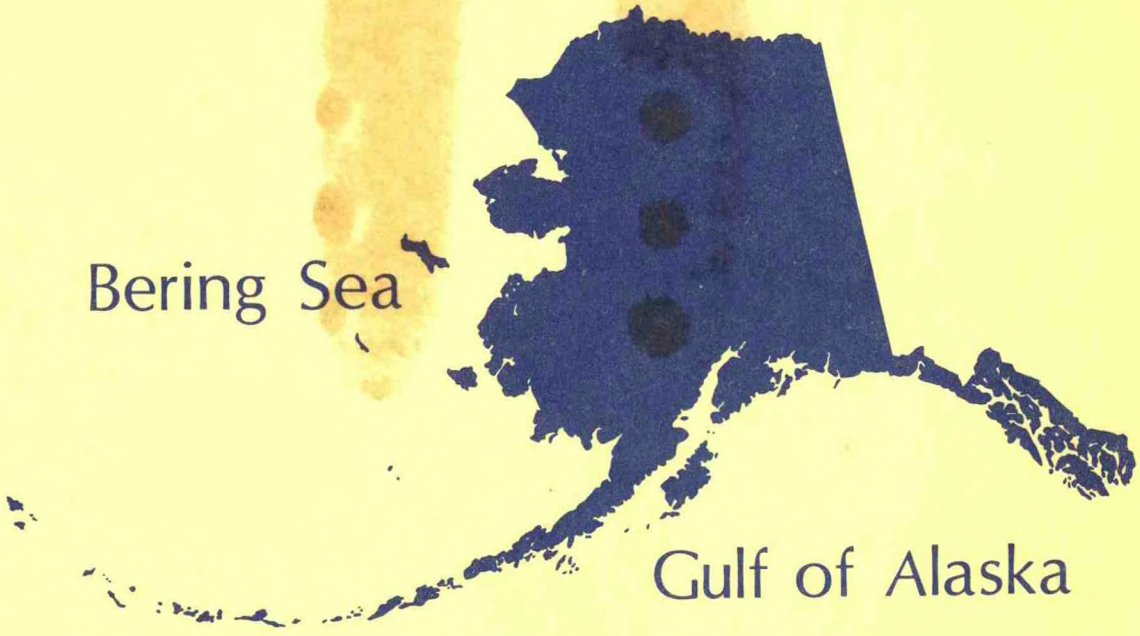
Outer Continental Shelf Environmental Assessment Program

FY84 TECHNICAL DEVELOPMENT PLAN:



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Oceanography and Marine Services
Ocean Assessments Division

Outer Continental Shelf Environmental Assessment Program

FISCAL YEAR 1984

TECHNICAL DEVELOPMENT PLAN:

ARCTIC OCEAN, BERING SEA, GULF OF ALASKA

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August 1983

This TDP is a document prepared for FY84 program planning. Inclusion of a project description is not to be construed as a commitment to any project or agency.

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Juneau, Alaska

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INTRODUCTION

The protection of the marine and coastal environment is mandated by the Outer Continental Shelf (OCS) Lands Act of 1953, the National Environmental Policy Act of 1969, and the OCS Lands Act Amendments of 1978. An essential responsibility of the Department of the Interior (DOI), as manager of the OCS Leasing Program, is to ensure that proposed OCS development and production activities will not irreparably damage the marine environment and its resources. To help meet this responsibility as it applies to development of the Alaska OCS, the Outer Continental Shelf Environmental Assessment Program (OCSEAP) was initiated by interagency agreement between DOI's Bureau of Land Management (now Minerals Management Service) and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA).

The objectives of OCSEAP are:

1. To provide information about the OCS environment that will enable DOI to make sound management decisions regarding the development of mineral resources on the OCS.

2. To acquire information that will enable DOI to identify those aspects of the environment that might be affected by oil and gas exploration and development.

3. To establish a basis for predicting the effects of OCS oil and gas activities on the environment.

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

In each OCS area for which oil and gas development is proposed, extensive studies must be conducted to meet these objectives before development is allowed. If the studies show that development of specific areas will result in unacceptable environmental impacts, those areas either will not be leased or mitigating measures will be designed to alleviate the impacts.

In response to the OCSEAP objectives and the environmental issues identified for each lease area, the scientific objectives of OCSEAP research as well as individual research projects are planned according to combinations or subdivisions of the following general study elements:

1. Contaminant Distribution: Determination of the predevelopment distribution and concentration of contaminants commonly associated with oil and gas development.

2. Environmental Hazards: Identification and estimation of the potential hazards posed by the environment to petroleum exploration and development.

3. Pollutant Transport, Weathering, and Fate: Determination of the ways in which contaminants would move through the environment and how they would be altered by physical, chemical, and biological processes.

4. Living Resources: Determination and characterization of the biological populations, communities, and ecological systems that are subject to impact from petroleum exploration and development.

5. Effects: Determination of the potential effects of contaminants and other insults on living resources.

Research, data management, and information synthesis under OCSEAP are planned and conducted by the Alaska Office of the Ocean Assessments Division, Office of Oceanography and Marine Services, National Ocean Service, NOAA, U.S. Department of Commerce, under interagency agreements with the Minerals Management Service (MMS), U.S. Department of the Interior.

Continuing and planned research units (RU's and PU's, respectively) are determined annually according to the needs and timing of specific leasing decisions. Technical Development Plans prepared by NOAA provide background material on areas proposed for leasing and describe each research unit. This TDP encompasses environmental studies already under way and those to be initiated in FY84 for the Arctic Ocean, the Bering Sea, and the Gulf of Alaska. It has been developed by NOAA's interdisciplinary staff in response to information requirements identified by MMS in its Regional Studies Plan for FY84, with input from other federal agencies, state agencies, and representatives of environmental and other interests.

The latest OCS oil and gas leasing schedule, proposed in July 1982, will make over 1 billion acres available for leasing within a 5-yr period. Over 56% of the acreage is located on the Outer Continental Shelf around Alaska (Figure 1). The schedule drastically increases the amount of land offered for leasing each year and demands unprecedented acceleration of the decisionmaking process. The body of environmental data required to predict potential impacts resulting from OCS development will have to be correspondingly large and comprehensive, and analyzed and disseminated under extreme time constraints. The enormous size of some planning areas makes the existing data base for those regions inadequate to identify environmental hazards, address conflicts with regional resource use, and delineate vulnerable populations, communities, and ecosystems. Several new studies designed to meet these needs are outlined in this document.

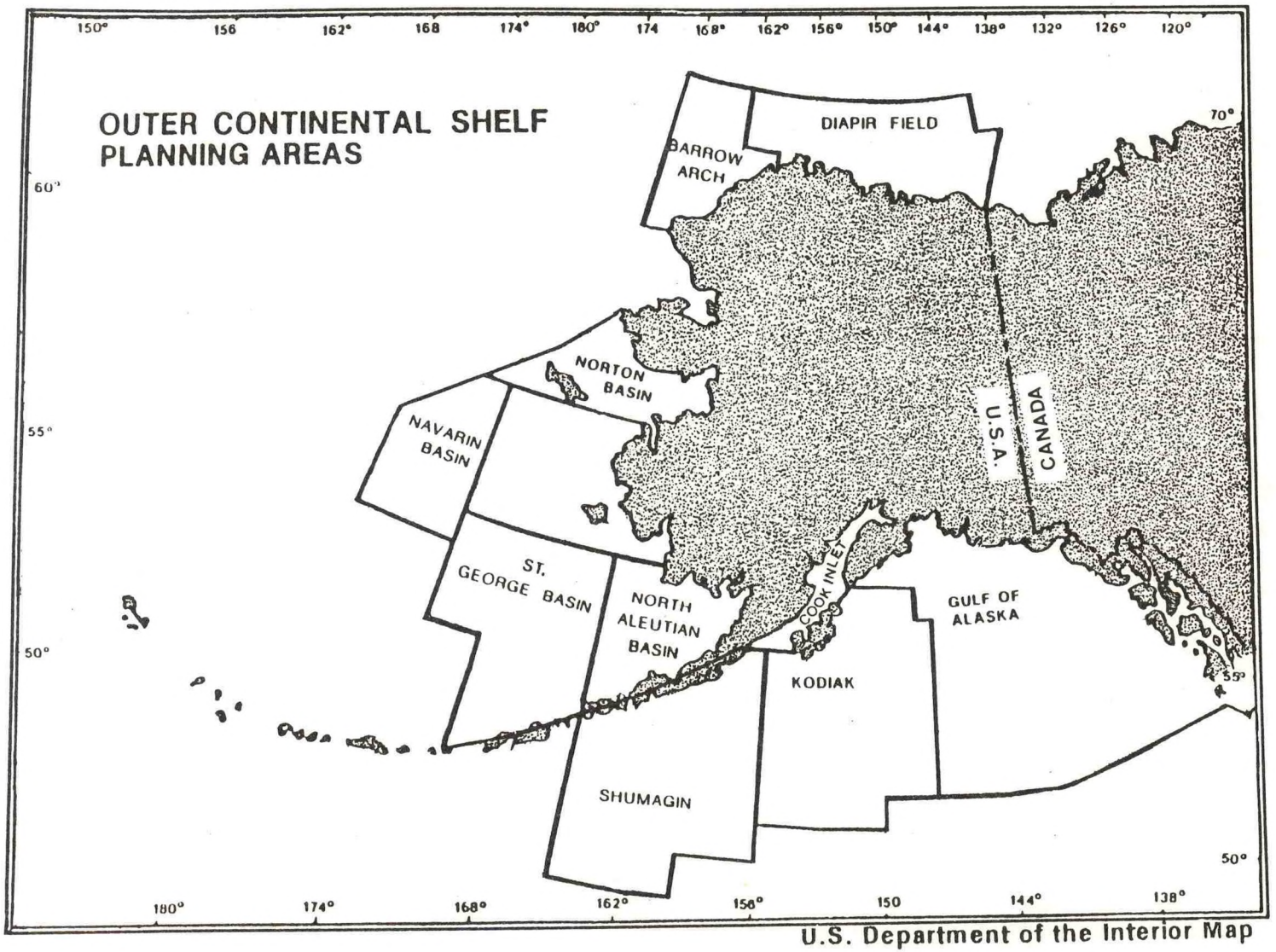


Figure 1.--Alaska OCS Planning Areas on the Current 5-Year Oil and Gas Lease Sale Schedule

REGIONAL SETTING

Arctic Ocean

The American sector of the Arctic Ocean extends from Bering Strait (66°N, 168°W) to Demarcation Bay (69°N, 141°W). This region comprises portions of both the Chukchi and Beaufort seas, and is bounded by over 1,000 km of coastline.

The Chukchi Sea is a shallow marine basin with water depths of less than 100 m extending several hundred kilometers offshore. Its circulation is influenced by ocean currents flowing predominantly northward and carrying relatively warm Alaskan coastal water into the region. These northward coastal currents combine with a westward drift along the southern margin of the Arctic ice pack to establish a broad counterclockwise summer circulation in the Chukchi Sea.

The Beaufort Sea has a relatively narrow continental shelf extending 50 to 100 km offshore. The adjoining Canada Abyssal Plain is more than 3,000 m deep. Circulation patterns in the Beaufort Sea are generally dominated by the circulation patterns of the Arctic Ocean. Ocean currents flow westward between MacKenzie Bay and Point Barrow under the influence of the clockwise Arctic gyre. These waters are generally colder than those in the Chukchi Sea, although recent studies have indicated that a narrow band of warm, brackish water flows along the coast with the prevailing westward currents. This band is usually 1-4 km wide, and periodically attains temperatures up to 10 to 12°C, as compared to offshore water temperatures of well below 5°C.

In both the Beaufort and Chukchi seas lunar tides are very small, reaching a maximum of 1.3 m at Kotzebue. Wave heights and storm surges pose more severe hazards in the Chukchi than in the Beaufort Sea, primarily due to the longer reaches of open water in summer and fall.

The Beaufort Sea coast is predominantly low-lying wetland tundra dotted by numerous thaw lakes. Offshore islands determine the nature of much of the nearshore physical and biological environment along the Beaufort coast. These islands effectively moderate the influence of polar pack ice where they occur, and in the few weeks of summer partially separate the cold, saline waters of the open Beaufort from the warmer, brackish waters near shore. Some of these islands are true barrier islands, bounding shallow lagoons (e.g., Jones Islands and Simpson Lagoon), while others lie farther offshore, with deeper waters between them and the mainland (e.g., Narwhal Island and Stefansson Sound). The islands themselves, and the mainland coast, where unprotected by these islands, are subject to considerable erosion by wave action.

The coast of the Chukchi Sea is more complex than the Beaufort coast. It has sections of higher relief such as dry tundra meeting the sea at a bluff, and occasional cliff faces, as at Skull Cliffs and Cape Lisburne. In these bluff and cliff face regions there are no barrier or other offshore islands. Elsewhere, however, extensive lagoon and semiprotected embayment systems exist in association with islands, spits, and bars.

Ice dominates the entire Arctic OCS area. Sea ice cover is close to 100% for 9 to 10 months each year and freezes up to 2.4 m thick in one season. Multiyear ice, up to 4 m thick, and icebergs with drafts of as much as 50 m are present. Landfast ice forms during the winter, extending from less than 1 km to as much as 50 km offshore. The ice pack moving westward past the Alaskan coast shears against the landfast ice, forming an extensive pressure ridge system. Pressure ridges and hummocks may exceed 10 m in height and are matched on the underside by ice keels several tens of meters deep. The sea floor of the continental shelf is scoured by dragging ice keels which form deep gouges. Ice gouges of indeterminate age have been found as far out as the 50-m isobath, though they are more numerous in shallower waters, especially along the ice shear zone. The ice season is somewhat shorter in the Chukchi Sea than in the Beaufort Sea, but ice conditions and ice hazards are more severe in the Chukchi. The extent of landfast ice along the Chukchi coast between Barrow and Cape Lisburne is much narrower than along the Beaufort coast. Thus, with the exception of Kotzebue Sound, severe ice conditions are encountered much closer to the coast.

The presence or absence of ice profoundly affects the occurrence of fish, birds, marine mammals, and other biota in the Arctic. During the July-September period, when ice cover is minimal, most of the annual primary production occurs and biological utilization of the area is high. Large numbers of anadromous whitefish, cisco, and char move seaward from their overwintering areas in rivers and feed heavily on epibenthic mysids and amphipods, as do cod and sculpin. They are joined by large populations of Oldsquaw, phalaropes, and other species of waterfowl and shorebirds which also feed heavily on epibenthic crustaceans. In the Beaufort Sea much of this activity is confined to the barrier island areas and the narrow band of warmer, brackish water along the coast. In the Chukchi Sea these species appear able to utilize a wider area of the warmer shelf waters, and are joined there by seabirds, salmon, and forage fish species which do not occur in the Beaufort Sea. During the ice-free period, bowhead whales, belukha whales, and several species of seals also frequent the nearshore areas of the Arctic Ocean.

In ice-covered periods primary production virtually ceases and the large populations of fish, birds, and marine mammals generally disappear. Arctic cod, however, remain in the area and become a major food item of ringed seals which bear and nurse their young in snow-covered lairs on the ice. Pregnant polar bears also construct dens on the ice in which they give birth and nurse their cubs.

In all arctic systems species are few and food webs are relatively simple. The warmer Chukchi Sea, however, supports populations of salmon, smelt, sandlance, and other commercial and forage fish species which are not found

in appreciable numbers in most of the Beaufort Sea. Seabird colonies occur in the Chukchi Sea but not in the Beaufort Sea, and include mixed colonies of puffins, murres, kittiwakes, and gulls at Cape Lisburne, Cape Thompson, and in Kotzebue Sound. Cape Lisburne is the northernmost major seabird colony on the west coast of North America. Gray whales and walruses occur in large numbers in the Chukchi Sea, and in far lower numbers in the Beaufort Sea.

Bering Sea

The eastern Bering Sea borders the western coast of Alaska, extending approximately 1,500 km from the Aleutian Islands to the Bering Strait. Almost completely surrounded by land, this region lies in an area of maximum meteorological gradient. Atmospheric vigor is extreme, comparable only to the "Roaring Forties" of the Norwegian Sea and the "Furious Fifties" of the antarctic region. Seasonal contrasts are also extreme: during winter over half of the sea surface is covered with ice; during summer, sea surface temperatures may become almost temperate, exceeding 16°C in the eastern portion of Norton Sound.

The strong westward flow of the Alaska Stream provides the waters which penetrate into the Bering Sea through deep passes in the Aleutian Islands. In the eastern part of the sea, three fronts (regions of enhanced horizontal gradients of properties) separate the water overlying the shelf into distinguishable domains with distinctive hydrographic and stratification properties. Shelf circulation is generally sluggish and characterized by the presence of nonstationary eddies.

Advances and retreats of the ice edge are correlated with fluctuations in sea and air temperatures, surface winds, and regional meteorological events. Ice formation usually begins in mid-October and may persist in some areas through June, although the retreat of the ice edge begins in April. In extreme years ice may extend as far south as Unimak Island; generally the southern limit is from northern Bristol Bay to the vicinity of St. George Island in the Pribilofs.

The continental shelf in the eastern Bering Sea is very broad, extending over 640 km offshore in the northeastern sector. More than 44% of the Bering Sea is covered by the shelf, the 200-m isobath approximately dividing the sea in half. In Bristol Bay this extensive shelf area is associated with high abundances of commercially valuable fish and shellfish and large populations of marine mammals and seabirds.

North of Bristol Bay the coastline flattens out into the broad deltaic lowlands of the Yukon and Kuskokwim rivers. Here, intertidal areas are often wide and storm surges extend as far as 40 km inland. Although this section of the Bering Sea is dominated by the sediment-laden waters of the Yukon and Kuskokwim rivers, so-called clearwater areas occur between the major distributaries. The clearwater areas have recently been pinpointed as being among the most productive areas in the central portion of the eastern Bering Sea coast.

Norton Sound, the northeastern portion of the Bering Sea, is a rather isolated body of water; its hydrography and circulation are dominated by local wind and atmospheric patterns. Recent evidence indicates that the outer part of Norton Sound is distinguishable from the inner by persistent oceanographic features. The water of the outer sound is dominated by a northerly flow between the sound and St. Lawrence Island.

The eastern Bering Sea supports a rich and diverse biota. Landings of fish and shellfish, principally king crab, snow crab, and salmon, by U.S. fishermen range between 45,000 and 90,000 t annually. Foreign fisheries take an additional million metric tons of bottomfish, mainly walleye pollock. The bulk of the commercial fishery resources occurs in the southern portion of the region.

Nineteen species of cetaceans and eight species of pinnipeds occur in the eastern Bering Sea. Some of these, including killer, fin, minke, humpback, and gray whales, migrate seasonally, feeding in large numbers in the northern Bering Sea during summer and then migrating south into the Pacific Ocean before the first ice is formed. Unknown numbers of the killer, fin, and minke whale populations remain in the Bering Sea during the winter. The Pribilof Islands are the primary breeding ground for most of the world population of northern fur seals.

Other species, such as bowhead and belukha whales, winter along the ice edge or ice-infested areas. The northern Bering Sea and southern Chukchi Sea are the feeding grounds for about 95% of the world population of gray whales. Several pinniped species, including ringed seal, bearded seal, ribbon seal, spotted seal, and walrus, are commonly associated with sea ice and are dependent upon it as a substrate for their breeding and molting.

The bird populations in the eastern Bering Sea compose one of the richest and most important avian faunas on earth. The total number of seabirds probably exceeds 26 million, of which approximately 11.5 million are seasonally restricted to densely populated breeding colonies. On the Pribilof Islands, for instance, some 225,000 Red-legged Kittiwakes--nearly the entire world population--nest along with approximately 100,000 Black-legged Kittiwakes, 1.5 million Thick-billed Murres, and enormous numbers of Crested and Least Auklets. Nonbreeding flocks of birds pass through the Bering Sea by the millions: Short-tailed Shearwaters, eiders, Oldsquaws, and scoters, among others. All of these birds depend upon the exceptionally high productivity of the Bering Sea waters for maintenance of their dense populations. In addition, millions of birds utilize the coastal areas. The Yukon-Kuskokwim Delta is a notable example; the vast delta at times hosts some 24 million shorebirds and breeding waterfowl. Izembek Lagoon and other lagoons along the north side of the Alaska Peninsula also are major coastal bird concentration areas.

Gulf of Alaska

The Gulf of Alaska is bounded by the south coast of Alaska, which is arcuate in form and extends for hundreds of kilometers, from the Alaska

Panhandle on the east side of the gulf to the Alaska Peninsula on the west. This coastline is the most complex in the state and contains a large variety of geomorphological features. A pervasive feature of the coastal region is the presence of rugged mountains. Proceeding from east to west, one encounters in turn the St. Elias, Chugach, and Kenai mountains; then, on the west side of Cook Inlet, the Alaska Range; and, finally, the Aleutian Range, which extends along the Alaska Peninsula. The islands of the Kodiak Archipelago are predominantly mountainous. The highest peaks are found along the east side of the gulf, where 5,500-m Mt. St. Elias dominates the scene.

Volcanic mountains are present in the Alaska and Aleutian ranges; many are active and have erupted in historical times. Among the more well-known volcanoes are Augustine in lower Cook Inlet, Katmai at the base of the Alaska Peninsula, and Pavlof on the southwest end of the peninsula.

As implied above, the Gulf of Alaska region is geologically very dynamic. Its location at the juncture of the North American and subducting Pacific crustal plates results in a large amount of regional seismotectonic activity. The activity is manifested most strikingly to man by the frequent occurrence of earthquakes and the resultant destruction due to ground shaking, tsunamis, and associated phenomena.

Coastal plains are intermittent in the Gulf of Alaska region. The only flatlands of any significant extent occur on the east side of Cook Inlet and between Dry Bay and Yakutat. The coastal segment extending from Cross Sound in southeastern Alaska westward to Prince William Sound is typified by unprotected beaches and has only three embayments of consequence: Lituya, Yakutat, and Icy bays. Prince William Sound is in essence an inland sea, being an island and fjord complex about the size of Puget Sound and relatively sheltered from the open gulf. The coastlines of the gulf side of the Kenai Peninsula and the Kodiak Archipelago are mainly rocky and indented by numerous fjords and embayments. Cook Inlet is a large, shallow estuary, some 250 km long and from 25 to 100 km wide. The south coast of the Alaska Peninsula is steep and rugged. Due to the asymmetrical topography of the peninsula, the drainage divide between streams emptying into the Gulf of Alaska and those entering the Bering Sea is generally less than 16 km from the gulf coast. Bays are numerous along the peninsula, as are islands along its western half.

The continental shelf in the Gulf of Alaska is narrow in comparison to the shelf in the Bering and Chukchi seas. Some 100 km wide in the vicinity of the Fairweather Ground south of Yakutat, the shelf narrows to about 10 km off Bering Glacier, then widens to about 150 km in the vicinity of Kodiak before progressively decreasing in width toward the tip of the Alaska Peninsula. The shelf is dissected by numerous sea valleys and troughs, a number of which appear to be glacial in origin. Major topographic highs include the Fairweather Ground southeast of Yakutat, Portlock and Albatross banks off Kodiak Island, and emergent features such as Middleton Island in the northern gulf and the many islands in the western gulf.

The climate of the Gulf of Alaska is maritime, characterized by heavy precipitation, cool summers, and relatively warm winters. Precipitation

occurs year round and, including snowfall, ranges from about 50 cm to more than 500 cm annually, with a mean of about 150 cm. On a regional basis precipitation shows a general eastward increase; it also increases with elevation. Mean annual snowfall also displays considerable regional variability, ranging from about 55 cm at Anton Larsen Bay on the west side of Kodiak Island to about 675 cm at Whittier on Prince William Sound. Much greater snowfalls occur in the coastal mountains; perhaps 20 m of snow are deposited annually in parts of the St. Elias Mountains. An annual temperature range of about 22°C is typical of coastal locations around the Gulf of Alaska. Mean low temperature is about -6.7°C and mean high about 15.5°C.

Due to the mild climate prevalent in the outer Gulf of Alaska, sea ice does not form in winter. However, the more rigorous climatic conditions and shallow water in parts of Cook Inlet promote ice formation, typically north of the Forelands and along the west side of the inlet, for about 2 months during the winter.

Major storms are commonplace in the Gulf of Alaska. They are most intense in winter when the distribution of atmospheric pressure is such that the storm tracks lie along and south of the Aleutian Islands and Alaska Peninsula. Storms generally move eastward through the region and stagnate in the eastern gulf. In late summer and fall, conditions are such that most storms move into the Bering Sea. High coastal winds also occur as a consequence of atmospheric pressure differences between interior Alaska and the gulf. Higher pressure in the interior promotes episodic, localized offshore wind flow through mountain passes and river valleys. These katabatic winds may attain speeds of 150 km/h and extend 30 km offshore. They are commonplace at the Copper River Delta and Dry Bay in the eastern gulf, and near Cape Douglas on the west side of Cook Inlet.

Much of the copious precipitation deposited on the gulf coast mountains as snowfall feeds icefields, piedmont glaciers, and valley glaciers. These features are especially prevalent along the eastern shore of the gulf, where some of the most extensively glaciated areas in the world are present. Many glaciers and icefields extend to near the coast and some enter tidewater, thus being localized sources of icebergs. Notable examples can be seen at Icy Bay and near Columbia Glacier in Prince William Sound.

Streams associated with the coastal mountains are mainly short and often of the glacial outwash type: typically of steep gradient, braided, and carrying high sediment loads. Few rivers from the interior penetrate the coastal mountains and enter the Gulf of Alaska. The only ones that do are the Alsek and Copper rivers. The Susitna, which enters the head of Cook Inlet, is the major stream draining the basin formed by the Alaska Range and Talkeetna Mountains. The circumstances of geography are such that coastal waters turbid with glacial rock flour prevail in the eastern gulf westward to Prince William Sound, and in much of Cook Inlet. Elsewhere in the gulf the waters are relatively free of sediment.

Tides in the Gulf of Alaska are mixed, predominantly semidiurnal. Tidal amplitudes vary considerably, averaging 3-5 m but attaining as much as 10 m at the head of Cook Inlet. Tidal currents may be strong in restricted areas. In the vicinity of the Forelands in Cook Inlet, currents exceeding

3 m/s are not uncommon. Due to the shallow depths and large tidal range of Cook Inlet, tides are a dominant factor in circulation there.

The Gulf of Alaska is rich in biotic resources. Kelp beds are widespread in the coastal waters wherever circumstances of substrate and water clarity are appropriate. Associated with the kelp are diverse fish communities and marine mammals such as sea otters and harbor seals. The shelf waters support a variety of commercially important fish and shellfish, including king and Tanner crabs, five species of salmon, and numerous groundfish. Salmon, crab, herring, and halibut form the basis of the domestic fisheries in the region, while foreign fisheries target on the groundfish.

Coastal and shelf waters also support large populations of birds and marine mammals. Large numbers of nesting seabirds are found at colonies throughout the region, such as St. Lazaria Island in the southeastern gulf, Middleton Island, and, most notably, along much of the coastline from the Kenai Peninsula westward through the Aleutian Islands. Millions of Southern Hemisphere shearwaters are also present over the continental shelf from spring through fall, as well as the breeding species. During spring and fall migration periods, millions of waterfowl and shorebirds congregate at coastal estuaries. The Copper River Delta is the major concentration area; the Yakutat Forelands and estuaries in Cook Inlet are also heavily used. Harbor seals and Steller sea lions are ubiquitous residents of Gulf of Alaska coastal waters. Fur seals are seasonally present throughout the gulf. The major rookeries of harbor seals and sea lions are located in the western portion of the gulf. Common cetaceans in the region include gray, fin, humpback, and killer whales; and Dall and harbor porpoises. Gray whales transit the region during spring and fall migrations, while the other species may be found in the gulf the year around.

MAJOR ENVIRONMENTAL ISSUES

Pollutant Transport, Weathering, and Fate

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

OCSEAP studies of pollutant transport are designed to (1) provide data that can be utilized to minimize risks to environmentally sensitive areas during the various stages of oil and gas development; (2) determine probable trajectories and landfalls in the event of an accidental release of contaminants, together with estimates of quantities of contaminants present along the path of transport and at landfall; and (3) provide information for cleanup operation plans in coastal and nearshore areas.

OCSEAP has sponsored the development of an oil spill trajectory model to predict the behavior and distribution of spilled oil and to simulate the movement of oil spills from a proposed OCS development area. The model also serves to integrate oceanographic data from various research projects into a holistic description of tidal and net circulation in a given region. OCSEAP modeling effort has already produced hypothetical oil spill trajectories for various lease areas under different development scenarios. It is likely to continue to provide such information for other OCS regions and lease sale tracts in Alaska.

In addition, the potential for retention of spilled oil in coastal habitats is an important consideration for the protection and cleanup of environmentally sensitive areas. Aerial surveys coupled with site-specific data on the biological, geological, and physical characteristics have already provided such information for much of the Alaskan coastline.

Because the composition and concentration of spilled oil changes with time and not all the components of petroleum are equally toxic or bioactive, the ability to predict the compounds and concentrations that will remain with the slick or spilled oil phase is necessary in order to (1) assess the potential impact of an oil spill along and at the end of the predicted trajectory, and (2) indicate the appropriate cleanup technique. Substantial progress has been made in describing the weathering and fate of spilled oil, although most of the existing data pertain to open water and subarctic conditions.

The formation, presence, movement, and melting of sea ice complicate and confound problems of pollutant transport and oil weathering in the Arctic Ocean. The probability of a mishap during normal oil field operations is significantly increased in the presence of moving ice. The technology for the cleanup of oil spilled in the presence of ice is still in early stages of development and cannot be assumed to be effective. The interaction between pollutants and ice could alter the structural characteristics of the ice and the weathering process of the pollutant, resulting in the release of toxic compounds to the environment at relatively large distances in space and time from the original release point.

The heavy seasonal loads of suspended particulate material resulting from intermittent river runoff also influence pollutant transport and oil weathering. These particles may scavenge oil from the water column in a compound-specific manner and settling rate.

Impacts on Commercial Fisheries

Planned offshore oil and gas development in Alaska has fostered a belief in the fishing community that its long-term interests in harvesting commercial species will assume a secondary importance in favor of the petroleum industry. The region as a whole is marked by a rural dependency on salmonid resources for a substantial proportion of annual residential incomes. There is also a prevailing public perception of impending environmental degradation and resultant losses to harvestable populations coinciding with offshore drilling.

Potential conflicts between the two industries pose a major problem in the southeastern Bering Sea, as this region is second only to the North Sea in demersal catches per area trawled and is fished extensively year round by U.S. and foreign fleets. Salmon and king crab catches from Bristol Bay are among this nation's most valuable. Salmon runs into Bristol Bay have been at record highs over the past 5 years, averaging more than 60 million fish with a worth of roughly $200 million to the fishermen at the dock. King crab catches reached a record 130 million lb in 1980, declined to 120 million lb in 1981, and crashed to about 2.5 million lb in the disastrous abbreviated 1982 season. Prior to the 1982 season, this resource also had an ex-vessel value in excess of $200 million. Foreign fleets operating on the continental shelf between the 100- and 200-m isobaths primarily target on pollock, Pacific cod, yellowfin sole, and other flounders of the southeastern Bering Sea. Foreign fleets pay the United States almost $8 million annually to fish in the Bering Sea and the total ex-vessel value of their catches has been estimated at more than $250 million. Domestic groundfish fisheries are expected to develop as new markets are found, and are forecasted to eliminate foreign fishing effort by the year 2000.

Current domestic fishing efforts in the Gulf of Alaska concentrate on shellfish, salmon, halibut, and, to a lesser extent, herring. Because of the overlapping seasons of specific fisheries and the diversification of fishing activities, commercial fishing is now a year-round activity in the region. The total salmon catch for 1979 in the Gulf of Alaska exceeded

47 million fish, and shellfish landings approached 60,000 t. Catch data for 1978 show that over 5,400 t of halibut were caught in an area extending from Cape Spencer to the Aleutian Islands. The herring fishery in the gulf is modest, but in specific localities, such as northern Prince William Sound, Kamishak Bay, Chinitna Bay, Uganik Bay, and Chiniak Bay, commercial catches are high and the fishery is economically attractive.

Groundfish catches in the Gulf of Alaska by foreign fishing fleets much exceed the domestic catch (the latter of which often represent joint venture fisheries). However, they are equal to only about 10% of the foreign groundfish catches from the Bering Sea. The principal target species are walleye pollock and Pacific (gray) cod in the western gulf; sablefish in the Yakutat area; and walleye pollock, sablefish, and various flounders in the southeastern gulf.

Commercial fishing is not a significant activity in the Arctic. Gillnetting for Arctic cisco, the only continuing fishery, is localized to the Colville River Delta where ciscos are caught during fall and early winter. A maximum of 50,000 ciscos may be taken but the usual catch is much lower.

The biological and socioeconomic aspects of regional fisheries could be affected in several ways by offshore oil and gas exploration and development activities. Fishermen could be preempted from catch areas by OCS facilities such as platforms and pipelines. Indeed, previous experiences off the coast of Labrador and in the North Sea have shown that just the appearance of petroleum exploration and production facilities on traditional fishing grounds presented an interference with fishing activities. This apparent problem has not been entirely substantiated in catch returns because catch variability results from variability of fishing effort, depletion of certain stocks or year classes due to over-exploitation, naturally fluctuating survival rates of larvae and juveniles, and changes in fecundity and growth due to year-to-year fluctuations in the physical environment. Fishermen may also experience losses in gear due to entanglement with OCS structures if they are not properly marked, increased support vessel traffic, and debris on the sea floor. Because Alaskan communities and lifestyles are closely tied to dependency on a resource income, proposed offshore leasing is often perceived as a possible mechanism of shifting employment away from traditional fisheries. Any OCS development activities will require the use of existing harbor and dock space for staging and support and this will undoubtedly result in increased competition for limited space in remote areas during periods when both industries are trying to expand.

A dominant issue surrounding OCS oil and gas development in Alaska is the potential impact of spilled oil on fishery resources. Oil might be released via tanker mishaps, ruptured pipelines, or blowouts of subsurface structures. Although rarely documented by field study after an oil spill, potential losses to populations have been perceived as great. Markets for Alaskan salmon are fragile as evidenced by the economic losses suffered after botulism-causing bacteria were identified in the packs of several leading Alaskan canneries in 1982. If major commercial species such as herring or salmon retain a kerosene-like taint after exposure to petroleum hydrocarbons, other crashes in marketability might occur.

Oil spills in nearshore waters less than 50 m deep or in embayments may be the most harmful, because toxic fractions may be present here in greater concentration and persist longer in the water column and bottom sediments. Coastal waters in Bristol Bay and other regions provide nursery habitat for the young of many commercially important fish and shellfish. In addition, these waters constitute the major migratory pathway for salmonid stocks from natal river systems to oceanic waters. The red king crab population may be most vulnerable to nearshore spills, as virtually all reproduction, pelagic larvae, and rearing juveniles occur there.

If significant losses are suffered by populations after an oil spill, these changes could have ecosystem ramifications. Large-scale changes in abundance of one species could be reflected in increases or decreases in total biomass of one or several other species. Depending on the magnitude of an oil spill, such spill-induced shifts could alter abundance and distribution patterns for one or more species. Recovery times to pre-impact conditions would have longlasting multispecies implications on the regional fisheries and their management.

Impacts on Subsistence Lifestyles

Numerous coastal communities around Alaska fish and hunt for subsistence, and substantial conflicts between modern technology and traditional subsistence lifestyles already exist in a few regions. With the exploration and development of oil and gas resources will come the inevitable intrusion of a cash economy and the concept of poverty and wealth. Protection of subsistence rights and resources is now a major issue throughout rural Alaska. The sociopolitical concerns of subsistence require that important subsistence species be studied for their distributions, natural histories, and productivities. If a subsistence species or its habitat is determined to be at risk from OCS development, appropriate mitigative measures can then be developed and employed.

The bowhead whale hunt in the Arctic by Alaskan Eskimos has been a subject of much governmental action, particularly in light of quotas established for the harvest (and attempted harvest) of whales for subsistence and to preserve cultural tradition. It is imperative that potential impacts on the species from oil and gas development, including long-term effects of noise and chronic pollution, be assessed and all necessary measures taken to ensure the continued existence of the species. The bowhead whale is also protected under the Endangered Species Act.

Along the Chukchi coast marine mammals form the bulk of the subsistence harvest. Bowheads are the prime target species during the spring when they follow nearshore leads and are thus accessible to the coastal hunters, especially at Point Hope, Wainwright, and Barrow. Belukhas are also consistently taken during the spring and early summer at Point Hope, Kotzebue, Kasegaluk Lagoon, and Wainwright. Ringed seals and bearded seals are taken year round, and to a lesser extent spotted seals during the summer. Walrus are taken opportunistically and in some years provide an important source of cash for villagers. Subsistence fishing is concentrated on obtaining

whitefish, Arctic cisco, smelt, and sheefish. Eiders and geese are very important resources at Point Hope, where residents use over 50 lb per person per year, and to a lesser extent at other Chukchi coastal villages.

Bowhead whales are available for both spring and fall hunting at Barrow. Other villages along the Beaufort coast have access to bowheads only during the fall, because the spring migration through the Beaufort is too far offshore. Villagers from Kaktovik annually and successfully hunt bowheads, and ringed and bearded seals are hunted year round. Belukhas are rarely taken in the Beaufort, for generally they are too far offshore. Caribou are heavily hunted for both food and hides. Eiders, Oldsquaws, and geese are the primary waterfowl taken by Beaufort Sea subsistence hunters and are more heavily utilized near Kaktovik than near Barrow. Per capita subsistence fishing catch is also higher in the eastern than the western Beaufort, with the catch predominantly Arctic cisco, smelt, whitefish, and, to a lesser extent, Arctic cod.

In the Bering Sea region, many marine bird, mammal, and fish resources are taken seasonally or year round. Specific regional use patterns vary considerably along the Bering Sea coast, making the potential impacts of offshore oil and gas development different in each of the proposed lease areas.

In the Bristol Bay region, subsistence fisheries are minor in comparison to commercial activities, but salmon are still a mainstay in the local diets. In 1980, 213,000 salmon were taken in subsistence fisheries in Bristol Bay. Caribou and moose are taken frequently along the Alaska Peninsula and coastal drainages; seals and other marine mammals are taken less often. Waterfowl provide a source of fresh meat during spring and fall migrations.

From Cape Newenham north to Nome, patterns of subsistence use are generally very similar. In this region commercial salmon fishing is the major economic base and other sources of income are limited. Therefore, hunting and fishing are vital activities throughout the year. Subsistence hunters pursue moose, caribou, seals, and belukha whales. In Norton Sound, walrus are harvested in winter prior to, during, and following periods of extended ice coverage. Similarly, ribbon, ringed, and bearded seals are captured during spring and fall migrations. Anadromous salmonids and coastally spawning forage fish compose the bulk of this region's subsistence catch. More than 650,000 salmon were taken for subsistence purposes from this region in 1980. Large numbers of breeding waterfowl are harvested during the summer when they are numerous on the deltas. Few seabirds, or their eggs, are taken from the small colonies on the north side of the Yukon River Delta.

West of Nome and on St. Lawrence Island, subsistence lifestyles are more dependent on the seasonal presence of marine mammals than in more southerly areas. Bowhead, gray, and belukha whales, four species of seals, and the Pacific walrus are taken. Subsistence fisheries target on several forage species, Arctic and saffron cods, flatfish and sculpins, and salmon. Almost 90,000 salmon were harvested by the subsistence fisheries in Norton Sound in 1980. The seabird colonies located in the northern Bering Sea provide fresh meat (young birds) and eggs during summer months. Waterfowl

are not as abundant here as they are around the Yukon and Kuskokwim deltas but are still an important source of food.

In Kotzebue Sound marine mammals, especially belukha whales and ringed, bearded, and spotted seals, are critically important to the subsistence lifestyle. Large-scale hunts of belukhas are annually organized in Eschscholtz Bay during the spring, and during 1982, 121 belukhas were taken there. Subsistence fisheries rely upon the same forage species as in Norton Sound. Salmon become progressively less abundant further north and the importance of sheefish, whitefish, and smelt increases. Migrating waterfowl, especially eiders, Oldsquaw, and geese, are important food resources which are harvested in the spring and fall. Murres and other seabirds provide fresh meat and eggs during the summer.

Although the subsistence lifestyle is well represented around the Gulf of Alaska, this region can be characterized as economically stable and dependent on a cash economy. As such, priority uses of fish and game resources remain those associated with recreational activities and commercial fishing. Subsistence harvests of salmonids are numerically insignificant in comparison to those reported elsewhere in Alaska, but are better documented than subsistence uses of all other species.

Relatively small but important localized subsistence catches of salmon are taken in major fishing areas around Prince William Sound, in the Chignik-Alaska Peninsula area, and in the Copper River near Chitina. Other very minor catches come from Kodiak Island, Cook Inlet, Yakutat, and southeastern Alaska. In the western portion of the Gulf of Alaska, villages are quite remote and rural diets are likely supplemented with salmon, halibut, crab, and other fishery resources; seabirds and waterfowl; seals and sea lions; and other wild game as it becomes available with season.

Protection of Regional Biota, Important Habitats, and Ecosystems

The ultimate goal of OCSEAP biological research programs throughout Alaska is to determine which populations, communities, and ecosystems are at risk from impacts associated with offshore petroleum development, and to develop strategies to mitigate adverse impacts. Particular attention is placed on marine birds, marine mammals, and their habitats, because of these animals' vulnerability to environmental disturbance (noise, physical barriers, chemical pollution); wide public concern for their welfare; and legislative mandates for the protection of certain species.

Both the Gulf of Alaska and the Bering Sea support large populations of seabirds, shorebirds, and waterfowl. In the gulf, large seabird colonies are located in the Barren Islands-Afognak Island area (690,000 birds, including over 300,000 storm petrels on East Amatuli Island); the Stepovak Bay region (798,000 birds); the Semidi Islands area (1.8 million birds); the Fox Islands area (1.02 million birds); the Unimak Island area (532,000 birds); and several sites in the western Aleutians. A large population of

Black Kittiwakes (150,000 birds) is found on Middleton Island. Additionally, millions of shearwaters visit the western gulf waters from the Southern Hemisphere during spring and summer and feed intensively in the pelagic zone. Migrant shorebirds are abundant in spring and fall at coastal estuaries between Kayak Island and Prince William Sound. Western Sandpipers and Dunlins may number in the millions at times; the sandpipers probably compose the world population of the species, while the visiting Dunlins represent the entire western Alaska breeding population of that species.

The Bering Sea supports one of the largest aggregations of seabirds in the world. At least 11.5 million birds have been counted at Bering Sea breeding colonies, most of the birds occurring in megacolonies supporting over a million birds each. Major colonies are located at the Pribilof Islands (2.8 million birds, including almost the entire world population of Red-legged Kittiwakes); St. Matthew Island (1.4 million birds); St. Lawrence Island (2.7 million birds); Little Diomede Island (1.2 million birds); and the Cape Newenham to Walrus Islands area (1.7 million birds). The nearshore areas and lagoon systems of the eastern Bering Sea are also extremely important for marine birds. Over 11.5 million waterfowl use these areas, including the entire world population of Black Brant which concentrates in Izembek Lagoon in October, and the entire world populations of Cackling Canada Goose and Taverner's Canada Goose which nest in the vegetated intertidal zone of the Yukon and Kuskokwim rivers.

Although not as rich as the Bering Sea and Gulf of Alaska, the Arctic coast supports large populations of birds. Alaska's most northerly large seabird colonies are found at Cape Thompson and Cape Lisburne; over half a million birds, principally murres, are found at these sites. North of Cape Lisburne seabird numbers diminish, but the extensive lagoon systems, which occur along the entire Arctic coast, are of major importance to shorebirds and waterfowl. Several million migrating shorebirds and waterfowl use the lagoon systems in the spring and fall; the King Eiders alone, which pass by Point Barrow in the spring, account for over a million birds. Other migrating species which use Arctic lagoons in large numbers for nesting, feeding, or molting include Pintail, Oldsquaw, and Black Brant. More than half the waterfowl breeding habitat of the Arctic is in the region west of the Colville River Delta; nearly one-half million ducks, geese, and swans use this area in the spring.

Among the nonendangered marine mammals which occur in the Gulf of Alaska, the largest single concentration of harbor seals in the world (13,000-20,000 animals) is found at Tugidak Island south of Kodiak Island. Steller sea lions are abundant throughout the Kodiak region, with major population aggregations in the Barren Islands, Marmot Island, Two-headed Island, Chirikof Island, and Cape St. Elias. These localities are also major rookeries, supplying the majority of pups to other areas of the Gulf of Alaska. Sea otters, which were virtually extirpated as a result of commercial fur hunting between 1742 and 1911, now occupy long stretches of rocky shorelines and kelp beds in Prince William Sound, Kamishak Bay, Shelikof Strait, and around Afognak Island. An apparently segregated population of about 400 belukha whales is believed to be resident in Cook Inlet. Large

numbers of Dall and harbor porpoises are found scattered in the northern Gulf of Alaska and Cook Inlet.

In the southern Bering Sea the single largest concentration of northern fur seals in the world pups and breeds on the Pribilof Islands each summer. The Pribilofs are essential to the maintenance of this species. Several other marine mammal species, such as walrus in the Walrus Islands and Cape Seniavin areas, sea otters in the Amak Island area, sea lions in the Akutan-Unimak area, and belukha whales in eastern Bristol Bay, congregate in tremendous numbers during certain seasons and would be vulnerable to lethal stresses following a major ecological perturbation.

In the northern Bering Sea, and throughout the Arctic Ocean, several species of ice-associated marine mammals occur. Walrus and spotted, ribbon, bearded, and ringed seals occur in large numbers on the pack ice and move with it. Ringed seals, the most abundant of these species, live on the shorefast ice for several months of each year. Their behavior of giving birth and nurturing their young on the ice makes them potentially vulnerable to the effects of on-ice road building and seismic activity. Sea lions are found in large numbers along the ice edge in winter. Belukha whales follow the ice leads in the spring. The effect which the ice front and lead systems has, of concentrating large numbers of marine mammals, is a serious problem when assessing the potential effects of OCS development in the Arctic Ocean.

Several embayments and coastal areas in the Gulf of Alaska have been designated as sensitive or critical according to the resource management policies of the State of Alaska. Examples include Kachemak Bay, McNeil River State Game Sanctuary in Cook Inlet, and the Copper River Delta. These areas are biologically rich and diverse and also provide important habitat for salmon spawning; migratory waterfowl and shorebird staging and feeding; and marine mammal feeding, breeding, or pupping. The coastlines of national parks and wildlife refuges, such as Tuxedni Wildlife Refuge, Chugach National Forest, and Glacier Bay National Monument, are also potentially vulnerable to impacts from petroleum development offshore. The maintenance and protection of environmental quality in these areas would require safe and environmentally acceptable technology, appropriate design of facilities, and a strategy of oil and gas development compatible with the existing biotic and aesthetic resources.

Similar situations occur in the Bering Sea, where several habitats are considered critical to the welfare and continued existence of many migratory species of wildlife. Unimak Pass and Bering Strait are major migration corridors for many species into and out of the Bering Sea and high densities of marine birds and mammals can be found there throughout much of the year. The Pribilof Islands have been mentioned for their importance to fur seal and Red-legged Kittiwake populations. The bays and lagoons along the north shore of the Alaska Peninsula are especially important resting and foraging sites for many marine birds and, at times, support major portions of either the North American or Pacific Flyway populations of several species of waterfowl en route to and from nesting habitats on the Yukon and Kuskokwim deltas. Izembek Lagoon is famous for its extensive stands of eelgrass and the enormous fall populations of Black

Brant and Canadian and Emperor geese that they support. Detrital exports from this lagoon are believed to have great influence on the benthic community structures and productivities of nearshore waters north of the peninsula. These coastal waters also contain the entire northeasterly range of sea otters in the Bering Sea.

The foremost concern with development of the Bering Sea OCS is the potential repercussions of accidental releases of oil on the ecology. Oil spilled during storms could be pushed far inshore over delta lowlands, driven into and entrapped within productive bays and lagoons along the Alaska Peninsula, or smeared along large segments of coastline. Losses of habitat or disruption of biological processes within these areas could have both immediate and long-term impacts on populations of regional, local, and global significance.

The recent discovery of isolated kelp communities associated with boulder patches in the Arctic Ocean presents another concern. The biota found in these communities are either new to science or represent a unique mixture of Atlantic and Pacific species. More importantly, the relatively high productivity of these kelp communities has a major effect on the abundance of invertebrate and fish species which may extend several miles downstream.

The barrier island-lagoon systems predominant along the Arctic coast have also been found to have relatively high productivity. During the open water season large populations of waterfowl gather in these lagoons to feed or molt. Large numbers of anadromous fish such as Arctic cisco, which are highly important in native diets, also use the warmer and more brackish waters of nearshore lagoons as migratory pathways. As the potential for perturbation of these previously undisturbed systems increases, strategies for their protection must be developed.

Endangered Species

The Endangered Species Act of 1973 provides a mechanism for the conservation of species that are endangered or threatened with extinction. These species and their habitats, including their migratory range, must be protected from adverse impact due to human activities or industrial development. Several cetacean species are of particular concern. The potential effects of oil and gas development and related human activities on whales may include (1) behavioral aberrations and disturbances caused by noise associated with seismic surveys and marine traffic, (2) fouling of the feeding apparatus of baleen whales, (3) disruption of respiratory functions, (4) ingestion of oil, (5) reduction of food supplies through contamination or alteration of the whales' principal habitats, (6) irritation of skin and eyes, and (7) alteration of migratory pathways to feeding and breeding grounds.

Six endangered species of whales occur in the Arctic Ocean: bowhead, gray, fin, humpback, and, rarely, blue and sei whales. Bowhead whales migrate through both the Chukchi and Beaufort seas. In the spring and fall they move between their overwintering grounds in the Bering Sea and their summer

feeding grounds in the Canadian Beaufort Sea. Their spring and fall migration routes are different: in the spring, bowheads follow nearshore leads through the Chukchi Sea and offshore leads through the Beaufort, whereas in the fall they move closer to shore in the Beaufort and further west in the Chukchi. When bowheads enter the American Beaufort in the fall they continue their feeding activities. The importance of feeding in the American Beaufort has not been documented, but feeding activities are seen from the Canadian border to Flaxman Island and, in some years, east of Barrow.

Gray whales are also seasonal visitors to Arctic waters. The Chukchi and northern Bering seas are the primary feeding grounds for the world's population of gray whales. From June through October groups are scattered throughout the Chukchi Sea and have been observed well into the eastern Beaufort. Historically, portions of the North Pacific populations of humpback and fin whales have used the Chukchi Sea for feeding; the current degree of use is unknown. The Chukchi Sea is considered the northern limit of range for the Pacific populations of sei and blue whales.

Eight endangered species of whales occur in the proposed lease areas of the Bering Sea: bowhead, gray, fin, humpback, blue, sei, right, and sperm whales. Population estimates for these whales vary considerably. Right whales, with only 150-200 animals remaining in the North Pacific, are the rarest. Humpback and bowhead populations, comprising 850-1,200 and 3,400-4,300 whales, respectively, are very low. The gray whale population is currently estimated at 15,000-17,000 whales and appears to be increasing. An estimated 780,000 sperm whales inhabit the Pacific Ocean, but only a small fraction of the population is believed to use the Bering Sea. The current status of other whale species in the Bering Sea is unknown.

Six or seven endangered species of whales occur in the Gulf of Alaska: gray, sei, fin, humpback, right, and sperm whales; and perhaps blue whales. Over 90% of the world's population of gray whales follows a coastal route through the Gulf of Alaska during spring and fall migrations. Unknown portions of the North Pacific populations of fin, humpback, right, and sei whales, as well as gray whales, migrate through Unimak Pass in spring and fall to feed in the Bering Sea. The Gulf of Alaska is also an important feeding area for whales during spring, summer, and fall where they feed on epibenthic invertebrates, copepods, euphausiids, and fish in different strata in the pelagic zone (i.e., photic zone, midwater zone) and in shallow benthic environment (gray whale only).

In responding to needs for more information regarding endangered whales, DOI has initiated several studies in recent years. Research units have examined seasonal occurrence and habitat use, migratory routes, and general biology and population status of several species of whales of endangered status. Of those whales occurring in the Bering Sea, bowheads and grays have received the most attention from OCSEAP. Estimates of bowhead populations were determined through OCSEAP surveys in FY78 and FY79. Systematic surveys of distribution and abundance of endangered whales in the Bering Sea were initiated in FY82. More information on the occurrence, biology, and habitat use of whales in the Bering Sea is needed. Accordingly, investigations of the endangered species have been carefully integrated

into the OCSEAP Marine Mammal Program and are coordinated with studies managed directly by DOI.

Three endangered species of birds have been recorded in Alaskan waters. The Short-tailed Albatross has occasionally been sighted in the vicinity of the Aleutian Islands. The Aleutian Canada Goose nests in the western Aleutians on Buldir Island and perhaps elsewhere. In fall the Buldir population migrates eastward to about Unimak Island before crossing the northeast Pacific en route to California. Two endangered subspecies of Peregrine Falcon, the American and Arctic peregrines, may be seen virtually anywhere along the coast of Alaska during spring and fall migrations, and a few individuals may overwinter there. Some nest as far north as the cliffs of the Beaufort coast. OCSEAP has not yet initiated studies on endangered species of birds.

Ice Hazards and Offshore Technology

The most prominent environmental issue in the Arctic is the extraordinary hazard of moving sea ice. Driven by winds acting over distances of many hundreds of kilometers, the pack ice compresses into large ridges, creating substantial internal stress in the ice prior to fracture. The resulting lateral force on man-made structures can be extreme, in some cases as much as one hundred times greater than in Cook Inlet, for example, because the Arctic multiyear ice may be up to four times stronger than the Cook Inlet annual ice, and up to 25 times thicker. Data on multiyear-ice movement, thickness, and mechanical properties have been used in the formulation of these designs. Statistically significant data sets taken in several regions over several years are required when designing offshore structures because of the known ice variability from year to year. New structures and operational techniques will rely heavily on the results of government research, as emphasized by the National Petroleum Council in their report on U.S. Arctic Oil and Gas Reserves. This research is central to the issue of prevention of environmental pollution in the Arctic.

Geologic Hazards

Geologic hazards, including those due to seismicity and volcanism, are of great concern in the Gulf of Alaska, less so in the Bering Sea; in the Arctic such hazards are primarily due to the movement of shorelines, gouging of the sea floor by sea ice, and existence of subsea permafrost. Geologic risk assessment data should be considered in the selection of tracts for lease sales, in choosing localities for offshore operations, and in setting design specifications for both coastal and offshore structures.

The Gulf of Alaska is located in a region of complex tectonics resulting from convergence of the northerly moving Pacific crustal plate and the more stationary North American (Alaskan) plate. Hundreds of seismic events have been recorded around the gulf over the past 80 years. Several magnitude 7 or greater earthquakes have occurred, some causing widespread and extensive

damage. Most recently, in 1979, a magnitude 7.7 earthquake occurred beneath the Chugach and St. Elias mountains in southern Alaska. Other large earthquakes in this region were four magnitude 7.8 to 8.5 earthquakes in the Yakutat area in 1899 and 1900; the magnitude 8.7 Shumagin Islands earthquake in 1937; the magnitude 7.9 earthquake on the Fairweather fault in 1958; the magnitude 8.5 Prince William Sound earthquake in 1964; and the magnitude 7.6 Sitka earthquake in 1972. A compilation of aftershocks from these and other large earthquakes has shown that they relieve strain energy over sharply limited regions. A plot of the quakes and aftershock zones shows specific areas which have not experienced a large earthquake for a period of time. These areas, known as seismic gaps, are considered the most likely sites of the next great earthquakes. Two seismic gaps have been identified in the Gulf of Alaska: one in the vicinity of the Shumagin Islands, and the other near Yakutat. Other things being equal, the longer the time since the occurrence of a great earthquake in a given gap, the higher is the probability of an earthquake occurrence there.

The numerous volcanoes of the western Gulf of Alaska are also a result of the subduction process. Three of the volcanoes in the Cook Inlet-Alaska Peninsula area have produced violent eruptions during historical times: Katmai in 1912, Trident in the 1950's and 1960's, and Augustine in 1883, 1963-64, and 1976. Recent eruptions of Augustine Volcano in Kamishak Bay produced eruptive columns several kilometers high, glowing debris, nuées ardentes, regional ashfalls, and a new lava dome at the summit. The hazard posed by Redoubt Volcano, on the western shore of Cook Inlet, is primarily from the accumulation of water at the summit caused by the heating and melting of glacial ice and snow. In 1976, breaching of Redoubt's summit crater resulted in flash flooding and the formation of several ice and mud dams along the Drift River. A similar occurrence could cause severe damage to the petroleum-related facilities which have since been built (and more are planned) at the Drift River terminus.

Hazards resulting from geological processes other than seismic and volcanic activity, while not as violent and well known, may also cause significant damage to man-made structures. A potential for slumping has been identified in numerous areas of the northern Gulf of Alaska. Major slump facies have been observed off the Copper River Delta in the Kayak Trough and seaward of Icy Bay. Although mass movement of sediment may be initiated by storm-wave loading, earthquakes are probably the dominant triggering mechanism. The amount of material that may be set in motion can be large; for example, an estimated 6 km^3 of sediment in the Kayak Trough is believed to have slumped during the past 70 years.

The migration of bedforms, as observed in lower Cook Inlet, poses hazards to offshore structures and pipelines if pilings are not placed deeper than the depth of migrating bedforms (as much as 60 m). Migratory sand waves could result in resuspension of sections of pipelines that lie on the seafloor, causing severe structural strain.

Another potential hazard to some types of submerged equipment may be erosion caused by high concentrations of suspended material in strong and persistent currents impinging on the equipment. Such hazards are probable

in Cook Inlet and may cause mechanical damage to equipment or remove corrosion-resistant coatings and insulation material.

The Bering Sea region, although quiescent relative to the Gulf of Alaska region, is prone to localized earthquake hazards. The available data indicate that in the vicinity of the Alaska Peninsula, earthquakes of up to magnitude 7.8 and accelerations of 0.7 *g* may occur. Another area of seismic activity is Norton Sound, where 6.0- to 6.5-magnitude earthquakes have occurred within the last 30 years. Active faulting resulting from tectonism is difficult to document; most often it is inferred from features such as fault scarps that offset the sea floor. Potentially active faults have been mapped at several locations in the Bering Sea, such as west of Nome and in the North Aleutian shelf.

Sediment instability is the most pervasive geological hazard in the Bering Sea. It is manifested in a number of forms and results from a number of circumstances. Observational data from the southeastern Bering Sea and Norton Sound show that in shallow waters rapid sediment sheet movements or scouring occurs during storms. Cyclic loading caused by storms may also cause liquefaction of sediments to depths of several meters in water depths up to 80 m. Biogenic gas produced by decomposition of organic matter is present at shallow depths over large areas of the Bering shelf. Such gas can be released under loading, as evidenced by the widespread occurrence of craters on the sea floor in central Norton Sound. The sound also has occurrences of deep thermogenic gas, which constitute a major hazard if released uncontrolled. Because the gas is under high pressure, oil and gas activities over the continental slope must contend with possible slumping and sliding of sediments; such features have been observed during reconnaissance surveys.

Finally, coastal facility siting must consider shoreline stability. Very high erosion rates have been observed in some areas, most notably near Nome where a 1974 storm surge eroded as much as 45 m off bluffs.

The presence of subsea permafrost poses special problems nearshore in the Beaufort and Chukchi seas, where it can exist at temperatures that are higher than in onshore permafrost and, therefore, is more susceptible to thaw and associated engineering problems. Drilling through permafrost or placing structures on it adds heat to the frozen sediment layers, potentially causing collapse of the structures or other damage.

Special Concerns Related to Arctic Development: Technological Approaches

The combined government and industry approach of stepping out cautiously into increasing water depths using proven onshore arctic technology has the effect of placing relatively greater reliance in the early stages of OCS development on coastal, nearshore, and estuarine resources and processes than is the case in more southerly latitudes. As a consequence, three industrial requirements in particular may pose environmental problems in development of the Arctic OCS oil and gas fields. These are the need for

disposing of drilling muds, cuttings, and formation waters; the need for fresh water; and the need for gravel and its disposition as artificial islands, roads, and causeways.

In low-energy shallow waters, particularly beneath landfast ice, toxic components of formation (produced) waters, drilling muds, and other wastes would be subject to minimum dilution, dispersion, and chemical breakdown for a greater part of the year.

Large quantities of fresh water are needed on and near shore by industrial operations, but supplies in the arid arctic are severely limited. Mining water from arctic rivers can severely affect overwintering fish populations that inhabit isolated pools of unfrozen water under the ice cover of arctic streams.

Large quantities of gravel and other select fill materials are required by industry in the coastal area for early phases of development of the Arctic OCS. Both the sources and disposition of these materials can be important concerns. Construction of artificial gravel islands and causeways raises concerns about the short-term effects of water turbidity, sedimentation, and smothering of benthic communities in the vicinity of the construction activity. The long-term effects of extended causeways, groins, and other coastal modifications have yet to be determined, but may include impeding the migration of invertebrates and fish; shunting of coastal warm water masses out of their normal locations, with resultant decreases in secondary biological productivity; and altering the sediment mass balance equilibria, resulting in new areas of deposition and accelerated erosion.

STATUS OF INFORMATION ON POTENTIAL LEASE AREAS

Arctic Ocean

Diapir Field (Sales 87 and 97)

The Diapir Field is considered the number one prospect for offshore oil and gas discoveries in the United States by the petroleum industry. Two lease sales have already occurred for this planning area: the Joint Federal/State Beaufort Sea Lease Sale in December 1979 and Sale 71 in September 1982. The former sale was challenged in federal and state courts, and was finally completed in 1980. The Joint Federal/State Sale exceeded $1 billion in revenues, and Sale 71 exceeded $2 billion. By the end of 1982, more than 20 wells had been drilled from natural and artificial islands, and several oil discoveries had been reported.

Two further sales in the Diapir Field are on the current lease schedule. Both are unspecified in terms of area and boundaries, but presumably cover the entire continental shelf of the Beaufort Sea from west of Barrow to the Canadian border, an area of over 200,000 km² extending to water depths of over 3,000 m.

Sale 87 is scheduled for June 1984. Environmental information for this sale was collected prior to a synthesis meeting in January 1983, 8 months before the DEIS was due in September 1983. FY84 work will be too late for this sale but not for Sale 97, which is planned for June 1986, allowing 18 months (FY84 and half of FY85) to carry out additional research prior to the deadline for input to the DEIS.

The current schedule for the two sales is as follows:

	SALE 87	SALE 97
Call for Information	10/82	10/84
Area Identification	1/83	1/85
DEIS	9/83	9/85
Public Hearing	11/83	11/85
FEIS	2/84	2/86
Sale	6/84	6/86

The environmental data base for the Diapir Field planning area is comparatively quite complete. Research on the inshore regions of the Diapir Field has received consistent funding since 1975. Synthesis meetings held in February 1977, January 1978, April 1981, and January 1983 have resulted in

a continuing reassessment of program directions and availability of data. A relatively broad and timely data base has been built in response to these sequential evaluations. Because the recently created Sale 87 and Sale 97 areas encompass a much larger region, however, data gaps still remain in the zones seaward of 20 m and the newly expanded area from Point Barrow westward to Peard Bay.

Contaminants

Reconnaissance studies of contaminants from OCS exploration and development in the Diapir Field indicate that the ambient concentrations of these contaminants in seawater and sediments are typical of concentrations in pristine areas. Sample density is not high and localized anomalies could have been missed.

Geologic Hazards

Remote sensing of sea ice has given us good details of pressure ridge distributions and statistics and open water leads, particularly in the fast ice zone. Ice gouging has been reasonably well documented for these areas. Future research in ice hazards must focus on the outer regions of the new lease areas, out to the shelf break, for which little information is available. The area planned for leasing is at least five times larger than the nearshore region which has been the subject of 7 years of intensive research. Potential hazards to OCS structures and facilities due to ice island and mechanical properties of multi-year ice in this outer zone, particularly, have not yet been evaluated. Subsea permafrost hazards have been outlined in very general terms by several research units.

Oceanographic and Meteorological Hazards

In the Beaufort Sea, oceanographic hazards due to wind and waves are minor when compared to the hazards resulting from ice forces. Extreme wave height calculations have not been made, but available information indicates that limited fetch due to ice would greatly dampen the occurrence of large waves. Storm surges are being documented and modeled.

Pollutant Transport

Pollutant transport in the Arctic Ocean is synonymous with transport of ice for most of the year. The process by which oil is constrained to move with ice is well understood from studies for OCSEAP. These studies indicated that a differential velocity between oil under ice and water of 20 cm/s or more is needed before oil and ice will move in different directions. Furthermore, when freezing is occurring, the oil is encapsulated as a lens in the ice where it probably does not weather. The amount of weathering expected when oil is incorporated into ice remains a significant data gap to be filled in FY84.

The motions of ice and oil together, under the influence of winds and currents, have been studied. According to model simulations run in 1979 and again in 1982, highly variable motions toward the west are expected in response to winds. These motions have been confirmed by unpublished satellite buoy data obtained by the U.S. Coast Guard and by observations of a meteorological buoy launched by an OCSEAP investigation. It is believed that mesoscale motion of ice and associated oil can be predicted, and that risk from oil spills under and on the ice can, therefore, be predicted as well.

While mesoscale transport of oil can be modeled with confidence, small-scale features, such as the behavior of oil in the presence of sediment-laden ice and at breakup, remain difficult to model.

Modeling the trajectory of oil spills in both open water and under the influence of the ice pack has been accomplished for the Beaufort Sea. The model, which includes the full equations of motion for both oil and ice, is also used to determine oil concentrations in the water column in the vicinity of a spill.

Field studies of currents offshore near the shelf break were instigated in 1978. Since then, currents have been studied in Harrison Bay, Simpson Lagoon, and Beaufort Lagoon. As a result of these studies, the current regimes on the Beaufort Sea shelf are well known and can be modeled satisfactorily.

Wind regimes which affect pollutant transport are also now well understood. OCSEAP-generated wind statistics were incorporated in the weather model used to drive the oil spill trajectory model. The effect of winds on the movement of sea ice was known from earlier studies by the University of Washington and University of Alaska's Arctic Ice Dynamics Joint Experiment (AIDJEX); coupling between wind and annual (thin) ice has also been demonstrated, from intensive studies by OCSEAP performed in the Bering Sea. A data gap has been identified in the effect of headlands on local winds on a scale length of 10 km or more and is the subject of a study proposed for FY84.

Living Resources

Biological studies conducted since 1975 in the Beaufort Sea have been successful in documenting (1) the distribution and abundance of biota, particularly birds, fish, and mammals; (2) energy flow and trophic relationships; (3) structural and functional aspects of lagoon systems and boulder patches; and (4) some effects associated with such lease activity-related perturbations as seismic exploration and causeway construction. Many of these studies have also been able to expand traditional summer research into the winter season.

Most of the distribution studies are complete. Fish surveys in the eastern, central, and western American Beaufort have generally filled in the picture of nearshore species dominance. Arctic char, Arctic cisco, Arctic flounder, and fourhorn sculpin are the dominant species in the eastern

region of the American Beaufort; least cisco, Bering cisco, and humpback whitefish are more dominant in the western region, although there is much overlap. Temperature preference studies indicate that the waterflood causeway does not act as a significant barrier to the migration of Arctic cisco.

Studies of shorebirds and waterfowl have delineated important concentration areas for nesting, molting, and feeding. The research indicates that there is some tolerance by Oldsquaws to aircraft, boat, and human disturbances.

Assessment studies on marine mammals in the Beaufort have focused on ringed seals, bowhead whales, and belukha whales. Studies on ringed seals have documented distribution, food habits, and responses to acoustic disturbance. The research indicates that although some localized displacement of ringed seals occurs in immediate proximity to seismic lines, overall displacement from acoustic exploration techniques is insignificant in the nearshore Beaufort. Belukha whale studies have noted aggregations of up to 5,000 whales approximately 160 km north of Barrow. These aggregations are much larger than those seen during the spring. Bowhead whale surveys during the fall by OCSEAP have noted the timing, abundance, and migratory path of this species in conjunction with similar MMS studies.

Energy flow studies using carbon isotope tracer techniques have revealed that fish and birds of the nearshore Beaufort Sea are almost totally dependent upon marine primary production despite the large quantities of terrestrial peat carbon available to the nearshore ecosystem. These studies indicate, however, that anadromous fish which overwinter in fresh water, and tundra nesting birds, are heavily dependent upon peat-based detrital food webs. Rates of primary production in the Beaufort have been found to be low. Ice algae typically produce 0-2 g $C/(m^2 \cdot yr)$ inside the barrier islands and 2-6 g $C/(m^2 \cdot yr)$ outside where clearer ice cover is available. Marine phytoplankton typically produce 5-20 g $C/(m^2 \cdot yr)$ inside the barrier islands and up to 40 g $C/(m^2 \cdot yr)$ outside the islands where the euphotic zone is deeper. Theoretical analysis of overall productivity patterns in the Beaufort Sea indicates two areas, one north of Barrow and one east of Barter Island, which apparently have disproportionately higher rates of annual primary production. These areas have also been shown to be areas of higher abundance for marine benthos, birds, and mammals.

Lagoonal studies have determined that epibenthic mysids and amphipods provide the major food base for the large populations of birds and fish which use Arctic lagoons. The annual available biomass of epibenthos appears to exceed the demand. Studies of the boulder patches indicate the presence of over 300 species, many of which represent a unique mixing of Atlantic and Pacific flora and fauna. The comparatively high biomass of benthos seen several kilometers downstream from the boulder patches reflects the high productivity of these kelp-dominated areas.

Barrow Arch (Sales 85 and 109)

No lease sales have occurred in the Barrow Arch planning area so far, but two are scheduled: Sale 85 for February 1985, and Sale 109 for February 1987. Most of the FY84 work will be too late for input into the Sale 85 DEIS, but the results of two intense field seasons will be available prior to the Sale 109 DEIS. The proposed schedule for each sale is as follows:

	SALE 85	SALE 109
Call for Information	6/83	6/85
Area Identification	9/83	9/85
DEIS	5/84	5/86
Public Hearing	7/84	7/86
FEIS	10/84	10/86
Sale	2/85	2/87

The Barrow Arch planning area extends from slightly north of Point Franklin to Cape Lisburne on the Chukchi Sea. Little work other than general surveys was done in this area prior to FY81. With Sale 85 scheduled for 1985, however, this region has begun to receive much greater research emphasis. In FY83, studies on the Barrow Arch received the greatest proportion of research funding among all Alaskan OCS lease areas.

Contaminants

Reconnaissance studies of the distribution of OCS development-related contaminants in the Barrow Arch indicate that ambient concentrations in seawater and sediments are typical of those in pristine areas. Sample density is not high and localized anomalies could have been missed.

Geologic Hazards

Ice and permafrost hazards in the shorefast ice regions of the Barrow Arch have been described in broad terms by several research units. Exceptions are the area between Wainwright and Barrow where the nature of the regional substrate and the possibility of finding unfrozen gravel in that area should be determined. These studies were to have started in FY83, but have not yet commenced. Because both scheduled lease sales are now likely to encompass the entire planning area, with the potential for exploration and development long distances out from the coast, greater emphasis should be placed on ice hazards in the open Chukchi Sea in future research.

Oceanographic and Meteorological Hazards

Oceanographic and meteorological hazards in the Chukchi Sea have not been addressed explicitly. Work performed in the Bering Sea on the probability

of occurrence of icing conditions and large waves may have applicability in the Chukchi Sea. OCSEAP investigators have provided the capability to quantify hazards to OCS development due to storm surge. Probabilities of extreme waves could be calculated from the weather models developed by OCSEAP research but this work has not yet been done.

Pollutant Transport

The Chukchi Sea, especially in the far north, is ice-covered for 8 to 10 months of the year and therefore the transport of oil spills becomes synonymous with that of ice. The process by which oil is constrained to move with the ice has been described by OCSEAP investigators, who found that oil moves with the ice until the water velocity relative to the ice exceeds a 20 cm/s differential. Furthermore, it has been demonstrated that if oil is present under the ice, it will become encapsulated in ice during the freezing process.

An OCSEAP research unit has synthesized both OCSEAP and AIDJEX data on the motion of ice in response to wind and arrived at a model system which accounts for all mesoscale features of ice motion. This model system encompasses both the Beaufort and Chukchi seas and was used to predict oil spill trajectories in the Beaufort. The trajectories were confirmed by generally westward motions seen in buoys launched by the U.S. Coast Guard in the eastern Beaufort Sea.

Mesoscale currents in the Chukchi Sea have been studied by means of current meter moorings since 1976 by OCSEAP investigators. These current data combined with studies of baroclinic currents yield a coherent picture of general circulation patterns in the Chukchi. Currents have also been measured very near the coast between Cape Lisburne and Point Barrow. The results of these studies indicate that currents in the Chukchi Sea have the same tendency to follow isobaths and to be coherent with alongshore winds as found elsewhere by OCSEAP studies.

The general circulation model developed by OCSEAP investigators, which is the basis for oil spill trajectories, shows wind and tidally driven currents in the Chukchi Sea that agree well with currents summarized from current-meter data. The model, which includes ice in its equations of motion, also predicts ice velocity relative to wind, and is in agreement with studies made of buoy motions in the Chukchi and Bering seas.

Meteorology of the Chukchi Sea coast has been studied during two seasons. As a result, the relation between coastal winds and pressure gradients is well known except for the local effects of headlands on the wind field. This is the topic of proposed research to be completed during 1984.

Although mesoscale pollutant transport can now be satisfactorily modeled for the Chukchi Sea, some gaps still exist concerning microscale events. These include weathering in ice (believed to be very slow), transport by sediment-laden ice at breakup, and transport by sediments in the surf zone. Each of these areas is proposed for study in FY84.

Living Resources

Studies of living resources in the Barrow Arch have been limited primarily to distributional analyses. One OCSEAP research unit has detailed the status of available information concerning fish resources. Others have described distribution and habitat usage by birds; timing, feeding, and areas of use by seals, walrus, and belukha whales; and the distribution of benthos and littoral biota.

During FY83 several studies will be initiated in the Barrow Arch area to investigate broader-scale ecological problems. These include a study of fish dependence on habitat types; a study of Peard Bay ecological processes which will provide data comparable to those gained for Beaufort Lagoon, Simpson Lagoon, and Stefansson Sound; a coast-wide study of general environmental sensitivities; bird monitoring studies at Cape Lisburne; and continuing studies on the effects of acoustics on ringed seals.

Bering Sea

Norton Basin (Sale 100)

The Norton Basin OCS planning area encompasses not only Norton Sound, but also the region westward to the United States-USSR Convention Line. The planning area is bounded south and north by latitudes 63° and 66° N, respectively. Norton Sound proper has been in the OCS leasing schedule since 1975. According to the then current schedule, a Norton Sound lease sale (Sale 55) was planned for September 1978. This sale was later deferred and replaced by a second lease sale in the northeast Gulf of Alaska which in turn was replaced by the Chukchi Sea (Hope Basin) sale; the latter was cancelled in 1978. The May 1982 proposed OCS leasing schedule for Norton Sound (Sale 57) called for the sale to occur on November 1982, which represented a 2-month extension of previously proposed dates. Further delay of Sale 57 occurred as a result of a suit filed by the State of Alaska and others which argued that the revised, streamlined OCS leasing schedule violates the 1978 amendments to the OCS Lands Act. A subsequent California court ruling requiring efforts to comply with State coastal zone management plans consequently caused delay of Sale 57 until March 1983. The FEIS for Sale 57 has been completed and is currently available.

An additional offering, Sale 100, is also being proposed for Norton Sound as part of DOI's revised leasing schedule. This offering, potentially including the entire Norton Basin planning area, is scheduled as follows:

Call for Information	2/84
Area Identification	5/84
NEPA Document (EIS)	1/85
State Comments	5/85
Sale	10/85

Because this sale was quite recently revised, a Norton Basin synthesis meeting originally planned for June 1983 is rescheduled for June 1984. Subsequent DEIS and FEIS documents for Sale 100 will require reexamination of existing data to identify areas where the data base is not sufficient.

Oil- and gas-related events in the Norton Basin region include State leasing actions and industry activities. A planned State submerged lands sale was cancelled due to lack of oil potential and Native organization opposition. Norton Sound COST well #1 was drilled 24 km south-southwest of Nome in 1980 and reportedly found no hydrocarbons. A second Norton Sound COST well was spudded on June 7, 1982 by the KEY SINGAPORE jackup rig some 110 km southeast of Nome in 15 m of water; it ultimately reached 4,538 m before being abandoned on September 19. Gas shows reportedly were discovered between 3,670 and 4,343 m.

The U. S. Geological Survey's mean estimate of producible oil in Norton Sound is 480 million bbl.

Contaminants

Petroleum hydrocarbon and trace metal concentrations in the seawater and sediments of Norton Sound are very low, as is normal for undeveloped areas. A gas seep located by OCSEAP investigators in central Norton Sound was found to be composed primarily of thermogenic carbon dioxide with lesser quantities of thermogenic natural gas. The plume of the seeping gas could be traced for several tens of kilometers, verifying surface and subsurface circulation predictions. Observations indicate that the local microbiological community is not impacted by the gas seep or else has adapted to it. Air pollution is not considered to be a current or future problem in this area, thus no sampling to establish ambient levels of airborne pollutants has been done or is anticipated. Funding for contaminant baseline studies in Norton Sound ended in FY80.

Geologic Hazards

The offshore environmental geology of Norton Sound is relatively well understood as a result of extensive sampling, seismic profiling, and other surveys performed there since about 1967. Seismic monitoring by OCSEAP investigators revealed significant shallow seismic activity and clusters of earthquakes which lie parallel to mapped structural trends. An increase in the density of seismographs by a research unit in FY80 led to a significant improvement in the accuracy of locating epicenters. Another research unit is compiling a uniform earthquake catalog which includes the Norton Sound area.

In 1979 a workshop on Alaska OCS Seismology and Earthquake Engineering established the need for regional geotechnical data to determine the possible effects of earthquake loading on the sediments and seismic energy transmission characteristics. In response to this, OCSEAP initiated geotechnical studies in selected areas of the Alaska OCS to elevate our knowledge of the engineering behavior and stability of sediments. A study

begun in 1981 to determine the degree of hazard presented by potentially unstable sediments in Norton Sound was completed in early FY83. Funding of geological hazards studies in Norton Sound was terminated in FY82.

The major geologic hazards occurring in the Norton Basin and their probable effects on oil and gas development are described in the 1980 Norton Sound Synthesis Meeting report. Hazards which were felt to present the greatest problems are faulting, thermogenic gas charging, biogenic gas-charged sediments, and liquefaction of seafloor deposits. Of these, stability characteristics of the sea floor are still inadequately characterized.

Oceanographic and Meteorological Hazards

The major storm which hit Nome in November 1974 typifies the hazard from storm surge and high waves in the Norton Sound area. During that storm, a maximum wave height of 7.5 m was estimated; the normal high tide in the area is 1.2 m. Hazards from similar meteorological events offshore will include the presence of unusually strong currents and the resulting force of ice, when present, against offshore structures.

Pack ice in Norton Sound can be up to 2 m thick, but is mostly less than 1 m thick. The motion of the pack ice under the influence of wind and currents constitutes the major oceanographic hazard to offshore structures. To put this hazard in perspective, OCSEAP investigators calculated maximum expected velocities, and made comparisons with conditions in Cook Inlet where offshore structures must withstand currents exceeding 5 kn and ice floes more than a meter thick and a few hundred meters in area. Another research unit examined the statistics of ice motion.

Moving pack ice also results in the gouging of the sea floor when ice keels are embedded in floes. This phenomenon is believed to occur yearly, though its frequency in a given area is not known. Bottom-founded structures must be designed to withstand the forces exerted by ice keels or must be buried. Ice gouging in Norton Sound is most prevalent near the Yukon Delta because of the combination of prevailing winds and shallow waters. Available OCSEAP study results show the approximate distribution of ice gouging there. Gouging by Bering Sea ice is believed to be limited to water depths less than 20 m.

Although site-specific ice studies in Norton Sound have been completed, OCSEAP continues to support long-term monitoring of ice motion and characteristics in Alaskan waters (including Norton Sound) via analysis of satellite imagery. In addition, generic investigations of ice ridge to keel relationships conducted in the Beaufort are providing data applicable to the Norton Sound region.

Pollutant Transport

Norton Sound transport studies began in August 1976 with deployments of several current-meter moorings. Fine-mesh conductivity-temperature-depth (CTD) surveys of Norton Sound also began during 1976. Fieldwork was

largely completed by FY81; however, modeling studies have continued with the intent of describing the general circulation patterns affecting the transport of spilled oil, oil weathering, and oil-ice interactions.

Analyses of OCSEAP and other data from the Norton Sound region show that advection by mean currents is a minor factor in transport of pollutants. Shoreward of the shelf break, currents are about 1-2 cm/s except between Norton Sound and St. Lawrence Island where there is a current of 10-15 cm/s associated with the northerly transport through Bering Strait.

Within Norton Sound currents are very weak, except for a baroclinic current along the north shore which near Nome may attain a speed of 75 cm/s. The hydrography suggests that exchange of water between the eastern end of the sound and the shelf to the west is slow and may be virtually absent during some years. During summer, vertical mixing is also restricted, there being a very pronounced stratification during most of the open-water season as a result of both ice meltwater and Yukon River discharge.

Oil spill trajectories under both ice cover and open-water conditions were modeled by RU 435. The results show the effects of extreme stratification and associated low turbulence on the response of the upper water column to wind stress.

Pollutant transport near the Yukon Delta will be affected by periodic run-off from the Yukon River. The depiction of effects of the runoff on overall risk from oil spills is believed to be within the capabilities of the present model. The possibility exists of subsurface oil being carried upstream in the estuarine salt wedge. This and other small-scale estuarine processes such as the clearwater bands between river distributaries have not been addressed to date.

Living Resources

The bird populations in the Norton Basin area are large and diverse during the ice-free season. Recent estimates indicate approximately 4½ million seabirds live in the area between St. Lawrence Island and the Lisburne Peninsula. Some 2 million waterfowl (excluding shorebirds) breed in the Yukon Delta region.

Within Norton Sound proper, however, one must be within 100 km of the seabird colonies at Sledge Island or 20 km of the colonies at Bluff to find significant numbers of seabirds. Low primary productivity in the relatively warm, low-salinity coastal waters dominated by the outflow of the Yukon River is believed to be the cause of low bird density within Norton Sound. West of Norton Sound, the colder, more saline and nutrient-rich waters support seabird populations two orders of magnitude more than within the sound. The majority of these seabirds are zooplankton-eating Crested, Parakeet, and Least Auklets. Population composition and productivity of major seabird colonies within Norton Sound are relatively well known, as is coastal habitat use, as a consequence of work by OCSEAP research units.

Within the Norton Basin planning area the greatest concentrations of marine mammals are found in the west between St. Lawrence Island and the Bering Strait. As many as 15,000-17,000 gray whales and 4,300 bowhead whales may frequent this region. Gray whales are present from May to November, principally as feeding individuals. Bowheads occur in this area in spring and fall; during the spring they may calve and breed, as well as feed. Recent OCSEAP mammal research has focused on the feeding ecology of gray whales in the Chirikof Basin, the distribution and movements of belukha whales, the population biology and trophics of walrus, and summer and autumn use of coastal habitats by marine mammals. Discussion at the Norton Sound Synthesis Meeting indicated a lack of information on the seasonal distribution and habitat use of fin, killer, and humpback whales.

Intertidal and benthic environments were studied by OCSEAP in 1976. In Norton Sound it appears that detrital input from the Yukon Delta and the many rivers within Norton Sound, as well as the sea grass beds and intertidal algae, represent the major sources of carbon for the benthos. The relative abundance of infaunal deposit feeders and their predators reflects the dominantly depositional environment of the sound.

An OCSEAP review of data on demersal fish and shellfish resources and field studies of demersal, pelagic, and nearshore fishes indicate that Norton Basin commercial fishery resources are minor in comparison to other Alaska OCS planning areas. Demersal fish stocks amount to only about 65% of those of the northeastern Gulf of Alaska (yet encompass twice the continental shelf area), and less than 3% of the eastern Bering Sea. Pelagic fishes are also less abundant. The salmon harvest averages 13% of the amount harvested in the Yukon-Kuskokwim region, 6% of the catches in Bristol Bay, and 2% of the amounts for both the Gulf of Alaska and southeastern Alaska. Chinook salmon are of major importance in Yukon River fisheries. Principal species harvested commercially also include chum and pink salmon, herring, and Arctic char. Cisco, whitefish, smelt, and capelin are harvested by local people for subsistence purposes.

The benthic faunal composition in the Norton Basin also differs from other Alaska continental shelf regions. In the Gulf of Alaska and eastern Bering Sea, for instance, over 90% of the epibenthic biomass comprises fish and invertebrates of current or potential economic importance. This component of the Norton Basin fishery resources represents only 25% of the total biomass, and the fish are largely of unharvestable size. The northern part of Norton Sound, particularly the region between Cape Rodney and Rocky Point south to 63°N, yields the largest landings of commercial species.

Little is known about overwintering fish populations in the Norton Basin. Research also needs to be carried out to characterize the fishery resources within the clearwater areas lying between the Yukon River distributaries, particularly the importance of these areas to migrating salmon.

Navarin Basin (Sales 83 and 107)

The Navarin Basin was initially proposed for oil and gas development in 1979. The planning area for these sales is quite large (15 million ha); it is bounded to the south and north by the 58° and 63° N parallels, on the west by the United States-USSR 1867 convention line, and on the east by the 174° W meridian. (Plans for these sales may be complicated by the pending Law of the Sea Conference boundary proposal, which if passed would move the dividing line for resource control well eastward from the 1867 convention line.) A Call for Information for Sale 83 was issued in May 1982. During the year, scoping meetings were held at Anchorage, Unalaska, Bethel, Nome, and Savoonga, as well as a synthesis meeting in Anchorage. The current planning schedules for Sales 83 and 107 call for the following:

	Sale 83	Sale 107
DEIS	6/83	6/85
Public Hearing	8/83	8/85
FEIS	11/83	11/85
State Comments	1/84	1/86
Sale	3/84	3/86

Industry has been actively preparing for the Navarin Basin sales. During the summer of 1982 one company drilled three soil borings to 91 m. Efforts were also underway to arrange a land swap to facilitate operations. Cook Inlet Region, Inc. was attempting to trade land on the Kenai Moose Range for about 10% of the acreage on St. Matthew Island, planning to lease the latter to ARCO Alaska, Inc. for use as a shore base for a COST well drilling operation supported by a consortium of oil companies. Delays in the trade forced ARCO to switch to Nome as a support base. Two Vertol 234 long-range helicopters flew support operations from Nome to the Navarin Basin COST well, which was spudded in May 1983. The Sedco 708 semisubmersible was the drilling rig used in Navarin Basin.

Estimates of undiscovered recoverable oil and gas reserves in the Navarin Basin are 1.74 billion bbl and 7.14 trillion ft^3, respectively.

Because of the large acreage of the proposed Navarin Basin lease area, its remoteness, and its relatively recent inclusion in the OCS planning schedule, the environmental data base from this region is comparatively scanty. However, a rather modest OCSEAP research program for the Navarin Basin in recent years has contributed significantly to addressing key data and information requirements identified by DOI for various decision points in the leasing process for Sales 83 and 107.

Contaminants

Reconnaissance studies of OCS exploration- and development-related contaminant distribution indicate that ambient concentrations in seawater and

sediments are typical of those in pristine areas. Sample density is not high and localized anomalies could have been missed.

Geologic Hazards

OCSEAP-supported geological and geophysical reconnaissance surveys of the Navarin Basin were begun in 1980 and a second year's work was conducted in 1981. As of this writing, no areas of serious sediment instability have been discovered, and few of the faults which have been mapped appear to offset the sea floor or recent near-surface sediments. Sand waves have been tentatively identified in one area, but it is not known whether these are active features or relicts from past periods of lower sea level.

Little or no seismic activity has been detected in the Navarin Basin, although it is possible that low-magnitude earthquakes occur there which go undetected because of the remoteness of the area. Damaging earthquakes have never been recorded for this basin, and are highly unlikely. Low-magnitude earthquakes which may be indicative of shallow fault activity can only be detected by ocean-bottom seismographs emplaced in the area. To date no such deployments have been made or are planned.

Oceanographic and Meteorological Hazards

Summarized observations from the Navarin Basin show that approximately 5% of the time, and throughout most of the year, wave heights will exceed 6 m. This includes periods when the advancing Bering Sea ice pack, which averages less than 1 m in thickness, is present. The combination of storm waves with the resulting motions induced in floating ice constitutes a hazard to structures. In the Navarin Basin water depths range from 30 to 100 m, and even greater near the shelf break. Wave-induced forces, especially in the presence of ice, cause large overturning movements on rigs at these depths. In comparison, existing production rigs in Cook Inlet must withstand ice 1 m thick in currents of about 250 cm/s (5 kn), though in depths to only 30 m.

Recently concluded OCSEAP studies will permit estimates of ice floe momentum in the presence of waves such as would be expected in the Navarin and St. George basins. Long period currents and tidal currents, which are certainly not expected to approach in magnitude those of tidal currents in Cook Inlet, have been computed by use of a hydrodynamic model.

Pollutant Transport

Studies specifically addressing oil spill transport on the broad shelf between Bristol Bay and Norton Sound began in 1981, with deployments of current meters along the shelf break in the Navarin Basin.

The marginal ice zone intrudes into the Navarin Basin in most years; it has been the subject of study by two research units. One studied data obtained by a U.S. Coast Guard icebreaker in 1980 and another, together with NOAA's

Pacific Marine Environmental Laboratory (PMEL), did fieldwork in 1981. Thus some understanding has been gained of currents and the behavior of ice where the transition to open water occurs in winter. Pollutant transport, on scales of 1-2 km, may be affected by the behavior of the ice floes due to wave reflection and hypothesized weak currents caused by meltwater. However, the preliminary results at hand are not expected to affect risk assessments on the spatial-temporal scale usually considered.

Analyses of OCS and other data suggest that pollutant advection by other than the wind-driven surface layer is a minor factor in the Navarin Basin. A narrow band of currents occurs over the shelf break and parallel to isobaths; it has a mean speed of approximately 4 cm/s, or about 0.8 km/d, toward the northwest. Shoreward of the shelf break, advection is an even lesser factor for water or water-borne pollutant transport.

The oil spill trajectory model used in 1980 to determine spill trajectories and risk in Norton Sound was expanded in 1981 to encompass all of the shelf between Norton Sound and Bristol Bay, including the Navarin Basin. Data required by the model have been acquired; they consist of sea-level pressure measurements along the model boundaries and some simultaneous current measurements for verification on the shelf. Data obtained from satellite-tracked platforms placed on ice floes are also available from the area immediately east of Navarin Basin for possible use in model verification.

Living Resources

OCSEAP-sponsored studies represent the bulk of biological research carried out by North American scientists in this region. They consist in the main of reconnaissance-level shipboard and aerial surveys. With the exception of several ice-edge cruises, most such projects have focused on species of economic interest or those protected by legislative mandates. Therefore, relatively little information is currently available on the non-ice-edge or non-commercially valuable species.

More intensive studies in other Bering Sea lease areas of species known to occur in the Navarin Basin have provided data on population dynamics and trophics that may be extrapolated to the Navarin Basin, but caution is necessary in such extrapolations. These studies have been primarily concerned with commercial fish species and the more common pinnipeds and seabirds. Over the past several years, icebreakers and NOAA vessels have traversed the Navarin Basin at various times during the winter and spring in an attempt to characterize the ice-edge ecosystem of the Bering Sea.

Little was known prior to 1975 about the demersal and benthic biota of the Navarin Basin. Two surveys conducted in 1975 and 1976 as part of a multi-vessel demersal resource assessment of the southeastern Bering Sea have provided partial areal coverage of the seasonal distributions of the major demersal species in the Navarin Basin. The region has subsequently been resurveyed as part of NMFS crab and groundfish resource investigations. Additional fisheries information from the Navarin Basin is available in the foreign catch statistics collected by the U.S. Observer Program. Results

of limited sampling of infaunal benthos during icebreaker cruises in the Navarin Basin region recently became available.

Limited information is available on the marine mammals present in the Navarin Basin. Trophic analyses of seals and walrus from other Bering Sea lease areas may be applicable to this region. OCSEAP initiated major seasonal surveys for marine mammals during FY82. During 1982-83, four marine mammal surveys were conducted in the Navarin Basin, combining ship-board and aerial efforts. These are expected to significantly increase our understanding of marine mammal use of this area. Marine mammals work in FY82 included a synthesis of previously collected ships-of-opportunity sightings and the delineation of the winter range of bowhead whales. The Navarin Basin is thought to be the major habitat of bowheads during winter; and of ribbon seals, and perhaps right whales, during summer. Therefore, these are the species most likely to be impacted by oil and gas development in this planning area. Like that of the bowhead whale, ribbon seal ecology in the Bering Sea is poorly understood. Historical and opportunistic data on the occurrence and pelagic distribution of marine mammals from the Navarin Basin, and the Bering Sea in general, were submitted in FY82 by several OCSEAP research units.

Information on marine birds in the Navarin Basin is still rather sparse, but improved as a consequence of FY82 activities. Distributional data on seabirds (shearwaters, guillemots, Black-legged Kittiwakes, murres, Northern Fulmars, and gulls) from observations taken during 1976-78 were incorporated into a data base developed for the St. George and North Aleutian basins. The broad-scale patterns of trophics of major marine bird species are well known. Icebreaker surveys during previous years have characterized winter bird use of open water, ice front, and deep pack habitats. Field efforts in FY82 examined the pelagic distributions of birds and their associations with several features of the Navarin Basin environment during the ice-free season. Additionally, the seabird colonies of St. Matthew and Hall islands were surveyed by OCSEAP and the U.S. Fish and Wildlife Service during FY82 and FY83 to determine the breeding phenology, foraging behavior, and reproductive success of major species.

Ecosystem studies of the Navarin Basin have been limited to the physical and biological information obtained during the icebreaker cruises of 1979 and 1980. A study to integrate the data from those cruises was proposed in FY82, but cancelled due to insufficient funding and priority.

St. George Basin (Sales 70, 89, and 101)

The St. George Basin was originally scheduled for sale (Sale 45) in March 1977. That sale was later postponed, then cancelled. Since that time several sales have been proposed. The most recent schedule shows three sales between 1982 and 1987 being proposed in the St. George Basin. These sales and associated leasing decision points are:

	SALE 70	SALE 89	SALE 101
Call for Information		4/83	4/85
Information Due		5/83	5/85
Area Identification		7/83	7/85
DEIS		3/84	3/86
Public Hearing		5/84	5/86
FEIS		8/84	8/86
State Comments	12/82	10/84	10/86
Sale	2/83	12/84	12/86

In 1980 the U.S. Geological Survey estimated the 5% (maximum), mean, and 95% (minimum) levels of recoverable resources in the St. George Basin as follows:

	MAXIMUM (5%)	MEAN	MINIMUM (95%)
Oil, billion barrels	3.04	1.12	0.24
Gas, trillion cubic feet	8.80	3.66	1.48

On May 19, 1982 ARCO Alaska spudded an exploratory COST well approximately 185 km northwest of Cold Bay. Drilling was from the Sedco 708 semisubmersible. The St. George Basin test had a target depth of 4,450 m.

Prior to the cancellation of Sale 45 in 1977, OCSEAP sponsored a number of environmental studies in the St. George Basin lease area. Field studies conducted during 1975-77 were designed to provide information on the region's physical oceanography and use by marine mammals, birds, and fish. Other OCSEAP surveys were conducted during this period to evaluate potential geologic hazards of this area to OCS exploration and development. With the cancellation of the sale, several studies were not completed.

The National Science Foundation has been funding the PROBES (Processes and Resources of the Bering Sea Shelf) research program since 1976. This program has conducted studies throughout the southeastern and central Bering Sea since its inception, with the major aim of describing the physical properties of the Bering Sea and how they affect nutrient distributions, primary production, the partitioning of pelagic and demersal ecosystems, and ultimately the production of pollock.

The St. George Basin (Sale 70) reappeared on a 1979 DOI offshore leasing schedule, and in 1980 OCSEAP resumed studies in the area. These studies have been primarily concerned with marine mammal, seabird, and crab populations in and around the proposed lease area.

Sale 70 was held in February 1983 but is now being litigated because the data on endangered whales reported in the FEIS for the sale do not adequately address the full range of impacts.

During 1981 OCSEAP convened the St. George Basin Synthesis Meeting. The proceedings of the meeting, published in October 1982, provide a synthesis of available data describing (1) the coastal and marine environments of the St. George Basin lease areas, and (2) environmental issues of concern and possible consequences of the proposed oil and gas development, including effects of hypothetical cases of oil spills and other pollution incidents.

Little new data will be available from OCSEAP studies for leasing decisions concerning the second (Sale 89) and third (Sale 101) offerings in the St. George Basin. During FY83 a survey of the commercial crabs in the Pribilof Islands region and aerial surveys of marine mammals will be completed. In the following year seabird distribution and use of Unimak Pass will be examined. In addition, oceanographic measurements will be taken and algorithms developed for Unimak Pass and waters south of the Alaska Peninsula where support facilities may be located.

Contaminants

Reconnaissance studies of OCS development-related contaminant distribution indicate that the ambient concentrations of these contaminants in seawater and sediments are typical of those in pristine areas. Air pollution is not considered to be a problem now or in future in this region, so no sampling to establish ambient levels of airborne pollutants has been done or is anticipated.

Geologic Hazards

OCSEAP-funded surveys conducted by the USGS in 1975-77 provided a large quantity of high-resolution seismic profiling data and sediment samples for evaluation of potential geologic hazards in the St. George Basin. The basin is bounded by growth faults. Seismic events probably occur along these boundary faults. The probability that a randomly selected site within the basin will experience ground motion in excess of 0.2 g acceleration within 40 years is 11%; for 0.5 g the probability is about 3%.

The low topographic gradient, age of sediment, lack of modern sediment deposition, sediment texture, and little reworking of sediment by bottom currents strongly suggest that the sediment in the St. George Basin is probably normally consolidated and stable as foundation material. There is substantial evidence for potential sediment instability along the continental slope from the Pribilof Canyon to Bering Canyon and for possible gas charging in deep subsurface sediments (300 m or more below the sea floor) of the St. George Basin.

Volcanic activity around the St. George Basin has also been evaluated as a potential hazard to OCS development. The probability of such activity in the Pribilof Islands is very low. On the other hand, several volcanoes of the Alaska Peninsula and the Aleutian Islands are highly likely to erupt and could cause damage to life and property.

Oceanographic and Meteorological Hazards

Sea ice will probably at least partially cover northern lease sale blocks between December and April, with the southern lease sale blocks covered only in March. Lateral forces and localized pressure from sea ice could damage ships and structures; storm waves could drive large ice floes into structures, causing suspension of operations or damage to equipment and facilities. During most months, wave heights exceeding 6 m occur more than 5% of the time near the St. George Basin.

Pollutant Transport

OCSEAP studies of the Bering Sea shelf began in March 1976 with deployments of current-meter moorings in Bristol Bay, four of them close to or within the confines of the St. George Basin. Fine-mesh CTD surveys also began in 1976 and have continued in all areas with the intent of describing the general circulation patterns which would affect the transport of spilled oil.

The St. George Basin is characterized by weak currents of 1-5 cm/s flowing toward the northwest. In the western portion of the area, over the shelf break, currents are stronger, 5-10 cm/s, but flow in the same direction. Tidal currents (M_2 tide about 20 cm/s) have great influence on mixing in this part of the Bering Sea, as they do throughout Bristol Bay, contributing approximately 90% of the total kinetic energy in the water column.

Vector mean wind speeds observed on St. Paul Island are about 1 m/s in the summer and 2.5 m/s in winter.

Full-scale oil trajectory calculations have been made from hypothetical surface launch points in the St. George Basin with a model developed by OCSEAP investigators. Model results indicate dissolved or dispersed fractions from the spills would be transported to the northwest by residual tidal currents acting alone in the first 10 m of surface. Oil slicks, which are largely a surface manifestation, will be advected downwind or eastward in summer and toward Unimak Pass and the Alaska Peninsula in the fall. During winter, slick movement would be to the west-southwest with little risk of a landfall along the Alaskan coastline.

Ice partially covers the St. George Basin on an average of 2 out of every 5 years. Studies of physical processes which may affect transport in the marginal ice zone were begun in 1980. Results of that work show the presence of baroclinic currents flowing to the northwest and are not expected to alter present conclusions as to pollutant transport on the scale length of environmental risk analyses.

In 1980 a study was begun of subsurface transport in the St. George Basin, due to concerns about the possible effects of a subsurface well blowout on crab populations. In this study the distribution of a biogenic methane source in the St. George Basin was modeled in order to quantify transport processes affecting behavior of a plume of dissolved and dispersed petroleum fractions, as would occur from an accidental subsurface release.

Living Resources

Reconnaissance-level studies on the intertidal and shallow subtidal biota of the Pribilof Islands were carried out in 1975-77 and resulted in the first algal collections made there since 1899. These data, which indicated the importance of ice scouring in limiting the richness of littoral communities, should be adequate for providing information to the EIS and final tract selection documents.

Patterns of phytoplankton and zooplankton productivity in the St. George Basin have recently received major emphasis through OCSEAP and PROBES studies, which indicate a partitioning of phytoplankton production into a detrital-based food chain in the shallower eastern portion of the area and a pelagic-based food chain in the deeper western portion. This work, in addition to OCSEAP ice-related research dating back to 1975, adequately addresses the needs of MMS for this type of information.

Since 1950 the annual harvest of northern fur seals on the Pribilofs has ranged from 20,000 to 120,000 animals. Because of the commercial use and international agreements on the management of this species, this population has received considerable research emphasis. During FY82, seasonal information about cetacean use of the St. George Basin was obtained through aerial censuses which also provided information on sea lions and other pinnipeds.

The Pribilof Islands' seabird colonies and distribution of foraging seabirds have been relatively well studied. A 1975-76 OCSEAP census of these colonies was repeated in FY82 to provide information on breeding population trends of major species. Other OCSEAP-sponsored seabird studies have examined coastal colonies and habitat use along the north side of the eastern Aleutian Islands. Seasonal data have been obtained regarding population numbers, species composition, distribution, flocking behavior, trophics, and other aspects of seabird ecology. A major remaining gap is the seasonal distribution and abundance of marine birds around Unimak Pass.

The St. George Basin supports substantial commercial fisheries for pollock, Pacific cod, Pacific Ocean perch, sablefish, halibut, herring, king crab, Tanner crab, and several species of flounder and sole. OCSEAP research since 1975 indicates that the shelf area in the eastern portion of the basin may be the most important portion of the shelf as far as the recruitment of commercial species is concerned. Seasonal migration of commercial stocks also appears to be an important determinant in understanding the susceptibility of these populations to marine pollution. At present, a large, relatively adequate data base (for EIS purposes) on the distribution of adults of major species exists. Information on the development and distribution of pre-recruit fish and shellfish is incomplete. During FY82 a report of existing information on commercial crabs, emphasizing early life stages, in the southeastern Bering Sea was completed. This work and synthesis discussions identified a major information gap regarding blue king and Korean hair crabs around the Pribilof Islands. Both populations are centered around the Pribilof Islands and are being studied during FY83.

North Aleutian Basin (Sale 92)

A lease sale for outer Bristol Bay (Sale 51) was originally scheduled for December 1977, but was deleted from the schedule in March 1977. In a schedule issued in June 1979, a North Aleutian Shelf sale (Sale 75) was proposed for April 1983. Revision of this schedule delayed the sale to October 1983, and in March 1982 Sale 75 was cancelled. In the July 1982 OCS planning schedule, Bristol Bay was again proposed for oil and gas leasing, this time as the North Aleutian Basin, Sale 92.

The original Bristol Bay sale area encompassed virtually the entire bay from Unimak Pass to Cape Newenham, covering roughly 12 million ha. The proposed North Aleutian Shelf lease area was much smaller and was located in the southwestern portion of Bristol Bay between Unimak Pass and Cape Newenham. The current schedule restores the Bristol Bay sale area to its originally proposed (Sale 51) size.

Major leasing decision points for the North Aleutian Basin (Sale 92) include:

Call for Information	8/83
DEIS	7/84
Public Hearing	9/84
FEIS	12/84
State Comments	2/85
Sale	4/85

Resource estimates were developed by the U.S. Geological Survey for the former Sale 75 area. Although the North Aleutian Basin planning area encompasses a larger area, these estimates are still worth consideration, as geological information suggests oil and gas would probably be present in the western portion of the basin. The estimates are:

	MAXIMUM (5%)	MEAN	MINIMUM (95%)
Oil, billion barrels	2.3	0.7	0.1
Gas, trillion cubic feet	5.8	1.5	0.1

During August 1982 a COST well was spudded in the North Aleutian Basin by ARCO Alaska, Inc. The exploratory well was drilled from a semisubmersible operating in the Port Moller region.

In March 1982 OCSEAP convened a synthesis meeting on the North Aleutian Shelf lease area. The three workshops held at that meeting focused on pollutant transport processes, regional fisheries, and coastal habitats. In addition, environmental issues of concern and environmental consequences of oil and gas development, including the effects of hypothetical oil spills north and south of the Alaska Peninsula, were discussed.

Contaminants

Reconnaissance studies of OCS development-related contaminants such as petroleum hydrocarbons and heavy metals indicate that concentrations in the North Aleutian Basin are within the norms for undeveloped coastal areas.

Geologic Hazards

High-resolution geophysical surveys and detailed geological sampling were first performed in the North Aleutian Basin under OCSEAP funding in 1980. Geologic hazards to petroleum development that are related to sedimentary processes include unstable seafloor deposits, rapid erosion and deposition, and dispersion of particulate pollutants. Sediments near major faults are potentially unstable due to liquefaction induced by seismic activity, which may result in subsidence or permanent settlement of sediments.

The entire Aleutian Arc and Alaska Peninsula region can be expected to experience frequent earthquake activity. Two major offshore fault zones have been identified in the North Aleutian Basin. One area, located in the western portion of the lease area near Amak Island, includes eastward extensions of faults from the St. George Basin. A second offshore fault zone, trending north-northwest to south-southeast, has been identified in the Port Moller region. Seismicity of the North Aleutian Basin is relatively diffuse and at a much lower level than along the Aleutian shelf. Earthquakes of magnitude 7.8 could be associated with faults in North Amak Fault Zone and result in peak ground accelerations between 0.5 and 0.7 g.

Potential hazards from earthquakes include destruction or weakening of structures by ground shaking, rupturing of pipelines and storage tanks resulting in fire and pollution, and damage from tsunamis.

Volcanoes also present a potential hazard to OCS development in the North Aleutian Basin. The Alaska Peninsula contains numerous active volcanoes that are evidence of the continuous process of crustal subduction. Possible hazards are associated with directed blasts, pyroclastic flows, ash falls, lava flows, and mudslides. Immediate effects of a major eruption would probably be confined to a radius of about 24 km or less from the volcano, with two exceptions: mudflows may travel considerable distances down river valleys and ashfalls can affect vast areas.

Oceanographic and Meteorological Hazards

Storm-induced waves are potentially significant mechanisms for placing seafloor sediments in motion, by generating relatively short-lived but strong currents that could transport great quantities of resuspended sediment. Waves exceeding 6 m in height occur infrequently, less than 5% of the time.

Sea ice when coupled with extreme wave heights may pose a hazard to OCS facilities and structures. In most winters ice can be expected in the North Aleutian Basin, with March and April the months of greatest

probability and ice coverage. There is a 20% probability of 70% ice coverage in March. In heavy ice years the ice extent is at a maximum in February.

Other meteorological hazards include those associated with extreme winds and fog. Winds are considered hazardous when speeds exceed 34 kn. Winds of this magnitude probably occur less than 5% of the time during winter. Fog occurs more frequently in the North Aleutian Basin, often resulting in less than 2 nmi of visibility. This may hinder support-vessel traffic and increase conflicts between the petroleum and fishing industries.

Pollutant Transport

Oceanographic studies have been conducted by OCSEAP in the southeastern Bering Sea, including the North Aleutian Basin, since 1975. These projects have included hydrographic surveys, current-meter moorings, sediment transport studies, circulation modeling, and synthesis activities. With the exception of nearshore circulation and dynamics, the physical features influencing contaminant distribution and persistence have been fairly well described.

Circulation on the entire Bering Sea shelf is weak and variable and the same is true over the North Aleutian Basin. A long-term mean current of 2-5 cm/s occurs along the shelf north of the Alaska Peninsula; it is believed to be continuous with a weaker current past Nunivak Island. The weak northeasterly net flow is likely the result of interaction of tides with the sloping bathymetry and of baroclinic pressure gradients, which tend to follow bathymetry. Although there is a mean current northeastward, the nontidal flow can be oppositely directed due to the high variability of wind stress.

Much of the North Aleutian Basin ranges in depth from 50 to 100 m. Wind and tidal energies are sufficient to cause near-homogeneity in vertical mixing out to the 50-m isobath. Tidal currents account for almost 90% of this mixing and may be two orders of magnitude greater than the energy contained in mean velocity.

During summer, the North Aleutian Basin water is composed of three physical domains separated by frontal structures where physical property distributions show sharper gradients than elsewhere across the shelf. Inside the 50-m isobath is a coastal domain characterized by being well mixed due to the high tidal energy sufficient to overcome the stability of the pycnocline. In deeper waters there is a middle domain of sharply stratified water where a pycnocline separates two well-mixed water masses. This domain extends to about the 100-m isobath. The outer domain beyond 100-m depths is also stratified but by a broader, weaker pycnocline. Below this pycnocline lies the deep Bering Sea water. In the winter the water column in the North Aleutian Basin becomes homogeneous as cooling breaks down density stratification.

Sediment flux in these domains has also been a topic of recent OCSEAP studies. Suspended sediment data from the coastal domain indicate that

resuspension of sediment occurs due to tidal currents, and that fine-grain materials are transported offshore beyond the frontal zone forming the boundary between the coastal and middle domains. Because of the strong tidal energy, suspended particles are in a state of transit in the coastal domain and little deposition occurs. Except during extremely stormy periods, the middle and outer domains remain stratified. Surface waters in these areas have a high content of organic suspended particulate matter (SPM). Just below the pycnocline, SPM concentrations are low, increasing toward the bottom due to local resuspension of sediments. Sediment flux to the benthos has been calculated at 2-9 g/(m^2•d).

The fate of oil released into the marine environment was considered at the North Aleutian Shelf Synthesis Meeting. Time-dependent concentrations of oil in space were described for several spill scenarios using trajectory analyses and circulation, and algorithms developed by OCSEAP. Both the oil trajectory and oil weathering models have been experimentally verified.

Living Resources

Because of the biological richness and lucrative commercial fisheries of Bristol Bay this area has received much scientific attention, resulting in an extensive literature describing many biological features of the region's salmon, halibut, and crab resources. The eelgrass meadows of Izembek Lagoon, thought to be the richest in Alaska, are well studied. This area has been designated the Izembek National Wildlife Range. The bird populations residing or seasonally staging at Izembek Lagoon, especially the migratory waterfowl, have been systematically inventoried over the past 20 years. Other recent research funded by the National Science Foundation through PROBES has focused on a better understanding of the relationships between the southeastern Bering Sea environment and the productivity of walleye pollock. Biological studies sponsored by OCSEAP were initiated in 1975 and essentially completed by 1978. Due to a delayed sale date, no new field efforts under OCSEAP's biology program in the North Aleutian Basin were conducted until 1981. Since then several programs have been completed, some are continuing from FY83, and several new taxon-specific and ecosystem studies have been proposed for FY84.

OCSEAP's study program is based on three approaches yielding different levels of data resolution and detail: reconnaissance studies, taxon-specific studies, and regional ecosystem studies.

At the inception of OCSEAP, basic information on habitats and the presence, abundance, and distribution of most commercial species and other biota was sparse or unavailable. Reconnaissance studies have consisted of aerial, shipboard, and on-foot surveys, and in some cases comprehensive literature reviews. These studies have yielded coastal, littoral, and subtidal habitat characterizations; sighting records of marine mammals and haulout areas; data on regional fishery resources; documentation of seabird distribution and colonies, and shorebird distribution and abundance; estimates of naturally occurring levels of disease in marine organisms; and an index of coastal vulnerability to oil spills based on beach morphology, oil retention, and biota.

Taxon-specific studies have concentrated on population distributions and dynamics, feeding ecology, productivity, and reproductive ecology. The selected species were either of commercial, ecological, or subsistence importance; known for their high aesthetic value and potential vulnerability to environmental disturbances; or protected by legislative mandates. These species have included gray whales; spotted, ribbon, ringed, and bearded seals; walrus; sea otters; shearwaters, murres, and other seabirds; and several of the more dominant demersal fish and shellfish.

Ecosystem studies have afforded multidisciplinary approaches in describing the variables that are important in selected waters, based on the seasonal occurrence of three hydrographic fronts in the southeastern Bering Sea. Major emphasis in these studies has been on the trophic relationships and larval development of commercially or ecologically significant species of fish and shellfish. Field investigations of ichthyoplankton occurrence in the North Aleutian Basin have provided a relatively sound data base of seasonal distribution for most commercial species. PROBES work has focused on describing the pelagic components and productivity (emphasizing pollock) of the southeastern Bering Sea. Currently available data and those collected in FY81 through FY84 are to be analyzed to prepare a comprehensive understanding of the benthic ecosystem with emphasis on the valuable crab resources of this area.

Ideally, at the conclusion of the biological community and ecological process studies, and after synthesis of the resulting information into an operational computer model, simulation studies to determine effects of various stresses on the biota and ecosystem would be initiated. Simulation techniques are valuable in studying the effects of perturbations in the pelagic and benthic zones where the environment cannot be delineated or controlled for experimental manipulation in the field. Two such efforts have been completed for the Bering Sea: (1) the effects of a spill on the foraging behavior and reproductive success of nesting seabirds; and (2) studies of the dynamic interrelationships between the marine mammal, bird, and fish resources of the Bering Sea, and the influence of human activities on these resources. During FY83, small-mesh-fisheries model simulations interacting with oil-weathering model and oil-trajectory model simulations were used to evaluate the extent of oil-induced mortalities from several hypothetical spills among selected fishery resources of the North Aleutian Basin.

Gulf of Alaska

Shumagin (Sale 86)

The Shumagin planning area is back on the OCS leasing schedule after a rather long absence. In 1975 the schedule included an Aleutian Shelf sale (Sale 56) that approximated the current Shumagin OCS planning area; i.e., the shelf along the south side of the Alaska Peninsula. That sale was removed from subsequent schedules, apparently because the area was considered lacking in petroleum potential.

The current schedule lists the following milestones for the 31 million-ha planning area to be offered in Sale 86:

Call for Information	10/85
Area Identification	1/86
DEIS	9/86
Proposed Notice of Sale	2/87
State Comments	4/87
Sale	6/87

It should be noted that potential OCS activities in the Shumagin planning area are not confined to Sale 86 per se. In the event of an oil discovery in the nearby St. George or North Aleutian basins, it is conceivable that an oil transshipment facility would be built on the south side of the Alaska Peninsula. Further, oil discoveries in the northern Bering Sea could lead to tanker traffic through the Shumagin area, as the vessels likely would use Unimak Pass to reach ports on the West Coast.

OCSEAP's research efforts in the Shumagin planning area have been minimal due to the removal of Sale 56 from the lease schedule in 1977. A draft review of existing information was prepared on that portion of the gulf, but not published. Some incidental data have been collected.

Contaminants

Limited studies of organics, hydrocarbons, and toxic metals in water and sediments were conducted on the continental shelf south of the Alaska Peninsula during FY76. They indicated that existing metal and hydrocarbon concentrations were as low as in other uncontaminated open-ocean regions. Given the sparse sampling density, it is possible that locally elevated concentrations would have gone unobserved.

Geologic Hazards

The bulk of OCSEAP's efforts have been devoted to investigations of the seismicity of the western part of the Alaska Peninsula. OCSEAP furnished support for operation and upgrading of a land-based seismographic network from 1975 through 1982. Additional observations were obtained through deployments of ocean bottom seismographs. Available data were used as input to a seismic exposure model that generated predictions of ground motions associated with earthquakes. As a consequence of OCSEAP and other research activities, a reasonably good understanding of the seismotectonics of this very active region exists.

Two areas of high seismic risk have been identified: the Shumagin seismic gap and a similar feature near Unalaska. It is likely that a great earthquake will occur in the region during the lifetime of any OCS activities. In addition to the ground shaking accompanying the earthquake, it is likely

that tsunamis and seiches would be generated. The tsunami triggered by the great Alaska earthquake of 1964 was the major cause of human fatalities during that event. The nature of tsunamis is such that a large one occurring in the Shumagin area could cause significant impacts elsewhere in the northeastern Pacific.

Volcanism also poses a significant hazard in the Shumagin planning area. Activity of Pavlof Volcano has been monitored in conjunction with the seismicity investigations through a network of seismographs around the mountain.

Geologic hazards reconnaissance surveys comparable to those done elsewhere in the Gulf of Alaska for OCSEAP have yet to be done in the Shumagin area. The currently available data on locations of potentially active faults, unstable sediments, and other hazards to bottom-founded structures are sparse at best.

Oceanographic and Meteorological Hazards

OCSEAP has not yet funded directed studies of tsunamis or extreme winds and waves in the Gulf of Alaska. However, summaries of available information on waves, winds, superstructure icing, and tsunamis are available in certain reports. Due to their interests in seeing that OCS activities proceed in a safe manner, industry and the U.S. Geological Survey have sponsored investigations of extreme events in the Gulf of Alaska; the results of some of these studies are presented in the published literature and proceedings of symposia.

Pollutant Transport

A minor amount of physical oceanographic and meteorological research has been conducted by OCSEAP in the Shumagin planning area. A Gulf of Alaska climatic atlas based on available data was completed in 1976, as was a review of the physical oceanography of the gulf. They provide general information on the region. Observations within the planning unit include a couple of current meter deployments, satellite buoy trajectories, and a limited number of CTD casts. These observations were largely restricted to the continental shelf. Thus the existing western Gulf of Alaska data base is inadequate to provide a coherent seasonal picture of mesoscale circulation features. The offshore portion of the region is better known than the inshore, where circulation is thought to be more complex due to effects of bathymetry, coastal winds, and freshwater influx.

Living Resources

OCSEAP has devoted little attention to biota in this part of the gulf. Available data consist of those obtained by resource management agencies and, in the case of OCSEAP studies, information generated through the conduct of broad-scale, regional investigations.

A limited amount of sampling along the Alaska Peninsula during a 1975 cruise formed the basis of an initial characterization of marine microbes in the waters and sediments of the Shumagin planning area; species composition, petroleum degradation potential, and heterotrophic potential have been examined.

A review and analysis of phytoplankton and primary productivity data collected through about 1974 provides a qualitative description of annual and geographic variations in community structure and other biological parameters in eastern subarctic waters, including the Shumagin planning area. As with the phytoplankton, OCSEAP has not sponsored any field studies of zoo- or meroplankton in the area. However, results of such work off Kodiak should provide at least a first-order approximation of the likely characteristics of these communities.

The littoral habitats in the Shumagin area were mapped from an aircraft in 1975-76; however, no field sampling was conducted. The nearest available data is likely that obtained during OCSEAP surveys in the Kodiak area.

Knowledge of the invertebrate benthos comes mainly from Russian research, which was confined mainly to the outer shelf, and exploratory fishery surveys and fisheries resource assessment cruises in the Shumagin area. The domestic data is of limited utility since it was obtained mainly by trawls, which do not sample small biota or infauna effectively. Also, the data are typically recorded in terms of major taxonomic groups rather than by species.

The fisheries resource information base in the Shumagin area is relatively good and current as a consequence of the intensive fisheries for crabs, salmon, and various groundfish pursued there. Even in this case, though, there are deficiencies. Little is known about the life history stages of most species prior to the time they are recruited into the fisheries. OCSEAP sponsored reviews of available information on salmon, nonsalmonid pelagic fishes, and demersal fishes which offer a perspective on the status of knowledge of some of the more common and commercially important species as of about 1976.

Marine birds have received some study in the Shumagin planning area. Some 4.5 million seabirds nest there, and millions of nonbreeding seabirds, shorebirds, and waterfowl are seasonally abundant. Coastal bird habitats have been mapped. Seabird colonies have been cataloged and breeding productivity of several species studied at colonies on the Shumagin Islands, Semidi Islands, and Ugaiushak Island. Gulf-wide seabird surveys provide some information on seasonal pelagic seabird distributions and abundances. Finally, trophics investigations elsewhere in the Gulf of Alaska provide basic information about the food habits of many of the species present in the Shumagin planning area.

Harbor seals, Steller sea lions, sea otters, Dall porpoises, and harbor porpoises are among the more common resident marine mammals in the Shumagin region. Fur seals and gray whales are seasonally abundant while migrating through the area. Numerous other mammals occur there, including minke, killer, fin, and humpback whales. The bulk of the data on marine mammals

in the region comes from opportunistic observations. Little in the way of systematic investigation has been done. Records of marine mammal sightings through 1981 have been compiled by the Platforms of Opportunity Program. Some shipboard transect data were obtained in the Shumagin area during a gulf-wide cetacean habitat use survey in 1980. Long-term investigations of harbor seals and Steller sea lions were conducted primarily further east, but they do provide a large body of useful information on life histories, population characteristics, food habits, and other biological parameters applicable to the Shumagin region. This information has been summarized in OCSEAP final reports. An annotated bibliography on marine mammal literature available up to 1979 has been prepared. Its scope of coverage is Alaska-wide. Repeated gray whale observations at Unimak Pass offer considerable information on population size and migration timing. In summary, a relatively complete picture of occurrence of marine mammals in the Shumagin planning area is at hand. Information on pinniped haulouts and rookeries is fairly good. Relatively little is known about the current population size and distribution of sea otters. Essentially no quantitative data are available on cetaceans.

Kodiak (Sale 99)

The first lease sale planned for the Kodiak area was OCS Sale 46, which was to be held in December 1980. The sale was cancelled in 1980 and replaced by Sale 61, scheduled for April 1983. Sale 61 was taken off the schedule in 1981. The Kodiak region is again on the leasing schedule in the form of Sale 99, encompassing a planning area of 23 million ha. The events leading to Sale 99 are planned as follows:

Call for Information	2/85
Area Identification	5/85
FEIS	1/86
Proposed Notice of Sale	6/86
State Comments	8/86
Sale	10/86

OCSEAP has acquired a fairly comprehensive environmental data base for the Kodiak region, largely as a consequence of the controversial nature of the oil and gas development issues there and cancellation or delays of proposed sales. However, as with the adjacent Gulf of Alaska-Cook Inlet planning area, the geographic disposition of data is heavily biased toward the continental shelf portion of the area.

Contaminants

Limited studies on hydrocarbon and trace metal concentrations in seawater, sediment, and biota have been conducted in the Kodiak area. The data show generally very low concentrations with only modest areal variability. So

far there is no evidence to suggest that low molecular weight hydrocarbons in the region originate from petroleum seepage. It is recognized that any significant external inputs of hydrocarbons or toxic metals can be detected against current ambient concentrations.

No air contaminant studies have been carried out in this area.

Geologic Hazards

Seismic monitoring and geological field studies conducted in the Kodiak region from 1975 to 1982 provide a characterization of seismic activity patterns and locations of surface faults, gas-charged sediments, potentially unstable volcanic ash deposits, and surficial sediment distributions. The results of most aspects of the geohazards research have been reported and synthesized. The results of the initial application of the Gulf of Alaska seismic exposure model developed for OCSEAP are also available. Final reports are still forthcoming on geotechnical properties of surficial sediments and selected seismicity investigations.

Oceanographic and Meteorological Hazards

The status of oceanographic and meteorological hazards studies for the Kodiak area is comparable to that described for the Shumagin planning area.

Pollutant Transport

OCSEAP-sponsored physical oceanographic and meteorological studies over the Kodiak shelf began in 1974 and were completed in 1981. Data acquisition and synthesis modes included literature reviews, Lagrangian and Eulerian current measurements, CTD casts, remote sensing, computer pollutant transport models, and coastal meteorology studies. As a consequence of this work, a relatively good mesoscale picture of regional circulation patterns and their associated driving processes has been developed.

Much of the data and information has been presented in synthetic overviews which suggest that the capability now exists to generate good probabilistic predictions of pollutant transport on a seasonal basis, but not on an instantaneous basis. Oil spill fate has been addressed in a site-specific manner via mapping of coastal oil spill vulnerability of the Kodiak Archipelago, and in a generic manner as discussed below for the Gulf of Alaska-Cook Inlet OCS planning area.

Living Resources

The biotic richness and productivity of the Kodiak region, as well as the importance of its commercial fisheries, prompted the large number of biological investigations sponsored by OCSEAP between 1975 and 1981. Three generic approaches were employed: reconnaissance studies, taxon-specific studies, and community studies.

Reconnaissance studies have included surveys of littoral and sublittoral habitats, pelagic seabirds and marine mammals, and seabird colonies and pinniped rookeries. Taxon-specific studies have emphasized population distributions and dynamics, feeding ecology, productivity, and reproductive phenology of selected species of commercial, ecological, or mandated importance. Community studies allowed a multidisciplinary approach to describe the biotic entities, community structure, and interrelations that are of importance in nearshore waters of the Kodiak Archipelago. Community studies focused on several east-side bays and the biota using them, principally seabirds and commercially important species of fish and shellfish. Major emphasis was placed on trophic dynamics, larval distributions and development, habitat use, and biotic associations.

Gulf of Alaska-Cook Inlet (Sale 88)

The huge, 46-million-ha Gulf of Alaska-Cook Inlet OCS planning area has had a checkered history of leasing activity. Numerous changes of lease sale schedules and lease area boundaries have occurred. Six federal sales have been held, but no commercial gas or oil discoveries have been made.

The northeastern Gulf of Alaska was the initial focus of activity, with a call for nominations in 1968 for Sale 39. This sale was scheduled for 1974 but was not held at that time. After a second call for nominations, Sale 39 occurred in April 1976. Eleven dry holes were drilled on the 76 tracts leased before industry departed in mid-1978. Federal OCS activities in lower Cook Inlet followed a similar course. Sale CI occurred in October 1977, with 87 tracts leased. Subsequent exploration through 1980 uncovered no commercial finds on the 10 tracts drilled. The next area leased was the eastern Gulf of Alaska, where Sale 55 occurred in October 1980. A moderate amount of interest was reflected in the bidding, which was concentrated off Yakutat and resulted in thirty-five tracts leased. Exploratory drilling began there in April 1983. Sale 60, held in 1981, consisted of tracts in lower Cook Inlet not previously leased, plus new tracts in Shelikof Strait. The sale evoked only a minor amount of bidding activity, with 13 tracts leased. Exploratory drilling on tracts in that area began in early 1983. Bidding activity in subsequent reofferings in the Sale 55 and Sale 60 areas was disappointing; one tract was leased off Yakutat, none in Cook Inlet or Shelikof Strait.

The proposed leasing schedule for Sale 88 is as follows:

Call for Information	2/83
Area Identification	5/83
DEIS	1/84
Proposed Notice of Sale	3/84
State Comments	8/84
Sale	10/84

Within the Gulf of Alaska-Cook Inlet planning area the environmental data base for leasing decisions is very uneven in coverage, due to the concentration of past research efforts in prior sale areas. Thus the available information for the northeastern Gulf of Alaska and lower Cook Inlet is relatively complete, that for the Yakutat and Shelikof Strait regions fair, while in the remainder of the planning unit it ranges from sparse to nonexistent. Very little research has been conducted, for example, in the deep waters off the continental shelf. Considerable information exists on southeast Alaska, but it is scattered and not currently in a format readily amenable to the types of assessments conducted by MMS. The deficiencies in the information base for Sale 88 may be more apparent than real, however, as it seems likely that any bidding activity would be concentrated in the Tertiary sedimentary province located along the periphery of the gulf and in Cook Inlet; i.e., in the relatively well-known portions of the planning area.

Much of the existing information is summarized in a series of synthesis reports prepared for earlier lease sales in lower Cook Inlet, the northeastern gulf, and the eastern gulf.

Contaminants

Reconnaissance studies of petroleum hydrocarbons and heavy metals have been conducted in the northeastern Gulf of Alaska, Shelikof Strait, and lower Cook Inlet. Ambient levels of these contaminants in water, biota, and sediments were low and typical of those in pristine areas. Investigations in the area of oil and gas production in upper Cook Inlet indicated the presence of somewhat elevated concentrations of petrogenic hydrocarbons in the water column and sediments; however, even these concentrations were not very high. Based on these observations, it is assumed that, with perhaps some localized exceptions, ambient concentrations of contaminants elsewhere in the Sale 88 region are likewise low.

Geologic Hazards

Considerable effort was placed on geologic hazards investigations in the Sale 88 area between 1975 and 1982. The area of coverage includes essentially all of lower Cook Inlet, Shelikof Strait, and the continental shelf eastward to Cross Sound. OCSEAP helped support a regional seismograph network and funded a series of geological reconnaissance surveys that included seismic profiling and sediment sampling. The objectives of these studies were to monitor seismic activity, identify active faults, and map and characterize areas of unstable sediments. A limited number of geotechnical measurements of surficial sediments were made. OCSEAP also funded a study to develop and apply a seismic exposure model to the Gulf of Alaska region. The model has the capability to employ subjective and historical data to calculate and map ground motion parameters. Finally, studies were conducted of active volcanoes in the Cook Inlet-Shelikof Strait region. Thus a fairly complete reconnaissance-level characterization of geologic hazards is available for the shallow portions of the Sale 88 area northwest

of Cross Sound. Relatively little has been done in continental slope and deep-water areas or in southeast Alaska.

Oceanographic and Meteorological Hazards

The information base on oceanographic and meteorological hazards for this planning area is comparable to that described for the Shumagin area.

Pollutant Transport and Fate

Physical oceanographic and meteorological investigations were conducted from 1974 to 1981 in the Gulf of Alaska-Cook Inlet planning area in response to information needs for the various OCS sales that have occurred. A fairly complete mesoscale characterization of currents and the processes driving them in the area is now available. No OCSEAP physical oceanographic investigations have been conducted south of Cross Sound; however, data available from other sources should allow at least a conceptual overview of the regional oceanography of southeast Alaska. Any further physical oceanographic study in the planning area likely will be in response to more localized information needs, as exemplified by the coastal oceanography study conducted near Yakutat in 1980-81.

Several investigations of pollutant fate have been conducted in the area. These include the generation of coastal vulnerability maps for the entire coastline extending from Shelikof Strait through Cook Inlet and eastward along the Kenai Peninsula and outer part of Prince William Sound to Cape Fairweather. The maps provide information on potential spilled oil longevity and, for some areas, the resources at risk. Other oil-related fate studies include a major modeling and experimental investigation of oil weathering under subarctic conditions, part of which has been conducted at Kasitsna Bay in lower Cook Inlet; and studies of the potential for suspended materials to adsorb, transport, and deposit oil. Some work was also directed towards the fates of drilling muds and cuttings, and trace metals.

Living Resources

Biological investigations of the Gulf of Alaska-Cook Inlet planning area have consisted of literature surveys, reconnaissance surveys, species-specific studies, and trophics- or habitat-oriented surveys. Major multi-year efforts during the period 1974-81 included seabird colony inventories and productivity surveys; seabird trophics studies; mapping of coastal bird habitats; pelagic seabird and marine mammal surveys; studies of the population dynamics, life history, and ecology of Steller sea lions and harbor seals; surveys of benthic, intertidal, and subtidal biota; analyses of existing data on salmon and other pelagic fish, shellfish, and groundfish, as well as some limited fisheries survey effort (mainly in lower Cook Inlet); and examinations of marine microbes. Relatively limited efforts included phyto-, mero-, and zooplankton surveys; sea otter censuses; razor clam surveys; a coral review; and marine mammal pathology and disease investigations.

The above investigations provide reconnaissance-level data on distributions and abundances of dominant biota in shallower portions of the planning unit and more detailed information for selected species. Trophic interactions are also fairly well known for the more common vertebrate consumers, including several seabird species, harbor seals, sea lions, and several commercially important fish and shellfish species. Habitats important to populations of birds, mammals, fish, benthos, and macrophytes have been identified in certain parts of the planning area, most notably lower Cook Inlet and, to a lesser degree, coastal segments of the eastern Gulf of Alaska.

Non-Site-Specific Information

Oil Weathering

Oil weathering studies have been concerned with the partitioning of pollutants between the air, sea surface, water column, and sea bottom through time and under various environmental conditions. A reiterative model-building approach using experimentally derived data has resulted in an open-ocean evaporation, dissolution, and dispersion model. The model incorporates concepts of interfacial mass transfer, considerations of both mechanically well-stirred and stagnant oil phases, the effects of slick spreading, and the boundary conditions imposed on the oil by the environment. The output consists of timed predictions of (1) the mass of oil remaining in the slick, (2) the chemical composition and physical properties of the slick, and (3) the concentrations of specific compounds in the air and water column in contact with the slick or other spilled oil phase. The results of this model are in good agreement with the results of oil weathering experiments conducted at Kasitsna Bay Laboratory, Kachemak Bay, under ambient subarctic conditions.

Effects

Laboratory Studies

Due to permitting regulations and logistical and design complexities in conducting experimental oil spills, a large portion of research on effects is conducted in the laboratory. The results of this research are applicable to most of the Alaska OCS areas.

Early OCSEAP studies were concerned primarily with the acute lethality of spilled petroleum. The acute toxicity (LC_{50}) of several crude oils and their components has been determined for a large assortment of subarctic and arctic marine invertebrates and vertebrates. The three major conclusions from this massive research effort are as follows. First, Alaskan marine species may be slightly more sensitive than similar species residing in more temperate regions. However, factors other than animal sensitivity *per se*--habitat, experimental temperatures, and the physiological and nutritional condition of the animals--all influence survival rates. Second,

larval stages of marine species are generally more sensitive to oil than adults. Increased larval sensitivity may be a reflection of increased surface to volume ratio or the higher metabolic rates associated with rapid growth. It has been suggested that the prolonged larval stages of cold water species may make them more vulnerable to pollutants than warm water species. Third, intertidal species are usually more tolerant of oil exposure than sublittoral species, presumably because of their greater ability to temporarily isolate themselves from the environment during stressful situations. The general impoverishment of the intertidal biota due to ice scour in the arctic and subarctic raises the possibility of an apparent enhancement in the overall sensitivity of the benthic community as a whole.

It has become apparent that, with the exception of a catastrophic spill, the most likely effects from spilled petroleum will be at the sublethal level. That is, the pollutant would interfere with one or more biochemical, physiological, and behavioral processes in such a manner as to impair the impacted organism's ability to function and reproduce normally, without actually killing it. Most biological processes can be altered by oil exposure, provided the concentration is high enough or the duration long enough. However, it is of little significance merely to demonstrate a biological response without considering questions such as: "Are the test pollutant concentrations those that may occur during an oil spill?" and "Are the observed effects likely to have direct, ecologically significant consequences?"

OCSEAP has investigated effects on avoidance, predation efficiencies, feeding rates, thermal regulation, growth, and fecundity of selected species exposed to sublethal hydrocarbon concentrations. The results of these studies, while indicating effects by petroleum in the range of concentrations that could result from a spill, are extremely difficult to use in predicting ecological significance. This is largely a consequence of the multitude of ways an organism could be impacted and a lack of detailed information about the ecological role of the species studied.

Field Studies

Investigations of petroleum hydrocarbon effects on carbon and nitrogen fixation, denitrification, and microbial productivity have been conducted in lower Cook Inlet and Shelikof Strait. Field studies on effects of petroleum on gull and kittiwake egg hatching success and sea otter thermal regulation were carried out in the northeastern Gulf of Alaska. Some work on the effects of aircraft disturbance on harbor seal productivity was done at Tugidak Island.

Quality Assurance

The ongoing OCSEAP analytical quality assurance program has resulted in a decline in interlaboratory hydrocarbon measurement variations from orders of magnitude to a factor of 2. This research unit has contributed to a growing confidence in analytical results.

RESEARCH PLANNED FOR FY84

Arctic Ocean

Diapir Field (Sales 87 and 97)

As noted previously, the research proposed for FY84 will come too late for use in the Sale 87 DEIS (input into which was due by March 1983), but not for Sale 97.

OCSEAP has funded several sea ice research units (Figure 2), three of which will continue in FY84. RU 88 will prepare a final report summarizing several years of research on profiles of multiyear-ice ridges. RU 205 will continue field studies of ice gouging with emphasis on the deeper parts of the Chukchi and Beaufort seas. RU 267 will continue to archive and disseminate satellite imagery describing ice motion events. Investigation into the mechanical properties of multiyear-ice ridges and ice islands remains an outstanding research need.

Meteorological and oceanographic hazards, usually equated with great waves, high winds, and icing conditions, have not and will not be addressed by any specific studies. Because of the ubiquitous presence of pack ice in the Beaufort Sea, the fetch required to generate great waves is usually not available, and hazards from wave-generated forces are never likely to approach the forces from the ice itself. Studies of storm surge (RU 627), although generally applicable to the Beaufort Sea, will be concentrated in Norton Sound and the Chukchi Sea.

Mesoscale forecasting of risk from oil spills in the presence of ice can now be modeled by RU 435, for which all needed data are believed available. As a result, no mesoscale studies of transport processes are planned in the Beaufort Sea, although large-scale ice movements in response to winds will be described by RU 519 and RU 267 using satellite imagery. These data will be used in ongoing comparisons between model performance and real-world events related to oil spill trajectories.

Because large amounts of sediment are annually carried into the Beaufort Sea by North Slope rivers, and because these sediments have a known affinity for hydrocarbons, PU 4004 will develop a model to predict the transport and deposition of oil and associated SPM at a selected location in the Beaufort Sea. RU 640 will study the weathering of spilled oil in ice-covered waters.

No research units concerned with nonendangered species of birds will be funded in FY84. Endangered Peregrine Falcons will be surveyed as part of PU 4013.

Research on nonendangered marine mammals in the Arctic Ocean will be limited to RU 232 and RU 636. Working in identified areas of pupping concentrations, RU 232 will focus on determining the relative abundance of seals, the timing of pupping, reproductive success, and responses to seismic activity. RU 636 will concentrate on the specific effects of on-ice, industrially generated sound spectra on ringed seals. Both RU 232 and RU 636 will concentrate their activities in the Barrow Arch. Minimal work will be done in the Diapir Field.

Subsistence fishing is an important component of the traditional arctic lifestyle. Previous literature reviews (RU 348) and abundance studies (RU's 233, 631) have surveyed Beaufort Sea fish resources. More recent work by RU 467 has concentrated on the response of Arctic cisco to environmental perturbations. No further research on subsistence and commercial fisheries in the Diapir Field is planned for FY84.

Several large-scale or long-term ecosystem studies have been completed in the Diapir Field, including studies of Simpson Lagoon, Stefansson Sound, and Beaufort Lagoon. If a monitoring program is recommended by the upcoming Beaufort Sea Monitoring Workshop (September 1983), PU 4017 will initiate the field program.

Research on endangered species in both the Beaufort and Chukchi seas is being coordinated by DOI and NMFS. Bowhead whales are a major focus of these investigations. DOI aerial surveys are being used to define bowhead distribution, migratory routes, and feeding areas. Population estimates of 3,400-4,300 bowheads have been derived from a combination of counts at ice camps and aerial surveys. The ice camp work is now being conducted by the Alaska Eskimo Whaling Commission under contract from NMFS. DOI is also directing a study on the reactions of bowheads to industrial noise, aircraft, and vessel traffic; and, in conjunction with USGS, is monitoring bowhead response to vessels conducting seismic operations during the fall. In addition, DOI has sponsored investigations on effects of oil on the filtering efficiency of baleen. Although OCSEAP will not conduct research directly dealing with endangered whales in FY84, PU 4016 will study the effects of oil on euphausiids, an important food resource for bowheads.

Barrow Arch (Sales 85 and 109)

A significant percentage of OCSEAP research in the Barrow Arch (Chukchi Sea) first took place in FY83. This was done in order to provide strong input to the DEIS for Sale 85. Research in FY84 will come too late for Sale 85 but will be used to prepare for Sale 109.

Ice hazards along the Chukchi Sea coast are in many respects even more severe than along the Beaufort Sea coast. The narrowness of the shorefast ice zone, for instance, limits the area of relatively "safe" ice over which transportation can be assured. OCSEAP has funded several sea ice research units, many of which have been active in the Chukchi Sea (Figure 2). In FY84 the same three research units described for the Diapir Field (RU's 88, 205, 267) will also be active in the Barrow Arch lease area.

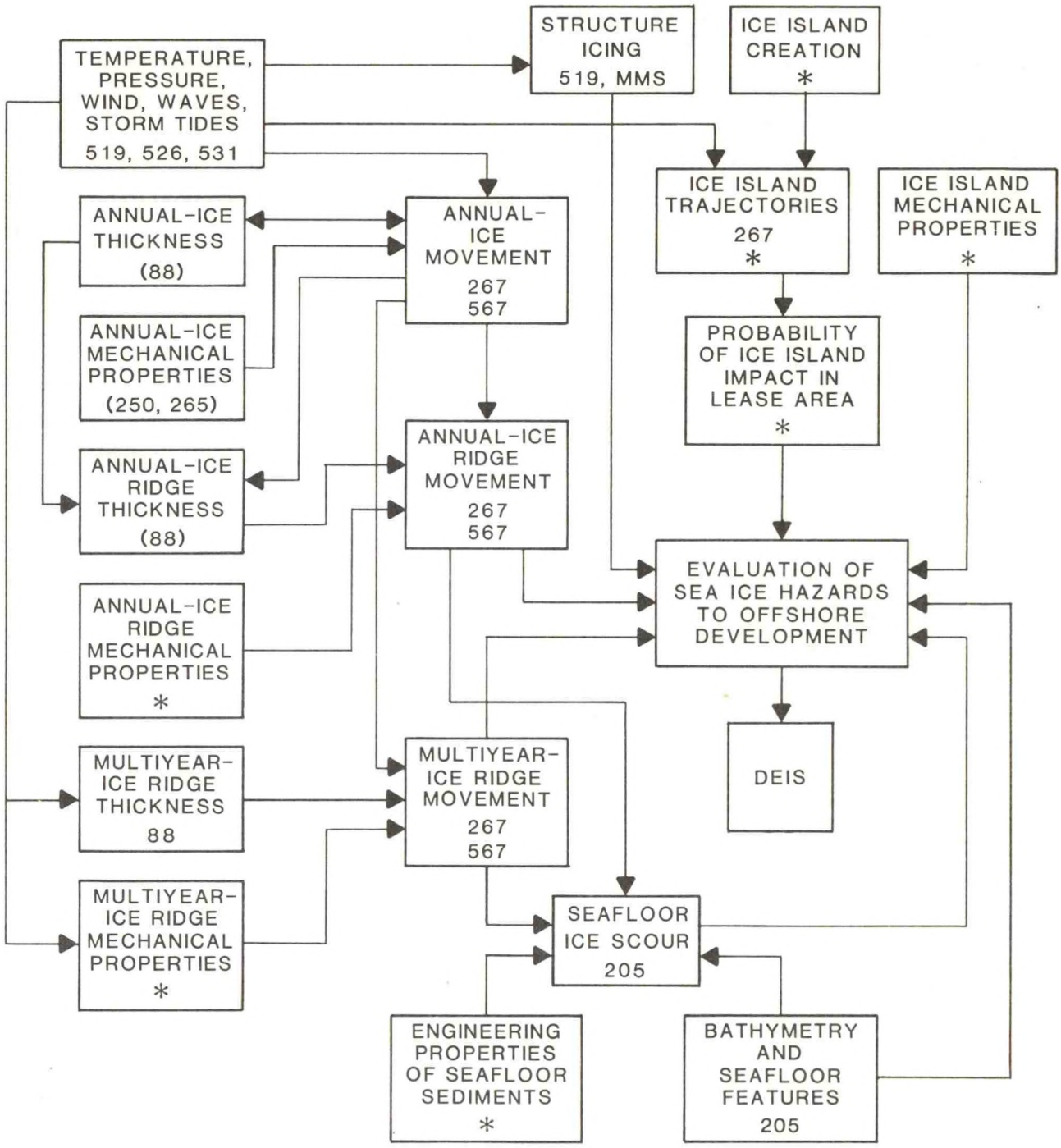


Figure 2.--OCSEAP Research on Ice Hazards.

Research unit numbers in parentheses indicate completion in FY83 or earlier; asterisk indicates areas where research is needed.

Hazards resulting from meteorological or oceanographic processes will not be directly addressed in FY84. The rationale is that structures which are built to withstand ice forces will be little affected by high waves, currents, or winds in open water. RU 519, however, will analyze drift buoy data from the Chukchi Sea to determine the relationship between synoptic winds and ice motion. It will also support the second phase of RU 641 (Peard Bay); develop a model to determine the effects of headlands on coastal winds; and provide statistics to RU's 267 and 627 to test cause and effect relationships between wind fields, observed ice motions, and storm surge. Oceanographic studies in the Chukchi Sea will also include the final reporting of results from the nearshore research undertaken in FY83 by RU 646.

All physical oceanographic and meteorologic data necessary to predict oil spill trajectories for risk assessment are available. Much of the data needed to describe weathering and behavior of spills are also available. Relevant data from the Bering Sea Surf Zone Smear Model (PU 4003), the Suspended Particulate Matter Distribution and Transport Study (PU 4004), and the Oil Weathering Model (RU 640), will provide other data needed to describe the transport, partitioning, and weathering of spilled oil in the Chukchi Sea.

As part of a long-term monitoring study of marine bird populations, the Cape Lisburne colony is being censused every other year. This colony is not scheduled for censusing again until FY85.

Two marine mammal studies will concentrate their activities in the Chukchi Sea: RU's 232 and 636. These projects will study aspects of ringed seal ecology and the effects of on-ice seismic exploration upon the seals during FY84. RU 232 will determine relative abundance of seals, timing of pupping, reproductive success, and responses to seismic activity. RU 636 is an acoustic study which will determine the types of sound spectra generated by on-ice seismic activity. Both studies will be closely coordinated. Information obtained from these projects should be of use by agencies which are responsible for writing restrictions and stipulations concerning on-ice activities.

Available data indicate that population densities of commercially valuable fish resources in the northern Chukchi Sea are low, but subsistence fishing, especially for salmon, whitefish, and smelt, is important to residents of villages along the coast. During FY83, seasonal movements, habitat dependence, and overwintering distributions of nearshore species were surveyed by RU 635. A final report by this project is due in FY84. The Peard Bay ecosystem study (RU 641), also begun in FY83, will continue in FY84. The fisheries component of this study will describe the timing and nature of lagoon use by anadromous and other fish species. It will also study feeding patterns and trophic relationships. Both RU 635 and RU 641 will include fish overwintering research. Fish overwintering habitat has long been a key issue in assessing the possible effects of Arctic OCS development.

The primary goals of the Peard Bay ecosystem study (RU 641) are to determine the ecological processes that structure biological use of Peard Bay

and to contrast the results with those of similar studies recently completed in the Beaufort Sea. Peard Bay was chosen because of the wide diversity of organisms using the bay and because it has been pinpointed as a probable area for construction of onshore facilities for OCS development. In FY84 the Peard Bay study will concentrate on describing the progression of ecological events that occur during the breakup period in the spring and on collecting a second year of open-water data. This study will continue to be supported by RU 519.

Bering Sea

Norton Basin (Sale 100)

Previous studies of geologic hazards in Norton Basin (Norton Sound) focused on the identification and description of geologic features and processes, including sediment transport and potential instabilities. These projects are now complete.

Ice hazard studies in Norton Sound are essentially extensions of studies conducted primarily in the Chukchi and Beaufort seas. In the Bering Sea, the planned studies are designed to provide additional data on the regional extent of the seasonal ice cover and the relationship between ice motion and wind fields (RU 267 and a new RU 519). Morphology of sea ice and the analyses of the severity of ice pile-ups along the coastline will be provided by RU 88 in a final report.

All studies of pollutant transport processes which are specific to Norton Sound proper are complete; however, more site-specific studies are planned for the Yukon Delta. There, the process of transport by storm surges will be investigated by RU 627 and transport by tidal and estuarine circulation processes will be investigated by RU 519, RU 435, and PU 4011.

The Yukon Delta lies very close to mean sea level and therefore is highly subject to storm surges, which are environmental hazards as well as mechanisms for transporting spilled oil into key habitats. The storm surge model previously used for the Chukchi and Beaufort seas will have been reconfigured for Norton Sound in FY83 and will be used to determine currents and surface water transport associated with storm surge. Estimates will be made of the probability of occurrence of storm surges of given heights and directions.

The protection of regional biota and habitats critical to their maintenance and welfare has been a major environmental issue addressed by OCSEAP. Most OCSEAP-sponsored studies on the biota have been completed. During FY83 a literature review (RU 647) was funded by OCSEAP to describe the current status of knowledge concerning the ecological processes of the Yukon River Delta. This region has been identified as a major use area for numerous wildlife and may be important to their continued survival. This is especially true for certain species of waterfowl and intermingling stocks of juvenile salmonids that are apparently present in great abundance in

summer months in the clearwater bands located between Yukon River distributaries. During FY84 the ecology of the nearshore waters of the Yukon Delta will be studied to better understand this region's vulnerability to planned OCS development in Norton Sound (PU 4011).

Navarin Basin (Sales 83 and 107)

Geological reconnaissance for hazards in the Navarin Basin was completed in FY82 following a DOI policy decision to discontinue such efforts.

Continued ice hazards studies are planned for FY84 to analyze data on the location of seasonal ice cover and significant movements of large ice floes related to local winds (RU 267 and RU 519).

Satellite imagery will be examined by RU 267 for significant large-scale ice motions and compared to wind fields provided by RU 519. The results will be examined for departures from free drift conditions, such as when floes impinge on islands or a convergence in the wind field causes compressive forces which result in ridge building. The opposite case, where divergence of the wind field causes leads to open, as has been hypothesized to occur in the Navarin Basin, is of special interest to studies of whale migration.

There is no pollutant transport fieldwork planned for the Navarin Basin. The existing circulation model and oil trajectory model are fully capable of addressing issues and anticipated questions relevant to impact assessment. Oil spill trajectories will be provided for the Navarin Basin Sale 107 DEIS by RU 435.

No biological studies will be conducted in the Navarin Basin in FY84. Ongoing work was concluded in FY83.

St. George Basin (Sales 70, 89, and 101)

Because of its regional tectonic setting and geographic location, seismic and sea ice hazards are not considered a major concern in the St. George Basin lease area. Seismic monitoring along a network of upgraded stations in the Alaska Peninsula-Bristol Bay-Pribilof Islands region was completed in FY82. No further geohazards work is proposed for this region as a result of policy decisions made by the DOI.

Since 1975, OCSEAP, PROBES, and other research programs have contributed substantially towards achieving a comprehensive understanding of the shelf circulation in the Bering Sea. Oceanographic data from these programs contained sufficient resolution and detail to allow prediction of oil spill trajectories at the sea surface from specified launch points within the lease area (RU 435). Combined research and synthesis efforts in FY82 and FY83 (RU's 435 and 597) adequately describe pollutant transport and dispersion within the water column (Figure 3).

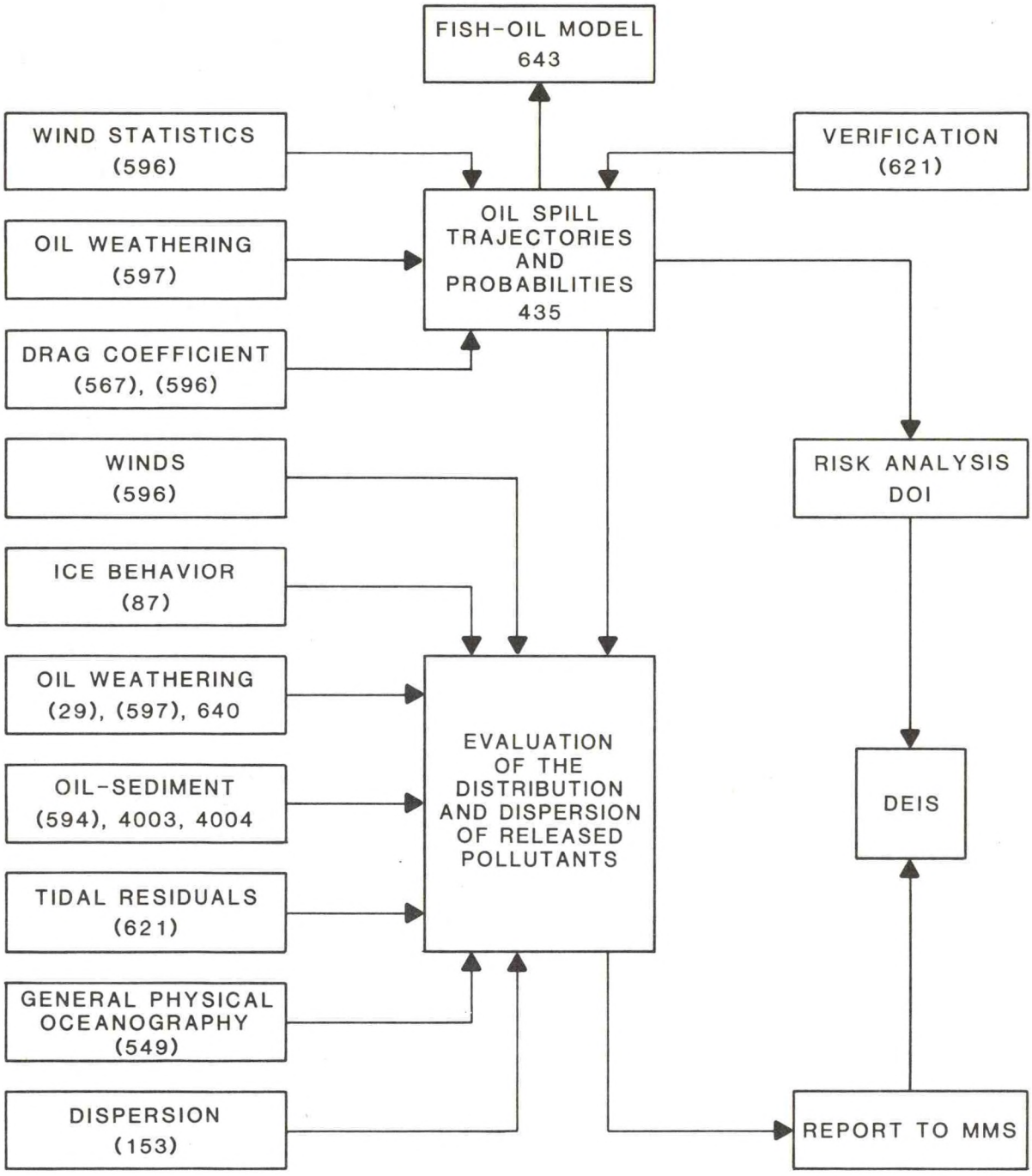


Figure 3.--OCSEAP Research on Pollutant Transport in Subarctic OCS Planning Areas.

Research unit numbers in parentheses indicate completion in FY83 or earlier.

Biological resource inventories and population studies on certain bird and mammal species were conducted earlier when the St. George Basin was offered as Lease Sale 45. A modest research effort to recensus seabirds nesting on the Pribilofs, initially censused during the 1975-76 field season, was conducted in FY82 to provide more current information on population trends. A similar census will be conducted in FY84 (PU 4009).

OCSEAP studies of the fishery resources of the Bering Sea have entailed literature reviews, broad-scale reconnaissance surveys, topical or species-specific research, and ecosystem characterization and modeling (Figure 4). In partial response to needs for energy development and management requirements for international and developing U.S. fisheries, OCSEAP and NMFS conducted a multi-vessel survey of the demersal resources of the southeastern Bering Sea beginning in 1975. This survey provided much information on the distribution, abundance, and stock conditions of principal commercial species and provided a baseline from which real or potential impacts to fisheries could be evaluated. With the passage of 200-mile extended jurisdiction in 1976, NMFS has fully or partially occupied the original sampling grid on an annual basis since the 1975 survey. The information gained by these surveys, as well as the historical reviews, has been used to develop a large-scale simulation technique describing fluctuations of Bering Sea populations in space and time and how they respond to changing fisheries policy, shifts in predation, and potential environmental perturbations.

OCSEAP reconnaissance, syntheses, and modeling efforts have led to the identification of many research needs regarding these populations and associated biophysical processes most vulnerable or at risk from offshore oil and gas development in or around major fishing areas in the southeastern Bering Sea. Recently completed PROBES work in the southeastern Bering Sea has provided a significant amount of new data and information on the regional physical oceanography, lower trophic level productivities, and early stages of pollock development that are applicable to OCSEAP.

Recent OCSEAP work has focused on the benthic ecosystem of the southeastern Bering Sea. Besides supporting extremely lucrative king and Tanner crab fisheries, the benthic environment is noted for its retention of petroleum hydrocarbons from oil spills and chronic discharges in higher concentrations and for greater periods of time than the pelagic environment. Seven projects were recommended for funding by OCSEAP in FY81 as part of an integrated study of the coastal waters north of the Alaska Peninsula. The study was designed to use all pertinent data and examine the physical components of transport and weathering of oil from a surface slick to the bottom, its degradation there, detrital sinking rates, benthic community structure and its productivity, and other functional elements of this environment that lead to its high yield of commercially valuable shellfish. Of those studies, only one directly related to the crab resources was initiated in FY81 and continued in FY82. This project examined the density distributions of decapod larvae in the southeastern Bering Sea (RU 609).

Discussions held at the St. George Basin Synthesis Meeting, April 1981, emphasized the need for information concerning crab populations near the Pribilof Islands. Blue king and Korean hair crabs were identified as being

potentially vulnerable to spilled oil, particularly if it were to impact these species at times when pelagic larvae or rapidly metamorphosing juveniles were abundant. During FY83 OCSEAP sponsored a survey (RU 638) to provide data on the distribution and abundance of early life stages of these species around the Pribilof Islands. Because most of the other commercial species that regularly occur in regions planned for OCS leasing in the St. George Basin are widely dispersed in the southeastern Bering Sea, and given the relatively rapid dissipation of toxic fractions of oil released in deep waters, these populations will probably not be imperiled in the event of offshore oil and gas development in this area. No further fisheries studies are being proposed for the St. George Basin in FY84.

North Aleutian Basin (Sale 92)

Seismic and sea ice hazards are not considered a major concern in the North Aleutian Basin lease area because of its regional tectonic setting and geographic location. Seismic monitoring along a network of upgraded stations in the Alaska Peninsula-Bristol Bay-Pribilof Islands region was completed in FY82, as was geohazards reconnaissance. No further geohazards work is proposed for this region as a result of policy decisions made by MMS.

Since 1975, OCSEAP, PROBES, and other research programs have contributed substantially to achieving a comprehensive understanding of the shelf circulation in the Bering Sea. Oceanographic data from these programs contained sufficient resolution and detail to allow prediction of oil spill trajectories at the sea surface from specified launch points within the lease area (RU 435).

Open-ocean pollutant transport and dispersion within the water column can be estimated by RU 435 with data from RU 597. During FY83, the oil spill trajectory model (RU 435) was modified to provide for modeling of transport of pollutants in three dimensions, as well as to enable it to perform on the scale of site-specific studies.

Planning for a proposed ecosystem study along the North Aleutian Shelf may require study of diffusive and advective processes to account for hypothesized distributions of marine organisms and commercial resources. The proposed approach is to assume that transport can be modeled as a steady-state system with parameters determined from existing field data such as the North Aleutian Shelf Transport Experiment completed in 1982, supplemented by data from the circulation model. Some additional field data may be needed, but requirements will not be known until more planning is accomplished.

The rich commercial fishery resources of the North Aleutian Basin have been the focus of several OCSEAP investigations (Figure 4), and of state, other federal, and university studies. The non-OCSEAP investigations have been primarily concerned with predicting harvestable quantities of salmon and crabs. More recently, as an outcome of extended jurisdiction legislation, the population health and composition of major demersal species have been studied. PROBES work in the southeastern Bering Sea has provided much new

information regarding the presence of oceanographic fronts and their influence on the partitioning of shelf waters into pelagic and benthic ecosystems. Recognizing a need for more information on the benthic environment in Bristol Bay, OCSEAP initiated several projects in the nearshore waters of the north side of the Alaska Peninsula. As mentioned previously in regard to the St. George Basin, this work was primarily concerned with providing a better understanding of the ecological processes responsible for the high benthic productivity of the area as evidenced by the abundance of king crab there. An initial study (RU 609) provided a status of knowledge on the decapod resources of the region, and by sorting existing and opportunistically obtained samples partially described larval king and Tanner crab distribution and abundance in the cancelled North Aleutian Shelf Sale 75 area. During FY82 the feeding ecologies of juveniles of both species were examined by RU 624. Seasonal information was obtained by this study and prey items in crab stomachs were identified and described through immunological assays and other more traditional food habit analyses. This study, in conjunction with another (RU 623) examining the relationship between sea otter distribution and benthic community structure, provided partial insight into the benthic biomass and overall carrying capacity of the region. These studies were completed in FY83.

During FY83 OCSEAP initiated a systematic survey (RU 639) of the phenology of king crab larvae and the distribution and abundance of juveniles in the North Aleutian Basin. Also during FY83, existing modeling capabilities at the NMFS Northwest and Alaska Fisheries Center were modified to run simulations quantifying oil-induced losses from several sizes of spills to selected fishery resources in nearshore waters between Port Moller and Cape Newenham (RU 643); this work will continue in FY84.

In FY84 OCSEAP will continue to focus its research emphasis on nearshore surveys. Oil releases in shallow-water regimes are thought to be of greater biological consequence than equivalent spills under open ocean conditions. This is due to the greater exposure concentrations of toxic fractions in shallow waters for longer periods of time. In addition, the nearshore waters of the North Aleutian Basin, inside the 50-m isobath, contain the major nursery grounds for many commercially valuable species and are a major migratory corridor for sea-bound salmonids. These waters are also important to the reproduction of forage species such as herring, capelin, and sandlance. Although their importance has been recognized, few data are available for any species in this region. During FY84 nearshore patterns of fish occurrence and habitat use will be examined by PU 4010. The causes of nearshore enrichment will be studied by PU 4001.

Gulf of Alaska

Shumagin (Sale 86)

The Gulf of Alaska synthesis (PU 3013) will largely meet information needs for the preparation of the Shumagin DEIS. However, existing physical oceanographic data are inadequate to serve as input to the planned oil

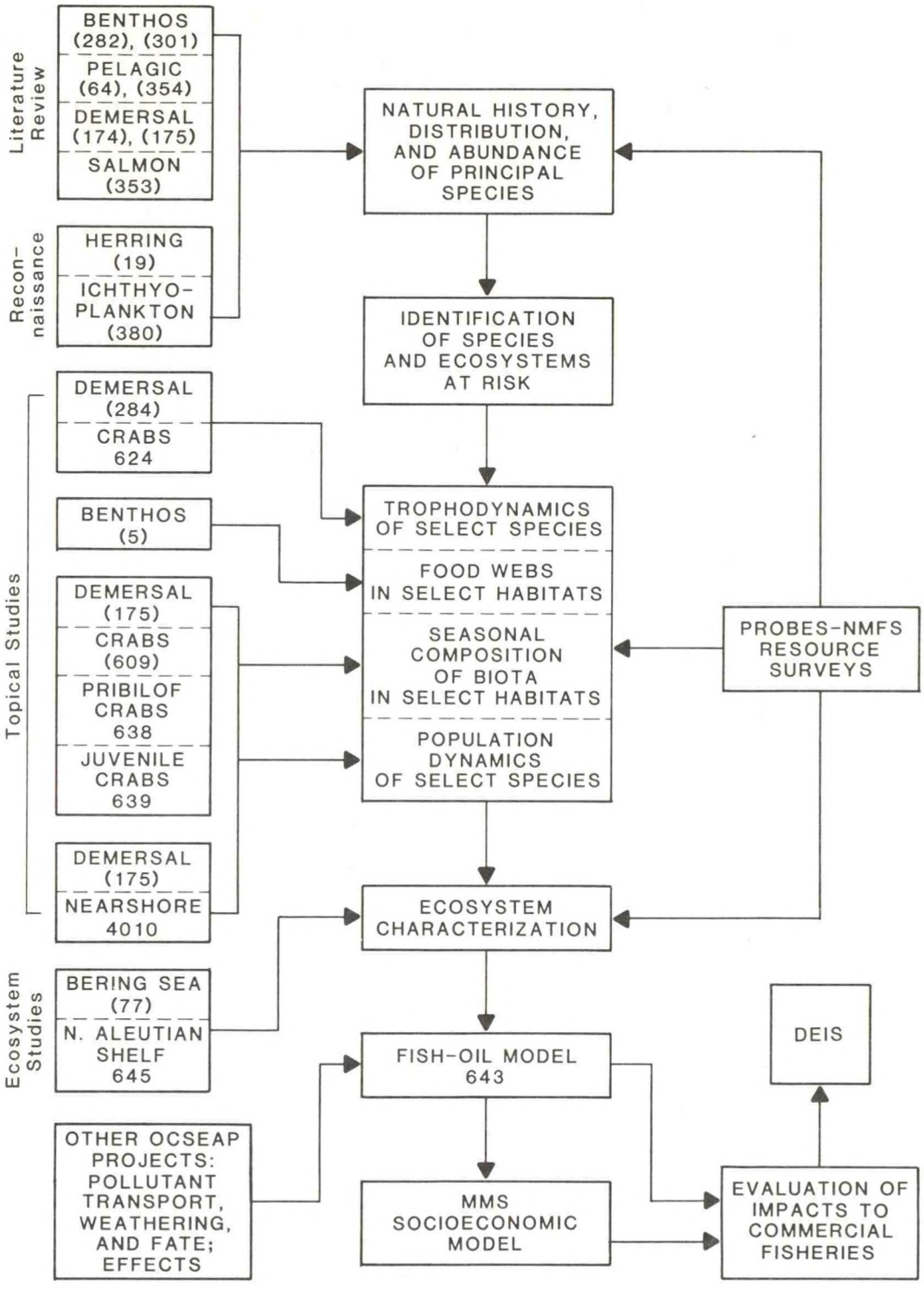


Figure 4.--OCSEAP Research on Fishery Resources of the Southeastern Bering Sea.

Research unit numbers in parentheses indicate completion in FY83 or earlier.

spill trajectory modeling for the DEIS. This deficiency will be remedied in FY84 through the collection of the necessary model input and verification data by PU 4000. Furthermore, the oil-weathering model (RU 435) will be reconfigured in FY84 to encompass the northern Gulf of Alaska. These activities will set the stage for model runs in FY85.

Kodiak (Sale 99)

A large amount of environmental data is available for the Kodiak OCS planning area. The geographic scope of the Gulf of Alaska synthesis (PU 3013) will include the Kodiak region. No other studies are planned for FY84.

Gulf of Alaska-Cook Inlet (Sale 88)

The lack of commercial oil and gas discoveries in the Gulf of Alaska OCS and program funding constraints dictate a minimal level of research in this area. However, as noted earlier, a considerable amount of research has been conducted in the Gulf of Alaska and Cook Inlet in response to prior OCS lease sales. OCSEAP's FY84 effort will be to synthesize the available data and information in order to provide a comprehensive overview of the biophysical features of the entire Gulf of Alaska (PU 3013). This approach is viewed as the most cost-effective and efficient means of addressing Sale 88 information needs.

Non-Site-Specific Research

Oil Weathering

Oil weathering processes are altered when the oil is incorporated into ice rather than released into the open ocean. Algorithms describing the weathering of oil in annual ice have been developed. During FY84 algorithms describing the weathering of oil in multi-year ice and pressure ridges will be developed (RU 640) and incorporated into a general predictive model for the weathering of oil in ice.

Suspended particulate material can scavenge petroleum hydrocarbons from the water column, thereby altering the vertical and horizontal transport of spilled oil. Quantification of the hydrocarbons scavenged depends on information concerning the size and composition of the suspended particulate material. These data are extremely site specific. The approach to the problem of the interaction and transport of oil by and with suspended material, therefore, is to develop a general mathematical model (PU 4004) capable of predicting the oil loading capabilities of a range of suspended material, and then to use this model to determine the transport of oil through a surf zone and along the beach (PU 4003).

Effects

Laboratory Studies

Laboratory effects studies will consist of the lethal and sublethal effects of oil on euphausiids (PU 4016) and herring (PU 4015). Euphausiids and herring were chosen as the subjects of effects research because the euphausiids are a principal food item of the bowhead whale, and herring also because they may be especially vulnerable to oil pollution due to their mating and spawning in intertidal areas. This study is designed to determine the effects of oil on reproductive behavior, fertility, and larval survival.

Field Studies

Laboratory studies often have little relation to the "real world" as the result of a mix of ecological and environmental factors. For this reason, field studies are required for an accurate assessment of pollution effects. The Baffin Island Oil Spill (BIOS) project (RU 606) is a long-term international field experiment being conducted in the Canadian arctic. This experiment will contribute both oil weathering and effects data.

Quality Assurance

Quality assurance is an ongoing problem. RU 557 will continue to distribute reference sediments to investigators interested in intercalibration both within and outside OCSEAP and MMS, and during FY84 will conduct an interlaboratory experiment with the objective of reducing variation in hydrocarbon analysis to less than 100%.

DATA MANAGEMENT AND SYNTHESIS

Management of Scientific Data

Historically, OCSEAP has devoted continuous effort to the management of the data collected by its investigators. The guiding philosophy has been that the information was collected at great expense, would be difficult or impossible to replace, and should be accessible to the scientific community both now and in the future. As a result of these efforts, information produced by OCSEAP dominates the Alaskan data base for several disciplines.

This scientific information takes several forms: digital and analog data, narrative reports, remote sensing imagery, and biological specimens. Digital data provide the most readily available and easily manipulated data base. The data are formatted, quality controlled, and ultimately archived for future use. During 1984, OCSEAP investigators will collect information in the following file types:

DATA	NODC FILE TYPE
Eulerian Current	015
Pressure Gauge	017
Salinity, Temperature, Depth	022
Marine Specimen	025
Phytoplankton Species	028
Primary Production	029
Bird Specimen and Feeding	031
Bird Sightings	033
Wind	101
Fisheries Resources	123
Zooplankton	124
Mammal Sighting and Census	127
Benthic Organisms	132
Marine Bird Colony	135

Narrative reports in standard formats include explanation of techniques, procedures, and protocols used by the investigators, and frequently present data in visual form such as maps, graphs, tables, and charts. These documents provide interpretations and analyses which are a necessary program product. User access to these publications is facilitated by the computerized OCSEAP Bibliography.

Analog data, collected principally by geological and geophysical research, is archived by the National Geophysical Data Center in Boulder, Colorado.

Remote sensing imagery, principally from satellite-borne sensors, is archived by the Geophysical Institute of the University of Alaska in Fairbanks and made available to OCSEAP investigators.

Voucher specimens of biological samples are archived at the California Academy of Sciences in San Francisco.

Although the OCSEAP data base lacks sufficient detail in some areas and disciplines to meet program objectives applicable to the Alaska Outer Continental Shelf, a capability now exists for displaying digital data in products which are directly usable for decisionmaking purposes. These data products, first produced in 1982, continue to evolve in response to MMS needs, and will be prepared on a schedule to support synthesis meetings and DEIS preparations. Examples of these products include:

MARINE BIRDS

- Sighting effort plots and tables
- Species summaries
- Graduated symbol plots
- Star diagram plots
- Seasonal statistical analyses
- Digital density plots
- Density histograms

MARINE MAMMALS

- Sighting effort plots and tables
- Species summaries
- Graduated symbol plots

HYDROCARBONS

- Concentration plots and tables
- Station position plots
- Concentration summary tables

TRACE ELEMENTS (10 metals)

- Total concentration plots and tables
- Station position plots and tables

PHYSICAL OCEANOGRAPHY

- Trajectories
- Current vectors
- Water quality distributions

Synthesis

The goal of OCSEAP's synthesis and data evaluation efforts is to organize and present the scientific information in a manner, format, and timing that is most useful to decisionmakers. The results and major findings of OCSEAP research are gathered and disseminated in journal articles, monographs, and books. More extensive data descriptions are provided in investigators' reports and digital data products. In addition, data products are developed internally by OCSEAP for DOI's use. Synthesis of data is typically accomplished by organizing and reviewing all existing understanding of the marine and coastal environments of the region and highlighting special program accomplishments, potential problems due to OCS development, and deficiencies in the data base for consideration by DOI.

OCSEAP synthesis meetings are interdisciplinary and address environmental issues and resource use conflicts which have arisen in a planned oil and gas lease area. OCSEAP investigators, other scientists, OCSEAP and DOI management personnel, and representatives from the State of Alaska, other federal agencies, petroleum industry, local residents, and various interest groups attend these meetings. The focal points for discussions at each synthesis meeting usually include the following:

1. Identification of unique environments.

2. Identification of key species and delineation of their habitats and migratory ranges. These species include those of commercial, subsistence, or sport value; those designated as unique, rare, or endangered; and those having preeminent and essential roles in the dynamics of a regional ecosystem.

3. Estimation of most probable oil spill trajectories and landfalls in case of accidental oil spills, and strategies for mitigation of oil spill impacts.

4. Identification, location, and severity of environmental hazards, particularly those due to sea ice.

5. Identification of short-term and long-term effects of petroleum and other substances discharged into the marine environment as a result of OCS development.

6. Environmental impacts of physical disturbance to or loss of principal habitats and migratory pathways of important biological populations.

7. Comparison of OCS development alternatives and scenarios and their relative environmental implications, only in cases where such plans are available.

8. Identification of data gaps.

Synthesis reports are based on the proceedings of the meetings and include interpretation of data by scientists and others knowledgeable about the lease areas or the environmental problems of offshore oil and gas development. These reports are organized along major environmental issues and are in a form that is relevant and readily understood by decisionmakers and management personnel. At the same time, the reports contain sufficient technical detail and scientific data to alert decisionmakers to significant problems that require special attention. Within OCSEAP, synthesis reports are the most direct avenue from scientists to decisionmakers.

During FY84, four meetings will be held in response to MMS information requirements for preparation of DEIS documents relevant to OCS lease sales. Leasing schedule milestones (as of May 1982) and potential meetings are given below:

AREA	SALE NO.	SALE DATE	DEIS	MEETING
North Aleutian Basin	92	4/85	7/84	2/84
Barrow Arch	85	2/85	5/84	11/83
Norton Basin	100	10/85	1/85	6/84
Navarin Basin	107	3/86	6/85	6/84

Given the fact that synthesis meetings have already occurred for three of the sale areas (North Aleutian Shelf, March 1982; Norton Sound, October 1980; Navarin Basin, October 1982), the FY84 meetings for those sale areas likely will differ from their predecessors. They may be more in the nature of updates involving fewer participants, more focused in breadth and subject matter coverage, and perhaps of shorter duration. Meeting structures and goals will be developed through consultation with MMS.

RELATIONSHIP BETWEEN NOAA'S TECHNICAL DEVELOPMENT PLAN AND MMS'S REGIONAL STUDIES PLAN

The Minerals Management Service's FY84 Regional Studies Plan (RSP) contains three categories of studies: MMS-administered socioeconomic studies, MMS-administered environmental studies, and environmental studies identified for implementation by OCSEAP. The research program outlined in OCSEAP's FY84 Technical Development Plan (TDP) is very consistent with the last group of studies within the limitations imposed by budgetary constraints.

Out of a total of 31 projects included in OCSEAP's FY84 program, only one is not specifically mentioned in the RSP: RU 627, Storm Surges. This study was added to the TDP after being determined important by NOAA and MMS staffs.

The storm surge model developed in 1982 and FY83 incorporated ice cover as a necessary condition in order to predict storm surge and flooding along the Arctic coast. During 1983 the model will have been used to determine the wind and pressure field configurations that result in flooding in Norton Sound and Harrison Bay. In 1984 the need exists to determine the range of meteorological conditions that result in flooding of the Yukon Delta (Objective 3 of the Regional Study Plan) in order for MMS to be able to assess the risk due to the combined occurrence of a storm tide and an oil spill. The frequency of occurrence of storm surge of a given height or more can be found by using the storm surge model to determine the bounds on location and intensity of storm centers which cause a given height of sea level and wave direction; then the data base for weather is searched for frequency of occurrence of storms within the bounds established.

Concurrently, the storm surge model will be used to verify cause and effect relationships inferred from observation in satellite imagery of major ice motions which happen to coincide with particular synoptic pressure patterns. Because the storm surge model includes the movement of ice in order to satisfactorily model propagation of long-storm waves, it becomes a tool for use wherever ice motion data in response to winds are required. Depending on the success achieved with incorporation of satisfactory constitutive laws for an ice sheet, it will also model the formation of leads under divergence of wind.

The combination of funding limitations and study priorities forced exclusion of a large number of environmental studies from the FY84 OCSEAP TDP. The RSP studies not included in the TDP are as follows:

P-unit.	Gulf of Alaska fish resources review	(Gulf of Alaska)
P-unit.	Effects of vessel traffic and aircraft on walrus	(Bering Sea)
P-unit.	Nearshore benthic community productivity	(Bering Sea)

P-unit.	Recovery potential of benthic macroinvertebrates	(Bering Sea)
RU 567.	Transport and behavior of oil spilled in and under under sea ice	(Arctic Ocean)
P-unit.	Suspended particulate matter: coastal hydrology; lagoonal and estuarine processes	(Arctic Ocean)
P-unit.	Effects of industrial noise and disturbance on reproductive physiology and behavior of pinnipeds	(generic)
P-unit.	Distribution and composition of economic, heavy minerals on the Alaskan Continental Shelf	(generic)
P-unit.	Causeway construction: impacts on marine environment	(Arctic Ocean)
P-unit.	Chukchi Sea subsistence fisheries resources	(Arctic Ocean)
P-unit.	Synthesis of information on environmental impacts of oil and gas development	(generic)
P-unit.	Effects of oil on reproductive physiology and productivity in waterfowl	(generic)
P-unit.	Monitoring petroleum accumulation in migratory seabirds	(generic)
P-unit.	Distribution of clay, silt, sand, and gravel in the Arctic	(Arctic Ocean)
PU 3001.	Mechanical properties of ice in multiyear ridges, ice islands, and ice island fragments	(Arctic Ocean)
PU 3001.	Avifauna in the Unimak Pass area	(Bering Sea)

Planning and discussion subsequent to the publication of the RSP inevitably caused modifications of some projects. Justifications for changes are outlined below.

RU 435. Circulation Models and Risk Analysis. Several deviations in emphasis have been incorporated into the RU description for Circulation and Oil Spill Risk Analysis. A major deviation from the tone of the Regional Study Plan results from recent progress in model development. Rather than ask for the design of high resolution capability, the RU description will call for the utilization of present capability to address particular questions which arise in ecological or other site-specific studies.

The RSP calls for providing a plan for using the oil spill risk analysis model in a real-time mode. As was agreed to by MMS, a meeting will be held among MMS, RU 435, potential users of the model, and OCSEAP to describe the model and how it might be utilized in real time for oil spill responses.

PU --. Oceanographic and Meteorological Measurements to Verify Circulation Model Output. All data required for initialization and verification of the circulation model for the Bering Sea and Arctic Ocean will have been acquired prior to FY84. Measurements will be made in the Shumagin and Kodiak planning areas, however, to extend the model to the western Gulf of Alaska (PU 4000).

PU 3005. Oceanographic data in support of ecosystem studies in the North Aleutian Basin and Yukon Delta will be obtained as part of PU 4001 and PU 4011, respectively. The objectives to describe and quantify the effect of sea breeze on trajectories, exchange rates and residence times, and transport of pollutant up river in the salt wedge will be accomplished by RU's 435 and 519. Fieldwork necessary to satisfactorily achieve all the objectives will be performed in 1984.

RU 567. No further efforts under this unit are planned. The study objectives in the RSP will be met by RU 519, Nearshore Meteorology; RU 267, Remote Sensing; and RU 435.

PU --. Western Gulf of Alaska Nearshore Oceanographic Processes and Pollutant Trajectories. A single P-unit was written to obtain all oceanographic and meteorological data needed to initiate and verify the model south of the Alaska Peninsula (RU 435). In accordance with discussions with MMS personnel, the oil spill trajectories will be obtained by means of the RU 435 model extended to cover the region from Dutch Harbor to Cook Inlet.

PU 4010. In the MMS FY84 TDP a study is proposed aimed at describing the seaward migration of salmon from natal streams around the Bering Sea and further describing salmonid use of lagoons and coastal waters north of the Alaska Peninsula. The cost to accomplish these objectives was estimated at $2 million. In addition to budgetary constraints, such an effort was deemed overly ambitious for one year's work, both logistically and with respect to the effort that would be necessitated in tagging and recovery programs. A smaller-scale study was subsequently recommended by both NOAA and MMS staff. This is the proposed study on habitat use by inshore species in the North Aleutian Basin.

PU 4016. The RSP calls for a major study on the toxicity of petroleum hydrocarbons to euphausiids, a major prey item of bowhead whales. The data would be used to evaluate the sublethal effects of oil on bowhead whales, through loss of prey organisms. However, toxicity data without the distribution and abundance data, cropping rates, caloric budgets of both whales and euphausiids, etc., will not allow these evaluations to be made. It was recommended that this study be cut to the determination of LC_{50} values only.

PU--. Integration of Suspended Particulate Material (SPM), Ice Freeze-up and Breakup, and SPM. The RSP identified the interactions of SPM and oil and the resultant alterations in the weathering and transport of oil as a major data gap. Discussion with MMS as to what was really needed indicated that the data on SPM composition and SPM spatial and temporal variation should be synthesized with the data on oil loading and weathering as a first step in filling the data gap.

CONTINUING AND PLANNED RESEARCH DESCRIPTIONS

CONTINUING AND PLANNED RESEARCH

Index to
Project Descriptions

Project milestones are shown in Tables 1-10, pages 145-154.

(RU 88) ICE FEATURES/ROUGHNESS

Effort by OCS Planning Area: Diapir Field 50%
Barrow Arch 50%

Schedule: October 1983 - September 1984

Performing Agency:

Agency: U. S. Army
Cold Regions Research & Engineering Lab

P.I.: Wilford F. Weeks, Ph.D.
Title: Research Glaciologist

P.I.: Austin Kovacs
Title: Research Civil Engineer

Background:

The ice hazards to offshore installations in the deeper areas of the Beaufort and Chukchi seas are predominantly multiyear ice ridges. The severity of these hazards depends primarily upon multiyear ridge thickness, velocity, and the mechanical properties of multiyear ice. Ice drift velocity is also a major factor in pollutant transport. The full thickness of multiyear ice ridges includes the ridge sail height and the ridge keel depth. Since these ridges are formed by quasi-random processes, there is a statistical distribution to be obtained. The statistics of ridge height distributions have been obtained from measurements on ridges using an airborne laser profilometer. Sail height to keel depth ratio, and keel profiles were measured in 1982 and 1983. The major tasks for FY84 are to summarize these data, compare them with data from other sources, and prepare an integrated description of multiyear ice hazards.

Objectives:

Prepare a final report summarizing all available field studies of multiyear ridge profiles, including a quantification of the relationship of sail height to keel depth, and the length, width, and thickness of multiyear ridges in the deeper waters of the Beaufort and Chukchi seas.

Methods:

Preparation of a final report on multiyear ridge profiles will require reduction of existing data and a search of other available literature and data sources.

Output:

1. Narrative Reports: A final report summarizing observations of multiyear ice ridge properties, including sail height, underwater profiles, and statistical distribution of these, for the Beaufort and Chukchi seas.

2. Digital Data: None

3. Visual Data: Graphs of statistical distributions of ice ridge heights, keel depths, and ridge and keel shapes and sizes for the Beaufort Sea.

Schedule of Deliverables:

1. Final report summarizing multiyear ice ridge observations due September 1984.

2. Participation of both principal investigators in the synthesis meeting for Sale 85, Fall 1983.

Outlook:

Preparation of the final report by this RU in FY84 will culminate several years of fieldwork and data analysis on the subject. Any additional fieldwork, i.e., to measure ice cover velocity and profile ice keel characteristics, will be planned as a separate study depending on the availability of appropriate sampling devices.

(RU 205) GEOLOGIC ENVIRONMENT OF THE ICE-COVERED BEAUFORT AND CHUKCHI SEA SHELVES

Effort by OCS Planning Area: Diapir Field 50%
Barrow Arch 50%

Schedule: October 1983 - September 1984

Performing Agency:

Agency: U.S. Geological Survey
Branch of Pacific-Arctic Branch of Marine Geology

P.I.: Peter Barnes, Ph.D.
Title: Research Geologist

P.I.: Erk Reimnitz, Ph.D.
Title: Research Geologist

P.I.: Ralph Hunter, Ph.D.
Title: Research Geologist

P.I.: Larry Phillips, Ph.D.
Title: Research Geologist

Background:

This project is studying seafloor conditions and processes which are unique to the Arctic shelf where ice plays a dominant role. The effect of ice in modifying bathymetry, shelf morphology, sediment transport, and sediment properties are investigated, using sediment sampling, coring, seismic and resistivity profiling, and diving; underwater video and still photography; side-scan sonar; and thermographic and oceanographic sensors. Field studies will include the deeper parts of both the Chukchi Sea and the Beaufort Sea in FY84.

Objectives:

The objectives are to obtain and analyze field data, and prepare summary reports, relevant to the following tasks:

1. Location of recent ice gouging, especially the maximum extent of modern ice gouging of the sea floor, including the study of concentration, depth, and directions of gouges.

2. Recent changes in bathymetry, shelf and shelf edge morphology, which may be related to shelf sediment transport by ice or other means.

3. Profiles of shallow sediment structures in selected regions, with emphasis on studies that will provide information on past history of ice involvement with the sea floor and the potential for sand and gravel resources.

4. Develop cooperative studies with Canadian geoscientists to assess similarities and differences concerning ice-seabed interactions on the American and Canadian Beaufort shelves.

Methods:

Summer ship transects in the deeper parts of the Chukchi and Beaufort seas, using side-scan sonar, seismic and resistivity profiling techniques, sediment corer and sampler, diving, underwater video and still photography, and oceanographic equipment. A change in ships from the KARLUK to a larger ship will be essential for summer work in deeper water.

Output:

1. Narrative Reports:

   a. Descriptions and comparisons of ice gouge distributions with emphasis on recurring rates of modern gouging.

   b. Discussions of profiles of shallow sediment structures and implications for transport of possible pollutants.

   c. Discussion of sediment profiles at selected locations, and implications for ice gouging depths, seafloor pipeline burial, and near-surface sand and gravel resources.

2. Digital Data: None.

3. Visual Data:

   a. Standard maps (1:250,000) of ice gouge density, directional trends, gouge depth distribution, and maximum gouge depth.

   b. Bathymetric charts.

   c. Standard maps of distribution and profile of marine sediments.

Schedule of Deliverables:

1. Annual report due April 1, 1984, will contain results of summer 1983 field season, with discussion of FY83 Beaufort and Chukchi Sea work. Annual report due April 1, 1985 will cover summer 1984 (ie., FY84) field season as described above. (It is anticipated that additional FY85 field data collection in the deeper parts of the Beaufort and Chukchi Seas will be required.)

2. A synthesis of information from this research unit as it is relevant to the decision points in the leasing process.

   Diapir Field (Sale 97): Input to the DEIS (synthesis meeting)

Barrow Arch (Sale 85, 109): Input to the DEIS (synthesis meeting)

Outlook:

Further field studies will be required in FY85 on ice gouging on the midshelf and in deeper waters.

(RU 232) MONITORING RELATIONSHIPS OF RINGED SEAL DISTRIBUTION, ABUNDANCE, AND REPRODUCTIVE SUCCESS TO GEOPHYSICAL EXPLORATION AND HABITAT CHARACTERISTICS

Effort by OCS Planning Area:

Barrow Arch	60%
Diapir Field	20%
Norton Sound	20%

Schedule: January 1984 - September 1984

Performing Agency:

Agency: Alaska Dept. of Fish & Game
P.I.: John J. Burns, M.S.
Title: Marine Mammals Studies Coordinator

Background:

Ringed seals are a circumpolar species and are the only species of pinniped to extensively utilize both the pack and fast ice in Alaska. During the winter these seals construct subnivean structures which they may use as breathing holes, resting lairs, or pupping lairs.

Aerial surveys in 1975-77 indicated that ringed seals may be displaced as a result of on-ice seismic activity. Densities of ringed seals in areas subject to seismic exploration were 12%-78% lower than in adjacent control areas. As a result of these surveys, seismic exploration on fast ice over water deeper than 18 feet was restricted to the November to March 20 period. This restriction has consistently been viewed by industry as costly and unnecessary. In 1982 the Marine Mammal Protection Act of 1972 was amended to allow the incidental take of ringed seals as a result of geophysical exploration in the Beaufort Sea.

In 1981 and 1982 this RU conducted a multifaceted field program which included aerial surveys, on-ice dog surveys, monitoring ringed seal structures from ice camps, and radio-tagging seals. Aerial surveys allowed the determination of seal density over a wide area of the Beaufort coast, while the dog surveys resulted in the location of ringed seal lairs and breathing holes in more restricted regions. Once found, these structures were classified by type (breathing hole, resting lair, pupping lair, etc.), marked, and periodically revisited to determine their fate as a result of on-ice industrial activity. Seals were radio-tagged and monitored to determine their behavioral and movement patterns.

The Beaufort study area contained a very low density of ringed seals during the winter with a higher than expected proportion of nonbreeding animals. The estimated densities of 0.36 to 0.41 seals/km^2 in the fast ice and 0.09 seals/km^2 in the pack found in 1982 were similar to those observed in previous years. The combination of a low frequency of mother-pup pairs seen on aerial surveys, few pupping lairs, and two of three animals captured being juveniles are strongly suggestive that the Beaufort overwintering population is not a major portion of the Alaskan breeding stock. Burns suggests that although ice conditions appear favorable for

use as pupping habitat and comparable to that found in regions of high ringed seal pupping activities, during the winter these seals may be food limited.

In other parts of the ringed seals' range important whelping areas are not randomly or uniformly distributed, but heavily concentrated in certain areas. In the White Sea and the Canadian Arctic pupping lairs represent 31-41% of all lairs and densities range from 1.5 to 10 pupping lairs/km^2. This contrasts strongly with conditions in the Beaufort where Burns found production very low; only 14% of the lairs are pupping lairs and these appear widely spaced (only 0.06 pupping lairs/km^2).

Monitoring of three radio-tagged seals in the study area indicated that each seal only used a single lair. Major differences were evident in the haulout patterns of each seal and between the adult and juvenile seals. The telemetered seals provide some information on the immediate responses of seals within lairs to Man's on-ice activities; e.g., in five of six cases seals departed their lairs in response to people walking on the ice within 0.5 km of the lairs.

Three factors were identfied as having an important impact on the use patterns of ringed seal lairs and breathing holes: (1) degree of disturbance caused by the investigators as they examined the structure, (2) Arctic fox, and (3) on-ice seimsic activity. Seismic activity was found to be largely a near-field effect; the fate of structures was significantly different if they were within 150 meters of a seismic line than beyond that distance or in control areas.

Given all of the above, Burns concluded "that some localized displacement of ringed seals occurs in immediate proximity to seismic lines but, overall, displacement in the Beaufort Sea resulting from this activity is insignificant (relative to the entire Alaskan ringed seal population)."

Determination of where the primary ringed seal whelping areas are and what the responses of seals are to various types of disturbance remain important unresolved questions. The 1983 fieldwork should provide significant insight into both of these.

Objectives:

1. Through field surveys, quantify density, relative abundance, and reproductive success of breeding ringed seals in the Chukchi and northern Bering seas.

2. Compare population parameters of study areas in Chukchi and northern Bering seas to areas presently or recently subject to geophysical exploration in the Beaufort Sea to determine the extent of the effects of these activities on ringed seals within these areas.

3. Compare differences in winter movement patterns and behavior in the Chukchi and northern Bering Sea with patterns observed in the Beaufort Sea.

4. Evaluate ringed seal population status on regional and site-specific basis and identify significant changes if any.

Methods:

1. Ringed seals will be censused by dog and aerial surveys. These surveys will be conducted in areas of high seal density (a) where on-ice seismic exploration is occurring and (b) in areas where no seismic exploration is occurring.

2. Seals will be captured, outfitted with radio tags, released, and monitored. Tagged animals will be monitored in regions near to and distant from on-ice seismic exploration. Such monitoring will allow determination of movement patterns, lair use patterns, and duration and extent of displacement.

3. Data will be analyzed by ANOVA, discriminant analysis, and other appropriate statistical techniques to identify differences in abundance, reproductive success, and behavior as a function of seismic activities and habitat differences.

Output:

1. Narrative Reports: The final report will discuss the four years of fieldwork on the winter ecology of ringed seals and the effects of on-ice seismic exploration on the Alaskan ringed seal population. This report will be in three parts. Part one will include a description of the data obtained by aerial and dog surveys on winter distribution of ringed seals in the Beaufort, Chukchi, and northern Bering seas, identification of important whelping areas, characterization of habitat requirements for whelping areas, and the fate of subnivean structures as a function of disturbance caused by on-ice seismic exploration. Part two will describe the data obtained from radio-tagged seals pertaining to lair use patterns, movement patterns, and behavioral responses of seals to on-ice seismic activities. Part three will include regional and seasonal differences in the responses of seals to on-ice seismic exploration and recommendations on how to monitor the effects of continuing on-ice seismic exploration and production on the Alaskan ringed seal population.

2. Digital Data: Data will be submitted in the following OCSEAP file formats: 025 (Marine Mammal Specimen) and 127 (Marine Mammal Census).

3. Visual Data: Such maps, charts, figures, tables, and photographs as necessary to describe and document the results presented in the annual report.

4. Synthesis Meetings: The PI will participate in the relevant OCSEAP synthesis meetings to be held during FY84.

Schedule of Deliverables:

1. Draft final report is due September 30, 1984 and an acceptable annual/final report is due 30 days after receipt of OCSEAP comments on the draft.

2. All digital data will be submitted by September 30, 1984.

Outlook:

This work will continue into FY85 as a monitoring effort.

(RU 267) REMOTE SENSING DATA ACQUISTION AND ANALYSIS

Effort by OCS Planning Area:

Diapir Field	33%
Barrow Arch	34%
Norton Basin	33%

Schedule: January 1984 - December 1984

Performing Agency:

Agency: University of Alaska, Geophysical Institute
P.I.: William Stringer, Ph.D.
Title: Assistant Professor of Applied Science

Background:

Satellite imagery has been evaluated on a continuing basis by RU 267 to provide data on the character and motion of ice in all lease areas affected by ice. Reports have been prepared which give the statistics of occurrence of multiyear ice in the Beaufort Sea and annual ice elsewhere. These data have been utilized when assessing hazards from ice movement and have also been used to verify transport models.

Methodologies developed to determine ice motion will now be combined with meteorological studies to establish cause and effect relationships and to predict ice movements.

Objectives:

1. Acquire, achieve, and disseminate satellite imagery which is of value to OCSEAP users.

2. Identify events of importance such as building of ridges and closing of polynyas and determine how often they recur. Correlate these with precursor meteorological events.

3. Identify and track ice island fragments.

4. Assemble a series of case histories of ice motion events correlated with meteorological events.

Methods:

Imagery will be archived as new material is acquired. OCSEAP investigators will be kept informed of accession procedures and holdings.

Images will be scrutinized for evidence of ice conditions which are relevant to each of the objectives. Sudden closing or opening of large leads or sudden advances and retreats will be catalogued and measurements taken of apparent motion.

Important ice features which meet criteria for being relatable to wind fields may be verified by aerial photography or site visits over the ice.

Important events will be described as fields of motion in a format which makes the event comparable with results found in ice motion models (RU's 627 and 435).

Output:

1. Narrative Reports:

   a. Case histories of events of major importance related to winds.

   b. Relationship between wind field configurations and notable ice movements (jointly with RU 519).

   c. Report of acquisitions to and inquiries of the archive of photos.

2. Digital Data: None.

3. Visual Data:

   a. Maps of ice velocity fields, with ridge locations and other features identified.

   b. Maps of ice island trajectories if they are found.

Schedule of Deliverables:

Reports suitable for presentation at synthesis meetings, including each of the appropriate categories of output will be provided in October 1983 and April 1984.

Outlook:

This project will continue into FY85.

(RU 435) BERING SEA-ARCTIC OCEAN CIRCULATION MODELS AND OIL SPILL RISK ANALYSIS

Effort by OCS Planning Area:

Diapir Field	9%
Barrow Arch	10%
Norton Basin	19%
Navarin Basin	19%
St. George Basin	5%
North Aleutian Basin	9%
Shumagin	10%
Kodiak	10%

Schedule: October 1983 - September 1984

Performing Agency:

Agency: Rand Corporation
P.I.: Jan Leendertse, Ph.D.
David Liu, Ph.D.

Background:

The Rand Corporation circulation model now encompasses the Bering, Beaufort, and Chukchi seas and has been used to provide general information on circulation patterns as well as data to be used in oil spill risk analysis. It has also been used in a preliminary way to show circulation in Peard Bay and Simpson Lagoon.

Analysis of risk from oil spills will be continued for each of the forthcoming leasing events. In addition, the model will be used to investigate problems in circulation which arise in ecosystem studies. The model now has capability to provide a highly magnified view of circulation within a small area within the broad area of the full model. For example, the model can be used to describe circulation in the vicinity of the Yukon River Delta in order to determine the vulnerability of the area to impact from oil spills.

At an early stage in development of the Bering-Chukchi Sea model, provisions were made to facilitate its expansion. This includes the stochastic weather sub-model which has in it the circular storm patterns of the northeast Pacific Ocean as well as those in the Bering Sea. Consequently, the model will be used to provide oil spill trajectories from spill sites south of the Alaska Peninsula which will be impacted by the transportation corridors associated with petroleum discoveries and developments in the Bering Sea. The approaches to Unimak Pass in particular have been singled out by MMS as subject to risk.

Any overland transportation across the Alaska Peninsula will result in tanker loading facilities and transportation routes through the many islands in and near the Shumagin Islands. The model, therefore, will be used in 1985 to provide data on currents on the shelf, particularly in between islands in addition to the calculation of oil spill trajectories.

Objectives:

1. Provide hypothetical oil spill trajectories for the Norton, Navarin, and North Aleutian basins. The trajectories will include ice cover as well as open-water conditions.

2. Provide preliminary data on modeled currents south of Alaska Peninsula from Kodiak Island to Unimak Pass in order to design field studies there.

3. Investigate one or more oceanographic processes which have been identified in time series data, such as the following:

   a. Long-term (several days) reversals of the currents through Bering Strait.

   b. Effect of ice cover on tidal currents.

4. Provide preliminary circulation data for embayments or coastal areas selected for site-specific study and recommend instrument deployments and studies which will provide data to improve the accuracy and resolution of oil trajectories, both surface and subsurface.

Methods:

This is a modeling study in entirety. Each phase of effort may require the general circulation model to be run under unique input conditions. In modeling the effect of meteorological events on transport, it is often sufficient to run the trajectory or response function model alone.

Output:

1. Narrative Reports:

   a. A narrative report will accompany each delivery of oil spill trajectories. The report will include a tabulation of wind statistics applicable to the lease area and a representative set of graphics of trajectories.

   b. A report will be provided which summarizes an investigation of circulation in Peard Bay by means of a circulation model. Results will be compared with field data taken in Peard Bay during the summer of 1983.

   c. A report will be provided which summarizes results of a model study of wind-driven currents and upwelling near Barter Island, together with water mass trajectories and water elevations in response to various winds. Oil spill motion relative to speed of motion of ice will be investigated under varying conditions.

d. A report will be provided which gives results of model investigations of currents near Cold Bay and a recommendation for placement of current meters for a field verification experiment (PU 4000). In the same report will be a preliminary discussion of circulation and exchange in Izembek Lagoon.

e. Boundary values will be provided for a Beach Smear Model - PU 4003.

2. Digital Data: None.

3. Visual Data:

a. Current fields.
b. Sea surface elevation fields.
c. Trajectories.

Schedule of Deliverables:

Oil Spill Trajectories for:

	North Aleutian Basin	October 1983
	Norton Basin	April 1984
	Navarin Basin	September 1984
Narrative Reports: (b), (c), and (d),	Preliminary	January 1984
	Final	September 1984

Outlook:

Modeling of circulation in Norton Basin and along the Yukon Delta, begun in FY84, will continue into 1985 for delivery prior to the Norton Basin (Sale 100) Synthesis Meeting in April 1984. Trajectory modeling will continue and final preparations will be made to model circulation and trajectories on the shelf south of the Alaska Peninsula, very early in FY86.

(RU 519) NEARSHORE AND MESOSCALE METEOROLOGY

Effort by OCS Planning Area:		
	Diapir Field	20%
	Barrow Arch	20%
	Norton Basin	20%
	Navarin Basin	20%
	St. George Basin	20%

Schedule: January 1984 - December 1984

Performing Agency:

Agency: Occidental College
P.I.: Thomas L. Kozo, Ph.D.
Title: Research Professor

Background:

A significant body of ice movement data obtained via NOAA satellite link and Project ARGOS has not been analyzed for relationship between motion and winds. These data were obtained from platforms placed on ice floes in Norton Sound and Chukchi Sea by a consortium of oil industry members and are in the public domain because the data were relayed via the NOAA satellite system. Analyses of these with other data are needed in order to increase our understanding of ice movement and for verification of constitutive laws of ice sheets.

During 1983, RU 267 will initiate a study of large-scale ice movements seen in satellite imagery, with special attention given to identification of motions which result in formation of leads and building of ridges. These motions will be correlated with concurrent and preceding wind fields provided by this (RU 519) research unit. Subsequent analyses will aim toward a conceptual model which relates wind field data to large-scale ice motion. These analyses will also be compared with ice motion observed in simulations of storm surge by RU 627.

This research unit will quantify the probable error in wind fields near a headland on the eastern Beaufort coast and will provide an algorithm for estimating the need for additional detail in wind fields near other headlands in risk analysis and real-time oil spill trajectory models.

Work was begun in FY83 to determine from historical weather data the frequency of conditions which lead to superstructure icing and the frequency of occurrence of conditions leading to extreme waves. These investigations will be continued into FY84.

Objectives:

1. Analyze drift buoy data from the Chukchi Sea for the relationship between synoptic winds and ice motion. Isolate instances of significant departure from theoretical speed and turning angle and relate those departures to some hypothetical cause. Develop a method for testing the hypotheses.

2. Working with other investigators, provide statistics on the joint occurrence of sea ice and wind fields which cause storm surge, massive ice ridging, and onshore ice pile-up.

3. Complete a model for predicting the effect of a headland on local coastal wind fields.

4. Continue investigations of the frequency of icing and extreme waves in the Navarin and St. George areas and extend the study to include the northern Bering Sea and the Chukchi Sea.

Methods:

Fieldwork in support of RU 641 will consist of placement of pressure gages and wind recorders for the duration of the winter and summer 1984 experiments.

Existing ice field (buoy) drift data and computed wind fields will be examined for sequences where the turning angle and drift speed are not according to existing theory. Satellite imagery will be examined for evidence of ice features which help explain the discrepancies. The data will also be examined for evidence of ice stresses in response to divergence of wind.

Another research unit (RU 267) will concurrently assemble case histories of ice movement events while RU 627 will have configured a storm surge model with which to test the cause and effect relationship between wind fields and observed ice motions.

An existing model for the effect of headlands on local winds will be modified and further tested against available data in order to provide a system which will be usable by management in planning the requirements for either risk analysis or real-time oil spill models.

Output:

1. Narrative Reports: Reports will be provided on the following topics:

   a. Deviation of buoy drift vectors from predictions and some hypotheses of causes including ridge building and the resultant increase in stress.

   b. Relationship between wind field configurations and notable ice movements found in satellite imagery (jointly with RU 267).

   c. The effect of headlands on coastal winds and an analysis of the deterioration of accuracy of oil spill transport prediction.

2. Digital Data: None.

3. Visual Data:

   a. Graphics showing motion of ice relative to winds.

   b. Graphics showing large-scale ice movements and features with superimposed wind.

Schedule of Deliverables:

1. Preliminary report on each of the study objectives, April 1984.
2. Final report on effect of headlands, September 1984.
3. Final report on buoys vs. wind, September 1984.
4. Synthesis report on wind fields and ice movements, December 1984.

Outlook:

This research will continue in FY85 to provide a final report.

(RU 557) QUALITY ASSURANCE PROGRAM FOR TRACE PETROLEUM COMPONENT ANALYSIS

Effort by OCS Planning Area: Non-Site Specific

Schedule: October 1, 1983 - September 30, 1984

Performing Agency:

Agency:	NOAA, National Analytical Facility
P.I.:	William D. MacLeod, Jr., Ph.D.
Title:	Manager, National Analytical Facility

Background:

Quality assurance for chemical analysis of petroleum components among DOI/OCS researchers is an objective of the DOI/OCS and OCSEA Programs. The NOAA National Analytical Facility (NAF) has conducted interlaboratory comparisons of individual hydrocarbon concentrations in reference sediments with Principal Investigators in the DOI/OCS program. Since the inception of these comparisons, each succeeding study has shown improvement over previous studies. For example, the varied and uneven responses found in the Duwamish I intercomparison were substantially corrected in the Duwamish II intercomparison through the institution of a few minimum requirements, viz., expertise with glass capillary gas chromatography $(GC)^2$ and the use of one of two published extraction methods. As a consequence, results of the Duwamish II exercise were substantially more complete and more consistent than those of the Duwamish I exercise. The third intercomparison, Sinclair I, has continued to specify the methodology in an effort to demonstrate that much of the variation in the analytical results can be eliminated. The results of this exercise are not yet available.

Necessary analytical methodology to identify and quantify polar organic compounds, which may be either components of petroleum or metabolic products produced as the result of exposure to petroleum, is being developed by this RU. Compounds labelled with tritium (^3H) or carbon-14 (^{14}C) can be used in laboratory studies but are not suitable for use in a natural environment; e.g., identifying and quantifying the metabolites in a fish exposed to an oil spill in the Bering Sea. A combination of several analytical techniques has been used by this investigation to update the metabolites from the liver of English sole exposed to No. 2 fuel oil. Four metabolites of the C_2H_5-naphthalenes, six of the C_3H_7-naphthalenes, and one each of fluorene, phenanthrene, and anthracene were characterized by GC/MS, and their concentrations were determined. Metabolic products were primarily alcohols and phenols. Previous analyses of nonradiolabeled environmental samples had not been able to identify or quantitate any metabolic products.

Objectives:

1. Coordinate and conduct an analytical quality assurance program that permits a meaningful comparison of results among investigators within OCSEAP as well as between OCSEAP and other DOI-funded investigators.

2. Develop new analytical procedures for trace polar organics derived by chemical or biochemical oxidations of petroleum components.

3. Recommend modifications to improve analytical procedures.

Methods:

1. Continue replicate analyses of interim reference materials, including tissue reference materials.

2. Explore, devise, and develop new methods for the analyses of petroleum-related polar compounds and metabolites in environmental samples.

3. Recommend these improved procedures to OCSEAP and DOI for routine use.

Output:

1. Narrative Reports: Autonomous, comprehensive reports will be provided describing the findings of the project. These reports will include the parameters measured, numbers of samples analyzed, methodology employed, improvements of or recommendations on methodology, and results from intercalibration studies with statistical evaluation of the data.

2. Digital Data: Digital data from chemical analyses will be tabulated in standard NAF format for target compounds normally reported by NAF.

3. Visual Data: Reports will be supported with charts and graphs (e.g., gas chromatograms, mass spectra) to illustrate the analyses of petroleum-related constituents in environmental samples, and the intercalibration results.

Schedule of Deliverables:

A semi-annual report will be submitted on April 1, 1983. An annual report will be submitted on October 1, 1983.

Outlook:

This is an ongoing project.

(RU 606) BAFFIN ISLAND EXPERIMENTAL OIL SPILL (BIOS) PROJECT

Effort by OCS Planning Area:

Beaufort Sea/Diapir Field	50%
Chukchi Sea/Barrow Arch	50%

Schedule: January 1984 - December 1984

Performing Agency:

Agency:	Environmental Protection Service, Canada
P.I.:	Peter J. Blackall
Title:	Coordinator for BIOS Project

Background:

The Baffin Island Oil Spill (BIOS) project is a long-term experimental oil spill, being conducted in the Canadian Arctic. The objectives of the experiment are to determine if the use of dispersants in the Arctic nearshore will reduce or increase the environmental effects of spilled oil, to assess the fate of spilled oil, and to compare the effectiveness of shoreline protection and cleanup techniques.

The project was initiated in the fall of 1979. During the first field season, 1980, baseline biological, chemical, and physical data were collected in a series of small bays at Cape Hatt on Baffin Island. These data were then utilized to select the experimental bays and as the basis of the pre-spill data set. During the 1981 field season, oil or oil mixed with dispersant (Corexit 9527) was spilled in the selected bays and two rounds of post-spill sampling (at 3 days and 3 weeks) were conducted prior to the close of the camp. Another round of post-spill sampling, at one year after the spill (1982 field season), has been conducted but the data are not available at this time. On the basis of the 1980 and 1981 pre- and post-spill data only, there were some indications of effects on a few species or groups but the marginal significance levels rendered the information doubtful. The shortness of the interval between the spills and the post-spill sampling (2-4 weeks) made it difficult to distinguish between animals that were alive or recently dead when collected. The data from the 1982 field season were taken at a significant interval (one year) and should allow the resolution of change in population and community structures.

Objectives:

The primary objectives are to be met as the result of individual but coordinated programs in chemistry, biology, and physics in conjunction with a shoreline cleanup and protection component. The objectives of these components are:

1. To assess and correlate quantitatively the various physical parameters——i.e., meteorology, oceanography, geomorphology, and ice mechanics——that would influence the fate and behavior of the spilled oil.

2. To assess the effects of nondispersed oil and dispersed oil on the macrophytic algae, the relatively immobile benthic infauna (e.g., bivalves, polychaetes), and the motile epibenthos (e.g., amphipods, urchins) in shallow Arctic waters.

3. To provide general environmental chemistry for use by the other project scientists.

4. To provide hydrocarbon analysis of water, sediment, and tissue samples collected by other project scientists.

5. To determine the impact of dispersed and nondispersed oil on microbial populations native to the water and sediments of the test area.

6. To assess the ability of the ambient microbial population to degrade both dispersed and nondispersed oil.

7. To compare the effectiveness of various cleanup and protection techniques; e.g., in situ combustion, mechanical mixing, low pressure flushing with Corexit 7664 and BP1100X, and spraying of the BP solidifier.

Methods:

The last field season will take place on Baffin Island in August and September of 1983. This field season will complete the statistical design of the experiment. The data base will consist of 1½ seasons' pre-spill data and 2½ seasons' post-spill data. The results of the 1983 field season's work will be presented in draft form at the BIOS Technical Workshop in February 1984.

Output:

Annual reports from each of the components will be submitted to the BIOS Project Office. These reports will be published by the Environmental Protection Service, Canada. Copies will also be submitted to the OCSEAP Office. At the termination of the project, a final report summarizing all findings will be submitted by each of the components, through the appropriate working committee. These reports, in addition to an executive summary of the project, will be published as a special edition of a recognized journal.

Schedule of Deliverables:

Annual reports to OCSEAP will be due September 1, 1983.

Outlook:

FY84 will be the last field season for this project.

(RU 627) STORM SURGE FREQUENCY AND MAGNITUDE

Effort by OCS Planning Area:

Barrow Arch	50%
Norton Basin	50%

Schedule: January 1984 - December 1984

Performing Agency:

Agency: Geophysical Institute, University of Alaska
P.I.: Zygmunt Kowalik, Ph.D.
Title: Research Professor

Background:

Storm surge has been identified as a hazard, generally, along arctic coasts; along the Yukon Delta it has been singled out as a phenomenon of special concern in connection with pollutant transport. A storm surge model was begun in FY82 and in 1983 will be tested against historical events in the Chukchi and Beaufort seas. Configuration of the model to include the north Bering Sea will begin in 1983 and verification of its performance on such events as the flooding of Nome will be undertaken in FY84.

Damage or environmental stress due to storm surge occurs via several mechanisms including coastal flooding, scouring due to associated strong currents, rapid ice motion and its subsequent pile-up, and the mobilization of oil by under-ice currents. This research unit will be concerned with quantifying the hazard due to coastal flooding and modeling the occurrence of extreme ice motions associated with storm centers and the resulting long water waves.

Objectives:

1. Complete verification of model results against documented storm surge events in the Beaufort and Chukchi seas.

2. Simulate the occurrence of storm surge on the Yukon Delta. Describe the characteristics of storms and storm movement which cause severe flooding.

3. Working with RU 519, estimate the recurrence rate for storms of different intensities and describe the resulting ice motions and sea-level changes near the Yukon Delta for storm waves approaching from different directions.

4. Provide storm surge model runs which simulate ice stresses caused by convergent or onshore winds. This will be done in conjunction with work by RU 267 on the statistics of ice motion and ridging observed via satellite and RU 519, Nearshore and Mesoscale Meteorology, which will provide wind field data.

Methods:

This effort is to be accomplished with a numerical model whose development was begun in 1982. That model simulates the coupling between air, ice, and water with wind as the principal energy source. Vertically integrated equations of motion are used and the ice is assumed to be either a viscous linear or viscous nonlinear layer, depending on its compactness.

Wind fields associated with historical storm surges and ice motions will be coordinated with RU 519, Nearshore and Mesoscale Meteorology, which has access to the historical data base, and with RU 267 which will provide satellite imagery to be associated with wind fields.

Output:

1. Narrative Reports:

   a. A report of storm surge off the Yukon River Delta and Norton Sound, with ice motions and current for typical directions of storm advance. Sea level heights will be shown relative to a time base to which motion of typical storms is also related. The recurrence rate of classes of storms will be discussed.

   b. A report showing preliminary results of a model which predicts ice stresses as a result of the divergence of the synoptic wind field. The report will describe the data necessary to advance to a model which predicts ridging and pile-up of ice on shore.

   c. A report which shows the verification of the model in Norton Sound.

2. Digital Data: None.

3. Visual Data. Included with narrative reports will be graphics showing height of storm surge with respect to time, and maps of surge extent. Maps will be provided on which are plotted values of ice stress as a function of wind divergence.

Schedule of Deliverables:

Report of ice motions	May 1984
Storm surge on the Yukon Delta	December 1984

Outlook:

Depending on the degree of success relating ice stresses, winds, and actual recorded ice features, this project will continue in 1985 to submit a final report.

(RU 636) DIRECT EFFECTS OF ACOUSTIC DISTURBANCE ON RINGED SEAL REPRODUCTIVE BEHAVIOR, VOCALIZATIONS, AND COMMUNICATION

Effort by OCS Planning Area:

Barrow Arch	60%
Diapir Field	20%
Norton Sound	20%

Schedule: January 1984 - December 1984

Performing Agency:

Agency: Tracor, Inc.
P.I.: Van Holliday, Ph.D.
Title: Senior Scientist

Background:

Marine mammals use sound as their primary mode of communication and perception of their environment. For communication these animals often use a narrow frequency band which is well matched to a valley in the ambient sound spectra. Detection of the environment occurs through both passive and active means: careful listening and echolocation.

One of the consequences of increased industrial activity in the ocean is an increase in the number and variety of new sources to the ambient sound spectra. Important man-made contributors to the ambient sound are vessels, aircraft, and seismic operations. Heavy equipment operating onshore and on the ice can also be significant contributors to the ambient sound spectra, for the land and the waters are surprisingly well coupled acoustically by the shorefast ice.

The variety of sounds emitted into the water from man-made sources is great. They range from low-level sustained pure tones to extremely intense impulsive signals.

The effects of these sounds on marine mammals are not well understood. It is suspected that by masking they will tend to decrease the range over which animals may communicate and perceive their environment. In addition, some sounds at particular levels may induce behavioral changes or be injurious to the hearing organs.

Previous OCSEAP research has included measurement of sound pressure levels, spectra, and directionality of Vibroseis equipment on the ice; animal sounds (ringed seals and whales); natural ambient noise; and location of nearby sound sources utilizing a hydrophone array. While these previous studies have not been exhaustive, they do provide a reasonable baseline.

This planning unit will complement RU 232 which is also examining the effects of seismic operations on ringed seals. It is the objective of RU 232 to determine the extent of the effects and the objective of RU 636 to determine the causes of these effects. A synergistic effect is anticipated by the close coordination between RU 232 and RU 636.

During 1983 this RU conducted a 1-month field program in the Beaufort Sea where RU 232 was conducting studies of radio-tagged seals. Preliminary measurements were made of the natural and man-made sounds impinging upon a seal lair via airborne, waterborne, and iceborne avenues.

Objectives:

Determine the response of ringed seals to on-ice exploratory activities in areas of low, medium, and high pupping activities.

Methods:

1. Working in conjunction with biologists in RU 232, the lairs of seals will be instrumented with hydrophones, geophones, and microphones to determine the frequency-intensity spectra of sounds impinging on the lairs through water, ice, and air. These lairs will be located in identified pupping areas of the Chukchi Sea and Norton Sound.

2. Standard acoustical analysis techniques, e.g., oscillographic, sonographic, and real-time spectral analysis, will be used to determine the absolute intensity and frequency spectra of the recorded noises.

3. Control and exprimental conditions, e.g., actual seismic operations and playbacks with concurrent behavioral observations, will be used to determine the range of sounds which cause seals to abandon their lairs.

4. Record winter vocalizations of individual ringed seals and analyze these sounds to assess whether acoustic techniques are appropriate and cost-effective methods of monitoring ringed seals during the winter, and whether regional differences in ringed seal vocalization patterns result in differential responses to on-ice exploratory activity.

Output:

1. Narrative Reports: The annual report will describe the methods, results, and interpretation of the data. Particular attention will be given to potential regional differences in how ringed seals respond to acoustic disturbances.

2. Digital Data: None.

3. Visual Data: Such charts, maps, figures, photographs, and tables as necessary to describe and document the results will be included in the annual report.

4. Audio Data: Annotated audio tapes of representative marine mammal sounds and man-made noise sources will be submitted.

Schedule of Deliverables:

1. Annual draft report due November 1, 1984 and revised annual report due within 30 days after receipt of OCSEAP's comments on the draft.

2. Audio data to be submitted by December 31, 1984.

3. Participation in the relevant 1984 synthesis meetings will occur.

Outlook:

Continuation of this study into FY85 will depend on an assessment of the FY83 and FY84 results.

(RU 640) PREDICTIVE MODEL FOR WEATHERING OF OIL IN SEA ICE

Effort by OCS Planning Area:

Diapir Field	50%
Barrow Arch	50%

Schedule: March 1, 1984 - March 1, 1985

Performing Agency:

Agency: Science Applications, Inc.
P.I.: James R. Payne, Ph.D.
Title: Senior Chemist

Background:

Crude oil is a complex mixture of many different compounds that upon release into the marine environment becomes the subject of an equally complex and interacting series of physical and chemical processes (weathering). These processes are perceived as the factors which determine the ultimate fate of spilled oil and thereby define its impact(s) on the marine environment. Because of vigorous interest in predicting the impact(s) of spilled oil on the marine environment, these weathering processes have been defined and algorithms developed for use in the construction of a computer model describing the weathering of oil in arctic and subarctic open-water environments. However, oil weathering processes in ice-infested waters are markedly different from those in ice-free systems and one-half of the Alaskan coast is ice-infested for 6-12 months of each year.

PU 3028 was initiated in FY83 to develop algorithms describing partitioning of oil spilled under annual ice. The second year of this study will be concerned with the development of algorithms to describe the physical and chemical partitioning of oil spilled in the presence of multiyear ice, the processes whereby oil is incorporated into pressure ridges, and the weathering of oil spilled in open leads in drifting ice.

Objectives:

1. To develop algorithms describing oil and ice interactions which will be used to predict the partitioning of oil spilled in icy waters. The ice-oil interactions to be described include (a) the incorporation of oil into multi-year ice and pressure ridges and (b) floating oil in leads in the ice sheet.

2. To quantify the alterations in the structure and physical characteristics of ice both on a macroscopic and a microscopic scale, which may result from the interaction of spilled oil with ice.

Methods:

1. A reiterative model building process using experimentally-derived data will be employed. The resulting model shall be fully incorporated and accessible through the present OCSEAP oil-weathering model.

2. Optical microscopy, mesoscale tests of critical physical properties, and scenarios of possible macroscale effects resulting from the incorporation of oil into ice will be employed in achieving Objective 2.

Output:

1. Predictive model of oil (in ice) weathering: A computer-driven model which can be used to predict the physical and chemical partitioning (i.e., weathering) of oil spilled in ice-covered waters will be developed. This model will be fully integrated with the oil-weathering model developed by RU 597. A hard copy of the developed model, as well as copies of the magnetic tapes containing the model supported by an annotated account, shall be submitted at the end of the contract.

2. User's Manual: A detailed description of how to access the model will accompany the submission of the model.

3. Narrative Reports: Reports will provide detailed statements of experimental design, analytical methdology, discussion of relevant data and information from the literature, and discussion and conclusions from the results. Computer algorithms will be presented, discussed, and rationalized for each aspect of weathering under study. Possible alterations in the physical structure of the ice as the result of the incorporation of oil will be presented and discussed, and macroscale implications made.

4. Digital Data: None.

5. Visual Data: Charts and graphs illustrating (1) the interaction of oil and ice under ice, (2) the oil-weathering process, and (3) alterations in the physical characteristics of the ice will be included in the narrative reports.

Schedule of Deliverables:

A semi-annual report will be due April 1, 1984, and a final report will be due January 1, 1985.

Outlook:

This is the second year of an anticipated 2-year study of oil weathering in annual ice and multiyear ice.

(RU 641) ENVIRONMENTAL CHARACTERISTICS AND BIOLOGICAL UTILIZATION OF PEARD BAY

Effort by OCS Planning Area: Barrow Arch 80%
Diapir Field 20%

Schedule: October 1983 - May 1985

Performing Agency: To be determined.

Background:

During the summer of 1983 a major ecosystem study (RU 641, formerly PU 3026) will have been initiated in Peard Bay on the Chukchi Sea coast. The primary goals of this study are to determine the ecological processes that structure biological utilization of Peard Bay, to contrast these with results from similar studies in the Beaufort Sea, and to determine the vulnerability of Peard Bay to activities associated with oil and gas development. Fieldwork by this study is scheduled for both the open-water and winter periods.

The purpose of this second year of RU 641 is to expand upon the seasonal coverage of Peard Bay by documenting the progression of events which occur during breakup and to provide a second look at open-water phenomena. The breakup research will investigate a period which has largely been overlooked in other ecosystem studies. Preliminary work by the University of Alaska indicates that the events which occur during breakup may have a very strong influence on the patterns of primary production which are observed during the open-water season. Research during the 1984 open-water season will allow a comparison of ecological processes occurring over two different years.

Objectives:

1. Document and describe the progression of ecological events occurring during the breakup period in the spring.

2. Provide a detailed characterization of biotic events and ecological processes occurring in Peard Bay during the summer of 1984 and compare these with previously collected data from that region.

3. Describe the vulnerabilities of Peard Bay to proposed and potential OCS exploration and development strategies.

Methods:

During breakup current meters, CTD's, or other similar gear should be lowered through ice and open-water areas to determine current pattenrs, T-S profiles, and changing brine levels. Nutrient levels should also be determined.

Biotic research during breakup should utilize SCUBA, drop nets, gill nets, or other appropriate methodology to follow changes in the epontic community, plankton, and fish. Observations of migrating birds and marine mammals and their relationship to open ice areas will also be made.

Research during the open-water period will be similar to that conducted in the summer of 1983. General meteorology, oceanography, and the progression of biological events will be described.

Output:

1. Narrative Reports: The draft final report for this project will be due in May 1985. This report will include a detailed description of field and laboratory results, interpretations of data, and a discussion of possible vulnerabilities of Chukchi Sea coastal ecosystems to oil-related activities during ice-influenced periods.

2. Digital Data: Digital data will be submitted in appropriate NODC formats to be specified in consultation with the P.I.

3. Visual Data: Maps, diagrams, and charts detailing the distribution of biota and physical properites during ice-covered and breakup periods will be prepared.

Schedule of Deliverables:

1. Draft final report due May 1, 1985.

2. Participation in Barrow Arch Synthesis Meeting, which is tentatively scheduled for Fall of 1984, will be required.

Outlook:

This is the second and final year of this Chukchi Sea ecosystem study.

(RU 643) BERING SEA FISH-OIL SPILL INTERACTION MODEL

Effort by OCS Planning Area: North Aleutian Basin 100%

Schedule: October 1, 1982 - September 30, 1983

Performing Agency:

Agency: Northwest and Alaska Fisheries Center
NMFS, NOAA
Seattle, Wash.

P.I.'s: R. Marasco, Ph.D.
T. Laevastu, Ph.D.

Title: Director, REFM Div., NWAFC

Background:

Prior to offshore oil and gas development in regions of productive fisheries, it is desirable to address the biological implications of spilled oil as realistically as possible. During FY83 OCSEAP initiated a study that would use state-of-the-art modeling capabilities to quantify oil-induced losses to selected populations from several hypothetical spills. This approach has relied greatly on the existing fishery, circulation, and oil weathering models, and much cooperation between OCSEAP investigators from Rand, SAI, and NWAFC.

During FY83 hypothetical oil spill scenarios were developed for RU 643. The scenarios involve blowout and instantaneous spill conditions of Prudhoe Bay crude and diesel oil, respectively. Oil spills were hypothesized to occur nearshore in the North Aleutian Basin at three spill locations. The seasonal consequences of the oil spills are also to be evaluated in the fish-oil simulations. Oil spill characteristics are described below.

HYPOTHETICAL OIL SPILL SCENARIOS FOR RU 643

Location	Latitude (North)	Longitude (West)	Depth fm	Oil Spills, bbls	
				Blowout	Instantaneous
Port Moller	56° 20'	161° 20'	27	100,000	240,000
Port Heiden	57° 10'	159° 0'	24	100,000	240,000
Cape Newenham	58° 0'	164° 0'	24	100,000	240,000

ENVIRONMENTAL CONDITIONS USED FOR MODELING OIL SPILLS

	Wind Speed, Knots						Temperature, °C		
	Apr.-May		June-Aug.		Sept.-Oct.		Apr.-May	June-Aug.	Sept.-Oct.
	Max	Avg	Max	Avg	Max	Avg			
Port Moller	30	10	30	10	40	20	2.5	9.3	9.3
Port Heiden	30	10	30	10	40	20	2.5	9.3	9.3
Cape Newenham	30	10	30	10	40	20	2.5	9.3	9.3

Because the spatial resolution of all biological and transport components must be the same, considerable effort in FY83 was spent developing a fine-mesh simulation able to describe the plausible interactions of spilled oil with Bristol Bay fishery resources. This work has required comprehensive literature review and extensive digitalization of biological information onto a grid size approximating the actual areal contamination from several sized spills in FY83. During FY84 the fish-oil spill model will be applied to sockeye salmon, red king crab, and yellowfin sole populations of the North Aleutian Basin.

Objectives:

1. To quantify the biological losses to selected Bering Sea fishery stocks from hypothetical oil spills through application of the fish-oil interaction model.

2. To provide documentation for the development of the simulation capability including a detailed synthesis of the results with work completed under this project in FY83 and FY84.

Output:

1. Narrative Reports: Preliminary simulation results will be available in December 1983. A narrative will document the application of the fish and oil interaction model to selected fishery resources in the Bering Sea, including an overview of the model systems; detailed discussion of the model components (to include assumptions, limitations, and data requirements); rationale for selection of oil spill scenarios and candidate species; and analyses of the results of simulations.

2. Digital Data: None.

3. Visual Data: In support of the narrative reports, the fish-oil model will be accompanied by the following graphics:

   a. Charts depicting a conceptual overview of the fishery-oil spill model and schematic presentation of individual sub-program components.

b. Tables depicting model components, formulation, data requirements; spill scenarios; oil properties; life history events for candidate species; fate of spilled oil; population parameters; and mortalitiy by age and size class.

c. Figures showing study area; spill trajectories; spawning locations and distributions of various life stages; time step distributions of hydrocarbon and mortalities; impacts to candidate species and years required for recovery; projections of lost catch as fish biomass; equilibrium catch distributions by age class; and profiles for temperature, salinity, and density contours.

Schedule of Deliverables:

Simulation results will be preliminarily summarized in tabular and graphical forms as input to the SESP damage function assessment by December 1984. Detailed descriptions of methods and inputs will accompany these results. Detailed synthesis and reporting of scientific and technical results will be prepared and published as a final report in September 1984.

Outlook:

RU 643 will be completed in FY84. Field verification should occur in FY85.

(PU 3013) GULF OF ALASKA BOOK

Effort by OCS Planning Area:		
	Cook Inlet	25%
	Shumagin	25%
	Gulf of Alaska	25%
	Kodiak	25%

Schedule: October 1983 - December 1984

Performing Agency: To be determined.

Background:

The purpose of this book will be to encapsulate the results of 7 years of intense OCSEAP research into a state-of-the-art reference volume while the work is still current and fresh in the minds of Principal Investigators. During FY83 an overall editor and major authors will be chosen for the project, and the book's format will be defined. During FY84 the major work of preparing the volume will be completed. This includes preparation and submission of chapters, refereeing, editing, preparation of camera-ready copy, and publication.

Objectives and Methods:

1. Utilizing the format determined during FY83, prepare, referee, and edit all chapters to be included in the Gulf of Alaska book.

2. Prepare camera-ready copy of the volume.

3. Utilizing a yet-to-be-determined printing agency, prepare and distribute copies of the Gulf of Alaska book.

Schedule of Deliverables:

Completion of the book is scheduled for December 31, 1984. Distribution will occur soon thereafter.

Outlook:

This project is scheduled for completion during FY85.

(PU 4000) CURRENTS AND POLLUTANT TRANSPORT IN THE WESTERN GULF OF ALASKA

Effort by OCS Planning Area:

Shumagin	75%
Kodiak	25%

Schedule: January 1984 - December 1984

Performing Agency: To be determined.

Background:

Currents around the immediate (100 km) vicinity of Kodiak are well known from previous OCSEAP studies. That is not the case in the general area of the Shumagin Islands and westward to Unimak Pass, where currents are known only for isolated points among the many islands. Along the shelf break, currents have been inferred from density data and the Alaska Stream immediately southeast of the shelf break is well understood.

A southwestwardly current of unknown magnitude is believed to flow among the islands as a continuation of currents found near Kodiak. If it behaves as do currents further to the northeast, it is quite likely to be subject to reversal with winds from the southwest and to be highly variable in space and time.

Oil development on the north side of the Alaska Peninsula may involve overland transportation and a port facility on the south side of the peninsula. Oil development in the Kodiak area or Shumagin Islands would imply some degree of risk from oil spills from both platforms and transportation corridors. In all events, transportation through Unimak Pass is anticipated. For these reasons a knowledge of currents in the area is essential.

The purpose of this research unit is to fill data and information gaps in oceanography of the shelf on the south side of the Alaskan Peninsula to the degree necessary to facilitate extension of the Rand model (RU 435) to south of the Alaska Peninsula.

Objectives:

1. Review existing data on tides, currents, and density gradients from existing National Ocean Service and OCSEAP sources.

2. Place current meters and tide gauges in locations suitable for initiating and verifying the Rand circulation model.

3. Obtain wind data from locations among the islands in order to establish the sensitivity of local surface currents to winds which are orographically steered by the mountainous islands.

4. Obtain density data at the time of deployment and retrieval of instruments.

5. Provide a report giving an analysis and interpretation of all data.

Methods:

Fieldwork will be accomplished in May or June of 1984. Early starting is dictated by the need to have data available to RU 435 by December. The fieldwork will be planned so that pressure gauge data records will be at least 29 days in length.

Electromagnetic current meters will be used in order to minimize wave-induced noise in the shallowest meters. Piezoelectric pressure gauges or other suitable gauges with internal recorders will be employed at all locations. Density data will be obtained with a CTD meter. Winds will be measured by recording weather stations placed on islands by means of a helicopter.

Tidal constituents will be found from the pressure records by a method based on Schureman (1958) and Dennis and Long (1971) such as is implemented in the R2D2 system (NOAA Technical Memo ERL-PMEL 29). Current-meter data will be analyzed by methods contained in the same volume to find means and variances.

Wind and current data will be correlated and the results used to find a relationship between winds and currents which can be portrayed on a map to show typical conditions in addition to long-term means.

Output:

1. Narrative Reports: A narrative report will be provided which includes graphics and tabulations of the data obtained. The report will describe the currents inferred from historical and newly acquired data. Tidal constituents will be reported.

2. Digital Data: All current-meter, pressure gauge, CTD, and wind data will be submitted to NODC in Formats 15, 17, 22, and 101, respectively.

3. Visual Data: A map will be provided which shows the station locations with current and wind vectors showing means and variance during selected periods of record.

Schedule of Deliverables:

All processed data will be available to OCSEAP and to RU 435 by October 1984 and a final report submitted by December 1984.

Outlook:

Data analysis may continue in FY85. Final report will be submitted in FY85.

(PU 4001) NORTH ALEUTIAN BASIN COASTAL ECOSYSTEM STUDY (PHASE II)

Effort by OCS Planning Area: North Aleutian Basin 100%

Schedule: January 1984 - May 1985

Performing Agency: To be selected.

Background:

The nearshore zone (0-5 km from the coastline) of the North Aleutian Basin lease area is a region of intense biological activity. Heavily utilized as a migration corridor by gray whales and outmigrating juvenile salmon, the Unimak Pass to Cape Newenham region is also extensively foraged by sea otters, walrus, juvenile king crab, and possibly gray whales. It is further utilized as a staging or feeding area by several species of waterfowl, shorebirds, and seabirds. Molting shearwaters occur in such number that windrows of their feathers have been observed along miles of coastline during summer months.

By October 31, 1983 a literature review (RU 645) of this nearshore zone will have been completed. The objectives of this review, which constitute Phase I of PU 4001, are to:

1. Describe the current status of knowledge concerning the biotic communities and organic productivity of the nearshore zone along the entire North Aleutian Basin lease area, from Unimak Pass to Cape Newenham.

2. Describe the ecological processes which might be causing the observed distributions, densities, and interrelationships.

3. Identify significant data and information needs in order to test hypotheses describing the causes of the observed distributions of biota.

4. Discuss potential vulnerabilities of this region to impacts from offshore oil and gas development.

The purpose of Phase II of PU 4001 is to evaluate the results of Phase I and to conduct the field research to fill information needs as appropriate.

Objectives:

1. Evaluate the results of Phase I of PU 4001 and determine the necessity for further research.

2. Conduct field research to determine the causes of the biotic usage of the nearshore zone of the North Aleutian Basin and the

vulnerabilities of these populations and processes to OCS oil and gas activities.

Methods:

The methodology to be used in Phase II will be determined after a review of results of Phase I. If additional field research is undertaken, the use of ecological modeling as a tool to provide a conceptual framework for hypothesis testing is anticipated.

Output:

1. Narrative Reports:

   The draft final report for Phase I is due on or before October 31, 1983. A draft final report for Phase II, if the project is initiated, will be due May 1985. This report will enumerate the processes believed to cause the observed biotic distributions along the North Aleutian Basin nearshore zone and the apparent roles which each of them has been determined to play. The effects which proposed oil and gas development may have on these processes will also be discussed in light of research results.

2. Digital Data:

   Field data will be submitted using standard OCSEAP formats for oceanographic parameters, productivity, benthos, plankton, fish abundance, and marine mammal and bird observations.

3. Visual Data and Statistical Treatments:

   a. Maps depicting the distribution of biota along the North Aleutian Basin shelf and through time will be updated as Phase II research results are made available.

   b. Statistical treatments will include figures and tables showing regression correlations or multiple factor ANOVA to illustrate significant relationships between seasonal and spatial distributions of nearshore biota and the apparent causes for organic enrichment of their environment.

Schedule of Deliverables:

1. If initiated, fieldwork will occur during the spring, summer, and fall of 1984. A draft final report detailing the results of this work will be due May 31, 1985.

2. Participation in synthesis meetings will be required.

Outlook:

Depending on the results of the 1984 field season, a second year of fieldwork may be undertaken in 1985 to substantiate conclusions drawn from that work.

(PU 4003) SURF ZONE SMEAR MODEL

Effort by OCS Planning Area: North Aleutian Shelf 100%

Schedule: January 1984 - December 1984

Performing Agency: To be determined.

Background:

As spilled oil approaches the shoreline, it becomes subject to the mixing action of the surf zone and alongshore as well as onshore transport. The magnitude and interaction of these processes determine the deposition of the oil. Oil, incorporated in large amounts directly into the sediments as a result of the intense mixing of oil and water by winds and turbulent tidal currents in shallow areas, may be extremely long-lived. For example, the break-up of the supertanker Amoco Cadiz in March 1978 off the coast of Brittany coincided with the annual rebuilding phase of the beaches. The result was the scavenging of oil droplets and mousse by sand, followed by transport and burial on the beaches. This buried oil still persists in layers which have migrated downward within the beach sediments and stabilized at or near the water table.

Objectives:

1. Determine the total and directional mixing energy(ies) of the nearshore turbulent (surf) zone.

2. Develop a mathematical model which describes and quantifies the partitioning and transport of oil in turbulent nearshore areas (surf zones).

Methods:

1. Determine seasonal wave heights (H, $H_{1/3}$, $H_{1/10}$) and their recurrence, wave periods, and onshore wave directions under various appropriate meteorological conditions.

2. Calculate water volumes transported onshore and correlate this volume with the wave heights of nearshore breakers.

3. Using beach face slope, wave height, wave period, and volume of the mixing zone, calculate total energy of the mixing zone.

4. Develop algorithms describing the above relationships which can be used in conjunction with data from (a) the oil-weathering model re: characteristics of subject oil, and (b) the coastal oceanography study re: volume and direction of alongshore currents, to estimate a mass balance of transported oil in nearshore areas.

Output:

1. Mathematical Model: A computer-driven model which can be used to estimate a mass balance for the transport of oil into and along a turbulent nearshore will be developed. A hard copy of the model, as well as copies of the magnetic tapes containing the model, supported by an annotated account, will be submitted at the end of the contract.

2. Narrative Reports: All reports will be comprehensive and autonomous. The final report will provide detailed statements of analytical methdology, discussion of relevant data and information from the literature, and discussion and conclusions from the results. Computer algorithms will be presented, discussed, and rationalized.

3. Digital Data: None.

4. Visual Data: Charts and graphs illustrating the onshore and alongshore transport of material will be included in the narrative reports to support the results and conclusions.

Schedule of Deliverables:

Semi-annual and annual reports will be due 6 months and 12 months, respectively, after the award of the contract. A comprehensive report and the model will be due at the termination of the contract.

Outlook:

This is anticipated to be a 2-year study. Additional field measurements and simulation modeling might be required in FY85.

(PU 4004) INTEGRATION OF SUSPENDED PARTICULATE MATTER DISTRIBUTION AND TRANSPORT STUDIES

Effort by OCS Planning Area:		
	Diapir Field	40%
	Barrow Arch	20%
	Norton Basin	20%
	North Aleutian Basin	20%

Schedule: October 1983 - September 1984

Performing Agency: To be determined.

Background:

It has become increasingly apparent that the impact(s) of spilled oil in the marine environment are more prolonged when the fate of the spilled oil includes sedimentation or those processes which have been reported to facilitate sedimentation; e.g., weathering of the oil leading to increased density, adsorption of oil to particles, or ingestion by zooplankton. Oil weathering, including changes in density, is presently being investigated by RU 597. The ingestion of oil by zooplankton, perhaps the most important natural agent in the eventual dispersal and degradation of oil in the open sea, is overshadowed in the nearshore by the adsorption of oil to particles. This latter process is dependent on availability of particles as well as the nature of the particulate material but may be extremely efficient. Data from sediment traps deployed after the Tsesis spill indicated that 30-60 tons of oil (10-15% of the approximately 300 tons that entered the environment), spread over an area of 42 km^2, reached the benthos within one month of the spill.

Previously, OCSEAP has funded studies of (1) the interaction of suspended particulate material and spilled oil, (2) the physical characteristics and distribution of suspended particulate material, and (3) the sources and sinks of suspended particulate material in nearshore areas. This project will integrate the results and data from these studies into a unified model which can be used to quantify the transport of oil associated with suspended particulate material.

Objectives:

1. Develop a mathematical model from existing OCSEAP and non-OCSEAP data which can be used to quantify the transport of oil, both vertically and horizontally by suspended particulate material.

2. Use the developed model to predict the transport and deposition of oil and associated SPM for a selected location in the Beaufort Sea.

Methods:

1. Develop algorithms describing the seasonal composition and rates of supply and loss of suspended particulate material derived from streams, shoreline erosion, and the littoral zone.

2. Develop algorithms describing the relationship of the suspended particulate material algorithms (see above) to hydrological, meteorological, and oceanographic processes.

3. Develop (or modify existing) algorithms quantifying the interaction of suspended particulate matter with spilled oil.

4. Integrate all algorithms into a unified model which describes the seasonal transport and distribution of oil and suspended particulate material.

Output:

1. Mathematical Model: A predictive model describing the distribution and transport, both vertically and horizontally, of oil associated with suspended particulate material will be developed. A hard copy of the model as well as copies of the magnetic tape containing the model, supported by an annotated account, will be submitted at the end of the contract.

2. Narrative Reports: Reports will provide detailed discussion of relevant data and information from the literature. The developed algorithms shall be presented, discussed, and rationalized.

3. Digital Data: None.

4. Visual Data: Report will be supported with relevant charts and graphs.

Schedule of Deliverables:

A semi-annual report will be due 6 months after the contract is awarded. The final report and model documentation will be due at the termination of the contract.

Outlook:

This is a 1-year study.

(PU 4009) MONITORING OF MARINE BIRD POPULATIONS IN THE ARCTIC OCEAN AND BERING SEA

Effort by OCS Planning Area:

St. George Basin	50%
North Aleutian Basin	50%

Schedule: January 1984 - December 1984

Performing Agency: To be selected.

Background:

Since 1975 OCSEAP has used the approach of periodic recensusing of seabird populations of selected Alaskan breeding colonies, and reexamination of key parameters (chick growth and survival rates, prey species composition, habitat use). This approach was conceived as a means for monitoring population numbers and productivity in order to document natural trends or fluctuations. However, the benefits of such monitoring studies have gone considerably beyond this original objective.

The long-term trends that initially defied explanation are now beginning to make sense, as parts of the story of ecological causation fall into place. Direct links and causative relationships between large-scale meteorological, oceanographic, and nutrient regimes on the one hand, and marine vertebrate consumers on the other, have been suggested or determined by monitoring of Arctic Ocean and Bering Sea bird populations. Economical field study procedures have been developed to estimate population status at large colonies and in littoral areas used by shorebirds. Modest expenditures since 1975 have yielded significant results to OCSEAP for both seabird and shorebird studies. A continued population and key parameter monitoring program at selected sites throughout Alaska should be sustained, both for its obvious benefits and those that cannot be predetermined.

Objective:

Determine population status and productivity at selected seabird colonies which have been previously assessed, but generally not within the past 2 to 5 years. In FY84, the Pribilof Island and Cape Newenham colonies are tentatively selected to be visited.

Methods:

Seabird monitoring relies on the periodic examination of selected dispersed locations to permit evaluation of geographic extent of trends in population numbers and productivity. Ideally, mixed species colonies are visited to allow concurrent evaluation of trends among several species.

Permanent plots are established for censusing and estimation of reproductive output. Plots are selected to represent a variety of cliff types and exposures. Counts are made on several days during the chick period; preferably two or more observers make independent estimates concurrently. Numeric changes of populations between years are evaluated by the appropriate statistical procedures. Reproductive output is

evaluated by comparing chicks fledged versus breeding birds present and prior years' data. Food habit data are collected via examination of bill loads or by collection of stomachs of adults.

Shorebird monitoring involves repeated counts of birds observed on established transects selected to represent major littoral zone habitats. As with seabirds, dispersed locations are selected to facilitate examination of geographic as well as inter-annual trends in populations. Information such as shorebird breeding densities and habitat use patterns is derived from the monitoring surveys.

Output:

1. Narrative Reports: Autonomous final reports will be produced for each colony studied. As noted above, in addition to providing current information on numbers of breedng birds and reproductive output, the reports will include comparisons with previous years' results and evaluations of changes and trends.

2. Digital Data: OCSEAP formats 031 and 033 will be used when food habits and transect data, respectively, are obtained.

3. Visual Data. Photographs of sections of seabird colonies for documentation of bird numbers and nest plots may be required. Maps, graphs, and tables will be included as appropriate.

Schedule of Deliverables:

1. Final report(s) due December 31, 1984.
2. Digital data will be submitted 60 days after each field sampling program.

Outlook:

This P-unit is intended to be a long-term, low-level effort to monitor specified seabird dynamics at selected sites on a periodic basis.

(PU 4010) SEASONAL HABITAT USE BY INSHORE SPECIES OF MARINE FISH NORTH OF THE ALASKA PENINSULA

Effort by OCS Planning Area: North Aleutian Basin 100%

Schedule: October 1, 1983 - September 30, 1984

Performing Agency: To be selected.

Background:

The nearshore waters of the North Aleutian Basin are believed to be of significant ecological value as nursery habitat for the young of many commercially harvested fish of the southeastern Bering Sea. This is especially true of the waters lying inside the 50-m isobath between Cape Sarichef on Unimak Island and Port Heiden along the north side of the Alaska Peninsula. This coastal region contains the seaward migration corridor for local salmon stocks from the peninsula, as well as some proportion of the millions of juveniles emigrating from the district each year. Although much has been speculated about the extent of fish use of this shallow water environment, few studies have been conducted there. Those data available have come from tag-recovery programs concerned with sockeye salmon movement from Bristol Bay, reconnaissance-level surveys of spawning forage fish and benthic standing stocks, and very limited sampling of juvenile halibut distribution and abundance. As such the shallow coastal and lagoonal waters of the north Alaska Peninsula remain poorly characterized according to their use by inshore species of fish. Seasonal fluctuations in abundance and vertical distribution are typical of inshore species and are probably related to age, temperature, seasonal changes in space and cover, and food abundance. Habitat disruptions, such as those associated with oil spills or facility siting, are possible consequences of planned offshore oil and gas development in the North Aleutian Basin and are potentially most damaging in shallow-water areas. Without an adequate data base of fish use in these waters, potential impacts to commercially or trophically valuable species cannot be evaluated. This study will provide the needed information prior to OCS leasing in the North Aleutian Basin.

Objectives:

This study will provide seasonal data on fish use, especially salmonid, of coastal portions of the North Aleutian Basin by completing the following objectives:

1. Characterization of physical and biological features of nearshore fish assemblages and habitat use in shallow-water areas in the North Aleutian Basin.

2. Description of seasonal changes in distribution of dominant species and age classes with emphasis on periods of peak abundance and vulnerabilities to proposed offshore oil and gas development in the North Aleutian Basin.

Methods:

During FY83 a literature review will be completed describing existing knowledge on nearshore habitats and ecological processes of the North Aleutian Basin. Representative habitat types shall be selected for intensive fish sampling and habitat characterizations. Nearshore waters from the coastline out to the 50-m isobath shall be sampled along transect lines with different strata defined by depth and substrate. This will facilitate relevant segregations and species associations. Purse seines, midwater trawls, gill nets, beach seines, fry traps, and tow nets will be the major fishing gears employed. Other options such as underwater photography may be considered. Bottom composition and sea conditions will be obtained by standard measurements and sampling techniques.

Output:

1. Narrative Report: The final report will provide documentation of inshore fish distributions and abundance by depth, occurrence in the water column, geologic features of the sea floor, and vegetative cover. Rationale for site selection as well as information on date, time, sea-surface temperature, and depth for survey location will be described. Catch and effort data will be sorted and analyzed as follows:

   a. Catch. Samples will be sorted to species which in turn will be counted, weighed, and sexed. State of maturity information will be collected for all species.

   b. Effort. Catch per unit effort data will be provided for each gear type as a general index of abundance for various habitats.

   c. Data Analysis. Fish density (number of fish/hectare) and biomass estimates (kilograms of fish/hectare) will be extrapolated for various nearshore habitats from catch data. Frequency of occurrence data shall be used to describe species richness, diversity, and fish associations in various nearshore habitats along the north side of the Alaska Peninsula.

2. Digital Data: Catch information will be reported on standard OCSEAP format File Type 123.

3. Visual Data: Charts, figures, tables, and other descriptive aids will be used as appropriate to supplement the final report.

Schedule of Deliverables:

Seasonal data will be collected in spring transition, summer, and fall transition periods. Interim survey results will be useful for the Sale 92 FEIS and Sale 101 EIS.

Outlook:

Because of the expected high variability in field data, a minimum of 2 years of sampling will be required. Data analysis and reporting could extend into FY86.

(PU 4011) YUKON DELTA PROCESSES STUDY (PHASE II)

Effort by OCS Planning Area: Norton Basin 100%

Schedule: January 1984 - May 1985

Performing Agency: To be selected.

Background:

The littoral zone of the Yukon River is a broad, heavily vegetated region which is often miles wide and regularly inundated by rising waters from river flooding or storm surge. Thousands of hectares of low-lying tundra wetland may be covered during these events. The tremendous shorebird and waterfowl populations which are dependent on the Yukon Delta are believed to be vulnerable to the effects of oil carried on flood waters. Oil-polluted waters could also severely affect the large stocks of salmon which make the Yukon one of the major salmon-producing rivers in North America.

Because of the importance of these bird and fish populations on a global scale, much recent attention has been focused on them with regard to the leasing of the adjacent outer continental shelf for oil and gas development. Satellite imagery indicates the presence of two large bands of relatively clear water lying between the extremely turbid waters flowing out of the major mouths of the Yukon River. Although the causative mechanisms leading to the formation of these bands are poorly understood, they persist through the summer and are critical to large populations of shorebirds, waterfowl, and possibly migrant salmonids. Very preliminary fieldwork indicates that the upper intertidal zone in the clearwater areas is heavily vegetated with sedge, while the lower intertidal and shallow subtidal zones have extensive stands of pondweed. Dense populations of small invertebrates feed and shelter among this intertidal vegetation. Pintail ducks and geese in particular utilize the interdistributary clearwater zones to feed and molt.

During 1983 a literature review of the Yukon Delta was begun (RU 647). The objectives of this review, which compose Phase I of PU 4011, are to evaluate the present status of knowledge concerning the coastal edge of the Yukon River Delta; to evaluate the ecological phenomena which lead to the formation of biotic zones along the coastal edge of the delta; to summarize the relative vulnerabilities of these zones to the effects of proposed OCS oil and gas activities; and to identify data and information needs necessary to more adequately define zonation and its causes and vulnerabilities along the coastal edge of the Yukon River Delta.

Objectives:

The objectives of Phase II of the Yukon Delta Processes Study will be to:

1. Evaluate the results of Phase I to determine the need for further studies.

2. Conduct field research to determine the cause of ecological zonation across the Yukon River Delta, especially in the area of clearwater zones. This research should also include collection of hydrographic and current-meter data such that the behavior of oil spills in this region could be modeled by RU 435.

Methods:

The methodology to be used in Phase II will be determined after a review of the results of Phase I. If research is initiated, it is probable that meteorological stations, current meters, and water-level gauges will be utilized in this work. The use of conceptual ecological modeling as a tool for hypothesis testing is also anticipated. Biotic observations will include studies of waterfowl and fish distribution relative to clearwater and other zones along the delta front.

Output:

1. Narrative Reports:

   The final report for Phase II, if the project is instituted, will be due May 1, 1985. This Phase II report should include descriptions of hydrography, physical oceanography, correlations between currents and winds, and an enumeration of the processes believed to cause the observed biotic zonation. Conclusions as to the probable effects which oil spills or oil and gas development might have on the area will also be drawn.

2. Digital Data:

   Field data will be submitted using standard OCSEAP formats for meteorology, oceanographic parameters, productivity, benthos, plankton, fish abundance, and bird observations.

3. Visual Data and Statistical Treatments:

   a. Maps depicting the distribution of oceanographic phenomena and biota within the greater Yukon Delta will be prepared as part of Phase I. These will be updated and expanded as Phase II research results become available.

   b. Statistical correlations, including the use of conceptual models, will be utilized to demonstrate the relationship between biotic zonation and physical conditions.

Schedule of Deliverables:

1. Fieldwork will occur during spring, summer, and fall of 1984. The final report detailing the results of these activities will be due May 1, 1985.

2. Participation in the Sale 100 synthesis meeting, tentatively scheduled for June 1984, will be required.

Outlook:

This study will be completed in 2 years ending in May 1985, unless a second year of fieldwork for comparative purposes is deemed necessary.

(PU 4015) LETHAL AND SUBLETHAL EFFECTS OF SPILLED OIL ON HERRING REPRODUCTION

Effort by OCS Planning Area: Non-Site Specific

Schedule: March 1984 - October 1984

Performing Agency: To be determined.

Background:

Pacific herring (Clupea harengus pallasi) are pelagic planktivores. They are highly adapted with large mouths and numerous fine gill rakers for efficient use of euphausiids, copepods, and other zooplankton. In turn, herring are important prey for marine mammals, birds, and fish. They also form the basis of a major international commercial fishery. Japanese and U.S. fishermen harvest over 30,000 t of herring per year in the eastern Bering Sea.

Herring stocks are unusually vulnerable to spilled oil because of their extensive use of intertidal and shallow subtidal waters for reproduction. After spawning the eggs are deposited on attached vegetation. They take 10 to 21 days, depending on water temperature, to hatch. The larvae remain in the nearshore for another 6-10 weeks before metamorphosing into juveniles and migrating offshore. This means that the time from spawning through larval development, a time which has been identified as an easily perturbed period in the life cycle of fish in general, is spent in those areas most susceptible to oiling; i.e., the intertidal and shallow subtidal areas. Also, herring are long-lived (12-15 years) and repeat spawners, but the standing stock biomass may consist almost entirely of one or two strong year classes. This means that the loss of a year class environmentally programmed to be "strong" could have severe repercussions on the stock and on the fishery.

Objectives:

1. To determine the effects of spilled oil on the reproductive potential of adult Pacific herring.

2. To determine the sensitivity of Pacific herring adults, eggs, and larvae to spilled oil.

Methods:

1. Nearly ripe adult Pacific herring will be kept in flow-through tanks and exposed to low levels (3, 10, 25 and 40% of the 96-h TLm) of the seawater-soluble fraction (SWSF) of Cook Inlet crude oil. These fish will be monitored for survival, mating behavior, time of spawning, success of egg hatch with no oil exposure after spawning, and success of egg hatch with continued oil exposure.

2. Artificially spawned Pacific herring eggs will be exposed to low levels of the SWSF of Cook Inlet crude oil in flow-through tanks and monitored microscopically for egg condition and development. The life stages and exposures to be tested will include:

   Fertilization to 1 h, 4 h, 1 d, and 4 d.
   Day 6 to day 7, and day 10.
   Day 11 to day 12, and day 15.
   Day 15 to day hatched.
   Larvae to 1 h, 4 h, 1 d, and 4 d.

3. Hydrocarbon concentrations in adults, eggs, and larvae will be determined and correlated with exposures.

Output:

1. Narrative Reports: Reports will describe the relevant methodologies and results, including interpretations of the results. All reports will be comprehensive and autonomous. The final report will include a thorough evaluation of existing data, together with (a) a detailed description of the experimental methodology, including protocols for collection and maintenance of test organisms, bioassays, and study results; (b) interpretation of the results illustrating the effects on survival, mating behavior, and reproduction, and correlating these data with hydrocarbon concentrations in the water and in the tissues of the exposed organisms; (c) discussions, including implication of laboratory data to the population dynamics of Bering Sea stocks of herring; and (d) recommendations for future research.

2. Digital Data: None.

3. Visual Data: Information will be portrayed in tables, graphs, and figures to support the narrative report.

Schedule of Deliverables:

A progress report will be due 6 months from the initiation of the project. The final report will be due on the date of termination of the project.

Outlook:

This is a 1-year project.

(PU 4016) LETHAL AND SUBLETHAL EFFECTS OF OIL ON FOOD ORGANISMS OF THE BOWHEAD WHALE

Effort by OCS Planning Area: Non-Site Specific

Schedule: October 1983 - September 1984

Performing Agency: To be determined.

Background:

Bowhead whales (Balaena mysticetus) feed intensively during the summer and autumn in the Beaufort Sea and little or not at all during the rest of the year when they reside in the northern Bering Sea. This means that the quantities and kinds of available food in the Beaufort Sea must be adequate to meet immediate energetic requirements of whales and to provide reserves for periods of reduced feeding.

Data on food organisms utilized by bowhead whales are scanty. Recently, samples of the stomach contents of five whales taken near Barter Island were made available for analysis. Copepods (primarily Calanus hyperboreus) and euphausiids (primarily (Thysanoessa raschii) in combination made up 90% to almost 100% of the contents. The relative importance of these two prey types varied from over 99% copepods in one sample to almost 98% euphausiids in another. All other food types were insignificant in terms of overall amount of food consumed.

It is possible that copepods and euphausiids are, overall, the most important bowhead foods in the Beaufort Sea. Of the two primary species of copepods and euphausiids, C. hyperboreus has been assayed for sensitivity to oil. However, the LC_{50} for this species is approximately 70 ppm, which is surprisingly high. There does seem to be general agreement that the state of the animal at the end of the bioassay suggests irreversible damage that would eventually prove lethal. There are no such data on T. raschii. This species is widely distributed in arctic waters and has been reported as the major food of whales in the Beaufort Sea, suggesting the widespread utilization of this organism by bowheads.

Objectives:

1. Determine the lethal effects of concentrations of petroleum hydrocarbons on T. raschii.

2. Extrapolate laboratory studies to the Beaufort Sea and estimate euphausiid population losses and probable recovery potential following a hypothetical crude oil spill.

Methods:

Euphausiids (T. raschii) will be exposed to varying concentrations of the seawater-soluble fraction of Prudhoe Bay crude oil in a flow-through bioassay in order to establish LC_{50}'s.

Output:

1. Narrative Reports: Reports will describe the relevant methodologies and results, including interpretations of the results. All reports will be comprehensive and autonomous. The final report will include a thorough evaluation of all existing data as well as (a) a detailed description of the experimental methodology, including protocols for collection and maintenance of test organisms, bioassays, and study results; (b) interpretation of the results illustrating the effects on survival and reproduction, and correlating these data with hydrocarbon concentrations in the water and in the tissues of the exposed organisms; (c) discussions of the implication of these data, estimating population losses and probable recovery times after a representative oil spill; and (d) recommendations for future research.

2. Digital Data: None.

3. Visual Data: Information will be portrayed in tables, graphs, and figures to support the narrative report.

Schedule of Deliverables

A progress report will be due 6 months from the initiation of the project. The final report will be due on the date of termination of the project.

Outlook:

This is a 1-year project.

(PU 4017) IMPLEMENTATION OF A MONITORING PROGRAM FOR THE ARCTIC OCS

Effort by OCS Planning Area: Beaufort Sea/Diapir Field 100%

Schedule: November 1, 1983 - October 31, 1984

Performing Agency: To be determined.

Background:

There is great public concern about the potential environmental consequences of petroleum development activities along the U.S. coast. This has been expressed in such ways as the Outer Continental Shelf Lands Act Amendments (1978) which state:

> Subsequent to the leasing and developing of any area or region, the Secretary shall conduct such additional studies to establish environmental information as he deems necessary and shall monitor the human, marine, and coastal environments of such area or region in a manner designed to provide time-series and data trend information which can be used for comparison with any previously collected data for the purpose of identifying any significant changes in the quality and productivity of such environments, for establishing trends in the areas studied and monitored, and for designing experiments to identify the causes of such changes.

The National Ocean Pollution Planning Act of 1978 (P.L. 95-273) mandates NOAA to provide national leadership in the planning and coordination of marine pollution research, development, and monitoring activities being pursued by the federal government. The principal mechanism used for interagency coordination under this act is a 5-year Federal Plan for Ocean Pollution Research, Development, and Monitoring prepared every other year. To assist in this preparation and implementation of federal plans, NOAA employs the Interagency Committee on Ocean Pollution Research, Development, and Monitoring (COPRDM) which is chartered within the office of the President's Science Advisor.

COPRDM conducted a review of marine oil pollution programs, April 1980, and recommended that a program " should be planned and initiated to investigate the long-term, low-level effects of OCS drilling and production." In response to this expressed concern, BLM sponsored a workshop (December 21-22, 1981) which outlined approaches to the detection and study of possible subtle, long-term environmental effects of oil and gas activities on the Outer Continental Shelf. The resulting recommendation for a review of existing data has been funded and is scheduled for completion in 1983. However, a decision was made at that workshop to eliminate arctic areas from consideration in the development of this program. This decision was

based on the presence and influence of ice on Arctic ecosystems. Ice sharply differentiates Arctic marine ecosystems. Because of this decision and because of the continued prominence of the Arctic OCS in the development and production of hydrocarbons, it is proposed to initiate a program to assess the long-term, low-level effect of OCS oil and gas production in an Arctic area.

Objective:

Implement an environmental monitoring program, consisting of a set of repetitive measurements of specific parameters and phenomena that can document changes in the coastal and marine environments of the U.S. Beaufort Sea, resulting from OCS oil and gas development and production in the region. The monitoring program will be based on the proceedings and products of the Beaufort Sea Monitoring Program Workshop held in FY83 (PU 3035).

Methods:

Sampling strategies and measurement techniques will be developed as part of PU 3035. In FY84, field sampling, chemical and biological analyses, and data reduction will be carried out by a number of existing and new research units.

Output:

1. Narrative Reports: A series of reports describing and evaluating methodologies, reporting the results, and interpreting the results in terms of the continued ability of the ecosystem to support similar numbers and species of organisms will be provided on an annual basis. Recommendations for changes in the research plan and management procedures will be a part of these reports.

2. Digital Data: None.

3. Visual Data: Information will be portrayed by charts, graphs, and figures to support the narrative reports.

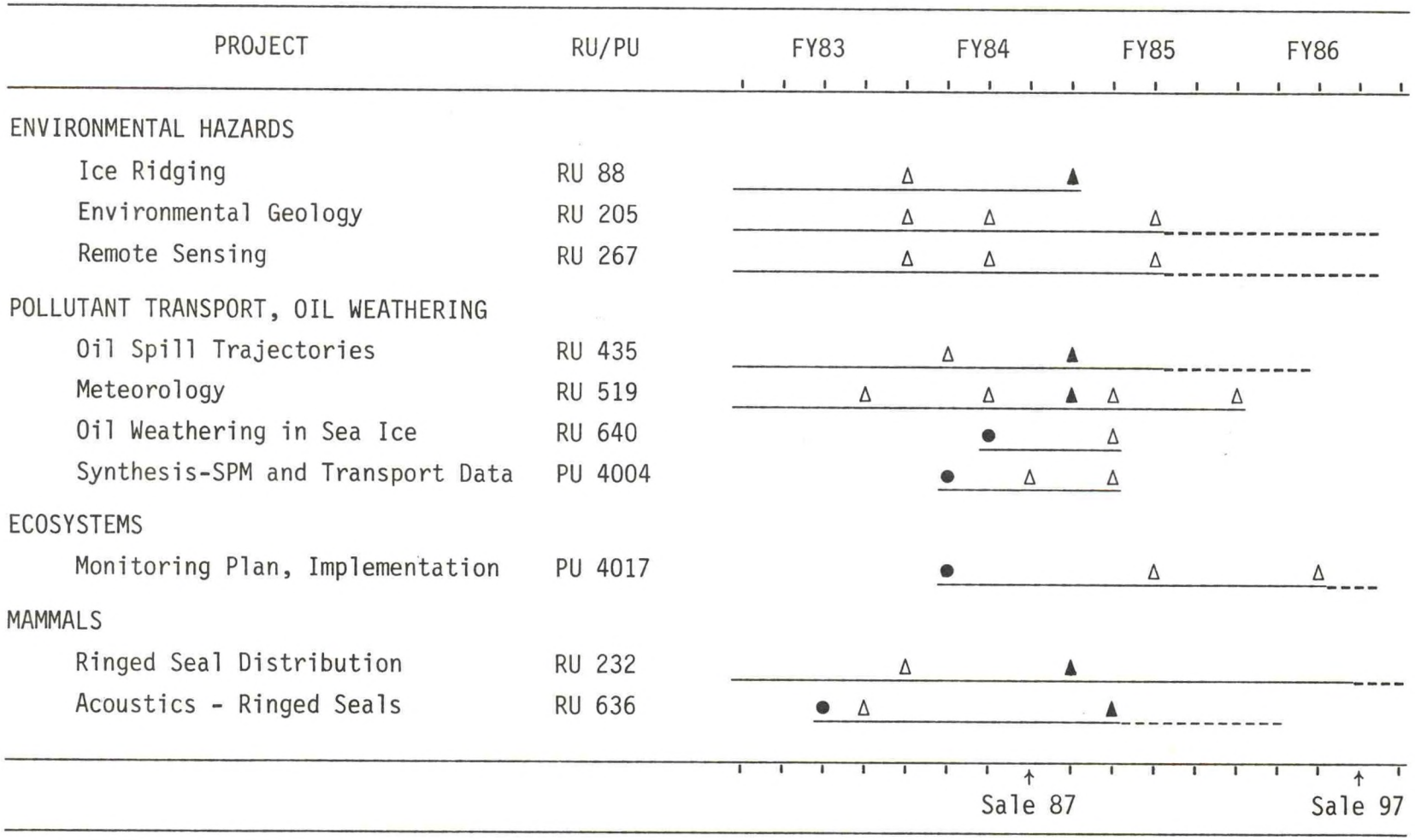
Schedule of Deliverables:

Annual reports will be due in March of each year.

Outlook:

This is a long-term, multiyear project.

Table 1.--Project Milestones for Arctic Ocean Research: Diapir Field, Sales 87 and 97



—— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

Table 2.--Project Milestones for Arctic Ocean Research: Barrow Arch, Sales 85 and 109

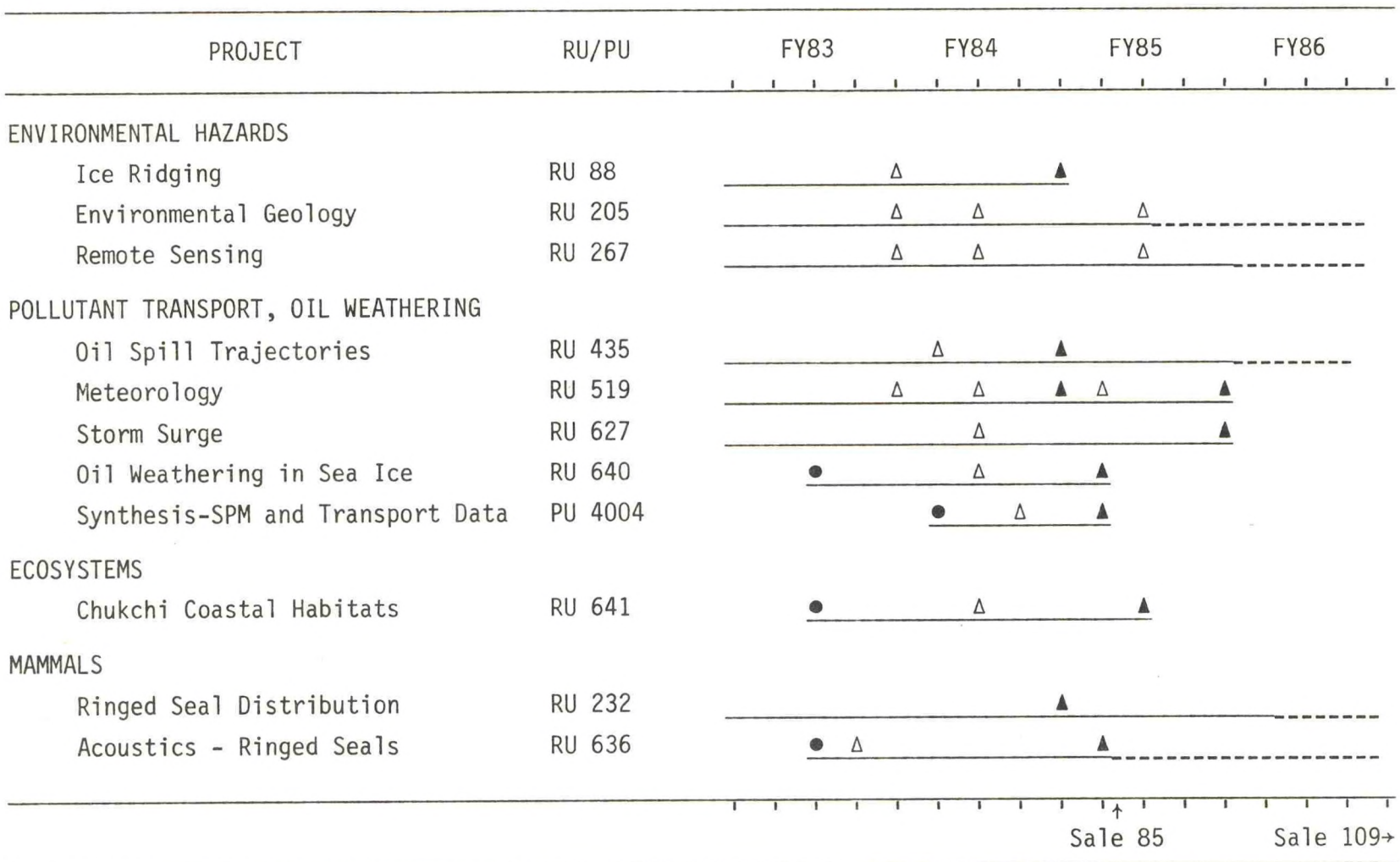
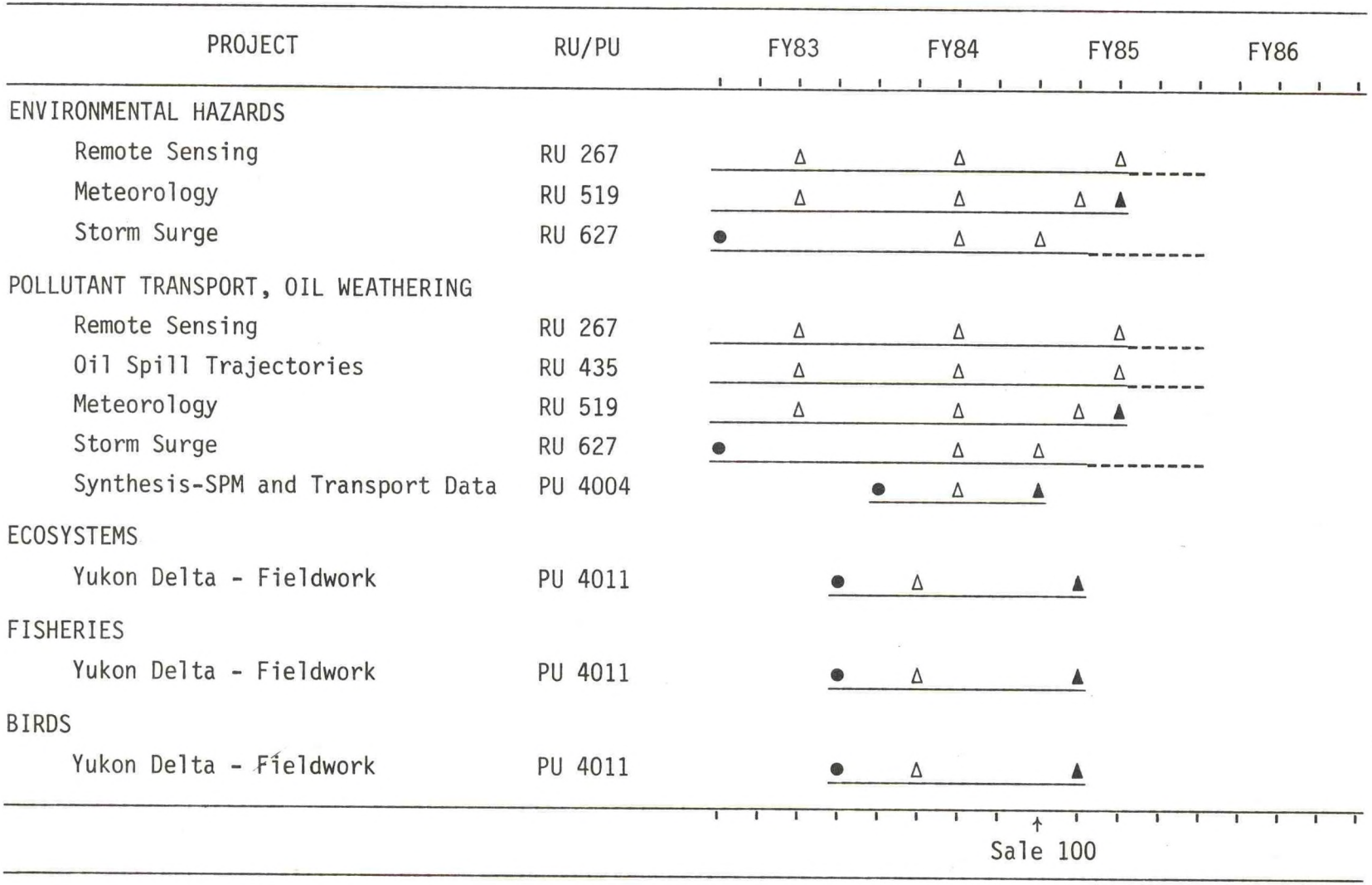


Table 3.--Project Milestones for Bering Sea Research: Norton Basin, Sale 100



—— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

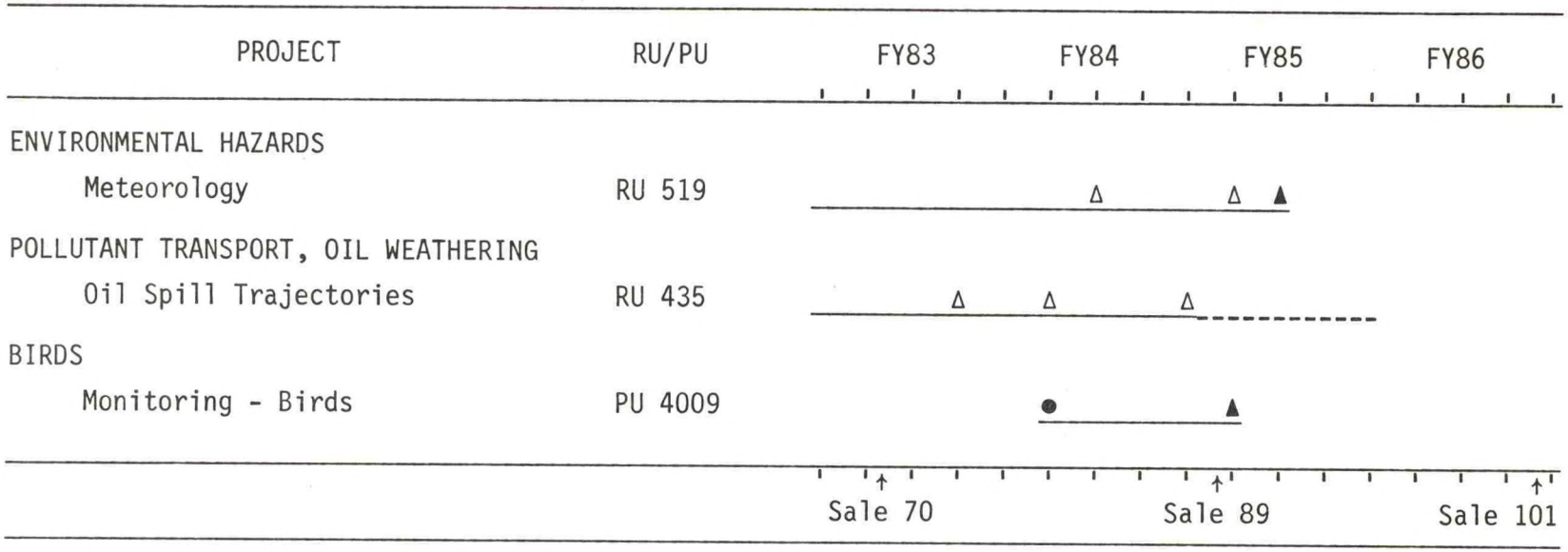
Table 4.--Project Milestones for Bering Sea Research: Navarin Basin, Sales 83 and 107

PROJECT	RU/PU	FY83	FY84	FY85	FY86
ENVIRONMENTAL HAZARDS					
Meteorology	RU 519		Δ	Δ ▲	
POLLUTANT TRANSPORT, OIL WEATHERING					
Oil Spill Trajectories	RU 435			Δ ----------	
Meteorology	RU 519		Δ	Δ ▲	
			↑ Sale 83	↑ Sale 107	

—— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

Table 5.--Project Milestones for Bering Sea Research: St. George Basin, Sales 70, 89, and 101



—— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

Table 6.--Project Milestones for Bering Sea Research: North Aleutian Basin, Sale 92

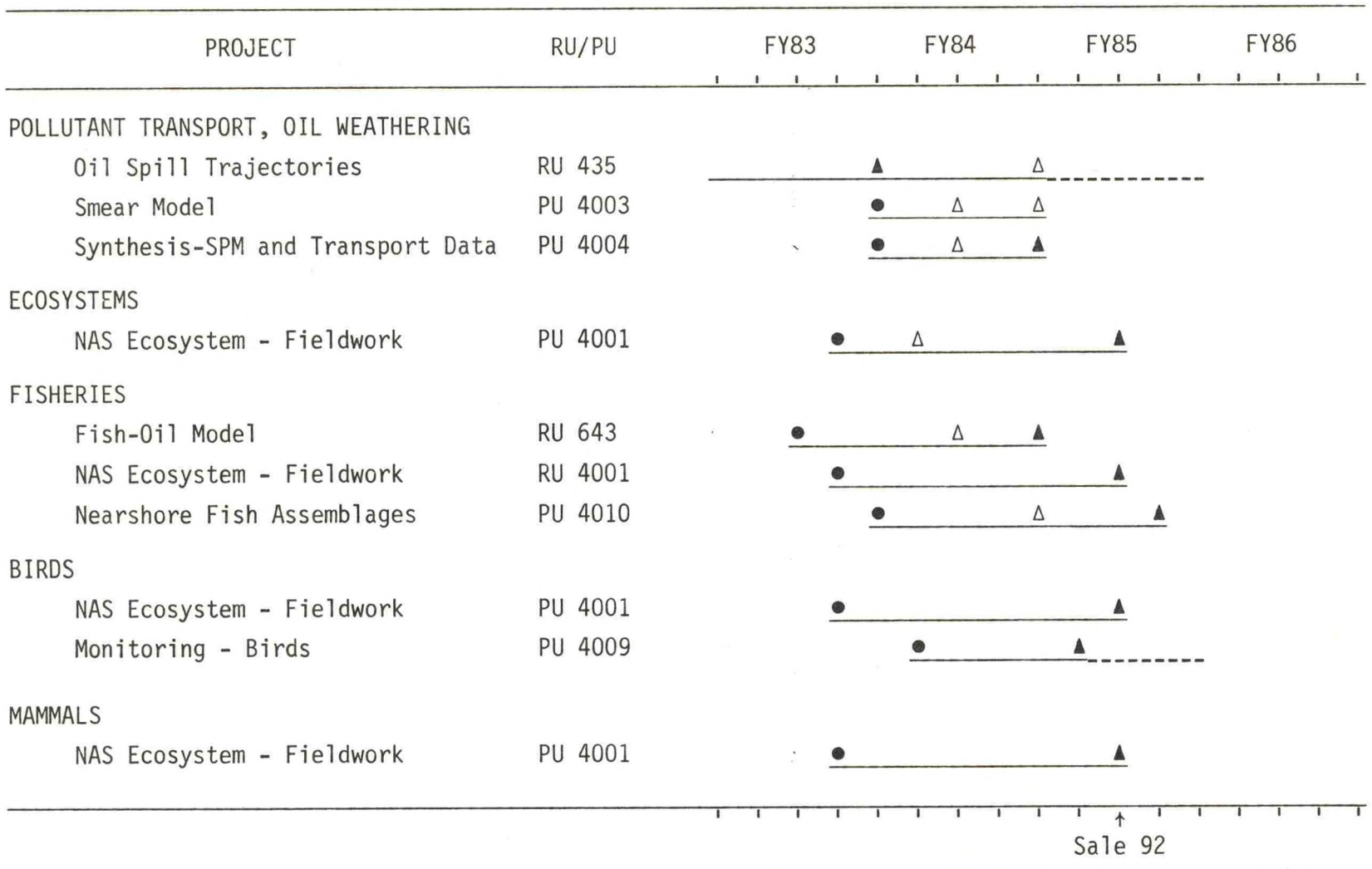
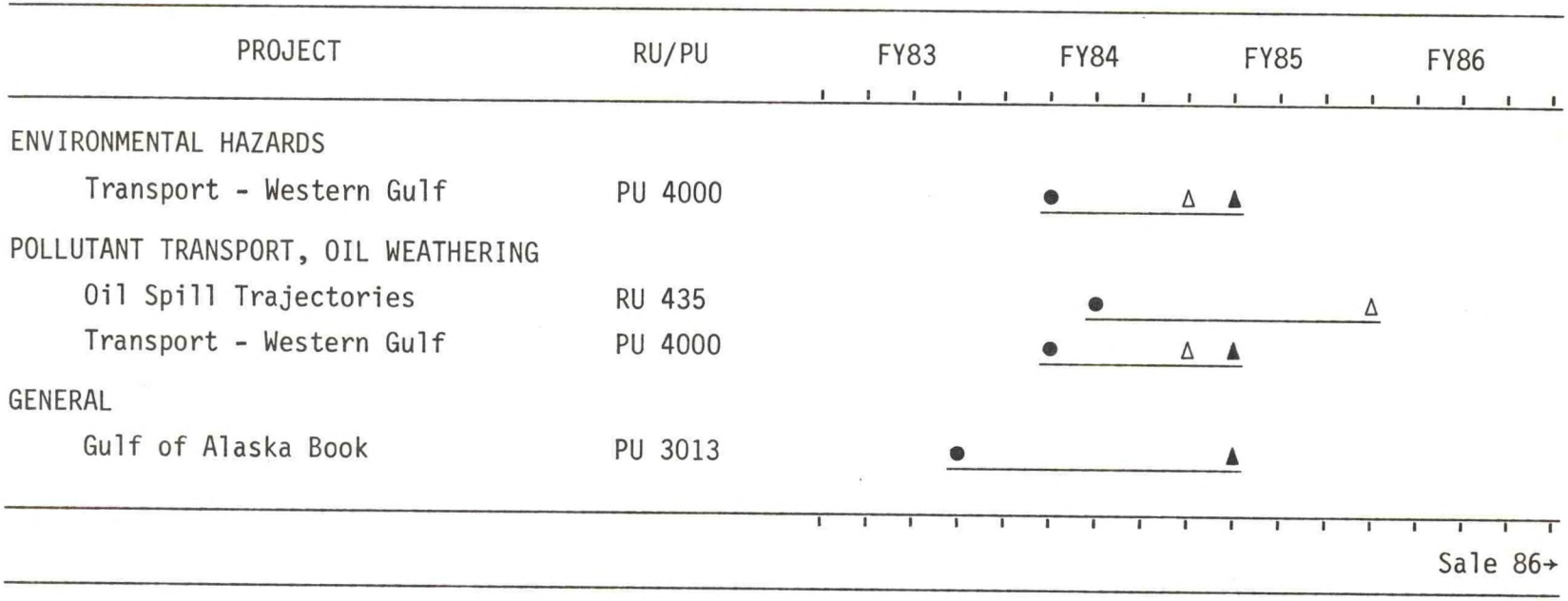


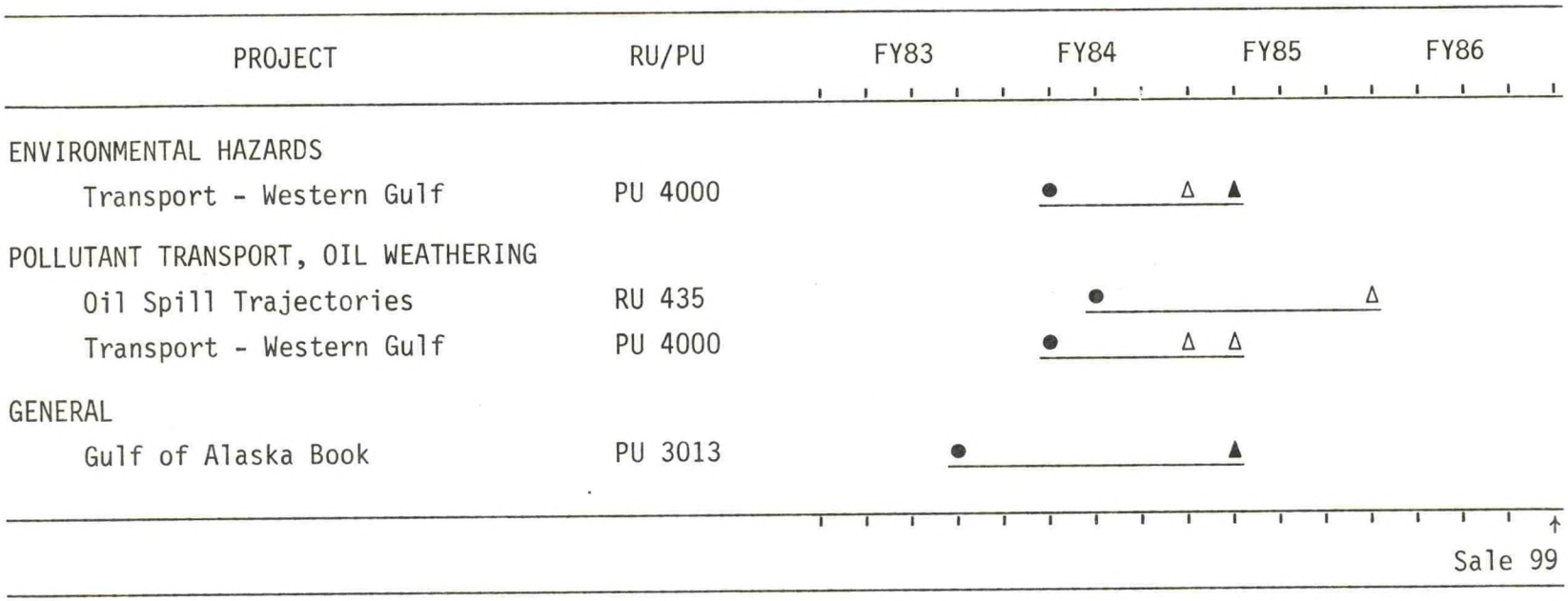
Table 7.--Project Milestones for Gulf of Alaska Research: Shumagin, Sale 86



—— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

Table 8.--Project Milestones for Gulf of Alaska Research: Kodiak, Sale 99



——— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

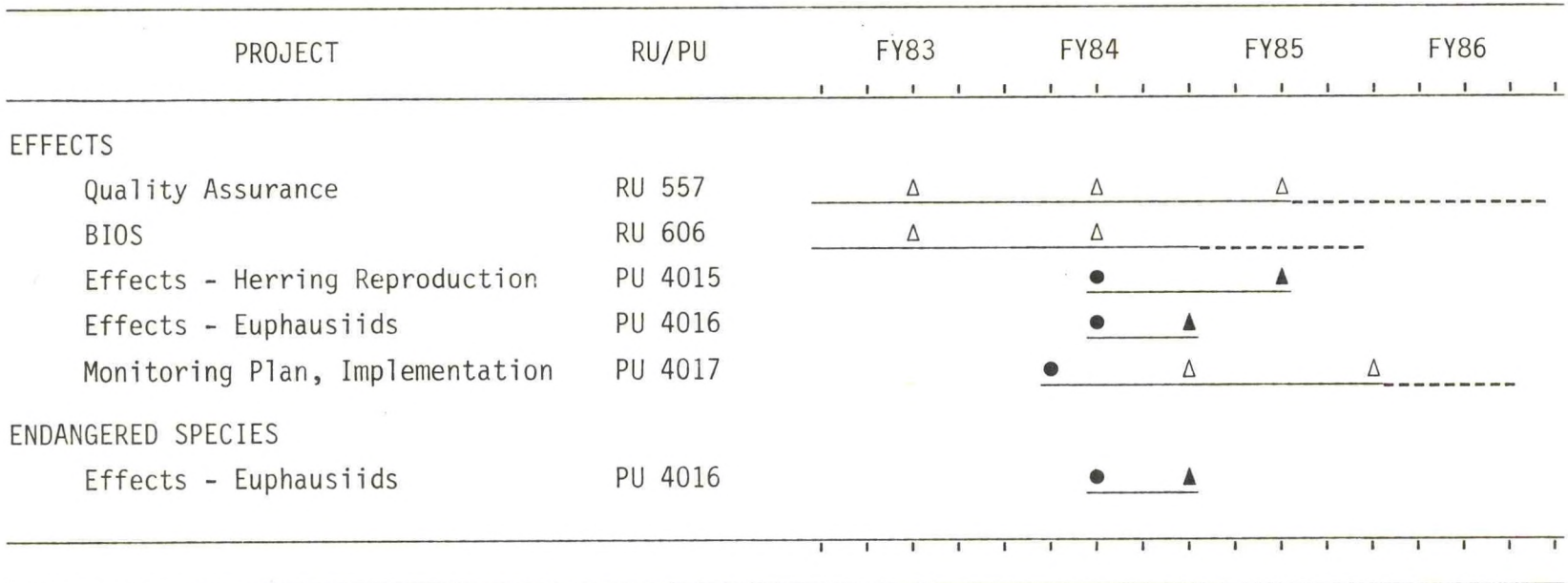
Table 9.--Project Milestones for Gulf of Alaska Research: Gulf of Alaska-Cook Inlet, Sale 88

PROJECT	RU/PU	FY83	FY84	FY85	FY86
GENERAL					
Gulf of Alaska Book	PU 3013	●	———	▲	
				↑ Sale 88	

——— Ongoing study
---- Possible extension of study

● Initiation of study
Δ Major or annual report
▲ Final report

Table 10.--Project Milestones for Non-Site-Specific Research



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