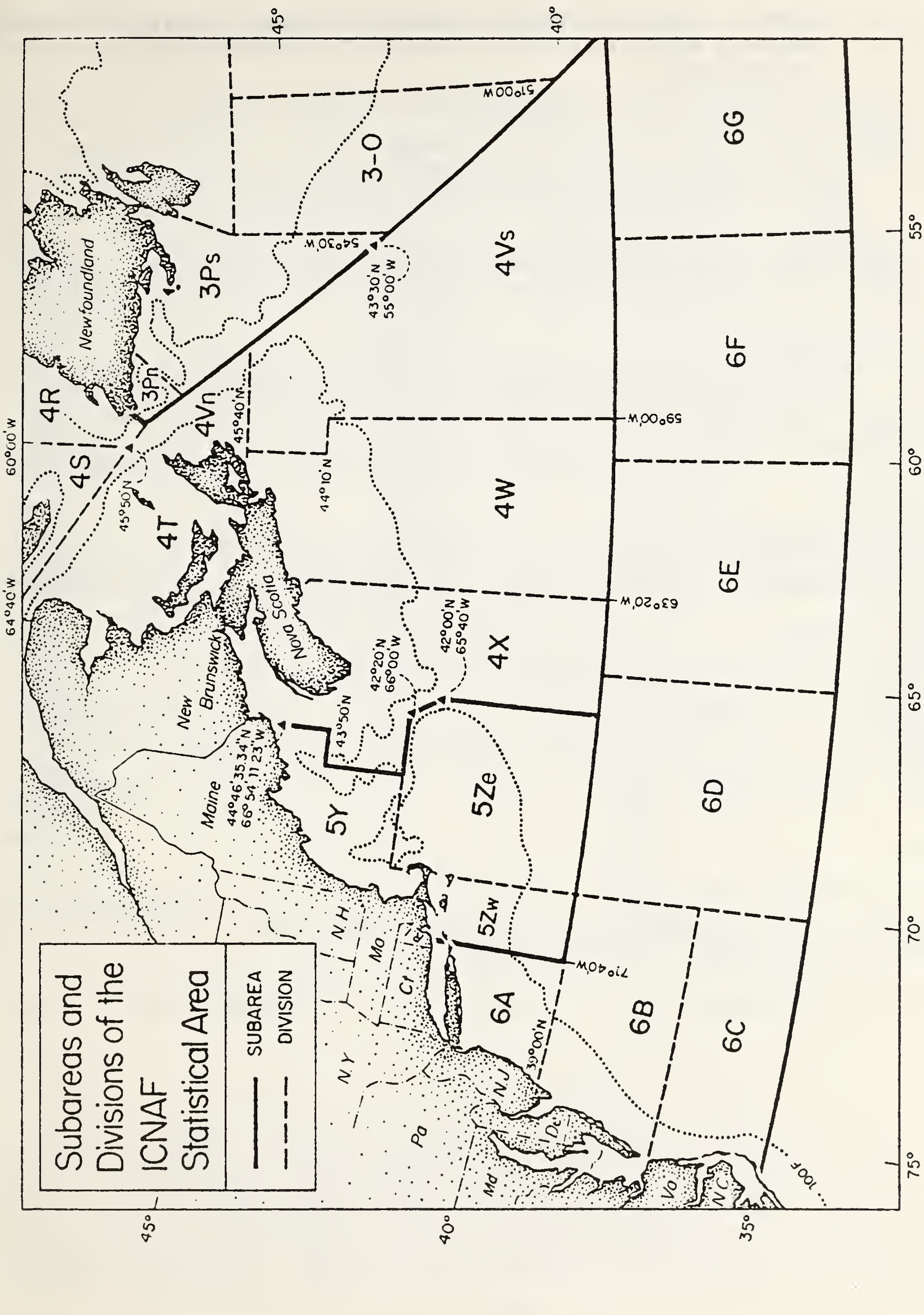

Figure 1.--ICNAF subareas 5 and 6 (SA 5 and 6)

Table 1.--Subarea 5 nominal catches as reported in ICNAF Statistical Bulletin Vols. 10 and 22 (ICNAF 1962a, table 1, and ICNAF 1974a, table 3, respectively.)

Species	1960	1972
	t	t
Atlantic cod	14,430	31,357
Haddock	45,801	6,669
Redfish	11,375	19,095
Yellowtail flounder	13,581	29,620
Winter flounder	6,953	10,505
Witch flounder	1,255	5,454
Scup	3,779	1,229
Pollock	10,397	12,989
Silver hake	46,688	107,113
Red hake	3,410	60,062
White hake	2,483	3,084
Groundfish not stated	[a]19,110	1,239
Atlantic herring	69,046	220,964
Atlantic mackerel	1,011	200,518
Alewife	8,669	8,656
Atlantic saury	--	3,429
Angler	8	4,332
Sculpins	--	4,862
Argentine	--	32,707
Sharks[b]	801	13,154
Skates	128	8,735
Other fish not stated	--	21,661
Squid	741	26,111
Total		

[a]15,320 listed as industrial catches presumed to be mainly red and silver hake based on U.S. national statistical studies.

[b]Includes dogfishes.

groundfish (Atlantic cod, haddock, redfish, flounders) that U. S. fishermen had historically concentrated on.

The first species to be affected by the distant-water fleets was herring, which had two good year-classes in 1960 and 1961. After the heavy harvests of the early 1960s more fishing effort was required to maintain the catches. Attention was turned to silver hake and then to haddock. Since a high of 110,000 t in 1929, haddock catches had averaged around 50,000 t a year. In 1965 the catch rose to 150,000 t followed by 127,000 t in 1966. Because the directed fishing for haddock in 1964 was already at the level of maximum sustainable yield (MSY), the 1965-66 catches drastically reduced the adult population and inflicted severe economic hardship on the coastal fishermen and processors.

As noted earlier, the situation with haddock was not unique. Of the 15 nations fishing in these waters during 1960-72, most participated in a fishery that was harvesting a species — either directly or incidentally as bycatch at a level above MSY. Indeed, by 1971, several species were being caught predominantly as bycatch in other fisheries (table 2).

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

Species caught	Taken as bycatch %
Atlantic cod	64
Haddock	61
Redfish	39
Silver hake	31
Flounders	31
Other groundfish	66
Other fish	86

*Source: ICNAF Redbook 1973, part 1, appendix I, supp. table 1.

The role of management during 1960-72 was minimal. A U.S.-U.S.S.R. bilateral agreement in 1967 established closed areas in the Middle-Atlantic area for large vessels (greater than 1,801 gross registered tons) in order to protect species such as scup, summer flounder, butterfish, and red and silver hakes during the winter when they are concentrated in the offshore deep waters before moving inshore where they become available to U. S. inshore commercial fishermen. This bilateral agreement was the first of several.

Between 1967 and 1972 most regulatory measures were established through the International Commission for the Northwest Atlantic Fisheries (ICNAF). At the insistance primarily of the United States, ICNAF established a Total Allowable Catch (TAC) for haddock in 1970 and for yellowtail flounder in 1971. Closed areas were also established during certain seasons to protect offshore concentrations of red and silver hakes and the spawning grounds of cod and haddock.

It was soon recognized that the goal of harvesting fish at a rate corresponding to MSY was no longer tenable. Also, the role of bycatches in setting TACs had to be considered. Another concept that emerged was to grant preference to a coastal country in setting TACs. By this principle, the United States and Canada were given quotas that allowed for development of their coastal fisheries while other countries were required to accept decreases in catch. In June 1972, preemptive quotas for 1973 were adopted for some species in order to prevent overfishing even though adequate assessments were lacking.

Fishery Management Efforts Since 1972

Since 1972 about 55 stocks have come under quota regulation by ICNAF at the prompting of ICNAF scientists. Some quotas were set with substantial biological evidence that quota restrictions were needed to prevent decline in productivity. Others were based primarily on commercial catch-per-day indices or U.S. research vessel bottom trawl survey indices, and still others were based on historical catches alone in order to prevent an overfishing situation which would result in lower yields. In January 1973, when it was clear that catches were continuing to increase (table 3) while the abundance of most species was decreasing [and had, in fact, undergone a 50-percent decline since the early 1960s (fig. 2)], the United States proposed that ICNAF adopt a 30-percent cutback in fishing effort in SA 5 and 6. This proposal, along with a proposal in June 1973 to limit the overall catch in the area, was rejected by ICNAF.

Table 3.--Catch of finfish plus squid, standardized effort with adjustment for learning, and catch per effort of fleets fishing in ICNAF SA 5 and 6 during 1961-76

Year	Catch	2d Tier TAC	Fishing (days effort)	Catch/effort
	t	t	days	t
1961	344,286		53,879	6.39
1962	472,263		108,816	4.34
1963	650,825		108,834	5.98
1964	786,346		165,896	4.74
1965	954,808		169,895	5.62
1966	988,568		191,583	5.16
1967	759,881		143,104	5.31
1968	942,762		180,260	5.23
1969	1,029,391		221,137	4.65
1970	840,267		182,667	4.60
1971	1,124,872		267,190	4.21
1972	1,144,597		315,316	3.63
1973	1,159,056		268,506	4.32
1974	942,188	923,900	238,705	3.95
1975	851,769	850,000	250,979	3.39
1976	634,369	724,000		
1977	[1]366,905	520,000		

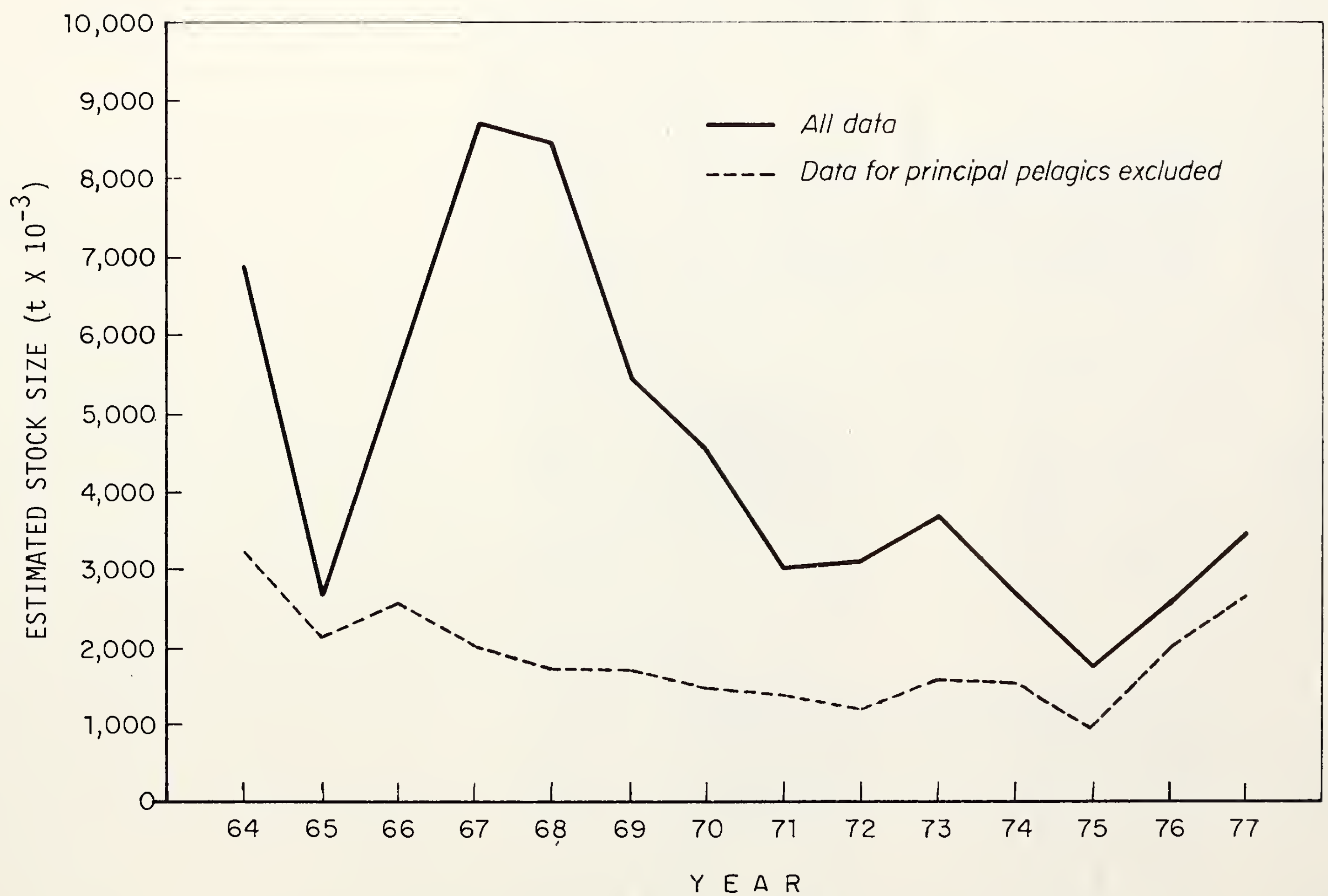

Figure 2.--Estimates of stock size for finfish plus squid in ICNAF subareas 5 and 6, 1964-77 (at beginning of each year).

In October 1973, however, it was documented that the additional mortality due to bycatch (estimated to be 33 percent in 1971) was substantial and would have to be accounted for in setting of quotas. Using linear programming techniques and bycatch ratios for 1971 it was demonstrated that in 1973 only 918,000 t of the total species TACs of 1,108,000 t could be taken if the U.S. proportion, because of coastal country preference, was preserved. With these facts in hand, ICNAF agreed on an overall (2d tier) quota of 924,000 t for 1974 with the allocation by country (1st tier) as given in table 4. At the same time it was suggested that an 850,000 t TAC for finfish and squid be approved for 1975, which eventually became reality. At the 1975 ICNAF meeting, it was noted that because the justification for the overall TAC was derived from fishing effort expended before the squid fishery was developed, the accepted 650,000 t 2d tier quota for 1976 should apply only to finfish. Consequently, the actual overall quota for 1976 set at 724,000 t and its breakdown by country is given in table 4. The country allocation scheme was based primarily on a country's historical fishing practices, plus special other considerations (e.g., coastal state preference, developing country).

Table 4.--Allocation of national quotas and catches[a] by country for ICNAF SA 5 and 6, 1974 -

Country	1974 Allocation	1974 Catch	1975 National Quota Allocation	1975 Catch	1976 National Quota Allocation	1976 Catch
	t					
Bulgaria	29,100	29,458	24,650	24,604	16,300	14,591
Canada	25,000	10,972	26,000	14,384	22,000	7,543
Cuba				4,058		12,037
France		3,832	2,950	3,363	2,950	1,100
FRG	27,000	26,760	24,850	25,201	16,700	12,636
GDR	97,600	95,439	82,850	82,081	54,700	48,677
Italy	4,700	4,680	4,150	4,402	8,450	6,313
Japan	24,300	25,798	21,250	20,822	15,700	25,163
Poland	152,200	152,887	129,250	127,054	87,600	74,460
Romania	4,300	9,785	3,850		3,850	
Spain	17,200	24,247	14,800	14,653	13,800	14,998
USSR	342,500	351,420	301,800	313,800	202,400	185,238
USA	195,000	206,244	211,600	217,347	246,000	231,613
Others	5,000	666	2,000		33,550	
Total	923,900	942,188	850,000	851,769	724,000	634,369

[a] All finfish and squids, except billfishes, menhaden, large sharks and tunas.

At the September 1975 Special Meeting of ICNAF, scientists generated considerable discussion on possible alternatives in fishery management. In particular, the goals of setting TACs at F_{msy} (the mortality rate set to achieve long-term maximum sustainable yield) or F_{max} (the mortality rate at which yield per recruit is maximum) were debated. Four objections to managing at F_{max} were cited: (1) the form of the relationship between catch-per-effort and fishing mortality varies for different stocks and in general is not well defined; (2) F_{max} does not necessarily correspond to F_{msy} (i.e., the mortality at which the greatest catch will be obtained from each recruit entering the fishery when the relationship between spawning stock and recruitment is overlooked does not necessarily agree with the fishing mortality that corresponds with the highest average MSY); (3) since F_{max} does not take account of stock and recruitment relationships, there is no guarantee with a management strategy based on F_{max} that the spawning stock will stay on an average at an optimum level; (4) the F_{max} level of fishing takes no account of possible economic objectives and factors. It was also noted that in a multispecies situation it is not possible to manage each stock at its own F_{msy} or F_{max} owing to biological and technological interactions. Moreover, managing a stock at F_{max} may lead to its depletion and a possible decrease in the long-term catch of principal components of the fishery. It was, therefore, suggested that a goal of fishery management should be to maintain an adequate spawning biomass of the desired species, and managing at $F_{0.1}$ was a step in that direction, where $F_{0.1}$ is defined as the level at which the change in yield per recruit with respect to a change in mortality rate is 10 percent of that of the fishery beginning on the virgin stock.

Bycatch and Associated Problems

The need to have some control over fishing other than or in addition to direct quotas was evident early in the 1970s. It was estimated that 33 percent of the catch in 1971 was taken as bycatch (table 2).

During 1972-75, the rate dropped slightly to 25 percent. The demonstration by U.S. scientists in October 1973 that the sum of the species quotas could not be taken without violation of some species quotas initiated interest in the effects of certain national quota regulations. For example, it was predicted that with the 1975 national species quotas only 450,000 t could be taken as directed catches, and that only a total of 626,750 t would be taken, far less than the sum of the species TACs of 1,058,300 t. As ICNAF considered the output of the linear programming technique to provide only a rough estimate of the true catch, the TAC was set at 850,000 t in 1975.

Status of the Biomass of Finfish Plus Squid. It had been clear from U.S. autumn research vessel bottom-trawl survey indices that the abundances of many stocks in ICNAF SA 5 and 6 were in a decline. In 1975, U.S. scientists documented that the biomass of finfish plus squid had declined about 50 percent from 1963 to 1974 (fig. 2). Table 5 presents the pounds/tow values for 1972-76 from the U.S. autumn bottom-trawl survey; however, the table marks some of the dominant trends of the individual species-stocks. The following report presents a brief summary of the trends of the more prominent species and lists the 1977 TAC for each stock.

Atlantic Cod - Gulf of Maine. The U. S. autumn bottom trawl survey data indicate a generally stable abundance for this stock. However, the 1976 pre-recruit index was the lowest since 1969. Estimates of fishing mortality have been as much as 67 percent in excess of the level (F_{max} = 0.30) giving maximum yield per recruit (YPR). The commercial catch in 1977 was projected to be 13,200 t and the recreational catch 5,600 t. Although the Scientific Advisers to ICNAF (STACRES) recommended a TAC of 3,200 t corresponding to $F_{0.1}$, ICNAF set the 1977 TAC at 5,000 t, which corresponded to F_{max}.

Atlantic Cod - Georges Bank. The catches from this stock since 1970 have stabilized around 26,000 t, although the TAC has been 35,000 t since 1973. Estimates of abundance derived from trawl surveys indicate a relatively stable population since 1963. However, since 1973 the U. S. autumn bottom-trawl survey index has increased annually owing, in part, to the strong 1971 and 1975 year-classes. Assuming stable recruitment, fishing at F_{max} = 0.30 would indicate a 1977 TAC of 24,000 t, whereas a catch of 26,000 t would generate an F of 0.36, STACRES recommended a TAC of 15,000 for this stock, corresponding to $F_{0.1}$, but ICNAF set the quota at 20,000 t.

Haddock - Gulf of Maine - Georges Bank. The haddock stock has been recovering slowly in recent years, although the stock size is still low. Since 1974, the recommended TAC for recovery of haddock has been 0 t, but because of bycatch, a TAC of 6,000 t has been implicitly accepted. The 1972 and 1975 year-classes were the strongest since 1967, and if recruitment continues at the average level observed during 1972-75, maintaining the 0 t TAC would eventually lead to an adult stock size of about 50 percent of the pre-1960 level. Unfortunately, the bycatch problem is still so severe with this stock (49 percent in 1975) that improvement in the stock size tends to result in increased bycatches.

Redfish (Ocean Perch) - Gulf of Maine - Georges Bank. Catch rates of U. S. commercial vessels that caught at least 50 percent redfish per trip have continued to decline since 1968. The U.S. 1976 autumn survey catch-per-tow index for this stock in the Gulf of Maine was the lowest recorded. Also, the survey length-frequency data, which had previously shown the presence of prerecruits in the inshore areas of the Gulf of Maine, indicated a drastic reduction in the number of these fish in 1976. Length frequencies of offshore fish showed no correlative increase in the number of these fish. At present, the fishery is sustained by a single year-class.

Because strong year-classes have historically occurred infrequently, the present stock will provide the bulk of the catch for the next few years. Analyses indicated that effort associated with F_{msy} in 1977 would result in a catch of 10,000 t, substantially below the long-term MSY of 17,000 t. For conservative purposes, ICNAF set the 1977 TAC at 9,000 t.

Silver Hake - Gulf of Maine. This stock has been severely reduced since the 1950s, and rebuilding of the stock has been hampered by the bycatch of immature hake in the fisheries for shrimp and silver hake. In 1975 it was determined that most of the stock biomass consisted of age 0 and 1 fish. However, the year-classes since 1971 are stronger than any produced during

Table 5.--Stratified mean catch per two for selected species of finfish and squid, U.S. autumn bottom trawl survey data for ICNAF SA 5 and 6.

Species	1972	1973	1974	1975	1976
			kg		
Atlantic cod	6.4	6.4	2.9	4.3	4.2
Haddock	2.2	3.3	1.3	4.5	8.7
Redfish	8.3	5.7	7.7	13.4	5.1
Silver hake	3.6	2.6	1.9	4.2	5.6
Red hake	2.6	1.6	0.7	3.0	2.1
Pollock	2.7	2.1	1.8	1.1	10.5
Yellowtail	7.9	1.6	1.0	0.5	0.7
Other flounder	4.3	4.2	3.5	4.1	4.9
Atlantic herring	0.1	1/	1/	0.1	1/
Atlantic mackerel	0.1	1/	1/	1/	1/
Other finfish[2]	43.3	54.5	27.4	51.3	50.9
Short-finned squid	0.3	0.3	0.4	1.5	7.8
Long-finned squid	4.6	7.6	5.8	7.6	8.1
Total finfish and squid	86.4	89.9	54.4	95.6	108.6

[1]Less than 0.05.
[2]Does not include data for American eel, white perch, sharks, swordfish, or tunas.

1966-70. Further, the fact that the 1975 year-class is about double the 1971 year-class causes optimism. The U.S. commercial catch-per-day index increased from 7.8 t in 1975 to 16.7 t in 1976, the highest catch rate since 1968. The 1976 autumn survey catch-per-two index was the highest since 1963. With a desirability to rebuild the stock to a higher level, STACRES suggested a TAC for 1977 of 5,000 t corresponding to fishing mortality of $F_{0.1}$. ICNAF set the TAC at 9,000 t.

Silver Hake - Georges Bank. The U.S. commercial catch-per-unit of effort increased by 50 percent from 1974 to 1975, after a decrease of 50 percent from 1973 to 1974 for this stock. It increased over 100 percent from 1975 to 1976, to the highest level since 1959. The 1971-75 year-classes are stronger than any produced during 1965-70; the 1972 year-class is estimated as the strongest since 1963. Improved recruitment combined with reduced fishing mortality has resulted in the stock biomass being increased by two to three times since the low level in 1969-70. ICNAF set the 1977 TAC for this stock at 70,000 t, corresponding to $F_{0.1}$.

Silver Hake - Southern New England-Mid-Atlantic. The 1971 and 1972 year-classes of this stock were the strongest since that of 1965. Survey data also indicate that the 1973 year-class was poor, but that the 1974 one was stronger than those of 1971 and 1972. The 1976 survey index was larger than that in 1975. The U.S. commercial catch per day increased from 5.3 t in 1975 to 6.6 t in 1976, the highest since 1970. The United States fishery (commercial and recreational) has been confined to the inshore areas, whereas the Soviet fishery has been offshore. Recent recruitment has resulted in an increase in stock biomass since the relatively low levels of 1970-71. ICNAF set the 1977 TAC for this stock at 50,000 t, corresponding to $F_{0.1}$.

Yellowtail Flounder - East of 69°W. Survey data indicate that the year-classes supporting the fishery in 1976-77 are less abundant than those in 1970-73. Recruitment is, in fact, equal to the lowest level since 1962, while catches have continued at the 15,000- to 20,000-t level. Fishing at $F_{0.1}$ = 0.4 in 1977 for a TAC of 7,000 t would result in a 10-percent increase in adult stock size. ICNAF set the 1977 quota at 10,000 t.

Yellowtail Flounder - West of 69°W. The three components of the stock are in a declining trend. The Southern New England stock, in particular, underwent a 90-percent decline between 1970 and 1975. The 1976 autumn survey index increased slightly but to only one-half of the 1971-72 level. Scientists recommended a 0 TAC for 1977 to maximize chances for recovery, although it was recognized that a bycatch was probably inevitable. ICNAF set the TAC at 4,000 t.

Atlantic Herring. Both stocks of herring (Gulf of Maine and Georges Bank-Middle Atlantic) have continued to decline since 1972. ICNAF decided in 1972 that the goal in managing these stocks was to maintain them above their respective sizes at the end of 1972 - these being 60,000 t for the Gulf of Maine stock and 225,000 t for the Georges Bank-Middle Atlantic stock. With the continued fishing through the 1970's, this goal indicated, according to

STACRES, a 0 TAC for 1977 for the Gulf of Maine stock and a 50,000 t TAC for the Georges Bank-Middle Atlantic Stock. ICNAF set TACs of 7,000 t and 33,000 t, respectively.

Atlantic Mackerel. The mackerel stock has continued its decline since the early 1970's as evidenced by survey data (table 4). Information in 1976 indicated that fishing mortality in 1975 was underestimated and that recruitment in 1975 was overestimated when providing the advice for setting TACs of 285,000 t and 254,000 t in 1975 and 1976, respectively. Late in 1976, ICNAF set a TAC of 75,000 t for SA 5 and 6 for 1977 with the provision that only pelagic gear be used in taking this species.

Other Finfish. This group includes some 60 species for which individual quotas have not been established. Total landings have decreased since 1973, apparently because of individual species TACs, and to the overall national quotas imposed on individual countries (table 4). There is no evidence that these stocks are declining under current catch levels. The U. S. bottom trawl surveys indicated that this group of stocks has stabilized since 1971. Close monitoring of this group is imperative, because it includes many of the stocks important to U. S. commercial and recreational interests.

Illex Squid. Although the survey indices of this species have increased from 1972 to 1976, the individuals have a 1-year life cycle, thus it is difficult to predict future stock sizes. Scientists recommended a preemptive TAC of 55,000 t for the stock (SA 3-6) for 1977, with 25,000 for SA 3 and 4 and 30,000 t for SA 5 and 6. Because the minimum estimate of stock biomass in 1975 was 197,000 t, these allocations did not seem too large, although they were higher than the catch in 1975. ICNAF increased the 1977 TAC to 35,000 t in SA 5 and 6.

Loligo Squid. Autumn survey indices indicate that this stock has gradually increased from 1972 to 1976, and that there has been a relatively stable population between 1974 and 1976 of about 4.5 billion individuals (about 5,000 t) during the autumn of the year. Catches have declined during the same period. ICNAF set a quota of 44,000 t for 1977, although catches since 1970 averaged around 33,000 t.

Other Finfish Plus Squid Biomass. Since 1972, the estimated biomass declined, reaching a low in 1975. However, a 32-percent increase in estimated biomass was observed at the beginning of 1976, and another increase of 32 percent was observed at the beginning of 1977 as well. These increases suggest a rebuilding of the total biomass (fig. 2). Table 6 lists the proposed and accepted overall TAC for 1977 (520,000 t) along with the national allocation by species.

Fishery Conservation and Management Act of 1976

In December 1976, an ICNAF meeting was held to complete the setting of 1977 TACs. The conditions presented by the United States under which it could remain in ICNAF and still conform with its new domestic law, the Fishery Conservation and Management Act of 1976, are as follows:

Table 6.--Accepted and proposed (1/) total allowable catches (TACs) and national allocations (2/) by stocks and ICNAF area (in metric tons).

STOCK	Cod 5y	Cod 5z	Haddock 5	Redfish 5	Red Hake 5Ze	Red Hake 5Zw+6	Silver Hake 5y	Silver Hake 5Ze	Silver Hake 5Zw+6	Pollock 4VWX+5	Yellowtail 5(E69°)	Yellowtail 5(W69°)+6	Other flounders 5+6
TAC[1]	3,200	15,000	0	9,000	16,000	28,000	5,000	70,000	50,000	30,000	7,000	0 a	20,000
BUL								760	1,000				
CAN	80	3,350	1,260	90	1,000	1,000		2,500		20,975	90		200
CUBA					920	1,810		5,375	4,140				
OEN													
FRA													
FRG													
GOR													
ITA													
JAP													
POL													
ROM													
SPA													
USSR					12,530	18,090		46,050	32,090				
USA	4,915	16,630	4,735	8,900	1,500	7,000	8,990	15,000	12,500	9,000	9,900	3,995	19,790
OTHERS	5	20	5	10	50	100	10	315 b	270 c	25	10	5	10
FINAL TAC[2]	5,000	20,000	6,000 a	9,000	16,000	28,000	9,000	70.000	50,000	30,000	10,000	4,000	20,000

STOCK	Mackerel 5+6	Herring 5y	Herring 5Z+6	Squid Illex 5+6	Squid Loligo 5+6	River Herring 5+6	Butterfish 5+6	Other finfish[3] 5+6	Other finfish[4] plus squids 5+6
TAC[1]		0	50,000	30,000	44,000	10,000	18,000	150,000	500,000
BUL	4,000		100	400				2,000	6,750
CAN	5,000	990	1,000	1,000	2,000		100	2,500	23,000
CUBA	2,000		700		5000			3,000	
OEN									14,950
FRA			1,000					200	1,100
FRG	1,100		4,825					200	6,300
GOR	12,400							3,000	16,850
ITA	300			980	1,640		400	900	5,000
JAP				3,440	7,820		3,300	7,000	25,000
POL	20,200		5,100	4,910	850			6,200	32,100
ROM	1,100		100					200	1,200
SPA				4,910	4,390		1,500	3,600	18,450
USSR	22,800		3,400	7,370	1,000			31,100	141,250
USA	6,000	6,000	12,000	11,500	25,000	9,900	12,500	62,000	228,000
OTHERS	100	10	50	490 a	300	10	200	100	50
FINAL TAC[2]	75,000	7,000	33,000 d	35,000	44,000	10,000 d	18,000 a,d	122,000 a,d	520,000 a

1. Recommended by Scientific Advisers to International Commission for the Northwest Atlantic Fisheries (ICNAF).
2. Total allocated catches.
3. Except TAC species, menhaden, billfishes, tunas, and large sharks other than dogfish.
4. Except menhaden, billfishes, tunas, and large sharks other than dogfish.

a. Reserved for bycatches only--no directed fisheries for these stocks.
b. 300 tons reserved for bycatch.
c. 250 tons reserved for bycatch.
d. Satisfies U.S. needs under Fishery Management and Conservation Act of 1976.

Countries: Bulgaria, Canada, Cuba, Oenmark, France, Federal Republic of Germany, German Oemocratic Republic, Italy, Japan, Poland, Romania, Spain, U.S.S.R., and United States.

(1) The ICNAF nations understand that the United States would enforce its national fisheries jurisdiction (within 200 miles) and that, within these limits of national fishery jurisdiction, the United States would enforce ICNAF regulations

(2) The United States establish, within the national limits of fishery jurisdiction, a national permit system determined by the United States and issued in a manner consistent with its domestic law

(3) ICNAF regulations would not intrude into the area of U. S. rule-making with respect to the management of fishery resources within the limits of U.S. fishery jurisdiction

(4) The task that ICNAF was about to consider, i.e., the quotas to be established for 1977 with respect to that area within U. S. fishery jurisdiction, take into account the setting by the United States of TAC and U.S. harvesting capacity before the allocation of any surplus

In accordance with these conditions, the United States presented a package of proposals for ICNAF SA 5 and 6 for 1977 for Atlantic herring, squid, Atlantic mackerel, silver and red hakes, and the second-tier quota. With each management proposal a "window," or area-time-gear restriction, was included within which directed fisheries for these species could be conducted. This management concept was believed to be beneficial because it: (1) eased enforcement, (2) helped ensure that bycatch limitations were not exceeded, and (3) reduced the potential for gear conflicts. In addition to these proposals, the categories of river herring and butterfish were to be taken from the "other finfish" categories and given individual TACs and national allocations, because these species were of prime interest to the United States and were anticipated to be large bycatch species in the directed fisheries for other species. Also, the Georges Bank-Middle Atlantic herring stock was to have a TAC of 33,000 t (not the 50,000 t TAC approved in June), with directed fishing to be undertaken only by Canada, France, Federal Republic of Germany, German Democratic Republic, Poland, and the United States in order to increase the probability of recovery. The United States declared a need for a 12,000 t allocation for Atlantic herring and a 10,000 t allocation for *Illex* and *Loligo* squid as requirements for 1978. Table 6 gives final allocations of all species for 1977.

International Research Since 1972

Table 7 presents the foreign vessels that have participated in research activities with the United States since 1972. Exchange of scientific personnel has almost always occurred. Most of this work was done at the initiative of the Northeast Fisheries Center of NOAA's NMFS and has been conducted to increase understanding of methods of collection and interpretation of data, and in particular to gain insight with the resultant indices derived. Data on weight, maturity, length, and age of fish species are routinely taken during surveys, oceanographic observations are made, and plankton samples are taken. New technological techniques have been tested with the cooperation of foreign countries (e.g., the development of hydroacoustical techniques for measuring stock abundance, gear comparison studies to allow for changes in catchability, etc.); foreign scientists have spent extended periods of time at the Center learning assessment techniques (e.g., virtual population analyses). A plankton sorting center has been set up at Szczecin, Poland, with United States scientists providing the bulk of the expertise to train technicians.

A Look at the Future

The catches in recent years have been low, because of quota regulations imposed by ICNAF. The long-term aim of management, a scheme suggested by scientists, is to build the stocks so that a sustained yield of 800,000 to 1,000,000 t will be possible in ICNAF SA 5 and 6. A few of the stocks have shown evidence of rebuilding in the production of strong year-classes, e.g., haddock and silver hake. The improved condition of the Georges Bank-Southern New England silver hake could be due in part to the reduction of the mackerel stock. The silver hake stock in the Gulf of Maine has increased since the collapse of the Northern shrimp fishery, which, because of the absence of mesh regulations, had been catching and discarding small silver hake. Some species continue to be in good shape. The squid, as well as the "other finfish" category, has shown stable or increased abundance in recent years (table 5.)

The goal was established in ICNAF to have the overall MSY level of 800,000 to 1,000,000 t reached by 1980. It appears, however, that a better understanding of the interrelationship between species is needed to predict with any accuracy when a stock will be rebuilt to its own MSY level, despite any management scheme to encourage it. In the last years of ICNAF the overall finfish plus squid biomass had begun to recover under a total biomass management program and a start was made toward sustained yield management of the ecosystem. This is the legacy that the United States inherited as the Fishery Conservation and Management Act of 1976 went into effect.

Extended Jurisdiction

In March 1977 the U.S. withdrawal from ICNAF finally took place. Preliminary management plans for Atlantic herring in Div. 5Z - SA 6, Atlantic mackerel SA 5 and 6, silver and red hakes in Div. 5Z and SA 6, and *Illex* and *Loligo* squid were established which incorporated with moderate refinements the 1977 regulations adopted by ICNAF. Foreign nations were restricted from other species fisheries. A management plan was adopted for haddock, cod, and yellowtail flounder similar to the earlier ICNAF regulations. Attention was also turned to shellfish resources, because of concern with previous heavy fishing (e.g., surf clams, sea scallops) and because of more recent developments (e.g., ocean quahogs).

Table 7.--Foreign vessels and cruises 1972-76

Date	Vessel (nationality)	General objective and area involved
1972		
June 27-July 1	Cameron (Canada)	Paired tow survey; Scotian Shelf
Aug. 10-Sept. 2	Blesk (USSR)	Groundfish survey; Scotian Shelf
Sept. 19-25	Blesk (USSR)	Trawl comparison; South of Nantucket
Sept. 30-Oct. 23	Blesk (USSR)	Groundfish survey; Georges Bank-Cape Hatteras
Oct. 1-Nov. 15	Wieczno (Poland)	ICNAF plankton survey; Georges Bank-Gulf of Maine
Oct. 1-Nov. 15	Anton Dohrn (FRG)	ICNAF plankton survey; Georges Bank-Gulf of Maine
1973		
Feb. 26-Mar. 15	Walther Herwig (FRG)	Fish survey; Georges Bank
Aug. 27-Sept. 5	Belogorsk (USSR)	Trawl comparison; South of Nantucket
Sept. 12-27	Wieczno (Poland)	Fish survey; Georges Bank
Sept. 26-Oct. 12	Belogorsk (USSR)	Fish survey (juvenile); Georges Bank
Oct. 1-Nov. 30	Cryos (France)	ICNAF plankton survey; Georges Bank and Gulf of Maine
Oct. 1-Nov. 30	Wieczno (Poland)	ICNAF plankton survey; Georges Bank and Gulf of Maine
Oct. 1-Nov. 30	Belogorsk (USSR)	ICNAF plankton survey; Georges Bank and Gulf of Maine
Oct. 1-Nov. 30	Walther Herwig (FRG)	ICNAF plankton survey; Georges Bank and Gulf of Maine
1974		
Mar. 20-Apr. 18	Khronometer (USSR)	Hydroacoustics and fish survey; Georges Bank-Cape Hatteras
Mar. 19-Apr. 5	Walther Herwig (FRG)	ICNAF juvenile herring and mackerel survey; Georges Bank
Aug. 14-27	Belogorsk (USSR)	Groundfish survey; Scotian Shelf
Sept. 14-24	Wieczno (Poland)	Juvenile herring and mackerel survey; Georges Bank
Sept. 6-24	Cryos (France)	Larval herring survey; Gulf of Maine-S. New England
Sept. 26-Oct. 21	Wieczno (Poland)	Larval herring survey; Gulf of Maine-S. New England
Oct. 18-30	Prognoz (USSR)	Larval herring survey; Gulf of Maine-S. New England
Nov. 15-26	Anton Dohrn (FRG)	Larval herring survey; Gulf of Maine-S. New England
Sept. 6-17	Belogorsk (USSR)	Bottom trawl comparisons; South of Nantucket
Sept. 20-Oct. 21	Belogorsk (USSR)	Groundfish survey; Georges Bank-Cape Hatteras
Oct. 23-29	Wieczno (Poland)	Hydroacoustics survey; Off Cape Cod

Table 7.--Foreign vessels and cruises 1972-76 (continued)

Date	Vessel (nationality)	General objective and area involved
1974 (continued)		
Oct. 26-Nov. 1	Belogorsk (USSR)	Juvenile herring and mackerel survey; Georges Bank-Hudson Canyon
Oct. 30-Nov. 6	Wieczno (Poland	Juvenile herring and mackerel survey; Georges Bank-Hudson Canyon
1975		
Feb. 26-Mar. 11	Ernst Haeckel (GDR)	Fish survey; Gulf of Maine and Georges Bank
Mar. 1-17	Wieczno (Poland)	Juvenile herring survey; Georges Bank-Hudson Canyon
Mar. 11-17	Ernst Haeckel (GDR)	Juvenile herring and mackerel survey; Georges Bank
Mar. 11-28	Walther Herwig (FRG)	Juvenile herring and mackerel, and plankton survey; Georges Bank
Mar. 20-Apr. 13	Poisk (USSR)	Hydroacoustics survey; Georges Bank and Mid-Atlantic
Mar. 20-Apr. 13	Wieczno (Poland)	Hydroacoustics survey; Georges Bank and Mid-Atlantic
Aug. 15-Sept. 8	Pormorze (Poland)	Transport of Helgoland; Germany to U.S.
Sept. 4-Dec. 6	Helgoland (FRG)	Herring spawning; Jeffreys Ledge
Aug. 6-26	Belogorsk (USSR)	Groundfish survey; Nova Scotia-Hudson Canyon
Sept. 4-19	Belogorsk (USSR)	Trawl comparison; South of Nantucket-Georges Bank
Sept. 24-Oct. 10	Belogorsk (USSR)	Larval herring survey; Georges Bank and Nantucket Shoals
Oct. 16-Nov. 16	Belogorsk (USSR)	Larval herring survey; Georges Bank and Nantucket Shoals
Oct. 31-Nov. 16	Anton Dohrn (FRG)	Larval herring survey; Georges Bank and Nantucket Shoals
Nov. 21-Dec. 11	Cryos (France)	Squid survey; N. of Georges-Bank-Delaware Bay
1976		
Mar. 1-9	Anton Dohrn (FRG)	Larval and juvenile herring survey; Georges Bank
Mar. 2-18	Ernst Haeckel (GDR)	Larval and juvenile herring survey; Georges Bank-Gulf of Maine
Apr. 9-May 4	Wieczno (Poland)	Larval herring survey

Table 7.--Foreign vessels and cruises 1972-76 (continued)

Date	Vessel (nationality)	General objective and area involved
1976 (continued)		
May 1-20	Wieczno (Poland)	Groundfish survey; Long Island-Georges Bank
May 20-29	Wieczno (Poland)	Groundfish survey; Long Island-Georges Bank
Aug. 5-23	Kvant (USSR)	Gear testing; Georges Bank
Sept. 4-13	Belogorsk (USSR)	Groundfish survey; New York Bight-Georges Bank
Sept. 14-30	Belogorsk (USSR)	Herring tagging; Georges Bank
Sept. 14-30	Yubileiniy (USSR)	Herring tagging; Georges Bank
Oct. 4-11	Belogorsk (USSR)	Herring larvae
Oct. 11-22	Belogorsk (USSR)	Groundfish survey; New York Bight-Georges Bank
Oct. 13-Nov. 4	Wieczno (Poland)	Herring larvae
Oct. 24-Nov. 3	Belogorsk (USSR)	Day/night catchability of mackerel
Nov. 6-16	Wieczno (Poland)	Day/night catchability of mackerel
Nov. 9-22	Cryos (France)	Bottom trawl (squid) survey; Georges Bank-Mid-Atlantic
Nov. 25-Dec. 3	Cryos (France)	Herring survey; Georges Bank-Mid-Atlantic
Nov. 14-Dec. 1	Anton Dohrn (FRG)	Herring larvae survey
Nov. 18-29	Wieczno (Poland)	Oceanographic-sonic tagging

(FRG) Federal Republic of Germany; (GDR) German Democratic Republic; (USSR) Union of Soviet Socialistic Republics

CHAPTER III

OFFSHORE DEVELOPMENT AND THE OCEAN ENVIRONMENT

Advances in technology are increasing the capability to remove minerals and fuels from the sea floor. The emplacement of large offshore structures and mining in near shore and deepwater areas will result in certain impacts on the local marine environment. The significance of these effects is now largely unknown. Before large-scale commitments of resources are made in offshore development activities, 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 for various environmental consequences for offshore development operations. This chapter describes some of the more significant research programs and activities carried out in this area during FY 1977.

OCEAN MINING

Vast quantities of hard minerals of economic and strategic importance to the United States are known to exist offshore and on the sea floor of the deep ocean. Manganese nodules, which occur on the deep seabed, are a potentially important source of copper, nickel, cobalt, and manganese. The United States is highly dependent on imports for nickel, cobalt, and manganese, and imports an increasing amount of copper. For a number of economic and political reasons, the Nation seeks to broaden its sources of these important minerals. U. S. industry has spent millions of dollars to delineate high-value deposits, develop deep ocean mining technology, and operate pilot processing plants. If legal barriers can be lifted and environmental concerns satisfied, commercial scale operations by U. S. industry could begin during the early 1980s.

Because environmental concerns could significantly delay U. S. entry into deep ocean mining, NOAA began addressing these in 1972 by holding meetings with industry and other Federal agencies and by sponsoring research cruises. Two years later, NOAA released plans for a two-phase Deep Ocean Mining Environmental Study (DOMES) Program.

The objectives of Phase I were to: establish environmental baselines at representative deep ocean mining sites in the North Pacific Ocean area of commercial interest; develop first-order prediction capabilities for determining potential environmental effects of deep ocean mining; and provide information for the development of preliminary environmental guidelines for deep ocean mining for use by industry and government. Field work for Phase I of DOMES was completed in November 1976. The final report, due in mid-1978, will update the findings of the Progress Report described in last year's report to Congress.

Phase II of DOMES officially began in FY 1977; however, planned monitoring operations to be held during prototype mining system tests were not conducted because of substantial slippage in the industry's test schedule. Nevertheless, the project devoted considerable time to the development of a test monitoring strategy. In April 1977 a technical workshop involving marine scientists from a variety of scientific disciplines reviewed DOMES research plans, and in late FY 1977 a cruise was made to test and evaluate monitoring equipment and strategy. Both of these efforts were successful and served to establish a high degree of confidence that the two monitoring efforts scheduled for FY 1978 would be both appropriate and effective.

A set of preliminary environmental guidelines for deep ocean mining was developed early in the year. The guidelines were later reviewed by environmental groups, academia, and industry; then revised and condensed for publication in the Federal Register (early in FY 1978).

The initial nodule processing studies noted last year are now completed and the results published. The systems of transportation, processing, and waste disposal are not expected to make unusual demands on the coastal zone. The ore carrier fleet used by each operator will consist of two or three ships. The exact fleet size and type will depend on corporate choices of mine sites, processing sites, whether they are seeking three or four metals, and whether they want to handle whole or slurried nodules. The processing plants do not have to be on the coast, and they should not place inordinate demands on land and on local infrastructures. Purchased power requirements will be in the range of 25 to 100 megawatts. Water used does not have to be potable, so that water consumption requirements are not excessive. While partial processing at sea is possible, full at-sea processing to the finished metals stage does not appear likely in first-generation systems.

During Phase II of the processing studies, representative geographical regions for the location of processing and associated facilities are being identified. The West Coast, Hawaii, or the Gulf Coast may be considered by industry for the siting of port facilities and onshore processing plants. The industry's ultimate decisions on siting will be based on total-system economics and regulatory and public attitude considerations in potential areas. The Phase II effort is nearing completion with respect to the West Coast, and a report will be published early in FY 1978. The Hawaii and Gulf Coast work started in FY 1977 and will be completed in FY 1978.

In addition to the environmental ramifications of deep ocean mining, legal and economic implications are inherent in each of the several Law of the Sea negotiating texts--as well as Congressional bills. Three studies were initiated in FY 1977 to address these particular uncertainties.

A computerized "Deep Ocean Mining Cost Engineering Model" was developed that breaks the system down into sufficiently small subsystems in order to estimate capital and operating costs, and then computes the profitability of a "typical" company. The model also permits the estimation of certain costs to government under different economic or regulatory conditions. For example, the model permits the following broad-scale evaluations:

(1) Corporate benefits and government costs of political risk protection for the industry

(2) Comparative costs to industry for requirements of U. S. vessels and U. S. processing plants

(3) Effects on industry of differing methods of tax treatment

(4) Effects on industry of delays at different stages of its operations

To ensure the credibility of the model, a government-industry-academia workshop was convened in March 1977 to review the adequacy of the model's equations and the reasonableness of the values inserted into the equations. Also discussed at the workshop was the attendees' assessment of the feasibility of using such a model as an aid in formulating government policy. They concluded it would be useful provided the model was used carefully and not "abused." The model has since been revised and will become available for use by government in the very near future.

While the computer model is a powerful tool, there are additional types of more detailed and specific economic studies needed. For example, one issue that has attracted much attention is the possible inclusion of a requirement in domestic legislation that U.S. flag vessels be used to transport the ore from the mining site to a U.S. port. Accordingly, a contract was awarded to compare the construction and operating costs of the following three situations:

(1) Use of U. S. flag ships with U. S. crews

(2) Use of foreign-built ships registered under the U. S. flag and operated by U. S. crews

(3) Use of foreign-built ships with foreign crews

The study, which is nearing completion, will provide information needed to assess: (1) the extent to which U. S. vessels are likely to be used in the absence of a legislative requirement for such vessels, and (2) the economic impact on the viability of the industry if U. S. flag vessels are required.

The environmental analyses of processing systems considered several waste disposal options; the following were those which received the most attention:

(1) Containment of process wastes in slurry form, in impermeable tailings

(2) Disposal of washed and dried wastes in landfill areas

(3) Disposal of washed and treated waste slurries at sea

It is not now known whether any of these approaches would be absolutely prohibited or approved in all circumstances. While a company will attempt to use the approach that is most economical, the government must know the environmental and economic consequences of these options in order to: (a) prepare an environmental impact statement and (b) develop regulations dealing with these waste disposal alternatives.

Although the Department's ocean mining emphasis dealt largely with deep ocean manganese nodules in FY 1977, other aspects of marine minerals research received considerable attention. For example, in the deep ocean investigation of metallogenesis at plate boundaries continued. On the continental shelf, the Department worked with the Department of the Interior to reassess the nature and extent of industrial interest in mining certain minerals. This project may lead to the development of an environmentally compatible offshore sand and gravel mining industry. In addition, university research, funded by NOAA's Sea Grant Program, involved 16 projects--over half of which dealt with the continental shelf mining of construction aggregates (sand and gravel, and shell).

Several studies were undertaken on the technology of marine mining, either in the deep ocean or on the continental shelf. The Marine Board of the National Research Council's Assembly of Engineering evaluated and reported on government, industry, and public requirements. A study was undertaken to identify federally developed or sponsored technology suitable for tranfer to the marine minerals industry. A report on this pilot project was prepared. In addition, the findings are being used to design a preliminary technology transfer system.

OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

The Alaska Outer Continental Shelf program has as its underlying objective the protection of the environment compatible with the oil and gas development essential to our country's needs. The following four classes of information are needed to meet this objective:

(1) Location of the critical wildlife habitats that must be protected
(2) Prediction of the effects from any pollutant release or other insult
(3) Identification and development of new monitoring techniques
(4) Definition of stresses that the environment puts on man-made structures so as to reduce the number of polluting and safety incidents

The Alaska Program is systematically developing all four classes of information in each of the nine areas (fig. 3) proposed for leasing in the Alaska Outer Continental Shelf. This effort is described in OCSEAP's Program Development Plan, the 10 Technical Development Plans, and the many reports generated by the program.

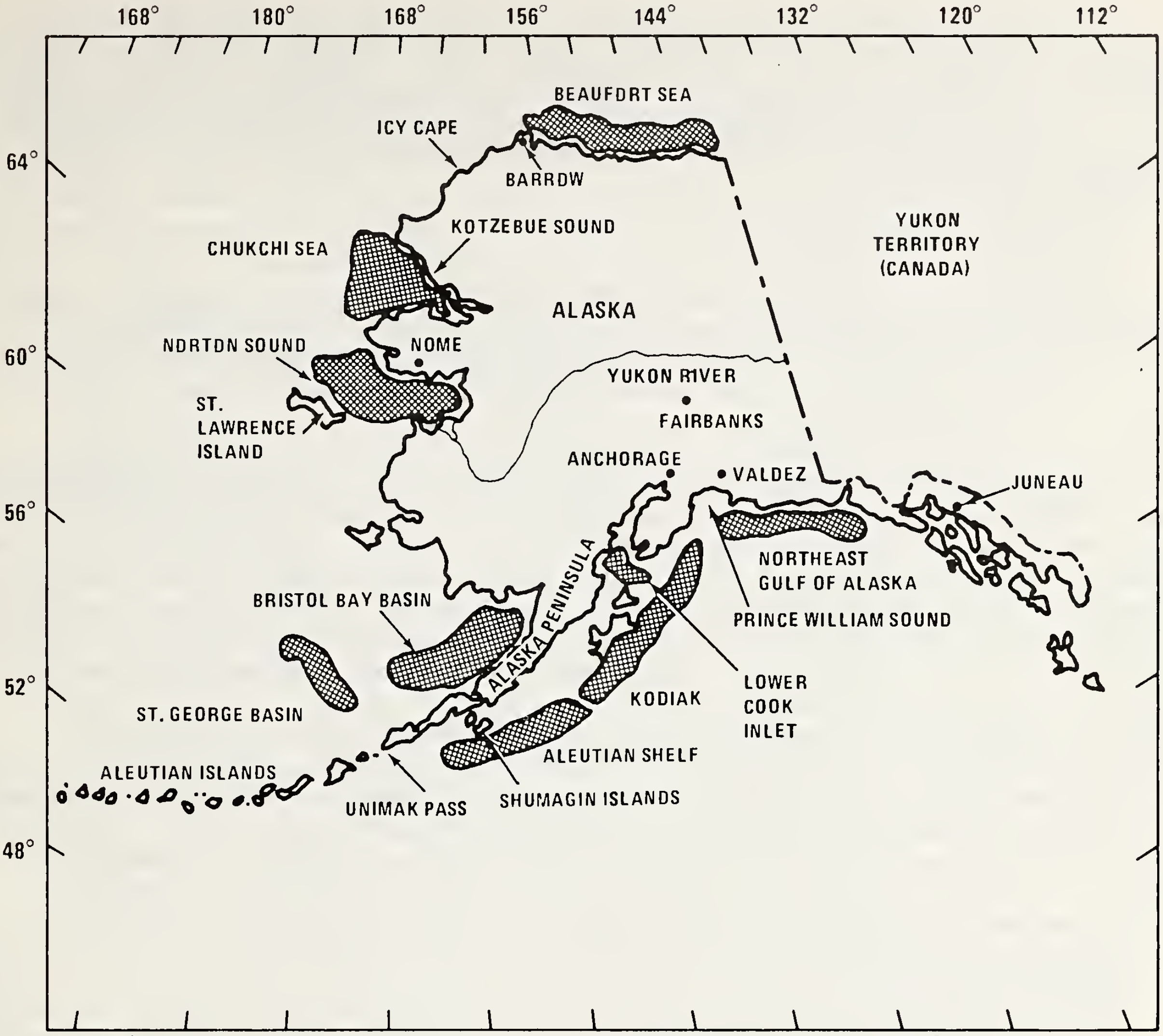

Figure 3.--Alaska Outer Continental Shelf lease areas.

In meeting these information needs, especially the one of prediction of effects, a wide variety of essential biological and physical studies is being directed toward understanding the processes and relationships in the environment. The environment is complex, and consequently the manner in which these studies relate to one another and to oil and gas development is not quickly or easily recognized.

Accomplishments FY 1977

The Alaska OCS region can be divided into three logical geographic units: the Gulf of Alaska, including the northeast Gulf, Lower Cook Inlet, Kodiak Island, and the Aleutian Islands; the Bering Sea, including St. George and Bristol Basins and Norton Sound; and the Beaufort and Chukchi Seas. The dominant environmental features in the Gulf of Alaska are the high seismic activity throughout the area, the strong cyclonic oceanic circulation along the shelf break, and the highly variable and weaker circulation over a relatively narrow shelf. This region is characterized by a subarctic climate which leaves the waters ice-free except some inshore waters such as Cook Inlet. The latter is a large tidal estuary and has features (for example, concentrated freshwater input, high turbidity, and heavy suspended sediment load) differentiating it from the rest of the Gulf of Alaska. Physical processes over the extent of the shallow Bering Sea shelf are governed by a seasonal ice pack, intrusions of warm Pacific Ocean water, and weak, fluctuating circulation patterns. These conditions appear to foster high biological production, because the Bering Sea is one of the world's leading fishery regions. Ice and its temporal fluctuations are the dominant features of environmental processes and levels of biological activity in the Beaufort and Chukchi Seas. Since each of these three geographic areas has different environmental mechanisms characterizing the ecological processes, the research emphasis necessarily varies from one to the other.

Beaufort-Chukchi

Although the Beaufort and Chukchi Seas areas share some physical and biological characteristics, more is known about the Chukchi. This is mainly due to the severe weather; long, dark, cold winters; storms; and ice hazards in the Beaufort Sea. The Chukchi is somewhat better understood, because weather conditions there are more bearable, the ice-bound season is shorter, and access to study sites is therefore easier. Both the United States and the Soviet Union have made numerous studies in past years in the Chukchi Sea region, so more background material is available.

Hazards and Transport. In the past year or two, ice condition maps have been compiled for the years from 1973 to 1976 in the Beaufort and Chukchi. They lead to the conclusion that nearshore sea ice behavior patterns are similar from year to year and consequently predictable. Morphology maps indicate yearly recurring ridge features, leads, and polynyas on a large area-wide scale.

Laser and radar observations off Prudhoe Bay show that fast ice is relatively stable and that its boundary is in 30 to 35 m of water and not in 18 m as generally assumed. Large, grounded, multiyear shear ridges were found along the 15-m contour rather than at 19 m. Other studies of ice conditions and climatic effects on ice breakup showed that 250 to 400 thawing degree days (TDDS) were required to remove fast ice and 400 to 500 TDDs to produce open water extending 80 km off Point Barrow by mid-September. The occurrence of grounded ice masses within the fast ice indicates that offshore structures may be subject to relatively large ice forces, even well inside the 20-m isobath. Stresses generated by an ice sheet moving against a grounded feature were recorded in a floe of multiyear ice near a grounded floe island indicating that offshore structures subject to multiyear ice floe pressures must withstand ice stresses greater than 250 psi.

Examination of vibracores revealed data on distribution of sea bottom environments, especially the absence of gravels except in the immediate vicinity of coastal bluffs and barrier islands. Ice scouring has been shown to rework the sea floor of the inner shelf, at water depths of 5 to 15 m, to 30-cm depths in 50 to 100 years, both width and depth increasing with distance offshore. In the Chukchi Sea, ice gouging is extensive as far south as Cape Prince of Wales into water depths of at least 60 m. Ice gouging apparently causes major disruption of benthic communities.

Data on coastal erosion and morphological changes in the Beaufort Sea were compiled from an impressive assembly of historical data and aerial photos that show the extremely dynamic nature of the Beaufort Sea coastline. Erosion rates are 1 to 2 m per year, with entire spits and islands disappearing in a single storm.

Subsea and ice-bearing (but unbonded) permafrost (material remaining below 0° C) was found most likely to exist over most of the Alaska Beaufort Sea shelf and probably over the northern Chukchi Sea shelf. It is largely absent on the Southern Chukchi Sea shelf (Hope Basin lease area) except in nearshore areas. Ice-bearing but ice-unbonded permafrost may be very irregular. Seismic reconnaissance determined that three barrier islands were not completely underlain by permafrost and might be completely free of ice-bonded permafrost, an important feature in their use for drilling or pipeline landfalls.

A summary of historic earthquake data revealed that the Beaufort-Chukchi Sea areas are relatively free of quakes. However, at Kotzebue, three distinct swarms of ice-quakes were recorded and identified with ice shear and wind-driven ice movement. Earthquake data for the Beaufort-Chukchi area, both historic and from recent OCSEAP studies, show a relatively low incidence of earthquakes, but more definitive work still remains to be accomplished in the use of seismic data to delineate trends of faults and mechanisms of seismic release.

Hope Basin sediments give evidence of gas saturation parallel to the east-west geologic structural trend. Sources of this gas have yet to be determined. Planning for offshore use of gas or oil resources here should give special attention to potentially unstable areas such as the Barrow Sea valley, which now appears to be active with dynamic sedimentation processes.

Coastal morphology work has included a number of studies leading to the following important conclusions:

(1) It is important to evaluate which bay and lagoon entrances in the Arctic are blocked by fast ice during the winter, because salinities in closed waters beneath the ice can be twice as high as those in the open ocean, with an associated temperature on the order of -5°C. Before isolation is completed, dense water may pass out the spill-point of the lagoon and flow seaward. Implications are for the potential of similar transport of pollutants

(2) The rate and depth of gouge activity clearly indicate that ice gouging must be considered in offshore installations, in particular for pipelines

Biological Studies. OCSEAP investigators have compiled an annotated bibliography of published and unpublished material dealing with marine mammals in Alaska. Others summarized the feeding ecology of ringed and bearded seals, major components of the marine mammal fauna of the Bering, Chukchi, and Beaufort Seas. Many species require areas of ice to carry out essential biological functions, and at certain periods they may be highly susceptible to oiling and other processes that lower or destroy thermoregulatory ability.

Results of feeding studies on ringed seals conform to those of previous studies in other areas, showing that ringed seals feed mostly on nektonic crustaceans and small-to medium-sized cod. Densities of this species over-wintering in the Beaufort Sea have been declining since 1970 to the present. Pregnancy rates are also down in Alaskan and especially Canadian ringed seals. Reason for this decline is not yet known.

Status of bowheads and belukhas in the Bering, Chukchi, and Beaufort Seas has been summarized. The area between Smith Bay and Point Barrow is apparently important for bowheads in fall and should be set aside as a critical habitat pending further studies. OCSEAP studies have considered the possible effects of oil pollution on the ecology of Beaufort Sea mammals. They note that productivity is confined to a short period in summer and that algae form the basis for all food chains. Oil spilled in the sea would tend to accumulate under the ice, decrease light penetration, and inhibit algae growth. The short food chain might result in dramatic effects, especially on ringed seals, in a short time. Further studies of petrochemical effects on marine organisms are important if valid predictions of effects on mammals are to be made.

The Beaufort Sea is ice covered for most of the year, but open water is found near the coast from June through October. Few birds were found associated with the pack ice; most are observed in open water within 5 miles of shore. August appeared to be the month of peak use of the Chukchi Sea area by birds. The waters immediately north of the Bering Strait were particularly important at this season, harboring large numbers of several varieties of birds. To date, information from aerial surveys is insufficient to determine potential impacts of OCS programs on the avifauna, as many areas remain unsurveyed at critical seasons. Ship-based studies are needed to be used in con-conjunction with aerial surveys to provide an integrated approach to details of avian distribution.

Studies have been made on seabird colonies at Cape Thompson and Cape Lisburne to provide current information on nesting ecology and population sizes. More populations were found to be about 50 percent lower in 1976 than in 1960. Black-legged kittiwakes exhibited reproductive failure in 1976. Some scientists attribute these effects to a low forage fish population in 1976, particularly arctic cod.

A study of avian community ecology on the Espenberg Peninsula was made to determine habitat use and breeding ecology of waterfowl and shorebirds and the effect of predators on nesting birds. The most important component of nesting failure in some species was predation. Most prevalent predators were red foxes, parasitic jaegers, and glaucous-winged gulls. Human activities here currently have minimal impact on bird populations. The waters around the Espenberg Peninsula support large numbers of molting and migrating fowl at certain seasons, but the mudflats are of prime importance. It was noted that this area appears to be one of the most important feeding and staging areas for shorebirds and waterbirds north of the Yukon delta, particularly as there are few alternate sites available. Long-term studies of "indicator species" are most likely to produce useful data. It is suggested that human activities should be severely limited in late summer when the area receives maximum use from wildlife.

It has now been conclusively demonstrated that shorelines in the arctic are crucial to the reproductive success of a number of arctic-breeding bird species. Preliminary comparisons between bird use of Chukchi and Beaufort littoral zones show the areas to be fundamentally different--critical for different species, different segments of the populations, and for different periods. Summer field efforts in 1977 should reveal whether the low reproductive success in 1976 was an anomalous phenomenon.

<u>Fish, Benthos, and Plankton</u>. In the Beaufort area, the major disruptive force upon nearshore fish fauna now foreseen as a consequence of OCS activity is gravel and water mining in river deltas, because these activities affect fall spawning and overwintering habitats.

Preliminary indications from range maps of benthic organisms suggest that changing sediment grain size may control species distribution patterns in the Chukchi. The regions of the Beaufort and Chukchi Seas may be characterized as poor in species and biomass.

<u>Microbiology</u>. Bacterial populations were lower in the ice-dominated summer of 1975 than in the milder summer of 1976, suggesting that summer ice

conditions are critical in determining bacterial population levels. Bacteria in ice also appear to be highly site-specific. Viable bacterial populations in sediment in winter did not show decreases as they did in water. In examining the potential of the indigenous populations to degrade petroleum hydrocarbons, it was found that their highest winter activity was in waters off Barrow and Prudhoe Bay, indicating that winter oil biodegradation can occur. High biodegradation potentials were also found in sediments.

Bering Sea

The Bering Sea includes three lease areas: Norton Sound, Bristol Bay, and St. George Basin. These have many features in common and will be considered both from the standpoint of similarities and also from points of difference. Most of the Bering Sea outer continental shelf is shallow and slopes gently to the west. The northern part, including Norton Sound, differs from the southern part in that it is heavily influenced by seasonal ice from late autumn through early spring. Shorelines in this section have steep bluffs or cliffs interspersed with a few small beach stretches. The Yukon River delta dominates the eastern portion of the Bering Sea as the Mississippi delta does the Gulf of Mexico. The delta is particularly important as it is the nesting ground of vast numbers of ducks and geese and is used by the large river population of salmon. It has been discovered that the Yukon delta, though it resembles a temperate climate delta, has some startling differences. Almost the entire area is underlain by permafrost and major flooding and changes in active river channels are associated with ice breakup in spring. The flooding would threaten significant damage to any construction in the delta area.

Bristol Bay is a large, comparatively shallow bay of the Bering Sea, similar to Norton Sound, with an average depth of 40 m, whereas the St. George Basin has a relatively steep continental shelf slope trending southeast to northwest. Both Bristol Bay and St. George Basin are biologically very productive. The eastern Bering shelf features one of the world's largest marine mammal populations, a very high abundance of shore and marine birds, the world's largest eelgrass beds, an extremely high commercial catch of fish, and some of the highest daily rates of primary productivity. Seasonal ice cover appears to prolong the period of productivity and enhances annual production. The shelf also provides a critical and seasonal feeding area for migratory birds and animals.

Data on ambient distribution and concentrations of contaminants in the northeastern Bering Sea are limited. It is known, however, that petrogenic (petroleum-derived) contaminants are present. The ratio of levels of methane to ethane confirmed the location of a gas seep south of Nome, attributed to petrogenic sources, but other hydrocarbon contaminants were from biogenic sources. Total hydrocarbon content of sediments in the areas of Bristol Basin and St. George was found to be very small, except for an anomalous value for sediment samples collected at the head of Pribilof Canyon, believed to be indicative of localized petroleum hydrocarbon contamination.

Hazards and Transport. Sea ice gouging of the sea floor results from deep keels of pressure ridges plowing through unconsolidated sea bed sediments in shallow water. It is a well-known feature in the Arctic Ocean and presents serious hazard to OCS development activities, especially pipelines. A large number of areas of ice gouging in Norton Sound have been identified, particularly near the Yukon Delta. An area of gas cratering of the sea floor was also discovered by using seismic profiling and side-scan sonar techniques. It has been noted in several areas, associated with sea floor oil seeps, and is a possible cause of rig failures. Therefore, gas cratering is a process to be carefully considered in planning placement of pipelines and offshore drilling rigs.

Development must also involve an understanding of processes affecting the coastline. Studies of the shoreline of the northern Bering Sea have identified a major cause of shoreline changes - the occasional severe storm during the ice-free summer season. The shoreline is fairly well protected in winter by shorefast ice extending several miles offshore, but it is the summer "storm surge" that causes damage from waves and wind driving the water far above usual high-tide levels.

Circulation studies in the Norton Sound lease area began during the summer of 1976. To date, only limited data are available for analysis. The circulation system appears to be composed of two regimes. The flow in the western two-thirds of the Sound was cyclonic (counterclockwise), and there was evidence of bathymetric steering. The circulation in the eastern one-third of the Sound was sluggish, and the exchange rate with the western basin appeared to be very low.

Maximum earthquake intensities extrapolated from field data for the Bering Sea areas reach magnitude 9.0 along the northern shore of the Alaska Peninsula, 8.0 in central Bristol Bay and close to Unimak Island, and 7.0 along the northern shores of Bristol Bay. A new network around Seward Peninsula, operating for the past several months, shows a sufficient number of quakes (largest magnitude 4.5) to indicate greater seismic activity than previously thought for the Norton Sound. Surface faults tend to be more abundant along the outer margins of the St. George Basin and along the Pribilof ridge.

Unstable sediments appear to be confined to the continental slope and rise and the Pribilof and Bering Canyons. Present knowledge suggests that the Yukon delta and eastern Bering Strait areas have a combination of most severe hazards: faulting and current scour are very intense in Bering Strait; and ice gouging, bottom currents, and storm surges are all intense for a wide area around the shallow pro-delta. Gas cratering may prove to be the greatest hazard of all in Norton Sound.

Studies indicate that major shifting of the location of the Yukon River has taken place several times during the late Pleistocene time, and it would be possible for river waters to reoccupy the more southerly Kashunuk River drainage during a spring ice breakup in the future. This would have staggering consequences, and caution must be exercised when planning construction that might affect the river hydrology.

Bristol Bay region is usually filled with new ice in winter, forming along the north side of the bay and moving seaward, out of the Sound. As it moves into the Bering Sea, the ice can cause extensive riding along the Alaska Peninsula. Contiguous ice is found only in well-protected, shallow areas on the north coast of the bay. The large tides in this vicinity are probably responsible for the limited distribution of contiguous ice.

Owing to its proximity to the shelf break and slope areas, the St. George lease area is characterized by only two zones, the central shelf and the shelf break. Preliminary circulation model results have shown a cyclonic gyre in the deep basin of the Bering Sea, probably advecting significant amounts of nutrients in selected areas.

Biological Studies. A summarization of existing literature and unpublished data on the distribution, abundance, and productivity of benthic organisms in the Bering Sea has been completed, including 6,500 references. An interesting sidelight to benthic studies was a collection and analysis of man-made ocean floor debris, showing that the seafloor is far from pristine. Most debris is assumed to be derived from fishing activities centered along the Bering Sea shelf break.

Plankton studies in the Bering Sea slope and shelf areas covered both the Bristol Basin and St. George Basin lease areas. These studies indicated that primary productivity over the shelf was marked by intense vernal bloom, which developed in response to light availability after the breakup and removal of ice cover. Usually, high values of chlorophyll and primary productivity were noted at stations inside the ice edge.

The Pribilof Islands present a unique and peculiarly vulnerable biological situation. While the ice scour makes the intertidal area appear relatively barren to the casual eye, many plants and animals occur in cracks and crevices intertidally, and the subtidal biota is rich and varied. In many respects, the Pribilofs can be considered a Bering Sea Galapagos. The vulnerability of the islands lies in their small size and lack of nearby areas to provide larvae and spores for repopulation. One major incident could permanently affect their entire shoreline.

Some studies on density distribution of fish eggs and larvae have been made in the eastern Bering Sea. It has been pointed out that limited-period surveys do not provide adequate information on the distribution of larvae or eggs of most or all the economically or ecologically valuable species. Seasonal sampling surveys would be required to understand the duration of spawning, the shape of the spawning cycle with respect to time, and the seasons of spawning and early growth.

Information on feeding biology of species collected by grab has been compiled, mostly from literature sources. The pollock, target of one of the world's largest commercial fisheries in the Bering Sea, is an important link in the food web for that area.

Most important demersal populations of the western Bering are either fully harvested or overfished. Pollock has a relatively large biomass, but the exploitable population is composed mostly of young fish, lowering the reproduction potential. The failure of one or two successive year-classes in such a young population would have disastrous consequences on population size and severely affect the large trawl fishing industry as well as the fish, bird, and marine mammal populations that forage on this species.

Some spawning locations found to be important are: 1) the slope region south of the Pribilof Islands, for Pacific halibut; 2) the area along the outer continental shelf between the Pribilof Islands and Unimak Pass, for pollock; and 3) west and northwest of the Pribilofs, also for pollock. In general, however, the spawning areas of most demersal fish populations in the eastern Bering Sea are not known or are poorly defined, and further studies are necessary if these areas are to be identified and protected.

The area from Cape Newenham to Ugashik Bay (on the north and south shores of Bristol Bay) is most important to western Alaska salmon production. Streams emptying into Kvichak and Nushagak Bays contribute 80 percent of the area's total salmon production, 86 percent of which is sockeye salmon. Peak spawning activity is in August. Investigations of distribution, abundance, demography, habitats, reproduction, and human use of forage fishes in Bristol Bay placed emphasis on herring, but considerable data were obtained on capelin, eulachon, and smelt. Capelin were second in abundance to herring among forage fishes. Populations of Pacific herring and rainbow smelt are greatest nearshore. Smelt occurred more frequently in Norton Sound than in the Chukchi Sea; on the other hand, herring were more common in the Chukchi.

A combination of mainland, island, shipboard, and aerial surveys provided an overview of bird dynamics in the Norton Sound area. The start of the seabird nesting season on St. Lawrence and King Islands was delayed for about 1 week as a result of prolonged snow cover. King Island is a major breeding area for common and thick-billed murres, horned puffins, and least, crested, and parakeet auklets; it also supports important populations of pelagic cormorants, tufted puffins, and pigeon guillemots. Studies primarily concerned with determining the distribution, abundance, breeding schedule, and reproductive success of these species were part of a larger study of the ecology of waterbirds in the Norton Basin. According to reports, black-legged kittiwakes failed to nest successfully in the region. In fact, they apparently disappeared from the region very early, as few were seen from shipboard or aerial surveys. Murres on King Island and at Bluff also fared poorly, with success rates of about 20 percent whereas reproduction on St. Lawrence Island seemed normal.

Major summer field work involved a study of habitats along the Yukon delta and of environmental conditions within 150 miles of Kotlik. During the summer study of the Yukon area, an abundance of birdlife was noted along the delta; pintails, lesser Canada geese, green-winged teal, shovelers, and sandhill cranes were predominant. In the winter study near Kotlik only four species of birds were observed. While the importance of the Norton Sound area to seabird population requires further documentation, it seems clear that spills in the Chirikov Basin could be serious.

Surveys of the coast of Bristol Bay and other areas identified critical avian habitats, such as the estuaries of Ugashik, Cinder River/Hook Inlet, Port Heiden, Seal Islands, Nelson Lagoon/Mud Bay, and Izembek/Moffet Lagoons. Bechevin Bay seems also to be of great importance to migrating birds. According to Arneson the only substantial colony area on the north side of the Alaska Peninsula is on the north end of Amak Island and on two small islands north of Amak. Two moderately large colonies were also reported on the north side of Unimak Island, one at Cape Mordvinof and the other at Cave Point. St. George Island appears to be the largest seabird colony in the Northern Hemisphere.

Marine mammal studies for OCSEAP include investigations of distribution, abundance, and the trophic role of fur seals and bearded seals in the marine ecosystem, description of the population of sea otters, extending from Cape Mordvinof to Cape Lieskof and including Bechevin Bay, Izembek Lagoon, and Moffet Lagoon. Most otter populations remain nearshore, and it has been concluded that all waters less than 60 m deep between Cape Lieskof and Cape Mordvinof should be considered critical for survival of this population, which includes over 17,000 otters. Other mammal studies in this area showed that sea lions were restricted to the first few miles of the ice front and were most abundant south of the Pribilofs.

Densities of ice-inhabiting pinnipeds were studied, and it was estimated that 80 percent of the sea lions in Bristol Bay are concentrated in the eastern Aleutians, from Ugamak Island to Adugak Island. The largest concentrations of harbor seals were at Cinder River, Port Heiden, and Port Moller. The two cetaceans most frequently sighted in the southern Bering Sea are the Dall porpoise and the minke whale.

The only OCSEAP study of marine mammals specific to the St. George area is an investigation of physiological impact of oil on pinnipeds. The Bering Sea was included in investigations on distribution of bowhead and belukha whales, and also in the investigations on effects of pack ice on the distribution of marine mammals. Important conclusions specific to Norton Sound are: 1) bowhead whales leave the Bering Sea in early spring for the Arctic, apparently bypassing Norton Sound, 2) belukhas also bypass Norton Sound in their spring migration; and 3) this area does not appear to be of particular importance to cetacean populations at any season.

Gulf of Alaska

The first Alaska OCS area to be selected for oil and gas development was the Northeast Gulf of Alaska (NEGOA). Thus the first environmental studies sponsored by OCSEAP were begun in this area. Initial efforts were directed toward specific known needs, such as studies of seismic hazards and circulation. However, late in 1976 emphasis in NEGOA shifted from broad-scale descriptive offshore studies to more specific nearshore studies.

Future studies will proceed logically from present understanding of vulnerability to studies of key environmental processes and ecological interrelations.

Initial sampling in Lower Cook Inlet has necessarily been of a reconnaissance nature. Data are generally limited, originating from only a few sampling stations. Hydrocarbon concentrations show a generally low content, less than 1 μg/kg. Only one sample (collected in Kachemak Bay) contained a measurable amount of tar, and that was less than 0.1 mg. Water samples collected southwest of Kodiak Island contained less than 1 ppb hydrocarbon concentration.

Data on heavy metal content of biota are likewise limited. Preliminary results indicate that the Kodiak and Aleutian lease areas are relatively free of heavy metal contamination. It has been concluded that petroleum contamination present in the Alaska OCS environment was minimal.

Hazards and Transport. Analyses of Alaska seismic history and analyses of earthquake intensities and recurrence rates have been added to the summary reported last year. These data, though minimal, indicate annual averages of about six earthquakes of magnitude 4.0 or greater have occurred in the NEGOA region, 2.9 for Lower Cook Inlet, 20.9 for Kodiak, and 10.5 for the Aleutians. Highest occurrence rates for quakes of larger magnitude were exhibited off Kodiak. Excellent seismicity data for Lower Cook Inlet showed three clusters of shallow earthquake activity: near Iliamna, around Augustine Island, and at Cape Douglas. These data need to be correlated with geologic structure data from studies centered on the identification of active faults and areas of sediment instability, types, and distribution.

Several apparently active faults have been identified on the Kodiak Shelf, with a major fault zone possibly along the Kodiak coast trending towards Middleton Island. The shelf off Kodiak shows no evidence of large-scale slides and slump structures as are seen in NEGOA. One fault zone extending along the Kayak Island platform has associated methane and higher molecular weight hydrocarbons along part of the fault trace. Seismic profiles indicate slides and slumps present throughout the Copper River prodelta, extending 20 km offshore, between Kayak and Hinchinbrook Islands. Seafloor slumping is also evident over a large area seaward of Icy Bay. Instability probably results from high sedimentation contributed by the meltwaters of nearby coastal glaciers (e.g., Malaspina).

One significant and unexpected finding by Carlson and Molnia was an area of probably relict glacial ice located at water depths of 180 to 230 m at the head of the glacially carved Bering Trough. High sedimentation rates in this area have possibly provided the necessary insulation to retard melting, but many river basins in the Gulf coast regions are subject to ice-damned lake outburst floods -- examples are the Knik River, the Snow and Kenai Rivers, Tazlina and Copper Rivers, and the Bering River.

Extensive physical oceanographical studies have defined several flow regimes as follows: 1) the Yakutat regime, characterized by small net transport westward with possible eddies and reversals induced by local bathymetry; 2) the Central regime, with consistent flow and apparently under the influence of the Alaska Stream offshore and freshwater input nearshore which separates near Kayak Island with part entering the gyre west of Cape St. Elias and part flowing along the shelf break south of Middleton Island; 3) the Copper River regime, between Kayak Island and Hinchinbrook Entrance, influenced by local freshwater input and bathymetry and a westward moving coastal jet apparently governed by Copper River discharges, moving along the coast; and 4) west and inshore of Middleton Island (part of Western regime), a weak midshelf flow stream exists. The flow between these regimes is continuous. The residence time of water will vary from regime to regime, the shortest time is associated with the Central regime and the longest residence time with Prince William Sound or the Western regim.

Current meter observations in the Northeast Gulf of Alaska and Kodiak lease areas are continuing to characterize mesoscale advective and diffusive processes on the continental shelf. From these and other observations it can be stated that the Alaska Current is intensified off the Kodiak Shelf, similar to a western boundary current. Its influence, however, does not extend into the Shelf where the flow is tidally dominated. The nature of the flow over the Shelf implies a long residence time of water and hence also of water-borne contaminants.

Biological Studies. Historic data on the distribution of nutrients, phytoplankton, and plankton primary productivity in the Gulf of Alaska and adjoining North Pacific Ocean have been tabulated and analyzed to describe annual, seasonal, and geographical variability. Regional and seasonal coverage was by no means uniform; a vast amount of data was from one location only, but the quantity of data and number of sources were extensive.

Seasonal mean values in NEGOA (based on combined data from 1958 to 1974) of chlorophyll a, primary productivity, and nitrate concentration showed generally low concentration of chlorophyll a, except in spring. High values of productivity are noted in spring in the upper 10 m, whereas only moderate levels occur in summer and fall. Nitrate concentration was low in surface and subsurface layers in summer.

Data were also reported on chlorophyll a, primary productivity, available solar radiation, and nitrate concentration in the lower Cook Inlet area. Average values for observations at all stations showed increasing chlorophyll *a* concentration from April through mid-July, decreasing to low levels in late August. Chlorophyll measurements at one station in the inner part of Kachemak Bay were consistently high in early and late May and include one of the highest values reported from natural marine environments. Further studies on the exchange of water in Kachemak Bay, especially in the inner part, will help explain the influence of circulation on the observed high productivity in this locality.

Larrance identified nearly 50 species of phytoplankton collected in the lower Cook Inlet. Four of the nine stations used in the Lower Cook Inlet studies by Larrance were in the vicinity of the Kodiak Shelf and showed the same pattern of increase in chlorophyll from April to July, decreasing to low August levels. Maximum concentration, northeast of Afognak Island, was noted in early May, reflecting a typical shelf bloom of phytoplankton. At another station, 200 miles east of Afognak in deep water, the concentration of chlorophyll remained moderately low, characteristic of deep oceanic waters. OCSEAP has not studied plankton in the Aleutian lease area, and applicable historical data are scarce.

Zooplankton studies in the Gulf of Alaska have identified nearly 200 different species, 21 of which were considered as numerically abundant or ecologically important. It is probable that all species with numerical and biomass importance have now been sampled and only rare species will be added in future sampling. Infauna appeared to be more diverse than epifauna. Research results showed that inshore, shallow shelf benthic infauna differ significantly from that of either the shelf break or the continental slope beyond. Inshore infaunal groups also change from east to west across NEGOA, indicating some change in the composition of the infaunal community along a gradient related to changes in depth.

A summary of existing literature and unpublished data on the distribution, abundance, and productivity of benthic organisms of the Gulf of Alaska and Bering and Chukchi Seas has been submitted with quantitative maps on distribution, abundance, and biomass. In addition, aerial photographic coverage of the entire Kodiak and Aleutian coasts permits quantification of major substrate types. Large beds of eelgrass occur in areas off Cape Sitkinak and the Geese Islands, for example. Floating kelps and benthic algal floras are also richly developed off southern Kodiak, contributing to the abundance of commercial shellfish, such as king crab, in this region.

A final report describing the marine benthic communities of Kachemak Bay has been submitted. In connection with this study, shallow subtidal and rocky intertidal habitats have been examined. Despite strong biological similarities, marked differences in community structure and energy pathways have been noted. Examination of distribution and size data from Kachemak Bay suggests that successful recruitment of major species of both algae and invertebrates is extremely patchy in time and space.

New insights are provided into production of subtidal brown algae around Kodiak. The average standing crop is similar to the highest values reported elsewhere, even from Nova Scotia, which had the highest previously reported value. Kodiak also has extensive beds of floating kelp so thick that small boats have difficulty pushing through them. The greatest number of kelp beds is on the southeastern section of the island, which has a generally wider shelf than the northern section.

It was pointed out at the Kodiak Synthesis meeting that the two most productive shellfish areas are the area east of the Trinity and Geese Islands and the Marmot Bay area on the northeastern side of Kodiak. Shellfish catch from Kodiak areas represented one-third of the total Alaska catch for 1976-77. King, tanner, and dungeness crabs occur in great quantities; studies have delineated Kodiak Island vicinities as of great importance to commercial shellfish fisheries of both the United States and Japan. Shrimp and scallops are also found in commercially harvestable quantities.

An excellent study of the temporal distribution patterns of the larvae of king and brachyuran crabs, and pandalid shrimps in Kachemak Bay has been made. However, the data do not provide any answers to the question as to whether or not Kachemak Bay is an "open" or "closed" system with regard to larval migration. Behavior patterns of larvae are poorly known. Also little is known about the biology of noncommercial invertebrate components of the Kodiak nearshore benthos, such as the razor clam; yet these may be the ones most significantly affected by offshore petroleum operations.

The current state of knowledge of salmonids in the Gulf of Alaska has been summarized for all four lease areas. Prince William Sound is the most important in the NEGOA lease area; the Copper River ranks second, followed by the Yakutat and Bering River districts. Within Cook Inlet the major part (57 percent) of the salmon run occurs along the east shore from Anchor Point to the Forelands. The Kodiak area produces the highest number of salmon, with pink salmon the most abundant.

Important studies on marine birds are being continued, detailing accounts of species and habitats as well as feeding, nesting, and abundance. Specifically, they are obtaining data on distribution, abundance, phenology, and productivity of some species breeding on the four Wooded Islands, constituting the site of one of the largest seabird colonies in the Gulf of Alaska. Another phase of the studies is to determine distribution, abundance, and productivity of shorebird food organisms on the tidal flats. Still another consists of studying breeding and migrations of sea- and shorebirds in the vicinity of Hinchinbrook Entrance to Prince William Sound. Censuses of the latter and Constantine Harbor areas revealed some data on use of this region and the Copper River delta by nonbreeding (migrant) seabirds, and on food habits of the species found. The annual report gives details for numerous species.

Shipboard and aerial surveys are filling gaps in information about seasonal distributions and abundances of birds in Alaska pelagic waters. By far the most numerous species are shearwaters, followed by murres, fulmars, and puffins. Preliminary analysis indicates that the most heavily used habitats are bays, embayments, and open coast, and the most abundant taxa are gulls and shorebirds. In Cook Inlet the largest seabird colony is on Chisik Island in Tuxedni Bay. Kachemak Bay has five known seabird colonies and is an important habitat for seaducks and alcids. Another habitat in Lower Cook Inlet is at Kamishak Bay, which is an important overwintering location for some species. Densest concentrations of birds on the water are observed in Whale Passage. Most abundant birds were shearwaters in summer, murres and guillemots in winter. Fulmars are plentiful on the Semidi Islands, but it was pointed out that glaucous-winged gulls destroyed about 70 percent of the fulmar eggs on Chowiet Island and that any activities favoring expansion of the gull population would threaten the fulmars (this would include establishment of garbage dumps or fish-processing plants). Results of investigations of effects of crude and mineral oils on the surfaces of gull eggs indicate that both oils greatly reduce hatchability. Examination showed embryos had died soon after the eggs were oiled.

Marine mammal studies show increasing numbers of sea otters around the NEGOA and Kodiak areas. A map giving general distribution has been received. The major area source for repopulating these animals is Prince William Sound.

Studies on harbor seals have determined that pups die when they are separated from their mothers because of noise from low-flying planes or helicopters. Increased air activity could result in much higher mortality. Largest center of population of these mammals was found to be Tugidak Island.

Major rookeries of sea lions in the Gulf of Alaska are found in the Kodiak-Barren Islands; migration patterns, hauling-out areas, overwintering areas, and the like have been identified. The Steller sea lion is the most abundant species of marine mammal in the Lower Cook Inlet region; major rookeries are at Marmot and Sugarloaf Islands. Pups born on Sugarloaf Island were observed as far west as Cape St. Elias, as far south as Chirikof Island, and as far east as Kayak Island. The sea lion is also abundant in all parts of the Kodiak lease area.

Microbiology. Other than chemical and physical processes, biodegradation is the only process by which petroleum hydrocarbons may be removed from the environment. OCSEAP-funded research is designed to characterize normal distribution and abundances of heterotrophs, chemotrophs, and pathogens, microorganisms that are essential components of any ecosystem. Special interest is focused on those that are capable of degrading petroleum contaminants to less harmful products, which can then be further degraded. Studies intended to define the behavior of the microbial groups in response to arctic and subarctic conditions have found the number of heterotrophs present in sediments is measurably greater than in water. Based on limited sampling, it has been concluded that there was no significant spatial variability of heterotroph abundance in the water column. However, the abundance of petroleum hydrocarbon degraders was found to be highest along sampling transects just south of Kodiak and Unimak Islands.

Plans FY 1978

The August 1977 revision of the BLM OCS lease schedule extended the June 1975 (or November 1976 schedule sale dates) 2 to 4 or more years into the future for most Alaska lease areas. This extension of the lease schedule provides for longer-term environmental studies before the lease sales in most areas. Sales through 1981 do not include areas in the Hope Basin, offshore Beaufort, Bristol Bay, St. George, and the Aleutians, or the Navarin Basin and the Barrow arch in the Chukchi. Several of these rank very high in industry interst:

Items from lease sale schedule

Lease sale number	Lease area	Proposed sale date (August 1977 schedule)		Duration of studies program, inception to sale (months)
39	NEGOA	April	1976	21
CI	Cook Inlet	October	1977	16
	Federal/State Beaufort	December	1979	55
55	Gulf of Alaska	June	1980	70
46	Kodiak	October	1980	65
60	Cook Inlet	March	1981	57
57	Bering-Norton	December	1981	66

OCSEAP environmental studies will proceed as rapidly as possible with available funds in the 4- to 6-year time frame specified by the new schedule. This will permit an adequate environmental data base for assessment based on the pre-sale environmental studies (specifically, hazards assessment, benchmark chemical characterization, circulation and trajectory analysis, and biological characterization) in the frontier OCS areas of Alaska. The OCSEAP Program Development Plan discusses the study content and typical phasing of projects.

Some tracts have been removed from consideration for sale because of hazards identified in the OCSEAP program (e.g. faults, unstable bottoms). Tracts and possibly entire lease areas have also been removed from sale consideration because there was insufficient environmental information to know that development could proceed safely. The OCSEAP is working hard to fill information gaps.

For adequate assessment of potential impacts from OCS oil and gas development, with data and techniques available to satisfy requirements at various decision points, the studies must continue at their current level of effort through 1981 and beyond, if additional lease areas are reinserted into the lease schedule. After the lease sales in each area, environmental studies should be intensified in those site-specific areas under consideration for development (including potential pipeline corridors and onshore facility sites).

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1978— 281-067/354

NOAA--S/T 78-291