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Living Marine Resources of the Hope Basin:

A Resource Assessment for the Hope Basin Oil and Gas Lease Sale Number 86

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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by
Byron F. Morris

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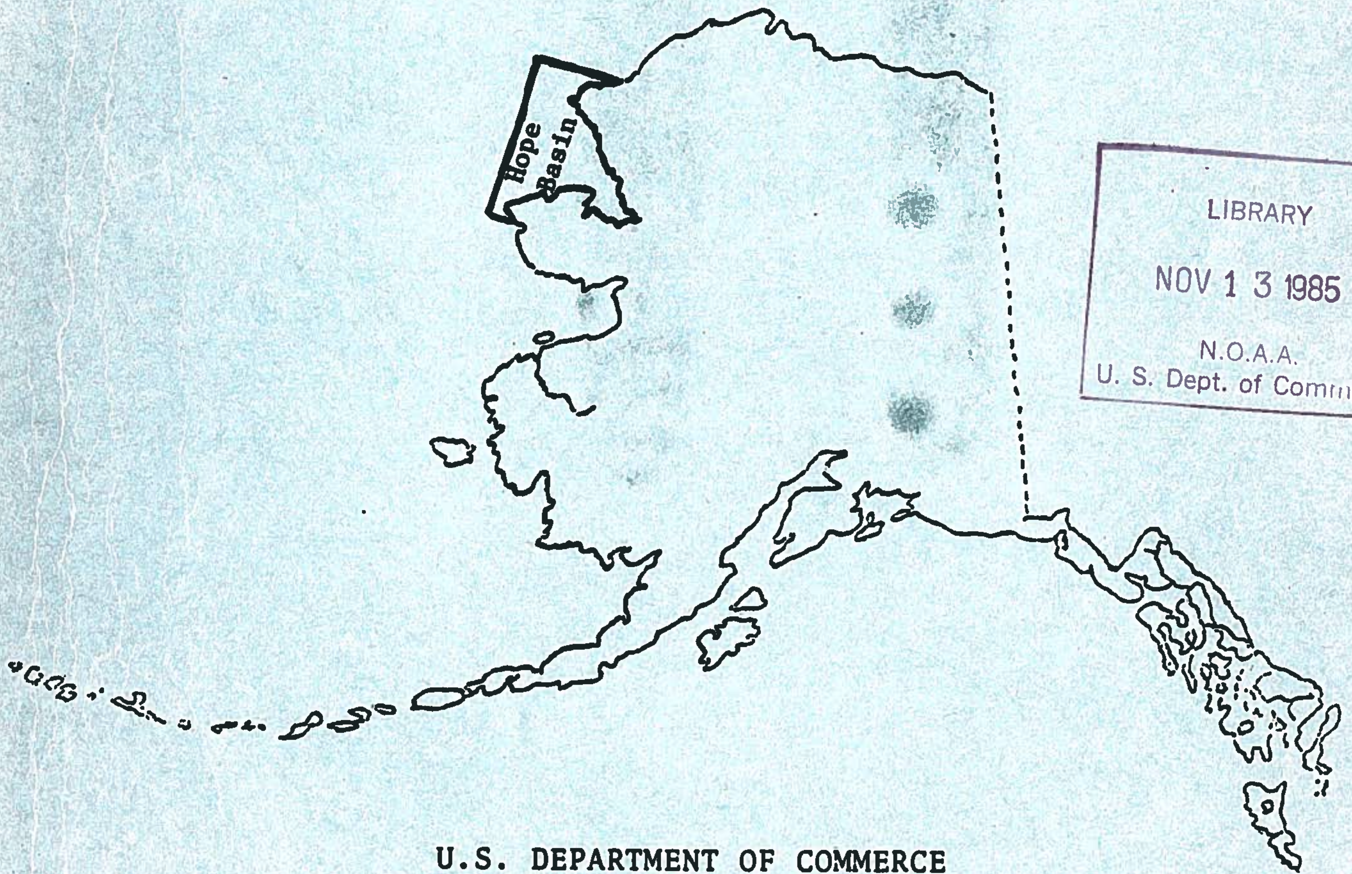

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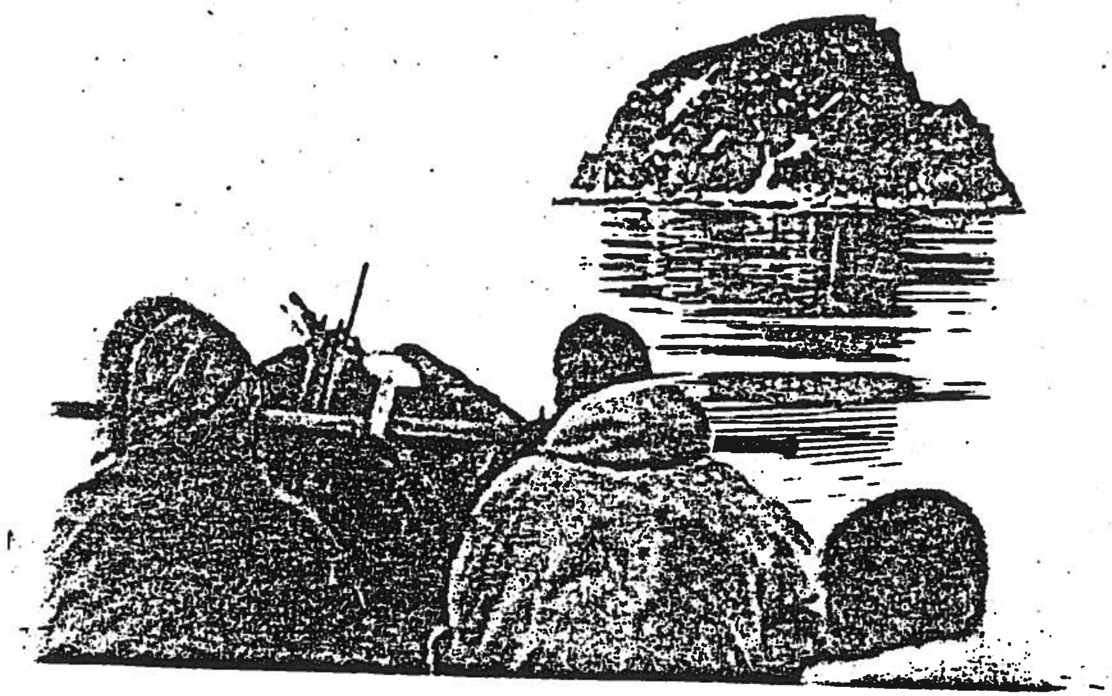

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June, 1981

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SUMMARY

1. An area of the outer continental shelf of the southeastern Chukchi Sea, termed Hope Basin Sale 86, is currently proposed by the Department of the Interior's Bureau of Land Management for oil and gas leasing in May 1985. The proposed sale area is located between Cape Prince of Wales on the Seward Peninsula and 68° 30'N latitude and is bounded on the east by the Federal/State 3-mile boundary, and on the west by the U.S.-Russia 1867 Convention Line.

2. This report discusses the biological resources of the southeastern Chukchi Sea that may be impacted by petroleum exploration and development, and proposes research needed to minimize and avoid potential biological impacts.

3. The southeastern Chukchi Sea shelf in the area under consideration is relatively shallow, within a depth range of 2 to 60 m, and is ice-covered for most of the year (November through June). The shorefast ice zone is relatively broad and stable over inner Kotzebue Sound but it is narrow along most of the outer coast. The winter pack ice is dynamic and extensive. Nearshore incursions of the moving pack ice occur regularly in many areas.

4. The Chukchi Sea supports large populations of marine mammals and seabirds, which depend on the fish and invertebrate populations of the region. The marine mammals of major importance in this region are the bowhead whale, gray whale, beluga whale, walrus, ringed seal, bearded seal, spotted seal, and polar bear. Less frequent but regular visitors to this area are the fin, minke, humpback, and killer whales, the harbor porpoise, and ribbon seals.

   * Virtually the entire population of the western Arctic stock of bowhead whales regularly follows the narrow nearshore lead systems through the eastern Chukchi Sea on their northward spring migration, generally

between April to June. Return migrations in the fall are poorly known, but appear to be more dispersed, farther offshore and are probably mainly along the Siberian coast.

* Beluga whales migrate north through both nearshore and offshore leads with some of the population summering in Kotzebue Sound and in certain other bays, lagoons, and river mouths, where feeding and calving occur. Their fall movements are poorly known.

* Gray whales enter the area during the summer. The southeastern Chukchi Sea is believed to be an important feeding area for the species.

* Walrus follow the seasonal retreat of the pack ice northward through the area, generally staying offshore of the fast-ice zone. They often occur in herds of several hundred animals and may move nearshore with pack ice incursions.

* Ringed seals overwinter and pup in the shorefast ice of the Chukchi Sea. Although the highest ringed seal densities occur north of this area, the greater expanse of stable fast ice in the southeast Chukchi Sea may allow for a greater total overwintering population of ringed seals than in other Alaskan areas. In summer they move northward to inhabit the polar pack ice.

* Bearded seals overwinter in broken pack ice, including the flaw zone of the southeastern Chukchi Sea. In spring they migrate through the region with the northward drift of the pack ice, to summer mainly at the pack ice edge.

* Spotted seals inhabit the Chukchi Sea during the ice-free season, and are common in many nearshore areas in the summer. They are the only Arctic seal to commonly haul out on land.

* Polar bears are common over the entire Chukchi Sea shelf during the ice-covered season. They commonly occupy the pack ice and flaw zone,

and less commonly enter the fast ice or even come ashore on feeding excursions. Denning in low numbers is suspected along the Lisburne Peninsula. During the summer, the polar bear retreats north to the pack ice.

* Other whales and seals are seasonal migrants that variously enter the Chukchi Sea depending on annual sea ice and hydrographic conditions. Knowledge of the occurrence and habitat usage by these marine mammals is scant, being based mainly on scattered sightings.

5. Subsistence take of marine mammals provides a major part of the diet of Chukchi Sea villagers. The bowhead whale is hunted at Wales, Kivalina, and Point Hope during the spring migration. Beluga whales, ringed seals, bearded seals, and walrus occasionally are also important subsistence resources. The take of these marine mammals varies by season and village. Beluga are especially important to Kotzebue Sound villages.

6. A commercial set gill net salmon fishery in Kotzebue Sound is a profitable source of income for Kotzebue Sound natives. This fishery, almost exclusively for chum salmon, realizes close to $1 million during its brief summer season.

7. Marine fish and invertebrate resources do not support viable commercial fishing operations. Biomass is low compared to the Bering Sea for the commercially important fish species known to also inhabit the southeastern Chukchi Sea. Subsistence fishing is important largely to supplement the meat diet (marine mammals, caribou) of the coastal residents.

   * Marine species of subsistence importance include shrimp, Tanner crab, Arctic cod, flounder, and herring.

   * Anadromous species taken nearshore or in fresh waters are primarily pink and chum salmon, smelt, Arctic char, and whitefish.

8. The oceanographic processes that control the biological productivity and marine populations of the Chukchi Sea are poorly known. Knowledge of the ecosystems, interactions between organisms and their environment, and food-web dependencies is largely fragmentary, and mainly confined to summer openwater conditions. The identification of key lower trophic level organisms, critical habitats, sensitivities of species, and studies of the responses of ecosystems to environmental perturbations have not been undertaken. Seasonal adjustments and changes in the environment in response to winter conditions need better understanding to address OCS impacts.

9. Potential biological impacts of major concern are:

   * The effects of oil spills during the winter-spring in open leads, in the shear zone, and in the moving pack-ice near the Bering Strait, and in the nearshore during the openwater season.

   * The impacts of noise and other human disturbance associated with all phases of OCS activity on marine mammals especially during the spring migration.

   * Habitat sensitivity and vulnerability to alteration and destruction resulting from construction, emplacement, and operation of OCS facilities.

10. Our primary recommendations are the following:

   * The initial lease sale should be limited to the stable shorefast ice zone of Kotzebue Sound. Subsequent leasing beyond the zone should require test structures to demonstrate the capability to deal with the moving ice forces.

   * Seasonal restrictions should be placed on downhole drilling activities similar to those in place in the Beaufort Sea to avoid potential oil spills during break-up.

* Any lease tracts located within a zone that would allow oil to move into the Bering Strait (either with ice or water currents) within 30 days of a spill should be carefully considered for deletion.

* Seasonal habitat usage, especially during the winter, needs to be better defined for the major species of marine mammals and fish.

* The locations of high subsistence use areas and subsistence activity patterns need to be identified to avoid potential impacts to the regional economy and culture.

* Studies on the effects of noise and other industry activity on marine mammal distribution and migration must be continued.

* The importance of nearshore waters, lagoons, and bays to anadromous fish needs study.

* Coastal circulation needs better understanding to develop oilspill risk models and shoreline vulnerability information. Winter circulation and ice-transported oil spill trajectories are also required.

1. INTRODUCTION

1.1 Request for Resource Report

The Bureau of Land Management of the Department of the Interior is proposing oil and natural gas lease sale 86 in the Hope Basin. This sale is currently scheduled for May 1985. The Area of Call encompasses the southeastern portion of the Chukchi Sea from Cape Prince of Wales on the Seward Peninsula to 68° 30'N. latitude near Cape Lisburne, and is bordered on the west by the U.S.-Russia 1867 Convention Line and on the east by the State/Federal three geographical mile line (Figure 1.1). In accordance with 43 CFR 3312.1, the Bureau of Land Management has requested a report from the National Marine Fisheries Service that describes the resources within the proposed lease area and identifies the potential effects of oil and gas operations upon these resources and their habitats.

The National Marine Fisheries Service (NMFS) is the branch of the National Oceanic and Atmospheric Administration (NOAA) that has mandates to manage, conserve and protect living marine, estuarine, and anadromous resources and their habitats. In carrying out these responsibilities, NMFS acts under the following legislative authorities:

* The Magnuson Fishery Conservation and Management Act of 1976 requires that fishery resources and their habitats within the 200-mile fishery conservation zone of the U.S. be managed and protected to provide sustained and renewable utilization.

* The Marine Mammal Protection Act of 1972 gives NMFS responsibility for protecting marine mammals and their habitats.

* The Endangered Species Act of 1973 mandates NMFS to ensure the continued existence of certain marine mammal species, primarily the great whales, whose populations are threatened with extinction as a result of man's past practices.

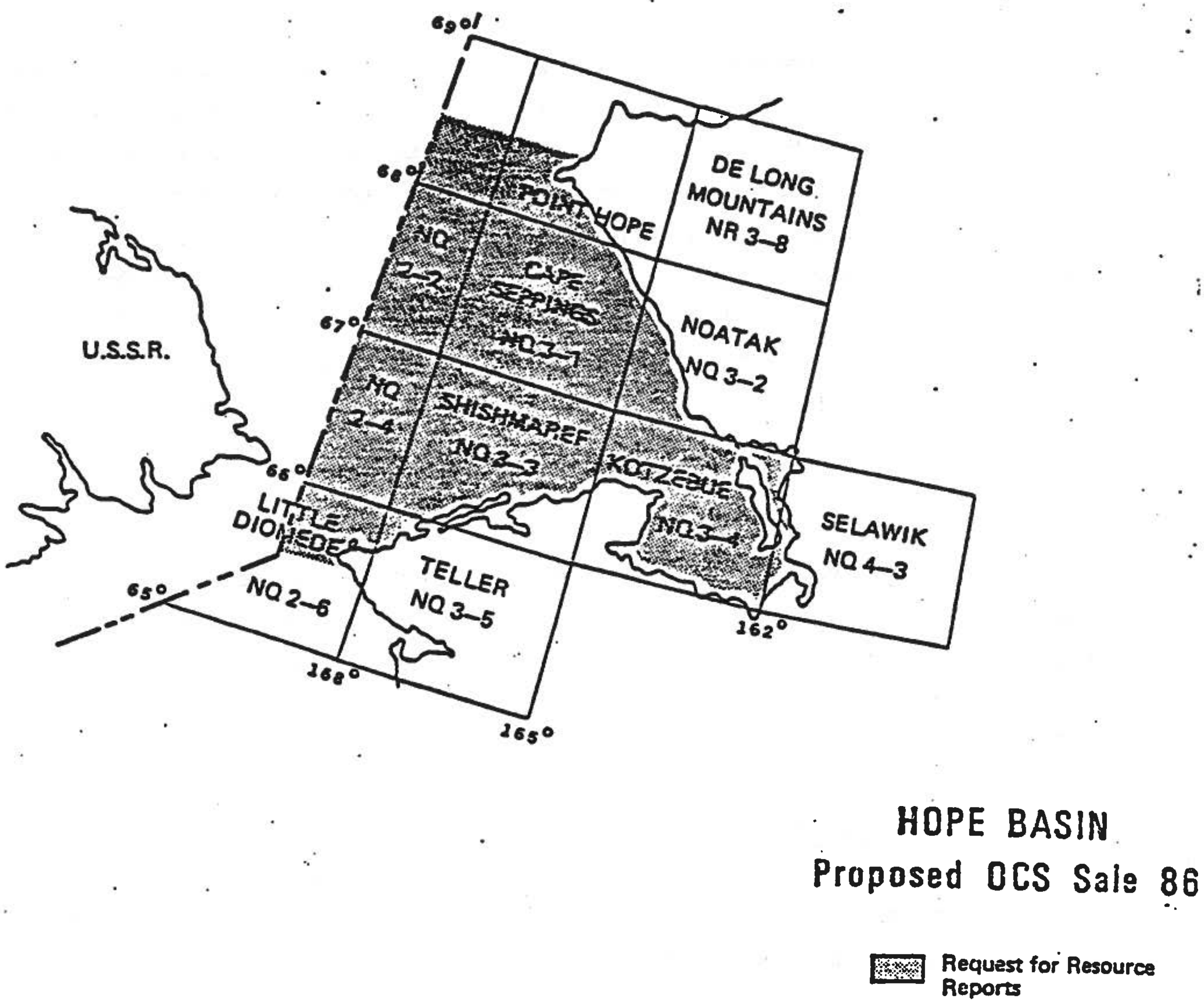


Figure 1.1 The proposed area of call for nominations for OCS Sale 86, the Hope Basin.

*The Fish and Wildlife Coordination Act of 1958 makes NMFS a cooperating agency in processing all Corps of Engineers permit applications for dredge and fill and construction on navigable waters, and Environmental Protection Agency permit applications for waste discharges.

This report addresses the living marine resources and their habitats that are within the purview of the National Marine Fisheries Service. The report covers the following subjects: (1) a general description of the environment and habitats encompassed by the proposed sale area; (2) a review of the fish and invertebrate resources of the southeastern Chukchi Sea; (3) the status of knowledge of marine mammal populations of the area; (4) the commercial and subsistence uses of these resources by coastal residents; and (5) potential effects of oil and gas development on these fish and marine mammal populations and their habitats.

For a more complete review of the resources and resource-use conflicts posed by OCS activity in the Chukchi Sea, the reader should also refer to the prior resource assessment for Chukchi Sea (now Barrow Arch) Sale 85 (Morris, 1981).

1.2 Hydrocarbon Resource Potential

The southeastern Chukchi Sea is a shallow body of water located south of Cape Lisburne, 100 miles wide and 230 miles long and extending into Kotzebue Sound. This area encompasses about 24,000 square miles. The crude oil and natural gas potential in the geological unit known as Hope Basin has recently been estimated by the U.S. Geological Survey (USGS, 1981). The estimated range of undiscovered recoverable crude oil is from 0 to 100 million barrels, with a mean estimate of "negligible" amounts (Table 1.1 and Figure 1.2). Estimated recoverable natural gas ranges from 0 to 1.8 trillion cubic feet with a mean of slightly over 300 billion cubic feet.

In terms of estimated oil and gas resources in the Alaska OCS, the Hope Basin would rank last of the 14 shelf regions in Alaska in which oil is believed to occur, and 12th of 14 for natural gas. By the economic standards that

Table 1.1. Estimates of undiscovered recoverable oil and gas in offshore provinces of the United States (from USGS Open File Report 81-192).

	Crude Oil (Billion Barrels)			Associated/Dissolved Gas (Trillion Cubic Feet)			Non-Associated Gas (Trillion Cubic Feet)		
	Low F_{95} 1/	High F_5 1/	Mean	Low F_{95} 1/	High F_5 1/	Mean	Low F_{95} 1/	High F_5 1/	Mean
SHELF (0-200 meters water)									
Region 1A. Alaska									
1. Beaufort *	1.9	16.7	7.0	3.0	26.8	11.1	6.4	58.5	23.9
3. North Chukchi *	0	4.2	.8	0	6.3	1.2	0	11.4	2.2
5. Central Chukchi *	0	3.3	.6	0	4.9	.9	0	10.4	2.1
→ 6. Hope *	0	.1	Negl.	0	.2	Negl.	0	1.6	.3
8. Norton	0	.9	.2	0	1.4	.2	0	4.1	1.0
9. Bristol	0	1.2	.2	0	1.9	.3	0	3.7	.7
10. Navarin Basin	0	3.7	.8	0	5.5	1.2	0	16.6	4.0
12. St. George Basin	0	2.2	.4	0	3.3	.6	0	7.4	1.7
13. Zhemchug	0	.2	Negl.	0	.3	Negl.	0	.7	.1
15. St. Matthew-Hall	0	0	0	0	0	0	0	0	0
16. Aleutian	0	0	0	0	0	0	0	0	0
18. Kodiak	0	1.0	.2	0	1.7	.3	0	5.2	1.0
20. Shumagin	0	.2	Negl.	0	.3	.1	0	1.6	.2
22. Gulf of Alaska	0	1.5	.3	0	2.2	.4	0	5.9	1.3
24. Cook Inlet	.1	1.0	.4	Negl.	.6	.2	.7	4.6	2.0
25. Shelikof Strait Shallow	0	.2	Negl.	0	.1	Negl.	0	.7	.1

1/ F_{95} denotes the 95th fractile; the probability of <u>more than</u> the amount F_{95} is 95%. F_5 is defined similarly.

* These quantities can be considered recoverable <u>only</u> if technology permits their exploitation beneath Arctic pack ice - a condition not yet met.

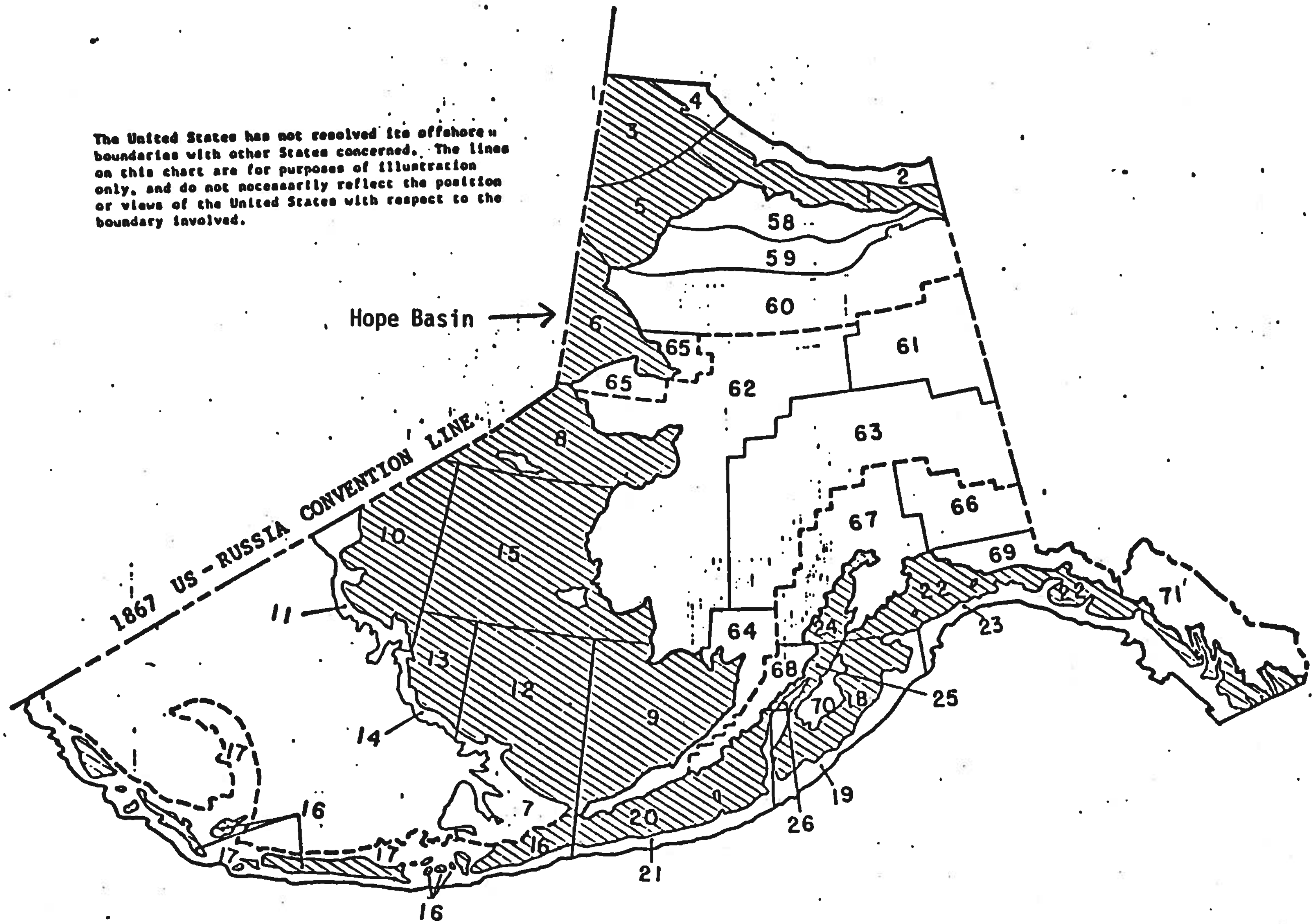


Figure 1.2. Index map of Alaska showing provinces assessed. Shading denotes offshore shelf areas; names of provinces are listed in Table 1.1 (from USGS - Open File Report 81-192).

industry requires to develop a field, the estimated amounts of oil and gas resources would probably not make it economical to produce.

However, these resource estimates are tentative. No offshore wells have been drilled in the Hope Basin, and it is uncertain how much geophysical information was available for these estimates. Further seismic exploration and exploratory drilling may well change the estimated resource potential.

The occurrence of petroleum deposits at any location depends on the simultaneous existence of certain key factors:

* Suitable hydrocarbon source materials, i.e., organic-rich rocks.

* Reservoir rocks with sufficient permeability and porosity to allow hydrocarbon migration and accumulation.

* A trapping mechanism, either stratigraphic or structural in nature, to retain the petroleum in the geologic reservoir.

Suitable conditions for oil and gas deposits are suspected to exist in portions of the Hope Basin. Two exploratory wells which have been drilled onshore bordering Kotzebue Sound were non-producing, but did recover sediments of non-marine siltstone, sandstone, and conglomerate overlying probable early Tertiary volcanic rock. These sediments are believed to extend offshore and would provide good porosity beds for the generation of hydrocarbons. An estimate of the probability of significant source beds occurring in the Hope Basin has been given as 50 percent.

An east-west tectonic arrangement of numerous elongate ridges and one major arch - The Herald Arch, transects the Hope Basin (Figure 1.3). This structure contains a series of east-west anticlines, synclines, and faults which could provide good structural and stratigraphic traps for hydrocarbons.

Sedimentary rocks are over 3 km thick in the central area of Kotzebue Sound and over 2 km thick over an additional 40,000 km2 area of the outer shelf. These thicknesses are considered to be minimal for the generation of hydrocarbons

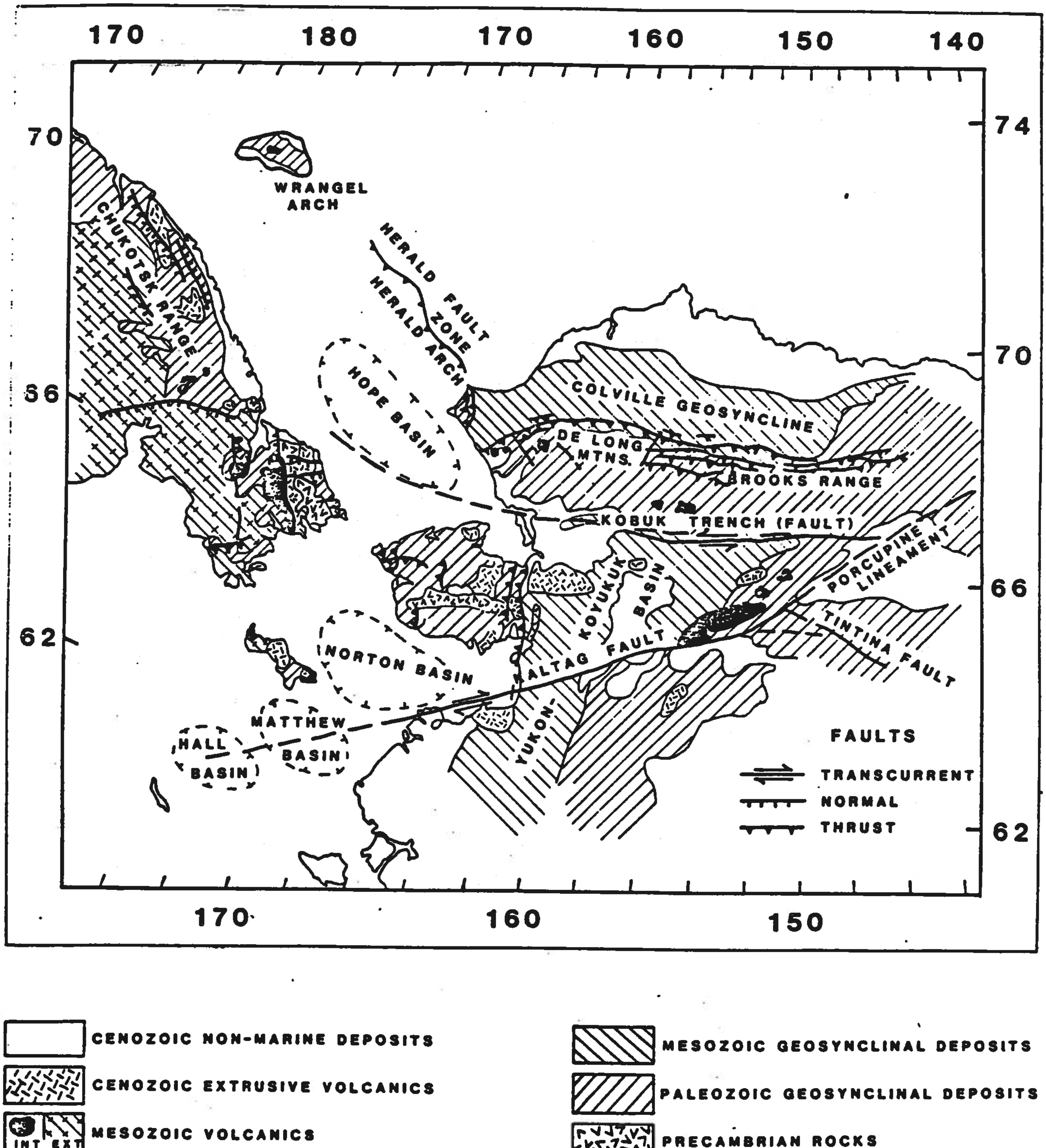


Figure 1.3. Geologic structures of the northern Bering and Chukchi Seas. The offshore shelf of the Chukchi Sea is a geologic extension of northwest Alaska and is believed to contain many of the same geologic units that are found onshore (from Holmes and Creager, 1981).

unless the area was subject to anomalously high heat flows. The onshore Tertiary volcanism and the evidence that this volcanic activity extended offshore may have provided the elevated heat flow in the Tertiary that was necessary to cook the source beds. The chances of such thermal events has also been estimated at about 50 percent.

Gas is suggested in this Basin by the occurrence of "bright spots" on seismic geophysical profiles. In addition, gas-charged sediments are suspected in near-surface sediments at depths of 5-15 m. Whether these are gases that have migrated upward along faults from deeper Tertiary sources or is gas generated in situ in the Holocene or upper Pleistocene sediments is unknown.

1.3 Potential Exploration and Development Scenarios

The presence of sea ice for up to nine months of the year and the absence of either existing shore-base facilities or transportation systems for any discovered oil place severe limitations on the oil industry's development options in the Hope Basin. To make it economically feasible to produce, discovered oil fields would have to be large to warrant the capital costs that would be required. Neverthe- less, the oil companies have outlined the future development options that are viewed as most feasible at present.

The United States Geological Survey (USGS, 1981) qualifies their resource estimates for the Hope Basin by stating that "These quantities can be considered recoverable only if technology permits their exploitation beneath Arctic pack ice - a condition not yet met." Industry views the sea ice problem as surmountable, and is developing plans for potential operation in these and other Arctic waters. For the Exploratory Phase, industry views on the type of equipment to be used vary from floating drilling rigs to man-made islands in shallow water. The use of artificial islands would allow year-round drilling, whereas floating rigs would be restricted to the brief open water season.

It is most likely that the exploration phase would proceed either from drill-ships or semisubmersible drilling rigs during the ice-free season. Table 1.2

Table 1.2 Exploration time-period estimates for the Hope Basin (in months) (R. Herrera, personal communication, 1979)

	Exploratory Drilling Using a Mobile Drill Rig
Preferred Month for Sale	Jan-April
Permitting Time	8-12
Equipment Mobilization Time	9-12
Site Preparation Time	0
Elapsed Time to Spud	15-18
Preferred Month for Start of Exploratory Drilling	July 1
Estimated Open Water Season	July 1 to Nov. 1 (4 months)
Exploration Drilling Season	July - November

is from an industry presentation (R. Herrera, p.c. 1979) outlining the schedule for potential exploration activity in the Hope Basin.

For the Development and Production Phase, industry views that present technology would permit development in the Kotzebue Sound where water depths are 20 m or less. Outside the Sound, estimates vary on the depths in which artificial islands could be constructed. Technological advances in operating in water depths greater than 20 m in the Beaufort Sea would be applicable to Hope Basin.

Department of the Interior projections (1981) based on their conditional resource estimates of 310 million barrels of oil and 1.29 trillion cubic feet of gas attempted to define the potential magnitude of OCS activity for the Hope Basin (Table 1.3). Their scenario calls for seven exploration wells to be drilled followed by 60 development/production wells from three production platforms. These development/production platform would probably be either man-made gravel islands or conical gravity platforms capable of operating in a water depth of up to 60 feet (DOI, 1980). Oil or gas transportation is envisioned to be by pipeline (225 miles total length) to Kotzebue Sound where a marine terminal, LNG facility, and support bases would be located. Oil or gas would then be loaded into ice-breaking tankers for shipment to the lower 48.

Another scenario proposes a pipeline of approximately 150 miles from the southside of Kotzebue Sound crossing the Seward Peninsula to the Nome area. This option would allow tanker shipment out of Nome on a year-round basis. Ice breaker type assistance would be required for only a few months out of the year.

1.4 Oilspills

The Department of the Interior (1981) estimates that for their conditional resource estimate of 310 million barrels of oil from 3 platforms and 60 wells, the statistically probable number of oil spills greater than 1,000 barrels in size is 1.80 over the life of the field including 0.78 greater than 10,000

Table 1.3 Estimated Resource and Activity Scenarios for the Hope Basin (DOI, 1981)

	Conditional Estimate
Total Oil (million barrels)	310
Total Gas (trillion cubic feet)	1.29
Million Acres Offered/# Sales	16
Exploratory Wells/First-Last	7/1986-1994
Development/Production Wells/First-Last	60/1990-2001
Platforms/First-Last	3/1989-1996
Pipelines (miles)	225
Statistically Probable # Oil Spills	
over 10,000 bbl.	0.78
over 1,000 bbl.	1.80
Oil Transportation[1]	P to T (to lower 48)
Gas transportation[1]	P to LNG facility T to lower 48
Possible Onshore Locations	not given[2]

1. P=pipeline

   T=tanker

   LNG=Liquid natural gas

2. Kotzebue Sound is given as a probable marine terminal, LNG and support facility for the Chukchi Sea.

barrels in size (Table 1.3). This number includes spills from both production and transportation sources and is based on statistical calculations of the volume of oil handled, age of tankers, number of tanker port calls, and miles of pipeline. Although there is a considerable uncertainty in the estimate, it does serve to provide some perspective of the degree of oil spill risk contained in the proposed OCS activity at the given resource estimate. By comparison, for the northeastern Chukchi Sea (Barrow Arch Sale 85) with a conditional resource estimate of 2.84 billion barrels of oil from 14 platforms and 560 producing wells, the estimated number of oil spills over 1,000 barrels was 16.49, including 7.18 greater than 10,000 bbl (DOI, 1981).

2. THE PHYSICAL ENVIRONMENT

The southeastern Chukchi Sea is a relatively flat and shallow shelf covered by water depths of less than 20 m in Kotzebue Sound to about 70 m in the deepest parts of the central shelf. The area is semi-enclosed with Kotzebue Sound occupying a large portion of the eastern region. The narrow waters of the Bering Strait form the southern boundary, while to the north the area opens into the broad northern Chukchi Sea shelf. There is an extensive coastline bordering the area which is formed by the shore of Kotzebue Sound and the Baldwin Peninsula to the east, and the projections of the Seward Peninsula on the south and the Lisburne Peninsula on the orth. Several large rivers empty into Kotzebue Sound, including the Selawik, the Kobuk, and the Noatak Rivers.

The southeastern Chukchi Sea contains numerous natural hazards. Sea ice is the most severe environmental hazard as the area is ice-covered at least 8 months of the year. Permafrost, gas-charged sediments, extreme cold, severe storms and storm surges are also present. On the other hand, the area is relatively aseismic and has no active volcanoes. The numerous normal and antithetic faults along the sea floor on the north side of the Kotzebue Arch (Figure 2.1) are considered to be inactive (Eittreim and Grantz, 1977). The nature of the physical environment and environmental hazards of this area is discussed in the following subsections.

2.1 The Coast

The shoreline and coastal waters of the Hope Basin proposed sale area extends from Cape Prince of Wales at about latitude 65°30'N. to slightly north of Point Hope at latitude 68°30'N. The following description of the coastal area is extracted primarily from the United States Coast Pilot 9 (USDOC, 1974). Geographical names used are shown on the map in Figure 2.2.

The coastal region of the northern Seward Peninsula between Cape Prince of Wales and Cape Espenberg is primarily a wide low coastal plain of sand, silt, and gravel alluvium. Plateaus, broad hills, and glaciated mountains form the

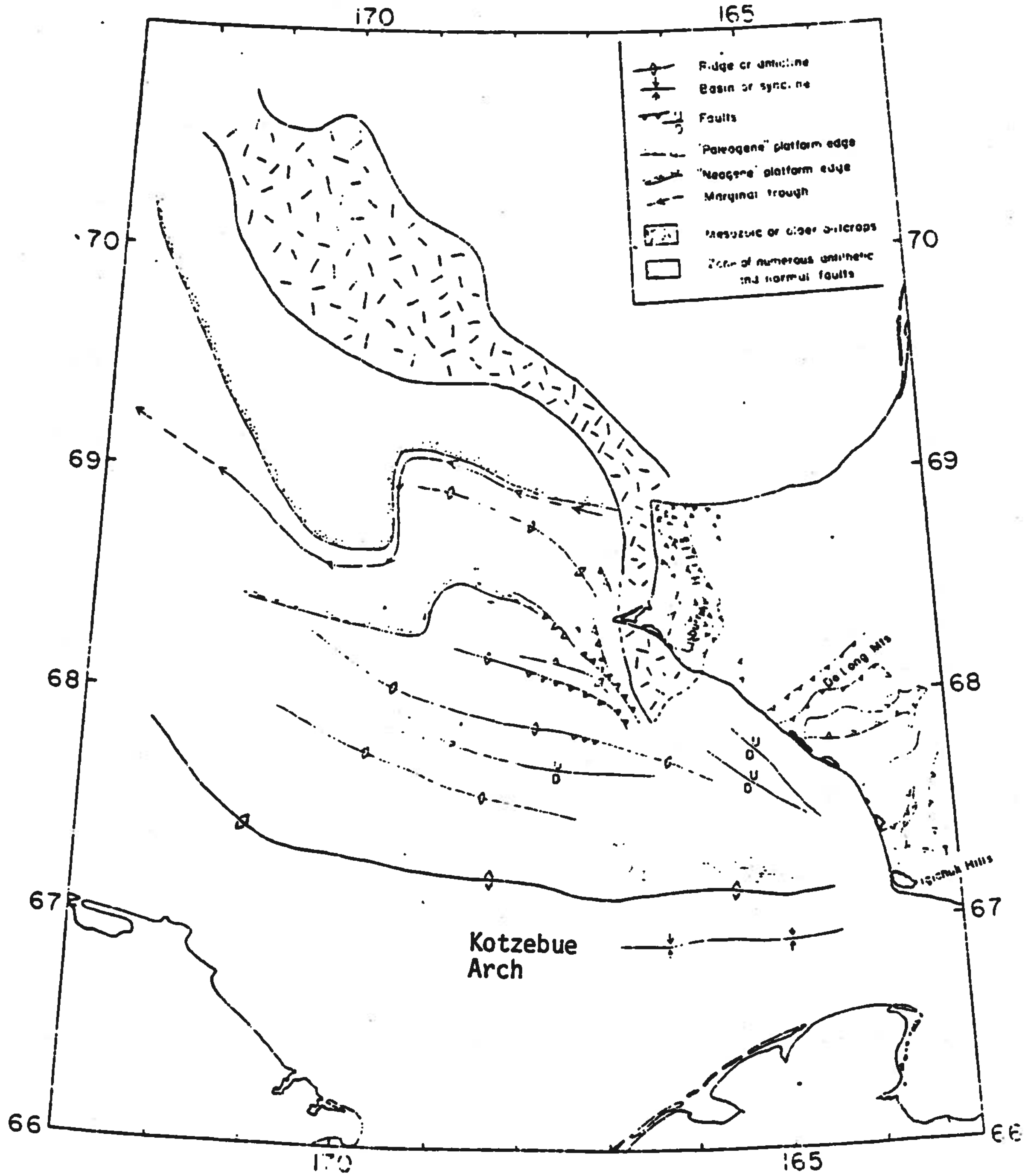


Figure 2.1 Hope Basin tectonic elements as interpreted from deep seismic data. The numerous faults on the northside of the Kotzebue Arch along approximately 67°N are believed to be inactive at present. The recency of the thrust faults west and south of Point Hope is uncertain (from Eittreim and Grantz, 1977).

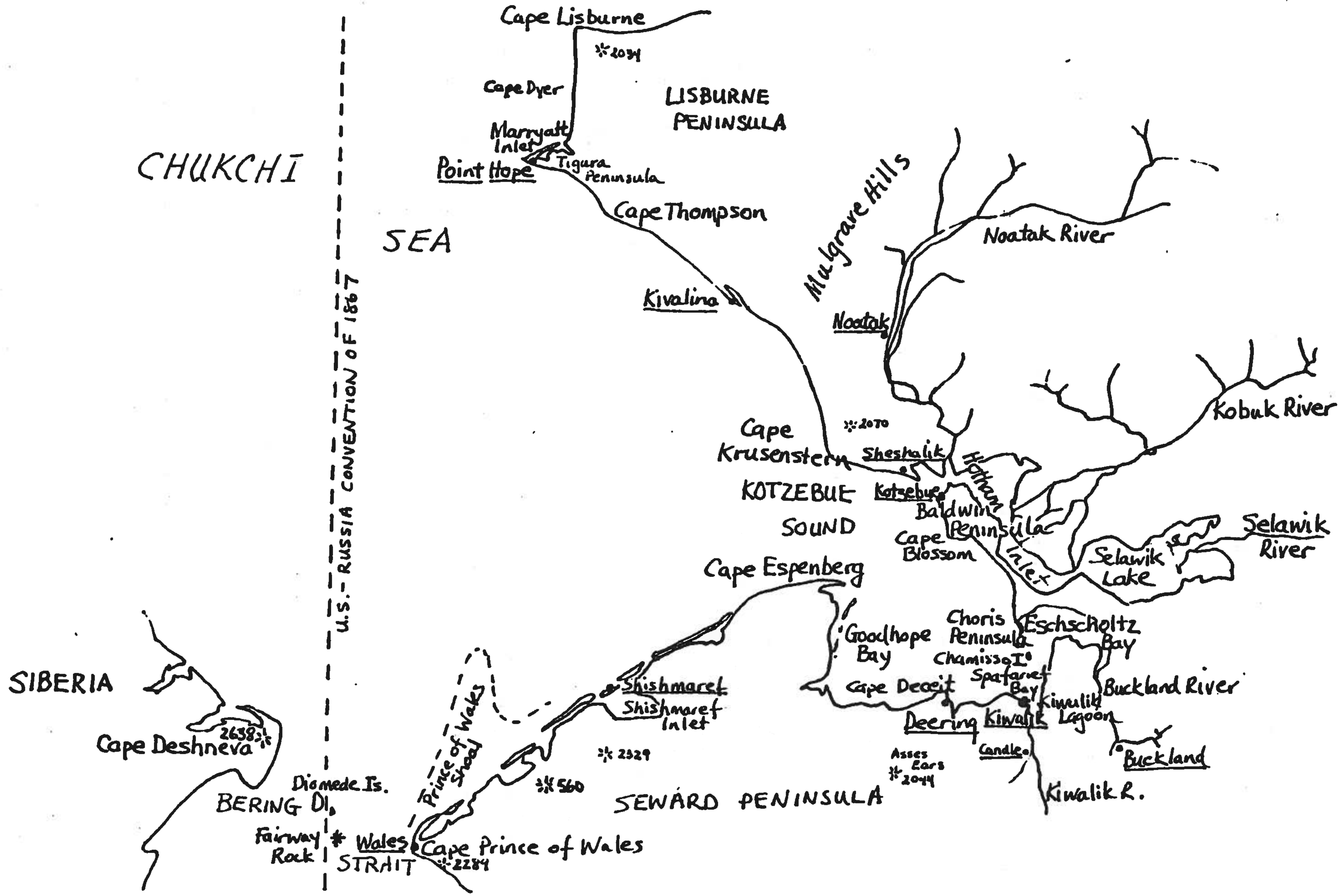


Figure 2.2. Map showing geographic name and locations along southeastern Chukchi Sea and Kotzebue Sound.

uplands which extend inward from the low-lying coastal regions. Many small but no large rivers drain this region. Vegetation in the coastal lowlands is "wet tundra" with low sedges and grasses. Higher slopes and summits have "dry tundra" of lichen-covered rocks, heaths, and dwarf shrubs.

Most of the coastline is fronted by barrier islands which are often breached by storm waves. Brackish and salt water lagoons form behind these sandy barriers and are used extensively for staging by birds prior to southward migration. Native settlements are scattered along the coast between Cape Prince of Wales and Cape Espenberg.

Cape Prince of Wales, on the Alaska side of the Bering Strait, is the western extremity of the Seward Peninsula. Cape Mountain, 2,289 feet high (Figure 2.3), is a mile back of the steep rocky shores on the southwest side of the cape.

Wales (1970 population 131), 2.5 miles northwest of Cape Mountain, is at the south end of a low sandy beach which extends 4 miles northward, then turns northeastward toward Shismaref Inlet. The village has a mission, a school, a store, and radiotelephone communication. Small planes carrying mail and a few passengers land on the beach in front of the village. Vessel anchorage off Wales is in depths of 10 fathoms, 0.8 mile from the beach. A nontidal current with a velocity of usually more than 1 knot, runs northward along this coast.

Prince of Wales Shoal is an elongate ridge of sand, 3 1/2 to 5 fathoms in depth, that extends for about 35 miles north-northeastward from the western extremity of the cape. The shoal is unmarked because of ice conditions and the remoteness of the locality, and is a hazard to deep-draft vessels.

Fairway Rock (Figure 2.4), 15 miles west of Cape Prince of Wales, is 534 feet high, square headed, and steep sided. The rock has deep water on all sides, and there are no outlying obstructions. Fairway Rock is regularly used as a hauling-out area by walrus, sealions, bearded, spotted, and ringed seals.

The Diomede Islands, midway between Cape Prince of Wales and the Siberian mainland, have nearly perpendicular sides and are without beaches. The tops

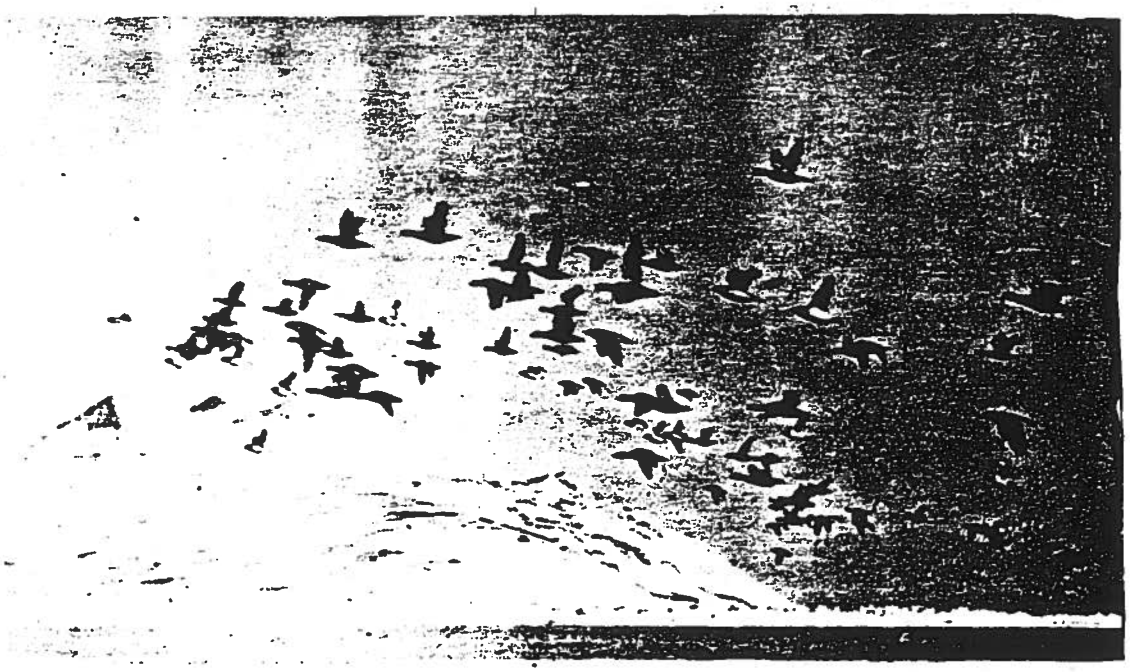


Figure 2.3 Cape Mountain, elevation 2289 feet, at the southwest tip of Cape Prince of Wales. Eiders and murres in the foreground migrating through the Bering Strait (from Bailey, 1971)

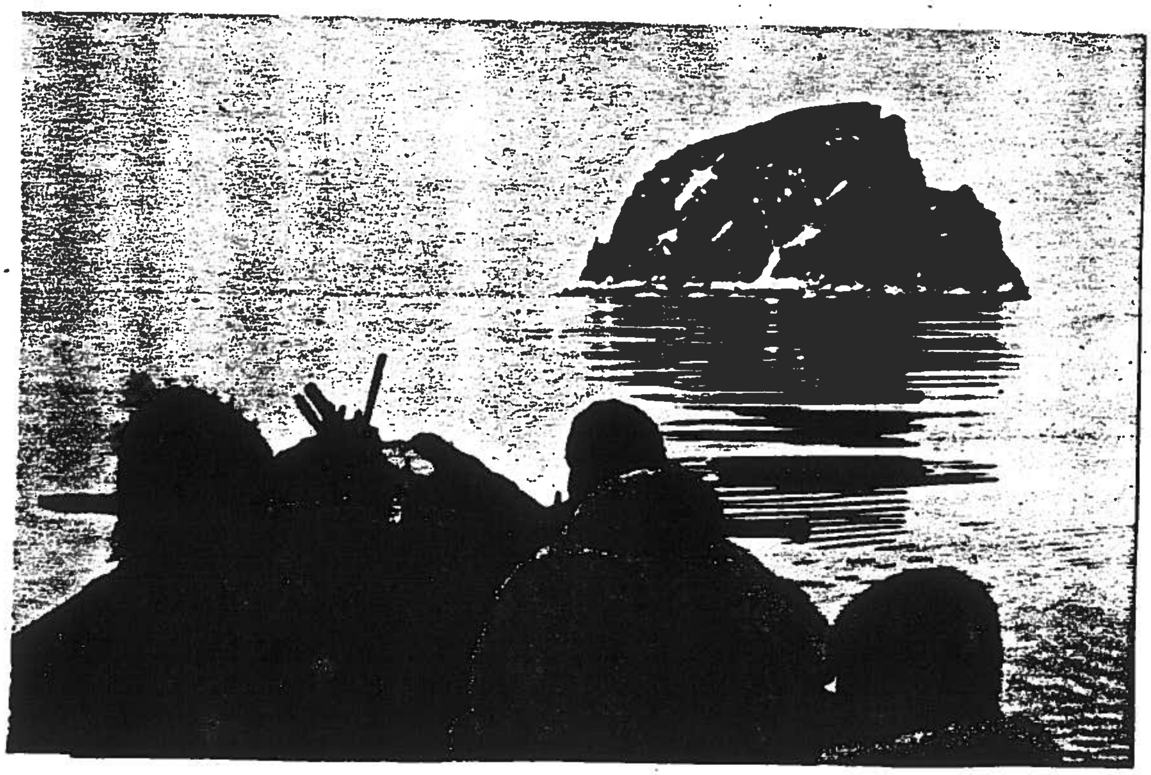


Figure 2.4 Fairway Rock viewed from the umiak of walrus hunters (from Bailey, 1971).

of the two islands are broken tablelands. The waters around the islands are deep, the bottom is mostly rocky, and anchorage is poor. The boundary between the U.S.S.R. and the U.S.A. passes between the two islands.

Little Diomede Island (Alaska), with an elevation of 1,308 feet, is 20 miles west-northwest of Cape Prince of Wales and 8 miles north-northwest of Fairway Rock. Diomede (Inalik) (1970 population 84), the only village on the island, is just north of a sandspit midway along the western shore. A reef extends westward from the sandspit toward the south end of Big Diomede Island.

Big Diomede Island (Siberia), 2.1 miles northwest of Little Diomede Island, rises to a height of 1,667 feet. Close to the western shore are some bare rocks. Deep water is reported between the two islands but passage is not advised for large vessels.

Cape Dezhneva (Siberia), 19 miles northwest of Big Diomede Island, is the eastern extremity of the mountainous peninsula at the northeastern end of the Siberian mainland. This peninsula, which rises to a height of 2,638 feet, resembles an island when seen from the distance because of the low, marshy land back of it. The coasts of the peninsula consist mainly of dark-colored cliffs rising steeply from the sea in jagged terraces.

From Cape Prince of Wales to Shishmaref Inlet, 60 miles, the coast is a low sand beach of barrier islands backed by lagoons and marshes. The mountains in the interior can be seen on a clear day; Potato Mountain, 1,400 feet, and Ear Mountain, 2,300 feet, are distinguishable.

Shishmaref Inlet is large and extends about 15 miles inland from the coast. Across its mouth is Sarichef Island, narrow and about 5 miles long.

Shishmaref (1970 population, 267), on Sarichef Island, is the most important settlement along this section of the coast. The village has a school, a mission, a store, a radio station, an airstrip, and limited supplies of gasoline, diesel fuel, food, and fresh water. Vessel anchorage is in depths of 5 fathoms 1.3 miles west-northwest of Shishmaref Light. Beach landings can be made only in calm weather on the seaward side of Sarichef Island because of the shallow water that extends 250 yards from shore.

A navigable channel into Shishmaref Inlet rounds the northeast end of Sarichef Island; a dangerous bar makes out 0.5 mile from the point on the north side of the channel. Vessels drawing as much as 7 feet may be beached on the channel side of the sandy northeast end of Sarichef Island; drafts of 3 feet may be taken to within 100 yards of the inner beach southwest of Shishmaref, and native skiffs can follow unmarked channels completely around the island.

For 60 miles northeastward and eastward from Shishmaref Inlet the coast is a line of low bluffs and small sand dunes that end in a very low spit at Cape Espenberg.

Cape Espenberg is formed by sediments transported by longshore currents flowing into Kotzebue Sound. Accretion is actively occurring on the north side of this peninsula, and sand dunes interspersed with ponds and marshes comprise the coastal land of the cape.

The coastal region between Cape Espenberg and Selawik Lake forms the western, southern, and eastern border of Kotzebue Sound, the largest bay on the Arctic coast. Baldwin Peninsula, a glacial moraine, separates Eschscholtz Bay and Kotzebue Sound from Hotham Inlet and Selawik Lake. Rivers flowing into the sound transport nutrients, sediments, and fresh water into the embayment. Deltas form as sediments are deposited at the river mouths. Additional sediments are added by the erosion of the sea cliffs at Cape Deceit.

Kotzebue Sound, at the northeast end of Seward Peninsula, is entered between Cape Espenberg and Cape Krusenstern, 33 miles to the northward. The Sound is a shallow embayment filled with sediments transported by the Noatak and Kobuk Rivers. Water depths are 6 to 9 fathoms throughout most of the sound.

Goodhope Bay on the 30-mile western side of Kotzebue Sound from Cape Espenberg south is relatively shallow, with depths of 3 fathoms as far as 5 miles from shore. The land on this side is mostly low.

The 45-mile southern shore of Kotzebue Sound proper is higher, rockier, and bolder than the western shore. Inshore depths are also greater, with 4 and 5 fathoms quite close to the promontories. Cape Deceit is halfway along the south shore.

Deering (1970 population, 85), on the east side of Cape Deceit, has a school, stores, and radio communication. Vessel anchorage is available in depths of 5 fathoms a mile east of Cape Deceit Light.

Kiwalik Lagoon, in the southeast corner of Kotzebue Sound, is shallow and has a mud bottom. A narrow channel winds through the lagoon to Kiwalik River which can be navigated only with local knowledge. Shallow-draft boats can operate in the lagoon during periods of high water, but the lagoon is almost dry when the water is lowered by adverse winds.

Kiwalik (1960 population, 10), on the gravel spit on the west side of the lagoon entrance, has a rough landing strip that will accommodate small planes; the diurnal range of tide is 2.7 feet at Kiwalik. Candle (1960 population, 103), about 6 miles upriver from Kiwalik, has stores, a school, and a gravel airstrip.

Spafarief Bay, also in the southeast corner of Kotzebue Sound but north of Kiwalik Lagoon, has depths of 3 to 5 fathoms.

Tundra-covered Chamisso Island (Figure 2.5), 231 feet high and about a mile long, is 11 miles northward across Spafarief Bay from Kiwalik Lagoon and 2.5 miles south of Choris Peninsula. The earth and rock bluffs that rim the island range in height from 15 feet at the south end to 80 feet at the northwest end. The shores are mostly broken boulders separated by short stretches of sand beach. Shallow water extends 0.3 to 0.5 miles from the north and east sides of the island. Just north of Chamisso Island is small Puffin Island with abundant colonies of murres, puffins, and kittiwakes.

Choris Peninsula (Figure 2.6), 300 feet in elevation, is a 6-mile southward projection from much larger and longer Baldwin Peninsula. The northerly of two hills on the small peninsula is joined to Baldwin Peninsula by a narrow neck of land about 20 feet in elevation. The outer end of Choris Peninsula

Figure 2.5. Mile-long Chamisso Island (elev. 231 ft) at the head of Eschscholtz Bay as seen from the ice in March (from Bailey, 1971).

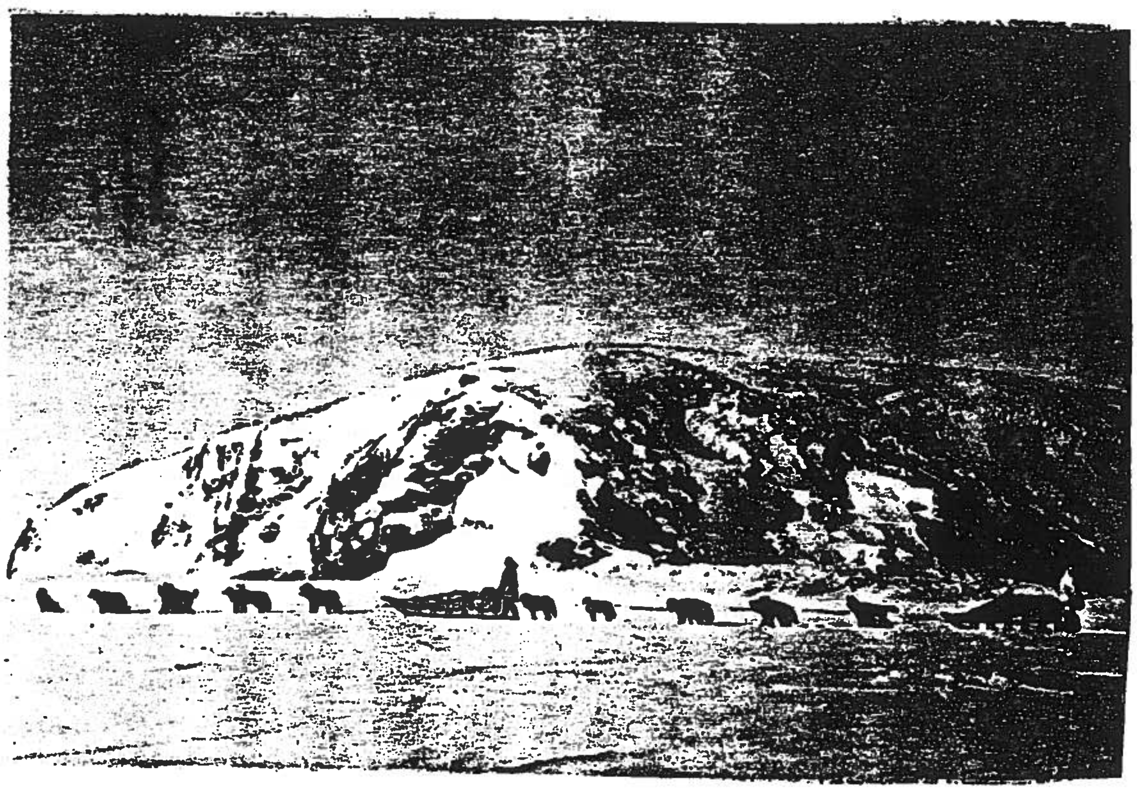


Figure 2.6. Choris Peninsula (elev. 300 ft) viewed from the south in March (from Bailey, 1971)

is the widest part, 2 miles, of the entire feature; the bluffs are 50 to 95 feet high and there are projecting rock ledges. The passage between Chamisso Island and Choris Peninsula has depths of 3 1/2 to 6 fathoms.

Eschscholtz Bay, behind Choris Peninsula, Chamisso Island, and Spafarief Bay, extends 20 miles eastward along the south side of Baldwin Peninsula and is mostly shallow. The shore at the head of the bay is rimmed with long muddy flats which bare at low water in some places as far as 0.3 mile from the beach. Buckland River, which empties into the head of Eschscholtz Bay, is large but shallow and has little traffic; Buckland (1970 population, 104), 10 miles upriver, has a radio station.

Northward of Choris Peninsula, Baldwin Peninsula is low for some distance, then rises to low bluffs which continue to the mouth of Hotham Inlet, 40 miles to the northwestward. The faces of the bluffs are deeply furrowed by the gradual melting and sliding of the surface ice and frozen mud. Cape Blossom (Figure 2.7) is a distinctive point in the Baldwin Peninsula bluffs, which are highest at this point and slope to either side.

Hotham Inlet entrance, 15 miles north of Cape Blossom and 30 miles east-southeast of Cape Krusenstern, is obstructed by vast mud flats and sandbars, some of which are bare at low water. The 3-fathom curve extends as much as 9 miles from shore and nearly as far south as Cape Blossom. The inner waters of Hotham Inlet are 4 to 15 miles wide and extend 45 miles southeastward behind the Baldwin Peninsula. Charted depths are 1 to 2 fathoms in what passes for a channel through this inner expanse, which has been known locally as Kobuk Lake. Landings cannot be made at many places in Hotham Inlet because of the extensive mud flats. The waters are little influenced by tides and are mostly fresh because of the near absence of any eastward current; prolonged southeast winds frequently lower the water level.

Kotzebue (1970 population, 1696) (Figure 2.8), 11 miles north of Cape Blossom and on the outer south side of Hotham Inlet entrance, has a school, a hospital, missions, stores, banking facilities, fur farms, airstrips, an aero light and radiobeacon, and telephone communication. Vessels of less than 6-foot draft can reach the town if they know the channel, which is shifting

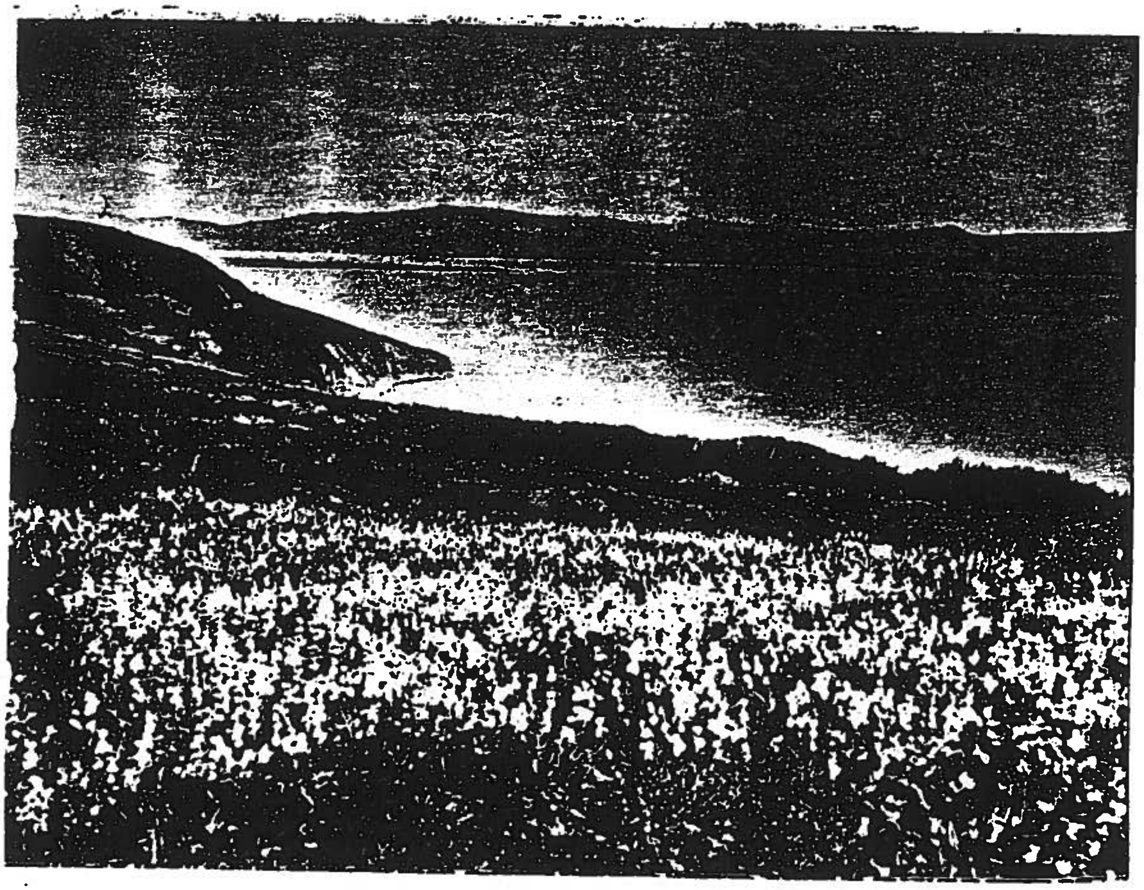


Figure 2.7. Cape Blossom on the Baldwin Peninsula about 15 miles south of Kotzebue. Cottongrass (Eriophorum sp.) in the foreground (from Bailey, 1971).

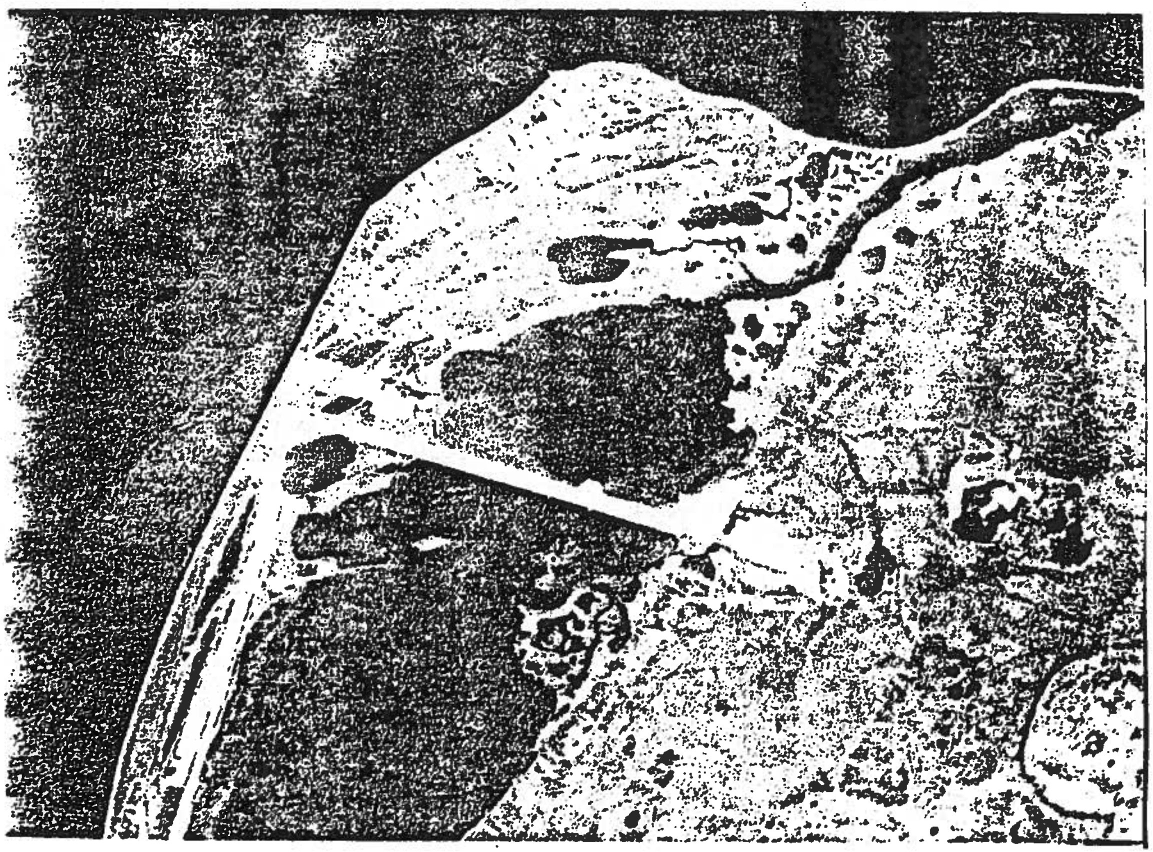


Figure 2.8. Aerial view of the city of Kotzebue at the northwest tip of the Baldwin Peninsula.

and difficult to follow. Deep-draft vessels approach Kotzebue as closely as possible and lighter their freight ashore. The usual anchorage for deepdraft vessels is in depths of 5 to 6 fathoms 3 to 6 miles southwest of Cape Blossom where protection is afforded from northerly and easterly winds. The trip by small boat from the anchorage to Kotzebue is about 15 miles and over many sandbars that are constantly shifting.

The coastal region between Selawik Lake and Cape Krusenstern forms the northern and part of the eastern boundary of Kotzebue Sound. Two major rivers, the Noatak and the Kobuk, flow into this region of Kotzebue Sound. The majority of the sediments entering from these rivers are deposited within Kotzebue Sound. Shallow bodies of water, such as Hotham Inlet, are areas where these sediments are accumulating. Some sediments moving in a west to east direction are accumulating to build Sheshalik Spit, a projection of land west of the Noatak River.

The Kobuk River empties into the east side of Hotham Inlet through a many mouthed delta which extends inland for about 30 miles; depths off the delta are 2 to 4 feet for as much as 3 miles. The delta channels are difficult to navigate but the river proper is comparatively wide and deep. The natives portage their canoes from the headwaters of Kobuk River to the Koyukuk River, a tributary of the Yukon.

The Noatak River, which empties into the north side of Hotham Inlet entrance, has numerous rapids and is not navigated for any great distance by anything larger than a canoe. The natives portage from the headwaters of the Noatak River to the Chipp River, where they can follow the latter to the Beaufort Sea. Noatak (1970 population, 293) about 35 miles upriver from Hotham Inlet, has an airstrip and a radio station.

The coast is low from Hotham Inlet to Cape Krusenstern, and shallow water extends nearly half the distance from the mouth of the inlet toward the cape; the edge of the shoal is steep. For the rest of the distance there are depths of 4 to 6 fathoms close to shore.

The area from Cape Krusenstern to Point Hope is primarily an erosional coast interspersed with a few lagoons and short barrier benches. These benches are typically narrow and backed by low cliffs. This coast is ice influenced for approximately eight months of the year. The mountains of the Brooks Range descend into the Chukchi Sea near Cape Thompson in a series of steep bluffs and cliffs that are fronted by narrow gravel beaches usually less than 60 m (200 ft.) wide. At freeze-up a "kaimoo", or bed of gravel and ice up to 2 m thick and as much as 12 m wide, forms to protect the beach from wave and ice action.

Erosion of the coastal cliffs and bluffs adds coarse sediments to the local beaches. Deposition of finer sediments is occurring on the southside of Cape Krusenstern, while active erosion is occurring on the western side. The projection of land called Point Hope is a region of deposition and convergence of local currents. Point Hope is receiving sediment from the Kukpuk River, the cliffs near Cape Thompson, and the cliffs north to Cape Lisburne. Sediments are accumulating on the south side of Point Hope, and erosion is taking place on the north side.

North of Cape Krusenstern the coast is a low, shingle beach backed by numerous lagoons which discharge through small shallow openings. The high ground behind the cape continues at some distance inland to the Mulgrave Hills, about 30 miles north of the cape. Beyond the hills is a wide plain which extends another 30 miles before the mountains again approach the coast and slope down to the water.

About 42 miles north-northwest of Cape Krusenstern is the inlet to Kivalina Lagoon which extends another 8 miles northwestward behind the barrier beach which separates it from the ocean. Kivalina (1970 population, 188), on the barrier beach near the inlet, has a school, a store, a radio station, and an airstrip. Small-craft anchorage is available along the inner side of the village where the channel bears in close to shore. Shifting shoals extends as much as 0.3 mile from either side of the inlet.

At Cape Thompson (Figure 2.9 and 2.10), 80 miles northwest of Cape Krusenstern, the mountains descend to the water in a series of steep bluffs

Figure 2.9. Cape Thompson cliffs (from Bailey, 1971)

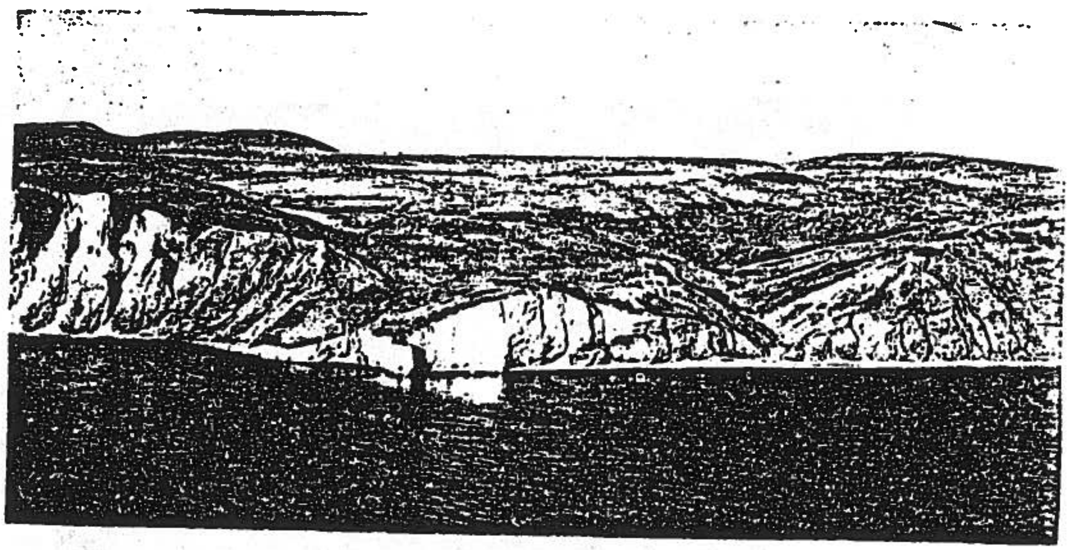


Figure 2.10. Cape Thompson cliffs (from Campbell, 1966).

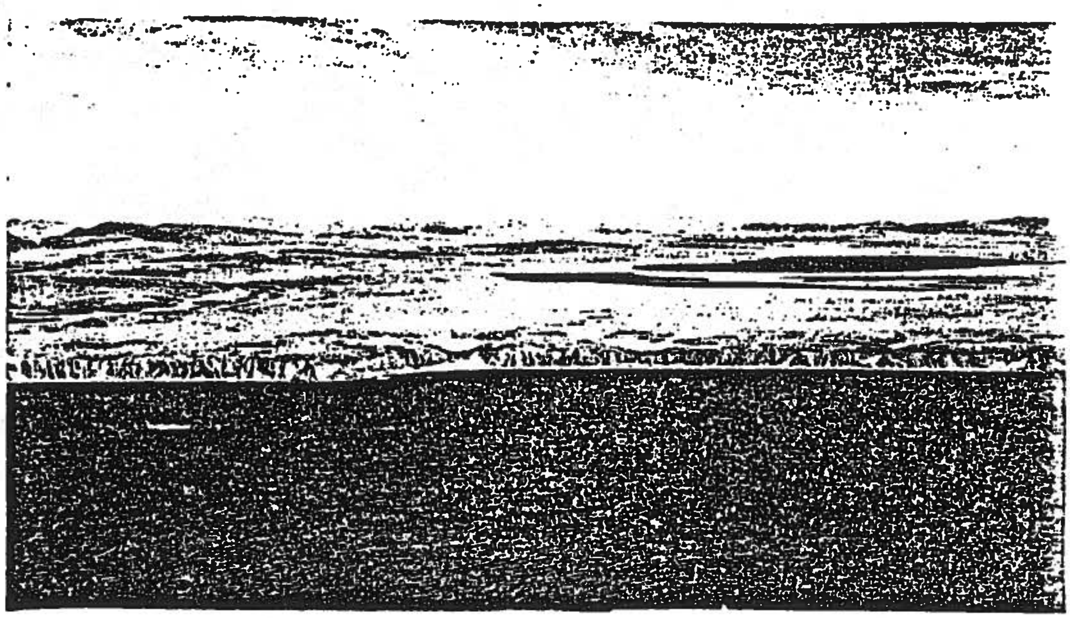


Figure 2.11. Wave-planed lowland coast about 10 miles north of Point Hope (from Campbell, 1966).

and cliffs about 500 feet high and 6 miles long. Thousands of sea birds nest along the bluffs and their eggs are an Eskimo source of fresh food supply in early summer.

This coast is without distinct promontories. In the bight 1 mile north of Cape Thompson, the water is fairly deep close to shore and remains calm in the severest northerly and easterly storms.

From Cape Thompson the mountains continue northward to Cape Lisburne, while the coast curves northwestward and westward to Point Hope. Point Hope, 22 miles northwest of Cape Thompson and 102 miles from Cape Krusenstern, is the seaward extremity of a low tongue of land, the Tigara Peninsula, that projects 16 miles westward from the general line of the coastal mountains. The point has a steep shingle beach which is backed by numerous lagoons. The village of Point Hope (1970 population, 386) is the most important settlement along this part of the coast and has a school, a mission, a store, a radio station, and an airstrip.

Marryatt Inlet, 10 miles east-northeast of Point Hope, is the entrance to a large lagoon. When the ice breaks in the lagoon, there is a strong outflowing current and the moving ice is more or less dangerous. North of Marryatt Inlet the mountains slope down to rugged shore cliffs (Figure 2.11). The few ravines in the cliffs have running streams.

Cape Lisburne (Figure 2.12), 35 miles north-northeastward of Point Hope, is a bare brown mountain 849 feet high. This rugged headland is distinctively marked by the pinnacles and rocks near its summit, and its shore faces are very steep. The cliffs are rookeries, and during the summer months the sky is sometimes darkened by flights of birds. The wind rushes down from the mountains in gusts of great violence and varying directions, and at such times passing vessels should stay well off the cape.

2.2 The Southeastern Chukchi Sea Shelf

The continental shelf of the entire Chukchi Sea including the Hope Basin area, is thought to be part of a large continent that has recently submerged.

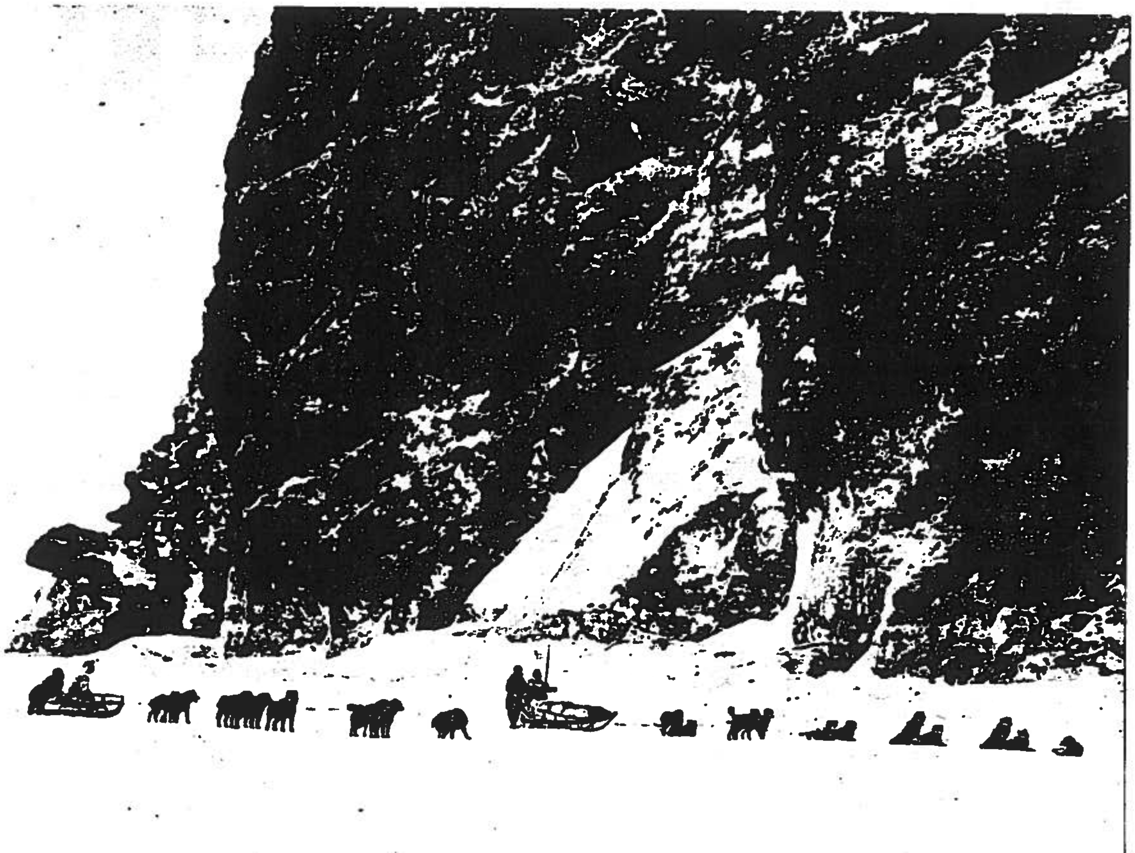


Figure 2.12. The cliffs at Cape Lisburne (from Bailey, 1971).

Bedrock stratigraphic and geomorphic structures suggest a dry intercontinental land connection of low mountains between Alaska and Siberia that existed until about one million years ago (Hopkins, 1959; Ostenso, 1968). This low mountain barrier was subsequently reduced by erosion to a peneplain-type feature that has been further modified by subsequent periodic rises and falls in sea level. Relief features have been substantially obscured by scouring and sediment deposition to the present time. The only remnants of the Tertiary landscape in the Chukchi Sea are the Hope Valley, the Barrow Canyon, and the Herald Shoal (Sharma, 1979).

2.2.1 Bathymetry

The seafloor of the southeastern Chukchi Sea is monotonously flat and relatively featureless (Figure 2.13). Water depths are shallow throughout and the contours are gentle. Nearshore depths along the coast are usually less than 20 m and remain less than 60 m throughout nearly the entire shelf. Maximum recorded depth in this area is 70 m (32 fathoms). In Kotzebue Sound between Cape Espenberg and Cape Krusenstern, the waters are shallow, rarely exceeding 20 m. Prince of Wales Shoal is a conspicuous lobate topographic feature that extends from the eastern margin of the Bering Strait northward for about 120 km. The shoal is narrow and less than 10 m deep near the Bering Strait but broadens rapidly northward to a width of approximately 50 km. The broad seaward end of the shoal slopes gently down and northward to a depth of 50 m.

A prominent S-shaped depression lying south of Point Hope is the east-west running Hope Sea Valley. This feature originates west of Cape Krusenstern and extends northwest and west. The deepest portions of the southeastern Chukchi Sea lies along the Hope Valley. It thought that this feature represents an ancient drainage channel of the former intercontinental land bridge.

Nearshore depths in this region are partially maintained by currents and altered by seasonal ice gouging. Storm actions shift sand spits and shoals considerably but there is little evidence of storm waves affecting deeper areas. Little else in the way of bathymetric features are present in this

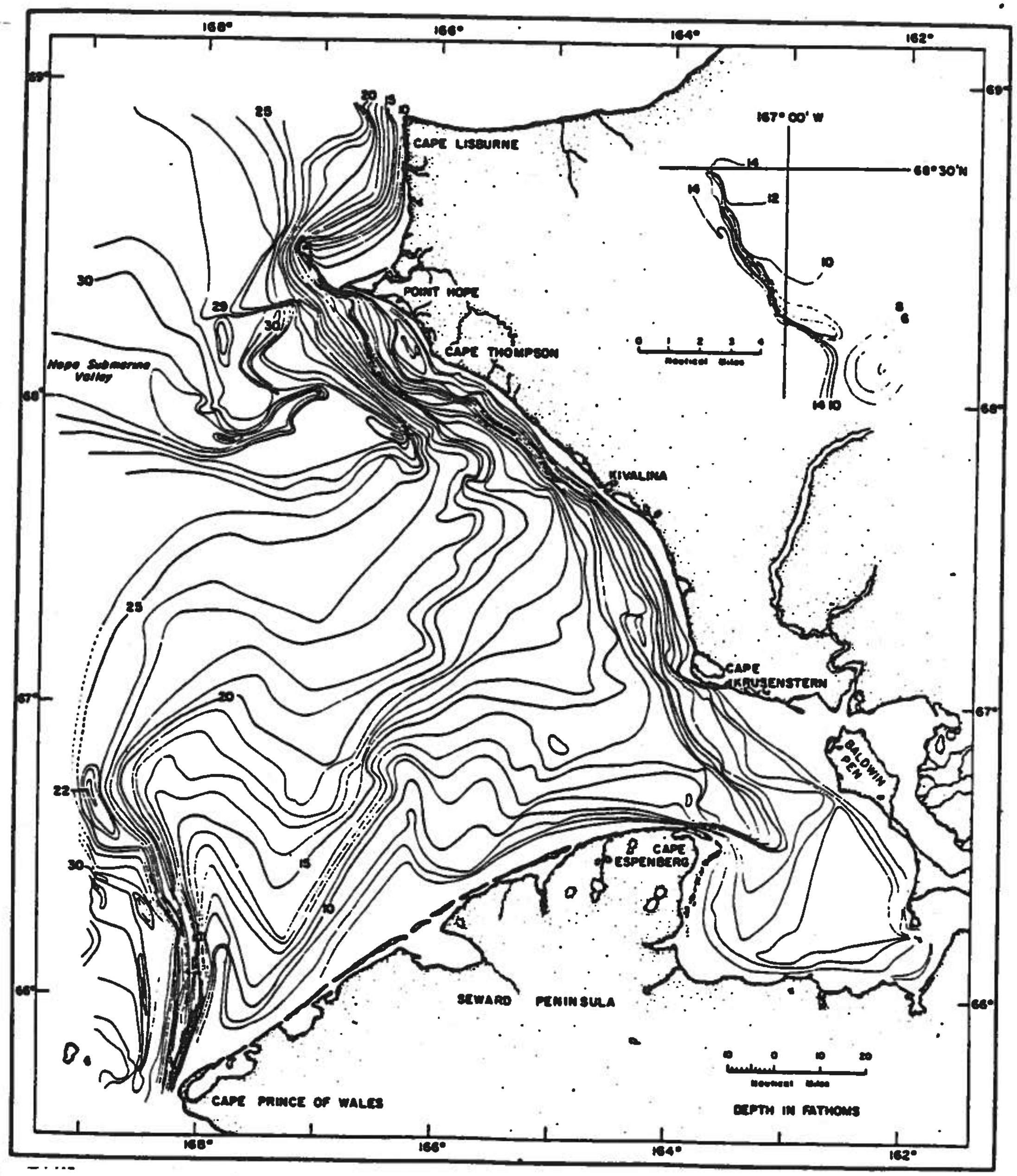


Figure 2.13. The bathymetry of the southeastern Chukchi Sea (from Creager and McManus, 1966).

area. Detailed bathymetry can be found in NOS Chart 16005 (6th edition, 1976).

2.2.2 Seafloor Sediments

The sediments laying beyond the depth of wave action along the Chukchi Coast appear to be a mixture of modern, relict, and residual deposits of silt, sand, and gravel. Modern sediments predominate in the Hope Basin area of the southern Chukchi Sea while relict and residual sediments occur north of Cape Lisburne (Figure 2.14).

The seafloor sediments of the Hope Basin tend to grade offshore from sand and gravel to sand, silt, and clay (Figure 2.15). Gravel deposits exist mainly as long narrow belts along the shore, as more expansive deposits at the base of the Lisburne Peninsula sea cliffs, and in several isolated offshore patches. Sands predominate over much of the nearshore area out to depths of 40 m (60-80% of sediment composition) and near river mouths. Silts with clay are most common in the farthest offshore and deepest waters (40-60%). Clays form a relatively minor component of the seafloor sediments on the Chukchi Sea Shelf (less than 5% nearshore, to 25% offshore).

This sediment cover is often thin and patchy (Table 2.1). In some areas its depth is reported to rarely exceed 10 m and is frequently only 3-5 m thick (Moore, 1964). In water depths greater than 50 m, bedrock is frequently exposed with only local patches of sediment filling depressions.

The Bering Strait area is covered with sand and some patches of gravel. Northward and northeastward of the Bering Strait, the seafloor sediments are mostly moderately to poorly sorted sand, especially prominent as the Prince of Wales Shoal. Sandy sediments extend across the mouth of Kotzebue Sound and along the northeast shore to Kivalina. A narrow belt of gravel lies along the shore from Kivalina to Cape Lisburne. Sand transported by currents occupies the nearshore region beyond the gravelly shore.

Seaward from the coast, the sediments generally become progressively finer, consisting mostly of silt mixed with sand and clay transported out from

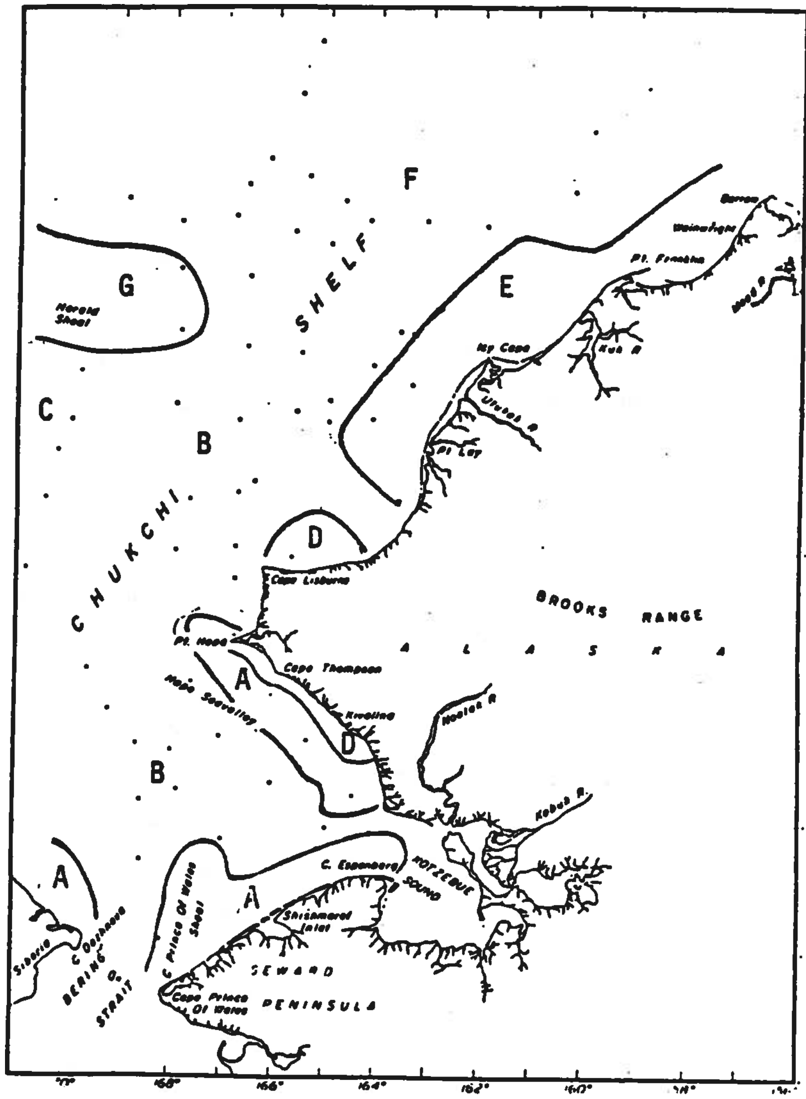


Figure 2.14. Sediment origin and composition on the Chukchi Sea Shelf. A=modern current-transported and current-deposited sand; B=modern silt; C=modern clayey silt; D=relict sand with gravel; E=relict and residual sediment; F=mixed sediment of ice-covered shelf; G=relict and residual sediment of Herald Shoal and Wrangel Island.

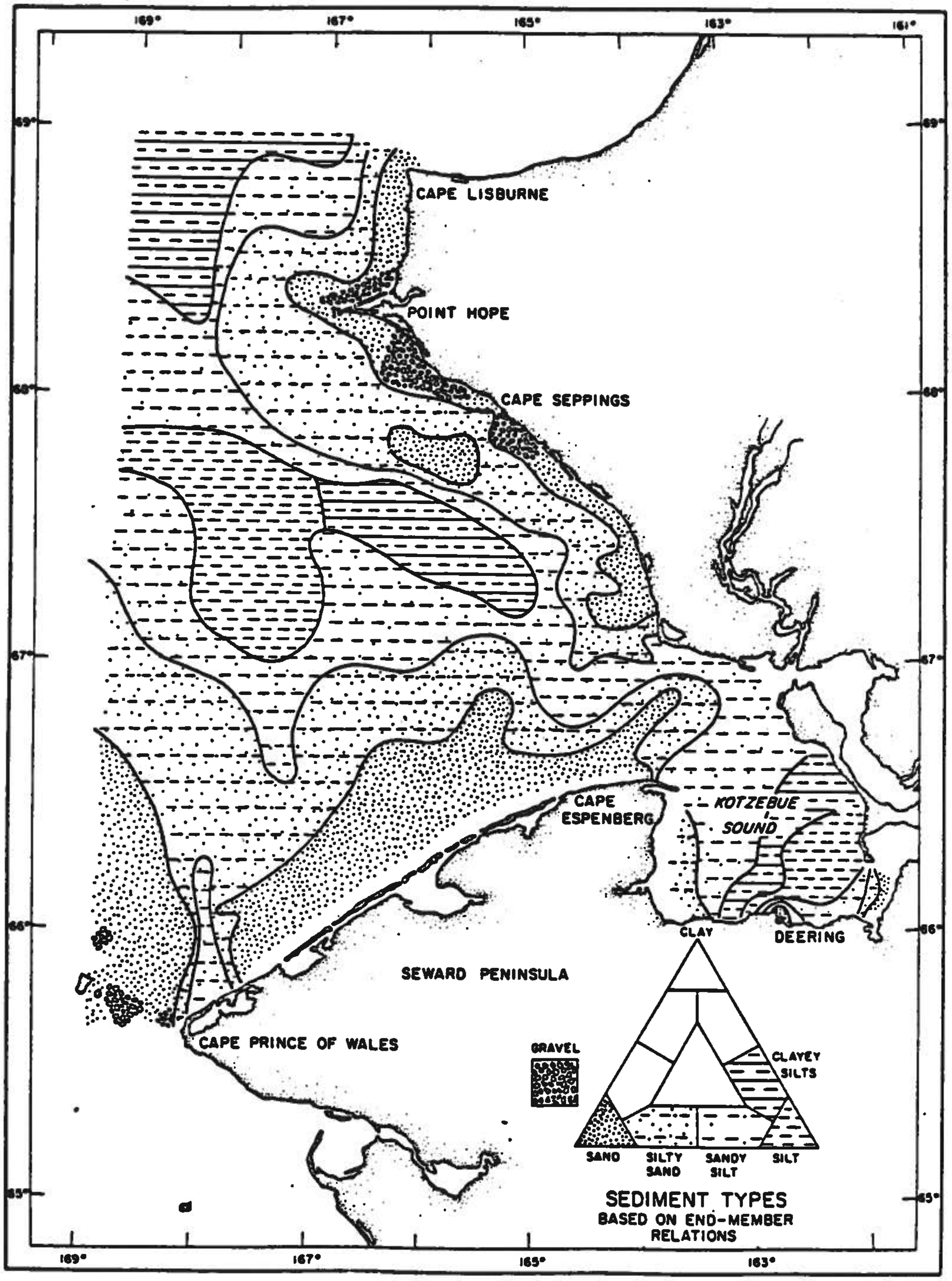


Figure 2.15. Distribution of sediment types in the southeastern Chukchi Sea based on end-member relations (from Creager and McManus, 1966).

Table 2.1. Surficial Sediments and Seafloor Geology of the Southeast Chukchi Sea (after AEIDC, 1975)

General Offshore Vicinity	Type of Sediment	Average Depth of Sediment Cover	Foundation
Bering Strait	sand	to 12m in depressions	structureless rock
Seward Peninsula	sand	3 to 7 m	rock?
Central Hope Basin	silt	nil	possible bedrock
Kivalina	silty sand	to 10 m	bedrock
Cape Thompson	silty sand	0 to 1 m	bedrock
Point Hope	silty sand	2 to 4 m	bedrock
Cape Lisburne	sandy silt	3 m	hard bedrock

shallower waters. In waters less than 50 m, silty sand is commonly deposited, while clayey silts are mostly deposited at water depths greater than 50 m. The offshore sediments west of Point Hope are mostly silt.

The degree of sorting of sediments (Figure 2.16) is mostly related to water energy. The sediment size and water depth relationship suggests that wave energy on the shelf is an important factor for sediment transport. In areas of intense current and wave action, such as along the northwest shore of the Seward Peninsula, the sandy sediments are moderately well sorted, while in lower energy environments, e.g., inner Kotzebue Sound, they are poorly sorted. Nearshore gravel deposits are usually poorly sorted. Sands deposited along the northern side of the Seward Peninsula are the result of wave sorting, whereas sands deposited near the mouth of Kotzebue Sound are influenced by tidal currents (McManus et al., 1969).

2.3 Climate and Weather

Detailed information on the climate and meteorology of the southeastern Chukchi Sea coast can be found in AEIDC (1975) and Brower et al. (1977). The following discussion summarizes this information.

The climate of the Chukchi Sea coast is cool in the summer and cold in the winter. The short summers are under the influence of maritime winds with much cloudiness, fog, frequent rain and drizzle, and continuous daylight. In winter, cloudiness decreases and cold northeasterly winds prevail along the coast. Average climatic conditions measured at the few recording locations in the Hope Basin region are given in Table 2.2.

Temperatures decrease with progression northward. Temperatures average -15°F to -12°F in the winter (January-February) and +49°F to +58°F in the summer (July-August). The low winter temperatures are often worsened by wind chill factors equivalent to -60°F to -100°F.

Total annual precipitation, like temperature, decreases from south to north. Year-round precipitation is light, usually averaging less than 12 inches annually, except at Wales which receives about 18 inches, mainly from Bering

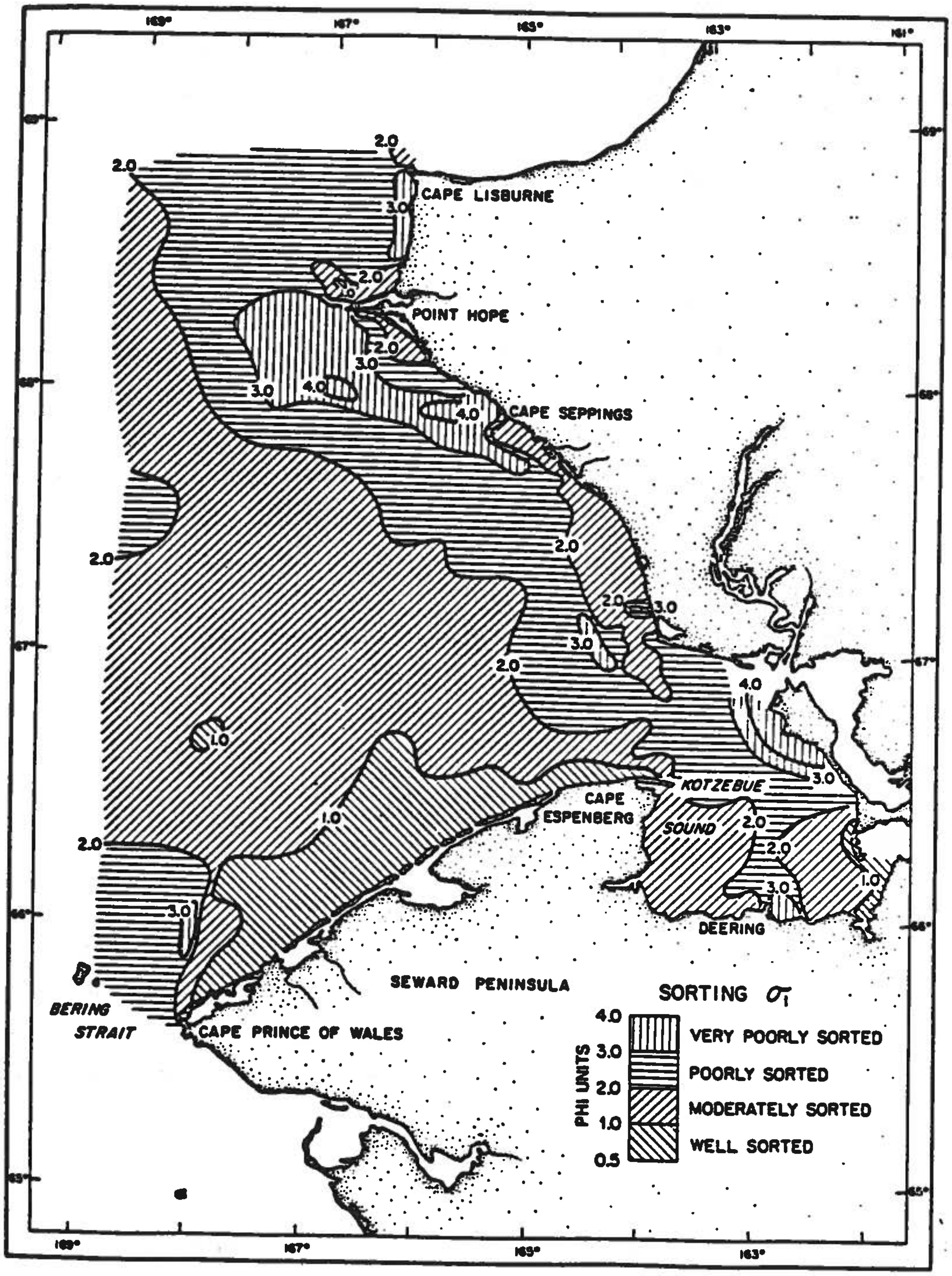


Figure 2.16. The relative degree of sorting of sediment grain sizes based on the standard deviation of phi size (from Creager and McManus, 1966).

Table 2.2 Selected Weather data for the Hope Basin.

	Wales-Tin City	Shishmaref	Kotzebue	Cape Lisburne
Temperature, °F				
Mean Monthly High	+49/Aug	+53/July	+58/July	+50/July
Record High	+75	+77	+84	+73
Mean Monthly Low	-12/Feb	-13/Jan	-12/Feb	-15/Feb
Record Low	-45	-48	-53/Feb	-47
Precipitation, inches				
Mean Monthly High	3.7/Aug-Sept	1.7/Aug	2.2/Aug	2.7/Aug
Mean Monthly Low	0.6/May	0.3/Aug	0.3/Feb	0.3/Apr
Mean Annual	18.1	8.0	8.8	11.3
Mean Annual Snowfall	69.3	32	47.4	49.8
Surface Winds				
Mean Direction/Speed (knots)	N/15	?	E/13	E/12
Max. Direction/Speed	NW/65	?	ESE/93	SE/70

? = unrecorded

Sea storms. Precipitation occurs mostly as rain in July to September. The average annual snowfall on the coast is moderate (32 to 69 inches), most of it in October-November. A snow-cover is usually established by late September and persists until June. The entire coastal area experiences extensive drifting of snow due to the strong winter winds.

Surface winds along the coast are fairly constant throughout the year. Winds are predominantly from east to northeast except for the stronger south winds associated with storms from the Bering Sea. A general average wind speed is 10-15 mph, or 15-20 mph at more exposed locations. Wind speeds greater than 25 mph occur generally less than 10% of the time except during the windiest months of August and September. Maximum steady winds of 35 mph can occur any month and gusts often attain much greater speeds. The predicted maximum sustained wind speed in the arctic region is 80 knots (90 mph). An extreme steady wind of 93 knots has been reported from Kotzebue.

Cloudiness is prevalent in summer and autumn, with low stratus clouds forming ceilings that are frequently less than 1500 feet. These overcasts result from low clouds and fog formed over the open water and moved onshore by the prevailing winds. Overcasts and low ceilings can persist for weeks. Cloudiness decreases in the winter when the surrounding water surface is frozen and fewer clouds form.

Fog is the most important visibility-limiting factor during the summer, while blowing snow most frequently reduces winter visibility. Advection fog, caused by warm, moist air moving over the cold water or ice, occurs along the Chukchi Sea coast about 15-20 days per month during June- September. At Cape Lisburne, minimum horizontal visibility of less than one mile occurs 20-24 days/month during the summer, and 10 to 20 days/ month during the winter.

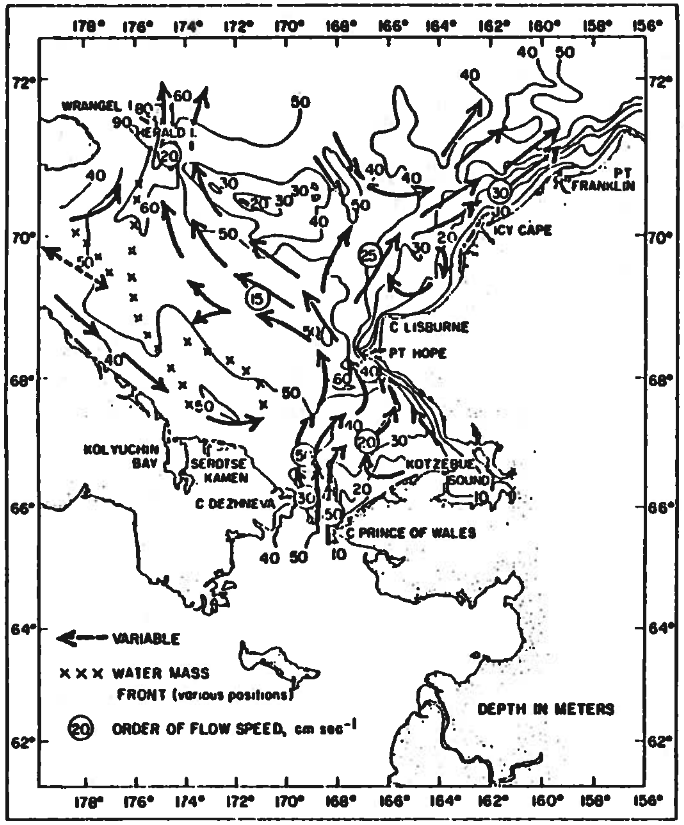
The Chukchi coast receives nearly continuous daylight from May to August. At Kotzebue, the sun never sets between late May and mid-July. During the winter there are a few days in late December when the sun does not rise above the horizon. In spring and fall the ratio of daylight to darkness is continuously changing. Twilight hours are important for light during the intervening seasons. Twilight may amount to 6 hours in late November and early February, but is reduced to 3 hours by December 21, the shortest day of the year. On a total annual basis, the Arctic receives about an equal amount of daylight as lower latitudes. However, because the sun's rays reach the Arctic at a low angle, the amount of incident radiation received is much less.

2.4 Physical Oceanography

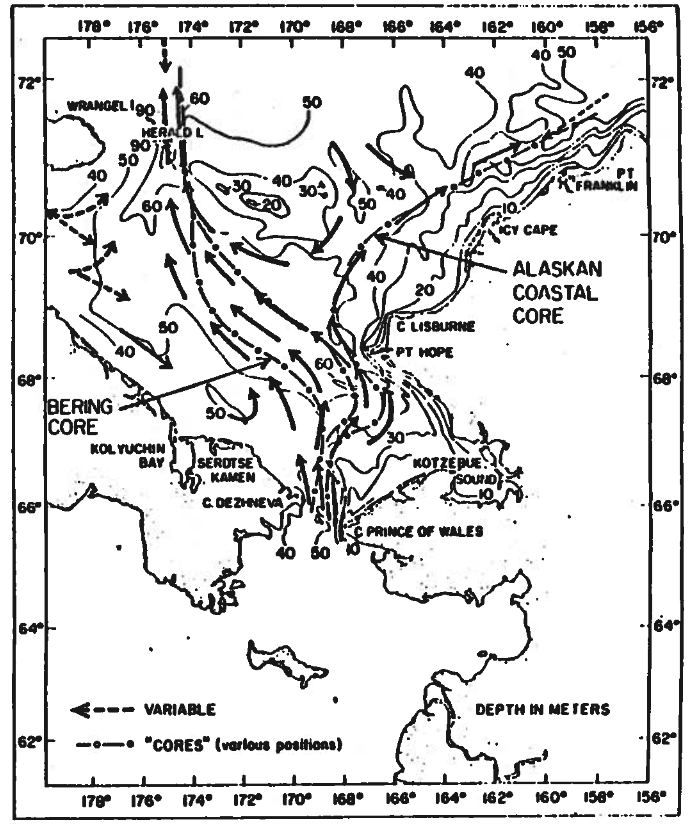
The waters of the eastern Chukchi Sea originate primarily from a northward flow of Bering Sea waters through the Bering Strait. These waters are derived from three sources: Alaskan Coastal Water, the Bering Shelf Water, and the Anadyr Shelf Water (Coachman et al., 1975). As they flow northward across the Chukchi Sea, these water masses undergo considerable modification by mixing, ice melt, and river input before eventually entering the Arctic Ocean as a subsurface water layer.

The hydrography and circulation of the southeastern Chukchi Sea are only generally understood. A northward flowing coastal current (Alaskan Coastal Water) enters on the eastern side of the Bering Strait and flows into the Chukchi Sea parallel to the bottom contours. In the summer near the coast, this water is identified as a warm (>1°C), low salinity (<31°/oo) water which generally occupies the entire water column of nearshore areas. The low salinity of this water mass results from the large freshwater discharge of Alaskan rivers into the Bering Sea and Kotzebue Sound. Farther from shore, the Alaskan Coastal Water often forms a warm surface water layer up to 25 m in depth. This warm coastal current has been traced as far north as the Colville River delta in the Beaufort Sea (Paquette and Bourke, 1974).

The Bering Shelf and the Anadyr Shelf Waters mix soon after passing the Bering Strait, and are found in the Chukchi Sea as a water mass termed the Bering Sea Water by Coachman et al., (1975). This water (Figure 2.17) covers the central portions of the Chukchi Sea, and is characterized by a temperature of at least 2°C and a salinity of greater than 31.5°/oo. Near the coast, Bering Sea water may occur as a subsurface water layer beneath Alaska Coastal Water.



Upper Layer Flow



Lower Layer Flow

Figure 2.17. Schematic of flow in the Chukchi Sea in the summer. Dotted arrows indicate variable currents. Various positions of water mass fronts are indicated. Circled numbers are estimated current speeds in cm/sec. (from Coachman et al., 1975).

An amount of high density residual water cooled by the previous winter usually remains in the southeast Chukchi Sea throughout the summer. This water, characteristically colder and more saline than either Bering Sea Water or Alaskan Coastal Water, tends to occupy the bottom layer of the deeper shelf areas.

Coachman and Aagaard (1981) have recently revised their estimates of water transport through the Bering Strait. Earlier data based on summer transport measurements suggested a mean flow north through the Bering Strait into the Chukchi Sea of 1.5 to 1.7 Sv ($Sv=10^6 m^3/sec$). More recent data, including a series of measurements over seven months from September, 1976 to March, 1977 showed significantly lower winter transport values and a high incidence of flow reversals. Their revised annual mean for northerly transport is 0.8 ± 0.2 Sv. Monthly transport means ranged from a low of +.03 Sv in October to +1.7 Sv in August, but these values were also subject to considerable temporal variation, depending primarily on atmospheric pressure conditions prevailing at the time. In any month, the mean transport value can vary considerably with the incidence and duration of southerly flow events. In addition, daily transport values vary considerably. The range of daily flows obtained was +3.1 Sv northerly to -5.1 Sv southerly. Major south flow is caused by strong north winds over the Bering Sea shelf that develop when a low pressure system to the southeast is accompanied by a high pressure system to the west, thereby moving water southward off the entire northern Bering Sea shelf and introducing a sea level gradient sloping downward to the south.

Practically all information reported on currents and circulation patterns is for the summer period when northward transport through the Bering Strait is highest and river discharge is maximum. The circulation patterns and water mass descriptions under the winter ice cover are largely unknown. The following discussion pertains mainly to the brief summer season only.

Along the Chukchi Sea coast, summer surface currents are on the order of 20 to 30 cm/sec but can reach 150 cm/sec or more. Current velocities throughout the Bering Strait are highest in the eastern channel where speeds in excess of ± 50 cm/sec (1.0 knots) are common. Once past the Bering Strait, the northward flowing current divides and one branch flows north (Bering Sea

Water) and the other northeast (Alaska Coastal Water). The northeast flow decelerates to about 15 to 20 cm/sec and follows the northern coast of the Seward Peninsula toward the mouth of Kotzebue Sound. Here it is deflected north and northwestward by the Kotzebue Sound waters to flow along the south side of the Lisburne Peninsula toward Point Hope. Near Point Hope this coastal current is accelerated to about 40-50 cm/sec and rejoins the northward flowing Bering Sea Water. Northward of Cape Lisburne the current again bifurcates into a northeastward flowing coastal current and a northward flow of Bering Sea Water toward Herald Shoal.

These nearshore currents in the Chukchi Sea are greatly influenced by wind, coastal configuration, bottom topography, and river discharge. Persistent northerly winds may temporarily stop or even reverse the normally northward flow. The responses of local currents to storms are not known, and their understanding will be essential for oil spill trajectory modeling.

Deflections of currents by protruding landforms generally causes separation of currents and the formation of eddies past capes. Clockwise eddies have been reported northeast of Cape Prince of Wales (McManus and Creager, 1963), east of Cape Espenberg (Sharma, 1979), and north of Cape Lisburne (Fleming and Heggerty, 1966). Similar eddies accompanying northerly winds have been reported at Point Hope (Wiseman et al., 1973).

The waters of Kotzebue Sound tend to circulate in a counterclockwise direction. The large river input from the Noatak, Kobuk, and Selawik Rivers significantly influences the temperature and salinity of the inner basin during the open water season (Figure 2.18). Most of this freshwater discharge is confined to the nearshore zone and added to the normal coastal flow (Coachman et al., 1975; Sharma, 1979). There is a pronounced vertical discontinuity between coastal and offshore waters, indicating that lateral mixing between these waters is quite small.

Tides are semidiurnal in the Chukchi Sea, but the tidal range on the Alaskan side is small. An average tidal range is 30 cm. At Kotzebue the maximum range is 1.5 m. Tidal action has a minor influence on beach scour by sea ice.

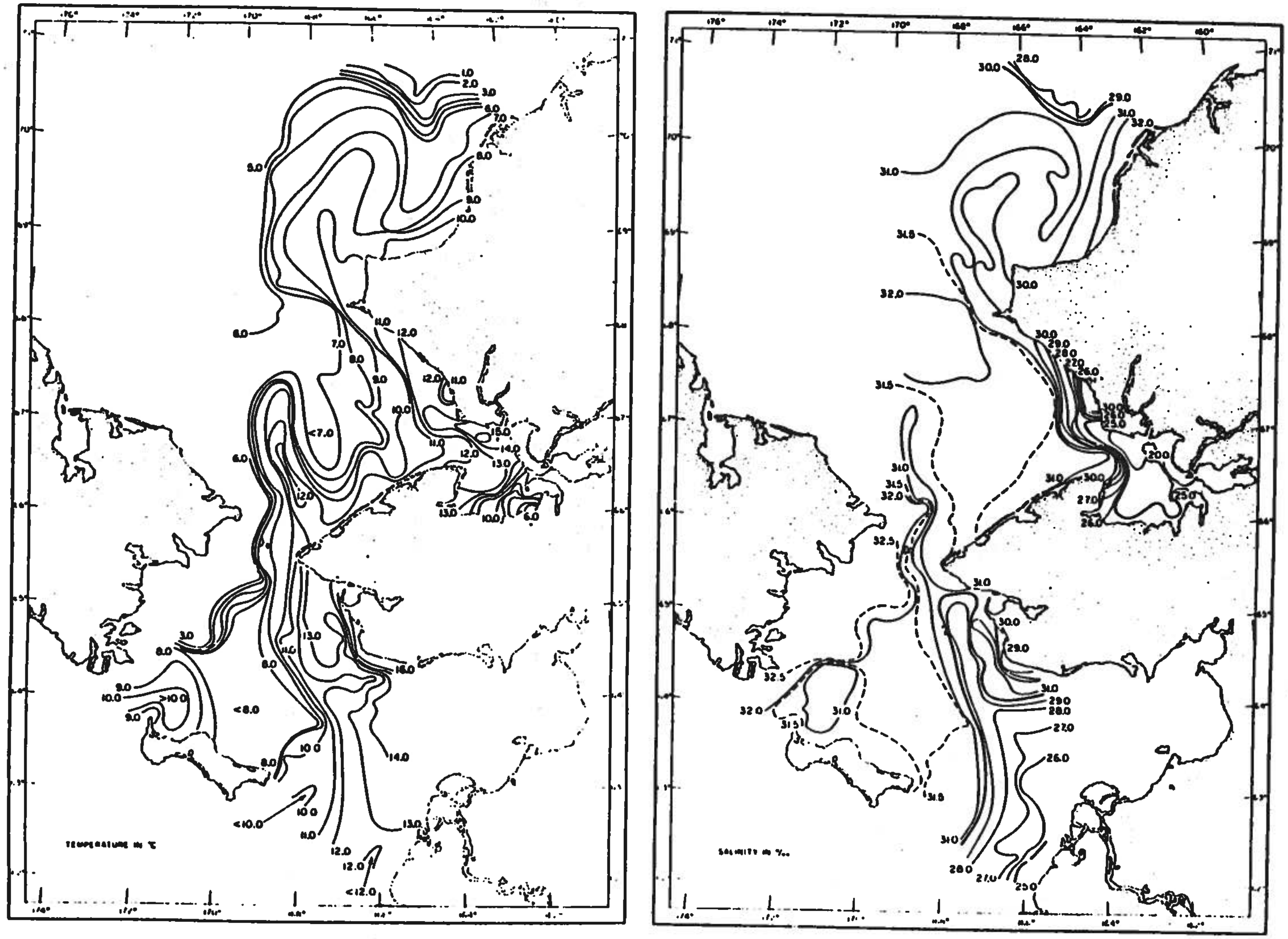


Figure 2.18: Temperatures and salinities of surface waters of the Chukchi Sea during the summer (from Fleming and Heggarty, 1966).

2.5 Water Quality

Data on the ambient levels of water quality conditions in the southeastern Chukchi Sea and Kotzebue Sound are very limited, but appear to indicate that the proposed lease area is essentially pristine. Heavy metal concentrations and petroleum hydrocarbon levels are at the background level, and floating tar has not been observed in the surface waters. These conditions are as expected for an area where marine traffic and industrial development are nil. There has been found however, evidence from low molecular weight hydrocarbon concentrations (Cline, 1977) of a petroleum seep on the Siberian shelf. A plume of alkane-rich water has been observed that is carried by near bottom circulation from the northwest into the southeastern Chukchi Sea and Kotzebue Sound. The source of this plume has not been located.

2.6 Sea Ice

The Chukchi Sea is ice-covered for most of the year. Total ice coverage in the Hope Basin region is greatest from December through April, averaging 95% of the sea surface. Ice coverage is least in the late summer months of August and September, but still averages 10% (AEIDC, 1975). First-year ice (fast ice and seasonal pack ice) forms nearly 100% of the winter ice cover. Multiyear ice (i.e., polar pack ice) does not extend south of Cape Lisburne except under the most extreme winter ice conditions. Between 60-100% of the first-year ice consists of large flows of 500 m or more in diameter. General ice conditions in the southeast Chukchi Sea are summarized in Table 2.3.

Freeze-up and break-up follow a latitudinal progression. Freeze-up progresses north to south from late October to December and breakup occurs from late May to July (Table 2.4). The first continuous fast-ice sheet is usually formed nearshore by mid-November, and it continues to extend and thicken throughout the winter. In general, stable landfast ice out to the 15 m isobath is formed by mid-December, and out to the 30 m isobath by March-April.

Table 2.3. Sea ice conditions in the southeastern Chukchi Sea (adapted from AEIDC, 1975; Weeks, 1977)

	Winter	Spring	Summer	Fall
Total Ice Concentrations, %				
average	98	74	40	74
range	90-100	0-100	10-100	10-100
First Year Ice				
thickness, inches	35	35	5	15
areal coverage, %	60	70	54	25
Multiyear Ice				
thickness, inches	35	35	5	15
areal coverage, %	26	8	35	14
Ratio first year: multiyear ice	2.3	8.8	1.5	1.8
Areal % of deformed ice				
ridged ice	25	18	6	5
hummocked ice	0	0	0	0
Pressure ridges				
Number/naut. mile	10	5	2	5
Ave. thickness, ft.	15	10	10	10

Table 2.4. Freeze-up and break-up dates of caostal fast ice at selected locations in the southeastern Chukchi Sea (from AEIDC, 1975).

	Freeze-Up		Break-Up	
	Ave.	Range	Ave.	Range
Wales	12/3	10/8-1/8	6/8	5/15-6/30
Shishmaref	11/10	10/6-12/18	6/22	5/30-7/8
Deering	10/16	10/3-10/18	5/27	5/13-6/11
Kotzebue 1/	10/23	10/2-11/5	5/31	5/17-6/8
Kivalina	10/22	10/15-11/1	5/19	5/15-5/26
Point Hope	11/11	10/6-12/19	6/20	5/30-7/8
Cape Lisburne	10/29	10/13-11/11	7/5	6/18-7/16

1/ Kotzebue breaks-up much earlier than Kotzebue Sound (Barry, 1977).

During the winter and spring, the Chukchi Sea ice is more dynamic than Beaufort Sea ice. The Beaufort Sea has a large area of stable landfast ice often with an even larger area of immobile pack ice attached to it. Along the Chukchi coast there is an extremely active flaw zone and lead system between the fast ice and the moving pack ice (Figures 2.19 and 2.20). This lead system often extends from the Bering Strait to Point Barrow. New ice in this flaw zone is continually being formed, detached, piled up, and transported southward. In some years, the flaw zone may exceed 50 km in width north of Point Hope (Burns et al., 1977). The pack ice in the Chukchi Sea is continually in motion because of the opportunity for it to be transported southward and out through the Bering Strait.

Ice conditions in the Hope Basin area are greatly affected by winds. The coastline from Point Hope to Kotzebue Sound is essentially perpendicular to the prevailing northeasterly winds blowing offshore during winter and spring. These winds tend to keep the heavy ice offshore, moving it seaward and leaving areas of open water behind protruding headlands. The prevailing winds maintain large recurring polynyas between Cape Lisburne and Point Hope, and southeast of Point Hope. Ice formed in these areas is transported south toward the Bering Strait (Figure 2.21). During stormy periods when winds are predominantly from the south the polynyas may close. In late spring, the c-hanging weather patterns push drift ice ashore, more frequently closing the polynyas.

Kotzebue Sound exhibits a continuous stable ice cover from freeze-up (late October) to break-up (June). There is a zone of weak and often moving ice just seaward of the mouth of the Sound that is probably potentially unstable.

The sea ice funnels through the Bering Strait nearly continuously throughout winter and spring. This moving ice tends to form extensive shear ridges due to the presence of numerous shoals and capes. Shear ridges are formed where blocks of sea ice are slid, broken, pushed, and packed together. In the Chukchi Sea this most frequently occurs at the boundary between the fast ice and the moving pack ice. These shear ridges generally have a sail height to keel depth ratio of 1:4.5, but this ration can vary from 1:3 to as much as 1:9. Throughout the winter and early spring ice movements create large and

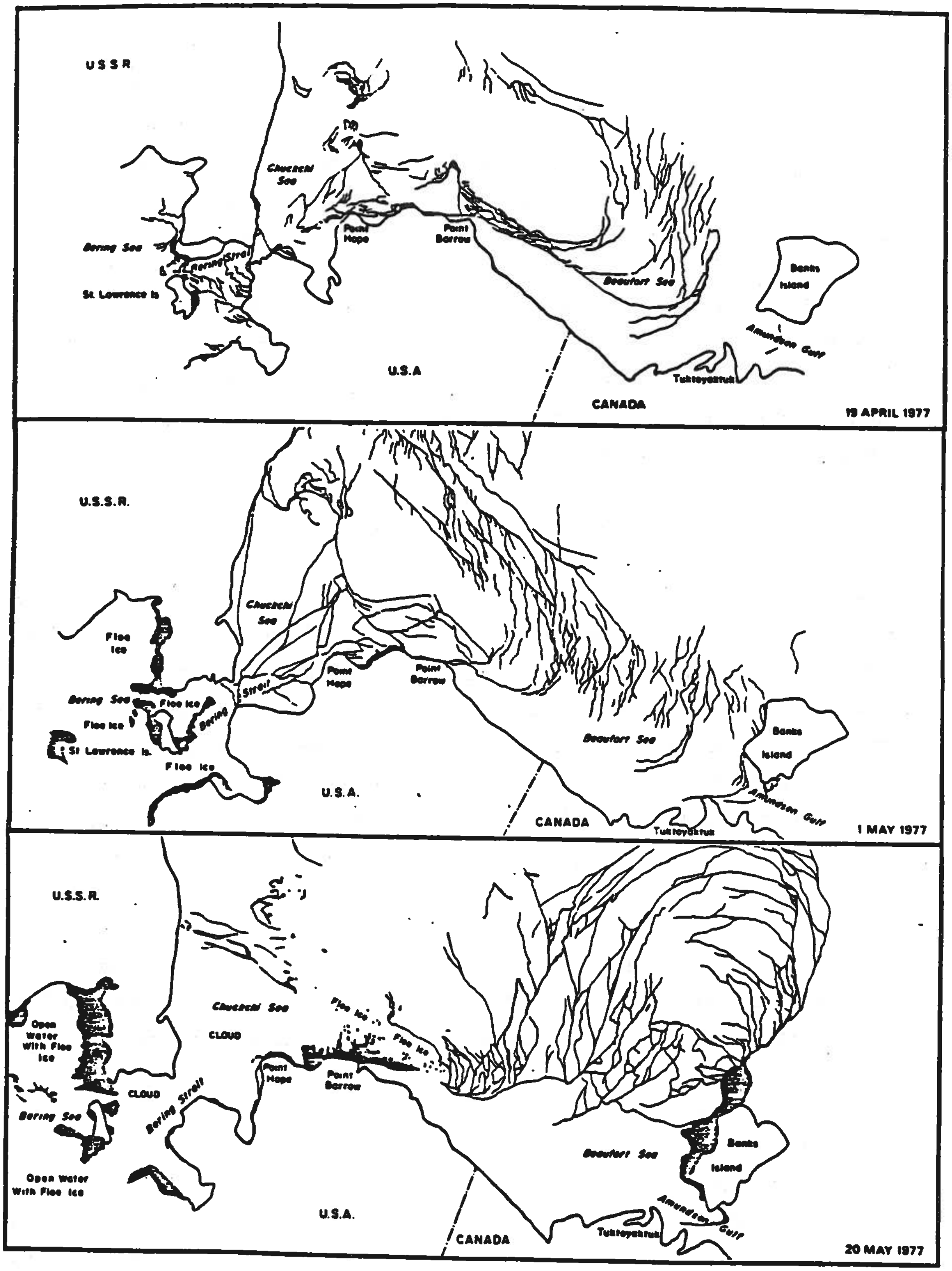


Figure 2.19. Pattern of lead development in the Bering, Chukchi, and Beaufort Seas, April and May 1977. Drawn from NOAA satellite imagery; differences in proportions between drawings are due to differences in satellite position (from Braham et al., 1980b).

Figure 2.20 Satellite visible image on June 9, 1981, of an early break-up in the eastern Chukchi Sea from Bering Strait to Point Barrow. The pack ice has retreated, leaving wide open-water conditions over most of the area. Shore fast ice is still present along the capes and in Kotzebue Sound. (NOAA-6 Polar Orbiting Satellite Pass courtesy of G. Hufford - NWS).

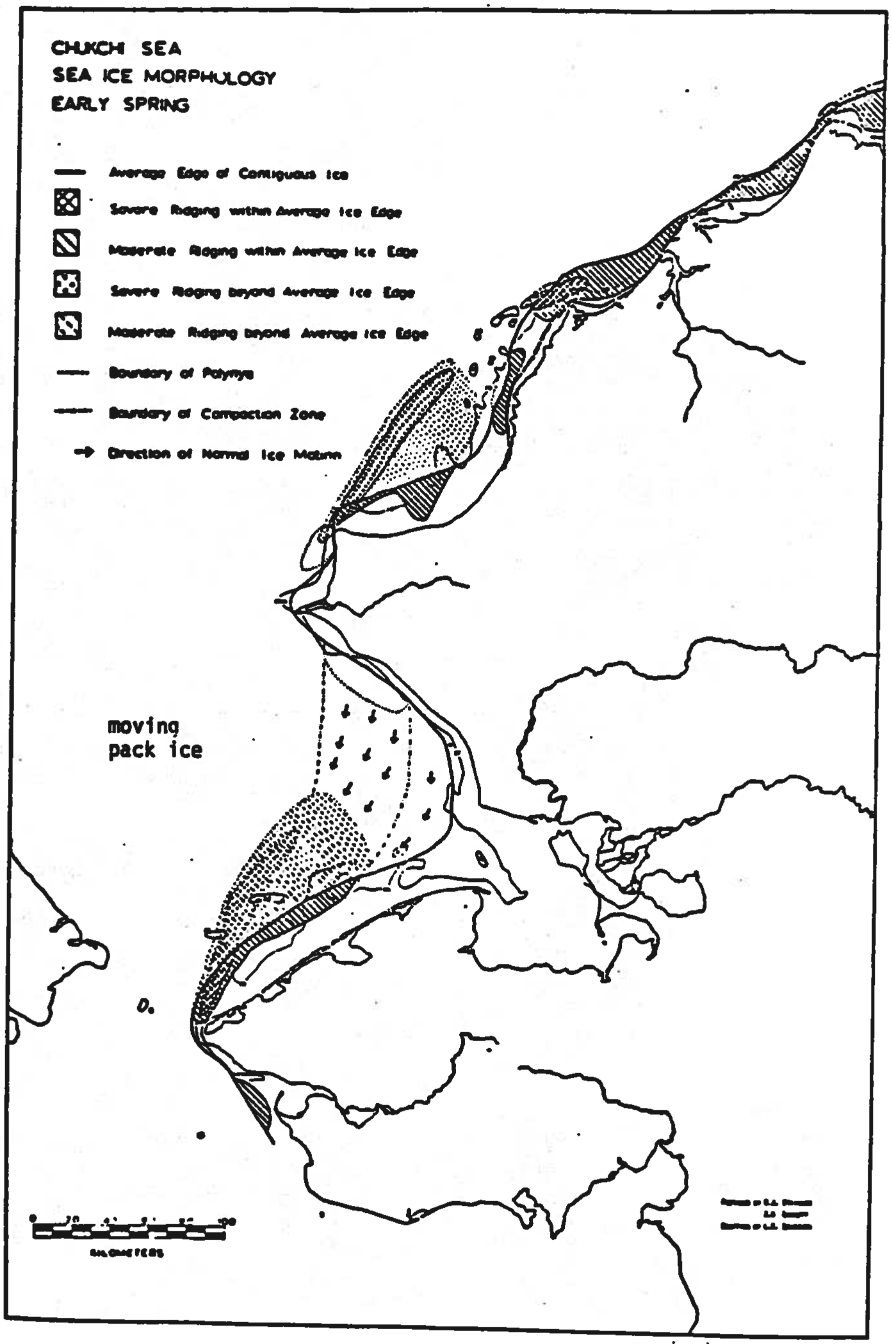


Figure 2.21. Chukchi Sea ice morphology in the early spring (from Stringer, 1978). The average edge of the shore fast ice generally follows the 20 m bathymetric contour. In the southeast Chukchi Sea, this ice is widest and most stable in Kotzebue Sound and narrowest and more subject to pressure ridging north of the Bering Strait. The Chukchi Sea is much more dynamic than the Beaufort Sea ice. Severe ridging occurs in the fast ice zone over Prince of Wales Shoal. A recurrent polynya tends to form southeast of Cape Thompson under prevailing northerly winds.

massive shear ridge systems. These shear ridges are most prevalent along the shoals that extend seaward from capes and headlands. The ridging is particularly extensive in the offshore area north of Cape Lisburne (Figure 2.21).

Moderate to severe ice ridging also occurs along the edge of the fast ice that overlies Prince of Wales Shoal. This ridging also extends for a considerable distance offshore into the moving pack ice where the pack ice funnels through the Bering Strait.

Pressure ridges differ from shear ridges in being formed by the compression of adjacent pack ice sheets with an accumulation of blocks of ice both above and below the abutting ice floes. These pressure ridges may be free-floating or grounded if in shallow water. Both types of pressure ridges are frequent in the Chukchi Sea, and sail heights of 18 to 20 feet are found. Most frequent ridging is north of Cape Lisburne. The frequency of pressure ridges in the southeastern Chukchi Sea is about 10 per nautical mile, and average ridge thickness in February (including sail and keel) is 15 feet (Weeks and Kovacs, 1977).

Ice gouging in the eastern Chukchi Sea is extensive at least as far south as Prince of Wales Shoal and into water depths of at least 60 m, but it is unevenly distributed (Barnes et al., 1977). Gouge densities greater than 200 per km occur in water depths less than 35 m. Gouge densities are less than 10/km in depths greater than 56 m. The maximum depths of gouge incisions are found between the 36 m to 50 m depth range where the maximum incision depth was 4.5 m. Some gouges are more than 100 m wide. Grounding of ice masses on shoals and other topographic highs is frequent and recurrent in this region. Due to the generally higher current velocities in the Chukchi Sea, ice grounding and gouging may make development more difficult here than in the Beaufort Sea.

Break-up occurs in late May to July. Average break-up dates for the Kobuk River are May 12-21 (Carlson 1976). Hotham Inlet remains frozen to at least mid-June. Fresh water from the Kobuk does not appear to overflow the sea ice in Hotham Inlet. Continued warming and summer insolation leads to melt pond formation on the ice by early June. The ice continues to thin and weaken and looses its attachment to shore through June. Open water begins to form in bays and near river mouths and grows in extent. Eventually winds, storms, or water currents dislodge the fast ice, and break-up usually occurs by late June (see Table 2.3). This marks the beginning of the "open season". Scattered leads open along the coast and the pack ice recedes offshore and begins its gradual disintegration.

As the ice breaks up and decreases in concentration, it drifts northward towards the Arctic Ocean. By July there is generally open water and navigable leads opened from the Bering Strait to Point Barrow. The main nearshore lead widens through August. August and September are the months with least sea ice in the Chukchi Sea and because the coastal area is generally free of fast ice, these are the best months for navigation (Figure 2.22). The north-setting Alaska Coastal Current usually keeps the Chukchi Coast free of ice through September. After this time, freeze-up and the incursion of the pack ice proceeds southward and prevents further shipping, other than for ice breakers.

2.7 Permafrost Conditions

The onshore areas of the southeast Chukchi Sea are usually underlain by permafrost. From Cape Lisburne south to Kotzebue the ground contains a thick layer of permafrost and ground water is generally not available. Along the southern side of Kotzebue Sound and along the Seward Peninsula, onshore permafrost varies from moderately thick to thin. Locally, in close proximity to larger water bodies, the permafrost may be absent. Ground water is irregularly available throughout this area in yields of 0-10 gallons per minute.

Permafrost must have formed over essentially the entire area now covered by the Chukchi Sea when it was exposed during Wisconsin and earlier glaciation periods. Although offshore permafrost may still occur under the nearshore waters of the Chukchi Sea, nothing is known of its depth, areal extent, thickness, or physical characteristics. Some investigators believe that onshore permafrost would not extend seaward more than a few hundred yards

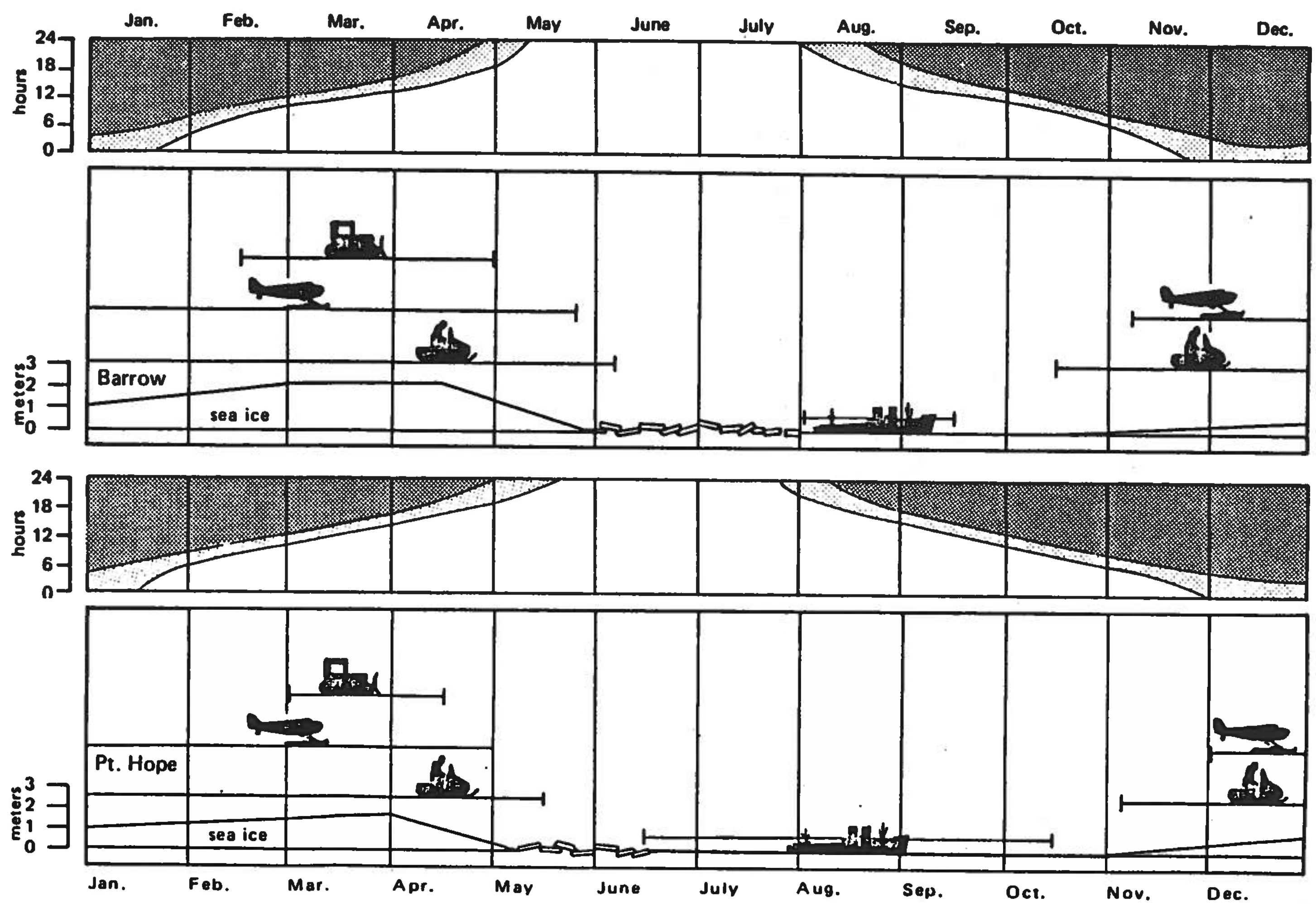


Figure 2.22. Seasonal daylight, sea ice, and transportation conditions for Point Hope and Barrow (from AEIDC, 1978).

from shore (Lachenbruch et al., 1966; Harrison and Osterkamp, 1977).

The average annual seabed temperature of the area is positive and any ice-bearing permafrost in nearshore areas would probably be overlain by a thawed layer except in the shallowest waters less than 2 m depth.

Any subsea permafrost that may be present offshore in the Chukchi Sea would have to be remnant permafrost originally formed in the subaerial environment during times of lower sea-level stands (AINA, 1974). The depths and thickness of this relict subsea permafrost would be determined by the equilibrium between thermal regimes, heat flow, bathymetry, geomorphology, and thermal physical properties of the seafloor environment. The characteristic thinness of the seafloor sediments of the Chukchi Sea probably prevents offshore permafrost from being present.

Except for some work performed in the Barrow area, there have been no reports of offshore drilling for evaluation of permafrost in the region. If present, permafrost would pose problems to the laying of drilling casing, burial of pipelines, and placement of foundations, especially in the nearshore zone.

3. THE BIOLOGICAL ENVIRONMENT

The seasonal ice cover is the dominant environmental factor in determining the kinds and abundance of marine life of the Chukchi Sea. Sea ice, in combination with the seasonal changes in available sunlight, govern the ability of phytoplankton to produce food for the zooplankton and subsequently higher organisms of the trophic system. Sub-zero temperatures prevent fish from overwintering in the shallow nearshore waters except at river mouths. The cold temperatures, in general, slow fish growth and may interfere with successful reproduction of certain species. The seasonal ice cover excludes many species of marine mammals from the area during the winter, and confines others to a more restricted habitat range.

3.1 The Plankton

The waters of Chukchi Sea are relatively fertile, particularly in the deeper layers and in areas of upwelling. River runoff provides added nutrients to the coastal waters during the summer season when sunlight is also available. When day length is increasing in the spring, the phytoplankton flourish at the ice edge, in ice leads and open waters, and even at the underlayer of the sea ice. Phytoplankton production during the growing season is estimated at about 150-250 mg C/M^2/day (FAO, 1972) but can reach $2gC/m^2$/day (Hameedi, 1978). In upwelling conditions off the Siberian coast, productivity values to $6gC/m^2$/day were found. High concentrations of phytoplankton are found in the Bering Strait and in the transition zone between coastal and offshore waters, but values in Kotzebue Sound are low. The contribution of the under-ice algae, mainly diatoms, to the productivity in these waters is uncertain but it is thought to be significant (Goering and McRoy, 1974; Horner and Alexander, 1972).

Phytoplankton production in the lead systems begins by late spring, as much as two months before the July peak in the open water. Because of the low angle of incident sunlight, the zone of highest phytoplankton productivity is limited to relatively near the sea surface (10-15 m). Since the waters are vertically stratified in the summer due to ice melt and surface warming, little additional nutrient is replenished from the underlying waters. This near-surface concentration of phytoplankton depletes the available nutrients in the surface waters relatively quickly, and limits the most productive period to about 3 to 5 weeks of the summer.

The lower total productivity of the Chukchi Sea results in lower abundances of zooplankton, benthos, and fish compared to the Bering Sea. However, their abundance is not poor. Zooplankton transported in from the Bering Sea are added to local population stocks to enhance the productivity of the Chukchi Sea. In many cases biomass and density are comparable to those found in many temperate regions, being about 50 to 200 mg/m^3 (FAO, 1972).

The zooplankton community of the Chukchi Sea shelf contains fewer species than in the Bering Sea (Cooney, 1977). This is probably due to the shallowness and neritic conditions over much of the area. The influence of river runoff is reflected in the species composition and decreased abundance of the zooplankton communities of the very nearshore and coastal areas. In Kotzebue Sound, zooplankton abundance is low, and a neritic community exists that is dominated by two cladoceran genera, Evadne and Podon, and the copepods Acartia, Pseudocalanus, and Centropages. This community is typical of coastal regions from Bristol Bay to Point Hope. The more open ocean community found on the Bering Sea shelf edge is advected northward and transported through the Bering Strait, and can be found offshore in the Chukchi Sea in summer and fall. Two large oceanic copepods, Calanus plumchrus and Eucalanus bungii characterize this community. Abundance of this open shelf assemblage is considerably greater than the neritic assemblage, and often equals the zooplankton densities found in the Bering Sea (Figure 3.1).

3.2 The Benthos

The invertebrate benthos of the offshore region of the Chukchi Sea is substantial, and is an important food source of marine mammals, especially the bearded seal and walrus. 1976 trawl surveys conducted by NMFS caught from 8 kg/km trawled near Cape Krusenstern to 1771 kg/km off Point Hope (Figure 3.2). The average biomass of epifaunal invertebrates in the southeastern Chukchi Sea

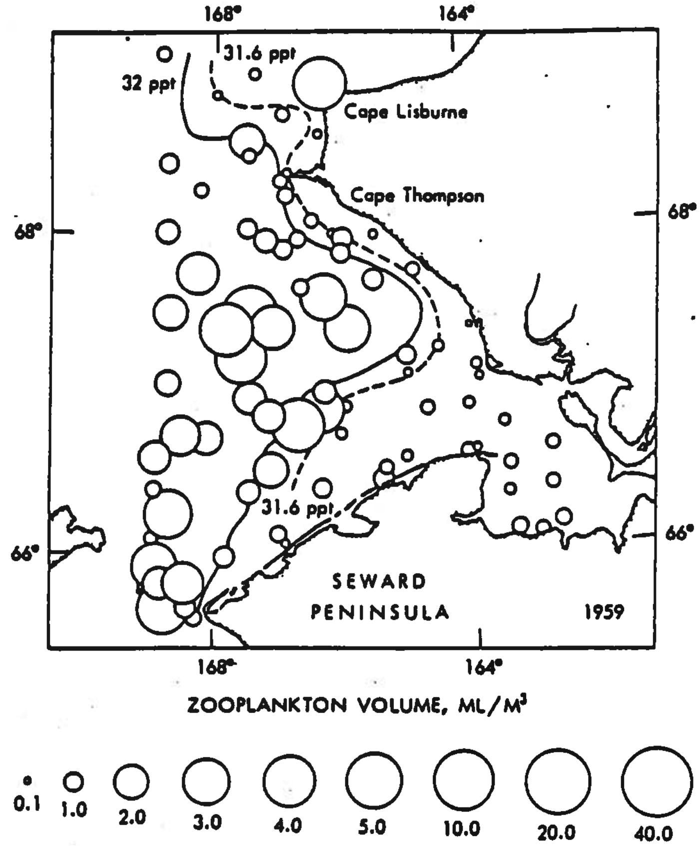


Figure 3.1. Plankton volumes taken during the cruise of the M.V. Brown Bear in 1959 in the southeast Chukchi Sea (from English, 1966). The mean volume for this cruise was 1.4ml/m^3.

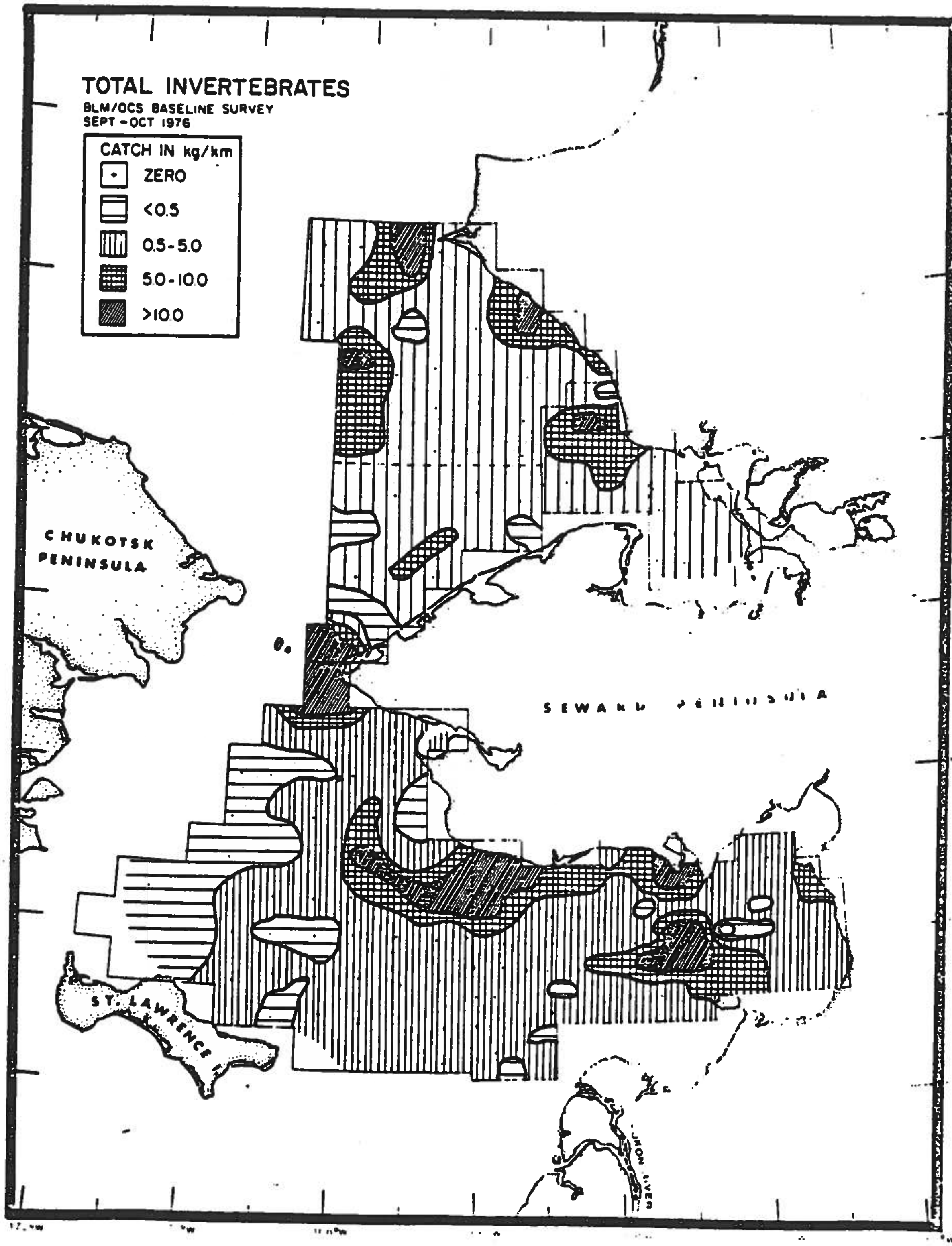


Figure 3.2. Distribution and relative abundance by weight of total invertebrates in the southeastern Chukchi Sea and adjacent waters (Wolotira et al, 1977).

averaged 3.31 g/m^2 (Feder and Jewett 1978), approximately the same level of abundance as found in Norton Sound (3.73 g/m^2), the northeast Gulf of Alaska (2.6 g/m^2) and two bays around Kodiak (4.7 g/m^2).

This fauna is dominated by deposit feeders, while suspension feeders, scavengers, and predators are more abundant in nearshore waters. Overall, echinoderms (basketstars, brittle stars, sea urchins) are the dominant members of the benthic fauna of the region. A variety of crustaceans are also common, including amphipods, shrimps, and crabs. Other frequently taken invertebrates were tunicates, molluscs, annelids, and coelenterates. Some trawl catches were dominated by jellyfish. Feder and Jewett (1978) have listed 171 species of invertebrates from the Chukchi Sea. A list of the most common invertebrates of the southeastern region is given in Table 3.1. and 3.2.

Nearshore areas contain a wider variety of organisms but lesser abundance than offshore. The effects of seasonal shorefast ice have a major role in forming this nearshore benthic fauna. Scouring of the inshore area by ice prevents any significant epibenthic invertebrate population from being established from the beach out to a depth of about 10 meters (Sparks and Pereyra, 1966). Mysids, cumaceans, sponges, soft corals, decapods, and a few other hardy or highly mobile forms usually dominate these areas. Sizeable concentrations of crangonid shrimp can occur in certain nearshore areas. Most of these nearshore invertebrates are species adapted to gravel bottoms.

The major controlling factors of species distribution are water depth and substrate texture (Barnes et al., 1977). Grain size of the sediment may control the distribution patterns of the individual species. Ice gouging can cause major disruptions in the benthic communities, and in areas of high ice gouge densities, the faunas may be periodically eliminated.

Compared to the estimated fish and invertebrate biomass of the eastern Bering Sea (5.9 million mt), the apparent biomass of the northern Bering (Norton Basin) and southeastern Chukchi Sea is quite small (0.34 million mt). Fish and demersal shellfish of current or potential economic importance accounted for less than 25% of the Chukchi Sea benthic fauna compared to over 90% for the eastern Bering Sea (Figure 3.3), a near 60-fold difference.

Table 3.1 --Rank order by frequency of occurrence and relative abundance of the 20 most common invertebrate taxa in the southeastern Chukchi Sea (AEC survey, 1959). (Adapted from Sparks and Pereyra, 1966) by Wolotira et al., (1977).

Rank	Taxon	Percent frequency of occurrence1/	Relative abundance index2/
1	Decapod crustaceans	98.6	5882.5
2	Starfish	77.0	2253.4
3	Gastropod molluscs	70.3	1064.5
4	Amphipod crustaceans	67.6	1039.0
5	Pelecypod molluscs	63.5	1422.5
6	Omphiuroidean echinoderms	62.2	2797.5
7	Annelid worms	56.8	2048.0
8	Anthozoan collenterates	56.8	1267.1
9	Ascidians	55.4	2715.0
10	Holothuroidean echinoderms	41.9	1354.0
11	Echinoidean echinoderms	32.4	922.5
12	Cirripedia crustaceans	32.4	625.0
13	Scyphozoa coelenterates	29.7	485.0
14	Bryzoans	27.0	377.7
15	Sponges	23.0	664.0
16	Hydrazoan coelentrates	21.6	286.4
17	Sipunculoidea (coelomate worms)	20.3	59.1
18	Nemertian worms	18.9	47.5
19	Isopod crustaceans	13.5	25.0
20	Amphineura molluscs	10.8	51.4

1/ Number of sampling stations (trawls or trawls and dredge): 74.

2/ Total number of animals present in all samples adapted from rank key presented by Sparks and Pereyra (1966).

Table 3.2. --Rank order by frequency of occurrence (percent) of the most common invertebrate taxa in the southeastern Chukchi Sea and Kotzebue Sound (Wolotira *et al.*, 1977).

			Subarea	
Rank		All areas combined	Southeastern Chukchi Sea	Kotzebue Sound
1	Starfish	95.8	95	96
2	Other invertebrates	90.6	91	89
3	*Argis* spp.	74.5	80	81
4	Tanner crab	67.2	95	85
5	*Neptunea heros*	64.1	70	41
6	*Neptunea ventricosa*	55.7	55	48
7	*Beringius beringii*	46.9	41	56
8	*Serripes groenlandicus*	44.3	30	56
9	Basketstars	37.5	50	22
10	*Telemessus* crab	35.9	18	48
11	Red king crab	33.9	2	11
12	*Pandalus goniurus*	30.2	25	19
13	*Crangon dalli*	24.5	7	15
14	*Sclerocrangon boreas*	24.5	14	41
15	*Neptunea borealis*	21.9	41	7
16	*Pyrulofusus deformis*	17.2	5	11
17	*Clinocardium ciliatum*	16.1	18	48
18	*Volutopsius fragilis*	13.0	23	19
19	Blue king crab	12.0	5	--
20	*Buccinium angulossum*	11.5	16	7

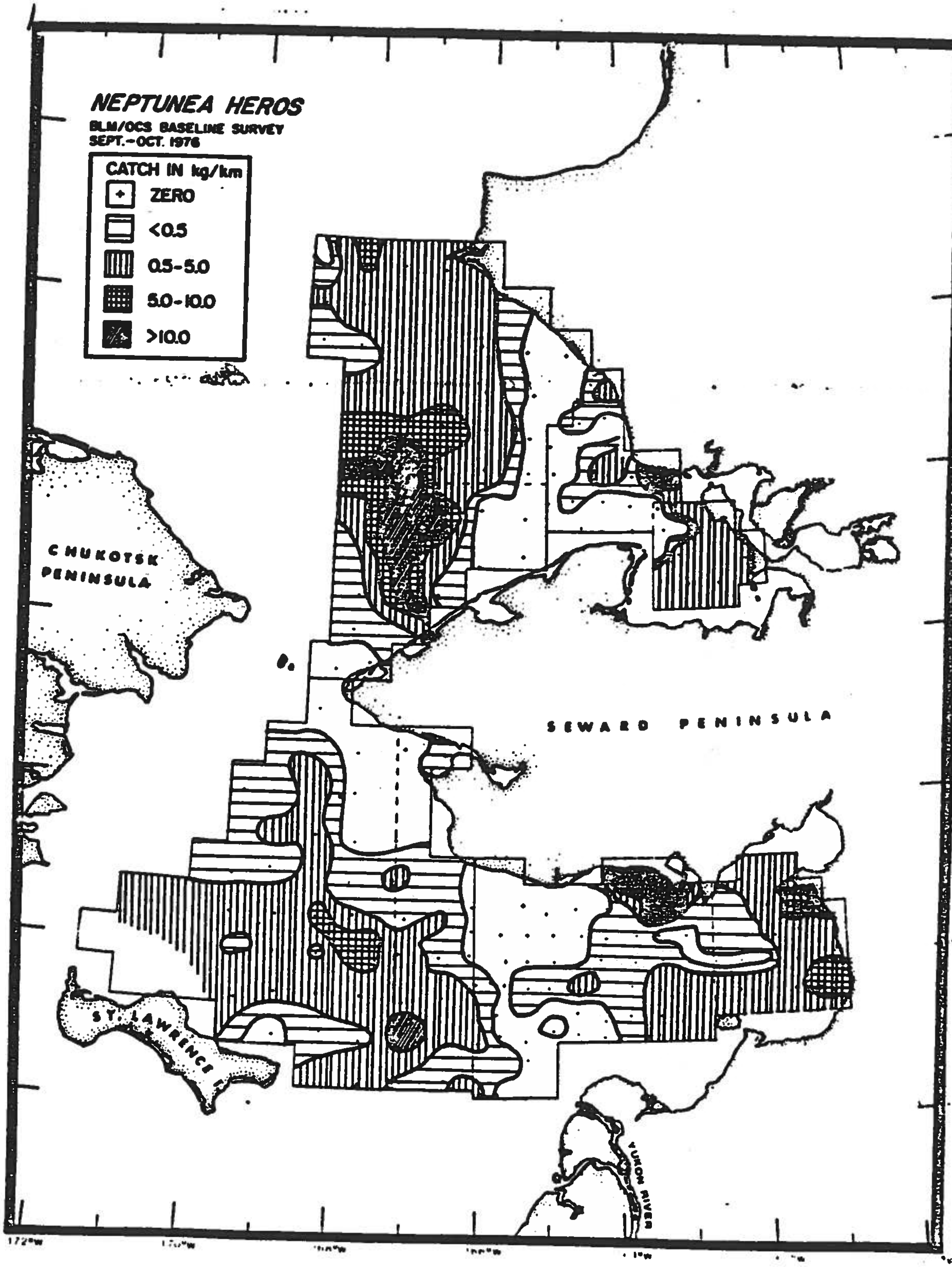


Figure 3.3 --Distribution and relative abundance by weight of Neptunea heros in Norton Sound, the southeastern Chukchi Sea and adjacent waters (from Wolotira et al, 1977).

Of the 20 most abundant invertebrate taxa of possible commercial importance in the southeastern Chukchi Sea (Table 3.3) and Kotzebue Sound (Table 3.4) Neptunea snails (primarily N. heros) and Tanner crab predominated in 1976 trawl surveys (Wolotira et al., 1977). Their catch distributions are shown in Figure 3.4 and 3.5.

Although commercially exploitable quantities of benthic invertebrates have not been located in the Chukchi Sea, the quantities of tanner crab, shrimp, scallops, and clams (Macoma calcarea) are sufficient for some seasonal utilization by native subsistence users. Tanner crabs (Chionoecetes opilio) and spider crabs (Hyas coarctatus) are frequently abundant offshore. Blue king crabs (Paralithodes platypus) occasionally occur.

The coastal lagoons behind the barrier islands do not provide stable environments and do not support large benthic populations. A limited number of mysids, some mussels, and numerous nemertine worms (Lepidurus) are the most common organisms found there. Other marine forms are occasionally washed in during storms and can form temporary populations during the ice-free season. Nevertheless, these lagoons provide unique habitats that are utilized by anadromous fish, waterfowl, and some marine mammals. R.H. Fleming (unpublished, 1959; quoted in Johnson, 1966) summarized the character of these coastal lagoons as follows:

> "The geological and oceanographic processes that have led to development and life history of these features are of major scientific interest. Because each of them may represent a variable but unique micro-environment, the biology of these lagoons is also of unusual interest because they represent a transitional series of marine to freshwater environments. At one extreme these lagoons are, in effect, the complex estuaries of rivers that flow only during the summer. At the other extreme the older lagoons, now permanently isolated from the sea and clogged with sediment and vegetation, are only distinguishable from aerial photographs. Between these two extremes are bodies of water, varying greatly in size, that must from time to time be flooded with sea water and then are closed off again and slowly diluted by the accumulation of precipitation and runoff."

Table 3.3. --Rank order of abundance of the 20 most abundant invertebrate taxa of possible commercial importance in the southeastern Chukchi Sea (Wolotira *et al*, 1977).

Rank	Taxon	CPUE 1/ (kg/km)	Proportion of 2/ commercially important invertebrate CPUE	Proportion 3/ of total CPUE	Cumulative proportion
1	*Neptunea heros*	2.77	0.477	0.071	0.447
2	Tanner crab	1.59	0.256	0.040	0.703
3	*Telemessus* crab	0.49	0.079	0.012	0.782
4	*Neptunea ventricosa*	0.48	0.078	0.012	0.861
5	*Argis* sp.	0.26	0.041	0.007	0.902
6	*Sclerocrangon boreas*	0.21	0.034	0.005	0.936
7	*Beringius beringii*	0.07	0.011	0.002	0.947
8	*Volutopsius fragilis*	0.04	0.006	0.001	0.954
9	*Cyclopecte randolphi*	0.04	0.006	0.001	0.960
10	*Pyrulofusus deformis*	0.03	0.005	0.001	0.964
11	Blue king crab	0.03	0.004	0.001	0.969
12	*Buccinum polare*	0.02	0.004	0.001	0.973
13	*Volutopsius castaneus*	0.02	0.003	0.001	0.977
14	*Serripes groenlandicus*	0.02	0.003	0.001	0.980
15	*Neptune borealis*	0.02	0.003	0.001	0.983
16	*Natica clausa*	0.02	0.003	4/	0.986
17	*Buccinum angulossum*	0.01	0.002	4/	0.989
18	*Polinices pallida*	0.01	0.002	4/	0.990
19	*Pandalus goniurus*	0.01	0.001	4/	0.992
20	*Buccinum scalariforme*	0.01	0.001	4/	0.993

1/ Overall catch per unit effort, kg/km trawled. Total effort = 139.2 km.
2/ Proportion of catch per unit effort for invertebrates of possible commercial importance; CPUE = 6.20 kg/km trawled.
3/ Proportion of total catch per unit effort, all fish and invertebrates combined. Total CPUE = 39.33 kg/km trawled.
4/ Proportion less than .0005.

Table 3.4. --Rank order of abundance of the 20 most abundant invertebrate taxa of possible commercial importance in Kotzebue Sound (BLM/OCS survey, 1976; Wolotira *et al*, 1977).

Rank	Taxon	CPUE 1/ (kg/km)	Proportion of 2/ commercially important invertebrate CPUE	Proportion 3/ of total CPUE	Cumulative proportion
1	Tanner crab	4.91	0.677	0.115	0.677
2	*Neptunea heros*	1.11	0.153	0.026	0.829
3	*Telemessus* crab	0.30	0.041	0.007	0.870
4	*Neptunea ventricosa*	0.27	0.037	0.006	0.907
5	*Argis* sp.	0.19	0.027	0.004	0.934
6	*Beringius beringii*	0.19	0.026	0.004	0.960
7	*Pyrulofusus deformis*	0.06	0.009	0.001	0.968
8	*Sclerocrangon boreas*	0.04	0.006	0.001	0.974
9	*Buccinum scalariforme*	0.03	0.004	0.001	0.978
10	*Volutopsius fragilis*	0.03	0.004	0.001	0.983
11	*Serripes groenlandicus*	0.02	0.003	4/	0.986
12	Red king crab	0.02	0.002	4/	0.988
13	*Astarte borealis*	0.01	0.002	4/	0.990
14	*Buccinum angulossum*	0.01	0.001	4/	0.992
15	*Clinocardium ciliatum*	0.01	0.001	4/	0.993
16	*Neptunea lyrata*	5/	4/	4/	0.994
17	*Pandalus goniurus*	5/	4/	4/	0.994
18	*Clinocardium californianaus*	5/	4/	4/	0.995
19	*Crangon dalli*	5/	4/	4/	0.995
20	*Natica clausa*	5/	4/	4/	0.995

1/ Overall catch per unit effort, kg/km trawled. Total effort = 86.6 km.
2/ Proportion of catch per unit effort for invertebrates of possible commercial importance only; CPUE = 7.26 kg/km trawled.
3/ Proportion of total catch per unit effort, all fish and invertebrates combined. Total CPUE = 42.87 kg/km trawled.
4/ Proportion less than .0005.
5/ Proportion less than .005.

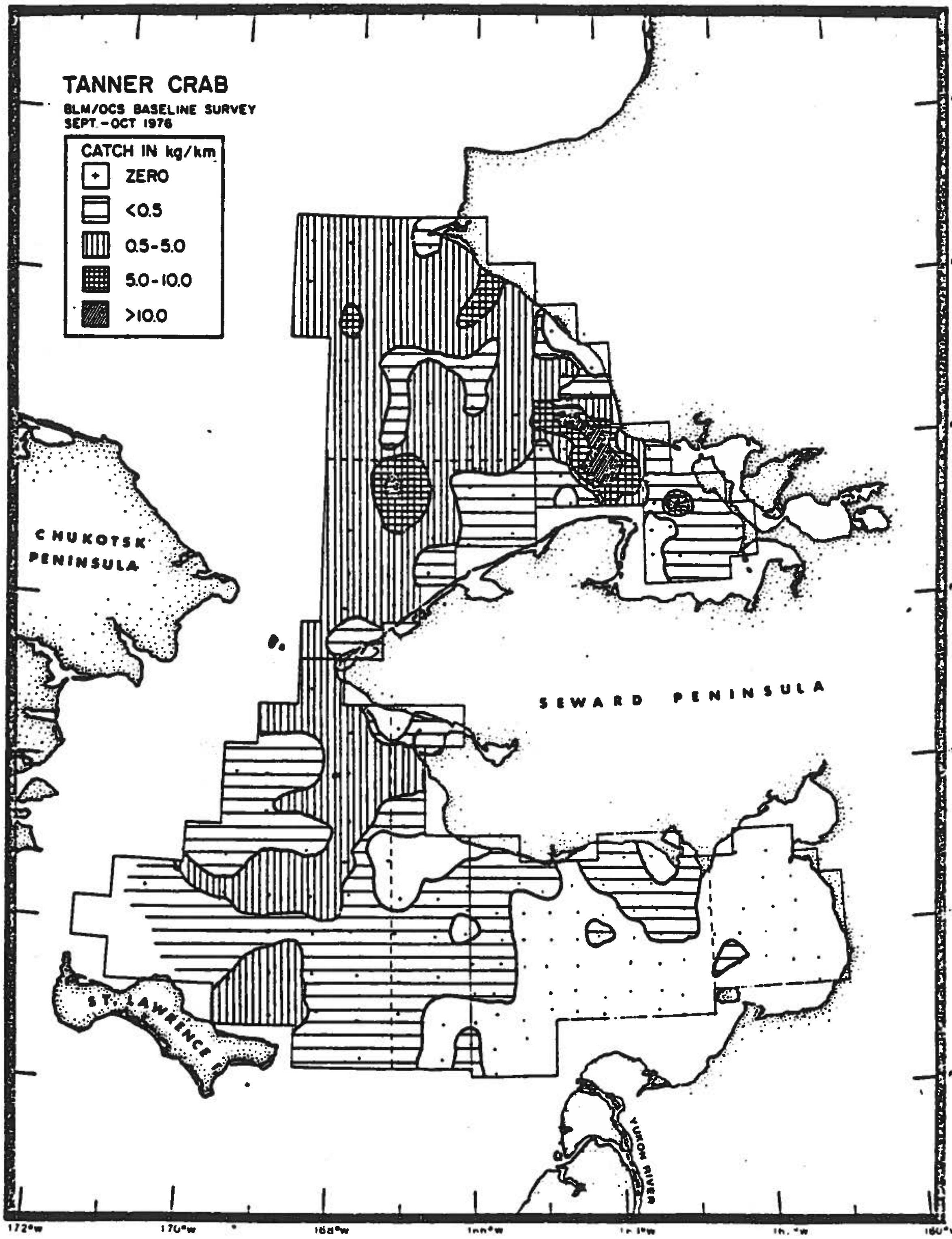


Figure 3.4. --Distribution and relative abundance of Tanner crab (C. opilio) in the southeastern Chukchi Sea and adjacent waters (from Wolotira et al., 1977).

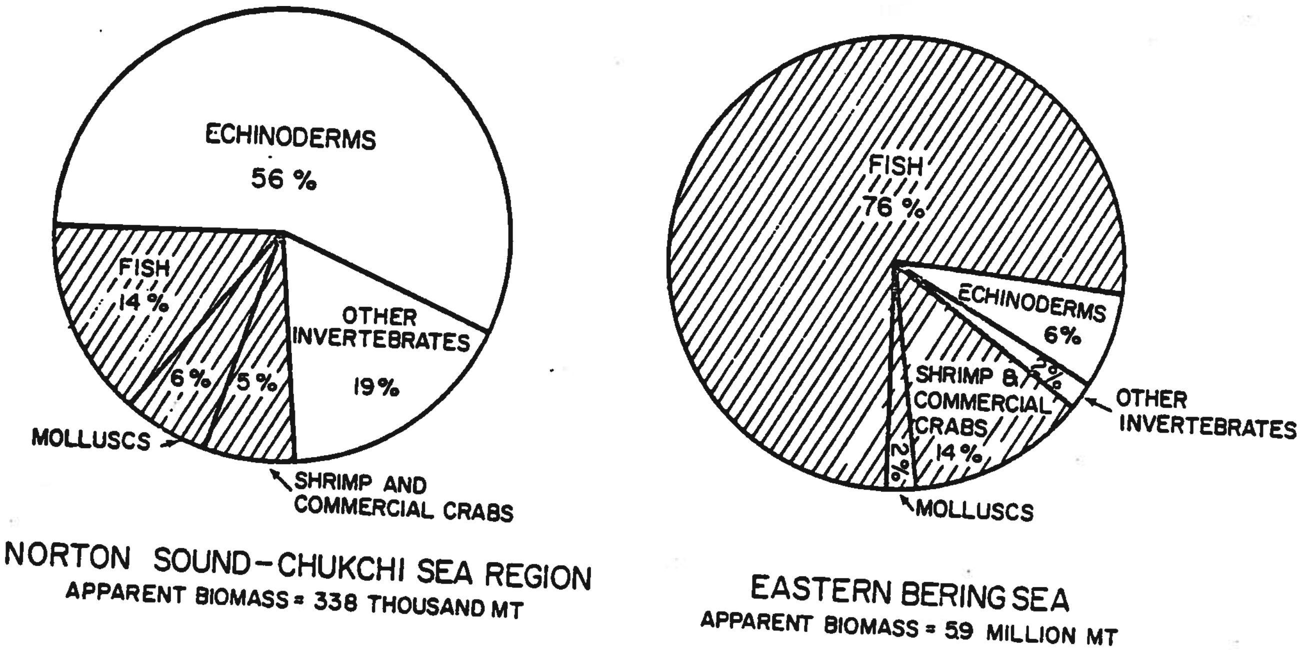


Figure 3.5. --Relative importance of demersal species groups in the Norton Sound-Chukchi Sea and eastern Bering Sea regions in terms of apparent biomass. Biomass estimates are from results of the 1976 BLM/OCS baseline survey of Norton Sound and the southeastern Chukchi Sea (Wolotira et al., 1977) and from Alton (1976).

Johnson (1966) studied nine lagoons in the Cape Thompson area and found dissimilar zooplankton populations in each, supporting Fleming's hypothesis that they represent unique micro-environments. At present, very little else is known concerning the ecology of these lagoons.

4. THE FISH RESOURCE

The fish populations of the southeastern Chukchi Sea region include marine (pelagic, demersal, coastal, and estuarine), anadromous, and freshwater species. There are small commercial fisheries in this region, mainly for salmon. Subsistence fisheries focus primarily on the salmon and other anadromous species. The marine fish populations are important primarily as a food resource for marine mammal and seabird populations of the region. The seven predominant families of marine and anadromous fish and the proportion of total species to the Chukchi Sea ichthyofauna is listed in Table 4.1.

The marine fish have been the subject of only a few studies (see Section 4.1), and anadromous fish (Section 4.2) are equally poorly known. The importance of lagoons, bays, and river mouths to the coastal habits of these fish needs to be determined.

4.1 Marine Fish

The marine fishes of the Chukchi Sea have received little attention in the past. The limited trawl surveys that have been conducted (Pruter and Alverson, 1962; Alverson and Wilimovsky, 1966; Quast, 1974; Wolotira et al., 1977), were mainly in the Hope Basin region with little effort north of Cape Lisburne. From the limited sampling, the number of marine fishes reported for the southeastern Chukchi Sea is 54 species representing 13 families (Table 4.2). Compared to the Bering Sea, this fish fauna is poor in terms of both species diversity and numerical abundance. It is, nevertheless, apparently greater than the fish fauna of the Beaufort Sea.

Four fish species contributed to over half the total fish biomass in the 1976 BLM/OCSEAP trawl surveys (Wolotira et al., 1977) in waters of the southeastern Chukchi Sea (Table 4.3). These were: starry flounder - 20.5%, Pacific halibut - 11.8%, saffron cod - 11.4%, and Pacific herring - 9.6%. Arctic cod, despite being the most frequent and abundant fish caught, ranked fifth biomass at 7.6% because of its smaller individual size. Arctic cod was also

Table 4.1. --Proportion of seven predominant families to total species composition of the southeastern Chukchi Sea fish fauna.

Family	No. Spp	Percentage of total fish species
Cottidae (sculpins)	20	29
Salmonidae (salmon, etc.)	12	17
Pleuronectidae (flatfish)	9	13
Stichaeidae (blennies)	5	7
Agonidae (poachers)	4	6
Gadidae (cods)	4	6
Zoarcidae (selpouts)	3	4
Total of seven dominant families:	57	81

Table 4.2. List of marine fish species known from the southeastern Chukchi Sea and adjacent waters[1/]

Species		Common Name
	CLUPEIDAE	
Clupea harengus pallasi		Pacific herring
	OSMERIDAE	
Mallotus villosus		capelin
Osmerus mordax		rainbow smelt
	GADIDAE	
Boreogadus saida		Arctic cod
Eleginus gracilis		saffron cod
Theragra chalcogramma		walleye pollock
Gadus macrocephalus		Pacific cod
	ZOARCIDAE	
Lycodes turneri		polar eelpout
Lycodes palearis		wattled eelpout
Gymnelis viridus		fish doctor
	HEXAGRAMMIDAE	
Hexagrammos stelleri		whitespotted greenling
	COTTIDAE	
Artediellus scaber		hamecon
Artediellus uncinatus		Arctic hookear sculpin
Enophrys diceras		antlered sculpin
Enophrys lucasi		leister sculpin
Gymnocanthus pistilliger		threaded sculpin
Gymnocanthus tricuspis		Arctic staghorn sculpin
Hemilepidotus jordani		yellow Irish Lord
Hemilepidotus zapus		?
Icelus spatula		spatulate sculpin
Megalocottus platycephalus		belligerent sculpin
Megallocuttus laticeps		?
Microcottus sellaris		?
Myoxocephalus axillaris		?
Myoxocephalus jaok		plain sculpin
Myoxocephalus scorpius		shorthorn sculpin
Myoxocephalus stelleri		?
Myoxocephalus quadricornis		fourhorn sculpin
Nautichthys pribilovius		eyeshade sculpin
Psychrolutes paradoxus		tadpole sculpin
Triglops pingeli		ribbed sculpin

Table 4.2. (Cont'd)

	AGONIDAE	
Aspidophoroides olriki		Arctic alligatorfish
Occella dodecaedron		Bering poacher
Pallasina barbata		tubenose poacher
Agonus acipenserinus		sturgeon poacher
	CYCLOPTERIDAE	
Eumicrotremus orbis		Pacific spiny lumpsucker
Liparis herschelinus		bartail snailfish
	ANARHICHADIDAE	
Anarhichas orientalis		Bering wolffish
	STICHAEIDAE	
Chirolophus polyactocephalus		decorated warbonnet
Lumpenus fabricii		slender eelblenny
Lumpenus medius		stout eelblenny
Stichaeus punctatus		Arctic shanny
Eumesogrammus praecisus		fourline snakeblenny
	AMMODYTIDAE	
Ammodytes hexapterus		Pacific sand lance
	GASTEROSTEIDAE	
Pungitius pungitius		ninespine stickleback
	PLEURONECTIDAE	
Atheresthes stomias		arrowtooth flounder
Hippoglossoides robustus		Bering flounder
Hippoglossus stenolepis		Pacific halibut
Limanda aspera		yellowfin sole
Limanda proboscidea		longhead dab
Liopsetta glacialis		Arctic flounder
Platichthys stellatus		starry flounder
Pleuronectes quadrituberculatus		Alaska plaice
Reinhardtius hippoglossoides		Greenland turbot

1/ Nomenclature from American Fisheries Society, 1980.

Table 4.3. --Rank order of abundance of the 20 most abundant fish taxa in the southeastern Chukchi Sea (subarea 1, Wolotira et al, 1977).

Rank	Taxon	CPUE 1/ (kg/km)	Proportion of 2/ fish CPUE	Proportion of 3/ total CPUE	Cumulative proportion of fish CPUE
1	Starry flounder	0.53	0.205	.014	0.205
2	Pacific halibut 4/	0.32	0.118	.008	0.323
3	Saffron cod	0.31	0.114	.008	0.437
4	Pacific herring	0.26	0.096	.007	0.533
5	Arctic cod	0.20	0.076	.005	0.609
6	Shorthorn sculpin	0.18	0.067	.005	0.676
7	Alaska plaice	0.16	0.058	.004	0.733
8	Unidentified snailfish	0.14	0.050	.003	0.784
9	Toothed smelt	0.10	0.037	.003	0.821
10	Polar eelpout	0.08	0.031	.002	0.852
11	Walleye pollock	0.08	0.030	.002	0.881
12	Bering flounder	0.07	0.027	.002	0.908
13	Arctic staghorn sculpin	0.06	0.021	.001	0.929
14	Yellowfin sole	0.03	0.013	.001	0.942
15	Sturgeon poacher	0.03	0.012	.001	0.954
16	Capelin	0.03	0.012	.001	0.966
17	Antlered sculpin	0.02	0.008	.001	0.973
18	Wattled eelpout	0.02	0.007	5/	0.980
19	Belligerent sculpin	0.01	0.005	5/	0.985
20	Slender eelblenny	0.01	0.004	5/	0.989

1/ Overall catch per unit effort, kg/km trawled. Total effort = 139.2 km.

2/ Proportion of catch per unit effort, total fish only. Fish CPUE = 2.70 kg/km trawled.

3/ Proportion of total catch per unit effort, all fish and invertebrates combined. Total CPUE = 39.33 kg/km trawled.

4/ Total catch for this species = 1 large fish (44.2 kg).

5/ Proportion less than 0.0005.

the dominant marine fish in both number and frequency of occurrence in the 1959 AEC trawl survey (Table 4.4; Alverson and Wilimovsky, 1966).

Table 4.5 lists the estimated average abundance of the 12 most common species in the 1976 trawl surveys in four sectors of the southeast Chukchi Sea. Outer Kotzebue Sound waters yielded greater fish catches (5.4 kg/km trawled) than the offshore waters of the southeastern Chukchi Sea (2.7 kg/km trawled) (Tables 4.5 and Figure 4.1). Pacific herring, saffron cod, and toothed smelt accounted for most of this greater yield. Flatfish were more abundant outside the Sound. However, fish in either area formed only a small fraction of the total trawl biomass (Table 4.6 and Table 4.7). Most of the trawl catch was invertebrates (see Section 3) - 93% in the outer area, 87% in Kotzebue Sound. This is in sharp contrast to the southern Bering Sea where only 24% of the biomass was invertebrates (Wolotira et al., 1977).

Very little is known about the life history, population dynamics, or ecological relationships of most of these species. Because of the shallow depths of this region, the species found are mainly littoral or sublittoral inhabitants.

The distribution of many of the marine species appear to be governed by temperature and salinity. Yellowfin sole and saffron cod tend to occupy the shallower and seasonally warmer nearshore waters of the Chukchi Sea, while Arctic cod and Bering flounder are usually found in the deeper and colder water area. Arctic flounder, starry flounder, and fourhorn sculpin are most frequent in low-salinity waters in bays, estuaries, and at river mouths. Most of the other marine species prefer higher salinity water and probably occur throughout the broad Chukchi Sea shelf. Very few fish overwinter in the coastal lagoons, the saffron cod being the major exception.

The majority of the marine fish of the Chukchi Sea are benthic or demersal as adults. Only a relatively few species are pelagic, i.e., Arctic cod, Pacific herring, smelt, capelin, and sand lance. The Arctic cod may be classified as semi-pelagic since adults usually occur close to the bottom when in shallow water.

Table 4.4 --Rank order by catch rate (numbers/trawl) and frequency of occurrence (percent) of the 20 most common fish taxa in the southeastern Chukchi Sea (AEC survey, 1959) (adapted from Alverson and Wilimovsky, 1966 by Wolotira _et al_, 1977).

Rank	Taxon	CPUE[1/] (No./trawl)	Proportion of total CPUE[2/]	Percent frequency of occurrence
1	Arctic cod	58.98	0.586	71.9
2	Arctic staghorn sculpin	10.58	0.105	68.4
3	Bering flounder	4.30	0.043	61.4
4	Capelin	4.04	0.040	22.8
5	_Artediellus_ sp.	3.68	0.037	43.9
6	Ribbed sculpin	2.11	0.021	45.6
7	Toothed smelt	1.96	0.019	22.8
8	_Myoxocephalus_ sp.	1.35	0.013	33.3
9	Saffron cod	1.32	0.013	24.6
10	Unidentified eelpouts	1.18	0.012	43.9
11	Unidentified snailfish	1.05	0.010	31.6
12	Sturgeon poacher	0.89	0.009	24.6
13	Leister sculpin	0.63	0.006	22.8
14	Slender eelblenny	0.60	0.006	24.6
15	Stout eelblenny	0.58	0.006	22.8
16	Yellowfin sole	0.54	0.005	14.0
17	_Triglops_ sp.	0.53	0.005	14.0
18	Pacific herring	0.49	0.005	14.0
19	Unidentified sea poachers	0.46	0.005	28.1
20	Eyeshade sculpin	0.19	0.002	14.0

1/ Overall catch per unit effort, no./trawl. Total effort = 57 trawls.

2/ Proportion of total catch per unit effort, fish only. Total CPUE = 100.63 fish/1 hr. trawl haul.

Table 4.5. Estimated biomass of 12 predominant fish species in the southeastern Chukchi Sea. The locations of these sectors is shown in Figure 4.1 (after Wolotira *et al*, 1977).

	Sector			
	Southern Chukchi Sea		Kotzebue Sound	
	IN	IS	20	2I
Area, $km^2 \times 10^3$	28.3	12.7	7.2	5.2
Estimated biomass, kg/km^2				
Arctic cod	12.5	11.7	9.3	1.2
Bering flounder	6.1	0.9	3.5	-
Starry flounder	3.0	91.0	7.6	12.2
Shorthorn sculpin	6.9	18.1	2.1	-
Walleye pollock	0.2	13.5	0.1	0.3
Alaska plaice	4.2	19.2	10.8	14.5
Saffron cod	6.6	40.9	102.1	1.6
Pacific herring	9.0	28.1	184.9	2.9
Toothed smelt	5.1	7.6	82.1	7.3
Yellowfin sole	-	5.9	3.6	16.9
Tanner crab	92.5	98.7	367.9	114.9
Neptunea heros	167.5	161.9	39.0	129.8

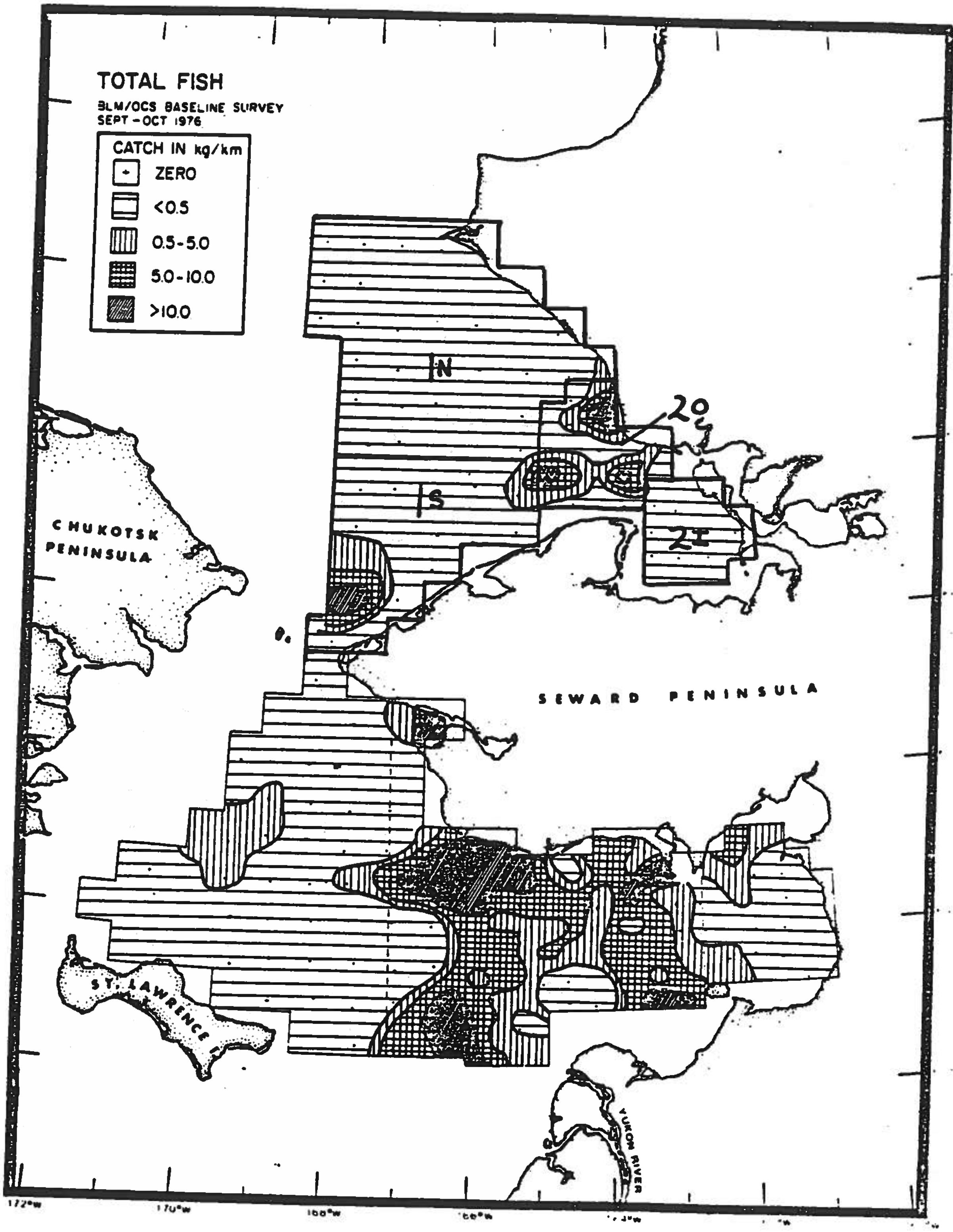


Figure 4.1. --Distribution and relative abundance by weight of total fish in the southeastern Chukchi Sea and adjacent waters (Wolotira et al, 1977).

Table 4.6. --Apparent biomass by major taxonomic groups by subarea estimated from the BLM/OCS survey in Norton Sound and the southeastern Chukchi Sea, September-October, 1976 (from Wolotira et al, 1977). SCS=Southeastern Chukchi Sea; KS=Kotzebue Sound; nBS=northern Bering Sea; NS= Norton Sound.

Taxa	Biomass for 1/ total survey area (mt)	Proportion of total biomass 1/	Biomass by subarea				Proportion of taxa biomass by subarea			
			SCS	KS	nBS	NS	SCS	KS	nBS	NS
Gadidae	22,692	.067	1,447	1,027	7,674	12,544	.063	.045	.338	.553
Pleuronectidae	10,509	.031	2,783	399	1,999	5,328	.264	.038	.190	.507
Cottidae	6,699	.020	695	101	4,547	1,356	.104	.015	.679	.202
Clupeidae	2,878	.009	637	1,607	453	181	.221	.558	.157	.063
Osmeridae	2,463	.007	320	740	1,035	368	.130	.300	.420	.149
Zoarcidae	888	.003	250	65	387	186	.282	.073	.436	.209
Cyclopteridae	574	.002	333	7	224	10	.580	.012	.390	.017
Stichaeidae	222	.001	45	24	23	130	.203	.108	.104	.586
Agonidae	248	.001	83	8	79	78	.335	.032	.319	.315
Other fish	271	.001	8	2	211	50	.029	.007	.779	.186
Total fish	47,444	.140	6,601	3,980	16,632	20,231	.139	.084	.351	.426
Gastropod molluscs	19,341	.057	8,649	1,253	6,368	3,071	.447	.064	.329	.159
Pelecypod molluscs	632	.002	191	40	99	302	.302	.063	.157	.478
Shrimp	2,904	.009	1,171	175	936	622	.403	.060	.322	.214
Chionoecetes sp.	8,741	.026	3,879	3,597	1,210	55	.444	.412	.138	.006
Paralithodes sp.	5,192	.015	76	13	1,515	3,588	.014	.003	.292	.691
Telemessus sp.	2,769	.008	1,199	217	330	1,023	.433	.078	.119	.480
Total commercially important invertebrates	39,579	.117	15,165	5,295	10,458	8,661	.398	.134	.264	.219
Starfish	161,251	.478	38,842	17,252	34,264	70,893	.24	.107	.212	.440
Other echinoderms	27,010	.080	4,221	42	22,626	121	.156	.002	.838	.006
Other invertebrates 3/	62,395	.185	31,337	4,804	19,243	7,011	.502	.077	.308	.146
Total invertebrates	290,235	.859	89,565	27,393	86,591	86,686	.309	.094	.298	.299
TOTAL CATCH 4/	337,679		96,166	31,373	103,223	106,917	.285	.093	.306	.317

1/ Apparent estimated biomass susceptible to the trawl.
2/ Total biomass for all fish and invertebrate taxa.
3/ Primarily includes coelenterates, pagurid crabs and ascidians.
4/ Total catch of all fish and invertebrate taxa.

Table 4.7. --Average catch per unit effort of major taxonomic groups by subarea estimated from the BLM/OCS survey in Norton Sound and the southeastern Chukchi Sea, September-October, 1976 (Wolotira *et al*., 1977).

Taxa	CPUE for total survey area	Proportion of total CPUE 1/	CPUE by subarea				Proportion of total CPUE by subarea			
			SCS	KS	nBS	NS	SCS	KS	nBS	NS
Gadidae	2.90	.067	0.59	1.40	2.75	6.74	.015	033	.074	.117
Pleuronectidae	1.34	.031	1.14	0.55	0.72	2.86	.029	.013	.019	.050
Cottidae	0.86	.020	0.28	0.14	1.63	0.73	.007	.003	.044	.013
Clupeidae	0.37	.009	0.26	2.20	0.16	0.10	.007	.051	.004	.002
Osmeridae	0.31	.007	0.13	1.01	0.37	0.20	.003	.024	.010	.003
Zoarcidae	0.11	.003	0.10	0.09	0.14	0.10	.003	.002	.004	.002
Cyclopteridae	0.07	.002	0.14	0.01	0.08	0.01	.004	3/	.002	3/
Sticheidae	0.03	.001	0.01	0.03	0.01	0.07	3/	.001	3/	.001
Agonidae	0.03	.001	0.03	0.01	0.03	0.04	.001	3/	.001	.001
Other fish	0.04	.001	0.02	—	0.09	0.02	.001	3/	.002	3/
Total fish	6.06	.140	2.70	5.44	5.97	10.87	.069	.127	.161	.189
Gastropod molluscs	2.47	.057	3.54	1.71	2.29	1.65	.090	.040	.062	.029
Pelecypod molluscs	0.08	.002	0.08	0.06	0.04	0.16	.002	.001	.001	.003
Shrimp	0.37	.009	0.48	0.24	0.34	0.33	.012	.006	.009	.006
Chionoecetes sp.	1.12	.026	1.59	4.91	0.43	0.03	.040	.115	.012	.001
Paralithodes sp.	0.66	.015	0.03	0.02	0.54	1.93	.001	3/	.015	.034
Telemessus sp.	0.35	.008	0.49	0.30	0.12	0.55	.012	.007	.003	.010
Total commercially important invertebrates	5.05	.117	6.20	7.24	3.75	4.65	.158	.169	.101	.081
Starfish	20.61	.478	15.89	23.57	12.30	38.10	.404	.550	.332	.663
Other echinoderms	3.45	.080	1.73	0.06	8.12	0.06	.044	.001	.219	.001
Other invertebrates 2/	7.99	.185	12.81	6.56	6.90	3.78	.326	.153	.186	.066
Total invertebrates	37.10	.860	36.63	37.43	31.08	46.58	.931	.873	.839	.811
TOTAL CATCH 4/	43.16		39.33	42.87	37.05	57.46				

1/ Catch per unit effort (kg/km) for all fish and invertebrate taxa combined.
2/ Primarily includes coelenterates, pagurid crabs and ascidians.
3/ Proportion less than .0005.
4/ Total catch for all fish and invertebrate taxa.

Many of the marine fish in the Chukchi Sea are believed to maintain their populations by recruitment of eggs, larvae, and juveniles transported north from the Bering Sea (Pruter and Alverson, 1962). This is indicated by the generally smaller size, younger age, and slower growth rate of individuals of these species in the Chukchi Sea relative to their Bering Sea populations. Bering flounder, yellowfin sole, Alaska plaice, and walleye pollock are some of the species present in low densities, and whose individuals exhibit slow growth rates, most likely related to the short growing season and low temperatures. Pruter and Alverson (1962) felt that yellowfin sole could not survive overwintering conditions in the Chukchi Sea, and are annually recruited from the Bering Sea.

Fish that probably do maintain their populations by resident breeding stocks include the Arctic cod, saffron cod, sand lance, capelin, and some of the flounders (Walters, 1955). These resident spawners tend to lay large, yolky eggs in shallow waters. Their larvae hatch and become planktonic during the summer, eventually sinking to deeper waters to mature.

Five fish families, Gadidae, Pleuronectidae, Cottidae, Clupeidae, and Osmeridae account for over 95% of the total fish biomass of the region. Each of these families is briefly discussed below.

<u>Gadidae (Saffron and Arctic cod)</u>

Four species of gadids occur in the Chukchi Sea. The two most abundant species are saffron cod (<u>Eleginus gracilis</u>) and Arctic cod (<u>Boreogadus saida</u>), comprising 99% of the catch of this family. These two species, at different times of the year, are probably the dominant ichthyofauna of most Arctic waters. Walleye pollock (<u>Theragra chalcogramma</u>) and Pacific cod (<u>Gadus macrocephalus</u>) are only occasionally encountered.

Little is known about the biology of either Arctic or saffron cod. Both species occur throughout the region, and juveniles are extremely abundant during the ice-free season. First year juveniles of the Arctic cod are always found near the sea surface (Hognestad, 1968). Quast (1974) estimated that over 21,000 mt (46 million lb.) of juvenile Arctic cod were present north of

Cape Lisburne during a 1970 survey. This fish is heavily utilized by the large populations of cliff-nesting seabirds (primarily thick-billed murres, common murres, and kittiwakes) of the Lisburne Peninsula. Swartz (1966) estimated that as many as 250 million Arctic cod are consumed annually by the Cape Thompson sea bird populations. Arctic and saffron cod are also important prey species for other fish, seals, walrus, beluga whales, as well as a food resource of coastal villagers.

Summer distributions of Arctic cod are unknown but the species appears to be more abundant in the more northern and deeper areas (Figure 4.2). Large schools reportedly form in the fall and approach the coast and warm waters of river mouths. During the winter months, Arctic cod are associated with the sea ice. Arctic cod spawn in the winter under the ice, but their spawning areas are unknown. Saffron cod also approach the coast in large schools during the late summer and early fall, and probably spawn in the winter. Summer distributions and winter spawning areas are also unknown.

Pleuronectidae (flatfishes)

There are 8 genera and 9 species of pleuronectids known from the Chukchi Sea. The family ranks second to the gadids in relative overall abundance of fish in the southeastern Chukchi Sea. In the outer region, it was the most abundant fish family in the 1976 trawl surveys. Three species, starry flounder (Platichthyes stellatus), Alaska plaice (Pleuronectes quadrituberculatus), and yellowfin sole (Limanda aspera) accounted for nearly 88% of the flatfish biomass. Their abundance was greatest north of the Bering Strait and generally decreased northward and toward the coast (Figure 4.3). In the 1959 AEC surveys, the Bering flounder (Hippoglossoides robustus) was the most numerous flatfish encountered (Pruter and Alverson, 1962).

Cottidae (sculpins)

Sculpins are the most diverse and third-most abundant bottomfish in the southeast Chukchi Sea. There are 11 genera and 20 species reported from these waters (Table 4.2). Three species, the shorthorn sculpin

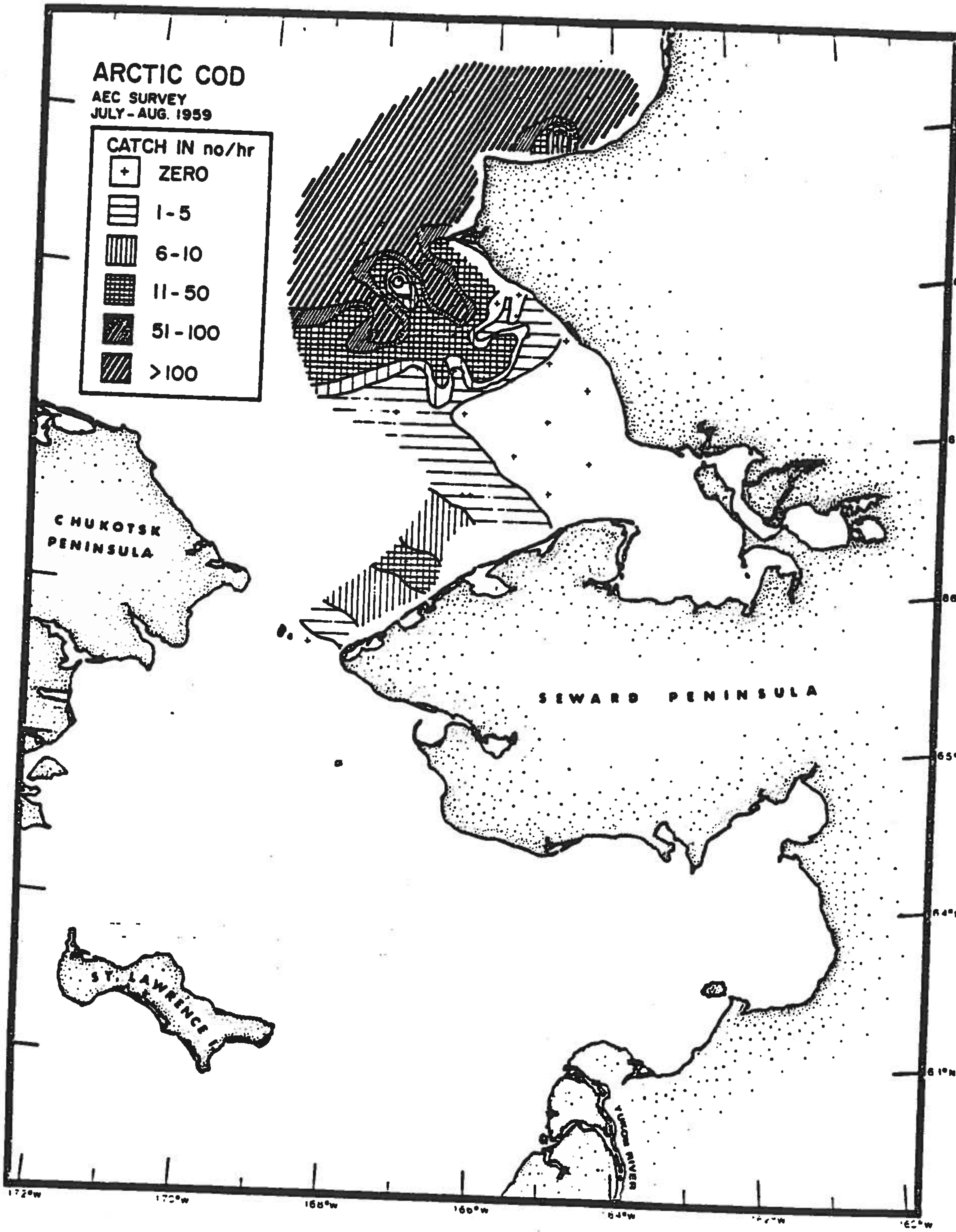


Figure 4.2. --Distribution and relative abundance by numbers of Arctic cod in the southeastern Chukchi Sea during 1959 (from Wolotira *et al*, 1977).

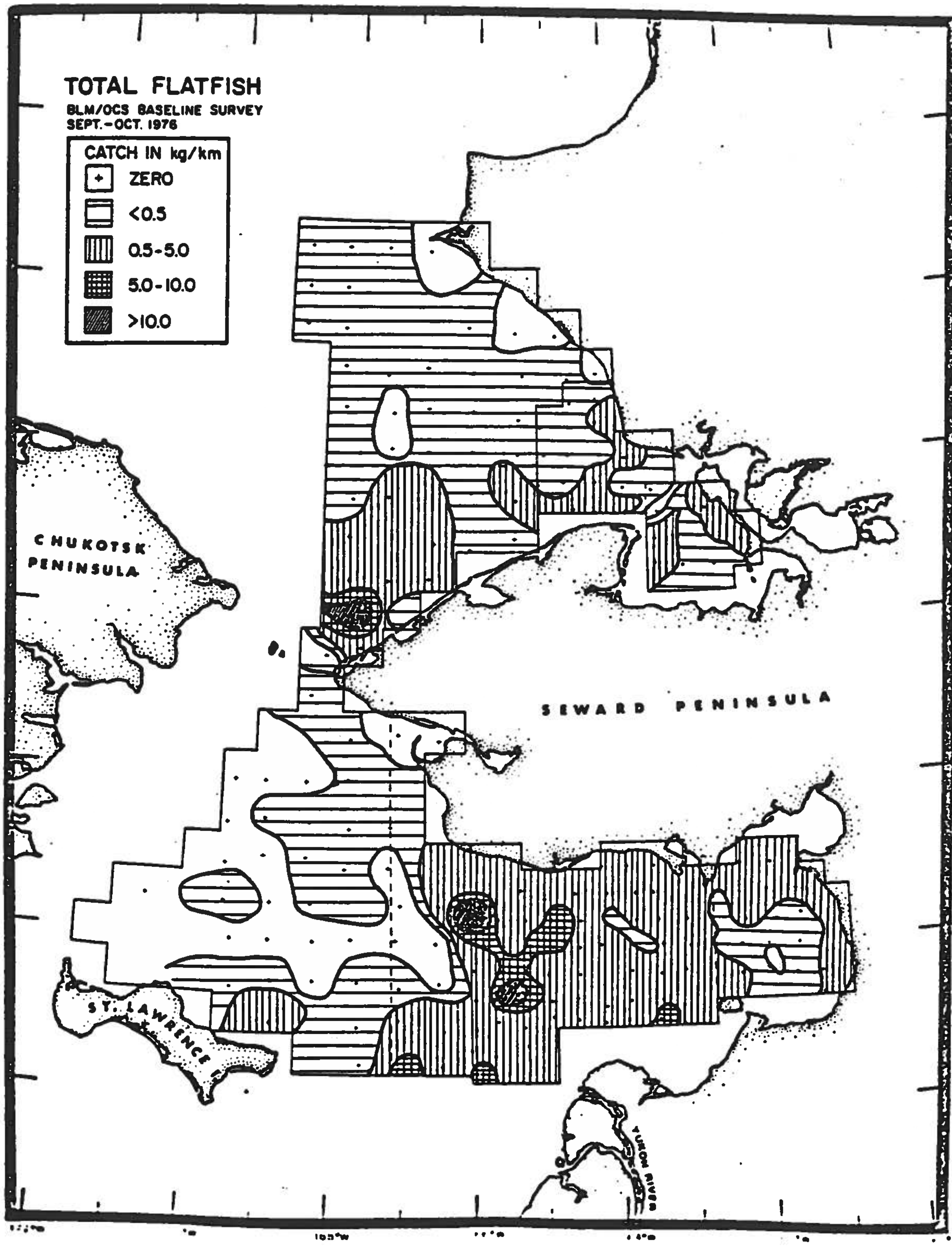


Figure 4.3. --Distribution and relative abundance by weight of total flatfish in Norton Sound, the southeastern Chukchi Sea and adjacent waters (Wolotira et al, 1977)

(Myoxocephalus scorpius), plain sculpin (M. joak), and Arctic staghorn sculpin (Gymnocanthus tricuspis) comprised 86% of the catch of this family (Wolotira et al., 1977). Sculpins were widely and fairly evenly distributed over the shelf, with apparent highest abundance nearshore on the Lisburne Peninsula (Figure 4.4). Sculpins are an important prey of ringed and bearded seals during the spring and summer.

Clupeidae (herring)

The Clupeidae family is represented by a single species, the Pacific herring (Clupea harengus pallasi). This was the most abundant fish in Kotzebue Sound (Figure 4.5) during the 1976 trawl surveys, with catch rates averaging 2.5 kg/30 min. trawl.

Pacific herring spawn in nearshore waters of the region in May and June, sometimes before the ice breaks up. A late spawning occurs in Kotzebue Sound in August (Figure 4.6). Known spawning sites in the area are along the coast from Cape Prince of Wales to Shishmaref, and in Eschscholtz Bay. Herring are gillnetted by local residents for subsistence use in late September and October. There is evidence from subsistence fishing that some herring populations overwinter in the area, and may be an independent stock from the Bering Sea herring populations (Barton, 1977).

Osmeridae (smelt)

Osmerids are represented in the southeast Chukchi Sea by capelin (Mallotus villosus) and two anadromous smelts, rainbow (or toothed) smelt (Osmerus mordax), and pond smelt (Hypomesus olidus). Toothed smelt were the second most abundant fish in Kotzebue Sound during the 1976 trawl surveys with catch rates of 0.7 kg/30 min. trawl. Capelin is an important pelagic prey species of seabirds, seals, and belugas. It is poorly sampled by trawl surveys, and little is known of its areal abundance and distribution along the Chukchi Sea

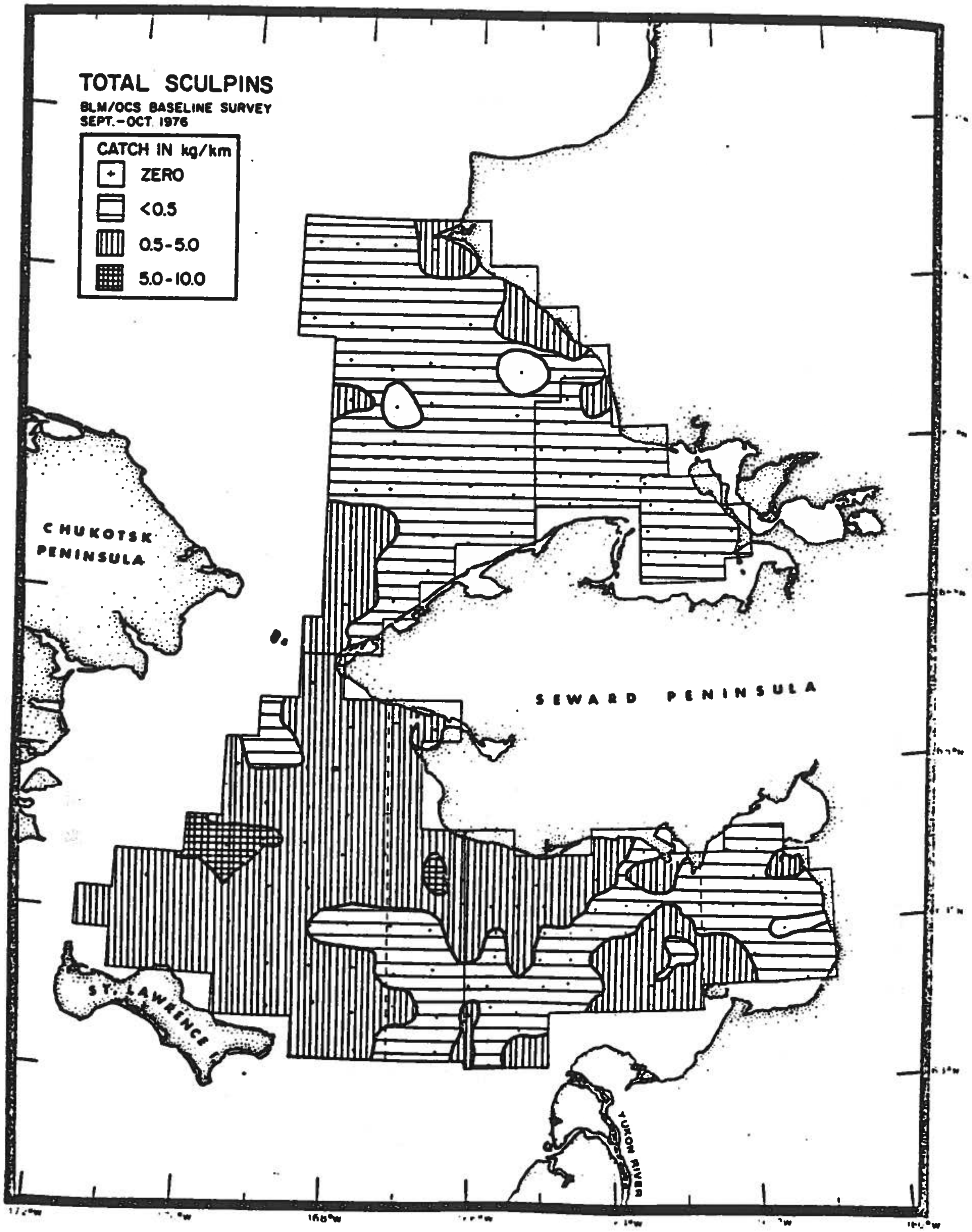


Figure 4.4. --Distribution and relative abundance by weight of total sculpins in Norton Sound, the southeastern Chukchi Sea and adjacent waters (Wolotira <u>et al</u>, 1977).

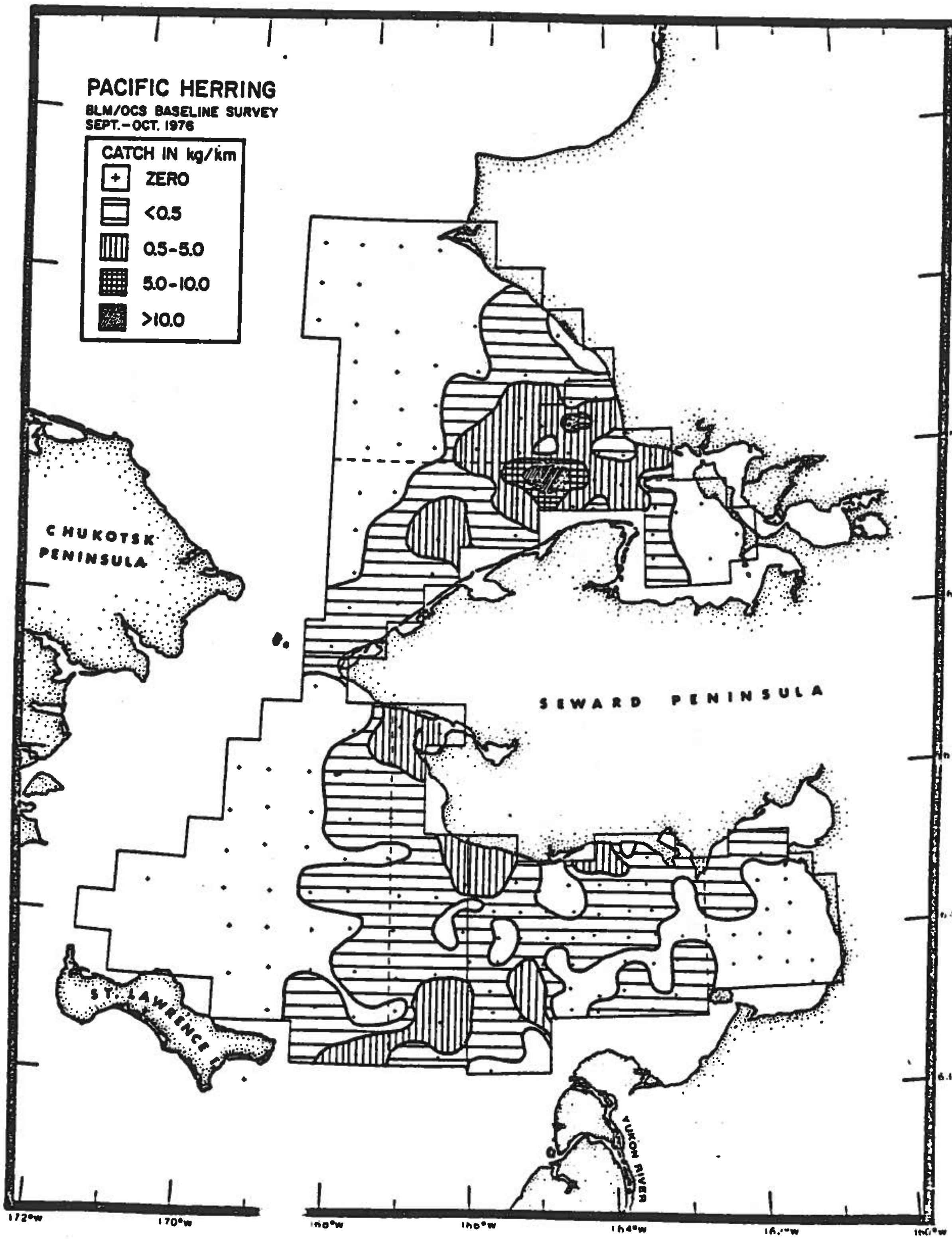


Figure 4.5. --Distribution and relative abundance by weight of Pacific herring in the southeastern Chukchi Sea and adjacent waters (from Wolotira et al., 1977).

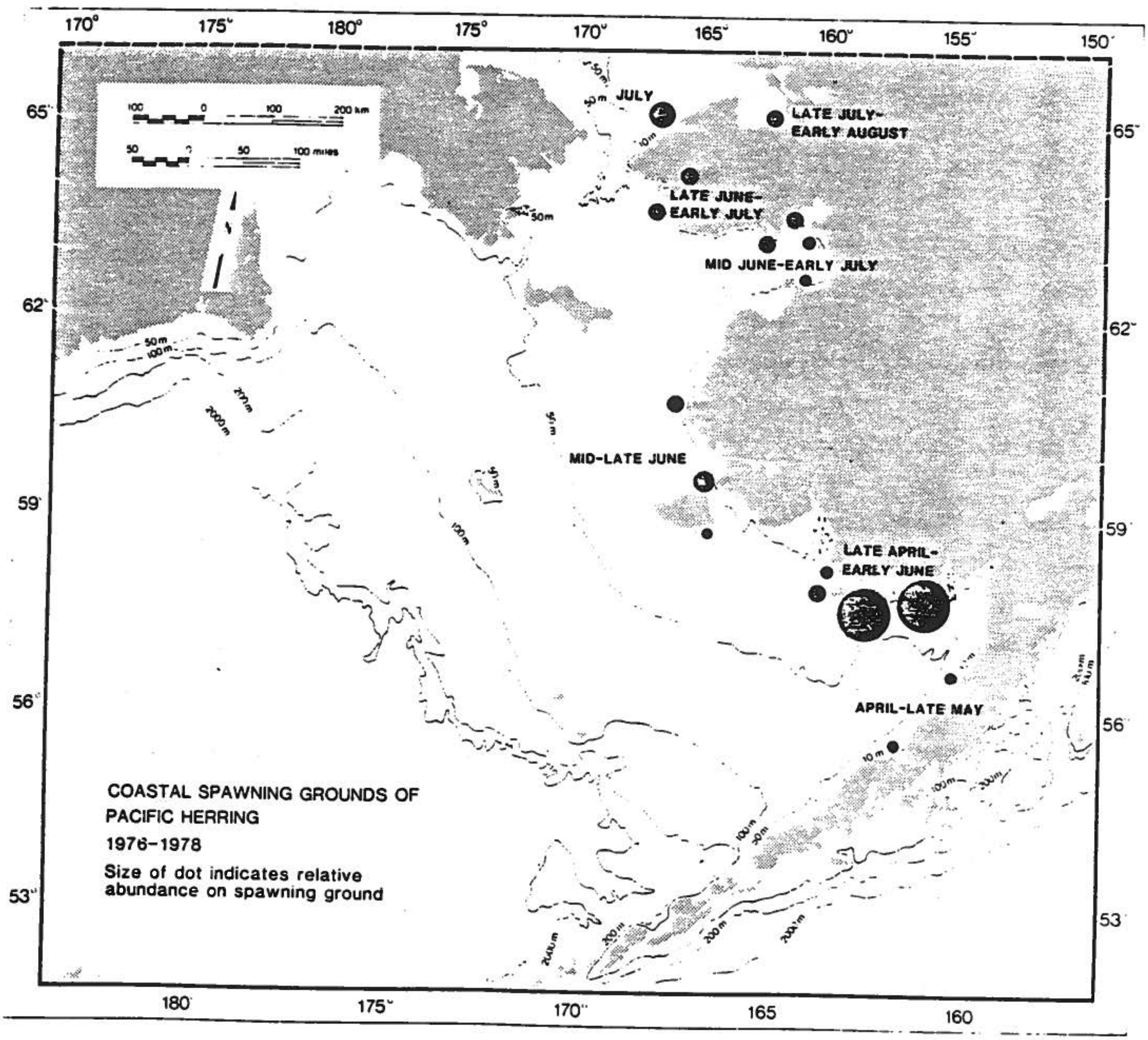


Figure 4.6. Distribution, time of spawning, and relative abundance of Pacific herring on coastal spawning grounds observed during aerial surveys, 1976-78 (from Wespestad, 1981).

coast. All three species are known to concentrate in high quantities at certain times. Capelin spawning has been reported at beaches along the Seward Peninsula from Cape Prince of Wales to Cape Espenberg (Barton, 1977).

Ammodytidae (sand lance)

The Pacific sand lance (Ammodytes hexapterus) are often found in large schools near the bottom in water depths to 120 m, and often bury into sandy bottom sediments. In summer they move inshore to feed, and are heavily utilized by the seabirds at Cape Lisburne and may be a principle prey species supporting these seabird colonies (Springer et al., 197 . They are also an important prey of ringed, bearded, and spotted seals, as well as other fish species.

Sand lance spawn during the winter (November to February) on sandy bottoms at depths of 50 to 75 m. They feed primarily on small planktonic crustaceans.

4.2 Anadromous Fish

Knowledge of the anadromous fish resources of the Chukchi Sea is poor. Of the 23 species of fish reported from freshwaters of the Arctic coast, 16 of these species (including 12 salmonids and 2 smelts) also occur in marine or estuarine waters during part of their life cycle. A list of the 16 anadromous fish species reported from the Chukchi Sea is given in Table 4.8. Some of these species undertake extensive migrations from freshwater as juveniles, mature at sea and return to freshwaters as adults to spawn. Among this group are the five species of salmon, the Arctic lamprey and the rainbow smelt. The remainder of the species seasonally enter the brackish or marine environment in the summer and spend most of their life in freshwater lakes and rivers. Three marine species also occasionally enter brackish or freshwater: the fourhorn sculpin, the Arctic flounder, and the starry flounder.

The distribution and abundance of these anadromous fish species is markedly affected by the seasonal sea ice. During the summer open-water season, anadromous species occur throughout the region in nearshore coastal waters, in

Table 4.8 List of anadromous fishes reported from the Chukchi Sea.

Scientific Name	Common Name
Family Petromyzontidae - lampreys	
Lampetra japonica	Arctic lamprey
Family Salmonidae - trouts	
Coregonus autumnalis	Arctic cisco
Coregonus laurettae	Bering cisco
Coregonus nasus	broad whitefish
Coregonus pidschian	humpback whitefish
Coregonus sardinella	least cisco
Oncorhynchus gorbuscha	pink salmon
Oncorhynchus keta	chum salmon
Oncorhynchus nerka	sockeye salmon
Oncorhynchus tshawytscha	King salmon
Oncorhynchus kisutch	silver salmon
Salvelinus alpinus	Arctic char
Stenodus leucichthyes	inconnu
Family Osmeridae - smelts	
Hypomesus olidus	pond smelt
Osmerus mordax	rainbow smelt
Family Gasterosteidae	
Pungitius pungitius	ninespine stickleback

brackish estuaries and river mouths, as well as in the freshwater drainages.

Most of these anadromous species spawn in the fall in lakes or streams (Table 4.9). There are at least 17 rivers draining into the southeast Chukchi Sea that are known to support anadromous fish populations (Table 4.10 and Figure 4.7). The most diversely utilized of these rivers are the Kobuk and Noatak Rivers entering Kotzebue Sound.

Salmon

All five species of Pacific salmon common along the Alaskan coast are known to spawn in freshwaters of the Chukchi Sea coast. Most abundant are the pink salmon (Oncorhynchus gorbuscha) and the chum salmon (O. keta). Sockeye (O. nerka), King (O. tshawytscha), and silver salmon (O. kisutch) spawn in low numbers in certain streams as far north as Cape Lisburne. All species spawn during summer and early autumn, requiring clear streams with clean gravel beds. The eggs develop in the gravel during winter, and the young emerge the following spring. The newly hatched young of pink and chum salmon migrate directly to the sea while the young of the king, silver, and sockeye salmon may remain in freshwater 2 to 3 years (Table 4.11). Little is known of the location of the actual spawning areas of these species in rivers along the Chukchi Sea coast.

The runs of salmon in Chukchi Sea tributaries are greatest in the rivers entering Kotzebue Sound. Large runs of chum salmon returning from the Bering Sea enter the Kotzebue tributaries, especially the Noatak and Kobuk Rivers (Figure 4.8). Straty (1981) estimated that Kotzebue Sound drainages produce only 1.5% of all five Pacific salmon species that pass through the Bering Sea, but 10.1% of the total chum salmon population.

It is hypothesized that the salmon stocks of the Chukchi Sea coast are limited in size by the long period of low winter temperatures in the spawning beds of most streams in this region. Although most streams are accessible and suitable, low air temperatures, sparse snow cover, and the permafrost base probably combine to produce unfavorable temperature conditions for spawning and

Table 4.9 Spawning season and habitat of anadromous fish in the Chukchi Sea

Season	Species	Spawning Habitat
Late Spring	ninespine stickleback	lakes and ponds, in vegetation
Summer	fourhorned sculpin	shallow inshore
Fall	Arctic char	lakes, streams, spring areas
	broad whitefish	river deltas
	humpback whitefish	rivers and lakes
	Arctic cisco	streams, on gravel
	Bering cisco	streams, on sand and/or gravel
	least cisco	streams, on sand and gravel
	chum salmon	rivers, streams, spring areas
	pink salmon	coastal streams

Table 4.10 - Anadromous fish streams of southeastern Chukchi Sea.

River	Fish Species	Pink Salmon	King Salmon	Chum Salmon	Silver Salmon	Sockeye Salmon	Arctic Char	Inconnu	Whitefish
1.	Nuluk					X	X		
2.	Kugrupaga						X		
3.	Arctic	X		X		X	X		X
4.	Serpentine	X		X		X	X		X
5.	Goodhope						X		
6.	Inmachuk			X					
7.	Kugruk			X					X
8.	Kiwalik			X					
9.	Buckland			X			X	X	X
10.	Kauk			X					
11.	Selawik							X	X
12.	Kobuk	X	X	X	X	X	X	X	X
13.	Noatak	X		X	X	X	X		X
14.	Kilikmak								
15.	Wulik	X	2/	X			X		X
16.	Singoalik	X							
17.	Kukpuk	X		X	X		X		X

1/ Most rivers are poorly surveyed, and no listing for a species may be due to a lack of information.

2/ Northern most record of King Salmon in Alaska is from the Wulik River.

River

1. Nuluk
2. Kugrupaga
3. Arctic
4. Serpentine
5. Goodhope
6. Inmachuk
7. Kugruk
8. Kiwalik
9. Buckland
10. Kauk
11. Selawik
12. Kobuk
13. Noatak
14. Kilikmak
15. Wulik
16. Singoalik
17. Kukpuk

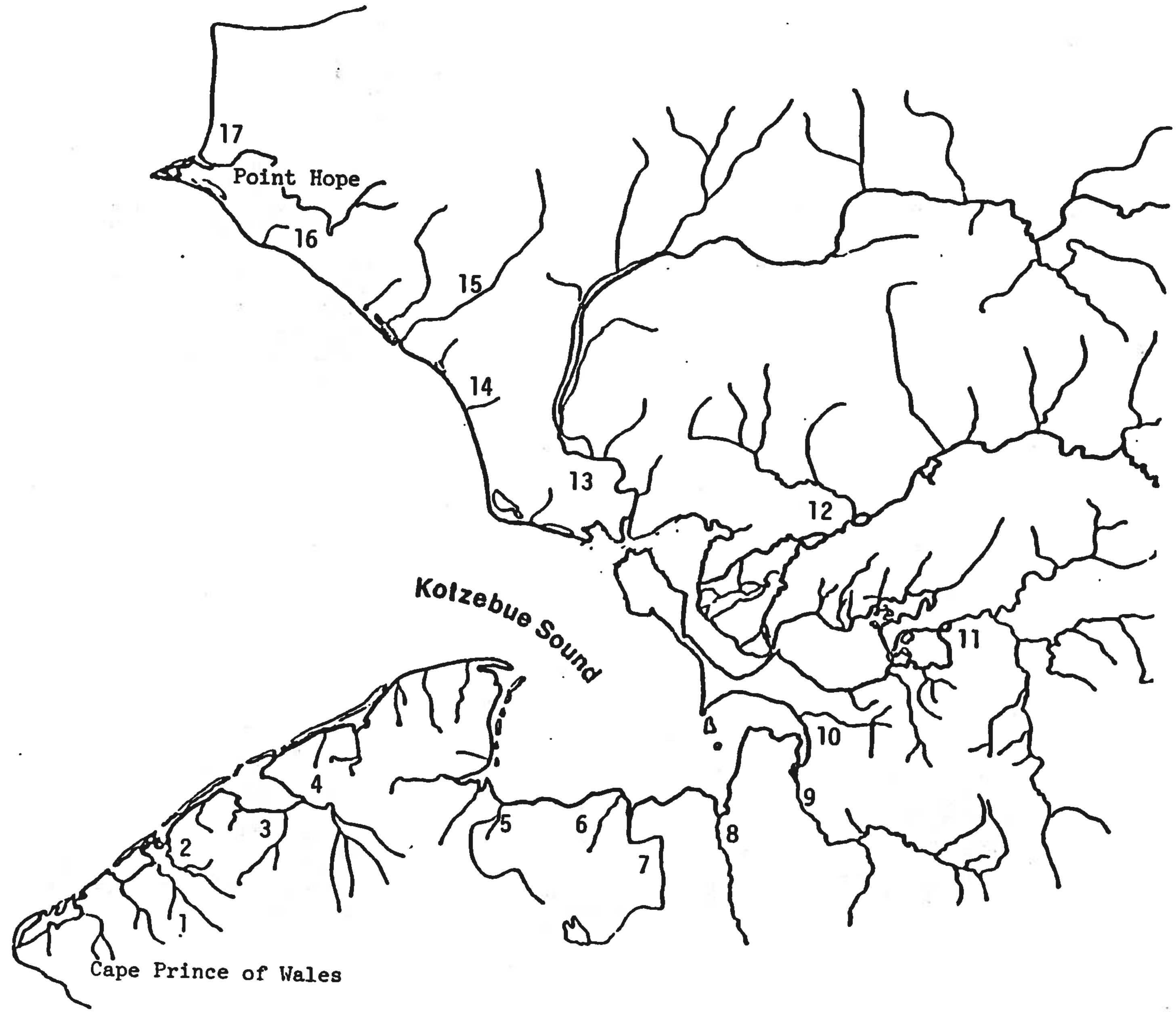
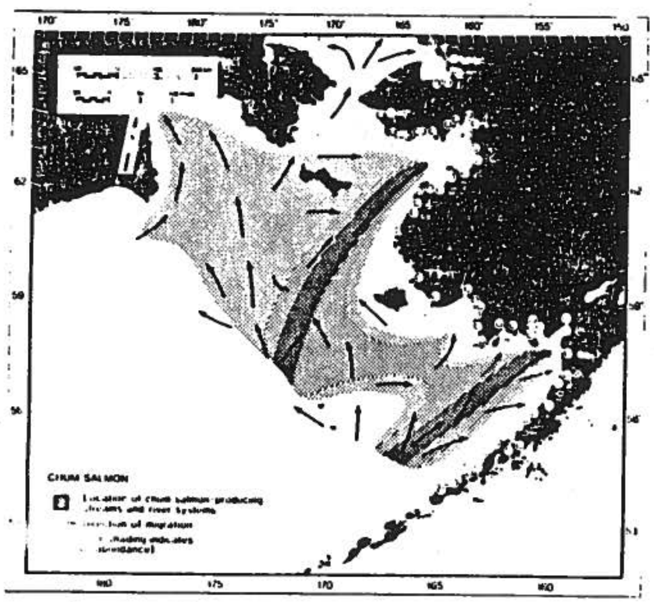
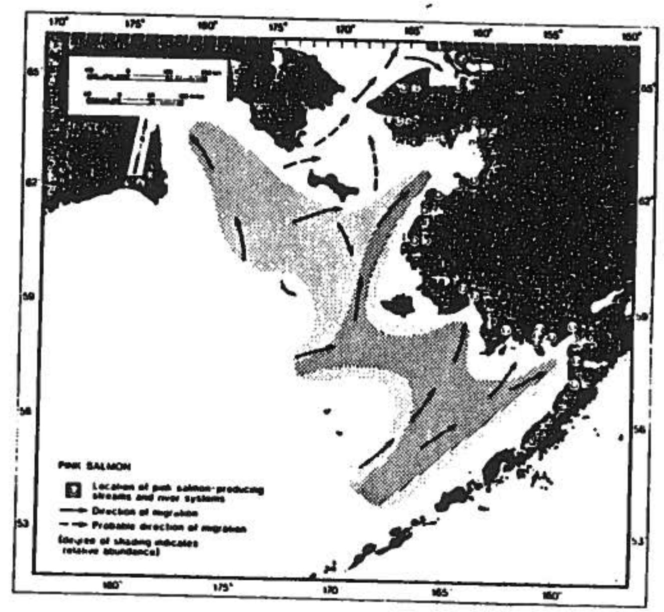


Figure 4.7. Locations of known anadromous fish streams in the southeast Chukchi Sea. Table 4.10 list the species of anadromous fishes known to inhabit these streams.





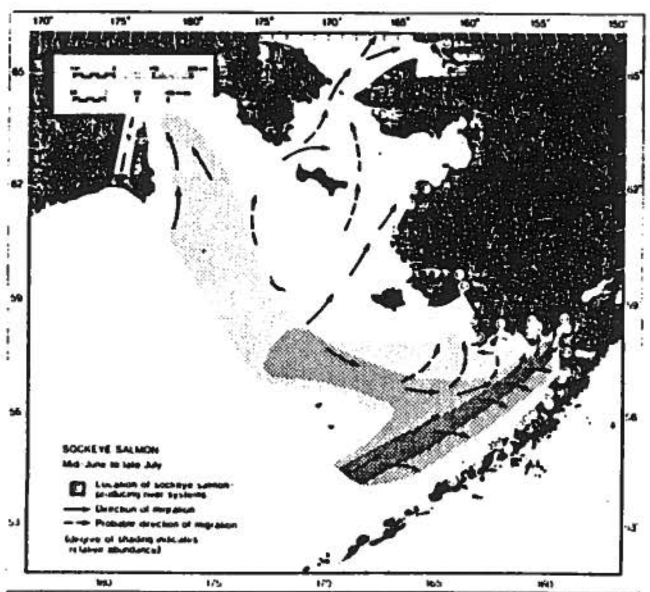


Figure 4.8. Return migrations of chum, pink, and sockeye salmon to spawning rivers in the Bering Sea and southeast Chukchi Sea (from Straty, 1981).

Table 4.11 - Data for five species of Pacific salmon occurring in Kotzebue Sound and the southeastern Chukchi Sea.

Item	Species				
	King	Pink	Sockeye	Silver	Chum
Length of time young stay in fresh water	few days to 2 years	few days	few days to 3 years	1 to 2 years	few days
Length of ocean life	1 to 5 yrs	1 1/3 yrs	1/2 to 4 yrs	1 to 2 yrs	1/2 to 4 yrs
Life at maturity, years	2 to 8	2	3 to 7	2 to 4	2 to 5
Length, average inches, at maturity	36	20	25	24	25
Length, range, inches, at maturity	16 to 60	14 to 30	15 to 33	17 to 36	17 to 38
Weight, average, pounds, at maturity	22	4	6	10	9
Weight, range, pounds, at maturity	2 1/2 - 125	2 to 9	1 1/2 to 10	3 to 30	3 to 45
Present in bays and estuaries	June-July	June-Aug	June-July	Aug.	June-Aug
Principal spawning months	July-Aug	July-Sept	July-Sept	Aug-Sept.	July-Sept
Fecundity-number of eggs	5,000	2,000	4,000	3,500	3,000

rearing, especially for those salmon whose young spend several winters in freshwater before moving to the sea.

Arctic char

The most widely occurring anadromous fish in the Chukchi Sea is the Arctic char (Salvelinus alpinus), being found in most streams, lagoons, and coastal waters of the region. Although the majority of the species is anadromous, some individuals remain year-round in freshwater. The coastal distribution and abundance of Arctic char in the Chukchi Sea is largely undefined.

Arctic char overwinter primarily at rivermouth deltas and in lagoons that are fed with freshwater and remain partially unfrozen throughout the winter. Some individuals overwinter in the deeper portions of spring-fed streams. The species avoids the sub-zero winter temperatures of the nearshore marine waters. Migration to the marine environment immediately follows spring break-up. While in coastal waters, they feed extensively on small fish and plankton as they travel along the shore. These migrations along the coast are generally limited to within 100 miles of their home streams. They begin reentering freshwater rivers in August, with the spawners entering first. Individual Arctic char spawn every other year in September and October, the eggs hatch in April, and the juveniles remain in freshwater for 3 or 4 years before migrating to the sea.

Whitefish and Ciscoes

Fish of the genus Coregonus, which includes the whitefish and the ciscoes, are common in Arctic Alaska waters. Humpback whitefish (Coregonus pidschian) are the most widely distributed, and have both anadromous and freshwater populations. The anadromous forms primarily inhabit the lower reaches of rivers, brackish deltas, and estuaries. They overwinter in freshwater before outmigrating at spring break-up to enter their summer feeding grounds in estuaries. Broad whitefish (Coregonus nasus) also occupy estuaries, but are most common in the slower moving waters of the larger rivers and in the interconnected lakes and slough systems.

The ciscoes are more estuarine and coastal than the whitefish. The Arctic cisco (Coregonus autumnalis) is primarily a nearshore and estuarine species that migrates upstream to spawn. Spawning occurs over gravel in flowing waters in early autumn. After spawning, adults return downstream in distinct migrations. Bering ciscoes (Coregonus laurettae) are most common near the mouths of rivers and in brackish lagoons. Little is known of their life history, but it is presumed to be similar to the coastal Arctic and least ciscoes. Least ciscoes (Coregonus sardinella) have both anadromous and freshwater races. Anadromous least ciscoes overwinter in freshwater, move downstream in the summer to river flats and river mouths, and return to freshwater streams to spawn in the autumn. The distribution and abundance of whitefish and ciscoes along the Chukchi Sea coast is poorly known.

Inconnu

The inconnu, or sheefish (Stenodus leucichthyes), is a large relative of the whitefish. This fish occurs in several drainage systems entering Hotham Inlet and Kotzebue Sound. The Kobuk and Selawik River areas are noted for the large sheefish (up to 60 lbs.) produced there. The species is estuarine-anadromous, overwintering in the brackish water of Hotham Inlet and Selawik Lake. At break-up, the fish move upriver to feed and spawn. They spawn in late September and early October in select streams with fast currents, clean coarse gravel beds, and a bottom depths of four to eight feet. After spawning the adults return downriver to their overwintering grounds.

4.3 Commercial and Subsistence Fisheries

Commercial Fisheries

Both the abundance of marine fish and their size drop dramatically north of the Bering Strait. Trawl surveys in 1959 (Pruter and Alverson, 1962) and in 1976 (Wolotira, et al., 1977) indicate that the availability of commercially valuable demersal fish resources in the Chukchi Sea is very poor. The 1959 trawl surveys caught less than 23 kg of flatfish (289 flounders) in a total of 59 half-hour hauls. The total catch of all trawl-caught fish was less than 180 kg. The NMFS trawl surveys in 1976 confirmed these findings and showed that the greatest proportion of the trawl-caught biomass in these northern waters was benthic echinoderms and miscellaneous other non-commercial invertebrates. Fish composed only 14% of the trawl catch of the 1976 surveys. It is not believed that there are any demersal fishery resources in this region of interest to commercial harvest.

The existing commercial fishery in this area is targeted almost exclusively on chum salmon although there is a small harvest of other anadromous fish. The fishing effort is centered predominantly in the Kotzebue district. While this commercial fishery is not nearly as productive as those of Bristol Bay or the Yukon River, it does hold an important place in Kotzebue's present economy. Nearly all commercial fishermen in this district are Eskimos from Kotzebue.

The history of the commercial salmon fishery in Kotzebue Sound dates back to 1914 when the Midnight Sun Packing Company opened a salmon cannery in Kotzebue which lasted until 1918. Fish purchased from local fishermen and brought from surrounding villages produced 10,130 cases (486,240 pounds) of canned salmon during this period. An additional 330 barrels of salted salmon were processed, presumably chum salmon.

In 1949 the Kotzebue district was reopened to commercial fishing, but the commercial salmon fishery did not resume until several years later. The initial commercial effort, during the winter of 1948-49, was ice fishing for inconnu and whitefish in Hotham Inlet and Selawik Lake. This fishery provided over 100,000 lbs of fish for market within Alaska. In both 1949 and 1950, over 150,000 pounds of inconnu were shipped from Kotzebue to Barrow. The commercial catch declined in subsequent years from apparent overfishing, and has yet to realize the intensity of earlier years, although some fish continue to be sold annually in local markets.

In more recent years, chum salmon has again become the major species sought. The chum salmon from Kotzebue Sound average 9 pounds and are in prime condition. The Kotzebue district fetches the highest price paid in Alaska for this species (as much as $.80/lb in 1979). A large catch of chum salmon in 1962 reinstigated the fishery. The harvest has since fluctuated from year to year, largely due to its northern location, but since 1962 the commercial catch has averaged 180,000 fish annually (Table 4.12 and 4.13). The 1973-1975 catch averaged 525,000 fish, exclusively chum salmon, valued at about $1.4 million. The commercial catch for 1976-1980 averaged 195,000 fish annually, considerably below the two highest catch years of 1974 and 1975, but near the annual average for the fishery since 1962. A good 1980 harvest of 367,300 chum was valued at $1,447,000 (ADF&G, 1980).

Since the fishery resumed in 1962, it increased rapidly and is now considered to be fully exploited. In 1975, 551 fisherman operating 275 set gillnets were licensed, and a total of 258 vessels, mainly open skiffs with outboard motors, were used. The major set gillnet fishing area is located at the mouth of Hotham Inlet between Cape Blossom on the Baldwin Peninsula and Cape Krusenstern (Figure 4.9).

Products of this salmon fishery in the Kotzebue district are canned chum salmon, fresh-frozen chum salmon, and fresh-frozen or cured salmon roe. There is little local processing beyond gutting and chilling. The majority of the salmon is flown out and processed in Anchorage or in plants on the Kenai Peninsula.

Small amounts of sheefish (25,000 lbs.), whitefish, and Arctic char are also harvested in Kotzebue Sound. The latter two are incidentally caught in the salmon fishery. These fish are sold as fresh and frozen products.

Subsistence Fishing

Subsistence fishing in villages along the Chukchi Sea is generally secondary to the harvest of terrestrial and marine mammals. These villages rely most heavily on subsistence fishing for their food when the marine mammal harvest is poor. Salmon does, however, provide a major food resource to the villages of the Kotzebue district. In other villages, salmon are in low number and

Table 4.12 Commercial salmon catch, Kotzebue area, in numbers of fish, 1962-1976, (from ADF&G, 1978).

Year	Total	Chum	Pink	King	Sockeye	Coho
1962	130,075	129,948	107	12	7	1
1963	54,588	54,445	136	7	--	--
1964	76,504	76,499	5	--	--	--
1965	40,034	40,034	--	--	--	--
1966	31,981	31,756	131	1	93	--
1967	29,404	29,400	3	1	--	--
1968	30,384	30,384	--	--	--	--
1969	59,383	59,335	48	--	--	--
1970	159,664	159,664	--	--	--	--
1971	154,957	154,956	--	1	--	--
1972	169,667	169,664	--	3	--	--
1973	375,437	375,432	--	5	--	--
1974	634,527	634,479	48	--	--	--
1975	563,381	563,345	36	--	--	--
1976	159,796	159,796	--	--	--	--

Table 4.13. Kotzebue district historical and current (1979) chum salmon catch statistics (from Bird, 1980).

Year	Commercial chum catch	Number of licensed boats	Mean seasonal catch/licensed boat	Boat-days fished	Mean seasonal catch/boat-day	Number of set gill nets	Mean price paid/pound to fishermen	Gross value of catch to fishermen
1962	129,948	84	1,547	793	164	102	0.35¢ 1/	$45,500
1963	54,445	61	893	693	79	60	0.35 1/	9,140
1964	76,499	52	1,471	560	137	52	0.05	34,660
1965	40,025	45	889	410	98	45	0.05	18,000
1966	30,764	44	699	548	56	44	0.11	25,000
1967	29,400	30	980	410	72	30	0.11	28,700
1968	30,199	59	512	634	48	59	0.14	46,000
1969	59,335	52	1,141	800	74	52	0.15	71,000
1970	159,664	82	1,947	1,368	117	82	0.15	186,000
1971	154,956	87	1,781	1,393	111	91	0.16	200,000
1972	169,664	87	1,950	3,666	46	101	0.17	260,000
1973	375,432	136	2,761	3,663	103	156	0.25	925,000
1974	626,912	174	3,609	5,948	106	191	0.34	1,822,784
1975	563,345	258	2,184	10,480	54	275	0.28	1,365,648
1976	159,656	219	730	3,520	45	225	0.41	580,375
1977	195,895	222	881	4,704	42	218	0.56	1,033,950
1978	111,494	208	536	2,738	41	241	0.57	575,260
1979	141,623	210	782	3,892	36	210	0.79	990,263

1/ Price per fish

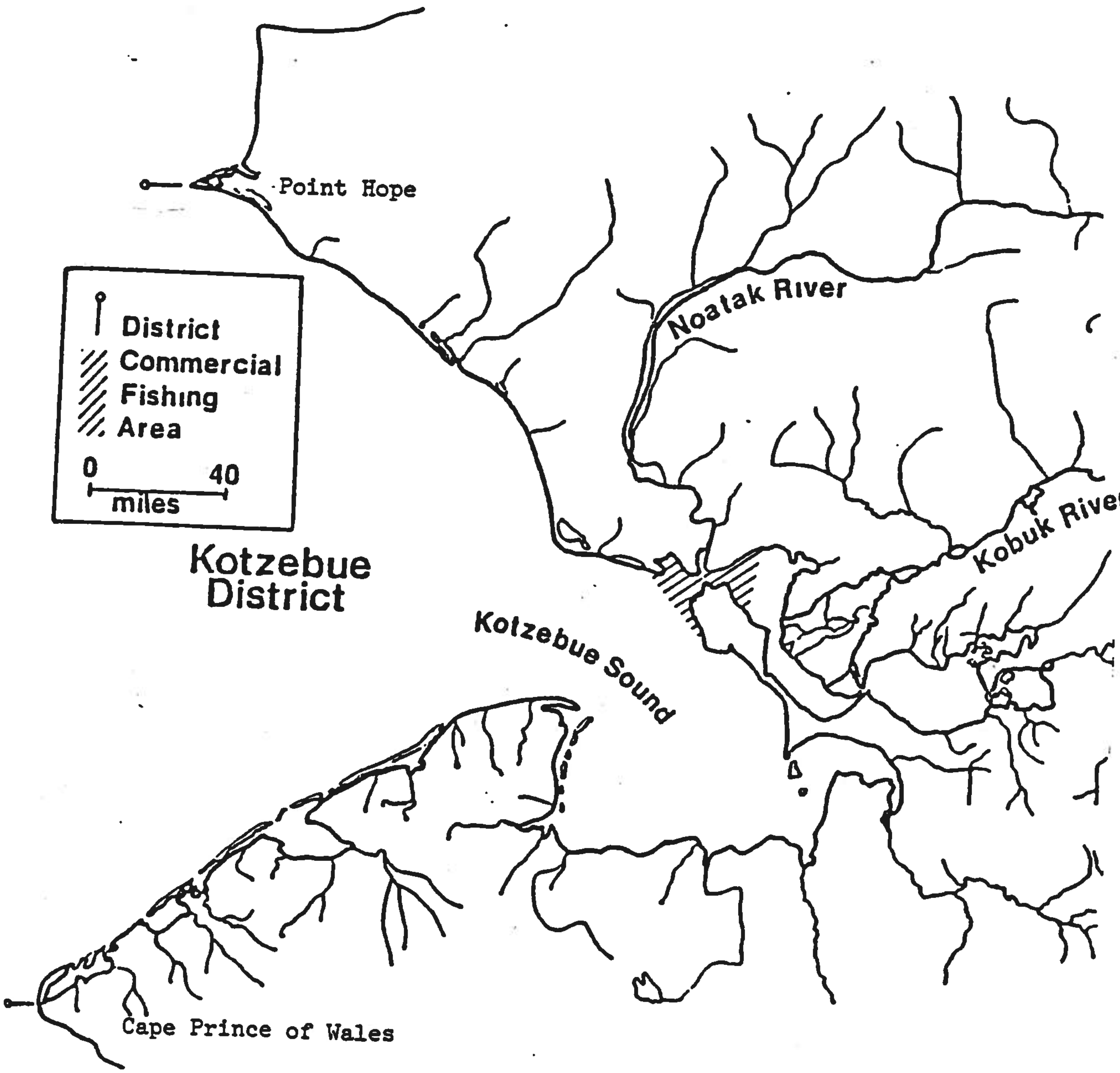


Figure 4.9. Kotzebue fishing district and fishery boundaries 1979 (from Bird, 1980).

whitefish, cisco, and Arctic char are the fish most frequently taken. Herring are an important subsistence item to the village of Shishmaref where both spring and fall runs are reported to occur. By mid-August fishing families at Shishmaref have taken about two barrels of herring apiece, enough for the winter to supplement subsistence hunting.

Barton (1977) quotes a long-time local resident as saying,"Subsistence fishing is going to increase because more and more people are becoming disenchanted with snow machines. About ten years ago, 50 percent of all fish catches went to dog sleds. Today the figures have decreased to about 10 percent, but because of high gasoline prices and the lack of maintenance skills, people are returning to their dogs."

An excellent account of subsistence fishing at Kivalina is given by Saario and Kessel (1966), where Arctic char is the main species sought. Fishing is usually by gillnet or rod and reel along the shore in June, or by seines in the Wulik River during September and early October.

Subsistence fishing follows a seasonal pattern. In the fall, natives fish for char and whitefish near their villages with nets or traps under the ice or hook and line through the ice. Recent winter subsistence fishing has centered on Hotham Inlet and Selawik Lake where large numbers of inconnu and whitefish are jigged through the ice. In June, after the ice has left, seine and gill net fishing is conducted for inconnu, whitefish, char, and grayling until the chum salmon arrive. Chum salmon, one of the most important food resources of the region, are obtained in quantity from June through August by seining and gill-netting. Fish camps are established along the major rivers for most of the salmon fishing. Salmon are used fresh during the summer, but most of the catch is dried and stored for winter use, mainly for dog food.

Subsistence salmon harvests in Kotzebue Sound during 1962-1976 ranged between 16,000 and 70,000 fish with an annual average of 29,000 (Wolotira et al., 1977). This is considerably greater than the results obtained in Barton's (1977) survey of four villages in this region (Table 4.14). Other fish taken in the subsistence fishery include the other four salmon species, Arctic cod, flounder, herring, smelt, and various shellfish. Arctic cod and some flounder

Table 4.14.– Survey results of subsistence takes (number of fish) for four villages from the Seward Peninsula to Point Hope, July 5 - September 5, 1976 (from Barton, 1977).

Village	1970 pop. census	Salmon					herring	Smelt Species	Whitefish Species	Tomcod (Saffron cod?)	Flounder Species	Arctic Grayling	Trout (Arctic Char?)	Bullheads	Lingcod	Skipjacks	Northern Pike	Cigarfish	Mud Sucker	Blue Cod	Pollock	Halibut	Blackfish Species	Needlefish	Sheefish (Inconnu)
		pink	chum	king	silver	sockeye																			
Shishmaref	267	410	300	5	5	50	X	X	X	X	X	X	X	X	X					X					
Deering	85	21	731	0	88		X	X	X	X	X	X	X	X				X							
Buckland	104	23	600	3	10		X	X	X	X	X	X	X	X					X		X				
Point Hope	386	X	X					X	X	X		X													

are generally fished through the ice in early winter.

Invertebrates are not a major food resource of Chukchi villages. Shrimp and crabs are the principal shellfish sought. Tanner crab, and occasionally king crab, appear in the subsistence diet of villagers of Point Hope. Crab fishing occurs from late February to break-up. Crab are fished by lowering a small wire grid baited with meat into the water in leads or through holes in the ice. The grid is left on the bottom for up to an hour and when hauled up usually catches crab which were feeding on the bait. Shrimp are often abundant. Whaling camps are reported to occasionally net shrimp in the spring, when they are of a large size, and utilize them for soup.

Sport Fishing

Sport fishing, though still inconsequential when compared to commercial and subsistence fishing, is growing. The main target fish for sport fishing is the inconnu, which is highly rated for its size (to 60 lbs.) and its scrappy fighting behavior. Some fishing is done in the winter through the ice in Hotham Inlet, but most is in the summer on the Noatak, Kobuk, and Selawik Rivers, and Selawik Lake.

5. THE MARINE MAMMALS

The southeastern Chukchi Sea is an important habitat for many Arctic marine mammals. Although the total number of resident species is relatively few, their abundances are often high. Table 5.1 lists the species of marine mammals known to occur in the Chukchi Sea.

The presence of marine mammals in the Chukchi Sea is strongly correlated with the seasonal cycles of sea-ice coverage of the region (Burns et al., 1980). Some marine mammals are closely ice-associated and are present in the area only with the sea ice. The main populations of the polar bear, bowhead whale, Pacific walrus, bearded seal, and ringed seal remain in close proximity to the sea ice year round. These seasonal residents of the region generally move north with the opening leads and retreating sea-ice to summer along the edge of the Arctic pack ice.

For other species, the association with the sea ice changes seasonally. Beluga whales, spotted seals, and ribbon seals inhabit the ice zone during the winter, and the coastal and ice-free waters during the summer season. Certain species are strictly open-water inhabitants, and reside in the Chukchi Sea only during the ice-free season, returning south ahead of the advancing sea ice in the fall. Several whales typically remain south of the seasonal sea ice, although they may have some association with it during their northward migration (i.e., humpback whales, gray whales, and killer whales).

The Arctic fox (Alopex lagopus) is a common inhabitant of the shorefast ice in the winter. Although it is not discussed further in the report, it is one of the more common mammals of the fast-ice environment. It preys chiefly on ringed seal pups during this season.

The seasonal occurrence and sea-ice relationships of the more common marine mammals in the Chukchi Sea (Bering Strait to Barrow) is given in Table 5.2 and illustrated in Figures 5.1 and 5.2.

The Chukchi Sea is an important feeding and reproduction area for most of

Table 5.1. A list of marine mammals of the southeastern Chukchi Sea and the frequency of their occurrence.

Scientific Name	Common Name	Occurrence
Order Carnivora		
Family Ursidae		
Ursus maritimus	polar bear	common
Order Cetacea		
Family Monodontidae		
Delphinapterus leucas	beluga	common
Monodon monoceros	narwhale	extremely rare
Family Delphinidae		
Orcinus orca	killer whale	common
Phocoena phocoena	harbor porpoise	uncommon
Phocoena dalli	Dall porpoise	uncommon
Family Eschrichtidae		
Eschrichtius robustus	gray whale	common
Family Balaenopteridae		
Balaenoptera physalus	fin whale	uncommon
Balaenoptera borealis	sei whale	rare
Balaenoptera acutorostrata	minke whale	uncommon
Balaenoptera musculus	blue whale	rare
Megaptera novaengliae	humpback whale	uncommon
Family Balaenidae		
Balaena mysticetus	bowhead whale	common
Balaena glacialis	Pacific right whale	rare
Order Pinnipedia		
Family Otariidae		
Callorhinus ursinus	northern fur seal	rare
Eumetopius jubatus	northern sea lion	rare
Family Odobenidae		
Odobenus rosmarus	Pacific walrus	common
Family Phocidae		
Phoca vitulina richardii	harbor seal	uncommon
Phoca vitulina largha	spotted seal	common
Phoca fasciata	ribbon seal	uncommon
Phoca hispida	ringed seal	common
Erignathus barbatus	bearded seal	common

Table 5.2. Relative abundance and activities of ice-associated marine mammals of the Chukchi Sea (after Burns et al., 1980)

Species	Ice type		Species	Ice type	
ARCTIC FOX	Consol. pack & fast	Abundant - winter, spring Feeding Travelling Mating	BEARDED SEAL	Open pack, flaw & front (winter, spring) & remnants (spring); Fringe (summer-fall)	Common-winter Feeding Abundant-spring, summer, fall Migrating Feeding Birth Nurture Mating Molting
POLAR BEAR	Consol. pack & fast	Abundant-all year Mating Birth Nurture Feeding Molt	RINGED SEAL	Consol. pack & fast (all yr); open pack, fringe & remnants (spring, summer)	Abundant-all yr Feeding Birth Nurture Mating Molting
BELUKHA	Open pack, flaw, & fringe	Abundant-all year Migrating Mating Birth Nurture Feeding	SPOTTED SEAL	Front, fringe, & remnants (winter, spring)	Abundant-spring, summer, fall Migrating Feeding Molting
BOWHEAD	Open pack, flaw & fringe	Absent-winter Abundant-spring Migrating Birth Nurture Feeding Rare-summer Abundant-fall Migrating Feeding	RIBBON SEAL	Front & remnants (winter, spring)	Uncommon-summer, fall
WALRUS	Open pack & front (winter); Flaw & remnants (spring); Fringe (summer-fall)	Rare-winter Abundant-spring, summer, fall Migrating Nurture Feeding Molt			

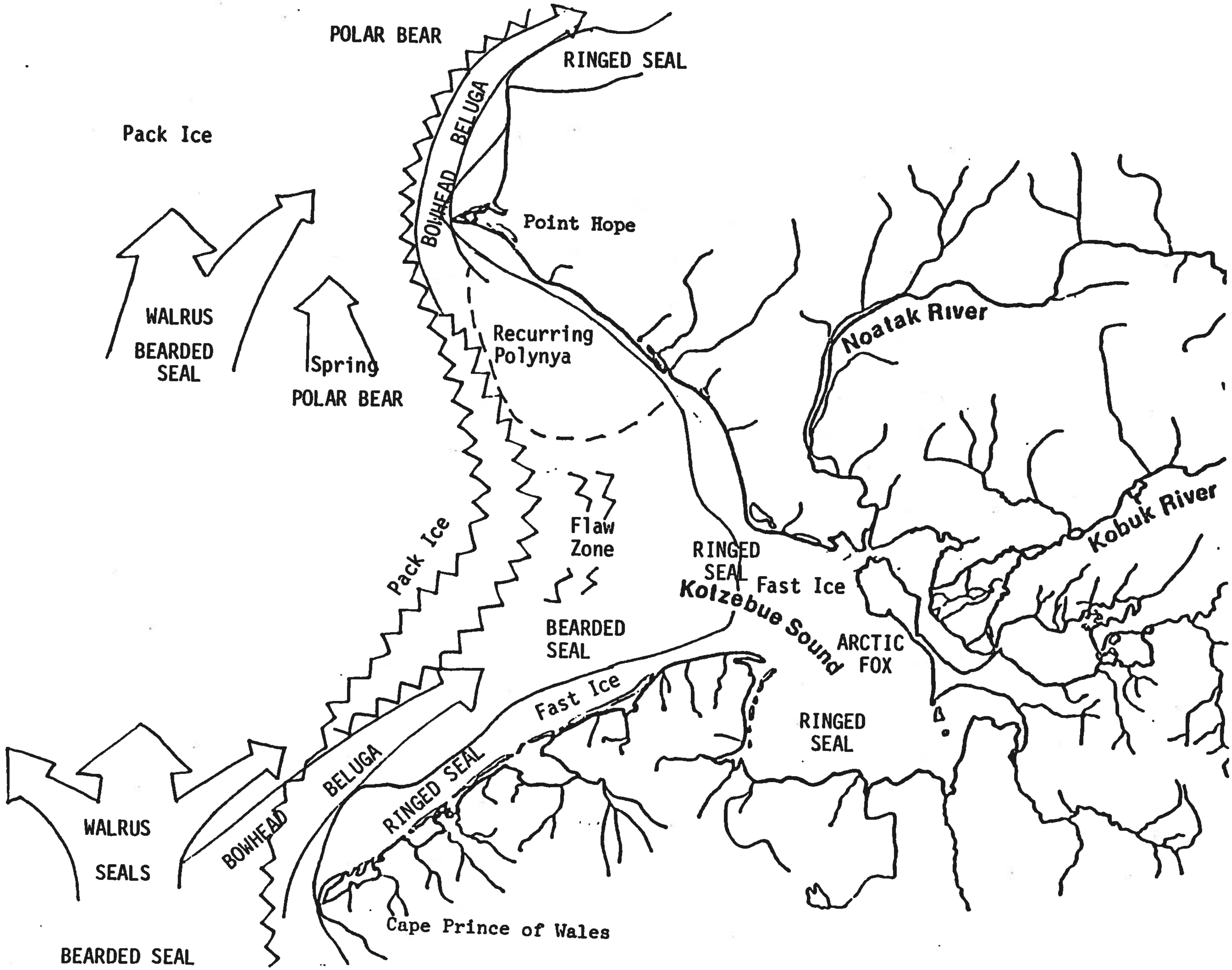


Figure 5.1. Winter - spring distribution and movements of marine mammals in the southeastern Chukchi. The variable nature of the sea ice will influence the general distribution and movements shown here.

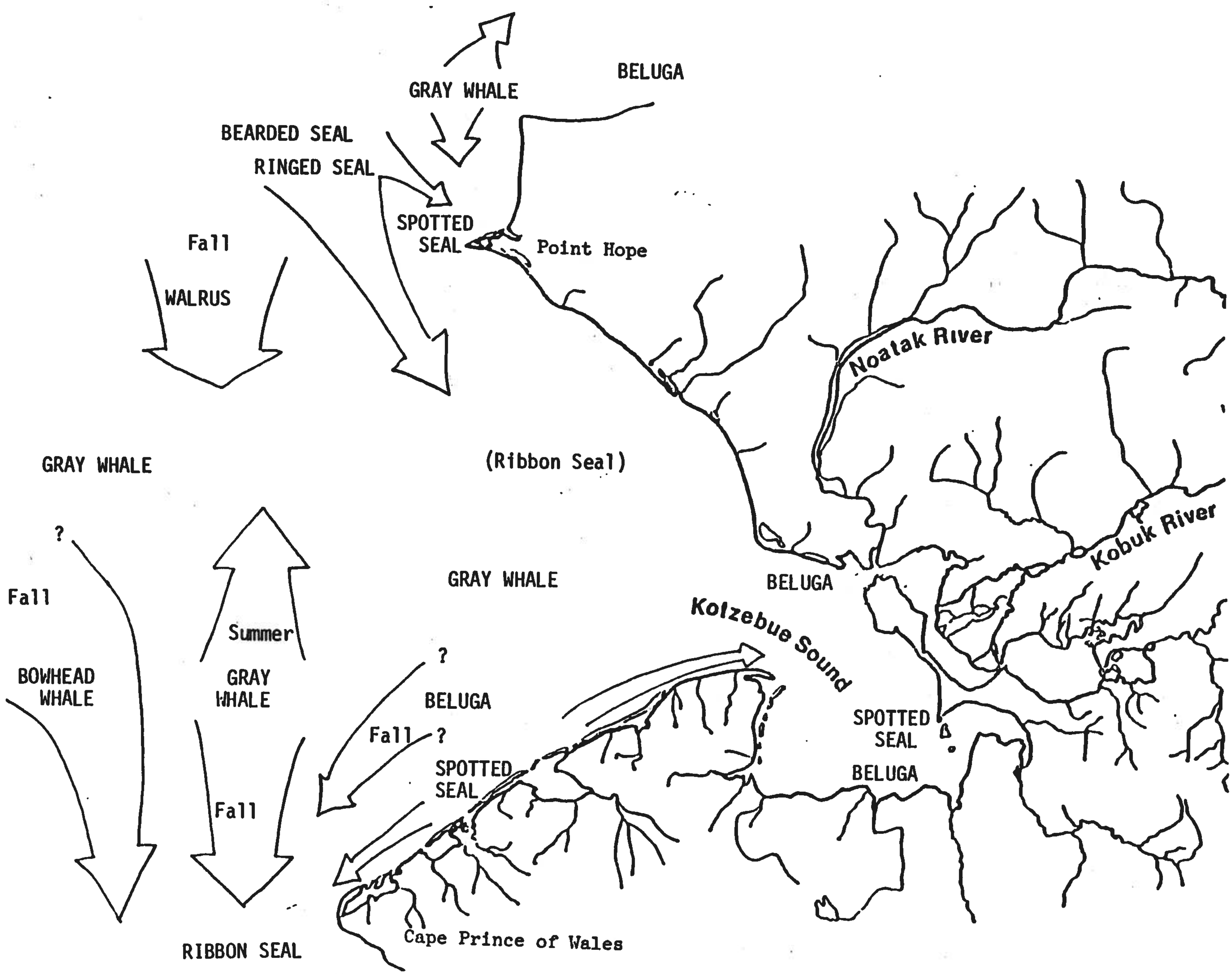


Figure 5.2. The summer - fall distribution and movements of marine mammals in the southeastern Chukchi Sea. Distribution and movements are generally broader and less well-defined than indicated here.

these marine mammals. Table 5.3 summarizes the seasonal aspects of the feeding relationships of the more commonly occurring marine mammals of this region and Figure 5.3 diagrams the relatively simple food webs of Arctic marine mammals. Fish and invertebrates are key food items directly supporting the seal and whale populations, and indirectly supporting the polar bear populations which prey chiefly on the bearded and ringed seals. The area is also an important breeding and/or rearing area for these marine mammals (Table 5.4).

5.1 The Bowhead Whale

Virtually the entire population of bowhead whales, (estimated at about 2300 $\pm$ 450, Braham et al., 1980a), transits the waters of the Chukchi Sea during their spring and fall migrations between the Bering Sea and the Arctic Ocean. Characteristic of their close association with the sea ice, the bowhead whales leave their wintering areas in the Bering Sea and follow the opening leads and retreating pack ice northward during the spring. Between March and June, the bowhead whale travels about 3000 km amid the ice through the northern Bering, Chukchi and Beaufort Seas on its way to the Canadian Arctic (Figure 5.4).

The northward spring migration of the bowhead whale from the Bering Sea begins with the break-up of the pack ice. This generally occurs in April or earlier in a mild ice year (as in 1979). Most whales travel north through the Strait of Anadyr, between St. Lawrence Island and the Chukotsk Peninsula, continuing north by northeast throught the Bering Strait on the Soviet side, west of Big Diomede Island. During an average ice-year, fewer whales migrate through the eastern half of the northern Bering Sea, because the ice is usually heavier there than to the west. Eskimo whalers at Wales do, however, periodically take bowheads along the Alaska coast near the Bering Strait. Most of the migrating animals have passed through the corridor between St. Lawrence Island and the Bering Strait by early May.

Upon entering the southeastern Chukchi Sea the whales move northeastwardly past outer Kotzebue Sound through newly opened leads in the shear zone between the moving pack ice and the shorefast ice. A few whales move into the polynya that characteristically forms between Kivalina and Point Hope. Some whales

Table 5.3 Important Prey Organisms of the Common Marine Mammals of the Chukchi Sea

	Bowhead	Gray	Beluga	Ringed Seal	Bearded Seal	Spotted Seal	Walrus	Polar Bear
WINTER	absent	absent	absent	Arctic cod Saffron cod Sculpins Amphipods Sand Lance	Shrimp Crab Other benthos (Arctic cod) (Sculpins) (Other bottomfish)	absent	absent	Ringed seal Bearded seal (Carrion)
SPRING	minor feeding Plankton (Benthos)	absent	Arctic cod Flounders Capelin Smelt Shrimp Squid	mixed winter-summer	same as above Clams	absent	Clams Other invertebrates	Ringed seal Bearded seal
SUMMER	absent	Amphipods Other benthos	above plus Salmonids Herring	Shrimp Amphipods Crabs Euphausiids Mysids	same as above	Shrimp Salmonids Herring Capelin Smelts	same as above	above plus Walrus calves
FALL	Plankton (Benthos)	Amphipods Other benthos	Same as spring	Sculpins Arctic cod Saffron cod Shrimp	same as above	same as above	same as above	same as above

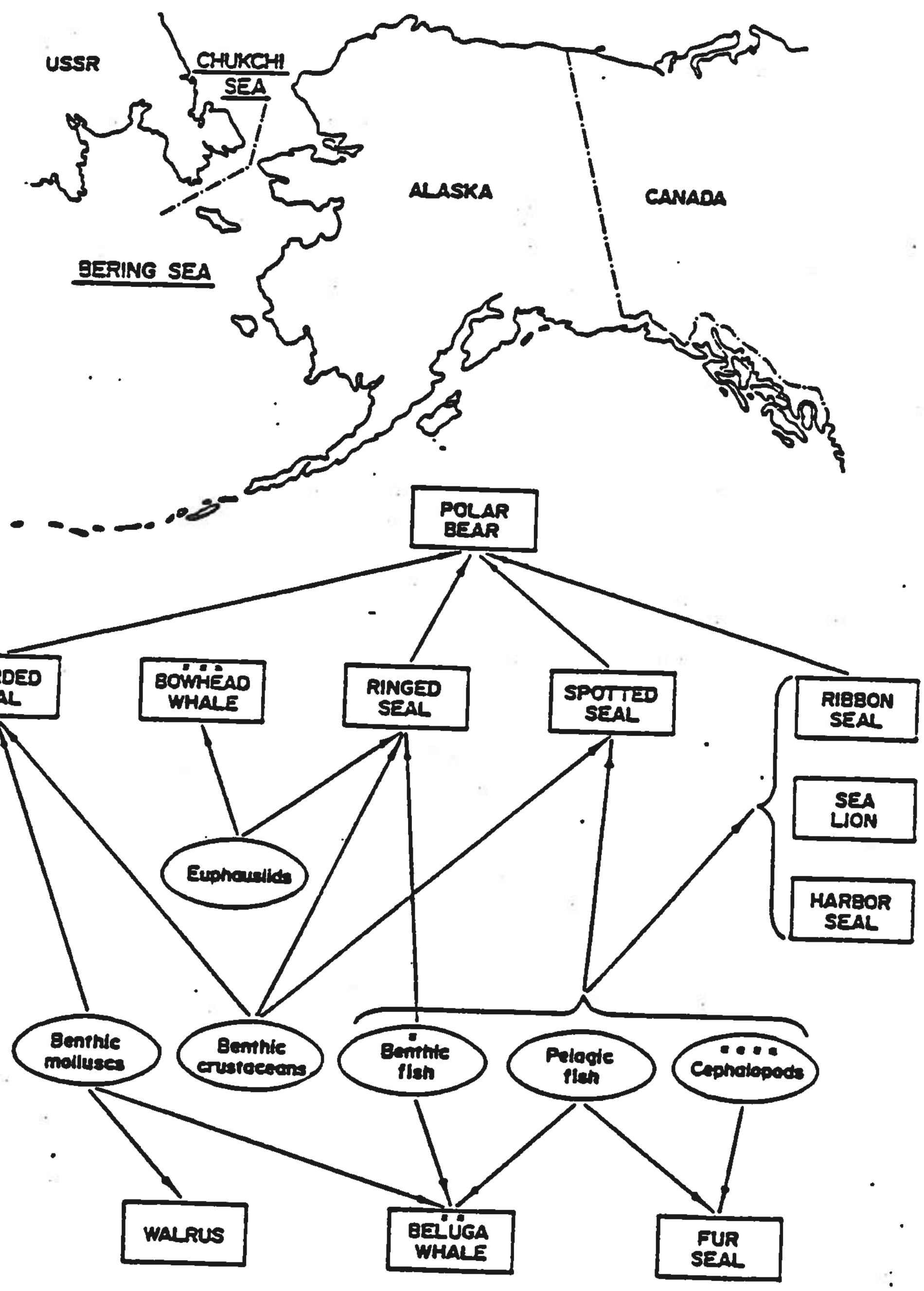


Figure 5.3 - Marine Mammal Food Relationships in the Bering and Chukchi Seas

* Benthic fish includes demersal species

** Beluga whale includes other toothed species

*** Bowhead whale includes other baleen species

**** Cephalopods includes squid and octopus

Table 5.4. The birth period, characteristics of birth sites, duration of dependency and mobility of the young of seven species of ice-associated mammals inhabiting the Chukchi Sea (from Burns _et al._, 1980)

Species	Birth Period	Characteristics of Birth Site	Duration of Dependency	Mobility of Dependent Young
Arctic Fox	May-June	Subsurface den on land	3-5 mos.	Restricted to den site until independent.
Polar Bear	Nov-Dec	Subnivian den mainly on land	24-28 mos.	2-3 mos. restricted to den site; then travel with mother
Beluga	June-Aug	Near shore-open water	24 mos.	Mobile - travel with mother
Bowhead	March-May	Leads in pack	24 mos.?	Mobile - travel with mother
Walrus	April-June	On pack	18-24 mos.	Mobile - travel with mother
Bearded Seal	March-May	On pack	2-3 weeks	Mobile - travel with mother
Ringed Seal	March-April	Subnivian lair on fast ice and heavy pack	4-6 weeks	Restricted to lair until weaned

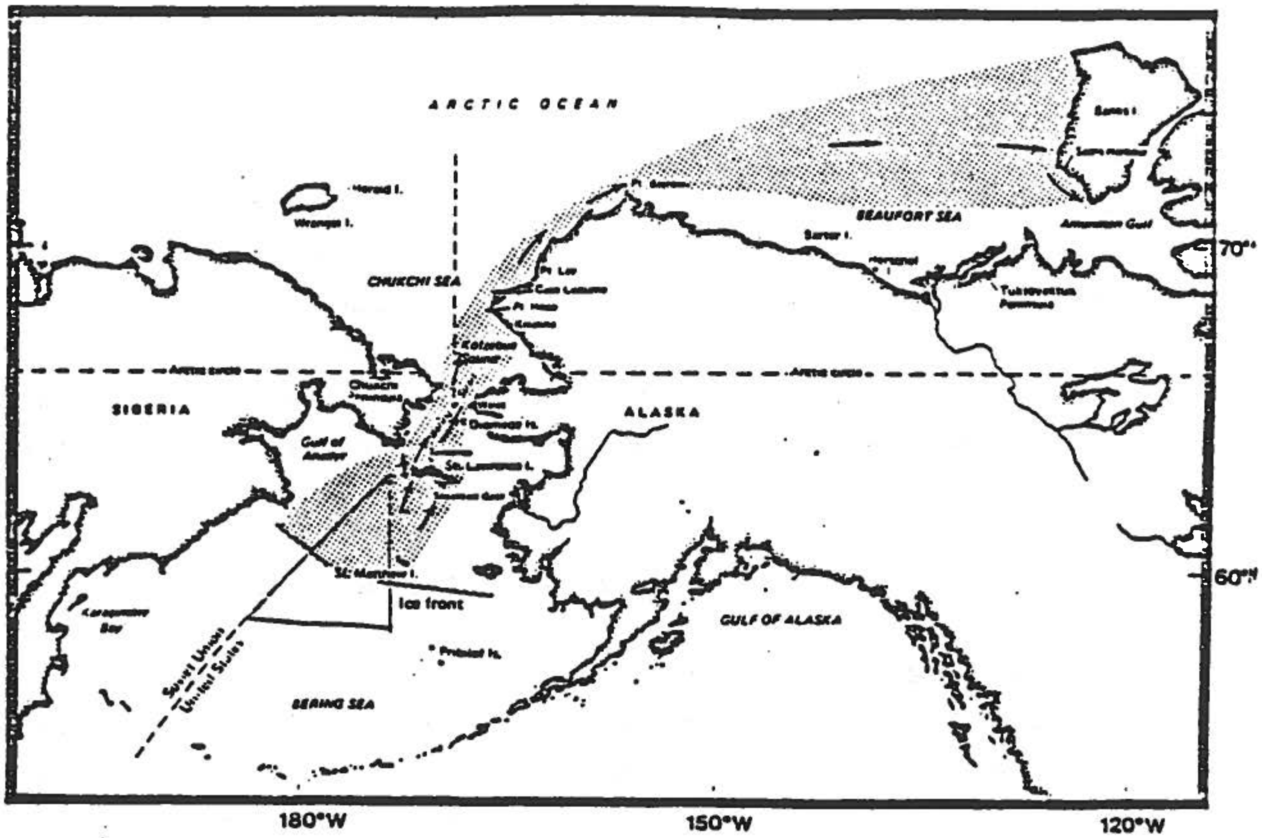


Figure 5.4 - Spring migration of bowhead whales (from Braham et al, 1980c)

pass close to shore near Point Hope where they are hunted by spring whalers. Other whales move past Point Hope offshore to at least 45 km. Some whales are said to move into the western Chukchi Sea in the spring, but this seems unlikely as the pack ice is heavy with few leads opened north of the Chukotsk Peninsula (See Figures 2.19, 2.20). Siberian Eskimos who lived along the north side of the Chukotsk Peninsula did not traditionally hunt bowheads in the spring as did their counterparts along the east side of the Peninsula or on the Alaska coast. The whales proceed north following open leads past Cape Thompson and Point Hope, and then travel northeastward to Cape Lisburne and on toward Point Barrow.

Field watches of bowhead whales at Cape Lisburne (Rugh and Cubbage, 1980) in April-June, 1978, observed that the spring migration of bowheads past Cape Lisburne commences during the latter half of April, the whales generally following a northeasterly course. It is estimated that the time needed for these whales to transit from Cape Lisburne to Point Barrow, a distance of about 300 nm, was 3-5 days. Swimming speeds necessary to traverse this distance would have to average 2.5 to 4.2 knots, well within these whales' capability (Braham, et al., 1980b).

The migration past Cape Lisburne seems to follow two or more corridors, depending on the number of leads, which usually range from 2-10 km offshore. The variable location and structure of the lead system may allow the whales to pass even farther offshore, and sightings have been made to 15 km offshore. Those animals migrating latest in the spring will usually find more open waters and may move farther offshore than the earlier migrants. No bowheads have been observed in the offshore leads past Point Barrow during four years of aerial surveys to 100 km offshore.

The migration along the northwest coast (Bering Strait to Point Barrow) essentially covers the period mid-April to early June, with a few whales migrating by thereafter. The majority of bowheads usually pass Point Hope by mid-May and pass Point Barrow shortly thereafter. The first arrival of bowheads at Barrow annually varies by about two weeks, probably due to annual differences in ice conditions. The timing of the tail-end of the spring migration through the Chukchi Sea and past Point Barrow is uncertain because ice conditions generally have not allowed observers to remain on the ice past mid-June. However, it is believed that very few whales pass Point Barrow after early June (Braham et al., 1980a), even in heavy ice years. Even during 1980, when heavy ice blocked the Bering Strait, and the first bowhead sighting off Barrow was not until May 21, the last sightings were recorded on June 2 (Johnson et al., 1981). By mid-June, almost all bowheads have passed Point Barrow and have entered the Beaufort Sea.

Several observers have described the whale migration as occurring in a number of pulses. According to NARL (1972) there are four pulses: small males pass first, large males second, the largest males next and, adult females with calves pass last. Marquette (1976) observed three waves of migration, the first and second being usually smaller animals of both sexes, and the third wave being made up of large males and of females with calves. Braham and Krogman (1977) postulated that these waves are governed by ice conditions and result from the closing and reopening of leads. Whether these pulses originate south of the Bering Strait or in the Chukchi Sea is unknown.

Most of the bowhead whales summer in the high Canadian Arctic in the vicinity of Banks Island and Amundsen Gulf (Figure 5.5). Although commercial whalers historically took bowheads in the Chukchi Sea, and even south of the Bering Strait in the summer, bowheads are no longer observed in these waters during this season. Braham et al., (1979) did not observe any bowheads during summer shipboard and aerial surveys of the Bering and Chukchi Seas. They speculate that whalers may have eliminated this southern portion of an earlier abundant bowhead population that was either resident in the Chukchi Sea or was a late migrating segment of the population.

In the fall, generally in September, the bowheads begin leaving their summer feeding grounds and start their general westward return following the Beaufort Sea coast between the shore and the polar ice pack. Their fall movements into and through the Chukchi Sea are not well known. Sergeant and Hoek (1974) and Marquette (1976) believe that the bowheads continue moving westward along the pack ice edge to the vicinity of Wrangel Island before turning southward along the Soviet coast on their return to the Bering Sea. This is supported by

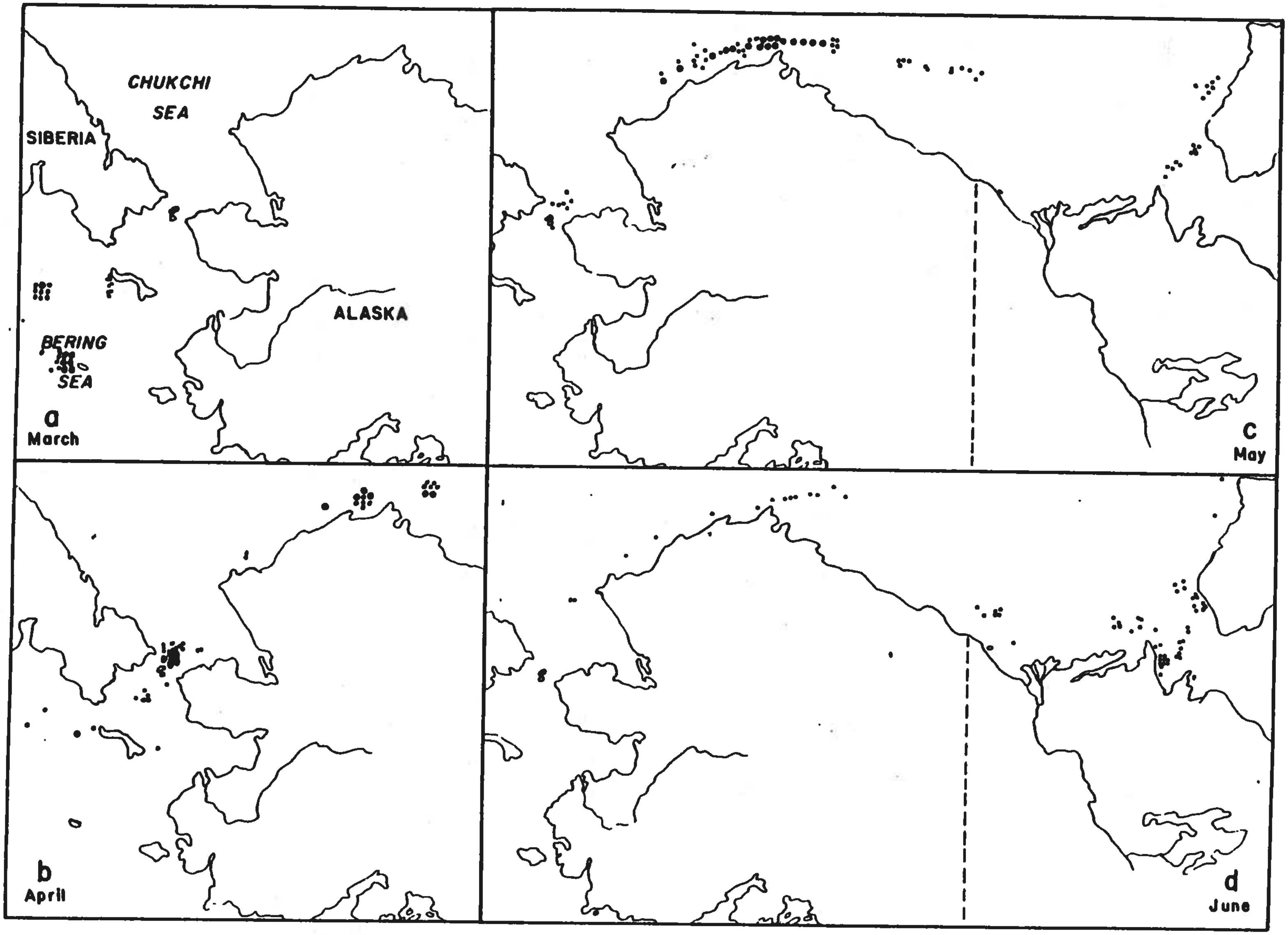


Figure 5.5. The location of observations of bowhead whales, 1974-79. Small dot = 10 whales (from Braham et al., 1980a)

evidence provided by the Soviets and reported by Braham et al., (1980a). (Figure 5.6). Few bowheads are believed to enter the southeastern Chukchi Sea during the fall.

Braham et al. (1980a), described fall movements of bowhead whales as follows (references omitted):

> "From Point Barrow the animals appear to move westward to Herald Shoal and Herald and Wrangel Islands, then south through the Chukchi Sea into the Bering Sea. There is speculation by Soviet scientists that bowheads pass to the Bering Sea by traveling the western Chukchi Sea. Some animals appear to move southwest along the northwest coast of Alaska past Point Barrow to the Bering Strait, but this probably varies with weather and ice conditions. Others in the population seem to migrate to the north side of the Chukchi (Chukotsk) Peninsula before entering the Bering Sea. (Certain researchers) believe thathe fall migration through the Chukchi Sea followed an offshore passage, since bowheads were not seen at Wainwright, Cape Thompson, Point Hope, or Kivalina in the autumn during their studies. Bowheads generally enter the northern Bering Sea in November and December, arriving in central Bering Sea wintering areas in December - February, thus completing their annual migration cycle."

These contentions are supported by evidence gathered by a joint U.S.S.R.-U.S. marine mammal cruise in October, 1979. Johnson et al. (1981) observed bowheads during October near Wrangel and Herald Islands of the northwest Chukchi Sea, and off the northeast coast of Siberia, especially nearshore along Cape Onman (Figure 5.7). Whether part of the population migrates along the Alaska side of the Chukchi Sea is not known. Because of the open water available in October-November, their return may be widely distributed in the area beyond the fast ice zone.

The life history, food habits, and behavior of bowhead whales have been reviewed by Braham et al. (1980a) and will not be discussed at length here. They are also summarized in the resource assessment for the Navarin Basin (Morris, 1981). Some aspects of these subjects pertinent to the southeastern Chukchi Sea deserve brief mention.

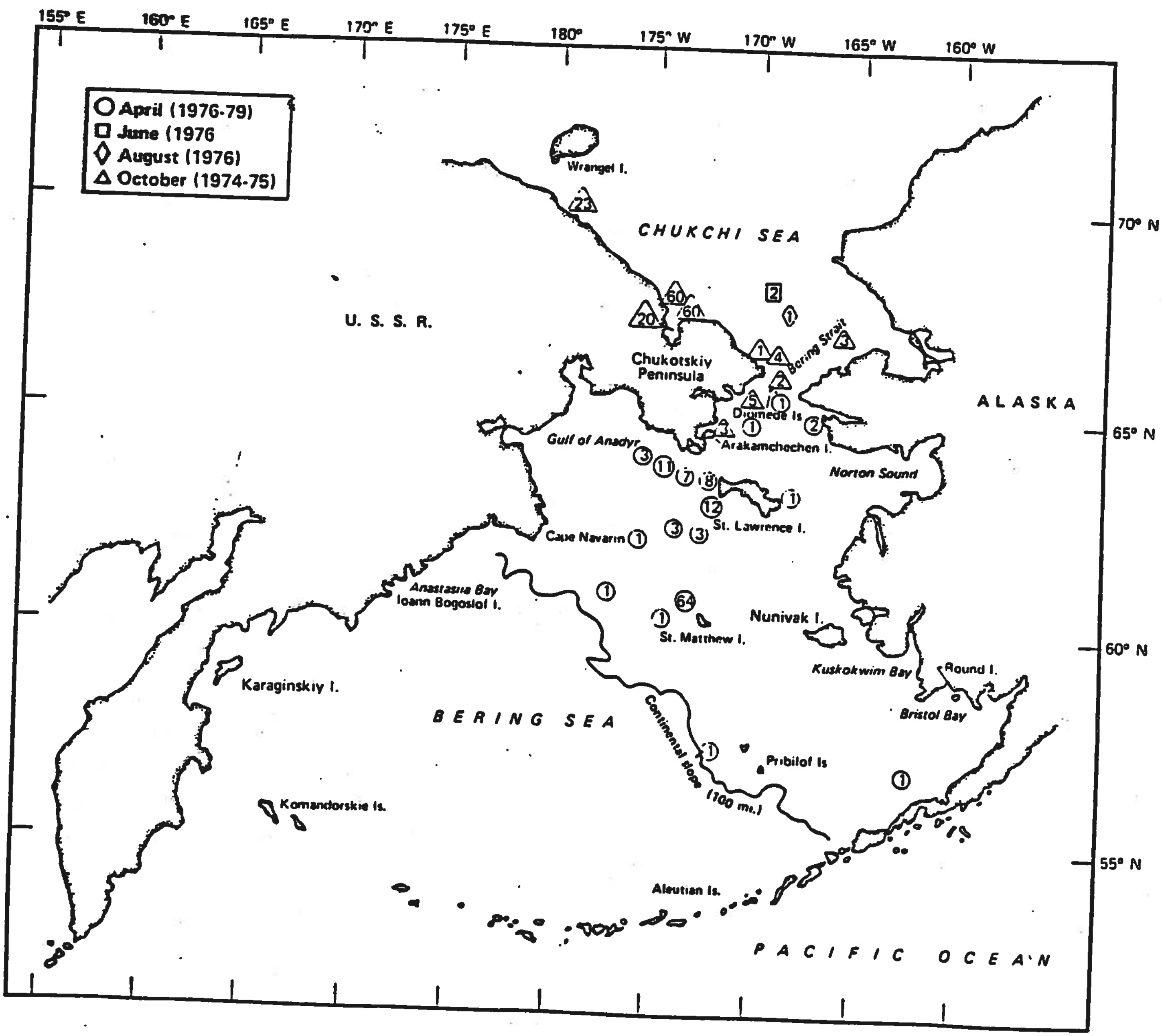


Figure 5.6. Bowhead whale sightings from other than NMFS aerial or ice-based methods in the Bering and southern Chukchi Seas, 1974-78. October sightings (Δ) (provided by A. Berzin, pers. commun.) indicate fall migration along the Soviet Coast of the western Chukchi Sea (from Braham et al. 1980a).

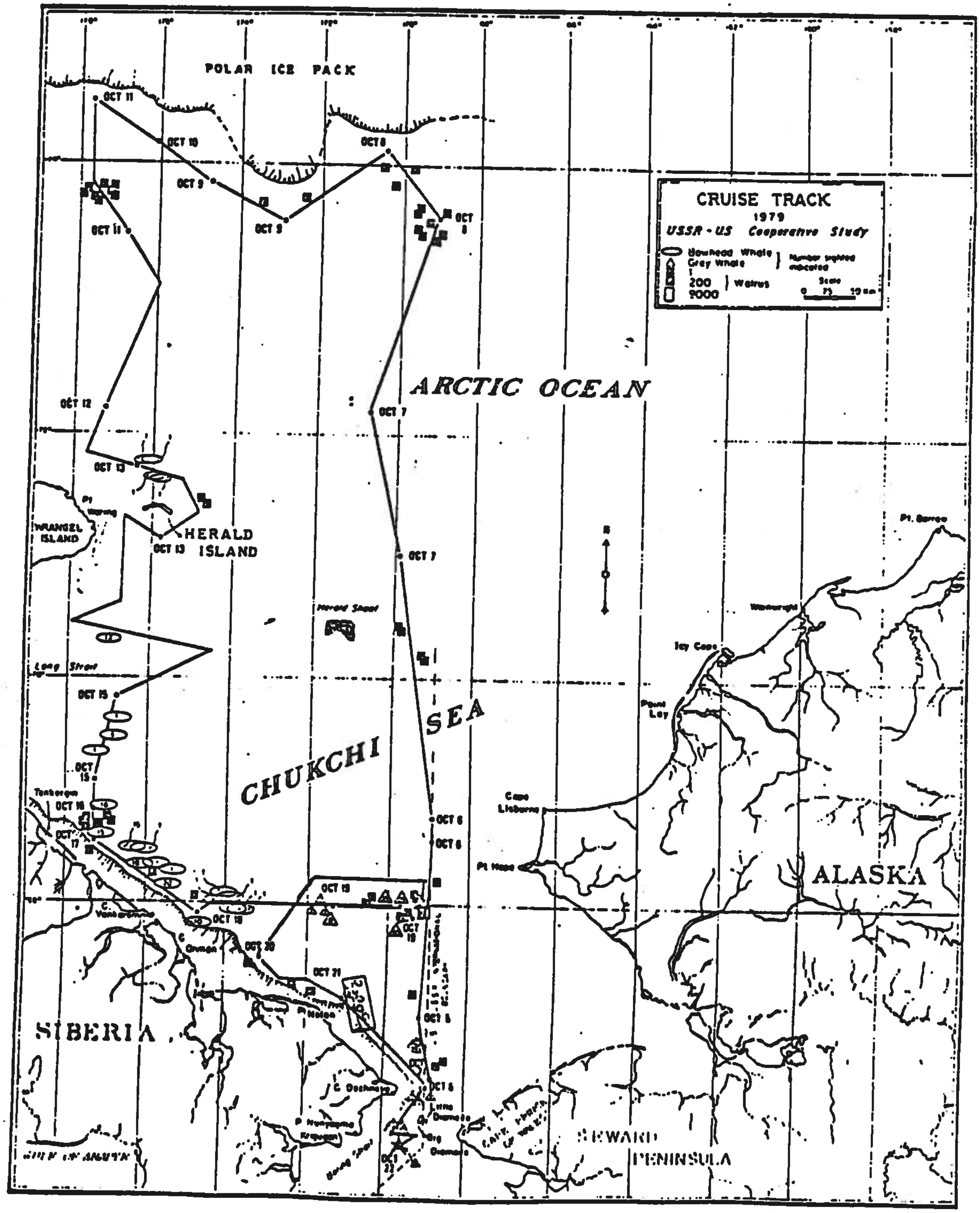


Figure 5.7. Cruise track of the joint U.S.S.R.-U.S. marine mammal cooperative study in the Chukchi Sea in October 5-22, 1979, on the M/V Avangard - a 64 m whale-catcher boat (from Johnson et al., 1981). Gray whales were common in the vicinity of the Bering Straits and to the northwest. Walrus occurred throughout the survey area. Bowhead whales were first observed in October 13 near Herald Island, and on subsequent days in Long Strait and along the Siberian coast.

Breeding and Calving: Breeding times for the bowhead are not well known. Durham (1972) believed that breeding occurs in early April before the whales reach Point Hope. However, possible copulatory behavior has been observed at Point Hope in May (Foote, 1964), and north of Point Barrow (Everitt and Krogman, 1979), also in May. Mating may occur throughout their spring migration path, including in the lead system along the southeastern Chukchi Sea.

Calving is reported to occur just prior to the time of breeding which is from early spring to early summer. Cows with calves are seen passing Point Hope and Point Barrow from mid-April to early June. Braham et al. (1980a) believe that most calving occurs during the April-June migration period. Thus calving may also occur along the southeastern Chukchi Sea lead system.

Feeding: The extent of feeding in the Chukchi Sea is undetermined, but does not appear to be an important activity during the spring migration. Stomach contents of bowheads taken during spring whaling are empty, or nearly so, compared to stomachs of whales taken in the fall. Although this may reflect a lack of food availability (i.e., plankton) in the water column during the spring, bowheads are also known to be bottom skimmers (Nemoto, 1976), and could presumably use the benthic food resource if desired. Johnson et al. (1966) found two of three spring-taken bowheads to have empty stomachs, while the third contained fragmentary remains of benthic animals (polychaetes, shrimp, snails, echinoids), plus sand and gravel.

Behavior: The spring migration through open nearshore leads between the Bering Strait and Point Barrow is a steady north and northeast movement when unobstructed by sea ice. A little time may also be spent resting, feeding, courting, and mating, or breaching. According to Braham et al. (1980b) most whales travel singly (75.4%), or in pairs (19.5%), and rarely in groups of four or more (9.7%). In obstructed leads the whales' behavior changes and its' progress is altered. Groups of whales have been observed milling in polynyas, and apparently diving to search for adjacent leads or polynyas. If unsuccessful, they apparently return to their original hole. Bowheads can also push up underneath the ice to breath, forming hummocks. They may even find air pockets underneath the ice in which to breath. Occasionally they have been known to be trapped under the ice and perish when not able to find suitable breathing space.

The reaction of the bowhead whale to any man-caused factor that may obstruct their migration is unknown. They react negatively to small boats, and normally avoid or vacate the area and flee pursuit. The reaction to aircraft disturbance is variable. Most bowhead whales react to aircraft overflights at altitudes of less than 405m (LGL, 1981) but some do not show signs of disturbance even down to altitudes of 65m (Braham et al., 1980a). It appears that their reaction to aircraft varies in unknown ways with the source, time of year, environmental conditions, and activity of the animals.

Their reaction to industrial noises such as dredges, ships, seismic operations, drilling rigs, is beginning to be studied (LGL, 1981), at least during the summer periodt the open waters of the MacKenzie Delta area. Reactions are variable and their patterns still remain to be determined. It is not clear, however, whether any behavior toward a source of disturbance in open waters would be the same as they would exhibit during the spring migration when confined to lead systems.

5.2 The Gray Whale

Most of the 15,000 to 17,000 California gray whales (Eschrichtius robustus) migrate annually between summer feeding grounds in the Bering and Chukchi Seas and their winter calving grounds along Baja California. Their northward migration reaches the Bering Sea by April, and whales are continuing north through July (Figure 5.8). Gray whales generally travel close to the shoreline (within 3 miles) until they reach the vicinity of Nunivak Island in the Bering Sea. From there they apparently divert offshore towards St. Lawrence Island. Gray whales occur mainly in shallow shelf waters (less than 50m) from St. Lawrence Island northward, where they remain to feed during the summer. Part of the population stays in the Bering Sea, while others pass north through the Bering Strait in late June or early July and disperse over the Chukchi Sea shelf area during July, August, and September.

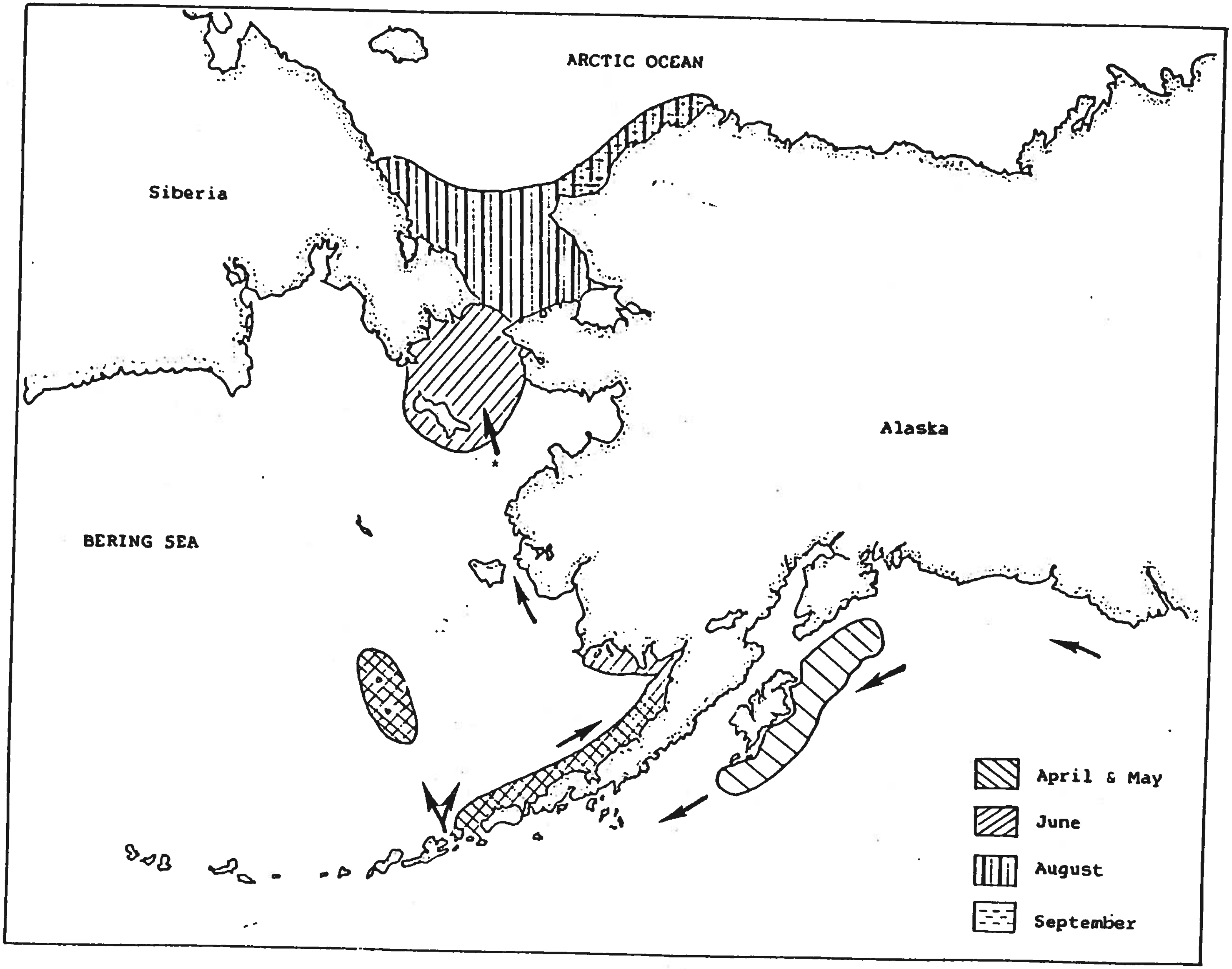


Figure 5.8. Monthly distribution of _Eschrichtius robustus_. Arrows depict the projected migration route (Braham _et al._, 1977).

Data from sightings in Soviet waters and from the literature suggests that gray whales are most common offshore in the central Chukchi Sea, and more common to the south and west than to the east and north of the central shelf area (Figure 5.9). They are most frequently sighted in the eastern Chukchi Sea in August and September (Braham et al., 1977 and 1980c). In the southeastern Chukchi Sea, gray whales are commonly encountered in the Bering Strait, outside of Kotzebue Sound, and nearshore between Point Hope and Cape Lisburne. More than 200 gray whales have been observed feeding in outer Kotzebue Sound in August. They may be regularly encountered in low numbers along the coast between Cape Lisburne and Barrow from July to September.

These animals remain in the Chukchi Sea to feed in areas rich in benthic amphipods until about October, when they start their southward migration. Gray whales may be dependent on their summer feeding areas, as they are not known to feed on their wintering grounds off California. By November gray whales have probably left the Chukchi Sea, and by December they have left the Bering Sea on their return south.

5.3 Beluga Whale

The beluga (belukha) or white whale (Delphinapterus leucas) is primarily an inhabitan of Alaska coastal waters. They have been observed in nearly all coastal waters of the Bering and Chukchi Sea (Figure 5.10). The majority of these animals is highly migratory and they move regularly from wintering areas in the Bering Sea through the Chukchi Sea to summer as far north as the Canadian Beaufort. Overwintering in the southeastern Chukchi Sea probably occurs only during mild ice years when there is sufficient open water in polynyas and lead systems. The pattern of their migrations, other than a general north-south seasonal movement is little known. It appears to be complex and variable from year to year or even from week to week with changing ice conditions. The size of the population that migrates through the Chukchi Sea is uncertain.

Northward migration occurs from March to early July, beginning in close

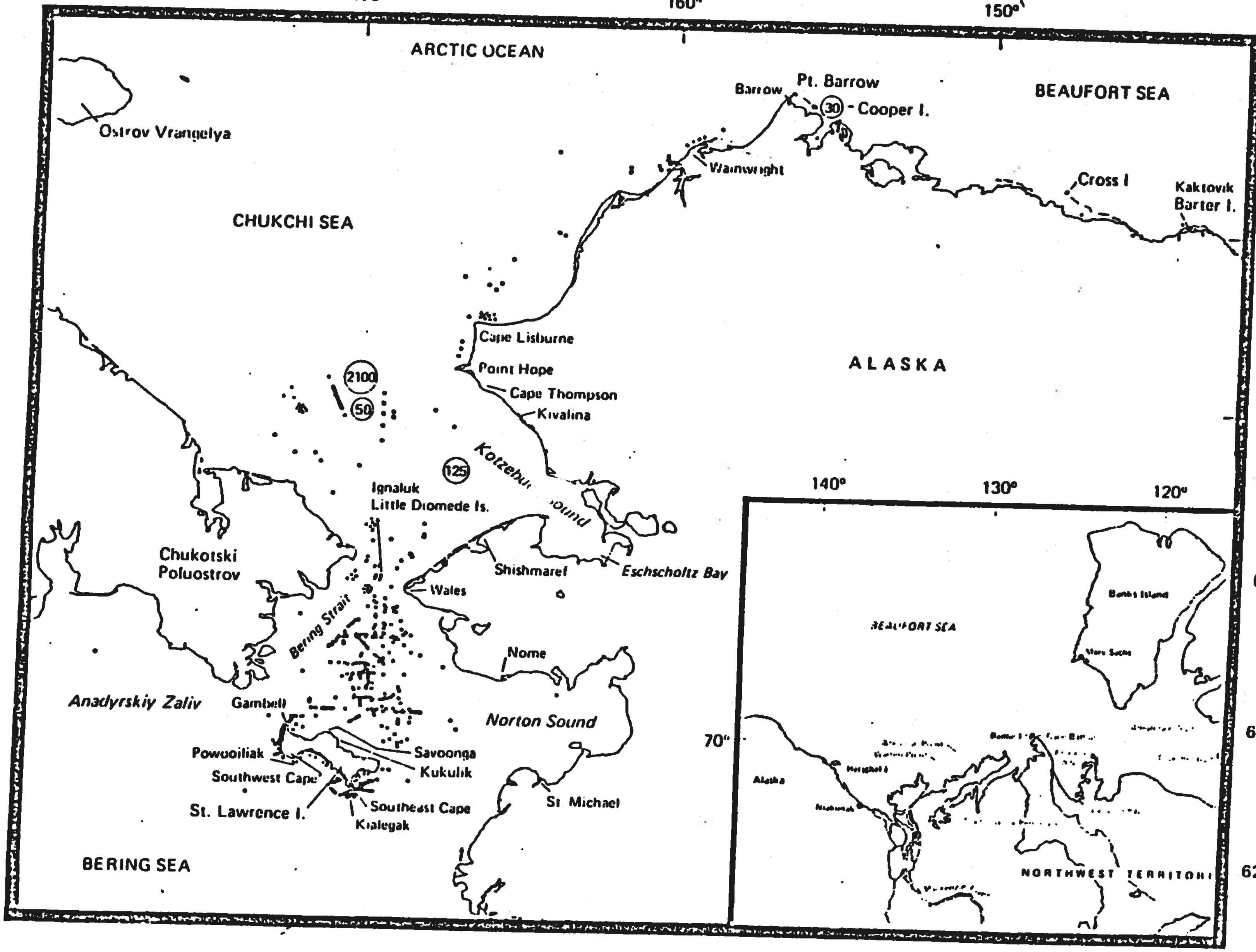


Figure 5.9. Gray whale sightings in the northern Bering, Chukchi, and Beaufort Seas since 1961. Data compiled from records of the NMFS Platforms of Opportunity Program 1974-1979, scientists, Eskimos, and from the literature (from Braham et al., 1980c).

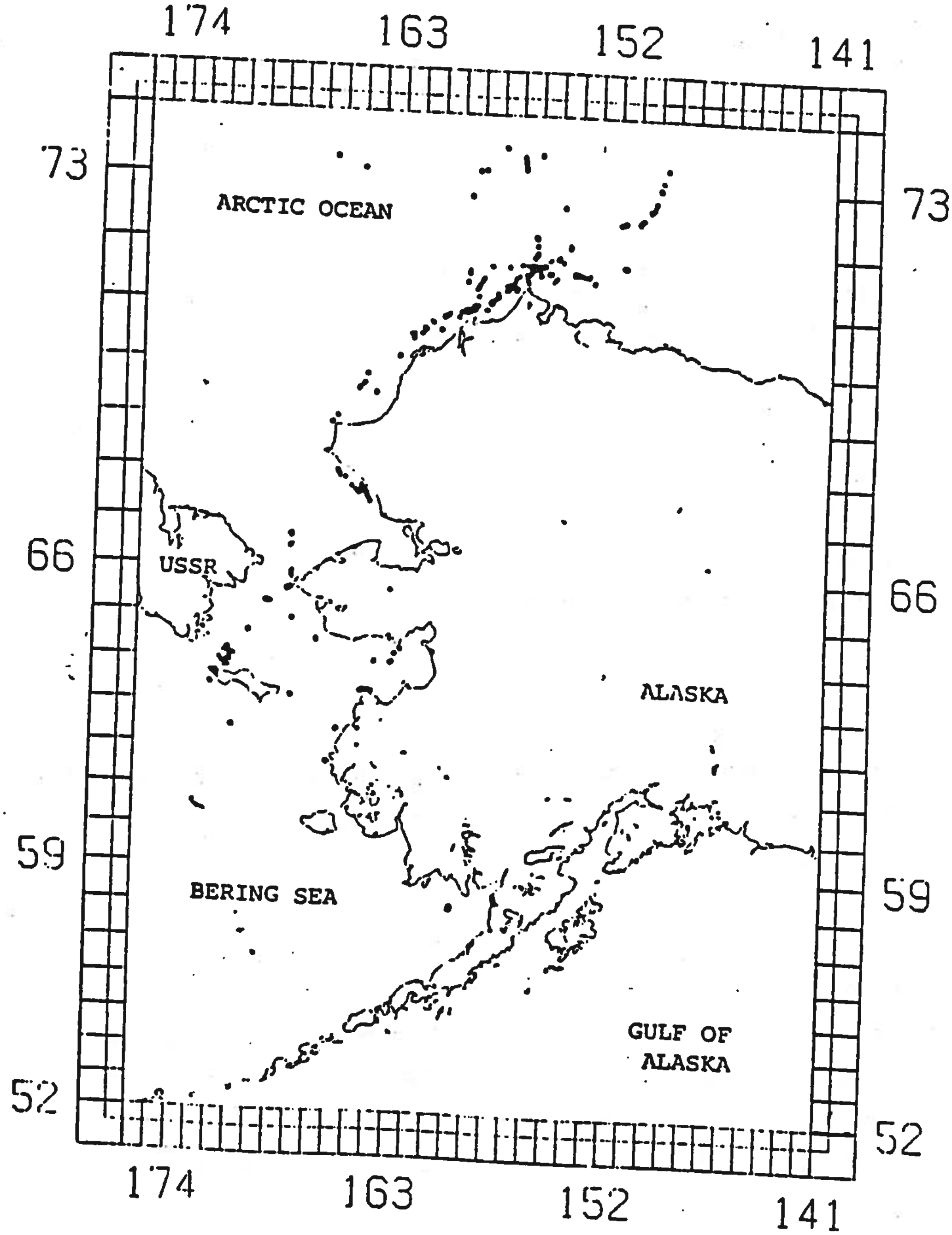


Figure 5.10. Sightings of white whales during aerial surveys conducted between the months of March and September, 1975-1977. The total number of sightings (419) corresponds to 2,002 whales observed (from Braham et al, 1980a).

association with the bowhead whale migration. However, belugas are more widely distributed in the Chukchi Sea than the bowheads. Migrating belugas follow both nearshore and offshore leads in April to June through the Chukchi Sea and into the Beaufort Sea. Aerial surveys (Braham et al., 1980a) have commonly observed them in the leads farther offshore (approximately to 60-150 km) and penetrating farther north into the pack ice than bowheads.

Belugas begin their travel in pods as large as 80 to 100 individuals, but as the pack ice begins to disintegrate, these congregations split into smaller groups of 2-4 animals until they reach their summering grounds.

Depending upon ice conditions, the first animals ordinarily appear in the open leads between Kivalina and Point Hope by mid-April, ahead of the bowhead migration, and individuals continue to move north toward Point Hope through July. By May and June, some belugas have passed Point Barrow and have entered the eastern Beaufort Sea (Braham et al., 1980a).

A segment of the beluga population summers in Kotzebue Sound, where they can be found in groups of 30 to 50. Buckland residents hunt belugas in Eschscholtz Bay and Spafarief Bay beginning in late June. They are also frequently seen in the vicinity of Cape Krusenstern and the village of Sheshalik. These areas are used for feeding, and possibly for mating and calving.

The southward fall migration commences in September, again ahead of the bowhead migration, and lasts until December if freeze-up and pack ice conditions permit. In the early fall, many belugas are often seen far north near the polar pack ice edge. Since belugas cannot maintain breathing holes except in the thinnest ice, they must avoid being trapped by newly forming ic-e. Their return movements are hardly documented, but are believed to be predominantly offshore in small groups of animals. By winter, belugas have left the Chukchi Sea.

The belugas observed in the Chukchi Sea during the summer are of uncertain origin. Braham et al. (1980a) believe that they are either 1) late migrants of a single Bering Sea population that remains in shallow water, or 2) stocks of a separate Alaskan or Soviet population. Too little is known of these whales to determine either the origin of these summer populations or the identity of the different stocks.

Calving and mating of belugas occurs in May and June, and perhaps earlier since calves have been observed as early as March. Some mating and calving is reported to occur during June in Eschscholtz Bay in inner Kotzebue Sound. Many calves are reportedly born here during years of early breakup. The warmer waters of these estuaries may be important to the survival of newborn calves.

Belugas feed mainly on fish, frequently in the nearshore estuaries, bays, and river mouths. The principal prey species and feeding areas along the Chukchi coast are not fully known. Prey items variously consumed were given in Table 5.3.

5.4 Other Whales

Pacific Right Whale: The Pacific right whale, *Balaena glacialis glacialis*, resides mainly in the waters of the North Pacific and during the summer is found along the continental slope of the Gulf of Alaska, Bering Sea, and Gulf of Anadyr. The northern limit of its range is thought to be in the northern Bering Sea, but sightings have been reported north of the Bering Strait (Nasu, 1960). The sighting of this whale in the southern Chukchi Sea would be an unexpected event.

Fin Whale: The fin whale (*Balaenoptera physalus*) enters the Chukchi Sea in low numbers only during the summer. There is no apparent migration pattern, and their distribution and abundance in these waters is uncertain. Like the humpback whale, they are common in low numbers in Soviet waters of the southern Chukchi Sea (Votrogov and Ivashin, 1980) between August - October, but are irregularly sighted in the Alaska sector (Figure 5.11).

Sei Whale: The sei whale (*Balaenoptera borealis*) is the least frequent of the great whales reported from the Chukchi Sea. There is controversy as to whether the species even passes the Bering Strait on their northward summer

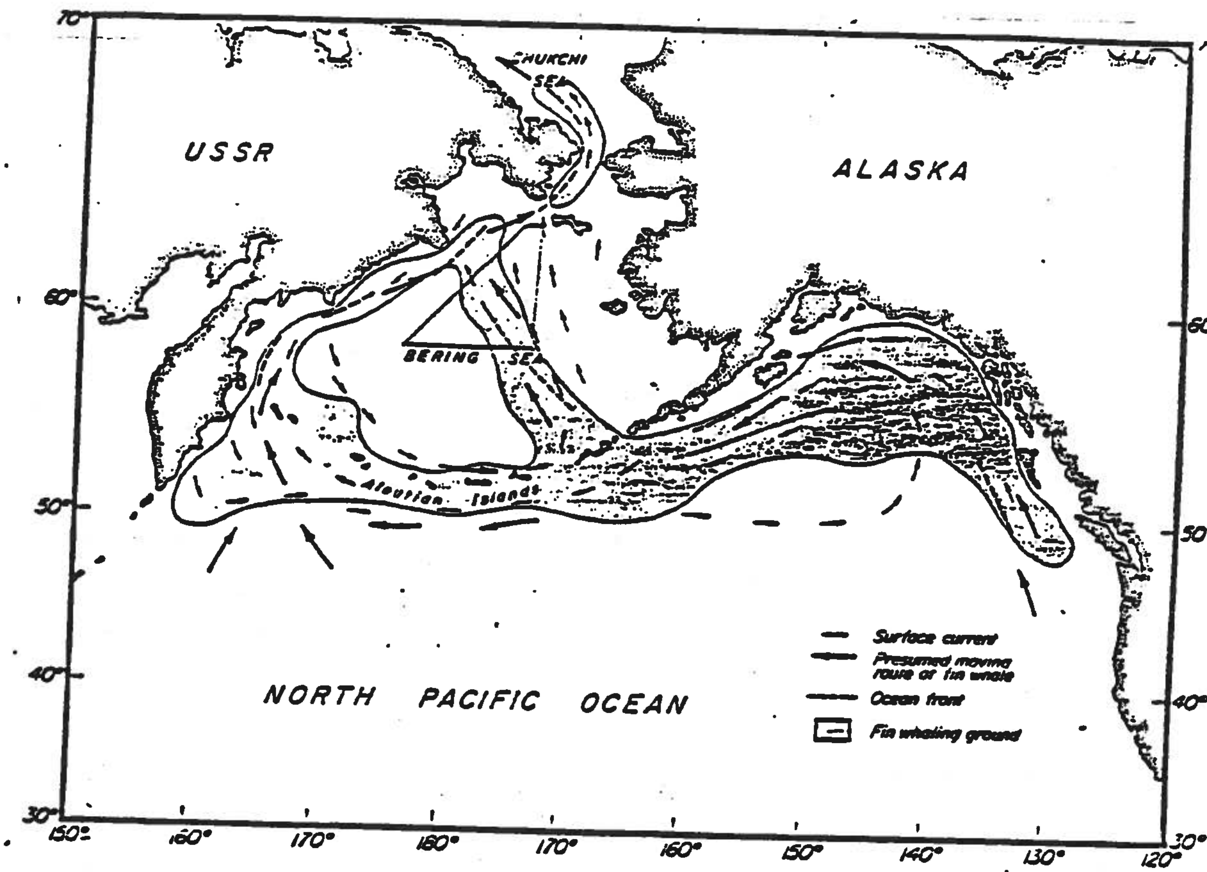


Figure 5.11 - Presumed migration route of fin whales in relation to oceanographic conditions, (from Nasu, 1974).

movements, although it was reported from the eastern Chukchi Sea by Tomilin (1957).

Minke Whale: The minke whale, (Balaenoptera acutorostrata) inhabits all oceans, except in tropical latitudes. The North Pacific population makes extensive seasonal migrations between high-latitude summering grounds and low latitude wintering grounds. In Alaska, the minke whale ranges from the Gulf of Alaska, throughout the Bering Sea, and into the Chukchi Sea during the summer. Pregnant females migrate to higher latitudes than do the lactating and immature females. Little is known of the movements or habitats of this whale in the Chukchi Sea.

Humpback Whale: The humpback whale (Megaptera novaeangliae) ranges into the Chukchi Sea in the summer, where it can be found in both open waters and areas of broken ice. They generally arrive in July and August with pregnant females arriving earliest and staying longest. They are known to occur regularly off the Soviet coast of the southern Chukchi Sea (Votrogov and Ivashin, 1980), usually in August - October. They are less frequently reported along the Alaskan coast. Like the gray whale, the humpback is a seasonal feeder, dieting in the summer mainly on euphausiids and occasionally small fish, and fasting during the winter breeding season.

Killer Whale: The killer whale (Orcinus orca) enters the Chukchi Sea during the open water season where it is often sighted along the coast or at the edge of the pack ice. The numbers and movements of these whales in Arctic waters is not known.

Narwhal: The narwhal (Monodon monoceros) inhabits mainly the northwestern Greenland and eastern Canadian Arctic, especially in Jones and Lancaster Sounds, and along the north and east coasts of Baffin Island. They are rare in the western Canadian Arctic and the Beaufort Sea and would normally not be present in the Chukchi or East Siberian Seas. Although there are no recent sightings of narwhals from the Chukchi Sea, two specimens have been reported from the Bering Sea (Geist et al., 1960). Old tusks of this unusual whale have also been obtained at Wainwright. An encounter with this species in the southeastern Chukchi Sea would be extremely unlikely.

Harbor Porpoise: A few harbor porpoise (Phocoena phocoena) enter the Chukchi Sea in the summer, primarily in August when the ice is out and waters have warmed. They occupy nearshore areas only, and often enter bays and river mouths. They avoid waters where sea-ice is present.

5.5 Ringed Seal

The ringed seal (Phoca hispida) is an ice-dependent seal of the Bering, Chukchi, and Beaufort Seas. It is the smallest of the northern seals and the seal most closely associated with the shorefast ice environment. It is also the most common marine mammal in the subsistence take of coastal residents of arctic Alaska.

Ringed seals show a strong dependency for sea ice, and move seasonally with its advance and retreat. Individuals are usually solitary, but often form molting groups during the summer. In the winter, this seal is not dependent upon leads, flaws, or open water to survive. It is adapted to severe ice conditions, and overwinters along the coast in the shorefast ice zone by maintaining breathing holes and lairs in the ice.

Ringed seals are most abundant in the stable fast ice over depths from 3 fathoms out to the shear zone. Densities of ringed seals along the southeast Chukchi Sea coast were reported from aerial surveys flown in June 1976 for seals hauled-out on the ice (Burns and Eley, 1978). Densities varied widely from a low of 0.7 seals/nm in Kotzebue Sound to 4.9 seals/nm at Cape Lisburne (Table 5.5). Ringed seal densities in the pack ice averaged only 0.2 seals observed/nm. These estimates are for the one survey only, but if typical, indicate that the shorefast ice zone of the southeastern Chukchi Sea is not as densely populated as the northeastern sector between Cape Lisburne and Point Barrow. In terms of absolute population size, this may not hold however, since the southeast portion has a larger overall area of shorefast ice for overwintering habitat.

Pups are born in nearshore birth lairs in late March through April. Until

Table 5.5. Densities of ringed seals in the fast ice zone of the eastern Chukchi and western Beaufort Seas during aerial surveys in June 1970, 1975, 1976, and 1977. Values are the average number of seals per nm^2 observed on the ice in each sector. Dashes indicate no surveys flown (from Burns et al., 1980).

Sector of Coastline	1970	1975	1976	1977	Ave.
Kotzebue Sound	-	-	0.7	-	
Cape Krusenstern - Point Hope	-	-	2.3	-	
Point Hope - Cape Lisburne	-	-	0.9	-	
Cape Lisburne	-	-	4.9	-	
Point Lay - Wainwright	5.4	2.9	1.9	3.3	3.4
Wainwright - Barrow	3.7	6.2	3.8	2.6	4.1
Barrow - Lonely	2.3	2.8	1.4	1.0	1.9
Lonely - Oliktok	1.0	1.4	1.1	0.5	1.0
Oliktok - Flaxman Island	1.4	1.0	1.4	0.7	1.3
Flaxman Island - Barter Island	2.4	1.8	0.4	1.2	1.5
Chukchi Sea - moving pack ice	-	-	0.2	-	
Beaufort Sea - moving pack ice	-	-	0.1	-	

they are weaned they are incapable of surviving in the water, and must remain in the lair or hauled-out on the ice, a period of time that generally lasts 4 to 7 weeks. In late spring, on sunny days, both adults and young can be observed hauled-out on the ice along cracks and open leads.

With breakup of the shorefast ice in late June or July, the ringed seals leave the nearshore zone to inhabit the edge of the pack ice, and will even penetrate into the consolidated ice pack to some extent. Preceding the formation of the shore ice again, the seals suddenly reappear along the coast in November where they remain until the following summer. It is believed that a sizeable portion of the population migrates through the Bering Strait, to and from the Bering Sea each season.

5.6 Bearded Seal

The bearded seal (Erignathus barbatus) is the largest and most widely distributed of the phocid seals found in the Chukchi Sea. It winters primarily in the Bering Sea along the ice edge and in broken pack ice with suitable open water. It generally prefers the heavier pack ice, and can be found wintering further north than the other offshore seals. Some bearded seals are reported to overwinter in the southeast Chukchi Sea in the highly fractured moving pack ice north of the Bering Strait, and to a lesser extent, in the flaw zone off the Chukchi and Beaufort Sea coasts (Burns et al., 1980). Although they can maintain breathing holes in ice, they rarely do so, and seldom occur amid the shorefast ice.

Marked seasonal migrations of this species follow the annual advance and retreat of the seasonal pack ice. These movements involve both active swimming and passive movement with the ice. During the spring their abundance in the Chukchi Sea increases as ice leads open and the northward drifting ice transports overwintering populations from the Bering Sea.

The nearshore area south of Point Hope and west of Cape Thompson reportedly has a high abundance of bearded seals in the spring (Johnson et al., 1966). During the summer and autumn, bearded seals migrate to the edge of the polar pack ice and are found in highest abundance when the pack ice edge occurs close to the coast.

Although adults are almost always associated with the sea ice, a portion of subadults remain in ice-free waters, particularly in bays and estuaries, but they rarely come ashore. Most bearded seals in the Chukchi Sea are adults (Sommerville et al., 1972). Most of the subadults remain in the Bering Sea, but a few are found in the open water or nearshore areas such as Kotzebue Sound and Marryat Inlet during the summer.

5.7 Spotted Seal

The spotted seal or largha seal (*Phoca vitulina largha*) is the ice-breeding subspecies of harbor seal. During the winter and spring, virtually the entire population of spotted seals concentrate along the southern margin of the seasonal pack ice in the central and eastern Bering Sea (Burns et al., 1980). These seals move northward and toward the coast as the ice retreats and disintegrates. Much of the population passes through the Bering Strait to enter the Chukchi Sea in June.

In the Chukchi Sea, the spotted seal is the only seal commonly found in coastal waters during the ice-free season. It occurs regularly in scattered numbers along the entire southeastern Chukchi Sea coast, and is particularly common in bays, estuaries, and near river mouths. It is also the only northern seal that will commonly haul out on land during the ice-free season. Chamisso Island in Kotzebue Sound is a regular haul-out area. Certain other isolated sandy beaches and barrier islands are also favored basking areas for the species and large numbers of spotted seals can often be found in these areas during the summer and early fall. Fall concentrations occur regularly in the Kukpuk estuary a few miles north of Point Hope (Johnson et al., 1966).

5.8 Ribbon Seal

The ribbon seal (*Phoca fasciata*) is a winter resident of the ice edge of the central Bering Sea. As the ice retreats northward in the late spring, ribbon seals abandon the ice and become pelagic until the ice reappears in the fall. Some individuals follow the ice retreat into the southern Chukchi Sea during the summer (Burns et al., 1980), but their distribution and abundance here is not known. A few ribbon seals are taken annually by Point Hope natives, generally in June and again in November.

5.9 Pacific Walrus

The Pacific walrus (Odobenus rosmarus) ranges from the Bering Sea to the Arctic Ocean in association with the pack ice (Figure 5.12). In general, walrus are south of the Chukchi Sea from December to March. They winter almost entirely in the northern Bering Sea south of 64°N and migrate northward with the receding ice in the spring and summer. Most of the walrus population passes through the Bering Strait in spring and fall. Some animals, predominately mature males, remain in the Bering Sea during the summer. The main migration route of the walrus after passing the Bering Strait is mainly offshore as a broad front, but a few animals pass within a few miles of the coast. Those migrating close to shore pass Point Hope in early July, and pass Wainwright and Barrow in early August. Adult females generally precede the males northward.

In late summer and early fall, walrus, like the bearded and ringed seals, are found concentrated along the edge of the polar pack ice from about 170°W eastward to beyond Point Barrow. Unlike the seals, walrus are highly gregarious and form herds sometimes numbering several hundred animals. They rarely come ashore along the Arctic coasts during the summer. However, during the 1930's, herds were frequently reported to haul out along the Lisburne Peninsula from Cape Thompson to Icy Cape. Fay (1967) believed that the reduced use of these grounds was a result of reduced population density, although continuous human disturbance could also have been a factor. Although the present walrus population is at or near its maximum size, these haul-out areas have not been reoccupied.

As the ice begins to reform in October, the walrus reverse their migration and return south again. Some generally pass Point Hope by the end of November. These migrations generally precede the southward advance of the pack ice

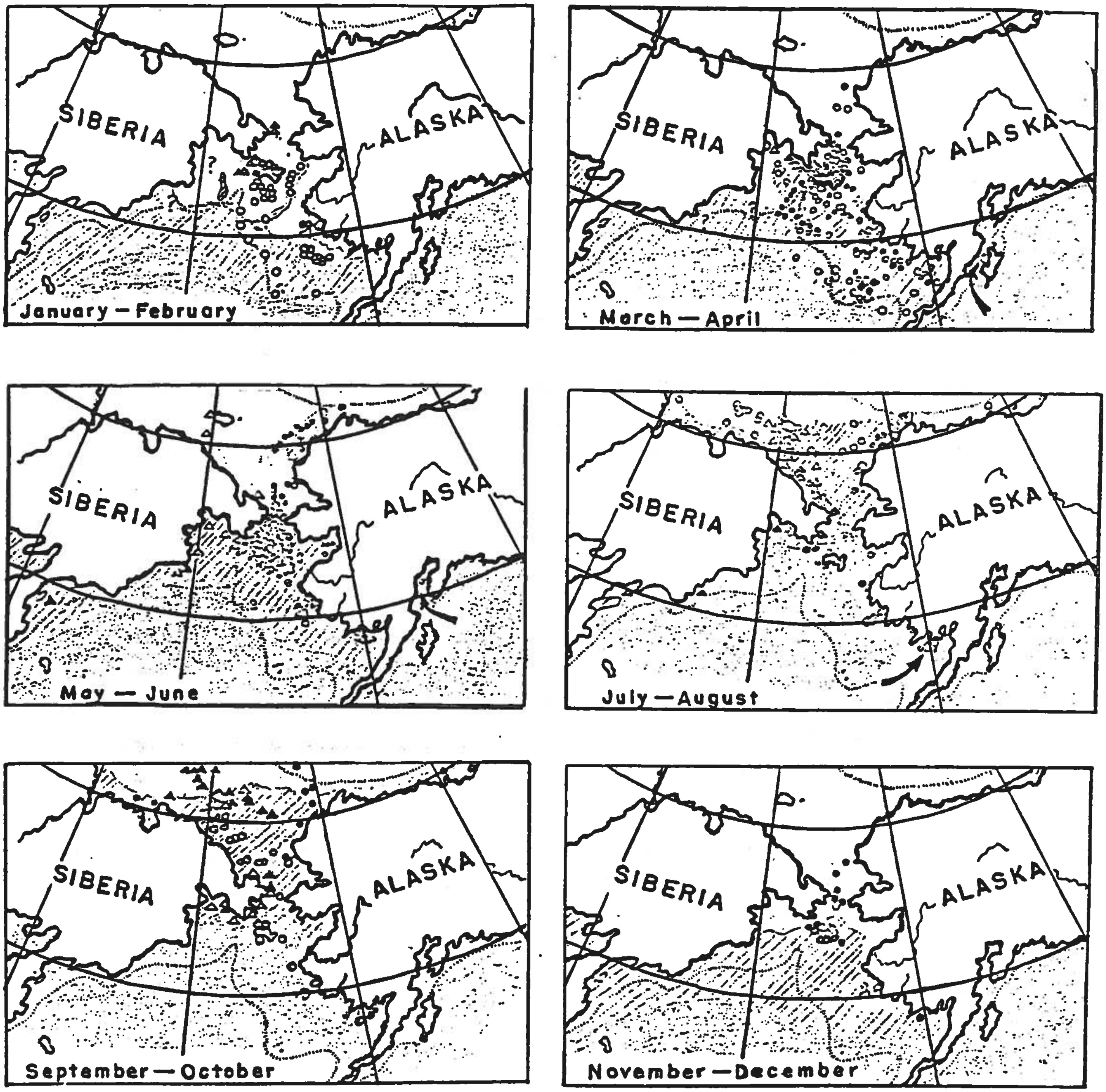


Figure 5.12. Distribution of walruses in the Bering and Chukchi Seas, in relation to approximate mean ice conditions. Each symbol represents the position of one or more animals, as reported in a published (▲△) or unpublished (●o) account. Solid symbols are for the first month of each 2-month set; open symbols are for the second month. The minimal extent of heavy ice navigable only by ice-breakers is shown by the unshaded area; the maximal extent of lighter or broken ice is cross-hatched; open water is shaded. Dotted lines show the approximate position of the 100-meter isobath (from Burns et al., 1977).

itself, and the walrus must swim to hauling-out grounds in the southwest Chukchi and northern Bering Seas. By December, the last walrus have usually left the Chukchi Sea.

5.10 Other Pinnipeds

Other pinnipeds that occasionally occur in the Chukchi Sea during the open-water period are the northern fur seal (Callorhinus ursinus), the northern sea lion (Eumetopius jubata), and the harbor seal (Phoca vitulina richardi). All are common residents of the Bering Sea, but are beyond their normal range when they pass the Bering Strait. Little detailed information is available on the occurrence of these species in the Chukchi Sea. The northern fur seal and the northern sea lion have been reported as far north and east as the Canadian Beaufort (McEwen, 1954; Maher, 1960).

5.11 The Polar Bear

The polar bear (Ursinus maritimus) occupies both the terrestrial and marine environments. Polar bears are common inhabitants of the Chukchi Sea, and their movements are directly tied to the seasonal dynamics of the polar pack ice. They live primarily on the outer edge of the pack ice during summer, and during winter when the pack ice is adjacent to the coast they are most numerous at the flaw zone between the moving pack and the shorefast ice. They frequently enter the shorefast ice zone to search for ringed seals, and on occasion come onto land in search of carrion or other food.

An increase has occurred since the mid-1970's in the number of bears observed nearshore in the vicinity of Cape Lisburne. Aerial hunting of polar bears was banned in 1972, and the population may be returning to the pre-1950's population abundance and distribution. In the first few months of 1981, 35 polar bears were tagged at Cape Lisburne by U.S. Fish and Wildlife Service biologists.

The polar bear is the largest carnivore of the Arctic and occupies the top level of a relatively simple food web. The principal prey species in the winter are bearded and ringed seals. They are also known to consume carcasses of other mammals, and occasionally eat plants and various small terrestrial mammals. In 1960, one polar bear was shot 14 miles up the Wulik River where it had been feeding on cached fish (Saario and Kessel, 1966). During the summer, they are found most commonly at the pack ice edge, preying chiefly on walrus calves, and bearded and ringed seals.

It is believed that there are two populations of polar bears in the western Arctic; a Chukchi Sea stock and an Arctic Ocean stock (Lentfer, 1976). The Chukchi Sea population, estimated to number about 6500-7000, is centered around the Wrangel Island area north of Siberia, where they regularly den and rear their cubs. The Arctic Ocean population is estimated to be about 2500 animals. Little interchange is thought to occur between these two populations. Most of the polar bears along the Chukchi coast, north of Icy Cape, are believed to come from the Arctic Ocean population, while those of the Bering Strait and southeast Chukchi Sea belong to the Chukchi Sea stock. The two stocks probably overlay north of Cape Lisburne.

Polar bears travel extensively among the pack ice in search of food and mates, and in conjunction with the seasonal movements of the ice. In the winter the bears travel southward, occasionally past the Bering Strait, reaching as far as St. Lawrence Island. The population shifts north- ward in the spring prior to breakup to maintain the association with the permanent pack ice. The bears move north from the Bering Strait beginning in March. Those wintering in the northeastern Chukchi Sea move eastward along the Beaufort coast in late April and May.

Mating occurs every third year, primarily in April, when females have abandoned their two-year old cubs. After mating, the females remain active all summer and eventually establish a den in October. One to three cubs, most commonly two, are born in the dens in late November or early December. The dens are vacated in late March to early April, but the female and her cubs remain close to the dens until the cubs are acclimated to the cold temperatures.

Most denning in Alaska occurs in heavy pack ice and on offshore islands of the

Beaufort coast between the Colville and Canning Rivers. Dens are sometimes only hollows made in the snow. Occasional denning occurs in the shorefast ice and river mouths along the northeast Chukchi Sea coast, at least as far as Point Lay, but rarely farther south.

5.12 Subsistence Harvest of Marine Mammals

Mammals play a greater role than fish and shellfish in the subsistence lifestyle of the villagers inhabiting the southeast Chukchi Sea coast. Marine mammals and caribou provide their major food resource, with fish and fowl providing important supplements to their diets. In years when hunting is poor, the latter resources are more heavily relied upon. Ray (1964) identified three general subsistence patterns historically practiced by the different villages of the area.

1) The Whaling Pattern, such as practiced by the villages of Little Diomede, Wales, and Point Hope, in which whales, walrus, seal and fish are used most extensively. The Eskimos of the Whaling Pattern are most oriented to the sea. Caribou and salmon are of lesser importance than marine mammals, although both products are obtained through trade or by traveling to another territory.

2) The Caribou Hunting Pattern, as practiced by the villages of Buckland, Deering, and Candle, in which caribou, fish, seal, and beluga are the mainstays of the subsistence economy. Winter caribou hunting is most important to these people. In spring, these villagers go to bays and coastal areas for beluga and seal hunting, e.g., Buckland villagers hunt in Eschscholtz Bay.

3) The Small Sea Mammals Pattern, followed by the Eskimos of the coastal villages of Shishmaref, Kivalina, and Kotzebue, in which seals, beluga, fish, and caribou are important in that order. Historically, these people traveled short distances inland for caribou, or in the winter the caribou came to the coastal villages, especially if the tundra pastures were snow-free. Caribou began to decrease on the Seward Peninsula in the late 1800's, and many

earlier villages disappeared as the inhabitants moved elsewhere. Today, the native caribou has been largely replaced by domesticated reindeer herds.

Although the Eskimo lifestyles have adapted to modern times, most of the villages are still economically and culturally dependent on their subsistence resources (Figure 5.13). With little exception, every settlement in this region is located where it is because of the seasonal availability of game or fish. Subsistence remains the primary occupation of most families in each village. A detailed account of the subsistence lifestyle of the village of Kivalina in the early 1960's is given by Saario and Kessel (1966). Other summaries can be found in Johnson et al., (1964) and Foote and Williamson (1966).

More recent information should be collected on the subsistence take of marine mammals to assess the potential impacts of OCS development on the native lifestyle. The following discussion outlines the importance of marine mammals to the subsistence economy of villages along the southeast Chukchi Sea coast.

Bowhead Whale

The spring whale hunt is practiced by Alaska Eskimos from St. Lawrence Island to Barrow. In 1980, 99 crews landed 15 whales and lost 16 more (Table 5.6). Three villages along the southeastern Chukchi Sea coast participate in the spring hunt of the bowhead. These are Wales, Kivalina, and Pt. Hope. Although Wales mounts a hunt each spring, 1980 was the first year that a bowhead was taken by this village since the 1950's. No whales were taken in the 1981 whale hunt.

At Kivalina, whaling is annually practiced but conditions are frequently unfavorable. In 1980 unfavorable winds prevailed and the lead was nearshore where the water was too shallow for bowheads to pass. No bowheads were struck or landed. In 1981, there were two struck and lost and no landings.

Point Hope had been a traditional whaling village since prehistoric times, and the whalers are often joined by crews from Kivalina. Camps are established on

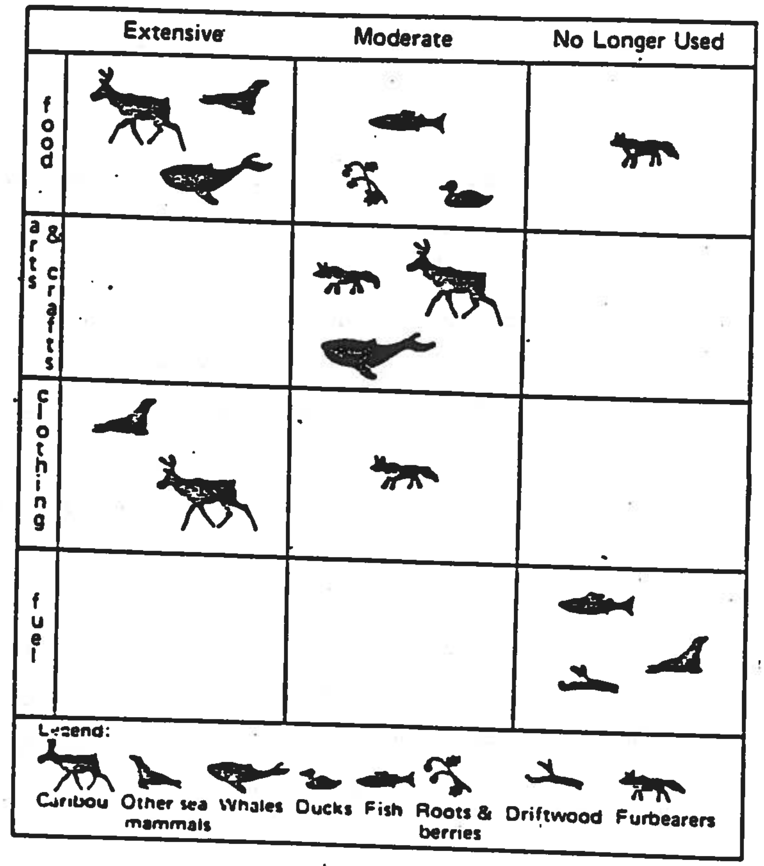


Figure 5.13. Major subsistence resources of the Chukchi Sea and their use by native villagers (from AEIDC, 1978). Seals and whales are used extensively for food, while seals also provide skins for clothing. Marine and anadromous fish are an important supplement to their primarily meat diet.

TABLE 5.6.---Bowhead whaling activities by Alaskan Eskimos, spring 1980 (from Johnson et al, 1981).

Village	No. active crews	Whaling began[1]	Whaling ended	Whales landed	Struck and lost	Total struck	IWC/US quota Landed	IWC/US quota Struck
Gambell	21	19 Apr	4 May	1	3	4[2]	2	3
Savoonga	8	12 Apr	20 Apr	2	0	2	2	3
Wales	3	12 Apr	4 May	1	0	1	1	1
L. Diomede	3	-	-	0	1	1	0	0
Shaktoolik	3	-	-	1	0	1	0	0
Kivalina	3	19 Apr	29 May	0	0	0	1	2
Pt. Hope	15	12 Apr	29 May	0	1	1	2	3
Wainwright	7	21 Apr	8 Jun	1	0	1	2	3
Barrow	36	18 Apr	8 Jun	9	11[3]	20	5	7
Totals	99			15	16	31	15[4]	22[4]

1/ Date first boat entered water.
2/ Unused Savoonga strike transferred to Gambell.
3/ Two whales killed and lost.
4/ Does not include autumn quota for Nuiqsut (1/1) and Kaktovik (2/3).

the ice during late April and May when the nearshore lead system is opened. Whaling is done from umiaks. No whales were landed in 1980 but one was struck and lost when the harpoon dislodged. In 1981, Point Hope landed four whales and lost one whale.

The skin and blubber (or "muktuk") is a prime delicacy for the Arctic Eskimo, and the meat and all soft parts are used for either human consumption or dog food.

Beluga Whales

Beluga are an important subsistence resource of many villages of this region. They are commonly taken all along the coast from Wales to Point Hope, especially within the waters of Kotzebue Sound.

Belugas are killed by rifle fire and then harpooned or hooked when they are weakened and can be retrieved. A common method of hunting is to anchor the boat in the strait between Kotzebue and Sheshalik Spit and watch for pods of belugas leaving and entering Hotham Inlet. Hunters attempt to herd the whales into shallow water before shooting. The beluga appears to have become shy of outboard motor noise and is increasingly difficult to hunt by a moving boat.

Beluga muktuk is a favored food item. The meat and other soft parts are used for human or dog food.

Gray Whales

Gray whales are taken only rarely by villages along the Chukchi Sea coast (Marquette and Braham, 1981). Evidence indicates that gray whales are hunted only when the bowhead harvest has failed that year. Wales natives landed one gray whale each in the years 1969 and 1970. They are not known to have been taken at either Point Hope or Point Lay. Wainwright whalers last took a gray whale in 1957. Barrow whalers last took a gray whale in 1965.

Bearded Seal (ugruk)

Bearded seal is the largest of the indigenous seals, weighing 200 to 600 pounds, and it is the preferred seal in the Eskimo diet. They are hunted primarily in the spring a@d fall when the seals are hauled out on floating ice. In the water, they usually sink instantly when killed.

At Shishmaref, bearded seal are hunted on the pack ice in late May and June, or as long as the pack ice persists and is safe. They are usually taken in good quantities, and during a good year enough seals are taken within a 2- to 3-week period to furnish a sizeable share of the meat and oil for the entire year. The meat is either air-dried or stored in seal oil in ringed seal pokes. The blubber is cut into small pieces, packed in pokes, and cold-stored. Prize young seal skins are used for clothing.

At Point Hope and Kivalina, bearded seals are hunted by boat during break-up. The skin is used for small boats and umiaks (when walrus is rare), for the soles of mukluks, and for rope and line.

Ringed Seal (netchek)

Ringed seals are the most commonly use marine mammal along the Chukchi Sea coast. They are used for food for both the people and their dogs. Ringed seal skins are more pliable than bearded seals skins, and are preferred for clothing.

Ringed seal hunting begins in November in areas where the shore-fast ice is solid enough for travel, and continues until the ice goes out, sometime in late May or June. At Point Hope, the sea ice forms along the north shore in early November and is accompanied by the return of the ringed seals. At Kivalina, good ice does not generally form until late December or January. In these villages, winter hunting is most frequently done at the edge of open leads and less often at the seals breathing holes. In June or early July, as the ice is breaking up, hunting is done from umiaks with outboard motors.

Spotted Seals

Economically, the spotted seal is not of prime importance to Chukchi Sea villagers. The hide is the part used most. The meat is less palatable than the ringed or bearded seals, and is mainly used for dog food.

A few spotted seals are generally taken at Point Hope during the summer, either in the river estuaries or off the point. In late October, there is usually a concentration of seals in Marryat Inlet near the outlet of the Kukpuk River, and these are taken to some extent.

Ribbon Seal

Ribbon seals are recorded in most years in the subsistence take of Chukchi Sea villages. Most occurrences are in June and November, during their migrations. It is not a valued seal in this region.

Walrus

Walrus are hunted most extensively by the Chukchi villages adjacent to the Bering Strait, i.e., Little Diomede, Wales, and Shishmaref. The main migration route of walrus is generally beyond the normal hunting area of the more northern villages. The occasional walrus may be taken at Point Hope or Kivalina during their northward migration in June, or less often, in October during their southward migration. Villages along Kotzebue Sound rarely see walrus.

Walrus are taken for their ivory, hides, and meat. The meat is primarily used for dog food, but the liver is considered a delicacy. Walrus hide is used for boat coverings, primarily by the villages in the Bering Strait region.

Polar Bear

Polar bears are much sought after but are relatively rare over most of the southern Chukchi Sea. They are shot when encountered, and are sometimes tracked over the snow. Most polar bear kills in this region are taken at Point Hope and Shishmaref, and only rarely within Kotzebue Sound. At Shishmaref one or two polar bears may be taken in some years, in other years none at all. The skin is highly valued and the meat is considered very good.

6. POTENTIAL IMPACTS AND RECOMMENDATIONS

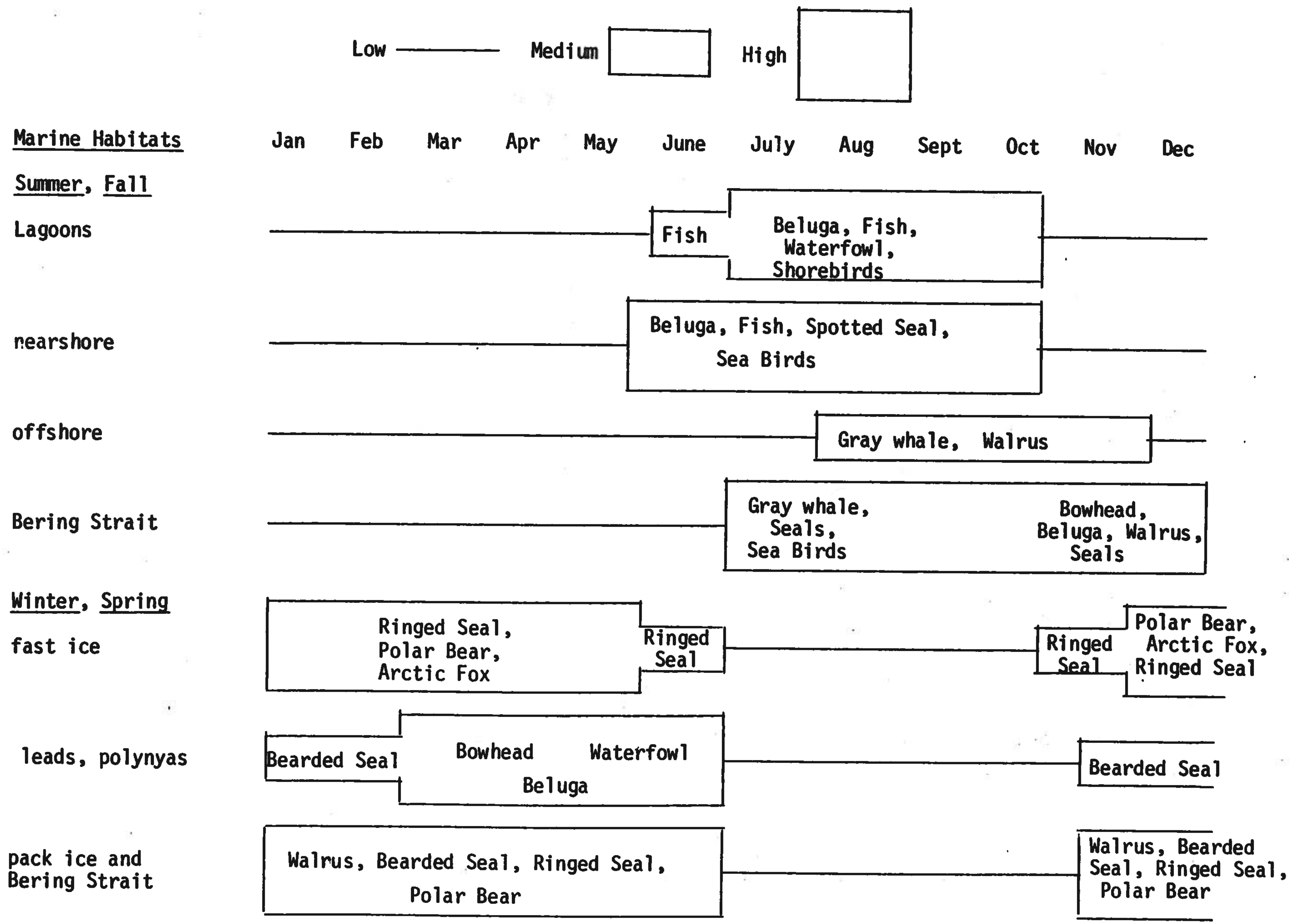
The major concerns of the National Marine Fisheries Service about oil and gas operations in the southeast Chukchi Sea are: 1) the possible effects on the marine mammals and their habitats in this region; 2) the impacts to coastal anadromous fish, key prey species of marine fish and benthos, and to their coastal habitats; and 3) the effect on native subsistence livelihood resulting from impacts to these marine mammals and fish resources.

Sensitivities of marine mammals, birds, and fish to OCS impacts differ seasonally with the changes in their distribution and abundance. In the southeastern Chukchi Sea this general relationship of sensitivity between habitat, species, and time of year is shown in Figure 6.1. The Bering Strait is a particularly sensitive area as it is a major migration corridor for most of the species seasonally inhabiting the Chukchi Sea (i.e., bowhead, beluga, and gray whales, and ringed, bearded and spotted seals, and walrus migrating north in the spring-summer and returning in the fall).

The subject of effects on fish and marine mammals of oil spills and industry activities has been extensively reviewed and will not be repeated here. Impacts to fish and shellfish resources were discussed in Higgins (1978) and NMFS (1979). Potential impacts are also usually similar to those faced in the Beaufort Sea, which are extensively discussed in OCSEAP (1978). The impacts to marine mammals have most recently been reviewed in Geraci and St. Aubin (1980). Each of these reports cites numerous other relevant referees on the subject of impacts. Figure 6.2 diagrams the relationships between the various OCS activities and their associated potential effects on marine mammals.

All stages of oil and gas activities in the southeastern Chukchi Sea potentially pose significant threats to marine mammals and fish and their environments, beginning during the pre-lease stage with seismic geophysical exploration. The severity of the impact will depend on the type of activity, its magnitude, timing, and location. Potentially severe impacts can be mitigated to some extent by regulating these activities, and by placing

Figure 6.1 Relative Sensitivities of Chukchi Sea Habitats



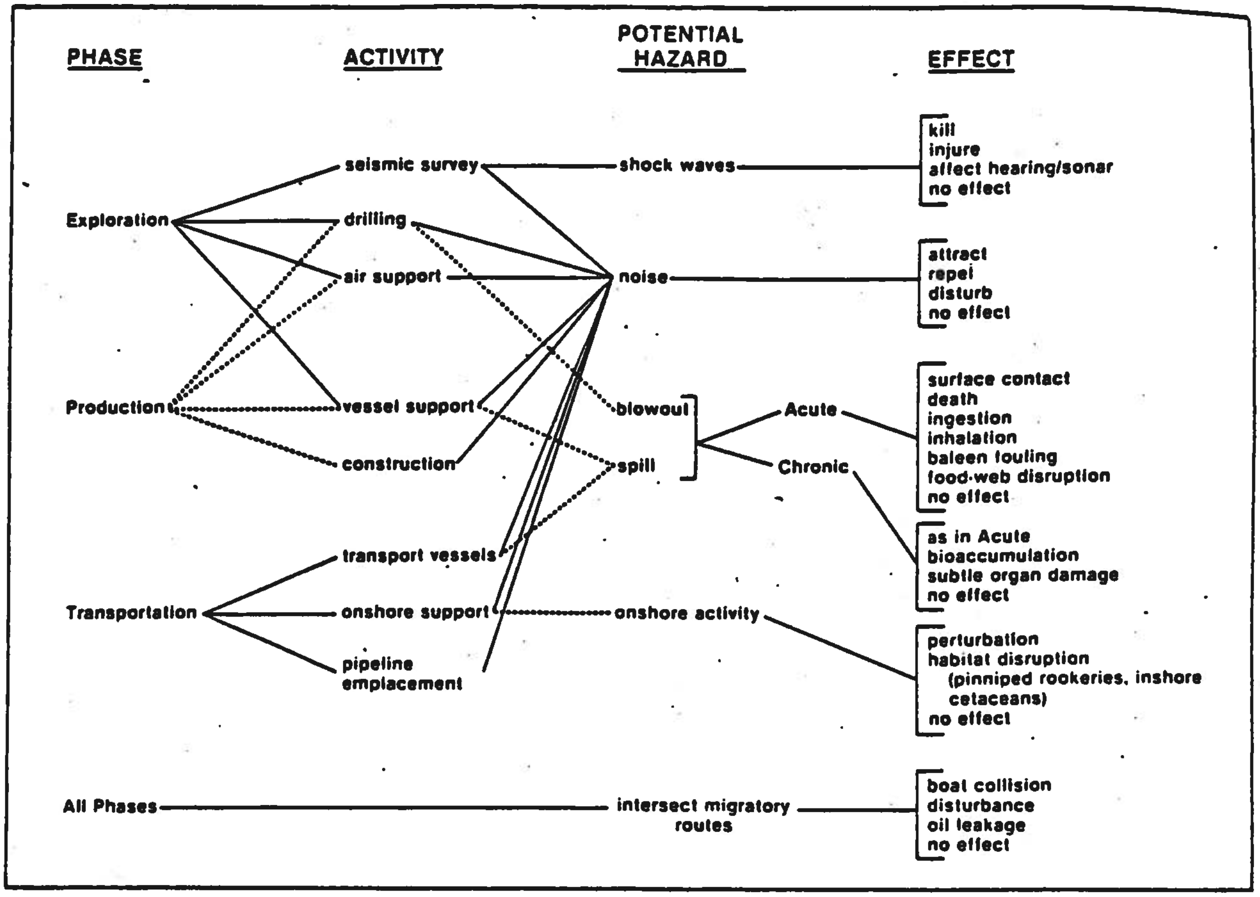


Figure 6.2. Impacts associated with OCS oil and gas activities and their potential effects of marine mammals (from Geraci and St. Aubin, 1980).

constraints on their scope of operations. The remainder of this section focuses on certain recommendations that will allow OCS activities to proceed in a more environmentally safe manner. Where necessary, research needed to reduce existing uncertainties over potential impacts is identified.

1. <u>An initial lease sale in the Hope Basin area of the southeastern Chukchi Sea should be confined to the stable shorefast ice zone and subsequent sales beyond this zone should require a demonstrated ability on the part of industry to deal with the moving ice conditions</u>.

Much of the Chukchi Sea area of call is a dynamic moving ice environment with shear zones, pressure ridging, pack ice incursions, ice override and grounding, and sea floor gouging. Technology has not been proven to be capable of withstanding these forces. Until test structures have been developed and tested that can counter these forces, activities should be restricted to the kinds of technologies that are already proven in familiar environments. Winter pack ice conditions are sufficiently severe to pose serious risks to structures even in certain shallow water areas. Studies should continue to measure ice forces, to determine the frequency, location and characteristics of sea ice hazards, and ultimately to develop useful sea ice reconnaissance and forecasting techniques.

As industry develops the capability to construct structures that can withstand the forces of moving pack ice, consideration could then be given to extending leasing into the offshore zone. Test structures should be required to demonstrate this capability prior to leasing these offshore areas.

2. <u>Pre- and post-lease geophysical exploration should be restricted in the winter period prior to March 20 for on-ice operations for the nearshore zone beyond 3 fathoms, and to the summer period between June 15 and October 1 for the offshore open water work</u>.

On-ice geophysical seismic exploration has the potential for adversely impacting ringed seal populations at the time of pupping. The Chukchi Sea fast ice zone supports high densities of ringed seals, and may be a critical breeding area for recruitment into adjacent regions. Pupping occurs in birth lairs in the shorefast ice, particularly beyond the 3-fathom depth in April and May. Seismic geophysical work should be completed by March 20 to avoid disturbing breeding animals during this critical time.

Vessel surveys should be restricted to the open water period (approximately June 15 to October 1) to avoid disturbance of migrating bowhead and beluga whales. These surveys should also avoid disturbance to summering populations of beluga whales in nearshore waters, and to gray whale feeding aggregations in the offshore waters.

Studies should be continued to determine the types of impacts and zones of disturbance of seismic surveys to ringed seals from on-ice activity and to bowhead, gray, and beluga whales from vessel-conducted activity.

3. <u>A buffer zone should be established for the Bering Strait, and any tracts from which an oil spill would have a significant probability of reaching the Bering Strait within 30-days should be withheld from the sale offering</u>.

The Bering Strait is a critical habitat for most Arctic marine mammals and many seabirds. It is used in the spring and fall as a migration corridor for virtually the entire population of the endangered bowhead whale, a large proportion of the endangered California gray whale population, a smaller number of individuals of five other endangered whales, and the major portions of the Alaska populations of beluga whales, Pacific walrus, bearded and spotted seals. The Bering Sea population of ringed seals and many ribbon seals, as well as some polar bears, also migrate seasonally through the Bering Strait. It is also a major flyway and oceanic corridor for marine birds of Arctic Alaska. Chum salmon and Pacific herring are two commercially important fish species that migrate through the Strait.

In addition to its importance as a migratory corridor, the Bering Strait region is a major wintering area for Pacific walrus and bearded seal, and an important summer feeding area for gray whales. The Diomede Islands and Fairway Rock are significant marine mammal haul-out areas and seabird colonies.

General water transport is north through the Bering Strait most of the year, but southerly flow reversals can occur in any month. Sea ice movement is generally south through the Bering Strait from December to May. An oil spill in the Hope Basin area in open water would more probably move with wind and currents away from the Bering Strait, but an oil spill in the moving ice would likely be transported by the ice toward the Bering Strait. Given these conditions and the degree of uncertainty surrounding their rates and directions, careful oil spill trajectory risk analysis should be imperative for tracts in this region.

The behavior of an oil spill in moving pack ice is uncertain. An oil spill would probably move with the ice, become entrapped in under-surface irregularities of the ice with some oil becoming incorporated into the ice, and some oil would fill the open water areas between ice floes. Oil contained by the ice would eventually be released when the annual ice melts in the spring. Oil in the open water between floes could severely impact marine mammals and seabirds which are dependent upon the recurring polynyas and open leads in the flaw zones of this region.

A 30-day trajectory buffer zone from potential spill sites is proposed to protect marine mammals and seabirds. In the winter it is unlikely that a spill would weather or disperse before this time to render the oil harmless. Sea ice and cold weather would likely prevent spreading and evaporation; significant amounts of oil may remain pooled in leads or trapped in the ice. During the open water season, a 30-day period should provide sufficient protection for this region, but a 10-day period probably would not. After 10 days the oil slick may be dispersed into smaller patches but these patches could be spread over a larger area than the original cohesive oil slick, and the oil would still be sufficiently fresh to seriously impact marine mammals that come into contact with the oil. Although it is less likely that an open-water spill would be transported south to the Bering Strait than it would for a winter spill in the moving ice, a 30-day buffer zone for tracts where this is the most probable trajectory direction would offer the best means of protecting the living resources of the Bering Strait under both conditions.

4. <u>Exploratory drilling should initially be limited to the stable ice zone only, and should be seasonally restricted to allow sufficient time for</u>

<u>control of blowouts and cleanup of oil spills by April 15</u>.

An oilspill in the flaw zone and lead systems in the spring has the potential of severely impacting bowhead and beluga whales during their migration through open-water leads along the Chukchi Sea coast. Since virtually the entire population of the endangered bowhead whale migrates through this area between mid-April and June, drilling dates should be established for tracts where such a risk exists (i.e., outer Kotzebue Sound and open coasts) that would allow for sufficient time to regain any loss of well control, and to contain and cleanup any oil spills by April 15. This situation is even more severe than in the Beaufort Sea due to the closer proximity of the whales to the nearshore environment, their earlier arrival in these waters, and their concentrated paths through the area. The drilling date restriction of March 31 in the Beaufort Sea, if applied to the Chukchi Sea drilling, would not allow sufficient time to mitigate the threat of an oil spill before the whales arrive. A cut-off date of March 1 would allow a 45-day safety margin. Down-hole activities that pose the risk of a blowout should not be permitted during the period of time that would not allow relief well to be drilled by April 15.

The possibility of allowing exploratory drilling in the open water season (July to October) either from drilling rigs or artificial islands needs further analysis and review. Location of leases, proximity to critical habitats, oil spill risk analyses, and sea ice hazards from pack ice incursions require better knowledge than currently exists.

Exploratory drilling should not be allowed during the winter beyond the fast ice zone until structures are tested and proven.

5. <u>Prior to the leasing of tracts, studies should be conducted and completed in sufficient detail to provide information on the following subjects</u>:

   a) <u>Oil spill trajectory analyses</u> are needed to accurately determine the probable direction and rate of movement of oil spills in the lease area during both open water and ice-covered seasons. Information will have to be collected on nearshore and offshore currents, seasonal wind regimes, winter ice movements, under-ice circulation, oil-ice interactions, and oil slick behavior in relation to ice types and under-ice topography.

b) The locations of critical habitats and the key ecological parameters that characterize these habitats in the southeast Chukchi Sea need better understanding for:

1. Beluga whale summer feeding, breeding, and calving areas.

2. Ringed seal pupping, breeding, and overwintering habitats.

3. Bearded seal and walrus wintering concentrations in the Bering Strait region.

4. Polar bear high-density use areas and the extent of denning along the Chukchi coast.

c) Determining the fall migration routes of bowhead and beluga whales on their southward return through the Chukchi Sea and Bering Strait is necessary.

d) Site specific studies should address the interactions and potential conflicts that may develop between whaling and other native subsistence activities and the petroleum industry operations in subsistence use areas during the exploration and development phases.

6. Prior to the exploration phase, studies should be conducted and completed in sufficient detail to provide information on the following subjects:

a) The locations of critical habitats and the key ecological parameters that characterize these habitats in the southeast Chukchi Sea for:

1. Winter under-ice habitat utilization by fish and invertebrates, especially in relation to the life history of key nearshore prey species such as Arctic cod, saffron cod, herring, and shrimp.

2. Locations of high abundance areas and movements of anadromous fish along the coast, in bays, lagoons, and river mouths, in both summer and winter seasons.

b) Ecological studies and habitat surveys of the coastal lagoons prior to the time that any potential construction or habitat alteration activities are conducted.

c) Non-site specific studies on the effects of seismic disturbance, noise disturbance from industry facilities, aircraft and vessel traffic, and other associated activities on bowhead and beluga whales, ringed seals, and polar bears.

d) Non-site specific studies on the effects of oil on representative marine mammals by direct contact through ingestion, inhalation, coating of hair, skin or eyes, fouling of baleen, or indirectly through destruction of food supplies from contamination or by alteration of habitat.

7. Prior to the initiation of the development phase, additional studies should be completed that haired detailed information on the following subjects:

a) Location and timing of use of critical habitats by marine mammals, fish, and birds and their critical biological activities on a site specific basis.

b) Quantitative characterization of natural hazards of sea ice, ice override and ice gouging, permafrost, storms and storm surges, and sea floor geotechnical properties.

c) Identification of freshwater and sand/gravel resources, their availability for industrial use, and the <u>habitat impacts</u> of their removal.

d) <u>Fate and effects studies</u> on the discharge of formation waters, muds and cuttings, and hydrocarbons into coastal waters and offshore and under the ice.

e) Effects of industrial noise on the behavior and migration of the marine mammals of the region.

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The cover illustration is from A.M. Bailey's "Field Work of a Museum Naturalist" (1971). It depicts native hunters from Little Diomede approaching Fairway Rock in their walrus skin umiak.

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