Environmental Assessment of the Alaskan Continental Shelf

Executive Summary

April 1976 - March 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

The facts, conclusions and issues appearing in this report are based on interim results of an Alaskan environmental studies program managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, and primarily funded by the Bureau of Land Management (BLM), U.S. Department of the Interior, through interagency agreement.

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ALASKAN MARINE CONCERNS AND KEY ISSUES, 1977

A Message From the Director

The Alaskan Outer Continental Shelf Environmental Assessment Program (OCSEAP) has as its underlying objective the protection of the environment compatible with the oil and gas development essential to our country's needs. 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 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.

In meeting these information needs, especially the one of prediction of effects, we find a wide variety of essential biological and physical studies 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.

The Alaskan Program of the National Oceanic and Atmospheric Administration is systematically developing all four classes of information in each of the nine areas proposed for leasing in the Alaskan OCS under sponsorship of the Bureau of Land Management (BLM). This effort is described in OCSEAP's Program Development Plan, the ten Technical Development Plans, and the many reports generated by the program. Within the context of the effort, a number of serious concerns or "key issues" have already been identified in the Alaskan marine environment.* A listing of these serves to illustrate the nature of OCS-related environmental

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*These key issues listed do not include socio-economic and certain non-petroleum contaminant issues, such as sewage, nor certain engineering design issues which are not assigned to OCSEAP for planning and management, but which are nevertheless of considerable significance.

problems confronting the OCSEAP. It also provides a brief overview of the scope of OCSEAP program content and demonstrates the imperative nature of the studies. This list is not exhaustive, and will no doubt be modified as the studies continue.

Arctic

1. The arctic marine environment is extensively controlled by the presence, character and behavior of ice. There is a close association between the biota and the ice edges and leads. This has the potential of concentrating the biota in the very places and at times where spilled oil may be confined. It is possible that the entire Beaufort population of some species makes use of a traditional lead during spring migration.

2. When the ice is far offshore, as in the summer of 1977, ice habitats for seals are limited. An ice remnant in Harrison Bay was seen to attract a large proportion of western Beaufort Sea seals. If this ice feature is found in future years, it should be classified as a critical habitat.

3. The significant decline in ringed seal population, compared to 1970, and reduced pregnancies is still unexplained. Ringed seal population is moving southward and westward as are polar bears. It is speculated that the population reduction is related to severe ice conditions and decreased availability of food. Since we are presently unable to explain such changes, we cannot confidently predict the impact of oil and gas development on these species.

4. There are great uncertainties in the endangered bowhead population, reproduction, migratory routes and overwintering range. Only 578 bowhead were counted passing Barrow in the spring quarter of 1977, most of those between May 1 and 16. Although possibly not threatened by low concentrations of oil (however, see item 27), the bowhead whale population may be threatened by presence of man and his activities. The bowhead are an endangered species and require special protection by man. Numbers of them congregate between Barrow and Smith Bay in the fall and this region should be treated as a critical habitat. OCSEAP is coordinating with other agencies funding complementary studies on bowhead whales.

5. Development must deal with the dynamic nature of the Beaufort coast, which erodes at 1-2 meters per year and in some areas as much as 30 meters per year. Entire spits and islands can disappear and reappear on occasion in single storms. Barrier islands are part of this dynamic system, and their stability and usefulness as habitats may be threatened by demand for gravel. Careless removal of gravel from river bottoms may also affect critical habitat for the overwintering of fish. Of equal concern to gravel removal in the arctic is the whole subject of freshwater removal in support of operations. Drawdowns of fish overwintering pools destroy local populations in winter.

6. Changes in circulation in the nearshore and lagoon regions are expected to be produced by causeways and other structures. The inshore and barrier island lagoon areas are especially important to fishes. One may expect changes in salinity and nutrient supply, both minerals and detritus, and possibly in barrier island building and movement when circulation is blocked. These changes would primarily affect nearshore fish species which are an integral part of the food web.

7. We also recognize the need for studies of the sensitivity to petroleum of arctic forage fish and other important trophic elements such as euphausiids and amphipods. Should the fry be especially sensitive, there could be serious consequences to mammal and bird populations even from modest oil contamination. There are few data on arctic organisms and we hesitate to extrapolate (to the arctic outdoors) results from laboratory studies on subarctic species. Because rates of reproduction and growth are slow in the arctic, organisms may be more vulnerable to insult and some populations of fish and mammals will recover very slowly from any resultant damage. Thus damage must be sedulously avoided or minimized.

8. The need for effects studies on arctic forage species is accented by the observations that the population of murres at Cape Thompson is down 50% compared to 1959-61, and there was virtually complete reproductive failure of black-legged kittiwakes in 1976. It is speculated that a shortage of forage fish was the reason. The drastic reproductive failure was observed in subarctic Norton Sound as well. Although many species are known to fluctuate widely in numbers from year to year, we have insufficient knowledge of the population dynamics of many Alaskan species to know whether such a failure is unusual, or is a threat to the species. The near doubling of the Least Auklet population in ten years is also unexplained; we do not even know if this is natural variability. This emphasizes our inadequate understanding of arctic systems and as a consequence our inability to predict reactions to development.

9. Storm surges are a frequent occurrence in the Beaufort Sea and observations of driftwood on islands and beaches suggest that some islands may be entirely awash during such surges. Storm surge heights may exceed two meters, and since the topographic relief along the Beaufort Sea coast is very small, spilled oil may be distributed quite extensively over islands and lagoons, salt marshes and estuaries during such events. Reliable statistics and research into conditions that induce such occurrences, as well as establishing the aerial extent of surges, remain to be completed.

10. Ice poses a spectrum of threats to development. In the nearshore zone, where leasing will occur first, the fast ice is not stationary but may move by several meters or even tens of meters during events that compress the ice. Even thermal expansion may cause movements up to a meter. There is a high density of pressure ridges in the fast ice, and ice-shove, the overriding of beaches by the ice by several tens of meters in distance, occurs regularly in some areas.

    Other ice hazards include the gouging of the ocean floor by the keels of the pressure ridges and ice islands, producing furrows up to 6 meters deep. Hundreds of criss-crossing gouge tracks per kilometer have been recorded, and in some areas the sediments get completely reworked every 30 years or so to a depth of 30 cm. The pressure ridges and keels that produce these gouges may be up to 50 meters thick and can exert large forces and threats to structures. Internal pressures up to 250 psi have been exerted by multi-year ice floes. Grounded shear ridges have been found in water depths as shallow as 15 meters.

11. Oil spill clean-up in the Arctic, is virtually impossible for most areas and for most of the year. Oil can be burned when it moves to the surface of the ice, but the effects of this on the biota are unknown, as are the effects of using detergents. There is some hope for effective summer clean-up if not too much ice is present, and some limited hope for tackling spills under fast ice, but there is no available method for cleaning up spills in the zone of moving pack ice. A moderately-sized well blowout (2500 barrels per day initially decreasing to 1500 barrels after one month) in the pack ice of the Beaufort Sea will probably produce a track of oiled ice 600 km long and one km wide, based on available ice statistics.

During winter bacteria able to biodegrade petroleum in the arctic are highly localized, so that the degradation of oil in a spill will be highly dependent upon its location. Further, degradation will be limited in winter by generally lower numbers of microorganisms and in late summer by abiotic limiting factors. Observations are that after two months time, degradation slows and the oil's chemistry changes little.

Subarctic

12. At least in the spring season, there are two gyres west of Kayak Island. The innermost and weaker of these gyres carries water from offshore toward the coastline and the Copper River delta critical habitat. It is

important to define this complicated gyral system further to determine whether these features are seasonal or permanent, to describe the circumstances under which offshore pollutants might become involved, and determine if these may be coincident with vulnerable biota.

Areas of low rate of water circulation and low flushing rates probably exist in all lease areas, and many have not been identified. Low circulation areas may entrap planktonic eggs and larvae as well as spilled contaminants. This has the potential of exposing the more sensitive life stages. Examples of these areas include the gyres west of Kayak Island, an area near Yakutat, and the coastal shelf area of Bristol Bay. Mean current in the St. George Basin is only a few km/day, which although it would possibly aid cleanup activities for acute spills, would also provide a long residence time for chronic exposure.

13. Lagrangian drifters released in the NEGOA lease area have shown a strong tendency to enter Prince William Sound. A better understanding of the factors influencing Prince William Sound inflow and outflow will be required to predict the path of pollutants from both the NEGOA development and from the tanker traffic in the area. Prince William Sound is an especially rich habitat for a wide variety of important biota ranging from whales and salmon to profuse benthic life. Hinchinbrook Entrance and Montague Strait are important concentrating or foraging areas for marine mammals.

14. The Kodiak lease area is known to be extremely productive in terms of commercial utilization and is probably equally important to non-commercial species. Unfortunately, nearshore circulation and biological data are not yet adequate to fully explain this productivity or to predict movement of pollutants. Trophic relationships on which higher forms depend are not yet defined.

15. Although experience with offshore oil development in the northern part of Cook Inlet has shown that environmental hazards short of major earthquakes can normally be dealt with, it is clear that Cook Inlet structures and pipelines must cope with high tidal currents, high rates of sediment movement, active faults and seismic activity, and the existence of ice during the winter months. Mt. Augustine is an active volcano and additional volcano eruptions are possible with accompanying tsunamis. In 1883 an eruption produced waves 30 feet high across the Inlet in English Bay.

16. Historical earthquake recurrence rates off Kodiak exhibit considerably higher frequencies than either NEGOA or Cook Inlet. Several faults have been identified, including a suspected major fault zone nearshore. A major earthquake is expected in the "Shumagin gap". Faults with vertical offsets (movements) as great as 20 meters have been observed in NEGOA.

17. The eastern Bering Sea is a productive ocean region containing some of the largest fish, crab, and marine mammal stocks in the world. Several factors may contribute to this productivity, which may be affected by petroleum pollution. For example, the ice edge, which has been shown to be biologically important, would be likely to concentrate and trap spilled pollutants in its many leads and irregularities.

18. Gas cratering, apparently due to gas from decaying peat in Norton Sound, has been observed off Nome and the mouth of the Yukon. The potential of cratering represents a threat to rigs and pipelines. Past craters may have been obliterated by ice gouging, which occurs in Norton Sound, particularly close to the Yukon delta, though with gouge depths generally less than one meter.

19. Norton Sound is subject to storm surges far above usual tide levels. The storm of November 1974 pushed water four meters above average sea level, and had waves three or four meters high. It is essential that these extremes be included in the planning of shore facilities and oil handling.

20. The Yukon delta is both a critical habitat for vast numbers of waterfowl and salmon, and an unstable, vulnerable foundation for man to build on. It is underlain by permafrost, has major flooding in the spring, and even has the potential for major relocation of the main channel. Its low elevation may permit the intrusion of contaminants on storm surges.

21. Northern sea lion numbers in the eastern Aleutian Islands appear to be at about one half of their 1950 levels. Eighty percent of these are in the Fox Island group, and large numbers remain there through the autumn. The population drop may be within the range of "natural" variability but may not. When we do not know either natural variability, its reasons, or the population dynamics of the species, we are unable to assess the effects which man's activities may have.

22. We are continually aware that oil and gas development may have a surprise side-effect on some species with a cascading disastrous effect on others. As an illustration, it has been hypothesized that if starfish are quite sensitive to hydrocarbons, eelgrass communities may suffer. Starfish control the sea urchin population which grazes the eelgrass beds -- important nurseries of the sea. A comprehensive understanding of the interrelationships among species and processes is needed to determine the reality of a multitude of such hypotheses.

23. The Pribilof Islands are clearly a critical habitat that must be carefully protected. Here is the bulk of the world's population of red-legged kittiwakes, a very large total population of birds, and the entire world's

northern fur seal population for a limited time period. The birds are disturbed by noise with significant resultant egg loss. The seals are subject to cold exposure upon oiling, with other possible effects of oil on them and their young as yet unknown. The islands are downstream from the St. George lease area and from Unimak Pass (through the Aleutians), which will eventally bear major tanker traffic. There are only a few sites that could be used for staging and loading in the development of the St. George Basin. Our concerns are whether the island populations can withstand any intrusion. Sufficient definition of oil transport in the water upstream from the Pribilofs is needed to be able to specify tracts and transportation corridors that represent threats.

<u>All Lease Areas</u>

24. We are concerned with the probable large increase in population of predators, e.g., foxes and gulls, that overwinter successfully with man's oil and gas developments. These predators will affect bird populations to a greater degree as development occurs.

25. There are apparently localized but important areas of "live bottoms" (e.g., boulder fields and reefs) which have been found in the Beaufort Sea. Others may exist elsewhere. The significance of these can be great and their sensitivities are unknown.

26. Long-term accumulation of hydrocarbon in tissue is not yet quantified. From a 60-day experiment, evidence is that accumulation in tissues of deposit-feeding organisms does occur. The significance of this is unknown.

27. We have no definitive knowledge of the effects of oil on large mammals including the bowhead whale. It is reasoned, and observed in controlled studies on seals, that nasal and eye effects occur, but effects on the total populations are totally unknown.

28. It is unknown what effects the presence of man will have on use of breeding and calving areas. There is a real possibility that whale calves could not survive in colder waters if driven from present "warm" water calving areas in the Mackenzie or elsewhere. One investigation observed a 10% mortality of harbor seal pups on Tugiduk Island as a result of disturbance by low-flying aircraft. This island, 20 miles southwest of Kodiak Island and downstream from the lease area, has the largest concentration of seals known, at least 13,000. Bird investigators have reported similar observations of disturbance, particularly for cliff-nesting species. It is not clear whether mortality will continue to increase with more frequent disturbances, or if tolerance could be induced.

29. The breeding areas and important migratory pathways have been identified for many bird and mammal species. It is not clear, however, how to predict or evaluate the results of a pollution event. First, breeding success may be due to availability of food, i.e., a suitable "prey" species. These trophic relationships are not well understood, and the vulnerabilities of prey species to petroleum pollution have yet to be defined. Second, if a breeding colony were wiped out, it would be difficult

to evaluate this impact without an understanding of recruitment rates and breeding success in other areas.

Future Plans

The August 1977 proposed revision of the BLM OCS lease schedule extended the sale dates two to four or more years into the future for most Alaskan lease areas. This extension of the lease schedule has the advantage of providing time for the longer term environmental studies prior to 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, nor the Navarin Basin and the Barrow arch in the Chukchi. Several of these rank very high in industry interest (Oil and Gas Journal, August 22, 1977).

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 (first)	October 1977	16
	Federal/State Beaufort	December 1979	55
55	Gulf of Alaska (second)	June 1980	70
46	Kodiak	October 1980	65
60	Cook Inlet (second)	March 1981	57
57	Bering-Norton	December 1981	66

Our plans are to continue studies filling the four classes of needed information mentioned earlier, of which the above issues are illustrative. The studies will proceed as rapidly as is possible with available funds, recognizing that 4-6 years minimum time is required to obtain environmental data in each lease area when adequate funding is provided. With constant level funding ($20 million from BLM and $6 million from NOAA), plus an inflation factor

OCSEAP believes that adequate data and techniques will be available to satisfy requirements of assessment at various decision points in the current lease schedule.

Some tracts have been removed from consideration for sale because of hazards identified in the OCSEAP program (e.g. faults, unstable bottoms). Also, tracts and, allegedly, entire lease areas have been removed from sale consideration because there was insufficient environmental information to know that development could proceed safely. The OCSEAP is working hard to obtain this missing information. In order to meet the 4-6 year study minimum for lease areas opening up after 1981, we must have adequate funding on a stable, continuing basis in all lease areas and adequate lead time to modify program emphasis in response to future changes in the lease schedule. Decreasing funds will not permit the attainment of adequate environmental information in time for decisions. After the lease sales in each area, environmental studies should be intensified in the specific sites under consideration for development (including potential pipeline corridors and onshore facility sites).

R. J. Engelmann, Director
Outer Continental Shelf Environmental
Assessment Program

November 22, 1977

EXECUTIVE SUMMARY

PREFACE

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) focuses on nine lease areas on the Alaska Outer Continental Shelf (OCS) from the Northeast Gulf of Alaska (NEGOA) to the Beaufort Sea (Figure 1). The vast geographic area included involves extreme environmental conditions. The harsh environment and resultant severe working conditions are largely responsible for the lack of marine environmental information on the Alaska OCS, less than on any other shelf and coastal area of the United States. The existence of oil under the continental shelf, the demand for new domestic sources of energy, and recognition of the lack of basic environmental information have accented the need for a well-developed research program.

Expeditious development of the Outer Continental Shelf (OCS) is essential to meet the energy needs of our Nation during the remainder of this decade and throughout the next. The OCS oil and gas deposits can provide a large national source of petroleum during a time when it is greatly needed. In each OCS area for which development is proposed, extensive environmental studies are to be conducted before such development can proceed with safety. As manager of the Outer Continental Shelf leasing program, the Bureau of Land Management (BLM) of the Department of Interior (DOI) has asked the National Oceanic and Atmospheric Administration (NOAA) to conduct the Outer Continental Shelf Environmental Assessment Program (OCSEAP) as an essential part of its management responsibility.

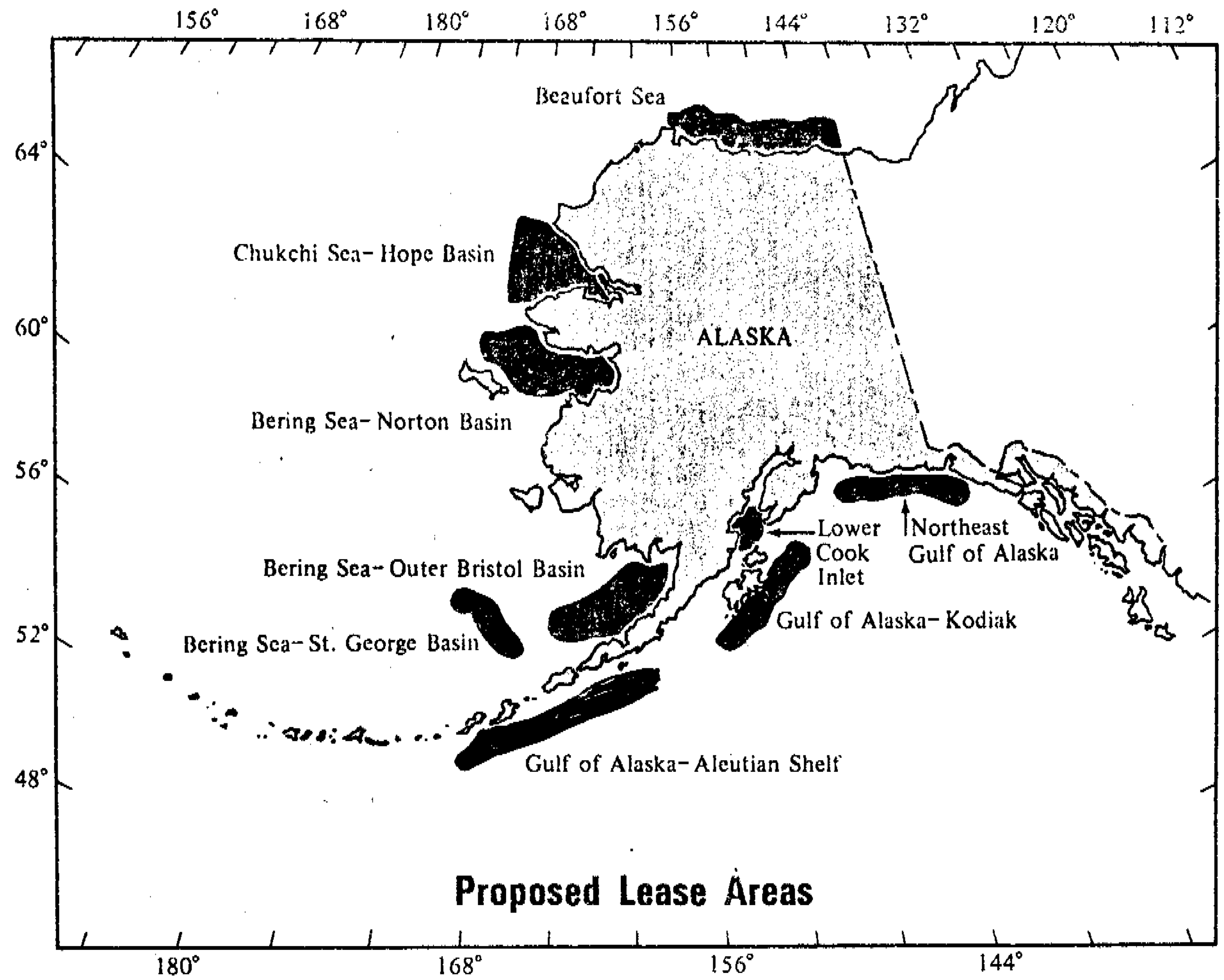

156°
168°
180°
168°
156°
144°
132°
120°
112°
64°
60°
56°
52°
48°
Beaufort Sea
Chukchi Sea- Hope Basin
ALASKA
Bering Sea- Norton Basin
Lower Cook Inlet
Northeast Gulf of Alaska
Bering Sea- Outer Bristol Basin
Gulf of Alaska- Kodiak
Bering Sea- St. George Basin
Gulf of Alaska- Aleutian Shelf
Proposed Lease Areas
180°
168°
156°
144°

FIGURE 1

INTRODUCTION

In May 1974, the BLM requested that NOAA initiate a program of environmental assessment in the Northeastern Gulf of Alaska in anticipation of possible oil and gas lease sales in that region early in 1976. These studies were initiated in July 1974. A major expansion of the environmental assessment program was requested by BLM in October 1974 to encompass eight additional areas of the Continental Shelf of Alaska during the FY 1975-1976 period. After an intensive planning effort including workshops, public comment and consultations with more than 300 scientists and other concerned persons, a program proposal equivalent to a plan was published. This document was entitled "Environmental Assessment of the Alaskan Continental Shelf, First 18-month Program - Gulf of Alaska, Southeastern Bering and Beaufort Seas, April 1975."

Since that document was approved, scientific efforts have been extended into the northern Bering Sea, Chukchi Sea, and Lower Cook Inlet. Many of these efforts are simply geographic extensions of the work underway in earlier areas, already subjected to wide review and comment.

The Program Development Plan (PDP), completed in December 1976, brings into one interagency document the planned environmental study program for all nine proposed lease areas of the Alaskan OCS. It presents an applied study program responding to the specific needs, goals and objectives of BLM. A program of studies for the nine lease areas of Alaska plus some non-area specific studies is planned and conducted for BLM by the National Oceanic and Atmospheric Administration's OCSEAP offices. This program is intended to assemble existing fragmentary historical data as well as to conduct and integrate new studies necessary to provide a basis for assessment of impacts of petroleum exploration and development.

Major efforts of studies since 1975 were those of broad scale surveys or reconnaissance. They produced information defining circulation patterns, current trajectories, ice hazards, seafloor faults, seismic activity, areas of unstable sediments, critical habitats, and biological populations. They also provided baselines for hydrocarbon and trace metal concentrations. Site specific studies will be amplified in fiscal year 1978 (FY 78) to fill data gaps in nearshore processes and trophic relationships of various biological communities.

A program management system assembled by NOAA contains the mechanisms for developing and implementing an interdisciplinary scientific program to include guidance to investigators, contracting for specific deliverables, and reporting the results, interpretations, and recommendations to BLM. This is accomplished through the use of an interdisciplinary staff in the planning activities and in the synthesis and integration of the results.

Needs stated by BLM and analysis of the program results are both used in the planning. The planning activity produces annually a Technical Development Plan (TDP) for each of nine lease areas and a Plan for non-area-specific studies. These are developed by the interdisciplinary staff of the NOAA-OCSEAP Office, with input from the Bureau of Land Management, the State of Alaska, and a Users Panel composed of representatives from several Federal and State agencies and from private environmental groups. Meetings are held with the scientists to coordinate efforts and to improve program direction. After approval and commitment of funding by BLM, these plans are implemented by NOAA and the results reported in quarterly status reports and summarized in annual reports.

NOAA-OCSEAP also provides and arranges for the ships (these in large part with NOAA funds) and the aircraft support needed to operate in the inhospitable Alaskan environment. OCSEAP monitors each contract and evaluates and reports on performance, adjusting resources as needed within the scope of the approved Technical Development Plans (TDP) for the Alaskan Outer Continental Shelf program.

The primary goal of the Alaska OCS program is to provide background information for management decisions required to protect the marine and coastal environment from damage. Meaningful data are required in a timely and effective manner so that preventive or corrective actions may be taken to avoid serious or irreversible impacts. Scientific objectives addressed must conform to the program and goals of the Bureau of Land Management for all OCS areas, including Alaska.

The objectives of the BLM environmental studies program for all OCS areas, including the nine Alaska areas and non-site-specific lease area studies are:

1. To provide information about the OCS environment that will enable the Department of the Interior and the Bureau of Land Management to make sound management decisions regarding the development of mineral resources on the Federal OCS.
2. To acquire information that will enable BLM to identify those aspects of the environment that might be impacted by oil and gas exploration and development.
3. To establish a basis for prediction of the impact of OCS oil and gas activities on the environment.

4. To acquire impact data that may result in modification of leasing regulations, operating regulations, and OCS operating orders in order to permit more efficient resource recovery with maximum environmental protection.

In response to these program objectives, the environmental investigations of the Alaska OCS Environmental Assessment Program must address scientific objectives (henceforth referred to as Tasks) which are to determine:

A. Contaminant Baselines - Determination of the pre-development distribution and concentration of potential contaminants commonly associated with oil and gas development.

B. Sources - Determination of the nature and magnitude of contaminant inputs and environmental disturbances that may be assumed to accompany exploration and development on the Alaskan continental shelf.

C. Hazards - Identification and estimation of the potential hazards posed by the environment to petroleum exploration and development.

D. Transport - Determination of the ways in which contaminant discharges move through the environment and how they are altered by physical, chemical and biological processes.

E. Biological Receptors - Determination and characterization of the biological populations and ecological systems that are subject to impact from petroleum exploration and development.

F. Effects - Determination of the effects of contaminants and other insults on individuals, populations, and ecological systems.

The interrelationships among the tasks, subtasks and research units is depicted in Figure 2.

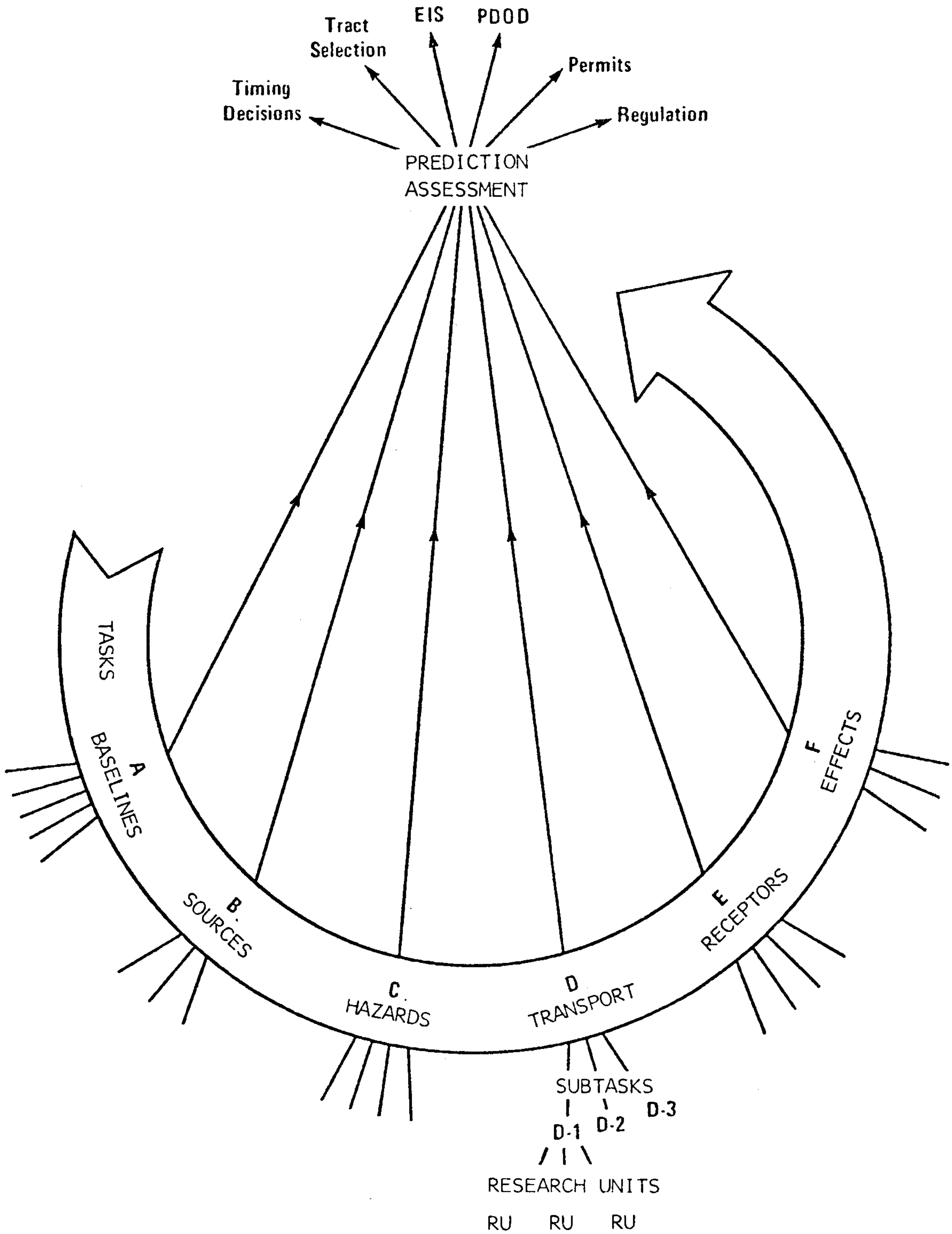


FIGURE 1-2 RELATIONSHIP BETWEEN INDIVIDUAL RESEARCH UNITS (RU) AND THE ASSESSMENT PREDICTION FUNCTION OF BLM. ALSO, THE SEQUENTIAL RELATIONSHIP AMONG THE SIX TASKS, ALL OTHER TASKS FEEDING INTO EFFECTS AND THENCE TO ASSESSMENT.

MANAGEMENT

General

Overall management, fiscal, and coordination responsibilities rest with the OCSEA Program Office in Boulder, Colorado. However, two project offices have been established in Alaska, one in Juneau, which coordinates with the State of Alaska, and the other in Fairbanks, which coördinates with the University of Alaska. These two project offices direct the research efforts of more than 150 scientists (principal investigators). Their chief responsibility is to maintain both an orderly flow of quality-controlled data to produce data products as called for in the TDPs and the contracts designed to fulfill the requirements of those TDPs. To accomplish this, the contracted studies are monitored or "tracked" by scientific personnel of the Project Offices. The Project Offices also provide and coordinate logistics needs, such as ships, aircraft, housing, and supplies.

NOAA also manages the data flow from the Alaskan program by providing formats and reporting, archiving, and analyzing the data. NOAA issues a catalog listing by file type the OCSEAP data received. NOAA monitors and works to improve data quality, both in the encoding and in the instrument quality, calibration, and standardization aspects.

The products and deliverables of the program are directly and immediately applicable to BLM needs for prediction, assessment, setting stipulations, and regulation. They include models for calculating oil transport and for estimating biological damage, charts of geological hazards and of the distribution of biological parameters and biota, probability distributions for hazards, and data sources and banks for future reference and analyses.

The authorized funds for FY 1977 Alaskan program were $21.1 million from BLM, plus NOAA ship-time contributions of $5.0 million. These funds were distributed by lease area in accordance with the lease schedule and deficiencies in environmental information. The planning recognizes that there will be successive sales in the same lease area, and that even after development proceeds, a continuing study and monitoring effort will be essential.

Planning

During April, 1976, NOAA submitted a draft Program Development Plan, FY 1975 -FY 1980 (usually referred to as the "Five Year Plan") which outlined the research plan for that period. After extensive discussion between BLM and NOAA, two types of planning documents were agreed upon. First, a new Program Development Plan (PDP) would be prepared to describe the program goals and objectives, technical approach, and management plan for the program in general. Second, Technical Development Plans (TDP's) for each lease area would be prepared each fiscal year describing in detail the work planned. The PDP was approved by BLM in December 1976 and since time did not permit the preparation of TDP's before the start of FY 77, research units were approved by BLM on an individual basis for FY 77. Work began in January on the TDP's for the FY 78 program, and these were approved on August 15, 1977.

Workshops

A number of workshops were sponsored during the period. Workshops were greatly varied in format and purpose but were of two general types: the disciplinary workshops, such as chemistry, bird studies, or microbiology, brought together the PI's with staff scientists to discuss the content of the ongoing research and preliminary results, to arrange coordination and data exchange, and to solicit PI comments on future research and program management; planning workshops, such as the Bering Sea meeting and the Barrier Island Lagoon study meeting, discussed the scientific program content of future integrated research efforts. These workshops have provided an excellent opportunity for discussion and exchange of ideas as well as essential feedback to the program management staff.

These workshops were held:

Canadian Beaufort Sea Project Review	23-25 June 76
Barrier Island Lagoon Study Planning	28-30 July 76
Microbiology	10-11 Aug 76
Bering Sea Integrated Program	3-6 Oct. 76
Oceanography-Meteorology	13-15 Oct. 76
Microbiology	19-20 Oct. 76
Bird Studies	20-22 Oct. 76
Barrier Island Lagoon Study	3-5 Dec. 76
Program Management & FY 78 Planning	6-10 Dec. 76
Permafrost	5 Jan. 77
Chemistry	16-18 Feb. 77
Lower Cook Inlet Planning	8-10 March 77
Barrier Island Lagoon Study	6-8 April 77

Synthesis

Four synthesis meetings were conducted which integrated disciplinary data for the particular lease areas in order to meet BLM decision-making needs and to provide inputs for future research. These meetings, attended by principal investigators, BLM personnel, OCSEAP management, and other scientists, concentrated on identification of key species, important processes and interactions in terms of possible impingement from oil and gas development. Such meetings provide a primary mechanism for arranging interdisciplinary interpretation of observed data. Draft reports summarizing results of proceedings were distributed to participants for their comments and corrections. (See later section on Synthesis meetings results.)

A special planning meeting was held coincidental with the Kodiak synthesis meeting to respond to a BLM request for a plan for an augmented Lower Cook Inlet research program. Although the proposed plan was not funded in FY 77, many aspects of it were incorporated into the program plan for FY 78.

The four synthesis meetings held were:

Lower Cook Inlet	16-18 November 1976
NEGOA	11-13 January 1977
Beaufort - Chukchi	7-11 February 1977
Kodiak	8-10 March 1977

Management Support

Support for OCSEA Program management was provided under contract by Science Applications, Inc., whose Boulder office is staffed with a complementary mix of disciplinary scientists. SAI's major tasks involved the planning and preparation of five lease area reports and results of the four synthesis meetings. These were all used in preparation of the April 1976 Annual Technical Summary Report which summarized the key findings of annual reports (14 volumes) submitted by the principal investigators. SAI also made important contributions on shorter term efforts, such as the integrated Bering Sea research plan.

Publications*

In addition to program planning documents already referred to, a number of other publications were prepared and distributed:

FY 76 Work statements	distributed May 76
FY 75 NEGOA Annual Technical Report Summary	to BLM April 76
PI Annual Reports (year ending March 31, 1976)	distributed October 76
Annual Technical Summary Report '76 including Annual Executive Summary	distributed March 77
PI Quarterly Reports (April-June 76)	distributed October 76
PI Quarterly Reports (July-Sept. 76)	distributed November 76
PI Quarterly Reports (Oct.-Dec. 76)	distributed March 77
Quarterly Report to BLM (Jan.-Mar. 76)	distributed May 76
Quarterly Report to BLM (April-June 76)	distributed August 76
Quarterly Report to BLM (July-Sept. 76)	distributed November 76
Quarterly Report to BLM (Oct.-Dec. 76)	distributed March 77

* A bibliography of publications relating to research funded by BLM/OCSEAP, but published by other than OCSEAP, will be provided separately at a later date.

Data Management

During this period a number of data management objectives were met which contributed to improved data flow and data tracking. The OCSEAP data tracking system has been completed and is operational. The tracking information is distributed quarterly to BLM and OCSEAP data management personnel with more frequent distributions to the Juneau Project Office. A number of products derived from the system have been distributed to OCSEAP personnel including telephone lists, lists of overdue ROSCOPs (a form describing data collected) and data sets and submission summaries.

A pre-processing and processing facility was established in Anchorage to increase capabilities for editing data sets and handling of investigators' coded data. Of the 321 digital data sets in the OCSEAP data bank, 313 were received during this reporting period. Approximately 60 percent of the sets are biological data, over 30 percent are physical data, 5 percent are chemical data, and several geological data sets are included.

A summary of data sets, data reports and ROSCOPs received during the past year is as follows:

	Total	Apr-June 76	July-Sept 76	Oct-Dec 76	Jan-Mar 77
Data Sets*	313	20	54	175	64
Data Reports	117	23	21	40	33
ROSCOPs	196	19	37	108	32

*Total for data sets through March 15, 1977

Data requests have increased gradually, with emphasis changing from earlier requests for archival data to products from the OCSEAP data bank. A significant number of meteorological data requests were completed during the past year. Several data products resulting from BLM and OCSEAP office requests have been developed including data inventories plotted on specific chart projections, formatted output listings for selected data file types, current meter summaries, water current rose plots, and products from the data tracking system.

The revised version of the taxonomic code has been completed. This code is used to provide a unique number designation for each marine species. Copies were distributed to OCSEAP and other OCS personnel, BLM offices, OCSEAP investigators and data processors, and other interested individuals. The new version contains over 16,000 numeric codes and is more comprehensive than earlier Alaskan codes.

Twenty-two new or modified versions of existing formats were distributed to OCSEAP investigators and other OCSEAP personnel. A copy of all codes used with OCSEAP formats was distributed to data management personnel during the third quarter, and one-page summaries for each format have been completed and forwarded to OCSEAP and BLM data management personnel.

In October our OCSEAP budget information computer system was brought on-line. This system provides up-to-date financial information to the OCSEAP staff to aid in program monitoring and management. A more sophisticated information system is being designed to aid in proposal and financial tracking. This system should be operational in October 1977.

SPILLED OIL RESEARCH (SOR) TEAM

The Spilled Oil Research (SOR) program was set up this year within the Environmental Research Laboratories component of NOAA. This program is designed to provide a quick response to oil spills so that required data on the behavior and fate of oil can be collected in order to improve modeling efforts designed to forecast or predict the movement of spilled oil in the marine environment.

Principal SOR Team members include Dave Kennedy, Project Manager, Jim Mattson, Chief Scientist, Rod Swope, Alaska Team Chief, Peter Grose, East Coast Team Chief, and Jerry Galt, West Coast Team Chief. The Program Director of OCSEAP determines whether or not the SOR Team will respond to any particular event. Decisions are based on current research priorities, the opportunity for productive research, and the logistic complexity of the required response. Typical factors considered are SOR Team readiness, characteristics of the spill, projection of spill duration and clean-up activity, experience obtained in previous spills and data gaps in the research programs.

In November, the Spilled Oil Research (SOR) team had its initial training sessions for approximately 30 persons at Coal Oil Point in Santa Barbara, California. Shortly thereafter, the ARGO MERCHANT ran aground off Nantucket Island. Within twelve hours of the grounding, SOR team personnel were on scene and over the next four weeks played an extremely important role in the scientific effort. The team was involved in the overall scientific coordination of spill research as well as specific research aspects to include slick mapping, current measurements, aerial photography, differential oil/water velocity measurements, etc. All of the SOR work was supported and coordinated through the Coast Guard On-Scene Commander. Much of the content and effort of the NOAA March 1977 Special Report on the ARGO MERCHANT was contributed by SOR Team Members.

The Spilled Oil Research team responded to the Bouchard 65 spill at Buzzards Bay, Massachusetts, in January and February 1977. This spill was particularly interesting to SOR because of the ice environment encountered. Four team members participated in research at the spill and SOR also contracted the services of Dr. Seelye Martin, University of Washington, and Mr. Paul Deslauriers, Arctec, both experienced oil-ice researchers. Work included ice coring and mapping, aerial photography, and oil/water sampling. A report of the research conducted is being prepared.

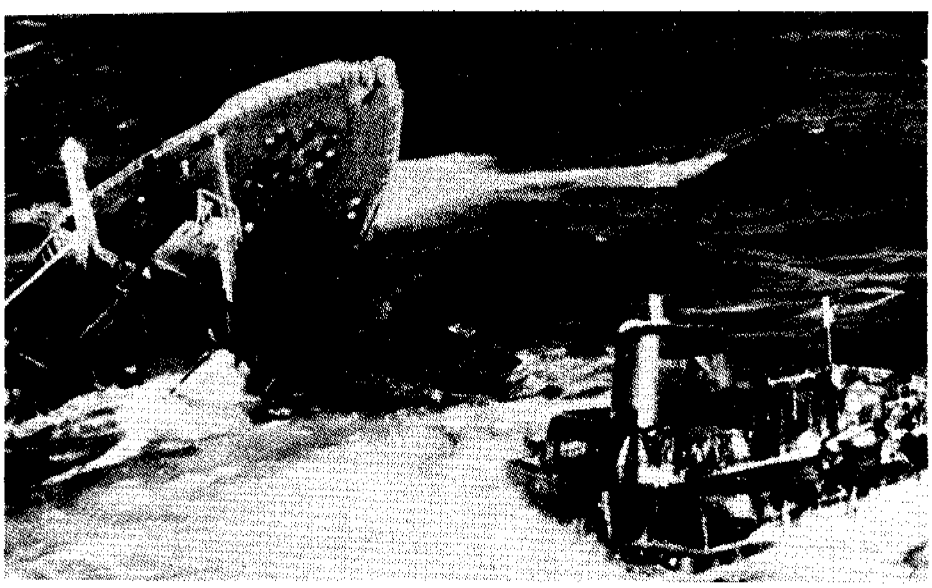


Figure 3. ARGO MERCHANT after first break, December 22, 1976.

FIELD ACTIVITIES & LOGISTICS

1 April 1976 - 31 March 1977

General

Field activities of this multi-discipline research program expanded to a peak level during 1976. Operations were extended from the original areas of interest in the Gulf of Alaska, S.E. Bering Sea, and Beaufort Sea into Lower Cook Inlet, Norton Sound, and the Chukchi Sea. Over 150 investigators were actively engaged in field research throughout all nine of the BLM designated lease areas during this second year of the program.

The increase in logistics support effort paralleled the increase in research. Funding levels for direct logistics support rose to a little over $4,000,000 in 1976 to meet the many diverse and geographically spread out requirements. This amount did not include the cost of operating the NOAA ships allocated to the program.

Planning and coordination of field activities and logistics support is primarily accomplished by the two project offices established by OCSEAP. The Juneau Office is responsible for scheduling and overseeing all work performed in subarctic areas (the seven lease areas south of the Bering Strait). The Fairbanks Office is responsible for the arctic areas (Chukchi Sea and Beaufort Sea).

Logistics support consisted primarily of obtaining and scheduling suitable vessel and aircraft platforms from which to conduct the planned research, arranging for adequate shore facilities to support the mobile vessel and air operations, and arranging for living accommodations and laboratory space for field parties working in remote regions.

Subarctic Operations

Major support for operations in the subarctic was furnished aboard three NOAA vessels and two NOAA operated helicopters. The NOAA ships DISCOVERER, SURVEYOR, and MILLER FREEMAN were virtually dedicated to the program, operating a total of 510 days at sea on a multiplicity of projects.

A leased Bell 206B helicopter was operated from onboard the SURVEYOR throughout her field season, flying a total of 574 hours in support of projects. A UH1H helicopter was obtained on loan from the U.S. Army in August 1976 and was operated as an independent field unit, flying a total of 195 hours on twelve different projects.

Significant amounts of vessel and aircraft time were chartered to meet the remaining field work requirements. The University of Hawaii vessel MOANA WAVE was contracted for 165 days at sea. Another 60 days were obtained aboard the University of Alaska vessel ACONA. A total of approximately 200 days at sea were accomplished aboard the USGS vessels SEA SOUNDER and LEE. Supplemental aircraft support included 34 days of chartered helicopter time for seven different projects.

The primary staging base for vessel operations continued to be the U.S. Coast Guard Support Center at Kodiak. Pier space, fuel, warehouse storage, repair assistance, and general support were provided through an interagency support agreement negotiated between the Coast Guard Support Center and the NOS Pacific Marine Center.

Arctic Operations

In the arctic, the Naval Arctic Research Laboratory at Barrow continued to provide the major portion of logistics support under the terms of an interagency support agreement between the Office of Naval Research and NOAA. This support included housing and subsistence, lab space, fixed wing aircraft, small vessels, supplemental helicopter time (on contract), and field camp installations and removals. A contract with a commercial construction company provided housing and subsistence, lab space, and general support at Deadhorse (Prudhoe Bay area).

After the severe ice conditions that occurred in the summer of 1975, prohibiting vessel movements in the arctic, the summer of 1976 saw a return to normal and a withdrawal of the pack ice offshore.

Major vessel operations carried out in 1976 included 35-40 days in the Chukchi Sea distributed between the two NOAA vessels DISCOVERER and MILLER FREEMAN and the University of Hawaii vessel MOANA WAVE, and four weeks in the Chukchi and Beaufort Seas allocated by the U.S. Coast Guard aboard the Cutter GLACIER. An 80 foot warping tug, the ALUMIAK, was brought up to Barrow under OCSEAP sponsorship and added to NARL's logistic resources in the summer of 1976. One 20 day cruise in the Beaufort Sea was accomplished by this vessel before the ice started moving back inshore. The NARL vessel, NATCHIK, and the USGS vessel, KARLUK, were also used in the Beaufort Sea for approximately 3 days and 65 days, respectively.

Primary helicopter time was provided by the NOAA operated UH1F, on loan from the USAF, and its successor, a UH1H, on loan from the U.S. Army. Between the two, a total of approximately 500 mission hours were flown on OCSEAP projects. Supplemental helicopter charters added up to 150 hours.

Fixed wing aircraft support consisted of 265 hours of single engine time and 430 hours of multi-engine time.

Cruise Schedules and Summaries

Schedules of major vessel and aircraft operations are shown in Figures 4a,b.

A summary of major vessel cruises and aircraft flying missions is also presented in Table 1.

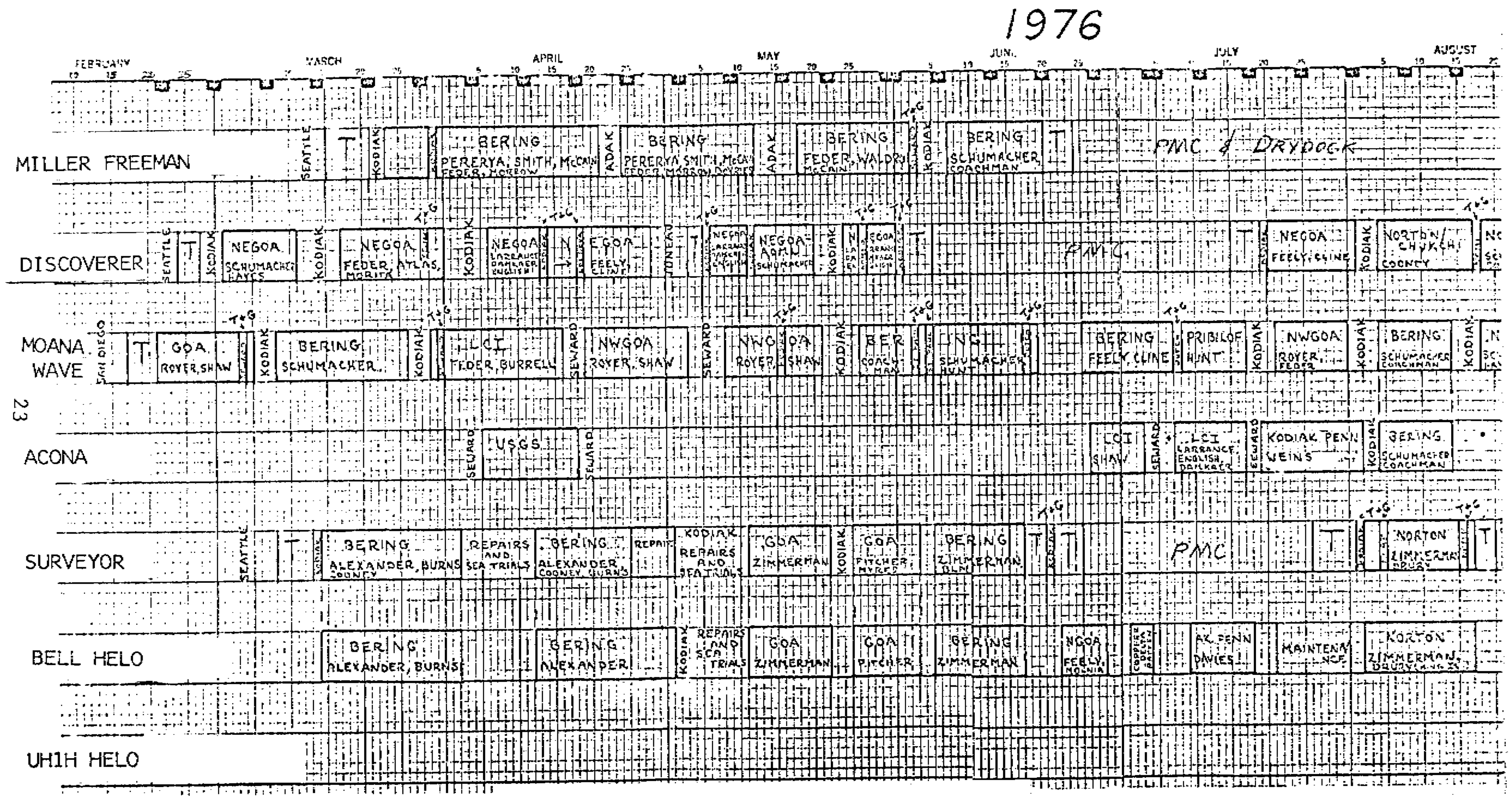


Figure 4a. Cruise Schedules

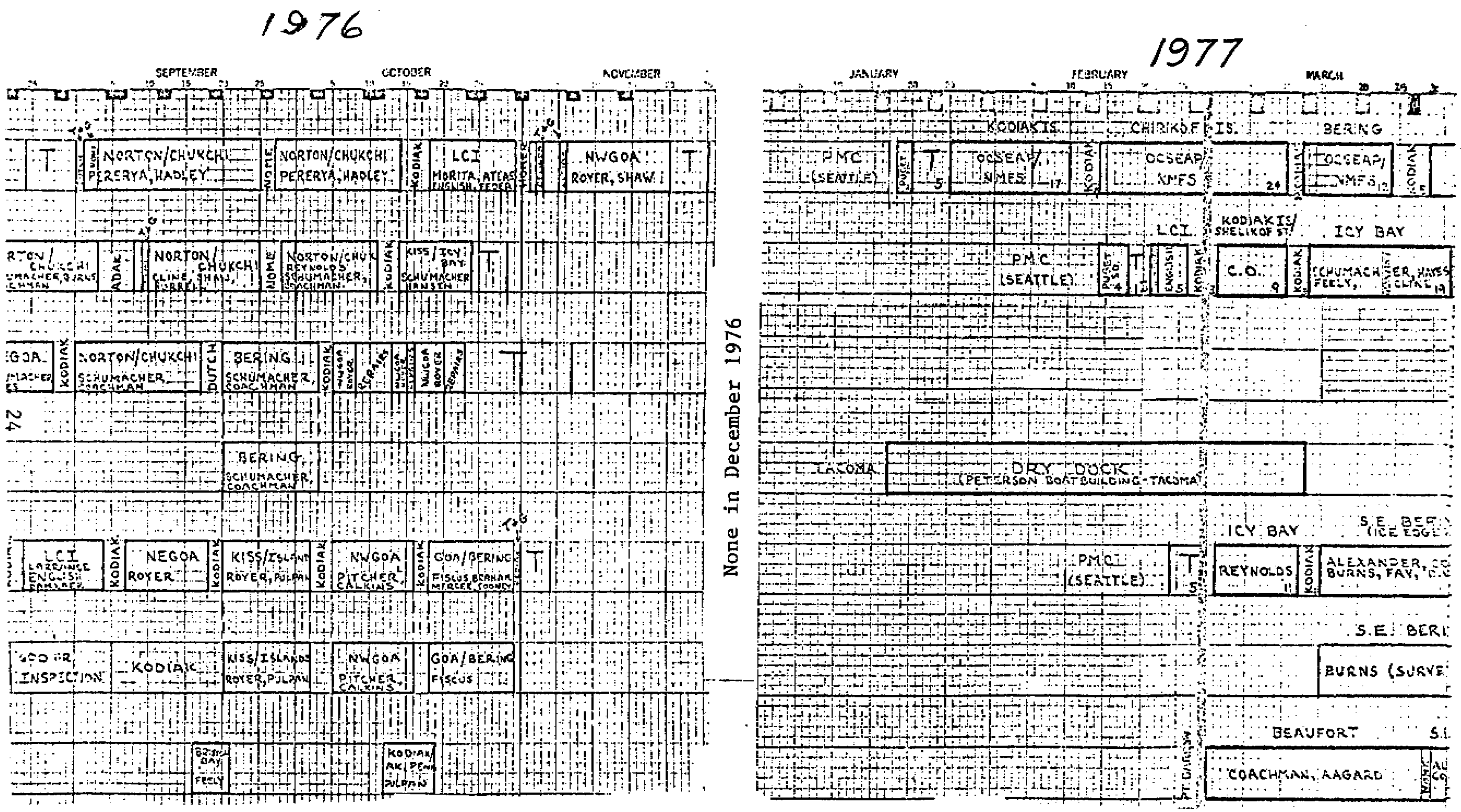


Figure 4b. Cruise Schedules (continued)

Table 1. SUMMARY OF MAJOR VESSEL CRUISES
April 1, 1976-March 31, 1977

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MILLER FREEMAN (NOAA)	28 MARCH - 21 APRIL 76	PEREYRA, NWFC SMITH, IMS FEDER, IMS MORROW, IM MCCAIN, NWFC LENSINK, USF&WS SHAW, IMS BURRELL, IMS	BERING SEA	DEMERSAL FISH ASSESSMENT BENTHOS PHYSICAL OCEANOGRAPHY	DEMERSAL FISH TRAWLS	53
					VAN VEEN GRABS	22
					CTD	11
					BIRD OBSERVATIONS AND COLLECTIONS	
					MAMMAL OBSERVATIONS	
MOANA WAVE (U OF HAWAII)	30 MARCH - 15 APRIL 76	FEDER, IMS BURRELL, IMS SHAW, IMS LENSINK, USF&WS	LOWER COOK INLET	BENTHOS TRACE METALS HYDROCARBONS	OTTER TRAWLS	6
					AGASSIZ TRAWLS	9
					BEAM TRAWL	3
					CLAM DREDGE	3
					PIPE DREDGE	42
					VAN VEEN GRABS	60
					HAPS CORES	6
					NISKIN WATER SAMPLES	34
					BIRD OBSERVATIONS AND COLLECTIONS	
					MAMMAL OBSERVATIONS	
DISCOVERER (NOAA)	6 APRIL - 13 APRIL 76	LARRANCE, PMEL DAMKAER, PMEL ENGLISH, U OF W LENSINK, USF&WS	LOWER COOK INLET/NORTHERN GULF OF ALASKA	PLANKTON BIOLOGY	BONGO NET TOWS	13
					NIO NET TOWS	13
					NEUSTON NET TOW	13
					ACOUSTIC PLANKTON PROFILES	12
					VERTICAL NET TOWS	13
					MILLER NET TOWS	1
					ROSETTE/CTD	13
					SECCHI DISC OBS	10
					BIRD OBSERVATIONS AND COLLECTIONS	
					MAMMAL OBSERVATIONS	

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
ACONA (U OF ALASKA)	8-19 APRIL 76	MOLNIA, USGS	NORTHERN GULF OF ALASKA	LITHOLOGY SUB-BOTTOM GEOLOGICAL STRUCTURE	SEDIMENT CORES AND GRABS SEISMIC REFLECTION	 UNKNOWN UNKNOWN
SURVEYOR (NOAA)	12-30 APRIL 76	COONEY, IMS ALEXANDER, IMS MUENCH, IMS DIVOKY, ADF&G BURNS, ADF&G SHAW, IMS BURRELL, IMS FISCUS, NWFC FAY, IMS	BERING SEA	ICE-EDGE BIOLOGY AND CHEMISTRY HELICOPTER AND LAUNCH SUPPORT	VERTICAL NET TOWS CTD ICE CORERS NISKIN WATER SAMPLES TUCKER TRAWLS 1-METER VERTICAL NET TOWS OTTER TRAWLS MAMMAL SPECIMENS AND OBSERVATIONS BIRD SPECIMENS AND OBSERVATIONS NEUSTON NET TOWS	15 17 2 15 8 22 17 11 41 14
DISCOVERER (NOAA)	13-30 APRIL 76	FEELY, PMEL CLINE, PMEL FISCUS, NWFC WEINS, OSU LENSINK, USF&WS	NORTHERN GULF OF ALASKA	SUSPENDED SEDIMENTS HYDROCARBONS	NISKIN WATER SAMPLES NEPHELOMETER MEASUREMENTS CTD TIME-SERIES STATION MAMMAL OBSERVATIONS BIRD COLLECTIONS AND OBSERVATIONS	50 46 50 1
MOANA WAVE (U OF HAWAII)	19 APRIL - 2 MAY 76	ROYER, IMS SHAW, IMS LENSINK, USF&WS	NORTHERN AND WESTERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD SURFACE WATER SAMPLES NEUSTON TOWS BIRD COLLECTIONS AND OBSERVATIONS	98 20 20

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MILLER FREEMAN (NOAA)	24 APRIL - 13 MAY 76	PEREYRA, NWFC SMITH, IMS FEDER, IMS MORROW, IMS MCCAIN, NWFC LENSINK, USF&WS SHAW, IMS BURRELL, IMS WALDRON, NWFC DEVRIES, SCRIPPS	BERING SEA	DEMERSAL FISH ASSESSMENT BENTHOS PLANKTON PHYSICAL OCEANOGRAPHY	DEMERSAL FISH TRAWLS VAN VEEN GRABS CTD BONGO TOWS NEUSTON TOWS BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS	38 14 9 16 16
DISCOVERER (NOAA)	3 - 9 MAY 76	LARRANCE, PMEL DAMKAER, PMEL ENGLISH, U OF W LENSINK, USF&WS	LOWER COOK INLET/NORTHERN GULF OF ALASKA	PLANKTON BIOLOGY	BONGO NET TOWS VERTICAL NET TOWS NIO NET TOW ROSETTE/CTD SECCHI DISC OBS ACOUSTIC PLANKTON PROFILES BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS	11 2 1 11 7 (12.6 HRS)
MOANA WAVE (U OF HAWAII)	7-21 MAY 76	ROYER, IMS SHAW, IMS LENSINK, USF&WS	WESTERN AND NORTHERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD CURRENT METER DEPLOYMENT (#9) BIRD COLLECTIONS AND OBSERVATIONS	17 1

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
DISCOVERER (NOAA)	12-20 MAY 76	SCHUMACHER, PMEL HAYES, PMEL HANSEN, AOML LENSINK, USF&WS WEINS, OSU MYRES, U OF CALGARY	NORTHERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD CURRENT METER RECOVERIES (SLS-9, SLS-8, 62G, 61B, 69A, 60B) [SLS-7 NOT RECOVERED] DEPLOYMENT (SLS-15, SLS-13, SLS-14, 62H, 61C, 69B, 60C) DRIFT BUOY DEPLOYMENTS BIRD COLLECTIONS AND OBSERVATIONS MAMMAL OBSERVATIONS	57 6 7 2
SURVEYOR (NOAA)	11-21 MAY 76	ZIMMERMAN, ABFL WEINS, OSU	WESTERN GULF OF ALASKA	INTERTIDAL BIOLOGY (HELICOPTER SUPPORT)	LITTORAL ZONE OBS AND SAMPLES BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS SUBLITTORAL ZONE OBS AND SAMPLES	11 10
MILLER FREEMAN (NOAA)	18 MAY - 4 JUNE 76	WALDRON, NWFC FEDER, IMS SMITH, IMS MCCAIN, NWFC LENSINK, USF&WS SHAW, IMS BURRELL, IMS	BERING SEA	DEMERSAL FISH ASSESSMENT BENTHOS PHYSICAL OCEANOGRAPHY	BOTTOM TRAWLS VAN VEEN GRABS PIPE DREDGES CLAM DREDGE NEUSTON/BONGO TOWS XBT BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS	16 30 44 1 43 47
DISCOVERER (NOAA)	24 MAY-5 JUNE 76	LARRANCE, PMEL DAMKAER, PMEL ENGLISH, U OF W MYRES, U OF CALGARY	LOWER COOK INLET/ NORTHERN GULF OF ALASKA	PLANKTON BIOLOGY	BONGO NET TOWS VERTICAL NET TOWS NIO NET TOW ROSETTE/CTD SECCHI DISC OBSERVATIONS BIRD OBSERVATIONS AND COLLECTIONS	12 8 1 12 5

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
SURVEYOR (NOAA)	25 MAY - 3 JUNE 76	PITCHER, ADF&G LENSINK, USF&WS	NORTHERN GULF OF ALASKA	MARINE MAMMAL SURVEY	MAMMAL COLLECTIONS AND OBSERVATIONS LAUNCH HYDROGRAPHIC SURVEY (ICY BAY) BIRD OBSERVATIONS AND COLLECTIONS	6 (98.3 NM TRACKLINE)
MOANA WAVE (U OF HAWAII)	26 MAY - 20 JUNE 76	SCHUMACHER, PMEL COACHMAN, U OF W HUNT, U OF CAL, IRVINE HANSEN, AOML LENSINK, USF&WS	BERING SEA	PHYSICAL OCEANOGRAPHY PRIBILOF BIRD SURVEY	CTD CURRENT METERS/PRESS GAGE ARRAYS (8C SERIES) RECOVERIES (2B, 3B, 7A, 13A, 1C) [12A NO RESPONSE 4B INTERROGATED BUT NOT RECOVERED] DEPLOYMENTS (2C, 3C, 4C, 5A, 6A, 8A, 9A, 10A, 11A, 13B, 14A, 15A) DRIFT BUOY DEPLOYMENTS BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS	154 4 12 3
SURVEYOR (NOAA)	5-25 JUNE 76	ZIMMERMAN, ABFL MYRES, U OF CALGARY HUNT, U OF CAL, IRVINE FISCUS, NWFC	BERING SEA AND GULF OF ALASKA	INTERTIDAL BIOLOGY (HELICOPTER SUPPORT)	LITTORAL ZONE OBS AND SAMPLES SUBLITTORAL ZONE OBS AND SAMPLES SEISMIC STATION INSTALLATION AND SERVICING BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS SHIP HYDROGRAPHIC SURVEY (CHIRIKOF IS.)	10 10 3 (95 NM TRACKLINE)

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MILLER FREEMAN (NOAA)	7-24 JUNE 76	SCHUMACHER, PMEL COACHMAN, U OF W WEINS, OSU LENSINK, USF&WS	BERING SEA	PHYSICAL OCEANOGRAPHY	CTD	19
					CURRENT METERS/PRESSURE GAGE ARRAY	
					RECOVERIES (WGC-2C, WGC-1C, BC-12A, PARTIAL BC-4B) [WGC-2B, WGC-3A NO RESPONSE]	3 1/2
					DEPLOYMENTS (WGC-2D, WGC-3B, WGC-1D)	3
					BIRD OBSERVATIONS AND COLLECTIONS	
					MAMMAL OBSERVATIONS	
MOANA WAVE (U OF HAWAII)	25 JUN-15 JUL 76	CLINE, PMEL FEELY, PMEL LENSINK, USF&WS HUNT, U OF CA, IRVINE	BERING SEA PRIBILOF ISLANDS	HYDROCARBONS SUSPENDED SEDIMENTS BIRD SURVEY	NISKIN WATER SAMPLES	55
					CTD	55
					NEPHELOMETER MEASUREMENTS	55
					SURFACE WATER SAMPLES	99
					VERTICAL PLANKTON TOWS	3
					BIRD OBSERVATIONS & OBSERVATIONS	
ACONA (IMS)	25 JUN - 2 JUL 76	SHAW, IMS	LOWER COOK INLET/ SHELIKOF STRAIT	HYDROCARBONS	INTERTIDAL COLLECTIONS	2
					SURFACE WATER SAMPLES	20
					SUSPENDED SEDIMENTS (WATER)	1
ACONA (IMS)	8 JUL - 15 JUL 76	LARRANCE, PMEL DAMKAER, PMEL ENGLISH, U OF W	LOWER COOK INLET	PLANKTON BIOLOGY	BONGO NET TOWS	11
					VERTICAL NET TOWS	14
					ROSETTE WATER SAMPLES CTD	11
					SECCHI DISC OBS	11
					INCIDENT SOLAR RADIATION MEASUREMENTS	CONTINUOUS
					CHLOROPHYLL A MEASUREMENTS	CONTINUOUS
					PRIMARY PRODUCTION MEASUREMENTS	6

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
DISCOVERER (NOAA)	15-31 JULY 76	FEELY, PMEL CLINE, PMEL LENSINK, USF&WS MYRES, U OF CALGARY HANSEN, AOML	NORTHERN GULF OF ALASKA	SUSPENDED SEDIMENTS HYDROCARBONS	NISKIN WATER SAMPLES NEPHELOMETER MEASURE- MENTS NIMBUS SATELLITE DRIFT BUOY DEPLOYMENTS BIRD COLLECTIONS AND OBSERVATIONS MAMMAL OBSERVATIONS CTD	50 50 3 50
ACONA (IMS)	20 JUL 1 AUG 76	WEINS, OSU	WESTERN GULF OF ALASKA	MARINE BIRD STUDIES	BIRD COLLECTIONS BIRD OBSERVATIONS	29 SPECIMENS 29 LOCATIONS
MOANA WAVE (U OF HAWAII)	21 JUL 1 AUG 76	ROYER, IMS FEDER, IMS LENSINK, USF&WS	WESTERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY BENTHOS	CTD PIPE DREDGES CURRENT METER ARRAY RECOVERY/DEPLOYMENT (#9) SEA SURFACE TEMPERATURE AND SALINITY BIRD COLLECTIONS & OBSERVATIONS	69 14 1 CONTINUOUS

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
SURVEYOR (NOAA)	26 JULY-20 AUG 76	ZIMMERMAN, ABFL DRURY, C OF A MYRES, U OF CALGARY	NORTON SOUND	INTERTIDAL BIOLOGY (HELICOPTER SUPPORT) BIRD INVESTIGATIONS	LITTORAL ZONE OBS & SAMPLES SUBLITTORAL ZONE OBS AND SAMPLES SEABIRD ROOKERY INVESTIGATIONS ROUTINE BIRD OBSERVATIONS MARINE MAMMAL OBSERVATIONS	17 10 8
ACONA (IMS)	3-13 AUG 76	SCHUMACHER, PMEL COACHMAN, U OF W	BERING SEA	PHYSICAL OCEANOGRAHY	CTD	85
MOANA WAVE (U OF HAWAII)	3-12 AUG 76	SCHUMACHER, PMEL COACHMAN, U OF W FISCUS, NWFC	BERING SEA	PHYSICAL OCEANOGRAPHY	CTD MARINE MAMMAL OBSERVATIONS	30
DISCOVERER (NOAA)	3-17 AUG 76	COONEY, IMS LENSINK, USF&WS	NORTON SOUND/ CHUKCHI SEA	PLANKTON BIOLOGY	BONGO NET TOWS VERTICAL RING NET TOWS HORIZONTAL RING NET TOWS TUCKER TRAWLS BATHYMETRY BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS	10 105 3 31

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MOANA WAVE (U OF HAWAII)	18-27 AUG 76	SCHUMACHER, PMEL HAYES, PMEL FISCUS, NWFC	NORTHERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD	15
					CURRENT METER ARRAY RECOVERIES (69A, 60C, 61C, SLS-10, SLS-11, 62H, SLS-12)	7
					DEPLOYMENTS (SLS-16, SLS-17, SLS-18, 62I)	4
					MAMMAL OBSERVATIONS	
DISCOVERER (NOAA)	18 AUG - 3 SEPT 76	SCHUMACHER, PMEL COACHMAN, U OF WA BURNS, ADF&W FISCUS, NWFC	NORTON SOUND/ CHUKCHI SEA	PHYSICAL OCEANOGRAPHY MAMMAL STUDIES	CTD	151
					54-HR CTD TIME SERIES	1
					CURRENT METER ARRAY DEPLOYMENTS (NC-1 THRU 15, NC-17 THRU 19)	18
					OTTER TRAWLS	23
					BATHAYMETRY	
					MAMMAL COLLECTIONS	3
					MAMMAL OBSERVATIONS	
SURVEYOR (NOAA)	24-31 AUG 76	ENGLISH, U OF W LARRANCE, PMEL DAMKAER, PMEL WEINS, OSU LENSINK, USF&WS	LOWER COOK INLET	PLANKTON BIOLOGY	CTD	13
					ROSETTE/NISKIN WATER SAMPLES	13
					VERTICAL RING NET TOWS	7
					BONGO NET TOWS	13
					SEA CHEST WATER SAMPLES	CONTINUOUS
					ACOUSTIC PLANKTON PROFILES	13
					SECCHI DISC MEASUREMENTS	15
					QUANTUM METER PROFILES	2
					RADIOMETER MEASUREMENTS (CONTINUOUS)	
					BIRD OBSERVATIONS & COLLECTIONS	
					MAMMAL OBSERVATIONS	

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MOANA WAVE (U OF HAWAII)	31 AUG - 16 SEPT 76	SCHUMACHER, PMEL COACHMAN, U OF WA WEINS, OSU LENSINK, USF&WS FISCUS, NWFC	ST. LAWRENCE ISLAND/ CHUKCHI SEA	PHYSICAL OCEANOGRAPHY	CTD BIRD OBSERVATIONS MAMMAL OBSERVATIONS	83
MILLER FREEMAN (NOAA)	24 AUG- 24 SEPT 76	PEREYRA, NWFC HADLEY, IMS BARTON, ADF&G MCCAIN, NWFC (MUENCH, PMEL)	NORTON SOUND/ CHUKCHI SEA	DEMERSAL FISH ASSESSMENT PELAGIC FISH ASSESSMENT	DEMERSAL FISH TRAWLS GILL NETTING PELAGIC TRAWLS MAMMAL OBSERVATIONS	174 22 8
SURVEYOR (NOAA)	7-16 SEPT 76	ROYER, IMS FISCUS, NWFC	NORTHERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD MAMMAL OBSERVATIONS	64
DISCOVERER (NOAA)	8-24 SEPT 76	CLINE, PMEL SHAW, IMS DIVOKY, ADF&G FISCUS, NWFC	NORTON SOUND/ CHUKCHI SEA	HYDROCARBONS TRACE METALS	NISKIN WATER SAMPLES SPECIAL SURFACE WATER SAMPLES NEUSTON TOWS HAPS CORES VAN VEEN GRABS BIRD OBSERVATIONS & COLLECTIONS MAMMAL OBSERVATIONS	79 12 27 31 62

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MOANA WAVE (U OF HAWAII)	17 SEPT - 3 OCT 76	SCHUMACHER, PMEL COACHMAN, U OF W LENSINK, USF&WS	BERING SEA	PHYSICAL OCEANOGRAPHY	CTD CURRENT METER ARRAY RECOVERIES (BC-10A, BC-8A, BC-11A, BC-9A, BC-4C, BC-15A, BC-2C BC-5A, BC-14A, BC-6A, BC-3C, WGC-1D) DEPLOYMENTS (BC-17A, BC-9B, 3C-4D, BC-15B, BC-2D, BC-13C, WGC-1E)	67 12 7
ACONA (IMS)	23 SEPT - 3 OCT 76	SCHUMACHER, PMEL COACHMAN, U OF W	BERING SEA	PHYSICAL OCEANOGRAPHY	CTD	
SURVEYOR (NOAA)	20 SEPT 2 OCT 76	CHARNELL, PMEL PULPAN, U OF AK KIENLE, U OF AK ROYER, IMS	KODIAK I./ AUGUSTINE I.	PHYSICAL OCEANOGRAPHY SEISMOTECTONICS	CTD SHIPEK GRABS BENTHOS AND PISTON CORES NEAR BOTTOM NISKIN SEAWATER SAMPLE AUGUSTINE ISLAND GAS STEAM SAMPLES AND TEMPERATURE MEASUREMENTS AUGUSTINE ISLAND ASH MAPPING SEISMIC STATION SERVICING GRAVITY MEASUREMENTS MAMMAL OBSERVATIONS	79 113 14 1 — — 9 4

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATORS	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
DISCOVERER NOAA	26 SEP - 9 OCT 76	SCHUMACHER, PMEL COACHMAN, U OF W REYNOLDS, PMEL FISCUS, NWFC	NORTON SOUND/ CHUKCHI SEA	PHYSICAL OCEANOGRAPHY METEOROLOGY	BOW BOOM METEOROLOGICAL Measurements CTD 25-HR TIME-SERIES 1- HR TIME-SERIES RADIOSONDE RELEASES BOUNDARY LAYER TETHERSONDE MEASUREMENTS CURRENT METER ARRAY DEPLOYMENT (#NC-16) BATHYMETRY MAMMAL OBSERVATIONS	(CONTINUOUS) 44 4 1 23 5 1
MILLER FREEMAN NOAA	27 SEP - 13 OCT 76	PEREYRA, NWFC MCCAIN, NWFC HADLEY, IMS BARTON, ADF&G	NORTON SOUND/ ST. LAWRENCE ISLAND	DEMERSAL FISH ASSESSMENT PELAGIC FISH ASSESSMENT	DEMERSAL FISH TRAWLS GILL NETTING PELAGIC TRAWLS BOTTOM PHOTOGRAPHY MAMMAL OBSERVATIONS MAMMAL COLLECTIONS	56 6 1 13 1
SURVEYOR NOAA	5-14 OCT 76	PITCHER, ADF&G CALKINS, ADF&G	WESTERN GULF OF ALASKA	MAMMAL STUDIES	MAMMAL COLLECTIONS MAMMAL OBSERVATIONS (AID OF HELICOPTER)	16 SITES/ 39 SPECIMENS
MOANA WAVE (U OF HAWAII)	5-8 OCT 12-20 OCT 22-30 OCT 76	ROYER, IMS LENSINK, USF&WS WEINS, OSU	WESTERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD BIRD OBSERVATIONS AND COLLECTIONS XBT	91 58

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATORS	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
DISCOVERER NOAA	13-27 OCT 76	SCHUMACHER, PMEL HAYES, PMEL HANSEN, AOML	NORTHERN GULF OF ALASKA/ KODIAK IS.	PHYSICAL OCEANOGRAPHY	CTD CURRENT METER ARRAY RECOVERIES (WGC-3B, WGC-2D, 62-I, SLS-14, SLS-13) SLS-15 LOST DEPLOYMENTS (KISS 1A-5A, WGC-3C, WGC-2E, 62-J, SLS-20, SLS-21, SLS-19) DRIFT BUOY DEPLOYMENTS MAMMAL OBSERVATIONS	38 5 11 3
MILLER FREEMAN NOAA	18-29 OCT 76	FEDER, IMS ATLAS, U OF LOUSIVILLE MORITA, OSU LENSINK, USF&WS ENGLISH, U OF W	LOWER COOK INLET	BENTHOS MICROBIOLOGY ZOOPLANKTON	DEMERSAL TRAWLS AGASSIZ TRAWLS VAN VEEN GRABS PIPE DREDGES CLAM DREDGES WATER SAMPLES SHORE STATIONS (MICROBIOLOGY) BONGO NET CASTS BIRD OBSERVATIONS & COLLECTIONS MAMMAL OBSERVATIONS	18 8 14 48 3 20 8 10
SURVEYOR NOAA	18 OCT - 3 NOV 76	FISCUS, NWFC COONEY, IMS	BERING SEA/ WESTERN GULF OF ALASKA	MAMMAL STUDIES (W/HELICOPTER) ZOOPLANKTON	MAMMAL OBSERVATIONS & COLLECTIONS(BEACH REMAINS) BONGO NET TOWS VERTICAL PLANKTON TOWS	 11 8
MILLER FREEMAN NOAA	1-23 NOV 76	ROYER, IMS LENSINK, USF&WS	NORTHERN AND WESTERN GULF OF ALASKA	PHYSICAL OCEANOGRAPHY	CTD XBT CURRENT METER ARRAY RECOVERY DEPLOYMENT (#9) BIRD OBSERVATIONS & COLLECTIONS MAMMAL OBSERVATIONS	159 30 1

SHIP	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
MILLER FREEMAN (NOAA)	19 JAN - 10 FEB 77	NMFS/OCSEAP LENSINK, USF&WS	KODIAK ISLAND	DEMERSAL FISH ASSESSMENT	DEMERSAL FISH TRAWLS BIRD OBSERVATIONS MAMMAL OBSERVATIONS	58
MILLER FREEMAN (NOAA)	15 FEB - 7 MARCH 77	NMFS/OCSEAP	KODIAK ISLAND	DEMERSAL FISH ASSESSMENT	DEMERSAL FISH TRAWLS PELAGIC TRAWLS MAMMAL OBSERVATIONS	64 2
DISCOVERER (NOAA)	17 FEB - 26 FEB 77	ENGLISH, U. OF W. LENSINK, USF&WS	LOWER COOK INLET	ZOOPLANKTON	BONGO NET TOWS BIRD OBSERVATIONS AND COLLECTIONS MAMMAL OBSERVATIONS	11 2
SURVEYOR (NOAA)	24 FEB - 10 MARCH 77	REYNOLDS, PMEL	ICY BAY	METEOROLOGY	BOW BOOM METEOROLOGICAL MEASUREMENTS BOUNDRY LAYER TETHERSONDE MEASUREMENTS RADIOSONDE RELEASES OPPORTUNISTIC CTD CTD SURFACE CURRENT MEASUREMENTS BIRD OBSERVATIONS MAMMAL OBSERVATIONS	CONTINUOUS 2 6 10 6 3
DISCOVERER (NOAA)	1 MARCH - 10 MARCH 77	CHARNELL, PMEL	KODIAK ISLAND SHELIKOF STRAIT	PHYSICAL OCEANOGRAPHY	CTD SEA SURFACE TEMPERATURE MAMMAL OBSERVATIONS	62 CONTINUOUS
MILLER FREEMAN (NOAA)	12 MARCH - 26 MARCH 77	NMFS/OCSEAP BRAHAM, NWAFC	BERING SEA	PELAGIC FISH ASSESSMENT TEST HERMAN-ENGEL MIDWATER TRAWL EQUIPMENT	PELAGIC TRAWLS DEMERSAL TRAWL MAMMAL OBSERVATIONS	4 1

SUMMARY OF MAJOR AIRCRAFT FLYING MISSIONS

April 1, 1976-March 31, 1977

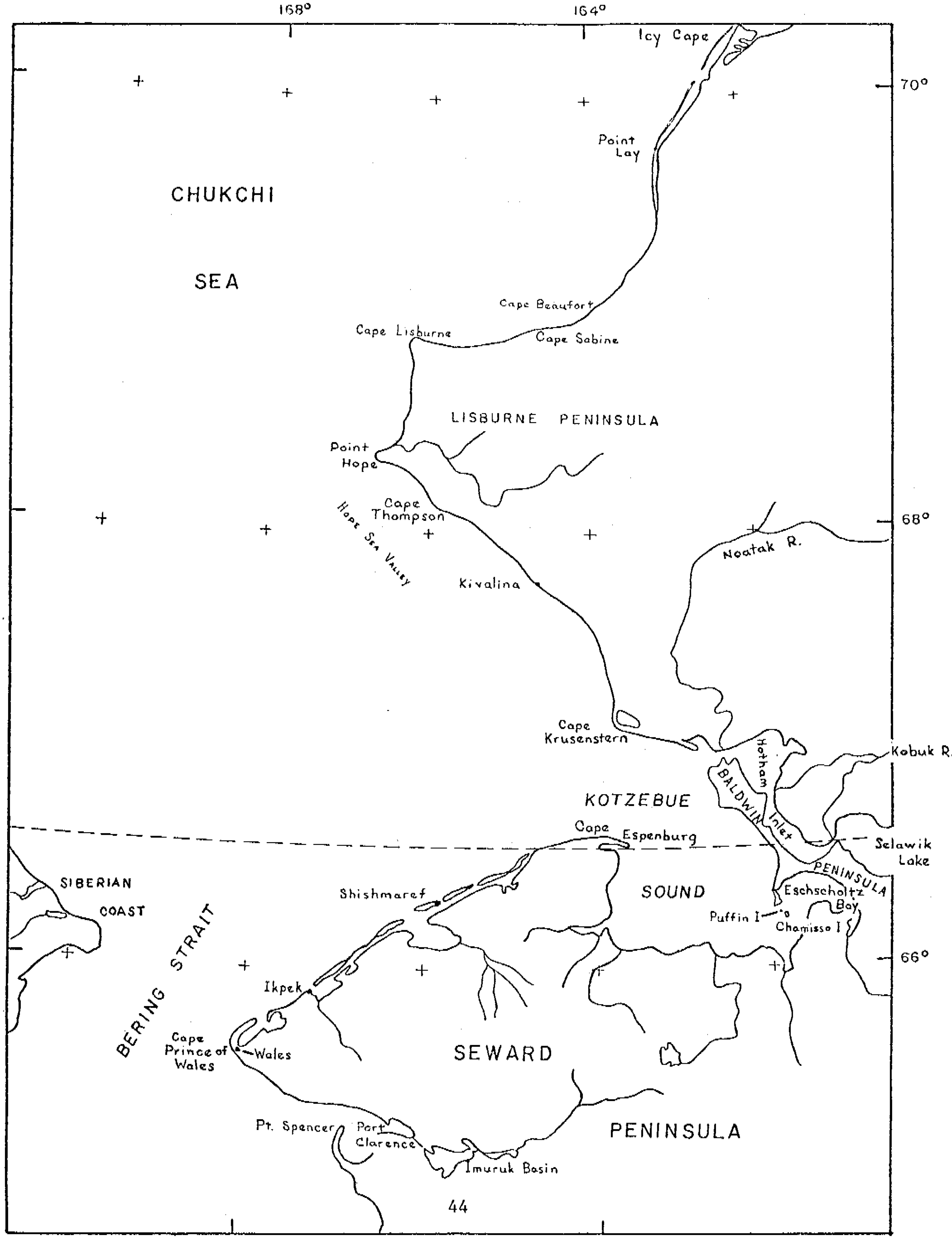
Two 4-day charters in June for sampling light hydrocarbons, NEGOA for NBS, LCI for IMS

HELICOPTER	CRUISE PERIOD	PRINCIPAL INVESTIGATOR	WORK AREA	NATURE OF INVESTIGATION	SPECIFIC OPERATIONS	NUMBER OF STATIONS
BELL 206B (NOAA)	9-17 JUL 76	DAVIES, LAMONT	ALASKA PENINSULA	SEISMIC NETWORK MAINTENANCE	SEISMIC STATION SERVICING	17
BELL 206B (KENAI AIR SERVICE)	8-15 JUL 76	ZIMMERMAN, ABFL	KODIAK ISLAND	INTERTIDAL BIOLOGY	INTERTIDAL COLLECTIONS	9
SIKORSKY S55T (ERA HELICOPTERS, INC.)	28 AUG-7 SEPT 76	ZIMMERMAN, ABFL	BRISTOL BAY	INTERTIDAL BIOLOGY	INTERTIDAL COLLECTIONS	14
SIKORSKY S55T (ERA HELICOPTERS, INC.)	6-12 SEPT 76	SALENGER, USGS	BRISTOL BAY	COASTAL MORPHOLOGY	BEACH PROFILING & SEDIMENT SAMPLES	42
UH1H (NOAA)	15-20 SEPT 76	FEELY, PMEL	BRISTOL BAY	SUSPENDED SEDIMENTS	SURFACE WATER SAMPLES FROM RIVERS	34
UH1H NOAA	12-18 OCT 76	KIENLE, U OF AK	LOWER COOK INLET	SEISMIC NETWORK MAINTENANCE	SEISMIC STATIONS SERVICING	7

SCIENTIFIC RESULTS

General

The Alaskan 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 and the strong cyclonic oceanic circulation along the shelf break with highly variable and weaker circulation over a relatively narrow shelf. This region is characterized by a subarctic climate which leaves the waters ice-free with the exception of some inshore waters such as Cook Inlet. The latter is a large tidal estuary and has features (for example, concentrated fresh water 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 as 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.



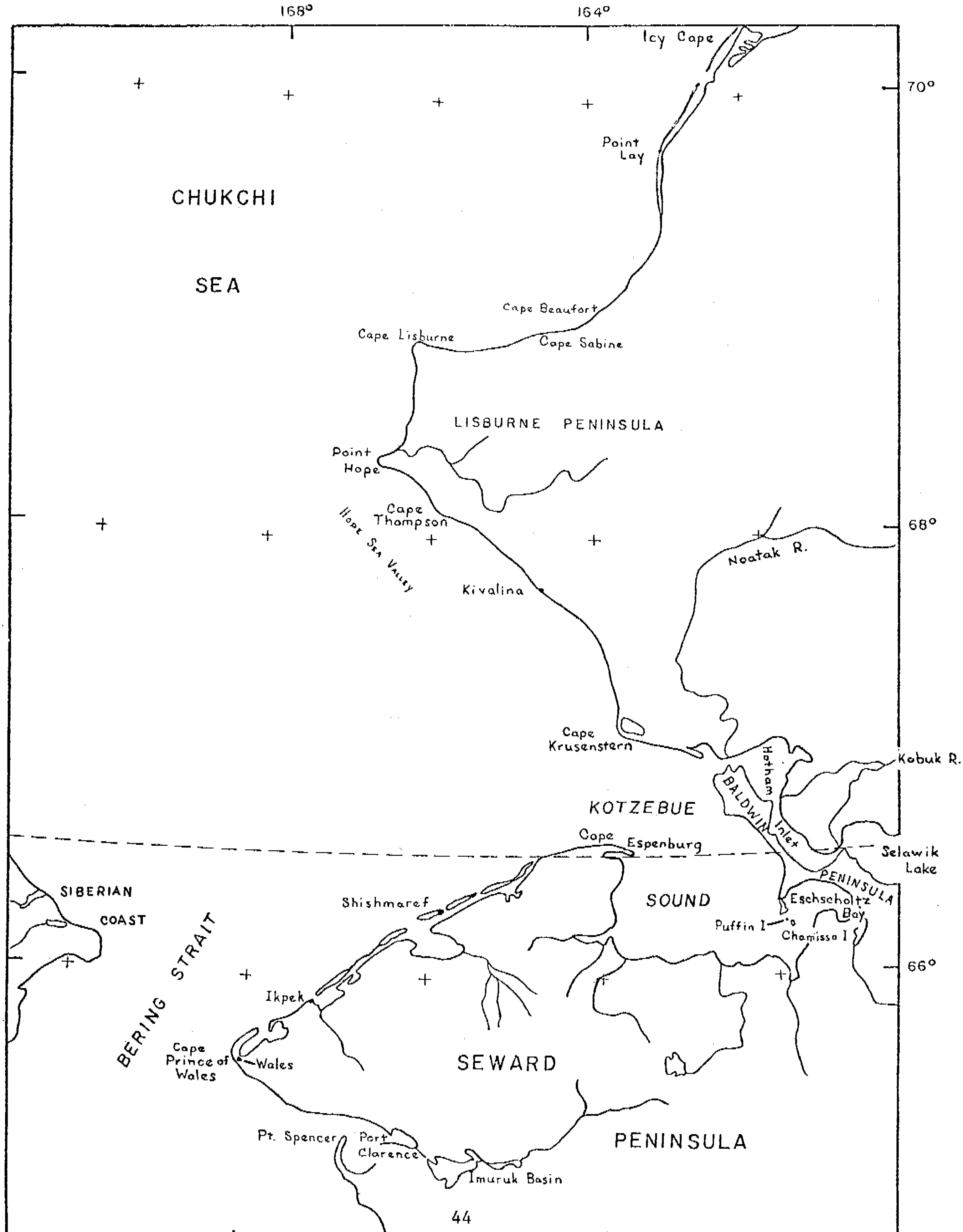
168°
164°
Icy Cape
70°
Point Lay
CHUKCHI
SEA
Cape Beaufort
Cape Lisburne
Cape Sabine
LISBURNE PENINSULA
Point Hope
Cape Thompson
Hope Sea Valley
68°
Noatak R.
Kivalina
Cape Krusenstern
Hotham
BALDWIN
Inlet
Kobuk R.
KOTZEBUE
Cape Espenburg
Selawik Lake
PENINSULA
SIBERIAN COAST
Shishmaref
SOUND
Eschscholtz Bay
Puffin I
Chamisso I
BERING STRAIT
66°
Ikpek
Cape Prince of Wales
Wales
SEWARD
PENINSULA
Pt. Spencer
Port Clarence
Imuruk Basin
168°
164°

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 former. The Chukchi is somewhat better understood since weather conditions there are more bearable, the ice-bound season is shorter, and access to study sites is therefore easier. Numerous studies have been made in past years by both the United States and Russia in the Chukchi Sea region, so more background material is available.

In the past year or two, maps have been compiled for ice conditions from 1973-76 in the Beaufort and Chukchi, leading to the conclusion that *nearshore sea ice behavior patterns are similar from year to year and consequently predictable.* Maps of 1) contiguous ice edge (yearly, seasonal and average), 2) ice ridges (yearly and composite), and 3) ice morphology were constructed by Stringer (RU 257) for the Chukchi and Beaufort Seas, and in addition, items 1) and 3) for the Bering Sea. The morphology maps indicate yearly recurring ridge features, leads, and polynyas on a large area-wide scale.

Other studies of ice conditions and climatic effects on ice breakup by Barry (RU 244) *showed 250-400 thawing degree days (TDDs) required to remove fast ice and 400-550 TDDs to produce open water extending 80 km off Point Barrow by mid-September.* He also constructed a calendar of the fast ice regime on the Beaufort sea coast and documented the occurrence of grounded ice masses within the fast ice. *He implies that offshore structures may be subject to relatively large ice forces, even well inside the 20 m isobath.*


168°
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Eschscholtz Bay
Puffin I
Chamisso I
BERING STRAIT
66°
Ikpek
Cape Prince of Wales
Wales
SEWARD
PENINSULA
Pt. Spencer
Port Clarence
Imuruk Basin
168°
164°

Laser and radar observations off Prudhoe Bay show that *fast ice is relatively stable and that its boundary is located in 30-35 m of water and not in 18 m as generally assumed. Weeks and Kovacs (RU 88) also found large grounded multi-year shear ridges along the 15 m contour rather than at 19 m.* Analysis of remote sensing data shows heavier ridging near Barter Island, decreasing toward the Chukchi Sea. Ridging was also found to decrease in a linear fashion from the coast out, showing no obvious break at the shear zone. Floe size distributions were also examined by SLAR imagery. Shapiro (RU 250) concluded from his studies of ice pressure ridges at Barrow that initial failure of ice at the start of the ridging process is predominantly by buckling with subsequent overriding. Failure in compression was observed at sites where the ice was driven onshore against a vertical bank.

Stresses generated by an ice sheet moving against a grounded feature were recorded in a floe of multi-year ice near a grounded floe island by Sackinger and Nelson (RU 259) whose work indicates that *offshore structures subject to multi-year ice floe pressures must withstand ice stresses greater than 250 psi.*

Further studies aimed at translating laboratory tests of ice strength to field conditions were conducted by Shapiro (RU 265). An understanding of microscale processes of oil in ice benefitted greatly from Seelye Martin's participation in Canadian oil-ice experiments which showed that *behavior of different crude oils varies greatly in the ice.*

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 5-15 m, to 30 cm depths in 50-100 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.* Detailed bathymetry surveys were made by Barnes and Reimnitz (RU 205), revealing motion of the Prudhoe Bay entrance channel toward the shore at the rate of one to two meters per year, but overall effects of the causeway on erosion and deposition is still unknown.

Data on coastal erosion and morphological changes in the Beaufort Sea were compiled from an impressive assembly of historical data and aerial photos. Lewellen (RU 407) has obtained results that show the *extremely dynamic nature of the Beaufort Sea coastline. Erosion rates are 1-2 meters per year, with entire spits and islands disappearing in a single storm.*

Permafrost studies conducted by Sellmann (RU 105), Hopkins (RU 204 and RU 473), Osterkamp and Harrison (RU 253), Rogers and Morack (RU 271), and Vigdorchik (RU 516) have resulted in important findings. *Subsea and ice-bearing (but unbonded) permafrost (material remaining below 0^{o} C) was found most likely to exist over most of the Alaskan 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,* in some places probably perforated due to the ocean transgressing large lakes of more than 2-meter depth; Prudhoe Bay is an example. Subsea sediments are ice-bonded in shallow waters where winter ice rests on the bottom, from depths of a few meters to several hundred. Further offshore subsea sediments are soaked with liquid brine to depths of 50 m or more and the relict ice-bonded permafrost is thinner. 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.

The summary of historic earthquake data displayed in the annual report of Biswas and Gedney (RU 483) *reveals that the Beaufort-Chukchi Seas areas are relatively free of quakes.* A network of stations was installed in the Norton-Kotzebue Sounds and around the Seward Peninsula. Results show a number of local earthquakes, indicating that the area is seismically active, but analysis of data is incomplete. *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 and suggest that magnitudes above 3.0-4.5 on the modified Mercalli scale are unlikely. More definitive work still remains to be accomplished in the use of seismic data to delineate trends of faults and mechanisms of seismic release.

Most faults in the Kotzebue area were deemed inactive from data so far obtained. Seismic reflections showed prominent scarps just off Point Hope, unusual for the flat Chukchi Shelf. *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.

Further work on faulting and sediment instability in the Beaufort was limited by severe ice conditions. Eittreim and Grantz (RU 432) have located some areas of active subaqueous slumping and sliding along the continental shelf-slope break. Planning for offshore exploitation of gas or oil resources here should *give special attention to potentially unstable areas such as the Barrow sea valley* which appears to be presently active with dynamic sedimentation processes.

Coastal morphology work has progressed under Cannon (RU 99) in the Chukchi and Barnes et al. (RU 205) in the Beaufort. The latter USGS team has completed a number of studies leading to the following conclusions:

1) There is supporting evidence for assuming an unfrozen sediment surface, at least for summer conditions.

2) Seismic records from southwestern Harrison Bay and the Kogru River area exhibit strong, linear and continuous reflectors down to a sub-bottom depth of about 70 m, a feature not observed on the Arctic shelf in general. This is thought to represent a geologic boundary between Quaternary (Gubic Fm.) deposits underlying the coastal plain from Barrow to Cape Halkett and farther east. How far south this unit extends is not known.

3) Erosion rates can be an important factor in selection of construction sites for petroleum development. 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

$-5^{o}C$. Before isolation is completed, *dense water may pass out the spillpoint of the lagoon and flow seaward. Implications are for the potential similar transport of pollutants.*

4) *The rate and depth of gouge activity clearly indicates that ice gouging must be considered in offshore installations, in particular for pipelines.*

5) The presence of current-produced bedforms adjacent to or within individual gouges suggests that gouge fields in the Chukchi Sea are more rapidly reworked by currents. Similarities between the Beaufort and Chukchi sea shelves are in the maximum values of ice gouge densities, ice gouge widths, and incision depths.

Biological Studies

OCSEAP investigators Severinghaus and Nerini (RU 67) have compiled an annotated bibliography of published and unpublished material dealing with marine mammals in Alaska. Studies of trophic relationships among ice-inhabiting phocid seal by Frost, Lowry and Burns (RU 232) summarize the feeding ecology of ringed and bearded seals, major components of the marine mammal fauna of the Bering, Chukchi, and Beaufort Seas.

Burns and Eley (RU 230) provided a comprehensive review of ringed seal life history including data on morphological variation, taxonomy, molt and breeding periods, dentition and dental anomalies, growth rate, productivity and reproductive behavior, and predation. Complementary information was supplied through other research studies supported by

OCSEAP (RUs 67, 194, 232, and 248). Aerial surveys were used to determine densities of ringed seals, but few data could be obtained on bearded seals. 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 overwintering in the Beaufort Sea have been declining since 1970 to the present. Pregnancy rates are also down in Alaskan and especially in Canadian ringed seals. Reason for this decline is not known.*

Hauling out behavior is part of the study by Burns, Shapiro and Fay (RU 248), relating sea ice conditions to marine mammal distribution by use of satellite imagery. 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.

Detailed information on basic biology, population sizes, and migratory routes for whales is sparse. Status of bowheads and belukhas in the Bering, Chukchi and Beaufort Seas has been summarized by Braham, Krogman, and Fiscus (RU 69). *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.* Fewer data are available for belukhas, but they appear in the eastern Beaufort Sea and Banks Island area by mid-June and many congregate in the mouth of the Mackenzie River. Lowry, Frost and Burns (RU 232) consider 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.* They emphasize that further studies of petrochemical effects on marine organisms are important if valid predictions of effects on mammals are to be made.

Aerial surveys of marine birds were made by Harrison (RU 337) in both the Chukchi and Beaufort Seas areas. 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 being observed in open water within five miles of shore.* Oldsquaws, loons, and phalaropes were the most common species found in pack ice (Divoky, RU 196). *August appeared to be the month of peak bird utilization of the Chukchi Sea area. The waters immediately north of the Bering Strait were particularly important at this season,* harboring large numbers of shearwaters, fulmars, and small alcids. By October many species had migrated out of the Chukchi Sea. 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 conjunction with aerial surveys to provide an integrated approach to details of avian distribution. Gould (RU 337) conducted shipboard surveys of marine birds in the western part of the Chukchi Sea to determine densities; shearwaters were dominant and auklets were common. Studies have been made by Springer and Roseneau (RU 460) on seabird colonies at Cape Thompson and Cape Lisburne to provide current information on nesting ecology and population sizes. *Murre populations were found to be about 50% lower in 1976 than in 1960. Black-legged kittiwakes exhibited reproductive failure this year. This may be attributed to a low forage fish population in 1976,* particularly arctic cod. The juvenile cod population increases with depth and is therefore less available to kittiwakes (a surface-feeding species) than to murres and other alcids (diving species). The low fish population accounts for the strong effect on the kittiwake populations. Murres' dependence on fish decreased in 1976 and prey species changed to a larger percentage of invertebrates (chiefly shrimp).

Mickelson (RU 441) studied avian community ecology on the Espenberg Peninsula to determine habitat utilization and breeding ecology of waterfowl and shorebirds and the effect of predators on nesting birds. For most species, nesting success seemed to be normal and in line with that found at other arctic localities. *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.* Mickelson notes 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 months* when the area receives maximum use from wildlife.

The role of shorelines in the arctic as crucial to the reproductive success of a number of arctic-breeding bird species has now been conclusively demonstrated by Risebrough and Connors (RU 172). Preliminary comparisons between bird use of Chukchi and Beaufort littoral zones show them to be fundamentally different--critical for different species, different segments of the populations, and for different periods. A coherent picture of the unique species assemblages, featuring auklets, murres, puffins and kittiwakes is beginning to emerge from the studies of Drury (RU 237). Banding of birds by Shields and Peyton (RU 458) will greatly aid documentation of nest site fidelity and migration stopover location use patterns. Field efforts in 1977 should reveal whether the low reproductive success in 1976 was an anomalous phenomenon.

Fish, Benthos, Plankton

In the Beaufort area, stomach analyses show nearshore fishes to be opportunistic feeders, utilizing a variety of marine, freshwater, and aerial invertebrates as well as other fish. *The major disruptive force upon nearshore fish fauna now foreseen as a consequence of OCS activity is gravel and water mining in river deltas*, as these activities would affect fall spawning and overwintering habitats (Bendock and Roguski, RU 233). In Beaufort field work, 28,369 fishes were caught, representing 15 species, 52% were anadromous species, principally Arctic char, Arctic cisco, and least cisco. The marine species were dominated by fourhorn sculpin and Arctic cod. Morrow (RU 285 and 348) has completed a partially annotated bibliography on fish of the Beaufort Sea, including literature sources from Russian authors. A useful illustrated key to otoliths of 142 species of forage fish is also complete. Pereyra et al. (RU 175) and Barton (RU 19E) used a stratified system sampling scheme to assess the status of the demersal and pelagic fish resources in Chukchi Sea and Kotzebue Sound. Codfish dominated the resource.

Mann (RU 205) compiled a list of benthic organisms from grab samples with range maps for each species. Preliminary indications suggest that *changing sediment grain size may control species distribution patterns in the Chukchi.* Separate species lists for Norton Sound and Chukchi Sea will be available in Feder's (RU 502) final report; abundance and distribution data for most invertebrates will also be included. Broad et al. (RU 356) continued a reconnaissance characterization of the littoral biota of the Beaufort Sea. The result is a species list that is reasonably complete. The regions of the Beaufort and Chukchi Seas may be characterized as species and biomass poor.

Examination of data from the Pitt Point transect of investigations by Carey (RU 6) indicates the benthic infaunal populations to be very stable, with similar values of abundance from season to season. His final report (RU 7), summarizing existing literature and unpublished knowledge of Beaufort Sea benthos, has been received.

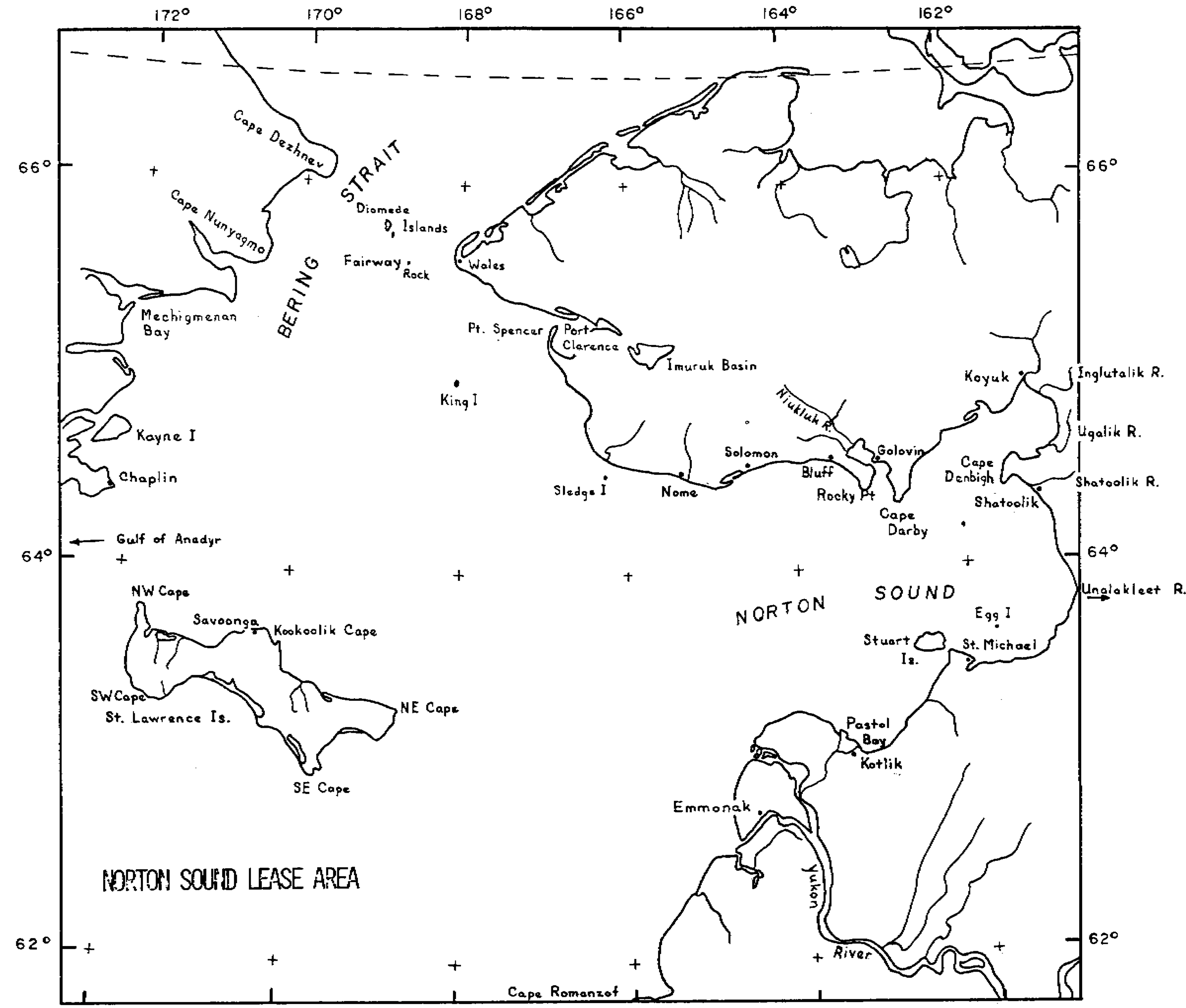
OCSEAP plankton studies in the Chukchi Sea during 1976-77 were limited to zooplankton and micronekton density distribution studies by Cooney (RU 426). Analyses are not complete, but data available so far indicate that the summer zooplankton community is characterized by predominantly neritic species. It also appears that dominant zooplankton species distribution is continuous from Bristol Bay to Pt. Hope. No OCESAP-sponsored studies of Beaufort Sea plankton were ongoing during FY 77, but data from the GLACIER 1976 cruise have been used to estimate annual production of phytoplankton in the northeastern Chukchi and western Beaufort Seas.

Microbiology

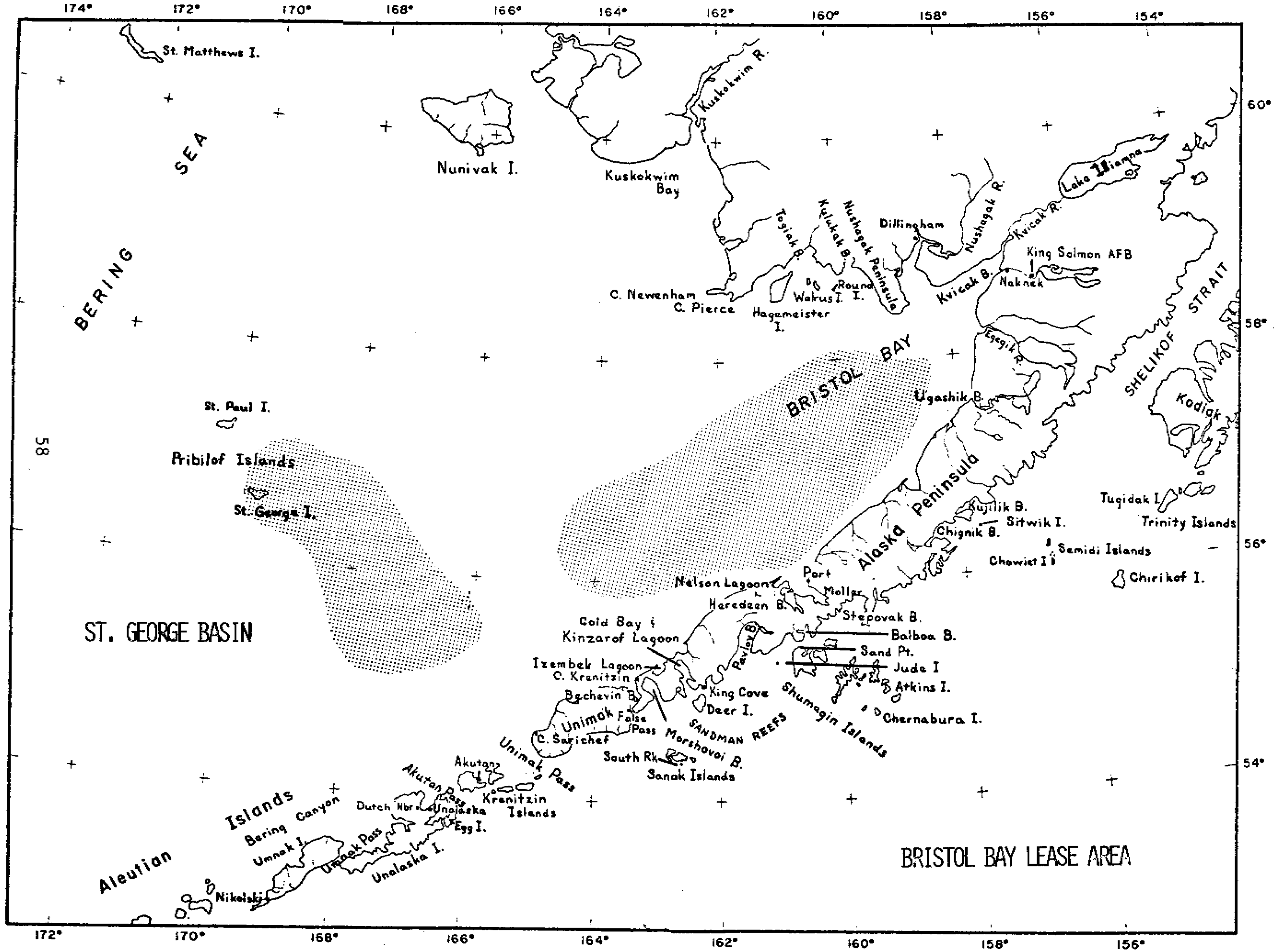
Bacterial populations were lower in the ice-dominated summer of 1975 than in the milder summer of 1976, suggesting that *summer ice conditions are critical in determining bacterial population levels.* Bacteria in ice also appear to be highly site-specific. Viable bacterial populations in sediment did not show decreases in winter as they did in water. In examining the potential of the indigenous populations to degrade petroleum hydrocarbons, highest winter activity occurred in water off Barrow and Prudhoe Bay, indicating that *winter oil biodegradation can occur.* High biodegradation potentials were also found in sediments. The lowest populations of hydrocarbon degraders, also the lowest in potential, were found in the ice (Atlas, RU 29).

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. Dupre (RU 208) has discovered that the Yukon delta, though it resembles a temperate climate delta, has some startling differences. Almost the entire area is underlain by permafrost, which fact greatly hampers construction operations; also major flooding and changes in active river channels are associated with ice breakup in spring--warm weather causes inland ice to break and move toward the coast, but unmelted ice in the delta produces ice dams, causing flooding. The latter would threaten significant damage to any construction in the delta area. Dupre's studies of the form and history of the delta should assist planning to minimize environmental impacts on OCS operations as well as development impacts on the environment. The Yukon 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.



NORTON SOUND LEASE AREA



St. Matthews I.
BERING SEA
Nunivak I.
Kuskokwim Bay
Kuskokwim R.
Togiak B.
Kulukak B.
Nushagak Peninsula
Dillingham
Nushagak R.
Kvichak R.
Lake Iliamna
King Salmon AFB
Naknek
Kvichak B.
C. Newenham
C. Pierce
Walrus I.
Round I.
Hagemeister I.
Egegik R.
BRISTOL BAY
Ugashik B.
SHELIKOF STRAIT
Kodiak
St. Paul I.
Pribilof Islands
St. George I.
Alaska Peninsula
Kujulik B.
Sitwik I.
Chignik B.
Tugidak I.
Trinity Islands
Semidi Islands
Chowiet I.
Chirikof I.
Port Moller
Nelson Lagoon
Herendeen B.
Stepovak B.
Balboa B.
Sand Pt.
Jude I
Atkins I.
Chernabura I.
Shumagin Islands
ST. GEORGE BASIN
Cold Bay & Kinzarof Lagoon
Izembek Lagoon
C. Krenitzin
Pavlof B.
King Cove
Deer I.
Bechevin B.
Unimak
False Pass
SANDMAN REEFS
Morzhovoi B.
C. Sarichef
South Rk.
Sanak Islands
Unimak Pass
Akutan
Akutan Pass
Krenitzin Islands
Unalaska
Egg I.
Dutch Hbr.
Bering Canyon
Aleutian Islands
Umnak I.
Umnak Pass
Unalaska I.
Nikolski
BRISTOL BAY LEASE 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 basins 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.

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. *Nelson (RU 429) has identified a large number of areas of ice gouging in Norton Sound, particularly near the Yukon Delta.* He has *also discovered an area of gas cratering of the sea floor,* 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. In Norton Sound, however, it comes from methane gas produced by shallowly-buried tundra peats and vented through craters. These have been observed especially in an area southeast of Nome and just off the mouth of the Yukon. Anomalies in seismic records suggest that gas accumulations are more widespread. 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. Sallenger (RU 431) has been studying the shoreline of the northern Bering Sea and has *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 were initiated by Coachman et al. (RU 541) during the summer of 1976. To date, only limited data are available for analysis. In particular, long-term current meter moorings were not recovered until the summer of 1977. The following preliminary interpretation of Norton Sound circulation patterns is inferred from short-term hydrographic and current measurements conducted during 1976. The circulation system appears to be composed of two regimes. The flow in the western two-thirds of the Sound was cyclonic (counter-clockwise), and there was evidence of bathymetric steering. Inflow from the west occurred primarily along the bottom in the deeper troughs. Outflow appeared to be concentrated in an intense westerly current off Nome. *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.* Sediment transport studies by Cacchione and Drake (RU 430) support the conclusion that the eastern and western portions of the sound are isolated from one another. However, their observations suggest a relatively greater flow of Yukon-derived water across the mouth of the sound. The long-term current-meter records received in

August 1977 should provide a clearer picture of the prevailing circulation pattern in this region. Leedertse and Liu (RU 435) are addressing the tidal and wind-driven circulation in Norton Sound through use of a three-dimensional numerical model.

Contaminant Baselines

Data on ambient distribution and concentrations of contaminants in the northeastern Bering Sea are limited. Burrell (RU 162) has done some sampling, but analyses are not complete. It is known, however, that petrogenic contaminants are present. Cline and Feely (RU 153) have found that 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. Hydrocarbon surveys have been made for most of the shelf area of the southeatern Bering Sea, which includes both Bristol Bay and St. George, considered as contiguous geographic continuations. Major differences are the freshwater input to Bristol Basin and the oceanic influences in the St. George area. *Total hydrocarbon content of sediments in these areas was found to be very small,* except for an anomalous value for sediment samples collected at the head of Pribilof Canyon. Kaplan et al. (RU 480) believe this to be indicative of localized petroleum hydrocarbon contamination. As in the western Gulf of Alaska, hydrocarbons in Bering Sea sediments in general originate from marine and terrestrial sources. Concentration of methane showed seasonal and spatial variability mostly reflective of seasonality and spatial preference in biological productivity.

Nelson (RU 413) has studied the trace metal content of bottom sediments in the northern Bering Sea. Analyses are completed and data are available in computer storage. Complete reports for all trace metals will follow as computer processing and maps are completed. Feely and Cline (RU 152) have continued studies of the composition and distribution of suspended particulate matter in the southeastern Bering and have found a high concentration of magnesium, aluminum, potassium and titanium, indicating probably terrestrial origin.

Hazards

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. In the Norton Sound region, maximum intensities greater than magnitude 6 are essentially restricted to the Seward Peninsula with lesser values recorded from northeast to southwest across Norton Sound (Meyers, RU 352). A new network around Seward Peninsula has been operating for the past several months (Biswas and Gedney, RU 483), but detailed analyses of the data have not been completed. During that short period records show a sufficient number of quakes (largest magnitude 4.5) to indicate *greater seismic activity than previously thought for the Norton Sound.* This seismic pattern reflects the fact that major underthrusting of the Pacific Plate beneath the American Plate occurs along the Aleutian Trench, south of the Alaska Peninsula. Historic seismic data are being supplemented by studies of faulting and unstable sediments by Gardner and Vallier (RU 206) in the St. George region. 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.*

A survey team headed by Nelson (RU 429) has provided a preliminary assessment of non-seismic hazards in the Norton Sound region. Included are faulting, ice gouging, gas cratering of surface sediments, and storm surge activity. 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; ice gouging, bottom current and storm surge activity 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.* Dupre's studies (RU 208) 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 it 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. Further information on coastal areas of Norton Sound is being obtained by Sallenger et al. (RU 431).

Sea ice hazards in *Bristol Bay* are being examined by Stringer (RU 257). This 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 ridging 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.

Hydrographic data for Bristol Bay and St. George areas were obtained in June 1976 in two cruises. In general the waters over the Bristol Bay shelf have been characterized in three zones according to differences in vertical stratification: coastal zone, central shelf zone, and shelf break zone (Schumacher, Charnell and Coachman, RU 141). Extensive moored current meter data (RU 141) and drifting buoy results (Hansen, RU 217) indicate that net flow over the central shelf is very small, particularly in comparison with the coastal shoal or shelf break regions.

Due to 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 (Leendertse and Liu, RU 435) have shown *a cyclonic gyre in the deep basin of the Bering Sea,* probably advecting significant amounts of nutrients in selected areas. Currents along the shelf break were in a northwesterly direction, veering east in the northern Bering Sea toward the Bering Strait.

Detailed hydrographic observations conducted under RU 141 have revealed extensive areas of water column static instability. The dynamic stability of these waters and the implications on vertical mixing processes are currently under investigation.

Biological Studies

Plankton studies conducted by Alexander (RU 427) and Cooney (RU 425) in the Bering Sea slope and shelf areas covered both the Bristol Basin and St. George Basin lease areas. The studies were intended to estimate plankton primary productivity, species composition and richness, and nutrient dynamics with special reference to the seasonal ice edge. 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. It should be noted that chlorophyll specific daily primary productivity during the two cruises of the investigations was only moderate; highest value, over 5 mgC/mgChl/day, was observed at a station in deep ocean.

Cooney (RU 156) continued zooplankton and micronekton studies in the eastern Bering Sea. Over 150 species have been identified from samples which have been grouped into four regimes for statistical analysis: open water, slope area, outer shelf (depths between 200 and 50 m), and inner shelf (depths less than 50 m). Sampling strategy during the last year was to describe the zooplankton and micronekton communities relative to the ice edge. Analysis of these data is continuing.

Zimmerman et al. (RU 78) have flown the coasts of Bristol Bay and St. George Island to ascertain major intertidal beach types. The data are currently being compiled to produce a compendium of information on beach slope and biological cover.

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 (Zimmerman et al., RU 78).

In addition to coastal zone surveys of Norton Sound, Zimmerman et al. have completed reconnaissance of the littoral benthos of the Yukon-Kuskokwim delta. Little or nothing was previously known of the biological significance of this coastline. Drift remains indicate the presence offshore of shellfish communities; in fact, a protected lagoon at Hooper Bay is habitat for shellfish subsistence of local inhabitants. Evidence of some intertidal populations was found. Trawl surveys for demersal fishes and epifaunal invertebrates was effective and integration of information on these two groups will be of value in understanding the shelf ecosystem. A large number of species collected in the study area were either sessile or slow moving forms. Both these groups could be greatly affected by oil spills in the area because of their inability to leave the area or because of their dependence on the sediments for feeding.

Some studies on density distribtuion of fish eggs and larvae have been made by Waldron and Favorite (RU 380) in the eastern Bering Sea. They point out that *limited-period surveys do not provide adequate information on the distribution of larvae or eggs of most or all of 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.

Feder and Mueller (RU 282) have *completed a summarization of existing literature and unpublished data on the distribution, abundance and productivity of benthic organisms in the Bering Sea;* 6,500 references have been included. Distributions of 30 widely spread abundant infaunal species have been plotted. Another group with Feder (RU 281) extended benthic studies into Bristol Bay and St. George areas in conjunction with Hoskin (RU 290). A total of 77 widely dispersed quantitative grab sampling stations were established in the Bering Sea. A trawl survey by Pereyra et al. (RU 175) conducted jointly with the National Marine Fisheries Service, achieved excellent coverage. Integration of epifaunal information from these cruises with infaunal benthic data will enhance understanding of the Bering Shelf ecosystem. There is now a satisfactory data base for the invertebrate species (infauna and epifauna) for the portion of the Bering Sea Shelf grid processed to date. It is probable that all infaunal and slow moving epifaunal species with numerical and biomass importance were collected during the 1975 trawl survey and that mainly rare species will be added to the list in the future.

Information on feeding biology of most 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. Small pollock are the major food of large pollock as well as several other large predatory fishes and marine mammals. An interesting sidelight to Feder's benthic studies was his *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.

The most important shellfish exploited is the crab, chiefly the king crab species. Several species of shrimp inhabit these areas and are commercially harvested. Pereyra et al. (RU 175) recently completed a comprehensive review of dermersal fish and shellfish resources of the eastern Bering Sea for the year 1975. Some important conclusions of this review follow. Yellowfin sole is another species of importance to the commercial fishery biomass, but the contribution of sole to the total commercial catch of all demersal forms is dwarfed by the large pollock removals. Most important demersal populations of the eastern Bering are either fully exploited 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 which forage on this species. Some demersal fish populations appear to winter along the upper slope and outer part of the continental shelf of the southeastern Bering Sea where water temperatures are relatively warm and uniform throughout the year. Important regions in terms of both biomass of commercial bottom animals and the fisheries are: 1) the southeastern Bering shelf and slope north of the Alaska Peninsula to the Pribilof Islands, and 2) the outer shelf and upper slope extending northwest of the Pribilof Islands towards Cape Navarin. Some spawning locations of importance are: 1) the slope region south of the Pribilof Islands, for Pacific halibut; 2) 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. Wall and Macy (RU 64) have reviewed the literature and are evaluating data sources on the abundance and distribution of non-salmonid pelagic fish in the Bering Sea, as well as in the Gulf of Alaska.

Feeding habits of halibut and pollock have been the subject of research by Smith et al. (RU 284). Still other important fish resources reported in these waters are salmon and char (Sternet al., RU 483). Data are still lacking on distribution, abundance, migration and timing of char. Sockeye salmon is the most important salmon species, following which are pink and chum. Some coho and chinook salmon are included in catches. Within Bristol Bay, catch statistics are reported on an area basis. *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 Kuichak and Nushagak Bays contribute 80% of the area's total salmon production, 86% of which is sockeye salmon. Pink salmon account for 80% of the salmon spawning run to the Aleutian Island region west of Unimak Pass, with sockeye second in abundance. *Peak spawning activity is greatest in August.* Barton et al. (RU 19) investigated distribution, abundance, demography, habitats, reproduction and human utilization of forage fishes in Bristol Bay. Emphasis was on herring, but considerable data were obtained on capelin, smelt and eulachon. *Capelin were second in abundance to herring among forage fishes.*

In a review of historical literature, Barton (RU 19E) found that pelagic forage fish have been an essential component in the diets of native peoples of western Alaska. Herring catches in Norton Sound have also contributed to this use. Salmon harvest in Norton and Kotzebue Sounds is presently an essential element in the local economics. Although once a major industry, since 1964 limited herring fishery has operated out of Unakleet and St. Michael. *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 (Pereyra et al., RU 175).

A combination of mainland, island, shipboard, and aerial surveys provides an overview of avian dynamics in the Norton Sound area. The start of the seabird nesting season on St. Lawrence and King Islands was delayed for about one week as a result of prolonged snow cover. Comparative data from the mainland, however, are insufficient to determine whether shorebirds and waterfowl experienced similar delays. 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. Field work by Drury (RU 447) in June and August 1976 was primarily concerned with determining the distribution, abundance, breeding schedule, and reproductive success of these species, as part of a larger study of the ecology of waterbirds in the Norton Basin. According to Searing (RU 470), *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%, whereas reproduction on St. Lawrence Island seemed normal (Searing). Suggested low hatching rates of shorebirds on the Akulik-Inglutalik deltas are based on such small samples that they cannot be compared (Shields and Peyton, RU 458).

Drury (RU 237) and Searing each independently suggested that *large numbers of murres and auklets were wandering for food in August 1976;* they suggested that many birds were possibly feeding in the Chirikov Basin and Anadyr Straits, where oceanographic conditions provide rich feeding areas. Aerial surveys (Harrison, RU 337) confirmed the presence and abundance of murres, auklets, and other species to the north and west of St. Lawrence Island, and shipboard studies (Gould, RU 337) indicated the scarcity of birds (and total absence of auklets) from Norton Sound.

Lensink and Jones (RU 488) conducted inventories of coastal habitats in the region between Cape Newenham and the Bering Straits. This area of unique importance to seabirds, waterfowl, and shorebirds, includes part of four present and several proposed National Wildlife Refuges. Most of the work was concerned with evaluating the large amount of existing literature and unpublished material. Major field work involved a study of habitats along the Yukon delta and a study of environmental conditions within 150 miles of Kotlik. *During the summer study of the Yukon area, the authors noted an abundance of birdlife along the delta,* with pintails, lesser Canada geese, green-winged teal, shovelers, and sandhill cranes in predominance. 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.

OCSEAP studies of birds in the Bristol Bay region during the past year include identification of 82 species of seabirds, shorebirds, and waterfowl in the Nelson Lagoon-Port Moller-Herendeen Bay region (Bartonek et al., RU 341). Arneson (RU 3) made surveys of the *coast of Bristol Bay and other areas identified as 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.* He indicates that *Bechevin Bay is also of great importance* to migrating birds. According to Arneson the only substantial colony area on the north side of the Alaska Peninsula is located on the *north end of Amak Island* and on two small islands north of Amak. This was presumably based on information by Bartonek and Lensink. However, the latter (RU 338) also report two moderately large colonies on the *north side of Unimak Island,* one at Cape Mordvinof and the other at Cave Point.

They also conducted shipboard surveys of birds on pelagic waters of Bristol Bay and St. George Basin in spring and summer 1976. Shearwaters were the most abundant birds present from May through July, whereas murres were more plentiful in February and March. Eiders and scoters also are present throughout the year, though they were not detected in all shipboard censuses. Fulmars and fork-tailed petrels tended to occur in areas over and beyond the shelf break. According to Bartonek et al,, St. George Basin is one of the three most important pelagic regions in Alaska for seabirds, the other two areas being Kodiak Basin and Alaska Peninsula South.

Myres and Guzman (RU 239) found heavy concentration of shearwaters along the southern coast of Bristol Bay in June 1976 and none in the Pribilofs until August, when they were abundant. Hunt (RU 83) determined density distributions of birds around the Pribilofs in 1976. Hickey (RU 38) concentrated census work on seabirds in the Pribilofs and concluded that *St. George Island appears to be the largest seabird colony in the northern hemisphere.*

Trophic relationships of marine birds in the eastern Bering Sea are being evaluated by Sanger and Baird (RU 77) and Bartonek et al. (RU 341). Principal prey are fish, squid, and nektonic crustacea. Shearwaters rank as the most abundant seabirds in this region, followed by murres and fulmars. Shearwaters and murres are given particular attention because of their great importance in the Bering Sea ecosystem. Shearwaters are migratory, breeding in the South Pacific and spending the boreal summer in the north Pacific. Murres on the other hand, are present in the Bering Sea the year round. Laevastu et al. (RU 77) have used conservative estimates for modeling the eastern Bering Sea ecosystem. Guzman (RU 239) has reported a single grouping of 10 million shearwaters (in 1975), whereas the model referred to estimates the entire population to be 10 million birds.

Marine mammal studies for OCSEAP include investigations of distribution and abundance and the trophic role of fur seals and bearded seals in the marine ecosystem. Schneider (RU 241) describes the population of sea otters as extending from Cape Mordvinof to Cape Lieskof, including Bechevin Bay, Izembek Lagoon, and Moffet Lagoon. Most otter populations remain nearshore, but members of this one range out beyond the 60 m depth. Schneider concludes 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.*

Burns et al., under two different research units, RU 231 and 248, surveyed the Bering Sea ice front by air in March and April 1976, with the following conclusions: 1) A large concentration of ice-breeding harbor seals was present in western Bristol Bay; distribution of breeding adults was continuous from Bristol Bay to the western limit of their surveys; 2) Walruses were numerous throughout Bristol Bay, particularly in the southern and central parts; 3) *Sea lions were restricted to the first few miles of the ice front* and were most abundant south of the Pribilofs; 4) Ribbon seals occurred over the entire survey area but were most numerous west of the Pribilofs; 5) Bearded seals and ringed seals are not commonly found in the ice front, especially near the southern boundary.

Braham et al. (RU 69) also determined densities of ice-inhabiting pinnipeds, finding them to range in the following descending order: bearded seals, largha seals, ringed seals, and walruses. They estimated that 80% of the sea lions in Bristol Bay are concentrated in the eastern Aleutians, from Ugamak Island to Adugak Island. *The largest concentration 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. Other whales (including gray, humpback, fin and sperm) and harbor porpoises are regularly seen. Fay (RU 194) conducted aerial surveys of beaches to census and examine dead animals. He found that 0.05 - 0.06 marine mammals per km of shoreline had been dead less than four months. In other Bering Sea areas, where hunting occurs, frequency was much higher and most had died of gunshot wounds.

Laevastu et al. (RU 77) selected fur seals and bearded seals as representative marine mammals for their ecosystem model of the eastern Bering Sea. Most of the fur seal population winters in the north Pacific, from the Gulf of Alaska to central California and migrates into the eastern Bering to breed and bear young on the Pribilofs in summer. By contrast, bearded seals winter in the Bering Sea, but most of them summer in the Arctic Ocean. Laevastu notes that the effect of fur seals on pollock populations may be very different from the effect of sea lions. Fur seals consume smaller pollock; sea lions older, larger ones. Since large pollock are cannibalistic, consumption of pollock by sea lions reduces cannibalism, which may influence pollock population growth.

The only OCSEAP study of marine mammals specific to the St. George area is an investigation of physiological impact of oil on pinnipeds by Kooyman et al. (RU 71). No studies were carried out during the past year dealing principally with mammal fauna of Norton Sound. However, the annotated bibliography of marine mammals in Alaska compiled by Severinghaus and Nerini (RU 67/68/69/70) is applicable to all areas of the state. The Bering Sea was included in the investigations of Braham, Krogman and Fiscus (RU 69) on distribution of bowhead and belukha whales, and also in the investigations by Burns, Shapiro and Fay (RU 248) on effects of pack ice on the distribution of marine mammals. Some of their conclusions which apply to Norton Sound are: 1) Braham's efforts were largely concerned with reviewing existing data in Norton Sound; 2) *Bowhead whales leave the Bering Sea in early spring for the Arctic, apparently by-passing Norton Sound.* Belukhas also by-pass Norton Sound in their spring migration; *this area does not appear to be of particular importance to cetacean populations at any season;* 3) Burns et al. found that ice in Norton Sound tends to be in motion most of the winter. Data on distribution of marine mammals in Norton Sound have not yet been incorporated into their analyses.

GULF OF ALASKA

The first Alaskan 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 seismic hazards and circulation studies. 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.

Lease sales in Lower Cook Inlet have pressed the need for information in that area also. Cook Inlet is a tidal estuary of the Gulf of Alaska, east of the base of the Alaska Peninsula. Offshore oil production in Alaska started in Cook Inlet with State of Alaska lease sales in the 1960's. These were interrupted in 1963 by a jurisdictional dispute with the U.S. Government, which was settled in 1975 by the U.S. Supreme Court in favor of the Federal Government. The Bureau of Land Management, as the government's agency for leasing of lands then requested NOAA to begin studies in Lower Cook Inlet, and these were initiated in the summer of 1976.

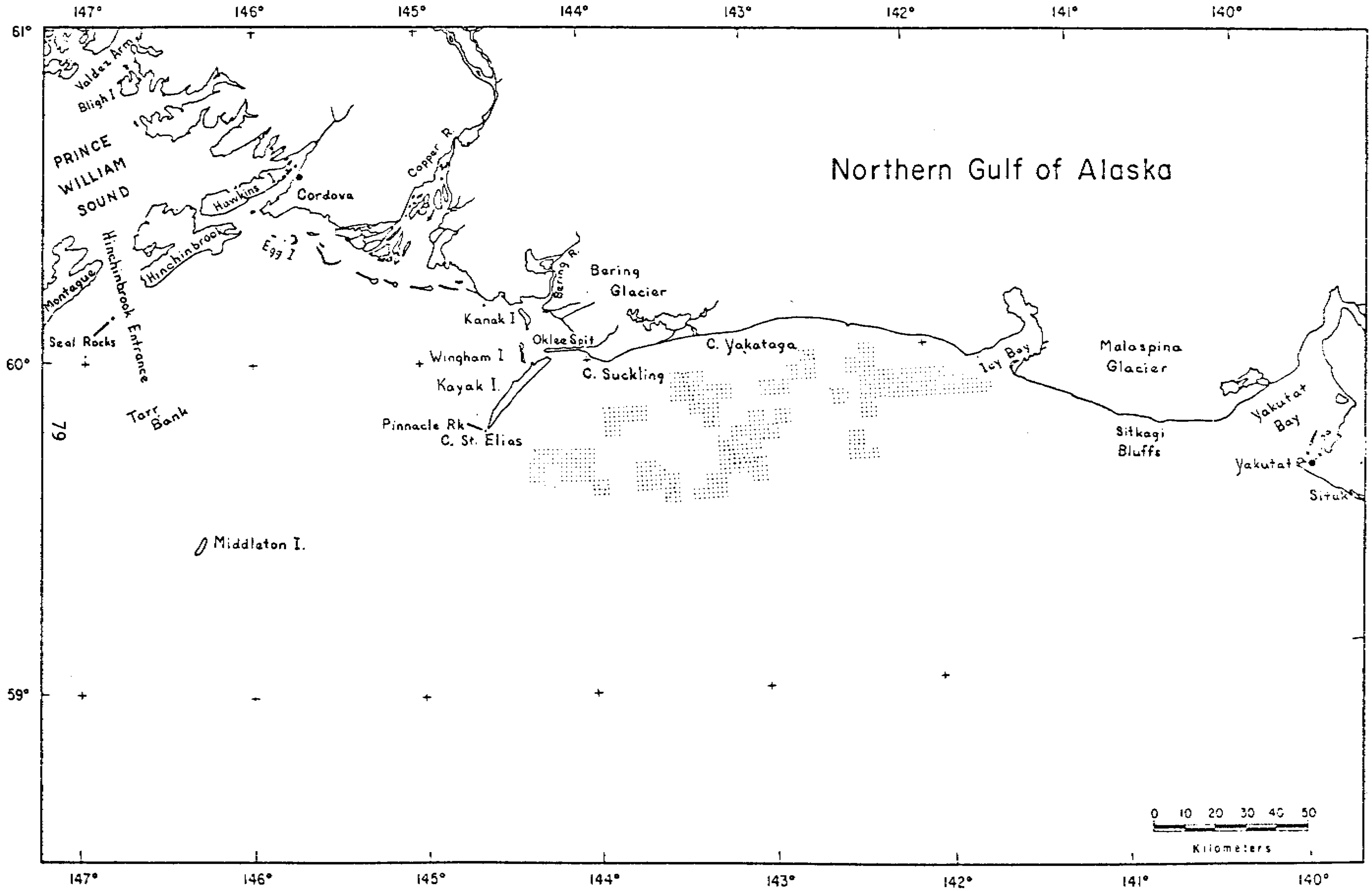
Initial sampling in Lower Cook Inlet has necessarily been of a reconnaissance nature. Data are generally limited, originating from only a few sampling stations. *Hydrocarbon concentrations by Shaw (RU 275) show a generally low content*, less than 1 μg/kg. Only one sample (collected in Kachemak Bay) contained a measurable amount of tar, less than 0.1 mg.*

* Hydrocarbon and trace metal concentrations are summarized for all lease areas in Table 2. The reader is referred to original reports for complete data.

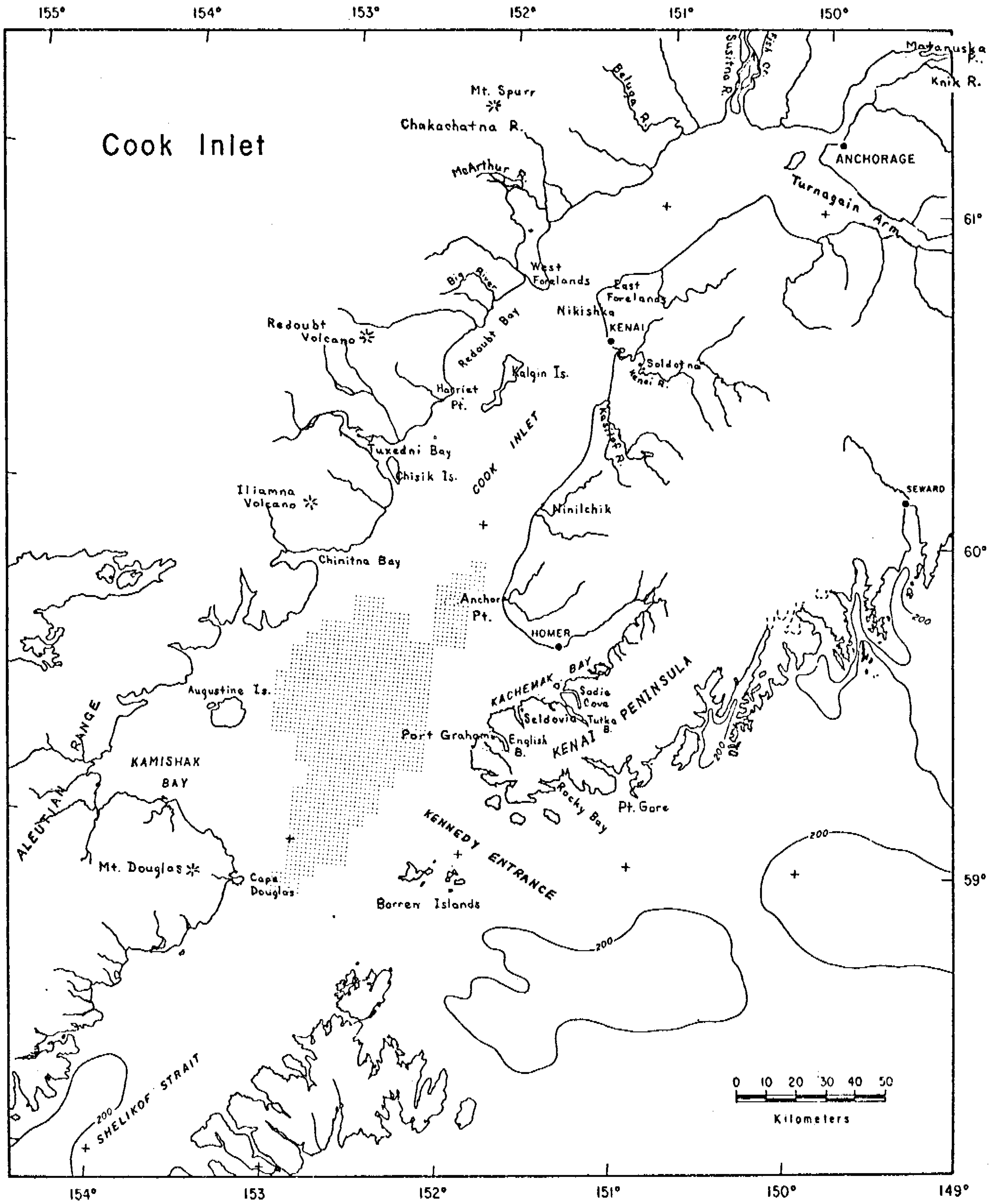
Table 2. HYDROCARBON AND TRACE METAL CONCENTRATIONS

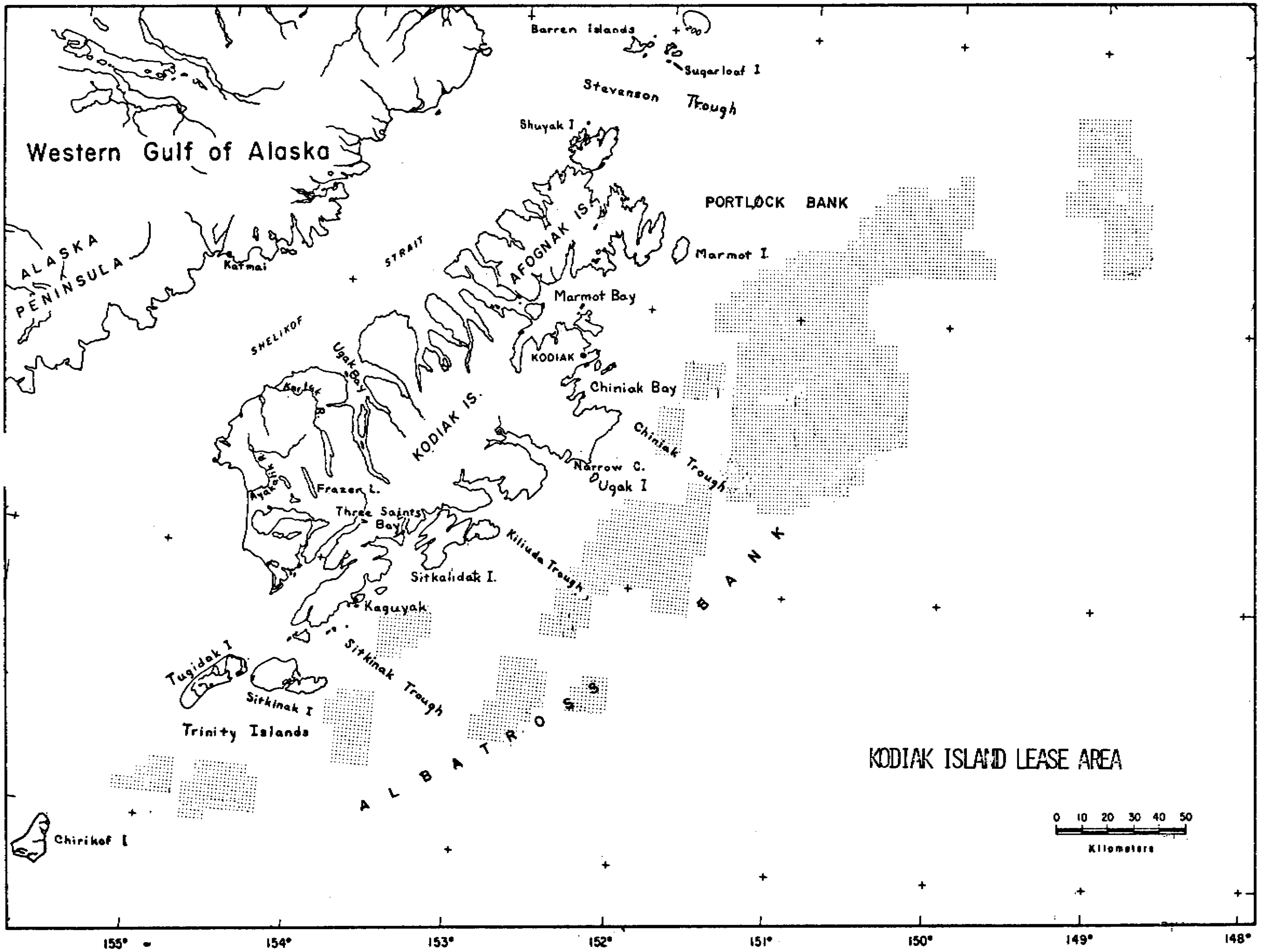
Lease Area	High Molecular Weight	Methane (C_1)	Ethane, etc. (C_2-C_4)	Tar	Metals
Beaufort	1 ppb	No determination	No determination	--	below determinable limit except Fe and Cu
Chukchi	1µg/kg	130 nl/1-338 nl/1	negligible	none	--
Norton Sound	<1µg/kg	100 nl/1-200 nl/1 > 2000 nl/1 east of Stuart Island	<1.0 nl/1 > 1.0 nl/1 near St. Lawrence Is.*	none	--
Bristol Bay	sediments 2-22µg/g	~ 100 nl/1 higher value at Herendeen Bay but no evidence of petrogenic origin	0.5-1.0 nl/1	--	less than NEGOA
St. George	sediments 2-22µg/g	~ 80 nl/1	0.3 nl/1	--	less than NEGOA
Aleutians	not avail. for water 3.3-19.5 µg/g sediments	none avail.	--	--	comparable to NEGOA
Kodiak Island	<1 ppb in water 1-26.7 µg/g sediments	none avail.	none avail.	0.02 mg/m^2	comparable to NEGOA
Lower Cook Inlet	<1µg/kg	100 nl/1-600 nl/1 much higher just south of Forelands	0.4 nl/1	<0.1mg/m^2	lower than NEGOA
Northeast Gulf of Alaska (NEGOA)	1 ppb	100-300 nl/1 much higher at Yakutat Bay*	0.80 nl/1 much higher at Yakutat Bay*	0.016 mg/m^2	uniformly low except for Cu

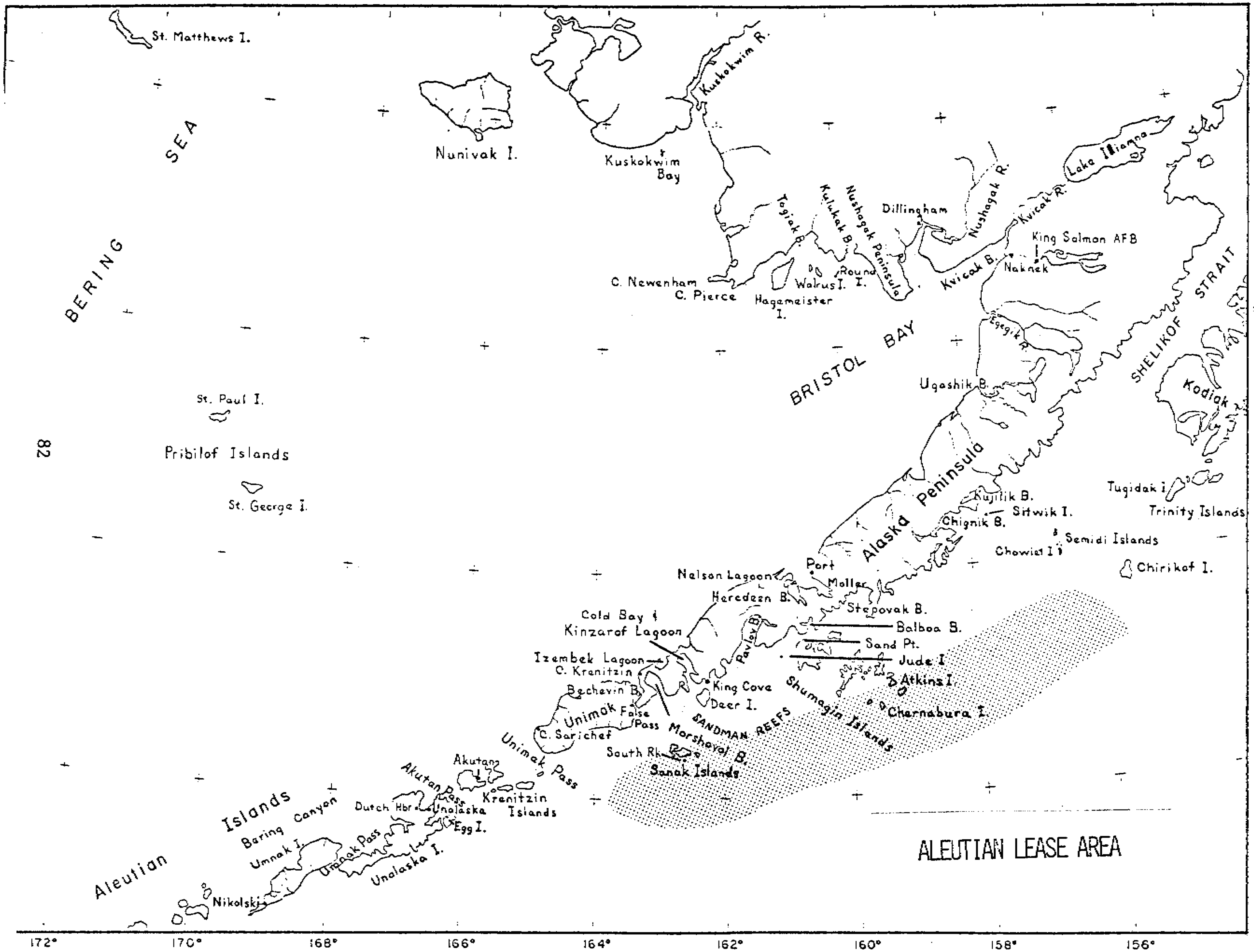
*ratio of methane to ethane plus propane indicates petrogenic source



Northern Gulf of Alaska
147°
146°
145°
144°
143°
142°
141°
140°
61°
60°
59°
Valdez Arm
Bligh I
PRINCE
WILLIAM
SOUND
Hawkins I
Cordova
Copper R.
Hinchinbrook
Montague
Hinchinbrook Entrance
Egg I
Seal Rocks
Bering R.
Bering
Glacier
Kanak I
Okalee Spit
Wingham I
Kayak I.
C. Suckling
C. Yakataga
Icy Bay
Malaspina
Glacier
Yakutat
Bay
Yakutat
Sitkagi
Bluffs
Tarr
Bank
Pinnacle Rk
C. St. Elias
Middleton I.
0 10 20 30 40 50
Kilometers


155°
154°
153°
152°
151°
150°
Cook Inlet
Mt. Spurr
Chakachatna R.
McArthur R.
Beluga R.
Susitna R.
Fish Cr.
Matanuska R.
Knik R.
ANCHORAGE
Turnagain Arm
61°
West Forelands
East Forelands
Big River
Nikishka
KENAI
Redoubt Volcano
Redoubt Bay
Kalgin Is.
Soldotna
Kenai R.
Harriet Pt.
Kasilof R.
Tuxedni Bay
COOK INLET
Chisik Is.
Iliamna Volcano
Ninilchik
SEWARD
Chinitna Bay
60°
Anchor Pt.
HOMER
200
Augustine Is.
KACHEMAK BAY
Sadie Cove
Seldovia
Tutka B.
KENAI PENINSULA
ALEUTIAN RANGE
KAMISHAK BAY
Port Graham
English B.
Rocky Bay
Pt. Gore
KENNEDY ENTRANCE
Mt. Douglas
Cape Douglas
Barren Islands
59°
SHELIKOF STRAIT
0 10 20 30 40 50
Kilometers
154°
153
152°
151°
150°
149°


KODIAK ISLAND LEASE AREA
Western Gulf of Alaska
ALASKA PENINSULA
Katmai
SHELIKOF STRAIT
Barren Islands
Sugarloaf I
Stevenson Trough
Shuyak I
AFOGNAK IS.
PORTLOCK BANK
Marmot I.
Marmot Bay
KODIAK
Chiniak Bay
Chiniak Trough
Ugak Bay
Karluk
KODIAK IS.
Narrow C.
Ugak I
Ayakulik
Frazer L.
Three Saints Bay
Kiliuda Trough
Sitkalidak I.
Kaguyak
Sitkinak Trough
Tugidak I
Sitkinak I
Trinity Islands
ALBATROSS BANK
Chirikof I
0 10 20 30 40 50
Kilometers
58°
57°
56°
155°
154°
153°
152°
151°
150°
149°
148°


St. Matthews I.
Nunivak I.
Kuskokwim R.
Kuskokwim Bay
BERING SEA
Togiak R.
Kulukak B.
Nushagak Peninsula
Dillingham
Nushagak R.
Kvichak R.
Lake Iliamna
King Salmon AFB
Naknek
Kvichak B.
C. Newenham
C. Pierce
Walrus I.
Round I.
Hagemeister I.
BRISTOL BAY
Egegik R.
Ugashik B.
SHELIKOF STRAIT
Kodiak
St. Paul I.
Pribilof Islands
St. George I.
Alaska Peninsula
Kujulik B.
Sitwik I.
Chignik B.
Semidi Islands
Chowiet I.
Tugidak I.
Trinity Islands
Chirikof I.
Port Moller
Nelson Lagoon
Herendeen B.
Stepovak B.
Balboa B.
Sand Pt.
Jude I.
Atkins I.
Chernabura I.
Cold Bay
Kinzarof Lagoon
Izembek Lagoon
C. Krenitzin
Bechevin B.
Pavlof B.
King Cove
Deer I.
Shumagin Islands
SANDMAN REEFS
Unimak
False Pass
Morzhovoi B.
C. Sarichef
South Rk.
Sanak Islands
Unimak Pass
Akutan
Krenitzin Islands
Akutan Pass
Dutch Hbr.
Unalaska
Egg I.
Aleutian Islands
Baring Canyon
Umnak I.
Umnak Pass
Unalaska I.
Nikolski
ALEUTIAN LEASE AREA
60°
58°
56°
54°
172°
170°
168°
166°
164°
162°
160°
158°
156°

No petroleum contamination was found in various biota checked for presence of hydrocarbons, so Shaw concluded that the absence of pollution in those key mollusc species was indication of the absence of oil in the environments. Investigations by Cline and Feely (RU 153) did not reveal anything to contradict that assumption, except for some anomalous values obtained near the Forelands. Data are insufficient to be definitive in regard to the latter, but the methane source measured in Kachemak Bay and near the Forelands may be petrogenic; this is substantiated by levels of ethane and propane also measured. Burrell (RU 162) investigated sediments for trace metal contamination, but found extractable components of the Lower Cook Inlet sediments much lower than from the adjacent northeast Gulf and more comparable with samples from the Aleutians and Bering Sea. Turbulent removal of fine grained sediment from this region evidently decreased the "sorption" capacity of the surface sediments in this locality.

Water samples collected southwest of Kodiak Island contained less than 1 ppb hydrocarbon concentration. No baseline studies on abundance and distribution of petroleum hydrocarbons, C_1 to C_4 hydrocarbons, or trace metals have been obtained by OCSEAP for either the Kodiak or Aleutian shelf areas, other than sediment studies by Kaplan et al. (RU 480). These show total hydrocarbon concentrations in sediments ranging less than 26.7 μg/g dry sediment. 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.* Shaw's results extended to the NEGOA area and were based on analyses of biota, water, sediments, and seston; he *concluded that petroleum contamination present in the Alaskan OCS environment was minimal.*

Meyers (RU 352) completed his analyses of Alaskan 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.* Historical records are being supplemented by Pulpan and Kienle (RU 251) with their western Gulf of Alaska seismic network, and by Davies et al. (RU 16). Pulpan and Kienle's work produced excellent seismicity data for Lower Cook, showing *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 Hampton and Bouma (RU 327) from studies centered on the identification of active faults and areas of sediment instability, types and distribution. Seismic records reveal a limited number of small surface faults and no slump phenomena in Lower Cook Inlet.

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* by Carlson and Molnia (RU 212), whose detailed studies of faulting, stability and sedimentation have contributed a number of maps defining those hazards. One prominent fault-associated scarp near Wessels Reef, Tarr Bank, exhibits vertical offset from 5 to 20 m., and three seismic events recorded there (Lahr and Page, RU 210) indicate a currently active fault.

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 180-230 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. NEGOA beach zone samples of sediment collected by Hayes and Ruby (RU 59) showed variation over a wide grain size, with a general reduction in grain size westward over the NEGOA area.

Studies of effects of streamflow on coastal areas of Alaska by Carlson (RU 111) have been completed and an encyclopedic stream classification has resulted, including ice breakup and freeze-up statistics. The Kenai Peninsula and Matanuska Valley are characterized as generally the first to be free of snow, usually in early May. Delayed runoffs result from seasonal lags, heavier snows at higher elevations, and marine climatic effects. *Many river basins in the Gulf coast region are subject to ice-dammed lake outburst floods* -- the Knik River, the Snow and Kenai Rivers, Tazlina and Copper Rivers, and the Bering River are examples.

Hayes and Ruby (RU 59), basing conclusions on field studies and a vulnerability to oil spills index, consider over 50 percent of the NEGOA shoreline studied as a high risk environment. Oil longevity in these areas is estimated to be from a few years to as much as ten years. It should be noted that some of these high risk areas located on the Copper River Delta and other river mouths are unlikely to receive oil spills because of fluvial flushing, except perhaps for oil carried by storm surges.

Hampton and Bouma (RU 327) found *evidence of sediments from the Copper River being carried into Cook Inlet* as far as Homer, there mixed with the Susitna River suite, and then deposited as far south as Kamishak Bay (where sampling ended) by currents flowing out of Cook Inlet.

Extensive physical oceanographical studies have continued the past year in the Gulf of Alaska. Royer (RU 229) has 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, 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 being associated with the Central regime and the *longest residence time with Prince William Sound* or the Western regime.

Schumacher and Hayes (RU 128) are continuing current meter observations in the Northeast Gulf of Alaska and Kodiak lease areas to characterize mesoscale advective and diffusive processes on the continental shelf. Field work off the Icy Bay region on a mesoscale meteorological process study was completed during FY 77 by Reynolds (RU 367). The results of these curculation and meteorological studies were used as input and verification data for modeling efforts conducted by Galt (RU 140). This combined study effort will be intensified in FY 78 as more data are processed and analyzed.

The Kodiak shelf and lease area are part of the Western regime, located west and inshore of Middleton Island and extending southwest of Kodiak Island. The currents follow bathymetric contours, especially along the shelf break. Over the shelf, currents are irregular and nonsystematic. A dramatic increase in the baroclinic flow and transport were noted in the Alaskan Stream off Kodiak. Estimated transport value was about 13 Sv (one Sv is equivalent to transport of one million cubic meters of water per second). Moored current meter data along the Seward transect have shown a generally southwesterly flow approximately along the direction of the shelf break contours. Hayes and Schumacher (RU 138) reported data from a station near the shelf break off Northern Albatross Bank showing a consistent longshelf, southwesterly current. From these and other observations it can be stated that *the Alaskan 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*.

The Aleutian lease area has been characterized as a part of the Alaskan Stream; collected data show that shelf water properties and circulation in this area are greatly influenced by the Alaska Stream offshore and local freshwater runoff along the coast, similar to the Central regime, between Icy Bay and Kayak Island. Water/contaminant residence times here are expected to be relatively short.

OCSEAP involvement in physical oceanography studies in Lower Cook Inlet has so far been minimal. Work by Barrick (RU 48) on a device capable of producing a map of near-surface currents on location in real time shows significant progress, and work on location in the Alaska environment is planned for the summer of 1977.

Biological Science

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 by Anderson and Lam (RU 58) to describe annual, seasonal and geographical variability. Regional and seasonal coverage was by no means uniform, a vast amount of data being 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 1958-74) of chlorophyll *a*, primary productivity, and nitrate concentration showed *generally low concentration of chlorophyll a, except in spring when values in the upper 25 m exceed 2 mg/m*^{3}. *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. It is not known if these low concentrations limit the level of primary productivity for sustained periods of time.

Anderson and Lam constructed a numerical model to describe observed changes in chlorophyll concentration at Station PAPA (a weather ship at 45° N 145° W) over the course of one year. This model was used for several simulations, one being to simulate the effects of an oil spill on the standing stock of chlorophyll, but results must be considered only preliminary, not definitive.

Species distributions of diatoms do not show clear and consistent differences attributable to areas of subarctic water, mixed water, Alaska gyre water and Alaska Stream water. A distinction between oceanic and neritic species cannot be made due to scarcity of data. Analysis of historic data shows that seasonal variation was more pronounced in neritic zones than in oceanic zones. There appears to be a relatively narrow range of both seasonal and geographical variations rather than a wide range of annual variation. Annual variation is seen more as a series of "biological events" than as a general trend.

Only a few studies have been made on phytoplankton biomass, species composition, and primary productivity in the Northeast Gulf of Alaska. Larrance reported on data collected between Yakutat and Resurrection Bays in 1975. As the samples were collected during only a three-week period in the fall (Oct.-Nov.), it is not possible to use them to estimate seasonal variation in primary productivity.

Larrance (RU 425) also reported data 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.* Primary productivity increased over 10-fold between early April and early May, then steadily decreased to low levels in late August. The increase in Kamishak Bay productivity from early April to mid-July was nearly 100-fold.

In Kachemak Bay, high primary productivity was accompanied by depletion of nitrate from the photic zone, though other parts of the inlet maintained nitrate concentration from high to moderate levels. This *suggests that the exchange of water in Kachemak Bay, especially in the inner part, was much slower than in the mid-channel area.* Further studies on this exchange will help explain the influence of circulation on the observed high productivity in this locality.

Larrance also 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, concentration of chlorophyll remained moderately low, characteristic of deep oceanic waters. No OCSEAP plankton studies have been conducted in the Aleutian lease area and applicable historical data are scarce.

In OCSEAP zooplankton studies in the Gulf of Alaska, Cooney (RU 156 - now 426) identified nearly 200 different species, 21 of which were considered as numerically abundant or ecologically important. A summary of use of the NEGOA lease area by prinicpal zooplankton species was also provided. As part of the same project, Damkaer collected 30 copepod species and reported vertical migratory patterns of selected species for a location in Prince William Sound. Further studies this past year by Damkaer placed sampling emphasis on Lower Cook Inlet and Prince William Sound. All samples have not yet been analyzed for species composition and numerical abundance.

Feder (RU 281) has established 42 widely dispersed permanent stations for quantitative grab sampling in NEGOA and 140 other stations were occupied with an otter trawl. 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. Feder's results showed that *inshore, shallow shelf benthic infauna differ significantly from that of either the shelf break or the continental slope beyond.* Deposit feeders dominate inshore and suspension feeders and deposit feeders are more evenly divided in the shelf break assemblages. 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.*

Feder and Mueller (RU 282) have submitted 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. Quantitative maps on distribution, abundance, and biomass have been plotted.

Zimmerman et al. (RU 78) have now supplied aerial photographic coverage of the entire Kodiak and Aleutian coasts, permitting quantification of major substrate types. Kaiser and Konigsberg have collected complementary data on Kodiak's sandy beach infauna, while making razor clam assessment studies (RU 24). Sandy beaches are rare, but more common in the Trinity Islands and on Chirikof Island. Northern Kodiak has a generally quite narrow littoral zone. This broadens further south so that extensive areas are exposed at low tide. *Large beds of eelgrass* *occur in these 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.

Although Feder extended his studies of NEGOA benthos into the Northwestern Gulf of Alaska, substrate characteristics of the Aleutian shelf (compact sand, gravel, rock) made it difficult to do quantitative sampling. Further sampling is necessary when higher priorities for this lease area make funding available.

Dames and Moore have submitted a final report to the Alaska Department of Fish and Game describing the marine benthic communities of Kachemak Bay. In connection with the above study Dames and Moore have been studying marine plant communities in Prince William Sound and the northern Gulf of Alaska (RU 27). Shallow subtidal and rocky intertidal habitats have been examined. Despite strong biological similarities, marked differences in community structure and energy pathways have been noted. Another difference is in the presence or absence of the mussel, an important secondary food source. Dames and Moore biologists concluded that snails and sea urchins are regulated in size and number by factors associated with recruitment and the physical transport of juvenile stages from one location to another. *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.* Benthic communities may be affected frequently by natural disturbances (such as red tide, ice scour, geological disturbances).

Zimmerman et al. (RU 78) have also provided new insights into production of *subtidal brown algae around Kodiak. The average standing crop is similar to the highest values reported elsewhere,* even from Nova Scotia, for which the highest value was previously reported. It appears that the Kodiak value for standing crop of intertidal as well as subtidal seaweeds could exceed the figure for Nova Scotia. *Kodiak also has extensive beds of floating kelp* so thick that small boats have difficulty pushing through them. The greatest number of kelp beds are on the southeastern section of the island, which has a generally wider shelf than the northern section.

It was pointed out by Jackson (ADF&G) 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 crab occur in great quantities; Pereyra and Shippen (RU 174) 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.

Kaiser and Konigsberg (RU 24) found razor clams occurring over a broad tidal range of samples from Kodiak Island and the adjacent Alaskan Peninsula. *Little is known about the biology of non-commercial invertebrate components of the Kodiak nearshore benthos, yet these may be the ones most significantly affected by offshore petroleum operations.* Feder et al. are working to fill this information gap (RU 517) and have reported on 89 species found in sampling from June, July, and August 1976.

Feder's benthic fauna studies (RU 281) extended into Lower Cook Inlet. A food web diagram, inclusive of major epifaunal species, is now available for this area. Clam age-growth studies will be available for the final report. Blackburn (RU 512) reports results from trawl stations occupied in Lower Cook Inlet. Tanner crab occurred in greater abundance than any other taxon, being present in 86% of the hauls. They were in greatest biomass near Seldovia and in the western part of Lower Cook Inlet south of the tip of the Kenai Peninsula. Haynes and Wing (RU 496) have made an excellent study of the temporal distribution patterns of king crab, pandalid shrimp and brachyuran crab larvae in Kachemak Bay. However, since their station pattern did not extend far enough seaward to determine other areas of larval abundance and their sampling ended in June when larvae were still present, their *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.

Pereyra and Ronholt (RU 174) have studied trawl survey statistics for demersal fish populations in the Gulf of Alaska from two surveys in a twelve year period from 1961-1973. Some important points of comparison included:

1) Flatfish catch decreased in percentage of total finfish catch, although catch per unit effort (CPUE) increased slightly.

2) Arrowtooth flounder were the most abundant and widely distributed pleuronectids in the northeast Gulf.

3) Roundfish percentage of total finfish catch more than doubled in the period of time; CPUE for roundfish increased 3-fold.

4) Walleye pollock was the dominant roundfish and finfish in 1973; CPUE increased almost 3-fold east of Kayak Island and 18-fold west of the island in the twelve years.

5) Pacific ocean perch were the dominant rockfish in both surveys.

6) Elasmobranchs (sharks and skates) were the least abundant group.

7) In 1973 starry flounder was the second most abundant flatfish, even though it was collected only on the inner shelf just south of Icy Bay.

Feeding studies on selected species have been summarized by Smith et al. (RU 284). They have also summarized data furnished by the International Pacific Halibut Commission and data from literature sources. Feder et al. (RU 28) also made feeding studies on numerous fish species in the Lower Cook Inlet, particularly on cod, halibut and sculpins. Blackburn (RU 486) is confining his efforts to trawl catches within Alitak and Ugak Bays; results from his sampling efforts are comprehensive and should enhance the state of knowledge on seasonal distribution of demersal species in these two locations. Other studies on distribution and abundance of 16 demersal fish species have resulted in a detailed, illustrated report by Pereyra and Ronholt (RU 174).

Blackburn's studies also involved collection of data on distribution and relative abundance of various demersal and pelagic fish species in Lower Cook Inlet. He has compiled a list of 23 families and 76 species of fish using Lower Cook Inlet waters. Based on otter trawl catch statistics, yellowfin sole were found to be the most abundant flatfish in this area, peaking in abundance in the central Inlet east of Augustine Island, south of Oil Bay, near Seldovia, and west of Anchor Point. Pacific halibut were next in abundance and were most numerous nearer shore and in the mouth of Kachemak and Kamishak Bays. Rock sole were third and most widely distributed. Tables of species distribution and abundance are given in Blackburn's annual report.

Stern et al. (RU 483) *have summarized the current state of knowledge of salmonids in the Gulf of Alaska, for all four lease areas.* Prince William Sound is the most important in the NEGOA lease area, contributing 82% of total catch there; the Copper River ranks second, followed by the Yakutat and Bering River districts. Pink salmon are most abundant, sockeye next, then chum, coho, and chinook. Within Cook Inlet the major part (57%) of the salmon run occurs along the east shore from Anchor Point to the Forelands. Pink salmon is also most plentiful there. The Kodiak area produces the highest number of salmon, with pink salmon again the most abundant. Migration in the Kodiak area continues into October and November. By June all salmon species are present in shelf waters, with peak spawning abundance in July. The Aleutian shelf is the second in numbers of salmon production in the Gulf, pink salmon comprising about 53% of the commercial catch and total spawning run.

Except for halibut and salmon, commercial exploitation of the Alaskan fishery resources is in the hands of foreign nationals, mostly Japan and Russia, although others participating are South Korea, Poland, and Taiwan (Pereyra, RU 174). Most of this occurs in the Northeastern Gulf of Alaska. Canada shares with the U.S. in the commercial catch of Pacific halibut, most of the catch coming from the Yakutat Bay and Chirikof Island area.

Morrow (RU 285) has completed a taxonomic key of forage fishes using otoliths. This provides an outstanding key for classifying the more common species throughout the Alaskan OCS.

Important studies on marine birds are being continued by Bartonek et al. (RU 341), 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 sea bird 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 shore-birds in the vicinity of Hinchinbrook Entrance to Prince William Sound. Censuses of the latter and Constantine Harbor areas revealed some data on utilization of this region and the Copper River delta by non-breeding (migrant) seabirds, and on food habits of the species found. Details for numerous species are presented in the annual report.

Shipboard and aerial surveys by Bartonek et al. (RU 337), Wiens (RU 108), and Myres and Guzman (RU 239) are filling gaps in information about seasonal distributions and abundances of birds on Alaskan pelagic waters. By far the most numerous species are shearwaters, followed by murres, fulmars and puffins. Aerial surveys established that a small population of shearwaters overwinters in the Gulf. In an attempt to identify critical habitats, Arneson(RU 3) has been sampling marine birds in the entire Gulf of Alaska. 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. Arneson's survey showed that bays in the Kodiak and Alaska archipelago, which are relatively ice-free, are wintering grounds for several species (for example, Uyak Bay for murres, auklets and seaducks). *Densest concentrations of birds on the water were observed in Whale Passage.* Bartonek et al. (RU 337) sampled pelagic bird densities in the Kodiak Basin, Semidi Islands and Aleutians. Most abundant birds were shearwaters in summer, murres and guillemots in winter; fulmars were plentiful on the Semidi Islands (Bartonek et al., RU 341). It was pointed out that glaucous-winged gulls destroyed about 70% 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). Patten and Patten (RU 96) have investigated effects of crude oil and mineral oil applied to gull eggs on Egg Island, off the northeast corner of Hinchinbrook Island, 20 km south of Cordova. Results indicate that *both crude and mineral oil on egg surfaces greatly reduce hatchability.* Examination showed embryos had died soon after oiling of eggs.

Fiscus et al. (RU 68) has summarized available information on seasonal distribution and abundance of all species of marine mammals (except sea otters) in the entire Gulf of Alaska. Data were obtained from numerous sources and have been computerized to produce printouts of marine mammal sightings by species and month.

Schneider (RU 240) reported *increasing numbers of sea otters around the NEGOA and Kodiak areas* and has provided a map giving general distribution.

Concentrations are found in NEGOA around the Copper River delta and between Yakutat Bay and Cape Fairweather, as well as in Icy Bay and elsewhere in Barren Islands, Shuyak-Afognak Islands and Trinity-Chirikof Islands areas. According to Schneider *the major area source for repopulating these animals is Prince William Sound.*

Pitcher and Calkins (RU 229) continued studies on harbor seals. Largest center of population of these mammals was found to be Tugidak Island. It has been determined that *mortality of pups results 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.

Calkins and Pitcher (RU 243) are also conducting studies of *sea lions in the Gulf of Alaska. Major rookeries are found in the Kodiak-Barren Islands;* migration patterns, hauling out areas, overwintering areas and the like are identified. The Steller sea lion is the most abundant species of marine mammal in the Lower Cook Inlet region, *major rookeries being 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.

Harbor and Dall porpoises and several species of whales are among other marine mammals regularly sighted in the Gulf of Alaska. Hall and Tillman (RU 481) are responsible for surveys of cetaceans in Prince William Sound and adjacent regions to determine abundance, distribution, foraging areas and congregating areas of all species. Some generalized feeding relationships have been summarized.

Microbiology

Other than chemical and physical processes, bio-degradation 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, micro-organisms 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. These studies are also intended to define the behavior of the microbial groups in response to arctic and subarctic conditions.

Morita and Griffiths (RU 190) found the *number of heterotrophs present in sediments measurably greater than in water.* Potential of maximum velocity of uptake by substrates (V_{max}) was higher in nearshore waters or sediments than in offshore waters, and higher in sediments than in any water samples. Atlas (RU 30) reported that in general viable counts were greatest from water samples collected in Kennedy Entrance to Lower Cook Inlet and lowest in water and sediment taken from the central Inlet. Based on limited sampling, excluding most of the Kodiak shelf, Atlas concluded that there was *no significant spatial variability of heterotroph abundance in the water column.* However, Atlas did find that the abundance of petroleum hydrocarbon degraders was highest along sampling transects just south of Kodiak and Unimak Islands. Results of cluster analyses on the physiological requirements and behavior of heterotrophs are provided in the annual report.

SIGNIFICANT RESULTS FROM SYNTHESIS MEETINGS

During the Lower Cook Inlet Synthesis Meeting two major issues developed; one concerned the surface currents in the central Inlet and the other dealt with the presence of discrete regions in the Inlet. In reference to surface currents, the central Inlet was defined by the participants as a low energy region with little net transport. However, a recent publication by Dames and Moore, utilizing the same data source, depicted the central Inlet as a high energy area with a significant net transport out of the Inlet. As a result of the meeting and publication of the Lower Cook Draft Synthesis, additional meetings were held to evaluate the data and to arrive at a concensus on the current structure of the central Inlet.

The participants also noted that the Inlet could be easily broken into critical areas. These areas were defined on the basis of biotic populations and physical characteristics. Kamishak and Kachemak Bays are two such areas and are of particular concern due to their major biological populations and the differing mechanisms that make these areas so biologically productive. For the most part participants were unable to define the mechanisms affecting the total Lower Cook environment. Their concerns pointed towards the need for additional data on all aspects of the Lower Cook environment; however, the need is particularly important for Kamishak and Kachemak Bays.

During the NEGOA Synthesis Meeting, the participants identified two points of concern. The first of these was the exclusion of Prince William Sound from the OCSEAP studies. Lagrangian drifter studies, satellite photographs of the Copper River sediment plume, and the results from the surface contaminant distribution model indicate that contaminants originating in the NEGOA lease area have a high probability of entering the Sound. Prince William Sound is noted for its commercial fishing industry and the economic import of this industry to adjacent communities. The salmon catch ranks second only to that of Bristol Bay and the area provides important spawning and nursery sites for this resource. Tourism is also an expanding industry in the Sound, providing another major source of revenue to the local villages.

The participants noted that since the Sound is characterized by sluggish currents and numerous fiords and bays, the Sound may act as a sink for contaminants. On this basis, most felt that Prince William Sound should be included in any future environmental and oceanographic studies in the NEGOA region. The participants believe that the effects of oil and gas production in NEGOA on the Prince William Sound should be considered prior to lease development.

The second point of concern was the region west of Kayak Island. Current patterns indicate the presence of a gyre that may act as a trap for surface borne contaminants entering the region. This area is also noted for its benthic populations, specifically detrital feeders such as Tanner crabs. Should contaminants enter this gyre and should the resultant delays in transport increase precipitation of the contaminants to the bottom, the indigenous benthic biota may be adversely affected. The participants suggested that additional environmental data are needed in this area to understand the relationships between the gyre and local biota and to evaluate the impact of contaminants on this region.

A meeting of OCSEAP investigators working in the Arctic was convened at Barrow in February 1977 with OCSEAP and BLM representatives in attendance to discuss subjects with regard to the Beaufort Sea research activities. Disciplinary group discussions produced summaries of the state of knowledge in each discipline and identified information gaps. Interdisciplinary group discussions considered likely impacts of OCS development, ranging from camp and causeway construction to well fires and major oil spills. This represented the first attempt in the USA to quantify the consequences of such impacts on the arctic biota and environment. Interactions and exchanges between the participants led to an integration of efforts in all disciplines and produced several new ideas for joint interdisciplinary studies, such as the plan for a trophic study cruise, which has since been executed by the USCGC GLACIER in August 1977. The need for inshore studies was voiced very strongly and revived the idea of a "barrier island-lagoon ecosystem study", which is now in full operation.

The issue causing most concern at the Kodiak Synthesis Meeting revolved around the "Western Gulf of Alaska Oil Spill Risk Analysis." This analysis indicated that most of the oil spill trajectories under consideration would exit not only the lease area but also the area considered for potential impact. Participants at this workshop were concerned that contaminants arising from oil and gas development in the Kodiak lease area may adversely affect areas beyond those boundaries defined in the development scenario. Since more than half of the oil spill trajectories leave the lease area, the participants thought that it would be essential to consider the ultimate fate of the trajectories before leasing. Considering oceanographic features, many participants believe that contaminants released in the Kodiak lease area would ultimately impact the southern coast of the Alaska Peninsula and the Shumagin Islands. Data on critical populations and areas is generally lacking for the Shumagin Islands - Alaska Peninsula area. Workshop participants thought it essential that the effect of oil and gas development on this area be considered prior to leasing in the Kodiak region.

RECOMMENDATIONS AND PLANS

The August 1977 revision of the BLM OCS lease schedule extended the June 1975 (or November 1976) schedule sale dates two to four or more years into the future for most Alaskan lease areas. This extension of the lease schedule provides for longer term environmental studies prior to the lease sales in most areas, as follows:

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

The four to six year time frames specified by the new schedule will permit an adequate environmental assessment based on the pre-sale environmental studies (specifically, hazards assessment, benchmark chemical characterization, circulation and trajectory analysis, and biological characterization) in frontier OCS areas, such as Alaska. The study content and typical phasing of projects are discussed in the OCSEAP Program Development Plan. For adequate assessment of potential impacts from OCS oil and gas development, the studies must continue at their current level of effort through 1981, and beyond if additional lease areas are reinserted into the lease schedule. Decreasing funds will not permit the attainment of adequate environmental information in time for decisions. 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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