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Opportunistic Feeding of the Northern Fur Seal, *Callorhinus ursinus*, in the Eastern North Pacific Ocean and Eastern Bering Sea

Hiroshi Kajimura

February 1984

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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742. Water structure at Ocean Weather Station V, northwestern Pacific Ocean, 1966-71. By D. M. Husby and G. R. Seckel. October 1980, 18 figs., 4 tables.

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ABSTRACT

The Pribilof Island population of northern fur seals, *Callorhinus ursinus*, feeds on a variety of prey throughout its subarctic range from California to the Bering Sea. A total of 53 species of fish and 10 species of squid has been identified from the stomachs of fur seals taken during 1958-74. Some fur seal prey species are commercially fished while others are not of commercial importance but are important forage food for many other predators including other marine mammals, seabirds, and fishes. The season and location are important considerations, as are the migratory characteristics of forage species, when studying the diet of fur seals in the eastern Pacific. Evidence suggests that fur seals are opportunistic feeders preying on the most available species throughout their range.

INTRODUCTION

The northern fur seal, *Callorhinus ursinus*, feeds on a variety of fishes and squids throughout its range in the eastern North Pacific Ocean and the eastern Bering Sea. Small schooling fishes are usually the principal forage species over the continental shelf region and oceanic squids are important seaward of the continental slope in deepwater areas. Fur seals are found from California to the Bering Sea in nearly all months of the year, with a few exceptions, and with peak abundance varying by time and area.

Evidence presented here suggests that fur seals are opportunistic feeders preying on the most available species throughout their range. The information used in reaching this conclusion was obtained primarily for the area off California and the eastern Bering Sea, focusing on the principal forage foods of fur seals as based on stomach content volume and the relative abundance of fishery resources available in the area. The principal forage species of fur seals for other areas between California and the Bering Sea will also be discussed, but in lesser detail.

Background

Following the purchase of Alaska by the United States in 1867, the most critical period for the survival of the northern fur seal, *Callorhinus ursinus*, occurred between 1879 and 1909 when no effective international conservation agreement existed. During this period, almost 1 million fur seals (mostly pregnant females) were taken at sea. Between 1889 and 1909 the number taken at sea was almost twice that taken on the Pribilof Islands (the northern fur seal breeding islands of St. Paul and St. George) in the eastern Bering Sea. Because of the unrestricted harvest of females at sea, the Pribilof Island fur seal population declined from about 2 million in 1880 to approximately 300,000 animals in 1909. In 1911 the United States, Japan, Russia, and Great Britain (for Canada) formed the Convention for the Preservation and Protection of Fur Seals which prohibited pelagic sealing. Since then under international management, the Pribilof Island fur seal population has recovered and now numbers about 1.3 million animals or nearly 80% of the world population of this species (Lander and Kajimura 1982). The food of the northern fur seal was first reported from seals collected in 1895 by Alexander (1896) as a part of the Jordan Commission investigations.

Present Treaty

The present Interim Convention on Conservation of North Pacific Fur Seals was signed February 1957 by Japan, Canada, the U.S.S.R., and the United States, and protects fur seals as did the Convention of 1911. The two broad objectives of the 1957 Convention are: 1) To achieve and sustain maximum productivity of the fur seal resource and 2) to determine the relationships between fur seals and other living marine resources. The terms of the present Convention during 1958-63 required each member country to conduct pelagic research and collect a minimum number, or "quota," of seals each year. At this time, when most of the seals were collected, it was necessary to find areas of seal concentration and to collect as many as possible to meet the quota required by the Convention. Effort was therefore directed toward collecting seals—thereby sacrificing the quality of systematic surveys to determine the density, distribution, or relative abundance of fur seals by time and area. The quota required by the Convention was modified after 1963. Initially, hunting was carried out in areas where seals were known to be seasonally abundant during the days of pelagic sealing and research voyages prior to 1958; marginal areas where seals were known to be scarce were generally neglected.

At present it is known that most fur seals found in the eastern North Pacific Ocean are from the Pribilof Islands (St. Paul, St. George, and Sea Lion Rock; Otter and Walrus Islands have no fur seal rookeries) in the eastern Bering Sea, which are the principal breeding grounds of the northern fur seal. Fur seals from the western Bering Sea (Commander

[1]Northwest and Alaska Fisheries Center National Marine Mammal Laboratory, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Islands), the western North Pacific (Kurile Islands), and the Okhotsk Sea (Robben Island) do not contribute significantly to this population. Two additional rookeries in the eastern North Pacific Ocean are off southern California on San Miguel Island and nearby Castle Rock near the southern limit of the fur seal's range. The San Miguel colony of fur seals was discovered in 1968 with about 100 fur seals (Castle Rock colony was discovered in 1972). By 1979 this San Miguel-Castle Rock colony had grown to more than 3,000 animals.

The U.S.S.R. manages rookeries on islands in the western North Pacific Ocean used by about 485,000 seals that return annually to breed on the Commander Islands (Medny and Bering Islands) in the western Bering Sea, Robben (Tyuleni) Island off Sakhalin Island in the Okhotsk Sea, and on a few of the Kurile Islands. Recoveries of tagged animals have shown that seals from the eastern and western breeding islands do intermix to some small extent at sea and on the breeding islands. Figure 1 shows the general ocean distribution and breeding islands of northern fur seals in the eastern and western North Pacific.

GENERAL DISTRIBUTION AT SEA

Northern fur seals occupy the subarctic waters of the North Pacific Ocean extending southward to the California-Mexican border (lat. 32°N) in the eastern Pacific and to about the middle of Honshu Island, Japan, (lat. 36°N) in the western Pacific. Very few fur seals have been sighted south of these latitudes. The 57,927 fur seal sightings shown in Figure 2 are from sighting data obtained primarily from pelagic fur seal cruises with supplemental data from other sources to provide a picture of fur seal distribution at sea. Sightings of seals in the western North Pacific Ocean area are primarily from the Japanese pelagic fur seal research cruises (1958-78), the National Marine Fisheries Service (NMFS) Dall's Porpoise Program (1978-80), and from salmon research cruises of U.S. vessels (1955-72). Sightings of seals in the eastern North Pacific Ocean area are primarily from Canadian and U.S. pelagic fur seal cruises (1958-74); other sightings are from NMFS programs which include the Platforms of Opportunity Program (POP), Outer Continental Shelf Environmental Assessment Program (OCSEAP), and Dall's Porpoise Program.

Some northern fur seals are found throughout their range in the eastern North Pacific Ocean in nearly all months of the year with periods of peak abundance varying by time and area. Many immature seals of both sexes remain at sea during the first year or two of life and do not return to their island of birth until ages 2 or 3 yr. Most fur seals spend about half the year at sea (November through May-June) and the remainder (July-October) on and around their home islands during the breeding season.

Fur seals are most frequently seen from about 70 to 130 km from land and usually in greatest numbers along the continental shelf and slope throughout their range primarily because of abundant food resources in this area. Most fur seals are still on or near the Pribilof Islands in October but by the end of November only about 30% or less of the population remains near the Pribilof Islands at a time when the first seals have completed their North Pacific (Gulf of Alaska) crossing and are beginning to appear off the coasts of southeastern Alaska, British Columbia, and Washington. During research cruises off California, Oregon, and Washington, the first seals were sighted on 5 December and on 25 and 27 November, respectively.

From January to March, fur seals are found along the continental shelf and slope, entering coastal waters in pursuit of prey, from the Gulf of Alaska south to California. Fur seals continue to increase in abundance during December and January off Washington and California. In February and March, seals are most abundant from California to Sitka, Alaska. The numbers of fur seals wintering off California reach a peak during late January through March and decrease as they begin their northward migration starting in late March. Most seals have left this area by early June.

In April fur seals are widely dispersed from Kodiak Island, Alaska, to California with the population reaching its peak in

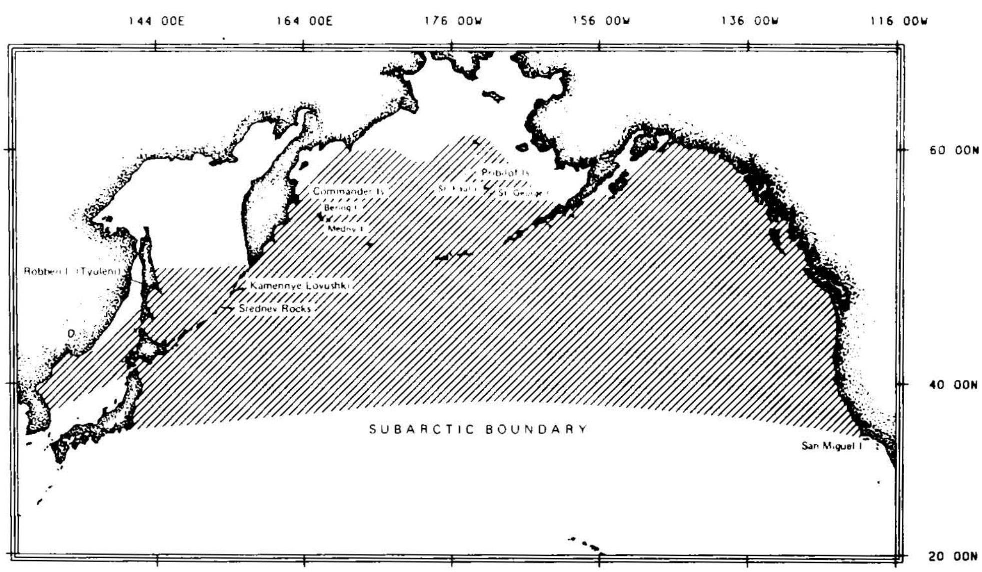

Figure 1.—The general ocean distribution and breeding islands of the northern fur seal (modified from: Fiscus, C. H. 1980. Range of the northern fur seal. Unpubl. rep., 7 p. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115).

the Gulf of Alaska during May. The northbound migration begins March-June, first in the southern limits of the range off California and proceeding past Washington in April and May, the Gulf of Alaska in May and June, and westward into the Bering Sea in June. In June, fur seals are scattered throughout the North Pacific Ocean. Fur seals are in the eastern Bering Sea and on or near the breeding islands of St. Paul, St. George, and Sea Lion Rock (Pribilof Islands) in greatest numbers during July, August, and September (most age groups of both sexes).

In the eastern North Pacific Ocean, any discussion of fur seal distribution at sea refers primarily to females because they represent about 90% of the pelagic catch (with some variation by time and area). Older females (age 5 yr and older) are generally more abundant off California than off Washington, while the younger seals are not fully represented (Append. Figs. A-1 to A-10). Females of all ages (and young males 1-4 yr old) are found in the Gulf of Alaska and the eastern North Pacific Ocean during winter and spring. Only the younger immature males (ages 1-5 yr) have been found south of Alaskan waters with a few exceptions. Nearly all of the older males winter in Alaskan waters—primarily in the Gulf of Alaska, north and south of the eastern Aleutian Islands, and probably in the Bering Sea. The catch of males diminished south of lat. 46°N (Washington-Oregon border) as shown by summaries of the monthly age and sex composition in Appendix Figures A-1 to A-10. Of 3,612 fur seals taken off California, only 2% or only 76 animals were males of ages 1-5 yr and only one seal was 5 yr old. The seals on which these percentages were based were taken prior to 1967, and the San Miguel Island males would at that time not have contributed to the offshore population. No attempt has been made to verify the distribution of older males because poor weather conditions during late autumn, winter, and early spring in the Gulf of Alaska and Bering Sea would severely curtail vessel operations and reduce sightings or catches.

Fur seals congregate in tight social groups on land but at sea they are often solitary. Solitary seals predominated in all areas (Appendix Table A-1). The frequency of solitary seals was highest in the Bering Sea (38-68%) where seals are more abundant during the breeding season. Off California, solitary seals represented 30 to 50% of the total sightings, whereas off Washington they comprised 30-64%. Larger groups of up to 20 seals have on occasion been sighted usually during spring migration but groups of this size are unusual. A few groups of seals numbering more than 20 have been seen off Washington and California when they were actively feeding on large schools of prey.

The subarctic water mass fluctuates seasonally—north in summer, south in winter. Seasonal and annual variations in temperature, salinity, dissolved oxygen, and water movement patterns occur on a worldwide basis. The role of such ocean currents and other oceanic factors in the distribution and migration of fur seals in the eastern North Pacific Ocean has yet to be examined systematically; however, some data are available. During our 1958-74 studies, the largest numbers of fur seals were collected where surface water temperatures ranged from 10° to 14°C off California, 7°-12°C off Washington, 5°-9°C in the Gulf of Alaska, and 8°-10°C in the Bering Sea (Kajimura 1980[1]). Upwelling of water from the depths is an important oceanic and coastal process which occurs when the surface layer is transported offshore (due to the stress of wind parallel to the coast on the sea surface) and is then replaced by nutrient-rich water from below. The western coast of North America is among the world's major upwelling regions. Here, upwelling probably influences productivity and concentration of primary producers and zooplankton. This in turn influences the distribution and recruitment of fish stocks which become available to the fur seal, and ultimately the distribution of seals because they winter and feed off the western coast of North America.

[1]Kajimura, H. 1980. Distribution and migration of northern fur seals (*Callorhinus ursinus*) in the eastern Pacific. *In* H. Kajimura, R. H. Lander, M. A. Perez, A. E. York, and M. A. Bigg. Further analysis of pelagic fur seal data collected by the United States and Canada during 1958-74, Part 1, p. 6-43. Unpubl. rep. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

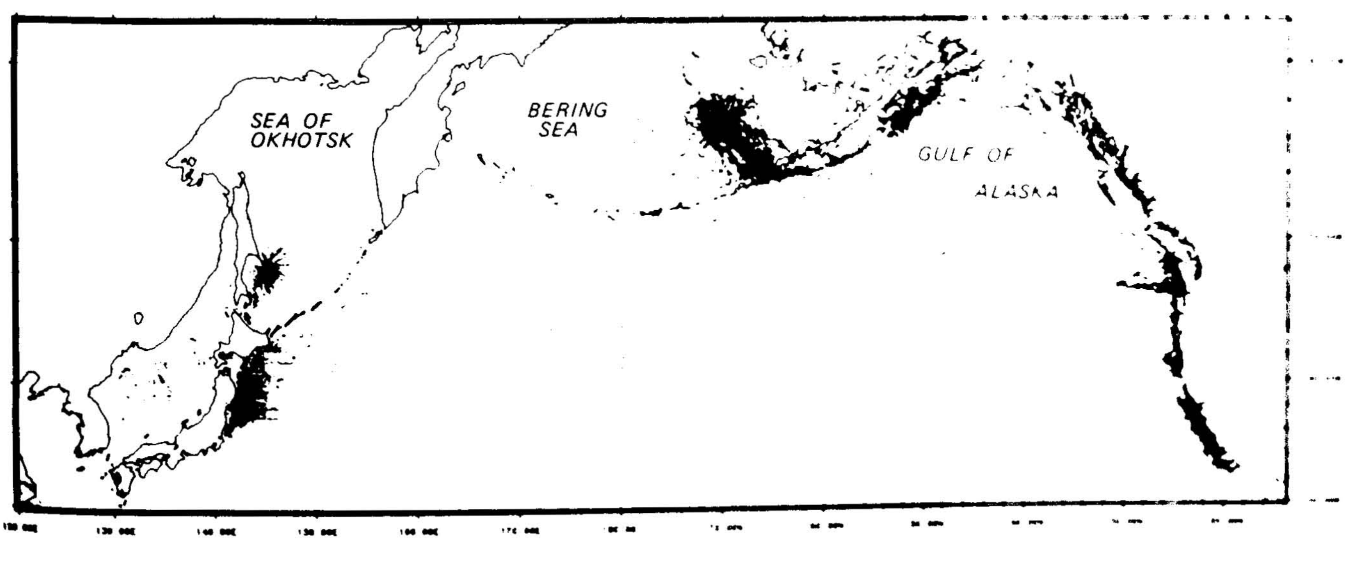

Figure 2.—Fur seal sightings in the North Pacific Ocean by Japan, Canada, and the United States, 1955-79

DATA COLLECTION

Field Procedure

Purse seine vessels (Append. Fig. A-11) were used by the United States for conducting pelagic research, with only a few exceptions. This type of vessel with the wheelhouse and flying bridge forward of amidship permitted greater visibility for sighting and following seals. The sizes of the chartered vessels were between 19.4 and 29.4 m (65-96 ft) registered length with a cruising speed of about 8 to 10 kn, with fuel, water, and food storage capability to stay at sea for at least 1 mo. The vessel complement normally consisted of eight men, including four crew, a captain, engineer, deckhand, and a cook with four wildlife biologists aboard. The vessel crew assisted the three to four scientists in all phases of research including sighting, tracking, shooting, and recovering seals. Fur seals were shot with 12-gauge shotguns using magnum loads of 00-buckshot. The scientists or biological crew collected the biological data and samples from each animal collected at sea.

Biological data collected from each seal included sex, length, weight, and any external irregularities which were recorded on field data cards (Append. Fig. A-12) before any biological specimens were removed from the animal. Both upper and lower jaws were cut off, and these sections boiled until the teeth could be easily removed. The four canines were labeled and tagged for final processing in the laboratory where age was determined.

Upon opening the abdominal cavity, if the seal was a female, the reproductive condition was determined by examining the uterine horns. The entire female genital tract was then removed as was the entire stomach and preserved in 10% Formalin for detailed examination in the laboratory.

Laboratory Procedure

The examination of female reproductive organs in the laboratory consisted of a thorough macroscopic examination of the uterine horns to verify field diagnosis. The ovaries were then sliced (1 mm thickness) and examined for Graafian follicles (size and ovulation) and the presence or absence of corpora albicantia or corpora lutea indicating past and present reproductive history. Age specific pregnancy rates are a major factor in assessing the overall health of the fur seal population (pups born) as an indication of its present status and in estimating future herd size for making management decisions.

The ages of all seals collected are determined by counting the annual growth layers in the dentine of the canine teeth which appear as alternate clear and opaque layers under transmitted light (high intensity lamps) and with the aid of magnifiers and dissecting microscopes. The ages of most young fur seals through age 6 yr can be determined with acceptable accuracy by counting the external growth increments on the upper canine; however, for older seals, the ages are determined by counting the internal annuli from longitudinal half sections of canine teeth.

All canine teeth of fur seals taken at sea were sectioned longitudinally (lengthwise), just off center, with a bandsaw. Lapidary equipment utilizing horizontal grinding wheels of various coarseness was used to grind the rough surface as close to midline as possible. The plane of cut and the degree to which the tooth is ground to the midpoint is critical in obtaining readable annual growth lines. For those teeth that do not show annual growth layers clearly, a technique reported by Pierce and Kajimura (1980) on acid etching and highlighting for defining growth layers will be of use in age determination.

The stomach was cut open by slicing the entire length of the stomach lining, cutting with care so food organisms would not be damaged. When the stomach contained whole fish or squids, the contents were placed directly into a weighing pan. If the contents were largely liquid they were placed in a sieve to drain. The contents were then transferred into the weighing pan. The stomach lining was rinsed to obtain all food particles, as otoliths and squid beaks often adhered to the stomach wall. Excess fluid was drained from the weighing pan prior to each weighing. Large stomachs required two or more weighings as did the volumetric measurements.

Stomach contents weighing < 10 g (or digested fish, squid remains, otoliths, squid beaks and pens, or vertebrae fragments) were recorded as "trace" amounts unless a whole specimen or fleshy parts were present. For contents with a weight of 100 g or less, the volume was not measured but was assigned a value as though the contents had the same density as water (e.g., if weight equals 55 g, the volume equals 55 cm^3). Weight and volume < 100 g were checked early in the program and found not to vary significantly. Nonfood items such as rocks, pebbles, shells, etc. were not entered on food data sheets as part of the total weight and volume. Stomach content volumes (cc) were obtained by the water displacement method in large graduated beakers capable of holding 2,000 cc.

A number was assigned to each specimen and recorded on a food card (Append. Fig. A-13). When the stomach was opened, weight and volume of contents were entered on this card and the contents identified. When two or more species could not be easily separated, the examiner estimated their proportionate volume to the nearest 5%. The weight and volume of each individual species were calculated by multiplying estimated percentage times total weight and volume. Specimens were identified by comparing them with known preserved whole specimens or known skeletal material in the laboratory collection and by using various cephalopod and fish identification keys. A direct count of complete specimens, squid beaks (dorsal and ventral), and fish skeletal remains such as total skulls, otoliths, or numbers of vertebrae approximating a complete fish skeleton was used to estimate the numbers of squid and fish in the stomach. Length and weight measurements of prey were taken whenever possible (measurement examples: snout to fork of tail; length of all vertebrae of fish, snout to hypural plate, and dorsal mantle length of squid).

FUR SEAL FEEDING AT SEA

Although fur seals are usually solitary at sea, they tend to congregate loosely in areas of abundant food supply and are most frequently seen from about 70 to 130 km from land and near the continental shelf and slope. Fur seal densities are often greatest near sea valleys, submarine canyons, seamounts, and along the continental shelf and slope where abrupt changes occur in depths and upwellings of nutrient-rich water, which influence productivity and concentrate primary producers and zooplankton. This, in turn, gives rise to the attraction, distribution, and recruitment of fishery resources which then become food for fur seals and other predators in the marine environment.

Fur seals feed primarily at night, perhaps influenced by the ct that many forage species rise toward the surface after dark d become readily available to fur seals and other predators ich feed primarily in the epipelagic and mesopelagic zones. e diel vertical migration of cephalopods was confirmed by dies conducted by Roper and Young (1975) and Pearcy et (1977). This vertical migration of squids makes them acces- le to fur seals foraging in the epipelagic and mesopelagic nes and the waters over the continental shelf. Oceanic squids e some of the principal forage foods of fur seals throughout eir entire range in the eastern North Pacific Ocean and east- Bering Sea. Bathylagids, deepsea smelts, also become ailable to fur seals because of their vertical migration wards the surface at night. Anchovies also display diel verti- l movements, rising to the surface at night and dispersing as wn approaches when they school tightly and return to eper depths. On occasion, anchovies form large dense sur- ce schools during daylight hours.

Fur seals seeking food are not limited to prey that are found ar the surface as depth-time recorders placed on fur seals in e wild recorded depths of dives to 208 m (624 ft) which lasted r 5.4 min.[3]

In the majority of fur seal stomachs examined, the quantity tal volume) of food in stomachs is generally highest in fur als collected soon after daylight. It gradually diminishes by id-afternoon and increases again towards dusk as the seals crease their feeding activities. The graph shown in Figure 3 is tained when the fraction of fur seal stomachs containing od is plotted against time (hour) of collection.

Fur seals usually swallow small prey whole below the surface d bring larger prey to the surface where they break them into smaller pieces before consuming. Fur seals are not necessarily limited to eating small fish. During pelagic sampling one large fish (a 160 cm long king-of-the-salmon, *Trachipterus altivelis*) was taken away from a fur seal as it was in the process of eating it (Niggol et al. 1959[4]).

The predominance of single food items in the stomachs of fur seals may reflect the availability and abundance of fish-squid species more than it reflects the selection or preference of one particular species over another. Location is important when considering diet of fur seals as prey species generally differ in abundance from area to area (north-south; inshore-offshore) and by season of the year. The migratory patterns of forage species must be considered since they may be available to fur seals only at certain times of the year. For example, Pacific (hake) whiting, *Merluccius productus*, does not become one of the important or leading forage species off the Washington coast until spring when it migrates into the area and then becomes available to fur seals.

Generally speaking the migration of fur seals is probably not influenced by the movement of migratory fishes on which they feed but is simply dependent on the collective abundance of the forage species in the area, the fur seals waiting to feed where food is abundant and "moving on" when it becomes scarce. Exceptions do occur as fur seals were reported abundant in the West Crawfish Inlet in 1950 and 1951 when Tlingit sealers took 148 seals feeding on spawning herring (Kenyon and Wilke 1953). In 1958, fur seals were found in Silver Bay but not in West Crawfish Inlet. The movement of fur seals into restricted bays in pursuit of prey usually involves only a small portion of the population. Most fur seals occupy the open ocean and are usually not found close to land or in protected waters. Notable exceptions are yearlings which may be found in southeast Alaska or British Columbia protected waters. If the animal is injured or is sick, it may appear and haul out some distance from its usual habitat.

Pike et al. (1961[5]) reported that yearling seals are known to appear in the vicinity of Knight Inlet, B.C., beginning in December and January and remain until March and April feeding on spawning populations of eulachon, *Thaleichthys pacificus*. Experience concerning seals "moving on" in response to food abundance or due to changes in oceanographic conditions as related to this study occurred off the Washington coast during the April and May spring collections of 1970 and 1972. Fur seals were generally abundant on the continental shelf area off the Washington coast during April of both years. However, during May of both years, seals were nowhere to be found on the continental shelf which necessitated surveying offshore waters (beyond the continental shelf over deepwater areas). Seals were located seaward of the shelf feeding on oceanic squids. Oceanic squids thus became the principal food consumed by fur seals off Washington during

[3]R.L. Gentry, National Marine Mammal Laboratory, Northwest and Alaska heries Center, NMFS, NOAA, 7600 Sand Point Way NE., Seattle, WA 98115, rs. commun. March 1982.

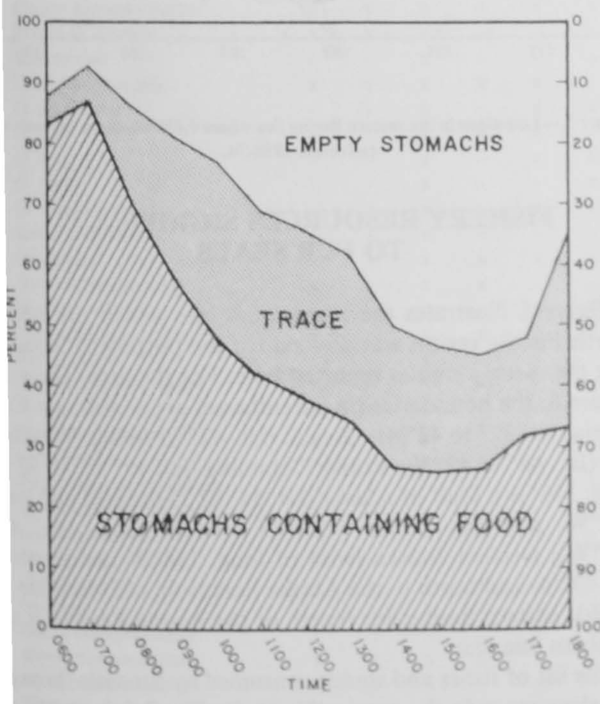

Figure 3.—General trends in the percentage of stomachs containing food in relation to time of collection.

[4]Niggol, K., C. H. Fiscus, and F. Wilke. 1959. Pelagic fur seal investigations California, Oregon, and Washington, 1959. Unpubl. rep., 92 p. U.S. Fish Wildl. Serv., Mar. Mammal Res., Seattle, Wash. (Avail. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.)

[5]Pike, G. C., D. J. Spalding, I. B. MacAskie, and A. Craig. 1961. Report on Canadian pelagic fur seal research in 1961. Unpubl. manuscr., 35 p. Fish. Res. Board Can., Biol. Stn., Nanaimo, B.C. (Avail. Pac. Biol. Stn., Dep. Fish. Oceans, P.O. Box 100, Nanaimo, B.C. V9R 5K6 Can.)

1970 and 1972 (Marine Mammal Biological Laboratory 1971[6]; Fiscus et al. 1973[7]). This information does not show in pooled data (combined years) because these data are generally concealed by the more abundant (dominant) species over the combined years of collection.

Because of such circumstances, the locality and time of collection dictate to a great degree the occurrence of certain prey species in the stomachs of fur seals. Consequently knowledge of the oceanographic conditions in the collection area, as related to time and seasonal movements of prey, is needed as an aid in understanding the feeding habits of fur seals. The dominant food of fur seals collected seaward of the continental shelf over deep water is usually oceanic squids (squids and deepsea smelt in the Bering Sea) while nearshore collections made over the shelf indicate fish as the primary food—the exception being the neritic market squid, *Loligo opalescens*, which is usually found over the continental shelf and in coastal waters and seldom over deep water. Some principal prey species that are important during yearly collections are not evid
when samples are combined over many years of collectio

Caution must be exercised in examining data on stoma
contents of fur seals during the early years of pelagic resear
(1958-63). During these years an annual and relatively hi
quota for the collection of fur seals was in effect which mo
or less dictated intensive sampling in areas where seals conce
trated. As a result, when concentrations of seals were encou
tered, as many animals as possible were collected to achie
annual research quotas. Examination of stomach conte
usually revealed that seals from one locality were feeding
the same prey. Collections of large numbers of seals from o
area may thus bias the importance of a particular prey speci
in that area (i.e., off California) for the season. It must
recognized that the time spent collecting samples in one loca
ity precluded collecting seals on predetermined random tra
sects to obtain representative samples. The locations of f
seals collected off California and in the eastern Bering Sea a
shown in Figures 4 and 5.

[6]Marine Mammal Biological Laboratory. 1971. Fur seal investigations, 1970. Unpubl. manuscr., 155 p. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[7]Fiscus, C. H., H. Kajimura, and A. A. Wolman. 1973. Part II. Pelagic fur seal investigations, 1972. *In* Marine Mammal Division, Fur seal investigations, 1972, p. 29-47, 67-91. Unpubl. rep. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Northwest Fish. Cent., Seattle, Wash. (Avail. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle. WA 98115.)

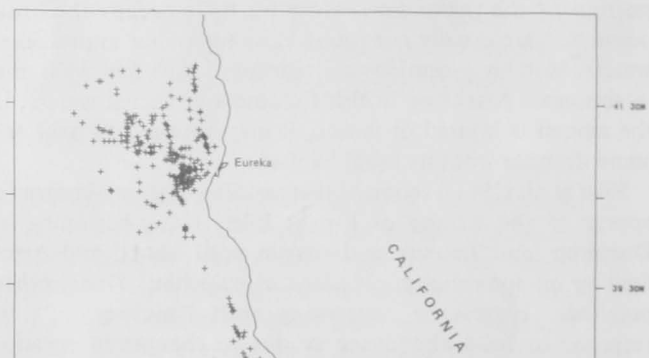

Figure 4.—Locations off California where 3,613 northern fur seals were collected, 1958-66.

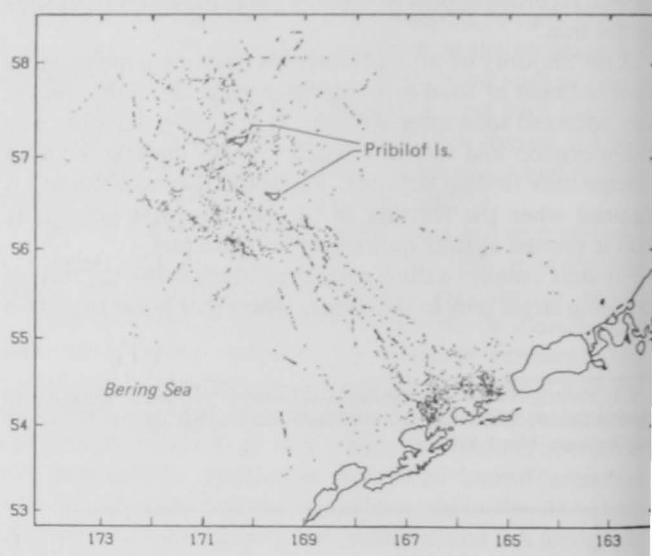

Figure 5.—Locations in the eastern Bering Sea where 4,659 northern fur seals we collected, 1958-74.

FISHERY RESOURCES SIGNIFICANT TO FUR SEALS

Figure 6 illustrates the seven areas into which the easte
North Pacific region was divided for the purpose of condu
ting the dietary studies reported here. For the areas shown
Figure 6, the boundaries (in parentheses) are as follows: Ca
fornia (lat. 32° to 42°N); Oregon (lat. 42° to 46°N); Washin
ton (lat. 46° to 49°N); British Columbia (lat. 49° to 54°30'
long. 146°W); Gulf of Alaska (lat. 54°30'N to coast and lon
158°W, and lat. 49° to 54°30'N between long. 146° an
158°W); western Alaska (west of long. 158°W and north
lat. 49°N, and north to the Alaska Peninsula and Aleutian I
lands); eastern Bering Sea (north of the Alaska Peninsula an
Aleutian Islands).

The list of fishes and squids consumed by fur seals throug
out their range in the eastern North Pacific Ocean and in th
eastern Bering Sea is shown in Tables 1 and 2. The princip
prey species of fur seals in each of these areas as based o

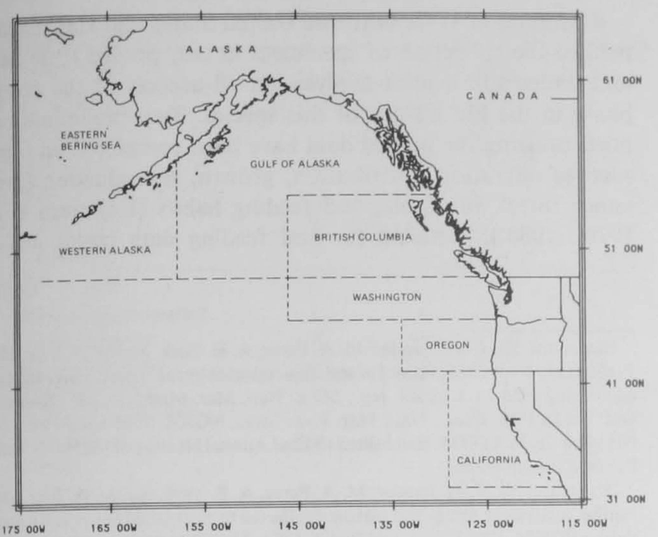

Figure 6.—The seven collection areas of northern fur seals, 1958-74.

stomach content volume generally does not change even though the ranking by volume within this list may change for each area (Table 3). The four principal prey species consumed, based on percentage of total stomach content volume by month for California, Oregon, Washington, British Columbia, Gulf of Alaska, western Alaska, and the eastern Bering Sea are shown in Tables 4 to 10.

The leading four prey species consumed by fur seals during each of the collection years off California (1958-59, 1961, 1964-66) contributed 82 to 99% of the total stomach content volume during these years (Fig. 7). Similarly for the Bering Sea, the principal prey species contributed 75 to 99% of the total stomach content volume from collections made in 1960, 1962-64, 1968, 1973-74 (Fig. 8). In the other areas the principal forage species contributed 64 to 99% of the total food volume off Washington (Fig. 9); 66 to 95% off British Columbia (Fig. 10); 89 to 99% in the Gulf of Alaska (Fig. 11); and 77 to 99% off western Alaska (Fig. 12).

Six prey species formed the major food of fur seals off California during the collection period and, as shown in the fol-

Table 1.—Fishes eaten by fur seals in the eastern North Pacific Ocean and eastern Bering Sea, 1958-74, by area.

	Location						
Food items	California	Oregon	Washington	British Columbia	Gulf of Alaska	Western Alaska	Bering Sea
Entosphenus tridentatus	x	x	x	x	x	x	x
Squalis acanthias	x	-	-	-	-	-	-
Hydrolagus colliei	-	-	x	x	-	-	-
Clupeidae	x	-	x	x	x	-	-
Alosa sapidissima	x	x	x	-	-	-	-
Clupea harengus pallasi	x	x	x	x	x	x	x
Engraulis mordax	x	x	x	-	-	-	-
Salmonidae	-	-	x	-	-	x	x
Oncorhynchus spp.	x	x	x	x	x	x	x
O. gorbuscha	-	-	x	-	x	x	x
O. keta	-	-	x	x	x	x	x
O. kisutch	-	-	x	-	x	x	-
O. nerka	-	-	x	-	-	x	x
O. tshawytscha	-	-	x	-	x	x	-
Salmo gairdneri	-	-	x	-	-	-	-
Osmeridae	-	-	x	x	x	x	x
Hypomesus pretiosus	x	-	x	x	-	-	-
Mallotus villosus	-	-	x	-	x	x	x
Thaleichthys pacificus	x	-	x	x	x	-	x
Bathylagidae	-	-	x	-	-	-	x
Tactostoma macropus	x	-	-	-	-	-	-
Scopelosaurus sp.	-	x	-	-	-	-	-
Paralepis atlantica	x	-	x	-	-	-	-
Myctophidae	x	x	x	-	x	-	x
Tarletonbeania crenularis	x	x	x	-	-	-	-
Symbolophorus californiensis	x	-	-	-	-	-	-
Lampanyctus sp.	-	-	-	-	-	-	x
Anotopterus pharao	-	-	-	-	x	-	-
Cololabis saira	x	x	x	x	x	-	-
Gadidae	-	-	x	x	x	x	x
Gadus macrocephalus	-	-	-	x	x	x	x
Merluccius productus	x	x	x	x	-	-	-
Microgradus proximus	-	-	x	-	x	-	-
Theragra chalcogramma	-	-	x	x	x	x	x
Gasterosteus aculeatus	-	-	x	x	x	-	-

	Location						
Food items	California	Oregon	Washington	British Columbia	Gulf of Alaska	Western Alaska	Bering Sea
Trachipteridae	x	-	x	-	-	-	-
Trachipterus altivelis	x	x	x	-	-	-	-
Trachurus symmetricus	x	x	x	-	-	-	-
Sciaenidae	x	-	-	-	-	-	-
Brama japonica	x	-	x	-	-	-	-
Medialuna californiensis	x	-	-	-	-	-	-
Scomber japonicus	x	-	-	-	-	-	-
Sebastes spp.	x	x	x	x	x	x	x
S. alutus	-	-	-	-	x	-	-
S. entomelas	-	-	x	-	-	-	-
S. jordani	x	x	-	-	-	-	-
Anoplopoma fimbria	x	-	x	x	x	x	x
Hexagrammidae	-	-	x	-	-	-	x
Pleurogrammus monopterygius	-	-	-	-	-	x	x
Cottidae	-	-	-	-	-	x	x
Cyclopteridae	-	-	-	-	x	x	x
Aptocyclus ventricosus	-	-	-	-	-	-	x
Trichodontidae	-	-	-	-	-	-	x
Trichodon trichodon	-	-	-	-	x	x	x
Ammodytes hexapterus	-	-	x	x	x	x	x
Bathymasteridae	-	-	-	-	-	-	x
Bathymaster signatus	-	-	-	-	-	x	-
Anarhichadidae	-	-	-	-	-	-	x
Anarhichas orientalis	-	-	-	-	-	-	x
Zoarcidae	-	-	x	-	-	-	-
Tetragonurus cuvieri	-	-	x	-	-	-	-
Atherinopsis californiensis	x	-	-	-	-	-	-
Pleuronectiformes	-	-	x	-	-	-	-
Citharichthys sp.	x	-	-	-	-	-	-
Pleuronectidae	x	-	x	x	x	-	x
Atheresthes stomias	-	-	-	-	x	x	-
Hippoglossus stenolepis	-	-	-	-	-	-	x
Lyopsetta exilis	x	x	-	-	-	-	-
Reinhardtius hippoglossoides	-	-	-	-	-	-	x
Porichthys notatus	x	-	-	-	-	-	-
Unidentified	x	x	x	x	x	x	x

lowing paragraphs, it may be concluded that these prey species were the most available food resource utilized by fur seals off California. Similarly for the eastern Bering Sea, the principal foods of fur seals were the most available food resource utilized by fur seals in the collection area. The abundance, distribution, and availability of the major prey species will be discussed to demonstrate the opportunistic feeding of fur seals primarily off California and in the eastern Bering Sea and to a lesser extent for the other areas.

The first major report on the food of northern fur seals was that of Lucas (1899) for the Bering Sea and subsequently by others as more information became available in later years. The food and feeding habits of the northern fur seal in the eastern North Pacific and eastern Bering Sea are well described from the extensive pelagic research conducted throughout this region by Canada and the United States during 1958-74. Both countries have reported findings in their respective annual reports and in the five joint reports of the North Pacific Fur Seal Commission (NPFSC) (1962, 1969, 1971, 1975, and 1980) for the period 1958 through 1976.

Beginning in 1975, both the United States and Canada suspended the collection of specimens at sea, pooled their data, and undertook a joint analysis on all aspects of the pelagic phase in the life history of this species. Two preliminary reports utilizing the pooled data have been completed on topics such as migration, distribution, growth, reproduction (pregnancy rates), life table, and feeding habits (Kajimura et al. 1979[8], 1980[9]). Detailed fur seal feeding data tables will be

[8]Kajimura, H., R. H. Lander, M. A. Perez, A. E. York, and M. A. Bigg. 1979. Preliminary analysis of pelagic fur seal data collected by the United States and Canada during 1958-74. Unpubl. rep., 247 p. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115. (Submitted to 22nd Annual Meeting of the North Pacific Fur Seal Commission.)

[9]Kajimura, H., R. H. Lander, M. A. Perez, A. E. York, and M. A. Bigg. 1980. Further analysis of pelagic fur seal data collected by the United States and Canada during 1958-74. Part 1, 94 p. and Part 2, 172 p. Unpubl. rep. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115. (Submitted to 23rd Annual Meeting of the North Pacific Fur Seal Commission.)

Table 2.—Squids eaten by fur seals in the eastern North Pacific Ocean and Bering Sea, 1958-74, by area.

	Species												
Area and year	*Loligo opalescens*	*Onychoteuthis* sp.	*Onychoteuthis borealijaponicus*	*Moroteuthis robusta*	*Abraliopsis* spp.	*Octopoteuthis* sp.	Gonatidae	*Gonatus* spp.[1]	*Berryteuthis magister*	*Gonatopsis borealis*	Chiroteuthidae	*Chiroteuthis* sp.	Unidentified squid
California													
1958	x	x	x	-	-	-	-	x	-	-	-	-	x
1959	x	x	-	-	-	-	-	x	-	-	-	-	x
1961	x	x	-	-	x	-	x	-	-	x	-	-	x
1964	x	-	x	-	-	-	x	x	-	-	-	-	x
1965	x	-	x	x	x	-	x	x	x	x	-	-	x
1966	x	-	x	x	x	-	x	x	-	-	-	-	x
Oregon													
1958	x	x	-	-	-	-	-	-	-	-	-	-	x
1959	x	x	-	-	-	-	-	x	-	-	-	-	x
1961	x	-	-	-	-	-	x	-	-	-	-	-	x
1964	x	-	x	-	-	-	x	x	-	-	-	-	x
1965	-	-	x	-	x	-	-	-	x	-	x	-	x
Washington													
1958	-	-	-	-	-	-	-	-	-	-	-	-	x
1959	x	x	-	-	-	-	-	x	-	-	-	-	x
1960	x	-	-	-	-	-	-	-	-	-	-	-	x
1961	x	x	-	-	-	-	x	-	-	x	-	-	x
1962	x	-	-	-	-	-	-	-	-	-	-	-	x
1963	-	-	-	-	-	-	-	-	-	-	-	-	x
1964	x	-	x	-	-	-	x	x	x	x	-	-	x
1965	x	-	-	-	-	-	x	x	-	-	-	-	x
1966	-	-	x	-	x	x	-	x	x	-	-	-	x
1967	x	x	x	-	-	-	x	x	x	-	-	-	x
1968	x	x	x	-	-	-	x	x	x	-	-	x	x
1969	x	x	x	-	x	-	x	x	-	-	-	x	x
1970	x	x	x	x	x	x	x	x	x	x	x	x	x
1971	x	x	x	-	x	x	x	x	x	x	x	x	x
1972	x	x	-	x	x	x	x	x	x	x	-	x	x
1973	x	-	-	-	-	-	-	-	-	-	-	-	-
1974	x	-	-	-	-	-	-	-	-	-	-	-	-
British Columbia													
1958	-	-	-	-	-	-	-	-	-	-	-	-	x
1959	x	-	-	-	-	-	-	-	-	-	-	-	x
1960	-	-	-	-	-	-	-	-	-	-	-	-	x
1961	x	-	-	-	-	-	x	-	x	-	-	-	x
1962	x	-	-	-	-	-	-	-	x	-	-	-	x
1963	-	-	-	-	-	-	-	-	-	-	-	-	x
1964	-	-	x	-	-	-	-	-	x	-	-	-	x
1966	-	-	x	-	-	-	-	-	x	-	-	-	x
1967	-	-	x	-	-	-	-	-	x	-	-	-	-
1968	-	-	x	-	-	-	-	x	x	-	-	-	x
1969	x	-	-	-	-	-	-	-	-	-	-	-	-
Gulf of Alaska													
1958	x	-	-	-	-	-	-	-	-	-	-	-	x
1959	-	-	-	-	-	-	-	-	-	-	-	-	x
1960	-	x	-	-	-	-	-	x	-	-	-	-	x
1961	-	-	-	-	-	-	-	-	-	-	-	-	x
1962	x	-	-	-	-	-	-	-	x	-	-	-	x
1963	-	-	-	-	-	-	-	-	-	-	-	-	x
1968	-	-	-	-	-	-	x	x	x	x	-	-	x
Western Alaska													
1958	-	-	-	-	-	-	-	-	-	-	-	-	x
1960	-	-	-	-	-	-	-	-	-	-	-	-	x
1962	-	-	-	-	-	-	x	-	x	x	-	-	x
1968	-	-	-	-	-	-	x	x	x	x	-	-	x
Bering Sea													
1960	-	-	-	-	-	-	-	-	-	-	-	-	x
1962	-	-	-	-	-	-	x	x	x	x	-	-	x
1963	-	-	-	-	-	-	x	x	x	x	-	-	x
1964	-	-	-	-	-	-	x	x	x	x	-	-	x
1966	-	-	-	-	-	-	x	-	-	-	-	-	-
1968	-	-	-	-	-	-	x	x	x	x	-	-	x
1973	-	-	-	-	-	-	x	x	x	x	-	-	x
1974	-	-	-	-	-	-	x	x	x	x	-	-	x

[1]Squids identified as *Gonatus fabricii* in earlier reports have been listed as *Gonatus* spp.

Table 3.—Principal forage species utilized by fur seals in the eastern North Pacific Ocean and the eastern Bering Sea, 1958-74, by area.

Forage species	Location: California	Oregon	Washington	British Columbia	Gulf of Alaska	Western Alaska	Bering Sea
Fish:							
Clupea harengus pallasi	-	-	x	x	x	x	x
Engraulis mordax	x	x	x	-	-	-	-
Oncorhynchus spp.	-	-	x	x	x	x	-
Mallotus villosus	-	-	x	-	x	x	x
Thaleichthys pacificus	-	-	x	x	-	-	-
Cololabis saira	x	x	-	x	-	-	-
Gadidae	-	-	-	-	-	-	x
Gadus macrocephalus	-	-	-	x	-	-	-
Merluccius productus	x	x	x	x	-	-	-
Theragra chalcogramma	-	-	-	x	x	x	x
Trachurus symmetricus	x	-	-	-	-	-	-
Sebastes spp.	x	x	x	x	x	-	-
Anoplopoma fimbria	x	-	x	x	-	x	-
Pleurogrammus monopterygius	-	-	-	-	x	x	x
Ammodytes hexapterus	-	-	-	-	x	x	x
Cephalopods:							
Loligo opalescens	x	x	-	x	-	-	-
Onychoteuthis sp.	x	x	x	-	-	-	-
Onychoteuthis borealijaponicus	-	-	-	-	x	-	-
Gonatus sp.	-	-	-	-	x	-	-
Berryteuthis magister	-	-	-	-	x	x	x
Gonatopsis borealis	-	-	-	-	-	-	x
Unidentified squid	-	-	-	-	x	-	-

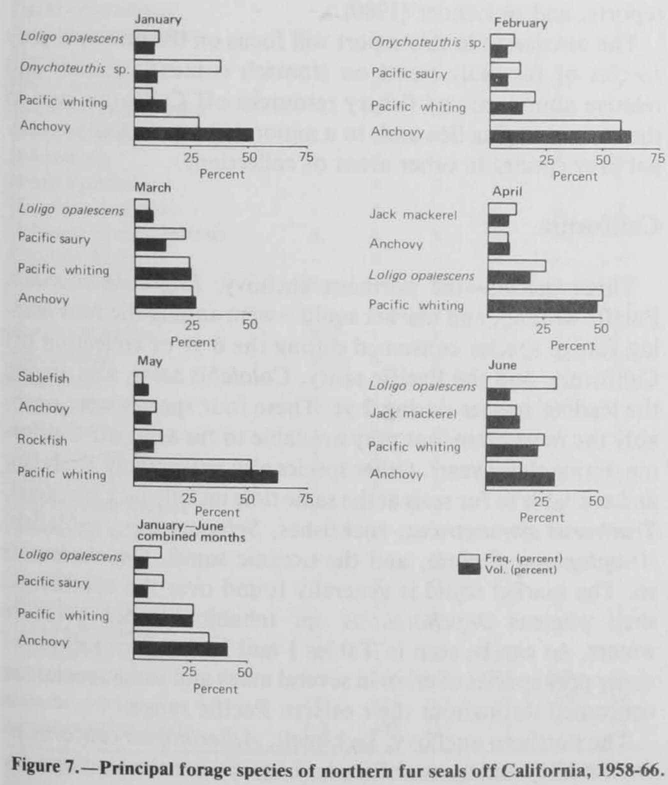

Figure 7.—Principal forage species of northern fur seals off California, 1958-66.

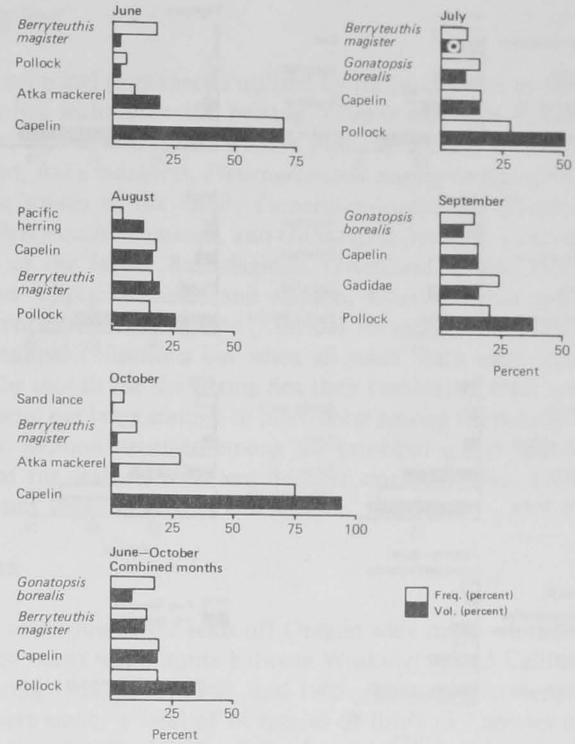

Figure 8.—Principal forage species of northern fur seals in the eastern Bering Sea, 1958-74.

Figure 9.—Principal forage species of northern fur seals off Washington, 1958-74.

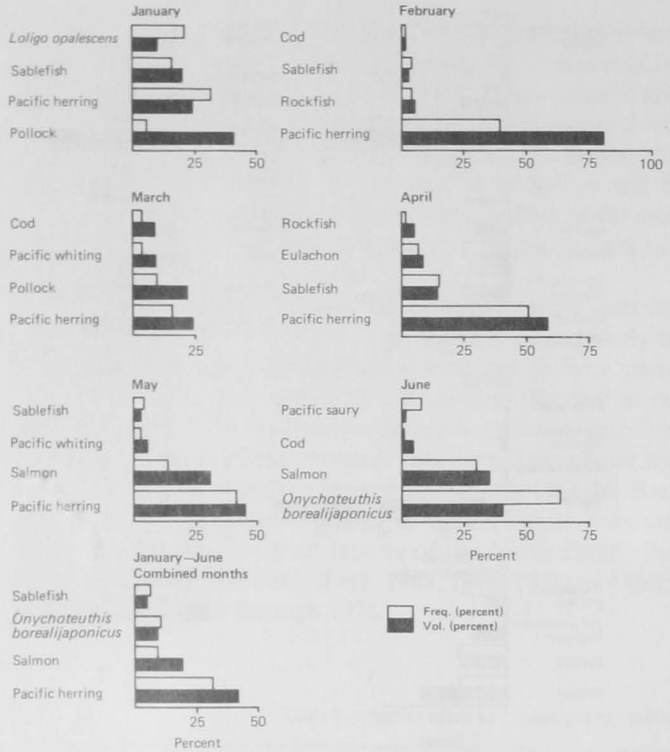

Figure 10.—Principal forage species of northern fur seals off British Columbia, 1958-72.

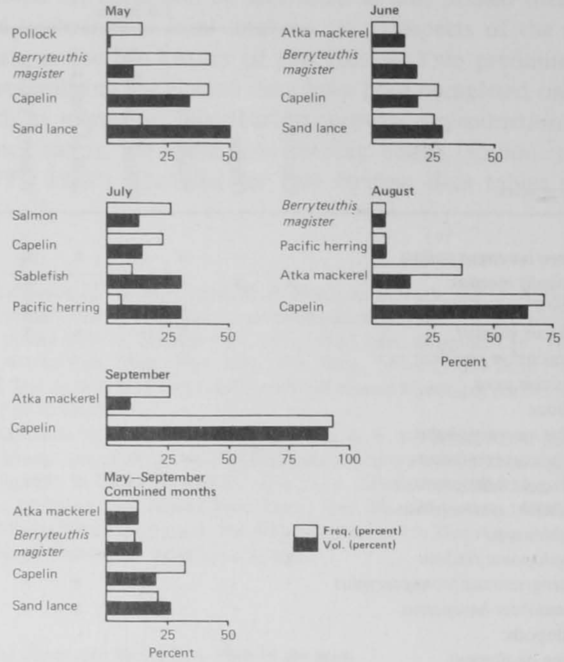

Figure 12.—Principal forage species of northern fur seals in western Alaska, 1958-74.

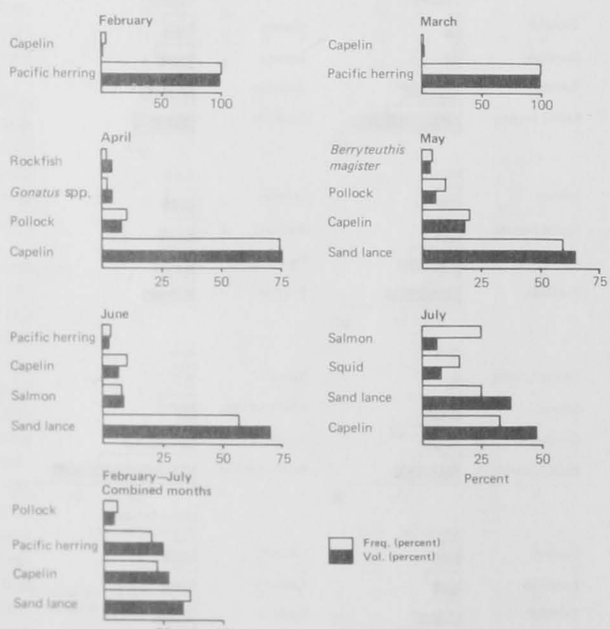

Figure 11.—Principal forage species of northern fur seals in the Gulf of Alaska, 1958-68.

found in these two reports, the annual reports, the NPFSC reports, and in Lander (1980).

The discussion in this report will focus on the principal prey species of fur seals based on stomach content volumes and relative abundance of fishery resources off California and in the eastern Bering Sea and, to a minor degree, on some principal prey species in other areas of collection.

California

Three species—the northern anchovy, *Engraulis mordax*, Pacific whiting, and market squid—were among the four leading forage species consumed during the 6 yr of collection off California, and the Pacific saury, *Cololabis saira*, was among the leading species during 2 yr. These four species were probably the most abundant prey available to fur seals off California during those years. Other species also presumably abundant and available to fur seals at the same time include jack mackerel, *Trachurus symmetricus*, rockfishes, *Sebastes* spp., sablefish, *Anoplopoma fimbria*, and the oceanic squid, *Onychoteuthis* sp. The market squid is generally found over the continental shelf whereas *Onychoteuthis* sp. inhabits deeper offshore waters. As can be seen in Tables 1 and 2, the distributions of many prey species overlap in several areas and some species are consumed throughout their eastern Pacific range.

The northern anchovy, jacksmelt, *Atherinopsis californiensis*, Pacific whiting, rockfish, and squid were the leading prey ecies of fur seals collected off California during February to pril 1952 (Taylor et al. 1955). Jacksmelt was not an importnt food of fur seals during the 1958-66 California collections lthough this species occurred in stomachs of fur seals during anuary, February, March, and April collections (Table 4).

The fur seals collected off California were taken before the iscovery of the San Miguel Island population (the samples ere collected during 1958-66). Thus, the San Miguel Island opulation, which numbered about 100 animals when disovered in 1968, would not have affected our findings or the esults of the 1958-66 surveys. The population of seals from he San Miguel-Castle Rock colony (which has grown to about ,000 animals in 1979) may now play an important role as ear-round residents in California waters.

Table 4.—Food of fur seals off California, January-June 1958-66.

ood items	Months					
	Jan.[1]	Feb.	Mar.	Apr.	May	June
ish:						
Entosphenus tridentatus	-	-	-	x	x	-
Squalus acanthias	-	-	-	x	-	-
Clupeidae	-	-	-	-	-	x
Alosa sapidissima	-	x	x	x	-	-
Clupea harengus pallasi	x	x	x	x	x	-
Engraulis mordax	1	1	1	3	3	1
Oncorhynchus spp.	-	-	-	x	x	-
Hypomesus pretiosus	-	-	x	x	-	-
Thaleichthys pacificus	-	-	x	x	-	-
Tactostoma macropus	-	-	x	-	-	-
Paralepis atlantica	-	x	x	-	x	-
Myctophidae	x	x	x	x	-	-
Tarletonbeania crenularis	x	-	x	-	x	-
Symbolophorus californiensis	x	-	-	-	-	-
Cololabis saira	x	3	3	x	x	x
Merluccius productus	2	2	2	1	1	2
Trachipteridae	-	x	x	x	-	-
Trachipterus altivelis	-	x	x	-	-	-
Trachurus symmetricus	-	x	x	4	x	3
Sciaenidae	-	-	x	-	-	-
Brama japonica	-	x	-	-	-	-
Medialuna californiensis	-	x	x	-	-	-
Scomber japonicus	-	x	-	-	-	-
Sebastes spp.	x	x	x	-	2	x
Sebastes jordani	-	x	x	-	-	-
Anoplopoma fimbria	-	x	-	x	4	x
Atherinopsis californiensis	x	x	x	x	-	-
Citharichthys sp.	-	x	x	x	-	-
Pleuronectidae	x	-	x	x	x	-
Lyopsetta exilis	-	-	x	x	-	-
Porichthys notatus	x	x	x	x	-	-
Unidentified	x	x	x	x	x	x
ephalopods:						
Ocythoe tuberculata	x	x	-	-	x	-
Loligo opalescens	4	x	4	2	x	4
Onychoteuthis sp.	3	4	x	x	-	-
Onychoteuthis borealijaponicus	x	x	x	x	x	x
Morotheuthis robusta	-	-	x	-	x	-
Abraliopsis sp.	x	x	x	-	x	x
Gonatidae	x	x	x	x	x	-
Gonatus sp.	x	x	x	x	x	x
Berryteuthis magister	-	-	-	-	x	x
Gonatopsis borealis	x	-	-	-	x	x
Unidentified squid	x	x	x	x	x	x
Stomachs with food	399	1,006	558	268	265	81
Stomachs with trace	172	222	161	69	107	35
Stomachs without food	198	405	255	77	75	15

[1]Numerals indicate the ranking of principal prey species based on percentage of total stomach content volume.

Bering Sea

The principal prey species utilized by fur seals in the eastern Bering Sea include Pacific herring, *Clupea harengus pallasi*, capelin, *Mallotus villosus*, walleye pollock, *Theragra chalcogramma*, Atka mackerel, *Pleurogrammus monopterygius*, and oceanic squids of the family Gonatidae—including *Gonatus* spp., *Berryteuthis magister*, and *Gonatopsis borealis*. Deepsea smelts of the family Bathylagidae, Greenland turbot, *Reinhardtius hippoglossoides*, and salmon, *Oncorhynchus* spp., were represented among the principal forage species during some annual collections but when all years' data were combined by month for the Bering Sea their cumulative total volumes were not large enough to place them among the principal species. Salmon occurred among the principal forage species food of fur seals in 1960 and deepsea smelts in 1963, 1968, 1973, and 1974.

Oregon

The collection of fur seals off Oregon were made while the research vessel was enroute between Washington and California during 1959, 1961, 1964, and 1965. Although the sample sizes were small, a total of 14 species of fish and 7 species of squids was identified in the stomachs of fur seals. The principal prey species included northern anchovy, Pacific whiting, rockfish, and squids (Table 5).

Table 5.—Food of fur seals off Oregon, January and March-May 1958-65.

Food items	Months			
	Jan.[1]	Mar.	Apr.	May
Fish:				
Entosphenus tridentatus	-	-	x	-
Alosa sapidissima	-	-	x	-
Clupea harengus pallasi	-	-	x	-
Engraulis mordax	x	-	1	-
Oncorhynchus spp.	-	-	x	-
Scopelosaurus sp.	-	-	x	-
Myctophidae	-	-	x	-
Tarletonbeania crenularis	-	-	x	-
Cololabis saira	x	-	x	-
Merluccius productus	-	3	2	x
Trachipterus altivelis	-	-	x	-
Trachurus symmetricus	-	-	x	-
Sebastes spp.	-	1	3	-
Anoplopoma fimbria	-	-	x	-
Lyopsetta exilis	-	-	x	-
Unidentified	x	-	x	x
Cephalopods:				
Loligo opalescens	x	-	x	-
Onychoteuthis sp.	x	-	x	-
Onychoteuthis borealijaponicus	-	-	x	x
Abraliopsis sp.	-	-	x	-
Gonatidae	-	-	x	-
Gonatus sp.	-	-	x	-
Berryteuthis magister	-	-	x	-
Chiroteuthidae	-	-	x	-
Unidentified squid	x	2	4	-
Stomachs with food	3	14	99	2
Stomachs with trace	0	8	41	0
Stomachs without food	1	6	41	1

[1]Numerals indicate the ranking of principal prey species based on percentage of total stomach content volume.

Washington

Among the seven designated collection areas (Fig. 6), the ocean area off Washington had the most extensive time coverage as well as the most variety of prey species eaten by fur seals than in any of the other six areas (Table 6). Surveys and collections were conducted from late November through early June with March, April, and May receiving the most time coverage. April was the only month in which collections were made during every collection year from 1958 through 1974.

The principal prey species utilized by fur seals off Washington included the Pacific herring, capelin, eulachon, northern anchovy, rockfish, salmon, Pacific whiting, sablefish, and the oceanic squid *Onychoteuthis* sp. These principal prey species contributed from 64 to 99% of the total food volume (Fig. 9).

Table 6.—Food of fur seals off Washington, December-June 1958-74.

Food items	Months						
	Jan.[1]	Feb.	Mar.	Apr.	May	June	Dec.
Fish:							
Entosphenus tridentatus	x	x	x	x	x	-	-
Hydrolagus colliei	-	x	-	-	x	-	-
Clupeidae	-	-	x	x	x	x	-
Alosa sapidissima	x	x	x	x	x	-	x
Clupea harengus pallasi	1	x	3	2	1	1	x
Engraulis mordax	x	2	2	3	x	-	x
Salmonidae	x	x	x	x	x	x	x
Oncorhynchus spp.	2	3	3	4	3	4	x
O. gorbuscha	2	3	-	4	3	-	-
O. keta	2	3	-	4	-	-	-
O. kisutch	2	3	4	4	3	-	x
O. nerka	2	-	-	4	-	-	-
O. tshawytscha	2	3	-	4	3	-	-
Salmo gairdneri	x	x	x	-	-	-	-
Osmeridae	x	x	x	x	x	-	x
Hypomesus pretiosus	-	-	x	x	-	-	-
Mallotus villosus	x	4	x	x	x	-	x
Thaleichthys pacificus	x	x	x	x	x	-	x
Bathylagidae	-	-	-	-	x	-	-
Paralepis atlantica	-	-	-	x	-	-	-
Myctophidae	x	x	x	x	x	-	-
Tarletonbeania crenularis	-	-	-	x	x	-	-
Cololabis saira	-	-	x	x	x	x	x
Gadidae	-	-	-	x	x	x	-
Merluccius productus	x	x	x	x	4	3	x
Microgadus proximus	-	-	-	x	-	-	-
Theragra chalcogramma	-	-	-	x	x	-	-
Gasterosteus aculeatus	-	x	x	x	x	-	-
Trachipteridae	-	-	-	x	x	-	-
Trachipterus altivelis	-	-	-	-	x	-	-
Trachurus symmetricus	-	-	-	x	-	-	-
Brama japonica	-	-	-	-	x	-	-
Sebastes spp.	3	1	1	1	x	-	-
Sebastes entomelas	-	-	-	x	-	-	-
Anoplopoma fimbria	4	x	x	x	x	-	x
Hexagrammidae	-	-	-	-	x	-	-
Ammodytes hexapterus	-	-	x	x	x	-	-
Zoarcidae	-	-	-	-	x	-	-
Tetragonurus cuvieri	-	-	-	-	x	-	-
Pleuronectiformes	-	-	-	x	-	-	-
Pleuronectidae	-	x	x	x	x	-	-
Unidentified	x	x	x	x	x	x	x
Cephalopods:							
Octopoda	-	-	x	-	-	-	-
Loligo opalescens	x	x	x	x	x	x	x
Onychoteuthis sp.	x	x	x	x	2	2	-
Onychoteuthis borealijaponicus	x	x	x	x	x	-	-
Moroteuthis robusta	-	-	-	-	x	-	-
Abraliopsis sp.	-	x	-	x	x	-	-
Octopoteuthis sp.	x	-	-	x	x	-	-
Gonatidae	x	x	x	x	x	x	x
Gonatus sp.	x	x	x	x	x	-	x
Berryteuthis magister	x	x	x	x	x	-	-
Gonatopsis borealis	-	-	x	x	x	x	-
Chiroteuthidae	-	x	x	x	x	-	-
Chiroteuthis sp.	-	x	x	x	x	-	-
Unidentified squid	x	x	x	x	x	x	x
Stomachs with food	273	257	569	1,082	647	32	78
Stomachs with trace	94	105	226	325	222	12	36
Stomachs without food	209	187	688	1,014	475	17	38

[1]Numerals indicate the ranking of principal prey species based on percentage of total stomach content volume.

British Columbia

Surveys and collections in British Columbia waters occurred from January through June, 1958-68, with extensive time coverage primarily during May and April.

The principal prey species of fur seals taken off British Columbia included the Pacific herring, eulachon, salmon, sablefish, rockfish, walleye pollock, Pacific cod, *Gadus macrocephalus*, Pacific whiting, Pacific saury, and squids, *L. opalescens* and *Onychoteuthis borealijaponicus* (Table 7). These principal prey species contributed from 66 to 95% of the total food volume (Fig. 10).

Table 7.—Food of fur seals off British Columbia, January-June 1958-72.

Food items	Months					
	Jan.[1]	Feb.	Mar.	Apr.	May	June
Fish:						
Entosphenus tridentatus	-	-	x	x	-	x
Hydrolagus colliei	-	x	-	-	-	x
Clupeidae	-	x	-	-	-	-
Clupea harengus pallasi	2	1	1	1	1	x
Oncorhynchus spp.	-	-	x	-	3	2
O. keta	-	-	-	-	3	-
Osmeridae	x	x	-	-	-	-
Hypomesus pretiosus	-	-	x	-	-	-
Thaleichthys pacificus	x	x	x	3	-	-
Cololabis saira	-	-	-	x	x	4
Gadidae	-	x	-	-	-	-
Gadus macrocephalus	-	4	4	x	-	3
Merluccius productus	-	-	3	-	2	x
Theragra chalcogramma	1	x	2	-	x	x
Gasterosteus aculeatus	-	x	x	x	-	-
Sebastes spp.	-	2	x	4	x	-
Anoplopoma fimbria	3	3	x	2	4	-
Ammodytes hexapterus	x	-	-	-	x	-
Pleuronectidae	-	-	x	x	-	-
Unidentified	x	x	x	x	x	x
Cephalopods:						
Loligo opalescens	4	x	x	-	x	-
Onychoteuthis borealijaponicus	-	-	-	-	x	1
Gonatidae	x	-	-	-	x	-
Gonatus sp.	-	-	-	-	x	x
Berryteuthis magister	-	x	x	-	x	x
Unidentified squid	x	x	x	x	x	x
Stomachs with food	19	89	79	44	170	62
Stomachs with trace	2	27	31	5	39	5
Stomachs without food	20	86	58	60	156	33

[1]Numerals indicate the ranking of principal prey species based on percentage of total stomach content volume.

Gulf of Alaska

Surveys and collections in the Gulf of Alaska occurred primarily during 1958 through 1968 with greater time coverage ccurring during May and June when fur seals were expected n this area in greater numbers enroute to the Pribilof Islands.

The principal prey species utilized by fur seals in the Gulf of laska included Pacific herring, capelin, salmon, walleye ollock, Pacific sand lance, *Ammodytes hexapterus*, rockfish, tka mackerel, and squids, *Gonatus* spp. and *B. magister* Table 8). These principal prey species contributed from 89 to 9% of the total food volume based on percentage of the total tomach content volume of seals taken in this area (Fig. 11).

Table 8.—Food of fur seals in the Gulf of Alaska, February-July 1958-68.

ood items	Months					
	Feb.[1]	Mar.	Apr.	May	June	July
ish:						
Clupeidae	-	-	-	-	x	-
Clupea harengus pallasi	1	1	x	x	4	-
Oncorhynchus spp.	-	-	x	x	2	4
O. gorbuscha	-	-	-	-	2	-
O. keta	-	-	-	-	2	-
O. kisutch	-	-	-	-	2	-
O. tshawytscha	-	-	x	-	-	-
Osmeridae	-	-	-	x	x	-
Mallotus villosus	2	2	1	2	3	1
Thaleichthys pacificus	-	-	x	-	-	x
Myctophidae	-	-	x	x	-	-
Anotopterus pharao	-	-	x	-	-	-
Cololabis saira	-	-	-	x	-	-
Gadidae	-	x	-	x	-	-
Gadus macrocephalus	-	-	x	x	x	-
Microgadus proximus	-	-	x	-	x	-
Theragra chalcogramma	-	-	2	3	x	-
Gasterosteus aculeatus	-	-	x	x	-	-
Sebastes spp.	-	-	4	x	-	-
Sebastes alutus	-	-	x	-	x	-
Anoplopoma fimbria	-	-	x	-	-	x
Cyclopteridae	-	-	x	x	-	-
Trichodon trichodon	-	-	-	x	-	-
Ammodytes hexapterus	-	-	x	1	1	2
Pleuronectidae	-	-	-	x	x	-
Atheresthes stomias	-	x	x	x	-	-
Unidentified	-	-	x	x	x	x
ephalopods:						
Octopoda	-	-	-	-	x	-
Loligo opalescens	-	-	x	-	x	-
Onychoteuthis sp.	-	-	x	x	-	-
Gonatidae	-	-	-	x	x	-
Gonatus sp.	-	x	3	x	x	-
Berryteuthis magister	-	-	-	4	x	x
Gonatopsis borealis	-	-	-	x	x	-
Unidentified squid	-	x	x	x	x	3
tomachs with food	33	205	225	505	328	24
tomachs with trace	1	9	22	53	68	4
tomachs without food	30	100	118	599	474	68

[1]Numerals indicate the ranking of principal prey species based on percentage of otal stomach content volume.

Vestern Alaska

Surveys and collections in the western Alaska region were nade primarily during June 1958, 1960, 1962, 1968, and 1974.

The principal prey species utilized by fur seals in this region ncluded the fishes Pacific herring, capelin, salmon, walleye ollock, sablefish, Atka mackerel, and Pacific sand lance as vell as the squid *B. magister* (Table 9). These principal prey pecies contributed from 77 to 99% of the total stomach conent volume for this area (Fig. 12).

Table 9.—Food of fur seals in western Alaska, May-September 1958-74.

Food items	Months				
	May[1]	June	July	Aug.	Sept.
Fish:					
Entosphenus tridentatus	-	x	-	-	-
Clupea harengus pallasi	-	x	1	3	-
Salmonidae	-	x	4	-	-
Oncorhynchus spp.	-	x	4	x	-
O. gorbuscha	-	x	-	-	-
O. keta	-	x	-	-	-
O. kisutch	-	x	-	-	-
O. nerka	-	x	-	-	-
O. tshawytscha	-	x	-	-	-
Osmeridae	-	x	-	-	-
Mallotus villosus	2	2	3	1	x
Gadidae	-	x	-	-	-
Gadus macrocephalus	-	x	-	-	-
Theragra chalcogramma	4	x	x	x	-
Sebastes spp.	-	x	-	-	-
Anoplopoma fimbria	-	-	2	-	-
Pleurogrammus monopterygius	-	4	-	2	x
Cottidae	-	x	-	-	-
Cyclopteridae	-	x	-	-	-
Trichodon trichodon	-	x	-	-	-
Ammodytes hexapterus	1	1	x	-	-
Bathymaster signatus	-	x	-	-	-
Atheresthes stomias	-	x	-	-	-
Unidentified	x	x	x	x	-
Cephalopods:					
Gonatidae	-	x	x	x	x
Gonatus sp.	-	x	-	-	-
Berrytheuthis magister	3	3	x	4	-
Gonatopsis borealis	-	x	x	x	-
Unidentified squid	-	x	-	x	-
Stomachs with food	7	350	30	35	15
Stomachs with trace	1	111	10	6	1
Stomachs without food	14	276	22	51	18

[1]Numerals indicate the ranking of principal prey species based on percentage of total stomach content volume.

PRINCIPAL FORAGE SPECIES OF FUR SEALS

California

The relative abundance of fishery resources available in the California Current System have been determined from egg and larvae surveys conducted by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). The basic pattern for the stations of the CalCOFI survey areas off California and Baja California since 1950 are shown in Figure 13. The sampling method, gear, and surveying techniques used for collecting data on fish eggs and larvae to determine distribution and abundance of fishery resources in the California Current System were summarized by Ahlstrom (1966) and Kramer et al. (1972). Based on surveys conducted by CalCOFI, the major fishery resources (arranged in order of their relative abundance) were determined to be: 1) Northern anchovy, 2) Pacific whiting, 3) rockfishes, 4) jack mackerel, 5) Pacific saury, and 6) *L. opalescens*. These fishery resources were considered to be among the most underutilized fishery resources off California (Ahlstrom 1968).

The California marine fish fauna consists of about 554 species of which 439 are found in coastal waters (to 120 m depth), 48 are meso- or bathypelagic species, and 67 are deepwater

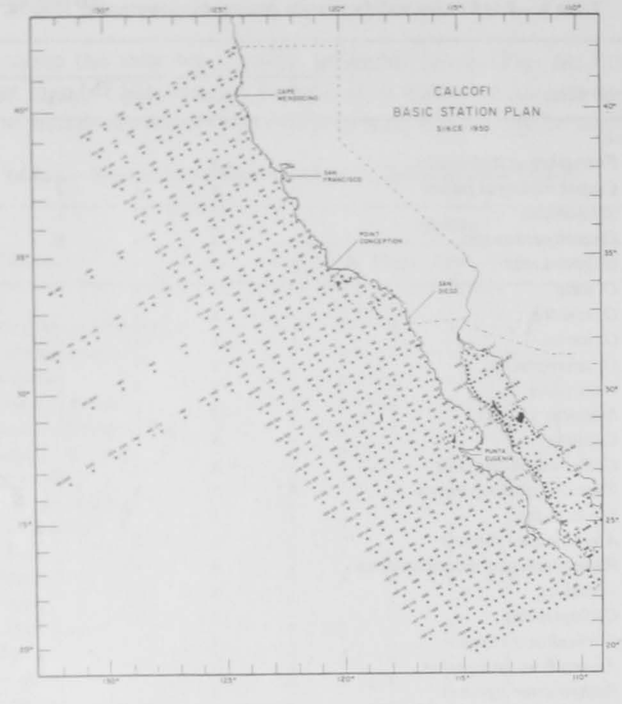

Figure 13.—Basic pattern for California Cooperative Oceanic Fisheries Investigations (CalCOFI) stations in survey areas off California and Baja California.

fishes (Miller and Lea 1972). In addition, 40 species of pelagi cephalopods are known to inhabit the waters off souther California and Baja California, Mexico (Young 1972). Th abundance of these species (cephalopods) is greatest in south ern California, gradually declining northward correlated wit increasing latitude and decreasing minimum surface tempera ture. They contribute only a small percentage to the commer cial catch of fish (Horn 1980). Among the top 10 commercia fish landings in California, tunas contribute approximatel 55% (primarily caught outside of California). Also among th top 10 are 4 of the major forage species of fur seals which tota 34%: Anchovy 24%, jack mackerel 6%, *L. opalescens* 3% and rockfish 1% (Oliphant 1973). The commercial landings o forage species significant to fur seals feeding off California ar shown in Figure 14.

The prey of fur seals along with other fish and invertebrate play an important role in the complex food web off Californi (Fig. 15). The prey species, including squids, anchovy, Pacifi whiting, and rockfish, shown in the food web, are also amon the most abundant species in the California Current Systen Antonelis and Fiscus (1980) summarized the known prey o pinnipeds inhabiting the CalCOFI study area and indicate tha there is a wide range in the list of prey consumed in the area b these pinnipeds. Many consume the same prey but differ pr marily by foraging in different zones. Ainley and Sange (1979) reported that most seabirds feed as secondary and te tiary carnivores and that certain of their prey characteristicall occur as the predominant items in the diets of other marin

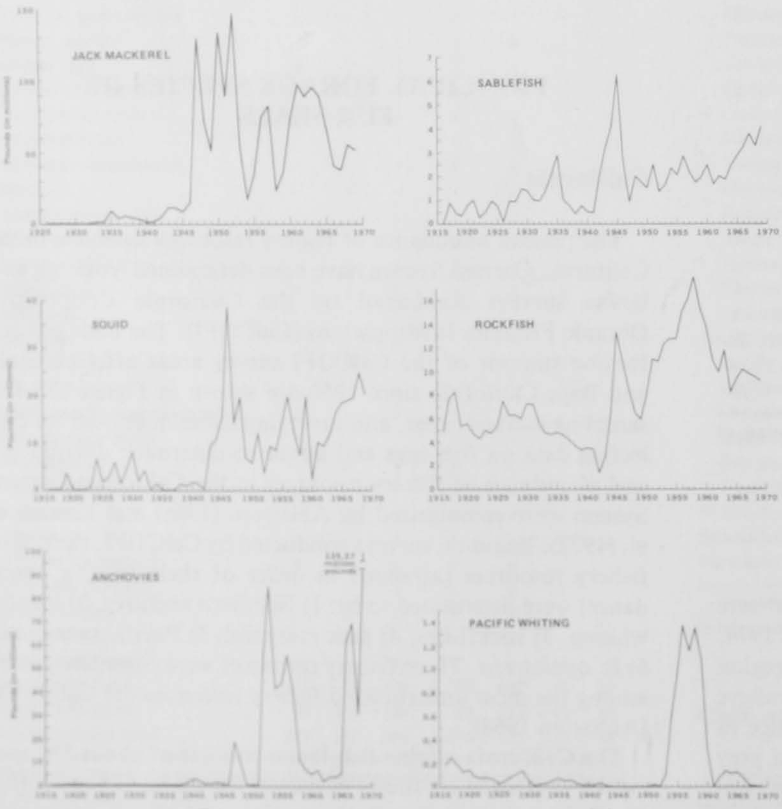

Figure 14.—Commercial landings of forage species significant northern fur seals off California (from Frey 1971).

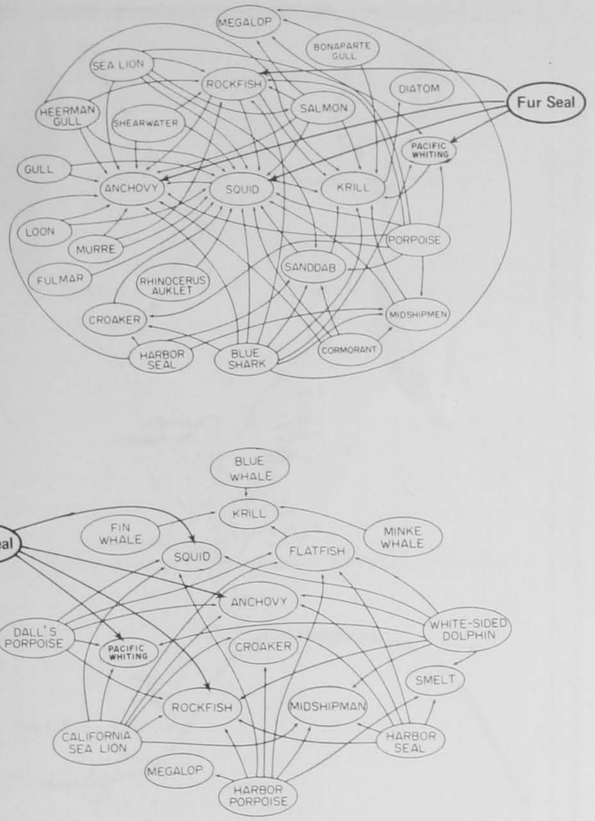

Figure 15.—Food web involving commercially important and abundant fish, birds, mammals, and squid *Loligo opalescens* (modified from Morejohn et al. 1978).

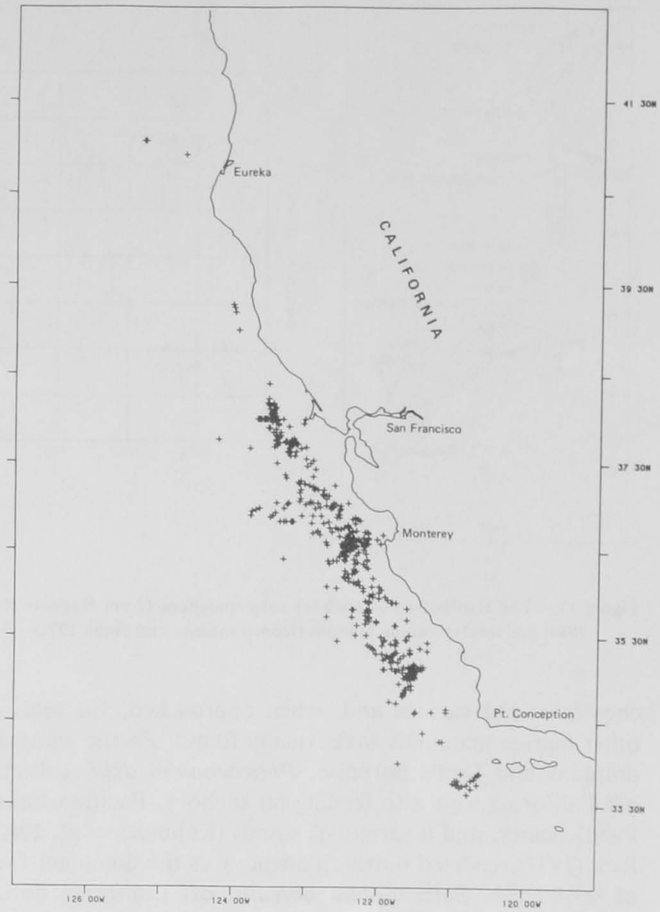

Figure 16.—Locations off California where 843 northern fur seals were collected whose stomachs contained northern anchovy, 1958-66.

birds in the eastern North Pacific Ocean. Seabirds are opportunistic feeders, foraging on smaller abundant schooling organisms such as euphausiids, squids, clupeids, and engraulids. Ainley (1980) described seabirds as marine organisms (similar to fish and marine mammals) because they are full-time participants in marine energy cycles as they derive all their food from the sea. Seabirds however, travel above the sea's surface instead of being confined to water, spending some time on land to raise their young, as do pinnipeds.

Northern anchovy.—The northern anchovy is one of the major forage species utilized by fur seals wintering off California and has been among the top four forage species consumed by fur seals during every monthly collection (January through June) off California (Fig. 7). The locations where fur seals were taken whose stomachs contained anchovy is shown in Figure 16. The northern anchovy is also the most abundant and largest fishery resource in the California Current System based on CalCOFI surveys and on acoustic-midwater surveys (Ahlstrom 1968; Frey 1971; Mais 1974). Anchovies, which are extremely abundant off southern California are heavily preyed upon by most predatory species (fishes, seabirds, squids, pinnipeds, and whales) in the California Current (Fig. 15). This species contributed 74% of the total stomach content volume in fur seals taken off California in 1966 (Marine Mammal Biological Laboratory 1969). Anchovy are also cannibalistic, feeding on their own larvae and eggs (Hunter and Kimbrell 1980). The extensive use of anchovy as bait in commercial and sport fisheries also shows its acceptance as food for a wide variety of fishes.

The largest concentrations of anchovies are usually found between San Francisco and Magdalena Bay, Baja California, with general distribution from the Queen Charlotte Islands, British Columbia, south to Cape San Lucas, Baja California, Mexico. The anchovy biomass increased tremendously during 1952-62 from about 640,000 to over 6 million tons (Fig. 17). Since 1962, the anchovy biomass has remained high, fluctuating between 5 and 8 million tons in a population consisting of three subpopulations (Fig. 17). North of the CalCOFI survey area, large concentrations of the anchovy have also been reported along the Oregon and Washington coasts. The anchovy is also one of the principal forage prey of fur seals off Washington during February, March, and April (Fig. 9). Although most fishes and squids rise toward the surface after darkness, the anchovy is also known to form large dense surface schools during daylight hours.

The known or suspected predators of anchovies including marine birds, mammals, fishes, and invertebrates have been summarized by Huppert et al. (1980). During pelagic fur seal operations off California, Pacific whiteside dolphins, *Lagenorhynchus obliquidens*, California sea lions, *Zalophus californianus*, fur seals, and seabirds have been observed feeding in the same school of anchovies. In many instances, concentrations of birds in the distance usually indicated schools of an-

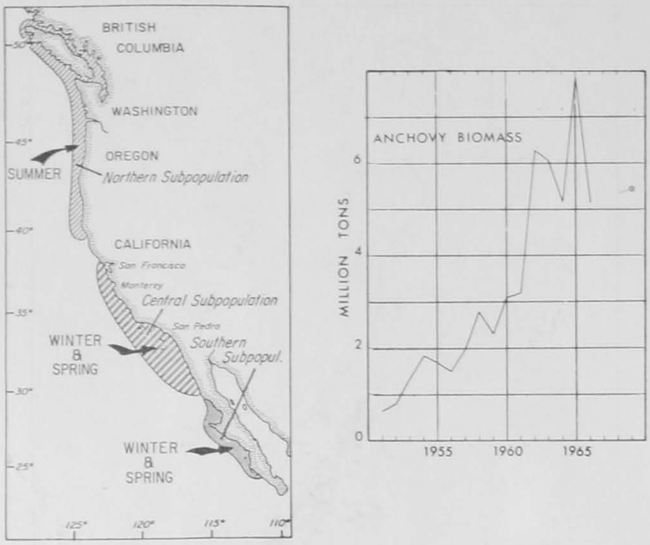

Figure 17.—The distribution of anchovy subpopulations (from Huppert et al. 1980) and total spawning biomass (from Vrooman and Smith 1971).

chovies at the surface and, when approached, fur seals or other marine mammals were usually found. Pacific whiteside dolphins and Dall's porpoise, *Phocoenoides dalli*, collected off California were also feeding on anchovy, Pacific whiting, Pacific saury, and a variety of squids (Kajimura et al. 1980). Rice (1977) reported northern anchovy as the dominant food of sei whales, *Balaenoptera borealis*, off California during June, July, and August. Rice also reported that anchovies occurred in 7% of the stomachs of fin whales, *Balaenoptera physalus*, and 60% of the stomachs of humpback whales, *Megaptera novaeangliae*. Although sperm whales, *Physeter macrocephalus*, are year-round residents off California, they apparently do not feed on anchovies as large forage species appear to be more to their liking, especially larger oceanic squids (Rice and Wolman 1970[10]).

Pacific whiting.—Pacific whiting has been among the leading forage species consumed by fur seals off California during April and May and second in importance during January, February, and March (Fig. 7). All months combined, whiting was second only to northern anchovy as the leading forage species consumed by fur seals off California. The geographic occurrence of whiting in stomachs of fur seals is shown in Figure 18.

Pacific whiting is a schooling fish that is distributed over the continental shelf and slope from the Gulf of California to the Gulf of Alaska. Egg and larval studies by CalCOFI also indicate that whiting is consistently ranked second to anchovy in annual estimates of relative abundance in the survey area (Ahlstrom 1969). Spawning occurs primarily during winter and early spring (December to April) in deepwater areas along the coasts of southern California and Baja California, Mexico. The whiting undertakes an annual migration northward in the spring and summer and southward beginning in autumn (Fig.

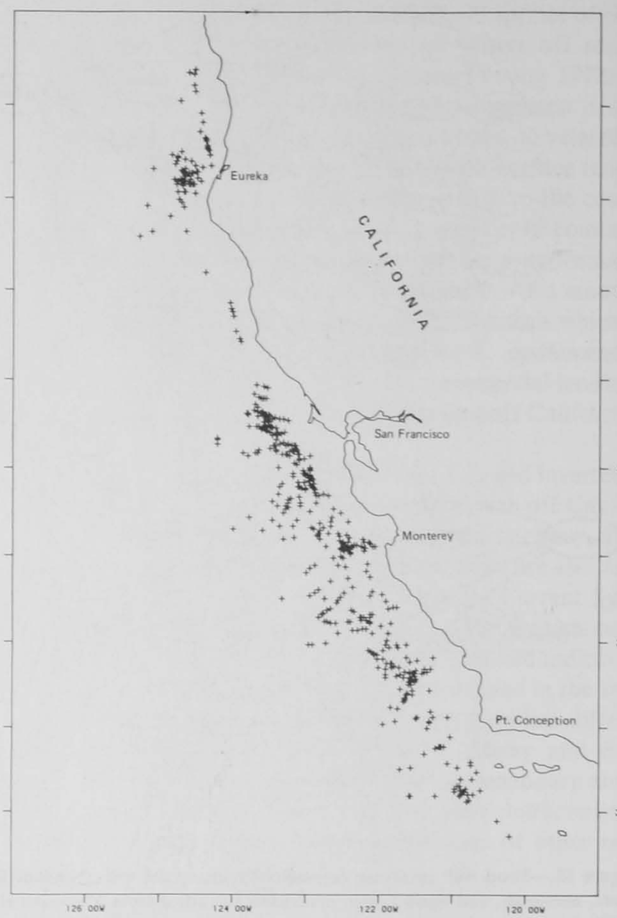

Figure 18.—Locations off California where 658 northern fur seals were collected whose stomachs contained Pacific whiting, 1958-66.

19). It is during this period, when feeding fish are over the continental shelf and slope, that the whiting is subjected to the foreign fishery. Although there is no major U.S. fishery for whiting off the western coast of North America, the species has been the subject of an intensive foreign fishery in this area since 1966. Dark et al. (1980) estimated the total whiting biomass at about 1.2 million tons (average annual foreign commercial catch of 167,000 tons) based on bottom trawl and midwater hydroacoustical trawl surveys conducted during July-September 1977. This survey also indicated the whiting biomass is nearly evenly distributed over fishing areas known as the Vancouver, Columbia, and Eureka grounds and less abundant to the south over the Monterey and Conception grounds.

Pacific whiting, which are cannibalistic, make pronounced diel vertical migrations to feed on anchovy, rockfish, and market squid. Fiscus (1979) summarized the known or suspected marine mammals and other predators which forage on whiting.

Market squid.—The market squid is an important forage food of many fishes, seabirds, and marine mammals and is an important link between zooplankton and the higher trophic levels in the pelagic environment of the California Current System (Fig. 15). Young (1972) reported that the market squid is probably the most abundant squid off the California coast. The market squid (a schooling species) is one of the leading forage species of the fur seal off California as evidenced in col-

[10]Rice, D. W., and A. A. Wolman. 1970. Sperm whales in the eastern North Pacific: Progress report on research, 1959-69. Submitted to Scientific Committee, sperm whale biology and stock assessment meeting, Honolulu, Hawaii, Doc. Sp/3., 18 p. (Avail. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.)

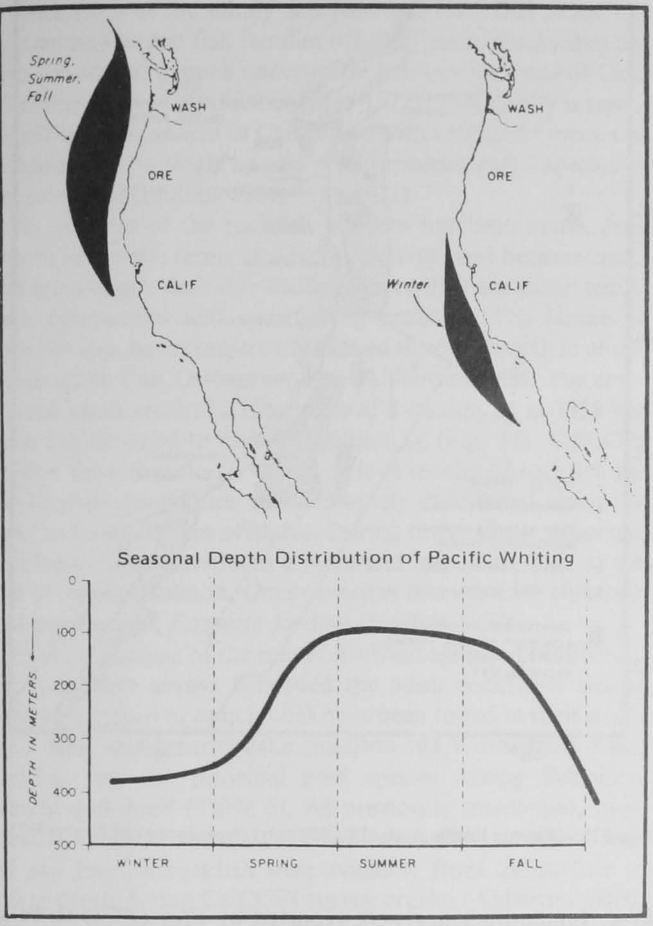

Figure 19.—Seasonal depth distribution of Pacific whiting (from Alverson and Larkins 1969).

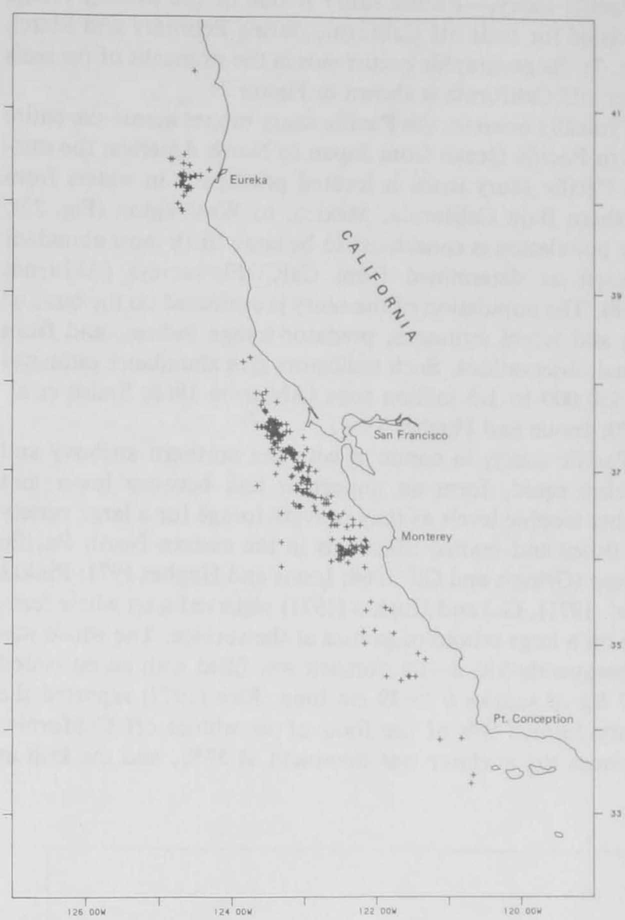

Figure 20.—Locations off California where 326 northern fur seals were collected whose stomachs contained market squid, 1958-66.

lections made during January, March, April, and June (Fig. 7). Its occurrence in stomachs of fur seals is shown in Figure 20. Among the eight taxa of squids identified in stomachs of fur seals taken off California, the market squid and oceanic squids, *Onychoteuthis* sp. and *O. borealijaponicus*, were identified most frequently.

The market squid population is considered to be large as are most cephalopod populations in the eastern North Pacific Ocean. Although the life history of the market squid is relatively well known (Fields 1965), the life histories of other pelagic cephalopod fauna of the eastern North Pacific Ocean are poorly known.

Based on CalCOFI surveys, the market squid ranked third among cephalopods in abundance (Okutani and McGowan 1969). Squid larvae found in greatest abundance were *Abraliopsis felis* and *Gonatus fabricii*. *Abraliopsis* sp. and *Gonatus* spp. were also consumed by fur seals taken off California. These species of squids normally inhabit the epi- and mesopelagic zones seaward of the continental shelf waters.

The market squid is neritic, being found over the continental shelf and in coastal waters but very seldom over deep water. The known geographic range of the market squid is from Hecate Strait, British Columbia, into Puget Sound, Washington, and south to Guadalupe Island and Turtle Bay, Mexico (Berry 1912; Okutani and McGowan 1969). A few occurrences of this species have been identified in stomachs of fur seals taken in the Gulf of Alaska in 1958 and 1962.

Studies of the feeding habits of the market squid in Monterey Bay show changes in diet with location and depth but with no changes with respect to size of squid or sex. Squids were found to be feeding primarily on euphausiids, copepods, megalops larvae, mysids, and amphipods as well as on fish and other cephalopods (Karpov and Cailliet 1979). Cannibalism is common among squids in the pelagic environment and the mature squids probably feed exclusively on fishes and cephalopods.

Most pelagic marine mammals feed to varying degrees on squids which are available in the epi- and mesopelagic zones whereas some of the deep diving mammals, such as the sperm whales, have diets which consist of 90% squids from the greater ocean depths. Laevastu and Fiscus (1978)[11] conservatively estimated the annual consumption of squids by the North Pacific sperm whales to be about 30 million tons and estimated 220 million tons of squids being consumed annually by all predators in the North Pacific marine ecosystem. Clarke (1977) estimated the worldwide squid consumption by sperm whales to be about 320 million tons. Okutani (1977) reported worldwide squid species (including cuttlefish) numbering between 450 to 500 species belonging to 30 families.

[11]Laevastu, T., and C. H. Fiscus. 1978. Review of cephalopod resources in the eastern North Pacific. Processed rep., 15 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Pacific saury.—Pacific saury is one of the leading forage foods of fur seals off California during February and March (Fig. 7). Its geographic occurrence in the stomachs of fur seals taken off California is shown in Figure 21.

Typically oceanic, the Pacific saury ranges across the entire North Pacific Ocean from Japan to North America; the eastern Pacific saury stock is located principally in waters from northern Baja California, Mexico, to Washington (Fig. 22). The population is considered to be large (fifth most abundant species) as determined from CalCOFI surveys (Ahlstrom 1968). The population of the saury is evaluated on the basis of egg and larval estimates, predator-forage indices, and from visual observations. Such indicators give abundance estimates of 450,000 to 1.5 million tons (Ahlstrom 1968; Smith et al. 1970; Inoue and Hughes 1971).

Pacific saury, in common with the northern anchovy and market squid, form an important link between lower and higher trophic levels as they provide forage for a large variety of fishes and marine mammals in the eastern North Pacific Ocean (Grinols and Gill 1968; Inoue and Hughes 1971; Pinkas et al. 1971). Gill and Hughes (1971) observed a sei whale feeding on a large school of sauries at the surface. The whale was subsequently killed—its stomach was filled with an estimated 227 kg of sauries 6 to 29 cm long. Rice (1977) reported the saury formed 9% of the food of sei whales off California, whereas the anchovy was dominant at 57%, and the krill at

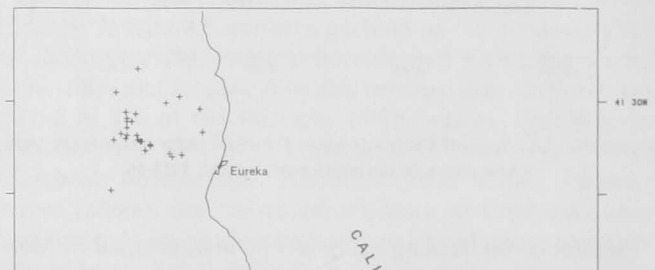

Figure 21.—Locations off California where 336 northern fur seals were collected whose stomachs contained Pacific saury, 1958-66.

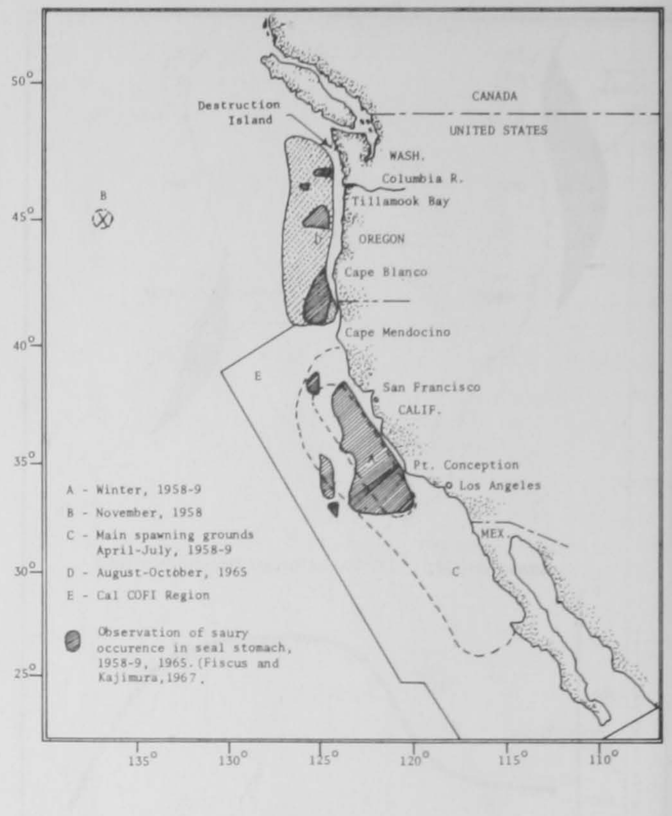

Figure 22.—Eastern Pacific stock of Pacific saury (from Inoue and Hughes 1971).

30%. Immature saury were reported by Frey (1971) to be a major food item of the albacore tuna, *Thunnus alalunga*.

Mais (1974) reported that a high percentage of successful night light stations contained the saury (48%). This was interpreted to be indicative of a large saury population but the study concluded that commercial concentrations were infrequent and erratic, resulting in a failure in the development of a commercial fishery off California. The reason for this lack of dense commercial concentrations was attributed by Trumble (1973) to the lack of large thermal boundaries comparable with that of the cold water-warm water boundary of the Kuroshio-Oyashio Current in the western Pacific Ocean.

Although Pacific saury eggs were found during all months of the year on CalCOFI surveys, 92% of the eggs were collected from February to July. Of these, 65% were taken during April, May, and June (Ahlstrom 1968). The coastal waters between lat. 26° and 40°N constituted the principal spawning grounds in the survey area. Areas off southern California and Baja California, Mexico, were reported to be nursery grounds containing mostly juveniles dispersed over a wide area. The largest concentrations of sauries were reported to be at distances of 64 to 193 km offshore (Frey 1971). Fur seals were most often seen from 70 to 130 km offshore near the continental shelf and slope.

Rockfishes.—Rockfishes ranked fourth in both volume and frequency as forage food of fur seals off California in 1965 (Fiscus and Kajimura 1967). All of the rockfish were immature juveniles (vertebral length from 47 to 99 mm); one seal stomach contained 137 of these small rockfish. Rockfish were most numerous in stomachs from seals collected off Monterey, Calif. (lat. 36°38′N, long. 121°55′W).

Rockfishes of the family Scorpaenidae form one of the important and largest fish families off California. Rockfishes are also considered a much underutilized fishery resource of California in terms of abundance (Frey 1971). This family is represented by three genera in California, with at least 55 species of *Sebastes* spp., a single species of *Scorpaena*, and 2 species of *Sebastolobus* (Phillips 1964; Frey 1971).

No estimate of the rockfish biomass has been made. It is known in general terms as a large resource, and because rockfish are a highly desirable food resource they are subjected to both commercial and sportfishing pressure. The larvae of *Sebastes* spp. have consistently ranked third or fourth in abundance in the CalCOFI survey area (Ahlstrom 1968). The commercial catch reached a maximum of 8 million kg in 1958 but since has dropped to about 4 million kg (Fig. 14). CalCOFI surveys show that the larvae of various species of rockfish occur in great abundance and are widely distributed along the coast as far as 500 km offshore. During their pelagic existence, rockfishes sometimes form a large and important part of the diet of chinook salmon, *Oncorhynchus tshawytscha*; albacore; and petrale sole, *Eopsetta jordani* (Phillips 1957).

Perhaps because of the numerous head spines of rockfishes, fur seals have always beheaded the adult rockfishes before swallowing them as only bodies have been found in their stomachs. This was generally the situation off Washington when rockfish was the principal prey species during February, March, and April (Table 6). As previously mentioned, most rockfish taken by fur seals off California were juveniles. Larval and juvenile rockfish were available from the surface to 140 m depth during CalCOFI survey cruises (Ahlstrom 1965).

Jack mackerel.—Jack mackerel is among the leading forage species of fur seals collected during April and June off California. The principal locations where this fish occurred, as indicated in stomachs of fur seals, are shown in Figure 23. The jack mackerel was second only to the anchovy in frequency of occurrence in midwater trawl catches conducted by CalCOFI scientists, with the highest catch rates and largest catches made in the southern and northern California regions (Mais 1974). Jack mackerel larvae are abundant in offshore regions from March through July (Kramer and Smith 1970).

Although the jack mackerel is widely distributed through the eastern North Pacific Ocean from Baja California, Mexico, to the Aleutian Islands (Fig. 24), it occurred in only one stomach of a fur seal north of California during 1958-74, probably because jack mackerel prefer warmer water and migrate into the Gulf of Alaska only in summer. Very few seals have been collected during summer in areas outside the Bering Sea.

Jack mackerel exhibit both coastal (north-south) and inshore-offshore movements. The larger and older fish are found offshore in deeper water, whereas the younger fish are generally found over rocky banks and shallow coastal areas (MacCall et al. 1980). Juvenile jack mackerel stay inshore (0-90 km) for the first 3 to 6 yr of their lives, gradually moving farther offshore with increasing age and size. Young fish commonly school beneath floating kelp in the open ocean (Mais 1974). Fur seals, which are often found in association with floating kelp, may be attracted by these juvenile jack mackerel.

The entire jack mackerel resource of the eastern Pacific Ocean was estimated between 2.1 and 4.8 million tons and the California and Baja California resource at 1.4 to 2.4 million

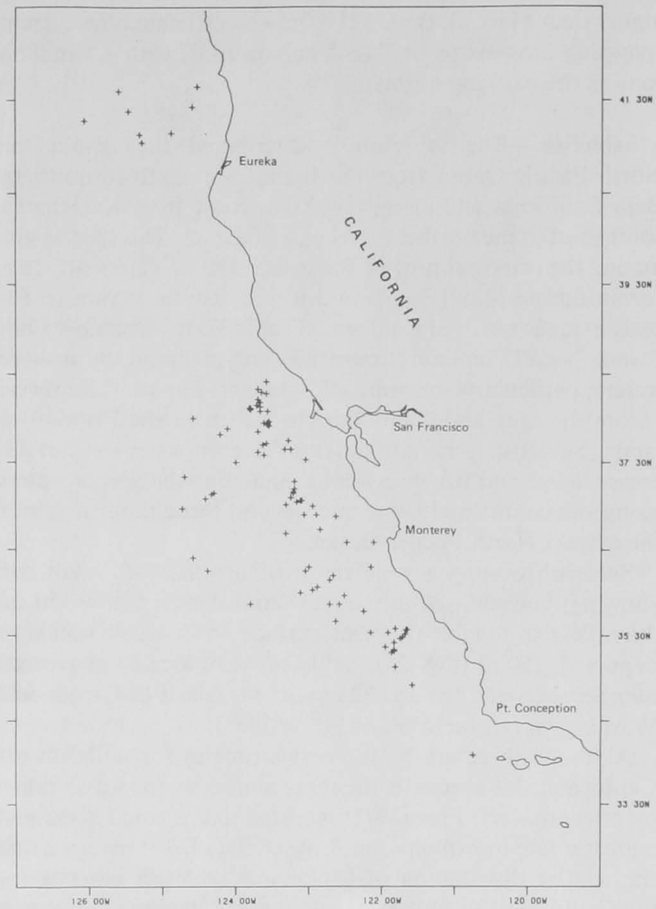

Figure 23.—Locations off California where 114 northern fur seals were collected whose stomachs contained jack mackerel, 1958-66.

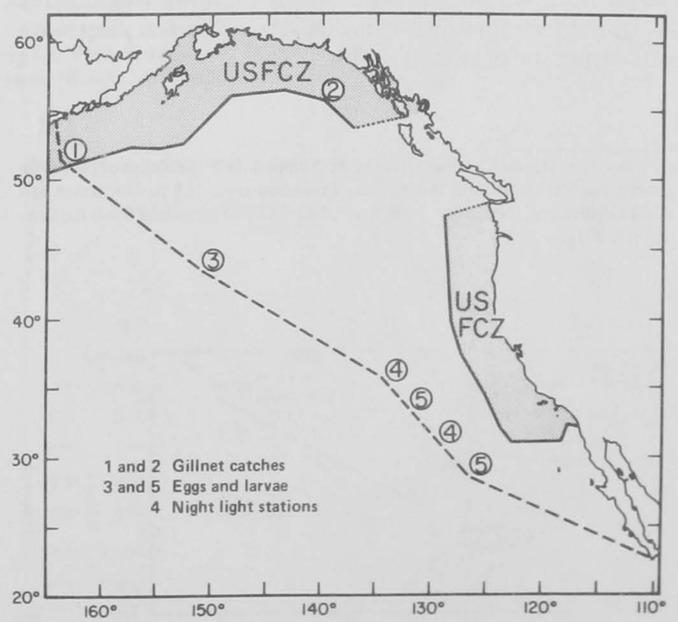

Figure 24.—Distribution of the jack mackerel resource (modified from MacCall et al. 1980).

tons (Ahlstrom 1968). Ahlstrom's estimate is considerably higher than MacCall et al.'s (1980), who estimated the current spawning biomass to be 1 to 2 million tons, with 1.5 million tons as the working estimate.

Sablefish.—The sablefish is distributed throughout the North Pacific Ocean from the Bering Sea south to northern Baja California and along the Asian coast from Kamchatka southward to the northeastern coast of Japan. This species was among the principal prey of fur seals taken in waters off California during May (Fig. 7) and it was also important to fur seals in areas north of California (Table 3). In waters off California, small immature sablefish are common in inshore waters, particularly in spring and summer. Fur seals, however, vacate the area about this time to return to the Pribilof Islands. Sablefish generally move to deeper water as they increase in age and size with adults inhabiting the deeper waters along the continental slope and beyond throughout much of the eastern North Pacific Ocean.

Sablefish occupy a wide range of depths, with adult fish showing daily diurnal movement from depths below 150 m. Juvenile fish inhabit the near surface and coastal waters to depths < 150 m (Fig. 25). Sablefish were located in greatest numbers between 366 and 823 m off the coasts of Oregon and Washington (Heyamoto and Alton 1965).

Although there are no biomass estimates for sablefish off California, this species is the most abundant roundfish taken by otter trawlers; Frey (1971) reported that it could withstand a greater rate of exploitation. Low et al. (1976)[12] reported that the relative distribution of exploitable sablefish biomass for the California-Vancouver and Bering Sea Region is 13% each —the Aleutian Region 7%, with the highest concentration located in the Gulf of Alaska contributing 67%.

Sablefish spawn from December to April, with peak activity occurring during January and February in deep water (250-750 m). There is no evidence of a spawning migration. They are relatively fast growing, attaining an average length of about 33 cm at the end of their first year and enter the fishery near the end of their second year when about 43 cm in length (Frey 1971). Fur seals prey on the smaller sablefish before they move into deeper water as mature fish.

[12]Low, L. L., G. K. Tanonaka, and H. H. Shippen. 1976. Sablefish of the northeastern Pacific Ocean and Bering Sea. Processed rep., 115 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

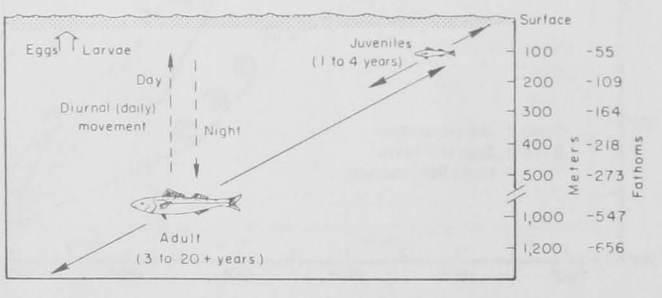

Figure 25.—Bathymetric distribution of sablefish (from Low et al. text footnote 12).

Oceanic squid.—The oceanic squids *Onychoteuthis* sp. and *O. borealijaponicus* were combined in this report for California (shown as *Onychoteuthis* sp. in Figure 7) as important food of fur seals during January and February. According to Young (1972), *O. borealijaponicus* is the only species found here, *O. banksii* replacing it in subtropical and tropical waters. Okutani and McGowan (1969) reported that *O. banksii* was the fifth most abundant squid in the CalCOFI survey area and was present throughout the entire California Current System. The occurrences of this squid in stomachs of fur seals taken off California are shown in Figure 26.

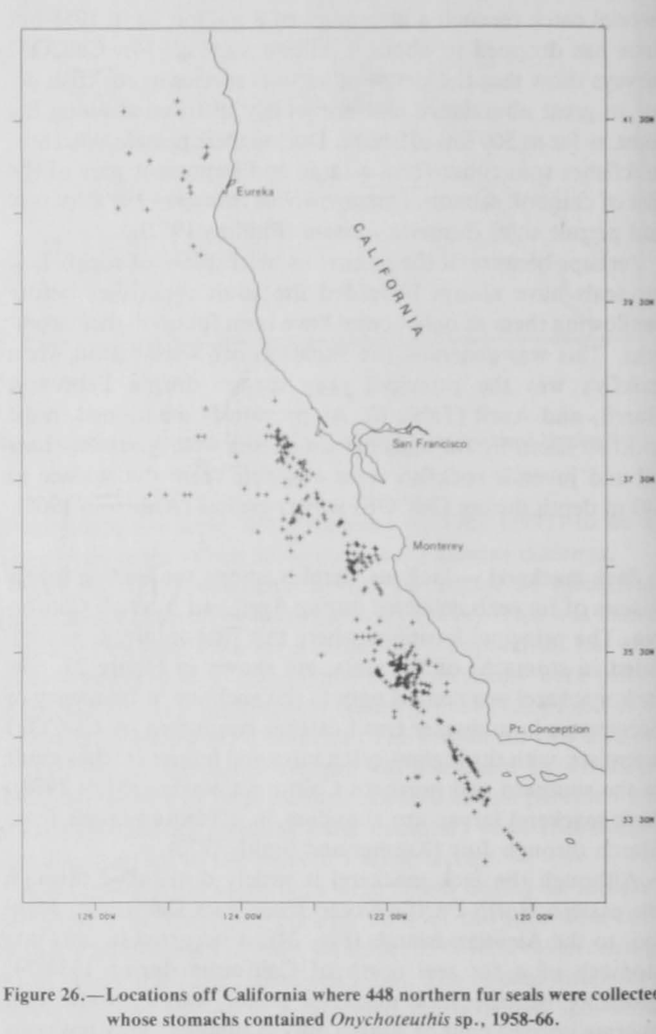

Figure 26.—Locations off California where 448 northern fur seals were collected whose stomachs contained *Onychoteuthis* sp., 1958-66.

Bering Sea

The Bering Sea marine fish fauna is made up of about 300 species of fish representing about 40 families (Quast and Hall 1972; Wilimovsky 1974). From this group, fur seals are known to prey on fish species from 17 families. Some have occurred only rarely in the stomachs of sampled seals while some species have occurred many times because of their abundance, migratory patterns, and spawning and feeding patterns—which coincide with the distribution, migratory, and feeding habits of fur seals (Table 10). Oceanic squids representing three genera from the family Gonatidae have also been identified in stomachs of fur seals from the eastern Bering Sea (Table 10).

Table 10.—Food of fur seals in the eastern Bering Sea, June-October 1958-74.

ood items	Months				
	June[1]	July	Aug.	Sept.	Oct.
ish:					
Entosphenus tridentatus	-	-	x	-	-
Clupea harengus pallasi	-	x	4	x	-
Salmonidae	-	x	x	-	-
Oncorhynchus spp.	x	-	x	x	-
O. gorbuscha	-	x	-	-	-
O. keta	-	x	x	-	-
O. nerka	-	x	x	-	-
Osmeridae	x	x	x	x	-
Mallotus villosus	1	2	3	3	1
Thaleichthys pacificus	-	x	x	x	x
Bathylagidae	-	x	x	x	-
Myctophidae	-	-	x	-	-
Lampanyctus sp.	-	-	x	-	-
Gadidae	-	x	x	2	-
Gadus macrocephalus	-	x	x	-	-
Theragra chalcogramma	3	1	1	1	-
Sebastes spp.	-	x	-	-	-
Anoplopoma fimbria	-	x	x	x	-
Hexagrammidae	-	x	x	-	-
Pleurogrammus monopterygius	2	x	x	x	2
Cottidae	-	x	x	-	-
Cyclopteridae	-	x	x	-	-
Aptocyclus ventricosus	-	-	x	-	-
Trichodontidae	-	-	x	-	-
Trichodon trichodon	-	-	x	-	-
Ammodytes hexapterus	x	x	x	x	x
Bathymasteridae	-	x	x	-	-
Anarchadidae	-	-	x	-	-
Anarhichas orientalis	-	-	x	x	-
Pleuronectidae	-	x	x	x	-
Hippoglossoides stenolepis	-	-	x	-	-
Reinhardtius hippoglossoides	-	x	x	x	-
Unidentified	x	x	x	x	x
ephalopods:					
Gonatidae	x	x	x	x	3
Gonatus sp.	-	x	x	x	x
Berryteuthis magister	4	4	2	x	3
Gonatopsis borealis	x	3	x	4	-
Unidentified squid	x	x	x	x	3
tomachs with food	69	924	1,441	375	29
tomachs with trace	17	364	560	145	3
tomachs without food	74	651	929	144	14

[1]Numerals indicate the ranking of principal prey species based on percentage of otal stomach content volume.

Other species of pelagic cephalopods known to inhabit the Bering Sea are deepwater species and therefore are probably not available to fur seals.

Three families of fish—Salmonidae, Gadidae, and Pleuronectidae—support the major commercial fisheries for finfish in the eastern Bering Sea. Pacific salmon, of course, are important in the Bristol Bay salmon fishery and northward into the Kuskokwim-Yukon area. The other two families make up the commercially important trawl fishery resource in the eastern Bering Sea. The relative abundance of the commercially important trawl or bottom fish resources in the Bering Sea is relatively well-known based on commercial fish catches and from U.S. research vessel surveys. The noncommercial species are not as well documented.

The rank order by frequency of occurrence (%) of the 20 most common fish species in the eastern Bering Sea (based on trawl catches) includes four of the principal forage species of fur seals. In order these are: First, walleye pollock (occurred in 91% of the stations fished); second, Greenland turbot (occurred in 78% of the stations fished); eleventh, Pacific herring (occurred in 37% of the stations fished); and capelin at seventeenth place occurred in 22% of the stations fished (Pereyra et al. 1976[13]). Principal forage species of fur seals not among the trawl catches include Atka mackerel, Pacific sand lance, deepsea smelt, salmon, and squids.

Although we know that trawls are selective (due to the inability to sample all substrates and incomplete sampling of the water column) and that estimates of standing stocks are representative only for those species which are accessible to the trawl, the total fish biomass for the Bering Sea was estimated at 4.4 million tons (Pereyra et al. footnote 13). Fishes of families Gadidae and Pleuronectidae accounted for over 90% of the Bering Sea fish catch. Based on trawl surveys, the highest biomass of fish was reported at the outer shelf region, subareas 2 and 3 (Fig. 27), which represented 63% of the fish biomass of the entire survey area. The average fish catch rate was highest in subarea 2.

Ichthyoplankton surveys conducted in the eastern Bering Sea are not as extensive as those conducted by CalCOFI off California. Waldron (1981), in summarizing ichthyoplankton studies conducted in the Bering Sea since 1955 by Japan, the U.S.S.R., and the United States, reported that the larvae of over one-third of the genera, over one-half of the families, and only about one-fifth of the species of fish present as adults in the Bering Sea have been collected and identified. Much of the ichthyoplankton surveys in the past have centered on walleye pollock. These surveys also show pollock (larvae and eggs) to be the most abundant taxa accounting for more than 95% of the catch (Waldron and Vinter 1978[14]).

In the Bering Sea, as for the waters off California, the location of fur seal collection influences the importance of different prey species as the principal forage food. If fur seals are

[13]Pereyra, W. T., J. E. Reeves, and R. G. Bakkala. 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975. Processed rep., 619 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[14]Waldron, K. D., and B. M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Processed rep., 88 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

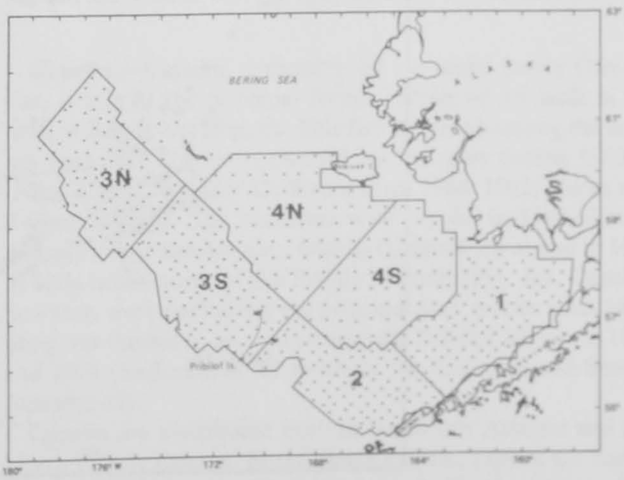

Figure 27.—Stations successfully trawled during the 1975 eastern Bering Sea baseline survey (from Pereyra et al. text footnote 13).

taken near the Aleutian Islands and Passes, the principal prey appear to be the Atka mackerel and capelin. If seals are taken beyond the shelf over deep water, the forage species will likely be oceanic squids of the family Gonatidae or deepsea smelts of the family Bathylagidae. Fur seals taken over the shelf are likely to be feeding on walleye pollock, Pacific herring, and Greenland turbot. The principal forage species utilized by fur seals in the eastern Bering Sea are shown in Table 3.

Walleye pollock.—Walleye pollock has been among the leading prey species (Fig. 28) during the 7 yr that fur seals were collected in the eastern Bering Sea (Niggol et al. 1960[15]; Fiscus et al. 1964, 1965; Fiscus and Kajimura 1965; Marine Mammal Biological Laboratory 1970; Kajimura et al. 1974[16]; and Kajimura and Sanger 1975[17]). The walleye pollock occurs as the leading prey species when fur seals are collected on the shelf or near the shelf edge. This fish was also the most frequently eaten prey of fur seals as reported by Lucas (1899).

Walleye pollock are widely distributed over the continental shelf in the eastern Bering Sea, forming schools near bottom during daylight and then dispersing into the water column at night (Smith 1981). Smith also reported that the seasonal movements of walleye pollock show that the shelf populations retreat to deep water along the outer shelf edge in winter. They move to the spawning areas along the outer shelf west and northwest of Unimak Island in spring and to the outer and central shelf in summer. In 1973 and 1974 when sampling was limited to an area around the Pribilof Islands, walleye pollock (and gadids which were most likely walleye pollock) were the leading forage species of fur seals, contributing 82 and 86% of the total stomach content volume. Fur seals forage on species other than walleye pollock when taken nearer the Aleutian Islands and the Aleutian Passes or beyond the shelf over deep water.

Walleye pollock is the most important demersal fish population in the eastern Bering Sea in terms of biomass and landings in the fishery and is the most abundant and most frequently occurring species in the eastern Bering Sea. Its biomass from the 1975 survey was estimated at 2.4 million metric tons (t) or 41% of the total fauna available to the trawl gear. Total biomass for all species was estimated at 5.9 million t (Pereyra et al. footnote 13). Various estimates of absolute population size of eastern Bering Sea walleye pollock based on research surveys, commercial fisheries catch data, and model estimates are shown in Table 11. This semipelagic fish is also the target of the largest single species fishery in the North Pacific Ocean, where the commercial catch peaked at more than 1.8 million t in 1972 and exceeded more than 1.2 million t in 1970 through 1976 (Table 12).

This species has a wide distribution extending from central California northward through the Bering Sea, Sea of Okhotsk, and the Sea of Japan (Hart 1973). Not only is it abundant in the Bering Sea (Fig. 29), it is also reported abundant at times near Kodiak Island. An 80 km long school of spawning walleye pollock (one to several kilometers wide and 75 m deep) was sighted on the west side of Shelikof Strait by the NMFS survey vessel *Miller Freeman* in mid-March 1980 (Fitzgerald 1980).

A 1975 NMFS trawl survey of the eastern Bering Sea found fish density highest in the area north of Unimak Island (subarea 2) of all subareas sampled. The presence of a large bio-

[15]Niggol, K., C. H. Fiscus, T. P. O'Brien, and F. Wilke. 1960. Pelagic fur seal investigations—Alaska 1960. Unpubl. rep., 60 p. U.S. Fish Wildl. Serv., Mar. Mammal Biol. Lab., Seattle, Wash. (Avail. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.)

[16]Kajimura, H., G. Sanger, and C. H. Fiscus. 1974. Part 5. Pelagic, Bering Sea. *In* Marine Mammal Division, Fur seal investigations, 1973, p. 31-47, 71-95. Unpubl. rep. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[17]Kajimura, H., and G. Sanger. 1975. Part 5. Pelagic—Bering Sea. *In* Marine Mammal Division, Fur seal investigations, 1974, p. 38-54, 102-122. Unpubl. rep. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

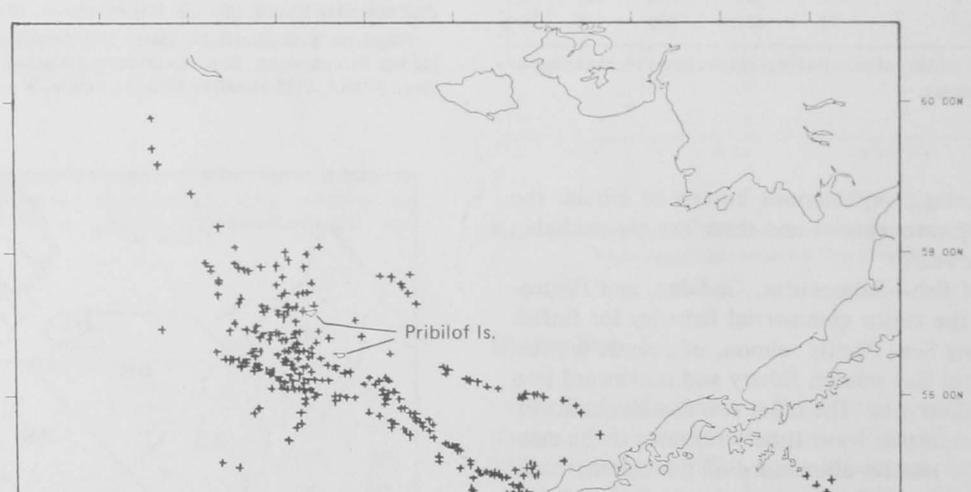

Figure 28.—Locations where 503 northern fur seals were collected whose stomachs contained walleye pollock, 1958-74.

Table 11.—Summary of estimates of absolute population size for eastern Bering Sea walleye pollock (from Smith 1981).

Source	Region and time period[1]	Method[2]	Estimated population (X 10⁶ t)
Based upon research survey data			
Pereyra et al. 1976[3]	Eastern Bering Sea shelf, Unimak Pass to 61°N (August-October 1975)	1	2.426
Bakkala and Smith 1978[4]	Eastern Bering Sea shelf, Unimak Pass to 59°N (April-June 1976)	1	0.679
Okada 1978[5]; Nunnallee 1978[6]	Aleutian Basin (June-July 1978)	1	0.840
Based upon commercial fisheries data			
Chang 1974	Eastern Bering Sea shelf, INPFC areas 1 and 2 (1969-1970)	1	2.3-2.6
Chang 1974	Eastern Bering Sea shelf, INPFC areas 1 and 2 (1970)	2	2.3-2.4
Low 1974	Eastern Bering Sea, primarily INPFC areas 1 and 2 (1964-1971)	1	3.45-5.83
Based upon model estimates			
Laevastu and Favorite 1977[7]	Eastern Bering Sea shelf	3	8.235

[1]A description of INPFC (International North Pacific Fisheries Commission) statistical areas is given in Forrester et al. (1978).

[2]Estimation methods: 1 = "area swept" (Baranov 1918; Alverson and Pereyra 1969); 2 = "cohort analysis" (Pope 1972); 3 = "model fitting" based upon commercial fisheries data.

[3]Pereyra, W. T., J. E. Reeves, and R. G. Bakkala. 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975. Processed rep., 619 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA 2725 Montlake Blvd. E., Seattle, WA 98112.

[4]Bakkala, R. G., and G. B. Smith. 1978. Demersal fish resources of the eastern Bering Sea: spring 1976. Processed rep., 234 p. plus 534 p. append. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[5]Okada, K. 1978. Preliminary report of acoustic survey and mid-water trawl on pollock stock of the Aleutian Basin and adjacent waters in summer of 1978. Unpubl. manuscr., 13 p. [In Jpn., Engl. summ.] Jpn. Fish. Agency, 2-1, Kasumigaseki, Chiyoda-Ku, Tokyo, Jpn.

[6]Nunnallee, E. P. 1978. Report on observations aboard the Japanese research vessel *Tomi Maru 52* during a Bering Sea (Aleutian Basin) pollock survey conducted in June-July 1978. Unpubl. manuscr., 31 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[7]Laevastu, T., and F. Favorite. 1977. Preliminary report on dynamical numerical marine ecosystem model (DYNUMES II) for eastern Bering Sea. Processed rep., 81 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Table 12.—Summary of annual catch (metric tons) of walleye pollock from the eastern Bering Sea by trawl fisheries, 1964 to 1979.[1] (From Smith 1981.)

Year	Japan	U.S.S.R.	Republic of Korea	China, Taiwan	Poland	Total
1964	174,792	0	0	0	0	174,792
1965	230,551	0	0	0	0	230,551
1966	261,678	0	0	0	0	261,678
1967	550,362	0	0	0	0	550,362
1968	700,981	0	1,200	0	0	702,181
1969	830,494	27,295	5,000	0	0	862,789
1970	1,231,145	20,420	5,000	0	0	1,256,555
1971	1,513,923	219,840	10,000	0	0	1,743,763
1972	1,651,438	213,896	9,200	0	0	1,874,534
1973	1,475,814	280,005	3,100	0	0	1,758,919
1974	1,252,777	309,613	26,000	0	0	1,588,390
1975	1,136,731	216,567	3,438	0	0	1,356,736
1976	913,279	179,212	85,331	0	0	1,177,822
1977	868,732	63,467	45,227	944	0	978,370
[2]1978	821,306	92,714	62,371	3,040	0	979,424
[3]1979	(774,630)	(60,000)	(85,000)	(5,000)	(25,000)	(950,000)

[1]Bakkala, R., L. Low, and V. Wespestad. 1979. Condition of groundfish resources in the Bering Sea and Aleutian area. Unpubl. manuscr., 107 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[2]Preliminary estimates.

[3]Foreign fishing allocations (Pileggi and Thompson 1979).

mass of fish in this area throughout most of the year may be due to its richness as a foraging area as well as to the fact that it is generally ice-free throughout the year. Zooplankton, such as copepods and euphausiids, and planktivorous fishes, like capelin and Pacific herring, are abundant throughout the year.

Capelin.—Capelin, a member of the smelt family Osmeridae, is one of the principal forage species of fur seals in the eastern Bering Sea (Fig. 8). This fish occurred among the leading four prey species consumed by fur seals during 1960-64 (Niggol et al. footnote 15; Fiscus et al. 1964, 1965; Fiscus and Kajimura 1965). The occurrences of capelin in 1960-63 were primarily near the Aleutian Islands (Unimak Pass) and in 1964 in seals taken north of the Pribilof Islands (Fig. 30). Capelin, however, were not among the principal prey species when sampling was limited to an area around the Pribilof Islands in 1973 and 1974 (Kajimura et al. footnote 16; Kajimura and Sanger footnote 17).

Capelin are distributed both in the North Atlantic and the North Pacific Oceans. In the North Pacific, capelin are found from off Washington (Strait of Juan de Fuca) northward to arctic Alaska and Kamchatka and in the Okhotsk Sea southward to Korea (Hart 1973). This fish is considered an arctic

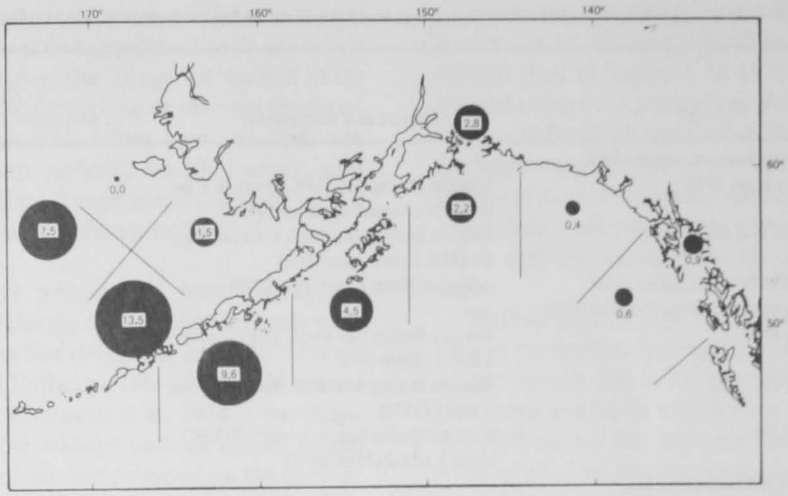

Figure 29.—Apparent density (t/km²) of walleye pollock in various regions in the eastern Bering Sea and the Gulf of Alaska as suggested from NMFS bottom trawl surveys (1973-78) at depths of 400 m and less (modified from Alton 1981).

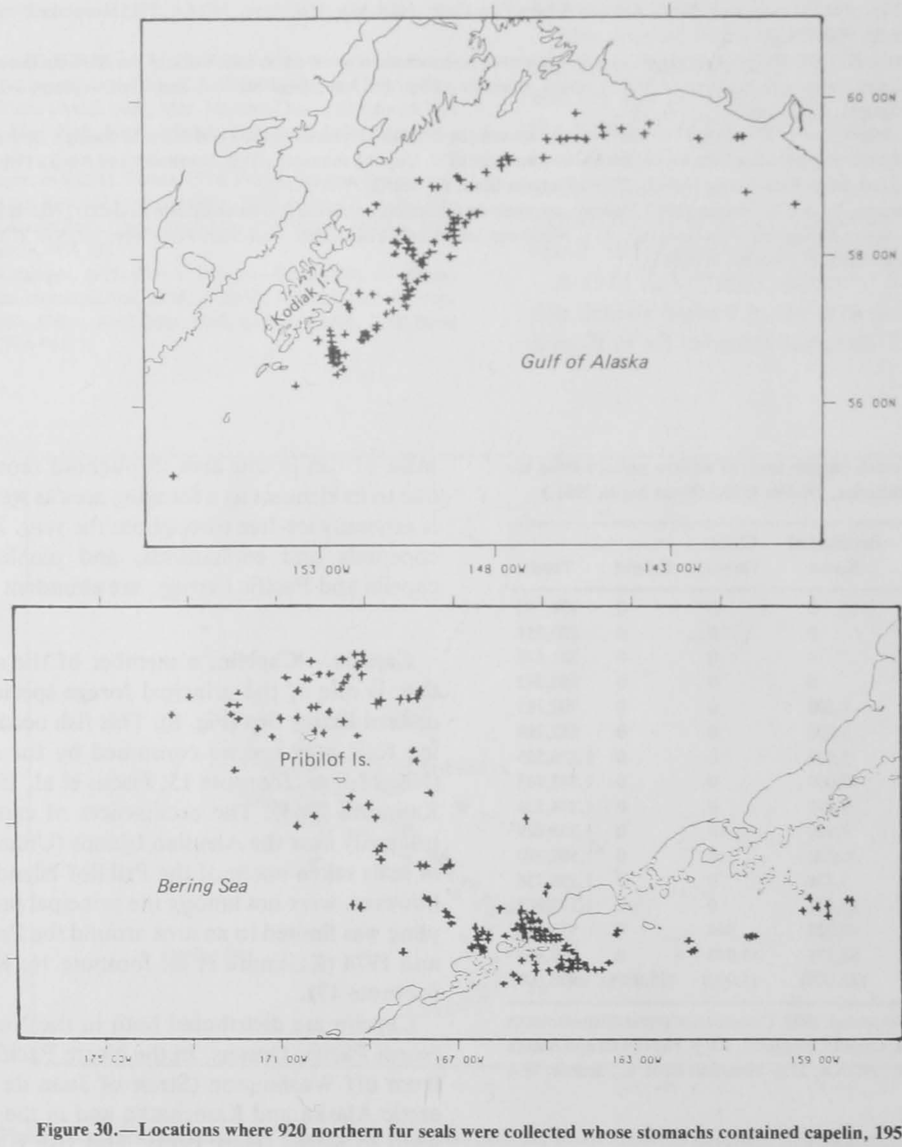

Figure 30.—Locations where 920 northern fur seals were collected whose stomachs contained capelin, 1958-74.

species with its center of abundance in the Bering Sea (along the Aleutian Islands) or Arctic Ocean (Hart and McHugh 1944). Capelin are a bathypelagic (benthopelagic) fish during most of the year and are located near the bottom, moving inshore as the spawning period approaches (Andriyashev 1954; Trumble 1973; Macy et al. 1978[18]). In some parts of the range, capelin spawn from April to October, spawning on beaches composed of fine gravel at high tide. In southern British Columbia, this fish spawns in late September and/or early October (Hart and McHugh 1944; Hart 1973).

Capelin ranked 17th by frequency of occurrence (%) of the 20 most common taxa in the eastern Bering Sea survey conducted in 1975 (Pereyra et al. footnote 13). Little is known as to the relative abundance of capelin in the Bering Sea but the species was observed in large numbers along the Alaska coast in shallow water at about the same time as spawning Pacific herring (Barton and Steinhoff 1980). Based on the analysis of fur seal feeding studies and because it is also an important link in the food chains of the North Pacific and Bering Sea for many fishes, marine mammals, and seabirds (Ainley and Sanger 1979; Kawamura 1980; Kajimura et al. 1980), capelin is probably a large and important resource in the North Pacific Ocean and associated seas. Based on an ecosystem model, Laevastu and Favorite (1980) estimated the pelagic fish species, consisting primarily of capelin and Pacific sand lance, biomass to be 4.3 million t for the Bering Sea. Capelin was also found in stomachs of humpback whales (Nemoto 1957). Capelin is not fished commercially but is considered an excellent food by those who capture them on the spawning beaches.

During an ichthyoplankton survey of the Bering Sea in 1977, capelin was the only smelt collected and its larvae were among the largest caught, ranging from 31 to 65 mm in length. The larvae are known to move offshore to deeper water after hatching but little is known of the deepwater phase of the life cycle of this fish. Eighty-six percent of the capelin were caught at night, primarily over the continental shelf within about 140 km (75 mi) of Unimak Pass. The larvae of this species were the sixth most abundant taken (Waldron and Vinter footnote 14).

[18]Macy, P. T., J. M. Wall, N. D. Lampasakis, and J. E. Mason. 1978. Resources of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea, Part 1. Unpubl. manuscr., 335 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Atka mackerel.—Atka mackerel was second only to capelin as the principal forage species based on percentage of total stomach content volume for seals collected in Unimak Pass and beyond the shelf area between the Aleutian and the Pribilof Islands during 1962 (Fiscus et al. 1964). When sampling was limited to a distance of 55 km around the Pribilof Islands in 1974, Atka mackerel was the third ranking principal forage species of fur seals. This species was found in the stomachs of seals taken south and west of St. George Island along the shelf edge in 1974 (Fig. 31).

Atka mackerel is distributed from off California northward to the Bering Sea and in the Sea of Japan (Miller and Lea 1972). During the breeding season it is concentrated in waters off the Aleutian Island chain from Attu to Unimak Islands, the Alaska Peninsula, the Shumagin Islands, and Kodiak Island and is widespread in the open ocean at other times. Evermann and Goldsborough (1907) reported that at Atka Island the larger males arrive first in May to await the females' arrival on the spawning grounds which is always near the various passes in the Aleutian Islands. They also reported that sea lions, killed at various times throughout the winter, frequently had stomachs filled with Atka mackerel, an indication that some fish stay near the Aleutian passes year-round. Larkins (1964) reported Atka mackerel catches incidental to high seas salmon gillnet sampling as the fourth most abundant species caught. Chum, *Oncorhynchus keta*, sockeye, *O. nerka*, and pink salmon, *O. gorbuscha*, were numbers 1, 2, and 3, respectively. Atka mackerel catches were more abundant in gillnet catches in the southern Bering Sea-Aleutian areas than in the northern or southern portion of the Gulf of Alaska.

Ichthyoplankton surveys in 1955-78 were summarized by Waldron (1981) who reported that Atka mackerel larvae were caught at 118 stations on 11 cruises in winter, spring, and summer from late February to August. These larvae were distributed from the Aleutian Islands to lat. 62°N and from long. 160°W in Bristol Bay to long. 175°E. In 1977, larvae of the family Hexagrammidae were the second most numerous larvae caught with Atka mackerel larvae consisting of about 29% of the Hexagrammidae catch (Waldron and Vinter footnote 14). The larvae were relatively large, ranging from 12 to 30 mm in length, and were caught at stations throughout the survey area during April and May over the shelf and extending well beyond the continental slope. The highest abundance was

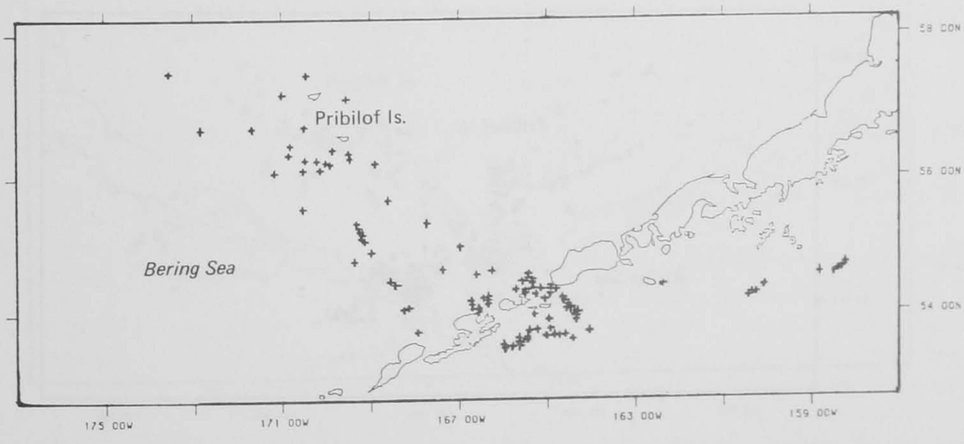

Figure 31.—Locations where 133 northern fur seals were collected whose stomachs contained Atka mackerel, 1958-74.

reported over the shelf during April and over the outer shelf in May.

To take advantage of the Atka mackerel's breeding habits, the commercial fishery for this species is centered near the Aleutian Islands (most abundant near Atka Island area) and near the Shumagin Islands and Kodiak Island. Commercial catches by Soviet vessels were reported at about 21,000 t in 1977 and the catch quota for the Aleutian area was set at 24,000 t in 1979 (Bakkala et al. 1979). The commercial catch of Atka mackerel in the Gulf of Alaska averaged 20,600 tons per year in 1974-78 (Alton 1981).

Atka mackerel and Pacific saury are the most commonly found fish prey of humpback and sei whales in the eastern North Pacific Ocean. The former is considered one of the favorite foods of humpback whales in waters off the western Aleutians and south of Amchitka Island (Nemoto 1957). Based on U.S. pelagic fur seal studies, it appears that fur seals collected in the Aleutian Islands passes during the summer months (June through October) prey principally on Atka mackerel.

Oceanic squids.—Oceanic squids constitute some of the principal forage foods of fur seals not only in the eastern Bering Sea but throughout their range wherever seals are taken seaward of the continental shelf over deep water (Table 2). The one exception is the market squid, *Loligo opalescens*, which is found principally on the shelf. In the eastern Bering Sea, only squids of the family Gonatidae have been identified in stomachs of fur seals. Although only gonatid squids have been found in stomachs of fur seals, eight other families of squids, which include 14 to 15 additional species, have been identified from stomachs of sperm whales taken in the Bering Sea-Aleutian Island areas (Okutani and Nemoto 1964; Kodolov 1970).

Squids of the family Gonatidae are found in the subarctic waters of the North Pacific Ocean and Bering Sea and include about 12 species representing three genera: *Gonatus*, *Berryteuthis*, and *Gonatopsis* (Young 1972; Okutani 1973; Naito et al. 1977; Anderson 1978; Bublitz 1981). In the Bering Sea, squids representing each genera have been identified in fur seal stomachs. These are *Gonatus* spp., *Berryteuthis magister*, and *Gonatopsis borealis* (Figs. 32, 33, 34). The latter two species have been among the principal forage species of fur seals collected during June to October 1958-74 in the Bering Sea (Fig. 7).

Berryteuthis magister was also among the principal forage species of fur seals in the western Alaska area (Fig. 8). Al-

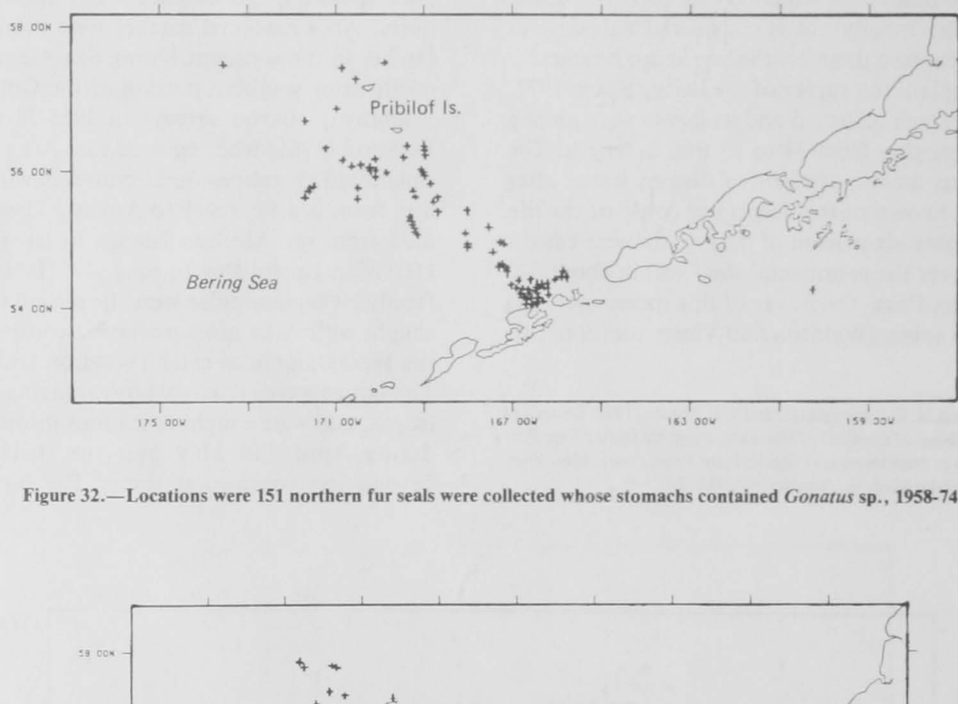

Figure 32.—Locations were 151 northern fur seals were collected whose stomachs contained *Gonatus* sp., 1958-74.

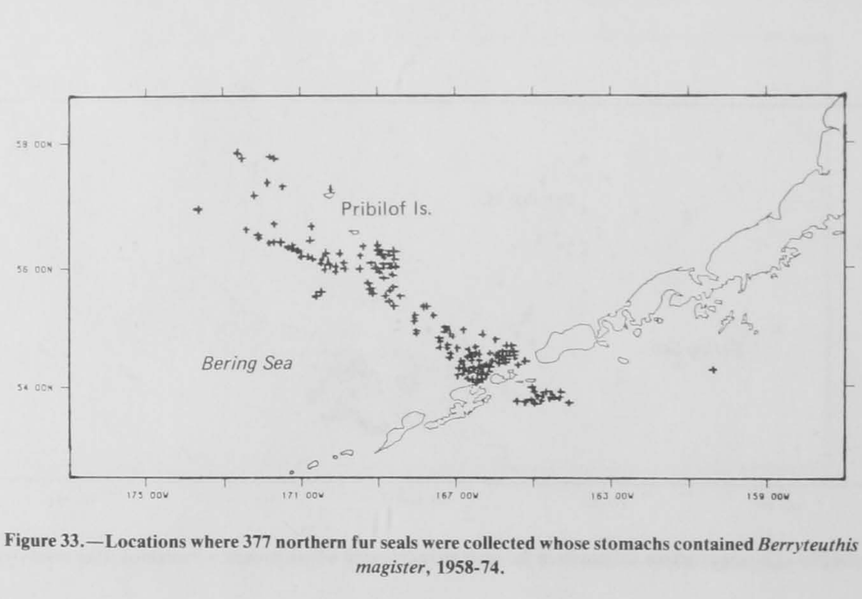

Figure 33.—Locations where 377 northern fur seals were collected whose stomachs contained *Berryteuthis magister*, 1958-74.

though gonatid squids have occurred throughout the fur seals' range, squids of this family were not among the four principal forage species in the areas south of Alaska.

Oceanic squids of the family Onychoteuthidae, *Onychoteuthis* sp. and *Onychoteuthis borealijaponicus*, are principal prey species of fur seals off California, Washington, and British Columbia (Figs. 7, 9, 10).

The oceanic squid fauna of the North Pacific Ocean and the Bering Sea are poorly known but the population of some pelagic squids can probably be considered large based on information obtained from the analysis of stomach contents of marine mammals and seabirds. Sanger (cited in Mercer 1981[19]) presented information on the trophic relationship of seabirds and squids based on stomach contents of seabirds collected in the Gulf of Alaska and the Bering Sea from 1975 through 1978. Sanger estimated that consumption of squids by seabirds during the summer in Alaska was at least 53,000 t. The population of the two species of gonatid squids, *B. magister* and *G. borealis*, can be considered a major resource based on fur seal feeding data collected during 1958-74 in the eastern Bering Sea. Even in the first feeding studies of fur seals in the Bering Sea, it was revealed that squids were principal forage species (Lucas 1899). Currently *B. magister* is fished commercially by Japan along the shelf edge in the Bering Sea.[20] Fiscus (1982) summarized the known predation by 25 marine mammals on squids and the possible predation by 20 other marine mammals in the eastern North Pacific Ocean and Bering Sea. He also discussed the species of squids that may be sufficiently abundant enough to support a commercial fishery.

Sperm whales are known to feed primarily on squids and should give a good indication of the available benthic squid fauna of the area. Kawakami (1980), in reviewing sperm whale feeding, reported that the frequency of squids in sperm whale stomachs was between 71 and 94% of total stomach contents in sperm whales taken in the Bering Sea-Aleutian area and 32% for the Gulf of Alaska. The occurrence of squid and fish in stomachs of sperm whales taken in the Gulf of Alaska and the Bering Sea-Aleutian area shown in Figure 35 gives some indication of the distribution of squids.

Based on estimated catch per unit of effort (CPUE) data by Japan and the United States (in subareas 2, 3S, and 3N (Fig. 27) in the 100 to 400 fathom (183-732 m) depth zone commonly fished by Japanese and U.S. vessels), the estimated squid biomass ranged from 16,842 to 27,037 t. The commercial catch of squids was about 9,000 t in 1978 and has dropped to about 5,000 t in recent years (Bakkala footnote 20). The gonatid squid *B. magister* is fished near the shelf edge while *O. borealijaponicus* is fished near the Aleutian Islands.

Pacific herring.—Pacific herring is important in the food web throughout its range as it is one of the primary forage foods of many animals in the marine environment including fishes, marine mammals, and seabirds. Pacific herring has been among the principal forage foods of fur seals in the eastern Bering Sea, southeastern Alaska (Sitka Sound), and especially important to fur seals off Washington and British Columbia, Canada (Tables 6, 7).

The importance of Pacific herring as forage food of fur seals off the Washington-British Columbia coast (Fig. 36) can be attributed to an abundant adult herring population estimated at about 350,000 tons and the fact that the main feeding grounds for juvenile and immature herring was located off the Strait of Juan de Fuca and in Hecate Strait (Hourston and Haegele 1980). About 200,000 tons of adults (19 billion fish) are found in several major concentrations of individual schools (each containing up to 10,000 tons) scattered along the edges of banks extending along 100 mi of coast off the Strait of Juan de Fuca. These aggregations move north or south during the summer presumably following their food supply with adult herring returning to their offshore feeding grounds in April and May. The abundance of herring in this area is probably the principal reason that Pacific salmon are also leading forage prey of fur seals off Washington and British Columbia (Figs. 9, 10). Both herring and salmon apparently feed on the rich zooplankton in the area. The Hecate Strait population (100,000 tons) is thought to be similar (Hourston and Haegele 1980).

In the Bering Sea, Pacific herring was one of the principal foods consumed by fur seals taken during August (Fig. 8), north and east of St. Paul Island. This fish represented 31% of

[19]Mercer, R. W. (editor). 1981. Proceedings of the squid workshop. NWAFC Processed rep. 81-11, 34 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[20]R. G. Bakkala, Northwest and Alaska Fish. Cent., NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, pers. commun. October 1981.

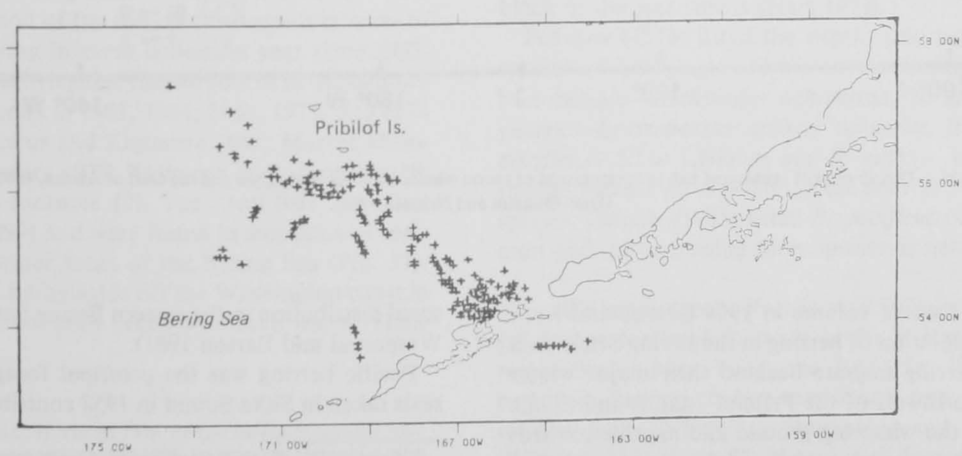

Figure 34.—Locations where 473 northern fur seals were collected whose stomachs contained *Gonatopsis borealis*, 1958-74.

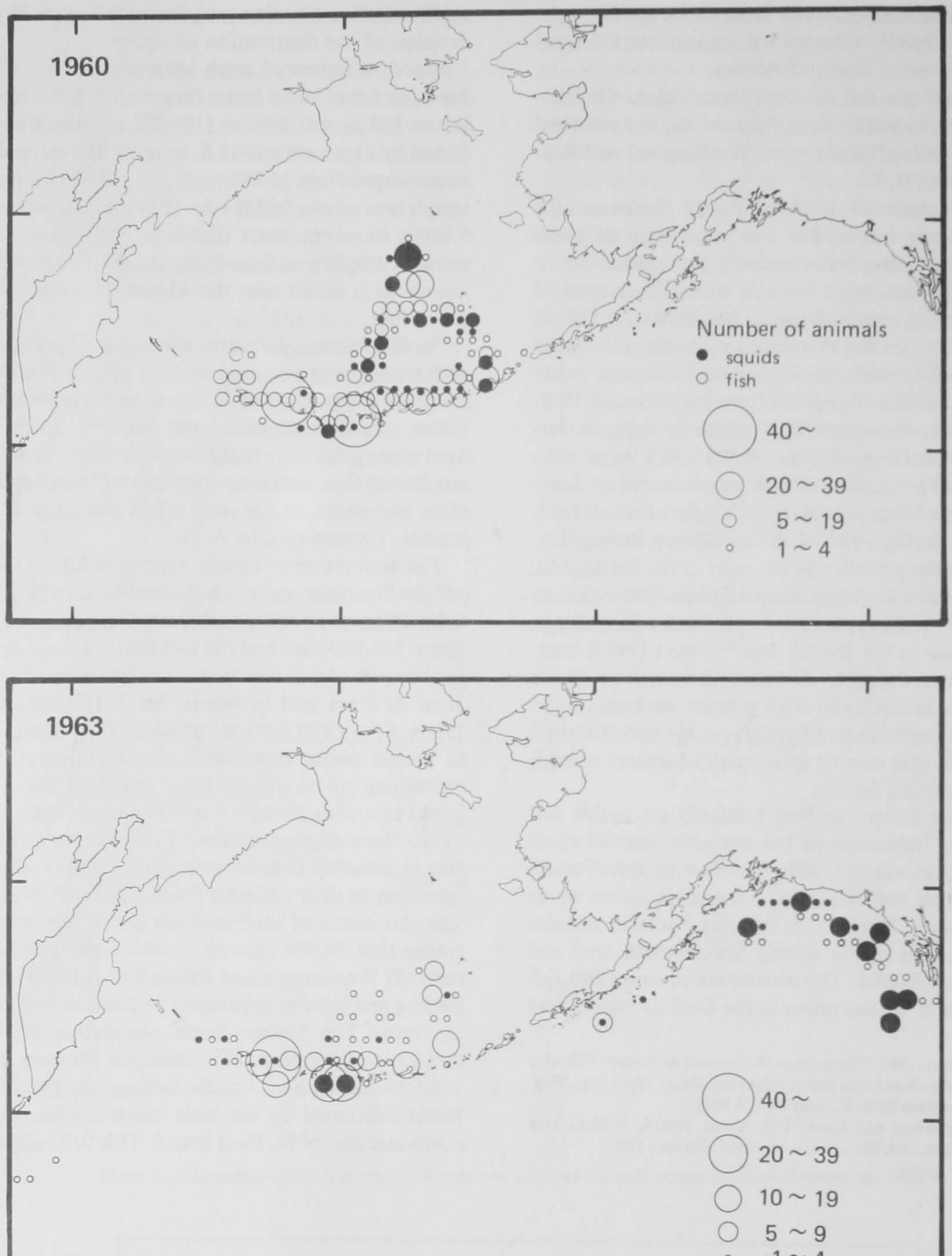

Figure 35.—Distribution of squids and fish in the stomachs of sperm whales from the Bering Sea and the Gulf of Alaska, 1960 and 1963 (from Okutani and Nemoto 1964).

the total stomach content volume in 1964 (Fiscus and Kajimura 1965). The migration of herring in the Bering Sea is such that in August, herring migrate back to their major winter grounds located northwest of the Pribilof Islands and in late March, they leave the wintering ground and migrate towards the coast where they spawn on intertidal vegetation during spring and early summer. Temperature apparently plays a major role in influencing the time of spawning and the seasonal distribution in the eastern Bering Sea (Wespestad 1978[21]; Wespestad and Barton 1981).

Pacific herring was the principal forage fish eaten by fur seals taken in Sitka Sound in 1958 contributing nearly 46% of

[21]Wespestad, V. G. 1978. Exploitation, distribution and life history features of Pacific herring in the Bering Sea. Processed rep., 25 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

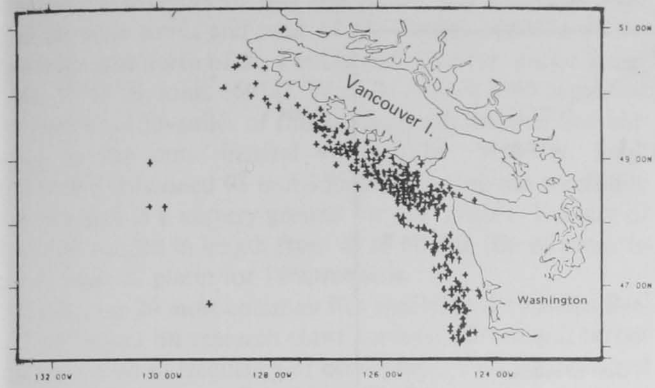

Figure 36.—Locations where 628 northern fur seals were collected whose stomachs contained Pacific herring, 1958-74.

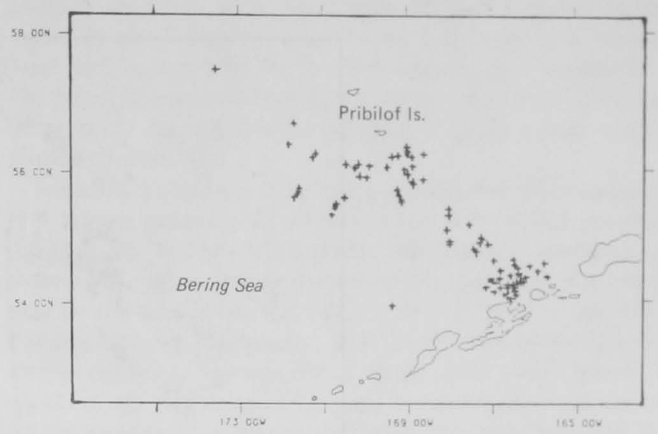

Figure 37.—Locations where 169 northern fur seals were collected whose stomachs contained deepsea smelt, 1958-74.

the total stomach content volume for seals taken in this area (Wilke et al. 1958[22]). As shown in Figure 11, herring was the principal food during February and March as based on samples which came mostly from Sitka Sound.

Pacific herring is distributed in coastal waters from Baja California, Mexico, northward along the North American coast into the Arctic Ocean and southward along Asian coastal waters to Korea, Japan, and the Sea of Okhotsk (Hart 1973). In the eastern North Pacific, the major concentrations of herring abundance are reported from Puget Sound, Washington, northward to Dixon Entrance and in the Bering Sea (Wespestad and Barton 1981; Hourston and Haegele 1980).

Pacific herring are taken by commercial fisheries in southeastern Alaska, Prince William Sound, and the Kodiak Island areas where concentrations of herring become abundant on the spawning grounds (Reardan 1981a, b). At present the commercial herring fishery in Alaska and British Columbia is primarily for eggs-on-kelp (kazunoko kombu), sac-roe (kazunoko), and the bait fishery. The first two fishery products are exported to Japan and the bait is generally used in the domestic commercial and sport fishery. There is no important food fishery for herring in Alaska but, in British Columbia, a small portion of the catch is sold for human consumption and as animal food to aquariums and zoos.

Deepsea smelts (Bathylagidae).—Deepsea smelts or "seal fish" are important food of fur seals in the deepwater areas of the Bering Sea occurring in every collection year since 1963. Fishes of the family Bathylagidae ranked fourth in importance by volume as food species in 1963, 1964, 1968, 1973, and 1974 (Fiscus et al. 1965; Fiscus and Kajimura 1965; Marine Mammal Biological Laboratory 1970; Kajimura et al. footnote 16; Kajimura and Sanger footnote 17). The "seal fish" was first reported by Lucas (1899) and were found in stomachs of seals taken from the deepwater areas of the Bering Sea (Fig. 37). The 10 occurrences of bathylagids off the Washington coast in May 1972 were also from seals taken over deep water. These fish were not among the principal forage prey of seals taken off Washington in 1972.

Jordan and Gilbert (1899) described a new species of bathylagid which they named *Therobromus callorhinus* "seal fish" because it was described from vertebrae found in stomachs of fur seals taken in the Bering Sea. Chapman (1943) subsequently identified this "seal fish" as a species of *Bathylagus*. The identification of bathylagids in stomachs of fur seals taken in the Bering Sea in 1963 was the first reported occurrence since *T. callorhinus* "seal fish" was reported by Lucas (1899) from seals collected over deep water in the same area. Lucas reported "seal fish" as the third most frequent prey eaten by fur seals; walleye pollock and squid ranked numbers 1 and 2 ahead of the "seal fish." The "seal fish" were from deep water areas between lat. 54°43′ and 55°29′N, and long. 167°41′ and 170°53′W.

Species of the genus *Bathylagus* of the family Bathylagidae are bathypelagic offshore in the northeast Pacific Ocean ranging from Baja California, Mexico, and north into the Bering and Okhotsk Seas (Hart 1973). Chapman (1943) and Rass (1967) reported bathylagid fishes (genus *Bathylagus*) as widespread in the world oceans from the Bering and Norwegian Seas to Antarctica. Fishes of this family are small in size (length 12-25 cm), usually found in deep water, and called black or deepsea smelts (Hart 1973).

Fedorov (1973) listed the depths and habitat for the four species of bathylagids found in the Bering Sea as follows: Mesopelagic—*Bathylagus ochotensis*, 30 to 1,000 m; bathypelagic—*Leuroglossus stilbius schmidti*, 0 to 1,800 m; *B. pacificus*—50 to 1,604 m; and *B. milleri*—60 to 1,420 m. Although there is no estimate on the relative abundance of these species, Grinols (1965) listed *B. pacificus* occurrence as common and the remaining three species as not rare.

Pacific sand lance.—Pacific sand lance is one of the principal forage foods of fur seals in the western Gulf of Alaska region during May, June, and July (Fig. 38). In 1958, 1960, and 1962, fur seals fed on sand lances near Sanak Island and on Portlock, Albatross, Shumagin, and Davidson Banks (Wilke et al. footnote 22; Niggol et al. footnote 15; and Fiscus et al. 1964). The Kodiak Island shelf region is an area of abundant zooplankton and high biological productivity (Kendall et

[22]Wilke, F., K. Niggol, and C. H. Fiscus. 1958. Pelagic fur seal investigations—California, Oregon, Washington and Alaska, 1958. Unpubl. rep., 96 p. U.S. Fish Wildl. Serv., Mar. Mammal Res., Seattle, Wash. (Avail. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.)

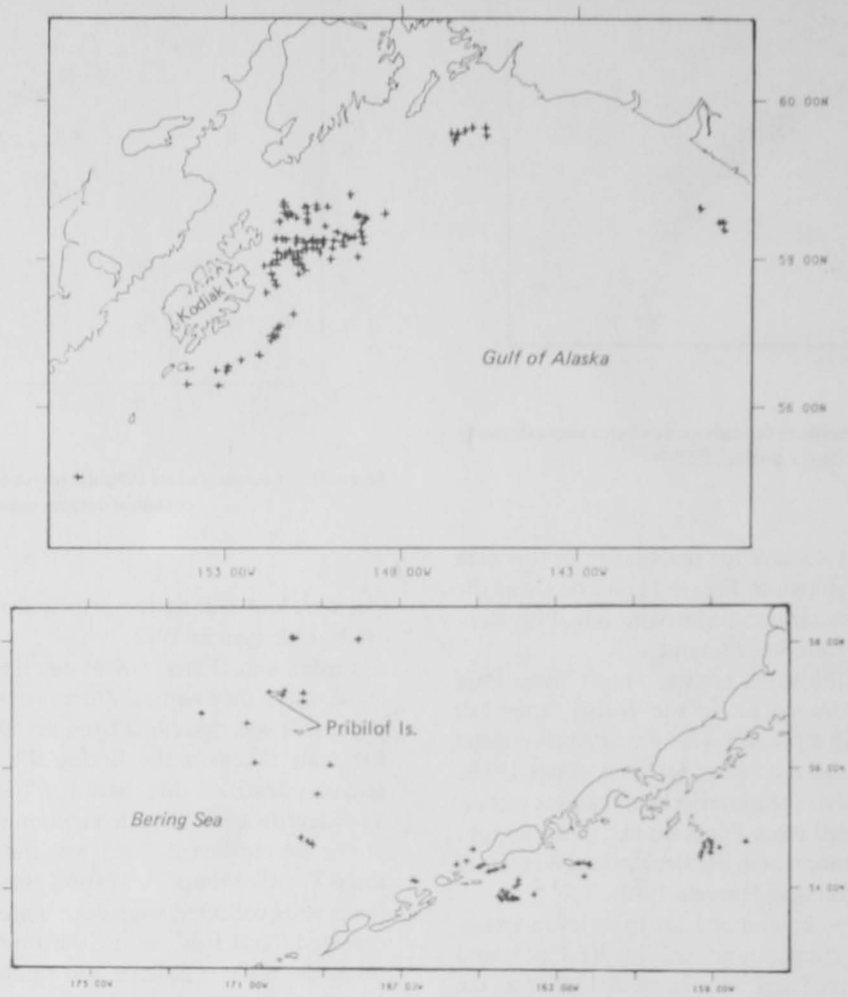

Figure 38.—Locations where 581 northern fur seals were collected whose stomachs contained Pacific sand lance, 1958-74.

al. 1980[23]). The abundance of sand lance in this region is probably due to ideal oceanographic conditions, the rich zooplankton which is the primary food of sand lance, and the available sandy bottom habitat needed by this species.

The Pacific sand lance is distributed in coastal waters from southern California northward to the Bering Sea, Aleutian Islands, Kurile and Commander Islands, and Okhotsk and Japan Seas (Hart 1973). This fish is widely distributed through the high latitudes of the Northern Hemisphere. The Atlantic species, American sand lance—*Ammodytes americanus*, which is commonly called sand eel, is fished commercially; the North Pacific species is not fished but probably could support a commercial fishery. Although no estimate of the relative abundance of this fish is available for the Gulf of Alaska, Laevastu and Favorite (1980) estimated capelin and sand lance biomass at about 4.3 million t for the Bering Sea. Sand lances in common with many of the other smaller fishes, form large schools both inshore and offshore and is an important link between lower and higher trophic level predators including salmon, halibut, seabirds, and marine mammals (Ainley and Sanger 1979; Hart 1973). This species was reported as one of the favorite foods of minke (piked) whales off Japan (Omura and Sakiura 1956).

[23]Kendall, A. W., Jr., J. R. Dunn, R. J. Wolotira with J. H. Bowerman, Jr., D. B. Dey, A. C. Matarese, and J. E. Munk. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed rep. 80-8, 393 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Greenland turbot.—Seven species of flatfishes of the family Pleuronectidae are among the 20 most common fish taxa in the eastern Bering Sea (based on trawl surveys conducted in 1975). Fur seals, however, generally have not preyed on these demersal species to any great extent. This is probably because of the fur seals' habit of swallowing fish whole. The general shape of flatfishes would make it difficult for fur seals to swallow those that are older than the juvenile stage. The only exception is juvenile Greenland turbot. Other species of pinnipeds (northern sea lion, *Eumetopias jubatus*, and harbor seal, *Phoca vitulina*), do feed on these flatfishes.

The first occurrence of Greenland turbot was noted in stomachs of fur seals taken north of the Pribilof Islands in 1963 and has occurred as prey of fur seals from the same general area in subsequent collections in 1964, 1973, and 1974 (Fiscus et al. 1965; Fiscus and Kajimura 1965; Kajimura et al. footnote 16; and Kajimura and Sanger footnote 17). In 1973, this fish was the fourth ranking principal finfish foraged by fur seals. The principal occurrences of this fish in fur seal stomachs were from an area south and west of St. George Island near the shelf edge and north of St. Paul Island. One fur seal collected at lat. 58°03′N, long. 169°47′W on 24 August 1963 contained 500 individual juveniles of this species while another seal collected in the same general vicinity (lat. 58°03′N, long. 169°50′W) contained 98 individuals indicating the possibility that this area is a nursery ground for this species. The size of these fish ranged in length from 45 to 60 mm (tip of snout to end of hypural plate) for 14 specimens.

Among the 20 most common fish species in the eastern Bering Sea (based on research trawl surveys), Greenland turbot ranked second in frequency of occurrence. This fish occurred in 78% of the stations fished in 1975 (Pereyra et al. footnote 13). In ichthyoplankton surveys the larvae of this species was the third most abundant flatfish larvae caught. The larvae were large, ranging in length from 16 to 22 mm and were primarily taken from the Aleutian Islands northwestward to north of St. George Island (Waldron and Vinter footnote 14).

In the eastern Bering Sea, adult Greenland turbot are considered deepwater flounders that mainly occupy continental slope waters whereas juveniles generally occupy the shelf area. Bakkala et al. (1979) reported that the highest trawl survey catches for this species occurred northwest of the Pribilof Islands.

The Greenland turbot is an amphiboreal species occurring in the North Atlantic and North Pacific Oceans. In the North Pacific Ocean, adults generally occur primarily in the northern portion of the species' range, in deep waters of the Pacific Ocean from Baja California, Mexico, to Honshu Island, Japan, through the Okhotsk and Bering Seas (Hubbs and Wilimovsky 1964; Hart 1973). Relatively few adults have been taken by trawl fisheries in the warmer portions of its range.

DISCUSSION AND SUMMARY

Although northern fur seals feed on a variety of fishes and squids throughout their range, evidence presented on the abundance and distribution of the principal prey species suggests that fur seals are opportunistic feeders preying on the most available species in the area. The principal prey species for this study were selected based on the percentage of total stomach content volume (fourth largest) by month for each of the seven collection areas.

In examining the variety of prey consumed by fur seals throughout the eastern Pacific range, about 53 species of fish and 10 species of squid have been identified from the stomachs of fur seals. From this total, about 14 species of fish and 6 species of squid are considered the principal prey of fur seals. The list of principal prey species of fur seals in each of these areas, as based on percentage of total stomach content volume, generally does not change over time even though the ranking by volume within this list may change. Some species are important in more than one area. Some are fished commercially while others are not of commercial importance but are important forage food for many other predators including fishes, seabirds, and other marine mammals.

The predominance of single food items in the stomachs of fur seals may reflect the availability and abundance of fish-squid species more than it reflects the selection or preference of one particular species over another. It is obvious that the prey that fur seals are observed to eat is selected from a larger group of species based on size. Some selection may also occur on the basis of factors such as taste and texture; however, these factors can only be studied through experimentation. The important point is that within the set of species known to occur in the fur seal diet the available evidence points to opportunistic feeding.

Location is also important in considering diet of fur seals, as prey species generally differ in abundance from area to area (north-south; inshore-offshore) and seasonally. The migratory patterns of forage species must also be considered since they may be available to fur seals only at certain times of the year. For example, off Washington, Pacific whiting migrate into the area in the spring and become available to fur seals. Generally speaking, the migration of fur seals is probably not influenced by the movement of migratory fishes on which they feed although the evolution of fur seal migration may have resulted from preference to feed upon selected prey species. There is no documentation concerning this subject. Taylor et al. (1955) and NPFSC reports (North Pacific Fur Seal Commission 1962, 1969, 1971, 1975, 1980) have shown that a small percentage of Pribilof Island fur seals intermingle with Asian seals, an indication that food is probably not a major factor in the migration of fur seals. Local movement and distribution is probably simply a result of the abundance of the forage species in the area. Fur seals move to and feed in areas where food is abundant and depart in search of other areas of concentrated prey when it becomes scarce.

Northern fur seals occupy the subarctic waters of the North Pacific Ocean southward to the California-Mexican border (lat. 32°N) in the eastern Pacific and to about the middle of Honshu Island (lat. 36°N), Japan, in the western Pacific. In the eastern Pacific, the Pribilof Island population (the major breeding islands) numbers about 1.3 million animals or nearly 80% of the world population of this species. The U.S.S.R. controls the breeding islands used by the remaining fur seals (population of about 485,000) in the western Pacific.

The eastern Pacific populations of northern fur seals are found throughout their range from California to the Bering Sea in nearly all months of the year with few exceptions and with peak abundance varying by time and area. Most of the Pribilof Island fur seals spend about half the year at sea (November through May-June) and the remainder on and around the islands during the breeding season. Fur seals are most frequently seen in greatest numbers along the continental shelf and slope throughout their range primarily because of abundant food resources in this area. Fur seals feed on a variety of fishes and squids throughout their range and as a general rule, smaller schooling fishes are usually the principal forage species over the continental shelf region and oceanic squids are important over deepwater areas seaward of the continental shelf and slope.

Fur seals feed primarily at night, perhaps due to the fact that many forage species rise toward the surface after dark and become readily available to fur seals which feed primarily in the epipelagic and mesopelagic zones. In the majority of fur seal stomachs examined, the total volume of food in stomachs is generally highest in fur seals collected soon after daylight, generally diminishes by mid-afternoon and increases again towards dusk as the seals resume their feeding activities. Fur seals usually swallow the smaller prey whole below the surface and bring the larger prey to the surface where they first break them into smaller pieces.

The leading four prey species consumed by fur seals during the six collection years off California contributed 82 to 99% of the total stomach content volume. From a total of 26 species of fish and 8 species of squid identified in stomachs of fur seals taken off California, only 6 species of fish and 2 species of squid are considered the principal prey of fur seals in this area. These principal forage species included northern anchovy, Pacific whiting, the market squid, Pacific saury, jack mackerel, rockfishes, sablefish, and the oceanic squid, *Onychoteuthis* sp. The first three species were among the four leading forage species during every monthly collection off California.

Similarly for the Bering Sea, the principal prey species contributed 75 to 99% of the total stomach content volume during the seven collection years. From a total of 23 species of fish and 3 species of squid identified in stomachs of fur seals taken in the Bering Sea, only 5 species of fish and the 3 species of squid were considered the principal prey of fur seals in this area. These principal forage species included walleye pollock; capelin; Atka mackerel; oceanic squids *Gonatus* spp., *Berryteuthis magister*, and *Gonatopsis borealis*; and Pacific herring. Deepsea smelt of the family Bathylagidae and salmon were among the principal forage species during annual collections but not when all years' data were combined by month for the Bering Sea. Salmon occurred among the principal forage food of fur seals in 1960 and deepsea smelt in 1963, 1968, 1973, and 1974. Greenland turbot was important in 1973.

Off Oregon, the collections of fur seals were relatively small as seals were collected while vessels were enroute between Washington and California. Of the 14 species of fish and 7 species of squid identified in stomachs of fur seals taken in this area, Pacific whiting, rockfish, northern anchovy, and squids were the principal foods.

Off Washington, the principal forage species contributed 64 to 99% of the total food volume. From a total of 33 species of fish and 10 species of squid identified in stomachs of fur seals taken in this area, only 8 species of fish and 1 species of oceanic squid were considered the principal prey of fur seals. The principal prey species included Pacific herring, rockfish, northern anchovy, capelin, eulachon, salmon, Pacific whiting, sablefish, and squid, *Onychoteuthis* sp.

Off British Columbia, the principal prey species contributed 66 to 95% of the total food volume. From a total of 15 species of fish and 4 species of squid identified in stomachs of fur seals taken in this area, 9 species of fish, the market squid, and the oceanic squid were considered the principal prey of fur seals off British Columbia. The principal forage species included Pacific herring; eulachon; salmon; squids, *Loligo opalescens* and *O. borealijaponicus*; sablefish; rockfish; walleye pollock; Pacific cod; Pacific whiting; and Pacific saury.

In the Gulf of Alaska, the principal prey species contributed 89 to 99% of the total food volume. From a total of 21 species of fish and 5 species of squid identified in stomachs of fur seals taken in this area, 7 species of fish including Pacific sand lance, capelin, Pacific herring, walleye pollock, Atka mackerel, rockfish, and salmon were the principal fishes while *Gonatus* spp. and *B. magister* were the principal squids.

In the western Alaska region, principal prey species contributed 77 to 99% of the total food volume. From the 19 species of fish and 3 species of squid identified in stomachs of fur seals taken in this area, 7 species of fish and 1 species of squid ranked as principal prey. The principal forage species included Pacific sand lance; capelin; squid, *B. magister*; Atka mackerel; walleye pollock; Pacific salmon; Pacific herring; and sablefish.

The major fish-squid resources as related to the principal forage species of fur seals off California and in the Bering Sea were discussed and included the known distribution, abundance, and migratory movements for each prey species as an aid in understanding the feeding habits of fur seals. In addition the principal forage species of fur seals off Washington, British Columbia, the Gulf of Alaska, and western Alaska were briefly discussed.

The major fish-squid resources off California (as determined from bottom trawl, midwater hydroacoustical, and CalCOFI surveys) in order of relative abundance are 1) northern anchovy, 2) Pacific whiting, 3) rockfishes, 4) jack mackerel, 5) Pacific saury, and 6) market squid.

The northern anchovy was the most abundant, and the largest fishery resource in the California Current System followed by the Pacific whiting which consistently ranked second to anchovy in annual estimates of relative abundance in the area surveyed. Although there was no estimate of rockfish biomass, it is known in general terms to be large. The jack mackerel, which is of widespread occurrence off California, was second only to the anchovy in frequency of occurrence in midwater trawl catches. Pacific saury was considered to be the fifth most abundant species as determined from CalCOFI surveys. The market squid, found over the continental shelf, was reported as probably the most abundant squid off the California coast.

The rank order by frequency of occurrence (%) of the 20 most common fish taxa in the eastern Bering Sea trawl catches included four principal forage species of fur seals. In order these are: First, walleye pollock (occurring in 91% of the stations fished); second, Greenland turbot (occurring in 78% of the stations fished); eleventh, Pacific herring (occurring in 37% of the stations fished); and seventeenth, capelin (occurring in 22% of the stations fished). The principal forage species of fur seals not among the trawl catches included Atka mackerel, Pacific sand lance, deepsea smelt, salmon, and oceanic squids.

Based on the principal prey species of fur seals (as determined from stomach contents) and the relative abundance of the fish-squid resources off California and the eastern Bering Sea (based on ocean surveys), we must conclude that fur seals are opportunistic feeders, foraging on the most abundant fish-squid species available to fur seals in an area. Opportunistic feeding by fur seals on the most abundant and available species prevails throughout their range in the eastern North Pacific Ocean and eastern Bering Sea.

NOTE ADDED IN PRESS

The 1983 Draft Environmental Impact Statement (DEIS) on the Interim Convention on Conservation of North Pacific Fur Seals[24] shows a decline in the Pribilof and Robben Island populations of fur seals to 975,000 and 84,000, respectively. The Commander Islands (325,000), Kurile Islands (54,000), and San Miguel Island (4,000) all show population increases.

[24]National Marine Fisheries Service. In Prep. Draft Environmental Impact Statement on the Interim Convention on Conservation of North Pacific Fur Seals. U.S. Dep. Commer., NOAA, NMFS, Wash., D.C.

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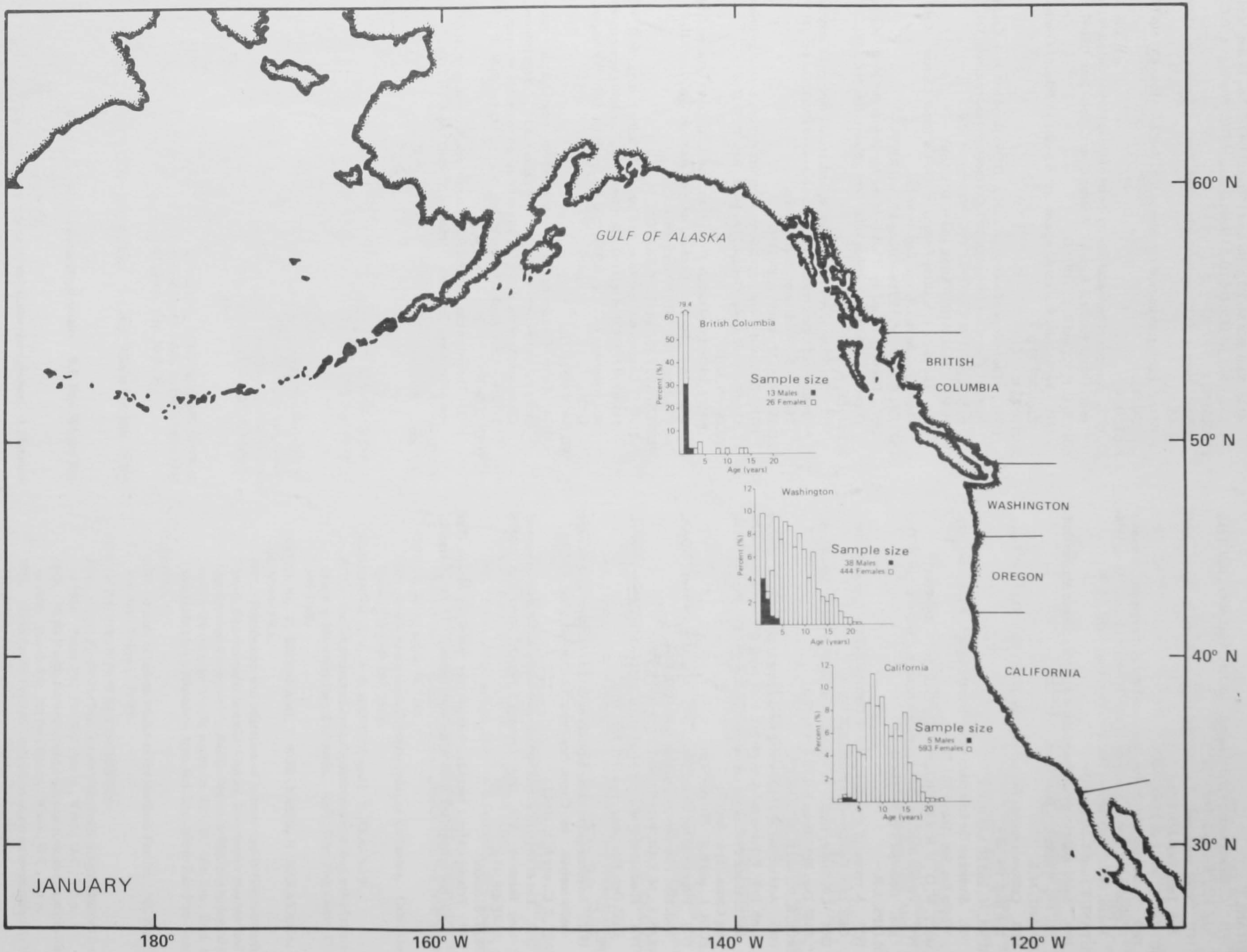
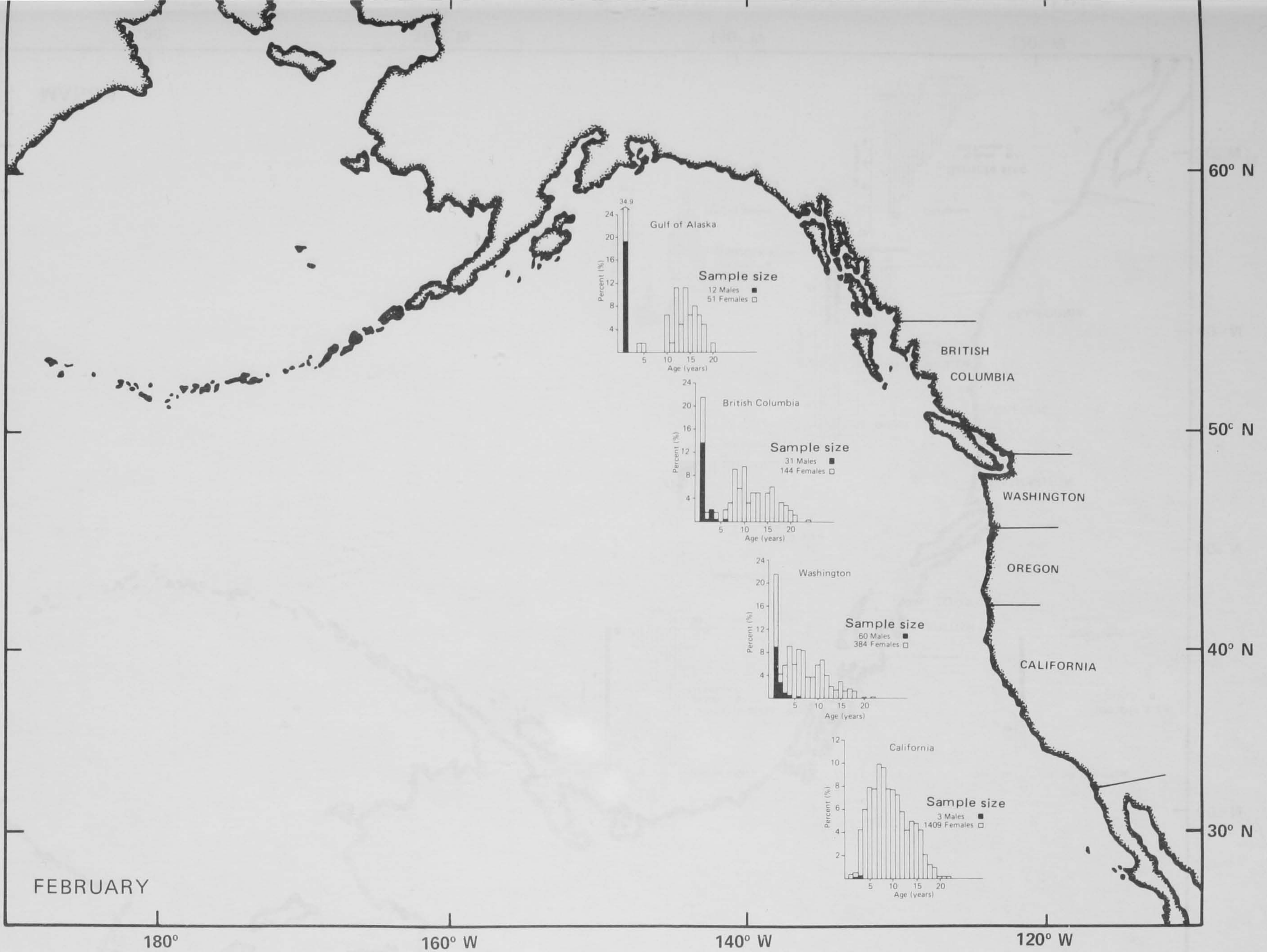
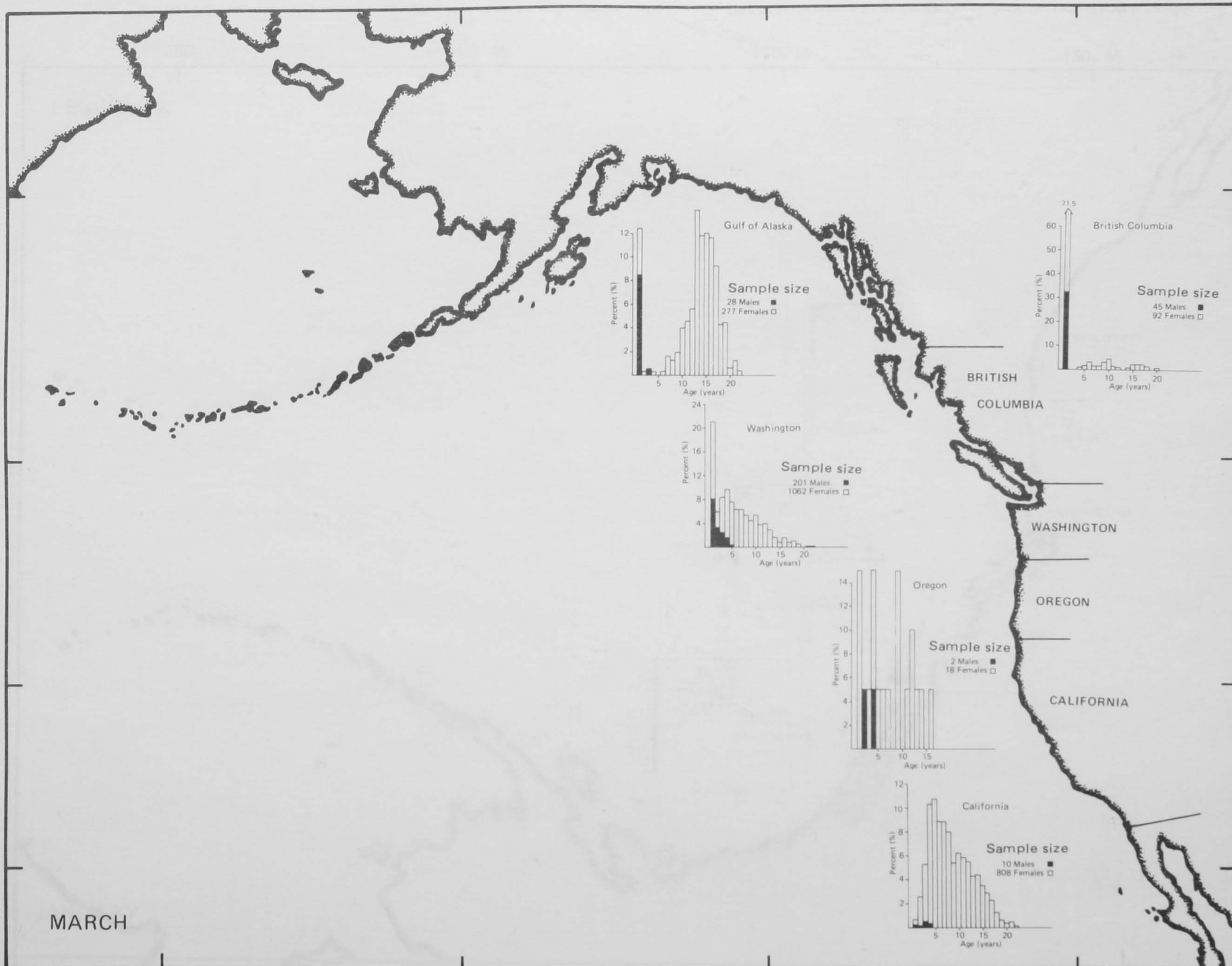


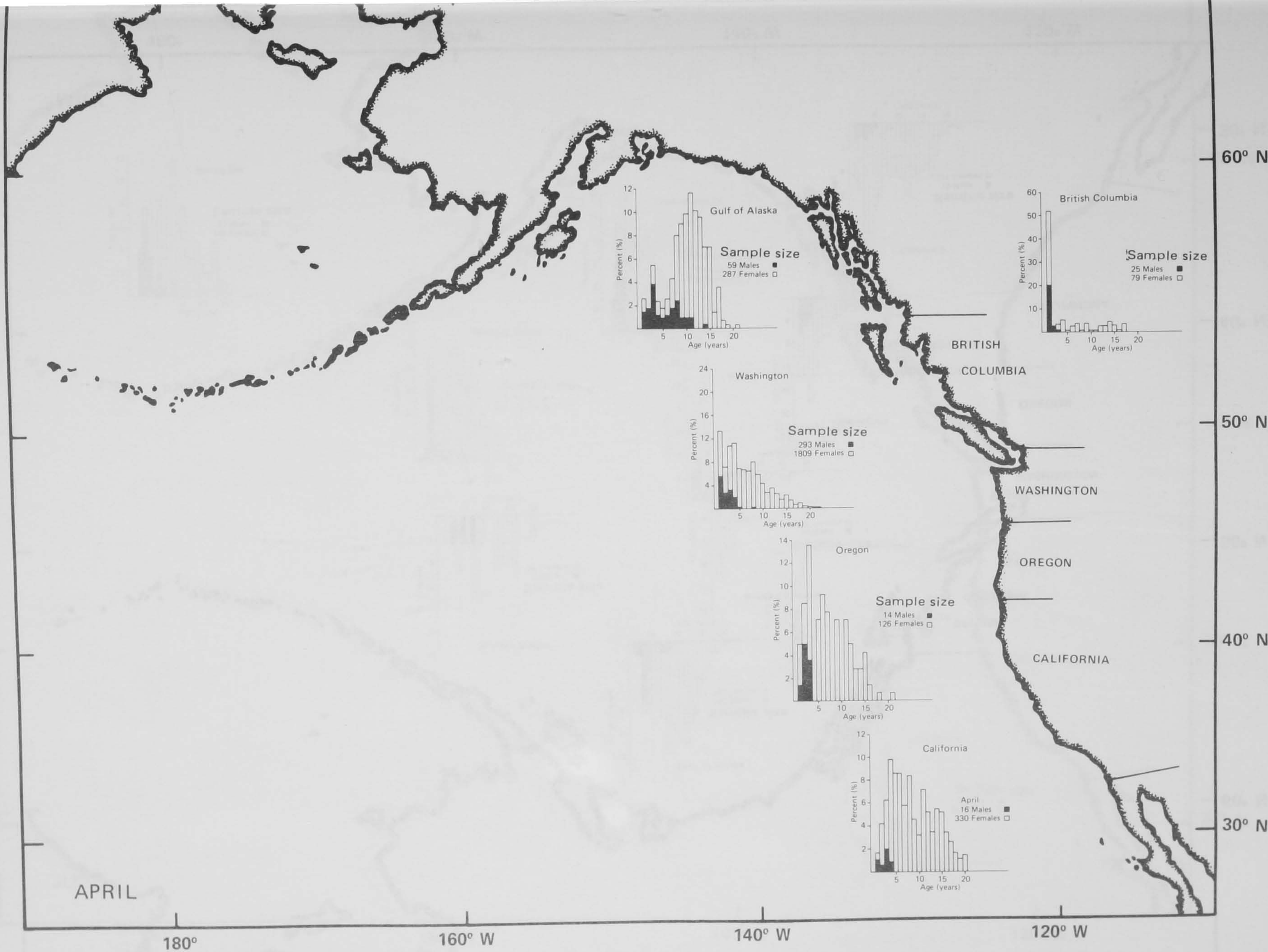
Appendix Figure 1.—Age and sex composition of northern fur seals collected during January 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



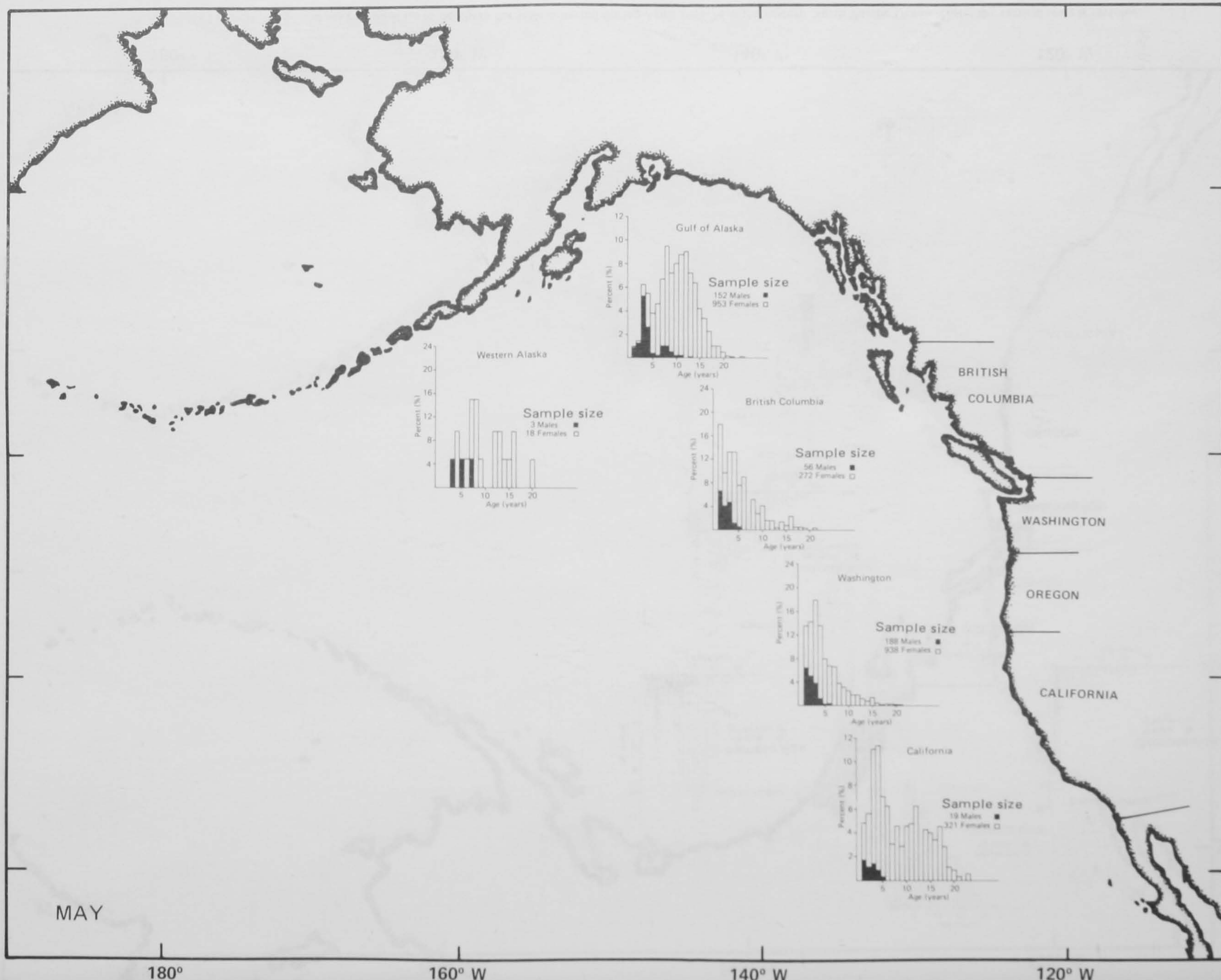
Appendix Figure 2.—Age and sex composition of northern fur seals collected during February 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



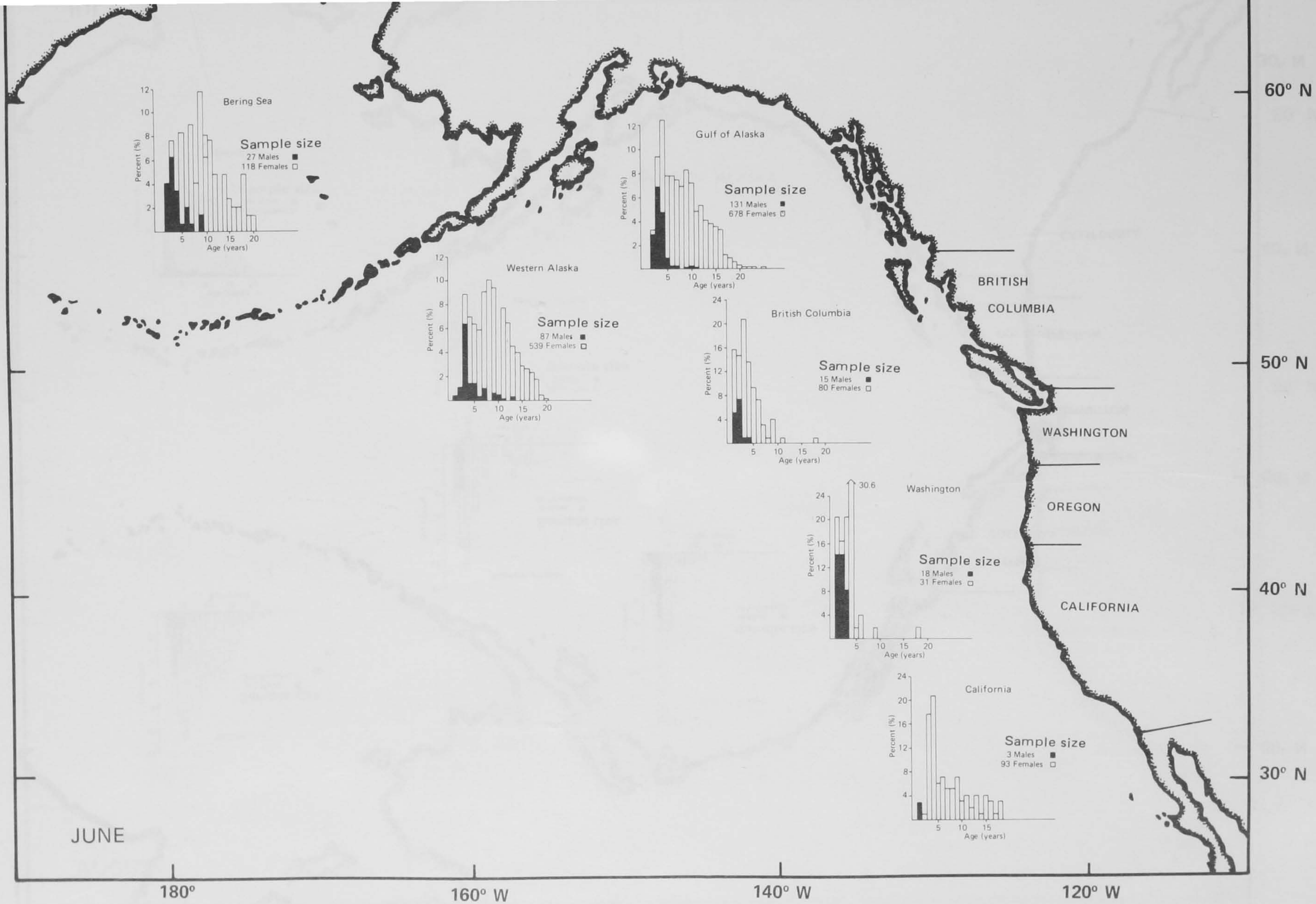
Appendix Figure 3.—Age and sex composition of northern fur seals collected during March 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



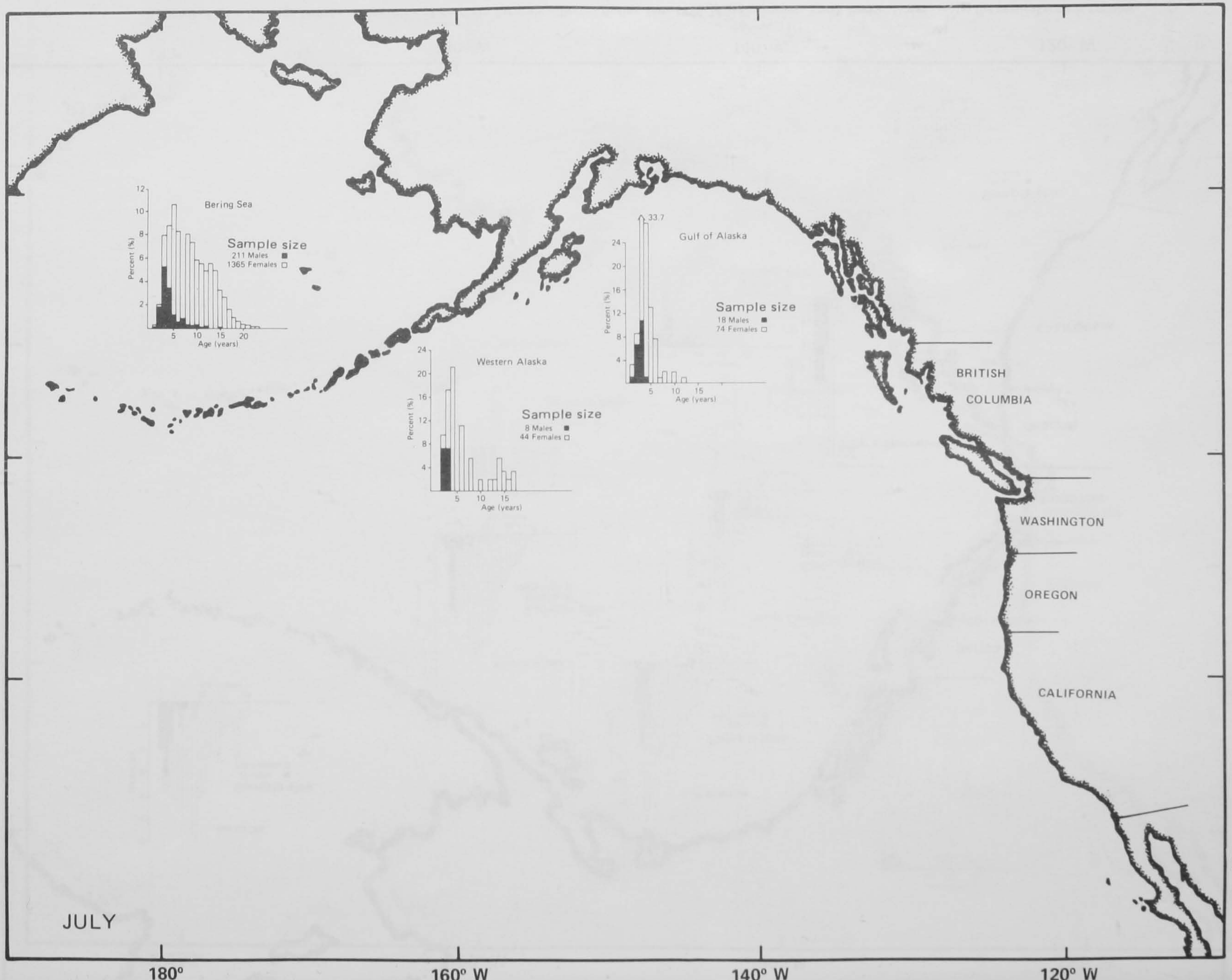
Appendix Figure 4.—Age and sex composition of northern fur seals collected during April 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



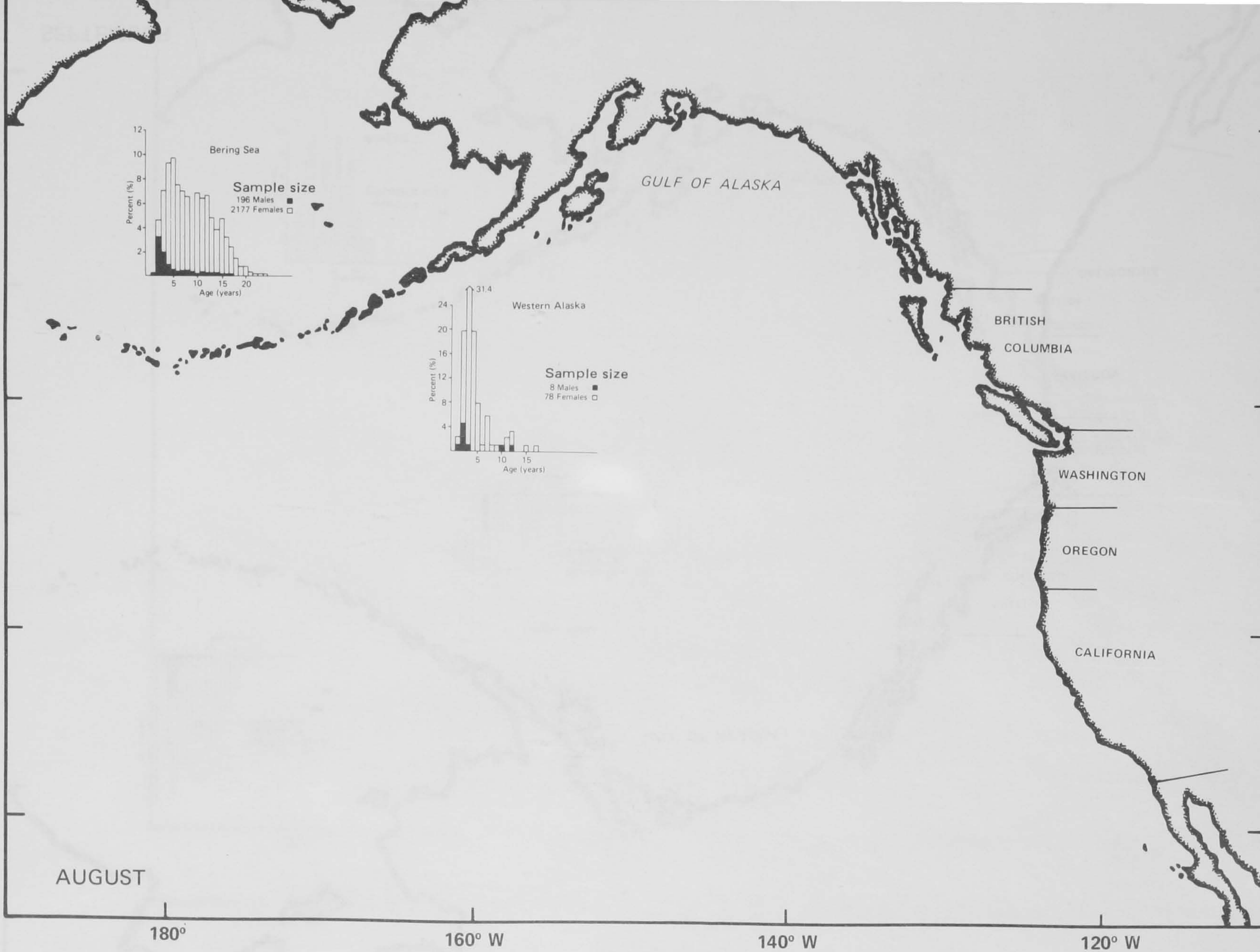
Appendix Figure 5.—Age and sex composition of northern fur seals collected during May 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



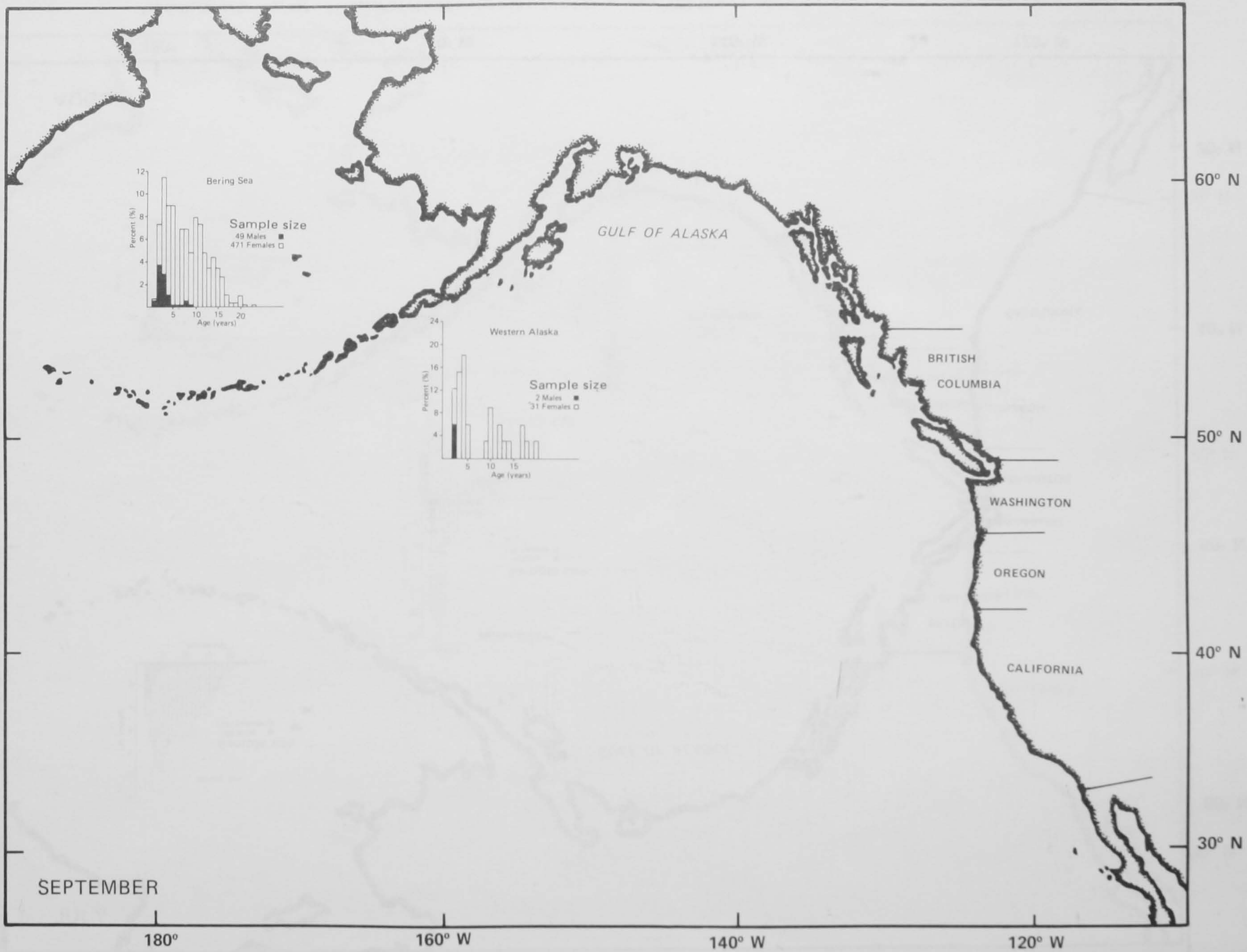
Appendix Figure 6.—Age and sex composition of northern fur seals collected during June 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



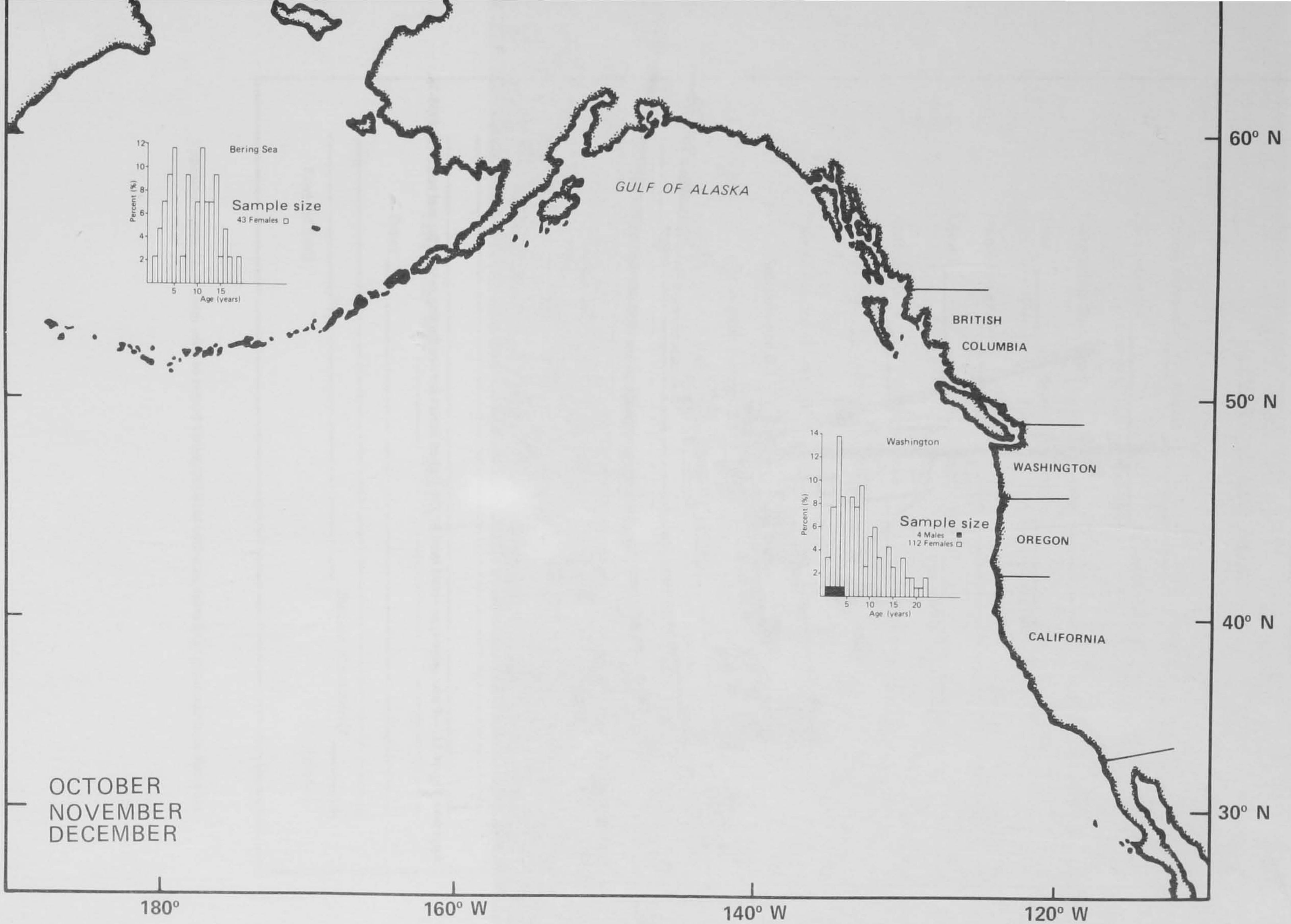
Appendix Figure 7.—Age and sex composition of northern fur seals collected during July 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



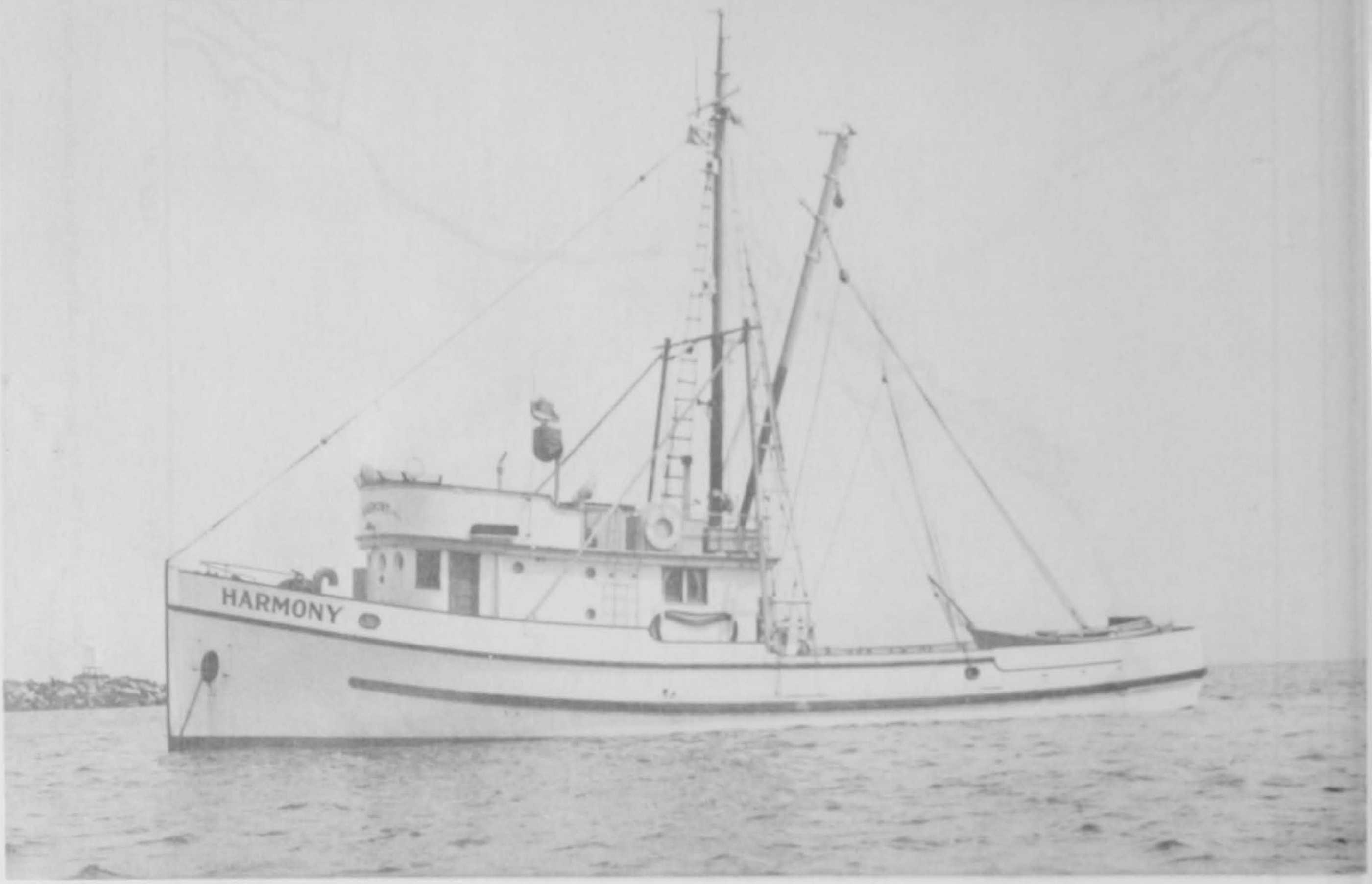
Appendix Figure 8.—Age and sex composition of northern fur seals collected during August 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



Appendix Figure 9.—Age and sex composition of northern fur seals collected during September 1958-74 in the eastern North Pacific Ocean. Note: the vertical scale is variable.



Appendix Figure 10.—Age and sex composition of northern fur seals collected during October, November, and December 1958-74 in the eastern North Pacific Ocean and Bering Sea. Note: the vertical scale is variable.



Appendix Figure 11.—Purse seine type vessel used by the United States for conducting pelagic fur seal research, 1958-74.

FIELD RECORD OF FUR SEAL

ADULT: Cruise number _____ Vessel _______________ Field number __________

Date collected ____________________ Location (state) __________
Example: 18 November 1969

Distribution Sq.: Horiz ____ Vert ____: __________ N., __________ W.

Time __________ Water Temperature __________ °C Sex ____ Age ____
Example: 1430 Nearest degree

Number in group ________ Tag ______________________________

Length ____________ cm (nearest) Weight ____________________ kg.
(one decimal, zero or number)

Nulliparous ________ Primiparous ________ Multiparous __________

Ovaries: left ___ right ___ Follicle size: left ___ (mm) right ___ (mm)

Uterine horn condition: (L) ___ (R) ___ Nulli young (L) ___ (R) ___

Nulli mature (L) ___ (R) ___ post partum (L) ___ (R) ___

nonpregnant parous (L) ___ (R) ___

Nipple crypts: clean ___ dirty ___ Visibility __________

FETUS: (yes) ___ (no) ___ Normal ______ Aborted ______ Resorbed ______

Sex ______ Length ____________________ cm. Weight ______ grams
(one decimal, zero or number)

REMARKS: ______________________________

Parts saved: Snout ________ Stomach ________ GT ________

Other ______________________________

Initials of examiner ______

Revised 1970 GPO 996-795

Appendix Figure 12.—Form used to record biological data collected from individual northern fur seals.

FOOD HABITS — FUR SEALS

PAGE ____

Card I.D.	Cruise No.	Field No.	0 1 2	Total Stomach Contents		Identification and volume of individual food items				
				Volume (cc)	Weight (gms.)	Food Code	Volume (cc)	SCIENTIFIC NAME	No. Items	Percent Volume
1	2 - 3	4 - 7	8	9 - 12	13 - 16	17 - 79				
Roundworms (Yes)___ (No)___										

COLLECTION DATA

Date collected ____________ Water Temp. °C ____________ Date examined ____________

Hour Collected ____________ Sex ____________

Area / vessel ____________ Age ____________ Location examined ____________

EXAMINED BY:

____

____

____

____________ FIELD NUMBER

Appendix Figure 13.—Form used to record stomach contents of northern fur seal.

Appendix Table 1.—Grouping of northern fur seals off California, Washington, and the Bering Sea, 1958-74.

Area/year	Number of seals per group in the water						Total number of seals
	1	2	3	4	5	Total	
	Percentage						
California							
1958	33.8	28.5	19.6	9.2	6.3	97.4	1,990
1959	29.7	19.5	13.7	8.0	4.3	75.2	5,132
1961	31.4	28.7	17.0	8.7	6.2	92.0	1,926
1964	29.8	23.7	18.7	12.7	3.6	88.5	979
1965	50.6	23.7	14.3	6.5	3.1	98.2	1,114
1966	31.3	22.4	16.9	10.5	5.9	87.0	2,704
Washington							
1958	56.8	30.6	6.5	3.5	—	97.4	229
1959	64.0	25.2	6.1	1.2	2.3	98.8	644
1961	41.5	27.9	12.7	4.9	5.1	92.1	1,068
1964	64.2	26.9	8.9	—	—	100.0	67
1965	31.6	25.3	15.2	9.4	7.8	89.3	513
1967	43.3	25.4	14.0	9.1	4.8	96.6	835
1968	40.8	24.9	13.6	9.3	5.1	93.7	1,078
1969	37.7	26.9	12.1	8.5	8.8	94.0	1,136
1970	29.5	27.0	19.0	9.3	6.6	91.4	1,886
1971	39.9	23.9	18.4	9.7	2.3	94.2	1,323
1972	37.9	29.2	11.7	9.0	4.1	91.9	849
Bering Sea							
1960	44.0	30.6	11.8	5.8	2.4	94.6	2,120
1962	43.7	30.4	14.4	5.2	2.9	96.6	6,111
1963	38.4	26.1	14.3	7.3	4.1	90.2	5,790
1964	56.2	28.1	11.7	2.9	0.8	99.7	1,799
1968	68.0	22.2	7.0	1.8	1.0	100.0	1,509
1973	58.6	25.3	10.1	3.1	0.4	97.5	2,430
1974	57.7	33.6	6.8	0.9	0.3	99.3	1,752