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An Assessment of the Living Marine Resources of the Central Bering Sea and Potential Resource Use Conflicts Between Commercial Fisheries and Petroleum Development in the Navarin Basin, Proposed Sale No. 83

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
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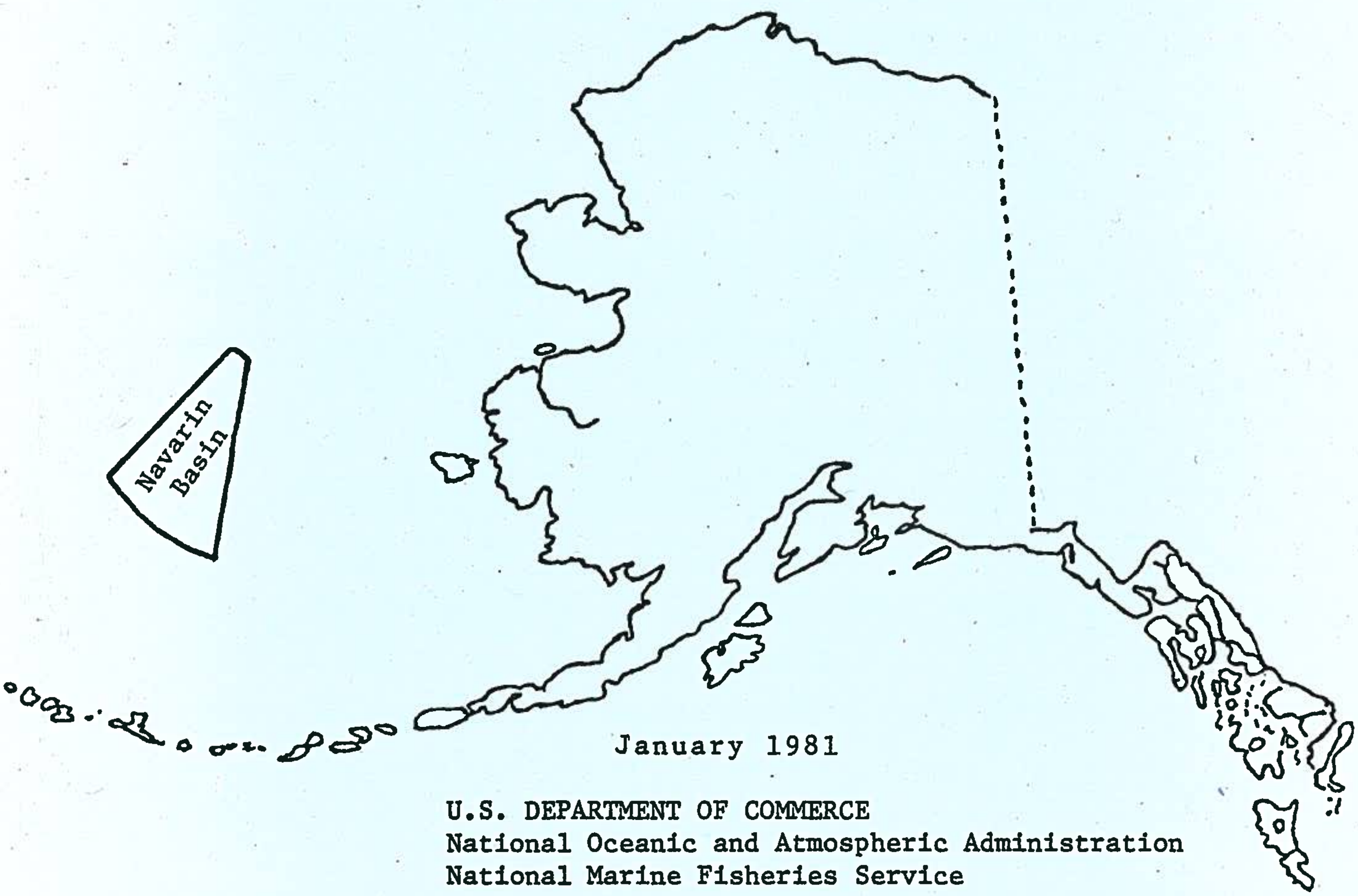
prepared by

Byron F. Morris



January 1981

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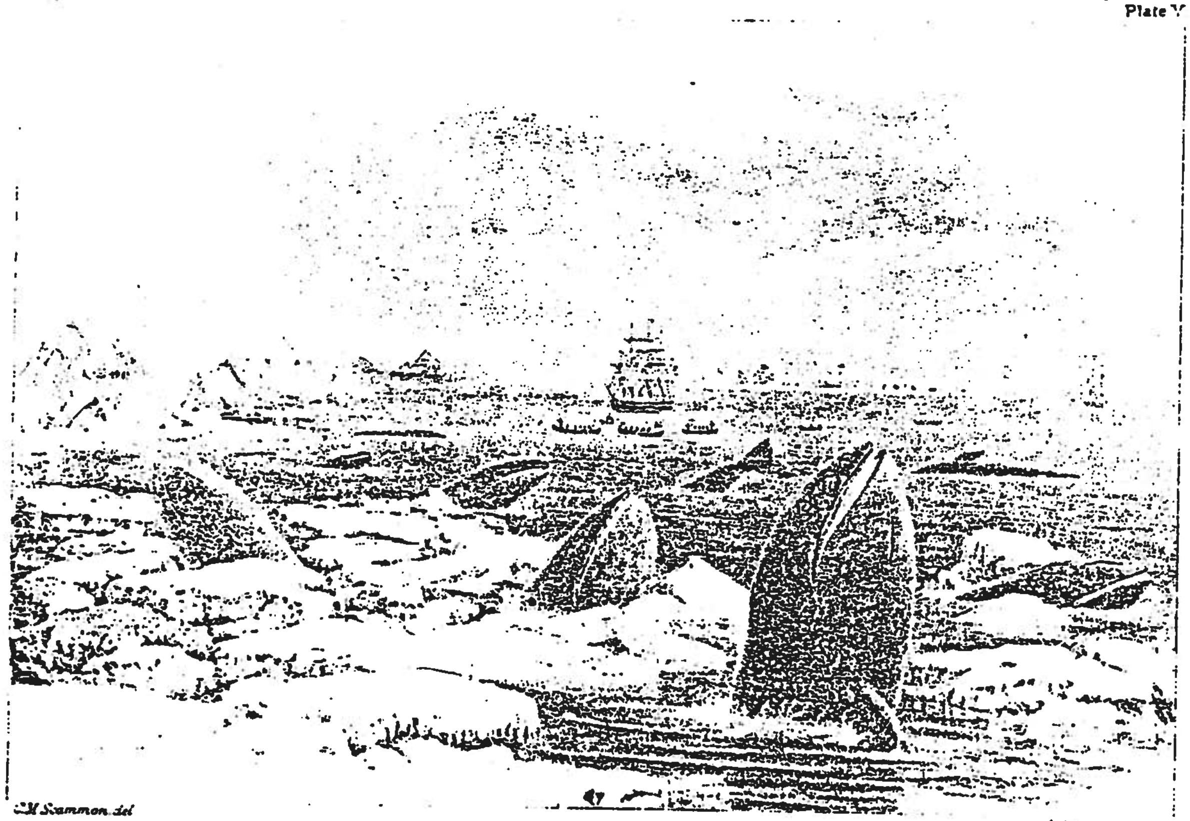
AN ASSESSMENT OF THE LIVING MARINE RESOURCES OF THE CENTRAL BERING SEA AND POTENTIAL RESOURCE USE CONFLICTS BETWEEN COMMERCIAL FISHERIES AND PETROLEUM DEVELOPMENT IN THE NAVARIN BASIN, PROPOSED SALE NO. 83

Plate V



CALIFORNIA GRAYS AMONG THE ICE

PREPARED BY

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ENVIRONMENTAL ASSESSMENT DIVISION

NATIONAL MARINE FISHERIES SERVICE

ANCHORAGE, ALASKA

JANUARY 1981

TABLE OF CONTENTS

SUMMARY

1. The Navarin Basin, which includes the continental shelf of the Bering Sea between latitude 58° N - 63° N, and westward of 174° W to the U.S. - Russia 1867 Convention Line, is under consideration by the Department of Interior's Bureau of Land Management (BLM) for potential oil and gas leasing in 1984.

2. The Navarin Basin area includes segments of the central and northern Bering Sea, including the continental shelf, continental slope, and the Aleutian Basin. The area is ecologically linked with three other proposed lease areas of the Bering Sea; the Norton Basin (September 1982), the St. George Basin (December 1982), and the North Aleutian Shelf (October 1983).

3. This report assesses certain commercial and biological uses of the Navarin Basin that may be at conflict from petroleum development, documents the national and international importance of the area's renewable living resources, and proposes recommendations on further research needs to minimize and avoid potential resource-use conflicts.

4. Navarin Basin is an area of high biological productivity, and contains some of the largest populations of fish, shellfish, and marine mammals in the world. Demersal fish (especially pollock), herring, tanner crab, and ribbon seals are particularly abundant.

5. Environmental conditions in the Navarin Basin area are harsh. Severe oceanographic and climatic conditions occur regularly, and sea ice is present in winter-spring.

6. Commercial fisheries conducted in Navarin Basin east of the 1867 Convention Line are primarily foreign nation fisheries for bottomfish, crab, and snails. In addition, the Japanese high seas fisheries for salmon in the Navarin area take salmon of North American as well as Asian origin.

7. Historic foreign landings have been between 1 to 2 million metric tons in the Bering Sea. Major species include pollock, cod, Pacific ocean perch, "turbot", and other flatfishes, and crab. Total foreign groundfish landings in the Navarin Basin area approximated 0.5 million metric tons during 1977-79, about one-third of the Bering Sea total.

8. The Japanese high seas salmon fishing season occurs in the period of May to July. Trawling for pollock and other groundfish in the Navarin Basin area takes place year-round. Japanese longline fishing for sablefish also occurs year-round. Japanese snail fishing with pots takes place during about May-September.

9. Major foreign catches of fish and shellfish occur as follows:

* Salmon - west of 175° W in the southern portion of the Navarin area.

* Herring - Traditionally on the continental shelf in the southeast portion of Navarin Basin. Now prohibited as a directed foreign fishery in U.S. waters, it is still a by-catch of the trawl fishery.

* Groundfish (pollock, cod, turbot, Pacific ocean perch, etc.) - shelf and slope areas in the Navarin Basin area has accounted for about 30 percent of the flatfish, 40 percent of the pollock and 30 percent of the cod harvested in the Bering Sea.

* Crabs - primarily Tanner crab (*Chionoecetes opilio*), throughout the shelf area but primarily northwest of the Pribilof Islands (foreign fishing prohibited after 1980).

* Shrimp - northwest of the Pribilof Islands. (Stocks presently depleted; incidental catches only).

* Snails - in the southeast portion of the Navarin Area to the area northwest of the Pribilof Islands.

10. Domestic production potentials for several bottomfish species could increase, and significant unharvested populations of pelagic fish and benthic invertebrates, including crabs and snails,have potential for future domestic fishing development.

11. The Navarin Basin may be a critical habitat area necessary for the successful reproduction and growth of many species of fish and shellfish of ecologic and economic importance in the Bering Sea. For example,

* Salmon, on their spawning migrations, move through the area in late spring - early summer, and may require the abundant food resources there for the success of their spawning runs.

* Herring overwinter and feed on the Navarin Basin shelf.

* Pollock and other demersal roundfish and flatfish live and feed there and may require it as a breeding habitat and rearing area.

* Tanner crab are abundant and probably spawn in the shelf waters.

12. Marine mammals are abundant. It is an important winter habitat for certain ice-associated pinnipeds and cetaceans. It is a summer feeding area for other marine mammals.

* Ribbon seals occupy the marginal sea ice zone in the Navarin Basin for pupping and breeding in the winter and occur there in summer pelagically.

* Bowhead whales overwinter and may calve in the sea ice zone of the Navarin Basin area.

* Other seals and whales, including their young, occur regularly in the Navarin Basin area and use the area for breeding and/or feeding.

15. Potential resource-use conflicts between petroleum development and commercial fishing include loss of fishing space, interference with fishing operations, loss of or damage to fishing gear, fouling of fishing gear by oil, and contamination of fish and shellfish of commercial importance.

16. Potential biological impacts include habitat alteration or destruction, noise and human disturbance, and pollution by oil and other contaminants. Impacts could be most severe during the ice cover season when several species of seals use the marginal ice zone for pupping and breeding. Significant ecologic and economic impacts on many fish species could occur from oil spills in spring-summer when the pelagic early life history stages of many commercial fish and shellfish species are in the water column.

17. Our primary recommendation is for postponement of the lease sale until further research is conducted to establish:

1) The timing and relative extent of use of the area during the early life history stages of commercial fish and shellfish species.

2) The abundance, distribution, and habitat dependencies of ice-associated marine mammals that overwinter in the area, especially the ribbon seal and the bowhead whale.

3) The summer utilization of the area by endangered cetaceans.

4) The transport mechanisms, their variability, and rates in order to predict the movements of oil spills in the area and to predict their impacts.

1. INTRODUCTION

The central Bering Sea is a highly productive ocean region containing some of the largest marine mammal, fish, and crab populations in the world. Almost all major fish and shellfish resources of the region are under commercial exploitation, principally by the distant-water fisheries of Japan and the U.S.S.R.. Since 1970, the annual catches of demersal fish and shellfish in U.S. waters of the Bering Sea have exceeded 1.7 million metric tons (mt); in the peak year of 1972, the catches reached almost 2.4 million mt. Compared to other fishery regions of the northern hemisphere, catch per unit area in the Bering Sea - 2.9 metric tons per square kilometer - is exceeded only by that of the North Sea - 3.3 metric tons per square kilometer (Figure 1.1). In 1974, landings of demersal fish and shellfish from the central and eastern Bering Sea were valued at over 400 million dollars.

The region, as well as being important for commercial fishing, may contain substantial petroleum reserves. Several areas are under consideration by BLM for leasing to allow the exploration and development of petroleum. The BLM has requested NMFS to provide an assessment of significant resources and potential impacts to the resources from potential oil and gas development in the Navarin Basin - Proposed Sale 83, presently scheduled for December 1984. This document is in response to that request. In it are presented: (1) a brief review of the importance of the area to commercial fisheries; (2) the relative importance of species in the central Bering Sea; (3) the distributions and current conditions of the principal commercial species; (4) the status of knowledge of marine mammal populations of the area; and (5) potential impacts to these resources from oil and gas development.

In the summer of 1975 and the spring of 1976, the Northwest and Alaska Fisheries Center (NWAFC) of the National Marine Fisheies Service (NMFS) conducted multivessel surveys of the demersal fishes and economically important invertebrates of the shelf and upper continental slope waters of the eastern Bering Sea. These surveys, carried out under BLM/NOAA'S

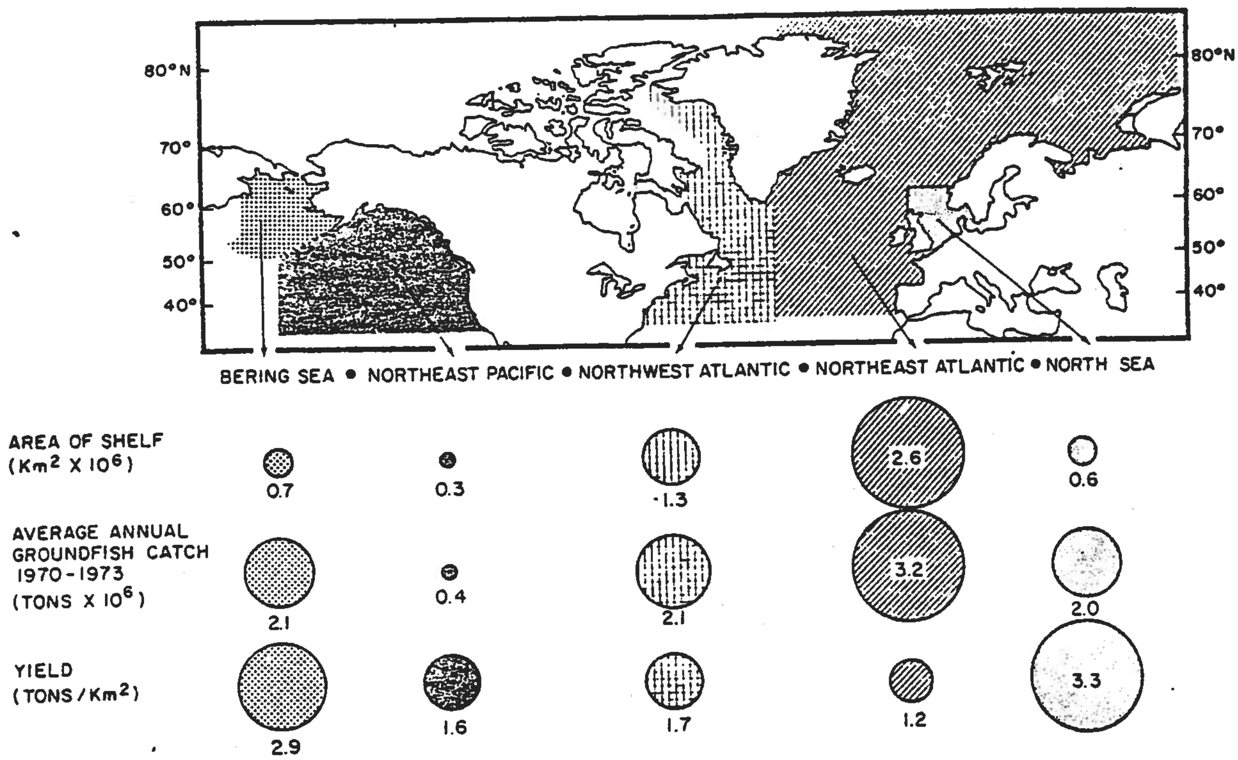


Figure 1.1 - Area of shelf (0-200 m), total catches, and yield of demersal fish from majro fishing areas in the northern hemisphere, 1970-73.

Outer Continental Shelf Environmental Assessment Program (OCSEAP) and NMFS'S Marine Resources Monitoring Assessment and Prediction (MARMAP) program by NOAA research vessels and chartered commercial fishing vessels, were the most extensive ever conducted in the Bering Sea in terms of areal and habitat coverage and biological data collection. These surveys have allowed NMFS to provide BLM with information on the distribution, abundance, and biological features of demersal resource of the Bering Sea - information which can be used in environmental impact statements to assess the risks involved in development of the potential offshore petroleum reserves.

The marine mammal data used for this report has come from several sources, including NOAA's Platforms of Opportunity Program, several OCSEAP studies between 1975 and 1978 (c.f. Braham et al., 1977; Braham, Krogman and Carrol, 1979), unpublished NMFS data collected in the 1960's, unpublished non-NMFS OCSEAP data collected in the late 1970's, and the available literature. A more detailed account of the available information on marine mammals of the Bering Sea is in progress (Braham, Rugh and Withrow,(in prep.).

For this assessment, the proposed Navarin Basin lease area includes that portion of the central Bering Sea identified by BLM as laying between 58° N. lat. from the U.S. - Russia 1867 Convention Line on the west to 174° W long. on the east (Figure 1.2 and 1.3). This area is almost equally divided between shallow continental shelf waters of 40-200 m depths and deep waters off the shelf which reach up to 3,500 m. It is unlikely that the petroleum industry will want to develop the deep water area because 1) they lack the capability at this time, and 2) the prospective geologic basin has been identified to occur in the shallower area of the shelf and upper slope. For this reason, this resource assessment is primarily directed toward describing the environment and resources on the central Bering Sea shelf and upper slope.

This area is the most poorly known of the proposed Alaska OCS lease areas, due mainly to its remoteness from human habitation and its seasonal cover of sea ice. The ocean surface circulation is variable in the Navarin Basin, frequently resulting in regional "eddies," but generally forming northwestwardly and westwardly moving currents, at least in summer and autumn. South flowing colder waters occur along the west side of the Basin during winter and spring. Winds averaging 32 km/hr (17 kt.) blow from the north and northeast throughout the winter and spring. Summer winds blow almost equally (on a percentage basis) from the north and northwest or south and southwest at an average speed of 19 km/hr (10 kt.). Skies are usually cloudy below 3,000 m altitude and fog is common, especially in summer.

These environmental conditions are important because they forge the kinds of habitat conditions suitable for marine mammals. For example, southwardly winds during winter and early spring move the pack ice to the central and sometimes southern Bering Sea. Here, in a somewhat less harsh environment than in the northern Bering and Chukchi Seas, more species of pinnipeds haul out and breeding animals are less concentrated. Presumably this means that greater food resources are available because

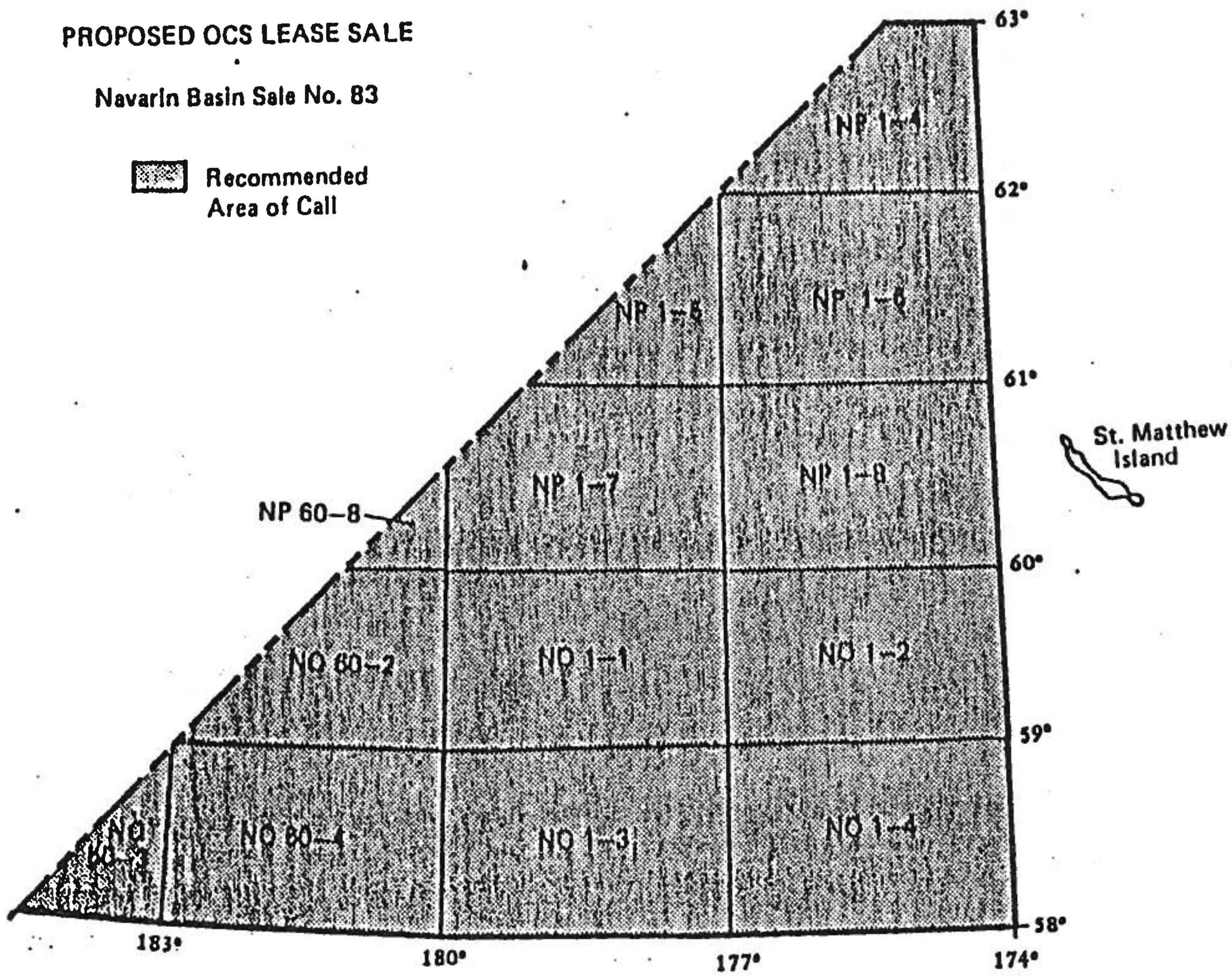


Figure 1.2 - Recommended Area of Call for proposed OCS lease sale No. 83, the Navarin Basin.

GENERAL CHART OF AREAS REFERRED TO IN TEXT

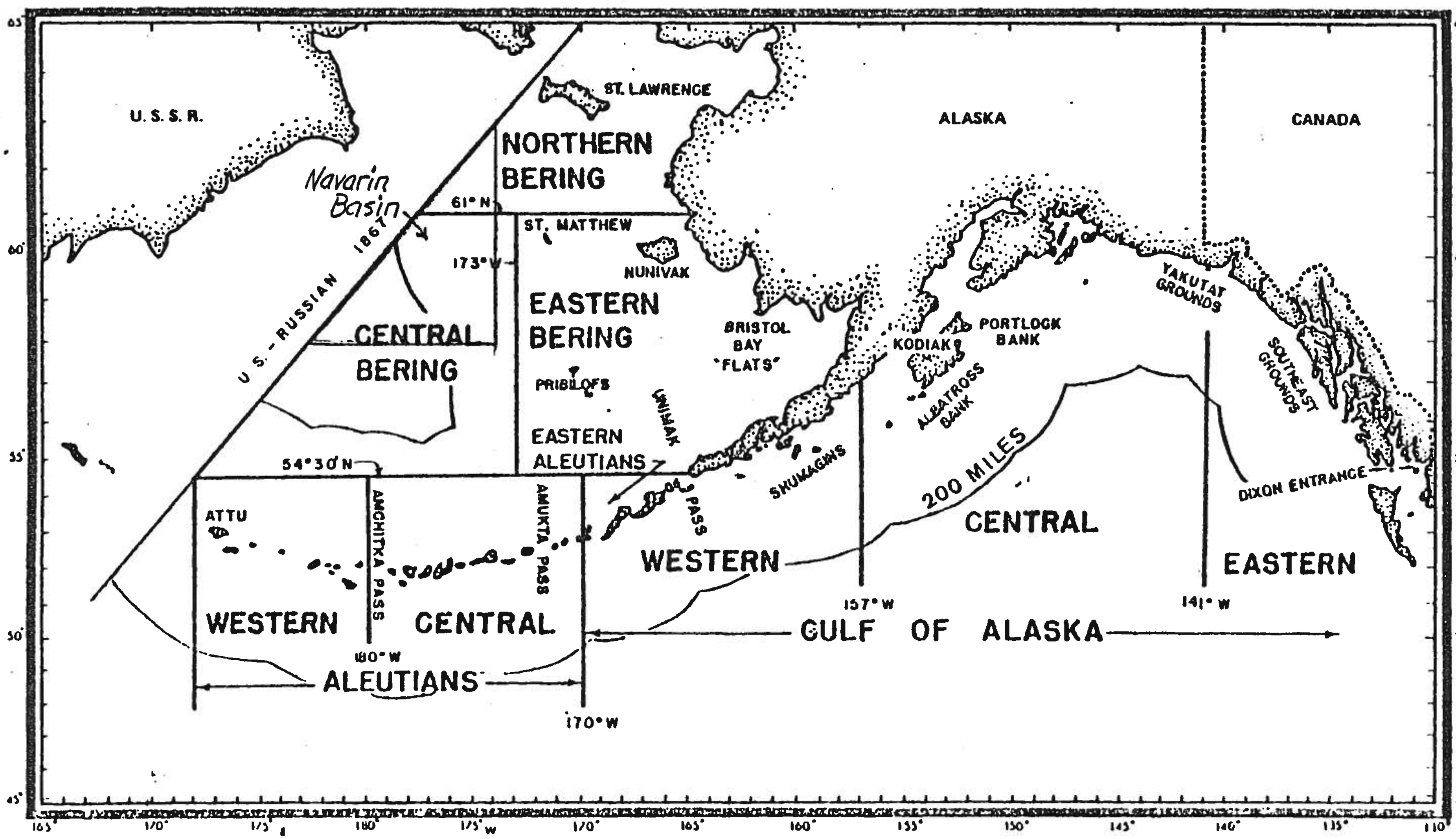
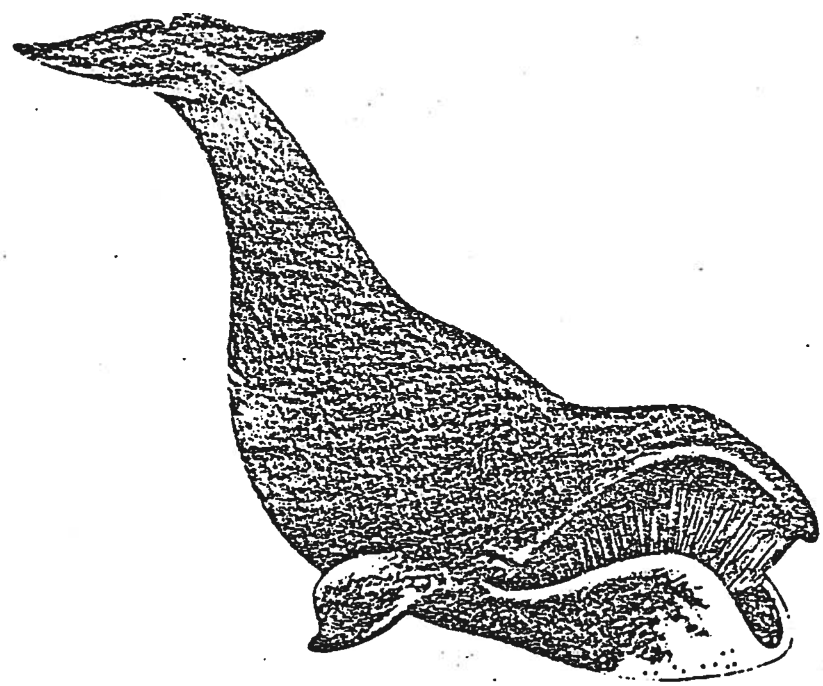


Figure 1.3 - Chart showing location of Navarin Basin in relation to other areas of the Alaska outer continental shelf.

a larger (or new) area can be exploited. The ice front generally extends across the Navarin Basin at approximately the location of the 100 m contour. Upwelling of nutrient rich waters are important for primary and secondary production near the Navarin Basin and along the continental slope. The waters over the shelf adjacent to the continental slope are seasonally productive, resulting in abundant fish and invertebrates and a potentially rich feeding area for whales and pinnipeds during open water periods. Although specific data are generally lacking for most marine mammal species in the Navarin Basin, the environmental and habitat conditions in the Basin suggest that many species might be found there.



Bowhead Whale

2. GENERAL DESCRIPTION OF THE ENVIRONMENT

2.1 The Physical Environment of the Central Bering Sea and the Navarin Basin

The Bering Sea (Figure 2.1) is predominantly a landlocked sea, bounded by Asia to the west and northwest, by Alaska to the east and northeast, and by the Aleutian Archipelago and Commander Island Arc to the south. The Bering Sea is linked with waters of the Pacific Ocean to the south by deep and wide straits between the Island Arc that permits exchange between the two water bodies. To the north, the Bering Sea is linked to the Polar Basin by the Bering Strait, a shallow and narrow area that minimizes the influence of Arctic waters on the sea.

The surface of the Bering Sea comprises 2.3 million km^2. The south and west central portion of the sea is a broad depression with steep slopes, and depths often exceeding 3500 m. This deep basin occupies 63% of the total area of the Bering Sea, nearly 49% of which is deeper than 2000 m.

The northeastern part of the sea consists of a shallow, relatively level shelf area with depths less than 200 m, and mainly between 25 - 100 m. This region comprises about 39% or 850,000 km^2 of the total area of the sea.

The remainder of the area of the Bering Sea, about 12%, is at depths between 200-2000 m, primarily along the continental slope and isolated deep shelf areas.

It is on the broad shallow shelf and the adjacent upper edge of the continental slope that the abundant resources of the Bering Sea are primarily located.

2.1.1 Physical Oceanography

A brief discussion of the oceanography of the Bering Sea is relevant to the understanding of the productivity of the ecosystems that support abundant marine life, and to the prediction of the movements of pollutants that may be released into the environment. The following is an attempt

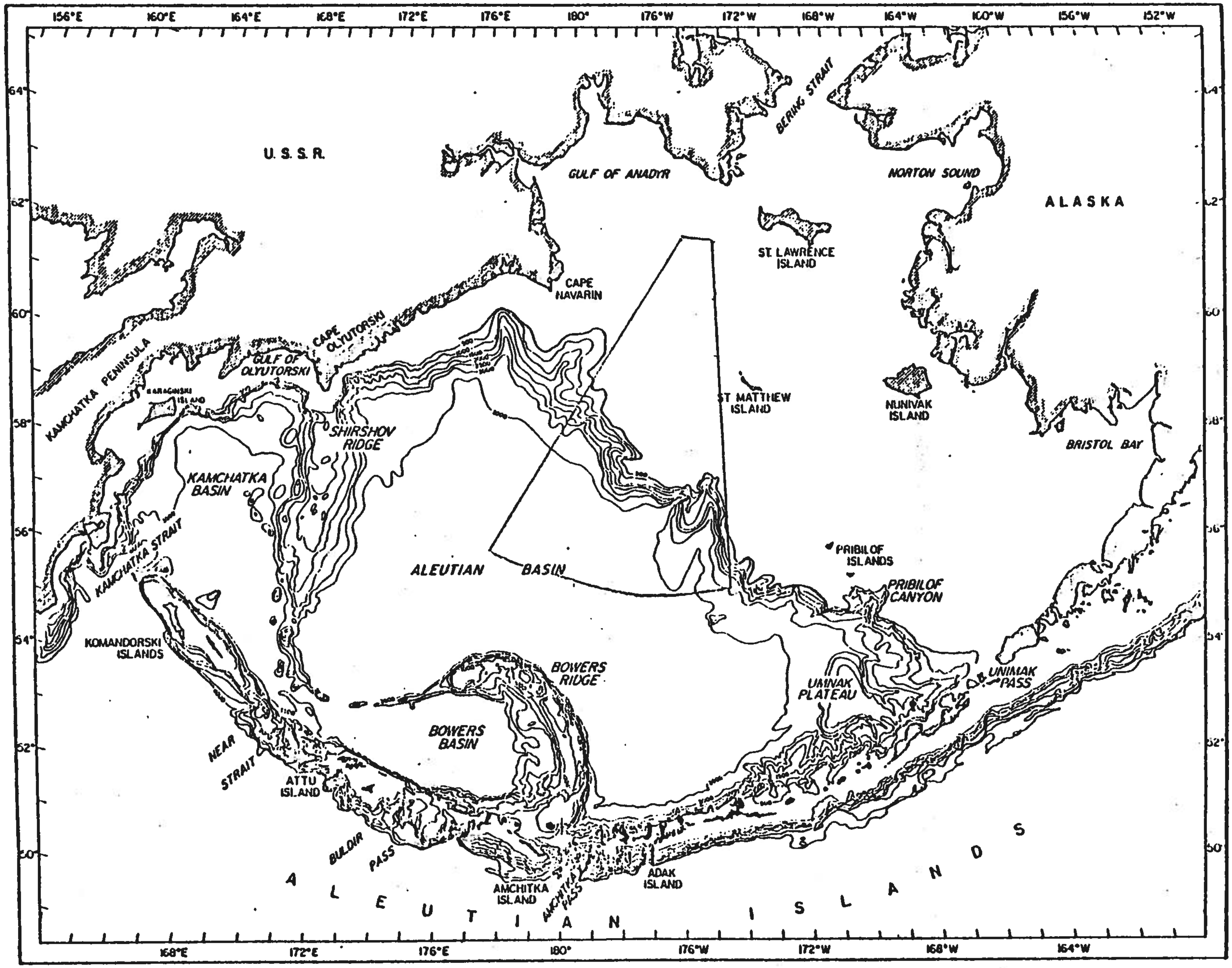


Fig. 2.1 - Bathymetric map of the Bering Sea showing approximate location of proposed Navarin Basin lease area.

to discuss our present understanding of the hydrodynamics and potential oil spill transport within the central Bering Sea.

The oceanography of the central Bering Sea is not as well known as other areas of the Bering Sea closer to the mainland. There is a history of fishery and oceanographic observations there by the U.S., Soviets, and Japanese. Unfortunately, much of the earlier work was based on single season (summer) observations that often tried to describe a dynamic and highly variable region as though it was a steady condition with little or no temporal variability. Figures 2.2 to 2.12 show some of the current patterns that have been inferred by earlier oceanographers, most of them from too few measurements, either in time or space. Most of these charts show a general pattern of north to northwest transport of surface water across the shelf area flowing toward the Gulf of Anadyr and Bering Strait, although some have shown a central gyral overlying the area. Hughes et al., (1974) have provided a recent review of this information, and they concluded that the primary driving force for the Bering Sea circulation is the winds, of which there can be considerable temporal variation in strength and direction, and that wind forces and their torque in the winter in ice-free waters is close to an order of magnitude greater than in summer. The effects of wind and other influences on circulation under the pack-ice is still poorly understood.

Hughes et al. (1974) mainly studied the deep water region off the shelf edge and did not clarify the circulation pattern on the shelf, except for identifying a northwesterly flowing current along the shelf break (Figure 2.13).

Tidal forces dominate the Bering Sea water movements. Tidal flow up to 50 cm/sec occurs daily, and residual mean current flows are probably an order of magnitude less than the tidal currents. Tidal modeling (Hastings, 1975) showed tidal reversals from W-SW to E-NE over the central Bering Shelf with velocities from 10-40 cm/sec. (Figure 2.14), but these flows have not been verified.

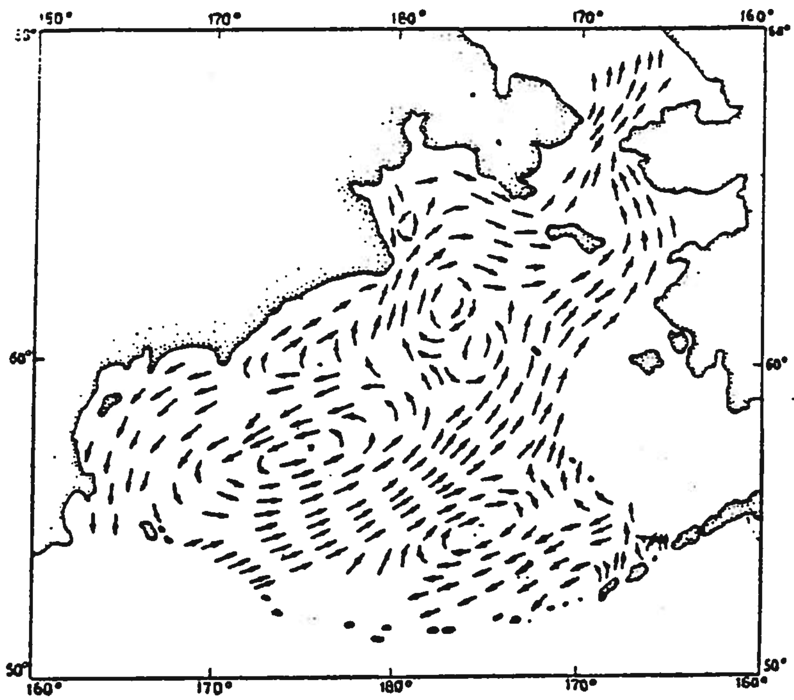


Figure 2.2 - Schematic representation of surface currents according to G.E. Ratmanov, 1937

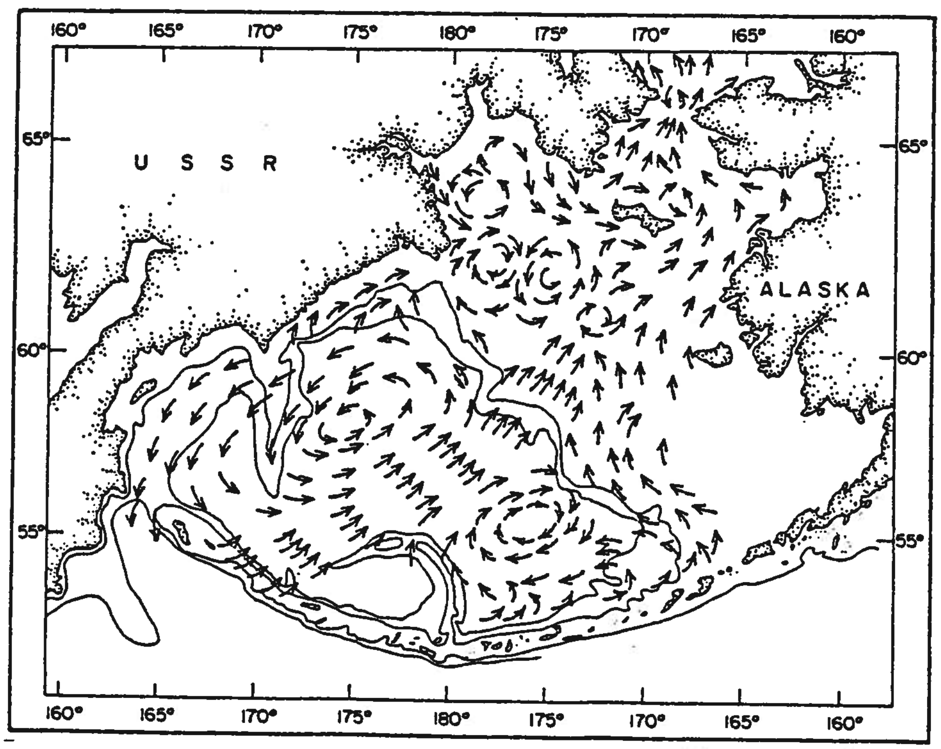
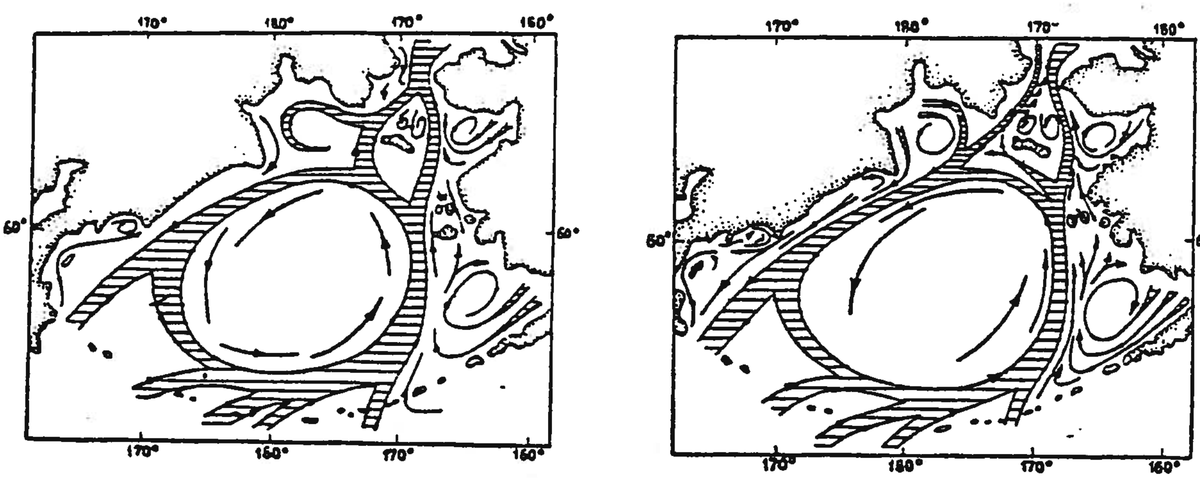


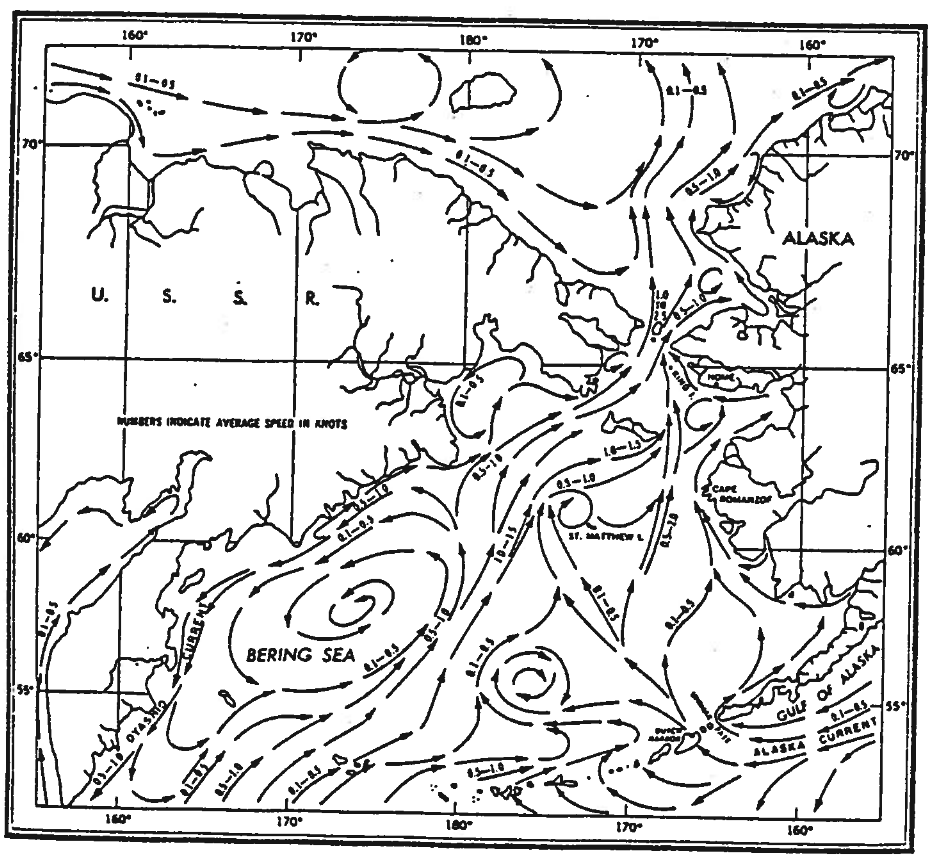
Figure 2.3 - Bering Sea circulation according to Goodman <u>et al</u>. (1942)



Summer Winter

Figure 2.4 - Schematic map of the general circulation of the Bering Sea water masses after Leonov, 1947.

Fig. 2.5 - Bering Sea circulation according to U.S. Navy Hydrographic Office (1958).



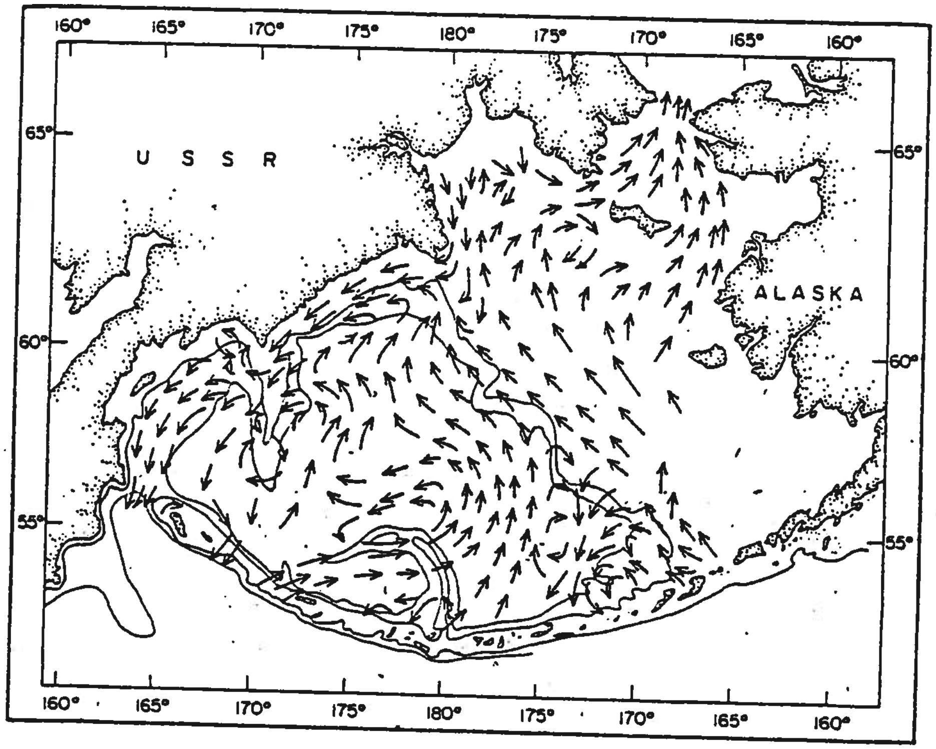


Fig. 2.6 - Bering Sea circulation according to Dobrovol'skii and Arsen'ev, 1959.

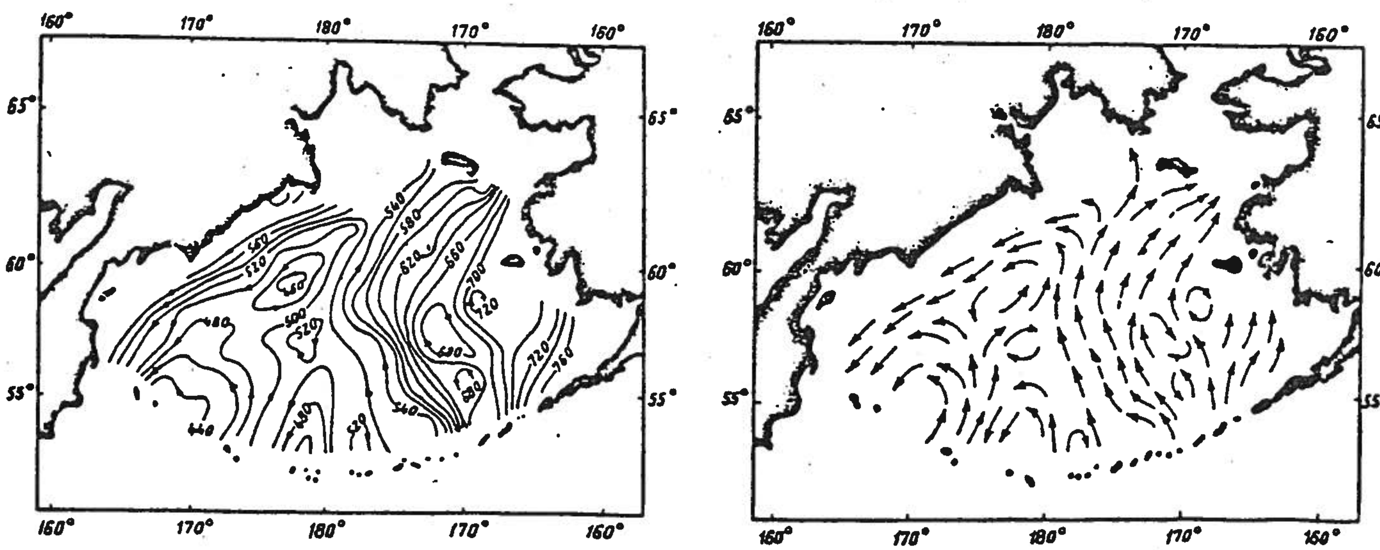


Figure 2.7 - Data obtained by the expedition in the summer of 1959, according to Natarov, 1963.

A - dynamic chart of the sea surface relative to 1,000-decibar surface;

B - schematic representation of surface currents

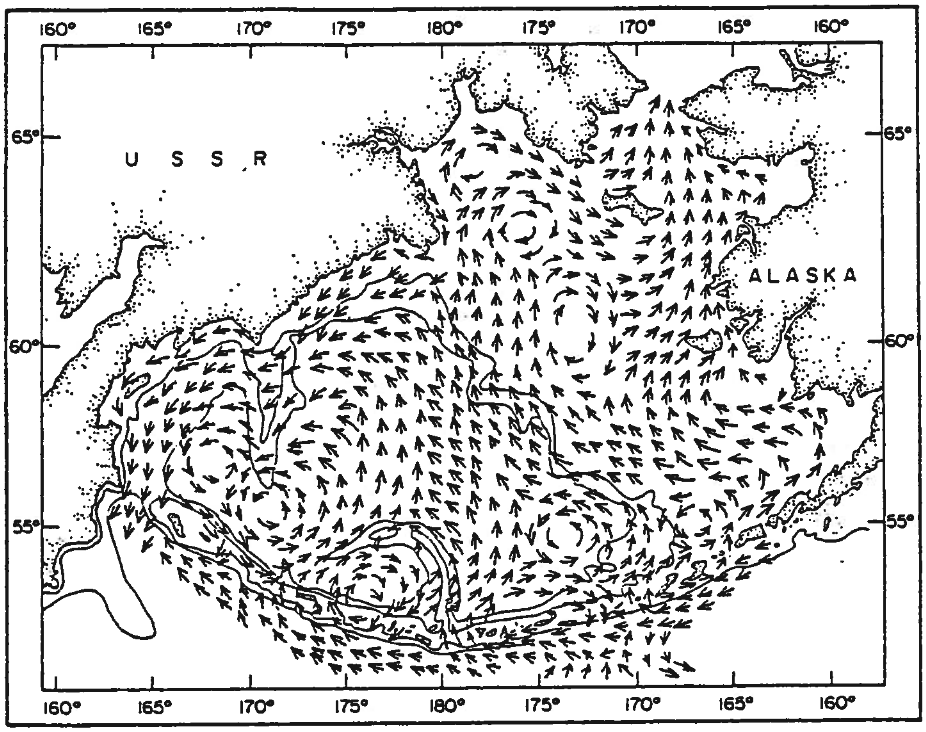


Fig. 2.8 - Bering Sea circulation according to Arsen'ev, 1967.

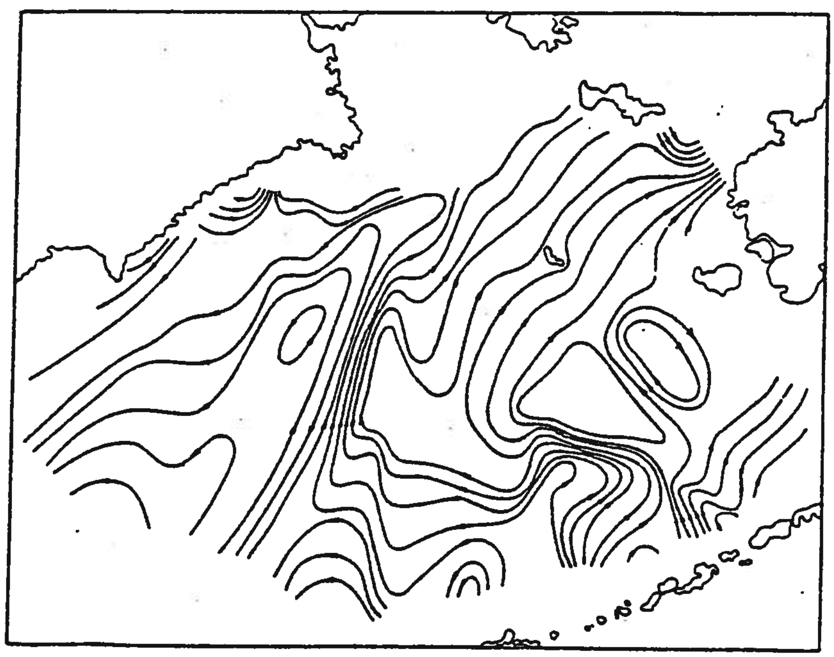


Fig. 2.9 - Dynamic map of surface currents in the Bering Sea (summer), according to Natarov and Novikov, 1970.

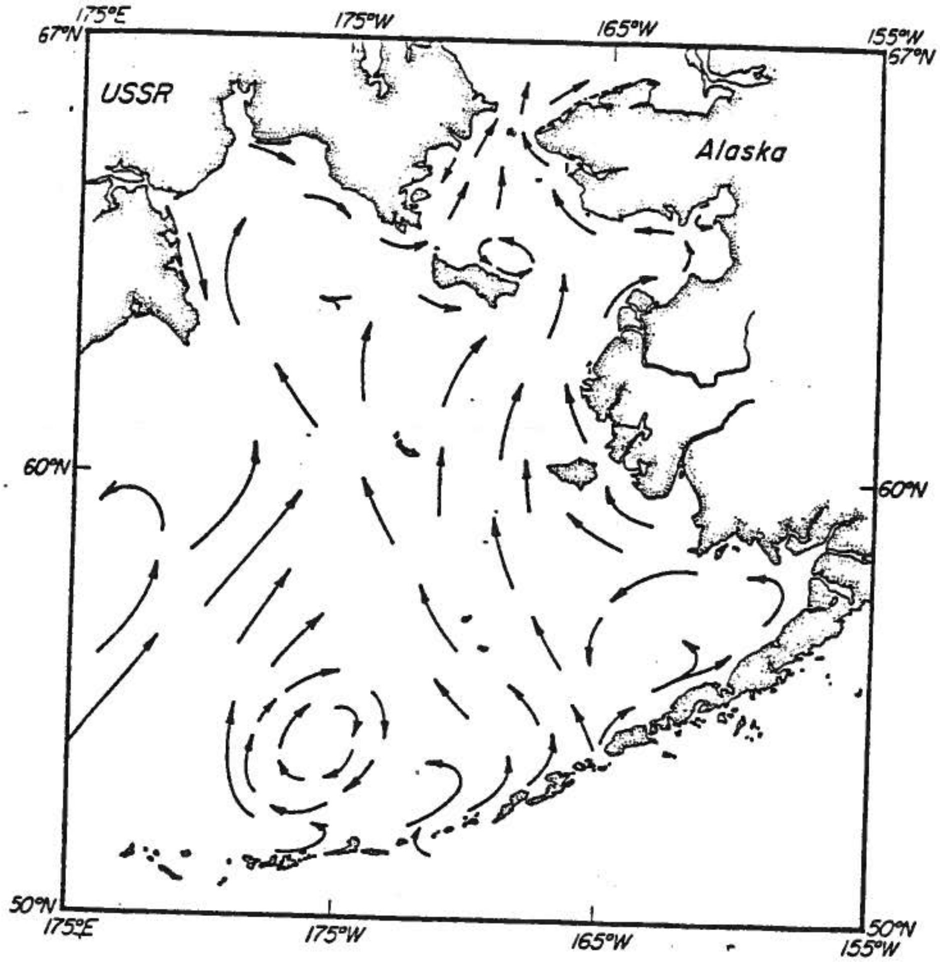


Fig. 2.10 - Major currents in eastern Bering Sea, as shown by Sharma, 1974.

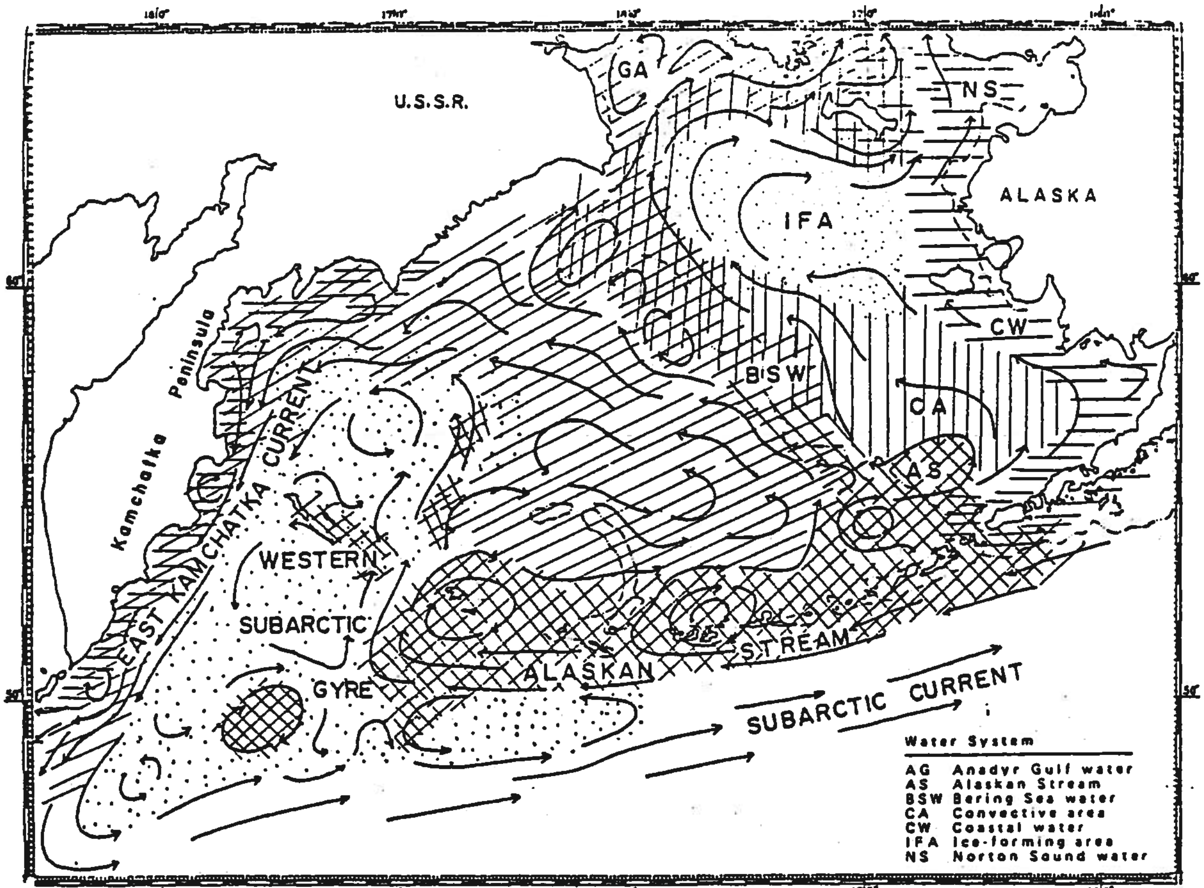


Fig. 2.11 - Schematic diagram of circulation and extent of water masses in the Bering Sea and northwestern Pacific Ocean, according to Takanouti and Ohtani, 1974.

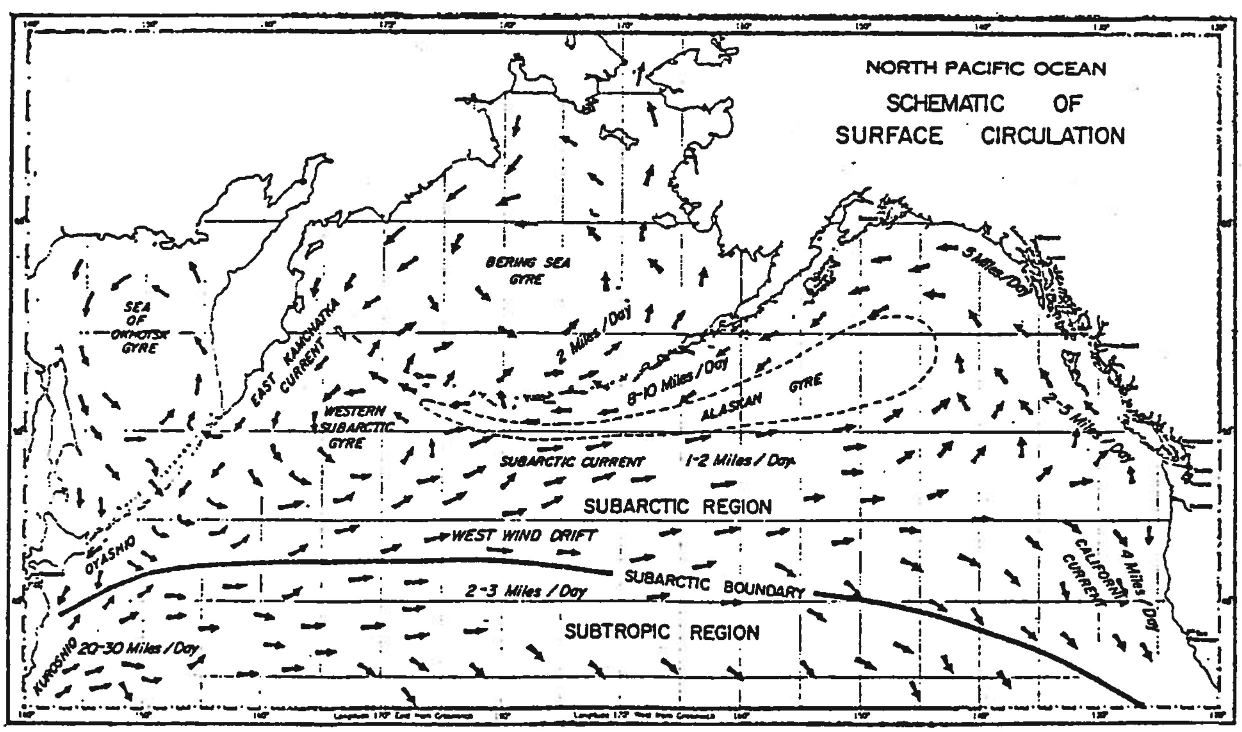


Fig. 2.12 - Schematic diagram of surface circulation in the North Pacific area, prepared by A.J. Dodimead, 1976.

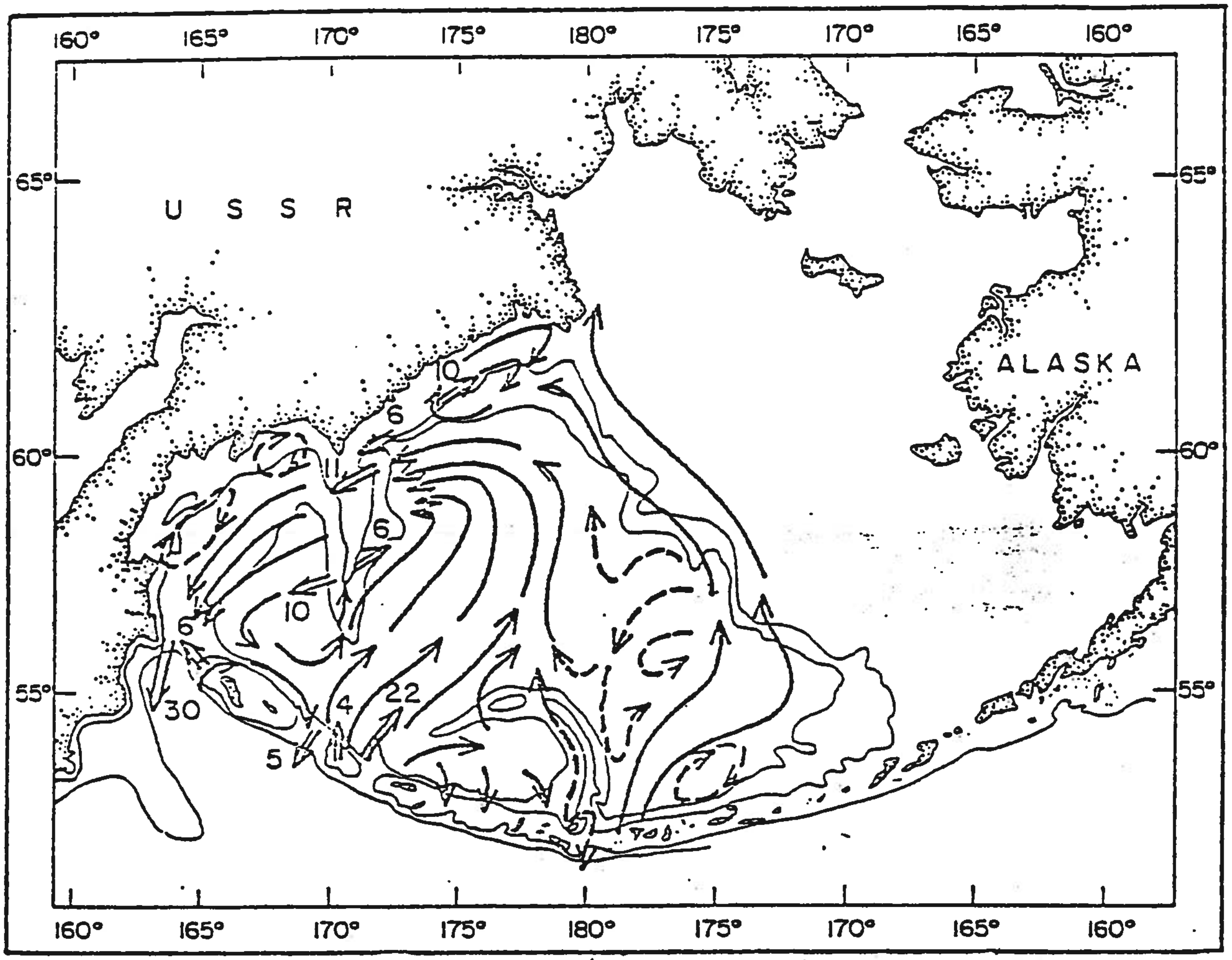


Figure 2.13 - Bering circulation over deep-water according to Hughes *et al.*, 1974

One recent circulation scheme (NMFS, 1974) proposes several distinct currents within the Bering Sea (Figure 2.15). The Bering Current System, which generally follows the northern periphery of the Aleutian Island Arc splits into the West Alaska Current, which flows northward along the Alaskan coast, and the Navarin Current, which flows northeast along the shelf edge to the east Siberian Coast. Both of these merge in the Bering Strait and flow into the Chukchi Sea as the Pacific Current. The Polar Current flows southeast along the coast of Asia. The St. Lawrence and Pribilof Currents flow westward across the shelf. Four other highly variable but local currents are associated primarily with river discharges--the Bristol Bay, Kuskokwim, Yukon, and Anadyr Currents. In addition, there are tidal currents, principally on the shelf and Aleutian passes, with normally higher velocities than the weaker permanent current systems.

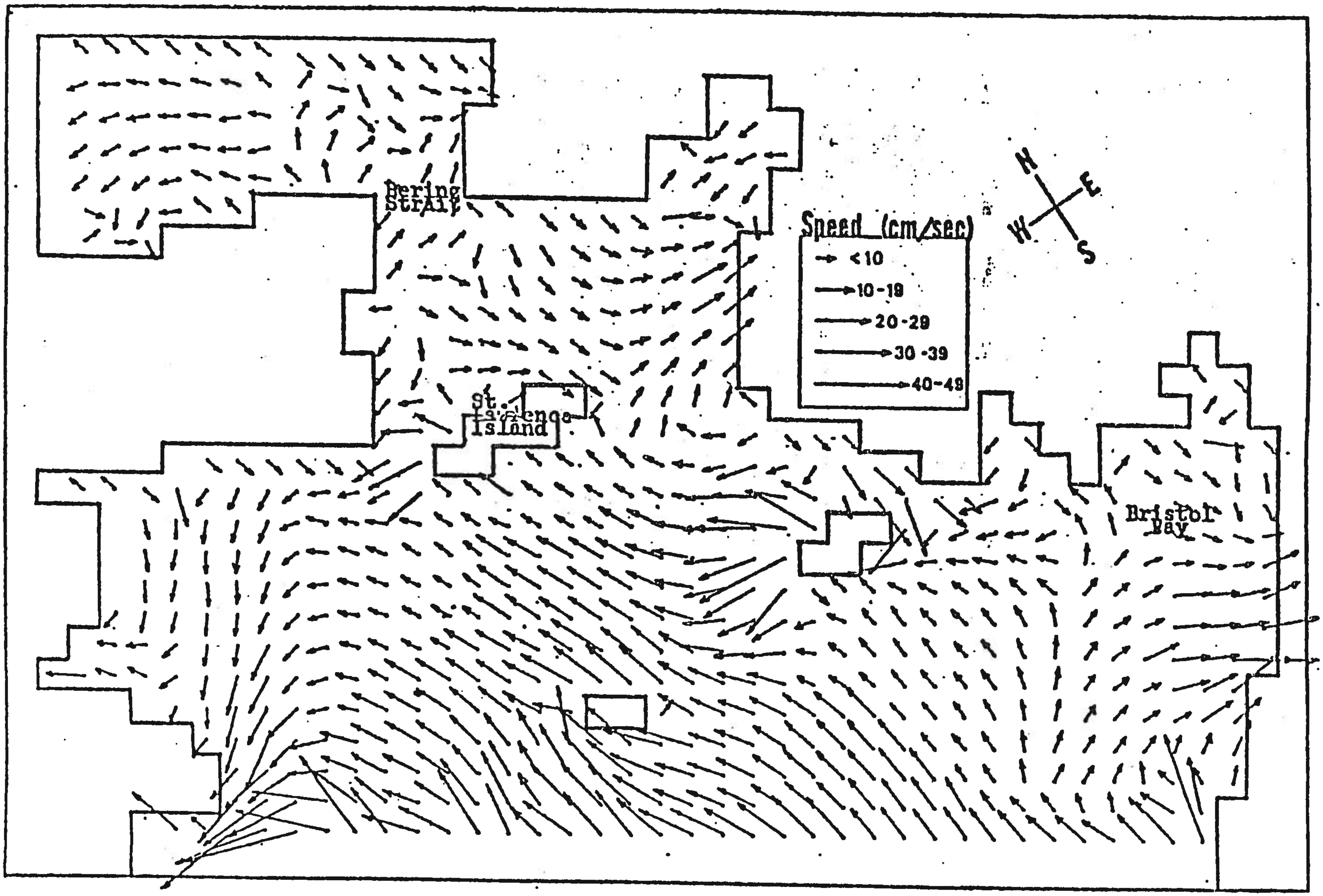
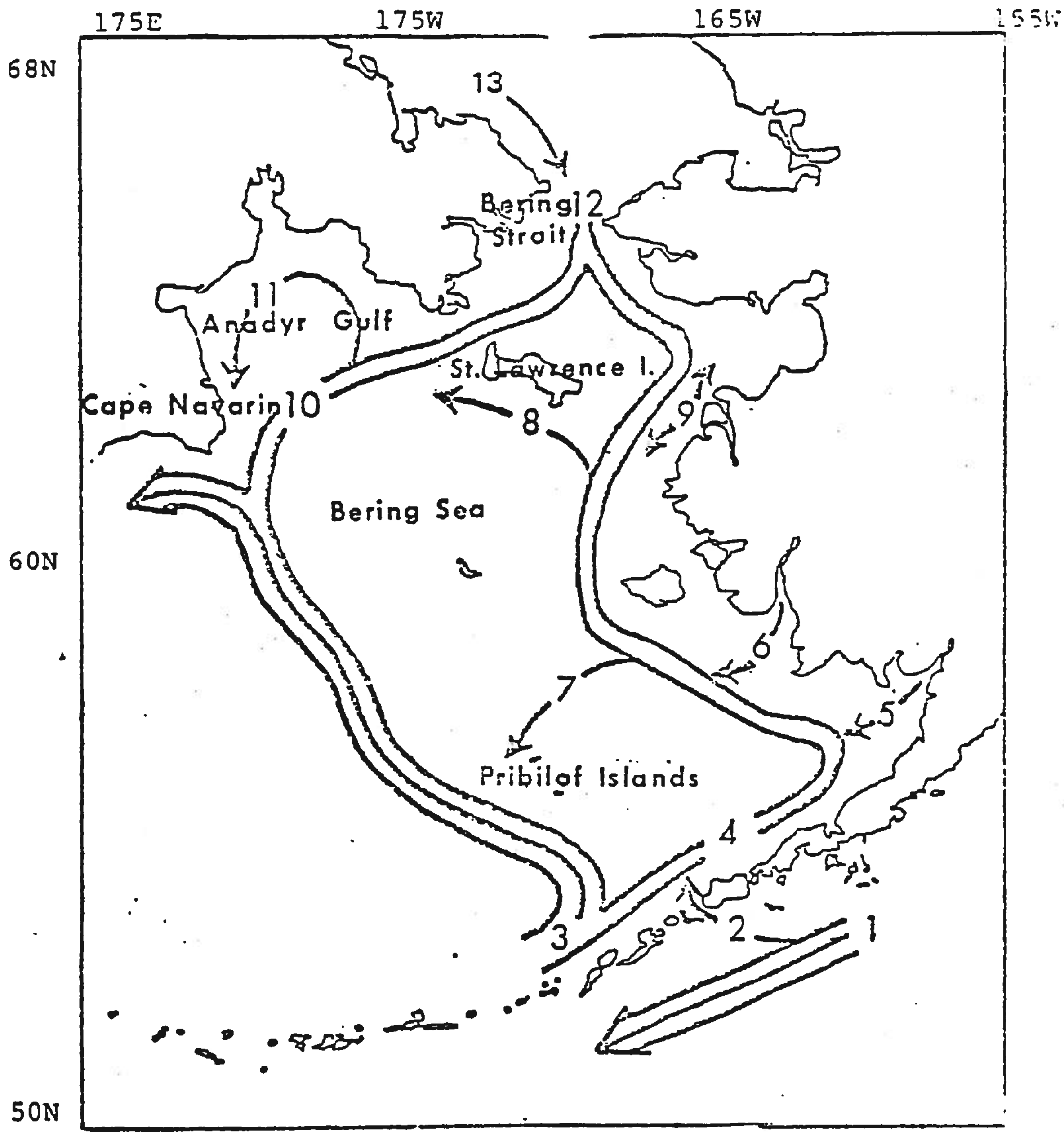


Figure 2.14 - Tidal Currents One Hour Before High Tide at the Western Boundary (Russian Mainland). Length of arrows are proportional to current speed, (from Hastings, 1975).



1. Alaskan Stream
2. Unimak Current
3. Bering Current System
4. West Alaska Current
5. Bristol Bay Current
6. Kuskokwim Current
7. Pribilof Current
8. St. Lawrence Current
9. Yukon Current
10. Navarin Current
11. Anadyr Current
12. Pacific Current
13. Polar Current

Figure 2.15 - Currents in the eastern Bering Sea, (NMFS, 1974).

Pacific Ocean water is thought to enter the Bering Sea through the Aleutian Island passes and flow to the northwest along the north coast of the Alaska Peninsula. The water moves along the northern coastline by tidal and wind driven currents until it reaches Nunivak Island where it is turned to the north. The magnitude of this influx is uncertain.

Long-term as well as short term variations are also apparent in the Bering Sea. McLain and Favorite (1976) have noted that unusually cold winter conditions prevailed over much of the eastern Bering Sea during 1971-75. Anomalous atmospheric circulations resulting in persistent northerly winds over the area during this five year period caused below normal sea water temperatures and unusually extensive sea ice cover. The relatively cold temperatures prevailing during 1971-75 undoubtedly affected the distribution and abundance of marine fish, shellfish, and mammals in the area.

Lagrangian surface current measurements on the outer continental shelf of the eastern Bering Sea by Hansen (1978) using satellite-tracked drogued buoys, have shown that although sustained current speeds of greater than 30 cm/sec rarely occur, the flow, quite unlike the Gulf of Alaska, is exceedingly variable. Preliminary results indicate that steady state circulation modeling may be of extremely limited utility in this area. Moreover, in spite of the extensive modeling effort of Bering Sea shelf tides and circulation being conducted for OCSEAP by Leendertse and Liu (1978), it appears that if surface oil spills occur in the Navarin Basin area, it will be extremely difficult to predict trajectories and take effective action to minimize potential damage to living marine resources and their habitats.

Recognition that the central and eastern Bering Sea shelf area is a two-layer system from late spring through early fall has required modification of our concept of water circulation and transport rates across the shelf. Because the shelf is shallow (average depth less than 100 meters), geostrophic circulation does not exist. Consequently, circulation and transports are dominated by tides and winds. Sea ice melt contributes to the formation of a halocline in late spring. As recently as 1977, water circulation on the shelf was believed to be a relatively simple cyclonic northeastward movement of waters advected onto the shelf from the eastern side of the Alaska Stream after leaving Unimak Pass (Coachman and Charnell 1979) (see Figure 2.11). Data of Hebard (1961) and others indicated a net velocity of 6 cm/sec (about 5 km or 2.8 n mi/day) superimposed on tidal velocities of 50 cm/sec.

Favorite (1974) showed that there were 3 sub-domains across the Bering Sea -- coastal, mid-shelf, and shelf-edge (Figure 2.16). Temperature conditions associated with these sub-domains are evidenced by marked temperature fronts. Navarin Basin lies essentially across the shelf-edge sub-domain, the transition or frontal zone and the mid-shelf sub-domain. Considerable effort has been focused on the characteristics or dynamics of the frontal zone between these sub-domains. The variability, which is in marked contrast to conditions in the mid-shelf and coastal subdomains, is caused by interactions between shelf and slope waters that are markedly influenced by the changes in bottom topography caused by submarine canyons.

It is generally accepted that the principal flow in this area, at least in terms of volume transport, is northwestward along the shelf edge--the Transverse Current of Favorite et al. (1976), the Navarin Current of others. But the surface flow is much more complex than previously imagined by earlier researchers (Favorite and Ingraham, 1972).

Physical oceanographers now classify Bering Sea shelf waters into three masses or domains separated by seasonal fronts or boundaries as follows:

(1) The coastal domain exists inshore of a front located between the 40-m and 50-m contours. In the coastal domain, tidal mixing is supplemented by wind mixing, which produces a water mass with nearly isothermal and isohaline characteristics. The coastal domain is quite narrow -- generally less than 20 km wide. Transport is by tidally-driven lateral diffusion. The Navarin Basin lies entirely outside of the coastal domain and is not under its direct influence.

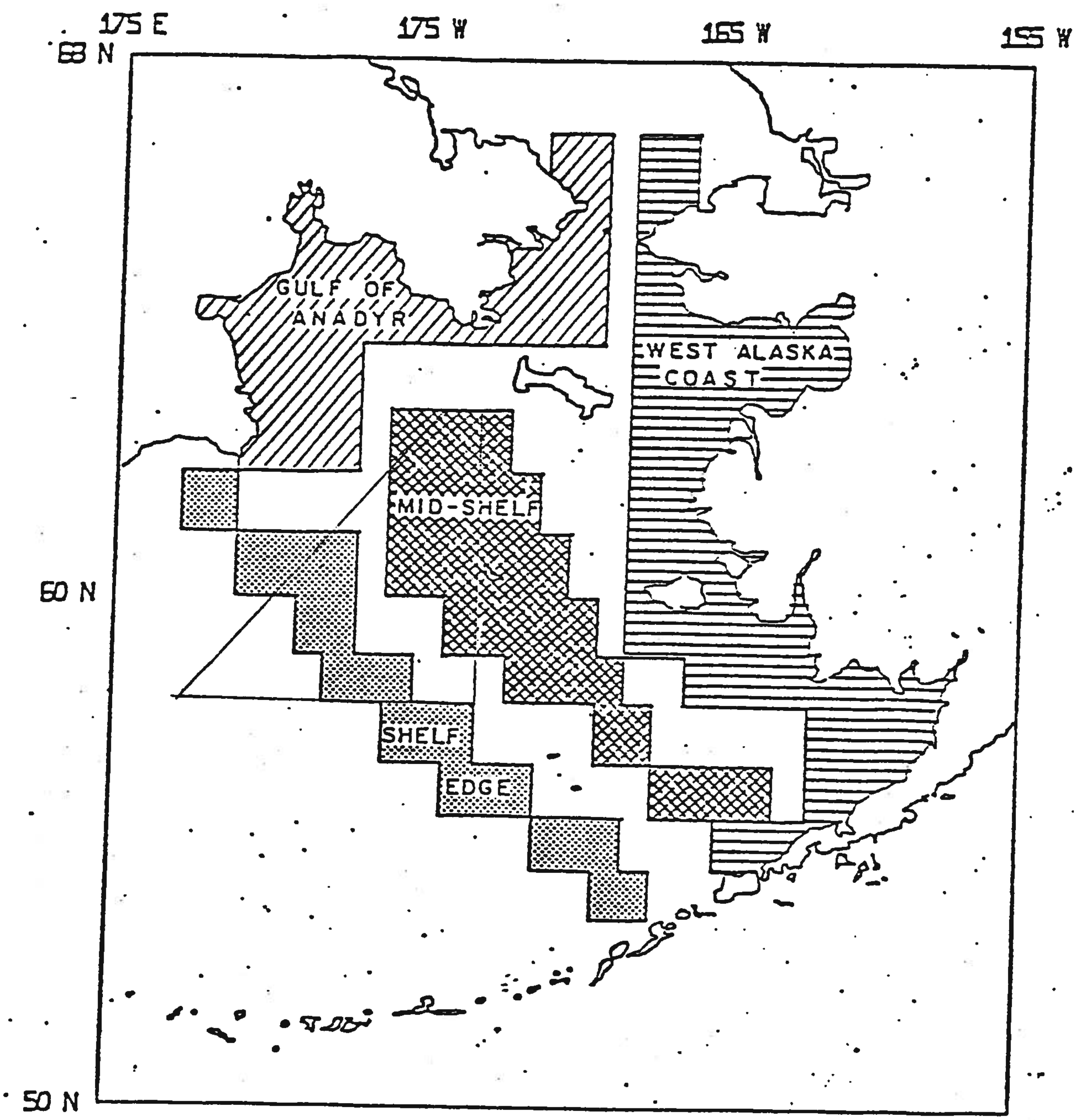


Figure 2.16 - Schematic diagram of shelf domains.

(2) The middle shelf domain is generally conceived as being the central shelf area between the 50-m and 100-m contours. These depths encompass much of the Bering Sea shelf and the domain extends across the Navarin Basin area. Thus, the middle shelf domain water movements are of critical interest. Unfortunately, this is also the domain for which transport theory is undergoing the most rapid change, and data for the Navarin Basin area have not been adequately obtained or studied.

Waters of the middle shelf domain are characterized by the development of strong summer stratification, and little or no stratification during the winter. Sea ice transported into the area melts in the spring and decreases the density of the surface waters. Because the water depths on the middle-shelf are greater than the wind mixed layer (about 50 m in spring to 20 m in summer) or the tidally mixed layer (30-40 m), a slight stratification is initiated that is strengthened by summer insolation. A sharp thermocline develops at about 10-30 m. Above the thermocline, in the wind-mixed layer, temperatures are usually 6-8°C, but may rise above 10°C in July to September (Figure 2.17), while below the thermocline temperatures usually remain below 4°C throughout the summer. There is significant year-to-year variation in the temperatures and salinities of these two portions of the water column. Generally, temperature and salinity increase or decrease together (Coachman and Charnell 1979). Summer bottom temperatures are strongly correlated with previous winter air temperatures.

Winter surface water temperatures in the middle-shelf domain of less than -1.5°C prevail over the ice-covered areas, and between 1-2°C in open waters south of the ice cover (Figure 2.17). Bottom temperatures of -1.5°C occur over the majority of shelf waters of this domain.

(3) The outer shelf domain is defined as generally lying seaward of the 150 m contour. Meterological conditions may shift the front between the middle and outer shelf domains far upon the shelf. These events may occur seasonally (e.g., only in winter), may vary annually in intensity, or may be of short duration.

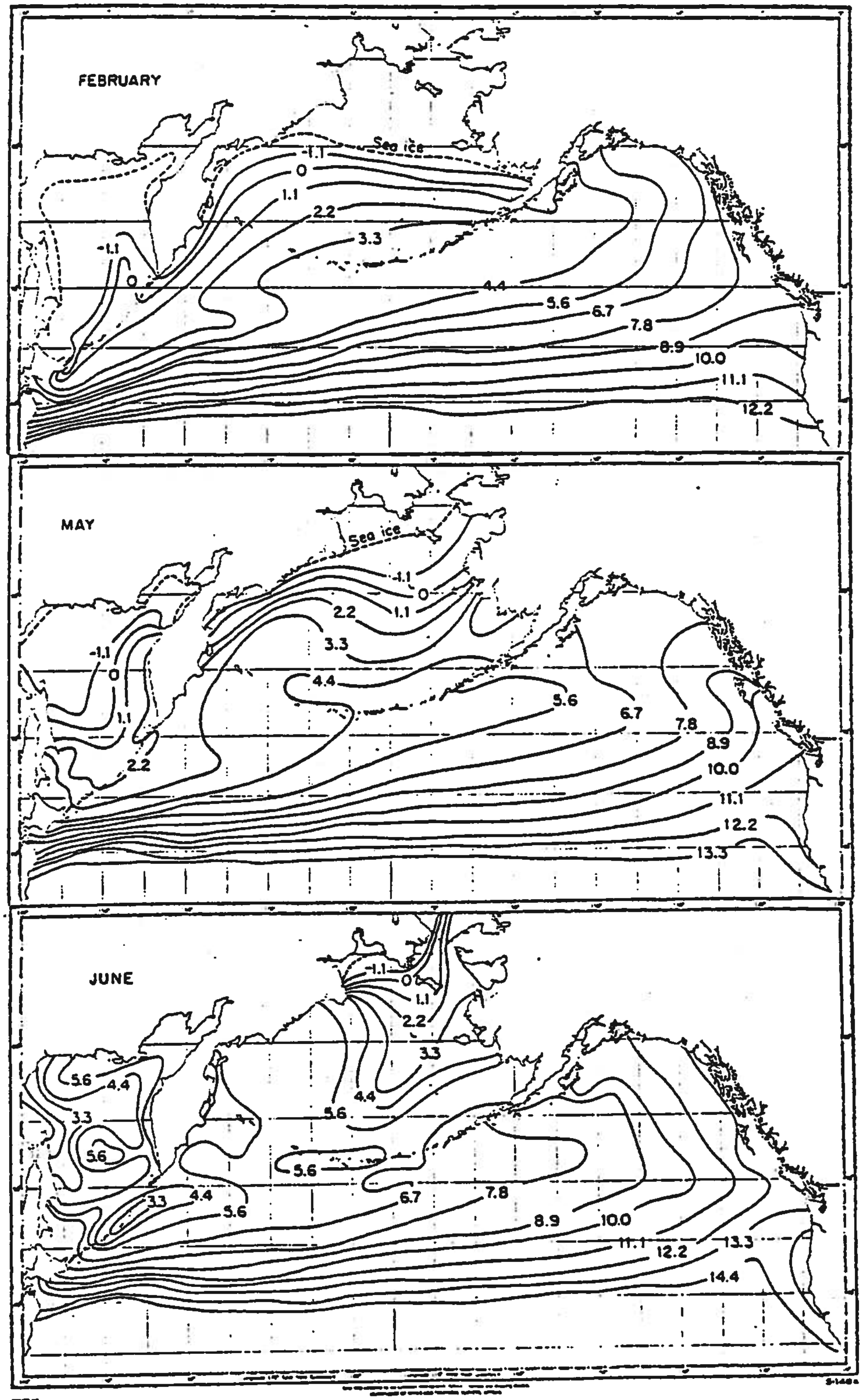


Figure 2.17 - Long-term mean surface isotherms in the North Pacific Ocean for representative months of winter, spring, and summer (from Laviolette and Seim, 1969). Temperatures have been converted to centigrade from the Fahrenheit values given in the above source.

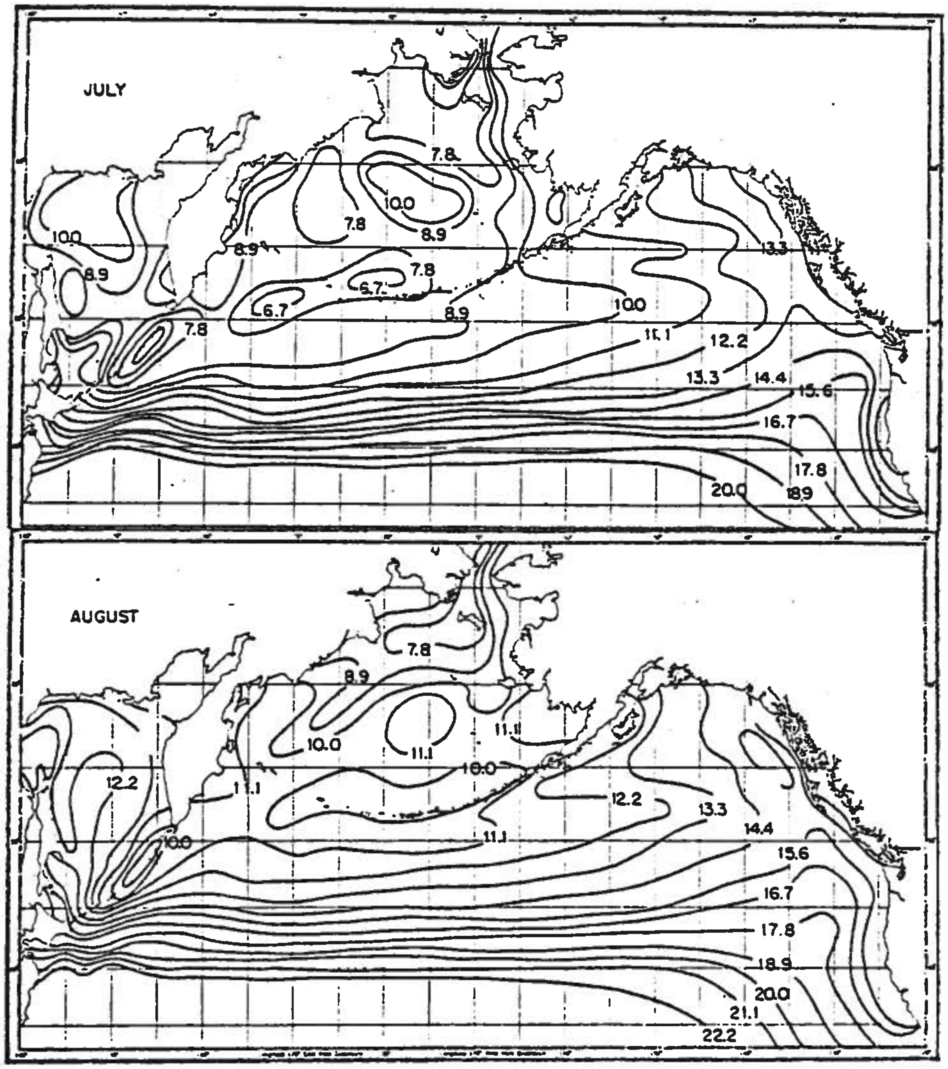


Figure 2.17 (cont).

The Outer Shelf domain has an upper layer that undergoes an annual warming and cooling cycle in which winter surface waters are colder (-1.5 to 0°C on the shelf, 1-2°C near the shelf break) and summer surface waters warmer (8-10°C) than bottom water (2-4°C). Salinities are between 33.0 and 33.2 ppt and temperatures between 3° and 4°C in the deeper water below 150 m. Surface salinities are usually 31.8 ppt to 32.5 ppt, being somewhat higher than middle-shelf domain waters. Net circulation of this domain, is probably offshore or parallel to the 150 m contour, as indicated by current meter and drogue data presented by Coachman and Charnell (1979).

2.1.2 Sea Ice and Winter Conditions

The Navarin Basin area is subject to sea ice cover generally from late November or December through April. The extent of ice cover and the location of the ice edge varies yearly (Figure 2.18). There is a progressive southerly advance of the sea ice through March-April and a rapid northerly retreat from May to June. During warm years (i.e. 1979) the ice boundary is frequently found somewhat north of the lease area but south of St. Lawrence Island. During cold winters (i.e. 1976), the sea ice covers most of the proposed Navarin Basin lease area (to the shelf edge) until mid-April. Maximum ice cover occurs in March or early April.

Most of the ice in the Bering Sea originates there and is transported southward by the prevailing northerly winter winds. The retreat of ice from the lee of the south coasts of land masses creates large open areas in which new ice is continually generated. As the southern limit of the pack ice advances, the ice tends to be broken and small floes may extend into open water beyond the heavy pack ice cover, especially with northerly winds, forming the "fringe" zone. From this zone inward for several kilometers, the pack ice is subject to ocean swell that tends to break up large floes into smaller ones with considerable brash ice in the water areas between the floes. This transition zone of broken ice between the fringe and the heavier, consolidated pack is termed the "front." Inward from the "front" zone is the consolidated pack ice zone proper which covers most of the northern Bering Sea Shelf, and of which there are several types of pack ice (Burns et al., 1980). This area is covered 85 to 100% by the ice (7-8 oktas).

The location of the front zone in the Navarin Basin varies annually (Figure 2.18). For most years the ice front across the Navarin Basin can be approximated by the 100 m bottom contour (±25 m). In some years (i.e. 1960, 1978) the ice front reaches across the area to roughly parallel the 200 m bottom contour. In warm years (i.e. 1967, 1979) the ice front lies north of the proposed lease area near St. Lawrence Island.

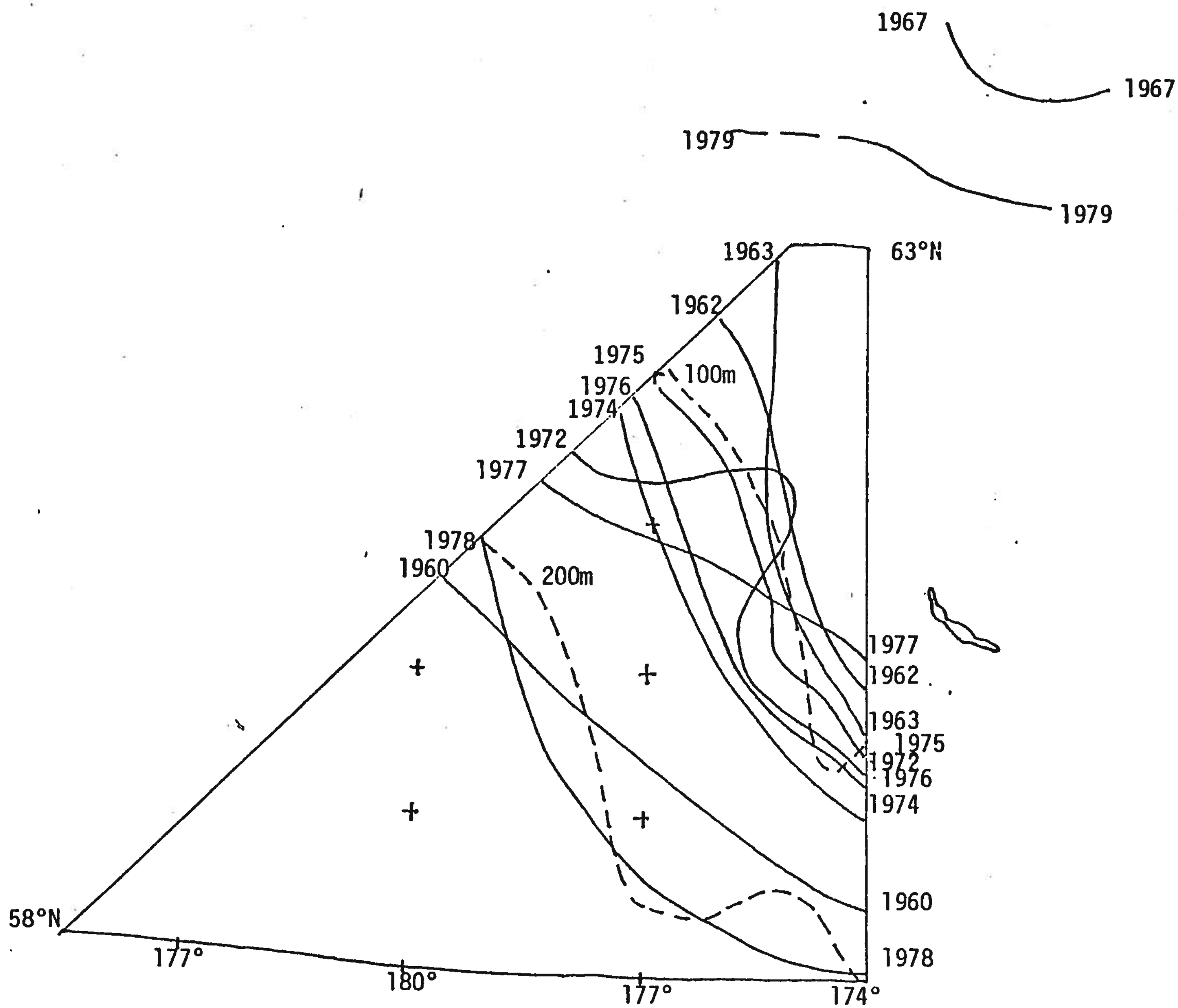


Figure 2.18 - Maximum extent of sea ice frontal margin across Navarin Basin in selected years between 1960-1979 in relation to the location of the 100m and 200m isobath.

The location of the front in the central Bering does not closely correspond to "normal" vs "cold" years as is indicated by the extent of the ice cover of the southeastern Bering Sea. For example, in the "cold" years 1962, 1972, 1975 and 1976 when there was maximum ice coverage in Bristol Bay, the ice front across the Navarin Basin area was "normal," following approximately the 100 m bottom depth contour. In 1960, when Bristol Bay experienced ice along the northern shore only, and in 1978 when it was ice-free south of Nunivak Island, the ice front in the Navarin Basin extended past the 200 m isobath.

Burns et al., 1980, surveyed the ice conditions in the sea ice front over part of the proposed Navarin Basin lease area in March-April 1976, when the ice extended slightly south of the 100 m contour. They described the ice as follows:

> "West of 169°W, ice conditions in the front in March-April 1976 were markedly different from those described above. Although the majority of floes were about the same size (approximately 20 m in diameter), they were made up of thicker (0.7 to 1.0 m) ice, even to the southern limit of the zone. Snow cover appeared to be much thicker, the degree of deformation was between 15 and 50 percent, and there was a strikingly higher proportion of clear, blue ice in the pressure ridges than was seen farther to the east. The ice edge extended south of the shelf margin in this region, from 174°W at least to 179°E, which was the western limit of our aerial surveys."

2.2 The Biological Environment of the Central Bering Sea and the Navarin Basin

The available information on primary productivity, and the secondary conversion of phytoplankton to zooplankton and benthos standing stocks in the Bering Sea is scattered, seasonally deficient, and occasionally contradictory. A good review of the literature has recently been reported (Laevastu and Livingston, 1980). The following discussion is excerpted from their report.

"The available estimates of annual primary production range from in excess of 300 g C/m^2 to lower values such as 150 g C/m^2 "inshore" and 55 g C/m^2 "offshore."

Some of the primary production values reported in the literature are given below. Motoda and Minoda (1974) observed mean primary production on the Bering Sea shelf between Pribilof and Bristol Bay to be 0.4 g C/m^2/day (= 146 g C/m^2/year). Smetanin (1956) reported the following primary production values: northern region 50 to 60 g C/m^2/year, western region, inshore 120 to 150 g C/m^2/year and offshore 35 to 55 g C/m^2/year.

According to Alexander (1978) the primary production in the Bering Sea can be as high as 300 g C/m^2/year. During the spring bloom period, which can last for over one month, 65% of the annual production occurs. This production is not effectively removed by grazing, but most of it sinks to the bottom. Ivanenko (1961) reported production in the Bering Sea during "growing season" as high as 605 g C/m^2 over the shelf and 230 g C/m^2 over deep oceanic area. McRoy and Goering (MS) reported annual mean values as 141 g C/m^2/year over the shelf and 133 g C/m^2/year over deep water, whereas Taguchi (1972) reported shelf water production to be only 89 g C/m^2/year, and central water production as 71 g C/m^2/year.

Meshcheryakova (1963) gives for phytoplankton standing crop in top 25 m between Pribilof and St. Matthews Islands in July over 3 g/m^3 and in June and October 1 to 2 g/m^3. Henrich (1962) gives basic organic production only as 35 g C/m^2/year." (The highest standing crops of diatoms, 10^9 cells/m^3 are reported to occur in early to mid-summer over the central Bering Sea shelf in the Navarin Basin area - Figure 2.19).

The best summary on the plankton in the Bering Sea is from Motoda and Minoda (1974) who stated that 80% of the zooplankton standing stock is in the upper 80 meters. They found the mean summer biomass of zooplankton to be 20 to 67 g/m^2, with a mean of 37 g/m^2 in the north central part of the Bering Shelf; 30 g/m^2 in the Bering Sea

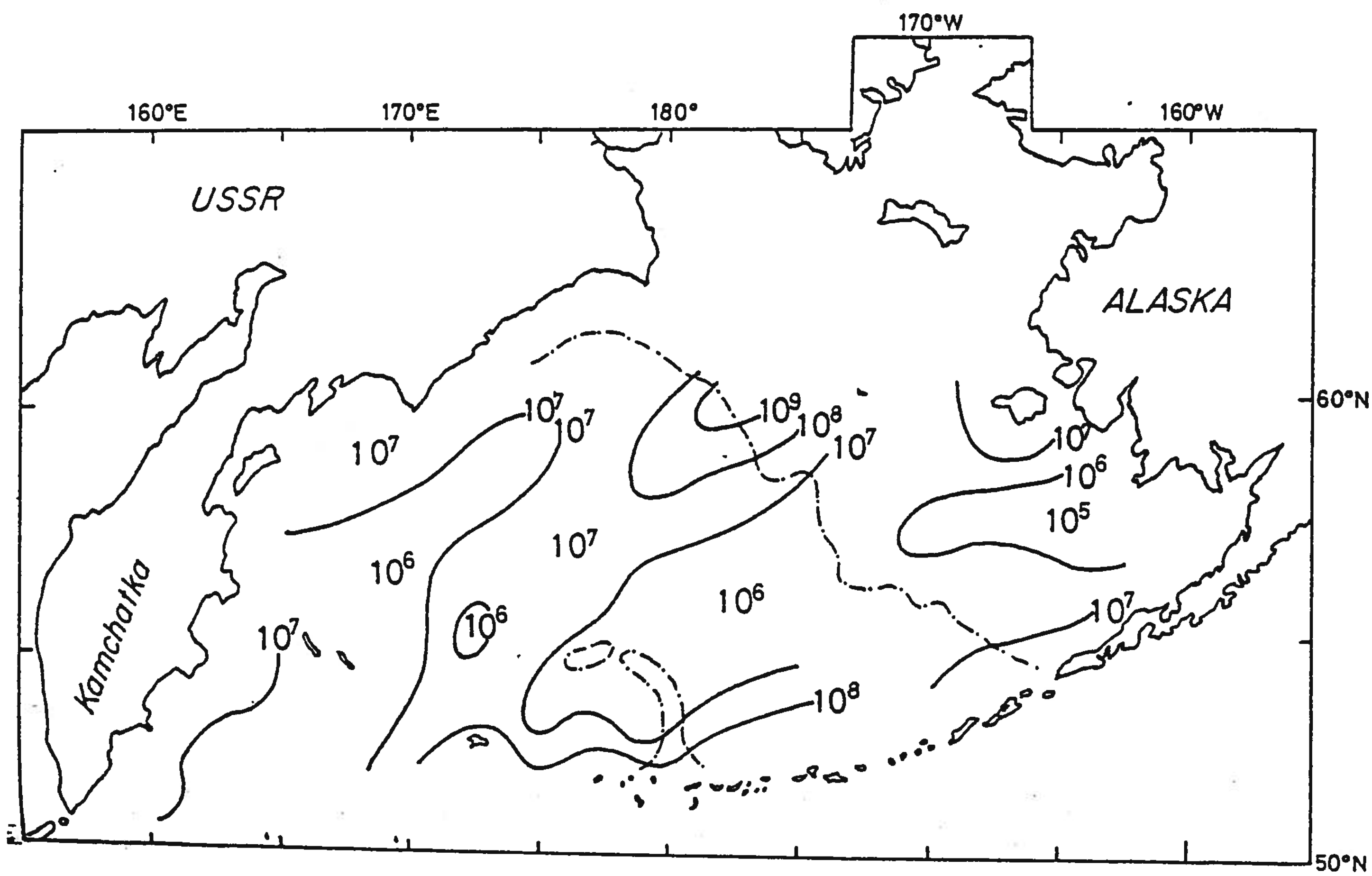


Figure 2.19 - The distribution of diatom standing crops (cells per m^3) at the surface in early to mid-summer (from Motoda and Minoda, 1974).

deep water; 50 g/m^2 in the south central shelf; and 67 g/m^2 on the slope near Pribilof (See Figure 2.20).

Quantitative data on abundant euphausids is nearly entirely absent. Very low values of copepod production such as 115 to 135 g biomass/m^2/year and 14 g C/m^2/year have been reported (Heinrich, 1962). Mednikov (1960) reported that 70 to 90% of zooplankton are copepods and gave for zooplankton production and standing stock the following values: production 115 g/m^2/year; standing stocks SE 0.1 to 0.5 g/m^3, W part 1.5 to 2.5 g/m^3. Meshcheryakova (1964) stated that off slopes and near the coast the zooplankton standing crop is 200 to 500 mg/m^3. The copepod fauna of the central Bering mid-shelf domain is apparently a mixed community composed of both oceanic and shelf

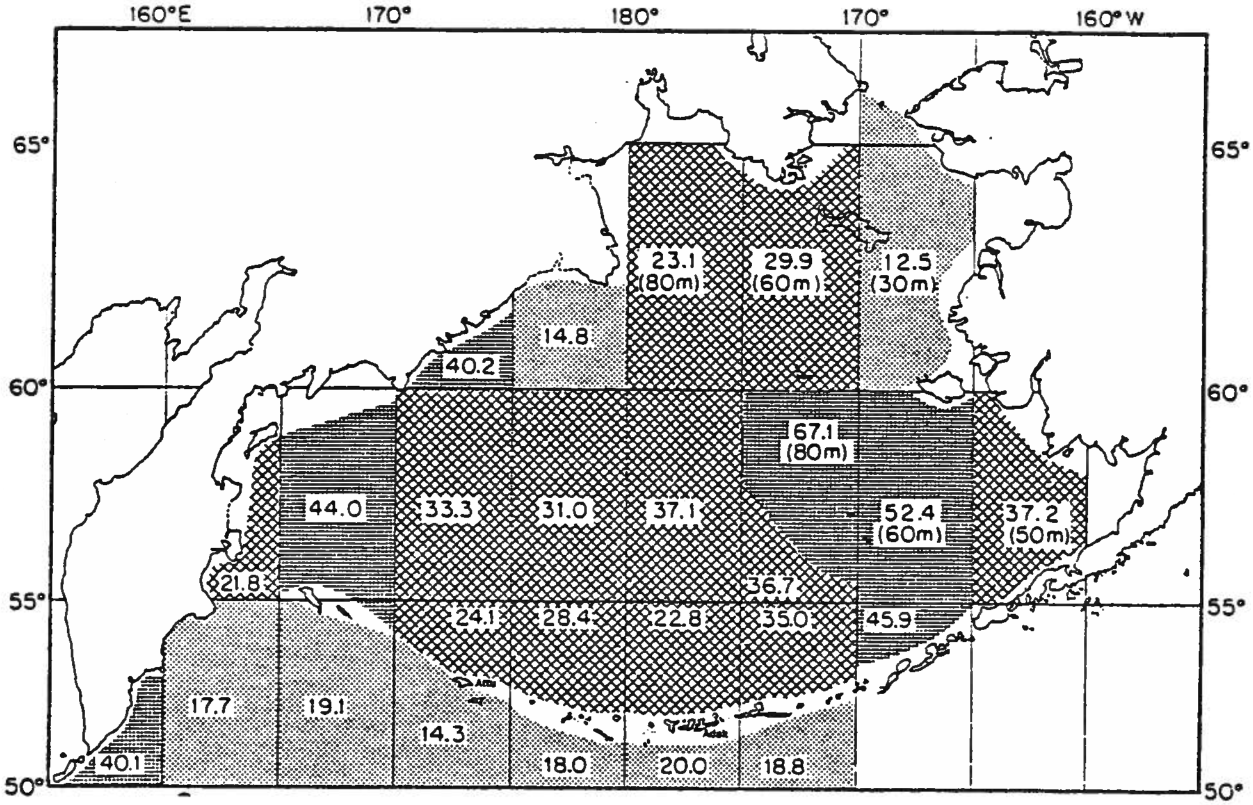


Figure 2.20 - Mean wet weight (g/m^2) of zooplankton taken with vertical tows in the summers of 1956 to 1970 (from Motoda, 1972). Unless otherwise shown, the water column sampled was from 0-80 m.

species (Figure 2.21). In the rest of the Bering Sea only in a few areas is the zooplankton standing stock greater than 100 g/m^2; normally in "rich" areas it is only 50 to 100 g/m^2. Furthermore, Meshcheryakova stated that in May zooplankton biomass did not exceed 100 mg/m^3; however, concentrations reaching 300 mg/m^3 were observed evening and night in the surface layer. In shallow areas the zooplankton concentration in June varied between 1 to 10 g/m^2 and in August 10 to 50 g/m^2. By September the zooplankton off St. Matthews Island increased to 10-15 g/m^2, but decreased markedly between Unimak and St. Lawrence Islands.

For comparison Sherman summarized a few available estimates on the zooplankton production along the NE coast of the U.S. in a paper for a fisheries-climate workshop in Columbia, Missouri, April 1976.

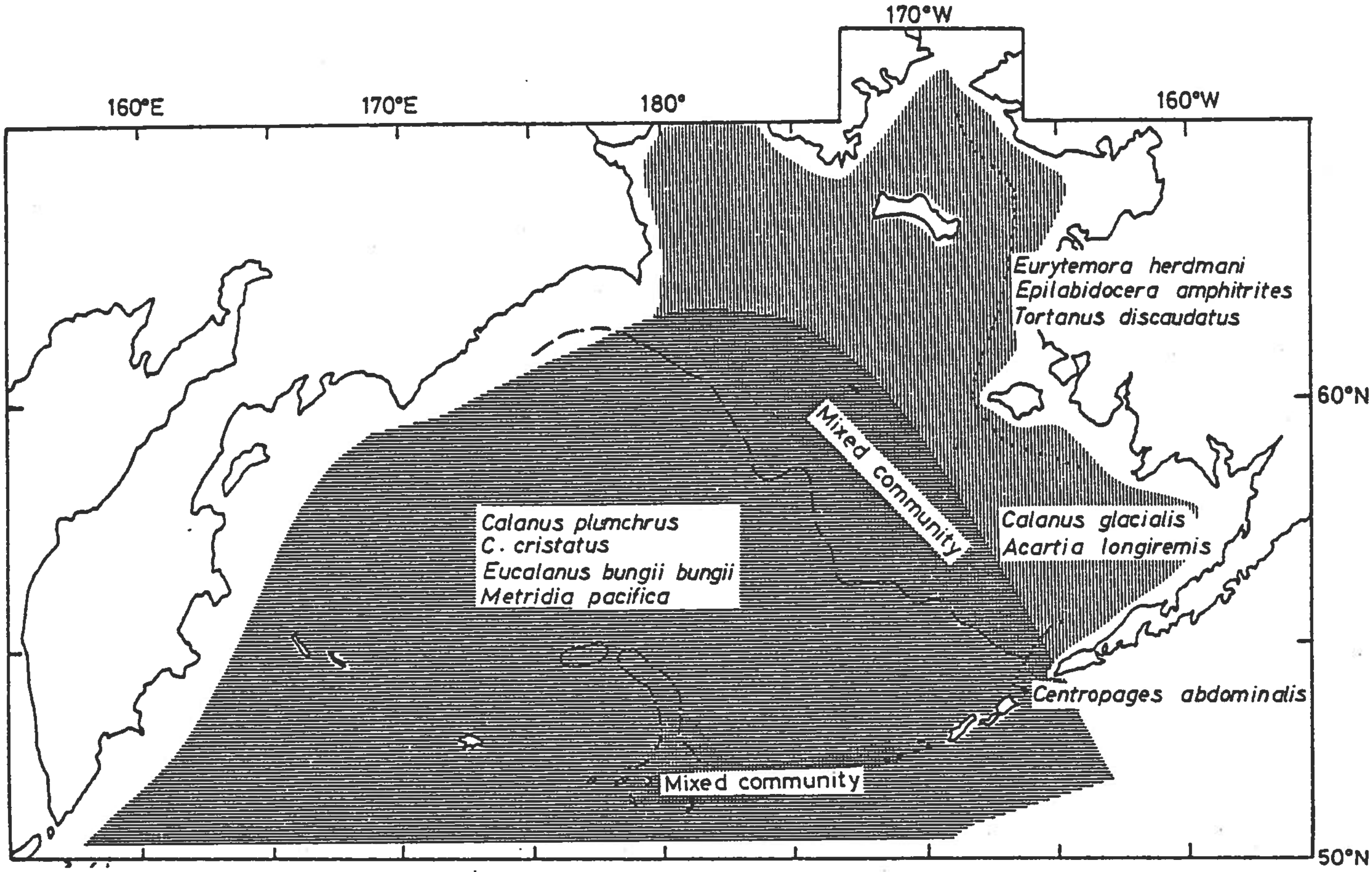


Figure 2.21 - Species composition of copepod communities in the upper layer in early to mid-summer (from Motoda and Minoda, 1974).

These estimates, obtained with different methods, ranged between 4 and 200 mg C/m^2/day. The average and plausible value was about 50 mg C/m^2/day, which gave 183 g C/m^2/year or t/km^2/year. This value (and other zooplankton production values) can only be taken as a very approximate estimate, and cannot serve as bases for any other production or its utilization calculations.

The data on benthos from the Bering Sea and its production are still more deficient than the data on plankton. Almost nothing is known on the annual production of different components of benthos. The quantitative data on benthos can be summarized as follows: The total benthos biomass ranges from 55 to 905 g/m^2 (See Figure 2.22). The average value for the north central part of the Bering Sea is 170 g/m^2. The overall mean is 100 g/m^2, whereby the highest

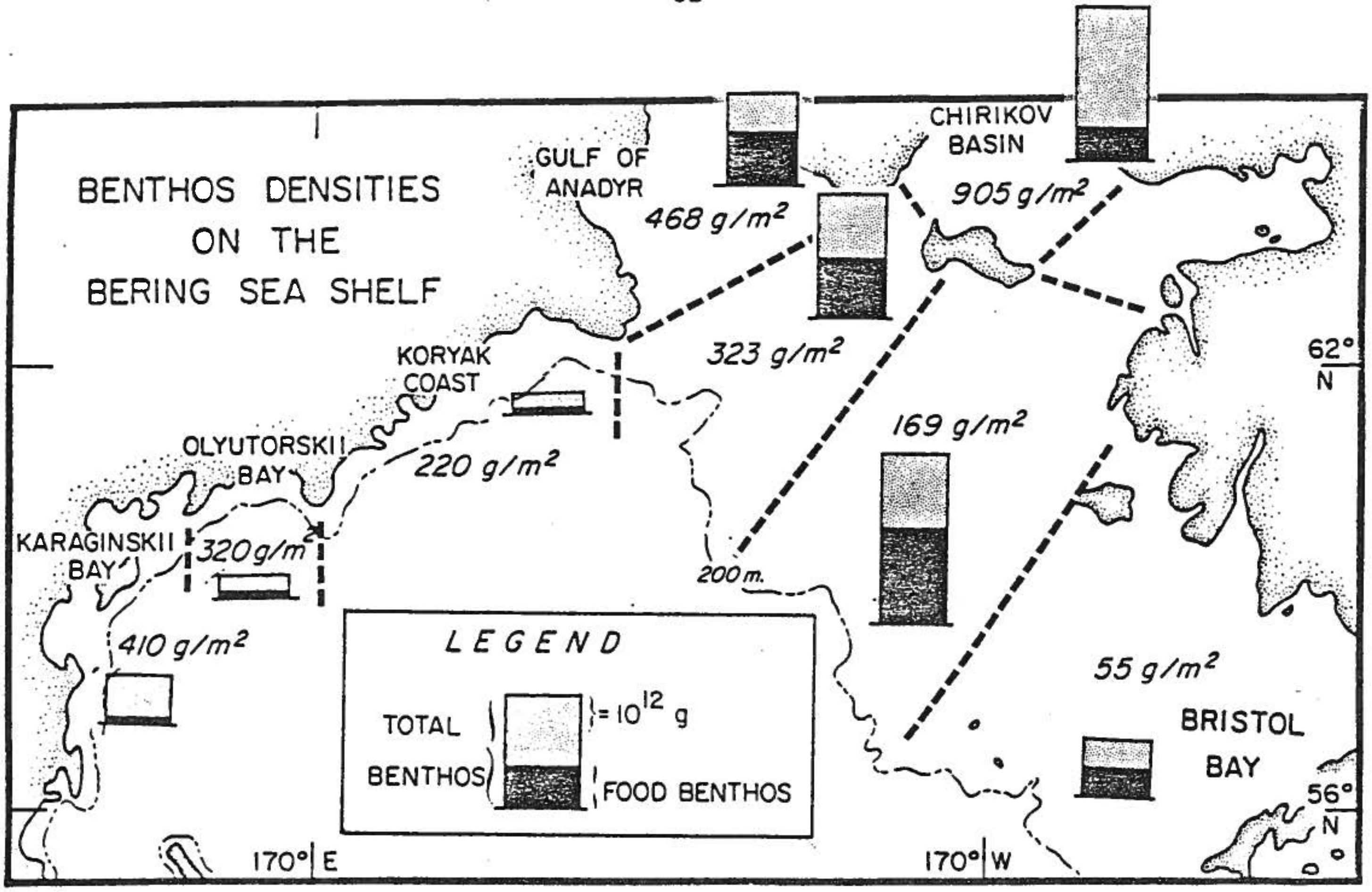


Figure 2.22 - Benthos density in various sectors of the Bering Sea shelf and slope (from Alton, 1974).

standing stocks of benthos occurred in depths between 50 and 150 meters. The best summary on Bering Sea benthos is from Alton (1972), which is briefly summarized below.

Density of the benthos is highest in the western and northern parts of the shelf, reaching a maximum average value of 905 g/m^2 in the Chirikov Basin. The lowest value is 55 g/m^2 for the broad shelf of the southeastern Bering Sea where major fisheries take place. (This low value is probably due to heavy predation). Of the total estimate of food benthos in the Bering Sea (64 million metric tons), only 17 percent (or 11 million metric tons) are accessible to commercial concentrations of demersal fish according to Alton (1972) because of the cold temperatures that prevail in many parts of the sea.

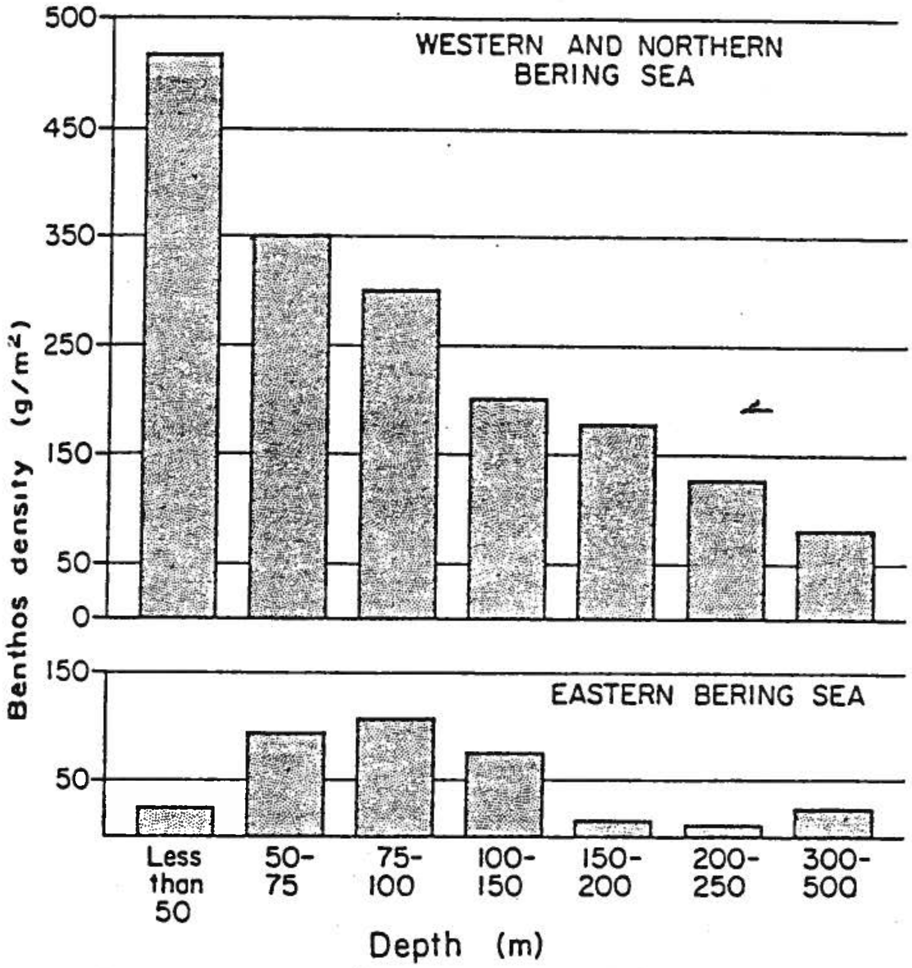
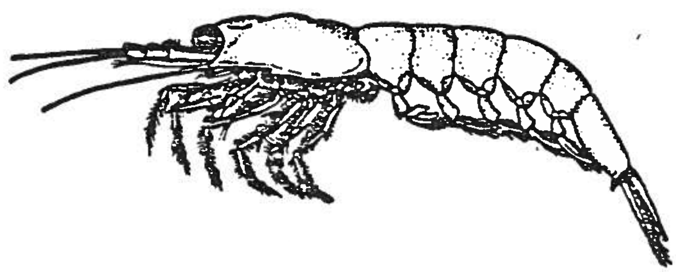


Figure 2.23 - Bathymetric trends in benthos density in the Bering Sea, from Alton (1974).

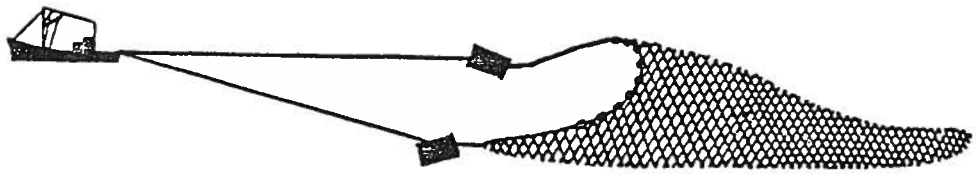
The highest concentrations of benthos occur in intermediate depths 20-150 m (see Figure 2.23). "Fish food" benthos in the southeastern (and central) region exceeds 50% of the total benthos and consists predominantly of small clams, polychaetes, and brittlestars.

The brief summary above shows that the production and biomasses of plankton are ill known and, most importantly, the pathways of these biomasses through the rest of the ecosystem as food sources are very variable in space and time and are equally ill known. However, these biomasses can serve as "production buffers" for the ecosystems in the sense that they, besides being utilized by the smaller (and younger) specimens, can be utilized by larger specimens when other preferred food is scarce. The benthos, however, serves as a steady food source for demersal and semidemersal species. Furthermore, the patchiness of plankton (and benthos) is a factor which affects its availability as a food source and might be one of the causes for aggregation and "feeding migrations" in many species."



Euphausia pacifica

3. COMMERCIAL FISHERIES IN THE CENTRAL BERING SEA



The Bering Sea is inhabited by over 300 species of fishes of at least 43 families. Among these are 8 families of commercial value. The following fish are taken in commercial fishing operations; including those of primary importance (**), secondary importance (*), and incidental catch.

Family Rajidae - Skates and rays

Raja spp. - skates

Family Clupeidae - Herrings

** Clupea pallasii - Pacific or sea herring

Family Salmonidae - Salmon

** Oncorhynchus nerka - sockeye or red salmon

** O. tshawytscha - chinook or king salmon

** O. gorbuscha - pink or humpback salmon

* O. kisutch - coho or silver salmon

* O. keta _ chum or dog salmon

Salvelinus malma - Dolly Varden or arctic char

Family Gadidae - Cods and Hakes

* Gadus macrocephalus - Pacific cod

Eleginus gracilis - saffron cod

** Theragra chalcogramma -walleye or Alaska pollock

Boreogadus saida - Arctic cod

Family Macrouridae - Grenadiers

Coryphaenoides spp. - rattails

Family Scorpaenidae - Rockfishes

** *Sebastes alutus* - Pacific ocean perch

Sebastes spp. - other rockfish

Family Anoplopomatidae - Sablefishes

** *Anoplopoma fimbria* - sablefish or black cod

Family Hexagrammidae - Greenlings

Pleurogramma monopterygius - Atka mackerel

Family Pleuronectidae - Right eye flounders

Isopsetta isolepis - butter sole

** *Reinhardtius hippoglossoides* - Greenland turbot

Platichthyes stellatus - starry flounder

* *Lepidopsetta bilineata* - rock sole

** *Hippoglossus stenolepis* - Pacific halibut

* *Hippoglossoides elassodon* - flathead sole

* *Pleuronectes quadrituberculata* - Alaska plaice

Glyptocephalus zachirus - rex sole

* *Atheresthes stomias* - American arrow-toothed sole

** *Limanda aspera* - yellowfin sole

L. proboscidea - longhead dab

Microstomus pacificus - Dover sole

In addition, there are commercial shellfish fisheries for a variety of invertebrates:

Crustacea

** *Paralithodes camschatica* - red king crab

* *P. platypus* - blue king crab

** *Chionoecetes bardi* - red Tanner or snow crab

* *Chionoecetes opilio* - blue Tanner crab

* *Pandalus* spp.- shrimp

Mollusca

* _Neptunea_ spp. - neptune snails
Spisula polynyma - Alaska surf clam
Siliqua patula - razor clam

The Bering Sea provides one of the world's major fishing areas (see Figure 1.1). Commercial exploitation of the resource dates back almost 100 years. Japanese distant water fishing vessels conducted operations in the Bering Sea as early as 1930, and harvested 43,000 metric tons (mt) mostly pollock, by 1937, but these efforts were halted by World War II. The fishery was resumed by the Japanese in 1954 with trawling operations targeting on the yellowfin sole. The U.S.S.R. joined in this fishery in 1958. Total catches of groundfish, shrimp, and herring reported by Japan, the Soviet Union, the U.S., and Canada in the Bering Sea rose from less than 15,000 mt in 1954 to over 1,550,000 mt in 1970 but have declined to 1,296,197 mt in 1979. Most of the catch has been taken by Japanese vessels. Canadian and U.S. vessels participated only in a longline fishery for halibut.

Beginning in the mid-1960's, the walleye pollock became the major target species of foreign fleets, and total catches of demersal fish rose sharply as exploitation of this large resource intensified. The Republic of Korea in 1967 and Taiwan in 1974 sent trawlers to join in this fishery.

At its peak, about 1970, foreign vessels landed more than 2 million metric tons of groundfish annually. As evidence accumulated in the 1970's of a decline in abundance of some of the Bering Sea fish resources, catch restrictions were imposed and allocations were granted to foreign nations on a quota basis.

With the establishment of the 200-mile fisheries zone in March 1977, the United States embarked on a new era of fisheries management off its shores through the implementation of the Fishery Conservation and Management Act (FCMA) of 1976. Under the FCMA, five preliminary fisheries management plans (FMPs) were developed for the Alaska area and regulations promulgated to implement them. They included the Gulf of Alaska trawl fishery, Bering Sea and Aleutian Island trawl and herring gillnet fishery, sablefish fishery, crab fishery, and snail fishery. Under these preliminary management plans, 1,673,400 metric tons of groundfish and shellfish were allocated to foreign nations off Alaska in 1977.

Six international fisheries agreements and four conventions were in force during 1977 (Table 3.1) between the United States and Japan, U.S.S.R., Poland, South Korea, Taiwan, Canada, and Mexico. All agreements are universal in acknowledging the U.S. 200 mile fisheries zone and the exclusive management authority it authorized.

3.0.1 History of Commercial Fishery in the Bering Sea

Japan was the first foreign nation to develop post-World War II fisheries in the Bering Sea, starting in 1954; the U.S.S.R. launched a fishery in 1959. During these years and through the early 1960's, the target species of these nations was yellowfin sole (Figure 3.1). Following the removal of 1.5 million mt of yellowfin sole within a 3-year period (1960-62), the catch declined drastically as did the average size of fish. The stock remained in a depressed condition until the early 1970's, when the appearance of strong year classes, spawned in the mid-1960's, resulted in an increase in the fishable population. Since 1969 the yellowfin sole fishery has operated in winter months (October to March) in shelf waters north of Unimak Island. Yellowfin sole catches in other areas are mainly incidental to walleye (Alaska) pollock landings.

With the decline in the yellowfin sole population and development of techniques of processing "surimi" (a semi-processed wet fish protein) at sea in 1964, walleye pollock became the target of the Japanese fishery. The Soviet Union also turned to walleye pollock as its principal target species but in somewhat later years. Since the mid-1960's, pollock has formed by far the major part of foreign catches (Figure 3.1) with average annual landings reaching 1.7 million mt during 1971-74. Pollock catches come mainly from along the outer shelf and continental slope, extending from Unimak Pass to Cape Navarin. Largest catches come from just northwest of Unimak Pass and

Table 3.1 - Agreements, Conventions, and Laws Enforced by National Marine Fisheries Service and United States Coast Guard off Alaska - 1977

International Agreements	Begin	Signed	Ends
Japan	11/29/77	3/18/77	12/31/82, Review in 2 years
USSR	2/28/77	11/26/76	Review in 2 years
South Korea	2/3/77	1/4/77	7/1/82 Review in 2 years
Poland	2/28/77	8/2/76	Review in 2 years
Taiwan	2/28/77		Review in 2 years
Mexico	9/27/77	11/24/76	1 year formal notice of termination
Canada	7/26/77	2/24/77	12/31/77

Note: All agreements acknowledge U.S. Fishery Conservation Zone.

Conventions	Originated	Extended	Expires
Fur Seal Convention (Act - 16 USC 1151-1187)	1911	1975	October 1980
Halibut Convention (Act - 16 USC 772-772j)	1924	1953	2 years notice
Whaling Convention (Act - 16 USC 916)	1937	1946	Within any year
INPC (Act - 16 USC 1021-1032)	1953		1 year notice

Public Laws			
P.L. 94-265 (200 Mile Fisheries Zone) (16 USC 1801-1882)	3/1/77		Indefinite

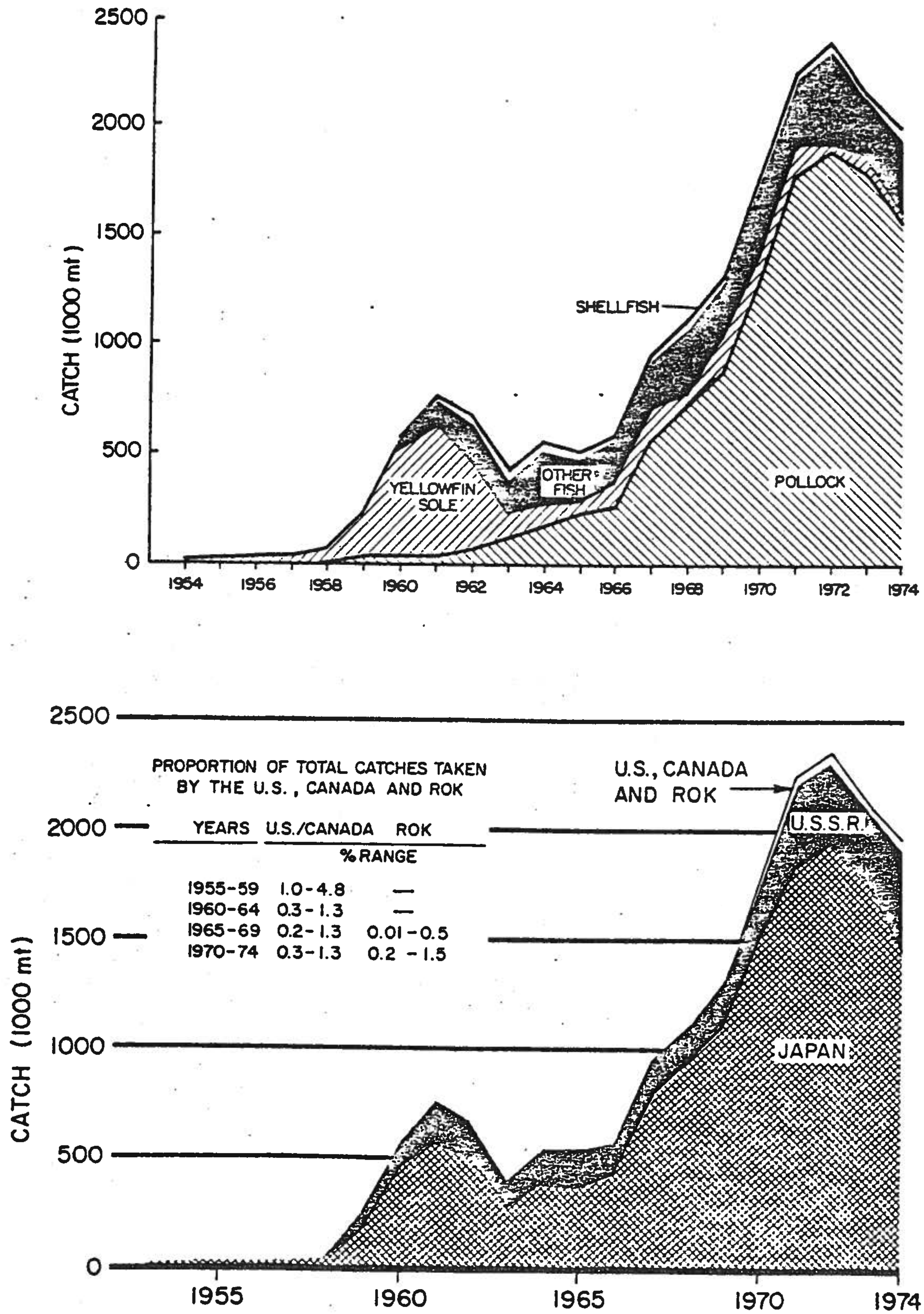


Figure 3.1 -- Total catches of demersal fish and shellfish in the eastern Bering Sea by species or species group (upper figure) and by nation (lower figure) in 1954-74. (ROK is the Republic of Korea.)

southwest of St. Matthew Island. Other commercially important fishes taken incidentally by the pollock and yellowfin sole fisheries (or by fisheries directed to these species) are flathead sole, rock sole, arrowtooth flounder, Greenland turbot, Pacific cod, sablefish, Pacific ocean perch, and Pacific herring.

Shellfish have also been targets of Japanese, U.S.S.R., as well as U.S. fishermen. U.S. crab fisheries in the eastern Bering Sea, which began in 1947, remained much smaller than those of Japan and the U.S.S.R. until the mid-1960's, but became dominant in the 1970's. The U.S.S.R. ended its participation in the king crab fishery in 1971, and Japan in 1974. The U.S. catch of king crab first exceeded that by Japan and the U.S.S.R. in 1971 (2.4 million crabs); in 1975 the U.S. catch reached 9.1 million crabs - an all-time record catch for this species.

The United States did not have a fishery specifically for Tanner (snow) crab prior to 1974, although some were taken by the king crab fishery. A purposeful U.S. Tanner crab fishery began in 1974 and has grown very rapidly with catches reaching 8.9 million crabs in the same year. The U.S.S.R. has not participated in the Tanner crab fishery since 1971.

Pink shrimp have also been a commercially important species. The main fishing area for this species is northwest of the Pribilof Islands with less important grounds off Cape Navarin and in the Gulf of Anadyr. Exploitation of shrimp stocks in the Pribilof Island area was mainly by Japan; the U.S.S.R. also fished for eastern Bering Sea shrimp in 1963 and 1964 but did not report the extent of their catches. Japanese catches reached a peak of 27,000 mt in 1963 but, due to overfishing and adverse environmental conditions, declined to only 200 mt or less in 1972-74. Shrimp are not a viable commercial fishery at present due to the poor condition of the resource, but recent trawl surveys indicate that the stock condition may be improving.

Snail resources in the central and eastern Bering Sea have been exploited exclusively by Japan. The fishery, which started in 1971, utilizes traps for the capture of snails and is conducted mainly in the vicinity of the

Pribilof Islands and to the northwest. Catches of recovered edible meat during 1972-79 ranged between 3,400 and 3,600 mt. The value of dockside landings of snails is estimated to average $3.9 million annually.

3.1 Domestic Fisheries in Alaska

The domestic harvest of fish and shellfish from Alaska waters in 1979 led the nation in commercial value, and ranked second to Louisiana in total quantity. Alaska yielded 14 percent or 408,000 mt (899 million pounds) of the record 2.9 million mt (6.3 billion pounds) total catch by U.S. fishermen nationally. The value of the Alaska catch was $597 million, including over 467 million pounds of salmon valued at $359 million. Crab landings comprised another 286 million pounds, including a Bering Sea harvest of 133 million pounds of king crab valued at $127.7 million, and 75 million pounds of Tanner crabs valued at $33.4 million.

Landings by U.S. fishermen of Alaska groundfish (pollock, cod, flounders, and rockfishes) in 1979 were 9.5 million pounds valued at $1.4 million, a 73 percent increase over 1978, almost exclusively taken from the Gulf of Alaska. The enormous groundfish resources available in the Bering Sea FCZ are presently beyond the capacity of domestic fishermen and processors, but developments now underway indicate a determination by U.S. fishermen to move into these highly productive fisheries. The perishable nature of groundfish requires that they be processed quickly (within hours of being caught) meaning that in the Bering Sea and other remote areas, at-sea processing is necessary. Several foreign nations long ago recognized this necessity and built entire fleets of distant water catcher/processors. Relatively few U.S. trawlers have processing and/or freezing capability. The U.S. subsidy vessel "Subfreeze Atlantic," now renamed the "Arctic Trawler," is the largest example of the very limited number of U.S. freezer vessels. Other U.S. trawlers are fishing in joint ventures with foreign processing vessels and have achieved increasingly notable success in harvesting groundfish. Additional U.S. vessels may soon initiate at-sea salting of split cod. These operations portend expanding U.S. fisheries aimed ultimately at full domestic utilization of the more than one million metric tons of groundfish in Alaskan waters presently taken by foreign nations.

3.2 Foreign Fisheries in the Bering Sea

Alaska waters have attracted foreign fishing fleets from Japan, the U.S.S.R., Republic of South Korea, Poland, Taiwan, and most recently West Germany (Figures 3.2-3.7). The total foreign fleet numbers over 1,000 vessels, including factory fleets for pollock, salmon, flounder, and Tanner crab; trawlers for groundfish; gill net vessels for salmon; pot vessels for crabs and snails; and longliners for sablefish.

Six foreign nations traditionally send vessels to Alaskan waters. Japan typically dominates the total foreign fleet, supplying over 80 percent of the vessels and associated fishing effort. In 1977, Japan dispatched 729 vessels, Soviet Union 297 vessels, South Korea 29 vessels, Taiwan 5 vessels, and Poland 14 vessels. The Bering Sea is the area where the majority of Japanese and Taiwanese vessels have operated, while most of the Soviet, South Korean, and Polish vessels have also operated in the Gulf of Alaska. Tables 3.2-3.4 summarize this foreign fishing effort in the Bering Sea and Aleutian region. Not shown in these tables is effort by the single West German vessel which began fishing in the Bering Sea in late 1980.

Since 1979, foreign fisheries in the Bering Sea have been in a state of transition with new Fishery Management Plans and foreign nation allocations coming into effect in 1980. The changes resulting from these new FMP's are too recent to be discussed in detail in this report. Information covering the years 1977 to 1979 is provided to illustrate the value of the area for fishery resources and potential domestic fishery importance, and is not an accurate statement of the current foreign fishing activity occurring there in 1980 and 1981.

The Bering Sea - Aleutian Islands area accounted for 89 percent of the total fishing effort and 87 percent of the total foreign fishing catch in Alaska waters in 1979. Groundfish are the focus of the Bering/Aleutian foreign fishing. In 1979 pollock comprised 73 percent of the total catch, followed by 14 percent

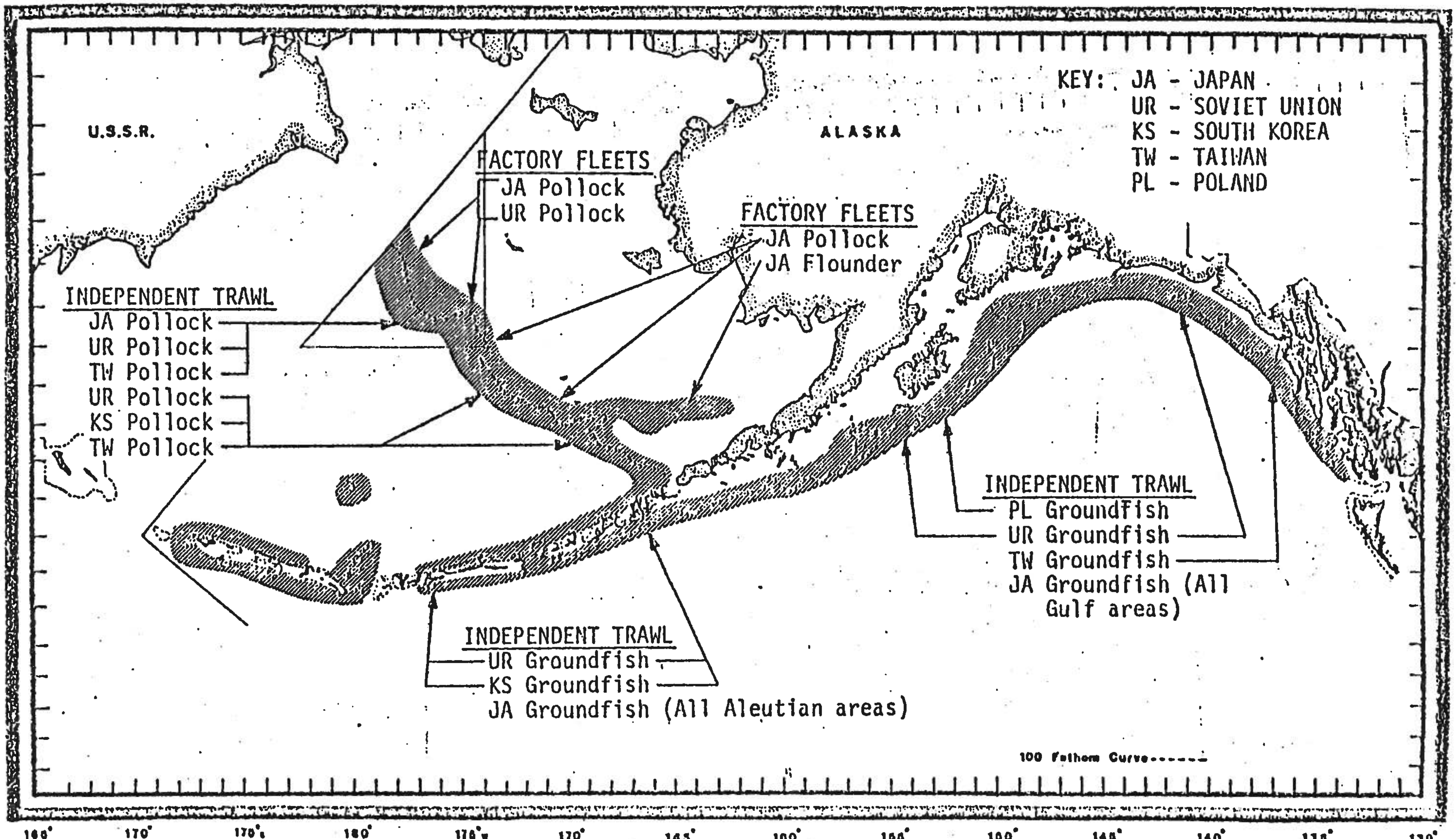
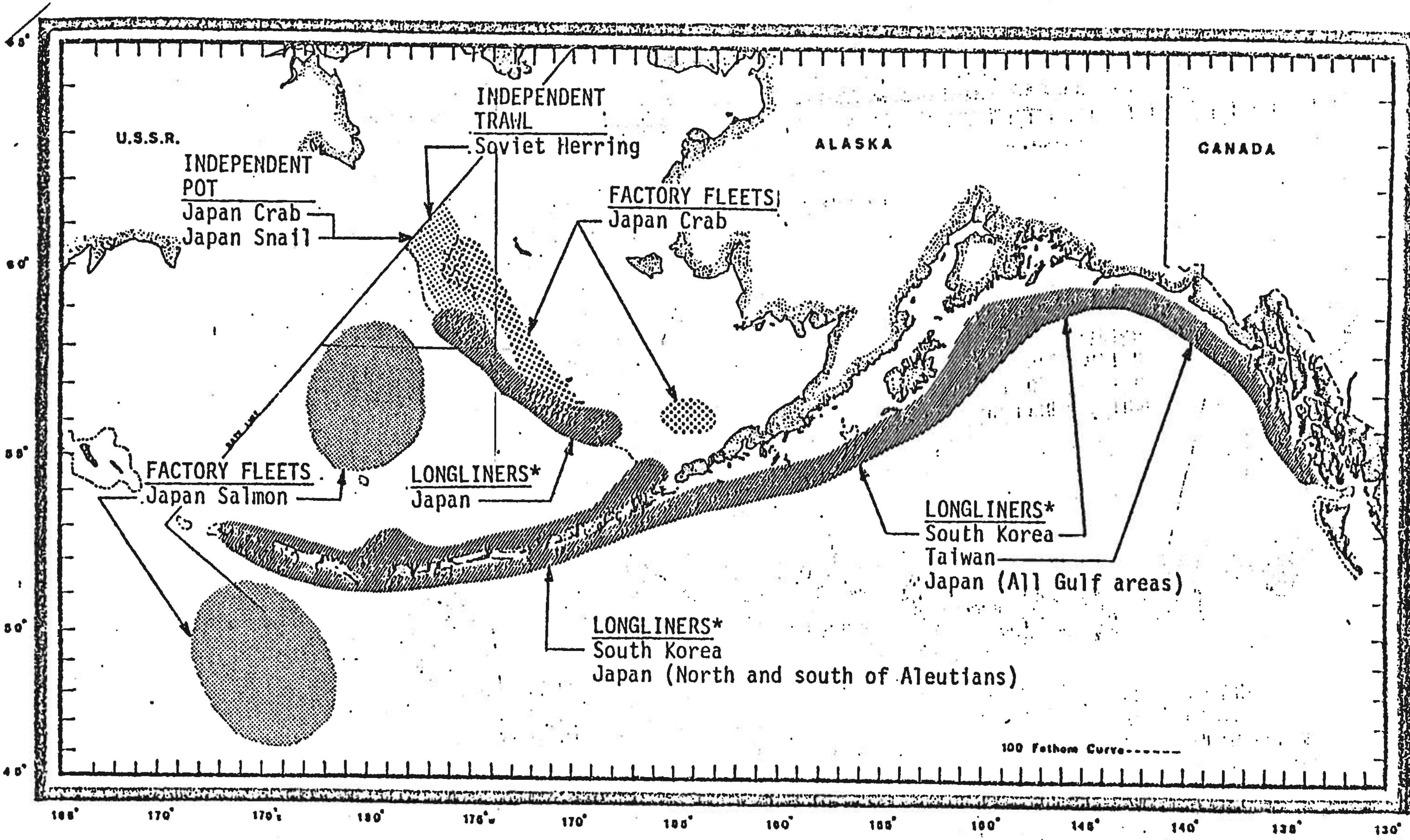


FIGURE 3.2

Alaska Fishing Areas for All Nations Landing Groundfish - 1977



* All longliners fish for sablefish

Figure 3.3

Alaska Fishing Areas for All Nations Landing Herring and Non-groundfish Species - 1977

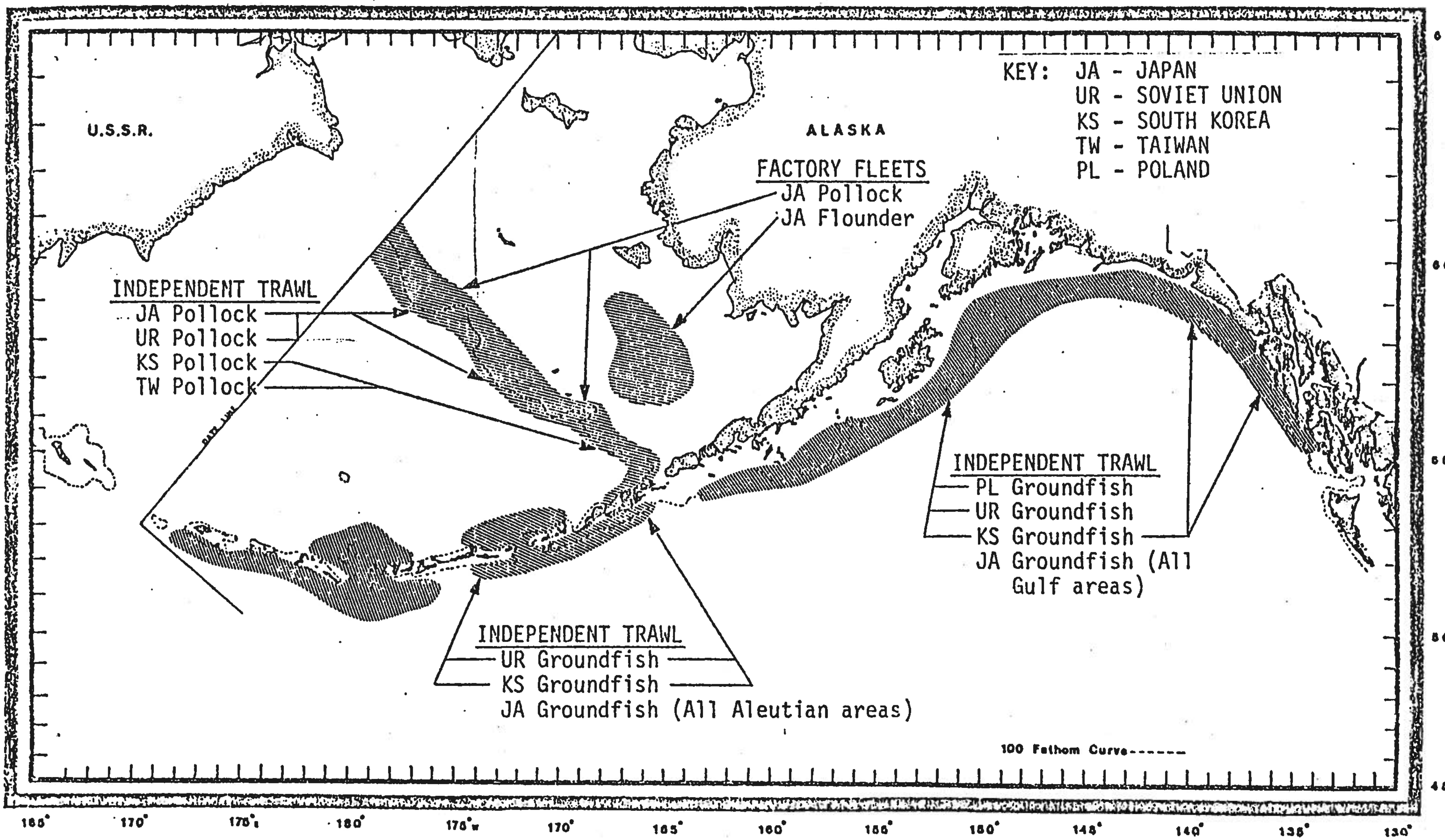
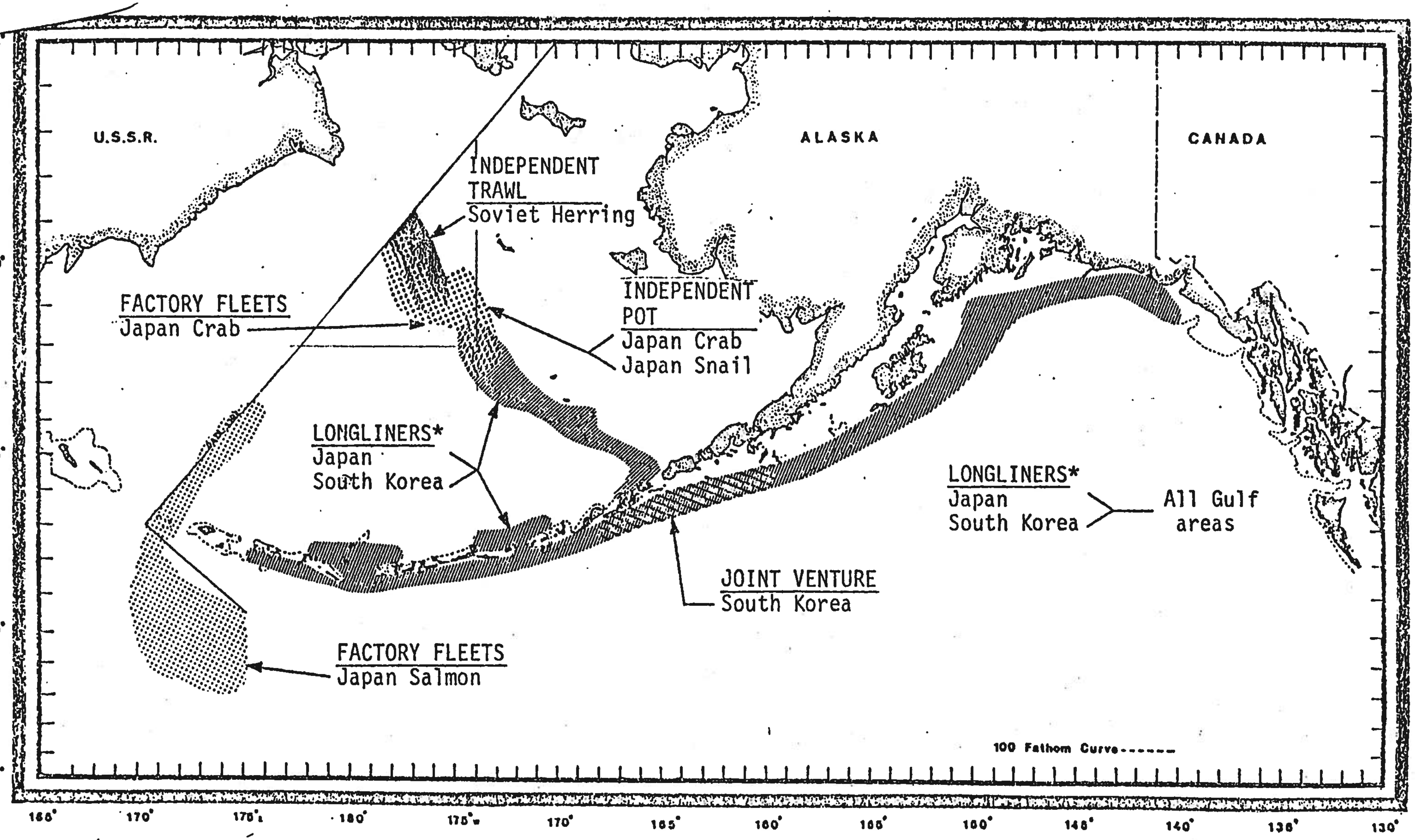


FIGURE 3.4

Alaska Fishing Areas for All Nations Landing Groundfish - 1978



* All longliners fish for sablefish

FIGURE 3.5

Alaska Fishing Areas for All Nations Landing Non-groundfish Species - 1978

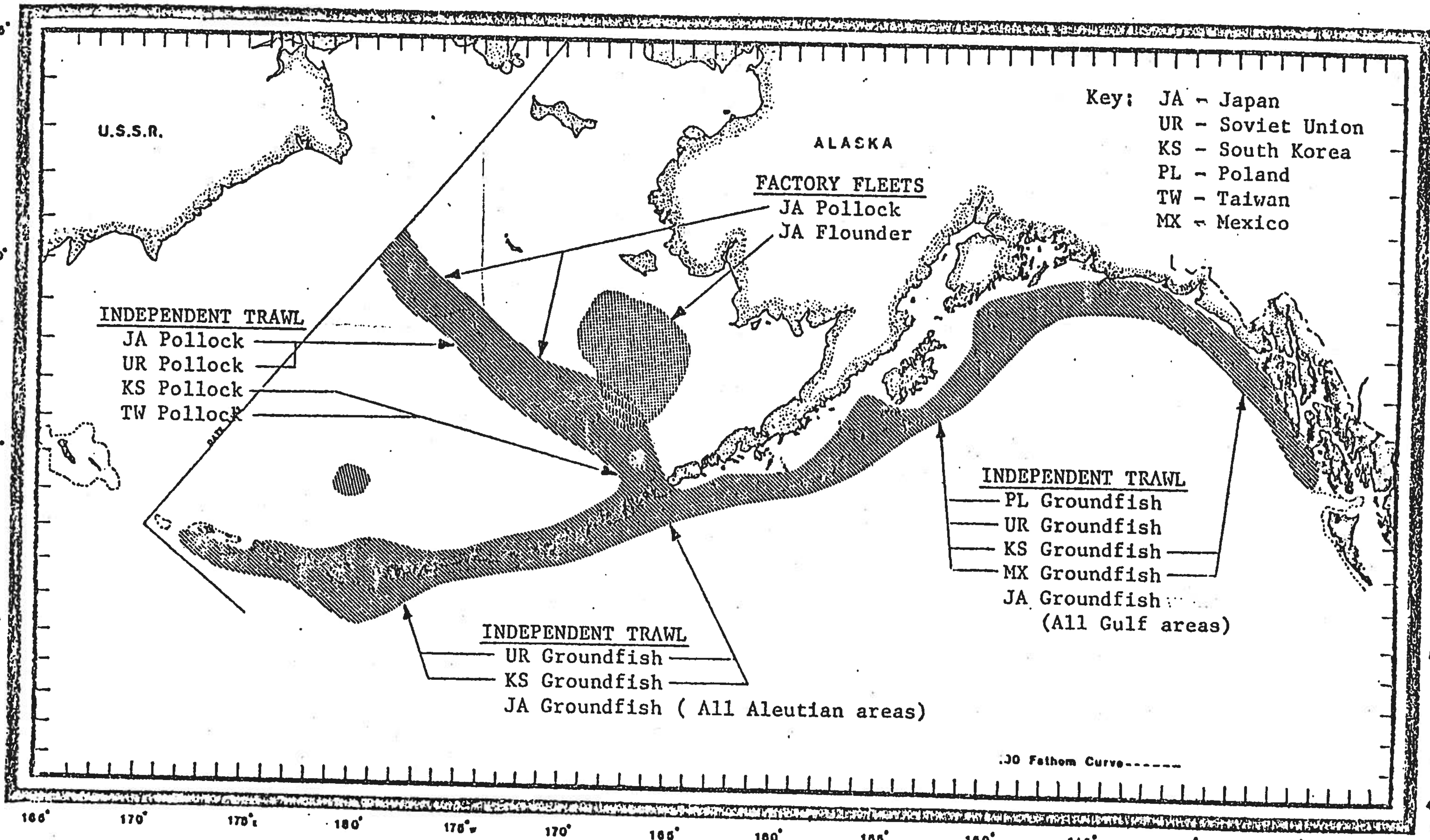


FIGURE 3.6

Alaska Fishing Areas for All Nations Landing Groundfish - 1979

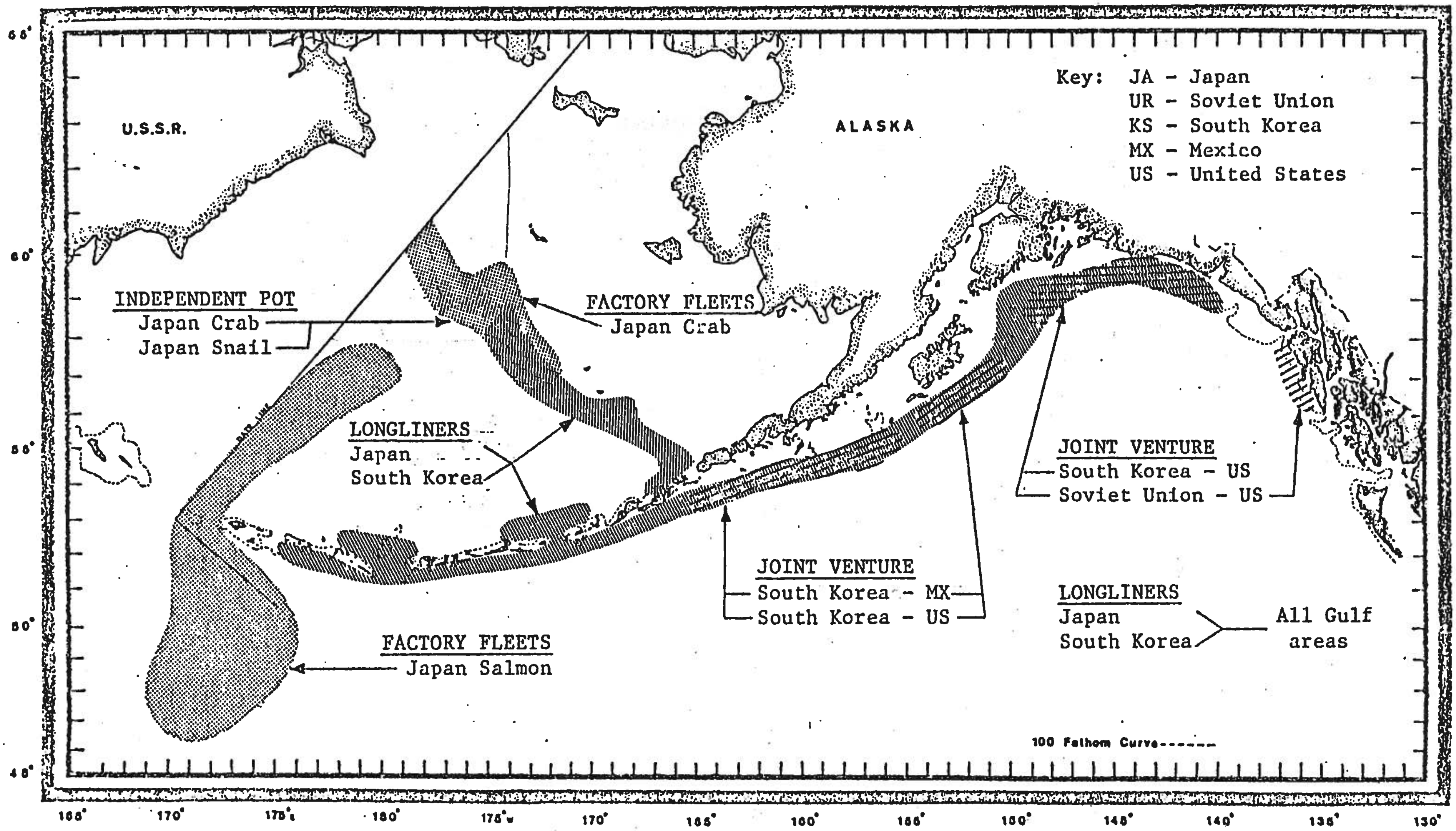


Figure 3.7

Alaska Fishing Areas for All Nations Landing Non-groundfish Species - 1979

Table 3.2. Selected Foreign Fleet Fishery Statistics for the Bering Sea-Aleutian Island Area, in 1977.

Total Vessel days/year	68,313 (187.2 yrs)
Number Vessels/month	74-617
Total Catch, mt	1,167,985
Total Allocation	1,376,400
% Take of Allocation	84.9%
Days Effort by Vessel	
Stern Trawlers	35,318
Factory Fleets	29,684
Other Vessels	3,311
Vessel Fees - Alaska Waters	
No. Permits Issued	642
Total Vessel Tonnage	766,274 gross tons
Total Tonnage Fees	$586,434
Total Allocated Catch Fees	$7.18 million
Total Fees	$7.77 million

Table 3.3. Foreign Fleet Fishery Statistics for the Bering Sea - Aleutian FCMA, 1977-1979.

Species Composition of Catch by weight (mt) and % of total catch.

Fish	1977 mt	1977 %	1978 mt	1978 %	1979 mt	1979 %
Pollock	888,552	76.1	977,749	69.8	941,665	72.6
Yellowfin Sole	58,986	5.1	110,312	7.8	96,093	7.4
Other Flounders	62,951	5.4	125,498	9.0	89,886	6.9
Pacific Cod	36,466	3.1	46,787	3.3	41,385	3.2
Atka Mackeral	0	0	24,225	1.8	23,265	1.8
Salmon	0	0	34,006	2.4	30,984	2.4
Herring	18,736	1.6	8,434	0.6	7,345	0.6
Rockfish	876	0.1	0	0	0	0
Pacific Ocean Perch	7,250	0.6	7,508	0.5	7,182	0.6
Sablefish	4,634	0.4	1,960	0.1	2,173	0.2
Halibut	100	nil	89	nil	0	0
Other Finfish	68,243	5.8	71,559	5.1	64,695	5.0
Total Fish	1,146,794	98.2	1,374,121	98.1	1,273,690	98.3

Shellfish	1977 mt	1977 %	1978 mt	1978 %	1979 mt	1979 %
Tanner Crab	12,471	1.1	14,962	1.1	14,954	1.2
Snails (meat)	404	nil	2,184	0.2	537	nil
Squid	8,316	0.7	9,407	0.7	7,017	0.5
Total Shellfish	21,191	1.8	26,553	1.9	22,508	1.7
Total Catch	1,167,985		1,400,674		1,296,197	

Table 3.4. Summary of foreign fisheries in the Bering Sea, 1978.

Fishery Plan	Nation	Vessel type	Target species	Vessel month
Bering Sea Tanner crab	Japan	Mothership	Tanner Crab	11.8
		Land-based fleet	Tanner Crab	29.5
High seas salmon gillnet	Japan	Mothership	Salmon	4.5
Bering Sea/Aleutian groundfish	Japan	Pollock mothership	Pollock	26.3
		Yellowfin mothership	Yellowfin sole	5.8
		Small stern trawler (land-based fleet)	Flatfish, Pacific cod, rockfish	805.4
		Medium stern trawler	Yellowfin sole	160.8
		Large stern trawler	Pollock	70.2
		Longline	Sablefish, Pacific cod	178.0
	USSR	Large stern trawler (eastern Bering Sea)	Pollock, yellowfin sole	29.2
		Large stern trawler (Aleutian Island)	Atka mackerel	62.4
	Korea	Large stern trawler	Pollock	1.0
	Taiwan	Small stern trawler	Pollock	7.5
Bering Sea snail	Japan	Independent pot vessel	Snail	29.6
Totals through 31 December 1978,				1398.4

Table 3.5. Catch by Nation by weight (mt) and % of total catch, in the Bering Sea Fishing Conservation Zone (FCZ).

	1977		1978		1979	
	mt	%	mt	%	mt	%
Japan	1,012,499 -	86.7	1,110,598 -	79.3	1,029,577 -	79.4
U.S.S.R.	112,041 -	9.6	220,985 -	15.8	148,656 -	11.5
Korea	41,843 -	3.6	65,775 -	4.7	97,668 -	7.5
Taiwan	1,502 -	0.1	3,227 -	2.3	2,013 -	0.2
Canada	100 -	nil	89 -	nil	0 -	0
Poland	0 -	0	0 -	0	18,283 -	1.4

nations, were not required to purchase permits under the FCMA to operate within U.S. waters. Fees for permitted vessels were based on gross tonnage and allocated catch totals (Table 3.2). Total fees paid by the five foreign nations were $7.77 million, with this amount divided among the nations in the same general proportions as the catch and effort statistics.

3.2.1 Japanese Fishing Activities in 1977

Japan dominates the foreign fishing in the Bering Sea. The 1977 fishing year was typical for the Japanese fishing fleet in the Bering Sea and can be used to illustrate the fishery. The total catch quota for Japan in 1977 was 1.06 million metric tons (2.6 billion pounds), accounting for 77.3 percent of all foreign allocations off Alaska in 1977. Permits issued to Japan included 387 to the Bering Sea - Aleutian Island trawl and herring gillnet fishery, 22 in the sablefish fishery, 43 in the crab fishery, and 17 to the snail pot fishery.

Japan deployed 729 vessels to Alaskan waters during 1977. The largest group of vessels fished for salmon west of 175° W. longitude (Figure 3.3) and included six factory ships and 246 gillnet vessels. Eight additional factory fleets worked in the Bering Sea. Two crab factory ships and 12 crab pot vessels fished north of 58° N. latitude for Tanner crab. One yellowfin sole factory ship and five groundfish factory ships utilized a fleet of 59 pair trawlers, 21 Danish seiners, and 9 dependent stern trawlers. Vessels distributed throughout Alaskan waters included 180 medium and 28 large stern trawlers, 22 longliners, and 88 support vessels. Twenty-three independent crab pot and three snail pot vessels completed the fleet. These vessels were distributed between 58 and 634 vessels per month.

Groundfish: Japanese vessels landed 981,225 metric tons of groundfish in the Bering-Aleutian Island region in 1977. Pollock comprised 77 percent of this total, and landings of pollock, Tanner crab, and salmon each fulfilled more than 98 percent of the quota assigned to them. Only catches of snail, squid, and miscellaneous species filled less than 90 percent of the quota assigned to those fisheries. A total of 40,330 fishing days (110.7 years) and 287 vessels were used by Japan to land the 1977 groundfish catch in the Bering Sea - Aleutian Islands area.

While trawler and longliner efforts are distributed throughout Alaska waters, the factory fleets were limited to the Bering Sea and western Aleutian Islands (Figure 3-2). The yellowfin sole and crab fleets fished the outer edge and flats of the Bering Sea continental shelf, while the groundfish factory fleets worked the 100-fathom curve from Unimak Pass northwest to the U.S. - Soviet 1867 Convention Line. The salmon fleets fished both north and south of the western Aleutians.

In 1977, six factory fleets targeted on pollock and yellowfin sole. These fleets were accompanied by the 59 pair trawlers, 21 Danish seiners, and 9 dependent stern trawlers. Effort exerted by these vessels totaled 13,008 days. The pollock factory fleets located the bulk of their effort to west and northwest of the Pribilof Islands in the general area of the Navarin Basin. The yellowfin sole factory fleet conducted operations on the traditional area on the continental shelf flats southeast of the Pribilof Islands. Factory fleets were present in the Bering Sea in all but February and March and were present in greatest number from May to October.

Independent large and medium stern trawlers made up the largest part of the Japanese groundfish fleet in Alaska and most of the trawl effort exerted by these vessels was spent in the Bering Sea. Like factory ship fleets, groundfish trawlers targeted on pollock and a few trawlers target on yellowfin sole. In 1977, nineteen factory trawlers and 178 medium trawlers fished in the Bering Sea-Aleutian Islands area a total of 26,334 vessel days. The number of trawlers in the Bering Sea ranged from a low of 21 to a high of 191 per month, with concentrations in excess of 140 trawlers per month operating from May to October.

Sablefish Longlining: Japan deployed 22 longline vessels to Alaskan waters in 1977 to catch sablefish. These vessels fished the central Bering Sea, central and eastern Aleutian Islands, the Shumagin Islands, and southeast waters in the Gulf of Alaska. More than 19 vessels fished for sablefish from June to November and at no time were fewer than 11 longliners fishing off Alaska.

Most of the 1977 longliner effort was located in the Gulf of Alaska (62%), with smaller efforts in both the Aleutians (25%), and Bering Sea (13%). Longlining in the southcentral Bering Sea continued much as in past years with a maximum of four vessels present in any month, with only a June-July period devoid of longliner activity. Japan was allocated 22,000 metric tons of sablefish in 1977, with 5600 metric tons allocated for the Bering Sea. These allocations made up 1.5 percent of all allocations made to Japan off Alaska for the year. For this, Japan paid $13.02 per metric ton of allocation, or 4 percent of the total tonnage fees paid by Japan to fish Alaskan waters.

A total of 18,858 metric tons of sablefish was landed by Japanese vessels in Alaskan waters during 1977 with 4,502 metric tons in the Bering Sea - Aleutian Islands region. The Bering Sea - Aleutian area achieved 80 percent of its allocation. Japanese prices for this product ranged from $ .45 to $ .95 per pound. After poundage fees, this represents an approximate worth of the Japanese sablefish fishery at about $27.8 million before expenses, or about $1,500 per metric ton.

The Japanese Crab Fleet: The Japanese crab fleet in 1977 was composed of two motherships and 12 crab pot vessels which fished solely for Tanner crab in the central Bering Sea. An additional 12 independent crab pot vessels also fished in waters west of 175° W. longitude in the central Bering Sea. These vessels were allocated 12,500 metric tons of crab under the Tanner Crab Preliminary Fishery Management Plan (Figure 3.8) and, during their operation in 1977, landed 15.6 million crab for a total catch of 12,471 metric tons (27.5 million lbs.). Independent crab pot vessels accounted for 24 percent of the total crab landed.

Japanese crab vessels fished Bering Sea waters from spring to fall. In 1977, two mothership fleets began fishing Area A on the continental shelf north of Unimak Pass during the second week of March. Both fleets shifted to Area B west of the Pribilof Islands by mid-April, and separated in mid-May when one fleet returned to north of Unimak Pass in Area A to complete its quota. In early June eleven independent crab pot vessels began fishing in Area C of the central Bering Sea and the motherships continued fishing as in May. By mid-July, the mothership fleets reached their catch quota and departed the Bering Sea. The independent crab pot fleet reduced to five vessels by early August. By late August, only one vessel remained and it departed in mid-October.

Salmon: Japan conducted the 1977-1979 high seas salmon fishery west of 175° W. longitude in the waters north and south of the western Aleutian Islands in or near the proposed Navarin Basin lease area. The size and scope of the fishery is determined by two dominating forces. These are the INPFC and the Japan-Soviet agreements for high seas salmon that exclude the Japanese salmon fleet from fishing within the Soviet 200 mile fishery zone, while imposing specific time, area, and catch limitations in other waters (Figure 3.9).

The 1977 salmon fleet was composed of 6 factory processing ships and 246 gillnet catcher vessels. The salmon fishery season extended over a 2-month period compared to 3 months in 1976. During that time, the six fleets expended 14,615 vessel days, over 19 percent of the total foreign effort off Alaska by all nations in 1977.

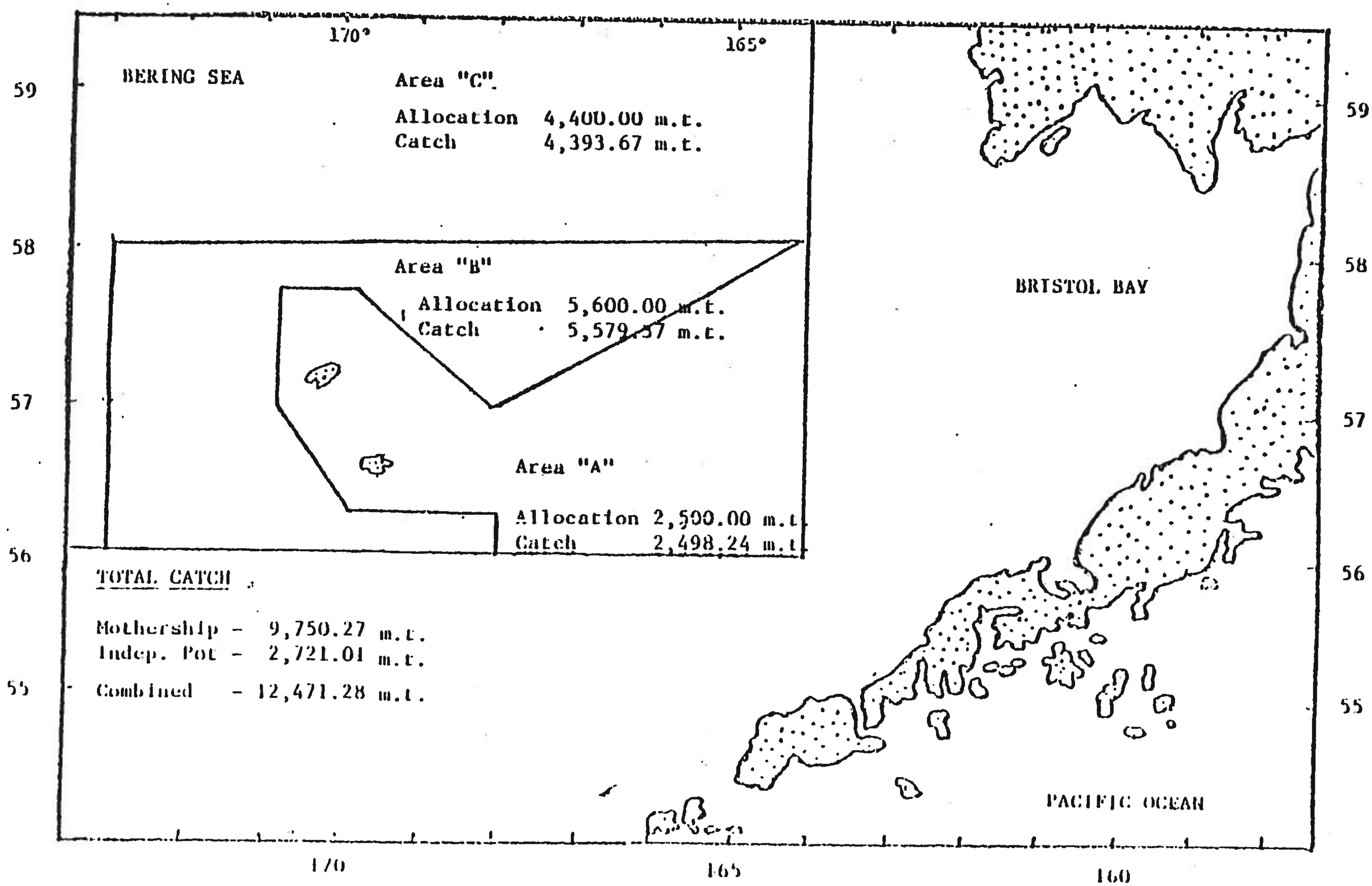


Figure 3.8 JAPANESE TANNER CRAB FISHING AREAS AND RESTRICTIONS - 1977

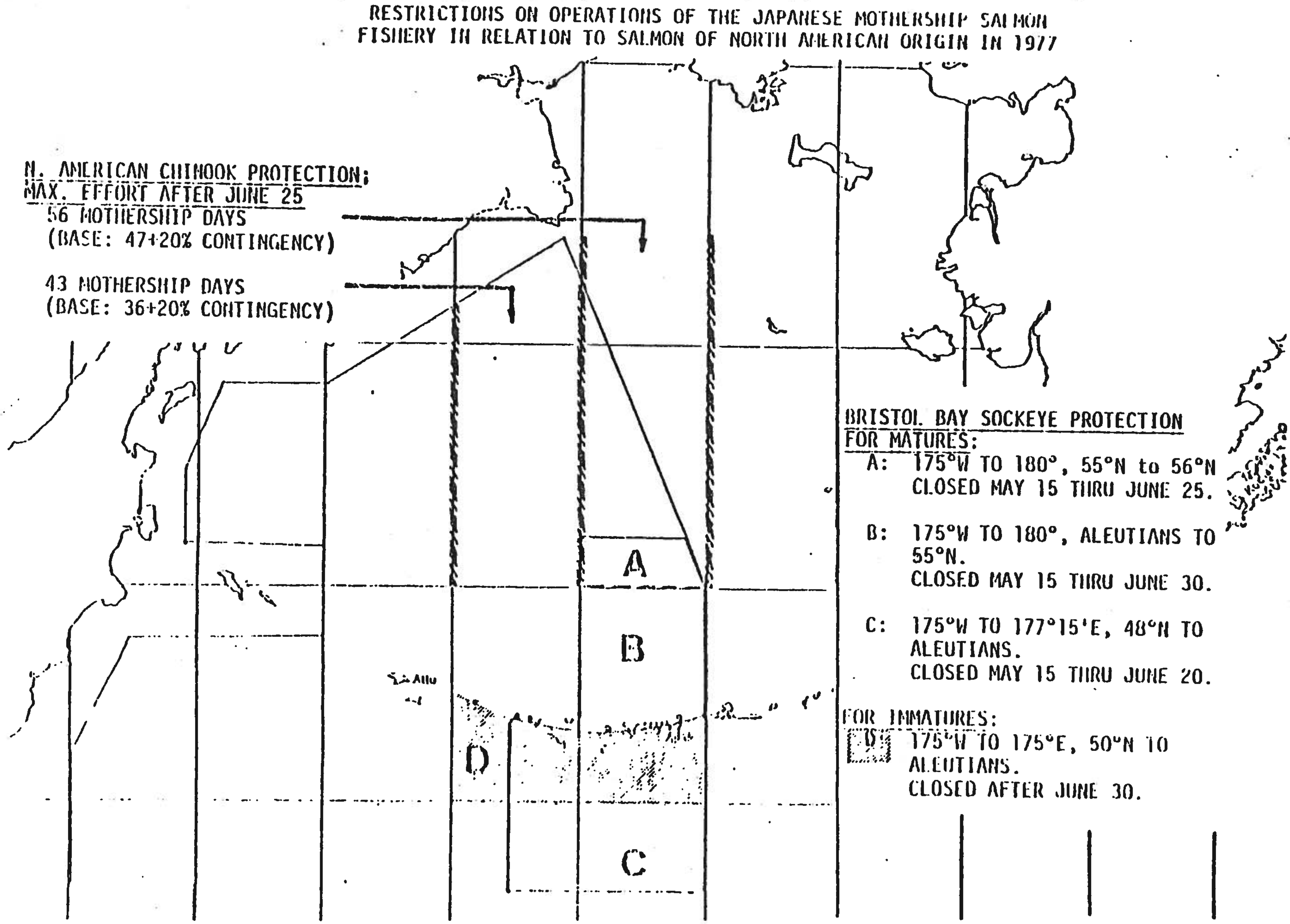


Figure 3.9 - Japanese Salmon Mothership Restrictions - 1977

The fleets began fishing in June south of the western Aleutians until late June when one fleet moved to the Bering Sea. Five fleets fished the central Bering Sea during July while one fleet remained south of the western Aleutians. The six fleets completed operations at the end of July and then returned to Japan.

Alaskan waters produced a salmon catch by the Japanese fleets in 1977 of 23,957 metric tons. The 1977 landings included interception of an estimated 1,007,000 red salmon destined for Bristol Bay (see Section 4.5.1.1). This was divided 779,000 mature and 228,000 immature salmon.

Snail Fishery: Japan deployed three snail pot vessels in 1977 which operated in the central Bering Sea northwest of the Pribilof Islands from June until mid-October. The vessels harvested 404 metric tons of edible meat from a 2,700 metric ton quota. This catch was a 73 percent reduction from 1976 levels although the 2,700 metric tons quota allowed for an 80 percent increase from 1976 catch levels.

3.2.2 Soviet Fishing Activities

In 1980 the Soviet Union was prohibited from fishing in the U.S. Bering Sea - Aleutian Islands Fishery Conservation Zone. Prior to 1980, the Soviet Union typically deployed the second largest foreign fleet to Alaskan waters. In 1977 a total of 297 Soviet vessels operated off Alaska, exerting 7,373 vessel days (20.2 years). These vessels operated throughout Alaska landing predominantly pollock, with secondary catches of herring in the Bering Sea and Atka mackerel in the Gulf of Alaska. Only forty-nine percent of the total 372,600 metric ton quota was landed, comprising a 12 percent share of the foreign landings off Alaska for the year. The fishing effort was 70 percent in the Bering Sea-Aleutian Island area.

Permit fees paid by the Soviet Union for fishing within Alaska's Fishery Conservation Zone totaled in excess of $1.03 million for both vessel gross tonnage and total allocation tonnage by species assigned. The Soviet Union deployed a fleet tonnage of approximately 402,000 tons, or 52 percent of the total foreign vessel tonnage off Alaska in 1977. For this, a vessel tonnage of approximately $296,000 was paid. The 372,600 mt catch quota fee totaled $737,689, or $1.08 per ton landed.

The Bering Sea-Aleutian Island region was the most productive for the Soviets, and provided 65 percent of the total Soviet Alaskan catch. The total allocation of 264,000 metric tons was 45 percent completed by the end of the year.

During 1977, the Soviet Union fished in the Bering Sea-Aleutian Island area in every month but August. The most concentrated effort was in January and February when up to 39 trawlers were joined by 4 factory ships targeting on pollock in the central Bering Sea, but landing a large incidental herring catch. By March 1, the onset of the FCMA, the factory fleets had departed and the effort became divided between the central Bering shelf and the Aleutian Island chain. All areas continued to decrease in effort until August when no vessels fished in either the Bering Sea or Aleutian Islands. In late September, the pollock fishery was resumed in the central Bering Sea and, by October, 18 trawlers were again targeting on pollock and herring. This trawler effort remained constant through year end.

3.2.3 South Korean Fishing Activities

The Republic of South Korea ranks third in foreign fishing effort in the Bering Sea. Twenty-nine different South Korean vessels operated off Alaska in 1977, with a maximum of 21 vessels during any one month. These vessels fished 1,702 vessel days (4.7 years). Catch fees of $385,584 were paid to land a catch valued at $9.3 million.

South Korea conducted its 1977 groundfish fishery with independent stern trawlers. The Bering Sea-Aleutian Island region had the most activity. Ten large stern trawlers supported by two refrigerated transports operated in the Bering Sea trawl fishery in 1977. The vessels fished primarily in the eastern Bering Sea between Unimak Pass and the Pribilof Islands. They began operations in June and continued throughout the remainder of 1977. South Korea was given an allocation of 43,090 metric tons of groundfish in the Bering Sea and Aleutian Island trawl fishery in 1977. South Korea vessels harvested 47,693 metric tons, which was almost exclusively pollock and 110 percent of the area allocation.

3.2.4 Taiwanese Fishing Activities

Taiwan has dispatched both trawl and longline vessels to Alaskan waters since joining the fishery in 1974, with efforts divided between the Gulf of Alaska and Bering Sea. Four stern trawlers and one longliner made up the Taiwanese fleet in 1977, an increase of one stern trawler and reduction of two longliners over 1976. These vessels fished 146 vessel days (0.4 years).

From mid-May through June, one stern trawler initiated Taiwan's 1977 pollock fishery by commensing fishing in the central Bering Sea - Navarin Basin area. This vessel departed in July. One stern trawler returned to fish north of Unimak Pass in August and was later replaced by another stern trawler which fished until late September. Again in November, one trawler arrived for a limited time prior to departing Alaskan waters north of Unimak Pass.

A total of 5,510 metric tons of pollock, sablefish, and miscellaneous species was allocated to Taiwan. All of these allocations were in the Bering Sea - Aleutian Island area and were divided: pollock - 5,000 mt; sablefish - 200 mt; and miscellaneous species - 310 mt. For these, Taiwan paid fees amounting to $4,264, an average $3.87 per metric ton. An additional $4,772 for gross tonnage fees was also assessed. Total Taiwanese allocations amounted to 0.4 percent of total allocations to all foreign vessels off Alaska in 1977.

The actual catch landed was far below allocated amounts. The total 1977 catch by Taiwan, including a brief longline fishery in the southeast prior to March 1 and a minimal stern trawler effort in the Bering Sea before the onset of FCMA, was 1,101 metric tons, valued at $120,000. This was 20 percent of the allocation assigned to Taiwan.

3.3 Commercial Fishing in Navarin Basin

The proposed oil and gas lease in Navarin Basin is located in an area of highly productive fisheries and intensive foreign fishing activity. Under the Fishery Conservation and Management Act of 1976, five nations are permitted to conduct a fishery in these waters. These nations send a variety of vessels to the region and conduct several types of fishing operations (Table 3.6). The number of vessels operating in the area varied seasonally from as low as 62 to over 200 in any one month in 1978 and 1979 (Table 3.7).

Within the Navarin Basin area there is an extensive trawling activity along the shelf break for groundfish, principally pollock. The stern trawl factory fleet from Japan annually fishes in this area year-round. A Soviet factory fleet fished there in 1977 but did not return in 1978 or 1979. Independent trawlers from Japan, U.S.S.R., Korea, and Taiwan also come to the area to harvest pollock and other groundfish (See Figure 3.2-3.7).

The Navarin Basin area is also a principal fishing area for a number of important non-groundfish species. The Japanese conduct their high-seas salmon gillnet fishery in and near the area. Factory fleets from Japan fish the area for the Tanner crabs, and independent pot vessels harvest Tanner crabs and snails there. Longliners from Japan and South Korea fish the southeast corner of the area for sablefish, and prior to 1979 the Soviets conducted an independent trawl fishery there during the winter for herring.

The area is the center of the highly productive pollock fishery in the Bering Sea, and is a principal fishing area within the Bering Sea for several other groundfish - i.e. Pacific cod, Greenland turbot, and other flounders. From 24% to 38% of all groundfish taken in U.S. waters of the Bering Sea in 1977-79 come from the Navarin Basin area (Table 3.8), including from 29% to over 42% of the entire catch of pollock in the Bering Sea.

Several non-groundfish species of commercial importance were traditionally fished for by foreign fleets in the central Bering Sea during the 1960's and 1970's. While foreign fishing for these species was prohibited in certain areas (Figure 3.10), primarily those closest to the Alaska shores, harvestable stocks of these species were allowed under earlier FCMA allocations to foreign fleets in the more distant Alaska waters. The allocation amounts (Table 3.9) were determined based on the estimated optimum yield of the species and the estimated U.S. fishery harvest capacity for the resource. Any surplus or reserve of the resource was allocated to foreign fisheries.

Table 3.6. List of Fishing Activities by Nation and Type of Fleet in Navarin Basin in 1978, 1979.

NATION	TYPE OF FLEET	TARGET SPECIES	SEASON	NO. VESSELS/MO.
Japan	Longliners	Sablefish	All year	0-8
	Crab Factory Fleets	Tanner crab	Feb-Sept	0-15
	Independent Crab/Snail Pot	Tanner crab Marine Snails	Apr-Oct	0-17
	Salmon Factory Fleets	Salmon	June-July	0-6
	Salmon Gillnetters	Salmon	June-July	0-242
	Factory Trawl Fleet	Pollock	All year	2-93
	Independent Trawl	Pollock	All year	23-99
	Total Vessels[2]			31-203
USSR	Factory Trawl Fleet	Pollock	Jan-Feb	2-4
	Independent Trawl	Pollock	All year	1-34
	Total Vessels[2]			1-36
Korea	Independent Trawl	Pollock	All year	3-8
	Longliner	Sablefish	June-Oct	
	Total Vessels[2]			1-15
Taiwan	Independent Trawl	Pollock	All year	0-3
Poland	Independent Trawl	Pollock		0-5
			Total Vessels:	62-211

1 - excluding salmon fleet

2 - including support vessels not enumerated

Table 3.7. Foreign Fishing Activity by Number of Fishing Vessels[1] in Navarin Basin (Area 52) by Month, 1978-79.

	J	F	M	A	M	J	J	A	S	O	N	D
						1978						
Japan	52	94	100	153	197	203	172	180	174	146	11	40
Korea	0	3	5	6	9	7	4	4	4	4	5	9
Taiwan	0	1	1	2	1	0	1	0	0	1	1	2
USSR	36	34	34	5	2	1	2	8	22	33	25	25
Total	88	132	140	166	209	211	179	192	200	184	142	76
						1979						
Japan	78	125	134	121	155	188	156	128	116	105	72	31
Korea	12	13	14	12	15	6	4	1	5	6	5	12
Taiwan	3	2	2	1	1	0	2	0	0	0	0	0
USSR	20	33	34	17	2	5	5	8	14	27	33	19
Poland	0	0	2	3	5	4	0	0	0	0	0	0
Total	113	177	186	154	178	203	167	137	135	138	110	62

[1] Excluding high-seas salmon fleets

Table 3.8. Foreign Groundfish Catches (mt) in Proposed Navarin Basin Oil and Gas Leasing Area Compared to Total Bering Sea Catch in U.S. Waters.

	1977			1978			1979		
	Navarin	All Bering	%	Navarin	All Bering	%	Navarin	All Bering	%
Pollock	367,445	886,222	41.5	385,588	943,165	40.9	268,808	923,254	29.1
Pacific Cod	11,407	36,463	31.3	16,418	45,473	36.1	7,360	38,083	19.3
Yellowfin Sole	3,003	58,524	5.1	4,974	112,918	4.4	2,421	100,327	2.4
Turbots	2,190	8,056	27.2	2,256	7,315	30.8	1,581	11,519	13.7
Other Flounder	19,099	56,956	33.5	33,849	114,198	29.6	18,520	79,406	23.3
Sablefish	593	4,608	12.9	241	1,770	13.6	69	2,009	3.4
Atka Mackerel	13	21,763	0.1	358	23,948	1.5	171	22,947	0.7
Ocean Perch	867	8,855	9.8	967	1,414	13.0	319	7,188	4.4
Rockfish	2,273	12,700	17.9	1,294	8,214	15.8	1,608	15,602	10.3
Others	18,999	52,313	36.3	27,968	69,966	40.0	18,401	58,643	31.4
Total	442,744	1,164,236	38.8	481,986	1,342,388	35.9	325,626	1,265,130	25.7

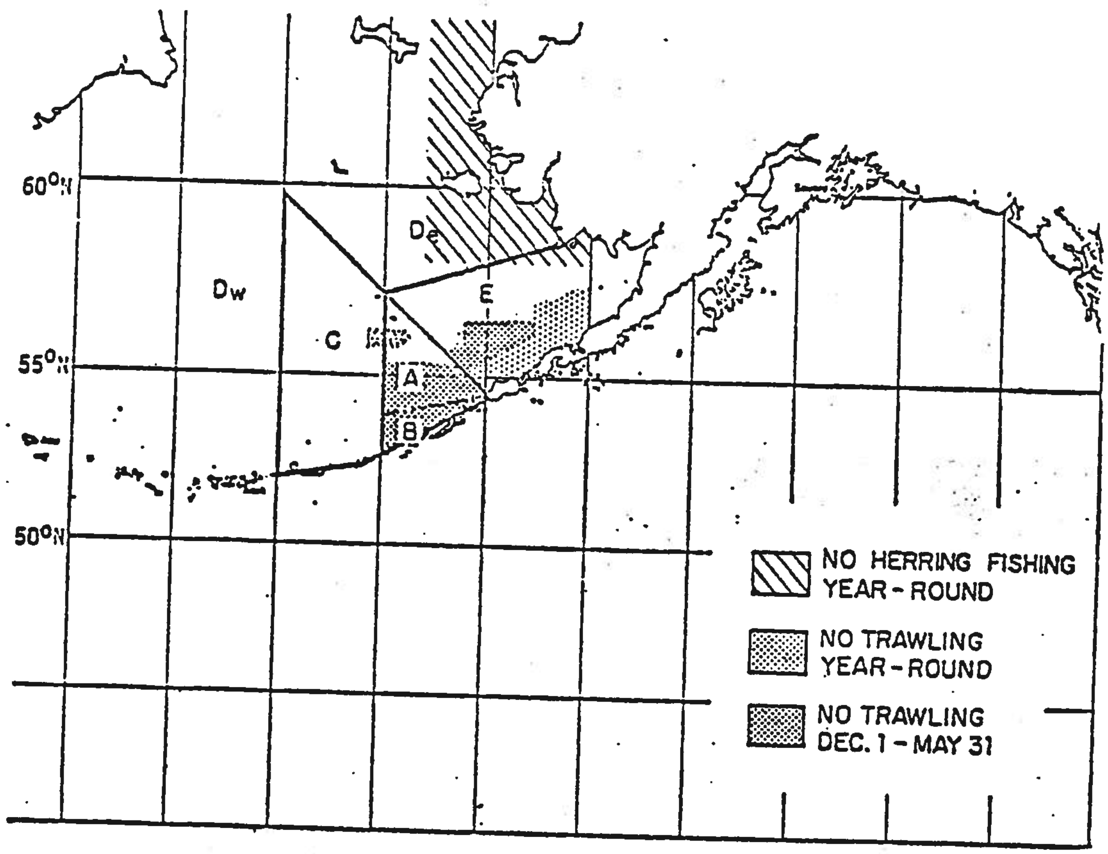


Figure 3.10 - Time-area closures pertaining to foreign fishing in the Bering Sea. Area descriptions are INPFC (International North Pacific Fisheries Commission) Halibut Conservation Areas.

Table 3.9. Summary of optimum yields (OY), projected U.S. capacities, and total allowable levels of foreign fishing in 1977[1/] in the Bering Sea and Aleutians.

	Bering Sea and Aleutians		
	OY	US	Foreign
Rockfish	21,500	0	21,500
Sablefish	7,400	0	7,400
Flounders	211,000	0	211,000
Halibut	2/	2/	0
Cod	58,000	0	58,000
Pollock	950,000	0	950,000
Atka mackerel	-	-	-
Hake	-	-	-
Jack mackerel	-	-	-
Herring	21,000	1,000	20,000
Squid	10,000	0	10,000
Other finfish	93,600	0	93,600
King crab	37,200	37,200	0
Tanner crab	37,400	24,900	12,500
Snails	2,700[3/]	0	3,000
Shrimp	0	0	0

1/ All values in metric tons

2/ To be set by International Pacific Halibut Commission

3/ Edible meats

Since 1979, there have been prohibitions placed on foreign fleets from taking halibut, herring, salmon, Tanner and king crabs. Nevertheless, a significant number of these species are taken as a by-catch of trawling for pollock and other demersal fish. The Navarin Basin area is a major area of these by-catches within the Bering Sea. Table 3.10 presents 1977-79 takes of these prohibited species in the Navarin area and compares them to the total Bering Sea by-catch for each species by the foreign fisheries. The Navarin Basin area accounted for 45-66% of the foreign by-catch of king crabs in the Bering Sea, 27-37% of the Tanner crab by-catch, 27-70% of the salmon by-catch, and 93-98% of all incidental herring harvests by foreign fleets.

By far the greatest fishing effort in the Navarin Basin area is by the Japanese fleet, which takes 76 to 82 percent of the pollock catch, and from 77 to 100 percent of all other groundfish (Table 3.11).

Table 3.10 - Estimated By-Catch of Prohibited Species by Foreign Fleets in Navarin Basin Area and Total Bering Sea, 1977-79.

	Harvest (mt or No.)		% from	% of Navarin Catch by Nation			
	Navarin	Bering Sea	Navarin	Japan	Korea	Taiwan	USSR
Halibut (mt)							
1977	614	2,232	26.4	99.5	nil	nil	0.4
1978	1,120	3,686	30.3	96.8	0.7	nil	2.5
1979	279	3,238	8.6	94.5	3.7	0	2.0
King Crab (No.)							
1977	522,929	1,034,246	50.6	99.9	nil	nil	nil
1978	1,767,025	2,675,350	66.0	100	0	nil	nil
1979	523,189	1,162,949	45.0	99.9	nil	nil	0.1
Tanner Crab (No.)							
1977	6,647,308	17,857,056	37.2	99.3	0.1	nil	0.5
1978	5,911,654	19,117,612	30.9	97.1	2.7	nil	0.1
1979	4,941,861	18,269,582	27.0	94.2	2.8	nil	3.0
Salmon (No.)							
1977	13,930	51,171	27.2	75.0	15.5	nil	9.5
1978	30,950	44,288	69.9	93.0	0	0.1	6.9
1979	41,480	110,473	37.5	73.0	18.2	0	8.8
Herring (mt)							
1977	16,933	18,162	93.2	22.4	0	0	77.5
1978	8,193	8,397	97.6	25.4	0.1	0	74.5
1979	6,371	6,547	97.3	20.7	1.0	0	78.3

Table 3.11. Groundfish Catch Percentage by Foreign Nations in the Proposed Navarin Basin Oil and Gas Leasing Area, 1977-79.

Fishery	Japan	Korea	Taiwan	U.S.S.R.
Pollock	76.3-82.1	1.3-7.6	nil	16.0-21.6
Pacific Cod	96.2-99.2	0-3.8	0-nil	nil-0.8
Yellowfin Sole	94.7-100	0-5.2	0	0-0.1
Turbots	100	0	0	0
Other Flounders	98.7-99.4	0-1.3	0-nil	0-1.0
Sablefish	79.3-99.0	0-20.7	0-1.0	0
Atka Mackerel	76.6-100	0-22.8	0	0-0.6
Pacific Ocean Perch	89.3-97.8	2.2-10.7	0	0
Rockfish	99.1-100	0-nil	0	0-0.9
Other	88.9-97.7	0.7-6.6	0	0.1-4.5
Total Groundfish	78.0-81.9	1.2-6.9	nil	15.0-18.7

4 THE FISHERIES RESOURCE

Fisheries resources, when properly managed, are renewable and inexhaustible - unlike oil and gas, which is a nonrenewable resource. The time-frame of utilization of these non-complementary resources cannot be compared. When the oil resource has been depleted, after an estimated 20-25 year life of the field, the fishery resource can continue to provide nutritional, economic, and social benefits.

In 1979, U.S. and foreign fisheries harvested about 1.7 million mt of crab, salmon, halibut, sablefish, herring and bottomfish worth over $400 million from U.S. waters in the Bering Sea. About 90 percent of this harvest now consists of demersal fish that provide a year-round fishery for foreign fleets. By the year 1990, it is estimated that harvest of. fishery resources in the Bering Sea will increase by about 200 thousand mt; much of the entire harvest will then be taken by U.S. fisheries. By the year 2000, it is anticipated that U.S. fisheries will replace all foreign fisheries in the U.S. Fisheries Conservation Zone (FCZ) of the Bering Sea. In addition to the size and value of the fishery resources themselves, it is important to keep in mind the other facets of the commercial fishing industry that benefit the economy, such as employment, fishing vessels, processing facilities, and infrastructure developments.

4.1 General Distribution of Commercial Species

OCSEAP/BLM - supported research vessel surveys (Figure 4.1) conducted by NMFS in August-October, 1975 and April-June, 1976 provided valuable biological information on demersal resources of the Bering Sea during the seasonal extremes of their distribution (Pereyra et al. 1976, Bakkala and Smith 1978). Results of these surveys demonstrated that the distributions of all commercially important species of demersal fish shift to deeper water in the winter and spring.

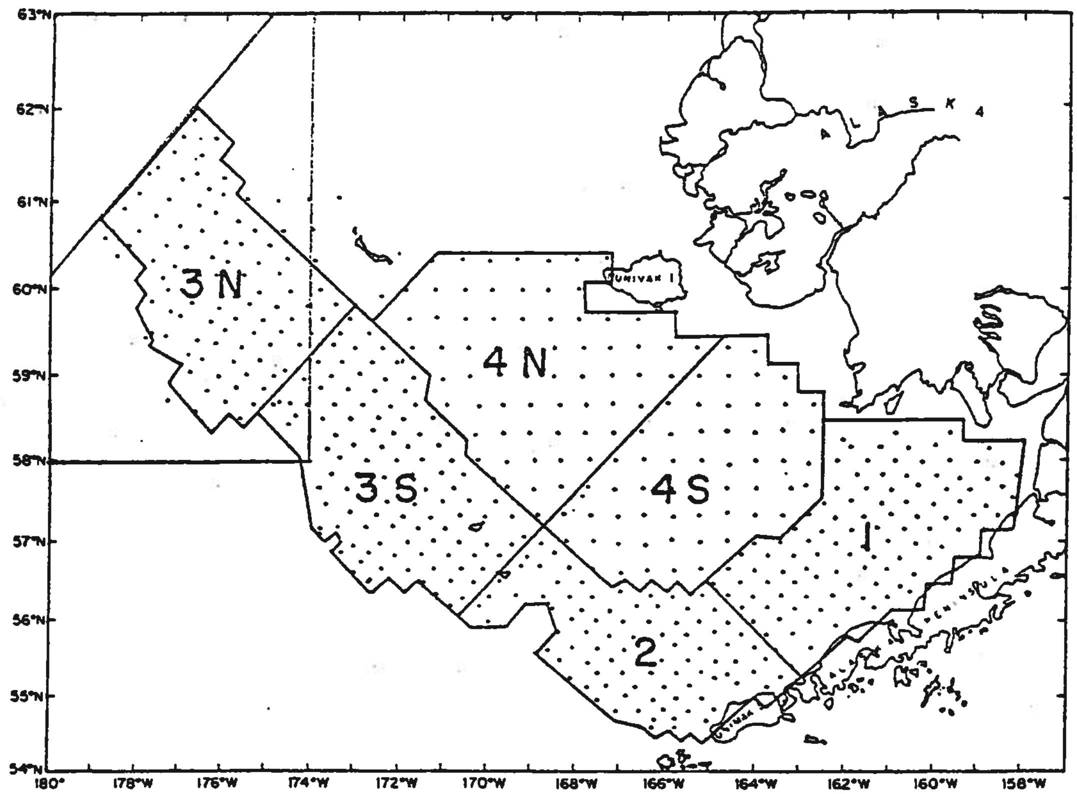


Figure 4.1-- The area of the Bering Sea surveyed during the NMFS multi-vessel trawl survey, August-October 1975, and April-June 1976. Also shown are subareas within the survey area.

These movements are most extensive for species that occupy the inner shelf region during the summer, such as yellowfin sole, rock sole, Alaska plaice, and Pacific halibut. Because of these offshore movements and some southward movements, the abundance of commercially important demersal fish is higher in the central Bering Sea area in winter and spring than in summer.

It is important to emphasize that these fishery resource surveys are recognized to have inadequately sampled some of the commercially important demersal species. The biomass of walleye pollock and Pacific cod was underestimated by the surveys because a large proportion of these populations was either above the trawling depth or distributed on the continental slope or outside the survey area. As discussed below, this was a major problem for pollock during the 1976 spring OCSEAP survey. In addition, some other fish (e.g., Greenland turbot, arrowtooth flounder, rockfish, and sablefish) were poorly sampled because of their location on the continental slope at depths not surveyed. Detailed results and problems encountered during the surveys are given in Pereyra et al. (1976) and Bakkala and Smith (1978).

The distributions of king and Tanner crab do not shift seasonally as extensively as some of the demersal fish. Most of the blue king crab were distributed in the vicinity of the Pribilof Islands and to the northwest in both summer 1975 and spring 1976. Major concentrations of opilio Tanner crab were located in the Navarin area during both surveys, while bairdi Tanner crab occurred mainly to the southeast.

Of special concern is the now depleted Pacific halibut resource of the central and eastern Bering Sea. Major halibut fishing grounds are located in the central Bering Sea, and possible halibut spawning areas are found there as well.

4.2 General Biomass Estimates

The biomass of species and ecological groups vary from one region of the Bering Sea to the other. There is a considerable biomass of pollock over deep water off the continental slope in the central and eastern Bering Sea. This pollock biomass is pelagic and subsists mainly on euphausiids and on their own offspring (cannibalism). This deep water biomass is also a source for the pollock biomass of the continental shelf where it is removed by the commercial fishery and by marine mammal predation. However, it is consistently underrepresented in resource surveys of the abundance of commercial fish.

Because of the seasonal offshore movements, the proportion of the overall biomass estimated by OCSEAP surveys to occur within the central Bering region was higher in spring 1976 than in summer 1975 for almost all species. The biomass of pollock was severely underestimated by the survey (Bakkala and Smith 1978). More recent efforts conducted jointly by U.S. and Japanese researchers in 1979 using improved sampling techniques (Tables 4.1 and 4.2) have increased the estimated biomass levels of many species in the Bering Sea.

Table 4.1 - Biomass estimates (mt) in the Bering Sea from Japanese and U.S. research vessels during the 1979 cooperative survey from common areas fished by vessels of each country.

Species	Continental shelf Japan	Continental shelf U.S.	Continental slope Japan	Continental slope U.S.
Pollock	3,090,417	2,687,594	87,725	54,682
Pacific cod	396,763	510,981	11,126	46,660
Pacific ocean perch	81	4,884	4,474	5,430
Other rockfish	65	318	4,157	3,987
Sablefish	28,673	39,258	6,096	1,980
Yellowfin sole	1,281,177	1,308,103	0	0
Rock sole	55,544	66,095	62	581
Flathead sole	101,565	110,311	2,929	1,641
Alaska plaice	185,215	280,576	0	0
Greenland turbot	166,876	210,288	86,131	30,955
Arrowtooth flounder	21,713	31,571	33,612	9,398
Pacific halibut	21,769	23,921	2,536	213
Herring	37,686	10,892	8	0
Sculpins	265,825	351,876	16,916	4,993
Eelpouts	374,528	673,954	2,318	511
Skates	14,902	69,257	4,140	1,511
Other fish	68,275	116,205	8,009	10,439
Squid	724	296	16,449	587
Octopus	5,044	69,509	953	694
Shrimp	2,188	21,823	748	574
Total	6,119,030	6,587,712	288,389	174,836

Table 4.2 - Biomass estimates (mt) of demersal fish taken during the comprehensive surveys of the eastern Bering Sea continental shelf in 1975 and 1979 by NWAFC research vessels.

Species	1975	1979
Pollock	2,426,400	2,876,500
Pacific cod	64,500	734,600
Yellowfin sole	1,038,600	1,907,700
Rock sole	170,300	182,800
Flathead sole	113,000	101,800
Alaska plaice	127,300	283,000
Greenland turbot	126,700	143,300
Arrowtooth flounder	28,000	42,000
Pacific halibut	30,600	64,200
Sculpins	122,500	269,200
Eelpouts	98,600	360,800
Poachers	12,800	28,200
Skates	42,000	74,000
Other fish	133,700	193,700
Total	4,535,000	7,261,800

Recent ecosystem modeling (Laevastu and Livingston, 1980) has estimated that the total finfish biomass on the central and eastern Bering Sea shelf is 36 tons/km2. Over the deep water in the central Bering Sea the standing stock of finfish is 30 tons/km^2, of which 21 tons are pollock.

4.3 Spawning and Nursery Areas

The spawning and nursery areas of only a few demersal fish and shellfish populations in the central Bering Sea are known. Extensive and intensive ichthyoplankton and trawl surveys are needed to locate major regions of egg and larvae release of spawning fish. Timing of the surveys is critical since reproduction occurs only once each year and is intense for only a short period of time, perhaps less than two months. Complicating the problem is variability from year to year in the exact location and months of major spawning in response to temperature variability and because the eggs and larvae of most species are pelagic and may be transported some distance from the spawning site when sampled.

The outer shelf and slope of the central Bering is an important spawning area for pollock, and a major proportion of the spawning population may inhabit this region in the spring. These spawning concentrations were not detected by bottom trawls during the 1976 OCSEAP survey, either because they move off the bottom for spawning or because they were located off the shelf in waters not surveyed. Results of other studies indicate that major spawning areas for pollock lie along two areas of the outer continental shelf: between the Pribilof Islands and Unimak Pass, and to the north and northwest of the Pribilof Islands.

Several species are known to spawn on the continental slope of the Bering Sea during winter months. These are sablefish, Pacific halibut, Greenland halibut, and arrowtooth flounder. Spawning locations are not well defined for these species. For Pacific halibut, the slope region south of the Pribilof Islands is thought to be an important site for spawning.

The spawning of several flounders (yellowfin sole, rock sole, flathead sole, and Alaska plaice) is confined to eastern Bering Sea shelf waters. Ichthyoplankton survey results suggest that yellowfin sole spawn over an extensive area of the inner shelf of Bristol Bay during the summer months, although the precise location can vary from year to year. Rock sole and flathead sole spawn at intermediate and outer shelf depths. Rock sole is unusual among most Bering Sea flounders in depositing demersal eggs.

In order to evaluate properly the specific importance of any region to the reproduction of fishes of the central Bering Sea, several facets of their life history require further research. The overall season and areas of spawning, larval drift, and nursery areas must be related to the proportion of the population using the area for these purposes. Most of this information is not available. Fish larvae of 21 taxa (identification to species is not possible at present for many larvae taken in the area) have been reported to be common in the ichthyoplankton of the eastern Bering Sea.

The geographic distribution of planktonic eggs of pollock in the eastern Bering Sea is relatively well known, because several studies have addressed this problem. Pollock eggs and larvae are in the plankton in spring and early summer. In each of 5 years studied intensively, the area of major abundance was in or near the St. George and Navarin Basins during March-May.

Knowledge of the distribution of juvenile fish and shellfish during their first year of life is also fragmentary. After the pelagic stage, the settling of the young of several flounder species (Pacific halibut, yellowfin sole, rock sole, and others) and king crab takes place in shallow waters of the shelf. As the young of most fish species further mature, they move into deeper water. This migratory behavior is reflected, frequently, in the finding of a mixture of old and young fish in shelf waters but mostly older fish in deeper water.

Most shelf waters of the eastern Bering Sea support developing juveniles. The southeastern region is most important for the young of Pacific halibut, yellowfin sole, rock sole, and red king crab. Considerable numbers of 1 year-old pollock were found during the 1975 survey from outer shelf depths west and northwest of the Pribilof Islands, where they made up 81 percent of the estimated number of pollock for that subarea. The importance of the central Bering Sea for the larvae and juveniles of other commercially important species is not well known.

4.4 The Demersal Fishery Resource

The demersal fish assemblage of the Bering Sea Shelf is dominated by cod-like fishes (Figure 4.2). By far the largest component of this group is walleye pollock; most of the remainder are Pacific cod. The next most important component of the demersal fish is the flounder. In the southeastern Bering Sea, this group is dominated by the yellowfin sole, but in the central Bering area other flounders such as the Greenland turbot, flathead sole, and Alaska plaice gain prominence. Halibut are probably at the northern limit of their range on the central Bering shelf, and are less abundant here than farther to the southeast from Bristol Bay to Nunivak Island. Abundant non-commercial bottomfish consist mainly of sculpins, eelpouts, skates, and poachers.

Crab in the central Bering Sea shelf area are third in abundance to the codlike fishes and flounders. This group is primarily represented by the commercially important Tanner crabs. The other most common invertebrates are starfish, snails, sea squirts (ascidians), and sponges.

The relative abundance of benthic fish and invertebrates in the continental shelf of the proposed Navarin Basin lease sale area (subarea 3) compared to other regions of the Bering Sea is shown in Figure 4.3. In the outer shelf areas (subareas 2 and 3) pollock constituted the main biomass component, with highest abundance in the Pribilof- Aleutians region (subarea 2). Greenland turbot was the abundant flounder of subarea 3. Total demersal fish biomass in the Navarin area averaged over 150 kg/km trawled.

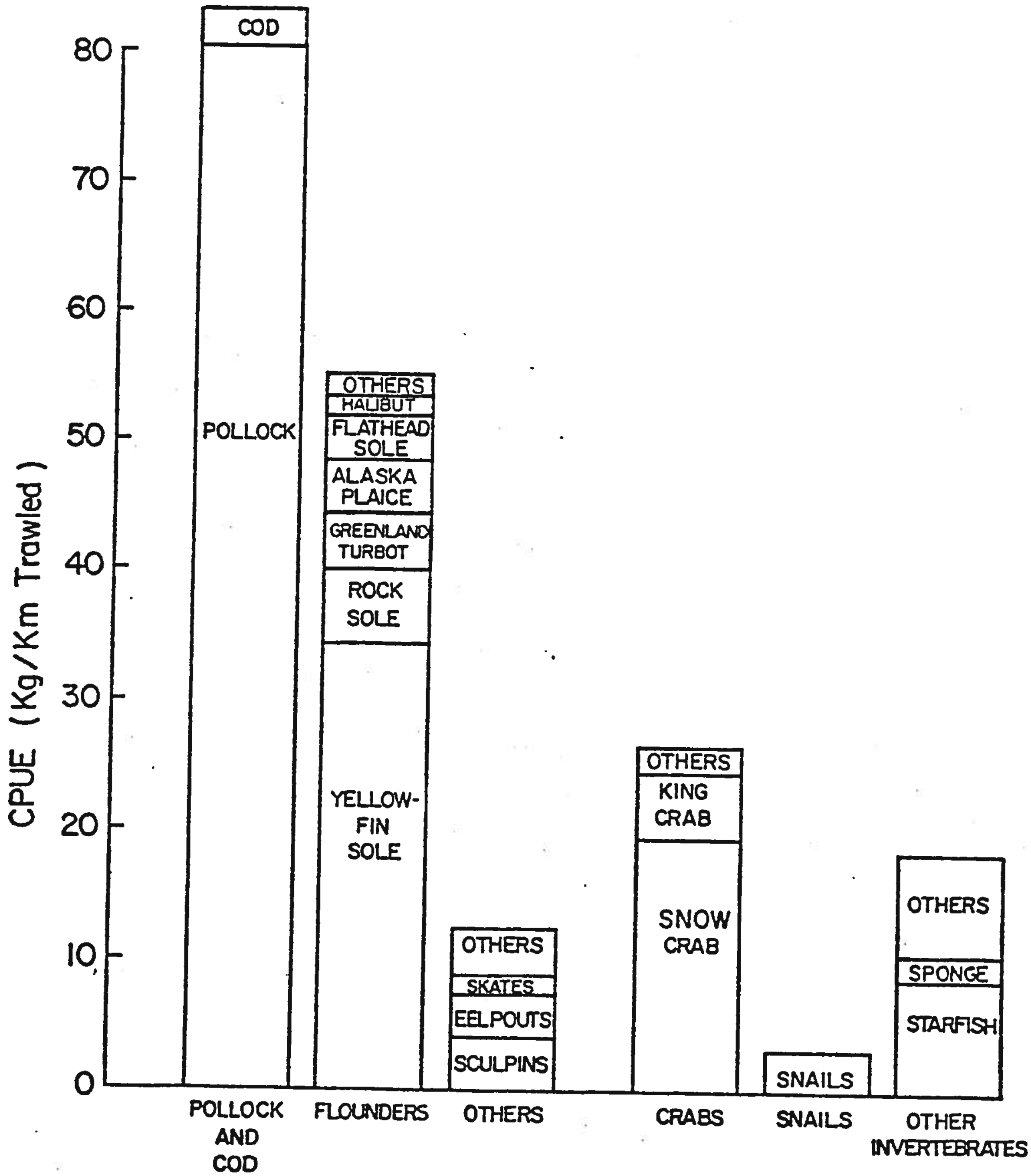


Figure 4.2--Relative importance of major groups of fish and invertebrates and of species or species groups within these major categories as shown by average CPUE values in the Bering Sea survey area.

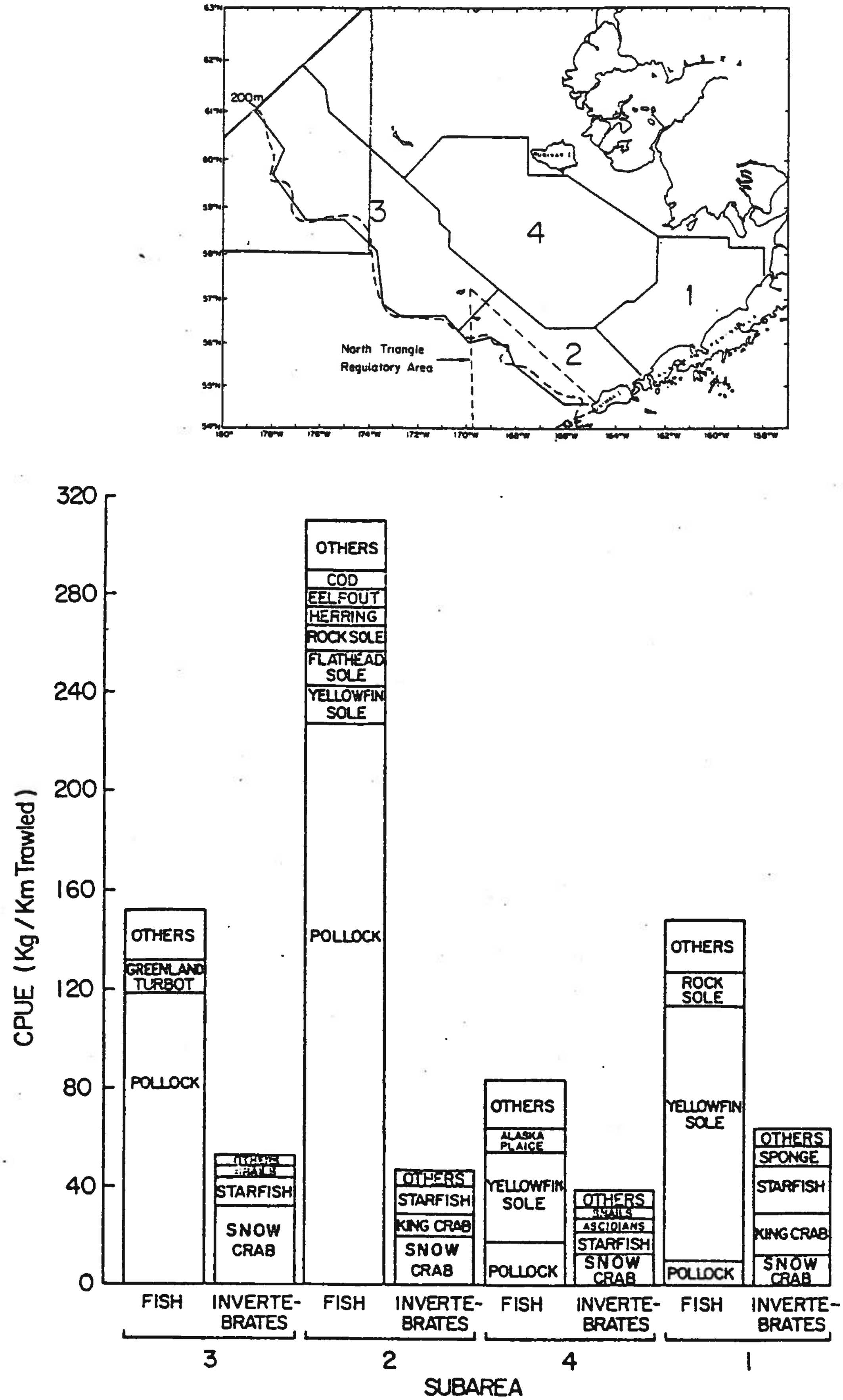


Figure 4.3 -- Relative importance of fish and invertebrates and species or species groups within these categories by survey subareas in the Bering Sea as shown by average CPUE values.

The total abundance of invertebrates does not differ significantly across the Bering Sea shelf. Tanner crab are the most abundant invertebrate in subarea 3, followed by starfish, snails, and other invertebrates. Total invertebrate biomass in the subarea 3 has been surveyed at over 50 kg/km trawled.

The most frequently encountered (and most abundant) species of demersal fish during NMFS surveys in the Navarin Basin (subarea 3) area were generally those also most important in the catches of the foreign fishing fleets. The average catch of these fish (kg/half-hour trawl) in subarea 3 were as follows: walleye pollock-469, Greenland turbot-69, Pacific cod-28, flathead sole-23, rock sole-8, and yellowfin sole-3.

Most of the important demersal populations of the eastern and central Bering Sea are either fully exploited or overfished (Table 4.3). The two most abundant species, walleye pollock and yellowfin sole, have been overfished. Other overfished stocks are the Pacific ocean perch, sablefish, and shrimp stocks. On the other hand, Tanner crab are abundant at this time and offer the potential for greater harvests.

Where in earlier years, the United States had agreements with foreign governments to control resource use in Alaska waters of the Bering Sea by means of catch quotas, area closures, and gear restrictions, under new legislation establishing extended fisheries jurisdiction (Public Law 94-265), the United States has developed a more rational scheme of resource management in offshore waters - a scheme which includes a standard system of reporting fishery statistics and related data. This accurate and consistent manner of reporting catch and effort by species and area, together with biological information on size and age, is allowing better estimates of the relative abundance of year classes. This improved information is aimed at enabling improved stock conservation and better regulation of fishing effort towards optimum sustained yields.

The following subsections provide brief discussions of the biology of the individual fish species of commercial importance as well as some details on their exploitation by the fishing industry. A summary of this information is given in Table 4.4.

Table 4.3 Condition of groundfish stocks in the Bering Sea off Alaska.

Region	Species group	Condition[1]	EY[2] (mt)	1980 Expected U.S. harvest (mt)[3]
Bering Sea & Aleutians	Pollock	Healthy	1,200,000	10,000
	Yellowfin sole	Healthy	169,000	1,000
	Turbot	Healthy	90,000	1,000
	Other flatfishes	Healthy	48,000	1,000
	Cod	Healthy	58,700	7,000
	Pacific Ocean perch	Depleted	18,000	1,100
	Other rockfishes	Healthy	7,727	1,100
	Sablefish	Depleted	3,700	1,000
	Atka mackerel	Healthy	24,800	0
	Hering	Healthy	50,000	30,100
	Squid	Healthy	10,000	0
	Others[4]	Healthy	55,000	1,400
	Total		1,735,427	54,700

1 Healthy: capable of producing near maximum sustainable yields (MSY).
Depressed: Current EY somewhat below MSY but signs of improvement in stock condition.
Depleted: Current EY less than half of MSY and no sign of improvement in stock condition.

2 Designates equilibrium yield in metric tons.

3 Excluding "joint venture" fisheries; current year for Gulf of Alaska, 1980 industry projections for Bering Sea-Aleutians.

4 Pacific halibut stocks are, however, depressed.

TABLE 4.4

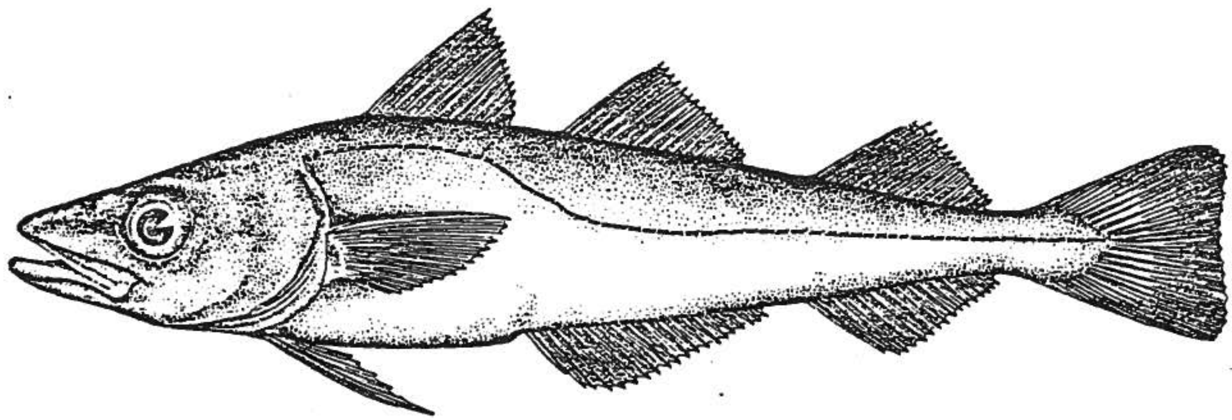
Life History Characteristics of Principal Groundfish Species in the Eastern Bering Sea (North Pacific Fishery Management Council 1979).1/

Life history characteristics	Species: Pollock	Pacific Cod	Sablefish	Pacific Ocean perch	Pacific Halibut	Arrowtooth flounder	Greenland turbot	Flathead sole	Rock sole	Yellowfin sole	Alaska plaice	Atka mackerel
Bottom depths of common occurrence (m)	15-110	5-80	30-245	30-140	5-140	15-165	30-190	15-110	5-55	5-165	10-50	coastal & open sea
Depths of high availability by season (m)	55-109 (winter) 30-80 (summer)	30-80 (winter) less than 55 (summer)	110-220 (winter) 55-245 (summer)	80-140 (winter) 45-80 (summer)	30-125 (winter) 5-55 (summer)	80-165 (winter) 45-110 (summer)	165-275 (winter) 45-220 (summer)	55-110 (winter) 30-00 (summer)	10-55 (winter) 10-30 (summer)	30-00 (winter) 10-30 (summer)	30-40 (winter) 10-30 (summer)	offshore (winter) inshore (summer)
Spawning period	March to July	Jan. to May	Dec. to April	March to June	Nov. to March	Dec. to Feb.	Oct.-Dec.	March to June	March to June	June to August	May-June	June to Sept.
Maximum age	17 years	12 years	20 years	30 years	42 years	22 years	25 years	21 years	16 years	21 years	19 years	?
Average age at maturity (female)	3 years	4 years	7 years	7 years	12 years	9-11 years	13-14 years	6 years	4-5 years	9 years	8 years	3-4 years
Average size at maturity (female)	30 cm	73 cm	71 cm	27 cm	125 cm	55 cm	70 cm	29 cm	22 cm	26 cm	30 cm	33-35 cm
Instantaneous natural mortality rate, M	0.43	0.30-0.45	0.22	0.27	0.17	0.2	?	0.2	0.26	0.25	0.2	?
Growth completion rate, K (female)	0.28	0.30	0.14 2/	0.11	0.10	0.10	0.10	0.11	0.15	0.11-0.18	0.1	?
Fecundity at average size at maturity	100,000	1,000,000 to 2,000,000	400,000	10,000	700,000	?	25,000	50,000	200,000	800,000	100,000	9,000

1/ Values and time periods given to this table are approximations.

2/ Sexes combined.

4.4.1 Walleye Pollock



WALLEYE POLLOCK

The Resource: Walleye pollock, Theragra chalcogramma, is the most abundant demersal fish in the Bering Sea shelf, alone accounting for about 55% total weight of all demersal fish species.

Massive schools of walleye pollock occur on the outer shelf, generally at depths shallower than 100 meters. Two principal centers of abundance were found in 1975-76 surveys (Figure 4.4), one in the southeast area between the Pribilof Islands and Unimak Pass, and the other, west and northwest of the Pribilof Islands. These populations apparently consist primarily of 2 - and -3 year old fish. Between these two regions, abundance is less and consists primarily of 1-year old pollock. In general, this central area of the outer continental shelf and the inner shelf regions appear to be a summer feeding area for juvenile pollock, while adults tend to remain in deeper water to the west, north and south.

The distribution of pollock appears to be strongly influenced by temperature. A distinct cooling trend in the eastern Bering Sea occurred in 1971-75, where the water temperatures were colder than in 1965-70. During the relatively warm years of 1965-70, moderate to high concentrations of pollock occupied the inner shelf in the southeastern Bering Sea as far east as Port Heiden in June and July-August (Figure 4.5). However,

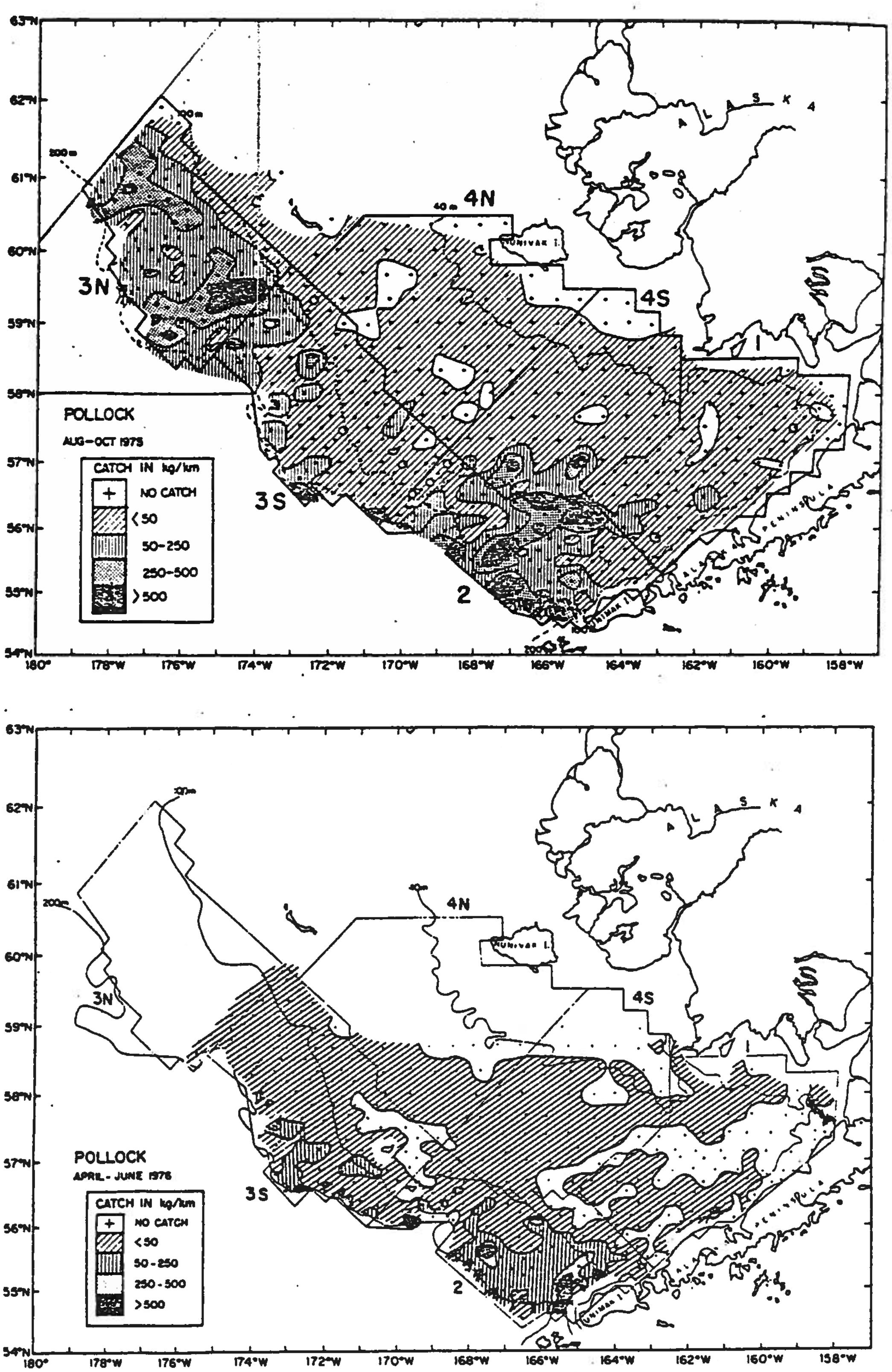


Figure 4.4 Distribution and relative abundance of pollock during the 1975 and 1976 surveys. Boundaries of subareas (1-4S) used during the survey are also shown.

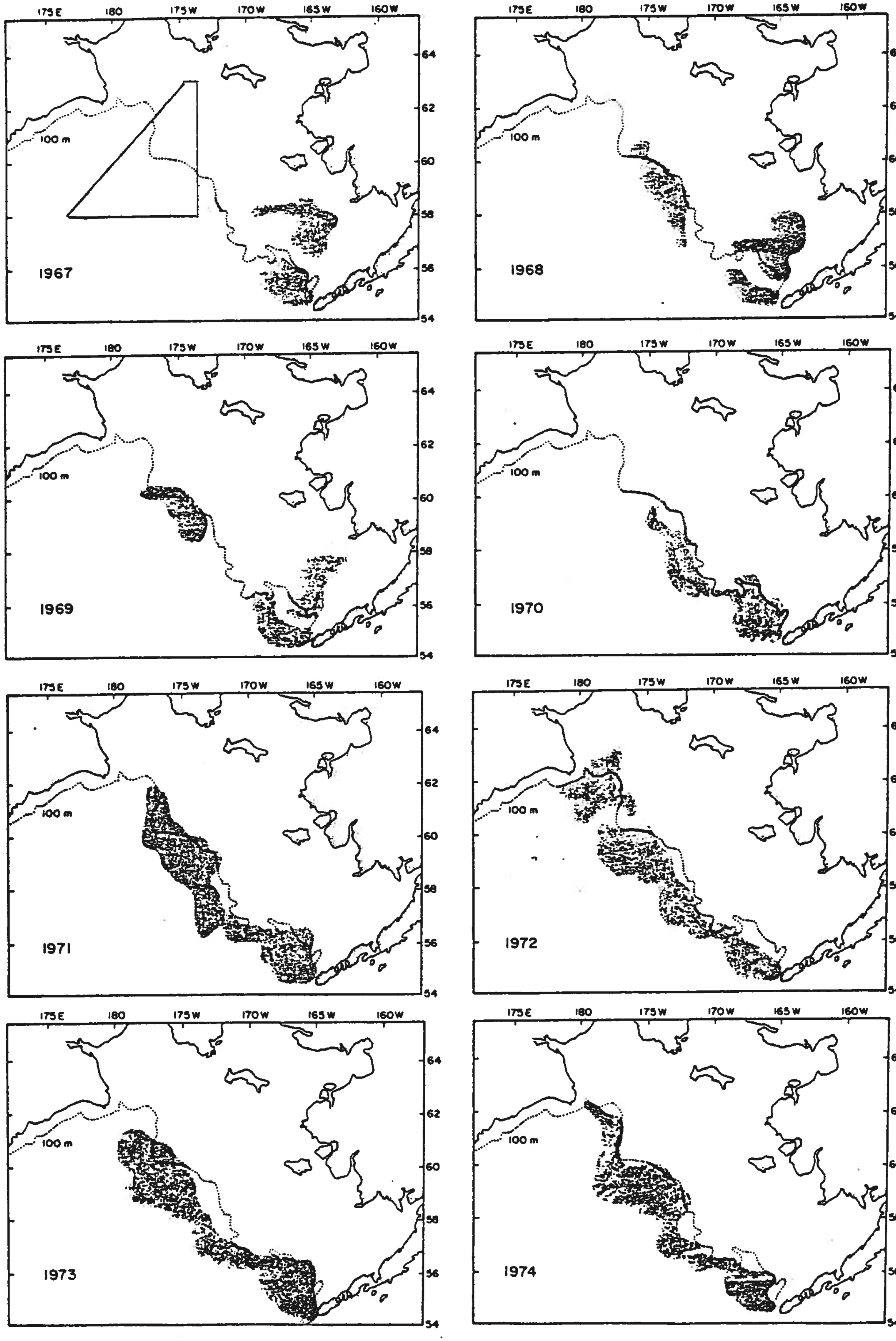


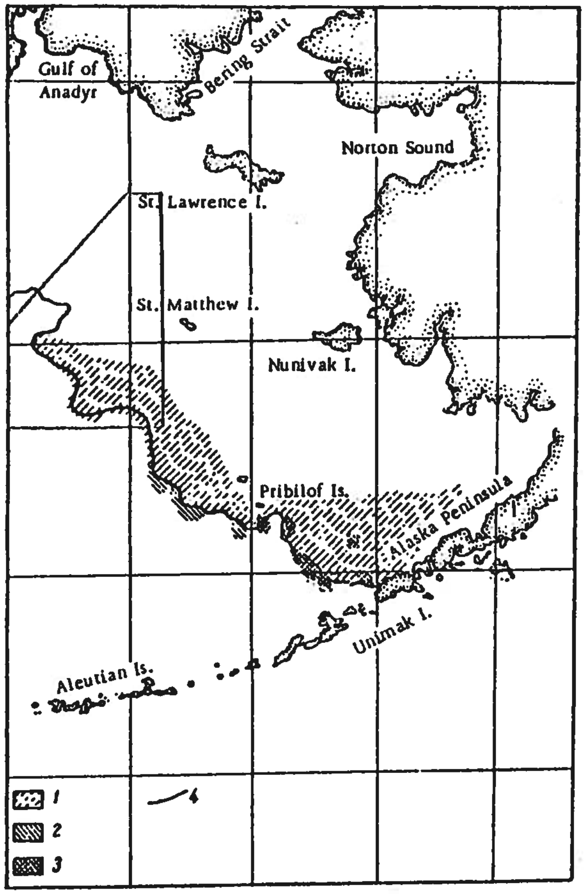
Figure 4.5 -- Distribution of walleye pollock catch in the Japanese trawl fisheries, 1967 - 74.

during the cold years of 1971-75, the distribution shifted to the outer shelf and slope areas that are warmed by oceanic waters. The distribution of pollock observed in the 1975 baseline survey in August-October (Figure 4.4, upper) was typical of historical survey data for July-August of cold years. The apparent change in distribution of pollock after 1970, as shown by the research vessel data, may account for some of the change in the distribution of Japanese fishing effort and decrease in CPUE referred to earlier. These annual shifts in area or depth occur in many other species as well.

Pollock undertake extensive seasonal migrations associated with feeding and reproduction (Figure 4.6). The main wintering grounds (Figure 4.6, left) for adult pollock in the central and eastern Bering Sea are along the outer shelf and upper slope (150-300 m) where bottom temperatures are relatively warm (2.5-4.5°C). As temperatures rise in spring, pollock migrate to shallower water (Figure 4.6 middle and left) and spawn at depths of 90-140 m or deeper.

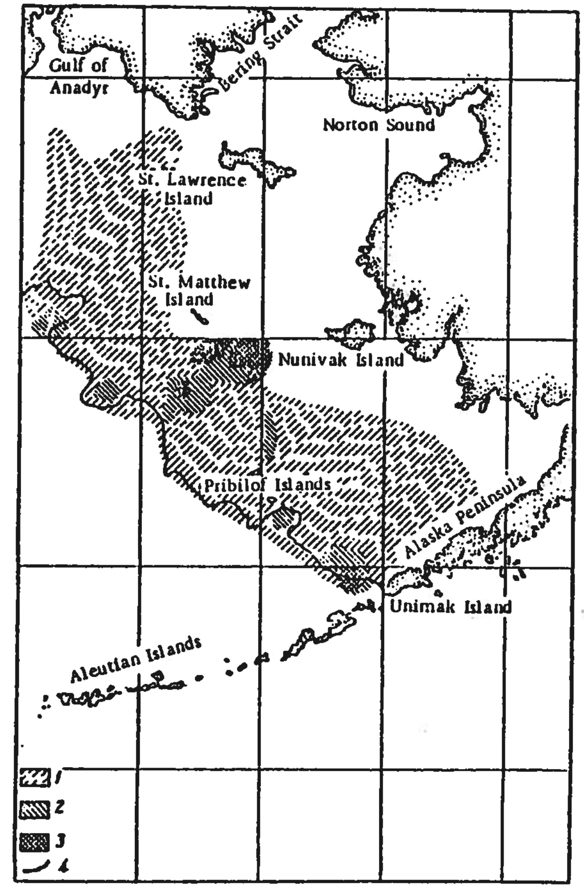
The bipartitioning of the older pollock stock has been thought to indicate the occurrence of two separate stocks. Recent modeling efforts by NWAFC however, shows that the bipartitioning phenomenon is probably a result of interaction between the consumption of pollock by seals, by foreign fishery activity, and by seasonal migrations. There is no bipartitioning in the younger pollock, and juveniles occur over the central shelf where the standing stock of older pollock is lower.

Although pollock have a relatively large biomass, the exploitable population is composed mostly of young fish of ages 3 and younger. Reproductive potential is presently lower than in the past when the population had a greater number of older, more fecund fish. Although pollock range to about 1 m in length, the average size of harvested fish is 0.33 m. Since maturity for most pollock is not reached until ages 3 or 4, the failure of one or two successive year classes in such a young population could have disastrous consequences on stock productivity that would severely affect the large trawl fisheries based upon this resource.



Catches: 1 — up to 500 kg; 2 — up to 1 ton; 3 — more than 1 ton; 4 — 200-m isobath.

Catches: 1 — up to 500 kg; 2 — up to 1 ton; 3 — more than 1 ton; 4 — 200-m isobath.



Catches: 1 — up to 500 kg; 2 — up to 3 tons; 3 — up to 10 tons; 4 — 200-m isobath.

Figure 4.6 The distribution of walleye pollock on the Bering Sea shelf in 1965 during winter - spring (left), spring - summer (middle) and autumn - winter (right), from Serobaba, 1970.

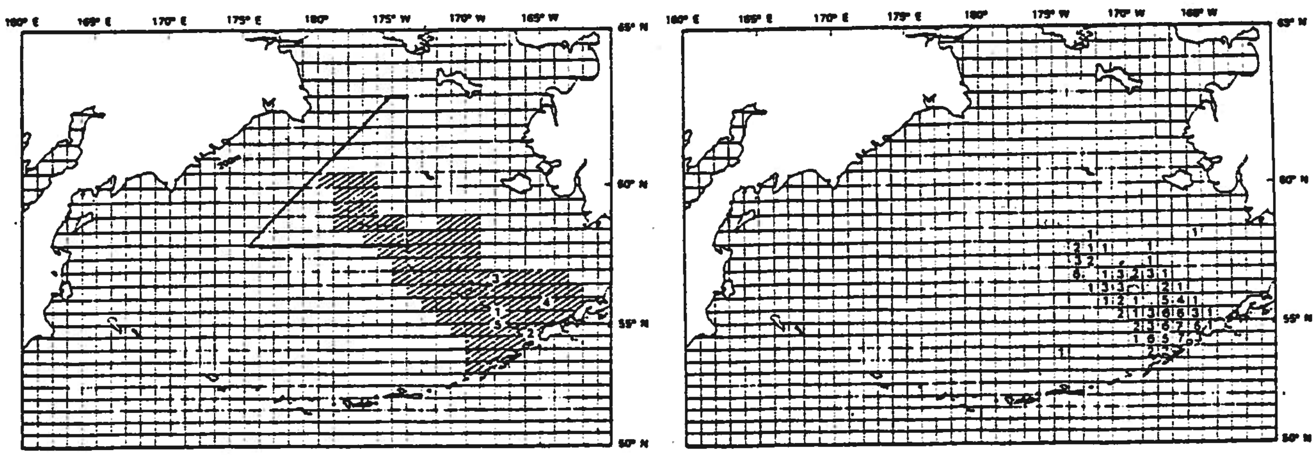


Figure 4.7 Areas where walleye pollock eggs and larvae have been caught in plankton tows in the eastern Bering Sea.

Left map - shaded area is where pollock eggs have been caught; superimposed numbers are areas of maximum abundance in five different years.

Right map - numbers of stations in each area at which larvae have been caught in spring.

Spawning occurs along the outer shelf, predominantly in the area between the Pribilofs and Unimak Island (Figure 4.7). Females produce about 100,000 eggs each, and when the pollock spawn in massive schools in March to July high densities of eggs (up to 600 per m^2) can be found floating in the water column. The eggs mostly develop in the surface layers. Pollock eggs hatch in two or three weeks, depending on the temperature, and the larvae float near the surface for an unknown period of time. Juvenile pollock become demersal at lengths of 35-50 mm and reach 90-110 mm during their first year, suggesting that larvae may drift pelagically for several months.

Pollock feed near the seafloor on zooplankton - especially euphausiids, but older (>50 cm) pollock are cannibalistic on young (<30 cm) pollock. Laevastu et al., 1980, reviewed the available information on fish trophics and provided estimates of percentage composition of food items for most of the commercial species of the Bering Sea. Table 4.5 provides this information for pollock and other major components of the Bering Sea ecosystem.

Table 4.5 - Initial mean composition of food (in %) for coastal (shallow) and offshore (deep) subregions for PROBUB model 80-1

	Shallow	Deep
Turbot, halibut (5)		
Infauna	20	5
Epifauna	52.2	36.0
Euphausids	5	30
Cottids and other demersal	5.3	4
Flathead sole	1	0.3
Yellowfin sole	1.5	0.5
Other flatfish	1	0.4
Crab	1	1
Shrimp	2	1.3
Cod	2	3
Rockfish	2	4
Pollock	6	8
Squid	1	6
Salmon	0.5	0.5
Flathead sole (6)		
Infauna	18	3
Epifauna	42	22
Euphausids	9	45
Cottids and other demersal	9	9
Cod	4	4
Crab	3	1
Shrimp	3	2
Pollock	8	8
Other flatfish	2	2
Capelin and other pelagic	1	2
Rockfish	1	2

	Shallow	Deep
Yellowfin sole (7)		
Infauna	18	3
Epifauna	38.5	11.5
Euphausids	12	44
Copepods	5	25
Capelin and other pelagic	5	5.5
Cottids and other demersal	4	2
Rockfish	3	1
Crab	2	0.5
Shrimp	3	0.5
Cod	2	1
Other flatfish	2	0.5
Pollock	3	3
Squid	1	2
Flathead sole	1.5	0.5
Other flatfish (8)		
Infauna	22	4.5
Epifauna	39	16
Euphausids	13	46.5
Copepods	5	19
Capelin and other pelagic	4	3
Cottids and other demersal	5	2.5
Rockfish	2	1.5
Crab	1	0.5
Shrimp	2	0.5
Pollock	3	4
Herring	2	1.5
Yellowfin sole	2	0.5

Table 4.5 - (Cont'd).

Cottids and other demersal (9)	Shallow	Deep
Infauna	10	3
Epifauna	25	6
Euphausids	22	41.5
Copepods	25	40
Turbot, halibut	0.5	0.1
Flathead sole	0.5	0.1
Yellowfin sole	0.5	0.1
Other flatfish	0.5	0.1
Cottids and other demersal	2.5	2.5
Cod	0.5	0.1
Pollock	2	1.5
Capelin and other pelagic	5	3.5
Crab	1	0.1
Shrimp	2	0.2
Rockfish	1	0.3
Herring	2	0.9

Sablefish (11)	Shallow	Deep
Infauna	7	1
Epifauna	18.5	7
Predatory benthos	9	2
Euphausids	18	54.2
Shrimp	3	2
Pollock	15	11
Turbot, halibut	1.5	0.2
Flathead sole	2.5	0.2
Yellowfin sole	3.5	1.2
Other flatfish	2.5	0.2
Cottids and other demersal	8	2
Squid	6	10
Cod	4	2
Capelin and other pelagic	3	1.5
Rockfish	3.5	3.0
Sablefish	2	3

Cods (10)	Shallow	Deep
Infauna	6	1
Epifauna	18.45	6
Predatory benthos	6	2
Euphausids	19	32.8
Copepods	13	33.5
Crab	2	0.5
Shrimp	3.5	0.8
Pollock	7	6
Flathead sole	1	0.2
Yellowfin sole	1.8	0.4
Turbot, halibut	0.75	0.1
Cottids and other demersal	6	2.5
Squid	7	10
Herring	2	1
Capelin and other pelagic	5	3
Sablefish	1.5	0.2

Pollock (12)	Shallow	Deep
Copepods	30	34
Euphausids	43.5	48.9
Pollock	8	9.4
Capelin and other pelagic	5	3
Herring	3	1
Cottids and other demersal	3	0.4
Epifauna	1.5	0.1
Rockfish	1.8	1.2
Shrimp	0.5	0.1
Flathead sole	0.2	0.1
Turbot, halibut	0.3	0.1
Yellowfin sole	0.6	0.2
Other flatfish	0.5	0.1
Atka mackerel	1.0	0.8
Crab	0.3	0.1
Cod	0.8	0.5

Table 4.5 - (Cont'd).

Rockfishes (13)	Shallow	Deep
Copepods	22	32
Euphausids	38	42
Capelin and other pelagic	8	5
Squid	5	10
Cottids and other demersal	5	3
Epifauna	5	1
Herring	2	1
Pollock	4	2
Crab	1	0.2
Shrimp	2	0.3
Cod	3	2
Halibut, turbot	0.5	0.1
Yellowfin sole	0.5	0.1
Flathead sole	0.5	0.1
Other flatfish	0.5	0.1
Atka mackerel	3	1.1

Herring (14)	Shallow	Deep
Copepods	60	60
Euphausids	32	35.3
Capelin and other pelagic	3	1.7
Shrimp	0.5	0.1
Crab	0.5	0.1
Atka mackerel	1.5	0.8
Pollock	2	1.5
Rockfish	0.5	0.5

Capelin and other pelagic (15)	Shallow	Deep
Copepods	36	38
Euphausids	55	55.8
Herring	2	1
Pollock	2	2
Rockfish	1	1
Atka mackerel	1	1
Capelin and other pelagic	2	1
Other flatfish	1	0.2

Atka mackerel (16)	Shallow	Deep
Copepods	45	48
Euphausids	35.5	43
Capelin and other pelagic	5.5	2.5
Herring	1.5	0.5
Pollock	3.0	2.5
Rockfish	3.5	1.5
Turbot, halibut	0.5	0.1
Flathead sole	0.5	0.1
Yellowfin sole	0.5	0.1
Cottids and other demersal	3.5	1.5
Shrimp	0.5	0.1
Crab	0.5	0.1

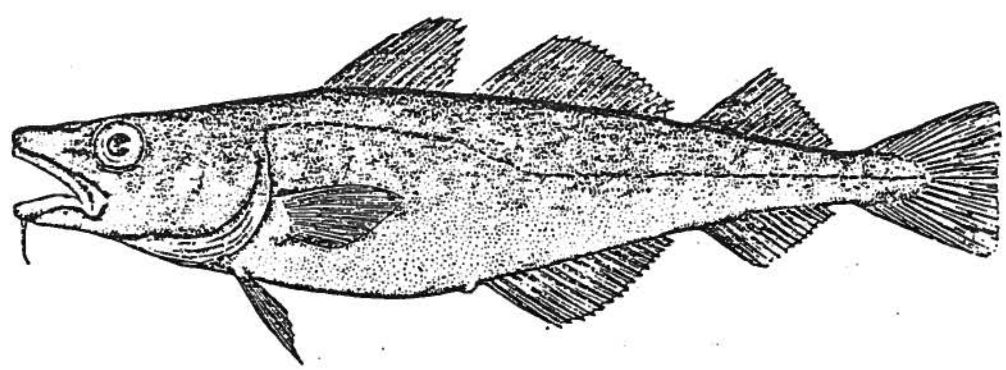
Table 4.5 - (Cont'd).

	Shallow	Deep
Salmon (17)		
Copepods	10	10
Euphausids	40	45
Herring	7	2
Atka mackerel	7	3
Capelin and other pelagic	10	4
Squid	12	28
Rockfish	4	2
Pollock	10	6
Squids (18)		
Copepods	11	14
Euphausids	32	40
Pollock	15	12
Atka mackerel	6	5
Capelin and other pelagic	6	6
Herring	4	2
Squid	23	20
Rockfish	3	1
Crabs (19)		
Infauna	32	30
Epifauna	39	30
Copepods	12.5	20
Euphausids	10	19.5
Shrimp	5	0.2
Yellowfin sole	0.5	0.1
Flathead sole	0.5	0.1
Other flatfish	0.5	0.1
Shrimps (20)		
Infauna	30	5
Epifauna	45	10
Copepods	13	50
Euphausids	12	35

	Shallow	Deep
Predatory benthos (21)		
Infauna	32	28.8
Epifauna	67	70.5
Cottids and other demersal	0.5	0.2
Shrimp	0.5	0.5
Infauna (22)		
Phytoplankton (detr.)	75	75
Copepods (detr.)	10	10
Euphausids (detr.)	10	10
Epifauna (detr.)	5	5
Epifauna (23)		
Infauna	40	40
Phytoplankton (detr.)	24	24
Euphausids (detr.)	18	18
Copepods (detr.)	18	18
Copepods and euphausids (25, 26)		
Phytoplankton	100	100

<u>The Fishery</u>: By the mid-1970's, the pollock fishery of the North Pacific had become the biggest single-species fishery in the world. More than 5 million metric tons were taken annually. The largest catches were by the Japanese from grounds in the Bering Sea between 165° W and 175° W. Annual catches of pollock by Japanese, USSR, and ROK fisheries in the central Bering Sea increased 10-fold from 1964, and from 1970 through 1974 the annual catch of pollock in U.S. waters of the Bering Sea and Aleutian Island area exceeded 1 million mt. The average and peak catches (1972) were 1.7 and 1.9 million mt, respectively. During those years, pollock constituted about 80 percent of the total fish landings from the central Bering Sea, with the Japanese mothership trawl fishery accounting for 83 percent or more of the catch in each year during this period. Although the all-nation fishing effort has remained near the record high, and although pollock still constitute a similar proportion of the total groundfish catch, pollock harvests have declined in recent years both in total quantity and size of individual fish. This evidence indicates a deteriorating stock and a worsening condition of the resource in the Bering Sea. The importance of this species to the Bering Sea fishery was discussed more fully in Section 3.2.

4.4.2 Pacific Cod



PACIFIC COD

The Resource: The Pacific cod, *Gadus macrocephalus*, is distributed along the outer continental shelf margin of the Bering Sea in a manner similar to the pollock. It is a somewhat more shallow-water species than pollock, and major concentrations occur in the eastern and central regions of the Bering Sea at depths of from less than 80 meters to 550 m. Pacific cod can weigh up to 200 pounds, and weights from 50 to 60 pounds are common except in heavily fished areas where they average usually no more than 8 to 12 pounds.

The migratory habits of Pacific cod are unclear. However, some researchers (e.g. Low, 1974) have reported eastwest movements as the fish migrate back and forth between the continental slope and shelf. Migrations extending into inner shelf waters apparently involve large numbers of cod only in relatively warm years.

The spawning period and area have not been delineated for cod in the central or eastern Bering Sea. In the northern Bering Sea, spawning takes place from January to March, and in the Commander Islands area from January to May. Peak spawning off West Kamchatka occurs at depths of 30-290 m between February and April. In general, Pacific cod appear to spawn below the mixed layer at temperatures of 0° to 5° C.

Females are highly fecund and produce from 1 to 2 million eggs per individual. Fertilized eggs are demersal and, initially, slightly adhesive. The incubation period for cod eggs is about 10-20 days.

Field collections from off Kamchatka and Sakhalin indicate that cod larvae were located in coastal waters at depths of 25 - 150 m, the majority of the larvae occurring between 75 and 100 m. Cod were not abundant in the southeastern Bering Sea in the relatively cold years of 1971-75, as compared with the relatively warm years of 1965 - 70. Cod were numerous and encountered frequently in inner shelf areas during the NMFS 1979 surveys (Figure 4.8); about 76 percent of the total estimated population occurred on the southeast Bering shelf, 30 percent in Bristol Bay. Most of these fish were juveniles ($<$20 cm). The juvenile cod (one year old) found in Bristol Bay near Unimak Island in early May 1979 were

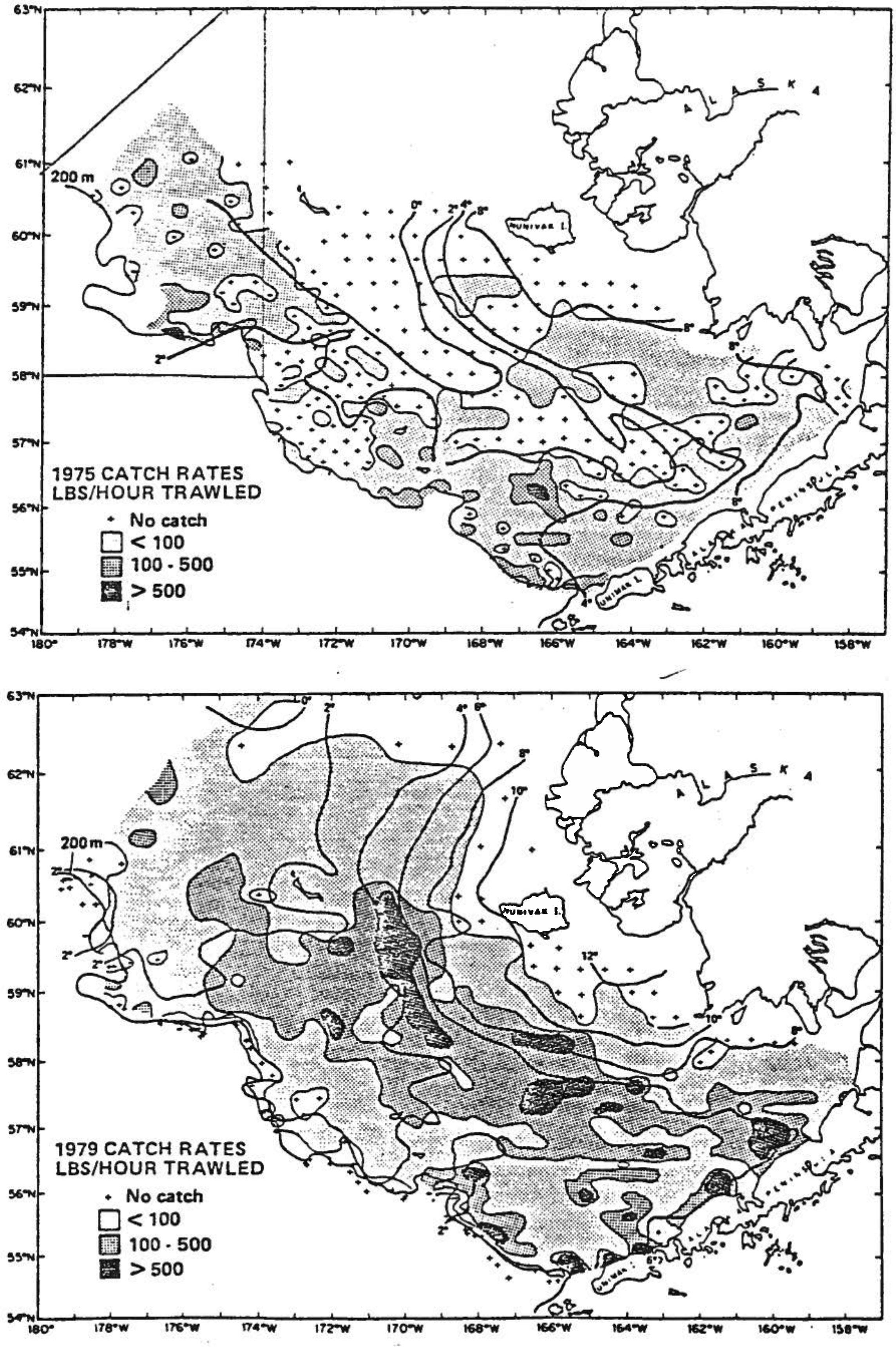


Figure 4.8 - Distribution and abundance of Pacific Cod in the eastern Bering Sea as shown by NMFS trawl surveys in 1975 and 1976.

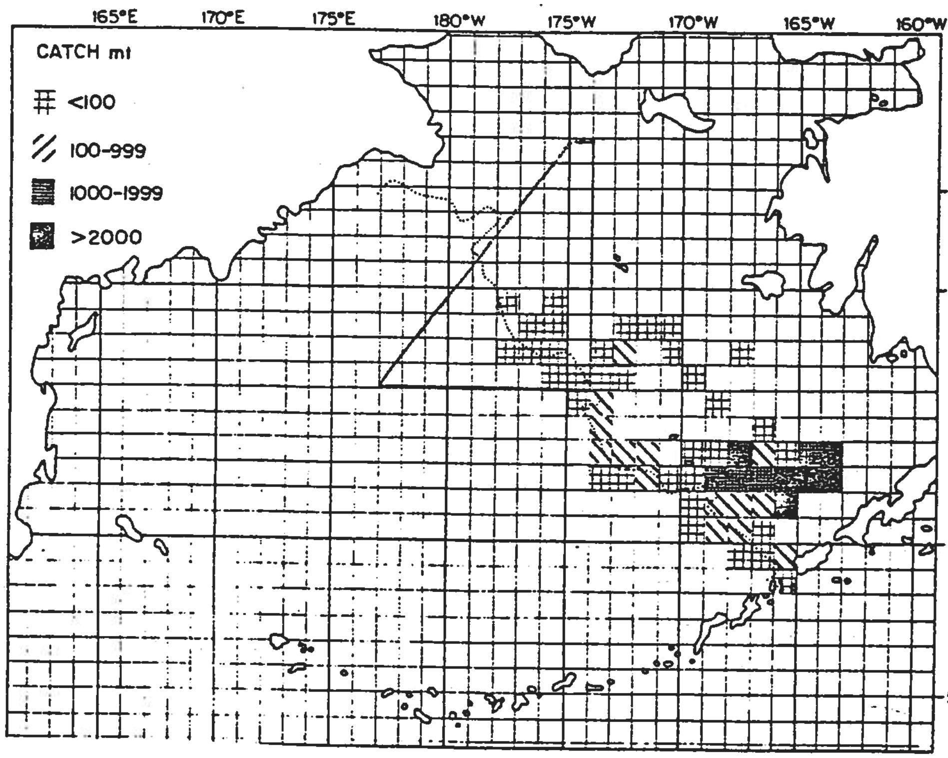


Figure 4.9 - Distribution of catches of yellowfin sole in 1974 by the Japanese mothership and North Pacific trawl fisheries.

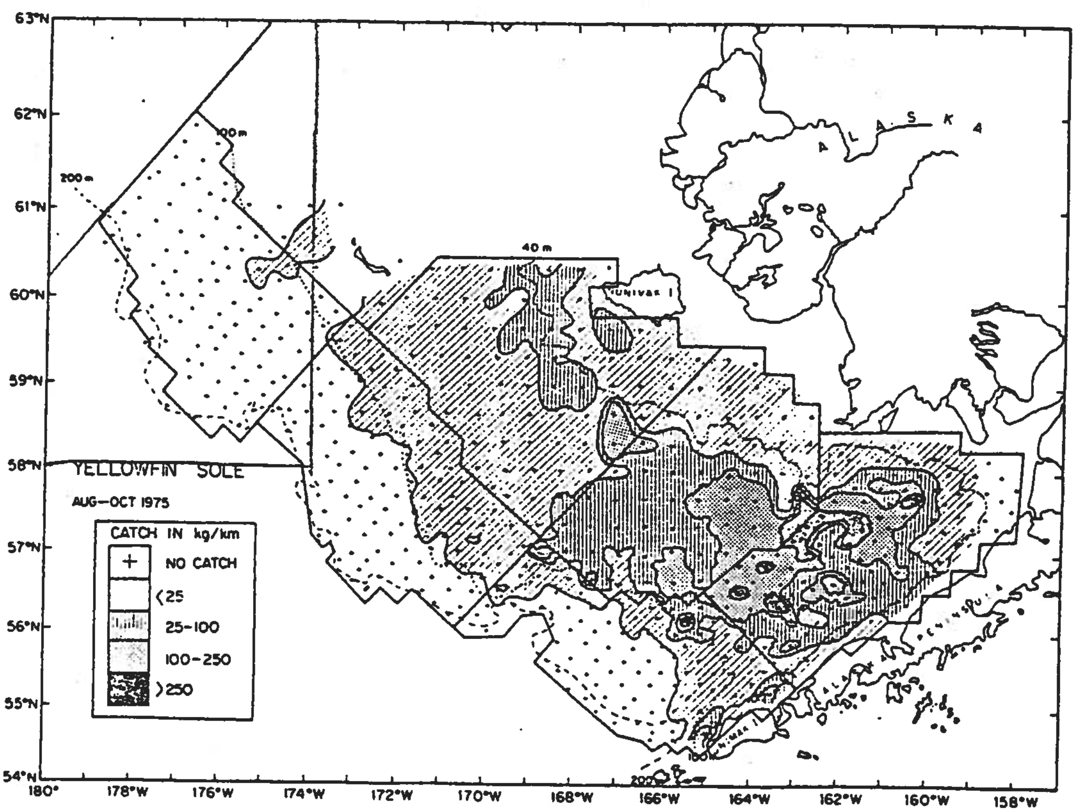


Figure 4.10 - Distribution and relative abundance by weight of Yellowfin sole in the eastern Bering Sea.

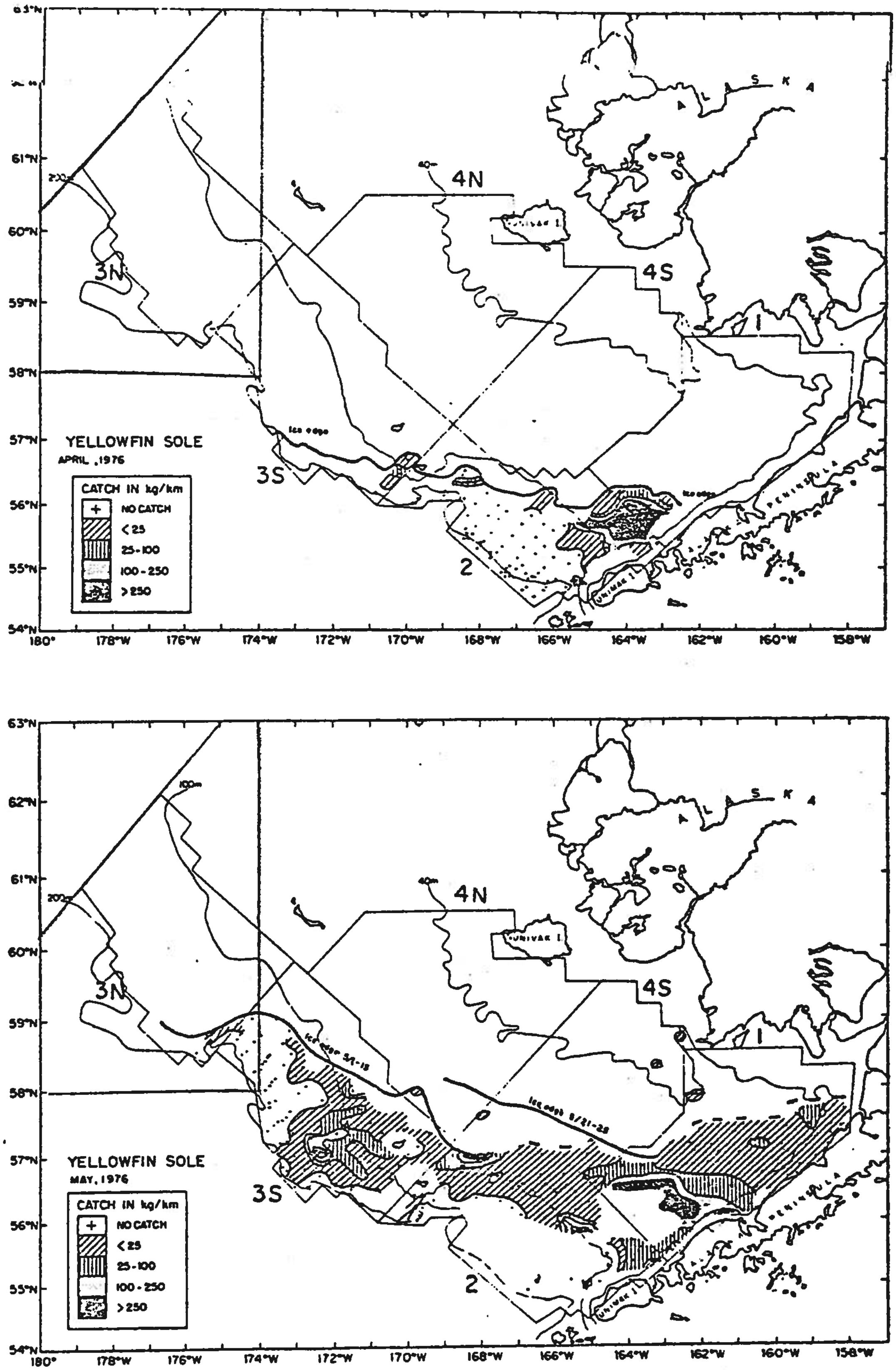


Figure 4.11 - Distribution and relative abundance of yellowfin sole as shown by sampling in April and May, 1976.

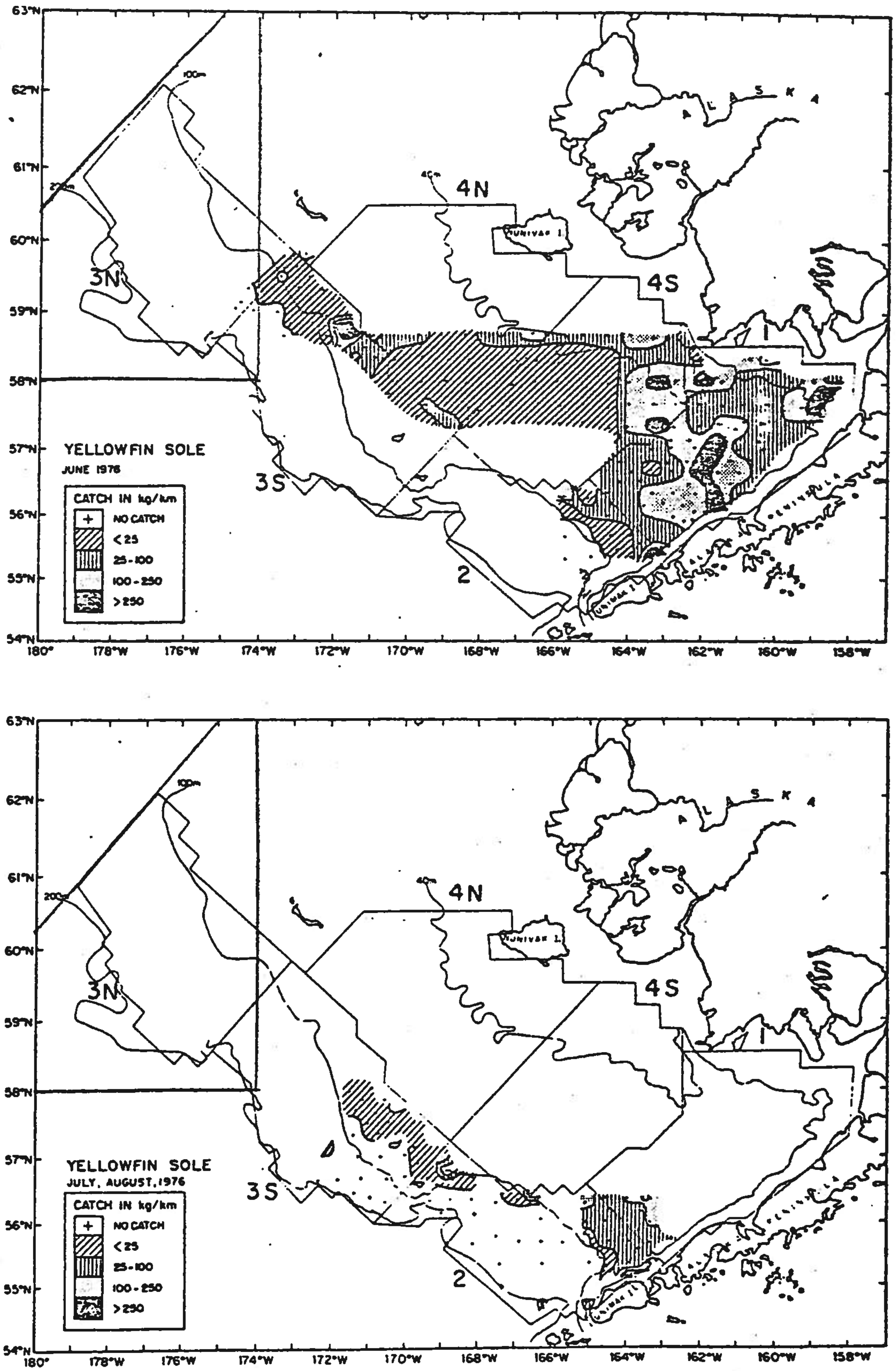


Figure 4.12 - Distribution and relative abundance of yellowfin sole as shown by sampling in June to early August, 1976.

at a depth of 100 m and a bottom temperature of 1.3° C. Cod feed primarily on benthic organisms and planktonic crustaceans (Table 4.5).

The Fishery: Beginning in 1964, the Japanese North Pacific trawl fishery for pollock expanded, and cod became an incidental catch in the pollock fishery. At present, cod are only an occasional target species when high concentrations are detected during pollock fishing operations.

The annual catch of Pacific cod by Japan increased from 19,100 mt in 1964 to a peak of 74,400 mt in 1970. Since then, catches have varied between 41,000 and 50,600 mt, averaging 45,800 mt during 1971-74. Catches by the U.S.S.R., reported only since 1971, increased from 2,500 mt in 1971 to about 16,600 mt in 1974 but have since declined to 2,400 mt in 1979. For all nations combined, the Pacific cod peaked in 1970-1974, averaging 59,300 mt, but total foreign catches have since declined to average about 40,000 mt in 1977-79.

Cod are taken almost entirely from trawls in depths down to about 450 meters, although some are caught on longlines and in pots intended for other species.

4.4.3 Yellowfin Sole

The Resource: Yellowfin sole, *Limanda aspera*, are widely distributed over the eastern Bering Sea shelf at depths less than 100 meters. The center of abundance of the species is found in the central region of Bristol Bay (Figures 4.9 to 4.12).

Central aggregations appear to be formed each year during May-October as a result of on-shelf migrations of adults to summer grounds for feeding and spawning. Mass spawning begins in early July on shelf waters at depths between 15-75 m and continues through August. In autumn the wintering migration to deeper regions begins and by winter most of the fish form dense concentrations in the lower shelf and upper slope zones between Unimak Island and the Pribilofs at depths of 90 to 200 m. One major overwintering area has been reported to occur to the west of the Pribilofs (Figure 4.11).

Most of the yellowfin sole are assumed to spawn in Bristol Bay during June and July. Drifting eggs accumulate in the central areas of well-developed gyres, where the eggs develop. The actual period of time the larvae are pelagic is unknown. However, metamorphosis and settling may occur at a length of about 17 mm after drifting pelagically for perhaps 4 or 5 months.

Young yellowfin sole (<15 cm long) are generally confined to the shallower parts of the species' range; they reside throughout the year in the inner shelf region, including Bristol Bay. Large numbers of juvenile yellowfin sole (<10 cm long) have been encountered during IPHC surveys along the southern shore of Bristol Bay and on the northern side of the Alaska Peninsula and Unimak Island. The nursery area for young yellowfin sole is believed to be in shallow depths; however, their distribution, survival, and feeding habits during their first 2 or 3 years of life are not known.

During the summer, when yellowfin sole are primarily at depths shallower than 60 m in Bristol Bay, they feed mainly upon benthic crustaceans (Table 4.5). Large Pacific halibut prey heavily on yellowfin sole in the southeastern Bering Sea.

<u>The Fishery</u>: Prior to the mid-1960's, yellowfin sole was the principal target species of the eastern Bering Sea trawl fisheries. From 1954 through 1957, the Japanese were the only users of this resource, and annual catches were less than 25,000 mt. In 1958, the Soviet fleet entered the fishery and the combined Japanese and Soviet catch increased to about 44,000 mt. The total catch subsequently increased substantially to 610,000 mt in 1961. Because of overfishing, production then fell off sharply to about 393,000 mt in 1962, fluctuated between 62,000 and 207,000 mt during 1963-71, and has remained below 100,000 mt since 1971 with a 1979 harvest of 96,000 mt. After 1963, the main effort of the Japanese and Soviet fisheries shifted to pollock.

Relatively low catch rates and continued reliance by the fishery on small, young fish indicate that the yellowfin sole resource of the eastern Bering Sea remains in the depressed condition caused by overfishing in the early 1960's.

4.4.4 Pacific Halibut

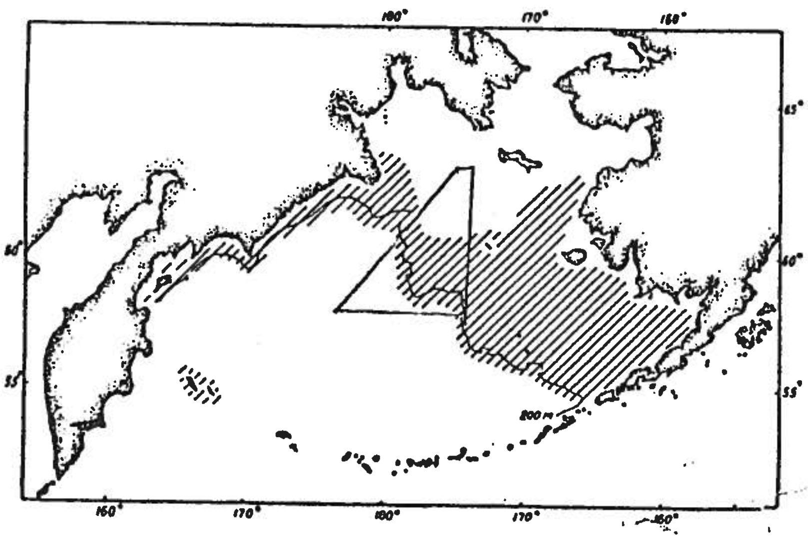
The Resource: The Pacific halibut, *Hippoglossus stenolepis*, is widespread in the Bering Sea, occupying the shelf edge and upper zones of the continental slope from Cape Navarin to Bristol Bay (Figure 4.13). The population is particularly abundant in the central Bering Shelf area in the vicinity of the Navarin Basin lease area, between 175° - 180° W. The northern limit of its normal range is placed at Norton Sound at about 64° north latitude.

Halibut occupy a wide range of depths, performing seasonal migrations to the shallows (30-140 m) in the spring for foraging and to deeper slope waters (250-550 m) for spawning in the fall and for overwintering.

The species is prolific and can produce up to 2 million eggs per female. Spawning occurs over a protracted period of time in the winter, from about November to February. Eggs and larvae are free-floating, but after about 4-5 months and at about 10 cm length, the juveniles settle to the bottom. Halibut mature slowly; a mature female will be about 13 years old and over a meter in length. Halibut are known to live to at least 42 years of age.

Halibut are opportunistic bottom feeders, and will consume whatever prey is readily available (Table 4.5). Juveniles feed primarily on small crustaceans.

The Fishery: The demise of the North American setline fishery in the Bering Sea (and the halibut resource which supported it) has been well documented over the past 15 years. Bering Sea catches and ex-vessel values have declined from a high of about 14,000 mt and $9.5 million in 1962 to 2,232 mt and less than $3.9 million in 1977. Part of this deterioration may have been caused by combined North American and Japanese setline catches during 1960-63, but the situation has undoubtedly been aggravated by the enormous incidental catch of juvenile halibut by Japanese and Soviet trawlers. Even though such incidentally caught halibut are to be returned to the sea by Japanese fishermen, most do not survive.



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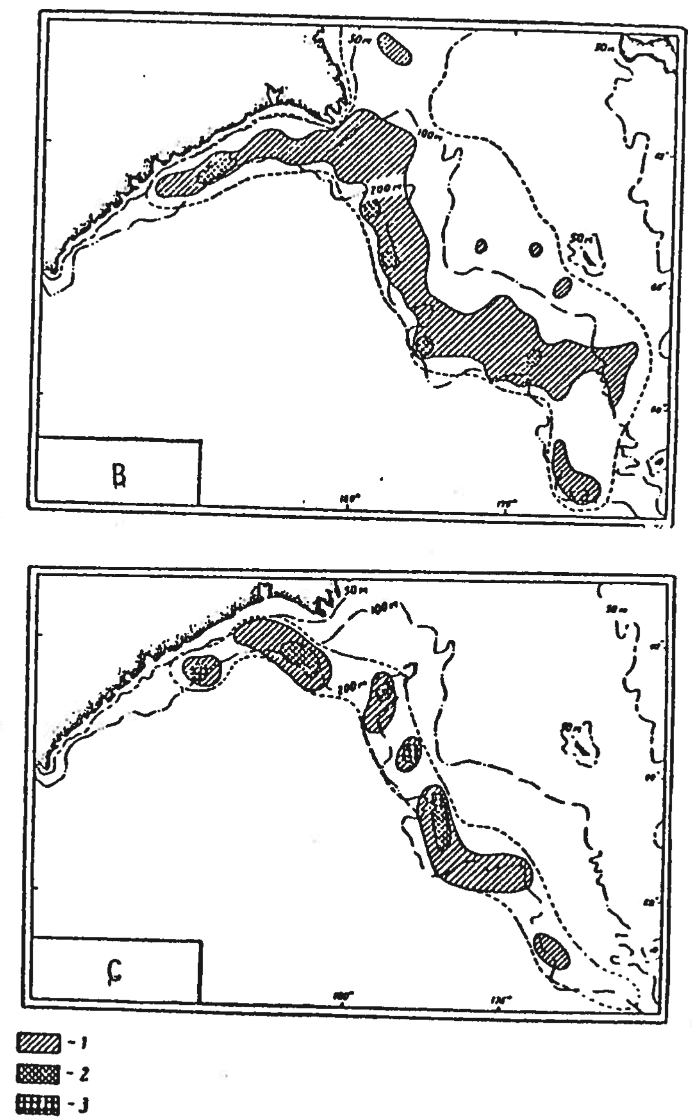


Figure 4.13 - Distribution of Pacific halibut in the Bering Sea according to Novikov, 1964.
A-- General distribution
B-- June - September, 1957
C-- August - September, 1958
Hauls per hour of trawling:
1 - less than 50 kg
2 - 50 to 100 kg
3 - 100 to 500 kg

The commercially fishable stock of Pacific halibut in the Bering Sea remains in an unsatisfactory state. Because of this, the North American setline fishery continues at a low level of effort, and the Japanese longline fishery has not operated since 1970. On the brighter side, the abundance of juvenile halibut has recently increased somewhat, such increase being probably attributable in part to trawl closures imposed on the Japanese fisheries in the eastern Bering Sea in 1974-1975

4.4.5 Greenland Turbot and Other Flatfish

The Resource: Flatfishes other than yellowfin sole and Pacific halibut are now, for the most part, caught incidental to the expanded pollock fishery. The most important of these species in terms of recent foreign commercial catch are Greenland turbot, arrowtooth flounder, rock sole, and Alaska paice.

The Greenland turbot, Reinhardtius hippoglossoides, is widespread in deep water throughout the Bering Sea shelf and slope (Figure 4.14) in association with pollock, cod and other flatfish. The largest concentrations occur in the Navarin Basin area to the west of St. Matthew Island. The species commonly occurs along the shelf edge over a depth range of 30 to 190 m, being found in the shallower waters in the summer and deeper waters in the winter.

Spawning occurs from October to December at depths greater than 100 m on the continental shelf and slope. The eggs are bathypelagic and develop in deeper waters, but the larvae rise to shallow depths of 30-130 m.

Other important flatfish that occur in abundance and are widely distributed along the Bering Sea shelf and into the Navarin Basin area include the arrowtooth flounder, Atheresthes stomias, flathead sole, Hippoglossoides elassodon, Alaska plaice, Pleuronectes quadrituberculata, and to a lesser extent the rock sole, Lepidopsetta bilineata.

The arrowtooth flounder occurs in the central Bering along the continental slopes at depths of 200-500 m during their first year, whereas older (larger than 30 cm) fish live on the slope at depths of 200-600 m (Figure 4.15). In winter, most of the young flounder migrate to the deepest parts of the shelf and upper slope.

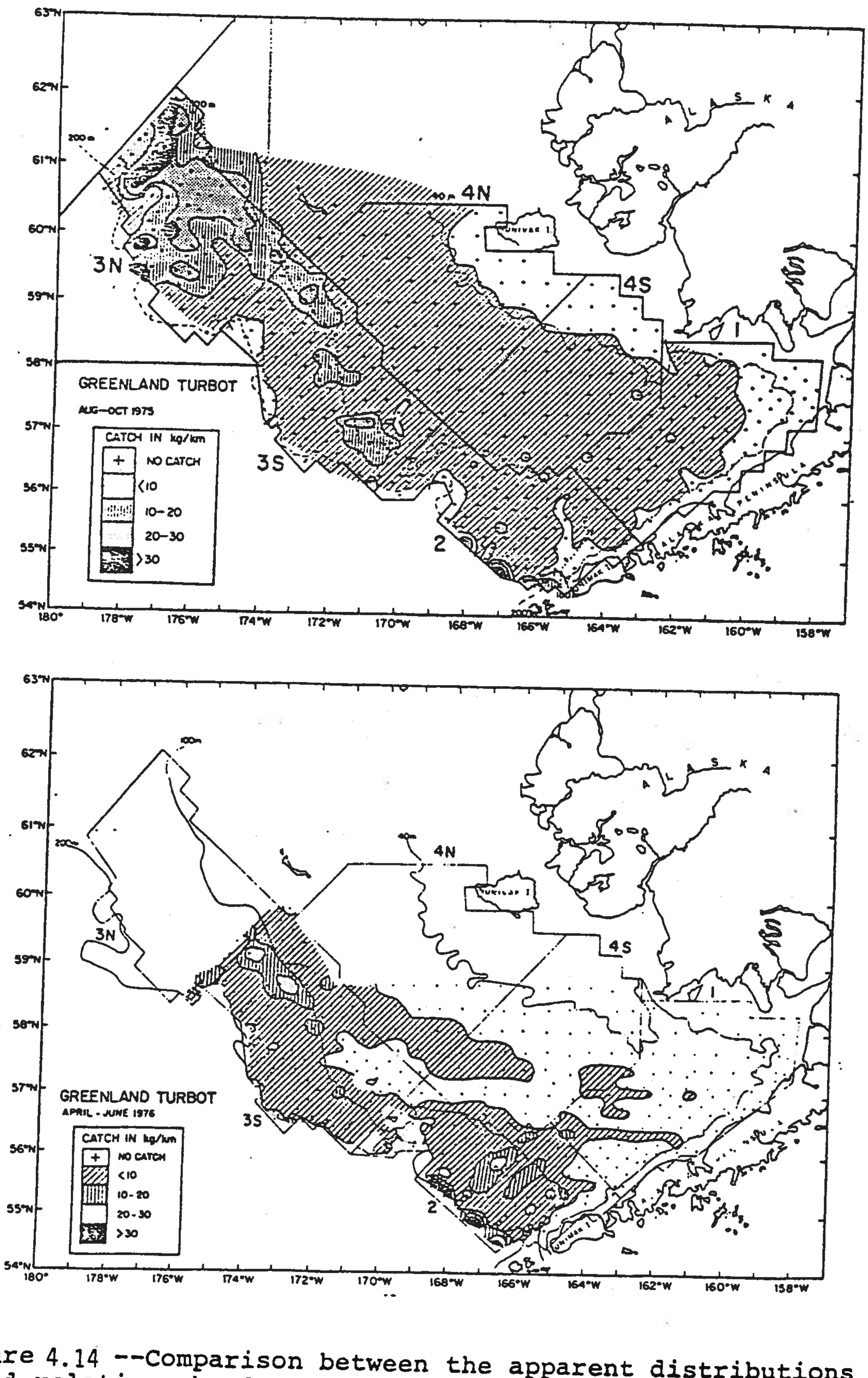


Figure 4.14 --Comparison between the apparent distributions and relative abundance of Greenland turbot during the 1975 and 1976 surveys.

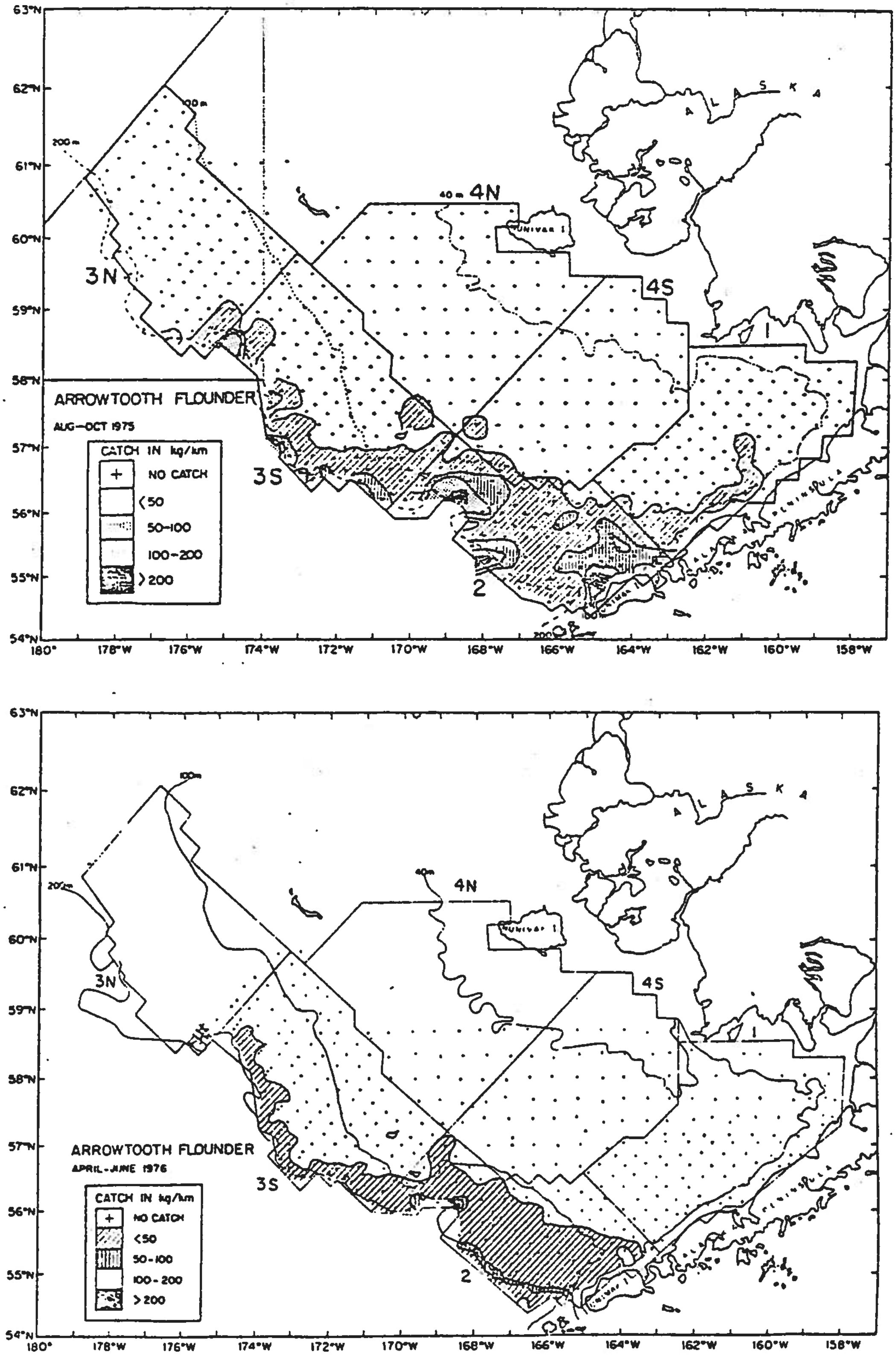


Figure 4.15 --Comparison between the apparent distributions and relative abundance of arrowtooth flounder during the 1975 and 1976 surveys.

Spawning of the arrowtooth flounder probably occurs from December to February. The eggs are bathypelagic, but the larvae are found in shallow waters on the shelf. Metamorphosis occurs after several months and the juveniles settle to the bottom.

Flathead sole are found mainly on the eastern Bering Sea shelf, but on somewhat deeper grounds than occupied by yellowfin sole and the rock sole (Figure 4.16). They are caught mainly as an incidental species in the yellowfin sole and pollock fisheries.

During the winter, flathead sole are usually found in deeper waters than yellowfin sole, rock sole, or Alaska plaice. Adults spend the fall and winter in deep water on the outer shelf and upper slopes at depths of 70-400 m where temperatures are 2.5° - 4°C. In the spring, these wintering groups migrate eastward to the shallower waters (20-180 m) of the shelf. During the summer, flathead sole are widely dispersed over the outer shelf area from Unimak Island northwest into the central Bering Sea. Some flathead sole remain on the slope during the summer, but these fish are dispersed. In addition to these geographic and bathymetric seasonal migrations, flathead sole may undertake limited diel vertical movements between dusk and dawn.

Flathead sole were the seventh most abundant species taken in the August - October 1975 OCSEAP survey; largest concentrations (>20 kg/km) occurred northwest of Unimak Island.

Flathead sole reproduce in the deeper shelf waters during the winter and spring (February - May) at depths of 100-200 m. Each female produces up to several hundred thousand free-floating eggs. Eggs may be transported from the spawning grounds to shallower (30 m or less) or deeper (to 500 m) waters. The pelagic larvae float near the surface until they metamorphose to adult form and descend to the sea bed.

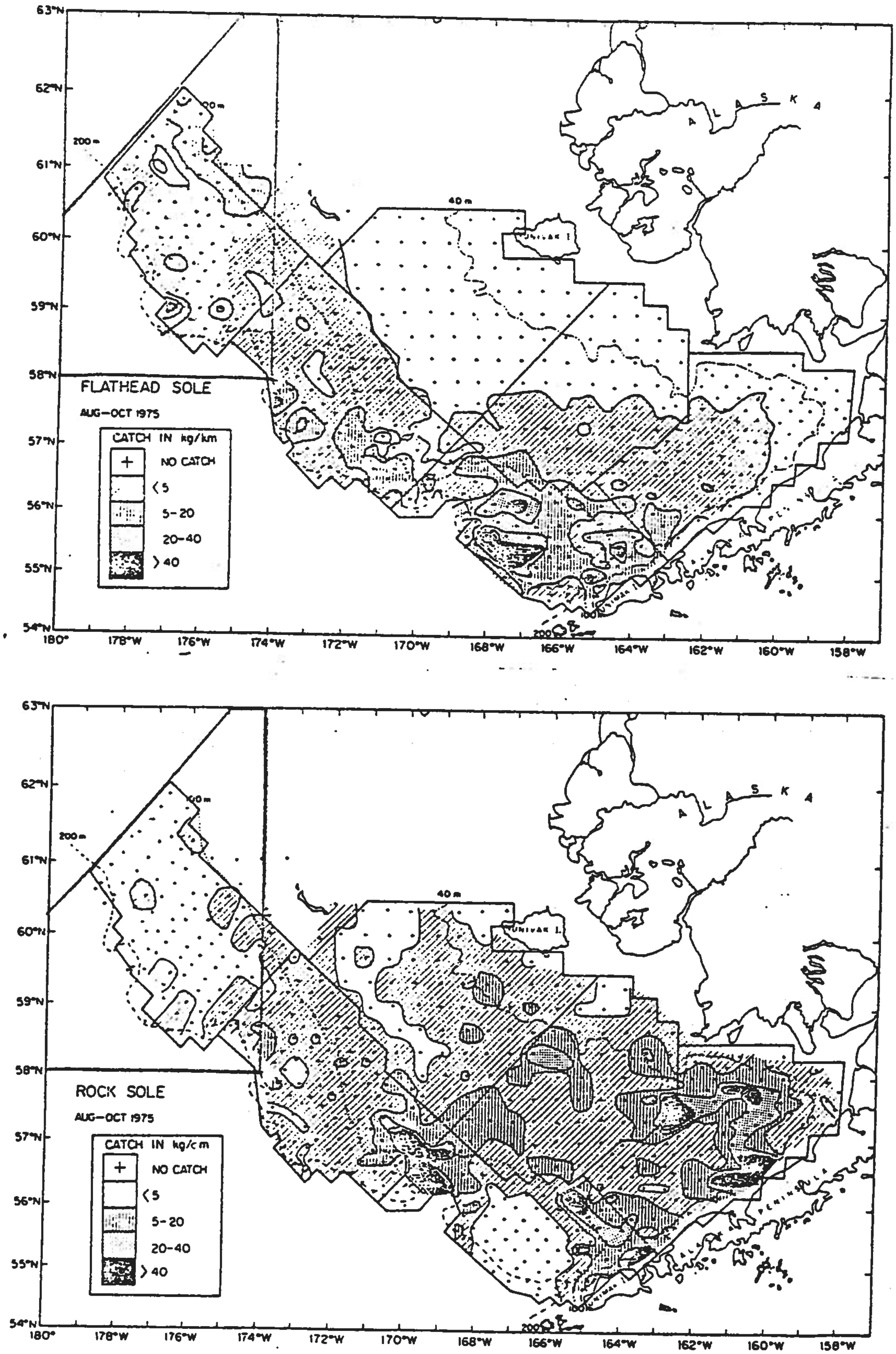


Figure 4.16 - Distribution and relative abundance by weight of flathead sole (above) and rock sole (below) in the eastern Bering Sea.

Rock sole are found mainly on the eastern Bering Sea shelf (Figure 4.16) where yellowfin sole predominate. They are often found in association with Greenland turbot, flathead sole, walleye pollock, Pacific cod, and Tanner crab. Rock sole was the second-most abundant (12.9 kg/km) and frequently caught species taken in Bristol Bay during the summer-fall 1975 OCSEAP demersal resources survey. During the spring, summer, and fall rock sole are most numerous on the shelf at depths generally shallower than 100 m in four main areas: 1) directly east of the Pribilof Islands, 2) in various locations in central Bristol Bay, 3) north of Unimak Island, and 4) south of Nunivak Island.

In the eastern Bering Sea and Bristol Bay, rock sole spawn during the spring (March-June at depths of 70-140 m and temperatures of 0.7 to 3.5°C). In contrast to yellowfin sole and nearly all other flounders of the eastern Bering Sea, which have pelagic eggs, rock sole deposit adhesive, demersal eggs. The larvae are pelagic, but few are taken in plankton tows.

Young rock sole (ages 2 and 3) were found almost exclusively in outer Bristol Bay and the Pribilof Island area during August-October 1975. Thus, it appears that these are important rearing areas for rock sole during their first three years of life.

In contrast to rock sole and flathead sole, Alaska plaice are always dispersed and do not form separate commercial concentrations.

In the eastern Bering Sea, Alaska plaice are usually found in continental shelf waters together with yellowfin sole. They apparently live throughout the year on the Bering Sea shelf. During the winter, Alaska plaice occur at depths of 90-130 m or deeper where bottom temperatures are 1° to 5°C. In summer, they apparently migrate to shallower water (30-100 m), where they show a preference for water colder than 3°C.

Alaska plaice were relatively abundant in the central shallows areas between Cape Newenham and Unimak Island, east of the Pribilof Islands, and west of Nunivak Island during summer and fall of 1976. Diel off-bottom movements may occur between dusk and dawn.

This species does not appear to form dense aggregations even during the spawning period. The spawning of Alaska plaice lasts 2 to 3 months during the spring (late April-mid June) immediately after the ice melts. Spawning occurs on the shelf, primarily on hard, sandy bottoms at depths of 75-150 m, at water temperatures of about -1.5° to 4.1°C. Eggs incubate for about two months. The developing eggs are partly carried to greater depths in the open sea, although some are transported closer to the shore. Small larvae occur primarily near the surface, although they are occasionally caught in deeper waters down to 50-120 m. The young larvae probably become demersal at a length of about 13-17 mm.

The Fishery: Arrowtooth flounder, Greenland turbot, and the other flounders are often grouped under the term "turbot" or "other flatfishes" in commercial fishery statistics. As such it is difficult to give accurate catch statistics by species. Japanese and Soviet catches of "turbot" during the period 1964-74 averaged about 46,000 mt per year and were heaviest along the continental shelf from the Pribilofs west.

The historical catch record of rock sole in the eastern Bering Sea has been poorly documented, particularly prior to 1964, largely because rock sole are usually a by-catch in the fisheries for other species, such as yellowfin sole and pollock. All-nation catches of rock sole varied between about 2,900 mt in 1965 and 9,800 mt in 1969, increased to the historical peak of 67,600 mt in 1972, then decreased to 37,600 mt in 1974. Catches averaged 21,700 mt/yr during 1964-74. Most of the rock sole catch occurs to the east of the Pribilofs and in Bristol Bay. Bristol Bay has accounted for about 42 percent of the total catch of rock sole in the Bering Sea, but more recently (1972-75) this area has declined to only about 11 percent of the catch.

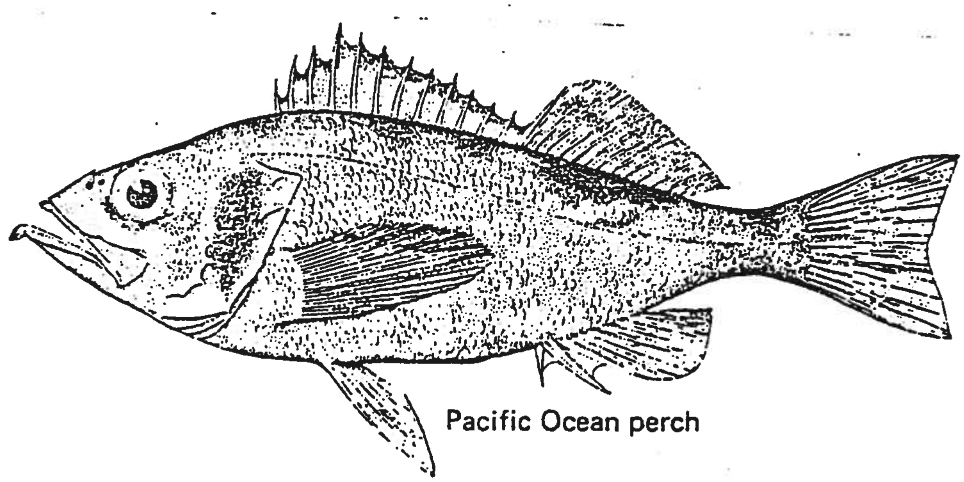
Flathead sole are taken mainly on the eastern Bering Sea shelf, but on somewhat deeper grounds than occupied by yellowfin sole and rock sole. They are caught mainly as an incidental species in the yellowfin sole and pollock fisheries. Catches of flathead sole have ranged from about 6,000 mt in 1965 to about 50,100 mt in 1971. From 1969 to 1971, the catch more than doubled (from about 20,300 mt to 50,100 mt), declined to about 15,000 mt in 1972, and increased again to about 27,800 mt in 1974. Catches averaged about 24,500 mt/yr during 1964-74. These values, however, may not be very accurate because of inconsistencies in the categorization of flathead sole as a separate species by Japanese fisheries. The U.S.S.R., on the other hand, provides no breakdown of the species composition of its flounder catch; it is assumed to be similar to that of the Japanese fishery. During the period 1964-73, about 70 percent of the total Japanese catch of flathead sole was taken west of Bristol Bay.

Information is not fully available to describe the importance of Alaska plaice in the Bering Sea fisheries because some catch statistics categorize Alaska plaice as "other flatfish." Annual catches for the Japanese mothership and North Pacific trawl fisheries in the Bering Sea during 1964-72 were approximately 1-3,000 mt.

The total catch of flounders in the eastern Bering Sea has declined since 1974 from 190,000 mt to a 1979 catch of 90,000 mt. Indications are that this fishery is becoming fully exploited and stocks may well be in the decline for future years.

Stocks of rock sole, flathead sole, arrowtooth flounder, and other flounder species have been subjected to intensive incidental catch in the trawl fisheries in the central Bering Sea for nearly a decade. The impact of the fisheries on these stocks has not been thoroughly assessed, however, due to lack of information.

4.4.6 Pacific Ocean Perch



Pacific Ocean perch

The Resource: The Bering Sea has large rockfish populations distributed along the continental shelf margin from the Aleutians to Cape Navarin. Several species of rockfish inhabit the upper part of the continental slope with its favorable water, habitat, and food environment. Each rockfish species has a preferred depth range.

The Pacific ocean perch, *Sebastes alutus*, is the most abundant and valuable of the Bering Sea rockfishes. Its abundance makes up for its relatively small size, which rarely exceeds 3 pounds in weight. Pacific ocean perch are widespread along the shelf edge and upper slope at depths ranging from 150-500 m. They are most abundant near the 180-m contour, about 20 m off bottom in gullies, canyons, and depressions of the upper slope.

In the Bering Sea, two main stocks are identified: (1) an Eastern slope stock along the southern half of the eastern Bering Sea continental slope and (2) a much larger Aleutian stock along both sides of the Aleutian chain. In the Bering Sea, the largest concentrations are located near the Pribilof Islands and on the southeastern part of the continental slope.

From January to May in the Bering Sea the densest concentrations of *S. alutus* are in spawning areas to the south and west of the Pribilof Islands at depths of 340 to 420 m. Except for distinct daily vertical migrations attributed to feeding, the schools are relatively immobile. From May to September the fish make an intensive foraging migration to the central Bering Sea; from September to January they return to their southeastern spawning areas. During this migration, the schools are in shallower water but are spread out at a greater range of depths (140-360 m).

Growth of the species is slow, a 14 year old fish rarely exceeds 40 cm. Sexual maturity is attained at age 6-8. Spawning occurs in March to June.

Rockfish give birth to live young. Females may produce an average about 10,000 larvae. The larvae are usually born in the spring and in that stage, and as juveniles, they are one of the chief food supplies of larger fish, including their own kin, a carnivorous relationship common to many fishes.

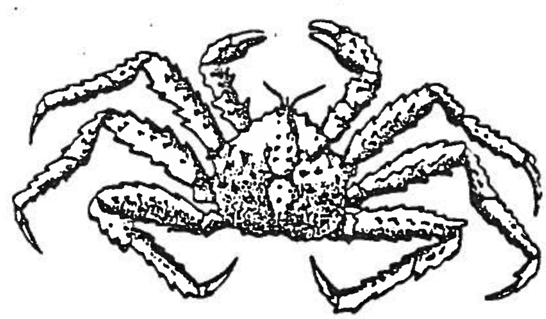
There is little definite knowledge of the early life cycle of most rockfishes. During the first year after birth, young ocean perch are planktonic. During their second year, however, the young fish take up life near the ocean bottom. Here they remain in waters 125-150 m deep until they reach the age of sexual maturity. Schools of juvenile perch are usually found at shallower depths than are the adults.

The Fishery: Japanese and Soviet fisheries for Pacific ocean perch in the central Bering Sea began in 1960. The Soviet effort involved 25-30 trawlers fishing along the edge of the continental shelf, and the Japanese effort was by trawlers of its mothership fishery. These countries also fished Pacific ocean perch along the Aleutian Islands where catches were larger than on the Bering Sea Shelf. Combined catches by Japan and the U.S.S.R. on the central and eastern Bering Sea slope ranged from about 16,800 mt to 47,000 mt during 1961-68. In subsequent years up to and including 1979, catches were much lower, ranging from 3,700 mt to 14,500 mt. Except for the years 1961 and 1974, Japanese catches have generally been much larger than Soviet catches.

Ocean perch catches in the Bering Sea are mainly made west of 165° W. Less than 1 percent of the Japanese catch during 1964-73 came from the southeastern area. Few ocean perch were taken during the 1975 OCSEAP survey.

Stock levels in both the eastern Bering Sea and Aleutian Islands region have remained relatively low since the latter 1960's when there were drastic declines in abundance from overfishing.

4.4.7 King Crabs



KING CRAB

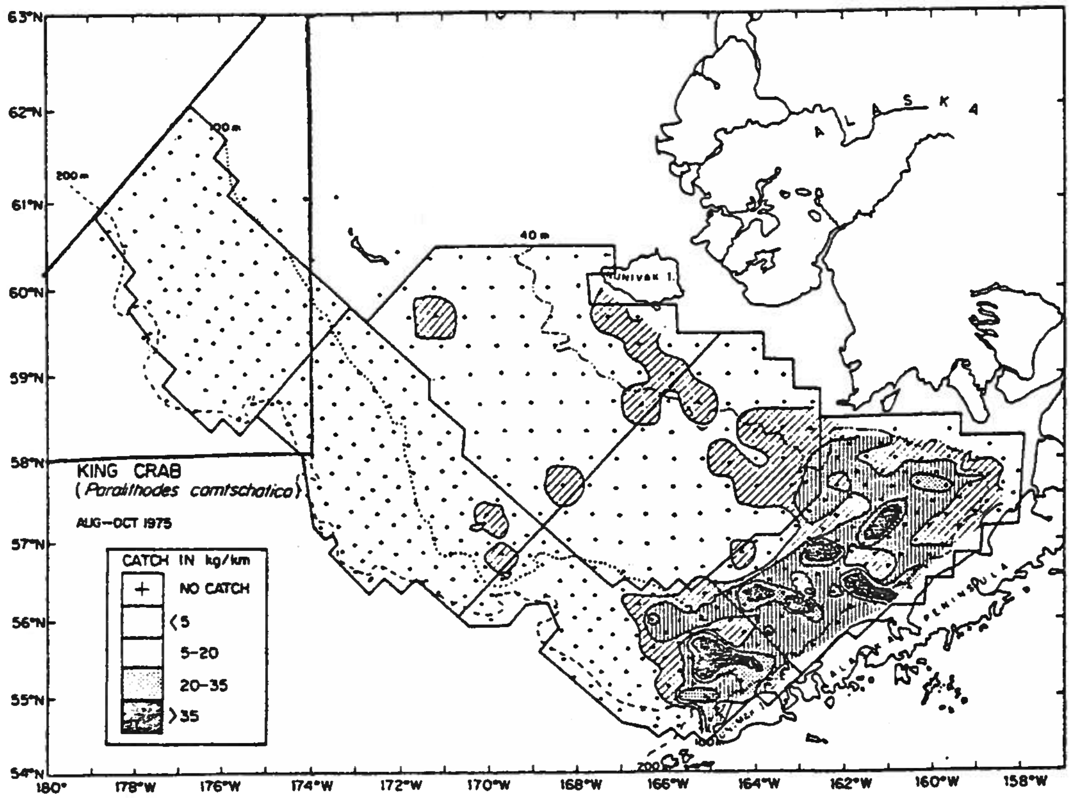


Figure 4.17 - Distribution and relative abundance by weight of red king crab in the eastern Bering Sea.

<u>The Resources</u>: The red king crab, <u>Paralithodes camtschatica</u>, is a widely occuring crustacean of the continental shelf of the North Pacific, from Alaska to the Kamchatka Peninsula and the Sea of Okhotsk. In U.S. waters of the Bering Sea, it is primarily in abundance in the southeastern Bering Sea, from along the north side of the Alaska peninsula from Unimak Pass eastward toward the head of Bristol Bay (Figure 4.17). The greatest abundance is in water depths of 50 to 130 m. It is virtually absent from the outer shelf areas north and west of the Pribilofs, where the blue king crab, <u>Paralithodes platypus</u>, predominates (Figure 4.18). The blue crab occurs along the outer continental shelf from the Pribilof Islands northward to St. Matthew Island and into Norton Sound but the average population abundance is estimated to be only 9% that of the red king crab. The golden king crab, <u>Lithodes acquispina</u>, is a deep water species, presently of little commercial importance.

Sexually-mature male king crabs begin breeding migrations from around the 200 m curve where they spend summer and autumn, and move into shallower water of 80 m or less in winter and early spring. This slow migration begins in late December or early January and lasts into April. Molting of male king crabs occur along the way to the breeding grounds, with the time of the molt varying according to race.

The migrating males are followed into shallow water by the females, with the younger females arriving on the breeding grounds first. Young females breed mostly in April, their elders in May. Breeding occurs immediately after the female molts. Favored breeding grounds are along shore or on offshore shallows in depths of 5 to 20 meters. When breeding is complete, both sexes return to deeper waters, often to 300 m or more. Despite these migrations, there is little interchange among regional populations, and the adult crabs seem to return annually to the same breeding grounds. They also seem to live in the same general area over their life span.

Females carry an average of 240,000 eggs in their brood pouch for nearly a year. Female blue king crabs have been observed in the process of molting and hatching eggs in late July near the Pribilofs. After the hatching, the crab larvae spend from 10 to 12 weeks as plankton, metamorphosing to juveniles after 4 molts. Juveniles settle to the bottom and seek shallow, rocky areas to feed and grow. They undergo numerous molts, 6 to 9 molts the first year, fewer in subsequent years until at about age 4 to 7, when molting occurs once per year. Beyond age 7, males may pass one or more years without molting. Adult females must molt annually to breed. Sexual maturity occurs at age 4 to 6. Males reach legal commercial size at about age 7. Females may not be harvested commercially.

The king crab is relatively long-lived, and individuals of age 15 and as large as 24 pounds have been taken in the fishery. Most commercially caught males are 8 or 9 years old and average about 7 pounds.

<u>The Fishery</u>: The eastern Bering Sea sustains crab populations of tremendous commercial importance. American fishermen, supported by federal funds, began exploratory fishing and studies on king crab (primarily the red king crab)

in 1940 and 1941, but the annual catch had risen to only 2 million pounds by 1953. Through the mid-sixties, the major fishing effort shifted to the south side of the Alaska Peninsula. In 1968 the U.S. catch in the Bering Sea began a dramatic increase which has continued to the present time. A peak catch of 23,000 mt was achieved in 1974. In 1974, the catch totaled 9,000 mt (20 million pounds) having a port landed (ex-vessel) value of $19 million.

Japan pioneered the fishery for king crab in the eastern Bering Sea in 1930, landing nearly 8 million crab by 1941. Japan resumed this fishery in 1953 (which had lapsed during and after World War II) and fished on a continuous basis until 1976. Japan's annual catch remained near 1 million crab through 1959, at which time the Soviet Union entered the fishery. Both nations rapidly increased their effort with a tangle net fishery and their combined catches reached an annual level of almost 9 million crab by 1964. Since that time bilateral agreements between the USA, Japan, and the USSR have eliminated fishing with tangle net gear and greatly reduced the foreign king crab catch in the eastern Bering Sea, totally excluding foreign fishing in the area of its central abundance in the Bristol Bay area.

From NMFS surveys and fishing data from 1959 to 1969 it was evident that the king crab stock in the eastern Bering Sea was reduced by overfishing. The decline stopped in 1970, and since 1970 increases in CPUE have been accompanied by slight increases in average carapace length and by continued increases in total annual catches (Figure 4.18). Results of 1973 and 1974 trawl surveys similarly indicate that numbers of male king crab, greater than 120 mm in carapace length, have increased since 1972. Results of 1974 trawl surveys indicate a modest increase in the number of king crab, showing signs of recovery from the low level in 1969.

The stock of P. platypus is limited in abundance to north and northwest of the Pribilof Islands. Although there had been some improvement in the CPUE of P. playpus for the U.S. fishery, surveys have been too limited to permit evaluation of the CPUE trends.

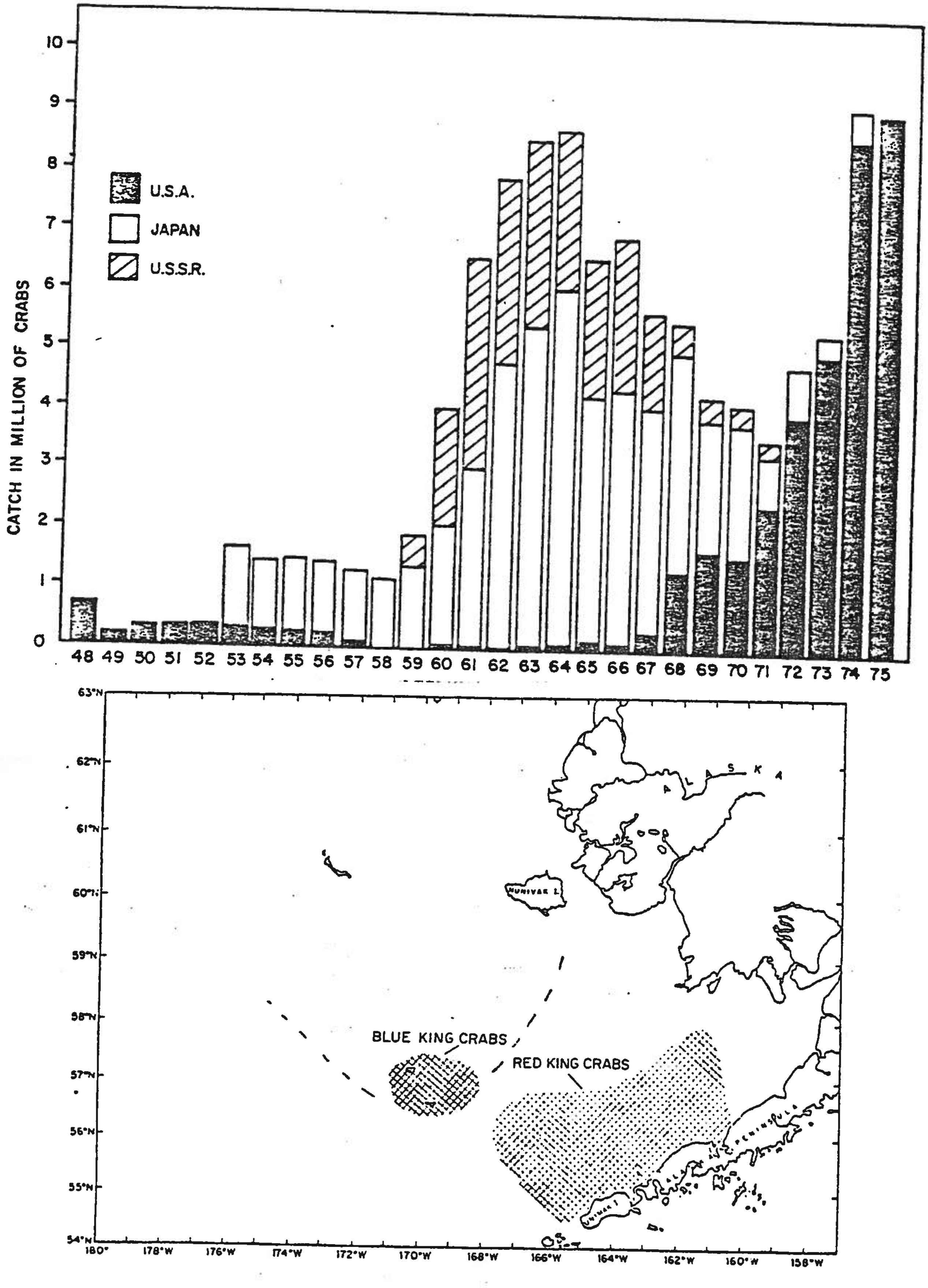


Figure 4.18 - Annual catches of king crab in the eastern Bering Sea, 1948 - 75 (upper figure); and map of locations of U.S. fishing areas (lower figure).

King crabs are caught with baited pots which are 6 to 7 feet square, 3 feet high, and weigh 500-700 pounds. A crab vessel may fish hundreds of pots soaking them for several days depending on crab concentrations.

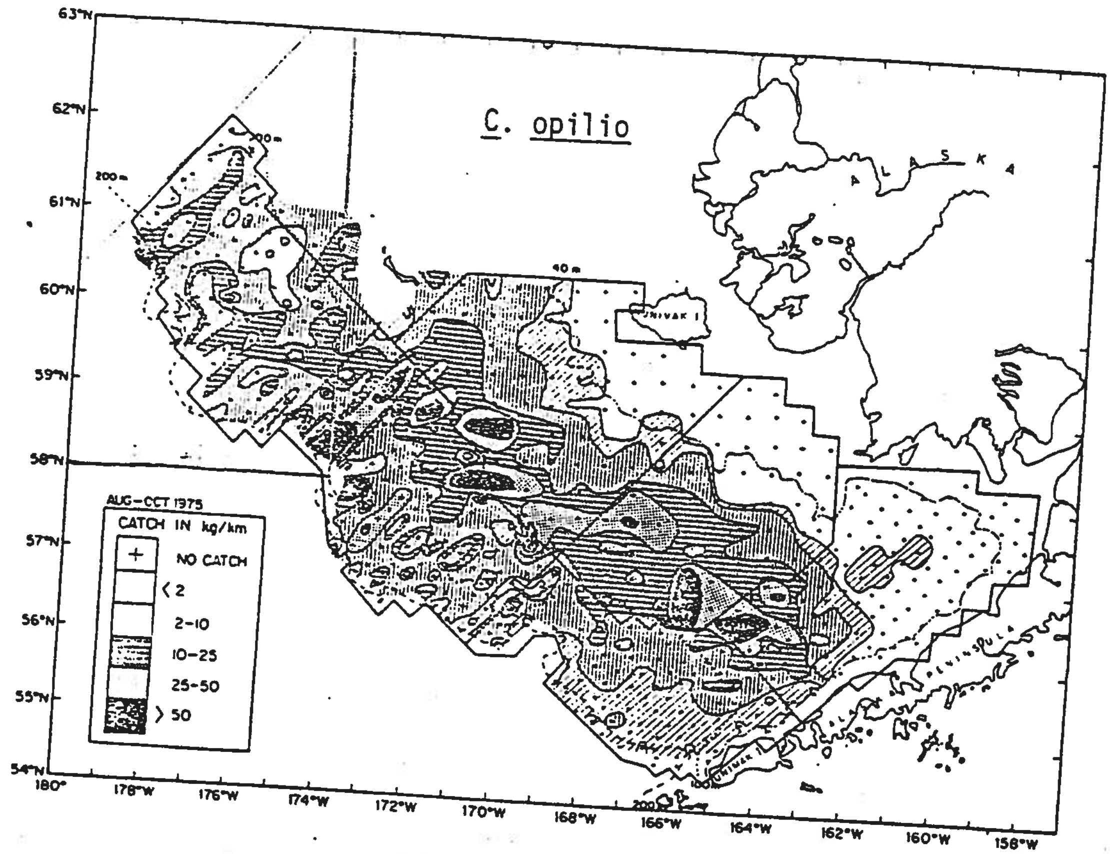
4.4.8 Tanner Crabs

The Resource: The Tanner, or snow crab, as it is called by its market name, is found mainly in shallow water from southeast Alaska to the Aleutians, into the Bering Sea and north past the Bering Strait. Two species of Tanner crab, *Chionoecetes bairdi* and *C. opilio*, and a hybrid of these species are widely distributed and abundant along the central and outer continental shelf of the Bering Sea. Although the two species occur together over most of their geographic ranges, a separation is found between each species' areas of highest abundance (Figure 4.19). High concentrations of *C. bairdi* were found in deeper water than *C. opilio*. Bottom temperature data suggests that the distribution of *C. opilio* is associated with colder waters than that of *C. bairdi*. The highest average abundance of Tanner crabs is to the south and north of the Pribilofs and in the Navarin Basin area where, *C. opilio* is the dominant species. Main concentrations are found in waters of 50-170 m.

Tanner crab range in carapace widths to 190 mm for *C. bairdi* and to 150 mm for *C. opilio*. They live to an estimated maximum age of 14 years. Males of commercial size usually range from 7 to 11 years old and from 2 to 4 pounds in weight. Sexual maturity is reached at age 5 or 6.

Migration patterns are not well understood. The sexes are separate during much of the year until they move to their breeding grounds. Like the king crabs, Tanner crab females breed during their annual molt. Eggs number from 85,000 to over 400,000, and are brooded for nearly a year. Hatching occurs late the following winter and spring. The hatched larvae are planktonic for 2 to 3 months, depending on water temperatures, during which they undergo numerous molts. Juveniles settle to the bottom to feed and grow. Tanner crabs feed on dead and decaying molluscs, crustaceans, and other organisms accumulating on the ocean floor.

The Fishery: The Tanner or snow crab fishery in Alaska waters began in 1961 and has grown to major commercial importance. Japan made small catches of



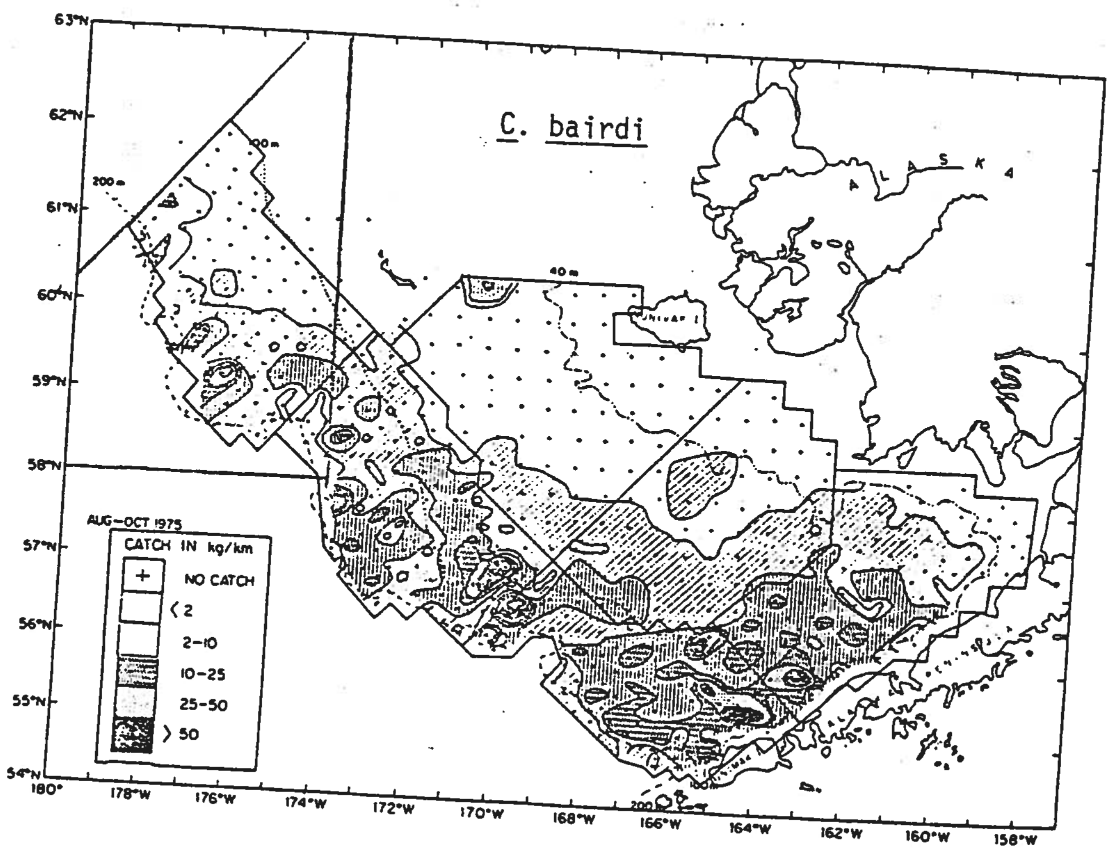


Figure 4.19 - Distribution and relative abundance of Tanner crab (C. opilio and C. bairdi) in the eastern Bering Sea.

Tanner crab before 1965, but with quota restrictions on king crab and improving world markets for other crab, Tanner crab catches rose from 1 million crab in 1965 to 18.2 million in 1970 (Figure 4.20). Quotas established through bilateral negotiation and FCMA allocation (Figure 4.21) have reduced the Japanese harvest to 15,000 mt of Tanner crab in 1977 and 7,500 mt in 1980. U.S. landings of eastern Bering Sea Tanner crab grew from 8 mt in 1968 to 35,000 mt in 1979.

From NMFS surveys it appears that the abundance of Tanner crab dropped to a relatively low level in 1972 but has since recovered. The CPUE for Japanese fishermen in 1974 was at the highest level since Japan began using pot gear in 1967. Conversely, a Soviet trawl survey in the eastern Bering Sea in 1974 indicated that stocks of male C. bairdi of exploitable size were low, but the survey detected a strong year-class which entered the commercial fishery in 1976-77.

U.S. fishermen and fishery scientists have been concerned for many years over the deleterious effects of the incidental catch of Tanner crab in the foreign trawl fisheries. Even with the incidental crab catch constituting only a small fraction of the total trawl landings, the large volume of groundfish harvested causes the incidental Tanner crab catch to be substantial. Japanese eastern Bering Sea groundfish fleets took an estimated 118 million individual Tanner crab in 1972 with a mortality of 60 - 70%. Japanese scientists made independent estimates and concluded the incidental catch may be even higher. As a result of these investigations, Japan, since the 1974 bilateral negotiations with the United States, has agreed to refrain from trawling in certain areas where the incidental catch of crab was high, and to conduct research to improve the selectivity of their trawl gear.

It is estimated that in the Bering Sea area north of 58° N latitude and west of 164° W longitude the Tanner crab population is capable of providing a sustained yield of over 100,000 mt annually of C. opilio.

Crab are taken by vessels ranging from small inshore vessels to large Bering Sea crabbers averaging 95 to 100 feet in keel length. Fishing gear

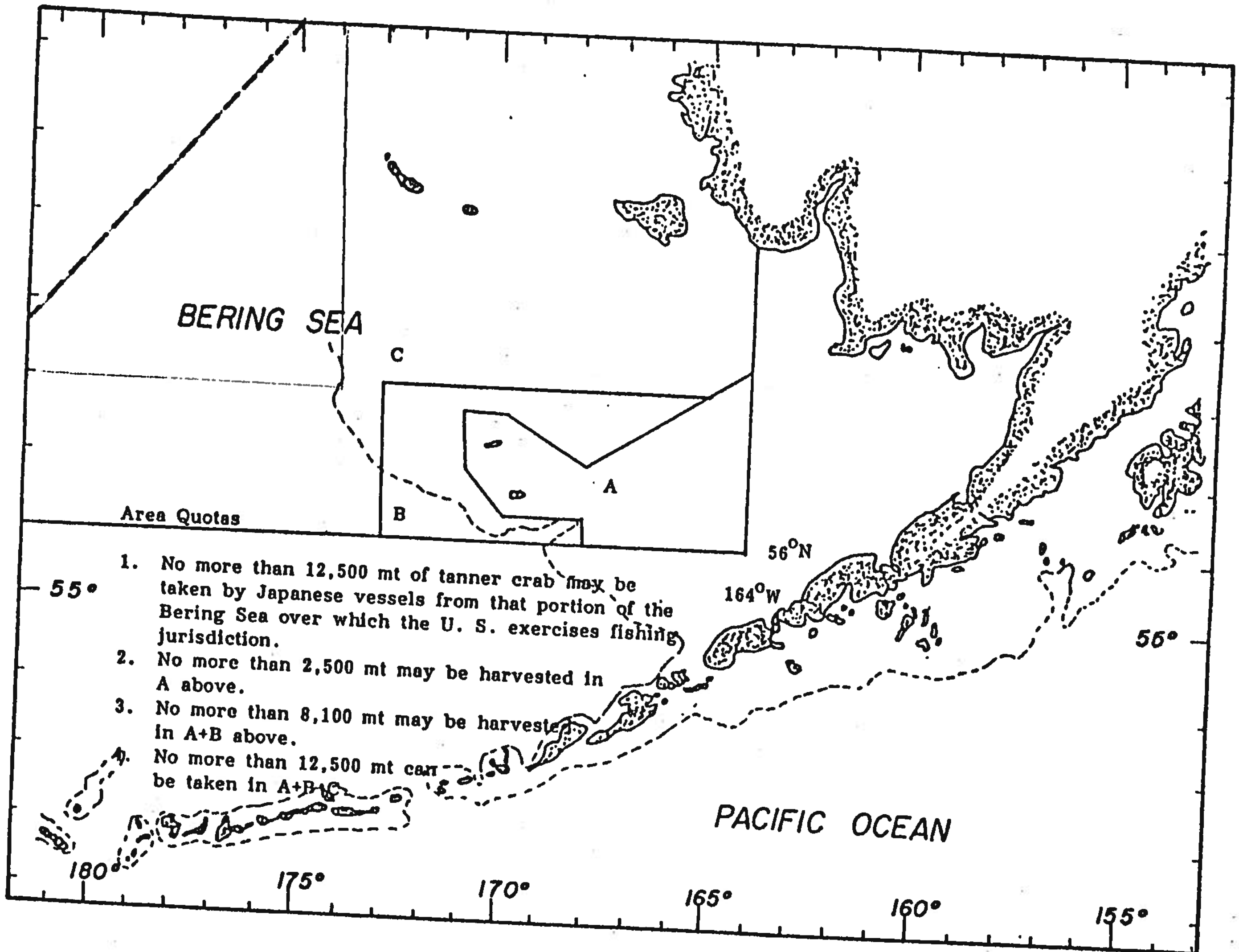


Figure 4.21 - Eastern Bering Sea Tanner crab quotas and fishing restrictions in 1977 established by U.S.-Japan and U.S.-U.S.S.R. crab management agreements.

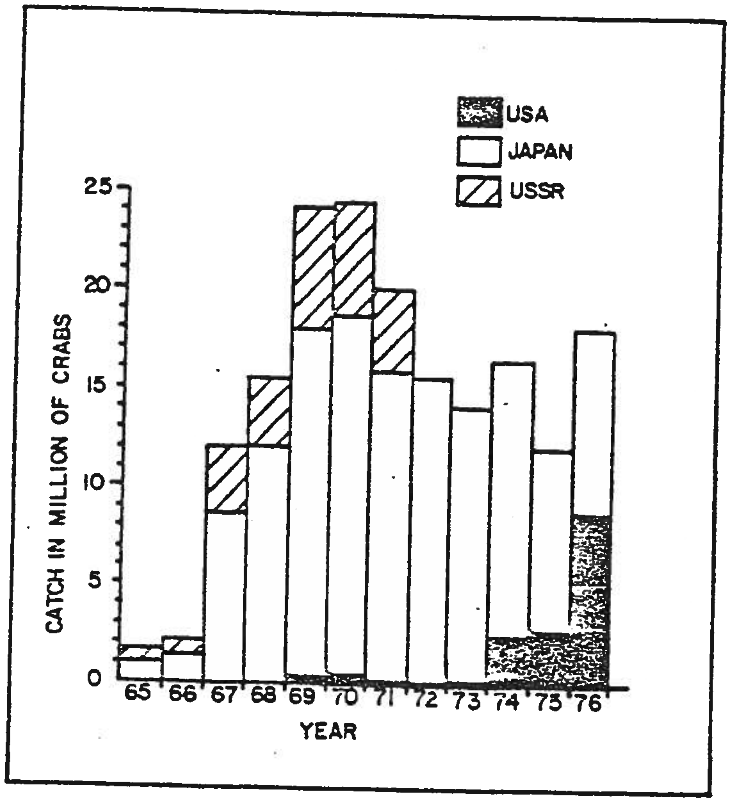


Figure 4.20 - Annual catches of Tanner crab in the eastern Bering Sea, 1965-76.

consists primarily of pots similar to those used for king crab. Most pots are baited with chopped herring and then soaked from one to three days.

4.4.9 Korean Horsehair Crab

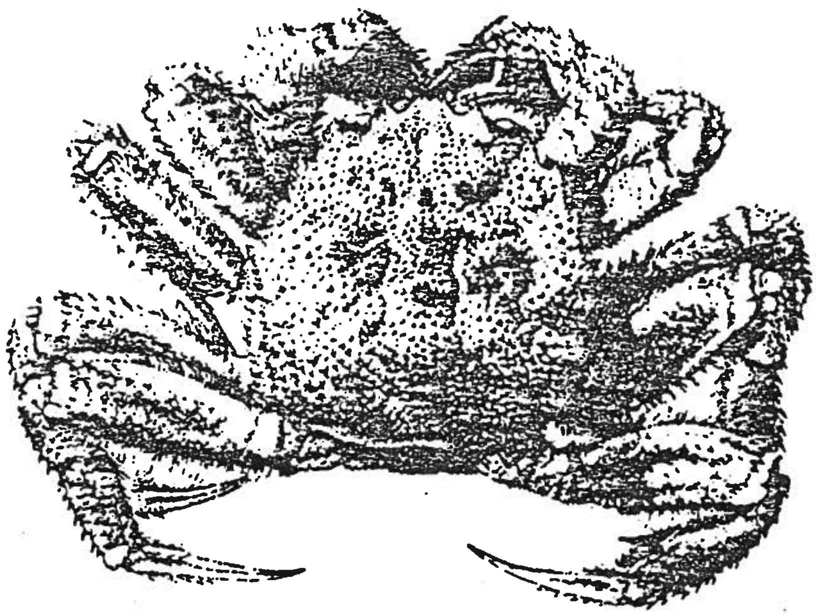
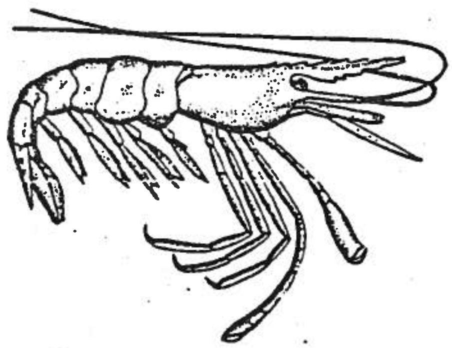


Figure 4.22 .—Korean horsehair crab.

The Korean horsehair crab, Erimacrus isenbeckii, (Figure 4.22), is a potentially exploitable shellfish resource of the Bering Sea shelf. Horsehair crab, are sparsely distributed throughout most of the eastern Bering Sea but appear to be concentrated in areas along the northern shore of the Alaska Peninsula and in the Pribilof Islands region. Information from recent NMFS crab-groundfish surveys in the central Bering Sea indicates an estimated biomass for market-size horsehair crab (over 3-1/2 inch carapace length) of about 15,000 mt (16 million crab). Several fishermen have harvested horsehair crab this year, and to date 1980 landings have exceeded 13 mt. Information from Japan indicates wholesale prices for horsehair crab in Tokyo are nearly $4.00/pound for live crab and $2.78/pound for boiled whole crab. Prices presently paid to Alaska fishermen are reported to be as high as 75 cents/pound.

4.4.10 Shrimp



SHRIMP

The Resource: Three principal species of pandalid shrimp are found in the Bering Sea, the sidestripe shrimp, *Pandalopsis dispar*, the pink shrimp, *Pandalus borealis*, and the humpy shrimp, *P. goniurus*. These species are of greatest abundance along the central outer shelf and slopes of the central Bering Sea area. The species of primary commercial interest in the Bering Sea is the pink shrimp. The main fishing area for this species was northwest of the Pribilof Islands (Figure 4.23).

These species are bottom dwellers, preferring relatively smooth sand and mud bottoms. The sidestripe is the largest species, with body length from 4 to 10 inches and it is commonly sold as prawns. Pink and humpy shrimp are smaller, average body length of from 3 to 5 inches, and are the so-called cocktail shrimp.

According to NMFS surveys, pink shrimp are found to the northwest of the Pribilofs and in the Bristol Bay. These distributional patterns appear to reflect the temperature requirements of the individual species. *P. borealis* evidently requires warmer temperatures and, particularly during relatively cold years such as 1975, occurs near the shelf edge where there were intrusions of warmer oceanic water. *P. goniurus* seems to tolerate sustained low temperatures and is found in shallower shelf waters where residual water cooling depresses water temperatures.

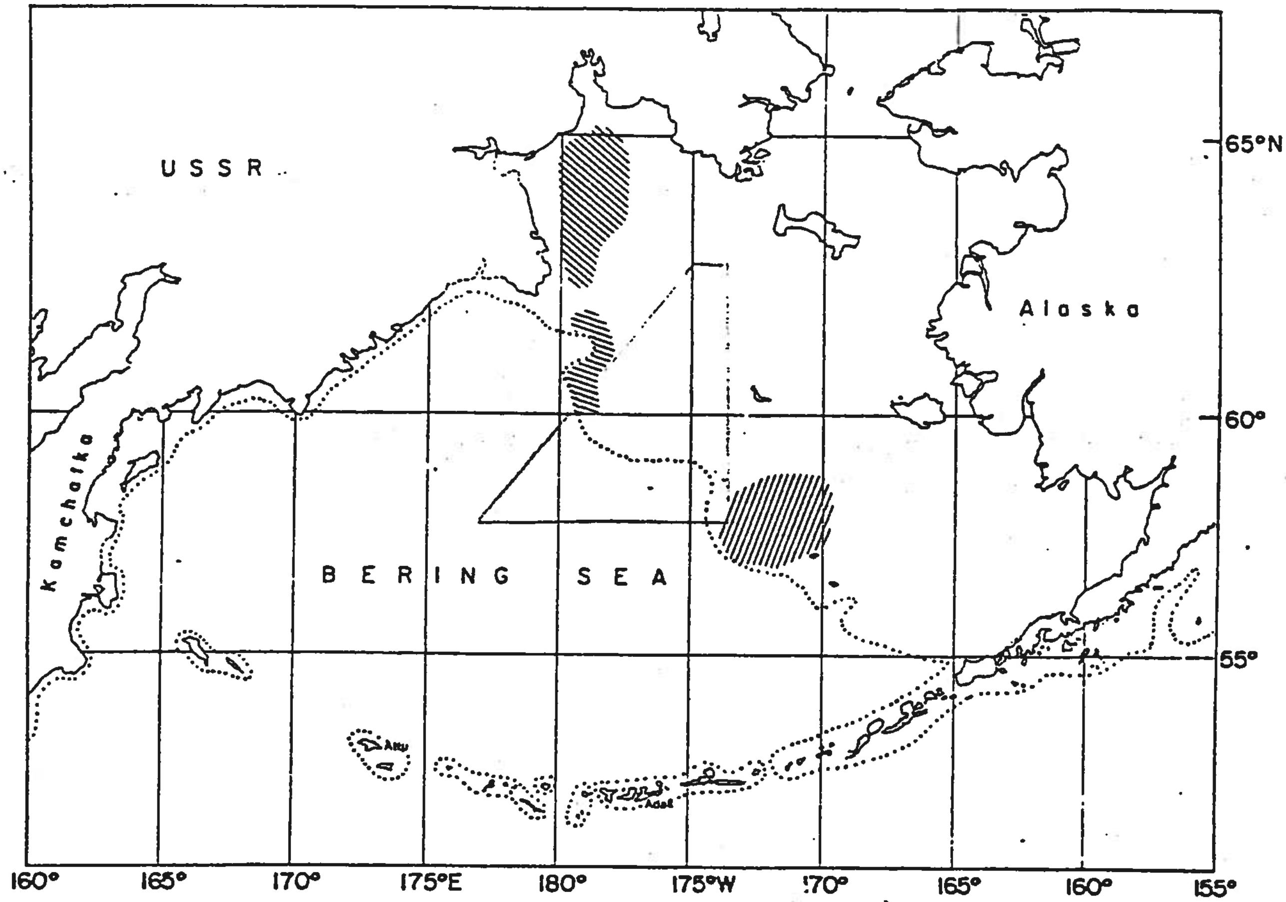


Figure 4.23 - Main fishing grounds for pink shrimp in the Bering Sea.

Shrimp populations are presently at low levels of abundance: P. goniurus was taken at the rate of only 0.08 kg/km in the eastern Bering Sea during the 1975 OCS/BLM baseline survey. However, the sampling gear employed during the survey probably did not adequately sample shrimp and other small invertebrates.

Diel vertical migrations of P. borealis are well documented. Research by Barr (1970) in Kachemak Bay, lower Cook Inlet, suggest diel vertical feeding migrations. Smaller individuals exhibit a greater tendency for vertical migration than do larger ones. Such migrations probably also occur in the Bering Sea.

The generalized life history of P. goniurus and P. borealis are probably similar. Pandalid shrimp are typically bisexual. P. borealis become sexually mature as males at age 2 or 3 years, when they participate for the first time in breeding. By the fifth year, most individuals change into breeding females. However, individuals called "primary females" are believed to exist in every shrimp population. These individuals never function as males, and their early maturation as females serves as a survival mechanism beneficial to the population.

Pink shrimp live about 6-7 years. Breeding takes place in the fall (September-October). Just before spawning, the female molts into a shell specialized for carrying the eggs. The eggs are fertilized as they are extruded from the female and are attached to specialized setae on the abdominal appendages. The eggs are carried for 7 to 8 months before hatching takes place in the spring.

The free swimming larvae are released in mid-spring, rise to the surface, and spend up to 3 months drifting passively or swimming weakly and feeding on planktonic organisms. The larvae molt about 6 times during this period. By the end of the summer the young closely resemble miniature adults and assume a semi-benthic existence, spending part of their time feeding in the water column and the remainder on the bottom. The juvenile shrimp then develop into males. Although shrimp are not of direct commercial importance in the Bering Sea at this time, all life stages are an important part of the food web supporting many fish, marine mammals, and sea birds.

The Fishery: Alaska has the dominant shrimp fishery in Pacific waters of the U.S., often amounting to over 25% of the national catch. The size of the resource is incompletely assessed, and it is uncertain how large the potential may be. NMFS surveys have estimated that more than 90,000 mt (200 million pounds) could be harvested in Alaska waters on a sustained yield basis. Other estimates have run as much as twice this amount. Vast areas of the Bering Sea overlay fairly shallow waters with good trawl bottom and shrimp habitat with a promising future potential.

Japan and the Soviets fished for shrimp in the Bering Sea since the early 1960's (Figure 4.23). Japan concentrated their efforts to the central Bering Sea north of the Pribilofs, and in 1963 achieved a peak catch of 27,000 mt. After 1963, the Japanese effort and catch declined rapidly, and by 1966 overfishing no longer made further commercial efforts profitable. Shrimp stocks have remained depressed, and the shrimp fishery in the central Bering Sea has not been resumed in recent years.

4.4.11 Marine Snails

The Resource: Large marine snails, some reaching 6 inches in shell length, are abundant in the waters of the central Bering Sea. The most common large snails are members of the genera *Neptunea* and *Buccinum*, but others such as *Fusitriton*, *Volutopsius*, *Beringius*, and *Plicifusus* are also well represented. NMFS surveys conducted in the summer and fall of 1975 assessed the snail resource of the Bering Sea shelf. Fifteen species of large marine snails were found to inhabit the continental shelf and shelf edge of the Bering Sea. All can be found in the Navarin Basin area (MacIntosh, 1980). The sizes of some of the most abundant species are given in Table 4.6. Snail distribution during the survey was patchy (Figure 4.24) and the areas of highest density also supported a high biomass of fish and other invertebrates. Snail biomass in some areas exceeded 3 mt/km^2. These gastropods composed 1.7 percent of the total biomass and 6.6 percent of the invertebrate biomass in the survey area.

Each snail species inhabits specific depth and temperature regions. Of the more abundant *Neptunea*, *N. pribiloffensis* and *N. lyrata* inhabit the warmer, deeper waters near the shelf edge, while *N. heros* and *N. ventricosa* inhabit shallower, seasonally cooled waters nearer the coast.

Among the large *Neptunea*, sexual maturity occurs at a shell length of 9-10 cm, or possibly at about age 10. Egg clusters are laid on both living and dead shells of other large snails as available, and without regard to species. Crawling young hatch directly from egg capsules, lacking a pelagic stage.

Table 4.6 Size of the Common Marine Snails of the Eastern Bering Sea (MacIntosh, 1976).

Species	Mean Shell Length (cm)
Neptunea pribiloffensis	10.0
N. lyrata	11.5
N. ventricosa	10.2
N. heros	12.1
Buccinum spp.	5.8 - 7.5
Fusitriton oregonensis	13.0

Very little is known about the feeding habits of these gastopods. All are carnivorous, and most are thought to be facultative predators and scavengers feeding on other benthic invertebrates.

The Fishery: Despite the fact that snails have long been harvested throughout the world, commercial development of this resource off Alaska didn't occur until the 1970's when Japan began to commercially harvest marine snails in the eastern Bering Sea in 1971. Statistics available since 1972 indicate an annual harvest rate of about 3000 mt of edible meat of this shellfish resource (Table 4.7). The fishery occurs primarily east of long. 175° W on the continental shelf to the northwest of the Pribilof Islands (Figure 4.25).

The 1978 season, as an example, lasted from May to November. Fishing effort peaked in August with nine vessels ranging in size from 96 to 490 gross tons and 25 to 50 m in length. Fishing gear consists of baited pots fished at intervals on a groundline. Up to 500 pots, each a webbed truncated cone slightly less than a meter in height, are attached to each groundline. In 1973 one vessel fished about 6,000 pots on 12 groundlines and took 3 days to pick and re-bait the gear. The average rate of catch reported by that vessel was 4 kg meat/pot per 3-day soak. Meats are generally extracted aboard the catcher vessel and frozen raw. 1973 catch values indicate that on the order of 200 million snails were harvested that year.

Table 4.7 - Catch and effort statistics of the Japanese snail fishery in the eastern Bering Sea, 1972-78, (from MacIntosh, 1980).

Year	Catch (t) edible meat	Total weight	Fishing effort (vessel days)
1972	3,218[b]	11,900	NA[c] (14 vessels)
1973	3,319[b]	12,300	NA (21 vessels)
1974	3,574[b]	13,237	NA
1975	3,447[b]	12,767	NA
1976	NA	NA	NA
1977	404[d]	1,500	152
1978	2,184[d]	8,100	749
1979	537[d]	?	?

[a] Values are estimates derived from the weight of edible meat and whole snails taken by the fishery in 1974.

[b] Data provided by the Japan Fisheries Agency through the U.S. Embassy. Tokyo, Japan.

[c] Not available

[d] As reported to the United States under provisions of the Fishery Conservation and Management Act of 1976.

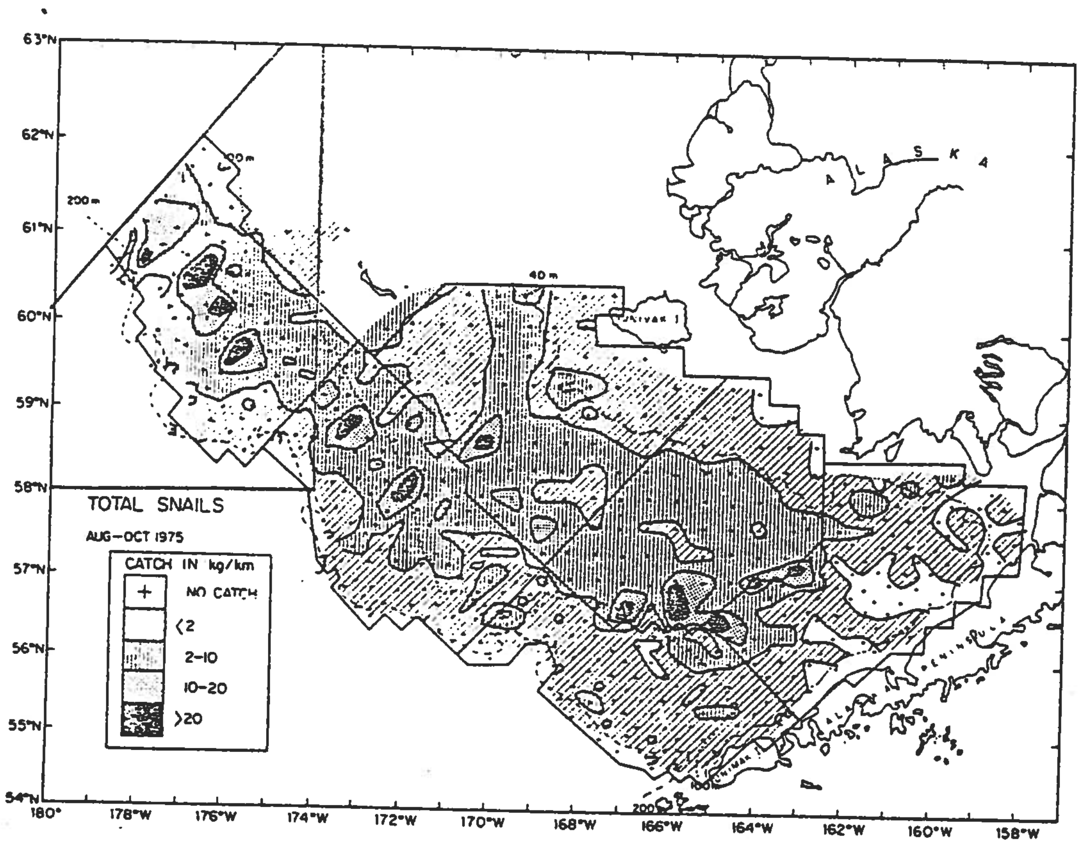


Figure 4.24 - Distribution and relative abundance by weight of snails in the eastern Bering Sea.

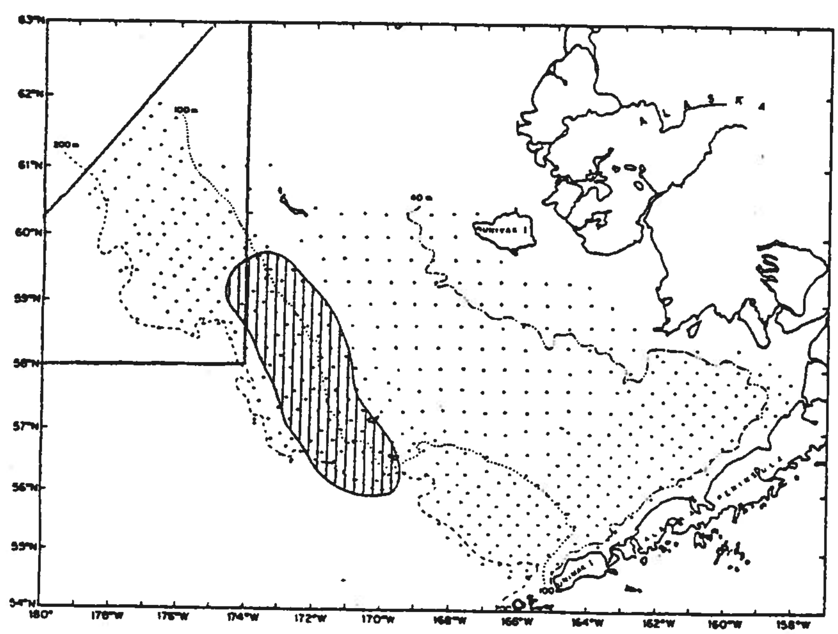


Figure 4.25 - The cross-hatched area indicates the location of the Japanese snail fishery in the eastern Bering Sea.

Table 4.8 - Species composition by percent number and weight of a portion of the 1973 Japanese eastern Bering Sea snail catch (adapted from Nagai, 1974).

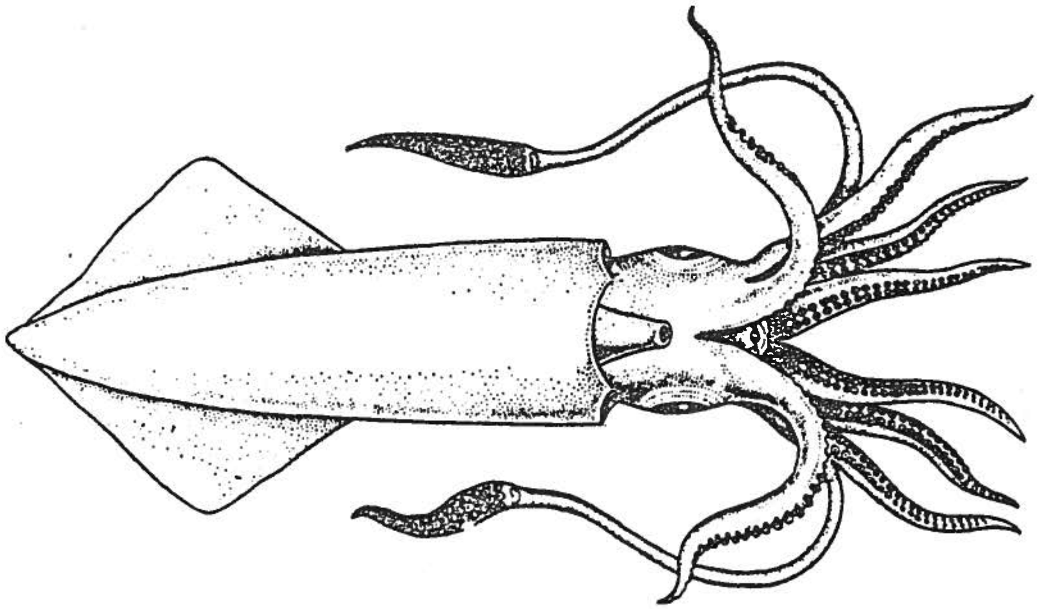
Species	Percent by number	Percent by weight
Neptunea pribiloffensis	47	70
Buccinum scalariforme	25	16
Buccinum angulossum	19	11
Plicifusus kroeyeri	4	2
Fusitriton oregonensis	0	0
Buccinum spp.	4	1
Miscellaneous	1	0

The most common marine snail in Japanese catches made northwest of the Pribilofs in 1973 was Neptunea pribiloffensis which composed 70% of the catch by weight (Table 4.8). Buccinum angulossum and B. scalariforme accounted for an additional 23 percent. The 1978 ex-vessel value of the resource was in excess of $3.0 million.

Snail meats are a delicacy in Japan, and are traditionally eaten with "sake" or rice wine. Attempts to initiate a U.S. snail fishery in Alaska have not been productive to date. In the eastern Bering Sea, the resource and harvesting capacity now exists in the crab fishing industry but processing and marketing techniques will have to be developed. There is promise of a potential off-season operation in the next few years using existing domestic crab vessels.

4.4.12 Squid

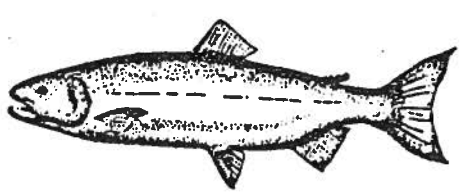
Several species of squid inhabit the Bering Sea waters. The exact nature and size of this resource is ill-defined, but it is generally agreed to be large. Illex vulgaris, a common Bering Sea squid, is a typical catch species, ranging in mantle size from 22-35 cm in length.



Much of the present squid catch is incidental to the catches of the demersal fishery. Five nations took squids in the Bering Sea during 1977-79. The largest catch was by the Japanese who took between 5,739 to 9,138 mt during these years. The Republic of South Korea was the only other nation to take sizable quantities, increasing their take from nothing in 1977 to 1,233 mt in 1979.

4.5 The Pelagic Fishery

4.5.1 Pacific Salmon



SALMON

The Resource: Five species of salmon inhabit Alaska waters. These are as follows:

Pink (humpback) salmon - Oncorhynchus gorbuscha
King (chinook) salmon - O. tshawytscha
Red (sockeye) salmon - O. nerka
Silver (coho) salmon - O. kisutch
Chum (dog) salmon O. keta

All five species occur in the Bering Sea (Table 4.9), migrating to spawning rivers and streams on both the Alaska and Siberia-Kamchatka sides. While their presence is transitory, salmon comprise a significant portion of the total pelagic fish biomass on the Bering Sea shelf.

All species of salmon are anadromous, the adults migrating from the ocean to fresh water to spawn. Spawning runs occur in the summer and autumn, with the fish returning to the home streams from which they hatched. Newly hatched fish remain in freshwater for some period of time before returning to the sea.

After the young salmon migrate to the sea, the length of time they remain there to feed and mature varies (Table 4.10). Both maturing and juvenile salmon are present in Bering Sea shelf waters from May to September, but their migration routes do not overlap appreciably (Figure 4.26). Juveniles migrate seaward along the coasts, eventually moving offshore as their size increases. Adults remain offshore until they near their home streams.

Spawning migrations of salmon enter the Bering Sea (Figure 4.27) from the North Pacific via Aleutian Island passes, move north for a considerable distance, and concentrate in the southeastern Bering Sea shelf region in two bands offshore, north and south of the Pribilof Islands. These salmon are bound for rivers on the north side of the Alaska Peninsula and those rivers tributary to Bristol and Kuskokwim Bays. The time spent by the salmon in the central Bering Sea area is relatively short, considering that the duration of spawning migrations by adults through the Bering Sea from their North Pacific Ocean feeding grounds is about 40 to 50 days.

Table 4.9 - Relative abundance (in thousands of fish) of Pacific salmon (Oncorhynchus spp.) produced in river systems tributary to the Bering Sea shelf as indicated by average U.S commercial catches 1961-77, inclusive [a,b] and available Soviet catch statistics.[c] (From Straty, In Press).

Area	Sockeye	Chum	Pink[d]	Chinook	Coho	Total	Percentage of total of all areas
Bristol Bay	7,349.2	496.9	1,181.6	97.6	43.0	9,168.3	82.1
Gulf of Anadyr	150.0[e]	410.5[f]	9.9[g]	scarce	scarce	570.4	5.1
Yukon River	0.002	315.6	0.54	98.1	14.2	428.4	3.8
Alaska Peninsula (north side)	285.3	75.2	8.8	4.7	32.8	406.8	3.6
Kuskokwim Bay	9.0	90.6	26.3	38.7	78.4	243.0	2.2
Norton Sound	0.02	114.5	59.5	3.0	5.8	182.8	1.6
Kotzebue Sound[a]	0.006	168.1	0.004	0.003	-	168.1	1.5
Arctic coast[h]	i	j	j	i	-	-	-
TOTAL	7793.5	1671.4	1286.6	242.1	174.2		
% by species	69.8	14.9	11.5	2.2	1.6		

a No reported catches for Kotzebue Sound in 1961.
b Source Alaska Department of Fish and Game, Juneau, Alaska.
c Pravdin (1940) and data available at TINRO.
d Even years only for U.S. waters.
e Estimated possible annual catch (Pravdin 1940).
f Average 1974-78 inclusive.
g Average 1975, 1977, and 1978.
h No estimates of number available.
i Unreliable reports of this species in American arctic rivers (Walters 1955).
j Documented reports of this species in Siberian and American rivers (Walters 1955).

Table 4.10 - Data for five species of Pacific salmon occurring in the Bering Sea.

Item	Species				
	King	Pink	Red	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 years	1 1/3 years	½ to 4 years	1 to 2 years	½ to 4 years
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	2½ to 125	2 to 9	1½ to 10	3 to 30	3 to 45
Principal spawning months	Aug.-Sept.	July-Sept.	July-Sept.	Sept.-Dec.	Sept.-Nov.
Fecundity-number of eggs	5,000	2,000	4,000	3,500	3,000

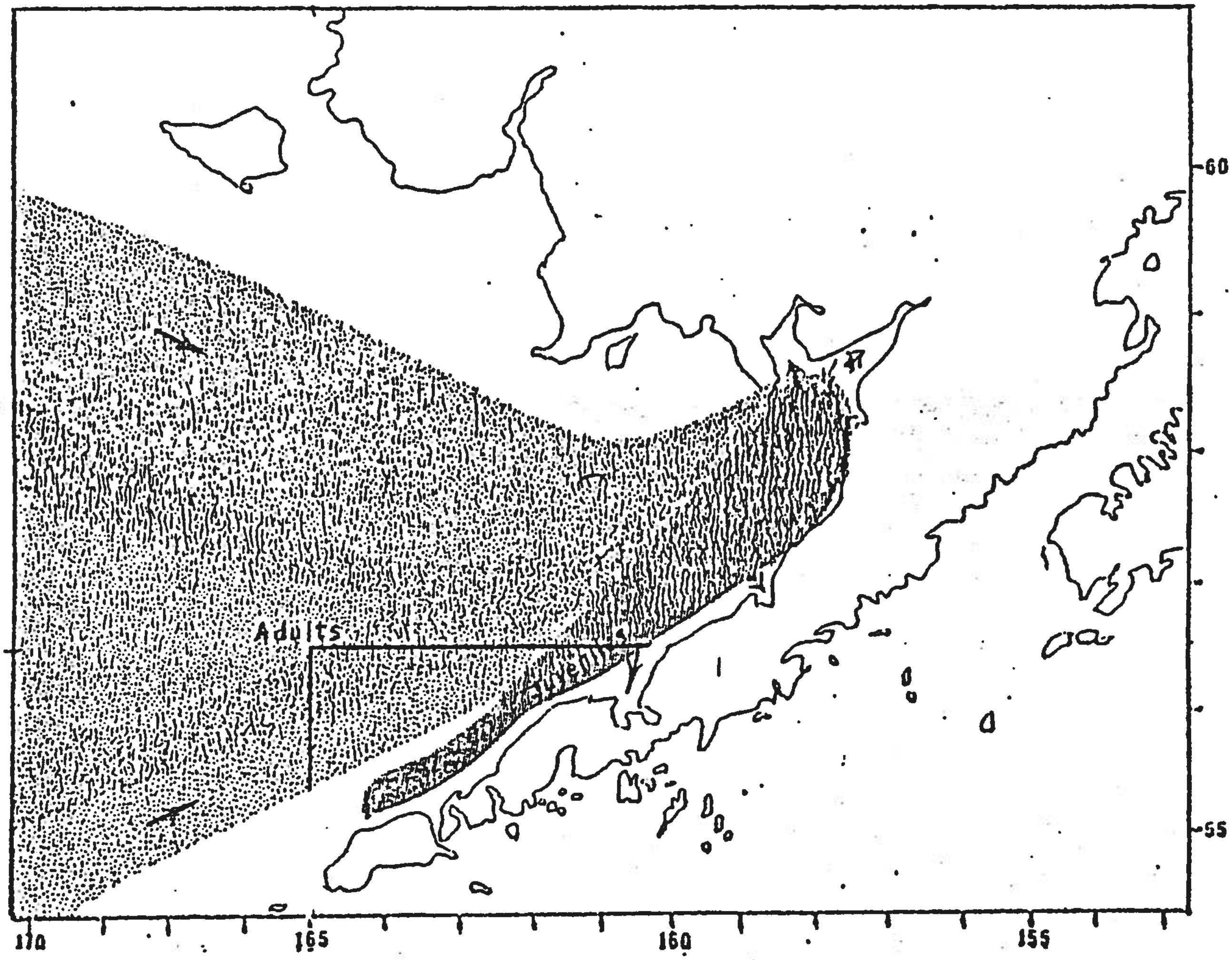


Figure 4.26 - Distribution of red salmon in Bristol Bay during migration. Main routes are indicated by heavier shading. (Adapted from Straty 1974, 1975).

Pink salmon are the shortest lived, completing their reproductive cycle in 2 years. Reds and kings, have the longest cycle and may require up to 8 years to reach maturity, although the majority of individuals return after 4 to 6 years.

Each species of salmon has its own food preferences, and these change somewhat during growth and development. Young salmon feed on plankton, chiefly copepods. Pink, red, and chum salmon throughout their life feed mostly on plankton, but will include some larger shrimp and squid (Table 4.5). Kings and silvers feed on herring and other small fishes, as well as some of the larger plankton such as euphausiids. They generally feed up to the time they return to freshwater streams on their spawning runs.

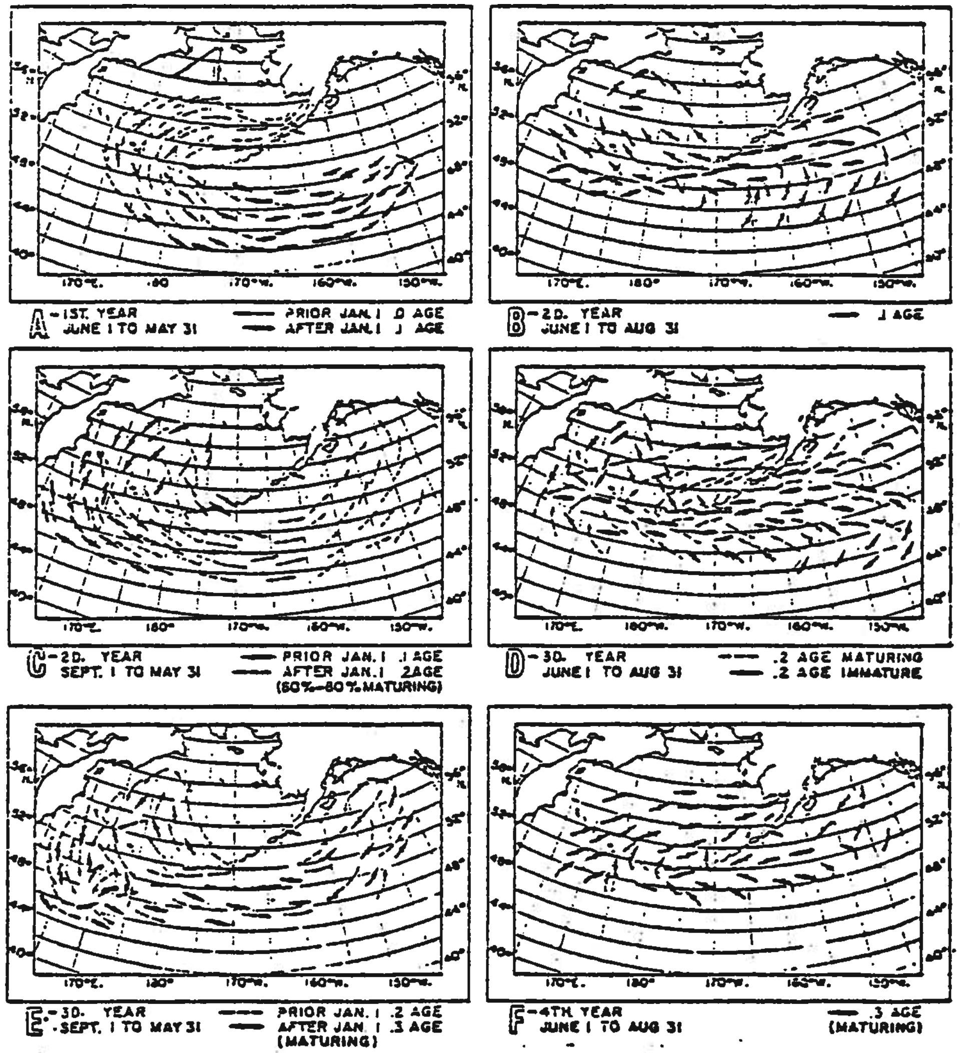


Figure 4.27 - Ocean migrations of Bristol Bay red salmon based on seine catch and tagging data through 1966; arrows indicate direction and approximate distribution (from Royce et al. 1968).

4.5.1.1 Japanese High Seas Salmon Fishery

The Japanese mothership high seas salmon gillnet fishery and landbased driftnet fishery, conducted by Japan in the North Pacific Ocean and Bering Sea, began operating in 1952. During the first 4 years, the mothership fleet primarily fished in the western North Pacific Ocean between 155° E and 175° E longitudes. In 1956, the fleet extended its range to the central North Pacific Ocean and central Bering Sea areas, fishing as far east as 175° W. This longitude forms the boundary beyond which Japan has agreed to abstain from fishing, as established by the International Convention for the High Seas Fisheries of the North Pacific Ocean (Figure 4.28).

In addition to the other species of salmon, the Japanese catch several million red salmon each year (Table 4.11 and 4.12). Between 1956-1975, the annual Japanese catch averaged 2.3 million fish. Yearly catches ranged from a high 7.3 million fish in 1957 to a low of 0.4 million fish in 1958. Including catches of immatures in years prior to the year of the run, total removal from the annual Bristol Bay run by the mothership fishery averaged about 11% of the average annual run of 20.2 million fish and nearly 23% of the average total (both Japanese and United States) catch of 10.1 million fish from the annual run.

Tagging studies conducted by fishery agencies of Canada, Japan and the United States - together with studies of the rates of infestation by parasites (specific to area of origin) conducted by Canada - have served to define the general oceanic distribution and areas of intermingling of Asian and North American stocks of red salmon. These studies indicate that the bulk of the red salmon present in the central Bering Sea east of 175° W are of either Asian or Bristol Bay origin (Figure 4.29 and 4.30).

The magnitude of these estimates clearly demonstrates that the Japanese mothership salmon fishery has a significant influence on the Bristol Bay red salmon runs. It also demonstrates the significance of the high seas fishery area, including the Navarin Basin area, to the maturing red salmon prior to their spawning runs.

The information on the landbased driftnet fishery shows that even more red salmon were taken by that fishery in 1974 than by the mothership fishery. As for the continent of origin of the sockeye taken by the landbased fishery, the results of racial studies conducted thus far are insufficient to make reliable determinations.

Table 4.11 - Catch of salmon by the Japanese North Pacific mothership fishery, in thousands of fish, 1952-74 (from NMFS 1976d).

Year	Sockeye	Pink	Chum	Coho	Chinook	Total
1952	736	699	626	24	1	2,086
1953	1,580	3,065	2,707	340	8	7,700
1954	3,816	5,804	9,404	1,398	74	20,496
1955	12,164	16,508	18,573	3,184	74	50,503
1956	9,364	12,006	17,167	3,758	136	42,701
1957	19,822	21,046	9,246	340	31	50,485
1958	11,971	13,199	17,165	3,342	45	45,722
1959	9,125	18,856	12,859	1,423	68	42,331
1960	12,879	1,885	10,517	962	180	26,423
1961	12,998	3,263	6,128	284	31	22,704
1962	10,590	1,139	6,372	1,532	122	19,755
1963	8,903	6,732	5,858	1,895	87	23,475
1964	7,097	2,281	8,641	3,535	410	21,964
1965	12,038	4,429	6,036	1,177	185	23,865
1966	7,254	2,553	8,562	469	208	19,046
1967	8,087	7,781	6,837	226	128	23,059
1968	6,373	3,823	8,107	898	362	19,563
1969	5,935	6,972	7,721	1,306	554	22,488
1970	6,944	1,726	9,638	180	437	18,925
1971	3,554	8,202	9,968	454	206	22,384
1972	3,184	3,795	13,373	614	261	21,227
1973	2,613	12,018	7,857	989	119	23,596
1974	2,282	7,556	9,283	1,085	361	20,567

Table 4.12 - Catch of salmon by the Japanese landbased offshore driftnet fishery, in thousands of fish, 1952-75 (from NMFS 1976d).

Year	Sockeye	Pink	Chum	Coho	Chinook	Total
1952	89	13,344	684	126	8	14,251
1953	191	10,270	1,476	272	17	12,226
1954	344	9,193	2,659	490	31	12,717
1955	511	22,396	3,949	728	46	27,630
1956	271	21,534	2,094	386	24	24,309
1957	488	30,353	3,770	695	44	35,350
1958	903	24,833	9,155	803	45	35,739
1959	845	35,129	9,045	1,204	70	46,293
1960	1,627	20,129	8,684	1,376	111	31,927
1961	1,192	34,559	6,104	1,486	77	43,418
1962	154	14,021	7,577	1,289	124	23,165
1963	18	31,255	7,538	1,492	102	40,405
1964	108	17,247	8,956	1,624	195	28,130
1965	159	29,142	8,330	1,913	93	39,637
1966	703	16,032	11,848	1,458	112	30,153
1967	2,566	23,051	11,078	1,329	110	38,134
1968	2,769	15,899	8,457	1,421	88	28,634
1969	2,495	23,610	4,908	3,328	83	34,424
1970	2,966	13,403	6,585	2,259	101	25,314
1971	3,026	16,977	6,250	2,373	134	28,760
1972	3,718	17,578	8,981	2,423	107	32,807
1973	3,316	24,227	7,837	3,796	165	39,341
1974	3,158	14,424	12,531	3,560	188	33,861
1975	2,660	15,206	11,029	3,038	144	32,077

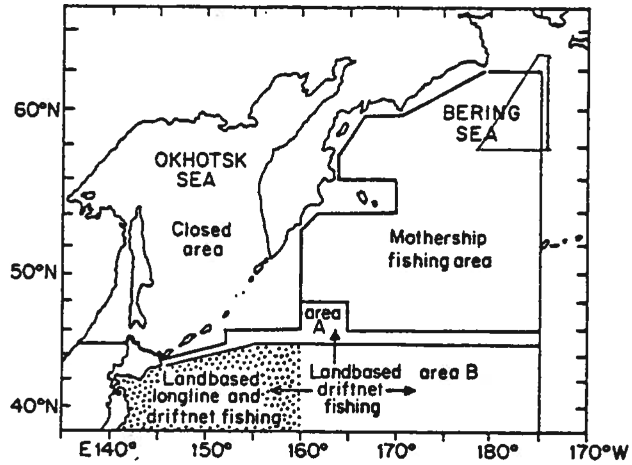


Figure 4.28 - Fishing areas of Japanese mothership and land-based fisheries (from INPFC).

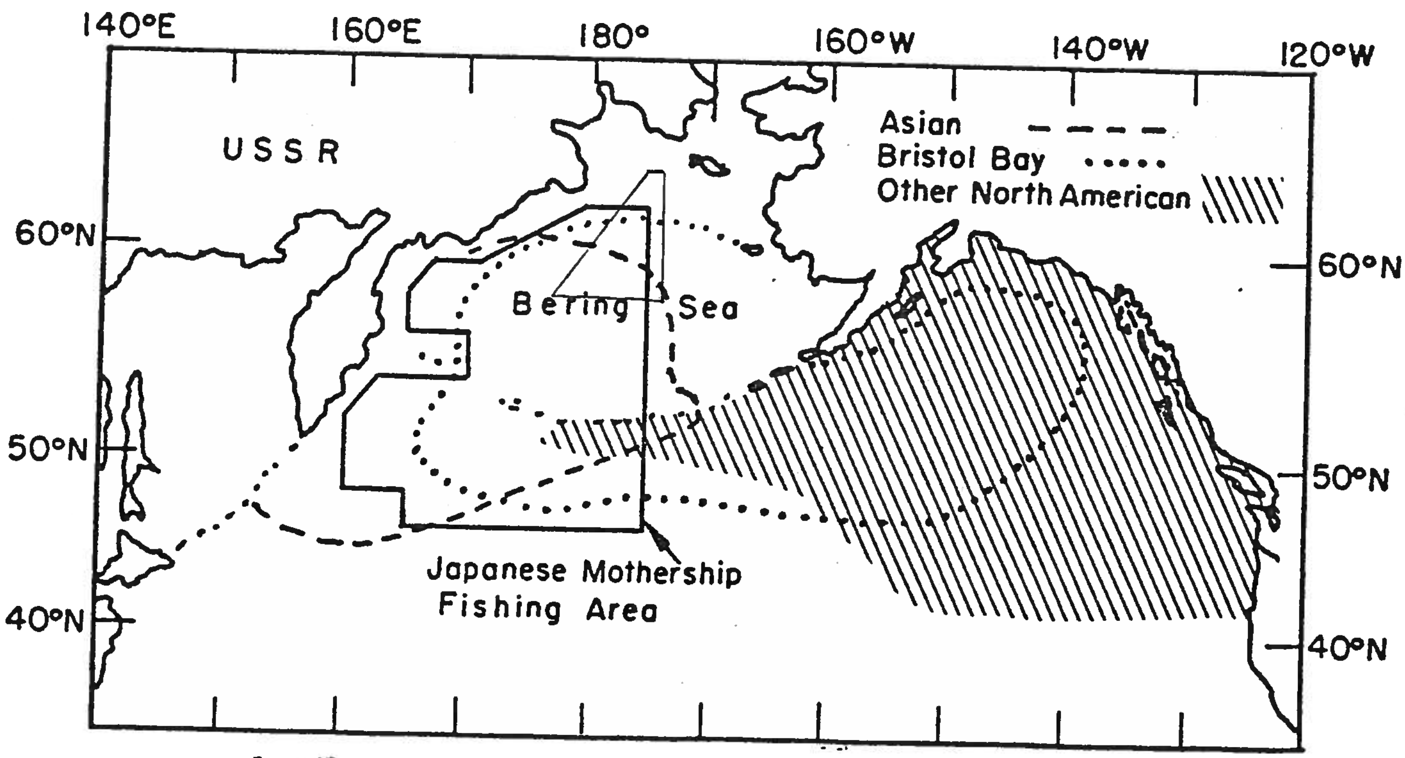


Figure 4.29 - Oceanic distribution of red salmon.

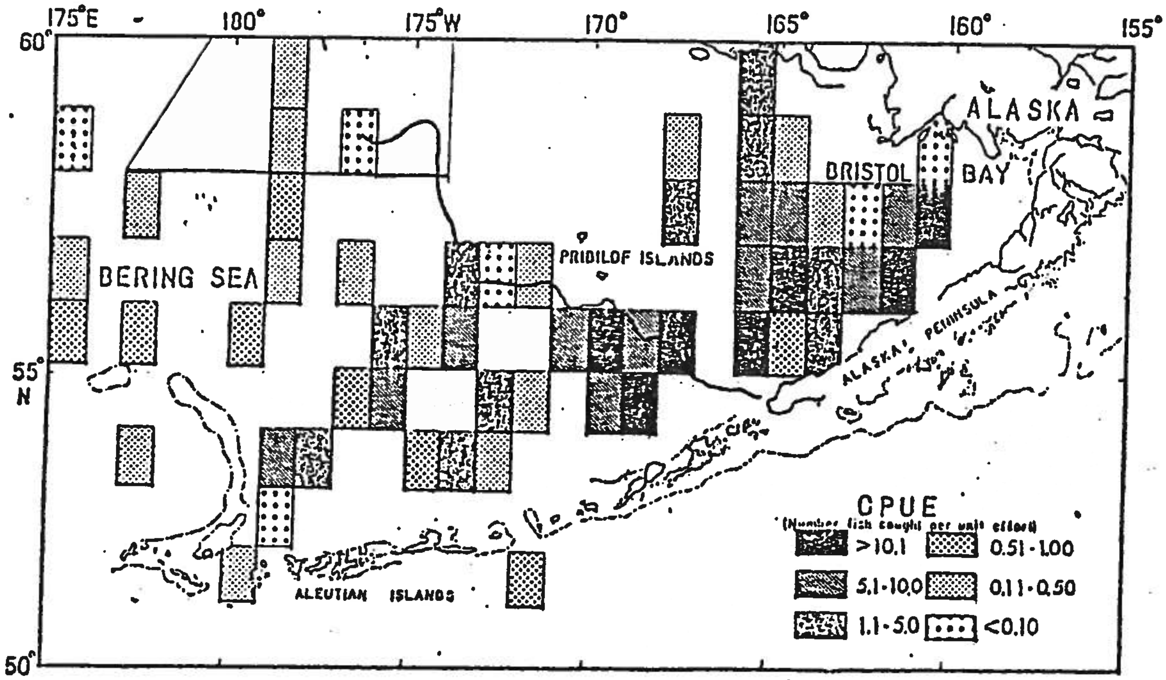


Figure 4.30 - Catch per unit effort of mature Bristol Bay sockeye salmon from early June to mid-July 1964-71, mean of seven years (after Nishiyama, 1974).

With regard to king salmon, U.S. scientists estimate that the Japanese mothership fishery intercepts several hundred thousand immature Alaska king salmon annually (Figure 4.31). In 1969 and 1970 they intercepted 480 and 380 thousand immature king salmon of western Alaska origin. These estimates represent approximately 85% of the mothership catches of chinook in the two years and are substantially greater than the catches by U.S. fishermen in western Alaska.

4.5.2 Sablefish

The Resource: The sablefish or black cod, Anoplopoma fimbria, lives mainly on the continental slope. Although schools of sablefish are geographically widely distributed, the exploitable biomass is largely confined to the depths of 150-1,200 m and to the central portion of its range in the Gulf of Alaska. About 13% of the estimated exploitable biomass is located in the Bering Sea region.

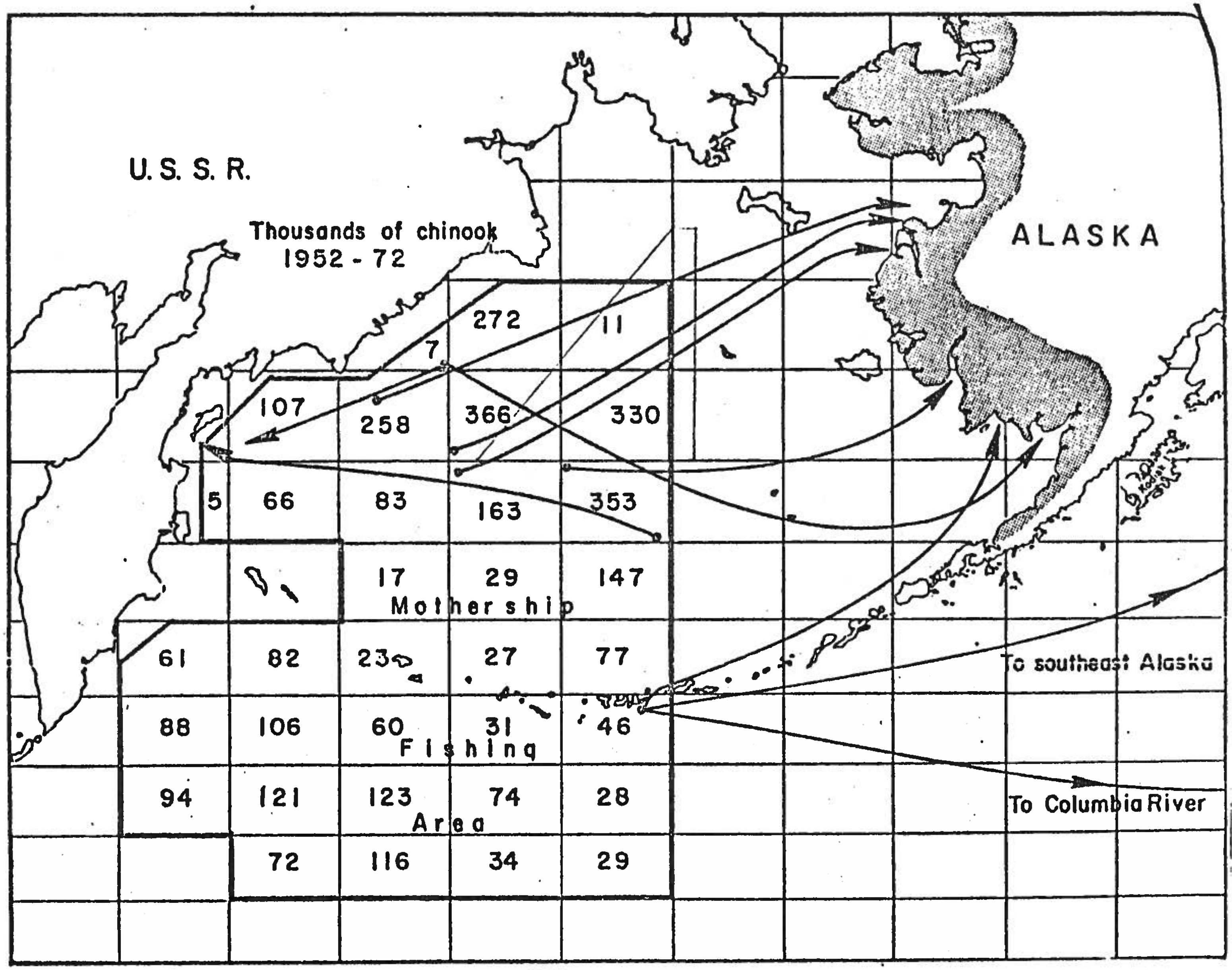


Figure 4.31 - Catches of king salmon within the Japanese mothership fishing area and the release and recovery locations of king salmon tagged there. The important western Alaska spawning area is shaded.

It is evident from tagging studies that some sablefish conduct extensive migrations (Figure 4.32). Interchange of fish probably takes place between the Bering Sea, the Gulf of Alaska, and the Pacific Northwest Coast. Sablefish also occupy a wide range of depths: the pelagic eggs and larvae in surface waters, juveniles in surface and inshore waters down to a depth of approximately 150 m, and adults from about 150 to 1,200 m.

Daily vertical movements of sablefish in the eastern Bering Sea, apparently associated with changing light conditions and food habits, have been observed. During the day, sablefish are in the upper water layers feeding on pelagic and off-bottom prey; at night, they lay near the sea bottom preying on bottom dwelling fish and invertebrates. If these diurnal movements occur regularly, they are opposite to those of other demersal species which descend to the bottom during the day.

An encapsulated view of a sablefish's life history might begin with a pair actively spawning at 550 meters, where the spawning female will produce up to 400,000 fertilized eggs. The mechanisms which effect the distribution of these eggs and subsequent larval forms are not fully known, but one year-old sablefish annually appear in shallow coastal waters. As maturity approaches, these young sablefish move seaward and become demersal. By the 5th year about half the males mature, but females require 7 years on the average. Fish to 12 years of age are common and the rare fish may reach 20 years of age. At that age they may attain a length of 107 cm (42 inches) and a weight of 81 kg (40 pounds). The average market size ranges upward from 70 cm (27.5 inches), weighing 2.3-6.3 kg (5-14 pounds)--or, in terms of age, 7-12 year old sablefish.

<u>The Fishery</u>: The sablefish, is the target of a substantial long-lining fishery in Alaska waters. It is also taken incidentally by trawlers. On the Washington to Northern California coast it is also fished using strings of pots, a relatively new technique developed in the late 1960's.

The annual catch of this species has decreased from the 1975 catch of 47,000 metric tons (104 million pounds), worth approximately $21,000,000 per year at current U.S. ex-vessel (landed) prices. Although most of the present catch is taken by foreign fishing vessels, the vast majority of the fish are caught along the continental shelf and slopes of North America (Figure 4.33).

The intensity of the sablefish fisheries, particularly those of Japan has caused considerable concern that the stocks are over-exploited. Commercial fisheries for sablefish have been conducted by North American fishermen since 1975, but landings have rarely exceeded 10,000 mt. The growth of foreign fisheries since 1958 placed an entirely new perspective on the size of this resource. By 1962, Japan was taking 28,000 mt from the Bering Sea and an additional, but unreported, catch was taken by the USSR (Table 4.13). One surprising result on this heavy exploitation was that several tagged sablefish released as juveniles in Washington State were recaptured by the Japanese in the middle of the Bering Sea, some seven years after release. Fish tagged in the Bering Sea have also been recovered off southeastern Alaska, British Columbia, and southern California. It is now believed that the sablefish population undergoes wide-spread movement and interchange occurs all along its 4000 mile range.

When both Soviet and Japanese fleets moved into the northeastern Pacific, removals of sablefish increased (Figure 4.33). By 1962, the Japanese alone took over 28,000 mt, over half of the total catch which was estimated at 46,800 mt for the year. Soviet catches reached 1,254 to 4,256 mt in 1968-73, but declined to 91 mt in 1974. Total Japanese and Soviet catches during 1970-74 averaged 13,745 mt, but were only 7,500 mt in 1974. Almost concurrently, the Bering Sea catches dropped sharply, a fact that focused attention on the tag recoveries noted above. Thus the concern for the welfare of stocks in the Gulf of Alaska was intensified by the possibility of stock erosion in the more southerly areas, primarily fished by U.S. and Canadian nationals.

During 1960-63, most sablefish caught in the Bering Sea-Aleutian area were taken on longline gear. However, since 1966, longliners have been phased out of the fishery in the Bering Sea since extensive trawling

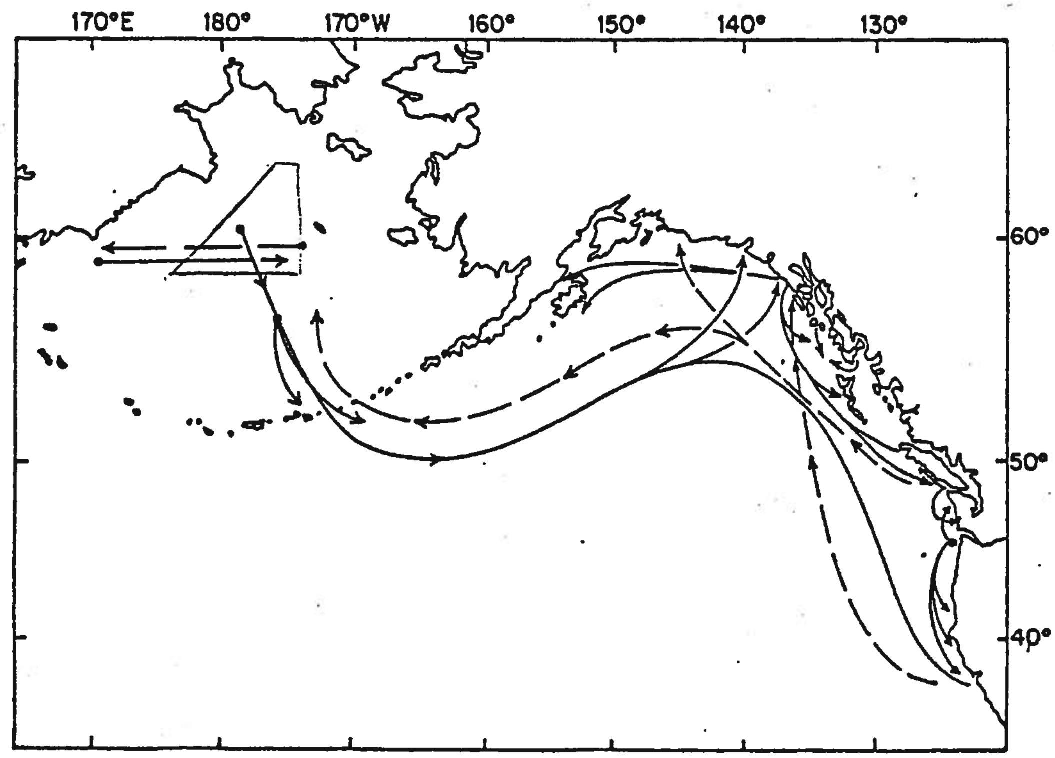


Figure 4.32 - Directional movement and extent of migrations exhibited by tagged sablefish.

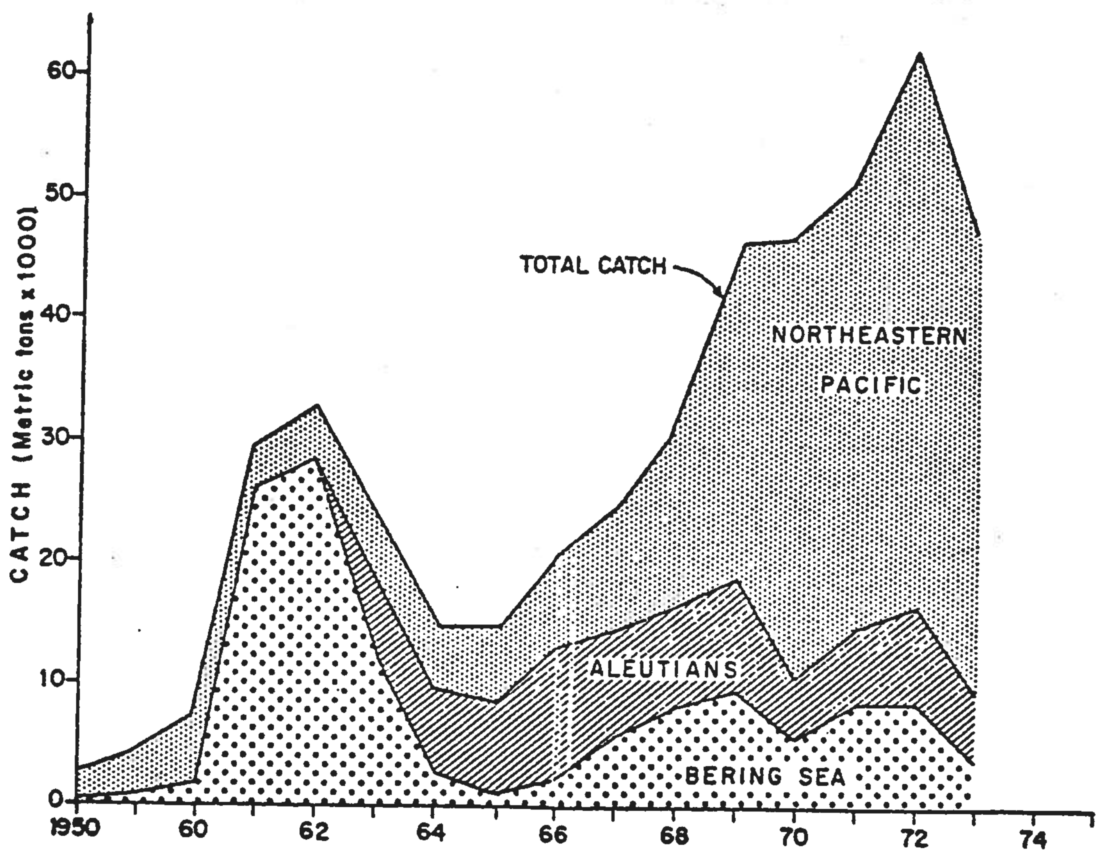


Figure 4.33 - Sablefish catch from major fishing areas, 1958-73.

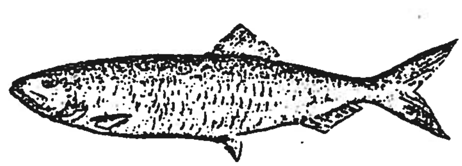
Table 4.13 - Sablefish landings (mt), by nation, in the Bering Sea and Aleutians, 1958-74 (from Low et al. 1976).

Year	Bering Sea & Aleutians		
	Japan	U.S.S.R.	Total
1958	32		32
1959	393		393
1960	1,861		1,861
1961	26,182		26,182
1962	28,521		28,521
1963	18,404		18,404
1964	9,237		9,237
1965	8,600		8,600
1966	13,088		13,088
1967	14,840	274	15,114
1968	16,258	4,256	20,514
1969	18,813	1,579	20,392
1970	10,904	2,874	13,778
1971	14,981	3,000	17,981
1972	16,538	2,406	18,944
1973	9,270	1,254	10,524
1974	7,409	91	7,500

activities for pollock have pre-empted the grounds. Japan and the Republic of Korea (ROK) also take sablefish incidentally in Danish seines.

Although the abundance of sablefish in the eastern Bering Sea has been declining for 5-10 years, it has remained relatively stable in the Aleutian Islands region. There is concern, however, about the resource in the latter area in view of the expanding ROK longline fishery in recent years.

4.5.3 Pacific Herring



HERRING

The Resource: The Pacific herring, *Clupea pallasi*, is a widely distributed species that exhibits strong schooling and migratory instincts (Figure 4.34). Herring spend about eight months each year in the open sea far from coasts. Spawning runs commence in March-May, arriving at the Bering Sea coastal spawning area in May-July depending on water temperatures. Adult herring remain in inshore waters and bays through the summer, then form large schools that migrate offshore to overwinter near the bottom in waters deeper than 100 m northwest of the Pribilof Islands and along the southern margin of the seasonal pack ice (Figure 4.35).

The bottom waters of the central Bering Sea in the Navarin Basin area are favorite wintering grounds. The exact location of these winter concentrations of herring varies from year to year, depending on sea ice and water temperature conditions (Figure 4.36). During severe winters, the school can range up to 15-20 fish/m3, over an area over more than 900 square miles. By day the schools lay densely on the bottom in a layer 5-10 m in height. At dusk the herring schools rise to mid-water layers from 20 to 50 meters off the bottom, to feed on euphausiids and other plankton.

Larvae herring hatch from adhesive eggs deposited on eelgrass and seaweeds in the coastal zone. After drifting pelagically for 6-8 weeks, they metamorphose to juveniles. The juveniles form small schools and gradually move seaward toward the mouths of bays and inlets in which they were hatched. By early fall, individuals about 4 inches long form schools of perhaps 1 million or more fish. Most of the schools move into deep or offshore waters by late fall. They stay at sea for about 2-1/2 years, then return to shallows to spawn for the first time.

The Fishery: The herring resource in the eastern Bering Sea, which has historically been fished much more intensively by Soviet trawlers than by Japanese vessels, is in poor condition.

A domestic herring fishery is centered in the Togiak district of Bristol Bay where herring are taken by seine and gill net. The total harvest for 1974 was about 2575 mt, worth about $900,000 to the fishermen. Most

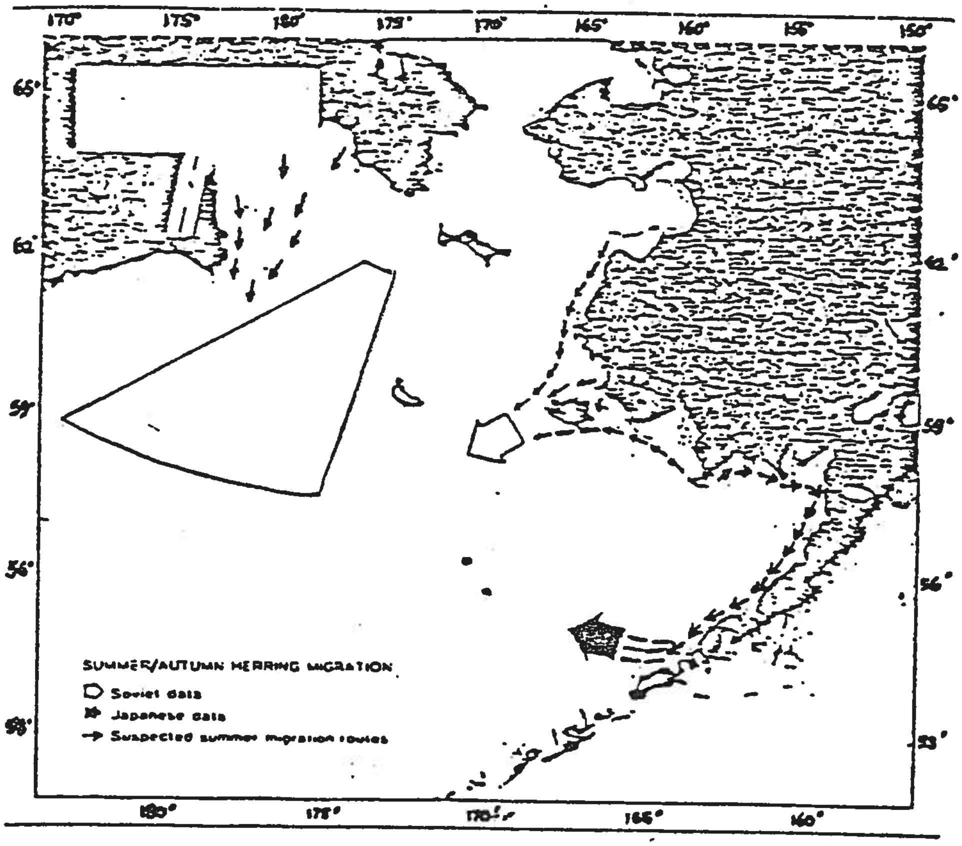


Figure 4.34 - Summer and autumn Pacific herring migration routes to winter grounds. Large arrows represent area of reappearence in offshore waters in autumn; small arrows represent possible summer feeding routes and autumn migration routes.

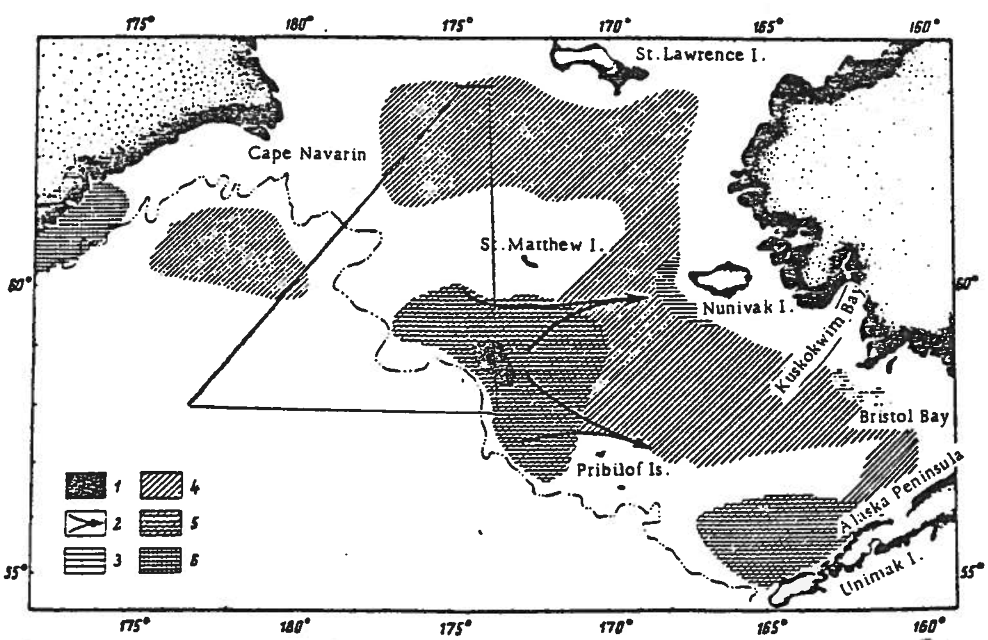
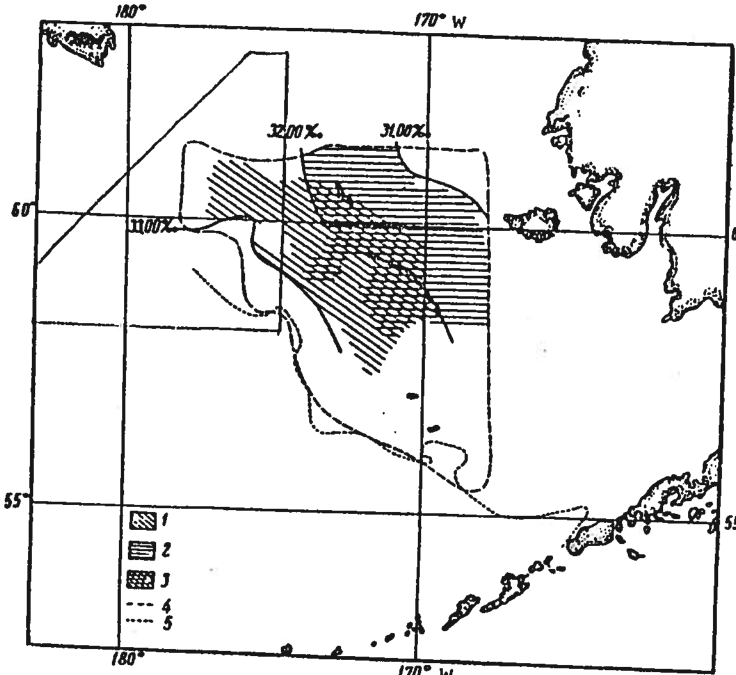


Figure 4.35 - Distribution of Pacific herring in the Bering Sea. 1-winter concentrations; 2-departure on spawning migrations; 3-area of spent adults; 4-distribution in June; 5-distribution in September - October; 6-fishing grounds of Soviets.



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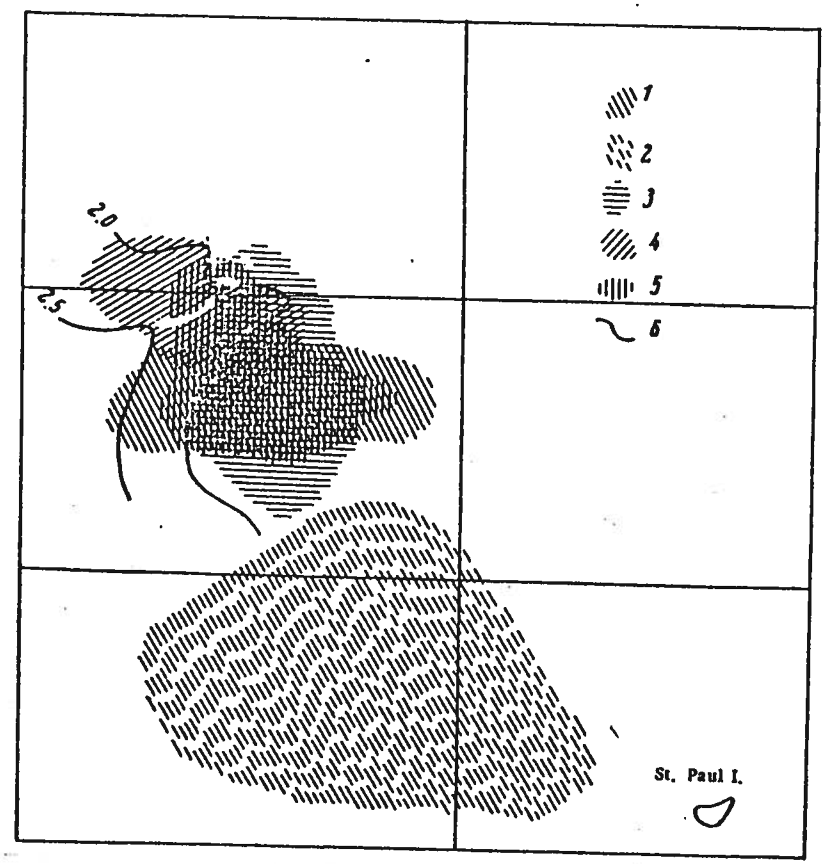

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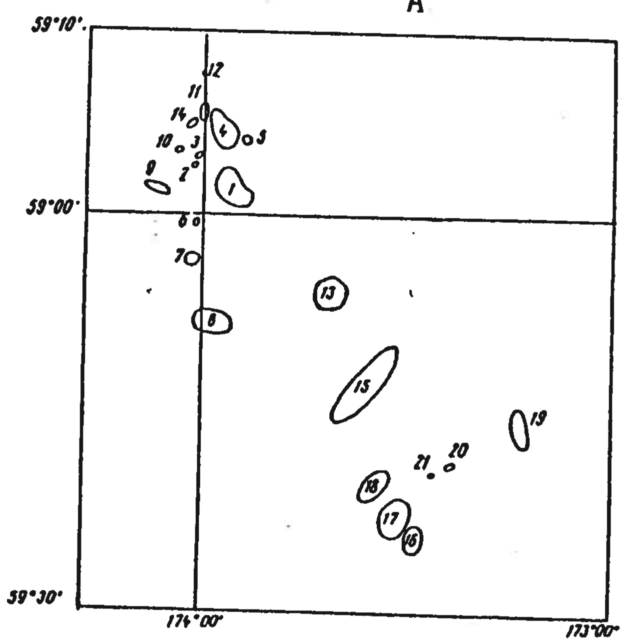


C

Figure 4.36 - A) Distribution of herrings in October; 1-mature; 2-immature; 3-mixed; 4-investigated regions; 5-200-m isobath.

B) Distribution of herring in the eastern part of the Bering Sea; 1-February 1961; 2-March 1961; 3-February 1962; 4-February 1963; 5-March 1963; 6-isotherms in February 1963.

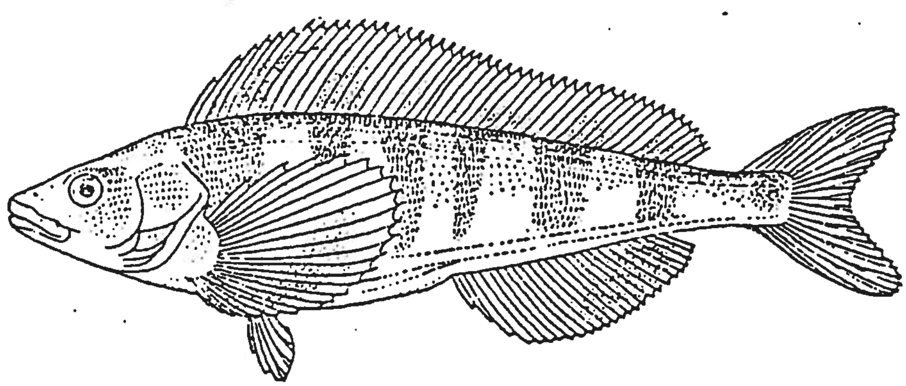
C) Distribution of herring schools in the eastern part of the Bering Sea (according to a hydroacoustic survey). Figures indicate the numbers of the school. [Geographical coordinates reproduced from Russian original.] (From Shaboneev, 1965).

of the herring were shipped to Japan. In addition, about 125 mt of herring roe-on-kelp were harvested; the estimated value to the fishermen was about $115,000. Herring also form an integral part of subsistence fishing to coastal residents in the spring during the spawning period of herring (April-June).

Prior to 1979, there were three principal foreign fisheries for Pacific herring in the eastern Bering Sea: a Japanese trawl fishery, a Soviet trawl fishery, and a Japanese gillnet fishery (Table 4.14). The Republic of Korea also conducted a minor trawl fishery for herring in the Bering Sea; the estimated catch by that fishery in 1977 was about 1900 mt. The main trawl fisheries worked along and inside the 200-m isobath between the Pribilof Islands and St. Matthew Island during the winter months, November to March.

The catch of herring by Japanese and Soviet trawlers in the central Bering Sea declined substantially during the 1970's; the total catch was only about 20,000 mt in 1974-77, compared with about 126,000 mt in 1968-69, a 500 percent decline. Herring is now a prohibited species for foreign fleets, and is taken only as an incidental catch in groundfish trawling. In the years 1978 and 1979, the by-catch of herring was 8,434 and 7,345 mt respectively.

4.5.4 Atka Mackerel



ATKA MACKEREL

Table 4.14 - Catch of herring, in metric tons, by Japanese and Soviet trawlers east of 180° in the Bering Sea and Japanese gillnet vessels west and east of 175°W in the Bering Sea, excluding the Aleutian Region, 1964-75 (from NMFS 1976h):

	Trawl Fisheries			Japanese Gillnet Fishery			
Fishing Year (July-June)	Japan	U.S.S.R.	Total	Calendar Year	West of 175°W	East of 175°W	Total
1964-65	1,362	a/	b/	1964	41,597	-	41,597
1965-66	3,117	a/	b/	1965	34,659	-	34,659
1966-67	2,831	a/	b/	1966	24,118	-	24,118
1967-68	9,486	9,800	19,286	1967	30,167	-	30,167
1968-69	50,857	75,379	126,236	1968	5,183	818	6,001
1969-70	23,901	92,228	116,129	1969	680	1,949	2,629
1970-71	24,236	60,126	84,362	1970	-	1,585	1,585
1971-72	13,143	67,547	80,690	1971	-	4,603	4,603
1972-73	346	39,999	40,345	1972	-	472	472
1973-74	219	16,810	17,029	1973	-	1,878	1,878
1974-75	2,685	19,342	22,027	1974	-	3,337	3,337
-	-	-	-	1975 c/	-	651	651

a/ Not available.

b/ Incomplete.

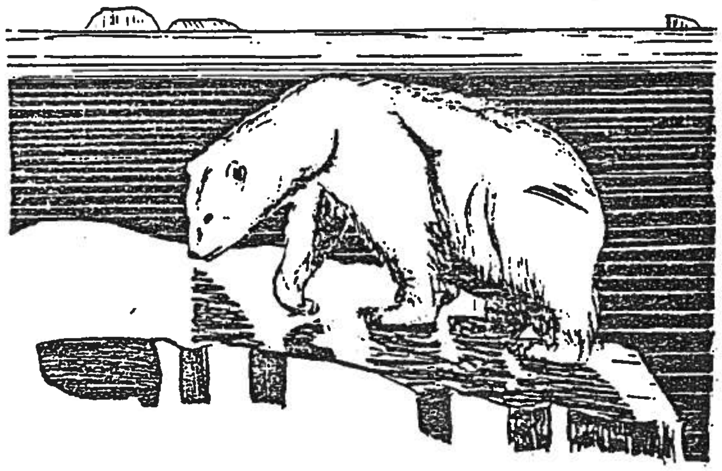
c/ Preliminary.

The Atka mackerel, *Pleurogrammus monopterygius*, occurs in the Bering Sea from the Aleutian Islands to Cape Navarin. It is a demersal marine fish, but is frequently also encountered in upper water layers.

In the Bering Sea, Atka mackerel spawn from June to September in coastal areas with stony or rocky bottoms. The eggs are benthic and are deposited in large masses on stones or in cracks among rocks. The hatched larvae are found at depths of 2-30 m and move to the surface at night. The larvae are widely dispersed for distances of up to 200-500 miles from shore.

Commercial landings of Atka mackerel in the Bering Sea have increased sharply in recent years from nil in 1977 to 24,000 mt in 1978 and 23,000 mt in 1979. The major effort in the fishery was by the Soviets, who took about 90% of the catch. U.S. fishermen landed 8.2 mt tons in 1979, marking the first time that this species has been separately reported in U.S. landings data.

5. MARINE MAMMALS OF THE CENTRAL BERING SEA



From a marine mammal resource assessment perspective, the Navarin Basin oil and gas lease area is the least understood of all outer continental shelf lease areas. The reason for this is clear: of the present ten designated potential oil lease areas in Alaska[1/], less research effort has occurred in the Navarin Basin than the others. Consequently, few data exist on most marine mammal species from which to make a reliable assessment of, for example, jeopardy which is required for endangered species under Section 7 of the Endangered Species Act of 1972. However, over the past 30 years some information has been generated which allows us to make a judgment as to the general patterns of occurrence of most marine mammals in or near the Navarin Basin.

The following account is simply that, an overview of the species thought to frequent the Navarin Basin and, where acceptable data are available, includes a review of the spatial and temporal aspects of distribution, abundance, an estimate of biomass, migration, and life history or annual life cycle activities of animals when in the Navarin Basin.[2/]

1/ Beaufort (Sea) Basin, Chukchi (Sea) Basin, Hope Basin, Norton Basin (No. Bering Sea), Navarin Basin, St. George Basin (So. Bering Sea), North Aleutian Shelf (Bristol Bay, Bering Sea), Kodiak Shelf (Gulf of Alaska), Lower Cook Inlet - Shelikof Strait, and Northeast Gulf of Alaska lease area.

2/ Dr. Howard Braham, National Marine Mammals Laboratory, NMFS, Seattle, WA kindly contributed much of the information contained in this section.

The occurrence of marine mammals in the central Bering Sea is largely determined by their preference, if any, for land, sea ice, or open water; whether they congregate into herds or pods or are solitary; whether they are principally pelagic or benthic feeders; and their seasonal migration patterns in relation to the seasonal movement of sea ice.

The environment of the central Bering Sea is the home for a variety of marine mammals. Some are winter residents only, living there in association with the sea ice and using the habitat for breeding and overwintering. Other marine mammals occur there only in the ice free summer season, feeding during their annual migratory pathways on the rich biota of the region. Table 5.1 lists the marine mammal species occupying the Navarin Basin region of the central Bering Sea, the season of their occurence, and the habitat use of the region by the species. Walrus, spotted seal, ribbon seal and bearded seal utilize the winter sea ice for pupping and hauling out. Sea lions, and northern fur seals breed on land but use the area for summer feeding. Belugas and bowhead whales possibly feed there while overwintering, while several other whales and dolphins also feed and migrate through the region, mainly in the summer.

The central Bering Sea supports a significant proportion of the population of several of the marine mammal species of the Bering Sea (Table 5.2). In the winter it is the favored overwintering habitat of the ribbon seal and the bowhead whale, as well as supporting a sizeable proportion of the Alaska population of bearded and spotted seals and beluga whales. In the summer it remains an important habitat for ribbon seals, but also provides summering habitat for sizeable populations of northern fur seals, spotted seals, gray whales, humpback whales, and beluga whales.

Laevastu *et al.* (1980) attempted to estimate the winter and summer populations of marine mammals in the central Bering. They divided their estimates between shelf and slope waters. Their calculations of the abundance of marine mammals in the central Bering region is given in Table 5.3.

Table 5.1 - Major habitat use patterns of selected marine mammal species in and immediately adjacent to the Navarin Basin oil lease area of the Bering Sea (approximate location between 58° and 63°N. lat. from the U.S.-U.S.S.R. 1867 convention line to 174°W. long.) Blank spaces are data gaps; all comments are estimates.

Species[1/]	Temporal use[2/]		Habitat use	
	When	Abundance	Conditions[3/]	Behavior
Pinnipeds				
N. fur seal		low	open water	feeding
N. sea lion	summer ?	low	open water	feeding
Ribbon seal	Feb-May	high	ice cover	breeding
Ringed seal	Mar-Apr	low	ice cover	
Spotted seal	Feb-May	low	ice cover	breeding
Bearded seal	Feb-May	low-med	ice cover	breeding
Walrus	Feb-May	low-med?	ice cover	
Cetaceans				
Bowhead whale[4/]	Feb-Apr	med-high	ice cover	
Fin whale[4/]	Jun-Nov	low	open water	migration-feeding
Humpback whale[4/]	Jun-Nov	low	open water	
Gray whale[4/]	Jul-Dec	low-absent	open water	migration[5/]
Sperm whale[4/]	summer-aut.	low-absent?	open water	feeding
Minke whale	May- ?		ice cover-open water	migration-feeding
White whale	Feb-Apr ?		ice cover	migration-feeding?
Killer whale	May- ?		ice cover-open water	migration-feeding
Dall's porpoise	Yr.around?	low	open water	breeding?-feeding

1/ Little or no information available on harbor seals, beaked whales, harbor porpoise (although unlikely in lease area), sei[4/], right[4/], and Bryde's[4/].

2/ Related to known and/or important annual life cycle activity listed under "Behavior" above; animals may be present at other times of the year, however.

3/ Only refers to presence or absence of ice.

4/ Endangered species.

5/ Korean stock?

Table 5.2 - Population and biomass estimates of marine mammals in the Bering Sea, including the proposed Navarin Basin OCS lease area. Population estimates are for the entire North Pacific (NP) or just the Alaska-Bering Sea (A). All estimates are gross and have been rounded off. Number of months (or parts thereof) spent in lease area refers to any portion of a population (other than a few individuals) which might be expected to occur in or traverse any part of the Basin. Blanks are data gaps.

Species	Populations size1/	Biomass (metric tons)	No. of months in lease area	% of Population on Cental Bering shelf Winter	Summer
Pinnipeds					
Bearded seal	250,000 (A)	60,000	3	30	9
Harbour seal	30,000 (A)	3,000	0	-	-
Spotted seal	70,000 (A)	7,000	3	41	18-29
No. fur seal	1,737,000 (NP)*	40,500		0.2-0.5	17-23
No. sea lion	100,000 (A)	60,000		1	5
Ribbon seal	50,000 (NP)	6,000	8+ ?	77	18-29
Ringed seal	150,000 (A)	20,000	2	0	0
Walrus	200,000 (A)	200,000	3	23	4
Cetaceans					
Bowhead whale	2,000 (A)*	70,000	5	25-50	0
Fin whale	1,000 (A)	50,000	5	0	5
Gray whale	15,000 (NP)*	450,000	4	0	13-20
Humpback whale	200 (A)	7,000	3?	0	10
Minke whale	3,000 (A)	75,000	6	0	7
Right whale	200 (NP)	7,000	3-4?	?	?
Dall's porpoise	580,000 (NP)*	58,000	4	0	0.1
Harbor porpoise	?	?	?	?	?
Killer whale	?	?	?	?	?
Sperm whale	15,000 (NP)	450,000	3?	0	3
Beluga whale	15,000 (A)	140,000	?	6-10	19

1/ Unless revised by author, indicated by asterisks (*) for fur seal, bowhead, gray whale and Dall's porpoise, population estimates are maximum values from Table 3 in "Living Marine Resources. Commercial Fisheries, and Patented Impacts of oil and gas development in the St. George Basin, eastern Bering Sea." NWAFC, NMFS unpublished report, October 1979. 105 p.

Table 5.3 - Estimates of Population Sizes during winter (Jan-Mar) and summer (July-Sept) for selected Marine Mammal species on shelf and off-shelf waters of the Central Bering Sea (from Laevastu *et al*., 1980).

	Shelf		Slope/Ocean	
Pinnipeds	Winter	Summer	Winter	Summer
Fur Seal	5-10,000	300-400,000	20,000	50-100,000
Steller Sea Lion	1,000	5,000	10,000	15,000
Walrus	45,000	8,400	10,000	500
Bearded Seal	65-85,000	22,000	5-6,000	1,000
Ribbon and Spotted Seal	170,000	30-50,000	50-70,000	10,000
Total	316-575,000	395-515,000	95-116,000	77-127,000
Whales				
Gray and Right	0	2-3,000	20-200	1000
Fin and Minke	0	200	0	2-3,000
Bowhead	500-1,000	0	50-200	0
Blue and Sei	0	0	0	0
Beaked Whales	0	200	0	500
Sperm	0	500	0	6,500
Humpback	0	20	0	50
Beluga	900-1,500	2,900	3,500-4,000	2,000
Killer	50-100	170	190	100
Dalls Porpoise	0	1,000	1-2,000	5,000
Harbor Porpoise	200-400	1,200	100	150
Total	1,650-3,000	7,290-8,290	4,860-6,690	17,300-18,300

In the waters off Alaska, many of these marine mammals are harvested for native subsistence purposes, and additional individuals are killed or captured for other reasons. Table 5.4 gives estimates of the annual take of ten marine mammals in Alaska for various purposes. Although most of these takes are in Alaska coastal areas, relatively distant from the central Bering Sea, the migratory nature of many of these subsistence species can place them in the region of the Navarin Basin sometime during their life. Only the polar bear, sea otter, and ringed seal can be considered to be rare in the central Bering Sea.

5.1 Food Requirements of Marine Mammals

The food web of the central Bering Sea is complex. In a general way it can be diagrammed as in Figure 5.1. More specific information has been presented by Laevastu et al. (1980) from the analysis of available literature (Tables 5.5 and 5.6). The estimates they provide are very general and represent the mean case only, but they take into consideration life stage, prey availability and selectivity, and habitat changes of the predator. In the absence of better detailed studies, they do nevertheless, indicate how different marine mammal species utilize and partition the available food resources of the Bering Sea environment.

Equally important as the choice of prey is the quantity of food that must be consumed to maintain the biomass and growth of the marine mammal predators. Most data on marine mammal food requirements originate from feeding experiments in aquaria, where animals are fed in captivity. These results are variable. Most reported values of food requirements by cetaceans are in the range of 4 to 6% body weight daily. These are relatively low values, considering the rapid rate of growth of most whales. An average value of 5% BWD (body weight daily) is a plausible food requirement by cetaceans. The food requirements of pinnipeds are somewhat better known than those of whales because they are more commonly kept in aquaria. Most commonly reported values are 4 to 8% BDW, with the range of reported values being 3 to 10% body weight daily. A reasonable average is 6% BWD. Based on the evaluation of data from various sources, food requirements of mammals were estimated by

Table 5.4 --Estimated take of marine mammals in waters off Alaska

Purpose for taking	Polar bear	Sea otter	Walrus	Sea lion	Harbor seal	Largha seal	Ribbon seal	Ringed seal	Bearded seal	Beluga whale
Scientific research 1/	--	20	10	60	170	30	20	50	20	45
Public display 2/	--	--	--	--	8	--	2	2	4	--
Native subsistence	50	--	2,240 3/	--	500	2,750	250	10,500	1,500	180
Fishing operations	--	5	--	1,140 4/ (4,125) 5/	1,440 4/ (289) 5/	--	--	--	--	20 4/
Estimated take under proposed action 6/	100	1,000	50	5,940	5,822	--	--	--	--	--
Totals	150	1,025	2,300	7,140	7,940	2,780	272	10,552	1,524	245

1/ Actual requests with some interpolation (control files of NMFS and FWS).
2/ Estimated from averaging 1973-74 requests with some interpolation (control files of NMFS and FWS).
3/ Does not include an estimated 50 to 60 percent of the kill which is not retrieved.
4/ Estimates were provided by United Fishermen of Alaska in their renewal of three general permits for takings incidental to domestic fishing operations.
5/ Foreign incidental take is a non-add item at this time in estimating the extent of the waiver.
6/ State estimate of additional take under the proposed waiver

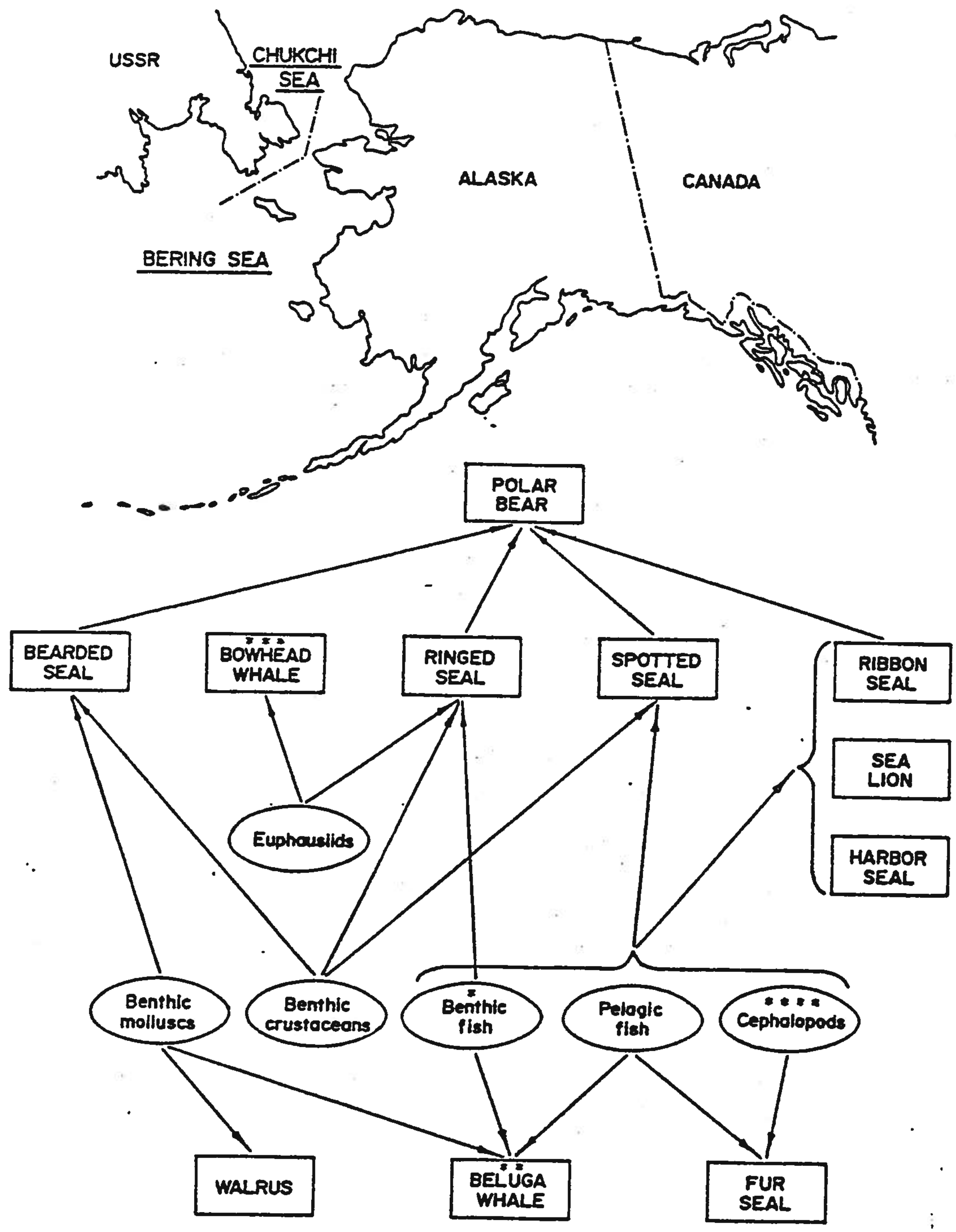


Figure 5.1 - Marine Mammal Food Relationships in the Bering and Chukchi Seas

* Benthic fish includes demersal species

** Beluga whale includes other toothed species

*** Bowhead whale includes other baleen species

**** Cephalopods includes squid and octopus

Table 5.5 - Mean Food Consumption of Selected Species of Pinnipeds in the Central Bering Sea (from Laevastu *et al.*, 1980) in percentage of diet in shelf waters.

Prey	Fur Seal	Steller Sea Lion	Harbor Seal	Walrus	Bearded Seal	Spotted and Ribbon Seal
Pollock	47	39	30	4	10	14
Cottids	8	7	13	5	8	10
Capelin	20	8	10	-	3	6
Epifauna	-	-	6	68	33	33
Predatory Benthos	-	-	-	10	25	-
Infauna	-	-	-	4	6	5
Euphausids	-	-	-	-	-	13
Cod	1	4	8	3	6	10
Salmon	2.5	4	3	-	-	2
Herring	8	6	7	-	1	2
Flatfish	1	14	4	6	3	1
Mackerel	7	4	5	-	-	-
Squid	3	5	8	-	-	-
Other Fish	2.5	9	6	-	5	4

Table 5.6 - Mean Food Consumption of Selected Species of Cetaceans in the Central Bering Sea (from Laevastu *et al.*, 1980) in percentage of diet in shelf waters.

	CETACEANS										
Prey	Gray and Right	Fin and Minke	Bowhead	Blue and Sei	Beaked	Sperm	Humpback	Beluga	Killer	Dall Porpoise	Harbor Porpoise
Euphausiids	45	68	10	64	-	7.5	20	-	-	-	-
Copepods	12	25	36	20	-	-	-	-	-	-	-
Epibenthos	25	-	31	2.5	8	2	6	-	-	6	6
Shrimp	5	-	4	-	-	-	-	-	-	-	-
Crab	-	-	2.5	-	-	-	-	-	-	-	2
Squid	3	3	1.5	7.5	25	77	12	10	8	29.3	-
Atka Mackerel	1.2	-	-	0.5	6	-	6.5	6	3	4	4
Capelin	2	1	4	-	7	2	10.5	10.5	6	8	10
Herring	1	1.5	3	0.5	5	2	3	6	3	10	8
Pollock	5.1	1	5.5	2	23	4	25	31	33.5	25	28.5
Misc. Fish	0.7	0.5	2.5	3.0	26	5.5	17	36.5	26.5	17.7	41.5
Mammals & Birds	-	-	-	-	-	-	-	-	20	-	-

Laevastu _et al._ (1980) in terms of body weight daily (Table 5.7). Food requirements of marine mammals do not of course, remain constant year around. This is especially true for those species which migrate to southern latitudes during the winter. In addition, several seal species are known to fast during breeding season (ca 60 days). Thus the values presented can be considered as approximations at best.

5.2 Pinnipeds of the Central Bering Sea and Navarin Basin

Eight kinds of pinnipeds live in the Bering Sea. They are the ribbon seal, _Phoca_ (_Histriophoca_) _fasciata_; the harbor seal, _Phoca vitulina richardii_; the spotted or largha seal, _Phoca vitulina largha_; the ringed seal, _Phoca_ (_Pusa_) _hispida_; the bearded seal, _Erignathus barbathus_; the Steller sea lion, _Eumetopias jubata_; the Northern fur seal, _Callorhinus ursinus_; and the Pacific Walrus, _Odobenus rosmarus_. Five of these species are ice-associated (pagophilic), and their distribution in the Bering Sea is strongly influenced by the presence of seasonal sea ice.

The ribbon and spotted seal are abundant at the frontal margin of the seasonal ice pack and often well back into it. They are not known to range into open water to the south. The bearded seal and the walrus are uncommon in the fringe of the winter pack, but occur mainly farther north in broken areas of the heavier consolidated pack ice. The ringed seal is rare, preferring to live nearshore in the extensive land-fast ice zone. The presence of the ice, rich foraging areas, and comparatively shallow waters make the Bering Sea an ideal environment for pinnipeds. The four ice-associated phocid seals give birth, nurse, mate and molt on the sea ice. Their biological activities depend directly on the timing and occurrence of the seasonal ice.

The Steller sea lion occurs only at the fringe of the pack and in open water south of the fringe. They often haul out on large floes at the ice edge, but use land for rookeries. Harbor seals utilize the fringe only when it is present in the southern Bristol Bay region. The fur seal does not form an association with the sea ice, are found only in open water areas, and form rookeries on land.

Table 5.7 - Food requirements of marine mammals.

Mammal group	Food requirement (% BWD)1/
Baleen whales	5
Sperm whales	5
Toothed whales	5
Dolphins and porpoises	5
Sea otter	12
Seals, group 1	6
Seals, group 2	6
Sharks	2

1/ Body weight daily

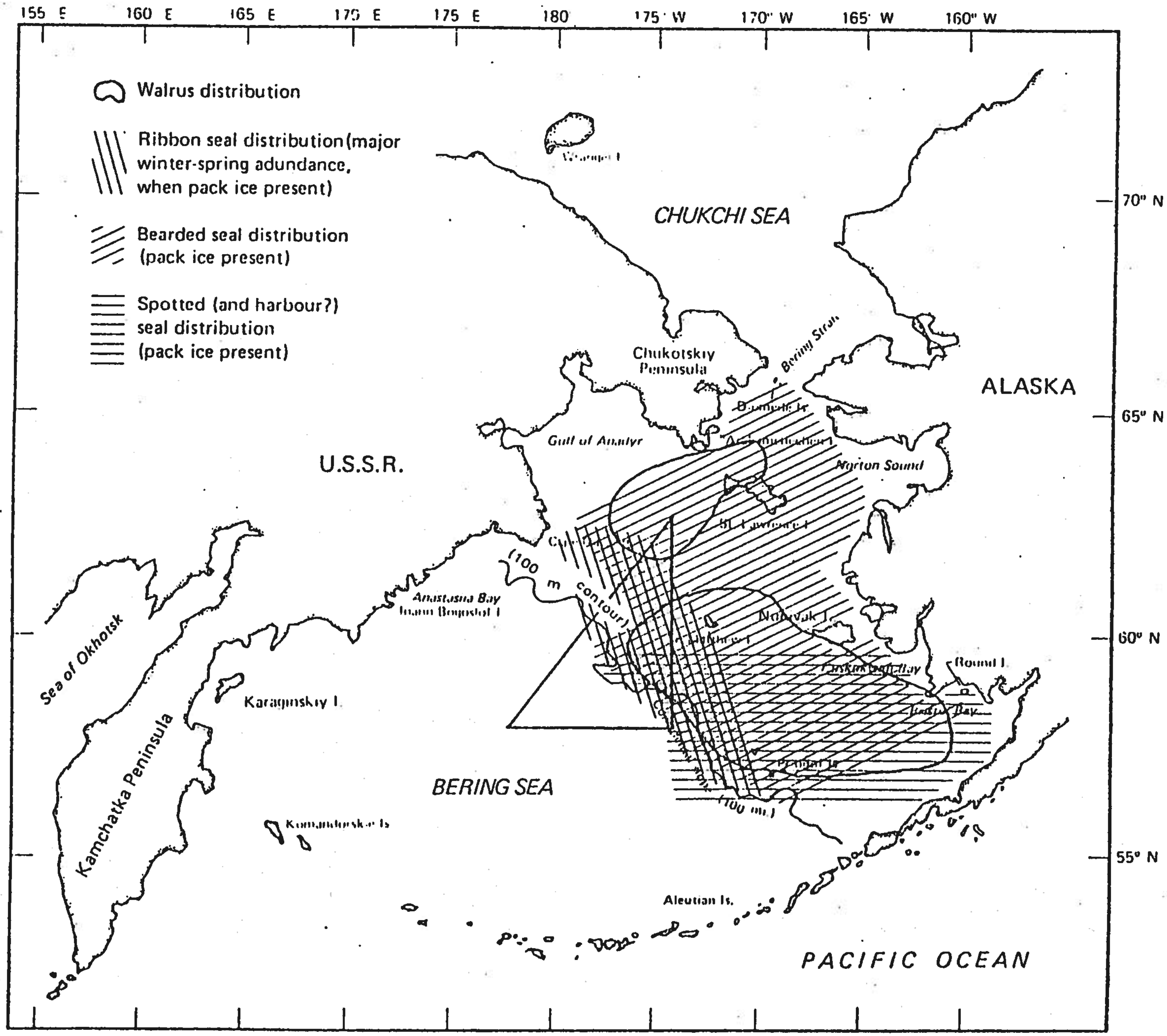
All of the above species with the exception of the harbor seal can be found within the Navarin Basin area. Depending on the season one or more of the above will be found there at any time of year. When pack ice is near its maximum extent, ribbon seals occur with greater frequency and density in the Navarin Basin than the other seals (Figure 5.2). Bearded seals and walrus also occur in the lease area during ice-covered periods but generally farther north in the upper third of the designated lease boundaries. Spotted seals as well as walrus may be found near the eastern edge of the Basin during ice coverage, but centers of abundance for these species are east (spotted seals) and east and north (walrus). Ringed seals usually are found on or near shore-fast ice, although a few have been reported near the Navarin Basin (Kenyon 1960; Burns and Harbo 1977; NMFS unpubl. data). The ice-associated pinnipeds again move north with the ice in late spring and vacate the Navarin Basin by summer for more productive waters in the northern Bering Sea and Arctic Ocean. Ribbon seals may be an exception, however, and remain free-swimming in the area during the ice-free season.

Northern fur seals occupy the continental slope near the Navarin Basin, however, the lease area appears to be close to the northwestern limit of their range. Steller sea lions occur regularly near the Aleutian Islands to the Pribilof Islands and along the ice front east and west of the Pribilof Islands. In autumn, sea lions have been seen to haul out on Hall Island northwest of St. Matthew Island (Braham et al. 1977), and thus sea lions may frequent the Navarin Basin for feeding (on fish) with greater regularity than has been documented.

The following sections summarize our present knowledge of the pinniped species inhabiting the central Bering Sea and Navarin Basin area. A summary of this biological data is presented in Table 5.8

5.2.1 Ribbon Seals

The ribbon seal, Phoca (Histriophoca) fasciata, ranges throughout the Bering Sea, chiefly among ice floes at the edge of the seasonal pack ice. During the winter and early spring, the entire population of ribbon seals is concen-



5.2 - Winter-spring distribution of ice-associated phocid seals and walrus in the central Bering Sea at maximum pack ice extent (near 100 m sea floor contour). Most species overlap near the eastern edge of the Navarin Basin lease area (triangle).

Table 5.6 Vital Parameters of Bering Sea Seals and Sea Lions

	Ribbon Seal	Spotted Seal	Bearded Seal	Steller Sea Lion	Northern Fur Seal
Population Size	50,000 AK 80-100,000 Total	70,000 AK 200-250,000 Total	250,000 AK 450,000 Total	100-200,000 AK 250,000 Total	1,300,000 AK 1,800,000 Total
Population Status	reduced	high, stable	high, stable	high, stable - declining in E. Aleutians?	high, stable
Harvest	250 US 8-9,000 USSR	3,000 US 10-15,000 USSR	2,000 US 5-8,000 USSR	"limited" US some fishing kill	30,000 US 5,000 USSR
Size: m, kg	Pup: 0.8, 10 Adult: 1.55, 80	Pup: 0.8, 7 Adult: 1.3-1.7, 90-114	Pup: 0.87, 43 Adult: 2.25, 275-340	Pup: 1,16-23 Female: 2,300 Male: 3,900	Pup: 0.66, 5 Female: 1.4, 43-50 Male: 2.1, 182-272
Birth, month	III-IV	III-V	IV-V	V-VI	VI-VIII
Mating, month	IV-V	V-VI	V	V-VI	VI-VII
Nursing	4 wks	4 wks	12-18 days	8-11 mo	4 mo
Gestation (delay)	10.5-11 mo	10.5 mo	10.5-11 mo	12 (3) mo	12 (3.5-4)
Maturity, female Maturity, male	2-4 3-5	3-4 4-5	5-6 6-7	4-5 5-7 sexual 7-9 social	3-4 4-5 sexual 9-15 social
Pregnancy Rate, %	85	95	75-85	75.6-85	60
Longevity, years	22-26	35	31	23	25
Mortality %, pups subsequent	44 11.2	35-50 8-10	unknown unknown	10-100; ave. 50 unknown	about 50 ave. 20 (male 38; female, 11)
Diet	Fish, Squid, Crustacea	Fish, Squid, Crustacea	Crustacea, Clam, Polychaeta, Fish	Fish, Squid, Shrimp, Clams	Fish, Squid
Daily Ration, % body wt.	unknown-6% est.	unknown-6% est	unknown-6% est	2-6	10

trated along the southern margin of the seasonal ice-edge. As the ice-edge retreats through the Bering Strait in late spring, most seals abandon the ice, become pelagic, and remain in the Bering Sea with main concentrations between the Gulf of Anadyr and St. Lawrence Island. A small portion of the population enters the Chukchi Sea each spring. Only basic information is available on Bering Sea ribbon seal populations and their biology. Recent estimates of ribbon seal populations abundance range from 50,000 to 100,000 individuals, of which at least 60% remain in the Bering Sea in the summer.

Soviet harvests of ribbon seals in the Bering Sea in the 1960's averaged 13,000 per year, and resulted in a severe population reduction from over-harvesting. Following major restrictions in their commercial harvest in 1960, to 3,000 per year, the Bering Sea population has seemed to recover to at least half of the pre-exploitation estimates of 100,000 to 114,000 animals. Ribbon seals seldom inhabit coastal areas, and there is subsequently little harvest of these seals in Alaska, usually less than 250 per year.

Ribbon seals give birth to white-coated pups on ice floes during late March to mid-April. Nursing lasts about four weeks. Sexual maturity is reached between 2 and 4 years for females and between 3 and 5 years for males. Breeding is annual; maximum longevity is at least up to 26 years of age. About 80 percent of the population are mature individuals. Pregnancy incidence of 85 percent has been reported. Natural mortality is high in the first year (44 percent) but declines substantially afterwards (11 percent to age 16 - 18).

Ribbon seals feed on pelagic and demersal fish, squid, and small crustaceans (crab, mysids, and shrimp).

The behavior of the ribbon seal is poorly known, The following account by Tikhomirov (1964) indicates that it is quite susceptible to harrassment during the pupping period:

"The ribbon seal lacks both maternal or marital affection. Abandoned pups of this species are encountered frequently. Apparently the female visits her offspring only at feeding time and then leaves it. We never observed a female protecting her young from humans or attempting to push it into the water. When approached, she invariably flees and abandons the young seal to whatever fate has in store for it. The male ribbon seals live apart from the females during the entire period on the ice."

5.2.2 Spotted Seal

Two subspecies of the seal *Phoca vitulina* occur in Alaska waters. The spotted seal, *P. v. largha* is the ice-associated subspecies that ranges from the Bering Sea northward to the Beaufort Sea. The land-breeding harbor seal, *P. v. richardii* is found in ice-free waters along the entire coastline of Alaska from Dixon Entrance to Kuskokwim Bay, including all of the Aleutian Islands and the Pribilofs.

The ice-breeding subspecies, *P. v. largha*, is seasonally dependent upon sea ice for the birth and nursing of its pups. Like the ribbon seal, during winter and spring the entire population of ice-breeding spotted seals is concentrated along the southern edge of the seasonal pack ice, primarily in the central and eastern Bering Sea. These seals move northward and toward the coast, from St. Lawrence Island to Barter Island, as the seasonal retreat and disintegration of sea ice progresses. Unlike the ribbon seal, a substantial portion of the spotted seal population remains with the seasonal pack ice as it retreats north through the Bering Strait into the Chukchi Sea. During the ice-free season the spotted seal is the dominant seal species along the northern Alaska coastline.

The Bering Sea spotted seal population is variously estimated at 70,000 in Alaska and 200,000 to 250,000 total animals. Populations appear to be relatively stable and free of significant man-induced pressures. About 20,000 spotted seals remain in the northern part of the Bering Sea in the summer.

During the pupping and mating season adults and pups are relatively evenly distributed along the ice-front in individual family groups (triads) of an adult male, adult female, and her pup. These groups are rarely closer than

0.25 km apart. Nonbreeding and subadults also occupy the ice front but seldom leave the water to haul out on the ice during this time of the year.

In Arctic Alaska, spotted seals are hunted by natives for food for humans and dogs, skins for clothing, and for hunting implements. The annual Alaska native harvest is about 3,000 to 4,000 animals. Combined American and Soviet harvests have been around 7,000 animals per year, well below the maximum substainable yield, and probably insignificant with respect to impact on population size.

Pupping occurs on drifting sea ice during late March to mid-April. There is one pup born per female. The pups are born with long white hair (lanugo) which is retained for several weeks. Nursing lasts about 4 weeks. Pups do not enter the water until the fetal coat is replaced by their first coat of adult-like hair.

Sexual maturity of the female occurs between 3 and 4 years, of the male between 4 and 5 years. Pair bonds form in March and last through the breeding season. A mature female will mate again at or near the end of the nursing period of her previous pup. Incidence of pregnancy among adult females is about 95 percent. Natural mortality is high during the first year and may approach 35 to 50 percent. Subsequent mortality declines to 8 to 10 percent annually. Maximum longevity of at least 35 years has been recorded.

The diet of the spotted seal varies with season and location and according to what is most readily available. Major prey include pelagic and demersal fish, such as herring, flounder, rockfish and cod, cephalopods, shrimp and small crabs. The spotted seal can dive to 300 feet and remain submerged up to 20 minutes, although 5 to 6 minute dives are most common. In autumn near the coasts, spotted seals feed mainly on salmonids.

Seals of this species are extremely sensitive to disturbance, and may leave an area temporarily or permanently after only minor harassment by people, equipment, and aircraft. Abandonment of a young pup by its mother is a common occurrence, especially if they are disturbed by hunting or other activities of man.

5.2.3 Bearded Seal

Erignathus barbatus, the bearded seal occurs in the Arctic Ocean, the Chukchi Sea, and in the Bering Sea south to Bristol Bay and the Pribilof Islands. In winter and spring it is widely distributed from the southern edge of the seasonal ice pack north to permanent ice wherever areas of broken, moving ice exist. Although they can maintain breathing holes in ice, they rarely do so, and seldom occur in areas of unbroken, land-fast ice. During the winter-spring, most of the bearded seal population is in the Bering Sea and in the highly fractured ice north of the Bering Strait.

Marked seasonal migrations of bearded seals are associated with the annual advance and retreat of the seasonal ice margin. During summer and autumn, they migrate north to the edge of the permanent polar pack ice in the Arctic Ocean. Adults are almost always associated with the sea ice, but a small portion of subadults often remain in icefree areas where they frequent bays and estuaries. However, they rarely come ashore in these areas.

The bearded seal is usually a solitary animal, but loose aggregations are sometimes observed during the breeding season. During their northward migration through the constricted waters of the Bering Strait and during late summer when sea ice has receded into the Arctic Ocean, localized concentrations of individuals can occur. As they are primarily benthic feeders, feeding in waters less than 150 m, few animals remain with the summer pack ice when its southern edge is over deep water.

Recent estimates indicate at least 250,000 animals for the Bering and Chukchi Seas, of which about 50,000 remain in the northern part of Bering Sea during the summer. Most of the population migrates seasonally into the East-Siberian and Beaufort Seas. The population is probably at or only slightly below pre-exploitation levels, and appears to be relatively stable. Natural mortality rates are not known.

The combined Alaska native and Soviet harvest of bearded seals ranged as high as 8,000 to 10,000 seals per year during the mid-1960's but has subsequently declined to less than 3,000. Hunting loss, however, is high because of sinking and many more seals are killed than are taken. In Alaska, the subsistence take has been less than 2,000 animals per year, mostly harvested during the spring, Soviet pelagic sealing has been prohibited since 1970, but land quotas are given of 5,000 for Okhotsk Sea and 3,000 for the Bering Sea.

The skins and blubber of the bearded seal have native subsistence use, and the meat is the most desirable of the northern seals hunted.

Bearded seals bear a single dark-haired pup on the ice usually during late April or early May. Pups are capable of swimming shortly after birth and are weaned in 12-18 days. The average weight of the pups at birth is around 75 pounds, and after the nursing period, its weight will have increased almost threefold, to about 190 pounds. This weight increase is primarily in blubber thickness as the length increase during this time is slight.

Reproductive maturity is not attained until 5 or 6 years of age for females, and 6 or 7 years for males. Most females breed within 2 weeks of weaning their pup. The incidence of pregnancy is about 85 per cent. Maximum longevity is at least to 31 years of age.

The bearded seal feeds almost exclusively on bottom invertebrates. Crustaceans (crabs, shrimp, amphipods) and molluscs (mainly clams) are the main prey items with polychaetes and the more sedentary fishes important locally.

The bearded seal reacts differently to disturbance depending on the season. In spring, when basking on ice, they frequently show little concern about the presence of man. During winter their alertness and wariness is well attuned, and they avoid human activity.

5.2.4 Steller Sea Lion

The Steller or northern sea lion, Eumetopias jubata is the most abundant sea lion in North America, ranging throughout central and southern Alaska waters from the Bering Strait to Dixon Entrance and south to islands off southern

California. Although covering a large range, no isolated or subspecific populations of the species are identified. Some seasonal movements have been recorded in the Bering Sea populations. Like the northern fur seal, the sea lion has established specific, well-defined locations along the Alaska coast for use as breeding and pupping rookeries and as hauling-out areas. The Pribilof Islands are their northernmost breeding grounds. However, a number of animals, mainly adult and sub-adult males, migrate farther north during the summer and early fall. Several hundred sea lions occupy St. Matthew and Hall Island during the summer, arriving after mid-July. A thousand or more regularly reach St. Lawrence Island in the summer. A few individuals have been observed during late summer and early fall as far north as Fairway Rock and the Diomede Islands in the Bering Strait. These animals move south again with the advance of sea ice in the fall. Most animals are believed to migrate south to the Aleutians during winter, but some are known to occupy the southern edge of the Bering Sea ice, and occasionally haul-out on large flows. Thousands of sea lions occupy the Pribilofs during the winter.

The closest sea lion rookeries and haulout areas to the Navarin Basin proposed sale area are the Pribilof Islands, and the seasonally utilized St. Matthew, Hall, and St. Lawrence Islands. However, many sea lions abandon rookeries and haul-out areas during winter and spring to feed far from shore, having been observed to follow herring schools in the spring.

The Alaska sea lion population has been estimated at 100-200,000 individuals. Between 1957 - 1977 there is evidence that Alaska's eastern Aleutian Island populations have decreased between 40 - 50%, for reasons as yet unknown. Estimates of abundance have ranged from 45,000 to 50,000 in earlier years to less than 25,000 in recent years. In other areas of Alaska the populations may be near their carrying capacity.

There is a limited native take of sea lions in Alaska, for traditional arts and crafts as well as for human consumption and animal food. Fishermen also kill some animals each year in fishing gear conflicts. Natural mortality of the adults is unknown. Pup mortality on breeding rookeries is highly variable (10 - 100 percent) due principally to weather and also to crowding effects (crushing and terrain). Overall first year mortality is typically 50 percent or greater. Drowning, abandonment, malnutrition, and predation (sharks, killer whales) are major causes of death in the yearling class.

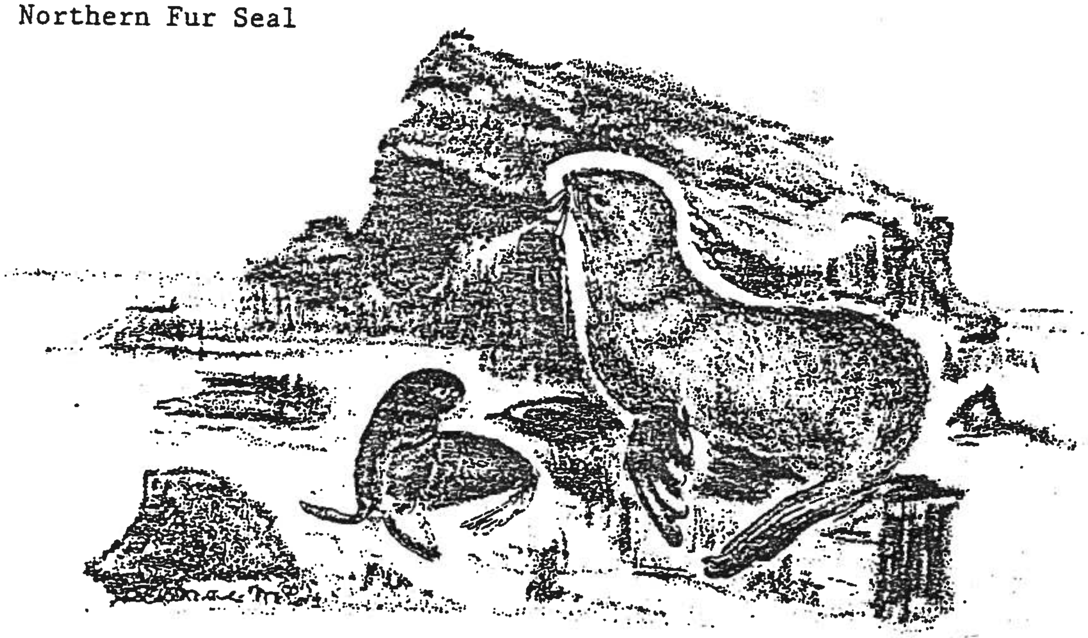
Pupping occurs in mid-May through June at established rookeries. Nursing is of long duration, typically 8 - 11 months, and individual females have commonly been observed nursing both a newborn pup and a yearling. Mating occurs 8 to 14 days after parturition. Pregnancy rates range from 6 to 85 percent, and vary with the tendency of females to wean pups of the year. As many as 25 percent of adult females may typically fail to reproduce each year. At rookeries where mothers fail to wean their pups before 11 months, pregnancy rates are lowest.

Although pups are able to swim within hours of birth, they rarely enter the water before one month of age.

Sea lions are opportunistic feeders and consume a wide variety of fishes, including lamprey, salmon, smelt, herring, sand lance, rockfish, sculpins, halibut, and sablefish. Invertebrates such as shrimp, clams, squid and octopus are also taken. They are voracious feeders, and require to 6 percent of their body weight per day.

Sea lions are sensitive to disturbance and harrassment, especially on their rookeries. Harrassment of breeding areas has been a "local" problem for some populations, especially prior to the Marine Mammals Protection Act 1972, and there is a long documented period of consistently high pup mortality at rookeries subject to human disturbance.

5.2.5 Northern Fur Seal



The northern or Alaska fur seal, Callorhinis ursinus, ranges throughout Alaska waters from the North Pacific, throughout the Bering Sea, and occasionally northward into the Beaufort Sea east of Point Barrow (Figure 5.3).

Northern fur seals breed on St. Paul and St. George Islands and Sea Lion Rock in the Pribilofs, as well as the Commander Islands and Kuril Islands off the Kamchatka Peninsula. About 80 percent of the northern fur seal population breeds on the Pribilof Islands.

Most of the adult fur seals are on their breeding grounds from May to November to give birth to pups and to breed. They are otherwise found at sea along the continental shelf from the Bering Sea south along both sides of the North Pacific Ocean to latitude 32° N. Most yearlings of both sexes and many two year olds spend the entire year at sea.

Unless sick or injured, fur seals rarely return to shore from the time they leave their rookeries in the fall until they return the following year. In the open ocean fur seals are found widely dispersed, either singly or in small groups usually of seven or less. Seal densities in open waters during the winter is extremely variable, but can exceed 70 per square mile. Many of the adult male fur seals remain in the Bering Sea during the winter, while most females and juveniles migrate into the North Pacific as far south as California.

The northern fur seal population is estimated at about 1.8 million of which 1.3 million are from the Pribilof stock. A program of reducing the population of Pribilof Islands fur seals was begun in 1956 with the expectation that the rate of survival would improve (Roppel, et al., 1963) and result in an increased yield of pelts. By 1968, it had become evident that the herd had been reduced to a level somewhat below that of maximum sustainable yield, and that an increase in the number of pups born was desirable. Thus, female fur seals have not been harvested commercially on the Pribilof Islands since 1968 in hope that the population would increase. However, less than average survival of several year classes, the cause of which is not understood, has prevented the expected increase. In 1975, the number of pups born was estimated to be 361,000; and in the past, the maximum yield of furs was produced when about 400,000 pups were born.

Apparently the Commander Islands fur seals have not become reestablished on a considerable portion of their original rookery area. Consequently, this population is below its sustainable level. Johnson (1972) estimated the abundance of northern fur seals by breeding islands, as follows:

Location of Fur Seal Rookeries	Estimated Number Fur Seals Thousands
Pribilof Islands	1,300
San Miguel Island	2
Commander Islands	265
Robben Island	165
Kuril Islands	33
Total	1,765

From June to November, approximately 1,043,000 of the estimated 1.3 million Pribilof Island fur seals are found in the central and eastern Bering Sea; of this number, approximately 550,000 would be at sea at any given time, having an estimated biomass of 24,800 metric tons (McAlister and Perez, 1979).

The species is highly polygamous. Adult males arrive earliest at the rookeries (early May) and establish breeding territories. During June, adult females begin to arrive and form harems of from 1 to over 100 females (the average is about 45) per adult territorial harem bull. Sub-adult males appear on separate hauling-out grounds adjacent to the rookeries, arriving in general order of decreasing age from June to October.

Most of the pregnant females arrive at the rookeries in late June or July. Within 3 days of her arrival, the female bears a single pup (twins are rare), and breeds again within one week. The pups are nursed and fed on a cycle of 2 days on land and about 8 days at sea for up to 4 months. The pups are weaned when the southward migration begins in October and November.

Pup mortality on land averages about 10% but can vary widely. Overall mortality is about 50% for the first year, and about 20% annually thereafter (11% for females, 38% for males). Natural longevity is to at least 25 years. Sexual maturity occurs between 3 to 5 years for females and 4 to 5 years for males, although males do not successfully establish harems until about age 10.

Fur seals feed during the evening through early morning hours when their important prey arise to the surface at night (Figure 5.4). They usually sleep during the day but may feed then also when food is abundant. Their diet consists chiefly of small schooling fish (e.g. anchovy, capelin, herring) and also squid. Salmon, sand lance, walleye pollock, Atka mackeral, and deep sea smelt are also commonly taken. Over fifty species of fish and 9 species of squid have been found in their diet. While maintaining rookeries, fur seals may range from 35 to 200 miles on their foraging excursions from shore. They can dive to at least 190 m in search of prey and remain submerged over 5 minutes.

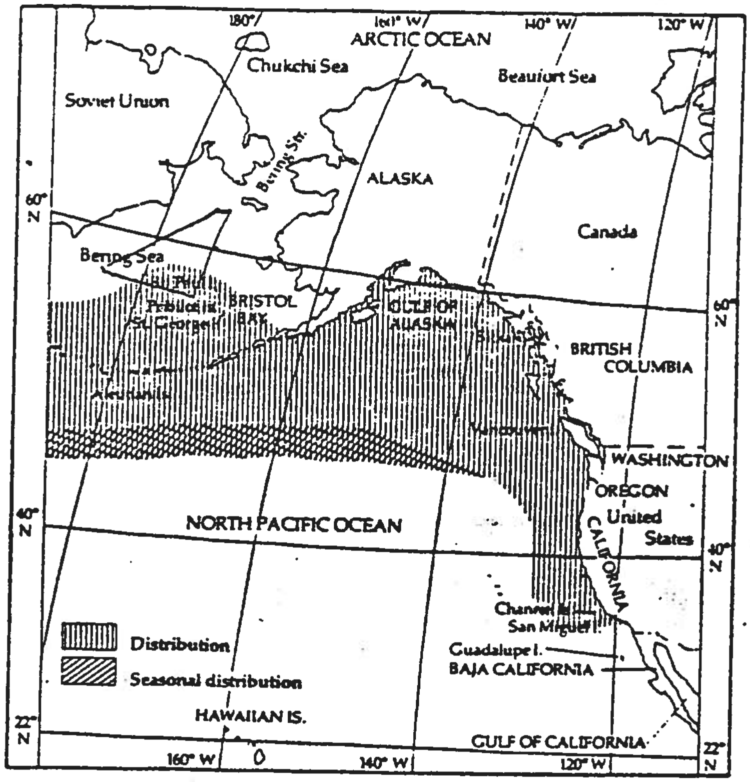


Figure 5.3 - Northern fur sea distribution. Stragglers are found north to Bering Strait (reprinted from an article by C. H. Fiscus in "Marine Mammals of Eastern North Pacific and Arctic Waters," (Pacific Search Press, Seattle).

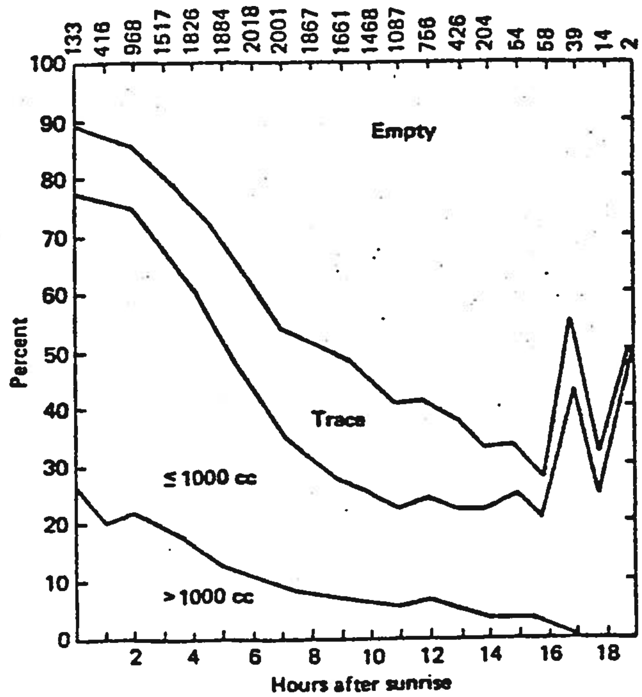


Figure 5.4 - The percentage of stomachs of fur seals containing food in relation to hours after sunrise in the eastern North Pacific Ocean and Bering Sea (combined months), 1958-74. The sample size is shown at the top of the figure. Volume of food in the stomachs is shown in four categories.

The commercial harvest of males of ages 2-5 averages about 30,000 on the Pribilofs. This is about 21-30% of male pups born annually. Pelts are auctioned publicly in the U.S.; they presently sell for about $90.00. The annual harvest and auctioned value of these pelts since 1970 is given in Table 5.9.

National Marine Fisheries Service activities on the Pribilof Islands, as set out in the Fur Seal Act of 1966, required a FY 1978 expenditure of $4,544,500. Of this amount, about $2,000,000 went directly in salaries to residents of the islands who are employed as Federal employees by NMFS. The activities of these employees cover a wide range of duties from fur seal harvesting and skin processing to building maintenance and construction and automotive maintenance. The sealing activities are the major yearly source of income to most of these employees.

In addition, the St. Paul village corporation (Tanadgusix Corporation) has an agreement with NMFS for use of the seal carcasses. They process (freeze) the seal carcasses at St. Paul for sale for various uses and also market the seal stix (male reproductive organ). The total local payroll for these two ventures would approximate $40,000. The village corporation, from time to time, also realizes a small profit from these ventures.

Thus, local labor directly involved in sealing and skin and carcass processing brings wages into the islands both from the Federal Government and the Tanadgusix Corporation. This is an important segment of the total village income as most of the people so employed would otherwise have no other employment during the year.

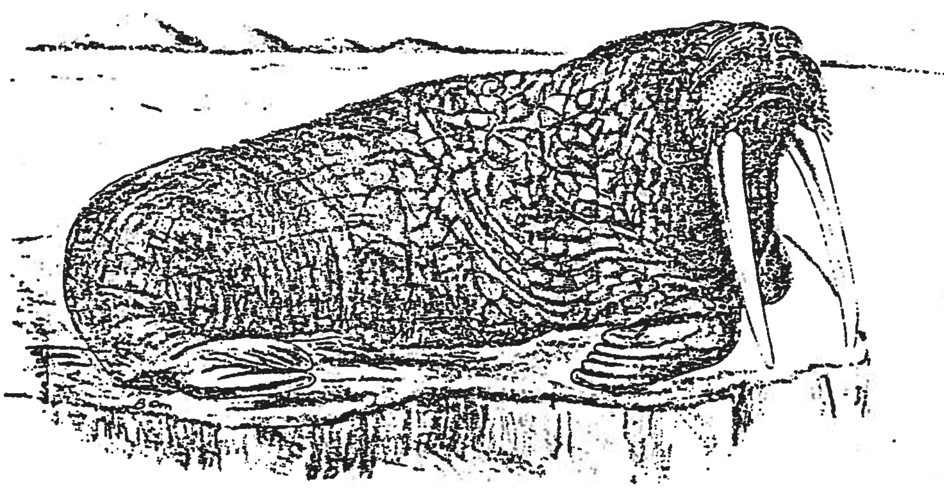
Although the economic values of the seal harvest are relatively easy to determine, the cultural or social aspects of the harvest are much more difficult to assess. The people of the Pribilof Islands have been involved in the fur seal harvest and allied activities since they were first brought to the islands about 200 years ago by the Russians for that express purpose. The seal harvest is a highlight in their yearly activities, and is looked forward to throughout the rest of the year. Young people look forward to becoming a

Table 5.9 - Harvest rates (number of animals) and approximate value of pelts of the Pribilof Island fur seal population

YEAR	HARVEST	VALUE
1970	42,179	$4,272,000
1971	31,824	$3,461,000
1972	37,221	$3,903,000
1973	28,418	$4,199,000
1974	32,934	&3,141,000
1975	28,849	$2,520,000
1976	23,188	$5,814,000
1977	28,328	$2,876,000
1978	24,843	$1,531,000
1979	16,100	

member of the sealing crew or to working in the processing plant for more than just the economic incentive. The members of this work force receive the recognition and respect of the rest of the village, and the positions are actively sought after. Furthermore, seal harvesting is something that they do well. They are extremely skilled in the various sealing and skin processing activities -- the best in the world, they say -- they take great pride in doing their job well. Should sealing be eliminated by whatever cause, it is difficult to say what would cause the most disruption to their culture: the economic loss of dollars or the loss of the traditional values focused on sealing and the processing of skins, as well as on other aspects of the seals.

5.2.6 Pacific Walrus



The Pacific walrus, Odobenus rosmarus, inhabits Alaskan waters in the Bering and Chukchi Seas, from Walrus Island in Bristol Bay, through the Pribilofs, and in the summer northward past Point Barrow, and occasionally eastward along the Beaufort Sea to the Canadian Arctic.

Pacific walrus follow a seasonal migration north in the summer and south in the winter in association with the seasonal movements of the pack ice. The entire population winters in the seasonal pack ice of the Bering Sea, mainly south of 64° N. The largest concentrations, composed mainly of females and young, occur 10 to 150 miles southwest of St. Lawrence Island. With the retreat of the pack ice in April - June, most of these animals move north into the Chukchi Sea, mostly west of the International Date Line. Males are gregarious outside of the breeding season, and about 8 - 10,000 males remain behind in the Bering Sea during the summer, hauling out on islands in Bristol Bay on the American side and the Gulf of Anadyr on the Soviet side. It is thought that these males do not rejoin the main herds until the latter have returned again south to their wintering areas, usually in late October to January.

Prior to commercial exploitation, the Pacific walrus population probably numbered about 200,000. Subsequent to their decimation during the late 19th and early 20th centuries to about 40-50,000 animals during the census of 1950-65, the population has been steadily increasing. Recent counts estimate the population to currently number about 200,000 and approaching the carrying capacity of its environment.

Since 1972 in Alaska, only Eskimos, Aleuts, and Indians have been allowed to take walruses for subsistence purposes, and no limit is placed on the number that can be taken. Recent harvest rates are about 1700 annually, but unretrieved kill is high, about 30-50% of total numbers killed. The utilization of the carcass varies. About 35% of the carcass is suitable for human consumption; the remainder is usually used for dog food. Of primary commercial importance is the tusk ivory, and it appears that most of the animals are harvested for this product. Other uses traditionally have included the skin for boat coverings, and the intestine for rain gear.

The Pacific walrus is one of the largest pinnipeds, second only to the elephant seals. Males weigh up to 1,600 kg and females to 1,250 kg. Calves at birth weigh about 60 kg.

Most females reach maturity at about age 6 or 7; males at age 7 to 10. The species is polygamous, and successful adult bulls form harems of about 5 cows. Mating occurs mainly in February - March. The gestation period lasts about 13 - 15 months, and calving occurs in April to June during the spring migration northward with the retreating ice pack. Each female bears a single calf on the ice floes, on average every 2 to 3 years, and nurse usually for 2 years. Longevity is up to about 40 years of age.

Walrus feed in shallow waters, primarily on benthic invertebrates of a wide variety - especially snails and clams, and may occasionally eat fishes, and even other marine mammals. They consume about 5% of their body weight daily; a 1 ton walrus will require about 18 tons of benthos per year.

Walrus are subject to harrassment, particularly by low-flying aircraft. However, unlike some other pinnipeds such as the ribbon seal and spotted seal, a female walrus will not abandon her calf when threatened. Major oil spills may have adverse effects. Since the Pacific walrus population is close to becoming food limited, any significant perturbation of their food benthos will have serious effects on the walrus population (Fay, 1977).

5.3 Order Sirenia - Steller's Sea Cow

The Steller's sea cow, _Hydrodamalis gigas_, was formerly abundant in the Bering Sea, but has been thought to be extinct for about 200 years. This relative of the manatee, 20 to 30 feet in length, was discovered in the Bering Strait in 1741, and was exterminated by Russian whalers within 30 years. The last remaining individuals were thought to have persisted near the uninhabited Commander Islands until 1768. Like the dodo, it was a big target and had no fear of man.

Berzin _et al._ (1963) reported two Soviet sightings of large, strange animals in the region of Cape Navarin in July 1962 that he felt were possibly Steller's sea cows. One sighting of about six animals was made by men from a whale-catcher. A second sighting of one animal was also reported. More recently, there have been additional unconfirmed reports from the Bering Strait region - one sighting by an oil exploration crew (location unknown), the other from strange tracks on the beach near Tin City.* These reports should not be dismissed without futher investigation. Should the continued existence of this species be verified, it would be exciting and welcome news.

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* Mr. Firn Spiering, Palmer, Alaska - Personal Communication, Nov. 1980.

5.4 Cetaceans of the Central Bering Sea

The Department of Commerce through its National Oceanic and Atmospheric Administration (NOAA) and National Marine Fisheries Service (NMFS) bears responsibility for the protection of marine mammals, including whales, under the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the Whale Conservation and Protection Study Act of 1976. In addition, under the Fish and Wildlife Coordination Act, NMFS bears responsibility for protecting the habitats for marine organisms, including whales, that may be threatened by man-induced environmental alterations.

Whale research by NMFS in Alaska waters has not had a long history. The NMFS contracted with the University of Southern California to gather biological data on bowhead whales in 1973. In the spring of 1973, a group of scientists from U.S. and Canadian Universities attempted to record underwater sounds of the bowhead whale. In the spring of 1974, the NMFS instituted its own research program on bowhead whales.

The NMFS is presently conducting ongoing research on seasonal distribution and abundance of whales and other marine mammals in the Gulf of Alaska, the Bering Sea, and Arctic Ocean under contracts with the Department of the Interior's Outer Continental Shelf Environmental Assessment Program (OCSEAP).

The Bering Sea is inhabited by a number of whales, all of which are protected by national legislation and international treaty. Some of these whales are of considerable importance to the subsistence and culture of certain Alaska coastal communities. Subsistence harvest of these protected whales is not generally considered detrimental to the populations of the species, and is permitted within quotas by existing law.

Several species of dolphins and porpoises are also common inhabitants of the Bering Sea. Population sizes are often unknown, but some species are considered to be quite abundant. There is no native subsistence take of dolphins and porpoises and there are no direct conflicts between the animals and man over competition for fishery resources in Alaska.

The following species of cetaceans occur seasonally in the central Bering Sea; those asterisked can be considered to be most common:

Baleen Whales:

* * Bowhead whale - Balaena mysticetus
* Pacific right whale - Balaena glacialis
* * Fin whale - Balaenoptera physalus
* * Minke whale - Balaenoptera acutorostrata
* Sei whale - Balaenoptera boraelis
* Blue whale - Balaenoptera musculus
* Humpback whale - Megaptera novaeangliae
* * Gray whale - Eschrichtius robustus

Toothed Whales:

* * Sperm whale - Physeter macrocephalus
* Bering Sea Beaked whale - Mesoplodon stejnegeri
* Baird's Beaked whale - Berardius bairdii
* Culvier's Beaked whale - Ziphius cavirostris

Porpoises and dolphins:

* * Beluga whale - Delphinapterus leucas
* * Killer whale - Orcinus orca
* * Dall porpoise - Phocoenoides dalli
* Harbor porpoise - Phocoena phocoena

Science recognizes two suborders of Cetacea; the baleen or whalebone whales, suborder Mysticeti; and the toothed whales, suborder Odontoceti. Baleen whales are so named because instead of teeth they have up to several hundred plates of whalebone or baleen suspended from the upper jaw. They use these plates to strain their food, usually either small plankton or fish, by taking water into the mouth and forcing it out through the fringes of the overlapping baleen plates. There are at least 8 species of baleen whales known to occur at least occasionally in the Bering Sea, ranging in size from the minke whale (25 - 33 feet) to the blue whale (85 - 90 feet).

The toothed whales possess teeth after birth, though their number may vary from one to over 250. This group includes animals commonly called dolphins or porpoises as well as some commonly called whales, such as the sperm whale.

There are at least 7 species of toothed whales known from the Bering Sea, ranging in size from the harbor porpoise (about 5 feet) to the sperm whale (55 - 60 feet).

Most whale species frequenting the Navarin Basin (Table 5.1 and 5.3) do so during periods of open water (summer - autumn) with at least two exceptions --the bowhead whale (Balaena mysticetus) and beluga whale (Delphinapterus leucas). Bowheads occur in the Basin during late winter and early spring (Figure 5.5), but apparently not during any other time of year (Braham et al. 1980). Essentially no data are available on beluga whales; but it is assumed that they occur with bowheads while they are in the Navarin Basin. This may be not entirely true, however, since beluga whales are often observed further north near St. Lawrence Island when bowheads apparently are further south (Braham et al. 1979).

So little specific sighting data on the other cetaceans are available from the Navarin Basin that the following discussions must be considered provisional. Enough information is available, however, to indicate that most cetaceans inhabiting the North Pacific enter the Bering Sea for at least some portion of the year, usually from late spring through autumn (c.f. Berzin and Rovnin, 1966; Nishiwaki, 1967). For example, fin (Balaenoptera physalus) and minke (Balaenoptera acutorostrata) whales, and perhaps a very small number of humpback whales (Megaptera novaeangliae) appear to migrate into the Bering Sea through the Aleutian Islands, especially in the east through Unimak Pass, and move over the continental slope to productive feeding grounds to the north (Figure 5.5).

Although the number of fin whales entering the Bering Sea is probably only a portion of the total North Pacific population (estimated at about 1,000, Table 5.2), they undoubtedly move into the eastern Bering Sea as well as the Navarin Basin to feed, some continuing north into the northern Bering and Chukchi Seas. Gray whales (Eschrichtius robustus) may occur in the Basin on their autumn migration south, or near the very northern tip of the Basin during summer feeding. If some grays still frequent the Korea calving grounds, they may move through the Navarin Basin, but in all likelihood they

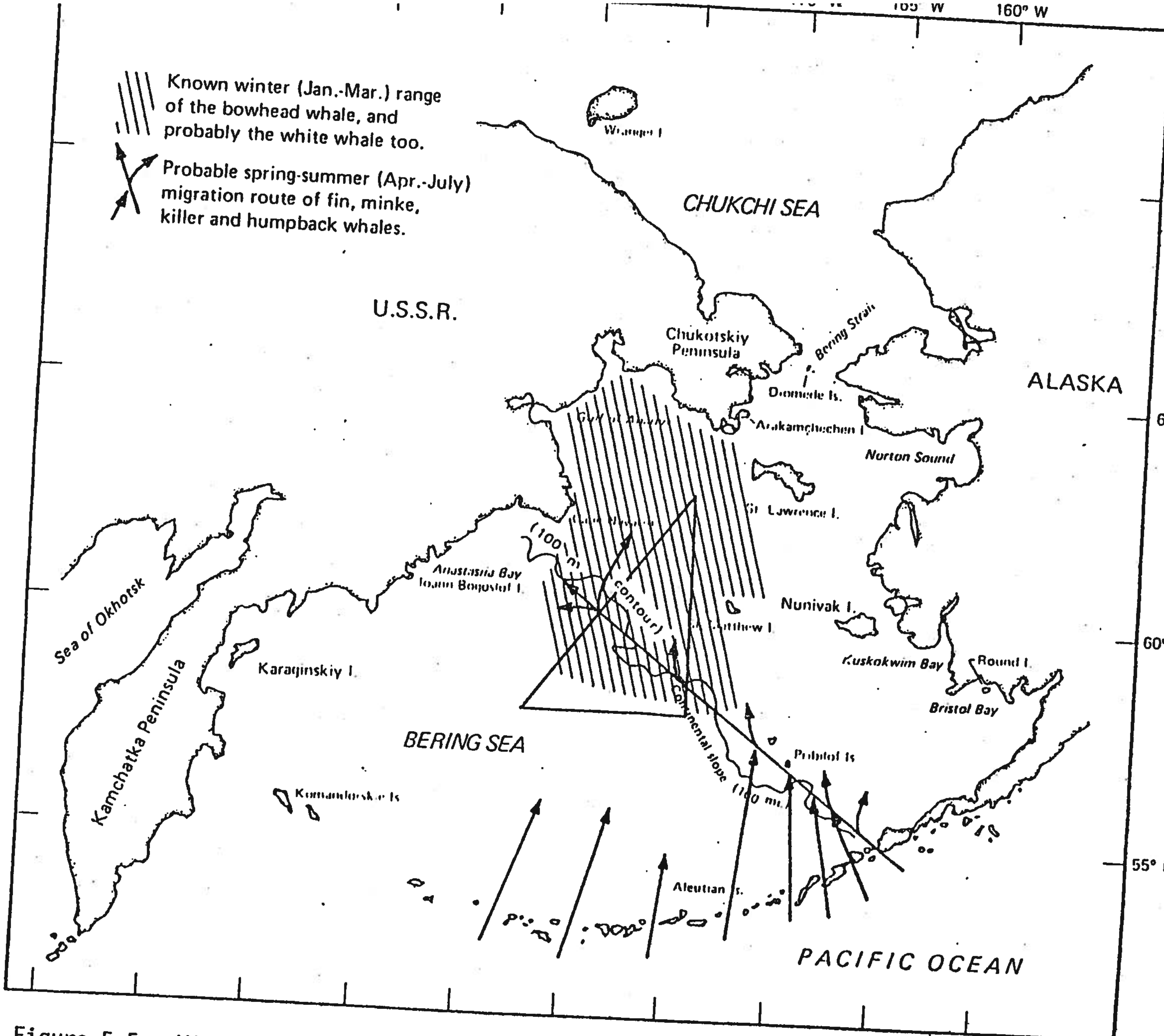


Figure 5.5 - Winter distribution of bowhead whales, and projected spring-summer migration routes for selected cetaceans through or near the Navarin Basin lease area (triangle). Summer to winter migration routes and feeding areas in or near the lease area are unknown.

would occur farther to the west along the Soviet coast. Pacific right whales (Balaena glacialis) are so rare that it is unlikely that we will ever see them in the central Bering Sea, but prior to commercial exploitation they were abundant in the southern Bering Sea probably including the Navarin Basin area.

The only toothed whales known to regularly (seasonally) frequent the Navarin Basin are the killer whale (Orcinus orca) and Dall's porpoise (Phocoenoides dallii). Although in low numbers, these whales move into the Bering Sea to feed on the rich fisheries resources in and adjacent to the Basin. The Navarin Basin appears to be within the northern range of the Dall's porpoise, but killer whales range into the Arctic Ocean. Sperm whales (Physeter macrocephalus) do not regularly range into the Bering Sea, but if present (most likely males) they would likely be off the shelf in deeper water during summer and autumn. All cetaceans entering the lease area are likely to be passing through on migration, north and south from April through November, and/or feeding. Other cetaceans, such as the beaked whales (Mesoplodon stejnegeri and Ziphius cavirostris) and harbor porpoise (Phocoena phocoena) are probably near year-round residents in the southern Bering Sea. Harbor porpoises occur near islands and along the coast, thus outside the Navarin Basin; beaked whales probably frequent the lease area, but data are lacking.

The following accounts discuss the status of knowledge of North Pacific and Bering Sea populations of these cetaceans.

5.4.1 The Bowhead Whale

The bowhead whale, Balaena mysticetus, is one of the rarest and least known species of great whales. It is an ice associated whale that inhabits arctic waters on both the eastern and western sides of the North American continent. An Atlantic population occurs in two areas: from Spitzbergen west to east Greenland, and in the Davis Strait, Baffin Bay, and Hudson Bay area of the Canadian Arctic. A Pacific population inhabits the Okhotsk, Bering, Chukchi, Beaufort and east Siberian Seas. The stock that inhabits the Bering and Chukchi Seas is the only sizeable population of the species that remains.

The bowhead whale migrates with the ice movement (Figure 5.6), usually traveling singly or in groups of 2 or 3. The population adjacent to Alaska moves north from its wintering area in the central Bering Sea during April and May in timing with the breakup of the pack ice, generally following open leads along the coast. The majority of the whales migrate north through the Strait of Anadyr to the west of St. Lawrence Island. A major portion of the population passes Point Barrow from April to nearly June and, following offshore leads between the seasonal and pack ice, reaches the vicinity of Banks Island in early summer. The whales disperse to feed in their summering waters in the Canadian Arctic off Banks Island and the Amundsen Gulf from July through early September. In autumn (September - October) they begin a westward, primarily nearshore movement through the Beaufort Sea into the Chukchi Sea and continue south in late fall to the Bering Sea in advance of the winter extension of the arctic pack ice.

Although the exact location of the wintering area for bowhead is poorly documented, past whaling records and observations by Alaska Eskimos support the hypothesis that bowhead winter distribution is mainly located south and west of St. Lawrence Island as far as the ice front edge, and perhaps further south into open water (Figure 5.5). The exact location probably varies with the type and extent of the seasonal ice edge. From December to April bowheads may frequent the area around St. Lawrence Island when broken ice and open water areas are available. During 1979 ice-breakers surveys, 64 bowheads were observed in the vicinity of St. Matthew Island among broken ice, and 45 were seen to the south and west of St. Lawrence Island.

A tentative estimate of the present size of the bowhead population in Alaskan waters has been derived from counts of whales migrating past Pt. Barrow in the spring. An estimated 2264 $\pm$ 500 whales are present in the western Arctic population. The population trend cannot be confidently judged. During the winter these whales are in the Bering Sea in the broken pack ice or at the ice edge. All bowhead populations were decimated by commercial whaling by the end of the 19th century because of the great value of the whale for oil and baleen.

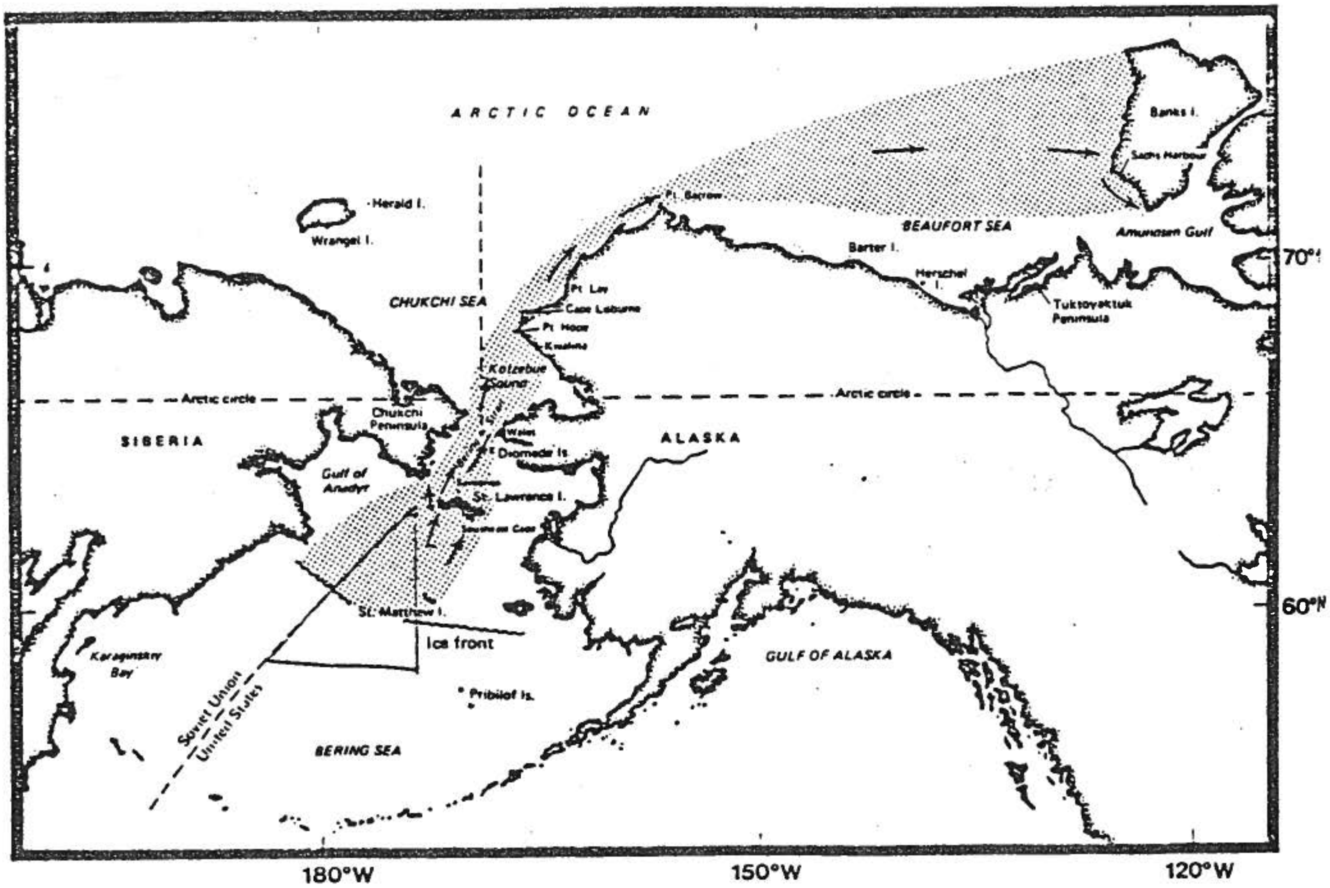


Figure 5.6 - Spring migration of bowhead whales.

Eskimos have a long history of hunting the bowhead whale for subsistence use. Hunting occurs during the spring and fall migrations where the whales pass near native villages. An increase of perhaps 100% in the hunting effort occurred after 1973, with an increase of from 45 to 90 whaling crews. The number of struck and lost whales increased at an even higher rate. As a result of the concern for the bowhead survival, the International Whaling Commission established struck and lost quotas to reduce the unnecessary kill rate.

The bowhead bears a single calf in April or May while on the wintering grounds or during their spring migration northward. The calf is nursed for 6 to 12 months. Breeding probably occurs from April through June. Gestation lasts 12 to 13 months, so an alternate year breeding is probable.

The bowhead feeds primarily on small crustaceans (euphausids, copepods, amphipods, mysids), but occasionally on bottom dwelling invertebrates and small fish (Table 5.6).

5.4.2 The Pacific Right Whale

The black right whale, Balaena glacialis, inhabits primarily temperate waters worldwide. The Pacific right whale is a geographically isolated population of the species that during the summer is found along the continental slope from the Gulf of Alaska and the Bering Sea to the Gulf of Anadyr. The northern limit of its range was thought to be about 63° N but some sightings have been reported in the Chukchi Sea. They appear in the Bering Sea in June and probably stay all summer. Most Bering Sea sightings have occurred in July between the Pribilof Islands and the Aleutians (Omura, 1958). They are rare in the Bering Sea however, occuring mainly as single individuals; the largest group seen was four. During the winter the population is off Oregon and California.

The right whale was originally very abundant, but heavy exploitation reduced all populations nearly to extinction. The North Pacific population is now estimated to number about 200 animals.

Very little is known about the biology or migrations of this species. Mating and calving occur in winter. Their principal food items are calanoid copepods and euphausiids, but also includes shrimp, pelagic molluscs, and schooling fish.

5.4.3 The Fin Whale

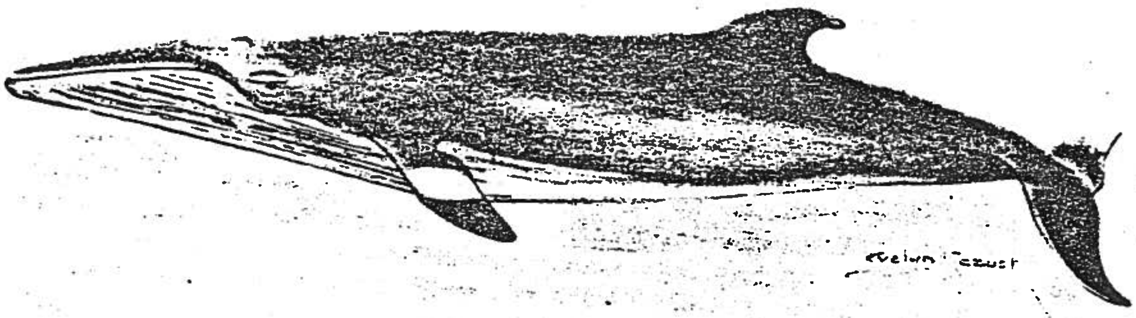
The fin whale, Balaenoptera physalus, occurs worldwide. In the eastern North Pacific it summers as far north as the Chukchi Sea and migrates to more southern latitudes in winter to mate and calve (Figure 5.7). They usually travel in small pods of 2 to 5 animals.

Fin whales entering the Bering Sea are divided into two groups (Nasu, 1974) one which closely follows the outer shelf front zone (Figure 5.8) as far as Cape Navarin, mainly mature males and females without calves, and a group which stays in the region north of Unimak Pass, mostly lactating feamales and immatures.

The North Pacific population of fin whales is estimated to have originally numbered 44,000 mature individuals, but has been reduced by commercial whaling to less than 17,000. During the summer from 1 - 5,000 are in the Bering Sea. Commercial harvests declined from 1,276 in 1969 to 508 in 1975, the last year of whaling before the species was given complete protection in 1976. The population may still be decreasing.

The fin whale is second only to the blue whale in size, reaching at least 70 feet in length. It feeds mainly on euphausiids, but often eats small schooling fish such as anchovy and capelin (Table 5.6).

5.4.4 The Minke Whale



Minke whale--Balenoptera acutorostrata.

The minke whale, Balaenoptera acutorostrata, inhabits all oceans, except in tropical latitudes. The North Pacific population is geographically isolated, and 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. Some calving may occur in the central Bering Sea region, including the Navarin Basin area.

The total size of the North Pacific population is unknown, and there is no knowledge of its original population size prior to whaling. During the summer, the Bering Sea population is estimated at about 3,000, mostly in waters off the shelf.

The minke whale has long been an important species in the "small whale" fisheries of the world. In 1976, catches were over 10,900 animals, about 900 of which are caught annually in the North Pacific. The world population of this species now numbers about 325,000 and is decreasing.

The diet of the minke whale is probably similar to that of the fin whale, mainly euphausiids and copepods (Table 5.6).

5.4.5 The Sei Whale

The sei whale (*Balaenoptera borealis*) is nearly world wide in distribution. In Alaska waters it is commonly found in the Gulf of Alaska and the Aleutian area during the summer (Figure 5.9), but migrates to more southern latitudes during the winter. A very few sei whales sometimes migrate into the Bering Sea, but would rarely occur in the Navarin Basin area and they do not pass the Bering Strait. They usually travel in small pods of 2 to 5.

The North Pacific population originally numbered over 40,000 sexually mature individuals, but has now been reduced to about 9,000, and is still decreasing. Catches of this species have also declined from over 5,000 in 1969 to about 500 in 1975. They were given complete protection in the North Pacific in 1976.

Sei's feed near the surface, mostly on copepods when in northern waters, but take a larger proportion of small pelagic fish (anchovies, sauries, mackerel) than in other baleen whales (Table 5.6).

The population is currently suffering from a unique disease that causes progressive shedding of the baleen plates and their replacement by an abnormal papilloma-like growth.

5.4.6 The Blue Whale

During the summer, the North Pacific blue whales, *Balaenoptera musculus*, range primarily between central North America on the east and the Japanese Islands on the west, north to the Aleutian Chain and the Gulf of Alaska. They rarely enter the Bering Sea, but some that do have been observed as far as north of the Bering Strait in the Chukchi Sea.

The wintering grounds of the North Pacific blue whale lie to the south off Baja California and Guatemala in the East Pacific, off Japan in the west, and in the mid-Pacific between 20° and 35° N latitude.

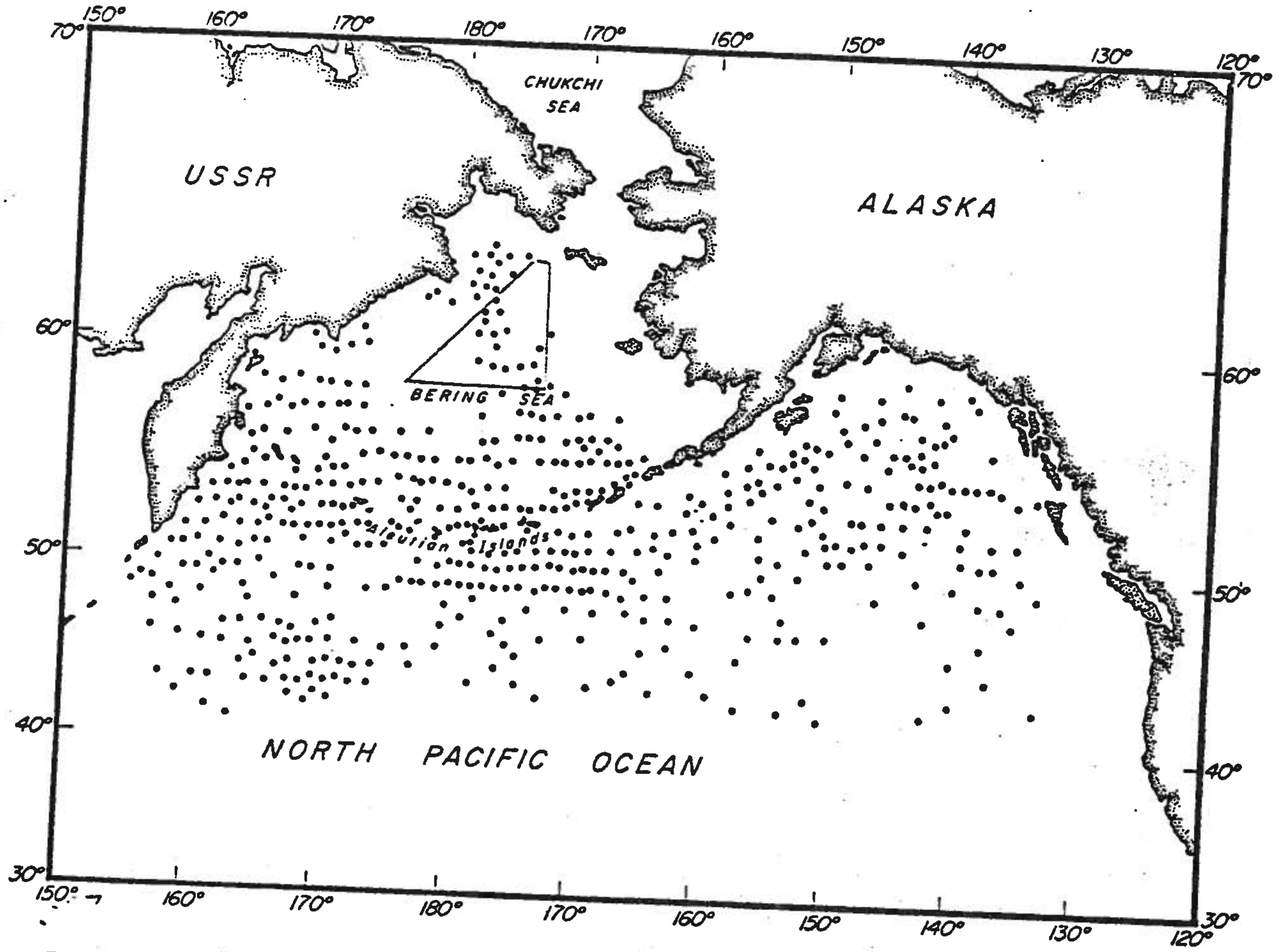


Fig. 5.7 - Distribution of sightings of fin whales, (from Nasu, 1974).

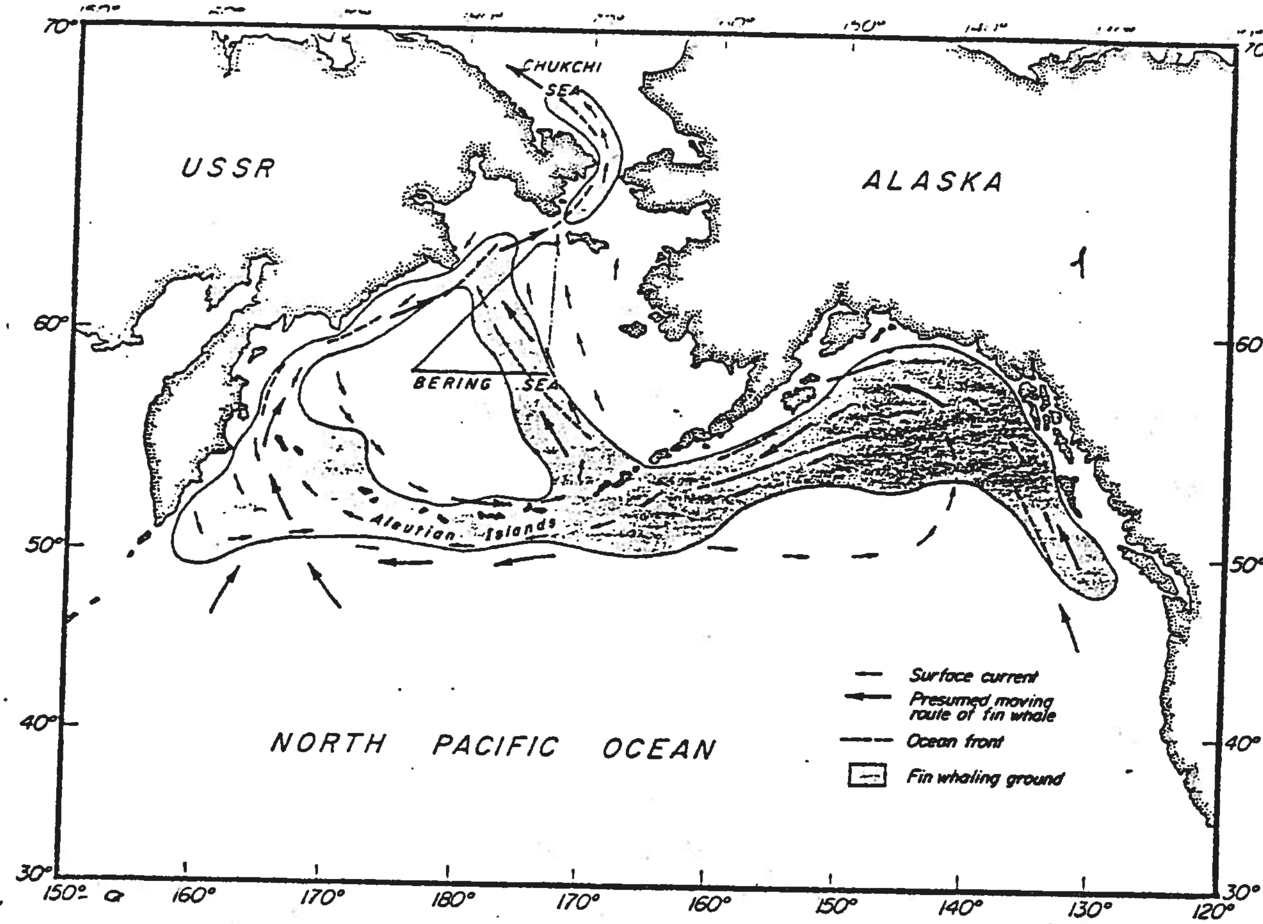


Fig. 5.8 - Presumed moving route of fin whales and oceanographic conditions, (from Nasu, 1974).

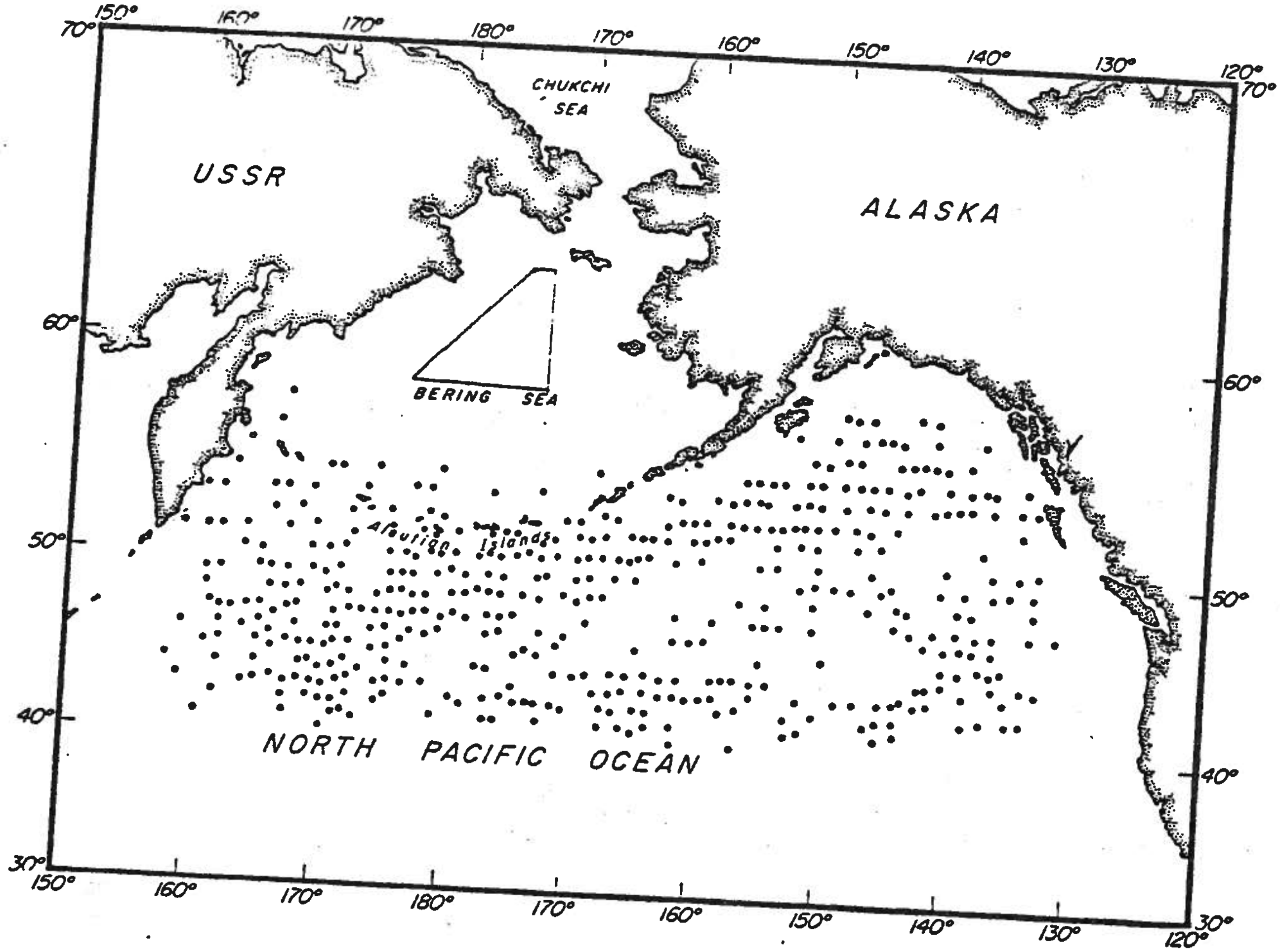
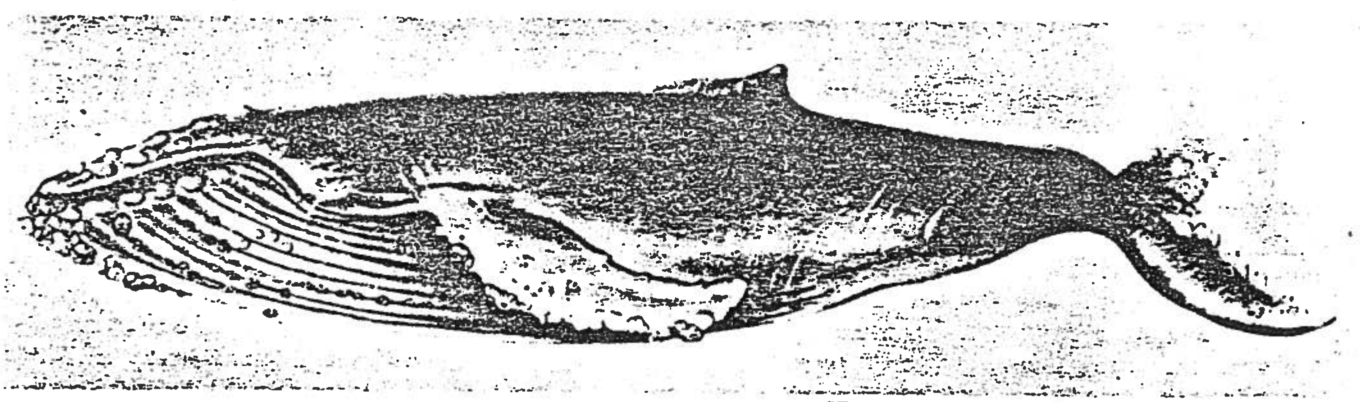


Figure 5.9 - Distribution of sightings of sei whales, (from Nasu, 1974)

Blue whales feed principally on "krill" shrimp like crustaceans called euphaussiids (Table 5.6). In the North Pacific the main species consumed is Euphausia pacifica. The lack of sizeable krill abundance on the continental shelf of the Bering Sea may be a major factor in limiting the summer occurrence of blue whales to waters south of the Bering Sea. They also take small proportions of small pelagic fish and squids.

The entire North Pacific stock of the whale probably numbers about 1,700 individuals of a population which once numbered about 5,000. The species has been protected from whaling since 1966 and appears to be slowly increasing, although significant restoration may require 50 years, even with total protection.

5.4.7 The Humpback Whale



Megaptera novaeangliae, the humpback whale

The distribution of humpback whales, Megaptera novaeangliae, in the North Pacific is believed to be similar to that of the fin whale. The species occurs in all oceans, typically migrating from high-latitude summering areas to low-latitude wintering areas. It occurs from southeastern Alaska to the Chukchi Sea during summer, where they spend up to 5½ months on their feeding grounds.

Calving occurs in October to March when the whale is at its southern latitudes.

As a result of commercial exploitation, this species is severely depleted. The original North Pacific population numbered about 15,000 but has now declined to about 1400 individuals, up to 200 of which are widely distributed during summer in the Bering Sea. The population has apparently not increased since complete protection was given to them in 1966, and may require 50 years or more for it to increase to a significant level.

Humpbacks feed mainly during the summer, primarily on euphausiids, but are known to also take anchovies, sardines, and salmon (Table 5.6).

5.4.8 The Gray Whale

The gray whale, Eschrichtius robustus, is restricted to two populations, an eastern Pacific ("Californian") stock and a western Pacific ("Korean") stock. The eastern stock summers in the northern Bering Sea, the Chukchi Sea, and the western Beaufort Sea, and winters along the west coast of Baja California and into the southern Gulf of California. The western stock summers in the Sea of Okhotsk and migrates to the southern coast of Korea to winter. Gray whales migrate in the spring to their summer feeding grounds in Alaska waters and leave again in the fall (Figure 5.10). Mating occurs in late fall while the animals are migrating south. Calving occurs in the winter in certain lagoons on the west coast of Baja California.

The whales first appear in the Gulf of Alaska in March and move into the Bering Sea from April through June. The migration route through Alaska waters is primarily coastal, usually within 1 km offshore, to Unimak Pass and into Bristol Bay. From Nunivak Island they move offshore to the northern feeding areas. Large concentrations of gray whales occur in the vicinity of St. Lawrence Island from July to November, where the waters of the major feeding areas are relatively shallow (20-60 m). Some animals continue north into the Chukchi and shallow Arctic seas to feed during the summer. A minimum of 5,000 gray whales summer in the Bering Sea, mainly in the northern part. Because of their preference for nearshore, shallow waters, gray whales probably do not occur in the central Bering Sea except for occasional individuals on their southbound migration in mid-October to December.

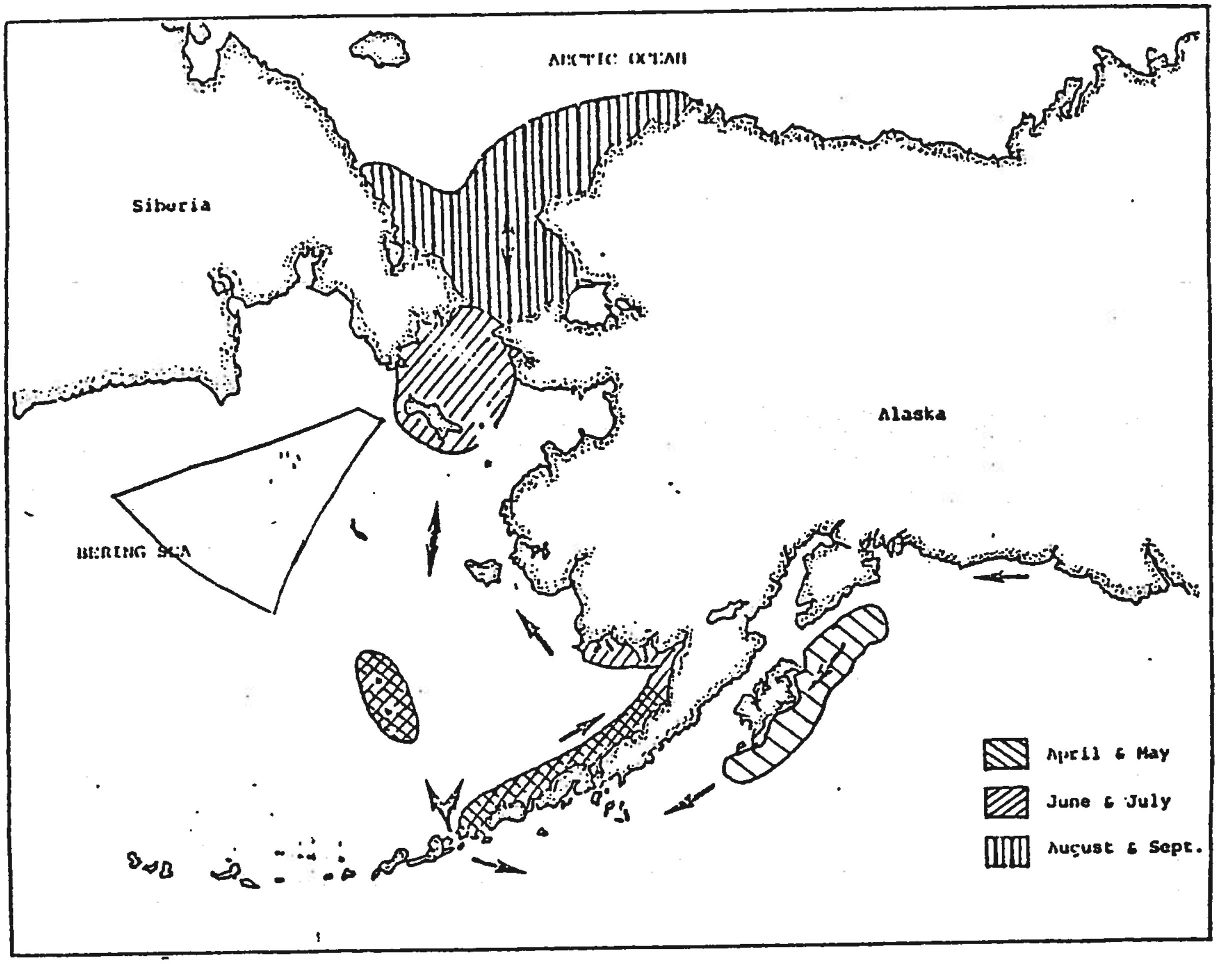


Figure 5.10 - Monthly gray whale distribution projections. (Arrows depict the projected migration route. The asterisk (*) depicts a May 1976 sighting by G. Fedoseev (pers. comm.). (From Braham et al., 1977).

The gray whales feed predominantly over the continental shelf on benthic invertebrates, mainly epibenthos and especially amphipods, during at least the latter part of their spring migration and in their summering areas, and fast during the fall migration and on their wintering grounds.

The eastern Pacific stock of the gray whale was greatly reduced by commercial whaling in the 1800's, but has increased since receiving complete protection in 1947. Its abundance is now estimated to number about 11,000 to 15,000 and has remained stable since 1967. The western stock, while never large, appears to be nearly extinct.

An average of about 160 gray whales are killed each year in a Soviet subsistence fishery on the Chukotski Peninsula. In Alaska, no more than 5 whales per year are taken by Eskimos.

5.4.9 The Sperm Whale

The sperm whales, Physeter macrocephalus, are nearly worldwide in distribution. They winter in temperate waters and migrate to higher latitudes in the summer. Only male sperm whales generally reach Alaska waters, the female and immatures are generally found farther south, between 40° and 50° north, but they may enter the Bering Sea in warm water years. Male sperm whales are known to occur as far north as the Bering and Okhotsk Seas in April to September, but do not pass the Bering Strait to more polar regions. The migration route of male sperm whales entering the Bering Sea is reported to run along the Aleutian Island chain westward towards the Commander Islands, through the Aleutian Straits, and along the continental shelf edge to Cape Navarin as far as 62° north (Berzin, 1971).

Male sperm whales are relatively abundant in the central Bering Sea (Nishiwaka 1967). The main area of concentration appears to be along the continental slope between the Pribilof Islands and Cape Navarin (Figure 5.11), in the vicinity of 180°.

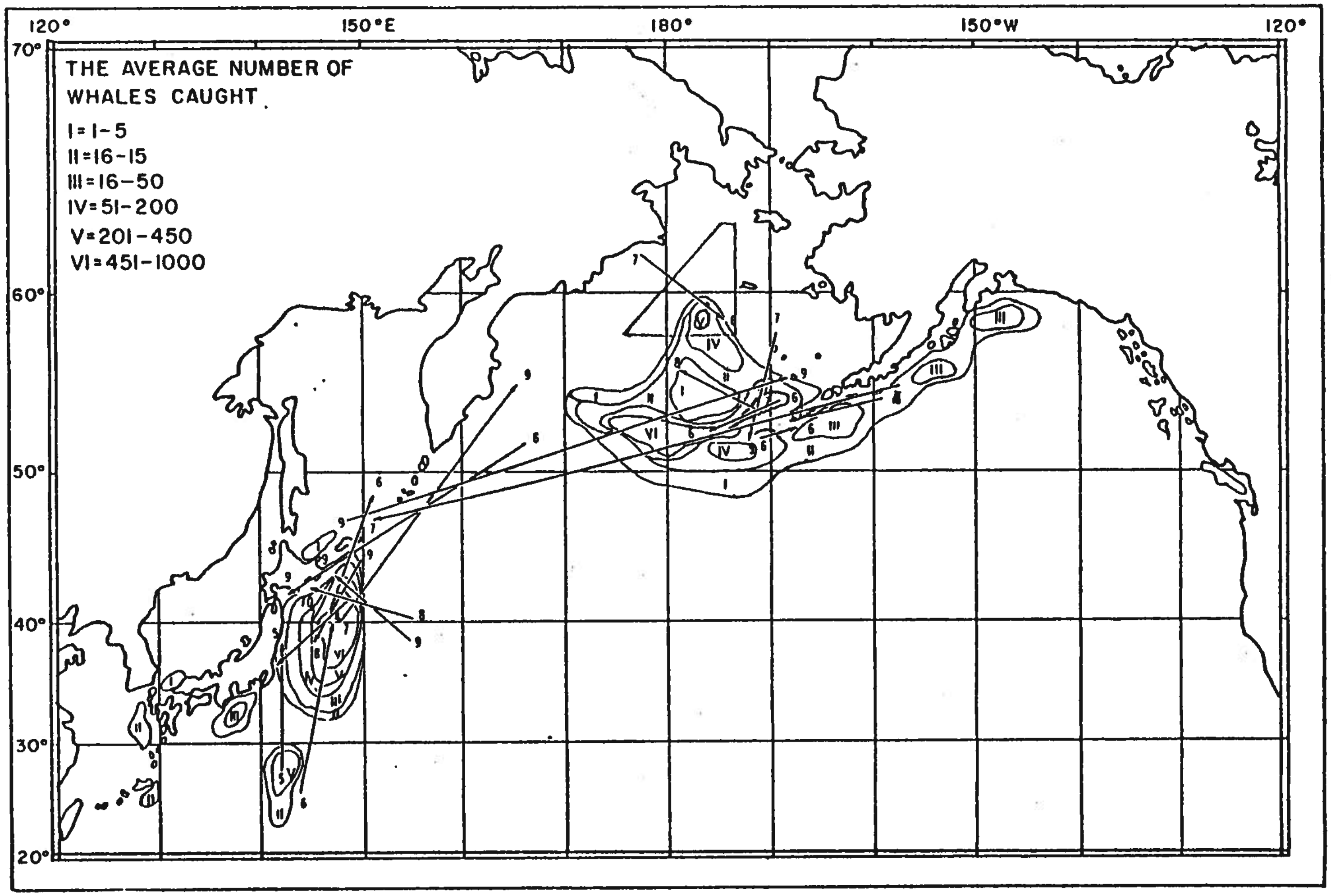


Figure 5.11 - Distribution of sperm whales in the North Pacific.

The sperm whale is currently the mainstay of the commercial whaling industry. Stocks in some regions of the world ocean are at or above their maximum sustainable yield level. In the North Pacific, the commercial take of sperm whales has steadily decreased in recent years, from 14,815 in 1970 to 5,854 in 1976, indicating that the North Pacific stock is probably on the decline. Estimates of the current size of the North Pacific population are approximately 175,000 harvestable males (over the legal limit of 9.2 m) and sexually mature females, down from the 1946 estimate of 400,000 individuals. Including undersized males and immature females, the total North Pacific population is probably twice this number. About 15,000 (mostly males) are in the Bering Sea during the summer.

Sperm whales tend to segregate by size and sex, a social phenomenon that facilitates their selective exploitation by whalers. Females and juveniles of both sexes move together, forming schools of 10 to 50 individuals. Younger mature males (10-25 years old) form "bachelor" schools of 10 or fewer. Older males are usually solitary except when they join schools of females in the spring and early summer for breeding.

Females mature at age 8 to 11. Males reach sexual maturity at about 10 years of age, but do not actively breed until at least 25 years old. Females breed once every 3 to 5 years, have a gestation period of 14 to 15 months, and bear a single calf. Calves are weaned between age 1 and 2.

The sperm whale feeds mainly on large deepwater squid, octopus, and demersal and mesopelagic fish (Table 5.6). It can dive to over 1000 feet and remain submerged for up to an hour.

5.4.10 The Bering Sea Beaked Whale

The Bering Sea or Stejneger's beaked whale, Mesoplodon stejnegeri, is a rare and poorly known species endemic to the North Pacific. It ranges throughout the southern Bering Sea from the Commander Islands to the Pribilofs and Bristol Bay, apparently preferring coastal waters. It also occurs in the northern Gulf of Alaska. Its migrations are unknown.

These whales are known mainly from single stranded individuals, which suggests that they are usually solitary. Its prey is reported to be fish and squid. Otherwise, nothing is known of their biology.

5.4.11 Baird's Beaked Whale

Baird's Beaked or the great bottlenose whale (Berardius bairdii) is endemic to the North Pacific where it ranges from St. Matthew Island in the Bering Sea south to Japan and California. It is an uncommon, but not rare species; between 100-400 are taken annually by Japanese whalers. The total North Pacific population may number about 10,000 with 2,000 occurring in the Bering Sea in the summer, primarily in coastal waters.

These whales usually travel in tight pods of up to 30 individuals. Their migrations are poorly known. They calve in December, probably in waters south of the Bering Sea,

Baird's, like other beaked whales, feed on deep water fish and squid.

5.4.12 Cuvier's Beaked Whale

Cuvier's beaked or the goose-beaked whale (Ziphius cavirostris) is found in all oceans except the polar seas. In the North Pacific it has been reported as far north as the Commander Islands and the Aleutians. The status and migratory patterns of the species are unknown. It may occur rarely in the central Bering Sea, probably only in summer. The population size is small, probably on the order of 500 individuals. The goose-beaked whale feeds on fish and squid.

5.4.13 Beluga Whale

The beluga (belukha) or white whale, Delphinapterus leucas is primarily an inhabitant of coastal waters of Alaska. There are resident stocks in Cook Inlet, Bristol Bay, and Kotzebue Sound. Small numbers are also commonly seen in the Kuskokwim and Yukon Deltas and in Norton Sound during the summer. The major population of animals however, is highly migratory, and moves regularly from wintering areas in the central and eastern Bering Sea north through the Chukchi Sea to summer at least as far north as the Canadian Beaufort Sea. Arctic Ocean belugas are summer residents which move to ice free portions of the Bering Sea or to leads and polynyas in the pack ice in winter. Belugas move with the drifting ice or through leads in pack ice, and have been known to break ice with their backs to form breathing spaces, when necessary. The polynya that forms south of St. Lawrence Island is a regular overwintering area.

The pattern of beluga movements, other than the general north-south seasonal migration, appears to be complex, and certain areas are visited only irregularly by beluga herds. The animals can be highly migratory, and actual distributions may vary from year to year or even from week to week as ice conditions or food availability change.

The Bering Sea population is estimated to number at least 10,000 animals, with 1,000-2,000 in Bristol Bay, 200-300 between the Kuskokwim River and Norton Sound, and perhaps 8-15,000 in the main group that migrates between the Bering and Beaufort Seas. In addition, 300-500 animals inhabitat Cook Inlet year-round. These populations are considered to be relatively stable in size.

Belugas feed primarily on fish (capelin, pollock, cod, herring, flounder, and salmon), but also consume squid, and crustaceans (Table 5.6). They tend to concentrate at river mouths and estuaries and may even move far up river in the summer to feed on salmon, smelt and other abundant prey. Feeding dives are generally less than 40 feet but can exceed 100 feet, lasting 3 to 5 minutes at a time.

Belugas are gregarious and occur in groups of two or three up to hundreds. Assemblages of 100 or more belugas can be found in areas of abundant food, usually in shallow waters near the coast or delta areas near the mouths of silt-laden rivers.

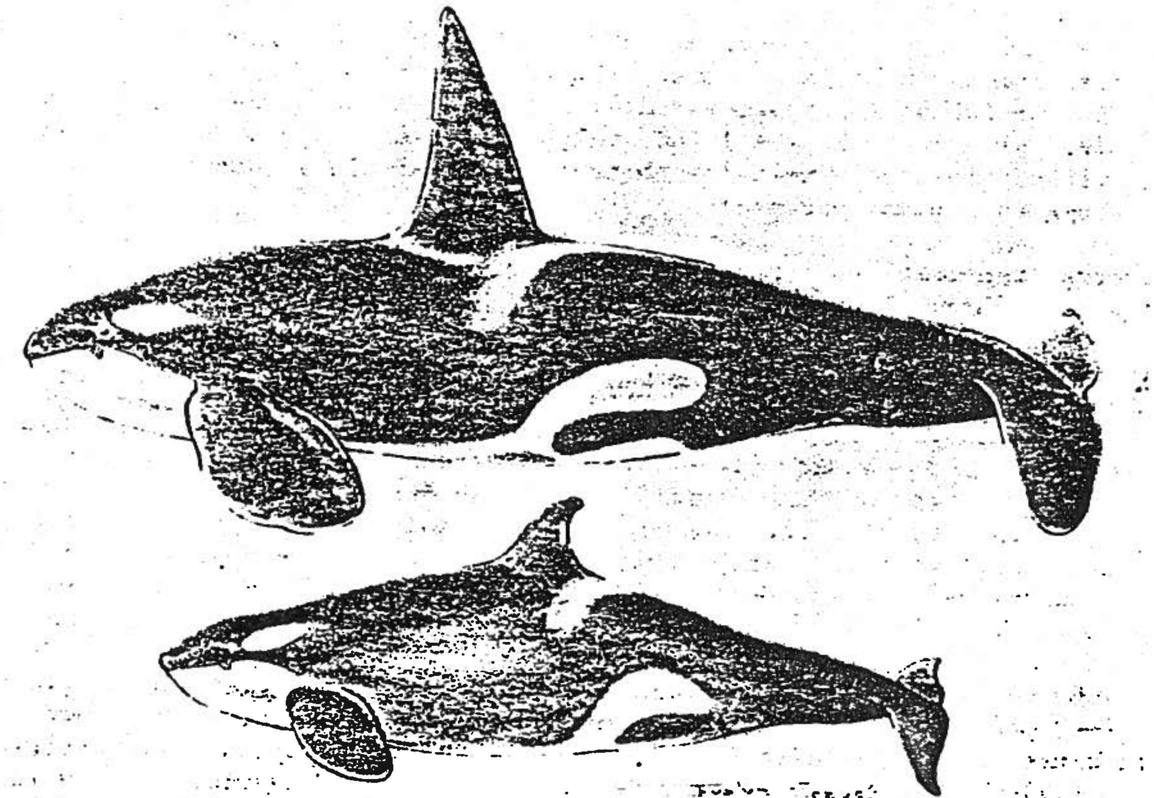
Belugas are polygamous and breed in the spring. Calves are born in shallow, brackish lagoons between May and July, and are nursed for about 20 months.

The female reproductive cycle appears to be every 2 or 3 years, and the gestation period is 14-15 months. Females reach maturity at about 5 years, and males mature a year later. Production in belugas has been estimated at 14% of the population per year.

Adults range in length from 11 to 16 feet and weigh over 3,000 pounds. The whales are taken in native subsistence hunting by Alaska coastal villages from Bristol Bay to Kaktovik. The harvest is relatively small (150-300 annually) and does not appear to be harming the population. The meat, skin, and blubber are utilized both for human and dog food, and the oil is used for cooking and for fuel.

The beluga is taken incidentally to the bowhead by whaling crews of Kivalina, Point Hope, and Wainwright but is seldom sighted or taken at Barrow. The Eskimos at Point Hope are not too interested in taking beluga during the bowhead whaling season because they sink quickly and require considerable effort to recover. Rifles are normally used to kill these animals, and they can be butchered in a few minutes when caught. Crew members at times eat some of the meat at the whaling camp, but usually take their shares directly home. Point Hope crews killed and recovered 6 beluga in 1974 and 13 in 1975.

5.4.14 The Killer Whale



Killer whales--Orcinus orca, male and female.

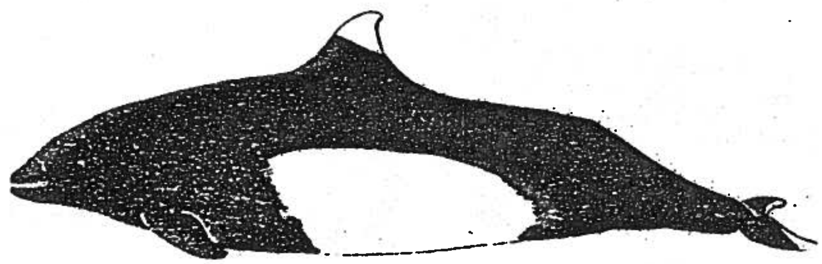
The killer whale, Orcinus orca, is worldwide in distribution and occurs commonly in all Alaska waters, particularly in coastal areas. Migratory habits are variable, and appear to depend on food supply. They are usually found in groups of 10 to 100 or more.

Killer whales range throughout the central Bering Sea during all seasons, but they are more abundant in the summer. Calving occurs in autumn, and may occur in this region.

Estimates of the size of the killer whale population, worldwide or in Alaska, are uncertain. The North Pacific population may be 3,000 or more, ranging from California to the Bering Strait. At least 800 are estimated to be year round in the Bering Sea and about 300 in the Gulf of Alaska. There is a small commercial take in the North Pacific by the Soviets and the Japanese, less than 50 per year.

Killer whales feed primarily on larger fish (salmon, pollock, rockfish) and squid, but also prey on seals, whales, and other dolphins (Table 5.6).

5.4.15 The Dall Porpoise



The Dall porpoise, Phocoenoides dalli , inhabits the cooler waters of the North Pacific. In Alaska, it ranges throughout the Gulf of Alaska and Bering Sea, where it is the most abundant porpoise. It occurs in the central Bering Sea mainly in the summer when water temperatures exceed 36° F. Calving occurs in the spring and summer and may take place in the Navarin Basin area.

Dall porpoises eat squid and fish (Table 5.6). The Japanese harvest between 4,500 - 7,500 annually in their coastal waters, with a reported decline in numbers in recent years. The Japanese high-seas gillnet fishery for salmon in the North Pacific and Bering Sea is destructive to the species, with accidental kills reported as high as 20,000 annually. This accidental mortality has probably decreased in recent years as the fishing has been curtailed.

The NMFS is actively involved in intensive research on the Dall porpoise in a cooperative effort with the Japanese. This work should lead to much better understanding of the biology and status of this species.

5.4.16 Harbor Porpoise

The harbor porpoise, Phocoena phocoena, is worldwide in distribution. The North Pacific population may number about 20,000 of which about 5,000 live year round in the Bering Sea. It occurs in Alaskan waters as far north as Point Barrow during the summer. It is primarily a coastal species frequenting inshore waters, the mouths of large rivers, harbors, and bays, and it is not expected to occur in the central Bering Sea far from land.

Harbor porpoises feed primarily on bottom fishes such as pollock, cod, flounder, also capelin and herring fry, and occasionally on invertebrates such as squid, clams, and crustaceans.

5.5 Predation by Marine Mammals on Marine Resources in the Eastern Bering Sea and in the Aleutian Region

The consumption of fish and other marine biota by marine mammals in the eastern Bering Sea and in the Aleutian region is summarized in Tables 5.10 and 5.11, which is taken from Laevastu et al., 1980. These estimates are believed to be about 12% greater than the probable consumption values due to: a) overestimation of the food requirements and growth rates of mammals using aquarium studies data; b) partial starvation or fasting of marine mammals in nature. Nevertheless, these calculations can be used to provide a relative comparison of the magnitude of natural predation vs commercial fishing exploitation of natural resources.

The total consumption of finfish by marine mammals on the central Bering Sea shelf is estimated by Laevastu et al. (1980), at about 0.5 million mt annually, of which about three-fourths are commercial species, including 200,000 mt of pollock. This consumption of fish by marine mammals is about equal to the present catch by domestic and foreign fisheries. The estimated consumption of crab and shrimp is 62,000 mt, of benthos 780,000 mt, of zooplankton 470,000 mt.

The greatest fish consumers are found to be the ice seals, followed by the fur seals and sea lions, and then the whales. Dolphins and porpoises consume a relatively small proportion of the resources. The effect of marine mammal predation on fishery resources as theoretically demonstrated, is lacking in empirical proof. The converse effect, i.e. the effect of fishing (competition

Table 5.10 - Consumption by marine mammals in the Bering Sea (In 1,000 tonnes.)

Species/groups of species consumed	1 Baleen Whales Bering Sea	2 "Sperm Whales" Bering Sea	3 Toothed Whales Bering Sea	4 Dolphins, porpoises Bering Sea	5 Other Seals Bering Sea	6 "Ice Seals" Bering Sea
Flatfishes	-	2.3	21.9	0.3	13.6	61.2
Cod and sablefish	19.0	2.2	21.3	1.1	15.3	114.9
Pollock	129.6	100.8	98.2	2.8	218.0	182.1
Herring	47.3	19.8	16.5	0.9	35.2	12.0
Salmon	-	3.3	10.3	0.4	15.3	5.5
Atka mackerel	16.5	38.8	2.7	0.5	32.5	-
Rockfish	15.2	24.4	9.5	0.5	22.3	-
Total commercial spp.	227.6	191.6	180.5	6.5	352.2	375.6
Other fish	75.0	25.8	58.9	1.7	107.4	169.9
Total finfish	302.6	217.4	239.3	8.2	459.6	545.5
Squids	109.5	1,209.2	8.3	2.2	39.7	-
Crab and shrimp	121.7	-	-	0.1	1.1	44.0
Benthos*	538.7	19.7	0.4	0.4	3.2	1,448.5
Zooplankton**	1,829.8	142.4	2.6	-	-	38.5

* Includes epifauna and infauna
** Copepods and euphausids

Table 5.11 Consumption of fish and other marine biota by mammals in the central Bering Sea (in 1,000 tons)

	CONSUMPTION		
	Central Bering Sea		
Species/groups of species consumed	Shelf	Slope & Ocean	Bering Sea Total
Flatfish	37.0	9.0	99.4
Cod and sablefish	57.4	41.5	173.7
Pollock	205.4	271.1	731.5
Herring	38.5	44.6	131.7
Salmon	10.3	13.2	34.8
Atka mackerel	19.8	48.3	91.1
Rockfish	15.6	36.7	71.9
Total commercial spp.	384.0	464.4	1,334.0
Other fish	152.2	96.3	438.7
Total finfish	536.2	560.7	1,772.7
Squids	95.4	1,151.2	1,368.8
Crab and shrimp	62.4	20.7	166.8
Benthos	778.8	86.8	2,011.0
Zooplankton	474.3	868.8	2,013.3

of fishermen with marine mammals for a common resource) on marine mammals could not be demonstrated, either theoretically or empirically because neither the causes of fluctuations in marine mammal abundance, nor the magnitude and periods of "natural fluctuations" of different fishery resources are known.

The "offshore" baleen whales feed on the same trophic level as most pelagic fish and consume the offshore zooplankton as a food resource, competing possibly with salmon, herring, and pollock in this regime. Gray whales and bowhead whales compete directly with many of the commercial fish on the continental shelf where they consume epibenthos.

Among pinnipeds, only walrus and bearded seals use considerable amounts of benthos as food. Because they consume larger benthic organisms which are unutilized by fish because of their size, the competition for the benthic food resource between demersal fish and these mammals is minimal. On the other hand, toothed whales and most pinnipeds feed directly on fish and, therefore, compete directly with man. Because mammals often feed on juvenile fish, their predation can affect both the size distribution of the fish and the size of the exploitable biomass of the fish.

Marine mammal populations and the fishery resources of the Bering Sea predate human exploitation. There is currently some competition for the same resources. However, the effects of commercial fishing on the food of marine mammals cannot be determined at present. There is no evidence to demonstrate that the fishery in the Bering Sea has adversely affected marine mammals by altering finfish biomass; in fact, there is good evidence that pollock, cod, herring, and yellowfin sole biomasses have actually increased during these years. The rejuvenation of biomass, which is a consequence of fishing, might instead be working in favor of marine mammals who feed predominantly on smaller fish than taken by the fishery. Although there have been significant fluctuations of the biomasses of some commercial fish species, there is no proof that the total finfish biomass has decreased. There is evidence, from several areas (e.g. North Sea) that fishing does not affect total finfish biomass, because when one species declines in abundance other species might increase. It is thus not possible to assume that marine mammals are under population pressure from the commercial fishing industry in the Bering Sea.

6. POTENTIAL CONFLICTS WITH LIVING RESOURCES

As stated in the preceeding sections of this report, the proposed Navarin Basin lease area is an important fish and marine mammal habitat. The present major use by man is commercial fishing. With the establishment of oil and gas related activities in this area there is considerable likelihood that resource use conflicts will develop between the petroleum industry and the commercial fishing industry. There is also the risk of damage to the marine environment from oil spills and other impacts that would harm the valuable commercial fish and the abundant marine mammal populations that inhabit the area.

International conflicts are possible if foreign fishing in the area within the 200-mile limit is adversely impacted. Determining liability for damage caused to foreign fishing by oil industry activity, may result in conflicts involving the U.S. government under international agreements between it and foreign nations whose fishing activity is affected.

The following section outlines the potential conflicts that the National Marine Fisheries Service views as representing significant concerns regarding the possible oil and gas development of the Navarin Basin area. For more detailed discussion, especially regarding lethal and sublethal effects of petroleum hydrocarbons on marine organisms, the reader is referred to Malins (1977), Higgins (1978), AIBS (1978), and NMFS (1979).

6.1 Impacts to Commercial Fishing

There are several potential impacts from petroleum development that could affect the commercial fishery without measurably affecting the resource it-self. These are discussed briefly below:

6.1.1 Loss of Fishing Grounds

The placing of offshore drilling rigs and platforms, and offshore loading terminals could cause a loss of traditional fishing space for the life of the field (up to 25 years). The extent of this loss will depend on the number and locations of these obstructions, the size of the safety zone required, the type of mooring system or foundation of the facility, etc. The prediction of only four platforms for this lease area (DOI, 1980) is questionable based on the estimated size of the resource (760 million barrels of oil), and the fact that in the North Sea there are over 78 operating platforms. In the North Sea, an estimated 0.79 sq km of fishing grounds have been preempted by each platform (University of Aberdeen, 1978).

Loss of fishing space can also result from the establishment of shipping lanes or pipeline corridors and the restriction of certain types of fishing operations in these areas.

6.1.2 Damage to Fishing Gear

Conflicts with commercial fishing in the Navarin Basin will undoubtedly arise from damage to fishing gear by seafloor completions, unburied pipelines, exposed well heads, mooring chains and anchors, or abandoned equipment and large debris left on the seabed. The major fisheries of the Navarin area use large bottom trawls or long strings of pots that can either sustain damage from or cause damage to oil industry equipment. A large amount of gear loss has occurred in the North Sea from pipelines and debris.

Vessel traffic, whether seismic exploration, exploratory drilling rigs, barges and other platform support vessels, or crude oil tankers to or from offshore loading terminals will undoubtedly damage fishing gear (crab pots, set lines, etc). Visibility is limited by fog, rain, and sea conditions which will hinder the avoidance of fishing gear sets by vessel traffic.

In the event of a major oil spill, fishing gear could become coated with oil and damaged or ruined. Oil would not only foul crab pots, long lines, purse seines, trawls, and gill nets, but might also make fishermen unwilling to recover their gear for fear of contaminating more of it. Moreover, fishermen might be unable or unwilling to fish until an oil slick had disappeared. Such resource-use conflicts would result in economic losses to the fishermen.

6.1.3 Navigational Hazards

Oil and gas activity would undoubtedly increase ship traffic in the Navarin Basin area, causing added navigational hazards to the fishery fleet. Maneuverability of large stern trawlers with trawls out is limited; crude oil tankers and the additional traffic increases the likelihood of vessel collisions, with risks to human safety and of oil spills.

6.1.4 Competition for Port Facilities

Unalaska is identified by DOI as the support base to supply the petroleum industry operations in the Navarin Basin, as well as those in the St. George and North Aleutian Shelf lease areas. The port (Dutch Harbor) is also currently the nations leading port in value of fishing landings, receiving 137 million pounds of fish and shellfish valued at $92,700,000 in 1979. Competition for dock space, warehouses and supply yards, and living accommodations and services between the fishing and petroleum industry may reduce their availability and increase their cost. The effect this will have on the fishing industry is uncertain.

6.1.5 Contamination of Catch

Oil fouling fishing gear would also foul the catch taken by the gear, and may require the catch to be abandoned. At-sea processors or crabbers that require sea water intake and circulation may encounter oil polluted waters that would contaminate the catch and render it unfit for sale for human consumption. This could be either by an unsavory flavor caused by oil contamination, or merely by purchasers', marketers', or consumers' attitudes towards the potential of the catch being contaminated by an oil spill. Even if still seemingly edible, some sea foods might not be safe to eat if contaminated with potentially carcinogenic oil fractions. Thus, the marketability and monetary return to the fishing and fish processing industries might be significantly reduced for some period of time. Because many species of marine organisms in the Navarin area are migratory and internationally important in many respects, their contamination by oil at sublethal and lethal levels could have important political, as well as environmental and economic impacts.

6.2 Impacts to the Resources

The living resources of the Navarin area could be significantly affected by uncontrolled routine or careless activities and accidental events associated with petroleum development. Some of the potential causes and consequenses of these impacts is outlined below:

6.2.1 Habitat Alteration or Destruction

The Navarin Basin is devoid of coastal areas that could be directly impacted by oil and gas development. St. Lawrence Island, St. Matthew Island, and Hall Island are the bodies of land closest to the proposed lease area. Should they be considered for on-shore facilities, further examination of the importance of their coastal areas as nearshore marine habitats for fish and their use by marine mammals and sea birds will be necessary. Oil spills could make their landfall there, but the probability of this happening is unknown.

If Aleutian ports such as Dutch Harbor are used for on-shore facilities or supply bases, the impact of the Navarin Basin leasing will have to be addressed as cumulative impact compounding on those of the St. George (Sale 70)and North Aleutian Shelf (Sale 75) sales.

Critical habitats may occur within the lease area. The marginal sea ice zone is a known critical habitat for ice seals (especially the ribbon seal). The exact size of this critical habitat needs better definition. Submarine canyons along the shelf edge may be critical for the successful overwintering and breeding of certain commercial fish species (e.g. Pacific ocean perch, pollock, Tanner crab).

The various detrimental biological impacts that could occur as a result of offshore and onshore petroleum activity include possible habitat alteration or destruction offshore due to platform placement, oil spills, disposal of drilling muds and cuttings, pipeline excavation, operation of ice breakers or ice-breaking super tankers, and onshore due to channel and harbor dredging and spoil disposal, road construction, construction and operation of dams for hydroelectric and water supply purposes, improper waste disposal, and gravel extraction and water withdrawal from streams. If such activities occur at times and in areas critical to the reproductive success of fish, crabs, and marine mammals, the species that depend on the habitat could be affected adversely.

6.2.2 Noise and Human Disturbance

Increased noise and human activity in the Navarin Basin could disturb marine mammals. Onshore facilities located near seal rookeries could, during the pupping period, significantly increase the incidence of pup deaths due to desertion. Rookeries that are continuously disturbed will be abandoned, thus effectively reducing the total area of favorable habitat. Beluga whales also appear to abandon favored estuaries that are subject to harrassment by small boats (Burns, 1976).

Ribbon seals are reported to be sensitive to disturbance also, and could abandon their haul-outs and pupping areas on ice-floes at the ice edge if subjected to noise and human activity. The behavior of whales, including overwintering bowheads as well as other seasonal migrants, is unknown and will require special attention to obviate any adverse effects.

6.3 Effects of Pollutants

The release of pollutants in Navarin Basin, either intentional or accidental, chronic and low-level or acute and major, will have some effect on the biota of the region. Whether this effect will be significant and measurable will depend on the magnitude, location, and timing of the release.

The probability of major oil spills in the Bering Sea will increase with the addition of the Navarin Basin to the other areas of the region experiencing petroleum activity, i.e. Norton Basin, St. George Basin, and the North Aleutian Shelf. Because of the environmental and ecological linkage of these proposed lease areas, the impacts of major oil spills cannot be separately considered by individual lease area. The entire eastern and central Bering

Sea, as well as adjacent waters north of the Bering Strait (i.e. Hope Basin and the Chukchi Sea) are under risk from oil spills. The extent to which these areas are shared by the same population of each marine species will need to be determined to assess the cumulative risk and impacts from oil and gas leasing over the entire region.

Laevastu and Favorite (1976) pointed out that minor perturbations propagate rapidly through a trophically controlled, unstable marine ecosystem such as that of the Bering Sea. Most ecosystems can tolerate some pollution and eventually recover after pollution occurs, the rate and extent of recovery being dependent on the magnitude of pollution, its constituents, and the elements in the ecosystem including seasonal species composition and life phases that are present. During recovery, however, a year class of commercially important species of fish or shellfish might be reduced in numbers, and any fishery dependent on it in the future could be affected. Chronic or recurrent, acute pollution however, might eliminate a species from an area entirely, and once eliminated, that species might not repopulate the area because of continuing pollution, or because its niche has been filled by a more tolerant, possibly less desirable, species (Evans and Rice 1974).

Our concerns with the effect of oil pollution on the marine environment have been discussed by Higgins (1978) and need not be repeated in detail here. In brief, they can be summarized as follows:

* Oil spill damage to shoreline and coastal habitats;

* Uptake and accumulation of hydrocarbons, food chain transfer, and tainting of commercially-important resources;

* Sublethal effects to reproduction, development, and survival from low level hydrocarbon concentrations;

* Lethal effects to adults, juveniles, and larvae of commercial species from exposure to oil spills;

* Oiling of marine mammals causing loss of insulation of fur-bearers, ingestion of oil or oil contaminated food, fouling of the baleen apparatus and blow-hole of whales, and blocking of ice leads with oil.

Most of the commercially important demersal and pelagic fish occurring in the Navarin Basin and discussed in the earlier sections have either pelagic eggs, pelagic larvae, or both (Table 6.1). An exception is the Pacific cod, which has demersal eggs and larvae. The eggs of crab and shrimp can be considered demersal in that they are attached to their bottom-dwelling parents. However, crab and shrimp larvae are pelagic. Herring eggs adhere to vegetation in shallow water, and are considered demersal, whereas the larvae of clams and scallops are pelagic. The eggs and larvae of marine snails remain benthic.

If a surface oil spill occurs coincident with the presence of pelagic fish and shellfish larvae, the year-class success of several species may be threatened.

Moreover, certain water-soluble fractions of oil could descend to deeper waters, thereby perhaps affecting demersal life, including egg, larval, juvenile, and adult forms, particularly those spawning.

In the event of petroleum exploration and development, this area's special biological significance and productivity demand that operations will be conducted with a high degree of environmental protection, and that the technology employed is capable of coping with the hazards of the environment. Unfortunately, it is difficult or impossible to predict the likelihood and extent of detrimental impacts based on existing imperfect knowledge, and the uncertainty of the level of petroleum activity in adjacent lease areas.

Leasing and petroleum development and production activities should be restricted, to the extent possible, to those areas, times and seasons that will be least likely to interfere with (a) maintenance of natural biological productivity and successful completion of normal migration patterns and reproductive cycles of marine fish, shellfish, and mammals.

Table 6.1 - Major fauna in the central Bering Sea which have pelagic (P) and/or demersal (D) stages during early life histories.

Fauna	Eggs	Larvae
Salmon	P*	P (Juveniles)
Herring	D	P
Pollock	P	P
Cod	D	D
Pacific ocean perch	D**	P
Sablefish	P	P
Yellowfin sole	P	P
Rock sole	D	P
Greenland halibut	P	P
Arrowtooth flounder	P	P
Pacific halibut	P	P
Alaska plaice	P	P
Flathead sole	P	P
King crab	D	P
Tanner crab	D	P
Shrimp	D	P
Snails	D	D

* In females migrating through Navarin Basin

** Larvae released directly (ovoviparous) in deep water

7. RECOMMENDATIONS

Considering the abundant living marine resources in Bering Sea, its high biological activity and productivity, the potential vulnerability of its habitats and organisms to petroleum development and oil pollution, the potential conflicts between its fisheries and petroleum developments, and the undeniable importance of the Bering Sea ecosystem to the continued production of protein for future generations, the nation's resource managers must carefully weigh the short-term necessity of developing potential petroleum reserves against the risk of harming long-term protein production based on renewable fishery resources in this area. To ensure that any petroleum development in the Navarin Basin and other Bering Sea lease areas are controlled by well-designed and strictly enforced regulations that will minimize environmental degradation, we recommend that additional research be undertaken to understand and evaluate the ways to best protect living marine resources for which NMFS bears responsibility. The following research needs are considered to be critical to the assessment and avoidance of significant adverse impacts:

1. Major emphasis should be placed on conducting additional research to further define critical habitats, including spawning and rearing times and areas and migration routes, of all marine mammals and commercially important species of fish and shellfish throughout the central and eastern Bering Sea. A problem-oriented approach to environmental research will be required to quantify the ecological value of various habitats and the magnitude of change that is likely to occur as a result of alteration of these habitats by various petroleum development and production activities.

2. Field research in other areas that addresses acute and chronic, the cumulative effects, both of oil pollution on marine life, including uptake through various food chains, should be emphasized and expanded to better understand the potential problems of oil pollution in the Bering Sea. In particular, studies on the effects of sublethal, chronic levels of oil should be emphasized.

3. The fate and effects of postulated oil spills should be determined through development and testing of transport models with valid field verification and completion of well-planned and executed field experiments to determine the fate of these spills.

4. Studies should be undertaken to determine the cumulative result of impacts to marine mammals from pollutants and behavioral disturbance.

5. Studies should be conducted to compare the long-term economic benefits of protecting renewable fishery resources with the short-term benefits of developing the nonrenewable oil and gas reserves in the Bering Sea.

6. And finally, because man has already severely stressed some commercial populations of fish and shellfish, we recommend that studies be accelerated and expanded that synthesize and integrate available data and seek to provide resource managers with information necessary to understand the possible consequences of various activities and the ramifications of various stresses on the entire Bering Sea ecosystem, including the probable recovery rate of its components following such stress.

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