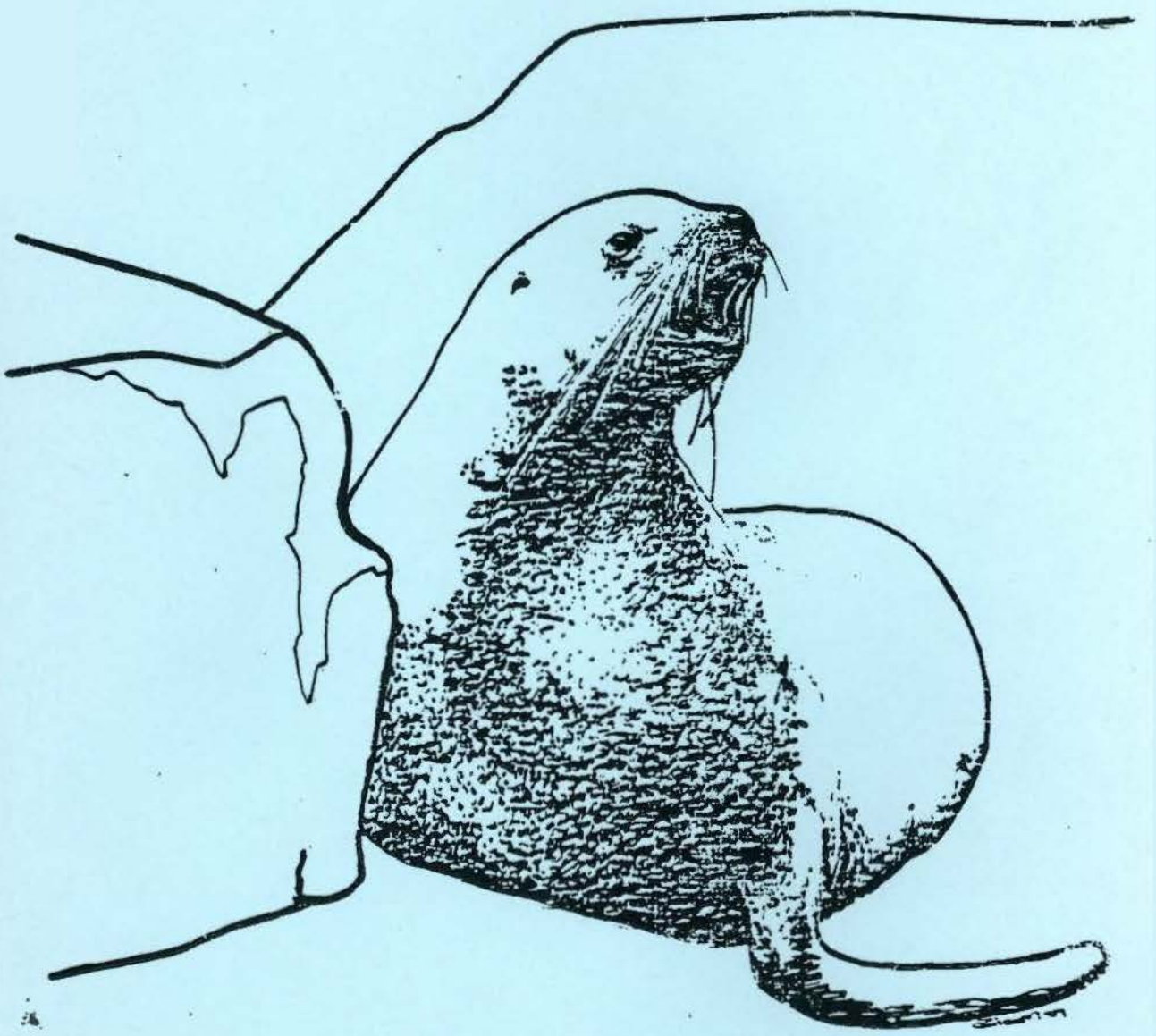
Population Assessment, Ecology and Trophic Relationships of Steller Sea Lions in the Gulf of Alaska



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INTRODUCTION

Steller sea lions (*Eumetopias jubatus* Schreber) are large, conspicuous pinnepeds which inhabit the north Pacific Ocean. They are the largest members of the Otariid family. The range of Steller sea lions extends from the southern California Channel Islands, northward along the eastern north Pacific to Prince William Sound, the Alaska Peninsula, the Aleutian Islands and the Bering Sea to Bering Strait (Kenyon and Rice 1961; Schusterman, unpub. m.s.). Steller sea lions are found in the Soviet Union in the Kuril Islands, the Okhotsk Sea, the Commander Islands and the Bering Sea (A. Perlov, TINRO, USSR pers. comm.). They have also been recorded as far south in the western north Pacific as Hokkaido, and northern Honshu, Japan and Korea (Ellerman and Morriason-scott 1951 and Okado 1938 as cited in Kenyon and Rice 1961).

The sea lion is a gregarious, polygynous mammal which gathers on specific well defined locations on land to breed, bear young and rest. They range seaward as far as the continental shelf break and may be found anywhere within nearshore waters in the Gulf of Alaska. The worldwide center of abundance of Steller sea lions is the northwestern Gulf of Alaska.

It was recognized that exploration for, development of, and production and transportation of petroleum reserves from the continental shelf of the Gulf of Alaska could impact this important segment of the Steller sea lion population. Field studies designed to investigate some as-

pects of the ecology and life history of sea lions were initiated in 1975 and continued through 1980. Objectives were to provide basic information about population status, distribution, movement patterns, population composition, reproductive biology, food habits, growth, pathology, and heavy metal and parasite loads.

The study area (Fig. 1) encompassed the entire north Gulf of Alaska. The shore bounds were Scotch Cap on Unimak Island and Cape Spencer on the north side of Cross Sound in southeastern Alaska. It was recognized that these arbitrary bounds only limited the study and did not reflect any discreteness of sea lion distribution.

The most complete study to be published on sea lion distribution in Alaska was accomplished between 1956 and 1958 by Mathisen and Lopp (1963). They photo-surveyed sea lions from Cape St. Elias to the Islands of the Four Mountains in the Aleutian Islands. Thorsteinson and Lensink (1962) reported on behavior, reproduction and food habits of sea lions, during an experimental harvest in the Gulf of Alaska. Fiscus (1961) studied the growth characteristics of sea lions taken from Chernabura Island. Fiscus and Baines (1966) collected sea lions from California to the Bering Sea and reported on the stomach contents. Imler and Sarber (1947) collected eight sea lions from the Gulf of Alaska for stomach content analysis. Sandegren (1970) conducted the most comprehensive study of sea lion behavior to date from the Gulf of Alaska.

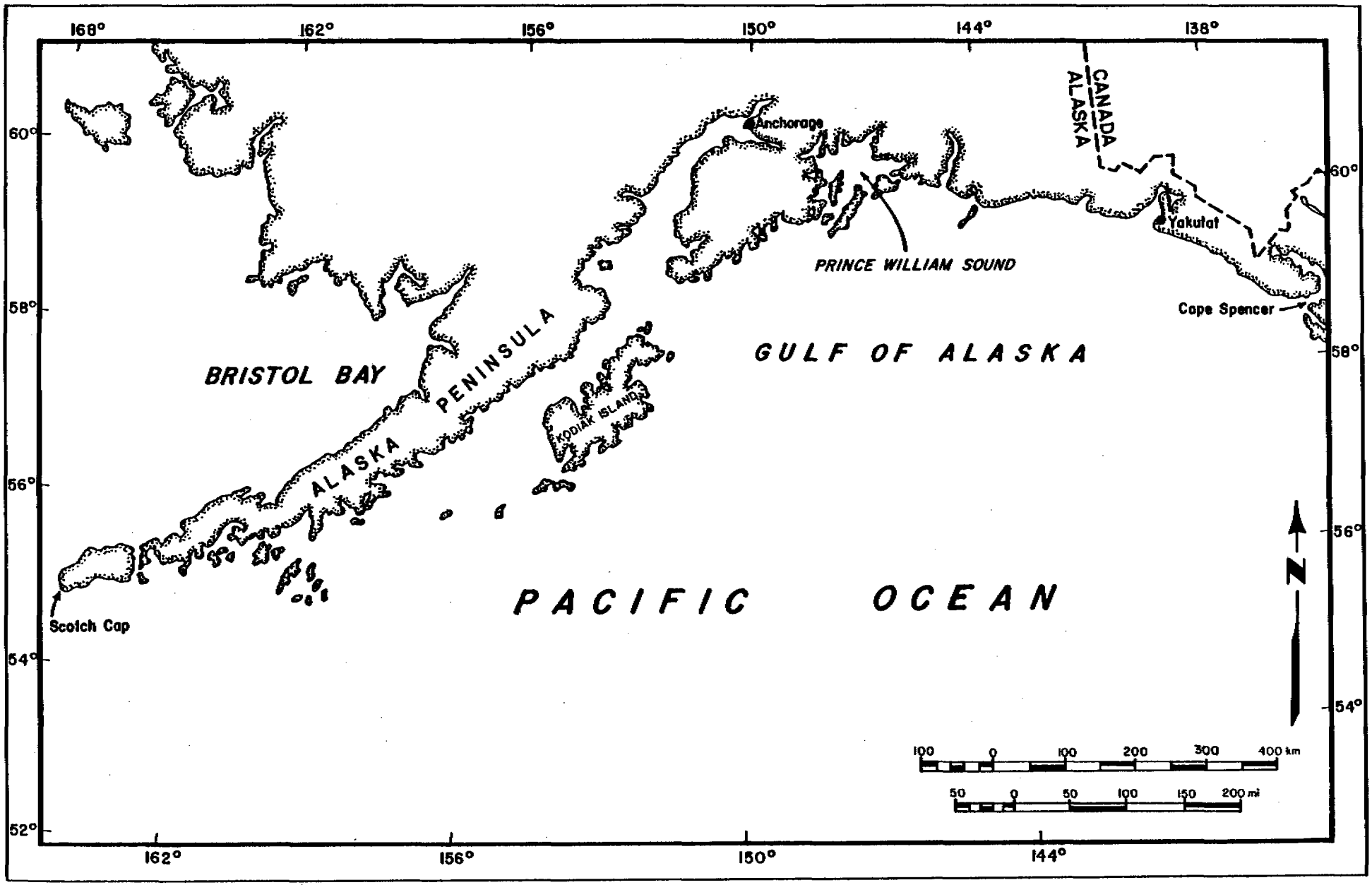

FIGURE 1. GULF OF ALASKA STELLER SEA LION STUDY AREA.

METHODS

Distribution and abundance studies were accomplished through the use of aerial surveys conducted at all known rookeries and hauling areas in the Gulf of Alaska. Survey methods were similar to those used for sea lions in the past by Mathisen and Lopp (1963), Kenyon and Rice (1961) and Fiscus et al. (1976). Since sea lions are known to shift seasonally, we decided to make one complete survey during winter and one complete survey in the summer breeding season. In 1976 we photo-surveyed all known hauling areas and rookeries in March and in June. Photo-surveys were accomplished by flying by the haulout at a speed of approximately 80 k and an altitude of approximately 50 to 75 meters. Horizontal distance from the sea lions averaged 100 meters. A hand-held 35 mm camera equipped with a motor drive unit was used to take overlapping slide photos. Films used were usually high speed ektachrome at ASA 160 and 200 in 36 exposure rolls. After the slides were commercially developed, they were projected onto a paper screen and the sea lions were counted individually and marked on the paper. A hand-held mechanical tally register was used to record the total count.

Sea lion movements were studied by branding pups on the rookeries and observing them at haulouts and rookeries throughout the Gulf of Alaska. Pups were branded at six rookeries and hauling areas as shown in Table 1. In 1975, pups were branded on the left front shoulder and in 1976 on the right front shoulder.

Table 1. Steller sea lions branded in the Gulf of Alaska 1975 and 1976.

Location	Number Branded	Letter Branded
1975		Left shoulder
Marmot Island	598	O
Sugarloaf Island	719	X
Total	1,317	
1976		Right shoulder
Marmot Island	3,669	T
Sugarloaf Island	1,443	X
Outer Island	249	V
Wooded Island	29	E
Seal Rocks	316	J
Cape St. Elias	23	L
Total:	5,729	

Total pups branded: 7,046

Pup counts were made at major rookeries by visiting each location with a helicopter or small boat and counting individual pups. Adults were driven off the areas and all possible pups were counted.

Branding locations were selected on the basis of size of rookery and location in the Gulf. A hot iron "cattle type" brand was used. The heat source was portable propane bottles. Gothic style letters were used and applied according to location.

Resightings of branded animals were made throughout the Gulf of Alaska and in southeastern Alaska by examining animals on rookeries and hauling areas, using binoculars and spotting scopes.

Near daily observations of sea lions on portions of two large rookeries; Sugarloaf Island (April 13-July 15, 1978; April 18-July 10, 1979; May 18-August 7, 1980) and Marmot Island (May 7-July 9, 1979; May 20-July 18, 1980), and the Cape St. Elias hauling area (March 9-June 14, 1977; March 5-July 1978), were used to supply information on branded animals, premature pupping, sex and age composition, sex and age segregation, breeding activity, behavioral activity related to disturbance, and timing and duration of the birth and breeding season, and incidence of lactation and weaning. Sightings of known aged animals nursing pups and suckling females provided information on sexual maturation, weaning and duration of the mother-offspring bond.

Between 1975 and 1978 250 sea lions were collected by shooting in nearshore waters and on rookeries and hauling areas of the Gulf.

Stomachs were removed and examined for food content, reproductive organs were preserved for examination, blood samples were taken for disease and parasite studies, body measurements were recorded for growth studies, skulls were retained for age determination, tissue samples were preserved for elemental analysis and pelage samples were taken for molt studies.

The study area was divided into five geographic units for food habits data analysis: northeastern Gulf of Alaska, Prince William Sound, Kenai Coast, Kodiak Island, and the Alaska Peninsula region. The most complete seasonal coverage was in the Kodiak area.

Stomach contents were removed in the field, wrapped in muslin and preserved in 10% Formalin solution except when large amounts of freshly eaten prey were encountered, in which case the prey were weighed, identified and disposed of in the field. Volumes and occurrences (number of stomachs in which a prey category was found) were determined for prey categories in the laboratory. Prey identifications were based primarily on skeletal materials, particularly fish otoliths and cephalopod mandibles (beaks) (Fitch and Brownell 1968; Pinkas et al. 1971). Otoliths and other skeletal components from fish were identified to the lowest taxon possible by comparison with reference materials. Precision of otolith identification was increased or verified by John E. Fitch, California Department of Fish and Game, Long Beach. Cephalopod beaks were classified as either squid or octopus with the aid of Pinkas et al. (1971) and squid beaks were identified

to family by Clifford H. Fiscus, National Marine Fisheries Service, Seattle. Other mollusks and decapod crustaceans were identified by Kathryn J. Frost and Lloyd F. Lowry, Alaska Department of Fish and Game, Fairbanks.

Volumetric and occurrence data were integrated into a single index of prey use, the modified Index of Relative Importance (Pitcher 1980). The original Index of Relative Importance (IRI) was calculated by summing numerical and volumetric percentage values and multiplying by the frequency of occurrence percentage value (Pinkas et al. 1971). Because of the disparity in size of sea lion prey, we deleted the numerical component of their formula. Therefore, the modified IRI was calculated as percentage of occurrences multiplied by percentage of volume.

Ovaries and uteri from collected females were preserved in a 10% formalin solution. Each uterus was opened and examined for the presence of an embryo or fetus and placental scars. Ovaries were sectioned at about 1 mm with a scapel and examined for follicles, corpora lutea and corpora albicantia. When possible, females were classified according to reproductive status; nulliparous, primiparous or multiparous and reproductive condition; not pregnant, implanted pregnant, missed pregnancy, resorption or abortion.

Epididymides from males were also preserved in formalin solution. Microscopic examinations of epididymal fluid were made to determine the relative abundance of sperm.

Second upper premolar teeth from collected animals were decalcified, sectioned at about 48 microns and stained with hematoxylin. Ages were estimated from counts of cementum annuli. Annual deposition of cementum annuli was confirmed by examination of sectioned teeth from nine, known- age animals (branded as pups). Both Fiscus (1961) and Spalding (1964) used dental annuli to estimate ages of Steller sea lions.

Stage of molt was determined by examining: (1) pigment distribution in the guard hair bulbs, (2) position of the tips of new guard hairs within the pelage, and (3) extent of wear and yellowing of mature guard hairs. The pieces of furred skin were first removed from formalin preservative. Sections of skin were then cut approximately 2/3 mm x 1 cm x 1 cm. The sections were cut with a razor blade parallel to the follicles; the blade cut perpendicular to the direction of the hair, downward and anteriorly. From each pelage sample several sections were cut, laid on a slide, and set under a lamp to dry. After 10 minutes under the heat source the skin sections were dry enough to absorb a drop or two of cedarwood oil. The cedarwood oil cleared the tissue immediately and allowed structures to be seen below the cut surface.

RESULTS AND DISCUSSION

Distribution and Abundance

Steller sea lions are found throughout the Gulf of Alaska, both near shore, and offshore as far as the continental shelf (Fiscus et al. 1976, Fiscus and Baines 1966 and Kenyon and Rice 1961). They are large and extremely mobile pinnipeds, capable of movements over long distances. Sea lion distribution is generally considered associated with specific features on land, where they haul out to rest, pup and breed and where they are most conspicuous.

The locations where sea lions haul out can be influenced by several factors: season, suitable exposure, proximity to a food source, tradition of use, and proper substrate. Probably the single most important factor is season. Sea lions utilize different locations according to time of year, concentrating on breeding rookeries in large numbers during the period of May through October and dispersing to many locations the rest of the year. Some areas are used as haulouts only in the winter, while others are used only during the breeding period. We have classified the different areas utilized by sea lions on the basis of their use as rookeries or haulouts.

A rookery is defined as a terrestrial site where all adult males present actively defend territories and where parturition and impregnation usually take place. Generally, most adult sea lions present on

a rookery are engaged in breeding, pupping or rearing young. A rookery may be used as a haulout area during the rest of the year. A haulout area is any area where sea lions haul out on a regular predictable basis but where few or no pups are born. We have further defined a stopover area (Table 2) as those locations where sea lions have been sighted on land but only on an irregular basis and in low numbers.

The following is an account of all known areas where sea lions haulout on a regular basis. Each of these areas has been photographed and the sea lions counted from the photographs at least twice during this study. Figs. 2 through 6 show the locations of these haulouts in the Gulf of Alaska.

Venisa Point and Sugarloaf Island Haulouts 58°18'04"N, 136°50'20"W

Located on the north side of Graves Harbor, Greg Streveler (U.S. Park Service, pers. comm.) reported sighting 11 sea lions hauled out on the south side of Sugarloaf Island in July 1974 and 3 at Venisa Point in June 1974. No sea lions were sighted here on the surveys of March and June 1976. This area is probably of minor importance and used only during periods of local abundance of sea lion prey species.

Table 2. Locations in the Gulf of Alaska where sea lions have been sighted but which are considered stopover areas and not true haul outs.

Name	Latitude	Longitude
Porpoise Rocks	60@19'00"N,	146@41'00"W
Fox Point	60@35'00"N,	145@57'00"W
Knowles Head	60@41'10"N,	146@57'00"W
Pleiades Islands	60@13'42"N,	148@00'50"W
Latouche Island	59@56'25"N,	148@02'25"W
Danger Island	59@55'30"N,	148@04'45"W
Fountain Rocks	59@35'00"N,	146@21'00"W
Wessels Reef	59@47'00"N,	146@12'00"W
Cape Puget	59@56'40"N,	148@27'00"W
Cape Junken	59@55'04"N,	148@38'25"W
Barwell Island	59@51'45"N,	149@16'40"W
Hive Island	59@53'12"N,	149@22'00"W
Aialik Cape	59@42'00"N,	149@32'00"W
Nuka Point	59@17'30"N,	150@43'00"W
Flat Island	59@19'40"N,	151@59'20"W
Sud Island	58@53'29"N,	152@12'49"W
Tonki Cape	58@20'45"N,	151@59'00"W
Ugak Island	57@22'15"N,	152@16'15"W
Sundstrom Island	56@41'30"N,	154@08'15"W
Bert Point	56@58'00"N,	153@51'00"W
Cape Hepburn	56@50'40"N,	153@57'50"W
Cape Alitak	55@50'45"N,	154@18'00"W
Sturgeon Head	57@30'30"N,	154@37'50"W
Noisy Islands	57@55'30"N,	153@33'00"W
Malina Point	58@02'30"N,	153@22'00"W
Steep Cape	58@12'00"N,	153@12'30"W
Cape Paramanof	58@18'15"N,	153@02'45"W
Augustine Rocks	59@13'30"N,	153@22'00"W
Cape Nukshak	58@23'30"N,	153@58'45"W
Cape Ugyak	58@16'35"N,	154@06'10"W
Cape Kuliak	58@08'25"N,	154@13'00"W
Foggy Cape	56@32'34"N,	156@58'45"W
Kak Island	56@17'15"N,	157@50'00"W
Kumlik Island	56@38'00"N,	157@24'00"W
Atkulik Island	56@16'50"N,	157@44'05"W
Seal Cape	55@59'20"N,	158@25'50"W
Mitrofania Island	55@50'15"N,	158@41'45"W
Kupreanof Point	55@33'55"N,	159@35'45"W
Whaleback Island	55@16'50"N,	160@05'05"W
Haystacks	55@16'30"N,	160@30'10"W
Unga Cape	55@07'55"N,	160@31'25"W
Simeonof Island	54@51'50"N,	159@18'00"W
The Twins	54@57'35"N,	159@52'00"W
Wosnesenski Island	55@09'40"N,	161@20'20"W
Cherni Island	54@37'20"N,	162@22'30"W

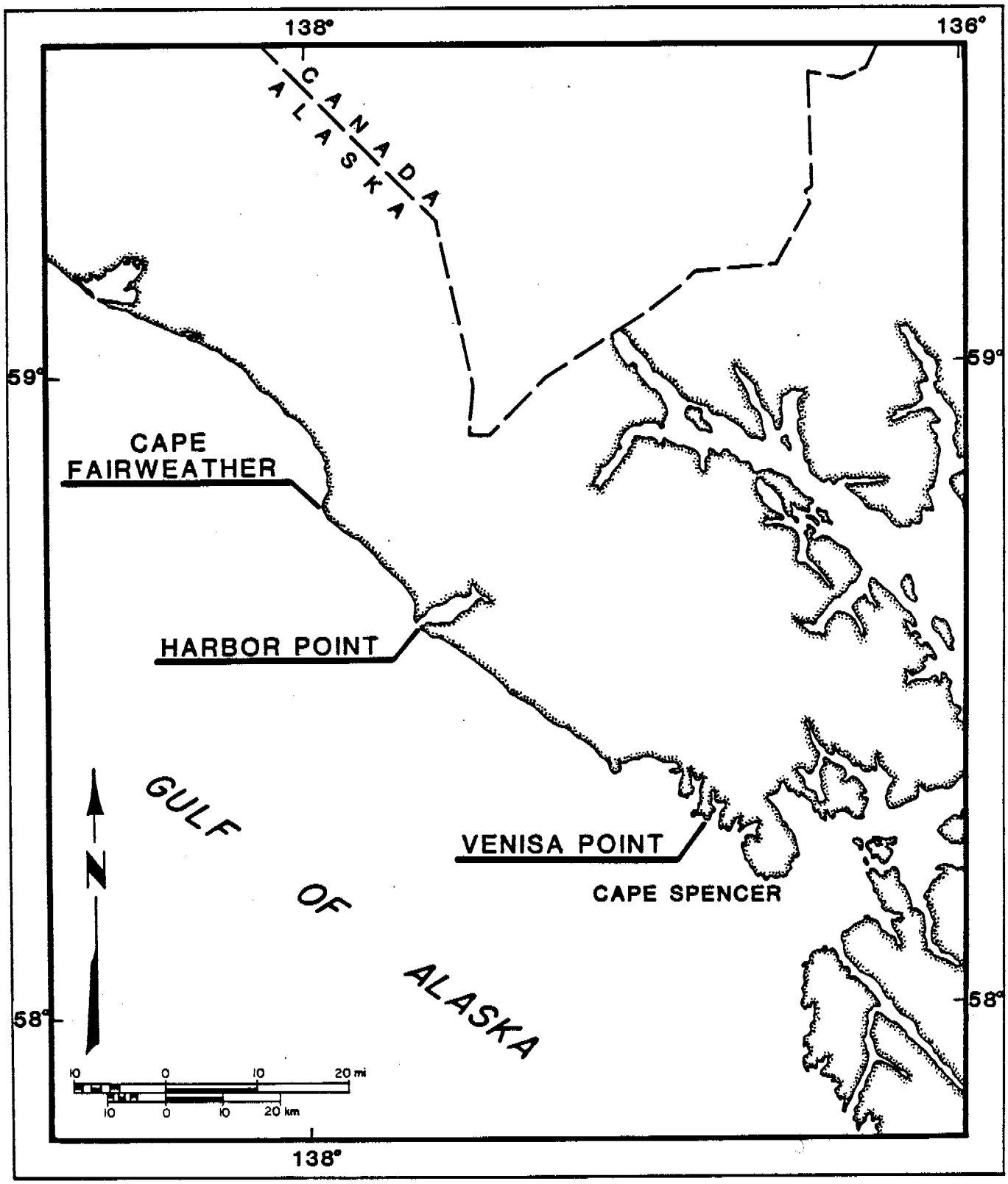

FIGURE 2. STELLER SEA LION HAULOUTS AND ROOKERIES FROM CAPE SPENCER TO CAPE FAIRWEATHER.

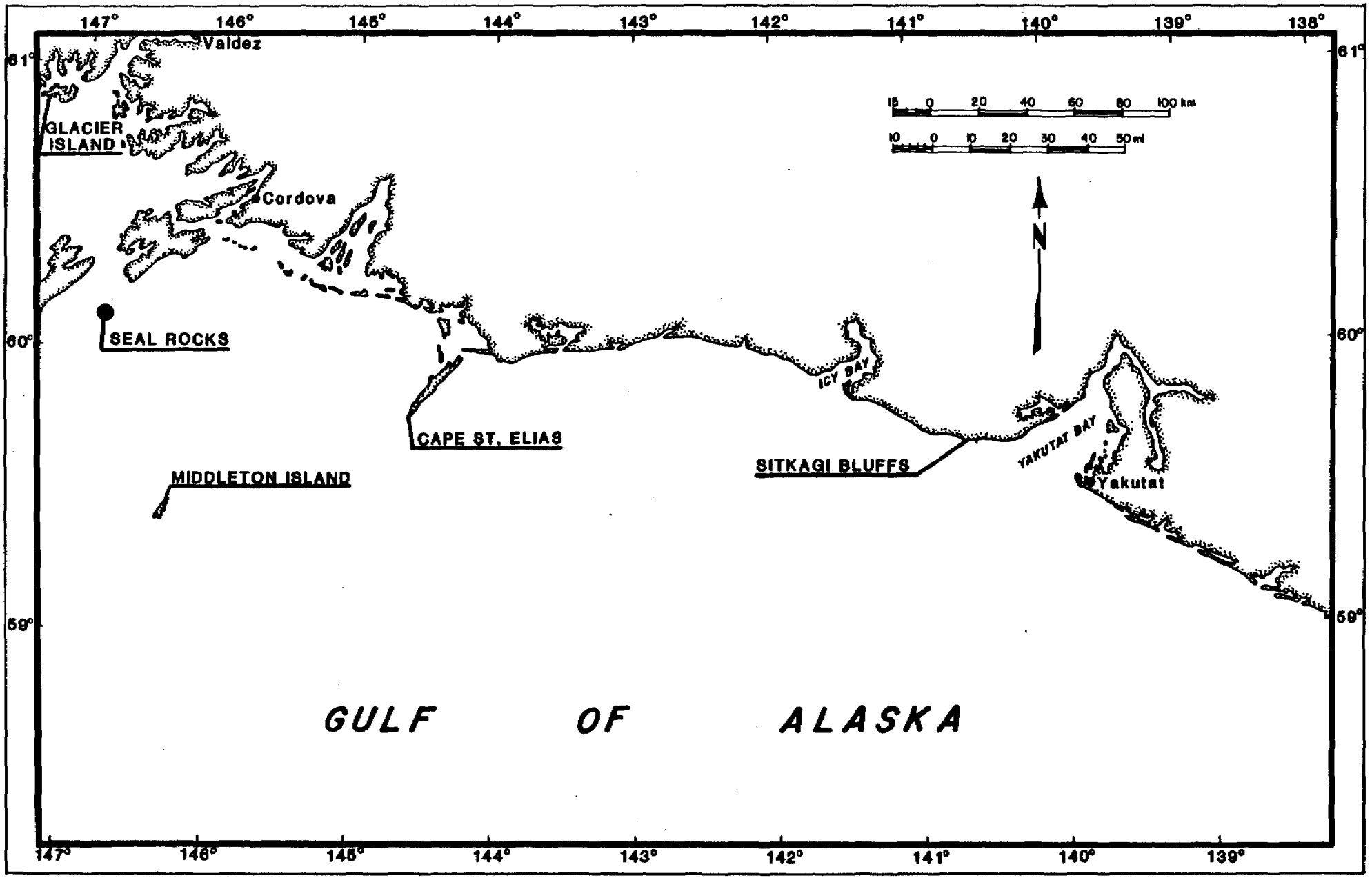

FIGURE 3. STELLER SEA LION HAULOUTS AND ROOKERIES FROM YAKUTAT BAY TO PRINCE WILLIAM SOUND. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

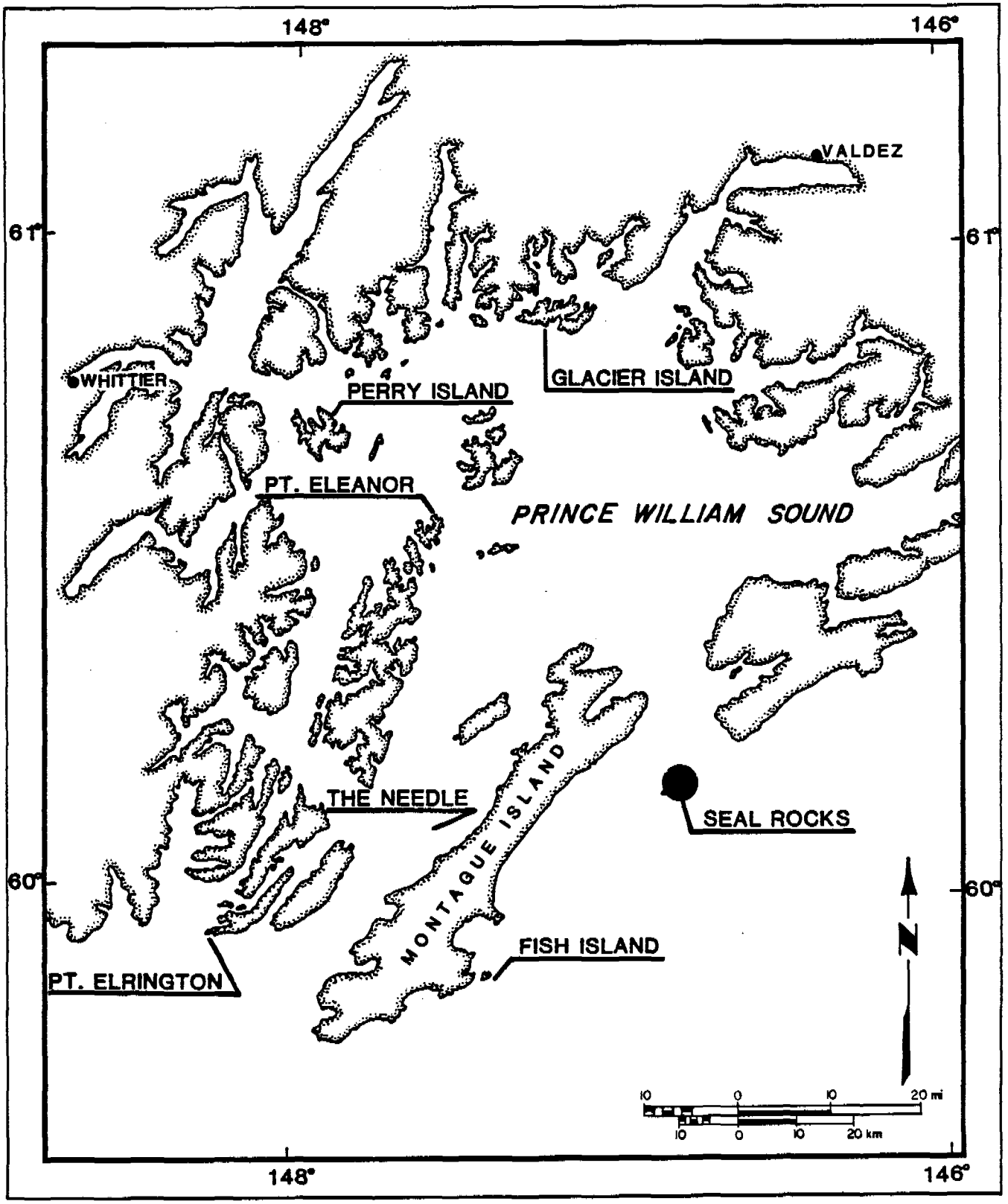

FIGURE 4. STELLER SEA LION HAULOUTS AND ROOKERIES IN PRINCE WILLIAM SOUND. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

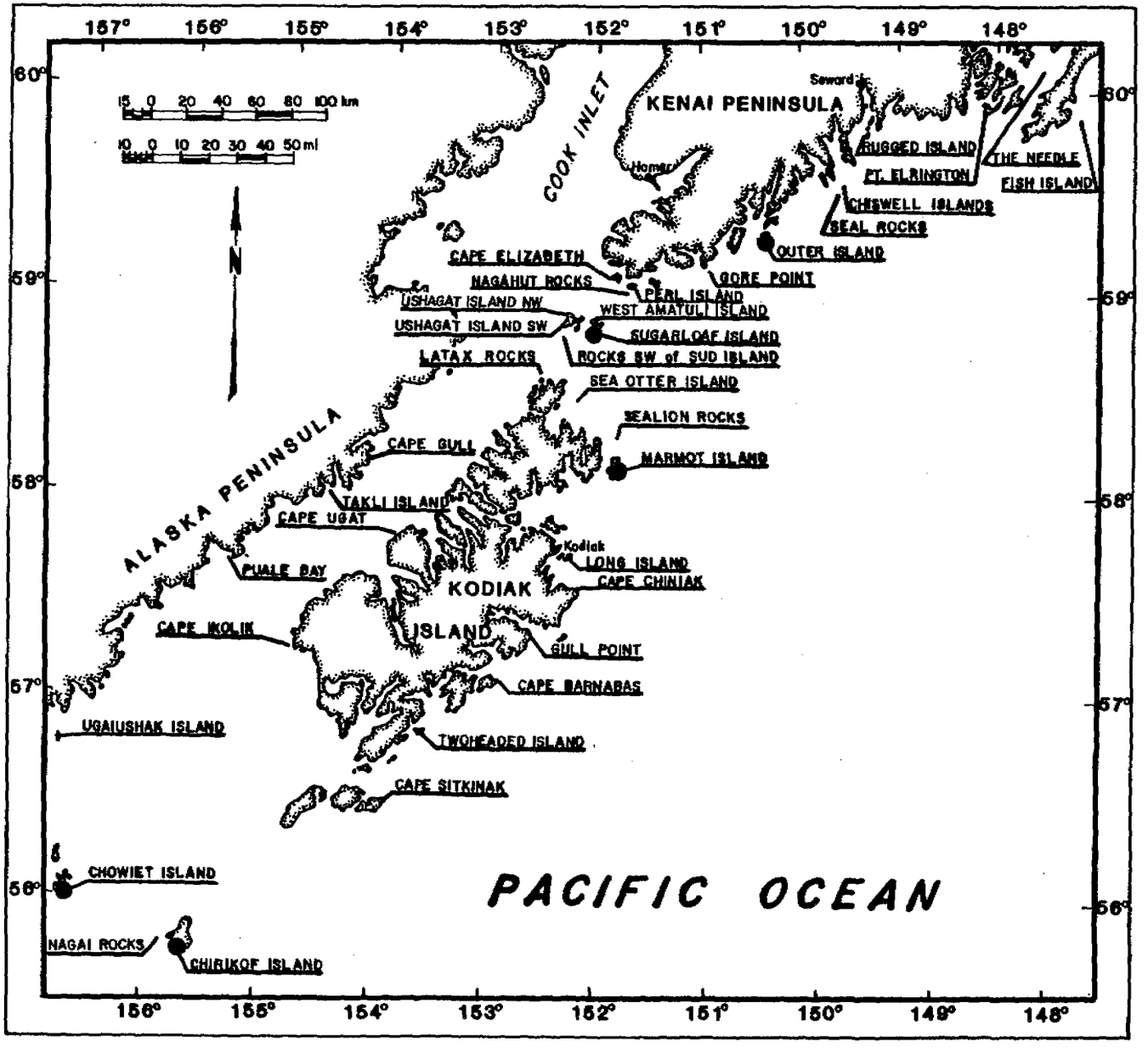

FIGURE 5. STELLER SEA LION HAULOUTS AND ROOKERIES FROM PRINCE WILLIAM SOUND TO CHIRIKOF ISLAND. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

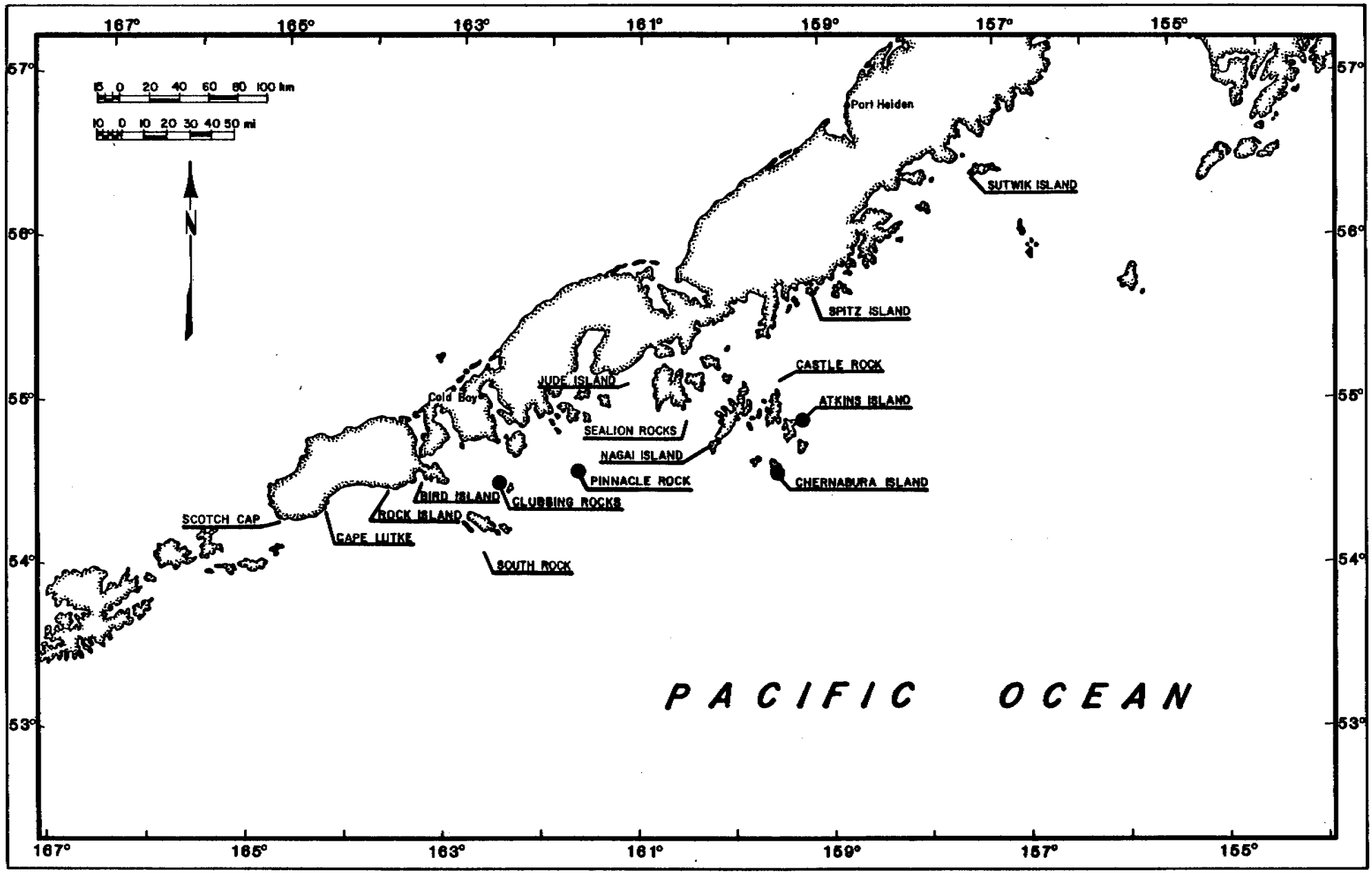

FIGURE 8. STELLER SEA LION HAULOUTS AND ROOKERIES FROM CHIRIKOF ISLAND TO SCOTCH CAP. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

Harbor Point Haulout 58°36'45"N, 137°39'10"W

On the south entrance of Lituya Bay, Streveler (pers. comm.) reported 40 sea lions in July 1970. A total of 5 sea lions were sighted here in March 1976 and none in June 1976. This hauling area is made up of a small number of large rocks which may be awash at high tide. It was probably used only during periods of peak local abundance of prey, or when moving from one feeding area to another, or to and from breeding areas. This area could be classified as a stopover area but data are presently insufficient.

Cape Fairweather Haulout 58°50'15"N, 137°56'30"W

Located 54 miles north of Cape Spencer, Streveler (pers. comm.) reported about 200 sea lions here in April 1970. Our survey showed a total of 258 sea lions in March 1976 and none in June 1976. This was probably used as a winter and early spring hauling area by animals moving along the coast or feeding offshore on the Fairweather grounds.

Sitkagi Bluff Haulout 59°13'00"N, 140°42'00"W

Formerly an ice cliff north of Yakutat, this area now has the appearance of a low glacial moraine. It was thought to have been used by as many as 1,000 sea lions (Alaska Department of Fish and Game 1973) although we counted only 199 animals here in March 1976 and 20 in June

1976. The haulout area is within a group of very large boulders on the open beach. This rocky beach is flanked on both sides by several miles of sand beach. Use is probably highest in winter and early spring.

Cape St. Elias Haulout 59°47'48"N, 144°36'05"W

Located on the south end of Kayak Island, this area has been surveyed several times in recent years. Mathisen and Lopp (1963) photo-surveyed this area on October 2, 1957 and counted 1,343 animals. Alaska Department of Fish and Game personnel (Calkins et al. 1975) found 1,548 adults and 18 pups in June 1973 and 505 sea lions in March 1974. Our photo-surveys showed 435 animals in March 1976 and 1,628 in June 1976. Twenty-three pups were branded here on June 26, 1976 from a total of 25 pups in the area. This haulout was used all year although an interesting seasonal shift took place. During the winter (all March surveys) the haulout area was located at the base of the southwest face of Pinnacle Rock on a boulder beach. shortly before breeding and pupping the sea lions moved to an elevated conglomerate of semi-flat rocks on the southeast side of Pinnacle Rock. No sea lions were seen using the southwest haulout in the summer and none used the southeast area in winter. This shift may have been an attempt by adult females to seek a more suitable pupping area in the summer and a movement away from exposure to severe storms in the winter.

Middleton Island Haulout 59°29'15"N, 146°18'30"W

Located about 50 miles south of the entrance to Prince William Sound, the sea lions hauled out on a small sand spit which arcs off the north end of the island. A survey in February 1975, (Calkins et al. 1975) showed 175 sea lions. We surveyed this area in March 1976 when we counted 92 sea lions and late May 1976 when we counted 2,901 animals. The large increase in sea lions here in late May does not mean this area is used as a pupping or breeding area. It is unlikely many pups could survive if born here, because the entire area is a sand bar which is completely exposed to storms and high, storm driven tides. It is more likely that this haulout is used as a rest stop by many sea lions moving westward across the Gulf to the larger breeding rookeries on the Kenai coast and the eastern Kodiak, Afognak, and Barren Islands areas.

Wooded Islands Haulout 59°52'50"N, 147°20'43"W

Located off the southeast end of Montague Island, sea lion use of this area has been well documented. The sea lions hauled out on the outermost island in this group. The island has been called either Fish Island or Lewis Island (Pitcher, in Calkins et al. 1975). Mathisen and Lopp (1963) counted 2,500 sea lions here in summer 1956 and 3,762 in October 1957. Alaska Department of Fish and Game surveys in June 1973 showed 1,261 and in March 1974, 1,114. On our surveys we counted 861 sea lions in March 1976 and 878 in June 1976.

Sandegren (1970) described extensive topographic changes which took place here as a result of the 1964 earthquake. Pitcher (in Calkins et al. 1975) speculated that these changes may have caused a reduction in the population here. It is entirely possible that a reduction in the available breeding and pupping area may have caused a segment of the population to shift to the nearby Seal Rocks rookery. Twenty-nine sea lion pups were branded with the letter E on the right front shoulder at the Wooded Islands on June 26, 1976. Thirty-five pups were counted just prior to branding.

Seal Rocks Rookery (Prince William Sound) 60°09'58"N, 146°50'30"W

Located 6 to 7 miles southwest of Cape Hinchinbrook, this is the largest breeding rookery in the Prince William Sound area. Pitcher (in Calkins et al. 1975) pointed out a substantial increase in the sea lion population here subsequent to the 1964 earthquake. Mathisen and Lopp (1963) surveyed this area in 1956 and 1957, counting a maximum of 183 sea lions. Alaska Department of Fish and Game surveys in June 1973 showed a total of 1,733 animals, including at least 200 pups, and in March 1974, 1,750 animals were sighted.

Our surveys provided a visual estimate of 2,500 in March 1976 and a photo-count of 1,709 in June 1976. A visual estimate of pups from the helicopter prior to branding was made but was known to be inaccurate at the time. A total of 300 pups were estimated present. Branding was accomplished on 316 pups here on June 27, 1976. These pups were branded on the right front shoulder with the letter J.

This rookery presents an interesting case as it constitutes a rookery with limited space for pupping and breeding with an apparent rapidly increased population. There was an unusually high pup mortality rate here. The area is made up of a small gravel beach which is flanked by two large rock masses, one of which is used by a small contingent of the breeding population. This leaves the majority of the breeding and pupping animals, and consequently the pups, confined in an area which is small for the numbers using it under normal conditions but which must be drastically reduced during storms or extreme high tides. During the branding in June 1976 a total of 85 dead pups were counted on the gravel beach indicating that more than 20 percent of the pups were killed due to crowding. If an accurate assessment of pup mortality had been possible, this figure may have exceeded 50 percent.

We photo-surveyed and counted pups on the ground here in 1978 and 1979. The adult count was 2,463 in 1978 and 545 pups. In 1979 we counted 491 pups and 2,961 adults.

Glacier Island Haulout 60°51'03"N, 147°10'57"W

On the north side of Prince William Sound, west of the entrance to Valdez Arm, sea lions haul out on the southernmost point of the island. This area was used only in winter. No sea lions were seen here on summer surveys. The Alaska Department of Fish and Game survey of March 1974 showed a total of 55 sea lions here (Pitcher in Calkins et al. 1975). We counted 197 sea lions in March 1976.

Perry Island Haulout 60°41'15"N, 147°51'05"W

In the northwestern part of Prince William Sound, the sea lions hauled out on the northeast side of the island. This also was strictly a winter hauling area. Mathisen and Lopp (1963) sighted 80 sea lions here in March 1957, Pitcher (in Calkins et al 1975) reported 153 in March 1974 and we counted 308 in March 1976.

Pt. Eleanor Haulout 60°35'00"N, 147°33'45"W

The northernmost point of Eleanor Island in Prince William Sound, this area was only used in the winter. Pitcher (in Calkins et al. 1975) reported 91 sea lions seen here on an Alaska Department of Fish and Game survey in March 1974 and we sighted 222 in March 1976.

The Needle Haulout 60°06'45"N, 147°36'40"W

In Montague Strait 3.8 miles from the nearest point on Montague Island and 5.5 miles southeast of Point Helen on Knight Island in Prince William Sound, this haulout area was used throughout the year. Peak use occurred in the winter primarily by males. Mathisen and Lopp (1963) saw 179 sea lions here in March 1957 and 130 in June 1957. Pitcher (in Calkins et al. 1975) counted 236 sea lions here in June 1974 and 568 in June 1973. We photographed 666 sea lions here in March 1976 and 537 in June 1976.

Pt. Elrington Haulout 59°55'48"N, 148°13'20"W

Located on the southwest end of Elrington Island, this area appeared to be more important than formerly recognized. It was a haulout area which was used year-round but probably more animals were there in winter than summer. Mathisen and Lopp (1963) counted 200 sea lions here in March 1957 and 250 in June 1957. Pitcher (in Calkins et al. 1975) counted 236 in June 1973 and 568 in March 1974. Our surveys showed 2,014 in March 1976 and 725 in June 1976.

Rugged Island Haulout 59°30'12"N, 149°22'53"W

On the east side of the entrance to Resurrection Bay, the sea lions hauled out on the southernmost point of the island. Probably used year-round although no sea lions were seen here in June 1976. Alaska Department of Fish and Game (1973) reported 100 sea lions. We surveyed this haulout in October 1975 when we saw no sea lions, March 1976, 215 sea lions and April 1976 when we estimated 150 sea lions. In April the animals using this haulout were primarily adult males.

Chiswell Islands Haulout 59°35'57"N, 149°33'59"W

This is a group of islands on the west side of the approach to Resurrection Bay which was surveyed by Mathisen and Lopp (1963) in March 1957 with a count of 4,705 and June 1957 with 2,012 sea lions. Alaska Department of Fish and Game (1973) showed 4,715. We surveyed

this area in October 1975 and counted 3,158 sea lions, March 1976 - 2,076 sea lions, April 1976 - estimated greater than 4,000 sea lions, and June 1976 we counted 1,106 sea lions. This area was used by both sexes and all age classes throughout the year but probably received maximum use in the winter.

Seal Rocks Haulout (Kenai Peninsula) 59°31'15"N, 149°37'00"W

The southernmost land feature in the western approach to Resurrection Bay, Mathisen and Lopp (1963) gave a count of 100 sea lions here in March 1957 and 250 in June 1957. Alaska Department of Fish and Game (1973) showed 500 animals. We counted 154 sea lions here in October 1975, 630 in March 1976 and 320 in June 1976. Like the Chiswell Islands this area was used by more animals in winter.

Outer Island Rookery 59°20'50"N, 150°24'07"W

The outermost and smallest of the Pye Islands on the east side of Nuka Bay of the Kenai Peninsula, Mathisen and Lopp (1963) counted 1,050 sea lions here in March 1957 and 2,989 in June 1957. Alaska Department of Fish and Game (1973) showed 6,000 sea lions here. This was the largest breeding rookery north of the Barren Islands. On our surveys we counted 2,904 sea lions here in October 1975, 1,528 in March 1976 and 3,847 in June 1976. On June 24, 1976 the pups were counted by helicopter and branded. Visual estimate of pups was in excess of 500 and a total of 249 were branded with the letter V on the right front shoulder.

We counted adults and pups here in late June of 1978 and 1979. The adults were photo-surveyed and pups were counted from a skiff and on the ground. In 1978 we counted 3,142 adults and 431 pups and in 1979 we counted 3,155 adults and 888 pups. Access was considerably better in 1979 and this pup count probably represents a closer estimate of the annual production here.

Gore Point Haulout 59°10'47"N, 150°57'50"W

The southeastern end of a prominent headland on the east side of the entrance to Port Dick. Mathisen and Lopp (1963) saw no sea lions here in March 1957 and 200 in June 1957. We saw two sea lions here in October 1975, estimated 200 in March 1976 and counted 535 in June 1976. Arneson (pers. comm.) reported 90 sea lions here February 10, 1976.

Perl Island, Elizabeth Island and Nagahut Rocks Haulouts 59°11'45"N, 151°39'31"W

All of these Islands are of the Chugach Island group located on the south coast of the Kenai Peninsula near the entrance to Cook Inlet. One small hauling area is located on each of these islands and more may exist at other locations in this island group. Alaska Department of Fish and Game (1973) or Mathisen and Lopp (1963) give the following counts: East Chugach Island - 20; Perl Island - 737; Nagahut Rocks -

90 and Cape Elizabeth on Elizabeth Island - 129. On our surveys we saw the following, East Chugach Island -0; Perl Island - March - 8, June - 33; Nagahut Rocks - March - 68, June - 344; Cape Elizabeth - March - 68, June - 124.

Sugarloaf Island Rookery 58°53'29"N, 152°02'19"W

One and one-tenth miles south of East Amatuli Island in the Barren Islands, Sugarloaf Island had one of the largest sea lion rookeries in the northern Gulf of Alaska. Alaska Department of Fish and Game (1973) showed a population of 10,000 here and Mathisen and Lopp (1963) counted 585 in March 1957 and 11,963 in June 1957. We counted 7,547 here in October 1975, 301 in March 1976 and 5,226 in June 1976. Vania (Alaska Department of Fish and Game, pers. comm.) felt that there was a significant amount of interchange of the breeding population between here and the large rookery on Marmot Island, off Afognak Island.

Sugarloaf Island has traditionally been a rookery with very high pup production. For instance, Schneider estimated 3,391 pups in 1965, and Vania estimated 5,200 pups in 1967, 3,000 in 1968 and 3,500 to 3,800 in 1971 (ADF&G Unpub. data). In 1975 and 1976, while branding here, we estimated in excess of 3,500 pups here each year. A total of 722 pups were branded here in 1975 with an X on the left front shoulder and 1,443 in 1976 with X on the right front shoulder.

We photographed this rookery for adult counts and counted the pups on

the ground in 1978 and 1979. The adult counts were 4,810 in 1978 and 4,374 in 1979 while the pup counts were 5,021 and 5,123 respectively.

Rocks Southwest of Sud Island Haulout 58°52'50"N, 152°18'43"W

This is a small group of unnamed rocks located 3 miles southwest of Sud Island not previously identified as a sea lion hauling area. We sighted 87 sea lions here in March 1976 and 670 in June 1976.

Rocks Southwest Of Ushagat Haulout 58°54'50"N, 152°21'55"W

A small group of rocks on the southwestern tip of Ushagat Island. Probably surveyed by Mathisen and Lopp (1963) and called Ushagat Island. Mathisen and Lopp (1963) saw no sea lions here in March 1957 and 834 in June. We saw 819 in March and 902 in June. This area was probably used primarily by excess animals from the large breeding rookery on Sugarloaf Island.

Rocks Northwest of Ushagat Haulout 58°57'31"N, 152°20'42"W

A small rocky area off the northwest tip of Ushagat Island, this area has not previously been identified as a sea lion haulout. We counted no sea lions here in March 1976 and 106 in June. This area appeared to be used primarily by non-breeding males in the summer.

West Amatuli Island Haulout 58°55'13"N, 152°W

This small group of rocks on the northeast side of west Amatuli Island was probably used by non-breeding males in the summer. We counted 57 animals here in June 1976.

Latax Rocks Haulout 58°41'25"N, 152°29'W

The northernmost feature of the Kodiak-Shuyak-Afognak group, 3,334 sea lions were counted here by Mathisen and Lopp (1963) in June 1957. We counted 466 here in October 1975, 322 in March 1976 and 1,164 in June 1976 and none in October 1976. This haul out was used at all times of the year by both sexes and all age classes.

Sea Otter Island Haulout 58°31'16"N, 152°12'35"W

Located 2 miles east of Shuyak Strait north of Afognak Island. We surveyed this area in October 1975 and saw 398 sea lions, again in March 1976 and saw 51 sea lions and in June 1976 we saw 541 sea lions. This area was used by both sexes and all age classes throughout the year.

Sea Lion Rocks Haulout 58°20'50"N, 151°47'50"W

Five and five-tenths miles east of Tonki Cape and 4 miles north of Marmot Island, 500 sea lions were listed by Alaska Department of Fish

and Game (1973). Mathisen and Lopp (1963) counted 1,600 here in May 1957 and 302 in June 1957. On our surveys we saw 121 in October 1975, 127 in March 1976 and 432 in June 1976.

Marmot Island Rookery 58°12'10"N, 151°47'40"W

Parallels the eastern side of Afognak Island. This was the largest sea lion rookery in the northern Gulf of Alaska. Unlike Sugarloaf Island, which was nearly vacated in the winter, this area was used extensively throughout the year as a hauling area. Alaska Department of Fish and Game (1973) showed a total of 10,000 sea lions here. Mathisen and Lopp (1963) counted 1,425 here in March 1957 and 4,157 in June 1957 with a high count of 6,790 in September 1957. On our surveys we counted 8,256 in October 1975, 3,655 in March 1976 and 9,862 in June 1976.

Clearly this was an area of major pup production, Vania (unpub. data) reported 5,900 pups in 1967 and over 5,000 in 1968. In 1976, while branding, we estimated a total of 4,900 pups here. In 1975 a total of 598 pups were branded with an 0 on the left front shoulder. In 1976, 3,669 pups were branded on Marmot Island with a T on the right front shoulder. During our pup counts in 1978 and 1979 we photographed the adults and counted the pups. In 1978 there were 6,140 pups and 8,506 adults and in 1979 we counted 6,741 pups and 6,381 adults.

Marmot Island rookery and haulout area is substantially different from

the majority of the other rookeries and haulouts in the Gulf of Alaska. Most areas on Marmot where sea lions were found are narrow sand/gravel beaches on the east side. Sea lions rarely hauled out on sand beaches anywhere else in the northern Gulf.

Long Island Haulout 57°45'N, 152°18'07"W

The easternmost island in northern Chiniak Bay. Mathisen and Lopp (1963) and Alaska Department of Fish and Game (1973) reported 50 to 75 sea lions here. We surveyed this area in October 1975 and saw no sea lions, in March 1976 sixty-two sea lions were seen and none again in June 1976.

Cape Chiniak Haulout 57°37'10"N, 152°09'10"W

The southeast point of Chiniak Bay, Mathisen and Lopp (1963) saw 645 sea lions in March 1957 and 772 in June 1957. Alaska Department of Fish and Game (1973) showed 600 sea lions. We saw 883 in March 1976, 365 in June 1976 and 122 in October 1976. The haulout is comprised of three locations in the rocks off Cape Chiniak. This area was used throughout the year by both sexes and all age classes.

Gull Point Haulout 57°22'58"N, 152°35'55"W

The southeast point of Ugak Bay on Kodiak Island, this was not previously identified as a sea lion hauling area. We sighted 28 sea

lions here in March 1976 and 145 in June 1976. The sea lions hauled out on a small group of rocks just off Gull Point.

Cape Barnabas Haulout 57°08'20"N, 152°53'03"W

The eastern end of Sitkalidak Island, Mathisen and Lopp (1963) counted 540 sea lions here in March 1957 and 1,598 in June 1957 and a high of 2,487 in September 1956. Alaska Department of Fish and Game (1973) reported 1,000 sea lions here. We sighted 120 sea lions in March 1976, 364 in June 1976 and 28 in October 1976. There appeared to be a substantial reduction in use of this area by sea lions.

Twoheaded Island Haulout 56°53'55"N, 153°33'30"W

Laying off the southern extremity of the western shore of Sitkalidak Strait, Mathisen and Lopp (1963) counted 2,740 here in March 1957 and 2,810 in June 1957 and a high of 4,261 in September 1956. Our surveys showed 1,636 sea lions in March 1976, 1,615 in June 1976 and 1,469 in October 1976. The sea lions use the east side of the Island. Although this was reported to have been a pupping rookery in the past (Vania pers. comm.), no substantial pupping activity was observed here during this study.

Cape Sitkinak Haulout 56°33'10"N, 153°51'45"W

The easternmost point of Sitkinak Island, which is the northernmost of the Trinity Islands off the south end of Kodiak Island, had 470 sea lions in March 1957 and 343 in June 1957 (Mathisen and Lopp 1963), and reported by Alaska Department of Fish and Game (1973) as having a population of 470. We photographed 257 sea lions here in March 1976, 120 in June 1976 and 302 in October 1976. The sea lions hauled out on a small group of rocks just off the Cape.

Chirikof Island Rookery 55°49'25"N, 155°44'20"W

Sixty miles south-southwest of the Trinity Islands, Alaska Department of Fish and Game (1973) reported 500 sea lions here and Mathiesen and Lopp (1963) counted 1,742 in June 1957 and 2,450 in September 1957. Our counts showed 3,870 in March 1976, 2,391 in June 1976 and 5,332 in October 1976. This area was used throughout the year by both sexes and all age classes and in excess of 1,000 pups were born here annually. The sea lions hauled out, bred, and pupped on the south side of the Island. This area was clearly a major pupping rookery with 1,573 pups counted in 1978 and 1,649 pups in 1979. Adult counts were 3,699 for 1978 and 5,199 for 1979.

Nagai Rocks Haulout 55°49'50"N, 155°46'50"W

Off the western most point of Chirikof Island, this had not been previously identified as a separate hauling area. We sighted 1,401 sea lions here in March 1976, 657 in June 1976 and 554 in October 1976.

Cape Ikolik Haulout 57°17'10"N, 154°46'50"W

Four miles south of Middle Cape which is the westernmost promontory of Kodiak Island, this location and several other points and rocks in the same area including Middle Cape, Inner Seal Rocks, Outer Seal Rocks, and Tombstone Rocks all made up the same general hauling area which we call Cape Ikolik. We sighted 1,913 sea lions here in March 1976, none in June 1976, and 1,213 in October 1976. The largest concentrations were found at the base of Cape Ikolik and the animals were most numerous in winter.

Cape Ugat Haulout 57°52'20"N, 153°50'45"W

On the eastern shore of Shelikof Strait, 12 miles southwest of Cape Uganik, Alaska Department of Fish and Game (1973) showed 50 sea lions at this location, our counts show 222 in March 1976 and none in June 1976. The haulout was located on Ugat Island on the northeast side, just off the Cape. This area was used primarily by males.

Cape Gull Haulout 58°12'40"N, 154°08'45"W

Five miles south of Cape Ugyak on the Alaska Peninsula, the sea lions hauled out on the rocks to the east of the point. We saw no sea lions here in March 1976 and 207 in June 1976 and none again in March 1977.

Takli Island Rock Haulout 58°03'40"N, 154°27'34"W

Between Cape Atushavik and Cape Iktugitak, north of Katmai Bay on the south side of the Alaska Peninsula, we counted 1,014 sea lions here in March 1976, 1,877 in June 1976 and estimated 700 in March 1977. The sea lions used the rocks due south of Takli Island.

Puale Bay Haulout 57°40'55"N, 155°24'05"W

Between Cape Kekurnoi and Cape Aklek on the south side of the Alaska Peninsula in the southern part of Shelikof Strait, Alaska Department of Fish and Game (1973) reported 2,800 sea lions here. We counted 1,014 in March 1976, 1,877 in June 1976 and estimated over 15,000 sea lions here in March 1977. This is an area that was used year-round by both sexes and all age classes. The sea lions hauled out in the group of large rocks on the north side of the bay.

Ugaiushak Island Haulout 56°47'25"N, 156°51'35"W

Six miles south of Cape Kuyuyukak on the south side of the Alaska Pen-

insula, Mathisen and Lopp (1963) reported 643 sea lions here in August 1956 and 213 in May 1957. Alaska Department of Fish and Game (1973) showed 600 sea lions here. We counted 125 sea lions here in June 1976 and none in March 1976 or March 1977. The sea lions hauled out on a small group of rocks to the southeast of Ugaiushak Island. These rocks may be awash at high tide.

Sutwik Island Haulout (west end) 56°32'10"N, 157°20'05"W

Alaska Department of Fish and Game (1973) reported the haul out here. We counted 40 sea lions here in March 1976, 6 in June 1976 and estimated 20 in March 1977. The sea lions hauled out in a small group of rocks on the southwest end of the island.

Chowiet Island Rookery 56°00'40"N, 156°41'W

The large southern island of the Semidi Islands, Alaska Department of Fish and Game (1973) showed 5,000 sea lions here and Mathisen and Lopp (1963) saw 6,323 sea lions in June 1957. On our surveys we counted 4,679 in October 1976 and were unable to completely survey the area in March or June 1976. In March 1977 we estimated 2,000 sea lions. The sea lions hauled out on the southwestern end of Chowiet Island, on Aliksemit Island and the small islands and rocks in the area. This was a breeding and pupping rookery where several thousand pups were born and was the largest rookery in the Gulf of Alaska south of Kodiak Island. We counted adults and pups here in 1978 and 1979. In 1978

the counts were 4,419 adults and 4,670 pups while in 1979 we counted 4,441 adults and 5,485 pups.

Spitz Island Haulout 55°47'20"N, 158°53'40"W

One and two-tenths miles southward of the south tangent of Mitrofania Island, Alaska Department of Fish and Game (1973) estimated 700 sea lions here. We counted 25 here in June 1976 but none in March 1976 or 1977.

Lighthouse Rocks Haulout 55°47'N, 157°25'W

Twenty-seven miles southward of Chowiet Island and 56 miles westward of Chirikof, this area has not previously been identified as a sea lion haul out. We surveyed it first in October 1976 when we counted 1,315 sea lions with some pups. This area was again surveyed in 1978 and 1979. At that time we counted 828 adults in 1978 and 250 pups. In 1979 we counted 737 adults and 112 pups.

Castle Rock Haulout 55°15'45"N, 159°29'45"W

Located about 1.5 miles north of Cape Thompson, the north point of Big Koniuji Island, Alaska Department of Fish and Game (1973) reported 400 sea lions here. We counted 189 sea lions in March 1976, and 401 in June 1976. The sea lions hauled out on the northeast side of the rock. We also photo-surveyed this area in June 1978 and counted 541 adults but saw no pups.

Atkins Island Rookery 55°03'05"N, 159°17'50"W

Off the northeast headland of Little Koniuji Island (connected by shoals) in the Shumagin Islands, Alaska Department of Fish and Game (1973) showed 3,100 sea lions here. We photographed 1,211 sea lions in March 1976 and 2,726 in June. The sea lions hauled out, pupped and bred on the east side of the island. This was the largest breeding rookery in the Shumagin Islands.

Atkins Island was surveyed for pup counts in 1978 and 1979. In June 1978 we estimated 3,943 adults here and counted 2,750 pups and in 1979 we estimated 5,000 adults and counted 4,538 pups.

Churnabura Island Rookery 54°45'15"N, 159°33'W

The most southerly of the Shumagins, Alaska Department of Fish and Game reported 2,000 sea lions here. We counted 1,667 in March 1976 and 1,437 in June 1976. The sea lions hauled out on the southeast side of the island. We counted 2,758 adults and 545 pups here in 1978 and 1,504 adults and 646 pups in 1979.

Nagai Island Haulout 54°56'N, 160°15'10"W

In the center of the Shumagin Group, 15 sea lions were listed by Alaska Department of Fish and Game (1973). We saw 233 sea lions here

in March 1973 and 405 in June 1973. The sea lions utilized a small group of rocks on the southwest side of the island, near the westernmost point.

Sea Lion Rocks Haulout (Shumagins) 55°04'50"N, 160°30'45"W

One mile southeast of Unga Cape, Alaska Department of Fish and Game (1973) showed 400 sea lions hauled out here. In March 1976 we photographed 187 sea lions here and 243 in June 1976.

Jude Island Haulout 55°15'50"N, 161°06'20"W

Thirteen miles northwest of Acheredin Point on the southwest end of Unga Island, a population of 3,000 sea lions shown by Alaska Department of Fish and Game (1973). Our counts showed 302 in June 1976 and none in March 1976 or March 1977.

Pinnacle Rock Rookery 54°46'15"N, 161°45'45"W

The easternmost named point of the Sandman Reefs, 980 sea lions reported by Alaska Department of Fish and Game (1973). We counted 141 in March 1976 and 1,745 in June 1976. In July 1978 we counted 3,692 adults and estimated 615 pups here and in late June 1979 we counted 2,731 adults and 2,748 pups.

Clubbing Rocks Rookery 54°42'50"N, 162°26'45"W

On the northwestern edge of the Sandman Reefs, Alaska Department of Fish and Game (1973) reported 5,600. Kenyon and Rice (1961) estimated 200 sea lions here. We photographed 1,217 in June 1976 but saw none here in March 1976 or 1977. This rookery consisted of three low rocks, each with an area of less than 5 hectares. In July 1978 we counted 2,663 adults and estimated 725 pups and in late June 1979 we counted 1,162 adults and 1,419 pups.

South Rock Haulout 54°17'43"N, 162°42'20"W

The southernmost named point southeast of Sanak Island, used by 3,200 sea lions according to Alaska Department of Fish and Game (1973). Kenyon and Rice (1961) estimated 1,000 sea lions here. Our surveys showed 972 sea lions here in March 1976 and 1,004 in June 1976. The sea lions utilized either of the larger rocky islands which make up south rock. We counted 1,320 adults here and 30 pups in June 1978.

Bird Island Haulout 54°40'10"N, 163°17'20"W

The most prominent land mark between Cape Pankof and Cape Aksit, in the mouth of Otter Cove on the northeast side of Unimak Island. Alaska Department of Fish and Game (1973) showed 260 sea lions here. We saw 112 sea lions here in June 1976, none in March 1976 or 1977.

Rock Island Haulout 54°36'30"N, 163°36'30"W

Located 1.5 miles west of Cape Lazaref on Unimak Island, 25 sea lions were sighted here on the June 1975 survey and 54 in June 1976.

Cape Lutke Haulout 54°29'25"N, 164°19'10"W

The southwest headland of Unimak Bight, we counted 22 sea lions hauled out on a small group of rocks here in June 1975.

Seasonal shifts in distribution and abundance have often been noted for sea lions (Nikulin 1937; Bonnot 1951; Bartholomew and Boolootian 1960, and Kenyon and Rice 1961). Generally sea lions are dispersed throughout the Gulf in winter occupying somewhat different haul outs than in summer. In some cases sea lions utilize more protected waters such as Prince William Sound in the winter and in fact some of the haulouts are used only in winter. Although all of the major pupping rookeries are used throughout the year, numbers are generally reduced in the winter. At Sugarloaf Island in the Barren Islands, winter numbers are reduced to less than 200 animals or less than 4% of the adult breeding population for this rookery.

Rookery Structure and Composition

By mid May sea lions began concentrating at the major pupping rookeries. Numbers of seal lions on rookeries build to a peak from mid to

late June (Tables 3 and 4). It is apparent that at Sugarloaf Island, where the total number of animals is reduced to a very low level in winter, the increase during the breeding season is due primarily to females arriving. In Table 4 the proportion of females in the counts reached 86% on June 23. At Marmot Island the proportion of adult females present did not exceed 58%. Marmot Island is used as a haulout by several thousand sea lions of both sexes and all ages during the rest of the year. The increased number of sea lions at Marmot during the breeding season was probably due to an increase in all ages and both sexes, although the largest increase of any single group was in adult females.

Generally the first arrivals at the rookery areas were the large adult males. The adult males establish themselves on territories which they defend throughout the breeding period (Gentry 1970, Sandegren 1970). At those locations where the sea lions remained throughout the year, on the areas which were used for pupping and breeding, there was a gradual change from a hauling area to a rookery. Prior to the breeding season the composition of those areas was often both sexes and all age classes. As the breeding season approached, subtle changes began to take place on the rookery. The adult males became increasingly aggressive toward juvenile males. As the adult males became more and more defensive of their territories, smaller males began to group on the fringes of the rookery. Eventually the juvenile males were excluded completely from the rookery areas and most appeared to congregate on "bachelor" areas adjacent to the rookeries.

Table 3. Steller sea lion counts on a portion of the Marmot Island Rookery, 1979.

Date	Total SL	Adult FF	% FF
May 16	3137	1138	36.3
20	4318	1600	37.1
26	4741	1057	22.3
June 2	4736	1935	40.9
5	5112	1982	38.8
10	5593	2769	49.5
13	5798	3163	54.6
17	5844	3386	57.9
22	5544	3040	54.8
27	5853	2941	50.3
July 2	5651	2926	51.8
8	4134	2199	53.2

Table 4. Steller sea lion counts of selected areas of the Sugarloaf Island Rookery 1979.

Date	Total SL	Adult FF	Percent FF
May 15	161	86	53.4
17	686	204	29.7
21	352	95	27.0
23	138	61	44.2
24	357	165	46.2
27	564	330	58.5
June 1	1346	860	63.9
4	1332	1010	75.8
6	1676	1267	75.6
10	2143	1709	79.7
15	3380	2760	81.7
19	3262	2653	81.3
23	3368	2889	85.8
26	3606	3055	84.7
28	2983	2477	83.0
July 12	3071	2591	84.4

As the breeding season progressed, conditions became crowded and competition for space increased. The adult females began seeking the more desirable areas to pup and most of the remaining juveniles were gradually forced out as the composition changed to adult females, territorial males and pups. Tables 5 and 6 show the increase in pups and adult males at Marmot and Sugarloaf Islands during the breeding season.

Table 5. Pup counts at Marmot Island 1979 and Sugarloaf Island 1978.

Sugarloaf Island		Marmot Island	
Date	Pup count	Date	Pup count
May 24	53	May 24	10
June 2	370	June 2	336
7	776	6	694
10	1308	10	1123
13	1776	12	1447
17	2026	15	1888
20	2123	19	1509
24	2245	26	3151
27	2467	28	3151
30	2620		
July 3	2907		

Table 6. Adult male counts on rookeries at Sugarloaf Island in 1978 and Marmot Island in 1979 (within breeding and pupping areas).

Sugarloaf Island		Marmot Island	
Date	Adult males	Date	Adult males
May 24	32	May 25	73
June 4	144	June 2	89
10	171	6	100
15	202	10	127
19	191	14	147
26	193	18	169
28	188	22	166
July 12	128	27	160
		July 1	156
		4	133
		8	92

MOVEMENTS

Shifts in distribution and movements of Steller sea lions have been noted historically throughout the range. Early recognition of seasonal changes in California were noted by Rowley (1929) who recorded movements of sea lions, particularly males moving northward after the breeding season. Rowley (1929) also quotes Scammon (1874) who found spear points in sea lions in California which he felt were made by natives of southeastern Alaska. Bonnot and Ripley (1948) spoke of movements of males along the west coast from the California Channel Islands to British Columbia and southern Alaska. Bartholomew and Boolootian (1960) observed an absence of adult males in the winter in California and the presence of either young males or females all year long which suggested seasonal migratory movements correlated with age and sex. Mate (1973) documented movements of sea lions onto Oregon rookeries. Pitcher (1973) indicated seasonal shifts in distribution of sea lions in Prince William Sound. Barabash (1936) noted seasonal movements of males between the Commander Islands and the Kamchatka Peninsula in the Soviet Union.

Large numbers of branded sea lions were sighted at Cape St. Elias on Kayak Island during intensive observations in 1977 and 1978 (Fig. 7). This indicated a movement of subadult sea lions away from the rookeries of birth and probably a major movement across the north Gulf to and past Cape St. Elias. Branded sea lions from the major rookeries at Marmot Island and Sugarloaf Island have been sighted as far away as Biali rocks in southeast Alaska; this represents a near-shore movement of approximately 1500 km, the longest movement of an animal marked in

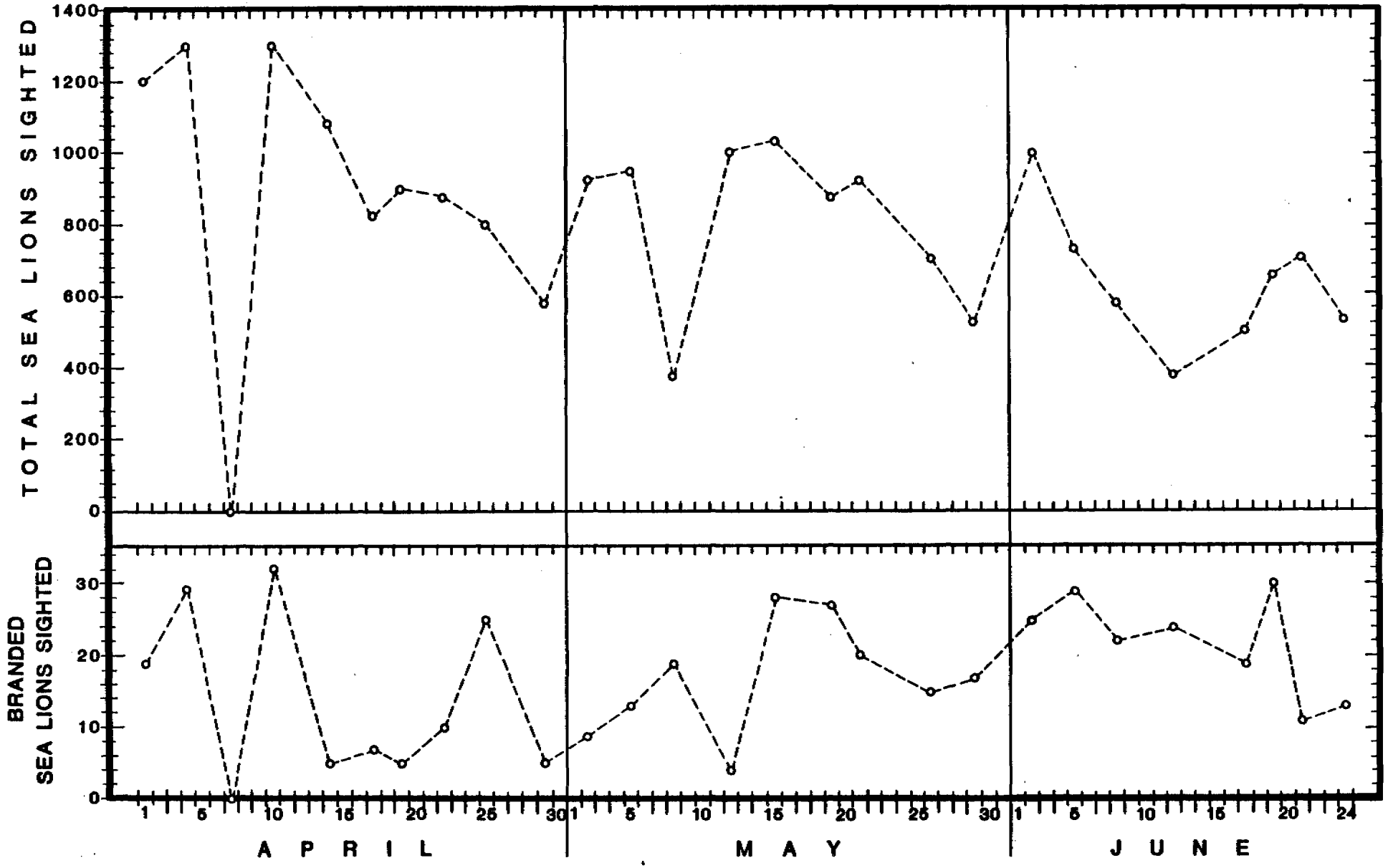

FIGURE 7. NUMBER OF BRANDED SEA LIONS SIGHTED AND TOTAL NUMBER PRESENT AT CAPE ST. ELIAS, KAYAK ISLAND, 1976.

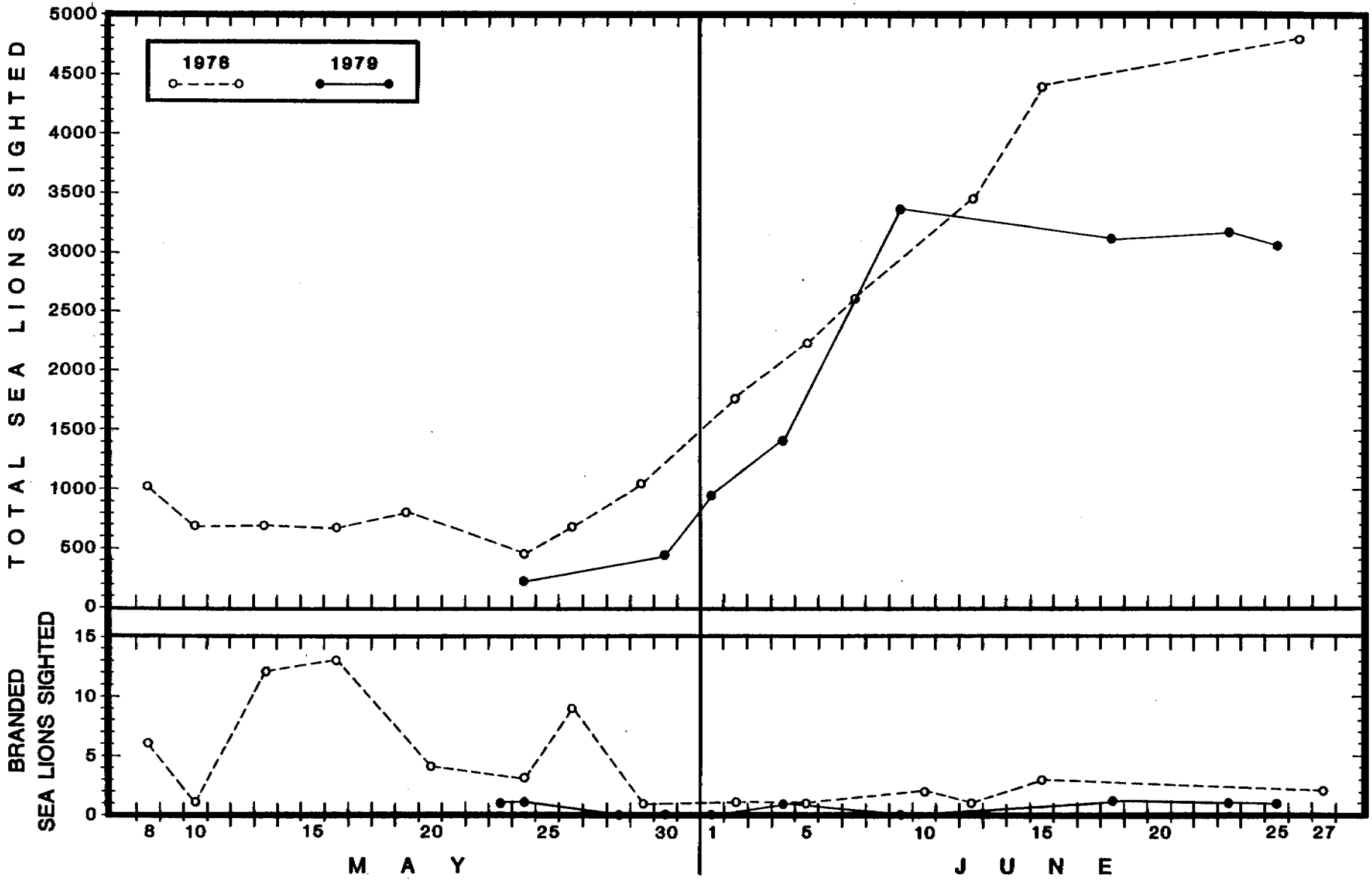

FIGURE 8. NUMBER OF BRANDED SEA LIONS SIGHTED AND TOTAL NUMBER OF SEA LIONS COUNTED, MAY AND JUNE 1978 AND 1979, SUGARLOAF ISLAND.

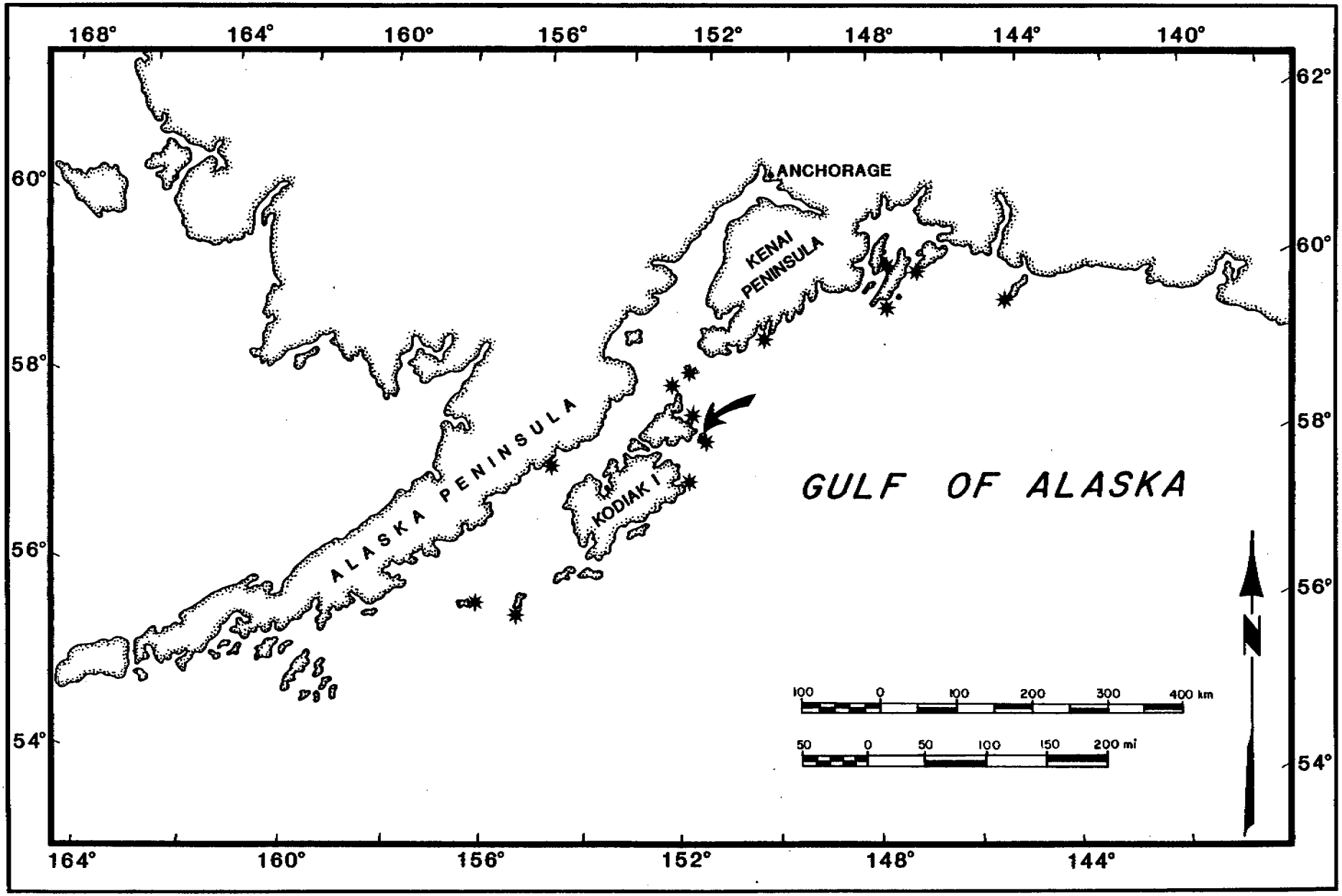

FIGURE 9. HAULOUTS WHERE SEA LIONS BRANDED AT MARMOT ISLAND (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

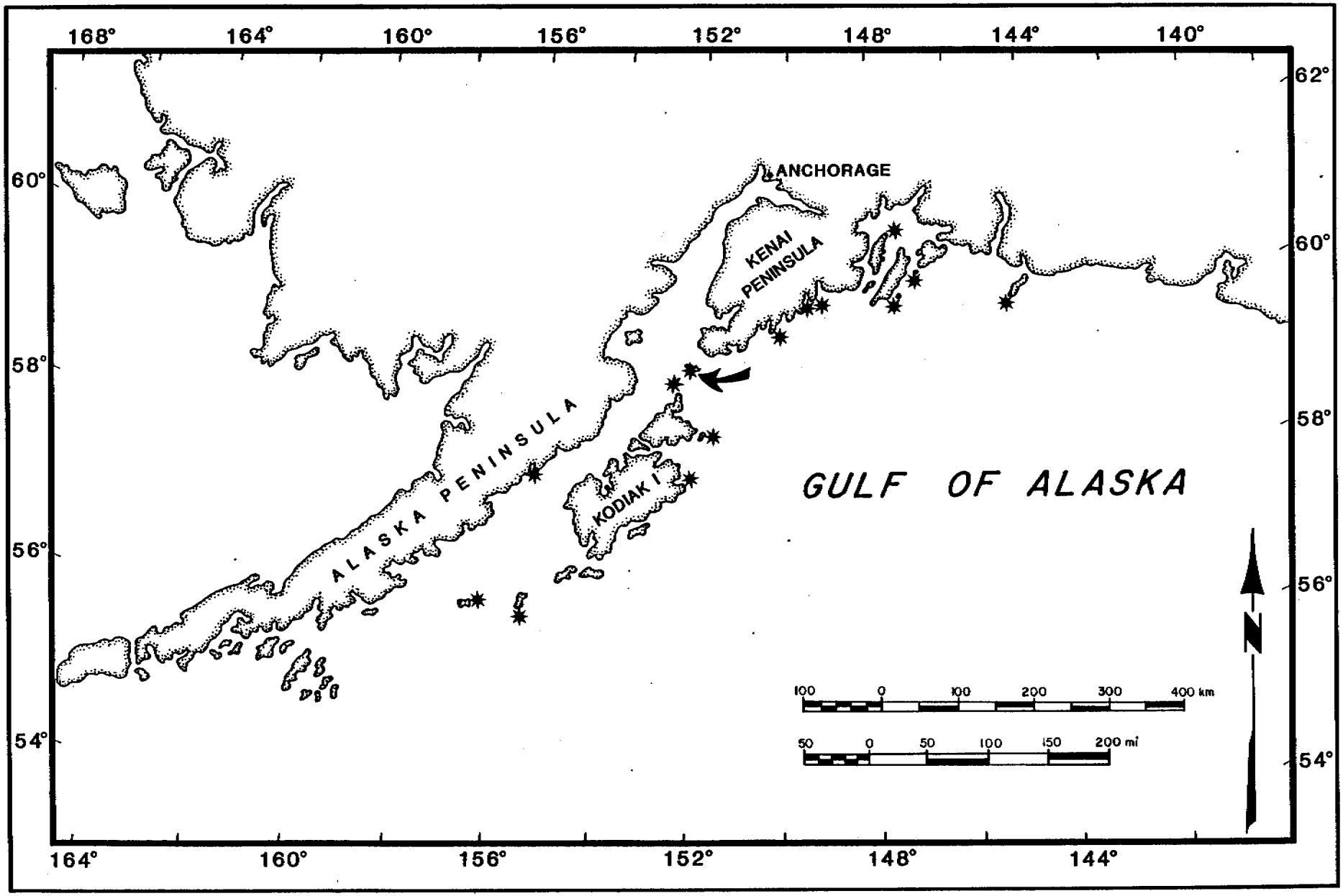

FIGURE 10. HAULOUTS WHERE SEA LIONS BRANDED AT SUGARLOAF ISLAND (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

this study. Similar movements of animals marked in a different study were recorded by us. We sighted subadult sea lions at Cape St. Elias which were ear tagged at Cape St. James, Queen Charlotte Island, British Columbia (H. D. Fisher Univ. of B.C pers. comm.) a near shore distance of approximately 1500 km.

The movement across the northern Gulf did not appear to be a directed, timed migration, more accurately, it could be considered a gradual, although directed dispersal. Evidence to support this conclusion included the sightings of marked sea lions from Sugarloaf and Marmot Islands on nearly all haulouts and rookeries between Marmot Island and Cape St. Elias, including many haulouts within Prince William Sound (Figs. 9 and 10). Also the pattern of movements at Cape St. Elias did not clearly show repeated annual peaks of branded animals.

There was a dispersal of young animals away from the rookeries of birth following the first summer of life. This trend was observed in juveniles until the study was terminated. The degree of this dispersal was dependent upon the type of rookery of birth. At Sugarloaf Island, where few animals remain overwinter, the dispersion is nearly complete. During intensive observations at Sugarloaf in 1978 and 1979, relatively few of branded sea lions were resighted (Fig. 8), although total numbers of animals older than pups of the year exceeded 4,000 in both years. The primary difference between Sugarloaf Island and Marmot Island, which is likely to be responsible for differential dispersion, is that as winter approaches the sea lions begin leaving Sugarloaf Island and by mid to late winter, few sea lions remain

there. At Marmot Island, numbers are reduced from the breeding season high but many sea lions remain throughout the year. Branded sea lions from Sugarloaf Island dispersed more and few returned as juveniles while some of those branded at Marmot remained there.

Although there seemed to be a distinct movement across the northern Gulf, sea lions also moved in other directions. Figs. 9 through 14 show all locations within the Gulf of Alaska study area where branded sea lions have been resighted. Resightings of branded animals outside the Gulf of Alaska study area have been made at haulouts in southeast Alaska. Branded animals were not sighted southwest of Chirikof Island and the Semidi Islands (Figs. 9-14). This may reflect reduced effort in this area, although we made two rookery surveys of the Atkins Island rookery. These surveys took place during the breeding season when the majority of animals present were adults, not those age classes which would have included branded animals. We are unable to conclude at this time if sea lions move from the large rookeries near Kodiak Island to the Shumigan Islands area and the south side of the Alaska Peninsula.

There appears to have been a directed effort by female sea lions to return to the rookeries of their birth to give birth to their pups. During the 1980 field observations when the branded sea lions were 4 and 5 years old, no cows 4 years old were observed with pups but 38 branded 5 year old cows were seen nursing new pups. Twenty five of these animals were seen at Sugarloaf Island and 13 at Marmot Island. Of the 38 branded sea lions which gave birth in 1980, 15 were identified on their rookery of birth. Only one of these animals gave

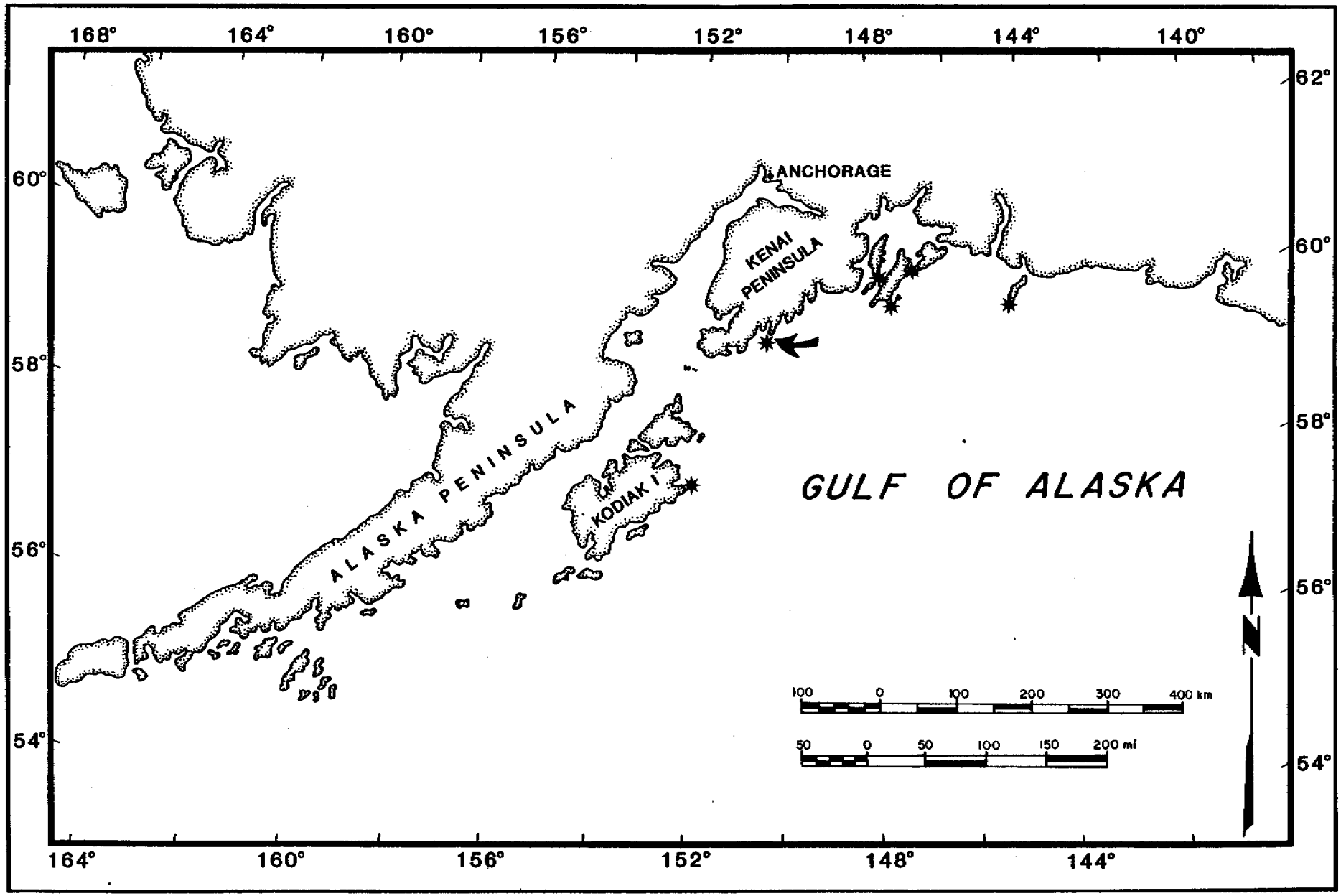

FIGURE 11. HAULOUTS WHERE SEA LIONS BRANDED AT OUTER ISLAND (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

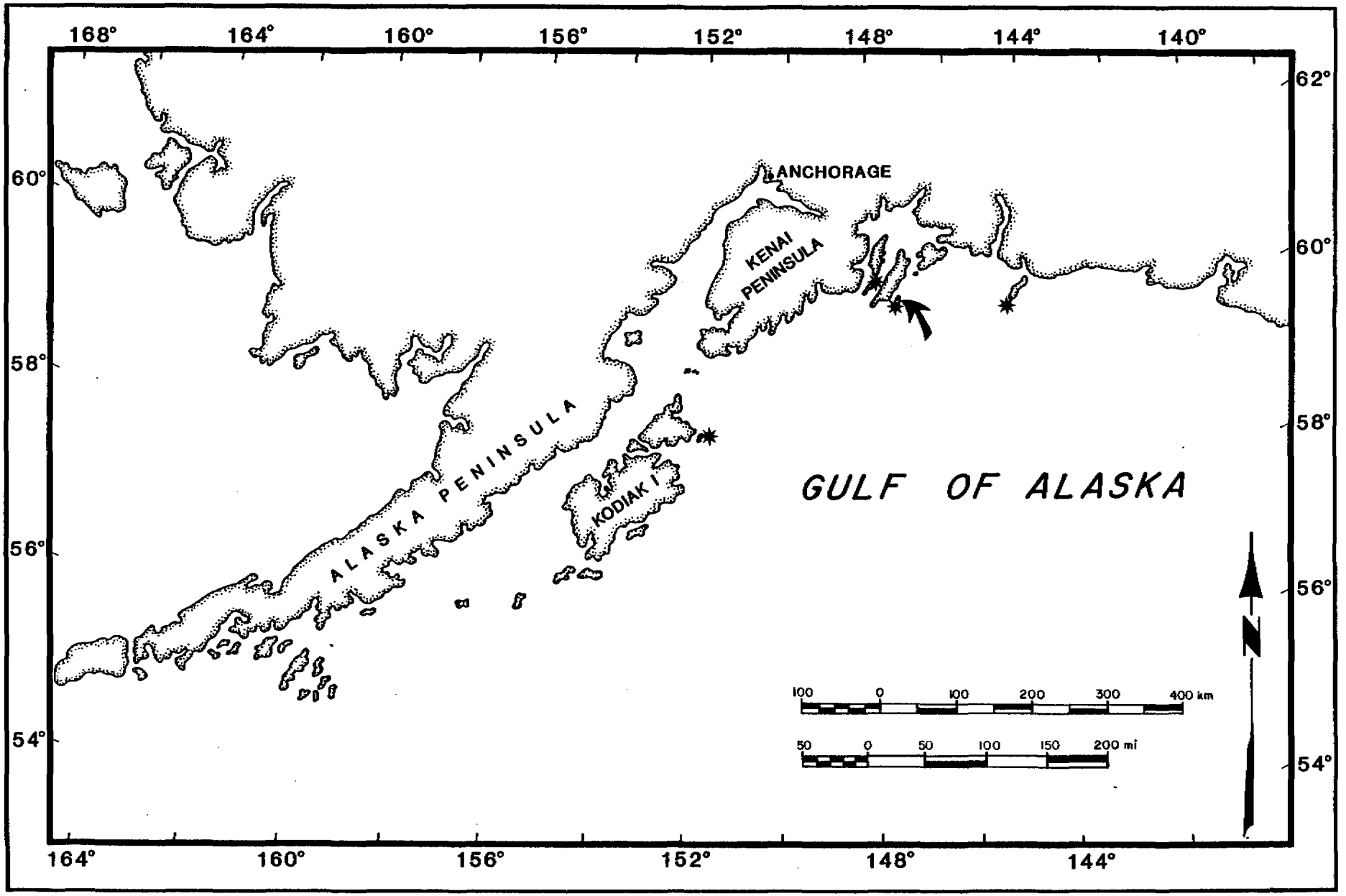

FIGURE 12. HAULOUTS WHERE SEA LIONS BRANDED AT THE WOODED ISLANDS (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

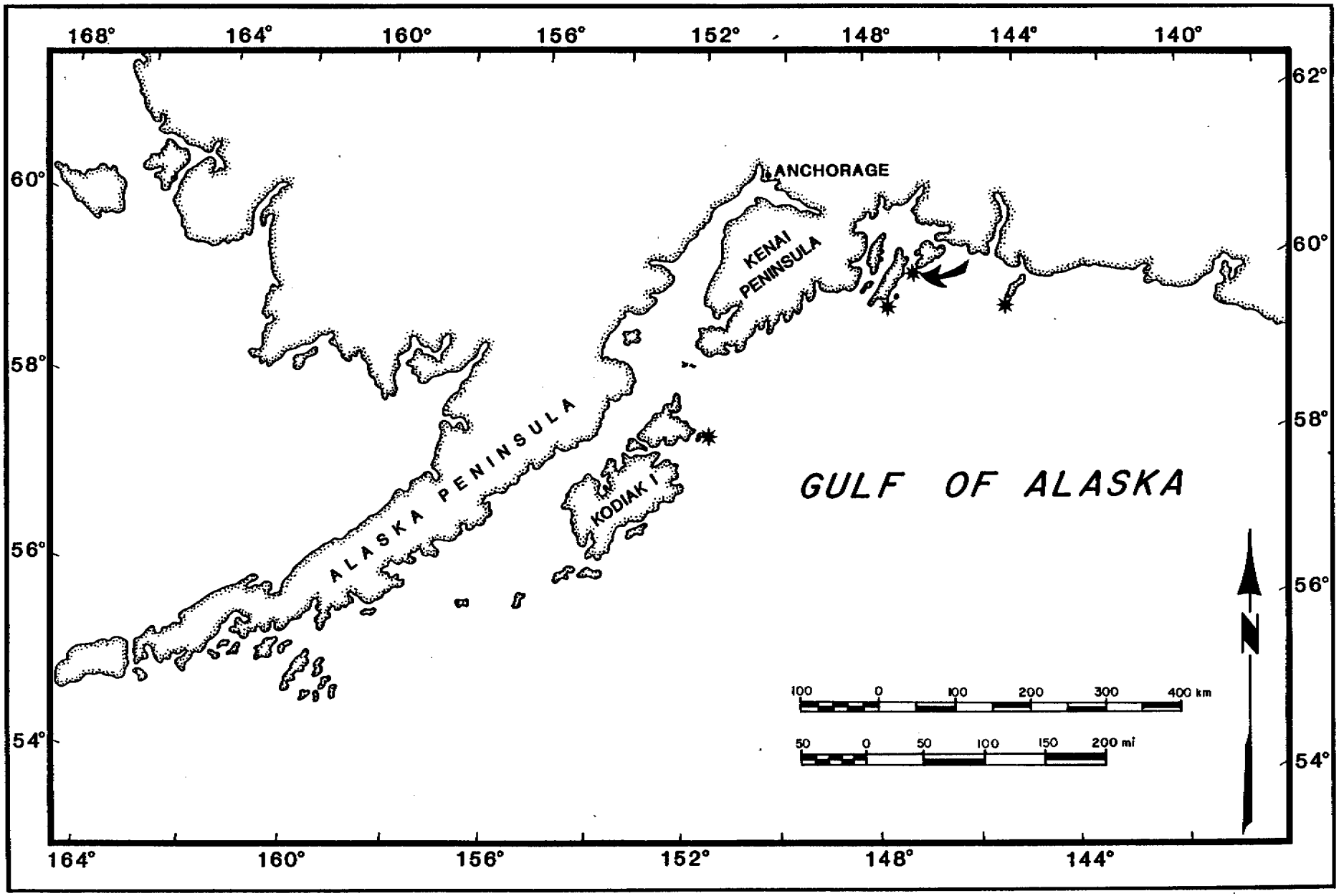

FIGURE 13. HAULOUTS WHERE SEA LIONS BRANDED AT SEAL ROCKS (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

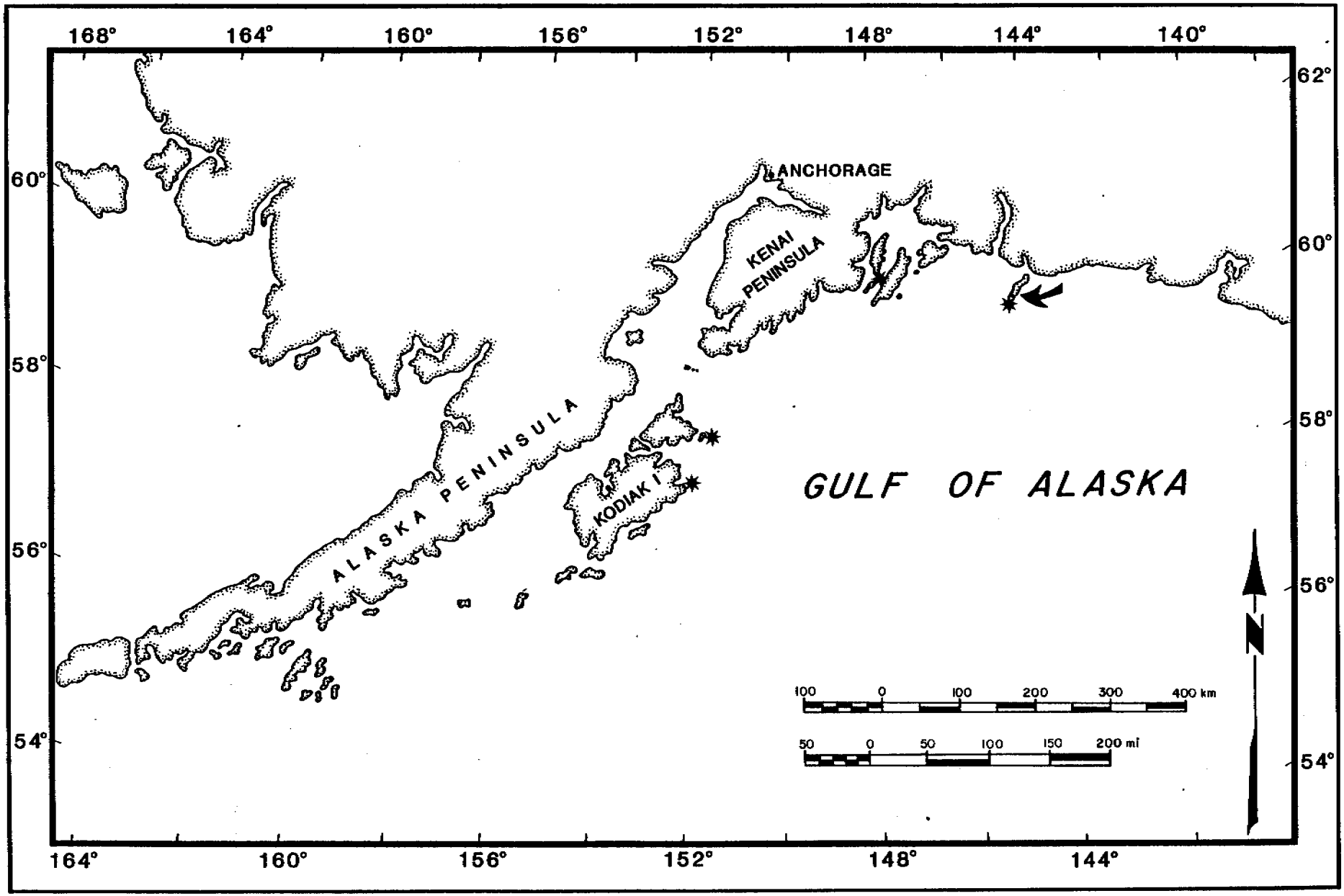

FIGURE 14. HAULOUTS WHERE SEA LIONS BRANDED AT CAPE ST. ELIAS (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

birth to a pup at a rookery other than where it was born. Nine cows which were branded at Sugarloaf Island in 1975 gave birth to pups there in 1976. The other 16 branded cows which gave birth to pups at Sugarloaf Island were not identifiable to their rookeries of birth. Five cows which were born at Marmot Island in 1975 gave birth to pups there in 1980, as well as one cow which was born at Sugarloaf Island in 1975. The other 7 branded cows which gave birth to pups at Marmot Island in 1980 were not recognizable to their rookeries of birth.

Of the 15 recognizable branded cows which gave birth on Marmot and Sugarloaf Islands in 1980, less than 7 percent gave birth at a rookery other than where they were born. These data are inadequate to conclude that all sea lions return to their birth place to bear their young, however, observations in the following years could support or deny this.

Table 7 shows the branded sea lion sightings which were made at Sugarloaf Island in 1978 through 1980. There was a dramatic increase in sightings between 1979 and 1980 with a sharp decrease in sightings between 1978 and 1979. This low in 1979 when the animals were 3 and 4 years old probably can be attributed to the movements of juveniles away from their rookeries of birth while the 17 fold increase in brand sightings in 1980 over 1979 probably indicates a return of adults to their rookeries of birth. In 1980, nearly 80% of the animals with identifiable brands sighted at Sugarloaf were born there.

Table 7. Branded sea lion sightings at Sugarloaf Islands in the Gulf of Alaska, summer 1980.

Location	Brands sighted	Number of sightings		
		1980	1979	1978
Sugarloaf I.	left shoulder X	208	6	26
	right shoulder X	273	16	34
	O	68	1	23
	T	54	5	42
	left shoulder unid.	271	18	57
	right shoulder unid.	54	8	55
	Total	928	54	251

FOOD HABITS

Prey items were found in 153 of 250 sea lion stomachs examined. Fishes comprised 72.8%, cephalopods 21.5%, decapod crustaceans 4.2%, gastropods 0.8% and mammals 0.4% of the prey occurrences (Table 8). The gastropods were marine snails. Cephalopods included octopus and squids of the family Gonatidae. Decapod crustaceans were shrimps and tanner and spider crabs. Fishes included a minimum of 14 species representing 11 families. The cod family (Gadidae) composed nearly one-half of the total occurrences and nearly 60% of total volume. Harbor seal (*Phoca vitalina richardsi*) remains were found in two stomachs. Major prey were ranked (Table 9) using the modified Index of Relative Importance. The seven top-ranked prey in order of ranking were walleye pollock, herring, squids, capelin, salmon, Pacific cod and sculpins. Pollock was by far the dominant prey accounting for about 39% of all occurrences and 58% of the total volume. Fisheries assessment studies in the Gulf of Alaska indicated that pollock was the predominant fish species, comprising 45% by weight of the total demersal fish stocks (Pereyra and Ronholt 1976).

Examination of seasonal use of prey in the Kodiak area (Table 10) indicated that predation on salmon and capelin was largely limited to spring and summer. This likely reflected seasonal, nearshore distribution associated with spawning by these species (Hart 1973; Jangaard 1974). Pitcher (1980) found a similar seasonal pattern of harbor seal predation on salmon and capelin in the Gulf of Alaska.

Remains of at least two harbor seals were found in the stomach of an

Table 8. Stomach contents of 153 Steller sea lions collected in the Gulf of Alaska, all areas and seasons combined.

Prey	Occurrences No.	Occurrences Percentage and 95% conf. lim.	Volume ml	Volume Percentage
Gastropoda				
Snails	2	0.8 % 1.2	20	<0.1
Cephalopoda	56	21.5 % 5.2	15,777	4.2
Octopus sp. (octopus)	20	7.7 % 3.4	250	<0.1
Gonatidae (squids)	35	13.4 % 4.3	15,507	4.2
Unidentified cephalopods	1	0.4 % 0.9	20	<0.1
Decapoda	11	4.2 % 2.6	130	<0.1
Shrimps	8	3.1 % 2.3	100	<0.1
Chionoecetes sp. (tanner crab)	2	0.8 % 1.2	20	<0.1
Hyas sp. (spider crab)	1	0.4 % 0.9	10	<0.1
Unidentified invertabrates	1	0.4 % 0.9	10	<0.1
Rajidae				
Raja sp. (skate)	1	0.4 % 0.9	960	0.3
Clupeidae				
Clupea harengus (herring)	16	6.1 % 3.1	76,920	20.6
Salmonidae				
Oncorhynchus spp. (salmon)	6	2.3 % 2.0	19,160	5.1
Osmeridae				
Mallotus villosus (capelin)	16	6.1 % 3.1	27,755	7.4
Gadidae	126	48.3 % 6.3	222,772	59.7
Eleginus gracilis (saffron cod)	2	0.8 % 1.2	815	0.2
Gadus macrocephalus (Pacific cod)	19	7.3 % 3.3	3,471	0.9
Microgadus proximus (Pacific tomcod)	1	0.4 % 0.9	680	0.2
Theragra chalcogramma (walleye pollock)	102	39.1 % 6.1	217,746	58.3
Unidentified Gadidae	2	0.8 % 1.2	60	<0.1
Zoarcidae				
Lycodes sp (eelpout)	1	0.4 % 0.9	10	<0.1

Table 8. Continued

Prey	Occurrences No.	Occurrences Percentage and 95% conf. lim.	Volume ml	Volume Percentage
Scorpaenidae				
Sebastes spp. (rockfishes)	4	1.5 % 1.7	3,030	0.8
Cottidae (sculpins)	6	2.3 % 2.0	4,960	1.3
Agonidae				
Podothecus acipenserinus (sturgeon poacher)	1	0.4 % 0.9	60	<0.1
Trichodontidae				
Trichodon trichodon (Pacific sandfish)	2	0.8 % 1.2	300	<0.1
Pleuronectidae (flatfishes)	7	2.7 % 2.2	1,030	0.3
Unidentified fishes	4	1.5 % 1.7	40	<0.1
Phocidae				
Phoca vitulina (harbor seal)	1	0.4 % 0.9	250	<0.1
TOTALS:	261		373,184	

Table 9. Rankings by modified Index of Relative Importance (IRI, see methods) of major prey of Steller sea lions collected in the Gulf of Alaska. Only those prey with IRI > 2 are included.

Rank	Prey	Modified IRI	Percentage of Occurrences	Percentage of Volume
1	Walleye pollock	2280	39.1	58.3
2	Herring	126	6.1	20.6
3	Squids	56	13.4	4.2
4	Capelin	45	6.1	7.4
5	Salmon	12	2.3	5.1
6	Pacific cod	7	7.3	0.9
7	Sculpins	3	2.3	1.3

Table 10. Seasonal occurrences of principal prey (N $\geq$ 4) of Steller sea lions from the Kodiak Island area.

Prey	January-March Occurrences of prey	January-March Percentage % 95% C.L.	April-June Occurrences of prey	April-June Percentage % 95% C.L.	July-September Occurrences of prey	July-September Percentage % 95% C.L.	October-December Occurrences of prey	October-December Percentage % 95% C.1.
Octopus	1	25.0 % 60.1	4	11.1 % 11.7	1	6.3 % 12.9	8	26.7 % 17.5
Salmon	0	0	1	2.8 % 6.8	3	18.8 % 20.7	0	0
Capelin	0	0	8	22.2 % 15.0	6	37.5 % 25.7	0	0
Pacific cod	1	25.0 % 60.1	5	13.9 % 12.7	1	6.3 % 12.9	2	6.7 % 10.6
Walleye pollock	2	50.0 % 69.4	9	25.0 % 15.5	3	18.8 % 20.7	5	16.7 % 15.0
Flatfishes	0	0	1	2.8 % 6.8	1	6.3 % 12.9	3	10.0 % 12.4
Total occurrences	4		36		16		30	

11 year old, male sea lion collected on 28 April 1977 at Gull Point, Kodiak Island. The sea lion which weighed 652 kg and had a standard length of 282.5 cm appeared to be in good condition with a blubber layer of 70 mm over the tip of the sternum. The harbor seal remains, which were examined and identified by Dr. F. H. Fay (University of Alaska, Fairbanks), consisted of the hind flippers and tail from a young seal, perhaps 1 year old and two ribs from a larger animal near adult size. Fay remarked that the hind flipper bones from the younger animal were small for its age (based on condition of the distal epiphyses) and speculated that it might have been a starveling.

Lanugo from either a fetal or newborn harbor seal pup was found in feces from the large intestine of a 6 year old female sea lion collected on 27 May 1977 at Cape Chiniak, Kodiak Island. The sea lion weighed 268 kg, had a standard length of 227.5 cm and had 28 mm of blubber over the sternum. She was pregnant with a near term fetus and was lactating.

Harbor seals formed only a small portion of the diet of 250 Steller sea lions collected in the Gulf of Alaska accounting for 0.4% of prey occurrences and ≤0.1% of total prey volume. However because two sea lions had eaten harbor seals and one of these had preyed upon two different animals they cannot be regarded as accidental occurrences. The finding of portions of two individual harbor seals in one stomach suggests that the sea lion may have regularly fed upon seals. It is interesting to note that two of the three harbor seals eaten by sea lions may have been particularly vulnerable to predation because of condition (starveling) or age (newborn pup).

Tikhomirov (1959) found the remains of a ringed seal pup (*Phoca hispida*) in the stomach of a large male Steller sea lion collected in the Okhotsk sea. Steller sea lions were estimated to kill between 3% and 6% of the northern fur seal pups (*Callorhinus ursinus*) produced on St. George Island (Gentry and Johnson In Press). No mention is made of predation on harbor seals or other pinnipeds in the published studies of feeding habits of Steller sea lions in the northeastern Pacific and eastern Bering Sea (Imler and Sarber 1947; Wilke and Kenyon 1952; Mathisen et al. 1962; Thorsteinson and Lensink 1962; Spalding 1964; Fiscus and Baines 1966; Jameson and Kenyon 1977).

Although comparisons of prey utilization between geographic areas were hampered by small samples and incomplete seasonal coverage, some differences were apparent. Walleye pollock was the top-ranked prey in all areas except for Kodiak where it was ranked second below capelin (Table 11). Herring and squids were extensively used by sea lions in Prince William Sound, but appeared to be unimportant in other areas. Harbor seals also appeared to utilize more squids and herring in Prince William Sound than in other areas of the Gulf (Pitcher 1980) which was attributed to differing water depths and bottom topography. Capelin and salmon ranked much higher in the Kodiak area than in Prince William Sound and along the Kenai coast. However, the observed differences may have been at least partially a result of the seasonal distribution of collected animals from these areas. Most sea lions collected in Prince William Sound were taken during fall and winter while the seasonal analysis from Kodiak (Table 10) indicated that predation on salmon and capelin was largely limited to spring and summer.

Table 11. Principal prey of Steller sea lions from five geographic areas in the Gulf of Alaska. Prey ranked in order of modified Index of Relative Importance (IRI, see methods). Only those prey with IRI ≥3 are included.

Northeastern Gulf of Alaska (stomachs with contents, 2; occurrences, 3; volume 4,400 ml).

Prey	IRI	Percentage of Occurrence with 95% conf. lim.	Percentage of Volume
Walleye pollock	3,323	33.3 % 86.6	99.5
Squids	7	33.3 %86.6	0.2
Capelin	7	33.3 %86.6	0.3

Prince William Sound (stomachs with contents, 73; occurrences, 129; volume. 272,543 ml).

Prey	IRI	Percentage of Occurrences with 95% conf. lim.	Percentage of Volume
Walleye pollock	2,799	45.0 %9.0	62.2
Herring	327	11.6 %5.9	28.2
Squids	133	23.3 %7.7	5.7
Sculpins	6	3.1 %3.4	1.8
Rockfishes	3	2.3 %3.0	1.1

Kenai Coast (stomachs with contents, 23; occurrences, 37; volume, 13,165 ml).

Prey	IRI	Percentage of Occurrences with 95% conf. lim.	Percentage of Volume
Walleye pollock	4,864	54.1 %17.4	89.9
Pacific tomcod	14	2.7 % 6.6	5.2
Pacific sandfish	5	2.7 % 6.6	1.7
Octopus	4	8.1 %10.1	0.5
Saffron cod	4	2.7 % 6.6	1.4
Pacific cod	3	5.4 % 8.6	0.5

Table 11. (Continued)

Kodiak (stomachs with contents, 49; occurrences, 86; volume, 64,551 ml).

Prey	IRI	Percentage of Occurrences with 95% conf. lim.	Percentage of Volume
Capelin	701	16.3 %8.4	43.0
Walleye pollock	504	22.1 %9.3	22.8
Salmon	131	4.7 %5.0	27.9
Pacific cod	36	10.5 %7.1	3.4
Octopus	3	16.3 %8.4	0.2
Skates	2	1.1 %2.8	1.5
Flatfishes	2	5.8 %5.5	0.3

Alaska Peninsula (stomachs with contents, 6; occurrences, 6; volume 18,525 ml).

Prey	IRI	Percentage of Occurrences with 95% conf. lim.	Percentage of Volume
Walleye pollock	6,250	66.7 %47.1	93.7
Salmon	210	33.3 %47.1	6.3

Four studies of sea lion feeding habits in which a total of 158 stomachs with food were examined, were conducted in the Gulf of Alaska between 1945 and 1960 (Imler and Sarber 1947; Mathisen et al. 1962; Thorsteinson and Lensink 1962; Fiscus and Baines 1966). A comparison of prey occurrences from those studies and this study shows some major differences (Table 12). Spearman rank correlation analysis did not show a significant degree of concordance ($r_s = 0.31$, $P \geq 0.05$) between the rankings of prey in the two data sets. There were significantly fewer occurrences ($X^2 = 36.99$, $P \leq 0.001$) of invertebrates in the 1975-1978 sample than during previous studies which was largely the result of fewer occurrences of clams, mussels and snails; 0.8% in our sample compared to 21.1% in the previous studies. Among the fishes, herring made up 6.1% of the occurrences in this study while they were not previously reported. Greenling (*Hexagrammos* spp.) and Pacific sandlance (*Ammodytes hexapterus*) comprised 7.0% and 6.0% of the occurrences, respectively, in the four previous studies, but were not present in our collections. Perhaps the most dramatic difference was in the use of walleye pollock. This species was the predominant prey in our sample (39.1% of total occurrences) but made up only 2.0% of occurrences in prior studies.

Concurrent with the apparent increase of pollock in the sea lion diet was an increase in pollock abundance in the Gulf of Alaska. Between 1961 and 1973-75 pollock increased from 5% to 45% by weight of total demersal fish stocks (Pereyra and Ronholt 1976). The apparent differences in consumption of invertebrates, herring, greenling and Pacific sandlance may have been in part the result of biases associated with limited seasonal and geographic sampling during prior studies. Nearly

Table 12. Comparative percentage of total prey occurrences of principal prey ($N \geq 4$) of Steller sea lions collected in the Gulf of Alaska during this study (153 stomachs with food; 1975-1978) and during prior studies (158 stomachs with food; 1945-1960[1]). Prey are ranked in descending order of occurrences.

Prey	1975-1978 Occurrences			1945-1960[1] Occurrences		
	Rank	Number	Percentage %95% C.L.	Rank	Number	Percentage %95% C.L.
Walleye pollock	1	102	39.1 %6.1	11.5	3	1.3 %1.7
Cephalopods	2	56	21.5 %5.2	1	61	27.2 %6.1
Pacific cod	3	19	7.3 %3.3	13.5	0	0.0
Herring	4.5	16	6.1 %3.1	13.5	0	0.0
Smelts	4.5	16	6.1 %3.1	4.5	15	6.7 %3.5
Crabs and shrimp	6	11	4.2 %2.6	6.5	14	6.3 %3.4
Flatfishes	7	7	2.7 %2.2	9.5	8	3.6 %2.7
Sculpins	8.5	6	2.3 %2.0	8	9	4.0 %2.8
Salmon	8.5	6	2.3 %2.0	11.5	3	1.3 %1.7
Rockfishes	10	4	1.5 %1.7	4.5	15	6.7 %3.5
Mussels, clams, snails	11	2	0.8 %1.2	2	42	18.8 %5.3
Other invertebrates	12	1	0.4 %0.9	9.5	8	3.6 %2.7
Greenlings	13.5	0	0.0	6.5	14	6.3 %3.4
Pacific sandlance	13.5	0	0.0	3	17	7.6 %3.7
Others		15	5.7 %3.0		15	6.7 %3.5
Total invertebrates		70	26.8 %5.6		125	55.8 %6.7
Total fishes		191	72.8 %5.6		99	44.2 %6.7
Total occurrences		261			224	

[1] Imler and Sarber 1947; Mathisen et al. 1962; Thorsteinson and Lensink 1962; Fiscus and Baines 1966.

all of those previous collections were near rookeries during the breeding season while we sampled throughout much of the year at a wide range of locations.

Four of the five top-ranked prey of sea lions were off-bottom schooling species. Many of the important prey reported in other studies of Steller sea lion foods also fit into this category and include herring; smelts; Pacific cod; Pacific hake (*Merluccius productus*); walleye pollock, some rockfishes and Pacific sandlance (Imler and Sarber 1947; Spalding 1964; Fiscus and Baines 1966). Use of this prey type may be important in minimizing foraging effort and conserving energy, compared to the energy expenditures of capturing more solitary species (Smith and Gaskin 1974; Pitcher 1980).

REPRODUCTION

Most published information on reproduction in this species has been based on observations of animals on rookeries and hauling areas (Pike and Maxwell 1958; Mathisen et al. 1962; Thorsteinson and Lensink 1962; Orr and Poulter 1967; Gentry 1970; Sandegren 1970; Mate 1973). These studies documented social and behavioral aspects of reproduction and provided information on timing and sequence of reproductive events. Some estimates of birth rates were made from counts of females and pups.

Perlov (1971) estimated ages of sexual maturity for males and females based on specimens from 115 sea lions collected in the Kuril Islands. The age distribution of 160 territorial bulls collected on rookeries in the Gulf of Alaska was examined by Thorsteinson and Lensink (1962).

Birth Season

During our study female Steller sea lions in the Gulf of Alaska gave birth to viable young between mid-May and mid-July. The earliest birth of a viable pup was seen on 13 May while the latest birth was recorded on 14 July. Nearly 70% of the births on Sugarloaf Island in 1978 and Marmot Island during 1979 occurred between 5 and 26 June (Tables 13 and 14).

Timing and duration of pupping on rookeries from California to the Bering Sea appears to be similar, occurring from mid-May until mid-July and peaking in June (Scheffer 1946; Pike and Maxwell 1958; Thorsteinson and Lensink 1962; Gentry 1970; Mate 1973).

Table 13. Progression of pupping by Steller sea lions on a portion of Sugarloaf Island during 1978, based on cumulative counts.

Date	Number of Pups	Birth/Day*
15 May	2	-
17 May	4	1.0
19 May	10	3.0
21 May	16	3.0
23 May	27	5.5
26 May	85	19.3
28 May	131	23.0
31 May	200	23.0
2 June	336	68.0
5 June	648	104.0
10 June	1,123	95.0
15 June	1,888	153.0
19 June	2,509	155.2
26 June	3,151	91.7
4 July	3,694	67.9

* Increase in pups/number of days.

Table 14. Progression of pupping by Steller sea lions on a portion of Marmot Island during 1979, based on cumulative counts.

Date	Number of Pups	Births/Day*
13 May	3	-
18 May	8	1.0
21 May	18	3.3
25 May	62	11.0
27 May	134	36.0
2 June	370	39.3
5 June	616	82.0
9 June	1,088	118.0
12 June	1,503	138.0
17 June	2,026	104.0
23 June	2,245	36.5
27 June	2,467	55.5
29 June	2,620	76.5
3 July	2,907	71.8
8 July	2,524	-

* Increase in pups/number of days.

Lactation and Weaning

Length of the lactation period and timing of weaning in Steller sea lions were not clearly defined and appeared to be highly variable. The "normal" female offspring bond was probably less than one year. About 63% of mature females gave birth to full term pups annually and it was uncommon to see females accompanied by young of more than one age class. However, we sometimes saw subadults (1-3 years), including known aged animals up to 37 months of age, suckling females. Milk was found in the stomach of a 39 month old female.

Some weaning probably takes place late in the gestation period as the proportion of lactating females appeared to decrease prior to partarition (Table 15). There was no discernible correlation between lactation and pregnancy status. There was no significant difference (X^2=0.30, P≥0.30) in the proportion of mature, nonpregnant females (13 of 16, 81%) and mature, pregnant females (43 of 60, 72%) which were lactating.

Rare (≤1% of nursing observations on rookeries) instances of females nursing two individuals simultaneously were seen and included females nursing two subadults, one subadult and one pup, and two pups. One bizarre observation was made of a large female nursing a smaller female who, in turn, was nursing a subadult. Milk was seen flowing from the nipples of both females. Observations were made which indicated that pups and subadults suckle females other than their mothers. Pups were seen apparently surreptitiously suckling a female who was nursing another pup; quickly laying down when the female looked back. One

Table 15. Percentage of multiparous female Steller sea lions lactating by seasonal period.

Seasonal Period	Number of Multiparous Females	Percentage Lactating
24 June - August	6	83%
7 October - 15 November	17	82%
4 February - 22 March	27	81%
12 April - 28 May	28	61%

recognizable female was seen nursing two different yearlings over a 17 day period.

Sandegren (1970) listed four ways in which the mother-offspring bond lasted more than a single year: (1) females did not give birth every year and retained the bond with their young into the second year, (2) females renewed the bond with their last young after loss of a pup, (3) females rejected the newborn and kept the older offspring and (4) the female kept both pup and yearling. He observed suckling subadults of at least two age classes including some nearly as large as their mothers.

Varying proportions of mature females accompanied by nursing subadults have been reported; 2% in California (Gentry 1970), 12% in Oregon (Mate 1973), 25% in British Columbia (Pike and Maxwell 1958), 81% in Alaska (Sandegren as cited by Mate 1973). On Marmot Island we found 28% of the adult females were accompanied by subadults while on Sugarloaf 1% of the females were with subadults. Mate (1973) suggested a north-south clinal gradation in length of the nursing period. However, it appears to us that the observed differences in proportions of nursing subadults were probably related to the type of areas where the observations were made i.e., rookeries, hauling areas or combinations of these. The two extremes were both in Alaska. Sandegren's high figure of 81% was from a hauling area where very few pups were born while the 1% figure was from Sugarloaf which is primarily a rookery.

Breeding

The earliest copulations were seen on 22 May 1978 on Sugarloaf Island and on 30 May 1979 on Marmot Island. Most (98%) of 215 copulations observed on Marmot Island in 1979 were between 7 June and 4 July. The latest copulation was seen on 12 July, however, limited breeding must have taken place after this as a few births were still taking place when observations terminated on 15 July.

Both Gentry (1970) and Sandegren (1970) were able to recognize individual females and to calculate the time elapsed between birth and copulation. Gentry reported that females bred from 6 to 16 days after giving birth ($\bar{X}$ = 11.4 days) while Sandegren found that breeding occurred from 10 to 14 days after birth ($\bar{X}$ = 11.8 days).

Delay of Implantation

Although most Steller sea lions breed between late May and mid-July the blastocyst apparently does not implant until late September or October. Eight mature females collected between 24 June and 1 August had ovulated and a corpus luteum was present in an ovary from each animal. No embryos or implantation sites were found in the uteri. Ten of 11 mature females collected between 7 and 14 October had small, implanted embryos weighing between 0.01 g and 25.9 g. The other female had a corpus luteum, but no embryo or implantation site was found. She may have been in the delay of implantation or the pregnancy had failed. All seven mature females collected between 27

October and 15 November had implanted embryos.

These observations support the findings of Vania and Klinkhart (1967) who postulated a 3 month delay of implantation, ie. the peak of breeding in mid-late June and the peak of implantation in late September.

A very small embryo weighing 0.4 g was found in the uterus of a female collected on 11 February. The embryo was comparable in size to those collected in October just after implantation. The average weight of 17 fetuses from females collected from 11-16 February was 4255 g.

Age of First Ovulation and First Pregnancy

First ovulations in our sample of female sea lions occurred between 3 and 8 years of age (Table 16). The largest number of first ovulations was found in the 4 year age class. The average age of first ovulation was 4.6 ± 0.8 years (95% confidence interval). Initial pregnancies also occurred between the ages of 3 and 8 years (Table 16). The average age of first pregnancy was 4.8 ± 1.2 years (95% confidence interval).

Observations were made of at least one known age, 3 year old female nursing a pup on Marmot Island during the summer of 1979. This indicated ovulation and breeding at 2 years of age and giving birth to a pup at 3 years of age. This is considered a rare occurrence as examination of reproductive tracts from 11 2-year-olds and 19 3-year- olds showed no evidence of ovulation in 2-year-old animals.

Table 16. Age distribution of first ovulations and initial pregnancies of Steller sea lions collected in the Gulf of Alaska.

Age	Number of First Ovulations	Number of Initial Pregnancies
≤2 years	0	0
3	5	3
4	6	2
5	2	2
6	3	2
7	1	1
8	1	1
>8	0	0

Perlov (1971) concluded that females from the Kurile Islands first ovulated at 3 or 4 years of age; all 5 year olds had ovulated and by 7 years all had borne pups. These results were nearly identical to ours except we found a wider range of maturation ages as might be expected in a larger sample.

Ovulation and Pregnancy Rates

Ovulation rates increased from 26% at 3 years of age to 100% by 6 years (Table 17). All females 6 years old and older which we examined had ovulated in the year they were collected. Observed pregnancy rates increased from 20% at 3 years to 87% for females between 8 and 20 years (Table 17). None of the three females older than 20 years were pregnant, possibly indicating reduced fecundity in the older age classes.

Reproductive Failures

Reproductive failures were classified according to the following terminology of Craig (1964) and Bigg (1969): (1) missed pregnancies where the female ovulated and either fertilization did not occur or the blastocyst failed to implant, (2) resorption of an embryo, and (3) abortion.

Evidence of reproductive failures was found in 20 of 85 sexually mature females which were collected throughout implanted gestion (Table 18). Missed pregnancies occurred most frequently in younger

Table 17. Ovulation and pregnancy rates for female Steller sea lions collected in the Gulf of Alaska, 1975-1978.

	Ovulation			Pregnancy		
Age	Number in Sample	Number Ovulated	Ovulation Rate (%)	Number in Sample	Number Ovulated	Pregnancy Rate (%)
0-12 months	6	0	0	6	0	0
1 year	7	0	0	6	0	0
2	11	0	0	10	0	0
3	19	5	26.3	15	3	20.0
4	16	13	81.3	15	8	53.3
5	10	8	80.0	7	4	57.1
6	7	7	100.0	6	5	83.3
7	12	12	100.0	10	7	70.0
8	9	9	100.0	6	6	100.0
9	6	6	100.0	6	5	83.3
10	6	6	100.0	6	5	83.3
11-15	22	22	100.0	23	20	87.0
16-20	4	4	100.0	5	4	80.0
21-30	3	3	100.0	3	0	0
TOTALS	138	95		124	67	

Table 18. Summary of reproductive failures in Steller sea lions collected in the Gulf of Alaska, 1975-1978.

Age of Female	Initial Pregnancy	Cause of Failure			
		Missed Pregnancy	Resorption	Abortion	Indeterminable
3 years	Yes	X			
4	Unk.	X			
4	Yes		X		
4	Yes				X
4	Yes	X			
5	No			X	
6	No			X	
7	No			X	
7	Yes			X	
7	No				X
7	No				X
8	No			X	
9	No		X		
10	No			X	
11	No			X	
13	No			X	
19	No				X
21	No				X
25	No				X
30	No				X

animals and appeared to be associated with initial ovulations, similar to the findings of Craig (1964) for northern fur seals. Abortions appeared to occur throughout a wide range of ages in mostly multiparous females.

Evidence of abortions was frequently seen on hauling areas and rookeries throughout the Gulf of Alaska (Table 19). The most extensive observations were made at Cape St. Elias where abortions were most frequent in late March. Abortions appeared to be an important source of prenatal mortality although the extent remains unquantified. No historical data are available to compare the incidence of premature pupping. This may be a recent (and perhaps temporary) development or it could be a normal occurrence among Steller sea lions in the Gulf of Alaska.

Gentry (1970) reported abortions of Steller sea lions on Ano Nuevo Island, California beginning in February and continuing until mid-May when viable pups appeared. In Oregon abortions were estimated to account for 4% of total births (Mate 1973). Abortions in California sea lions (*Zalophus californianus*) have been associated with disease (Smith et al. 1974; Smith and Akers 1976), organochlorine pollutants (Delong et al. 1973) and element imbalance (Martin et al. 1976).

Birth Rate

The actual birth rate (full term pups) was lower than the pregnancy rates presented in Table 17. Pregnancy rates were calculated from females collected throughout active gestation. Reproductive failures

Table 19. Summary of premature births of Steller sea lions documented in the Gulf of Alaska, 1975-1979.

Location	Dates of Observations	Number of Abortions
Cape St. Elias	9 March-14 June 1977	20
Cape St. Elias	22 March- 5 July 1978	21
Seal Rocks	7 April 1977	1
Wooded Islands	7 April 1977	1
NW Ushagat Island	12 April 1978	1
Sugarloaf Island	13 April-15 July 1978	7
Latax Rocks	13 April 1978	1
Marmot Island	13 April 1978	3
Marmot Island	7 May - 9 July 1979	3
Chirikof Island	18 April 1978	5
Puale Bay	19 April 1978	6

took place throughout gestation, therefore the pregnancy rate progressively declined (Table 20). Abortions continued through mid-May, therefore the actual birth rate was slightly lower than the 67% pregnancy rate for April and May. The declining pregnancy rates indicated a monthly prenatal mortality rate (assuming a linear relationship) of 4.7%, resulting in a projected birth rate of about 63% for sexually mature females.

Gentry (1970) estimated the birth rate for Steller sea lions on Ano Nuevo Island in California at 68% based on counts of pups and females. He stated that this figure might be high because some females may have been at sea while their pups were on land when the counts were made. Using the same method, Pike and Maxwell (1958) estimated a birth rate in excess of 70% for sexually mature females on a rookery in British Columbia.

Male Reproduction

Studies of male reproduction were limited by the small number (18) of males collected during the breeding season. Males were considered sexually mature if abundant epididymal sperm were found during the breeding season (Hewer 1964; Bigg 1969). The youngest mature male was 3 years old (Table 21). The oldest immature male was 6 years old. All five males, 8 years old and older, were mature. Perlov (1971) found that males matured between 5 and 7 years. Ages of 160 territorial bulls collected by Thorsteinson and Lensink (1962) ranged between 6 and 15 years with most (88%) between 9 and 13 years. Therefore, it seems that most males are sexually mature before they are able to successfully defend breeding territories.

Table 20. Pregnancy rates of sexually mature, female Steller sea lions by 2 month periods from implantation to birth, 1975-1978.

Months	Number of Females	Number Pregnant	Pregnancy Rate (%)
Oct.-Nov.	19	18	95
Dec.-Jan.	0	0	-
Feb.-March	34	26	76
April-May	36	24	67

Table 21. Age and sexual maturity of 18 male Steller sea lions based on the presence of abundant epididymal sperm during the period of 15 May through 31 July, 1975-1978.

Age	Number of Males	Epididymal Sperm			Percentage Sexually Mature
		Absent	Trace	Abundant	
0-12 months	1	1			0
1 year	1	1			0
2	3	3			0
3	4	3		1	25
4	1			1	100
5	1			1	100
6	1		1		0
8	3			3	100
11	1			1	100
12	1			1	100
18	1			1	100

Abundant epididymal sperm were found in all mature (≥7 years) males collected between 20 April and 1 August (Table 22). Conversely, none of the mature males taken between 27 October and 22 March had abundant epididymal sperm, demonstrating seasonality of spermatogenic activity in Steller sea lions. As previously noted, the earliest copulation was seen on 22 May, however, mature males are apparently in breeding condition somewhat earlier.

Table 22. Seasonal spermatogenic activity in male Steller sea lions ≥ 7 years collected in the Gulf of Alaska, 1975-1978.

Time Period	Number of Animals	(Epididymal Sperm) None	Trace	Abundant
17 February	1	1		
22 March	3	2	1	
20-28 April	2			2
21-23 May	2			2
21 June	3			3
28 July-1 August	2			2
27 Oct.-15 Nov.	4	4		

Information on growth and condition of Steller sea lions has been meager prior to this study. Fiscus (1961) presented an analysis of skull growth along with total body length and girth measurements for 39 sea lions taken at Chernabura Island, Thorsteinson and Lensink (1962) recorded lengths by age of 91 adult males taken between Kodiak and the Krenitizin Islands. They also reported on bacula weights. Spalding (1964) presented length data on female sea lions collected in British Columbia.

We have collected growth data on sea lions ranging in age from shortly after implantation to 30 years of age. All measurements presented were taken in accordance with Scheffer (1967), with the exception of standard length which was recorded with the animal laying ventrally rather than dorsally. Figures 15, 16 and 17 show the curvilinear length, girth and weight of 47 fetuses and 117 animals in the first 11 months of life. Our first fetal measurements taken in the field were obtained in February, 4 to 5 months after implantation. No significant sexual dimorphism was detected ($P \geq 0.5$) until the seventh month after implantation. After the seventh month after implantation only a very small difference in size was detected ($P \leq 0.1$) between sexes.

There appeared to be rapid growth between the seventh month after implantation and up to 2 months after birth. There was a significant difference between the sexes ($P \leq 0.001$) for this time period. Growth was rapid for all parameters measured during the first year of life. By the eleventh month after birth no detectable difference was found between male and female lengths and weights ($P \geq 0.2$).

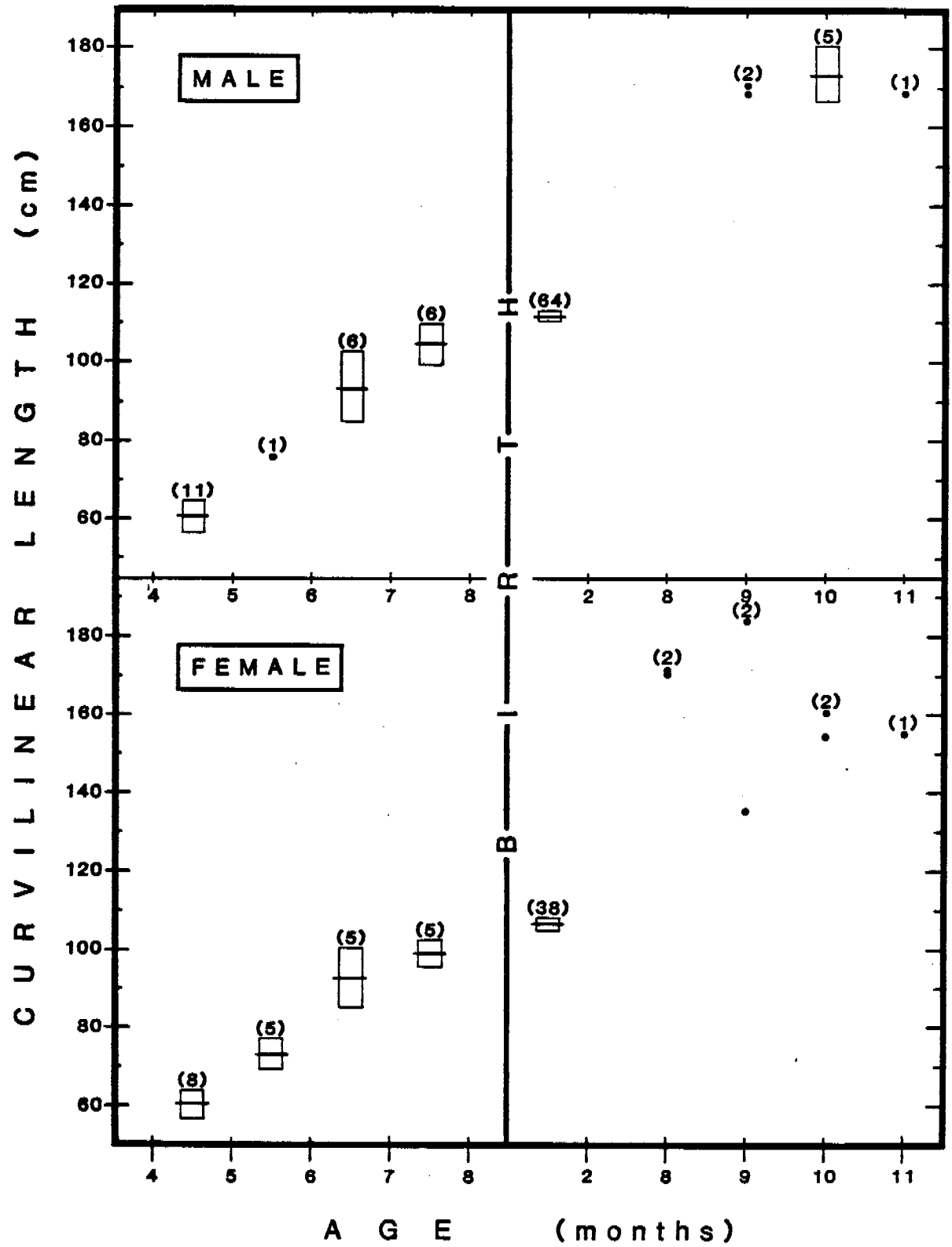

FIGURE 15. CURVILINEAR LENGTH OF MALE AND FEMALE STELLER SEA LIONS FROM THE FOURTH MONTH AFTER IMPLANTATION (FEBRUARY) UNTIL THE ELEVENTH MONTH AFTER BIRTH. BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, SAMPLE SIZE <4.

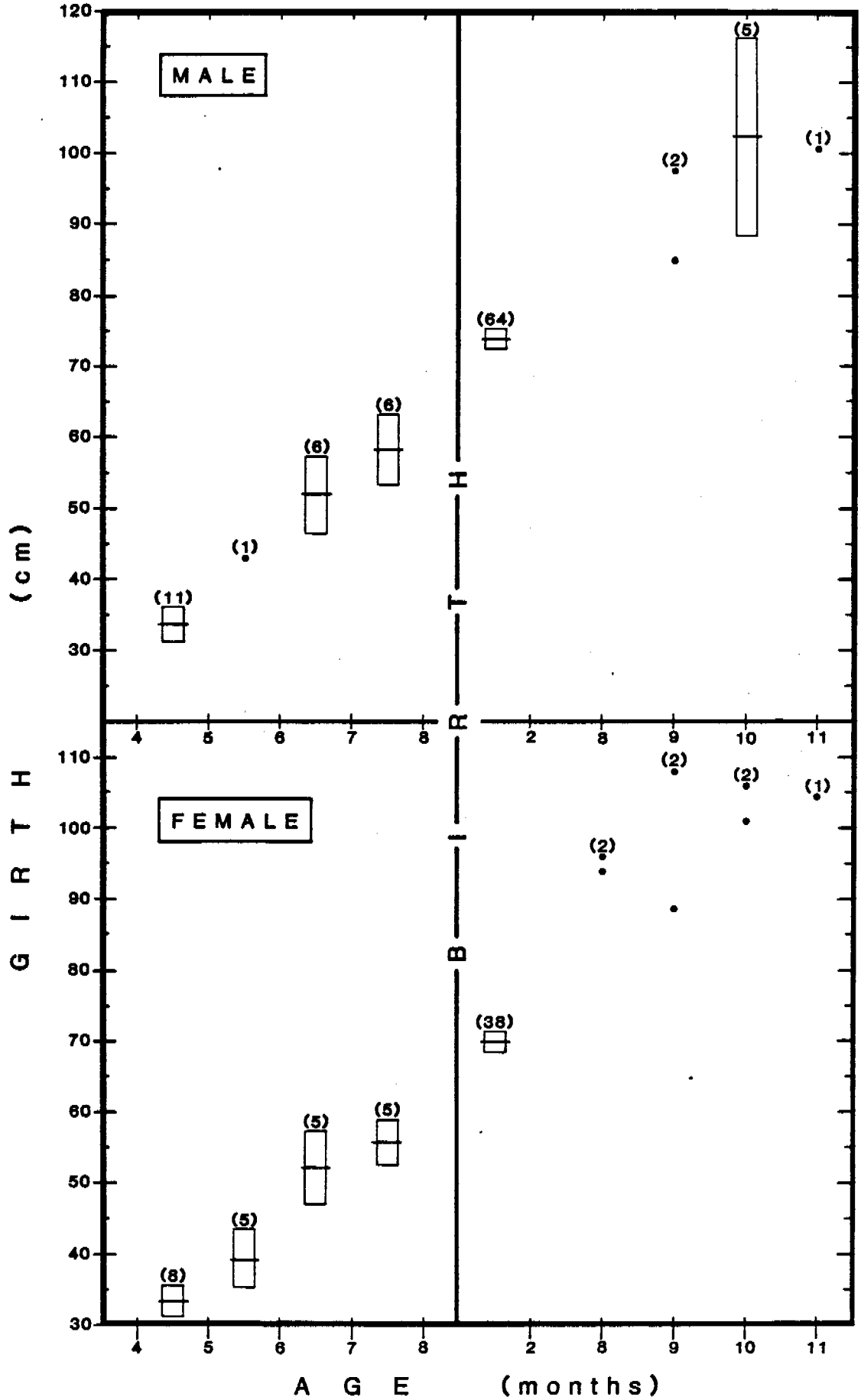

FIGURE 16. GIRTH OF MALE AND FEMALE STELLER SEA LIONS FROM THE FOURTH MONTH AFTER IMPLANTATION (FEBRUARY) UNTIL THE ELEVENTH MONTH AFTER BIRTH. BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, SAMPLE SIZE <4.

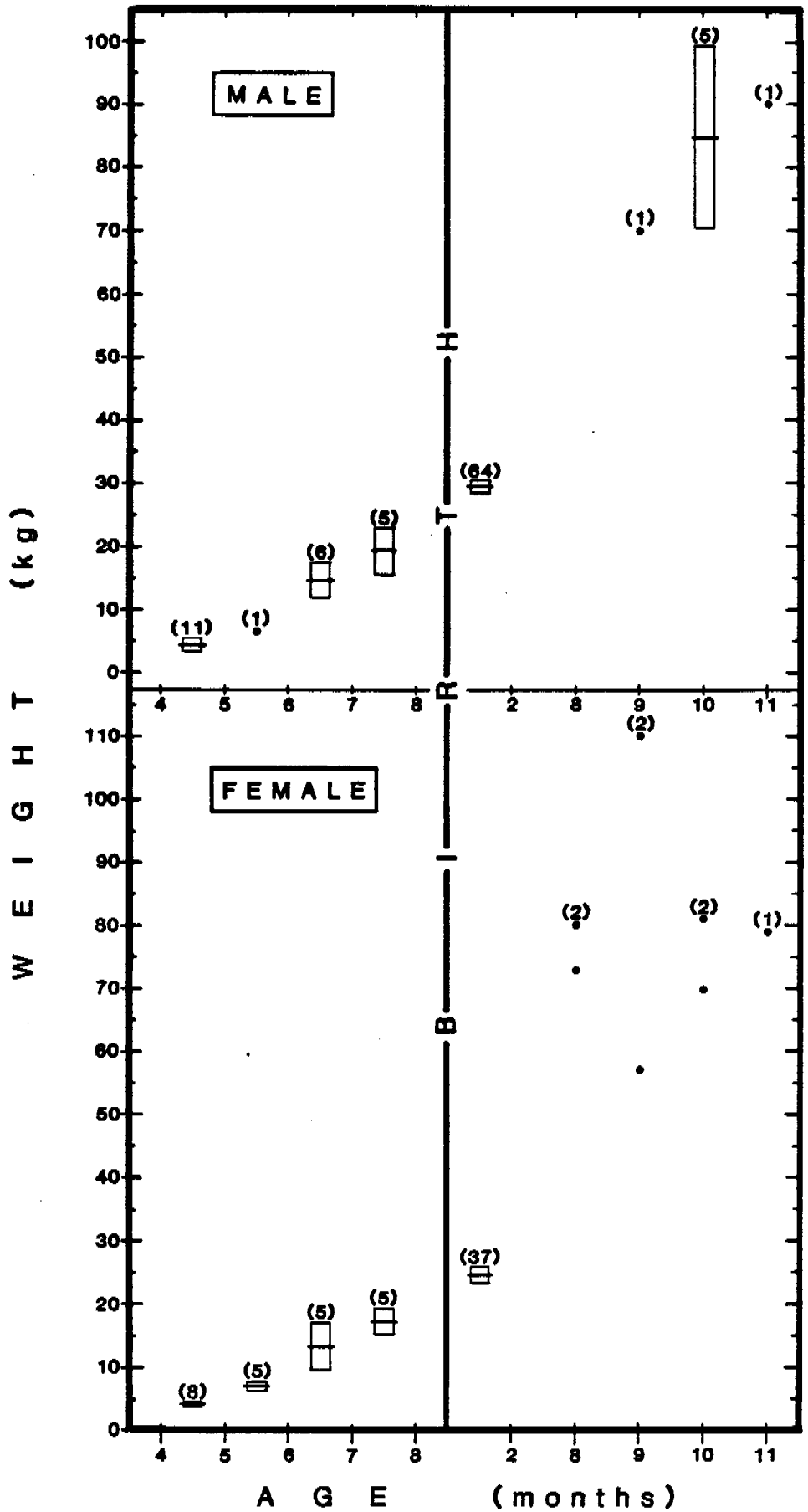

FIGURE 17. WEIGHT OF MALE AND FEMALE STELLER SEA LIONS FROM THE FOURTH MONTH AFTER IMPLANTATION (FEBRUARY) UNTIL THE ELEVENTH MONTH AFTER BIRTH. BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, SAMPLE SIZE <4.

Growth patterns for 240 sea lions collected in the Gulf of Alaska between 1975 and 1979 are shown in Figs. 18 through 21. In Fig. 18 we have shown the standard length measurements of 99 males and 141 females. Female sea lions grew rapidly through the first 5 years but slowed and appeared to level off after the sixth year. Males continued the rapid growth phase through the tenth year after which they slowed and leveled off by the eleventh year. Although there was a great deal of variability, it appeared that females reached adulthood and maximum skelatal growth in about the sixth year. Males generally reached adulthood as indicated by maximum skeletal growth in the eleventh year.

Figure 19 shows the weights of 95 males and 122 females. Weight gain is rapid in females through approximately the fifth year when there appears to be a slowing trend until it levels off at about the sixth to seventh year. Males continued to gain weight at a rapid rate through the seventh year. After the seventh year weight gain slowed in males and leveled off by the eleventh year.

In comparing length increase by age class (Fig. 18) to weight gain by age class (Fig. 19), we show the pattern is similar in both: a rapid increase followed by a slower increase followed by a leveling off between the sixth and seventh year for females and between the eleventh and twelfth year for males. There was large variability within age classes for all measurements as indicated by the large ranges and broad 95% confidence intervals in Figs. 18 through 21. Within age classes variability was even greater for weight than for standard length in both males and females.

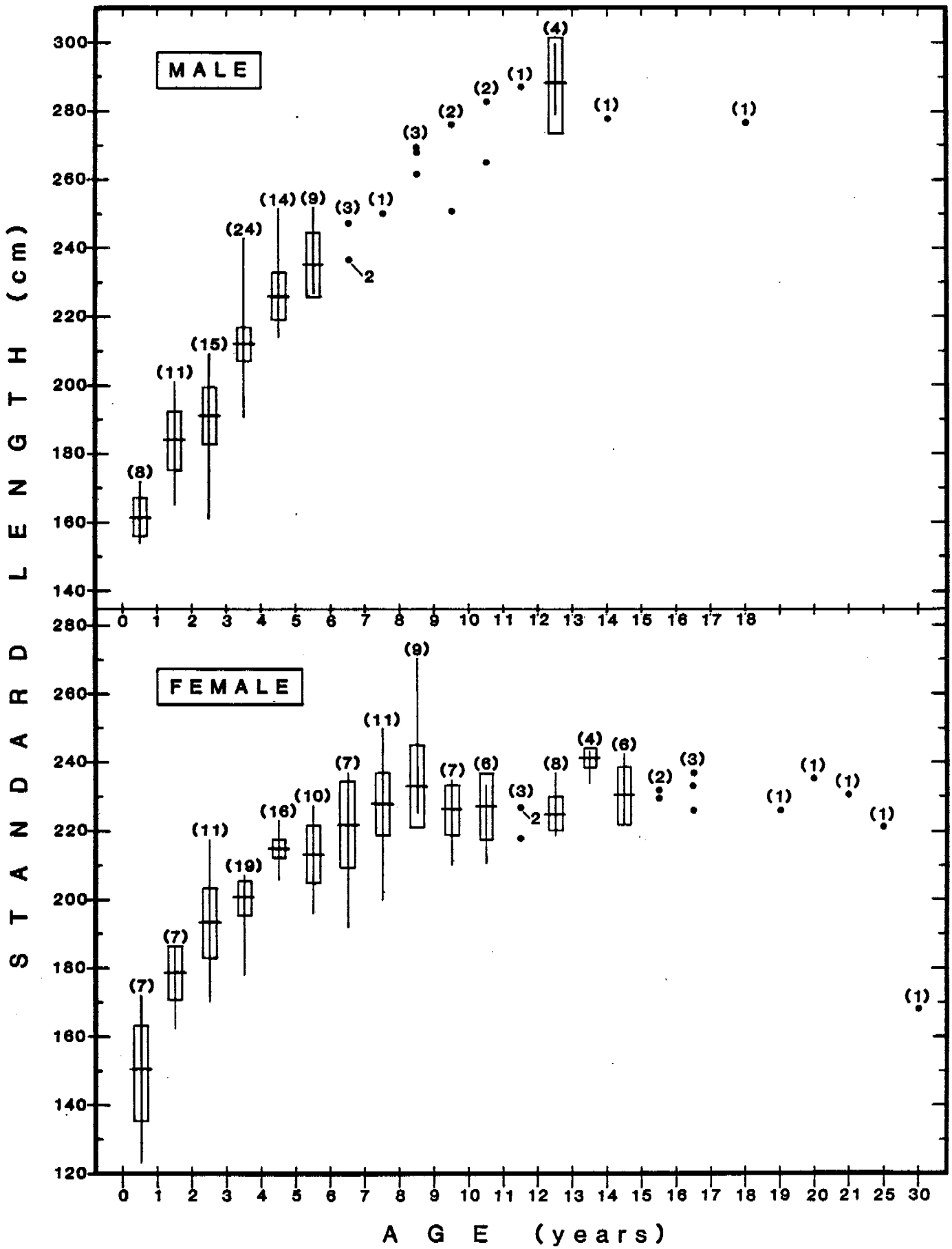

FIGURE 18. STANDARD LENGTHS OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL LENGTHS OF SAMPLE SIZE <4.

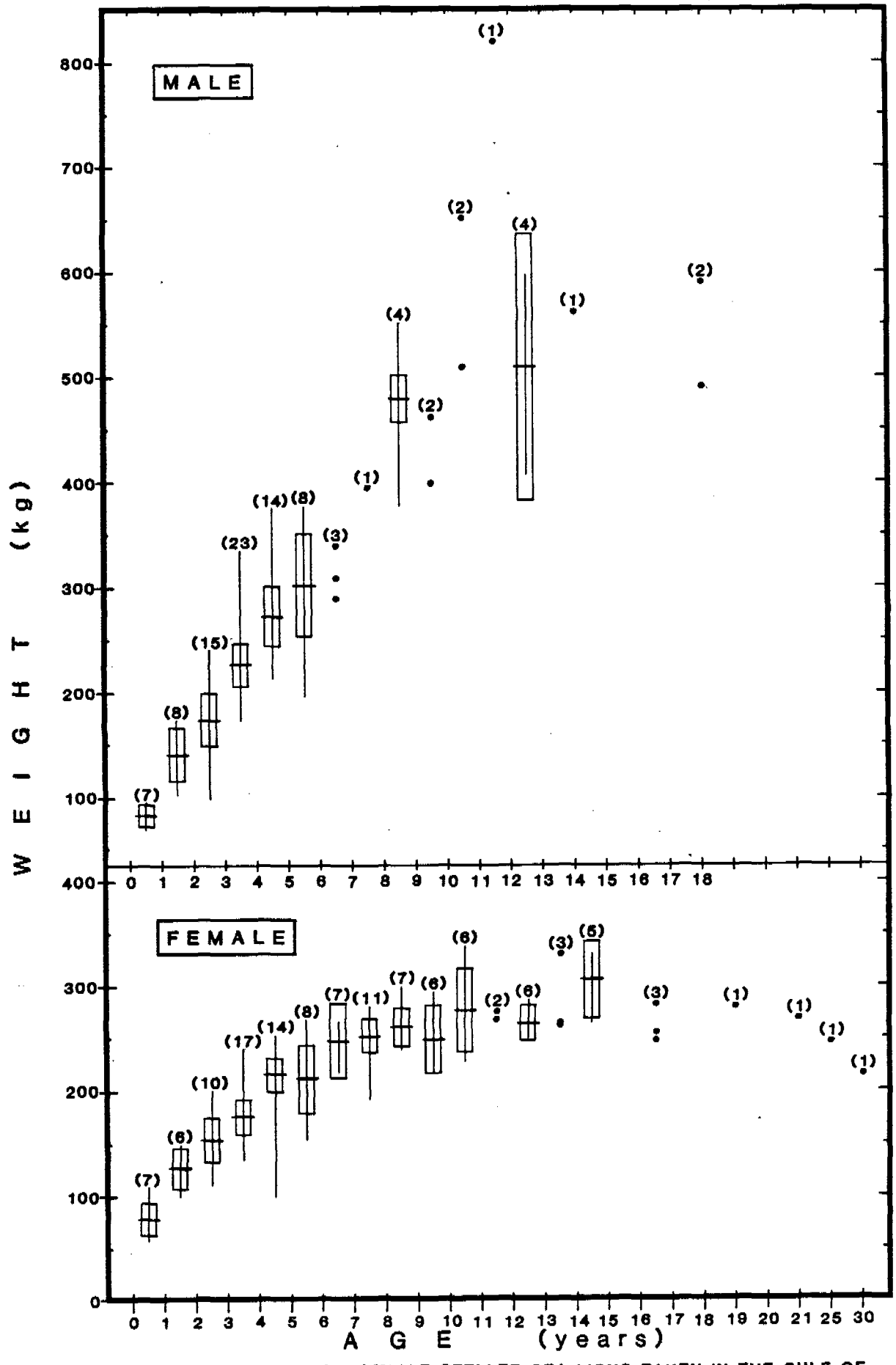

FIGURE 19. WEIGHTS OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL WEIGHTS OF SAMPLE SIZE<4.

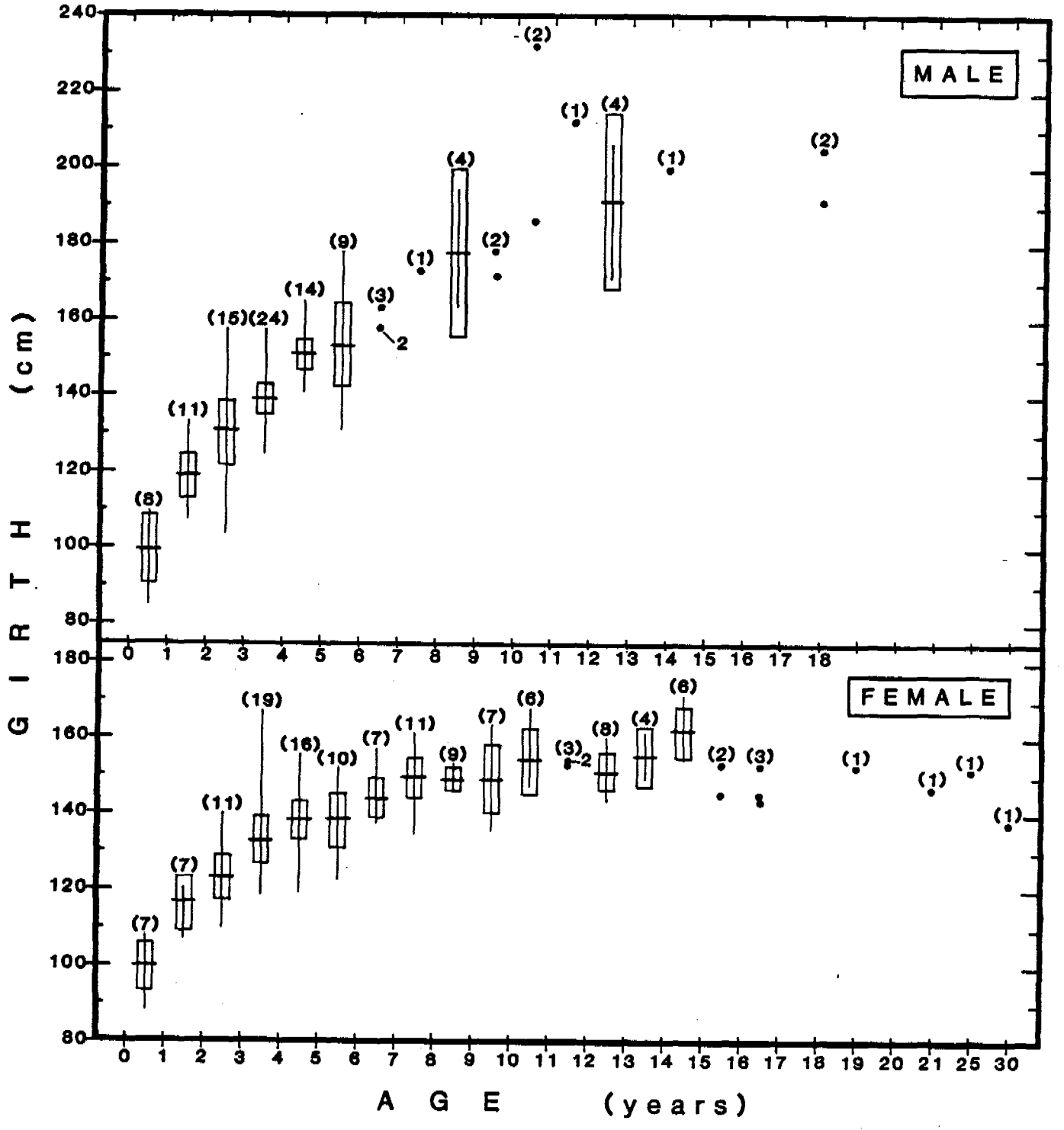

FIGURE 20. GIRTHS OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL GIRTHS OF SAMPLE SIZE <4.

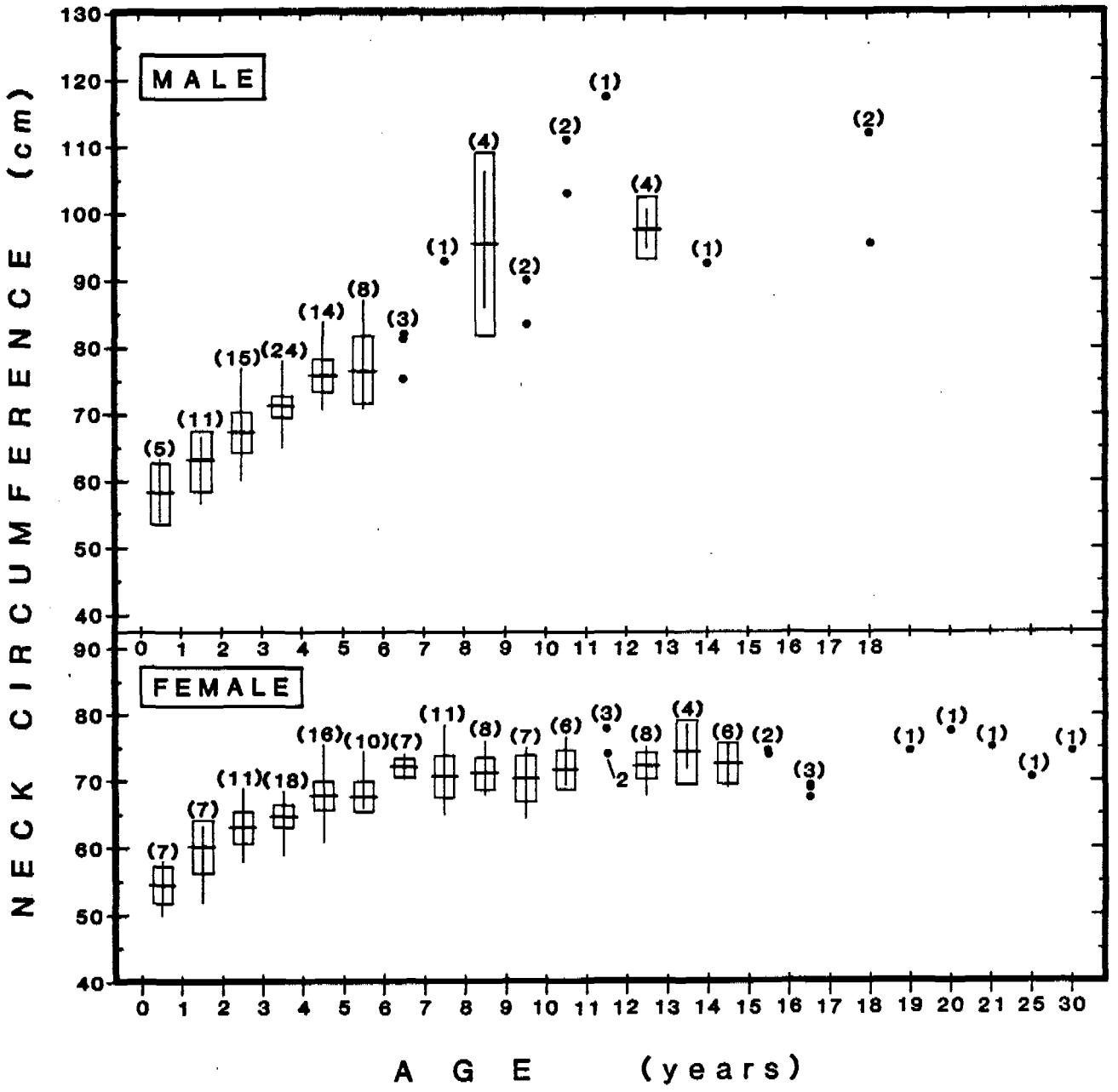

FIGURE 21. NECK CIRCUMFERENCES OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL CIRCUMFERENCES OF SAMPLE SIZE<4.

The mean weight of all adult females (7 years old and older) taken in this study was 263.5 kg (n = 53). The range of adult female weights was 192.8 kg to 330 kg. The 95% confidence interval of adult female weights was ±8.38 kg. The mean weights of adult males (10 years old and older) was 566.2 kg (n = 10) with a range of 409 to 810 kg and a 95% confidence interval of ±79.01 kg. Mean standard length for adult females was 227.6 cm (n = 64). The range of female standard lengths was 165 cm to 270 cm and the 95% confidence interval was ±3.05 cm. The mean lengths of adult males was 282.23 cm (n = 9) with a range of 265 cm to 290.5 cm and a 95% confidence interval of ±7.2 cm.

No differences in length were detected between sexes through the first 4 years ($P>0.2$). No difference in weight was detected until after the first 3 years ($P>0.2$). After the third year significant differences were detected between male and female weights ($P<0.001$) and after the fourth year, differences were detected between male and female lengths ($P<0.01$). Since we cannot see a difference in length until after the fourth year and there is such broad range within age classes for all animals, it is nearly impossible to determine sex or age of any Steller sea lion younger than 5 years of age on the basis of growth characteristics.

Girth measurements (Fig. 20) showed a similar pattern to weight and length. There was a rapid increase in both male and female girths until the twelfth year in males and the thirteenth year in females, after which there appeared to be a leveling off.

Neck measurements were recorded for all animals (Fig. 21). These

measurements were taken at the base of the skull just posterior of the external ears. In fact, the ears were allowed to overlay the tape. Although this is not truly a neck measurement, we considered it the only measurement of a secondary sexual characteristic which could be consistently measured. No difference was detected between sexes through the first 2 years. After the third year some difference was noted between male and female neck sizes ($P<0.05$) and by the end of the fourth year the difference had become highly significant ($P<0.001$).

Although blubber thickness was measured throughout this study, no patterns were noted which indicated relative condition, either seasonal or long term. Body condition of sea lions was not successfully assessed in this study.

Sex Ratios

We recorded sex of 7,043 pups during branding operations. These animals were approximately 1 day to 3 weeks old. Slightly more males were counted than females. Fifty-one percent males were recorded (3,624 males and 3,419 females) which is significant at the 0.05 level ($Z=2.44$). Kenyon et al. (1954) noted sex ratio is even at birth in fur seals.

Pup Production

During the latter part of the pupping period (late June, early July) in 1978 and 1979 we surveyed the major pupping rookeries in the Gulf of Alaska. The adults were photographed from a helicopter for later counting and the pups were counted individually from the ground. In 1978 we selected 15 different areas on the basis of numbers of animals using them and locations. Ten of these areas proved to be major pupping rookeries and were surveyed again in 1979. Table 23 shows the results of those surveys. Figures 2 through 6 illustrate the locations of the 10 most important pupping rookeries in the Gulf of Alaska.

In 1978 we counted 22,956 pups in the Gulf of Alaska. In 1979 we counted 29,778 pups. There are several possible explanations for the

Table 23. Steller sea lion pup and adult counts at pupping rookeries in the Gulf of Alaska for 1978 and 1979.

Rookery	1978 Pups	1978 Adults	1978 Totals	1979 Pups	1979 Adults	1979 Totals
Marmot Island	6,120	8,506	14,646	6,741	6,381	13,122
Sugarloaf Island	5,021	4,810	9,831	5,123	4,374	9,497
Chowiet Island	4,670	4,419	9,089	5,485	4,441	5,926
Atkins Island	2,750	3,943 est.	6,693	4,538	5,000	9,538
Chirikof Island	1,573	3,699	5,272	1,649	5,199	6,848
Clubbing Rocks	725 est.	2,663	3,388	1,419	1,162	2,581
Pinnacle Rocks	615 est.	3,692	4,307	2,748	2,731	5,479
Seal Rocks	544	2,463	3,008	491	2,961	3,452
Chernabura Island	486	2,758	3,244	646	1,504	2,150
Outer Island	431	3,142	3,573	888	3,155	4,043
Totals	22,956	40,095	63,051	29,778	36,906	66,636

larger count in 1979. It is possible, although unlikely, that there were actually 6,822 more pups produced in 1979. Weather and sea conditions allowed better access to nearly all of the pupping rookeries in 1979 which certainly produced a higher count. The only location where access was not better in 1979 than 1978 was at Seal Rocks, at the entrance to Prince William Sound. At Seal Rocks in 1979 the conditions and therefore total count, were similar to 1978. The most significant differences were noted at Chowiet Island in the Semidi Islands and at Clubbing Rocks and Pinnacle Rock in the Sandman reefs. At all three of these areas, access to at least part of the pupping rookeries was prevented in 1978 but allowed in 1979 by weather and sea conditions.

Although the total number of pups was higher in 1979 than 1978, the total number of adults (older than 1 year) was lower in 1979. Numbers of adults on rookeries fluctuated greatly during late June and early July and a count of this type can only reflect an instantaneous number of animals present at a given time.

Mortality

KL_x series life tables were constructed for sea lions (Tables 24 and 25) using ages of collected animals (Caughley 1966). It is possible that animals were not fully represented in our sample until 3 years of age, therefore, we deleted age classes 1 and 2 years from the analyses. Age class frequencies ≥3 years were smoothed using probit regression (Caughley 1977). Initial pup production was estimated using the smoothed age frequencies, maturation rates and birth rates (see Reproduction Section).

Table 24. Life table for female Stèller sea lions collected in the Gulf of Alaska, 1975-1978.

Age (years)	Frequency*	Survival	Mortality	Mortality Rate
0	31.00**	1.000	0.532	0.532
3	14.51	0.468	0.062	0.132
4	12.58	0.406	0.409	0.121
5	11.07	0.357	0.040	0.112
6	9.83	0.317	0.034	0.107
7	8.78	0.283	0.029	0.102
8	7.87	0.254	0.026	0.126
9	7.06	0.228	0.023	0.101
10	6.34	0.205	0.022	0.107
11	5.68	0.183	0.019	0.104
12	5.08	0.164		
1330	26.48			

* Age frequencies $\geq$ 3 years smoothed by probit curve.
** Estimated value derived from age frequencies, maturation rates and birth rates.

Table 25. Life table for male Steller sea lions collected in the Gulf of Alaska, 1975-1978.

Age (years)	Frequency*	Survival	Mortality	Mortality Rate
0	31.00**	1.000	0.737	0.737
3	8.14	0.263	0.038	0.144
4	6.98	0.225	0.029	0.129
5	6.07	0.196	0.024	0.122
6	5.32	0.172		
7-18	29.55			

* Age frequencies $\geq$ 3 years smoothed by probit curve.
** Estimated value derived from female age frequencies, maturation rates and birth rates.

Assumptions which must be met in order for valid analyses are: that the initial size of each age class was equal, and that age specific mortality and reproductive rates have remained constant over the range of age classes present. We cannot demonstrate conclusively that all assumptions were met, however, it appeared that they were at least approximated. Treatments were terminated when smoothed frequencies for an age class fell below five as suggested by Caughley (1966).

The mortality rates from birth to 3 years were estimated at about 0.53 for females and 0.74 for males (Tables 24 and 25). For females, mortality appeared to slowly decrease from the third year (0.13) through the seventh year (0.10) and then remained relatively stable through 11 years. Mortality rates for males decreased from 0.14 during the third year to 0.12 in the fifth year. It appeared that males had higher mortality than females through all age classes examined. The oldest male we collected was 18 years while the oldest female was 30 years.

Lander (1979) estimated mortality of male northern fur seals from birth to 2 years of age at 0.65. Data presented by Chapman (1964) indicated mortality of males to 3 years of age of 0.74. His estimates of annual adult mortality were 0.11 for females and 0.36 for males. All these estimates appear comparable to our calculations for Steller sea lions with the exception of adult males where our sample was limited to animals through 5 years of age.

Population estimate

Estimates of the various segments of the total number of sea lions

within the Gulf of Alaska study area were calculated using information gathered in this and other studies on sea lions and fur seals. The initial female segment was estimated in Table 26 by calculating the number of female pups produced in 1979 from the 1979 pup counts (which were conservatively rounded to 30,000) and the observed sex ratio of 0.485. We then applied the calculated survival rate for age classes 0-3 (from Table 23) to the total number of pups born. This gave us a total number of survivors from 0 to age 3. This survival was then partitioned between age classes 1 and 2 on an estimated basis.

For age classes 3 through 12 we applied survival rates for each individual age class calculated (from Table 23) to get numbers of females surviving in each age class. We estimated the total number of females in age classes 13 through 30 by calculation the proportion of animals that were in the 13-30 year category (21/116) of the adult females (≥3 years) in our collected sample and applying this to the sum of the females which we calculated in ages 3 to 12 in Table 26. We then summed the numbers of females surviving in the age categories to estimate total number of females. The final estimates for the females are: total females 3 years old and older = 51,689, total females 1 year old and older = 69,262 and total females 0-30 years = 83,812 (Table 26). The most precise estimate is for the 3 year old and older segment. While we had an estimate for mortality between birth and 3 years of age, the annual distribution was unknown making the estimate less precise. As a check on the female estimate we applied our estimates of sexual maturation and birth rates to the estimates of numbers of mature females surviving in each age class and estimated annual production of 27,462 pups (Table 26). This was reasonably close to

Table 26. Estimation scheme for female segment of Gulf of Alaska sea lion population based on total pup count and survival rates with check based on age specific reproductive rates.

Age	Survival Rate	Number of females	Percent mature	Birth Rate	Number of pups
0		14,550	0	0	0
1	0.47	9,603	0	0	0
2	0.66	7,970	0	0	0
3	0.83	6,839	0.32**	0.63	1,379
4	0.86	5,949	0.57**	0.63	2,136
5	0.87	5,236	0.83**	0.63	2,738
6	0.88	4,660	1.00	0.63	2,936
7	0.89	4,194	1.00	0.63	2,642
8	0.90	3,774	1.00	0.63	2,378
9	0.90	3,397	1.00	0.63	2,140
10	0.90	3,057	1.00	0.63	1,926
11	0.90	2,751	1.00	0.63	1,733
12	0.90	2,476	1.00	0.63	1,560
13-30		9,356	1.000	0.63	5,894
				Total pups	27,462

* Estimated from the proportion of adults (≥3 years) in our collection that were in the 12-30 year category (21/116)

** Smoothed by linear regression.

Totals Females ≥3 years = 51,689
Totals Females ≥1 year = 69,262
Totals Females 0-30 years = 83,812

our total count of 30,000 pups thus lending confidence to our estimates.

Male estimates were more difficult and less precise because of more limited mortality data, the life table analyses extended only through 5 years of age and only rough estimates of mortality could be made for older age classes based on the distribution of collected animals and data on the age distribution of harem bulls presented by Thorsteinson and Lesink (1962). We used the same method to estimate mortality in the males for age categories 0-3 as was used for females and the calculations of male survivors in all age categories was similar to those for females. We began by calculating the initial number of pups by applying the observed sex ratios at birth to the rounded off figure of 30,000 pups for the Gulf of Alaska in 1979 (Table 27). To this we then applied the overall survival rate for age categories 0-2. This overall survival was then partitioned between age categories 1 and 2. For male age categories 3-5 we used the survival rate which we calculated from Table 24 and applied each survival rate as calculated to each age category. We then estimated survival for male age categories 6 through 18 using distribution of the collected animals and data obtained from Thorsteinson and Lensink (1962).

When the male and female estimates are combined the overall population estimates for Steller sea lions in the Gulf of Alaska are: 74,702 ≥3 years, 105,666 ≥1 year and 135,666 for all age classes including pups. These are the most accurate estimates of the population currently available and are more precise than instantaneous counts at rookeries and hauling areas as they include all segments of the population as well as those which are at sea at any given time.

Table 27. Estimation scheme for male segment of Gulf of Alaska sea lion population based on total pup count and survival rates.

Age	Survival Rate	Number of Males
0	0.26	15,450
1	0.55	8,498
2	0.65	5,523
3	0.75	4,017
4	0.86	3,455
5	0.87	3,006
6	0.88	2,645
7	0.88	2,328
8	0.88	2,049
9	0.80	1,639
10	0.75	1,229
11	0.70	860
12	0.65	559
13	0.60	336
14	0.50	168
15	0.40	67
16	0.30	20
17	0.20	4
18	0.20	1

Total males $\geq$3 years = 22,383
Total males $\geq$1 year = 36,404
Total males 0-30 years = 51,854

MOLT

Thirty of 153 sea lions were found to be molting. Active molt stages were seen from the end of July to the first week of December. An exception was a nonreproductive female in beginning molt during the last week of June 1978. During the second week of October 1976, two of 18 sea lions killed had not molted, as indicated by their worn pelage.

There are three major ways that sea lions can be affected by oil and oil contamination: 1) direct contact with oil from a spill, 2) contamination of habitat and 3) reduction of prey. Other potential hazards to sea lions generated by OCS activities are disturbance and loss of habitat.

Direct external contact with oil should have little effect on thermoregulation since sea lions rely on a subcutaneous fat layer for insulation (Kooyman et al. 1976). Davis and Anderson (1976), studying the effects of oil on gray seal (*Halichoerus grypus*) pups, found that oiled pups had significantly lower body weights than unoiled pups, but attributed this to either interference of the mother-pup relationship due to masking of the identifying smell or due to the greater human disturbance of oiled pups. While sea lions locate their pups through vocalizations, they also probably depend, to a great extent, on scent to recognize their pups.

There is little data on the ability of sea lions to avoid oil slicks. Smith and Geraci (1975) found that ringed seals (*Phoca hispida*) did not try to avoid oil under experimental conditions. Sea lions are known to frequently pick up foreign objects in their mouths, a behavior which makes them susceptible to ingestion of oil in the form of tar balls. We have observed sea lions at Cape St. Elias with tar lodged in their throats and others with a tar-like substance around

the lips, jaw and neck. Petroleum-like substances were also found in their feces.

The ingestion of crude oil has been shown to cause kidney damage in ringed seals (Smith and Geraci 1975). It was hypothesized that the route of entry included accidental swallowing and absorption through their skin and mucous membranes. Respiratory absorption may be an important pathway, especially with fresh crude oil, which still contains the more volatile fraction. Eye damage, including lacrimation, conjunctivitis and corneal erosion also occurred, with the severity of damage related to exposure time (Smith and Geraci 1975).

It has been hypothesized (Smith and Geraci 1975) that oiling of nursing pups may prove detrimental due to ingestion and absorption of oil. LeBoeuf (1971) found no effects of oiling on elephant seal (*Mirounga angustirostris*) pups, but these young had already been weaned. Brownell and Le Boeuf (1971) also concluded that oiling did not contribute to California sea lion (*Zalophus californianus*) pup mortality. Most of the oil in question was weathered before contacting the pups and probably had lost the more toxic, aromatic fractions.

The behavior of pennipeds exposed to crude oil includes squinting, arching the back out of the water and submerging for long durations (Smith and Geraci 1971). Other reports of aberrant behavior includes Pearce (1970 in Nelson-Smith 1975) who stated "after the "Arrow" spill

in Nova Scotia, young gray seals were found blundering about in the woods one half mile from shore, unable to find their way because of oil around the nostrils and eyes."

Steller sea lions are probably most vulnerable to acute oil spills during mid-May through mid-July, the period of time they are on the pupping and breeding rookeries. An oil spill near any of the 10 major pupping and breeding rookeries during this time could cause abandonment of pups and interrupt the normal breeding cycle. Loss of a majority of pups from one of the large rookeries such as Sugarloaf Island, Marmot Island or Chowiet Island plus failure to impregnate cows from that rookery could result in the failure to produce from 10,000 to 15,000 sea lion pups. This in turn has serious implications to the health and stability of sea lion populations throughout southeastern Alaska as well as the Gulf of Alaska.

Loss of prey species probably poses the most serious, long terms threat to sea lions in the Gulf of Alaska. Oil pollution can reduce populations of prey species such as walleye pollock, octopus, capelin, herring, and Pacific cod (Evans and Rice 1974; DeVries 1975; Struhsaker 1977; Craddock 1977; Patten 1977).

Low levels of occasional disturbance probably has little long term effect on sea lions. Disturbance from aircraft and vessel traffic has extremely variable effects on hauled-out sea lions. Sea lion reaction to occasional disturbances ranges from no reaction at all to complete

and immediate departure from the haulout area. The type of reaction appears to depend on a variety of factors including time of day, both present and recent weather, time of year, location and type of disturbance. Sea lions have temporarily abandoned some areas after repeated disturbance, but in other situations they have continued using areas after repeated and severe harrassment. When sea lions are frightened off rookeries during the breeding and pupping season, pups could be trampled or even abandoned in extreme cases.

SUMMARY

A broad ecological investigation of steller sea lions was conducted from 1975 through 1980 in the Gulf of Alaska from Cape Spencer in southeast Alaska to Scotch Cap on Unimak Island. These studies were designed primarily to yield information useful for assessing potential and real impacts of exploring for and developing petroleum resources of the outer continental shelf of the Gulf of Alaska. Information on distribution and abundance was provided by periodic surveys of rookeries and hauling areas. Movements were studied by branding over 7,000 pups on the rookeries of their birth and monitoring their movements to other rookeries and hauling areas. Food habits, reproduction, molt growth and condition and natural mortality were investigation by collecting individual animals.

All known haulouts and rookeries in the Gulf of Alaska are described. Sea lions were counted at each location at least twice in the study. Sea lions gather on a few specific, well defined, pupping rookeries on land to breed and bear their young. The ten most important rookeries in the Gulf of Alaska are Seal Rocks at the entrance to Prince William Sound, Outer Island on the Kenai Peninsula, Marmot Island off the east side of Afognak Island, Chirikof Island south of the Kodiak Island Archipelago, Chowiet Island in the Semidi Islands, Atkins Island in the Shumagin Islands, Churnabura Island in the Shumagin Islands, Pinnacle Rocks and Clubbing Rocks, both in the Sandman Reefs. The world's largest sea lion rookery is Marmot Island.

Movement of pups, juveniles and subadults occurred on a large scale

and extensive, although they appeared to be mostly non-specific. Sea lions born at the large rookeries of Marmot Island and Sugarloaf Island were sighted through the Gulf to the Shumagin Islands in the southwest and to Biali Rocks in the southeast. The longest movement of an individual sea lion recorded in this study was approximately 1500 km. Sea lions are highly mobile and may travel long distances from the rookeries of their birth, although they probably return as adults to breed and bear their young.

The seven top ranked prey in order of ranking were walleye pollock, herring, squid, capelin, salmon, Pacific cod and sculpins. Pollock was by far the dominant prey, accounting for about 39% of all occurrences and 58% of the total volume.

Steller sea lions are born from mid-May to mid-July, nursing usually for less than a year although some nurse as long as 3 years. Breeding took place about ten days after birth but blastocysts did not implant until late September or early October. The average age of first ovulation was 4.6±0.8 yrs. and the average age of first pregnancy was 4.8±1.2 years. By 6 years of age all females had ovulated and 87% of females between 8 and 20 years were pregnant. Reproductive failures occurred in 24% of mature females. Birth rate was approximately 67%. Males became capable of breeding between 3 and 7 years of age, however, few have the opportunity until they are capable of holding a territory on a rookery after 9 years of age. Mean weight of adult females (7 years old and older) was 263.5 kg and mean length was 227.6 cm. Mean weight of adult males (10 years old and older) was 566.2 kg and mean length was 282.23 cm.

Sex ratio at birth was found to slightly favor males with fifty-one percent males recorded.

Mortality rates from birth to three years was estimated at about 0.53 for females and 0.74 for males and both decreased after that.

The overall population estimate for the Gulf of Alaska was 74,702 ≥3 years, 105,666≥1 and 135,666 for all age classes including pups.

Active molt was recorded from the end of July to the first week of December.

Potential impacts from OCS activities could include disturbance and displacement from rookeries and hauling areas, contamination from oil and loss of prey through oil contamination.

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