Environmental Assessment of the Alaskan Continental Shelf

Final Reports of Principal Investigators

Volume 19 December 1983

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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ENVIRONMENTAL ASSESSMENT
OF THE
ALASKAN CONTINENTAL SHELF

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U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
OFFICE OF OCEANOGRAPHY AND MARINE SERVICES
OCEAN ASSESSMENTS DIVISION

JUNEAU, ALASKA

The facts, conclusions, and issues appearing in these reports are based on interim results of the Outer Continental Shelf Environmental Assessment Program (OCSEAP), which is managed by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and primarily funded by the Minerals Management Service, U.S. Department of the Interior, through interagency agreement.

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SELECTED ANNOTATED REFERENCES ON MARINE MAMMALS OF ALASKA

by

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Introduction

Under contract to the Bureau of Land Management (BLM), U.S. Department of the Interior, and administered through the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, the Marine Mammal Division (MMD)* of the Northwest and Alaska Fisheries Center (NWAFC) gathered information on the abundance and distribution of pinnipeds (seals, sea lions, and walruses) and cetaceans (whales, dolphins, and porpoises) in the waters of Alaska. This was part of the BLM and NOAA's Outer Continental Shelf Environmental Assessment Program (OCSEAP). The contracts provided mainly for the performance of field research, but also called for the collection and annotation of relevant literature to assist researchers in formulating and in writing up their field work, and to give managers and administrators an overview of the kind of work which has been done and of the current state of knowledge.

An earlier form of this list came out in January 1977 as a processed report of the NWAFC entitled "An annotated bibliography on marine mammals of Alaska" by Nancy C. Severinghaus and Mary K. Nerini.

This list supplements four OCSEAP research units (RU's). These follow with their formal delimitations: RU 67 -- the eastern Bering Sea from the north edge of the Alaska Peninsula including the Fox Islands (Unimak to Umnak Islands) north to the 66°N latitude line over the continental shelf; RU 68 -- the Gulf of Alaska from 130°W longitude to the west end of Umnak (169°30'W longitude, 53°40'N latitude), and from 52°N latitude to the Alaska coast; RU 69 -- bowhead and beluga whales in the Bering, Chukchi and Beaufort Seas west of the US-USSR 1867 Convention line, and east to the American - Canadian border at 141°W longitude; and RU 14 -- early spring distribution, density and abundance of the Pacific walrus (Odobenus rosmarus) in 1976.

This reference list has not been strictly limited by these geographical borders; that is, many of the references cited here report on data gathered outside the designated area. However, they will concern a species which is represented in that area but about which information is relatively scarce (e.g., the minke whale), or they will concern animals which migrate into the designated area at another season of the year (e.g., elephant seals in California). Presumably some inferences can be made from these reports which bear on the animals found in the Alaskan waters under study.

Some references are included on polar bear and sea otter, though these were not called for. Polar bears in Alaska subsist mainly on ringed seals and bearded seals and thus are relevant to an assessment of the populations of those seals.

The citation style follows the National Marine Fisheries Service Style Manual (U.S. Department of Commerce, NOAA, NMFS, Seattle, Washington; November 1972). References are arranged alphabetically by the author's surname. Multiple authors are alphabetized by first author surname, then by

*(now called the National Marine Mammal Laboratory)

second author surname, and so on. Citations by the same author or authors are arranged chronologically. When no author is shown on an item, the name of the journal is used as the author instead of "anonymous". Names of journals and periodicals are abbreviated using the Word-Abbreviation List, American National Standards Institute, Standards Committee Z39, published by the National Clearinghouse for Periodical Title Word Abbreviations.

A number of articles translated from the Russian are cited here. The original Russian titles of these articles appear with Cyrillic characters transliterated into Roman ones. (Transliterations by this author conform to the guide given by Standards Committee Z39 of the American National Standards Institute; those done by translators may differ slightly.) In only one or two cases the original Russian title could not be obtained. Titles of Soviet periodicals are abbreviated in transliterated form according to the Word-Abbreviation List (mentioned above) and/or the Russian title word abbreviation list prepared by Mr. Paul Macy, NWAFC. Information on the translation is given in parentheses. Most but not all of these Russian language citations were reviewed by Mr. Macy before his retirement.

The contents of the index are listed at the beginning of the index section (on yellow paper). Following this is a key to index codes, which also serves as a species list.

The index consists of three sections: species index, area index, and subject index. Species in the species index are arranged alphabetically by scientific name within these categories: pinnipeds, other carnivores, sirenians, and cetaceans. In the species index each entry is followed by letter codes indicating whether that source contains information on abundance, distribution, feeding, Beaufort Sea, Chukchi Sea, Bering Sea, Aleutian Ridge, Gulf of Alaska, or a combination of these. In the area index and the subject index, entries are followed by letter codes indicating the species dealt with. Under all index headings, entries are arranged in chronological order. The intention here was to give a rough picture of the accumulation of knowledge over time. It may be that the bias in inclusion of articles (favoring those more easily available) and the small total number of these make this arrangement less than instructive. Feedback from users on this matter and on usefulness of index codes will be appreciated.

Bibliographic sources consulted are listed at the end of this report. By far the most important of these is the National Marine Mammal Laboratory itself, with its collection of volumes, reprints, and unpublished material.

Thanks go to Roger Pearson for guidance on citation style, to Paul Macy for special help with Russian language items, to Howard Braham for his patience with the numerous unavoidable delays which have beset this project, to Dale Rice for a critical reading-over of the annotations, to Teresa Bray for proofreadings and for a myriad of smaller things, and of course to Mary Nerini who contributed many annotations and welcome energy to the first "edition" of this list.

Selected Annotated References
on Marine Mammals of Alaska

Addison, R.F., and P.F. Brodie.
1973. Occurrence of DDT residues in beluga whales (Delphinapterus leucas) from the Mackenzie Delta, N.W.T. J. Fish. Res. Board Can. 30(11):1733-1736.

About 1,500-2,000 beluga whales are found in the Mackenzie delta estuary through July and into August. Authors report no evidence of feeding in July 1972 and all sampled stomachs were completely empty. Tissues from 14 whales of the native catch of July 1972 were examined. DDT and DDE content of liver, muscle, and blubber is given. The migratory movements of this population of whales are thought to be confined to the Beaufort and Chukchi Seas. Possible sources of contaminants are discussed. 1 tab., 16 ref.

Alexander, A.B.
1953. Manuscript report by A.B. Alexander concerning fur seals, 1892. Records of the U.S. Fish Commission. Gen. Serv. Admin., Natl. Archives, Washington, D.C. 23 p.

Description of pelagic fur sealing, which began along the northwest coast of North America perhaps as early as 1879, and in the Bering Sea in the early 1880's. Includes descriptions of vessels and equipment used, Neah Bay Indians as fur seal hunters, feeding habits and other behavior of fur seals, sealing on Japan coast, and killer whales.

Allen, K. Radway.
1974. Current status and effect of a moratorium on the major whale stocks. Rep. Int. Comm. Whaling 24:72-75.

Projects the possible effects on 6 whale species of a complete and protracted moratorium on killing. Table gives species, stock, present condition, expected effect, and source of data for right, blue, humpback, gray, sperm, and fin whales. Brief text explains use of terms in table and methods of estimation used.

American Society of Mammalogists - Standing Committee, Marine Mammals.
1976. Report submitted to 56th Annual Meeting of the American Society of Mammalogists at Lubbock, Texas, June, 1976. Edmonton, Alberta, 26 May 1976. 30 p.

Chairman Ian Stirling and nine committee members present status reports on various species of marine mammals, and on research activities. Committee members are Michael A. Bigg, John J. Burns, Clifford H. Fiscus, Roger L. Gentry, Ancel M. Johnson, William F. Perrin, Dale W. Rice, Aryan I. Roest, David E. Sergeant, and Thomas G. Smith. Bigg, Sergeant and Smith are from Canada; others are from U.S.

1977. Report submitted to the 57th Annual Meeting of the American Society of Mammalogists at E. Lansing, Mich., June, 1977. Edmonton, Alberta, 1 June 1977. 32 p.

In addition to individual reports on various marine mammals, a brief statement on sea otters is included, summarizing the "sea otter problem" in California, and possible solutions.

Anas, R.E.
1974. Heavy metals in the northern fur seal, _Callorhinus ursinus_, and harbor seal, _Phoca vitulina richardi_. Fish. Bull., U.S. 72(1):133-137.

Fur seals studied came from the Pribilof Islands and from waters off the state of Washington. Harbor seals came from coastal waters of California and from other points northward to the Bering Sea. All fur seal samples had mercury, lead and cadmium, but no arsenic. Mercury appears to be accumulated in fur seal livers. In harbor seals, only mercury was investigated, and levels found were similar to levels found in fur seals. (Maximum concentrations were 700ppm in a harbor seal from San Miguel Isl., and 170ppm from a fur seal.)

Andrews, R.C.
1909. Observations on the habits of the finback and humpback whales of the eastern North Pacific. Bull. Am. Mus. Nat. Hist. 26:213-226.

Data were gathered during the spring and summer of 1908 on vessels and at whaling stations; animals were from waters off the west side of Vancouver Island and off the southern end of Admiralty Island, Alaska. Includes description of respiration, inspiration. diving movements, duration of dives, feeding habits and stomach contents. 30 fig. (photos)

Anthony, A.W.
1924. Notes on the present status of the northern elephant seal, _Mirounga angustirostris_. J. Mammal. 5(3):145-152.

Notes from a voyage to Guadalupe Island in July of 1922 and 1923. Estimation of the herd size was 1,250. No evidence of recent hauling grounds was found to the south of Guadalupe. 8 photos.

Arsen'ev, V.A.

1941. Pitanie polosatogo tyulenya (Histriophoca fasciata Zimm.) [Feeding of the ribbon seal]. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 20·121-127. (Transl. by John J. Burns, Alaska Dep. Fish Game, 1977, 8 p.)

Stomachs of 398 ribbon seals were examined by author and G. Pikharev. Seals were caught in the ice of the southwestern Okhotsk Sea in spring 1939. About 83% of the stomachs were empty; 54 out of the 68 containing food were sampled. Listed in descending order of occurrence, the following animals were found: pollock, cephalopods, cod, pandalid shrimp, lumpsuckers (Aptocyclus), capelin, and crangonid shrimp. Majority of seals with food in stomachs were taken in 100-200m of water or more. Amount of food taken at one time is inferred from condition of stomach contents. Relation of feeding to molt is discussed. Previous stomach dissections are reviewed. 2 tab.

1969. Mezhdunarodnye koordinirovannye issledovania po morskim kotikan (International coordinated research on fur seals). P. 24-33 in V.A. Arsen'ev, B.A. Zenkovich, and K.K. Chapskii (eds.), Morskie mlekopitayushchie (Marine mammals) [a collection of articles containing materials from the 3rd All-Union Conf. on Mar. Mammals], Akad. Nauk SSSR, Min. Rybn. Khoz. SSSR, Ikhtiol. Kom.. Izd. "Nauka", Moscow. In Russian. (Transl. by Fish. Res. Board Can., 1970, Transl. Ser. 1510. Summary only.)

Describes organization of the International Commission on fur seals, and its recommendations for maintaining maximum sustainable yields. Describes the goals of the [Interim] Convention [on Conservation of North Pacific Fur Seals], and briefly gives the basic results of the first six years of coordinated research.

1971a. O lokal'nom raspredelenii morskikh kotikov Yaponskom More (The local distribution of fur seals in the Sea of Japan). Atl. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (AtlantNIRO) 39:138-150. In Russian. (Transl. Fish. Mar. Serv., Can., 1974, p. 226-239 in K.K. Chapskii and E.S. Mil'chenko (eds.), Research on Marine Mammals, Transl. Ser. 3185.)

Preliminary analysis of data collected in pelagic research in 1958-61 and 1964-66, by the USSR, the USA, Canada and Japan, indicates that in the Sea of Japan fur seals form mixed aggregations including animals of both sexes and almost all age groups. 4 tab., 7 fig.

1971b. Vozrastno-polovoi sostav morskikh kotikov, zimuyushchikh v zapadnoi chasti Tikhogo okeana (The age and sex composition of marine fur seals wintering in the western Pacific Ocean). In Morskie mlekopitayushchie (kotiki i tyuleni) [Marine mammals (fur seals and seals)]. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 80 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 82):25-43. In Russian. (Transl. by Fish. Res. Board Can., 1973, Transl. Ser. 2567, 21 p.)

Research has been conducted in waters off Japan in hopes of discovering separate accumulations of fur seals by age and sex, so that it might be possible to harvest males at sea. Such accumulations were not found, although at the end of wintering young males sometimes predominated over females in the kill. 13 maps with tables.

1972. (On maximum sustainable yield of fur seals on the Commander Islands). Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) (Transl. avail. from Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115, 8 p.)

Data are insufficient for determination of the maximum sustainable yield from the Commander Islands. Bulls began decreasing in 1966 and continue to do so. Advent of bachelors has been weak in all North Pacific rookeries; thus kills have decreased.

Arsen′ev, V.A., V.A. Zemskii, and I.S. Studenetskaya.
1973. Rod serye kity _Eschrichtius_ Gray, 1864 (Gray whales genus _Eschrichtius_ Gray, 1864). P. 30-35 _in_ Morskie mlekopitayushchie, Izd. "Pishch. Prom.", Moscow. In Russian. (Transl. by Israel Progr. Sci. Transl., avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 744-50059.)

At present found only in the North Pacific, until the beginning of the 18th century gray whales were also found in the Atlantic. The article briefly covers food items, behavior, reproduction and growth. Migratory patterns are noted in a general fashion.

Bailey, Alfred M.
1928. An unusual migration of the spotted and ribbon seals. J. Mammal. 9(3):250-251.

Following sudden freeze-ups of lagoons in the vicinity of Cape Prince of Wales, both spotted and ribbon seals are reported to have travelled over high country, covering a few miles a day, to reach open water to the south.

Bailey Alfred M., and Russell W. Hendee.
1926. Notes on the mammals of northwestern Alaska. J. Mammal. 7(1):9-28.

An expedition of 16 months in 1921-22 is recounted. Authors were landed at Wainwright, their winter base. on 6 August 1921 by Coast Guard cutter, having visited King and St. Lawrence Islands, and points on the Siberian coast. Bailey visited Barrow and Demarcation Pt. with the cutter ("Bear"). Point Hope. Kivalina, Kotzebue, and Wales were visited by dog-sled. Observations are included on: polar bear, "Pribilof harbor seal" or spotted seal, ribbon seal. bearded seal walrus, bowhead whale (bowhead hunting at Wainwright is described at length), "inito" [=ingutuk] (arctic whale similar to bowhead but smaller and differing in other ways, which are described), gray whale, beluga whale, killer whale, and harbor porpoise (seen at Unalaska).

Baker, Ralph C., Ford Wilke, and C. Howard Baltzo.
1970. The northern fur seal. U.S. Fish Wildl. Serv., Circ. 336, 20 p.

Author's abstract: "The early history of worldwide fur sealing; the distribution and movement of northern fur seals; and their food, physical characteristics, reproduction, and mortality and disease are discussed. Information is also given on fur seal population, management, and research; sealing on the Pribilof Islands; and processing and sale of fur seal skins." 1 drawing, 13 photos.

Balcomb, K.C.
1973. Cuvier's beaked whale from Washington state. Murrelet 54(3):37.

A skull of *Ziphius cavirostris* was found on Ruby Beach, Washington, in February 1972. This was the first record from Washington state.

Baldridge, A.
1972. Killer whales attack and eat a gray whale. J. Mammal. 53(4):898-900.

In May of 1967, a pod of 5-6 killer whales killed a gray whale calf off the California coast. The whales consumed the tongue, jaw and ventral blubber of the animal. It is suggested the killer whales held the gray calf under water, eventually causing its demise by drowning.

Barabash-Nikiforov, I.
1935. The sea otters of the Commander Islands. J. Mammal. 16(4):255-261.

Reports on observations of 600-700 sea otters mostly on Copper Island, from 1930 to 1932. Covers external characters, habits, competitors, enemies and parasites. Size and weight are tabulated by age, from embryo to over 8 years. *Eumetopias*, *Callorhinus*, and *Phoca ochotensis macrodens* [= *P. vitulina* and/or *P. largha*] also inhabit Copper Island.

1938. Mammals of the Commander Islands and the surrounding sea. J. Mammal. 19(4):423-429.

Briefly describes geography, climate, flora and fauna of the islands, and describes 18 species of marine mammals: otter, 7 pinnipeds, five great whales, 3 beaked whales, killer whale and 3 other dolphins. Notes seasonality of most species.

Barr, Lou.
1975. Steller sea lion. Oceans 8(4) 18-21.

Author notes population totalling 240,000-300,000 worldwide, with half of that in Alaskan waters; habit of hauling out on rocks, often high above the water· opportunistic feeding; curiosity about scuba divers; graceful, controlled swimming; and occasional roaring under water. Author describes underwater encounters at Auke Bay (near Juneau, Alaska) and off Point Ivakin (Amchitka Island, Aleutian Islands). 4 photos.

Barr, N. and L. Barr.
1972. An observation of killer whale predation on a Dall porpoise. Can. Field-Nat. 86(2):170-171.

Describes 2 killer whales pushing a Dall porpoise October, 1971, near Auke Bay, Alaska. Shortly thereafter, the whales disappeared, and presumably killed their prey.

Bartholomew, G.A., Jr.
1952. Reproductive and social behavior of the northern elephant seal. Univ. Calif. Publ. Zool. 47(15):369-472.

Observations were made from April 1949 to May 1950 on San Nicolas, Los Coronados, Guadalupe, and San Benito Islands. Good descriptions of social behavior and locomotion. Elephant seals are extremely gregarious and prefer to be tightly packed. Fighting usually occurs between individuals of the same size but the skin is not broken. Breeding behavior is described in detail. Breeding occurs from December to March. These seals are polygamous and the dominant males have harems with perhaps 13 females. Only one young is born to a female per year.

Bartholomew. G.A., and C.L. Hubbs.
1960. Population growth and seasonal movements of the northern elephant seal, Mirounga angustirostris. Mammalia 24(3):313-324.

Population has increased from 50 in 1892, to 13,000 in 1957. Article traces the history of the population changes. Census figures (for Guadalupe and other islands) show a ten-fold seasonal fluctuation. Adult males apparently range out to sea as far north as Oregon and Washington. 1 tab., 2 fig., 4 pl., 20 ref.

Bee. James W. and E. Raymond Hall.
1956. Mammals of northern Alaska on the arctic slope. Univ. Kans. Mus. Nat. Hist., Misc. Pub. 8, 309 p.

Description and discussion of 42 species, including white whale, narwhal, killer whale, harbor porpoise, gray whale, bowhead whale, polar bear, fur seal. walrus, and harbor, ribbon, ringed and bearded seals. New records of occurrence and those previously published are listed and mapped. 4 pl., 127 fig., 5 tab.

Beier, John C., and Douglas Wartzok.
1977. Mating behavior of captive spotted seals (Phoca largha). Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 26. (Avail. from first author, The Johns Hopkins Univ., 615 N. Wolfe St., Baltimore, MD 21205.)

Underwater mating behavior of a pair of seals was observed during April and May, 1973-1977. Seven types of behavioral interactions and six types of vocalizations (all drawn from repertoire observed throughout year) increased significantly during mating season.

Benson, S.B. and T.C. Groody.
1942. Notes on the dall porpoise (Phocoenoides dalli). J. Mammal 23:41-51.

From a specimen captured in San Francisco Bay. morphological notes were taken on the Dall porpoise.

Berg, Ronald J.

1977. An updated assessment of biological resources and their commercial importance in the St. George Basin of the eastern Bering Sea. _In_ Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 555-680. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

The commercial fisheries, major fisheries, major shellfishes, and marine mammals (only those under jurisdiction of the National Marine Fisheries Service) of the St. George Basin are discussed. The National Marine Fisheries Service recommends the establishment of a marine sanctuary to include this very productive and important area. 13 tab., 32 fig., 174 ref.

Berzin, A.A.

1959. O pitanii kashalota v Beringovom More (On the feeding of sperm whales (_Physeter catodon_) in the Bering Sea). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 47:161-165. In Russian. (Transl. by School Fish., Univ. Washington. Seattle, 1970, 9 p.)

Reports on examination of stomachs of 110 whales taken from waters of the Aleutian ridge and the northwestern Bering Sea. About 64% of stomachs contained squid only. Stomach contents and degree of filling were analyzed by area. Nine species of squid, and fish representing 8 families were found. In the northern area only, fish predominated over squid, but less food was taken. Concludes that the Commander Islands area is the major feeding area for sperm whales in the Bering Sea. 2 tab.

1964a. Opredelenie vozrastnogo sostava stada kashalotov Beringova morya i prilezhashchikh chastei Tikhogo okeana (Determination of age composition of the sperm whale stock of the Bering Sea and adjacent parts of the Pacific) Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (TINRO) 52):267-270. In Russian. (Transl. by Israel Progr. Sci. Transl., 1968, p. 263-266 _in_ P.A. Moiseev (ed.), Soviet fisheries investigations in the northeast Pacific, Pt. 3, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 67-51205.)

Pacific sperm whales are composed of two independent stocks: Asiatic and American. American stock said to migrate from California to Aleutian Islands and into Bering Sea. Catch information in 1950-61 indicated that American stock was becoming younger on the whole because intensive whaling since 1954 had removed older animals. 1 fig.

1964b. Rost kashalotov severnoi chasti tikhogo okeana (Growth of sperm whales in the North Pacific). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (TINRO) 52):271-275. In Russian. (Transl. by Israel Progr. Sci. Transl., 1968, p. 267-271, _in_ P.A. Moiseev (ed.), Soviet fisheries investigations in the northeast Pacific, Pt. 3, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 67-51205.)

Age of 605 sperm whales was determined by dentin lamination in 1959-1960. Newborn whales are 400-430cm long. They grow 170-200cm the first year and 1m a year for the next 7 years. Females reach physical maturity at 15-17 year (11m). Males reach physical maturity at 23-25 years (15.9m). Life span was determined to be 35 for females and 45 for males.

1971. Kashalot (The sperm whale). Izd. "Pishch. Prom.", Moscow. 367 p. In Russian. (Transl. by Israel Progr. Sci. Transl., 1972, 394 p., avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 71-50160.)

A compilation of knowledge about the sperm whale. Includes discussion on taxonomy, detailed morphology, distribution, migration, behavior, biology and whaling.

Berzin, A.A., and A.A. Kuz′min.
1975. Serye i gladkie kity okhotskogo moria (Gray and right whales of the Okhotsk Sea). P. 30-32 in G.B. Agarkov and I.V. Smelova (eds.), Morskie mlekopitayushchie (Marine mammals), Part 1, (Materials 6th All-Union Conf. [on Studies on Marine Mammals]), Kiev, 1-3 Oct. 1975. Min. Rybn. Khoz. SSSR, Ikhtiol. Kom., VNIRO, Akad. Nauk SSSR, Inst. Evol. Morfol. Ekol. Zhivotn., Inst. Biol. Razvit., Zool. Inst., Akad. Nauk USSR, Inst. Zool. Izd. "Naukova Dumka", Kiev. In Russian. (Transl. avail. Natl. Mar. Fish. Serv., Off. Int. Fish., Lang. Serv. Branch, Washington, D.C., 2 p.)

Gray whales: Korean-Okhotsk population, almost hunted out in the last century, is very small and appears to be decreasing. Search voyages in June and July 1967 and August 1974 in the Okhotsk Sea showed that only individual whales arrived there for the summer, and were sometimes seen in Tugur Gulf and western coastal areas. Gray whales are known to be caught off Korean shores. Right whales: Pacific right whales (Eubalaena glacialis sieboldii) are present in the central and northeast areas in the summer. Greenland right whales (Balaena mysticetus) are found in the western areas in the summer. Differences (e.g. angle of spout) have been discerned between Greenland right whales of the Okhotsk Sea and those of the Bering and Chukchi Seas and it is proposed that they are now separate subspecies after prolonged genetic isolation.

Berzin, A.A., and A.A. Rovnin.
1966. Raspredelenie i migratsii kitov v severo-vostochnoi chasti Tikhogo okeana, v Beringovom i Chukotskom moryakh (Distribution and migration of whales in the northeastern part of the Pacific Ocean, Bering and Chukchee Seas). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:179-207. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Washington, 1966, p. 103-136 in K.I. Panin (ed.), Soviet Research on Marine Mammals of the Far East.)

Information on sperm, humpback, finback, blue, gray, and Pacific right whales has been gathered by Russian research vessels and whaling fleets, and is presented here. Migration patterns are shown to be complex and therefore the traditional concept of "American" and "Asiatic" stocks of whales should be abandoned. Three oceanographic factors are discussed as they relate to whale distribution: salinity of water, cyclonic current systems, and distribution of preferred food species. 8 fig.

Berzin, A.A., E.A. Tikhomirov, and V.I. Troinin.
1963. Izchezla li stellerova korova? (Is the Steller sea cow extinct?) Priroda 52(8):73-75. In Russian. (Transl. by Fish. Res. Board Can., 1965, Transl. Ser. 548, 4 p.)

Reports two sightings, possibly of sea cows, in vicinity of Point Navarin in July 1962. First sighting was of about six animals; second of one animal. Reviews reports of sea cows since their supposed extermination around 1768.

Bigg, Michael A.
1969. The harbour seal in British Columbia. Bull. 172, Fish. Res. Board Can., Ottawa, 33 p.

From author's abstract: "The results of a field study made on the harbour seal, Phoca vitulina richardi, in British Columbia are reported and discussed. The study, based on field observations and a collection of 415 specimens, describes the method of determining age, the reproductive cycle and ages at sexual maturity, prenatal and postnatal growth, and population composition and dymanics. .... The number of seals in British Columbia just prior to the pupping season is estimated to be at least 11,400; a more likely estimate is calculated to be about 35,000 seals." 9 tab., 19 fig., 30 ref.

1973. Census of California sea lions on southern Vancouver Island, British Columbia. J. Mammal. 54(1):285-287.

Between June 1971 and February 1972, 4 aerial and 2 land censuses were made. All the sea lions were adult or sub-adult males. On hauling out rocks, they prefer the inner, less exposed side of the islands. Census table given.

Bigg, M.A., and I.B. MacAskie.
1971. Report on Canadian pelagic fur seal research in 1971. Unpubl. manuscr., 24 p. Pac. Biol. Stn., Fish. Mar. Serv.. P.O. Box 100, Nanaimo, B.C. V9R 5K6, Can.

(See Pike, Spalding, et al. 1958.) From January to April seals were hunted off southwestern Vancouver Island and Washington State. Tissue samples were collected for mercury and pesticide analyses. 7 tab., 6 fig.

1972. Report on Canadian pelagic fur seal research in 1971-72. Unpubl. manuscr., 21 p. Pac. Biol. Stn., Fish. Mar. Serv., P.O. Box 100, Nanaimo, B.C. V9R 5K6, Can.

(See Pike, Spalding, et al. 1958.) From December to February, seals were hunted off southwestern Vancouver Island. 8 tab., 3 fig.

1974. Report on Canadian pelagic fur seal research in 1972-3. Fish. Res. Board Can.. Pac. Biol. Stn. Nanaimo, British Columbia, Manuscr. Rep. Ser. 1292, 21 p.

(See Pike, Spalding, et al. 1958.) From November to February seals were hunted off southwestern Vancouver Island. Two fur seals were seen in northern Johnstone Strait, Vancouver Island, in August. 8 tab., 4 fig.

1975. Report on Canadian pelagic fur seal research in 1973-4. Fish. Res. Board Can., Pac. Biol. Stn. Nanaimo, British Columbia, Manuscr. Rep. Ser. 1337, 20 p.

(See Pike, Spalding, et al. 1958.) In December and January seals were hunted off southwestern Vancouver Island and Washington. In June and July 1974 seals were hunted in Unimak Pass, Alaska. 9 tab., 4 fig.

Bishop, R.H.
1967. Reproduction, age determination, and behavior of the harbor seal, Phoca vitulina L., in the Gulf of Alaska. M.S. Thesis, Univ. Alaska, College, Alaska, 120 p.

This study was carried out in 1963 in Aialik and Harris Bays, and on Tugidak Island in 1964. Age was determined by dentition and cementum development. Females mature at 3-4 years and males at 5-6 years. Gestation is 271 days. Pupping occurs from 5 May to late June. Lactation lasts 3 weeks and ovulation occurs 2 weeks later. The stomachs of 4 collected animals contained octopus beaks and unidentified small fish. Description of breeding behavior, growth patterns, pelage and molt also included. In 1963, the author counted 500 seals at each of the 2 bays. In 1964, the estimates for Tugidak Island were 4-5,000 in May, 9,500-10,000 in June, and 6,000 at the end of July. The pup crop is estimated to be 5,500 annually.

Bockstoce, John.
1975. Contacts between American whalemen and the Copper Eskimos. Arctic 28(4):298-299.

Copper Eskimos (of the western Canadian arctic) probably had contact with white men in the 1890's. Evidence comes from records of whaling ships and from ethnographic collections. Bowhead whalers were present in the vicinity of Banks Island, Victoria Island, Coronation Gulf, and the Coppermine River, in the 1890's.

1977. Eskimo whaling in Alaska. Alaska 43(9):4-6.

[This September issue contains several pieces concerning bowhead whaling.] Current conservationists' concern is that bowheads of the western arctic (the last important stock left) may be close to extinction and that paucity of scientific knowledge dictates careful husbandry. Beginning of Eskimo whaling is dated at 800 AD in northwest Alaska, and perhaps 1,000 years earlier on St. Lawrence Island. From this time until the 19th century Eskimos and whales lived within a stable ecosystem. From 1848-1908 Yankee whalers exploited bowheads of Alaska. During later years of this period (1880's to end), when bowhead stock had been considerably depleted, Yankee whalers established shore stations at Pt. Hope and Pt. Barrow and hired many Eskimos to hunt in the traditional manner (attracting natives from all over the Northern Interior). Number of native crews operating was then two or three times what the aboriginal level had been. After the collapse of the baleen market in 1908, Eskimo whaling as a subsistence activity resumed. From 1910-1920 an estimated total of 10 whales per year were taken in all of Alaska, perhaps less than 1/4 of aboriginal take, because of depletion of stock by 60 years of commercial whaling. Eskimos continued to use weapons (darting gun, shoulder gun) introduced by Yankees, and subsistence hunt continued at a fairly constant level until about 1970. High-paying jobs (on the pipeline) became available and Eskimo whalers were able to buy thousands of dollars worth of commercially produced equipment. The number of whaling crews increased dramatically. Alaskan Eskimos took 48 bowheads in 1976 and in the spring of 1977 took 28 and reportedly struck and lost an additional 73. This trend is disturbing; however, the fact that no good estimate of the bowhead population is available makes resolution of the conservationist-Eskimo controversy difficult. 3 photos.

Bogdanov, L.V., V.A. Chernoivanov, V.I. Polyakovsky, and T.I. Bashurova.
1977. Biokhimicheskii polimorfizm severnogo morskogo kotika Callorhinus ursinus iz trekh raionov severo-zapadnoi chasti Tikhogo okeana (Biochemical polymorphism of northern fur seal Callorhinus ursinus from three regions of the north-west Pacific Ocean). Genetika 13(6):1008-1014. Akad. Nauk SSSR, Moscow. In Russian. (English summary)

Frequencies of genes for certain blood proteins were compared among northern fur seals from three regions: "Pelagic of Commander Islands (n=164), Rockery [sic] of Robben Island (Sakhalin population, n=308), winter todder [sic] region to the east of Honshu Island (n=110)." Reliable differences were found between fur seals of the Commander and Sakhalin populations. Fur seals from winter todder region were closer to the Commander Islands population than to the Robben Island population. Originality of gene frequencies of locus Ap (alkaline phosphatase), was found in the todder region animals. It is established that hemoglobin of northern fur seal consists of two components (Hb I + Hb II). Individual variability of hemoglobin results in the variation of the colour intensity of the "slow" component (Hb II)." 5 tab., 4 fig., 11 ref.

Borodin, R.G., and V.A. Vladimirov.
1975. (Evaluation of the present conditions of the Komandorskiye Islands fur seal population). Promysl. Ikhtiol. (7), Ref. Inf., Ser. 1, Min. Ryb. Khoz. SSSR: 7-8. In Russian. (Transl. avail. Natl. Mar. Fish. Serv., Off. Int. Fish., Lang. Serv. Branch, Washington, D.C.)

In 1973, the estimated fur seal population of the Komandorskiye Islands included: 77.0-107.8 thousand mature females and 1,787 mature males. Excessive killing of bachelor bulls from 1959-1967 has resulted in a deficit of mature males.

Braham, Howard W.
1977. California gray whale (Eschrichtius robustus) spring migration in Alaska. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 59. (Avail. from author, Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

Data collected from aerial surveys, ships, and land camps since 1975 reveal that gray whales arrive in northeastern Gulf of Alaska in March, enter the Bering Sea through Unimak Pass by early April, and enter the northern Bering Sea by late May. Migration route is mainly coastal, to Nunivak Island; then it is offshore. Coastal migration route would make gray whales vulnerable to human-related near-shore perturbations (e.g., oil drilling).

Braham, Howard W., Robert D. Everitt, Bruce D. Krogman, David J. Rugh, and David E. Withrow.
1977. Marine mammals of the Bering Sea: a preliminary report on distribution and abundance, 1975-76. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 90 p.

Research was conducted in the Bering Sea between June 1975 and October 1976, and information on observed distribution and abundances is presented. Ice seals (ringed, bearded, larga and ribbon seals, with walrus observations included): Ice seal data were collected using long-range survey aircraft. Larga seals were the most numerous in Bristol Bay (southern Bering Sea), followed by bearded, ringed, and ribbon seals; north of 60°N, most commonly sighted were bearded seals, then ringed, then larga. Sea lions and harbor seals: These observations were made using smaller, more maneuverable aircraft. For sea lions, several "new" hauling areas were identified, and counts showed a population decline in the eastern Aleutian Islands area. Of harbor seals sighted, 80% were found along the north side of the Alaska Peninsula. Cetaceans: Cetaceans sighted during vessel and aerial surveys were gray, fin, minke, sei, killer, and goosebeaked (*Ziphius*) whales, and harbor and Dall porpoises. 13 tab., 49 fig., 73 ref.

Braham, Howard W., Robert D. Everitt, and David J. Rugh.
1977. Preliminary evidence of a northern sea lion (*Eumetopias jubatus*) population decline in the eastern Aleutian Islands. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 30 p.

A comparison of counts made in 1957, 1960, 1965, and 1968 with systematic counts made by the authors from June 1975 to June 1977 by aerial survey, shows a decline of 40-50% in the population of sea lions in the eastern Aleutian Islands (from Amak Island and Sea Lion Rock on the north side of the Alaska Peninsula (near the tip), to Samalga Island at the western end of the Fox Islands group). Statistical treatments are described. 7 tab.

Braham, Howard W., Clifford H. Fiscus, and David J. Rugh
1977. Marine mammals of the Bering and southern Chukchi Seas. *In* Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 1-199. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

[Also appears as processed report. See Braham, Everitt, Krogman, et al., 1977.] Includes recommendations and summary of 4th quarter operations. 13 tab., 49 fig., 60 ref.

Braham, Howard W., and Bruce D. Krogman.
1977. Population biology of bowhead (Balaena mysticetus) and beluga (Delphinapterus leucas) whale in the Bering, Chukchi and Beaufort Seas. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 29 p.

Aerial surveys in the Chukchi and Beaufort Seas (from Point Hope to Barter Island) were conducted from 29 April to 20 June 1976 from Barrow, Alaska. Effort was concentrated in offshore areas between Barrow and Wainwright and north of Barrow to about 72°N Lat. At the same time (25 April - 2 June), whales passing in the shore lead north and northwest of Barrow were counted from two camps on shorefast ice. Aerial surveys were found to be more useful for counting belugas, ice camp surveys more useful for counting bowheads. The ice crew counted 259 bowheads and 309 belugas, and an additional 98 bowheads were counted by Eskimos. Aerial crew counted 108 bowheads, 1020 belugas. Pre-existing whale records are reviewed. Based on all observations combined, an offshore migration route for bowheads in the eastern Chukchi and Beaufort Seas is hypothesized, modifying the existing hypothesis of a near-shore route along the northern Alaska coast. Sightings (from several sources) of bowheads and belugas in the Bering and southern Chukchi Seas in 1976 are tabulated. Sightings of bowheads in the Soviet sector of the Bering and Chukchi Seas in fall 1974 and 1975 are tabulated. 3 tab., 11 fig., 34 ref.

Braham, Howard W., Bruce Krogman, and Clifford Fiscus.
1977. Bowhead (Balaena mysticetus) and beluga (Delphinapterus leucas) whales in the Bering, Chukchi and Beaufort Seas. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 134-160. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Reports on the same data as does Braham and Krogman (1977), and is similar in large part. Sightings of other marine mammals during 1976 aerial surveys of northeastern Chukchi and western Beaufort Seas are tabulated (bearded and ringed seals, walrus, gray whale, polar bear, unidentified whales and seals). Includes summary of quarterly activities.

Braham, Howard, Bruce Krogman, Stephen Leatherwood, Willman Marquette, David Rugh, Michael Tillman, James Johnson, and Geoff Carroll.
In press. Preliminary report of the 1978 spring bowhead whale research program results [SC/30/Doc. 36]. Rep. Int. Whaling Comm. 29. 57 p.

Describes operations through 30 May 1978. Research activities: Aerial surveys were flown over areas from St. Lawrence Island north to Pt. Barrow and eastward to Banks Island. Two ice camps were operated north of Pt. Barrow by the National Marine Fisheries Service (NMFS) beginning 15 April (expected to continue into June) to census passing whales. The Alaska Eskimo Whaling Commission sponsored an additional whale counting camp, also near Pt. Barrow. Eskimo whalers also provided input to census

activities. A land-based whale count was conducted by the NMFS from Cape Lisburne beginning 2 April (expected to continue into June). Biologists were stationed at St. Lawrence Is., Pt. Hope, Wainwright, and Barrow to monitor the harvest and collect biological samples. A study was carried out near Barrow on the feasibility of censusing whales with acoustic and sonar equipment. From Summary and conclusions: Based on ice camp counts the number of bowhead whales that passed Pt. Barrow between 15 April and 30 May was estimated at 2,264. Aerial surveys indicated that all migrating whales were within sight of the ice camp censusers. Observation conditions were better and counting effort was higher than in previous years. Migration route hypothesis previously proposed in Braham and Krogman (1977) was corroborated (i.e., in spring eastbound whales pass Barrow then head north and east offshore towards northwestern Banks Island). Vocalizations of bowhead whales were recorded successfully; sonar equipment tested proved inadequate for censusing. Both methods may be useful when refined. Ten whales were landed and five struck and lost as of 30 May. Chromosome number for one reported "ingutuk" whale was the same as that of bowhead. It is estimated that 29 calves may have been added to the bowhead population this year. The NMFS has taken steps to improve effectiveness of the darting gun and shoulder gun, malfunctions and/or misuse of which have caused whales to be struck and lost. 9 tab., 7 fig., 2 ref.

Braham, Howard, Bruce Krogman, Willman Marquette, David Rugh, James Johnson, Mary Nerini, Stephen Leatherwood, Marilyn Dahlheim, Ronald Sonntag, Geoff Carroll, Teresa Bray, Steven Savage, and James Cubbage.
1979. Bowhead whale (*Balaena mysticetus*) preliminary research results, June through December 1978. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Seattle, Wash., NWAFC Processed Rep. 79-8, 40 p.

Fixed site counts: Spring counts by National Marine Fisheries Service (NMFS) at Barrow [See Braham et al., in press.] now undergoing further analysis; reports on behavioral observations progressing. Spring count from Alaska Eskimo Whaling Commission counting station at Barrow (24-28 April, 1-19,21-24 May) tabulated; 885 whales counted plus 39 "conditionals", with average watch of 21 hrs/day. This count was significantly lower than that of NMFS south camp; discrepancy possibly arises from differing watch periods, number of observers, and camp locations (5 km apart). Eskimo whalers' logbooks indicate "pulses" in bowhead migration April 14-21 at Gambell, May 1-3 at Pt. Hope, and April 19 - May 2 at Pt. Barrow (possibly the same whales), and (though notations were inconsistent) indicate relative numbers of bowheads and belugas recorded at Barrow, Pt. Hope, Gambell, and Savoonga. At Cape Lisburne between April 2 and June 7 during 690.7 hrs of watch, 280 bowheads were counted; this was extrapolated to 478. Interpretation of "duplicate" sightings discussed. Apparently most bowheads on spring migration do not begin moving into the nearshore lead until they pass Cape Lisburne. No research wil be conducted there in 1979. Daily observations made from vicinity of Gambell May 16 to December 31, 1978: sightings of bowhead, gray, fin, minke, beluga, and killer whales reported; bowheads seen routinely until May 20, not seen again with regularity until many sightings were made in January 1979 (somewhat later than usual). During 19 aerial and 3 vessel surveys June-September in

southern Chukchi-northern Bering area (including Soviet waters), no bowheads were seen, indicating that no more are still migrating north after the spring whaling season (as Townsend's (1935) records indicate they once did). (Sightings of other marine mammals during one vessel survey, June 14-July 15 in Bering and Chukchi Seas, are tabulated.) Preliminary biochemical-genetic studies indicate "ingutuk" whales not separate species from B. mysticetus. Fall bowhead harvest: 2 taken, 1 struck and lost at Kaktovik (making 1978 totals of 12 taken, 6 reported struck and lost). Hydrophone array tested on killer whales in Puget Sound, Washington, found capable of revealing presence and direction of movement. Feasibility of counting whales with passive sonar not demonstrated. High-quality recordings obtained of vocalizations of a bowhead under observation in western Beaufort Sea in October. 5 tab., 2 fig., 5 ref.

Braham, Howard W., and Stephen Leatherwood.
1978. Ingutuk: preliminary remarks on a morphological variation of the bowhead whale (Balaena mysticetus). Unpubl. manuscr., 12 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Paper addresses the question of the relationship of the bowhead whale to the smaller similar whale of the same distribution. References to this smaller arctic whale, variously called inyuto, inito, inyutok, kairalik, ingutuk (today's term), are reviewed. Twenty-two characters of Ingutuks which have been reported to differ from those of bowheads are tabulated. Ingutuks have been calculated to compose around 15% of the total bowhead population. Conclusion is that the two forms are not separate species, but that the Ingutuk represents a persistent genetic variation within the entire breeding population of bowhead whales. 2 tab., 21 ref.

Branson, J.H.
1968. Walrus sighting on Kodiak Island. Memorandum of January 24, 1968 (to Reg. Dir., Bur. Commer. Fish., Juneau) by J.H. Branson, U.S. Dep. Inter., Fish. Wildl. Serv., Bur. Commer. Fish., Kodiak, Alaska.

Reports a sighting on 8 or 9 September 1967 on the northwest side of Kodiak Island. The walrus was amidst a band of sea lions.

1971. Killer whales pursue sea lions in Bering Sea drama. Commer. Fish. Rev. 33(3):39-40.

On 23 January 1971, a pod of 7 whales was seen chasing a band of 20-25 Steller sea lions. The sea lions were taking refuge under the bow of a fishing trawler (position 54°18'N, 167°51'W). Within an hour, one sea lion strayed from the band and was taken. The outcome of the drama was unknown.

Bree, P.J.H. van -- SEE Van Bree, P.J.H.

Brooks, James W.
1954. A contribution to the life history and ecology of the Pacific walrus. Univ. Alaska, Alaska Coop. Wildl. Res. Unit, Spec. Rep. 1, Univ. Alaska, 103 p.

One of the first comprehensive treatises on the walrus. Details on classification, distribution, breeding biology, harvesting and management given. Data presented are from the eastern Bering and Chukchi Seas during the spring and summer of 1952-53. The distribution is bounded by the south end of the arctic ice pack, a line from Bristol Bay to the Gulf of Anadyr, and Pt. Barrow. Most of the population spends the summer in the western Chukchi. Bands of animals segregated by sex migrate separately. Females always migrate south in the winter, whereas males will occasionally remain residents on northern grounds. Explicit migration patterns given by month. The bivalve Mya truncata was the dominant food item with Molpadia arctica of secondary importance. Cows and immatures favor small mollusks like Astarte and Macoma in addition to worms. Population in 1953 is estimated at 15,000 in the eastern Bering Sea.

1957. Marine mammals in relation to commercial fisheries in Alaska. Science in Alaska, Proc. Eighth Alaskan Sci. Conf., Anchorage, Alaska, Sept. 10-13, 1957, p. 23-24. [Abstr. only.]

[Author represented Alaska Department of Fish and Game.] Of the 7 pinnipeds and more than 12 cetaceans common to Alaska, only the fur seal and the walrus are of major present commercial importance; however, Eskimos utilize ringed, bearded, harbor, and ribbon seals, and beluga, bowhead and gray whales on a smaller scale. Beluga whales, harbor seals, and northern sea lions are discussed as predators on commercial fish. Control of this predation is discussed.

1963. The management and status of marine mammals in Alaska. Trans. 28th North Am. Wildl. Nat. Resour. Conf.:314-325. Wildl. Manage. Inst., Washington, D.C.

Sea otters: Author, of the Department of Fish and Game of Alaska (Juneau), reviews the near-extirpation, recovery; notes recent experimental harvest by his department. Hair seals: Author notes bounty on harbor seals, recounts dynamiting of harbor seals in gill-net fishery areas, and Eskimo seal harvest. Ringed and bearded seals are noted as crustacean eaters; ribbon and elephant seals are rare. Pacific walrus: discusses population estimates (18th century - 200,000; early 20th century - 40,000; at present - at least 70,000), present kill and management. Polar bear: Harvested only by natives until about 1948 when airplane shooting by whites became possible and popular. Bag limits were imposed beginning in 1949. Most biological data come from harvested animals. Beluga whale: Total Alaska population is unknown; predation by belugas on red salmon in Bristol Bay river mouths has been studied by author and is discussed. Steller sea lion: Alaska population is estimated at 150,000-300,000. Because of disturbance to fisheries, there is discussion of starting a killing program. Special considerations: A bill to remove authority over sea otter, polar bear, and walrus from the state to the federal Department of the Interior (HR 7490, passed in 1962 by the House) is discussed.

In press. Status of marine mammal stocks in Alaska. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 17 p.

Legal status: Certain of Alaska's marine mammals are included in the terms of: the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, the International Whaling Convention (1948), the International Convention on Trade in Endangered Species of Wild Fauna and Flora (1975), the Interim Convention on North Pacific Fur Seals (US,USSR,Canada,Japan), an Agreement on the Conservation of Polar Bears (US,USSR,Canada,Denmark,Norway), the Fishery Conservation and Management Act of 1976, and the US-USSR Marine Mammal Project - Environmental Protection Agreement. Statuses of each of 13 cetaceans, 8 pinnipeds, sea otter, and polar bear are summarized in terms of 1) distribution and migration, 2) abundance and trends, 3) general biology, and 4) current research (if any). Cetaceans rare but known in Alaskan waters are noted but not discussed (i.e., narwhale, beaked whales, pilot whale). Author praises the work of the State of Alaska in research on marine mammals and voices support for the Alaska Department of Fish and Game's currently proposed research plans. 4 ref.

Brower, Ronald.

In press. Cultural uses of Alaska marine mammals. [This is an edited version of the transcript of Mr. Brower's presentation.] Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 7 p.

Resident Native of Barrow comments on: recent changes in the arctic environment such as those related to oil development, confusion among Eskimos in transition period mixing traditional with Western culture, renewed use of beluga oil and seal oil as medicine, new ideas for use for baleen of bowhead, increase in catch and decrease in full utilization of walrus, use of spotted seal for clothing, enquiry into early history of Eskimo hunting of bowheads, Eskimo art (objects from beluga bones, dances) expressing interrelationship of people with animals, bowhead hunting controversy and protection of human rights.

Brown, S.G.

1974. Whale marking progress report 1973. Rep. Int. Comm. Whaling 24:60-61.

Table shows whales marked in 1972 and 1973, and Antarctic season 1972-3. Eleven species (including right, killer and pilot whales) were marked, 146 of those in the North Pacific. Short text accompanies table. Recovered marks totalled 44.

1975. Whale marking - progress report 1974. Rep. Int. Comm. Whaling 25:83-84.

Short text accompanies table entitled "Whales marked during 1973 and 1974, and in the Antarctic season 1973/74". Totals of 9 blue, 88 fin, 83 sei, 13 Bryde, 29 humpback, 1 bottlenose, 1 killer, 23 minke, 15 gray, 4 right, 328 sperm whales were marked. Soviet, Canadian, Norwegian, Japanese, and international cruises participated. In the North Pacific (1973) the Japanese marked 20 fin, 27 sei, 13 Bryde's, and 67 sperm whales and Russians marked 15 gray whales.

Brownell, Robert L., Jr.
1977. Current status of the gray whale. Rep. Int. Whaling Comm. 27:209-211.

Current and former distributions and population sizes of 2 Pacific and 2 (extinct) Atlantic stocks are discussed, along with history of exploitation (California stock apparently stable at about 11,000, Korean stock likely to become extinct without careful protection); problems of protection (industrial development and tourist harrassment around calving areas, threat of oil spills in northern feeding area, vulnerability of Korean stock to exploitation by non-signatories of the International Whaling Convention); and appropriateness of current "protection stock" designation (should remain so designated). 1 tab.

Bruemmer, F.
1969. The sea unicorn. Audubon 71(6):58-63.

Provides a historical account of the narwhal. Their distribution is given as the Canadian arctic although they are known to venture into the Chukchi Sea. Migration patterns are unknown. Estimates the Canadian - Greenland population to be 10,000.

Burgess, S.
1973. Marine mammal phenology in western St. Lawrence Island waters. Science in Alaska, Proc. 23rd Alaska Sci. Conf., Fairbanks, August 15-17, 1972, p. 49. [Abstr. only.]

From Eskimo activities it was determined that the highest concentration of seals in St. Lawrence waters occurs in late summer and fall, and is dominated by *Phoca vitulina largha*. Ringed seals are taken in winter. The bearded seal, ribbon seal, northern sea lion and walrus appear in the spring. Beluga and bowhead whales can be seen going south in December and heading north in April and May. Gray whales appear about the same time in spring and remain until late summer.

Burns, John J.
1965a. Marine mammal investigations in northwestern Alaska. Western Assoc. State Game Fish Comm., Proc. 45th Annu. Conf.:129-133.

Discusses biology and management of walrus and bearded seal, with concise presentation of natural history.

1965b. The walrus in Alaska: its ecology and management. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 5, 48 p.

History of walrus exploitation, economic role in Alaska, and recent and current research are discussed. .Research reported includes collection and examination of tusks, lower canine teeth, and reproductive tracts of females to determine reproductive behavior related to age; magnitude of Alaska harvest; collection of observations to determine migration and distribution patterns. Walruses first breed at about 6 years of age. Most mature females bear one calf every 2 years. Population is estimated at at least 90,000. Major food species are *Mya truncata* and *Clinocardium* nuttalli (clams). Also discussed: predation on seals; seasonal migration and distribution; hauling out areas (including the Walrus Islands and the Punuk Islands); behavior. Extensive bibliography.

1965c. Marine mammal report. Alaska Dep. Fish Game, Div. Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 6, 45 p.

Reports on research conducted in 1964. Walrus: major spring migration through Bering Strait occurred during the last week in May and the first week of June. This was at the same time as during previous years, in spite of an unusually slow retreat of the pack ice. Forty-one adult females examined were 64% parturient, 24% pregnant, and 12% barren. Parturition rate was found to be one calf every 2.02 years, among 29 animals. Also contains short sections on migration (with notes on correlates of ice movement), segregation of sexes, and foetal development, as well as reproductive investigations. Total walrus kill was 2,061 - 2,215; retrieved kill was 975 - 1040. In general it was a poor season (with high utilization) because of ice conditions, and economic impact is discussed. (It is noted that 10 or 12 whales, mostly grays, were taken at Barrow during summer.) Bearded seals: Bearded seal specimens have been collected since 1962 (mostly from 1964, an extremely poor walrus season). For 85 reproductively mature seals, average length was 91 in. and weights were up to 610 lb. Delay of implantation is 2-1/2 to 3-1/2 months, total gestation period about 12 months. Nursing period is short, 12-18 days, and by weaning time the pup has reached 69% of adult length. Migration is generally concurrent with the seasonal advance and retreat of the pack ice, although young seals are sometimes found where there is no ice. The retrieved kill of bearded seals in Alaska is approximately 3,000 animals per year, with a total kill of around 6,000.

1966. Marine mammal report. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 7, 47 p.

Reports on research conducted in 1965. Walrus biology and populations: The main migration moved through Bering Strait 20 May - 18 June. Teeth examined from known-age walruses --current interpretation method validated. Female reproductive tracts examined (160 animals from nursery herd) -- 71% newly parturient, 21% pregnant, 8% barren. Females first breed at age 5 or 6, calve from then on, averaging one calf every 2.2 years. Adult females reach weight of about 2,100 pounds. About 2/3 of a walrus can be used for food. Walrus harvest and utilization: Total kill 3,213 - 3,322; retrieved kill 1,712 - 1,767. Utilization highest at Wainwright, with large human and dog populations. Positions and dates of walrus concentrations are noted. Seal biology and harvest: From just south of Nunivak Island to Barrow, 512 hunters harvested and bountied over 21,000 seals, more than half ringed seals, the rest bearded and harbor seals.

1967a. The Pacific bearded seal. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 8, 66 p.

A thorough, general article. Reviews knowledge of biology, and current status. Incorporates original data compiled from 1962-1966 on 671 seals harvested by Alaskan natives; data relate to growth, reproduction and feeding. Age determination is done using claws; teeth cannot be used because diet of hard-shelled animals results in extreme tooth wear. In northern Bering and Chukchi Seas, the southern boundary of range roughly coincides with southern edge of sea ice throughout the year. However, young animals are often found in ice-free waters (e.g., in Kotzebue Sound). Further details of timing of migration are given. Management considerations, population dynamics and behavior (including sound production) are discussed.

1967b. Marine mammal report. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 8, 44 p.

Reports on research conducted in 1966. Walrus biology and population: Analysis of age composition of 353 male walrus taken at Savoonga indicated annual mortality rate of about 12% (maximum) for year classes 14 though 28, and about 14% (maximum) for year classes 14 through 33. Population apparently continuing to increase. Walrus observations reported from Nushagak Bay (May), Round Island in Bristol Bay (May-June), Big Diomede Island and the Punuk Islands (early December). Walrus harvest and utilization: Total kill about 5,600 animals; retrieved kill reported at 2,788 animals, one of the largest harvests by resident Alaskan hunters. Of these, 80% were taken by villages of Gambell, Savoonga, Diomede and King Island. It is noted that some male walrus winter, singly or in small herds, much further north than the main groups (occasionally as far north as 70°N Lat. in late February). Concentrations of animals were moving through Bering Strait May 28 to July 4. Main villages involved in the winter harvest (Jan. to mid-Apr.) are given, with their and dates of hunting. Summer harvest was successful only at Wainwright. Because harvest was high, and villagers do not stop hunting when needs of village are met but continue as long as animals are available, utilization of animals was relatively low. Dollar value of harvest and changes in populations of villages which traditionally take walrus, are discussed. Seal biology and harvest: The natural history and ecology of ringed, ribbon, bearded, and harbor seals and walrus in the northern Bering Sea are discussed. Their distribution in April-early May (pupping season) is mapped, and discussed as it corresponds to their different adaptations.

1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3):445-454.

Author's abstract: "Five species of pagophilic (ice-loving) pinnipeds live in the Bering and Chukchi seas: *Odobenus rosmarus*, *Phoca* (*Pusa*) *hispida*, *Phoca* (*Histriophoca*) *fasciata*, an ice-breeding population of *Phoca* (*Phoca*) *vitulina*, and *Erignathus barbatus*. Breeding adults of these species are mostly separated from each other during late winter and early spring, when throughout the pupping and subsequent mating periods, *P. vitulina* and *P. fasciata* occupy the edge-zone of the seasonal pack ice, *E. barbatus* and *O. rosmarus* are mainly farther north within the heavier pack ice, and *P. hispida* occupies areas of extensive land-fast ice. This paper discusses differences in body structure, ecological adaptation, and behavior in relation to distribution of the five species." Distribution map.

1973. Marine mammal report. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 13, 29 p.

Three research projects conducted in 1971 and 1972 were: "Spotted seal life history", "Analysis of biological aspects of the marine environment", and "Data analysis and reporting of investigations conducted to date". Cruises were conducted in the Bering Sea in March-April of both years, and in the Juneau area (where 21 harbor seals were collected), in November 1972. Table shows location, weight, length, sex, etc. of 76 harbor seals and 3 ribbon seals tagged. Fish and invertebrates were collected preparatory to studying pinniped feeding. Involvement with a satellite observation project was begun as a new way to monitor sea ice movement. Also included are status of stocks reports for the Marine Mammal Protection Act of 1972, for Phoca vitulina largha, Phoca fasciata, Erignathus barbatus and Phoca hispida. These include information on biological and commercial status, including seasonal distribution. Hair seal harvests in northern Alaska are tabulated for 1965, 1971 and 1972. 1 fig., 4 tab.

1977. Marine mammal management in northern Alaska: contemporary conflicts. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 24. (Avail. from author, Alaska Dep. Fish Game, 1300 College Rd., Fairbanks, AK 99701.)

Political, sociological, economic and biological factors affect (native) harvests of polar bears, bowhead whales, walruses, seals and belukha whales.

1978. Ice seals. P. 192-205 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

Concerns ringed. larga, bearded and ribbon seals. [See Haley, 1978a.]

Burns, John J., and Loren W. Croxton.

1963. Marine mammal investigations. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 3, 38 p.

Walrus biology and population status (1 April-30 June 1962): Northward migration passed Gambell May 8-24, Savoonga May 3-23, Bering Strait June 1-7. Collected for later examination were: 694 pairs of lower canine teeth, 163 female reproductive tracts, and 200 sets of eyes. Walrus harvest and utilization (1 May 1961 - 30 June 1962): 1961--total kill 2402-2972, harvest 1201-1486; 1962--total kill 2829-3064, harvest 1263-1353. Utilization varied widely village to village. Recommendations: decrease traffic in raw ivory, study dependency and interaction between Alaskan island villages and walrus, and changes in these relationships. Sea otter investigations: Between 16 Jan. and 25 Feb. 1962, 150 sea otters were shot at Amchitka Island. More research is suggested, in order to determine the optimum harvest season and harvest size for sea otters.

Burns, John J., and Thomas J. Eley.
1977. The natural history and ecology of the bearded seal (Erignathus barbatus) and the ringed seal (Phoca (pusa) hispida). In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 226-302. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Bulk of this report concerns ringed seals. Existing information is summarized. Specimens obtained: 307 ringed, 133 bearded seals. Aerial surveys were flown over southeastern Bering Sea ice front, 27 March - 23 April (sightings of bearded and ringed seals shown on computer maps), and over landfast ice of the northeastern Chukchi and Beaufort Seas east to Barter Island, in June. Ringed seal discussion includes distribution and taxonomy, pelage, dentition, growth rates and productivity, polar bear predation on seals (25 cases tabulated), sex and age composition, literature review, and density of ringed seals (highest densities found between Cape Lisburne and Pt. Barrow). Some results of heartworm study are presented. Harvests of ice-associated marine mammals are totalled (ringed, bearded, spotted, and ribbon seals, beluga and bowhead whales, & polar bear). Results of stomach content analyses are reported elsewhere (See Lowry, Frost & Burns, 1977). Translation of Gol'tsev (1976) is appended to this report. 9 tab., 9 fig., 105 ref., + app.

Burns, J.J., and F.H. Fay.
1973. Comparative biology of Bering Sea harbor seal populations. Science in Alaska, Proc. 23rd Alaska Sci. Conf., Fairbanks, August 15-17, 1972, p. 48. [Abstr. only.]

Two populations of Phoca vitulina are described. P. v. largha inhabits the seasonally ice-covered areas of the Bering Sea (Bristol Bay), whereas P. v. richardii is found in southern ice-free water (Bristol Bay to Commander Islands). Largha seals migrate north and toward the coasts in the summer, from St. Lawrence Is. to Barter Is. Pair bonds form in March and last through the breeding season. Pupping occurs in late March to mid-April on the ice. The pup is suckled for 4 weeks. Maximum longevity is 35 years. Richardii seals are sedentary. Pupping occurs in late May to June on rocky islets or sandbars. The white coat is shed in utero. Maximum longevity is 30 years.

Burns, John J. and Samuel J. Harbo, Jr.
1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4):279-290.

Flights were made to survey the landfast ice from Point Lay to Barter Island, from 8-15 June 1970, to establish baseline distribution and density of ringed seals. The density of seals in sectors east of Point Barrow was low and relatively uniform (2.28, 1.06, 1.38, and 2.43 seals/mi^2). Within sectors southwest of this point, density was substantially higher (5.36 and 3.70 seals/mi^2). Minimum population was estimated at 11,612 animals. Areas of previous seismic oil exploration within the survey area were compared to undisturbed portions and no appreciable difference in ringed seal occurrence was found. 4 fig., 3 tab.

1977. Surveys of spotted seals, Phoca vitulina largha, in the ice front of the Bering Sea. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 6. (Avail. from senior author, Alaska Dep. Fish Game, 1300 College Rd., Fairbanks, AK 99701.)

Survey flights were made during March and April 1976 and 1977. Large concentrations of sub-adult seals (1 to 5 years of age) occurred in western Bristol Bay in both years. Elsewhere density was lower and animals were mainly adults with pups. Overall, density ranged from 0 to 6.75 animals per nautical mile square.

Burns, John J., and James E. Morrow.
1973. The Alaskan arctic marine mammals and fisheries. Paper presented 5th Int. Congr. Found. Francaise d'Etudes Nordiques, called "Arctic Oil and Gas: Problems and Possibilities", May 2-5, 1973, Le Havre, France, 22 p. (Avail. from first author, Alaska Dep. Fish Game, 1300 College Rd., Fairbanks, AK 99701.)

Authors discuss fishes and marine mammals of the Chukchi Sea and the arctic coast of Alaska with respect to offshore oil development. Much of this discussion is pertinent also to the northern Bering Sea. Seismic exploration by several different concerns often involves a succession of explosions in the same areas, which destroy fish. Oil spilled in arctic waters will persist, due to the low temperature and slower decomposition, for 10 years or more. Marine mammals in the area are: polar bear, ringed seal, largha [sic] seal, walrus, bearded seal, beluga, bowhead, and gray whales, & harbor porpoise. Regular visitors are humpback, finback, sei, little piked and killer whales. Occasional visitors are listed as northern fur seal, Steller sea lion, ribbon seal, narwhal and blue whale. The harbor seal, harbor porpoise and beluga whale might suffer significantly from direct effects of oil development. Indirect effects are next discussed. Food webs in the arctic tend to be short, interdependence is high, and thus arctic ecosystems are very sensitive to disruption. Epontic algae grow on the under surface of the ice. Accidental or chronic gradual discharge of oil would spread under the ice, be trapped there for long periods of time, and either kill the algae there or be incorporated into the food chain from there on up. The same results can occur among benthic organisms when oil is deposited on the bottom. Destruction or pollution here will affect all higher consumers in the ecosystem.

Burns, John J., G. Carleton Ray, Francis H. Fay, and Peter C. Strickland.
1972. Adoption of a strange pup by the ice-inhabiting harbor seal, Phoca vitulina largha. J. Mammal. 53(3):594-598.

On 20 April 1971 at Lat. 57°51'N, Long. 165°54'W, the authors replaced the 4-week-old pup of a pair of seals with a previously captured 2-week-old pup. They subsequently observed the new pup nursing from the female. During their cruise from 11-20 April they sighted 103 pairs of adult harbor seals in the 20-mile wide ice front zone to the north and east of the Pribilof Islands. 2 photos.

Burns, John J., Lewis H. Shapiro and Francis H. Fay.
1977. The relationships of marine mammal distributions, densities and activities to sea ice conditions. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 503-554. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Using satellites, vessel surveys, and small aircraft surveys (mostly in March and April), information was gathered on (A) occurrence, duration, and interrelationships of ice conditions in 20 areas of the winter pack, (B) location and structure of the spring ice front (Ice front zone harbors main breeding populations of spotted and ribbon seals in winter-spring months during birth and nurture of young.), (C) development and duration of spring ice remnants (utilized by ribbon, bearded, and larga seals to rest and molt in May and June), and (D) seasonal distribution of marine mammals in relation to ice (walrus distribution data are mapped; ice conditions appear to be principal constraint on walrus distribution in winter). Annual ice cover in Bering and Chukchi Seas classified into seven types. Satellite imagery confirmed existence of broad flaw zone along northwestern coast of Alaska in winter; large polynyi south of Pt. Hope, western Seward Peninsula, eastern Chukotka, and St. Lawrence Island which tend to close with southerly storm winds; and highly variable ice conditions in Bering, Anadyr and Yukon Straits. 13 fig., 27 ref.

Caldwell, D.K., M.C. Caldwell, and D.W. Rice.
1966. Behavior of the sperm whale, *Physeter catodon* L. P. 677-717 in K.S. Norris (ed.), Whales, dolphins, and porpoises, Univ. California Press, Berkeley.

A review paper primarily discussing behavior, although information on habitat, diving, food, and senses is also given. Sperm whales appear to be most common in areas of divergence and cold, productive waters. Although males are cosmopolitan, females may be bounded by the 17° isotherm (40°N to 40°S). Migration occurs annually to higher latitudes in summer, and to the equator in winter months. Sperm whales are polygamous, and males are considerably larger than females. The diet is composed mainly of squid with demersal fishes and sharks occasionally taken. 1 fig., 174 ref.

Calkins, Donald, and Peter C. Lent.
1975. Territoriality and mating behavior in Prince William Sound sea otters. J. Mammal. 56(2):528-529.

Observations were made in small lagoon on south side of Stockdale Harbor, Montague Island, during July and August 1971. One pair of otters with pup, plus one other male, inhabited the lagoon. Aggression between males and patrolling of well-defined boundary zone is described. Attempted copulation was hindered by pup, which was nearly as large as its mother.

Calkins, Donald G., and Kenneth W. Pitcher.
1977a. Population assessment, ecology, and trophic relationships of Steller sea lions in the Gulf of Alaska. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 433-502. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Nearly half of Gulf of Alaska pups are produced at Sugarloaf and Marmot Islands (northern Kodiak Island area). A large proportion of these seals disperses in late fall to the east and possibly to the south. Reproduction and growth are discussed. A total of 7046 pups were branded. In June 1976, 37,973 sea lions were counted at 11 rookeries, and the total annual pup production is estimated at 17,950. Sixty hauling grounds have been located and are described individually. Examination of stomachs and large intestines from 83 sea lions showed primary food item to be pollack. 10 tab., 10 fig., 32 ref.

1977b. Unusual sightings of marine mammals in the Gulf of Alaska. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 53. (Avail. from first author, Mar. Mammal Biol., Alaska Dep. Fish Game, 333 Raspberry Rd., Anchorage, AK 99502.)

Twenty-one belukha whales were seen in Yakutat Bay, 400mi outside known normal range. California sea lion (1 sighting, apparently the first documented sighting in Alaska), and northern elephant seal (3 sightings) were also seen outside normal ranges.

Calkins, Donald G., Kenneth Pitcher, and Karl Schneider.
1975. Distribution and abundance of marine mammals in the Gulf of Alaska. Unpubl. manuscr., 39 p.+ 31 charts. Alaska Dep. Fish Game, Div. Game, 333 Raspberry Rd., Anchorage, AK 99502.

Report prepared under an OCSEAP [Outer Continental Shelf Environmental Assessment Program (Bureau of Land Management)] contract to NOAA [National Oceanic and Atmospheric Administration]. Sea otter, northern sea lion, and harbor seals discussed at length. Other marine mammals mentioned: northern fur seal, black right whale, gray whale, minke whale, sei whale, fin whale, blue whale, humpback whale, north Pacific white-sided dolphin, killer whale, harbor porpoise, Dall porpoise, sperm whale, Bering Sea beaked whale (*Mesoplodon stejnegeri*), goose-beaked whale (*Ziphius cavirostris*), northern right whale dolphin, short-finned pilot whale, belukha, Pacific giant bottlenosed whale (*Berardius bairdi*). Charts show sea lion and sea otter distribution; others show harbor seal density. 4 tab., 31 charts, 26 ref.

Carlson, Richard.
1975. Nose to nose with a sea lion. Alaska 41(10):48.

Author describes encounter with 25-30 peaceful, curious Steller sea lions during scuba diving at 60 feet in Auke Bay near Juneau, Alaska. photos.

Chapman, D.G.

1973. Management of international whaling and North Pacific fur seals: Implications for fisheries management. J. Fish. Res. Board Can. 30(12) part 2:2419-2426.

Since 1911 fur seal management aims have changed from restoring depleted herds, to developing exploitation strategy for abundant herds. Whale stocks have not been managed so effectively by the unwieldy and powerless International Whaling Commission. Many baleen whale stocks have been decimated; sperm whale stocks deserve close attention now that their exploitation is increasing. Fish stocks have a much larger replacement rate and hence can sustain more exploitation, but foresight and lessons from past management programs must be applied.

In press. Marine mammals and ecosystem management. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 18 p.

In addition to establishing a moratorium, the Marine Mammal Protection Act opened new ground in legislative activity, not only introducing the optimum sustainable population concept, but also focusing management on the ecosystem concept. Most of the discussion relates to this Act, and includes fisheries/marine mammals interactions (including tuna/porpoise and salmon/seal situations), subsistence exemptions (involving bowhead whale and other Alaskan marine mammals), and human impact other than exploitation (involving stress, mortality and loss of habitat among monk seals, manatees, sea otters, harbor and gray seals, and gray whales). The difficulty of applying ecosystem management is illustrated with the examples of 1) the Antarctic krill fishery (in competition with whales and seals), 2) a potential Bering Sea clam fishery (competing with walruses), and 3) northern fur seals (which _may_ be suffering from the competition of the Bering Sea groundfish fishery; however, the ecosystem relations of even this most studied marine mammal are not known for certain). 1 tab., 6 ref.

Chapskii, K.K.

1967. Morfologo-taksonomicheskaya kharakteristika pagetodnoi formy largy Beringova morya (Morphological-taxonomical nature of the pagetoda form of the Bering Sea larga). Tr. Polyarn. Nauchno-issled. Proektn. Inst. Morsk. Rybn. Khoz. Okeanogr. (PINRO) 21:147-176. In Russian. (Transl. by Fish. Res. Board Can., 1968, Ottawa, Transl. Ser. 1108, 68 p.)

During April to July 1964, 80 specimens and 60 additional skulls of the larga seal were collected from drifting ice in the Bering Sea. Color patterns, craniological features and dentition are discussed. Author suggests that the sub-species, _Phoca vitulina largha_ should be a species named _Phoca largha_.

Chugunkov, D.I., and V.G. Prokhorov.

1966. Novye svedeniya o zimovke kotikov v Beringovom more (New information on the wintering of fur seals in the Bering Sea). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:233-234. In Russian. (Transl. by Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 137-139 _in_ K.I. Panin (ed.), Soviet research on marine mammals of the far east.)

Fur seals, single animals or groups of up to ten, have been encountered regularly in the course of winter herring trawling in Olyutorsk Bay. Among them, three animals with American tags were caught: two males and one female. Sea lions occur there in greater numbers, and both species follow the vessels, feeding on herring and Alaska pollock from the nets. Figure shows fur seal encounters over years 1959-1964, by month.

Clarke, Robert.
1957. Migration of marine mammals. Norsk Hvalfangst-tid. 46(1):609-630.

A general review of migrations of the large whales and of a small number of small cetaceans, fur seals, phocid seals, and walruses. Notes lack of understanding of mechanisms of migration. 11 fig., 76 ref.

Cowan, I.M.
1939. The sharp-headed finner whale of the eastern Pacific. J. Mammal. 20(2):215-225.

Two specimens (minke whales) are described. Skeletal measurements of animals taken from Atlantic and Pacific are compared.

1944. The Dall porpoise, _Phocoenoides dalli_ (True), of the northern Pacific Ocean. J. Mammal. 25(3):295-306.

Five animals were collected in the summer of 1939 from waters adjacent to Queen Charlotte Sound, B.C. They were examined in detail to ascertain the variation in external and skeletal features. Four of the stomachs were full and contained only herring. Measurements and 5 photos are included.

1945. A beaked whale stranded on the coast of British Columbia. J. Mammal. 26(1):93-94.

Article refers to the stranding of a beaked whale on 25 May 1941, at Estevan Point, Vancouver Island. The cetacean was first incorrectly identified as _Hyperoodon rostratus_. Subsequent identification as a species of _Ziphius_ is corroborated. Author suggests that the misleading bulbous forehead of the Estevan specimen was perhaps due to age.

Cowan, I.M., and G.C. Carl.
1945. The northern elephant seal (_Mirounga angustirostris_) in British Columbia waters and vicinity. Can. Field-Nat. 5(9):170-171.

Reports many sightings of elephant seals by various fishermen and Makah natives of British Columbia. Suggests _M. angustirostris_ is not uncommon in these latitudes.

Cowan, I.M., and C.J. Guiguet.
1952. Three cetacean records from British Columbia. Murrelet 33(1):10-11.

1)Lagenorhynchus obliquidens (Gill): Skull found in June of 1943, at Estevan Point, Vancouver Island. 2)Stenella euphrosyne (Gray): Skull found in Nootka Sound, Vancouver Island, during the winter of 1948. 3)Ziphius cavirostris (Cuvier): Badly worn skull from Fisherman's Bay, Cape Scott, Vancouver Island, found in 1950; part of a lower jaw found at Estevan Point in 1945.

Cowan, I.M., and J. Hatter.
1940. Two mammals new to the known fauna of British Columbia. Murrelet 21(1):9.

A skull of Ziphius cavirostris was found on the north tip of Vancouver Island in 1937. The other mammal mentioned was a rabbit (Sylvilagus nuttalli nuttalli).

Daetz, G.M.
1959. Alaskan challengers of the sea. Nat. Hist. 68(6):334-347.

Picture article on Steller sea lions based on a summer's experience at Rookery Islet, off Montague Island, Prince William Sound, Alaska. Rookery behavior and parasites are described. 22 photos.

Dawbin, W.H.
1966. The seasonal migratory cycle of humpback whales. P. 145-170 in K.S. Norris (ed.), Whales, dolphins, and porpoises, Univ. Calif. Press, Berkeley, Calif.

A general discussion of factors influencing migratory routes, migration rate and timing. Data drawn almost exclusively from the southern hemisphere. Migration is south in winter, north in summer along coastlines. Travel north is in same direction as cold current.

DeLong, Robert L.
1978. Northern elephant seal. P. 206-211 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Doi, T., T. Nemoto, and S. Ohsumi.
1967. Memorandum on results of Japanese stock assessments of whales in the North Pacific. Rep. Int. Comm. Whaling 17:111-115.

Gives tables on natural mortality, population size and sustainable yield for fin, sei, blue, humpback, Bryde's, and sperm whales. Values given for each of six areas in the North Pacific. Age composition given for sei population.

Doroshenko, N.V.
1971. Kit s priznakami finvala i blyuvala (A whale with the features of fin- and blue whales). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 70:255-257. (Transl. avail. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115, 4 p.)

In August 1965, a female whale, 19.7m long, was taken northeast of Kodiak Island. It appeared to be the offspring of a fin whale and a blue whale. Ovaries showed what appeared to be evidence of ovulation, but none of pregnancy. Table compares characteristics of blue whales, fin whales, and the hybrid whale.

Doroshenko, N.V., A.A. Kuz'min, O.R. Nikol'skii, and N.M. Pashchenko.
1974. O razmnozhenii malogo polosatika (A study of the reproduction of the minke whale). P. 145-152 in S.M. Konovalov (ed.), Issledovanya po biologii ryb i promyslovoj okeanografii, Vypusk 5 (Studies on fish biology and fishery oceanography, Issue 5). Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO), Vladivostok, USSR, 166 p. In Russian. (Engl. abstr. in Aquat. Sci. Fish. Abstr. 5(4):128 (abstr. #5Q3944).)

A brief review of the material on the reproduction biology of minke whales available from literature is followed by an account of findings based on material collected during the Antarctic whaling seasons of 1968-1973. The smallest mature male measured 7.0m and the largest immature male was 8.1m long. Females were found to attain sexual maturity at the length of 8.0-8.1m. The pregnancy lasts 10-11 months; calves measure 300-330cm at birth.

Durham, Floyd E.
1972a. Eskimo effort in bowhead whaling at Pt. Barrow, Alaska. Unpubl. manuscr., 19 p. (Avail. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

Author describes transition from self-sufficiency to dependence on outside industries, from barter system to modern monetary system, from full utilization to commonplace waste in whaling; cost of whaling as it is now done (with store-bought equipment). In conclusions it is noted that though bowhead whaling was for centuries the mainstay of a very successful subsistence economy, it is now an unprofitable "luxury sport". "Nevertheless, the instinct to kill, the intent to survive, and the notoriety of a whale kill remains."

1972b. Greenland or bowhead whale. P. 10-14 in Alice Seed (compiler), Baleen whales in eastern north Pacific and arctic waters, Pacific Search Books, Seattle, Wash.

Adaptations of whales since Miocene times are sketched, focusing on development of three genera of the ice environment: bowhead, belukha, and narwhal. Predation upon bowhead is inconsequential, disease almost nonexistent. Absence of dorsal fin facilitates navigating under ice. A large bowhead would contain some 600 baleen plates up to 13 ft. long, weighing perhaps a ton. On a diet of plankton, bowhead avoids fish, larger crustaceans, and mollusks - the secondary hosts of most internal parasites of marine mammals. Five known drift ice advances from 1600 to 1910 cut whales off from their preferred summer feeding grounds and contributed considerably to the decline of the bowheads of Greenland. The same drift cycle probably occurred off the Alaskan coast and was in its concluding melting phase in mid-19th century at the beginning of commercial whaling there. After 1853-54 (greatest harvest of oil and baleen) ice increased and harvest decreased. Subcycles in these 60-year ice cycles are discernable today (viz 1968).

1972c. History of bowhead whaling. P. 5-9 in A. Seed (compiler), Baleen whales in eastern north Pacific and arctic waters, Pacific Search Books, Seattle, Wash.

Bowhead whaling is traced beginning with coastal Eskimo villages subsistence hunt. Then Eskimos begin to supply their inland neighbors with bowhead products. European bowhead whaling begins, first in Spitsbergen area east of Greenland (1610), then further west towards Greenland coast, then around Greenland into waters off Canada, decimating these stocks. Yankee whalers discover and decimate bowhead stock in Okhotsk Sea in northwest Pacific (1840's). Yankee whalers discover and hunt bowheads north of Bering Strait (1848), later extending this whaling activity into the Beaufort Sea (1889), and devastate this stock. After development of fossil fuels, demand for baleen alone kept bowhead fishery alive until 1904. Invention of plastics saved the whale. After 1910, the arctic was abandoned. Killing bowheads for baleen only was particularly damaging to the stock since large breeding animals with long baleen were selectively hunted. Remainder of whale was wasted.

1973. Ancient and current methods of taking the bowhead whale. Univ. Alaska, Sea Grant Program, Alaska Sea Grant Rep. 73-9, 15 p.

Some methods of primitive whale-hunting societies are described briefly. Early Eskimo bowhead whaling is described, including taboos, charms, ritual, and legend relating to the hunt. Discussion of Yankee whalers as bowhead hunters in late 1800's includes the prior development of their commercial whaling techniques. Effect on Eskimo whaling of Yankee whalers is discussed. International whaling codes (and their failure to recognize that the methods being used in "aboriginal" whaling included those weapons introduced by Yankee whalers) are outlined. From summary and conclusions: "By the beginning of the 20th century . . . the old Eskimo technique had been forgotten and the new Yankee technique had been corrupted. . . . The opportunity is ripe to relearn the old Eskimo hunting skills and to reteach the Yankee technique of killing whales from open boats." 5 photos, 22 ref.

1979. The catch of bowhead whales (Balaena mysticetus) by Eskimos, with emphasis on the western arctic. Contrib. Sci. Nat. Hist. Mus. Los Angeles Cty. 314:1-14.

Author's abstract: "The success of Eskimo spring whaling along the northwestern coast of Alaska depends on the opening of offshore leads in the sea ice, the presence of bowheads, and the number and ability of the hunters to kill, secure, and butcher these animals. Physical factors, such as wind, current, and temperature affect the formation of leads. The number and proximity of leads to shore, the frequency and manner of passing of bowheads, and the topography and duration of the ice platform are variable, but are most dependable at the promontories where the major whaling villages are located.

The time period and the actual number of years for which data are available (in parentheses), the number of whales killed, and the yearly average at the principal villages are: Barrow, 1852-1973 (52 yrs), 371 whales, 7/yr; Pt. Hope, 1879-1973 (60 yrs), 241 whales, 4/yr; and Wainwright, 1922-1973 (32 yrs), 48 whales, 1.5/yr.

The total of the three villages is 660 whales with a combined average of 12.5/yr. Five of the several minor stations active from 1961 to 1973 took 22 whales, average of 2/yr, making a total average of known whales secured in Alaska 14.5/yr through 1973. Recent harvests (1974-1977) have been considerably higher than the stated average." 1 tab., 4 fig., 32 ref.

Eley, Thomas J.

1977. An analysis of polar bear predation on ice-inhabiting pinniped populations of Alaska. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 18. (Avail. author, c/o Fairbanks North Star Borough Animal Shelter, Box 1267, Fairbanks, AK 99707.)

Field studies beginning in March 1976 conducted at Cape Lisburne and Barrow, Alaska, showed that polar bear diet in spring consists of 92% ringed seal and 5% bearded seal. Primarily male ringed seals are taken. Most are taken at breathing holes in the ice. Polar bear movements and population size appear directly dependent on ringed seal population.

Engelhardt, F. Rainer, Joseph R. Geraci, and Thomas G. Smith.

1977. Uptake and clearance of petroleum hydrocarbons in the ringed seal, Phoca hispida. J. Fish. Res. Board Can. 34(8):1143-1147.

Authors' abstract: "Ringed seals showed rapid absorbtion of petroleum hydrocarbons from Norman Wells crude oil into body tissues and fluids when exposed by both immersion and ingestion. Relatively low but significant levels were found in tissue, blood, and plasma. Levels in bile and urine were high, indicating these to be routes of excretion." 1 tab., 2 fig., 26 ref.

Estes, James A.

1977. A discussion of assessment problems: walruses and other ice inhabiting pinnipeds in the Bering/Chukchi region. Preliminary working paper from a meeting of the Project on Marine Mammals within the framework of the US/USSR Agreement on Environmental Protection, 18-25 January 1977, La Jolla, Calif., 14 p. (Avail. from author, Univ. Calif., Cent. Coastal Mar. Stud., Div. Nat. Sci., Applied Sci. Build., Santa Cruz, CA 95064.)

Four methods of assessing populations are discussed: (1) direct sightings -- Aerial surveys by U.S. scientists in fall, 1975 (coordinated with Soviet surveys) indicated that estimates of population abundance by aerial surveys over ice are extremely variable [See Estes and Gilbert, 1978]. Recommendations for future aerial surveys over pack ice include: systematic, rather than random, sampling design; photographs of high enough resolution to determine sex and age of walruses; testing for individual differences among observers' visual estimates; fixed strip width samples. (2) Catch per unit effort -- The Alaska Department of Fish and Game has 15 years of catch records, but conditions have not been constant. Problems are discussed. (3) Mark-recapture -- Some thousands of walruses would have to be marked to obtain a return useful for a population estimate; several years would be needed with an ice-breaking ship and good techniques for handling walrus. (4) Analysis of catch statistics -- Before stable age distribution and rate of growth or decline of a population of walrus can be determined, biological parameters must be known, and stocks must be identified. For the latter, direct sightings seem most reliable at this time; need is for knowledge of activity and behavior. A reliable method of age determination is needed. U.S. and Soviet age determinations (by tooth sections) are now being compared to check that results are consistent. Biological data from native harvests in Alaska have just begun to be collected. Possible means of assessment of biases in catch data are discussed.

Estes, J.A., and J.R. Gilbert.
1978. Evaluation of an aerial survey of Pacific walruses (Odobenus rosmarus divergens). J. Fish. Res. Board Can. 35:1130-1140.

Authors' abstract: "An aerial survey of Pacific walruses (Odobenus rosmarus divergens) was evaluated to determine the reliability of estimates of population abundance. [The surveys were flown over the eastern half of the Chukchi Sea over the period 1-12 September 1975, in conjunction with Soviets' surveys over the western half. See Gol'tsev, 1976.] The probability of detecting groups of walruses on the pack ice remained uniform to at least 0.93 km from the flight line, whereas the probability of detection decreased significantly beyond 0.23 km for walruses in the water. Walruses were more abundant along the ice-edge zone between 162 and 165°W than in other areas of the Chukchi Sea during September 1975. Few walruses were observed in consolidated pack ice north of the ice-edge zone or in ice-free water to the south. More walrus groups and larger mean group size were observed on September 8 than on other dates. We estimated abundance for each day and all days combined using methods based on sample area and numbers of strip samples. Estimates varied among days by over an order of magnitude; this variation is attributed to the combined effect of chance sampling of an aggregated population and variation in the fraction of walruses hauled out. The coefficient of variation of the estimates ranged between 0.25 and 0.99. [From text: "Population estimates ranged from 818 to 1760 in the open-water area, while in the ice-edge zone these estimates ranged from 2475 to 100 568. All estimates of total abundance lacked precision...."] This imprecision was due to the aggregated distribution of walruses and the large variation in group size. Using the survey data as a basis for stratification, we calculated that, due to the high variability within strata, a sample size of 40% of the total area or 56% of the total available strips would be required to obtain 95% confidence limits within 10% of the estimate of total abundance. Variation contributed by observer error in estimating group size also is relatively unimportant to the precision of abundance estimates. Studies of natural history, particularly those oriented toward activity and habitat selection would help investigators estimate bias due to the variable fraction hauled out

and design surveys based on meaningful strata. Estimates of total abundance based on limited survey efforts will provide information of little reliability." 9 tab., 4 fig.,14 ref.

Everitt, Robert D., and Howard W. Braham.
In press. Harbor seal distribution and abundance in the Bering Sea: Alaska Peninsula and Fox Islands. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 21 p.

Between June 1975 and July 1976, six aerial surveys were conducted along the north Bristol Bay coast from Cape Newenham to Kvichak Bay, the north side of the Alaska Peninsula, and the eastern Aleutian Islands as far west as Samalga Island. Harbor seals (Phoca vitulina richardii) were present throughout the survey area; 80% of the total number observed were on eight hauling out areas along the north side of the Alaska Peninsula. The maximum harbor seal count for the north side of the Alaska Peninsula (June 1976) was 25,802. The maximum count for the eastern Aleutian Islands (August 1976) was 4,023. (These counts are conservative.) Seventy percent more seals were observed on a low tide than in the same area surveyed near high tide (tidal range 10 to 12 feet). A minimum abundance estimate for the study area is 28,000 to 30,000. 3 tab., 3 fig., 22 ref.

Everitt, Robert D., and Bruce D. Krogman.
In press. Sexual behavior of bowhead whales observed off the north coast of Alaska. Arctic 32(3), 4 p.

At 1620 hours on 8 May 1976 approximately 32 km east of Point Barrow ($71^{o}24.4'N$, $156^{o}11.0'W$), authors observed a group of six bowhead whales engaged in sexual behavior in an open water "lead" in the pack ice. A series of 15 35mm photographs were taken using a motor drive attachment. A representative photo is included. [One of this series of photos is published in Krogman, 1977.] To facilitate discussion of the sequence of events, the whales are numbered and outlined in a sketch made from the photograph shown. One whale, with his penis protruding, was apparently trying to copulate with another. The latter may or may not have been a female; intromission was not observed. Eight other articles concerning sexual behavior of bowheads, southern right whales, gray whales, and dolphins, are cited.

Fay, Francis H.
1952. The Pacific walrus: a progress report of field investigations conducted during 1952. Arctic Inst. North Am., Montreal/Washington/New York, Proj. ONR-77, 17 p.

During May and June 1952, 191 walruses were examined from St. Lawrence Island. Distribution patterns are sketched out. Ageing techniques based on growth layers of the teeth are described. Life history and harvest are briefly discussed. Food samples collected consisted of 5 species of mollusks, 3 species of crustaceans and an echuiroid. 2 fig.

1953. The Pacific walrus: a progress report of laboratory work on the specimens collected in the 1952 field season. Arctic Inst. North Am., Montreal/Washington/New York, Proj. ONR-77, 4 p.

From 56 tusks collected in 1952 from St. Lawrence Island, age determinations were attempted. It was thought that each ring of the dentin layers represents a breeding season, and the layers between rings correspond to one year's growth. Wear at the tip varies with age and prevents precise age determination. Cheek teeth, baculum and os clitoris were also examined in an attempt to age specimens.

1954. The Pacific walrus: a progress report of field and laboratory work in 1954. Arctic Inst. North Am., Montreal/Washington/New York, Proj. ONR-77, 10 p.

Due to strong easterly winds apparently driving the ice and walrus near the Siberian mainland, walrus hunting was the poorest in 30-40 years. Bearded seal hunting was also poor. Further laboratory investigation during 1954 on the tusks, teeth, claws and body measurements of walruses indicate no method is an exact age determinant for all age classes and both sexes.

1955. The Pacific walrus (Odobenus rosmarus divergens): spatial ecology, life history, and population. Ph.D. Thesis, Univ. British Columbia, Vancouver, B.C, 171 p.

Life history is given, detailing reproduction, the young, growth and mortality. Distribution is defined by accessibility of food, air, haul-outs, as well as ambient air temperature. Walruses must stay south of the unbroken polar ice pack in summer, and south of the northern Bering and Chukchi Seas in winter. Further restrictions are imposed by the need for hauling places. This limits the walruses to coasts or the ice front where floes are common. In addition, the major food (pelycepods) can be found in 0-50 fathoms of water. Ostensibly, the southern limit is influenced by the air temperature, and appears to coincide with the 50°F isotherm. Exception to this is the herd in Bristol Bay where extreme temperatures may reach 80°F. The total world population of Pacific walrus is given as 40,000 animals.

1957. History and present status of the Pacific walrus population. Trans. 22nd North Am. Wildl. Conf.:431-443. Wildl. Manage. Inst., Washington, D.C.

The population from 1650 to 1850 (extrapolated from archeological digs) is estimated at 200,000. By the 1900's the range had been significantly reduced and the population numbered less than 100,000. Between 1900 and 1930, the range was further reduced, and few walruses were observed below 60°N. There was little change in the population from 1930-1950, remaining about 60,000. Reduction in range is attributed to a lack of population pressure. Walrus harvest is reviewed. Suggests actions to assist walrus management.

1958. Pacific walrus investigations on St. Lawrence Island, Alaska. Unpubl. manuscr., 54 p. Alaska Coop. Wildl. Res. Unit, U.S. Pub. Health Serv., Arctic Health Res. Center, Anchorage, AK.

Summarizes author's observations 1952-1958 on walrus hunting at Gambell. Average annual harvest was about 170. Outlines history of Gambell walrus hunt. Describes procedures and degree of success of hunting, uses of walrus products, percent utilization, and possible alternatives to walrus products for native use. People of Gambell are discussed with regard to future management strategy. Management should decrease number of animals unretrieved during hunting and increase utilization. It is noted that northern sea lions and harbor seals are found on south and east coasts of island in late summer and fall. 7 tab.

1960. Carnivorous walrus and some arctic zoonoses. Arctic 13(2):111-122.

Zoonoses are diseases of lower animals that can be transmitted to man. Information on carnivorous walrus is reviewed. Eskimos report that eating carnivorous walrus liver produces the same illness as does eating polar bear liver. Both species eat largely ringed and bearded seals. This illness is probably hypervitaminosis-A. Trichinosis has been identified with some walrus meat, but the incidence of infected walruses seems very low.

1963. Unusual behavior of gray whales in summer. Psychol. Forsch. 27:175-176.

On 26 July 1960, near Kangee on the southern coast of St. Lawrence Island, the author observed three whales involved in what appeared to be courtship behavior, and possibly copulation.

1974. The role of ice in the ecology of marine mammals of the Bering Sea. P. 383-399 in D.W. Hood and E.J. Kelley (eds.), Oceanography of the Bering Sea, Inst. Mar. Sci., Univ. Alaska, Fairbanks.

Describes different kinds of ice; describes seasonal changes of ice and corresponding movements of marine mammals. Lists 25 species of marine mammals in 3 categories according to contact with ice. Offers good detail, understanding of habitats, and insights into evolution.

1975a. Mammals and birds. P. 133-138 in D.W. Hood and Y. Takenouti (eds.), Bering Sea Oceanography: an update. Rep. No. 75-2, Inst. Mar. Sci., Univ. Alaska, Fairbanks, Alaska.

Contains: (1) Estimates of biomass of marine mammals in Bering Sea, and biomass consumed and produced by them; (2) descriptions, in varying detail, of about 15 recent and/or current marine mammal research projects, with their sources of funds, involving eight federal agencies, Alaska Department of Fish and Game, and four universities; (3) brief account of birds: estimated numbers and biomass, paucity of knowledge, recent study by U.S. Fish and Wildlife Service. Items discussed include: (a) new knowledge of walrus biology, (b) new and sophisticated research tools tried, (c) investigation of ecological role of benthic feeding ("tilling the benthic soil") by walrus and gray whale, and (d) possibility that commercial fishing has depleted fur seals' food supply to the extent that their productivity is reduced.

1975b. Morbidity and mortality of marine mammals. In Environmental assessment of the Alaskan continental shelf, Principal investigators' reports, July - September 1976, Vol. 1, p. 35-42. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Labs., Boulder, Colo.

Several areas of Alaska coastline were surveyed for marine mammal carcasses: the north coast of the Alaska Peninsula from Bechevin Bay to the mouth of the Naknek River; the eastern shore of Kuskokwim Bay from Chagvan Bay to Jacksmith Bay; the coast of St. Lawrence Island; the Punuk Islands; and Kotzebue Sound from Sheshalik to Point Hope. Nearly four hundred carcasses were found. Well over half of these were walrus, with thirteen species in all. Causes of death included gunshot, trauma, predation, hemorrhage, and probable bacterial infection. 3 maps.

1977. Morbidity and mortality of marine mammals - Bering Sea. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 161-188. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

(Author was assisted by Robert A. Dieterich and Larry Shults.) From 107 carcasses found along the coast in the Bristol Bay and Bering Strait regions in 1976, plus 236 others examined during research cruises in southeast Bering Sea, and plus 361 others examined during earlier investigations, it is estimated that about 6% of Bering Sea marine mammals have some grossly evident pathological condition -- mostly abcessed wounds (majority of those necropsied had died of gunshot wounds), mycotic skin infections, tumors, and liver disease. Dead and dying marine mammals are deposited at the rate of about .05/km/yr on shore of the eastern Bering Sea, except in areas close to major hunting areas and major hauling out sites, where rate is 10 times greater. Species found were walrus, harbor and ringed seals, sea otter, beluga, minke, and gray whales, and harbor porpoise. 5 tab., 30 ref.

1978. Belukha whale. P. 132-137 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

In press. Industrial utilization of marine mammals. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 12 p.

During the recent era of protection and management of Alaskan marine mammals, which followed an era of severe over-exploitation, most stocks have come back strongly, some to the point where their renewed impact on commercial fisheries is causing some dissatisfaction. Former (and potentially future) uses by industry of Alaskan marine mammals are considered. Multiple use management - including subsistence, industrial, and non-consumptive uses - seems a feasible and desirable goal for the future.

Fay, Francis H., Howard M. Feder, and Samuel W. Stoker.
1977. An estimation of the impact of the Pacific walrus population on its food resources in the Bering Sea. Final rep. to U.S. Mar. Mammal Comm., for contracts MM4AC-006, MM5AC-024, 38 p. (Avail. Natl. Tech. Inf. Serv., Springfield, Va., as PB 273-505.)

Assessments of population of benthic invertebrates over 5 years at 176 oceanographic stations in eastern Bering and Chukchi Seas and examination of stomachs from 107 walruses taken by Eskimos in the region from St. Lawrence Island to Bering Strait indicate that walrus population is at or near carrying capacity of its environment (walruses removing about 11 x 10^6 tons of benthos per year from the Bering and Chukchi shelf) and that any perturbation of benthos will have a significant adverse effect on walrus population. 9 tab., 5 fig., 17 ref.

Fay, Francis H., and G. Carleton Ray.
In press. Reproductive behavior of the Pacific walrus in relation to population structure. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978. [Abstr. only.]

From authors' abstract: "Histological evidence now indicates that the mating season is from January to April. Hence, we have studied walrus behavior at that time and concurrently sampled the composition of the population. Our findings suggest that the population as a whole comprises about 35 percent immatures, 15 percent adult males, and 50 percent abult females; that is, the sex ratio of animals of breeding age appears to be at most 1:3. During the mating season, nearly all of the adult females and the largest males (bulls) congregate in two areas: north-central and southeastern Bering Sea. ...[Behavior during mating season is described, and characterized as resembling a lek or arena system, but with the arena being mobile.]... In any case, polygyny is strongly indicated and, as in other polygynous pinnipeds, is correlated with an unequal sex ratio of adults and with sexual dimorphism. These findings are of considerable significance to management of the walrus resource since they suggest that the productivity of the population is much higher than was predicted previously. Because the sex ratio at birth is 1:1, they suggest also that there is a substantial "surplus" of immature males that could be harvested without affecting the structure or productivity of the adult population. Present information on these two points is not conclusive; much additional information needs to be gathered. ... A full report is in preparation for the first volume of joint marine mammal studies under the US-USSR Marine Mammal Project, to be published in 1979."

Fay, Francis H., Larry M. Shults, and Robert A. Dieterich.
In press. Natural mortality of marine mammals in Alaskan waters. Science in Alaska, Proc. 29th Alaskan Sci. Conf., Fairbanks, Alaska, August 15-17, 1978. [Abstr. only.]

From authors' abstract: "We began an investigation of the causes and rates of occurrence of natural morbidity and mortality in Alaskan marine mammal populations in 1975, with initial emphasis on the Bering Sea and, later, on the Gulf of Alaska-Cook Inlet region. Data were obtained from carcasses cast ashore by the sea and from necropsy of samples drawn from the living populations [about 500 specimens of pinnipeds so far]. ... About 10 percent of the carcasses were cetaceans, mainly gray whales (Eshrichtius robustus), and the most frequently identifiable cause of death in these was predation by killer whales (Orcinus orca). Most of the remainder were pinnipeds, especially walruses (Odobenus rosmarus) with a few sea otters (Enhydra lutris). The majority of the pinnipeds had died from gunshot wounds, but a significant proportion appeared to have died from natural causes, the most frequent of which were malnutrition (mainly in pups of the year), predation, parasitism, and infectious diseases. ... In general, the rate of occurrence of beached carcasses was about 1/2.5 to 3 km in areas downstream from major subsistence hunting sites and about 1/25 to 30 km in other areas. ... Preliminarily, the mortality rate of walruses from natural causes appears to be about 2 percent per year."

Fedoseev, G.A.

1962. O sostoyanii zaposov i raspredelenii Tikhookeanskogo morzha (The status of reserves and distribution of Pacific walruses). Zool. Zh. 16(7):1083-1089. In Russian. (Transl. by U.S. Nav. Oceanogr. Off., Washington, D.C., 1969, Trans. 432, 11 p.)

During aerial surveys in late September to late October 1960, walruses were counted. The total number of walruses is estimated at about 50,000. Most spend summer and autumn in the Wrangel and Herald Island areas. Apparently only males inhabit shores of Chukchi Peninsula and Alaska at this time of year.

1966. Aerovizual′nye nablyudeniya za morskimi mlekopitayushchimi v Beringovom i Chukotskom moryakh (Aerial observations on marine mammals in the Bering and Chuckchee Seas). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:173-177. In Russian. (Transl. by Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 98-102 in K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Reports on flights totalling 114 hours, flown from 28 September to 17 December 1960, for the primary purpose of counting walrus. Author surveyed coastal waters around the Chukchi Peninsula from the mouth of the Kolyma River (in the E. Siberian Sea) to Kresta Bay in the Gulf of Anadyr, plus the waters surrounding Wrangel and Herald Islands. The totals of animals counted were: 41,000 walrus (with an estimated population of 46,000 for the area surveyed); 498 baleen whales; 516 belugas, and 207 seals. Seven bowhead whales were identified in and near Longa Strait. Concentrations of gray whales were seen along the coast from Bering Strait north to Serdtse-Kamen′ Cape. Water around gray whales was often brown-rust color and gulls were present. Humpbacks and fin whales were identified in Kresta Bay and Gulf of Anadyr. Belugas were seen north of Lat. 69°N, and a group of 500 passed north of Wrangel Island. Bearded and ringed seals were identified up to 35 miles north of Wrangel Island as well as coastally. Three polar bears were seen on Wrangel Island. Concentrations of birds are noted.

1973. Morfo-ecologicheskaya kharakteristika populyatsiy krylatki i obosnovanie ee zapasov (Morphological-ecological characteristics of ribbon seal populations and factors affecting the conservation of usable stocks). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 86:158-177. In Russian. (Transl. by Dep. Environ. [Can.], Fish. Mar. Serv., Ste. Anne de Bellevue, Quebec, 1973, Transl. Ser. 3365, 50 p.)

Data collected from sealing vessels in 1970-1971 in the Okhotsk Sea are added to previously gathered data from the Bering Sea. Comparison of the 2 seal populations is made. Information on length, weight, craniological features, growth rates, maturity and reproductive activity is given. Population in the Bering Sea is quoted as 80,000-90,000 in 1964, and 60,000 in 1969. The need to cease hunting of ribbon seal is emphasized.

1975. Ecotypes of the ringed seal (Pusa hispida Schreber, 1977) and their reproductive capabilities. In K. Ronald and A.W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:156-160.

From 1960 to 1970 author studied ringed seals from 3 areas: Okhotsk Sea, southwestern Chuckchee [sic] Sea, and Bering Strait. Author states (p. 156): "There is strong evidence that 2 ecotypes exist: the ringed seals of the drift-ice (seals from the Okhotsk Sea and the South Chuckchee Sea) and the ringed seals of the fast ice of bays and gulf (Bering Sea seals)." In his conclusions, he states: "Ringed seals inhabiting the drift ice have smaller body and skull dimensions, a relatively higher rate of growth and accordingly an earlier sexual maturity than ringed seals of the fast ice. Reproductive capability of the populations was estimated at 21%, and from calculations of the natural mortality of the different age groups, the increase of the populations did not exceed 4-5% at the best." 2 tab., 1 fig., 16 ref.

1976. Summary of the results and main aspects of investigations of seals of Phocidae family and walrus of the northern Pacific Ocean. Paper presented at Meeting of the Project on Marine Mammals within the framework of the US-USSR Agreement on Environmental Protection, January 1976, Moscow, 12 p. (Avail. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle WA 98115.)

A summary of investigations carried on between 1930 and 1975. Discusses breeding, reproduction and age structure of populations. Suggests possible topics of collaboration for American and Soviet scientists.

Fedoseev, G.A., and Y.I. Nazarenko.

1970. K vaprosy o vnutividovoi strukture kolchatoi nerpy arktiki (On intraspecific structure of ringed seals in the Arctic). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 71:301-307. In Russian. (Transl. by Fish. Res. Board Can., Mar. Ecol. Lab., Dartmouth, N.S., 1972, Transl. Ser. 2411, 11 p.)

Age analysis, growth patterns and morphological features were compared between ringed seals (Pusa hispida hispida) of the Bering and Barents Seas. It appears that there is only one subspecies, but the 2 populations represent local ecological races.

Fedoseev, G.A., and G.G. Shmakova.
1976. Some results of investigations of spatial structure of ribbon and larga seals of the Bering Sea. Paper presented at Meeting of the Project on Marine Mammals within the framework of the the US-USSR Agreement on Environmental Protection, January 1976, Moscow, 9 p. (Avail. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

The skulls of 196 ribbon seals and 123 larga seals were analyzed. Apparently the larga seals form 3 local populations: Karaginsky, Anadyr and the eastern Bering. The ribbon seal forms 2 reproductive groups in the eastern and western Bering Sea, which are weakly differentiated morphologically.

Fiscus, Clifford H.
1972a. Fur seal, Callorhinus ursinus, and northern (Steller) sea lion, Eumetopias jubatus, observations south of the western Aleutian Islands. P. 109-123 in Marine Mammal Biological Laboratory, Fur seal investigations, 1971, unpubl. manuscr. [132 p.], Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Reports by pelagic sealers of the 1890's indicated possible abundance of northern fur seals south of the western Aleutian Islands. Recent surveys of this area being lacking, author joined the R/V George B. Kelez (on salmon research cruise) as observer, from 16 May to 9 June 1970. His tabulated observations total 40 fur seal observations, 87 sea lion observations. Survey area: Long. 74°W-74°E, Lat. 48°N-52°N. Seals have been sighted in this area from May through October, being probably more numerous in spring and early summer than other seasons. Sea lions are more abundant here than seals. Sea lion censuses of the western Aleutians are reviewed. Seal observations during the passage from Amutka Pass to Cape Flattery, Washington (11-18 June) are included (total of 57 fur seal observations). Behavior of Dall porpoise, sea lion, fur seals, and marine birds vis à vis salmon-nets and salmon is discussed. Among these animals, sea lion is probably principal predator of salmon in this area. Stomach contents of fur seals collected during such cruises 1963-1970 are tabulated (11 animals). 2 tab., 2 fig., 7 ref.

1972b. Northern fur seal - Steller's sea bear. P. 5-11 in A. Seed (ed.), Seals, sea lions and walruses in eastern North Pacific and arctic waters, Pacific Search Books, Seattle, Wash.

A thorough, general discussion of the fur seal, briefly describing its distribution in the North Pacific, physical characteristics, life span, population, reproductive biology, schedule of coming and going from the Pribilof Islands, migration, wintering range of different age and sex classes, feeding habits, history of exploitation and current management of the Pribilof Islands herd. 2 photos.

1978. Northern fur seal. P. 152-159 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Fiscus, C.H., and G.A. Baines.
1966. Food and feeding behavior of Steller and California sea lions. J. Mammal. 47:195-200.

The stomachs of 34 Steller sea lions and 7 California sea lions were collected during 1958-1963. Food species found in Steller sea lions suggest nearshore, shallow water feeding, whereas food species taken by California sea lions are found in both shallow and deep waters. Feeding occurs in either small or large groups. Size of the aggregate is apparently dependent upon the presence of schooling fish or squid. In either size group, feeding takes place within 15 miles of the rookery. Steller sea lions were sighted in the northern Gulf of Alaska in April and May, 1958 and 1960. They were also seen in the Bering Sea between the Pribilof Islands and the Aleutian Islands during July and August 1963.

Fiscus, Clifford H., Gary A. Baines, and Hiroshi Kajimura.
1965. Pelagic fur seal investigations, Alaska, 1963. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 489, 33 p.

From July to September fur seals were collected in the Bering Sea, largely north of Unalaska Island. Most animals appeared to travel 60 to 90 miles from the Pribilof Islands to feed. Age and sex of seals collected were determined. Postpartum females predominated in the collection. Food and feeding habits were investigated. Squids were the major food, followed by several fish species including 3 commercial species -- salmon, pollock and herring.

Fiscus, Clifford H., Gary A. Baines, and Ford Wilke
1964. Pelagic fur seal investigations, Alaska waters, 1962. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 475, 59 p.

Fifth year of pelagic research as required by the Interim Convention on Conservation of North Pacific fur seals was conducted in Unimak Pass and adjacent Bering Sea. Includes data on food, distribution, and abundance as well as reproductive biology.

Fiscus, C.H., H.W. Braham, R.W. Mercer, R.D. Everitt, B.D. Krogman, P.D. McGuire, C.E. Peterson, R.M. Sonntag, and D.E. Withrow.
1976. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest & Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 238 p.

A comprehensive report of marine mammal sightings in the northeast Gulf of Alaska and the Kodiak shelf area from July 1975 to October 1976. Sightings are recorded and mapped by month for each of 19 species. Population estimates offered. 5 tab., 7 fig., 142 ref., + app.'s with 17 tab., 119 fig., 57 ref.

Fiscus, Clifford H., and Hiroshi Kajimura.
1965. Pelagic fur seal investigations, 1964. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 522, 47 p.

Pelagic research was conducted off California, Oregon, and Washington in April, and in the Bering Sea from 4 July to 8 September. Number of seals encountered, age and sex composition of catch, distribution in Bering Sea, tagged seals caught, and barnacle and algae infestation, were compared with previous studies in the same areas. Stomach contents were examined.

1967. Pelagic fur seal investigations, 1965. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 537, 42 p.

Pelagic research was conducted off Washington and California (April to June). Locations of seal concentrations are given. Seals were most abundant from 30 to 40 miles offshore. Of 387 females taken, 44% were pregnant. Moroteuthis robusta (a squid) is reported for the first time as fur seal food.

Fiscus, Clifford H., and Willman M. Marquette.
1975. National Marine Fisheries Service field studies relating to the bowhead whale harvest in Alaska, 1974. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest Fish. Cent., Seattle, Wash., Processed Rep., 23 p.

Eight Alaskan communities engaged in bowhead whaling in 1974: Kaktovik (Barter Island), Nuiqsut, Barrow, Wainwright, Point Hope, Kivalina, Gambell and Savoonga. Twenty whales were taken, 3 were killed but lost, and 28 were wounded but lost. In the spring, 3 or 4 "waves" of bowheads usually pass Pt. Hope and Barrow, from early April to June. Observations of ringed seal, walrus, belukha whale, and birds, are included. 7 tab., 7 photos, 1 map.

Fiscus, Clifford H., Karl Niggol, and Ford Wilke.
1961. Pelagic fur seal investigations - California to British Columbia, 1961. U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Biol. Lab., Seattle, Wash., Processed Rep., 87 p.

The fourth successive year of pelagic research, under the Interim Convention on conservation of North Pacific Fur Seals, was conducted from November 1960 through April 1961. Of 1,352 seals collected, 77 were male, and 29 bore tags. British Columbia waters yielded more yearlings than other areas. Well-developed corpora lutea in ovaries without implantation scars in uterine horns suggest that about 14% of mature females miss pregnancy through failure of egg implantation. Ages were determined. One seal carried twins. Stomach contents are reported. One killer whale was collected.

Fiscus, C.H., D.W. Rice, and A.M. Johnson.
1969. New records of Mesoplodon stejnegeri and Ziphius cavirostris from Alaska. J. Mammal. 50(1):127.

Skull was collected from a floating carcass of Mesoplodon steinegeri (True) sighted west of Cape Edgecombe, Alaska ($57^{o}04'$N, $146^{o}32'$W), on 20 May 1968. This is within the known range of the cetacean. On 7 June 1968, a skull of Ziphius cavirostris (Cuvier) was found in Trident Bay, Akun Island, in the eastern Aleutians ($54^{o}09'$N, $165^{o}33'$W). There are 4 other reports of the species from the Aleutians.

Fiscus, Clifford H., and Victor B. Scheffer.
1962. Variety of food remains in stomachs of Steller sea lions. Unpubl. manuscr., 13 p. U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Biol. Lab., Seattle, Wash.

Paper summarizes findings of 11 investigators. A total of 131 sea lion stomachs were examined between 1901 and 1961, from Ano Nuevo Island, central California, northward to the northwest tip of Vancouver Island, B.C.; from Alaska; and from the Commander Islands (western Bering Sea). Approximately 40 kinds of food organisms are tabulated. Stated purpose of the paper is to show the wide variety of invertebrates and fishes eaten by sea lions.

Foote, Don Charles.
1965. Exploration and resource utilization in northwestern arctic Alaska before 1855. Ph.D. Thesis, McGill University, Montreal, Quebec, Can., 400 p.

From author's abstract: "...carefully outlines the visits of Europeans and Americans to the region before 1855. ...Knowledge of the Eskimo seasonal activities, diet, caloric needs and the nutritional value of certain animals and plants is combined with the estimated number of people and their dogs to construct a theoretical kill of wildlife." Wildlife utilized includes white whale, bowhead whale, harbor seal, ringed seal, bearded seal, walrus and polar bear. Appendices: A - Population statistics; B- Caloric content of animals; C- Caloric needs of Eskimo groups. 235 ref.

Fraker, Mark A., David E. Sergeant, and Wyb Hoek.
1978. Bowhead and white whales in the southern Beaufort Sea. Department of Fisheries and the Environment [Can.], Beaufort Sea Project, 9860 West Saanich Road, P.O. Box 6000, Sidney, B.C., V8L 4B2 [Can.], Beaufort Sea Tech. Rep. #4, 114 p.

Includes information on reproduction, food/feeding, utilization, and migration of both species', and on age/growth of white whales. Possible effects on them of oil and gas exploration are assessed. The bulk of the report concerns white [=beluga] whales in the Mackenzie estuary. White whales migrate from the Bering Sea to the southeast Beaufort Sea/Amundsen Gulf region in May and early June using far offshore leads between Barrow and Banks Island. There is a move westward into the Mackenzie estuary through the nearshore lead, usually in late June. Most congregate there from late June to early August. Many others spend the summer around Amundsen Gulf, still others in Eskimo Lakes. Westward migration to winter grounds occurs late August and September. Maximum abundance in the Mackenzie estuary at any one time (not including dark-colored juveniles) is at least 4,000 and may be as high as 6,000. Bowhead whales probably follow the same general path into the Beaufort Sea, by way of far offshore leads in May and June, returning in August and September by a coastal route. "Most bowheads spend late spring and summer in Amundsen Gulf." History of bowhead exploitation is described; Marquette's (1977) estimate of total numbers (1000 to 3000) is cited. Effects of current oil and gas exploration (north of the Mackenzie estuary) which could disturb, impede or halt whales' movements include traffic of boats, barges, hovercraft and aircraft; artificial islands and borrow operations. An offshore oil blowout, though unlikely, is probably the most serious potential threat to whales. Direct impacts of oil (e.g., through contact or ingestion) and indirect impacts (e.g., on whales' foods) are considered according to seasonal whereabouts of whales. 21 maps, 10 pl., 3 fig., 11 tab., 7 app., 63 ref.

Frame, G.W.
1971. Occurrence of polar bears in the Chukchi and Beaufort Seas, summer 1969. J. Mammal. 53(1):187-189.

Thirteen bears were seen during a cruise on an icebreaker 13 days in July-August of 1969. Three of the 13 bears had young of the year. All were seen in seas 65-95% ice covered; none were found on the heavy ice. Walrus were seen in the Chukchi but none in the Beaufort, presumably because the deeper water in the Beaufort makes clam beds inaccessible.

Fujino, K.
1954. On the body proportions of the fin whales (Balaenoptera physalus L.) caught in the northern Pacific Ocean I: a preliminary report. Sci. Rep. Whales Res. Inst. 9:121-163.

Twenty-two body measurements of whales caught from 1941 to 1952 off Kamchatka are compared with those of whales caught off the outer Aleutian Islands. No differences were recognized between the 2 stocks.

1960. Immunogenetic and marking approaches to identifying subpopulations of the North Pacific whales. Sci. Rep. Whales. Res. Inst. 15:85-142.

Blood groups and marking are discussed with regard to subspecies of fin whales (Balaenoptera physalus). Also mentions blood types of Stenella coeruleo-albus [sic], Berardius bairdii, Physeter catodon, Balaenoptera edeni, Balaenoptera musculus, Megaptera nodosa.

Gaskin, D.E., P.W. Arnold, and B.A. Blair.
1974. Phocaena phocaena. Mammal. Species 42:1-8.

A compilation of general information on the harbor porpoise; characteristics, form, distribution, fossil records, function, ontogeny, ecology and behavior are discussed. Migration patterns are unknown.

Geist, O.W., J.L. Buckley, and R.H. Manville.
1960. Alaskan records of the narwhal. J. Mammal. 41:250-523.

Three observations reported extend the southern range of the narwhal. (1) In 1957, a specimen was found on Kiwalik Bay (Lat. 66°N). (2) Also in 1957, a narwhal was found at the mouth of the Caribou River (56°N), and (3) a specimen was found at Wainwright, Alaska.

Gentry, Roger L.
1977. The influence of female feeding patterns on otariid social systems. Abstr. only. in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 28. (Avail. from author, Northwest and Alaska Fish. Cent.. Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv.. NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

Feeding patterns of northern fur seals and Steller sea lions are presented to support the contention that absence of social bonding between individuals was an important precondition for development of the extreme forms of polygyny seen in extant otariids.

Gentry, Roger L., and David E. Withrow.
1978. Steller sea lion. P. 166-171 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Geraci, J.R., and T.G. Smith.
1976. Direct and indirect effects of oil on ringed seals (*Phoca hispida*) of the Beaufort Sea. J. Fish. Res. Board Can. 33:1976-1984.

Authors' abstract: "Ninety-six ringed seals (*Phoca hispida*) were taken from nets at Brown's Harbour, Northwest Territories in the fall of 1974. Comparison with two other net samples from 1971 and 1972 revealed a lower proportion of young-of-the-year and a lower mean weight of seals in all age-classes. Six seals immersed in Norman Wells crude oil for 24 h at the field netting site suffered only transient eye problems and minor kidney and possibly liver lesions; no permanent damage was observed. Three seals transported to the University of Guelph all died within 71 min after oil was introduced into their pool. Hematologic and blood chemical studies indicate that death was caused by oil superimposed on the stress of captivity. Six, 3-4 wk-old wild whitecoat harp seal (*P. groenlandica*) pups at the Magdalen Islands, Quebec, were coated with crude oil. No significant differences in core body temperatures were noted and no deleterious effects were observed. Five captive ringed seals at Guelph were subjected to a cumulative dosage of Normal Wells crude oil fed with their fish food. High dosage (75 ml) and low dosage (25 ml) of crude oil were also fed to two groups of six harp seal pups. No significant lesions or behavioral changes were noted. These experiments were of an acute nature and reflect the effects of a brief contact with oil only. Effects of longer contact as would probably be the case in an offshore oil well blowout situation are discussed. Possible effects of large-scale offshore oil fields are also considered." 3 fig., 33 ref.

Gill, C.D., and S.E. Hughes.
1971. A sei whale, Balaenoptera borealis, feeding on Pacific saury, Cololabis saira. Calif. Fish. Game 57(3):218-219.

The capture of a sei whale in August of 1969, 85 miles west of Point Reyes, California, is reported. Feeding behavior prior to capture is described. The stomach, filled to capacity, contained 227kg of sauries.

Gill, T.
1873. The ribbon seal of Alaska. Am. Nat. 7:178-179.

The distribution of Phoca fasciata is described as northern Alaskan waters. Pelt coloration and dentition noted.

Gilmore, Raymond M.
1956. Rare right whale visits California. Pac. Discovery 9(4):20-25.

Description of whale sighted from Scripps Institution of Oceanography, La Jolla, and followed by boat. Discussion of the history of the species. Data from California shore whalers show only a handful of right whales taken. One animal was killed in April 1924 off the Farallon Islands. Map shows "original" distribution in North Pacific and Bering Sea. Mentions Kodiak Gyre and Kodiak Ground. 3 photos + drawings.

1959. The California gray whale. U.S. Dep. Inter., U.S. Fish Wildl. Serv., Sect. Mar. Mammal Res., Seattle, Wash., Processed Rep., 70 p.

A report on the gray whale, offering explicit migration patterns, distribution, behavior studies, shore censuses 1952-1957, and data from aerial surveys 1952-1957. Counts of gray whales passing San Diego indicate a population size of 2,900 in 1952-3, and 4,400 in 1956-7. The bulk of the whales spend the summer (June to September) in the northwestern Bering Sea and adjacent Chukchi Sea. A small number are believed to summer 75-100 miles north of Humboldt Bay, California.

1978a. Right whale. P. 62-69 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

1978b. Some news and views of the gray whale, 1977; Part 1. Migration into and out of the Bering Sea. Whalewatcher 12(1):4-8.

Author reviews development of his thoughts on the migration route of gray whales. In light of recent observations, present proposed route includes coastal passage between Vancouver Island and the Bering Sea and is close to shore all the way from Baja California and into Bristol Bay. (Route proposed earlier had been offshore.) 3 illus. (charts), 10 ref.

Gogan, Peter J.
1977. A review of the population ecology of the northern elephant seal (Mirounga angustirostris). U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 68 p.

Contents: Introduction; annual cycle; food habits; reproduction; mortality; parasites and diseases; the population; critical habitats; conclusions; literature cited. Oceanic sightings from 8 publications (most recent from 1969) are tabulated, and include two from Chatham Strait, Alaska, one in May, one in September. 10 tab, 6 fig, 75 ref.

Gol′tsev, V.N.
1968. Dinamika beregovykh lizhbishch morzha v svayazi s ego raspredeleniem i chislennost′yu (Dynamics of coastal walrus rookeries in connection with distribution and numbers of walrus). Tr. Vses. Nauchno-issled. Inst. Morsk. Inst. Rybn. Khoz. Okeanogr. (VNIRO) 68 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 62):205-215. In Russian. (Transl. by Israel Program Sci. Transl. 1971, p. 201-212 in V.A. Arsen′ev and K.I. Panin (eds.), Pinnipeds of the North Pacific, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 70-54020.)

Studies were carried out mainly in 1960, 1962, 1964 and 1965, on 4 Soviet coastal rookeries. Rookeries are divided into 2 types: stable and temporary. Coastal rookeries tend to form when there are no ice floes. The number of rookeries, and walrus on them, is determined by ice conditions. Visual counts in 1964 indicated 47,000-51,000 animals in the rookeries. 2 tab., 3 fig., 17 ref.

1972. Raspredelenie i uchet chislennosti tikhookeanskogo morzha osen′yu 1970 goda (Distribution and assessment of numbers of the Pacific walrus in the autumn of 1970). P. 25-28 in Tezisy Dokladov Pyatogo Vsesoyuznogo Soveshchaniya po Izucheniyu Morskikh Mlekopitayushchikh (Abstracts of Papers 5th All-Union Conf. Studies Mar. Mammals) 19-21 Sept. 1972, Makhachkala. Makhachkala: Minist. Rybn. Khoz. SSSR, Ikhtiol. Kom. VNIRO, KaspNIRKh, Akad. Nauk SSSR, Zool. Inst., Inst. Evol. Morfol. Ekol. Zhivotn. im. A.N. Severtsova, Inst. Biol. Razvit. (Transl. by F.H. and B.A. Fay, Univ. Alaska, Fairbanks, 1974, 3 p.)

Records presence of walrus on former hauling grounds and sightings in areas further south than usual. This has been interpreted to indicate an increase in the walrus population. Some data were collected in mid-September to mid-October 1970 by aerial surveys of the Chukotsk Peninsula and the western Chukchi. On 18 October, 41,700 walruses were photographed on 3 hauling grounds. The total population is estimated at 101,000 and the annual recruitment at 5,000 to 6,000 animals.

1976. Aerouchet tikhookeanskogo morzha v sovetskom sektore osen′yu 1975 (Aerial surveys of Pacific walrus in the Soviet sector during Fall, 1975). Processed rep., Magadan Branch, TINRO [Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr.], 18 p. + 4 fig. In Russian. (Transl. by John J. Burns, Alaska Dep. Fish Game, Fairbanks, Alaska, 26 p.)

[This paper was presented at a meeting of the Project on Marine Mammals within the framework of the US-USSR Agreement on Environmental Protection, 18-25 January 1977, La Jolla, Calif.] During the period from 17 Sept. through 16 Oct., aerial surveys were conducted in the Soviet sector (west of the International Dateline) of the Bering and Chukchi Seas. These flights were coordinated with flights by U.S. scientists in the U.S. sector [see Estes and Gilbert, 1978]. Seven coastal hauling grounds in the Bering Sea (including two newly discovered hauling grounds on Nuneangan Island and Ioann Bogoslov Island), and two in the Chukchi Sea were found. Ice hauling grounds were found in the western part of the Chukchi Sea rather near shore. A total of 128,000-130,000 walruses were found in the Soviet sector - 96,900 on hauling grounds and the remainder on ice hauling grounds or in the water. Growth of population and expansion of range southward were found.

Gol′tsev, V.N., V.N. Popov, and M.V. Yurakhno.
1975. O lokal′nosti stad beringovomorskoi largi (On the localization of Bering largas). P. 100-102 in G.B. Agarkov and I.V. Smelova (eds.), Morskie mlekopitayushchie (Marine mammals), Part 1, Materials from 6th All-Union Conf. [on Studies of Mar. Mammals], Kiev, [1-3] October 1975. Min. Rybn. Khoz. SSSR, Ikhtiol. Kom., VNIRO, Akad. Nauk SSSR, Inst. Evol. Morfol. Ekol. Zhivotn., Inst. Biol. Razvit., Zool. Inst., Akad. Nauk USSR, Inst. Zool. In Russian. (Transl. by F.H. Fay, Inst. Mar. Sci., Univ. Alaska, Fairbanks, AK 99701, 3 p.)

Over the years 1966-1973 material was obtained from 794 largas from two populations. One resides along the eastern coast of Kamchatka and is concentrated in spring on the ice of Karaga Gulf. The other is located in a more northern part of the sea, from the Koryak coast to Bering Strait with the center in the Gulf of Anadyr. Specimens from the two localities were compared as to size and weight, degree of sexual dimorphism, skull measurements, and helminth infestation. The differences found "allow us to regard both populations of larga as being discrete. The border that separates them may be considered conditionally as Cape Olyutorskii. Interchange of individuals between populations probably exists, but it is very insignificant."

Gudkov, V.M.
1962. O svyazyakh v raspredelenii zooplanktona, morskikh ptits i usatykh kitov (Relationship between the distribution of zooplankton, seabirds and baleen whales). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:298-313. In Russian. (Transl. by Dep. Nav. Oceanogr. Off., Washington, D.C., 1974, 16 p.)

During a 1955 expedition to the Bering Sea there was found a high coincidence of birds, baleen whales and plankton in space and time. Stomach contents of birds and whales were analyzed. Among the principal food forms were members of Calanoida. All concentrations of shearwaters coincided with the presence of whales, but only half of the albatross, kittiwake, least auklet, forktailed petrel, and tufted puffin concentrations were associated with whale sightings. Presumably both whales and marine birds are exploiting the same food source, explaining their similar distribution patterns.

Guiguet, C.J., and G.C. Pike.
1965. First specimen record of the grey grampus or Risso's dolphin, Grampus griseus (Cuvier), from British Columbia. Murrelet 46(1):16.

In May 1964 a grampus was shot on the west side of Stuart Island, British Columbia. The stomach contained nematodes and squid beaks. No measurements are available. Also, sightings made from a Canadian weathership stationed at 50^{o}N, 145^{o}W are given as follows: July 1958 (1), October 1959 (6), August 1960 (5), and September 1960 (4).

Gulland, J.A.
1974. Distribution and abundance of whales in relation to basic productivity. P. 27-52 in W.E. Schevill (ed.), The whale problem, Harvard Univ. Press, Cambridge, Mass.

Headings are: Distribution, primary and secondary production; general distribution of sperm whales; relative abundance of sperm whales in different areas; distribution of baleen whales; relative distribution and abundance of different species of rorquals; magnitude of production and potential harvest; rational utilization and conservation. Figure maps world distribution of zooplankton. Detailed distributions of whales and zooplankton are not discussed. 5 tab., 2 fig.

Haley, Delphine (ed.).
1978a. Marine mammals of eastern North Pacific and Arctic waters. Pacific Search Press, Seattle, Wash., 256 p.

Volume contains current information on abundance, distribution, natural history, research methods, human impacts, and other salient facets of over 40 species. The editor and 21 marine mammal researchers contributed chapters. [Relevant chapters are cited individually and indexed by species, but because of pressure of time they are annotated only very briefly or not at all. See Burns, DeLong, Fay, Fiscus, Gentry & Withrow, Gilmore, Haley, Kenyon, Leatherwood & Reeves, Lentfer, Marquette, Mate, Mitchell, Newby, Newman, Reilly, Rice, Scheffer, and Wolman.] 125 photos including 16 color pl., 30 distribution maps, 12 drawings, 142 ref.

1978b. Steller sea cow. P. 236-241 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Hall, E.R., and J.W. Bee.
1954. Occurrence of the harbor porpoise at Pt. Barrow, Alaska. J. Mammal. 35(1):122-123.

An adult Phocaena vomerina (Gill) was caught in August 1952 in a net at $71^{o}21'$N, $156^{o}35'$W. Two weeks later an immature animal was found in the same net. The stomach of the adult contained whitefish (Leucichthys). Measurements are given.

Hall, John D., Craig S. Harrison, Jay Nelson, and Andrew Taber.
1977. The migration of California gray whales into the Bering Sea. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 8. (Avail. from first author, P.O. Box 58, Kasilof, AK 99610.)

Aerial surveys in springs of 1976 and 1977 revealed that gray whales migrated along the coast from Cape St. Elias to Unimak Pass, normally passing within 400m of shore (none seen passing more than 5km from shore). Shore observations from Cape Sarichef on Unimak Pass indicated that about 9,000 gray whales (including very few cow/calf pairs) entered the Bering Sea by this route between 7 April and 26 May 1977.

Hall, John D., and Michael F. Tillman.
1977. A survey of cetaceans of Prince William Sound and adjacent vicinity -- their numbers and seasonal movements. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 681-708. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Aerial and vessel surveys were used. In 1976 cetaceans sighted totalled: 974 Dall porpoises* (peak in August); 185 harbor porpoises* (peak in May); 500 Pacific white-sided porpoises (Lagenorhynchus obliquidens) (sighted in October just outside Montague Strait); 167 killer whales* (peaks in August and April); 23 gray whales (spring and fall); 106 humpback whales* (estimated summer population 40-60); 23 fin whales (May to July); 52 minke whales (summer and fall); one belukha; 5 sei whales. Last two are casual visitors only. Beaked whales (Mesoplodon, Ziphius, and Berardius) may occasionally appear. Cetaceans appeared to be less numerous in winter, but winter weather conditions made confident assessment impossible. *Sightings of these animals are individually graphed by month. 1 tab., 14 fig., 8 ref.

Hanna, G.D.
1920. Mammals of the St. Matthew Islands, Bering Sea. J. Mammal. 1(3):118-122.

Survey in July 1916 yielded cetacean skeletal remains (bowhead, humpback, sulphur-bottom, killer and Baird's whales), sightings of hair seals (Phoca sp.), and walrus. Polar bears were formerly abundant, but their occurrence is believed to have ceased in the 1890's. Fur seals were common up to within 8 miles of St. Matthew, in June of 1916.

1923. Rare mammals of the Pribilof Islands, Alaska. J. Mammal. 4(4):209-215.

Records rare sightings and strandings of sperm whale, beaked whales (Berardius bairdii), killer whales, harbor porpoises, walruses, bearded seals and sea otters.

Harry, G.Y., Jr.
1971. Recent development in research and management of northern fur seals (*Callorhinus ursinus*). Science in Alaska, Proc. 22nd Alaska Sci. Conf., College, August 17-19, 1971, p. 138. [Abstr. only.]

Between 1889 and 1909 no effective international conservation agreement existed. The North Pacific Fur Seal Convention signed in 1911 was terminated by Japan in 1941. In 1957, Japan, the USSR, the USA and Canada signed the Interim Convention on Conservation of North Pacific Fur Seals. Between 1956 and 1963, female seals were harvested on the Pribilof Islands, the herd having grown beyond the level of maximum sustainable yield. However, estimates of pups born and of the female survival rate later appeared to have been inflated. At present the fur seal population level is similar to that in the early 1930's, but rapid increase is not occurring now as then. If permanent adverse changes have occurred in the marine environment, expectations of fur seal yield must be revised.

Hart, F. Gordon.
1977. Observations on the spring migration of gray whales near Pachena Point, British Columbia. Murrelet 58(2):40-43.

Literature is reviewed. Observations were made during winter and spring of 1974-75 from Pachena Pt. (southwest shore of Vancouver Island). Frequency distribution of group sizes observed in northward migration is tabulated. Several pairs passed which appeared to be mother-calf pairs in late March. Breaching, "spy-hopping", "loafing", rolling together showing heads and flukes, possible feeding, and sexual behavior (5,6, and 14 April, with apparent copulation 14 April). 1 tab., 1 fig., 6 ref.

Hatler, D.G.
1971. A Canadian specimen of Risso's dolphin (*Grampus griseus*). Can. Field-Nat. 85(2):188-189.

Specimen washed ashore on Vargas Island, near Vancouver Island (49°10'N, 125°58'W) on 17 April 1970. Measurements taken. Stomach contained eel grass only.

Hatler, D.G., and J.D. Darling.
1974. Recent observations of the gray whale in British Columbia. Can. Field-Nat. 88:449-459.

Observations from Vancouver Island were made from 1965-1973, except for 1967. There is a peak in migrant animals in April, and the data suggest the whales hug the Vancouver coast for both the north and south migration. The authors note that the whales have been observed feeding along the coast during all parts of the year. It is not clear whether these are resident animals.

Heizer, Robert F.
1968. A bibliography of aboriginal whaling. J. Soc. Bibliogr. Nat. Hist. 4(7):344-362.

Consists of a short introduction, index, and 233 references. Introduction discusses genuine aboriginal whaling. "At least three radically different techniques of killing large whales are known to have been practiced among primitive peoples." 1) Whales are impounded in small bays and inlets and shot with darts tipped with pathogenic bacilli. Whales die within a few days and are brought to shore. Infected area is cut out and used to grow more bacilli. (Scandinavian coast, especially Norway.) 2) Whale is harpooned from boat carrying crew and harpooner. Harpoon line has inflated buoys or wooden drags attached it. Whale is harpooned again when it resurfaces, or may be lanced if possible. (Europeans and Americans in the 17th-19th centuries, Eskimos and Northwest Indians, aborigines of Siberia.) 3) From a two-man baidarka paddled with double-ended paddle, a lance with a stone tip coated with aconite is thrown into the whale. Whales dies and is retrieved if and when it washes in to shore. (Aborigines of coast of northeastern Asia, Aleutian Is., Kodiak Is.)

Heyland, J.D., and Keith Hay.
1976. An attack by a polar bear on a juvenile beluga. Arctic 29(1):56-57.

On 26 July 1974, in Cunningham Inlet, Somerset Is., in the Canadian arctic, a young female beluga whale was found stranded. Deep but well-healed scars were found on her back. It was determined that the scars were made by a polar bear's claw. Other reports of predation by polar bears on beluga whales are reviewed. 2 fig., 6 ref.

Houck, W.J.
1961. Notes on the Pacific striped porpoise. J. Mammal. 42(1):107.

Records a dead porpoise (Lagenorhynchus obliquidens) found at 41°03′N, 124°09′W, in September 1958. The stomach and esophagus were completely filled with sauries (Cololabis saria [sic]). A large, incompletely swallowed scad (Decapterus polyaspis) is thought to have caused death by choking the porpoise.

Howell, A. Brazier, and Laurence M. Huey.
1930. Food of the gray and other whales. J. Mammal. 11(3):321-322.

A male gray whale of 39 feet was caught near Crescent City, California, and was landed at Trinidad, California, 21 July 1926. Euphausia pacifica were found in its mouth and among baleen. Euphausiids and "small mackerel-like fish some 10 inches in length" are reported from fin and humpback stomachs from California.

Huey, Laurence M.
1952. An Alaskan record of the narwhal. J. Mammal. 33(4):496.

One animal was collected in summer 1928 near mouth of Colville River. Skull and tusk were sent to San Diego Society of Natural History. Alaskan records are almost nonexistent.

Ichihara, Tadayoshi.
1958. Gray whale observed in the Bering Sea. Sci. Rep. Whales Res. Inst. 13:201-206.

Gray whales seen near St. Lawrence Island, one gray whale seen in Unimak Pass in 1957, and 3 groups found west of St. Lawrence Island in 1955 suggest a migration route through the eastern Aleutian passes, as Kellogg proposed in 1929, rather than around to the west of the Commander Islands as Gilmore proposed in 1955. 2 fig.

Ichihara, Tadayoshi, and Kazumoto Yoshida.
1972. Diving depth of northern fur seals in the feeding time. Sci. Rep. Whales Res. Inst. 24:145-148.

In the western Japan sea, May 1970, fur seal dives were observed from shipboard using echo-sounder. Dives of 100 meters or more are reported. 3 fig.

Imler, R.H., and H.R. Sarber.
1947. Harbor seals and sea lions in Alaska. U.S. Fish Wildl. Serv., Spec. Sci. Rep. 28, 22 p.

This 1945-46 study was an attempt to determine the extent of damage to the fishing industry by seals and sea lions. Stomach analyses of some 400 seals indicated that in the Copper River district eulachon (smelt) was the primary food source, and in SE Alaska, gadids (cods) were common prey. During July-August, shrimp appeared to be a preferred prey. From 15 sea lions, it appeared that pollack was the predominant food; commercially important fish comprised 14% of the stomach contents. Harbor seals are common throughout Gulf and SE Alaska, and especially abundant near large stream mouths. Copper River population is estimated at 6,000. Sea lions inhabit entire coast of SE Alaska with total abundance of 3,000. West of Seward their abundance increases.

International Commission on Whaling.
1974. Japan - Progress report on whale research June 1972 to May 1973. Rep. Int. Comm. Whaling 24:214-219.

Japanese government chartered catcher boat for 50 days beginning in February in sub-tropical North Pacific. Three whaling companies operated sighting cruises in Antarctic. Marking: Antarctic - 131 whales marked, 6 recovered; North Pacific - 146 marked, 24 recovered. (All tabulated in appendices.) The latter marks were recovered from area 35°-50°N, 145°E-163°W. These whales were 16 sei, 5 fin, and 3 sperm, and had been marked in area 15°-55°N, 143°E-160°W.

International Commission on Whaling, Scientific Committee.
1971. Report of the special meeting on sperm whale biology and stock assessments. Rep. Int. Comm. Whaling 21:40-50.

The groupings adopted in 1963, which delineated 3 breeding stocks in the North Pacific, were not modified. Information on age, growth, reproduction, ecology and fishing effort offered. Rate of natural mortality for N. Pacific sperm whales is about 6%. Methods of stock assessments were detailed, but no population estimates given.

1976. Japan - Progress report on whale research - June 1974 to May 1975 [SC/27/Progress Report 2]. P. 416-424 in Rep. and papers of the Scientific Committee of the Commission - 1975. Int. Comm. Whaling. [By the prior procedure, the material in this volume would have been published with the 26th report of the International Commission on Whaling.]

Included are sighting reports of prohibited whales by catcher boats in North Pacific, 1974: 131 blue whales and 13 humpback whales were reported in the eastern Gulf of Alaska; 5 right whales were reported elsewhere in the N. Pacific. 7 tab., 2 fig.

1977. Japan - Progress report on whale research - June 1975 to May 1976. Rep. Int. Whaling Comm. 27:88-91.

Included are sighting records of prohibited whales by catch boats in North Pacific 1975: 70 blue whales and 5 humpbacks were thus sighted in the eastern Gulf of Alaska. Four right whales are reported from the northwestern Pacific. 7 tab., 2 fig.

Ivanova, E.I.
1961. O tikhookeanskoi kosatke (*Orcinus orca* L.) [The Pacific killer whale (*Orcinus orca* L.)]. Tr. Inst. Morfol. Zhivotnykh Akad. Nauk SSSR 34:205-215. In Russian, with Engl. abstr.

From July to August 1951-1956, 19 female and 14 male killer whales were studied. Sexual dimorphism was apparent in fin size and number of teeth. Of 21 stomachs examined, 11 were empty and 10 contained fish and squid residues.

Ivashin, M.V., and A.A. Rovnin.
1967. Some results of the Soviet whale marking in the waters of the North Pacific. Norsk Hvalfangst-tid. 56(6):123-135.

Soviet whale marking in the North Pacific began in 1954. Marking was first done only in the northwestern Pacific but has expanded to cover the entire North Pacific (and Bering Sea) north of Lat. 40°N. Soviets have marked a total of 1,452 whales: 8 blue, 51 fin, 72 humpback, 43 sei, 29 gray, 20 Pacific right, 6 killer, and 1,223 sperm whales. Speed of movement of sperm, sei and humpback whales is discussed. A total of 66 marks have been recovered, from sperm, sei, humpback, fin and blue whales. Positions of marking and recovery are tabulated and charted. One fin whale marked in the Sea of Okhotsk was recaptured in the Gulf of Alaska. Local populations of sperm whales mingle north of Lat. 50°N. 4 fig., 6 tab., + appendix.

Ivashin et al. 1972. See Moiseev.

effries, Steven J., Tim J. Moore, and Murray L. Johnson.
1977. The relationship of behavior to censusing of harbor seals (P. v. richardi). Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego,, California, 12-15 December, 1977, p. 70. (Avail. from authors, Puget Sound Mus. Nat. Hist., Univ. Puget Sound, Tacoma, WA 98416.)

Aerial and surface counts have shown close correlation between haul-out patterns and daily tidal cycles. Group bottom-resting and other behavioral factors affect census accuracy.

Jellison, W.L.
1953. A beaked whale, Mesoplodon sp., from the Pribilofs. J. Mammal. 34(2):249-251.

Reports a stranding of a species of Mesoplodon on St. Paul Island on 7 September 1951.

Johnson, A.M.
1975. The status of northern fur seal populations. In K. Ronald and A.W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:263-266.

Estimates of abundance in 1970-1971 are: Pribilof Islands - 1.2 million; Commander Islands - 265,000; Robben Island - 165,000; Kuril Islands - 15,000; San Miguel Island - under 1000. Methods of estimating yearly pup populations are discussed. 1 fig., 2 tab.

Johnson, Brian W.
1977. The effect of human disturbance on a population of harbor seals. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 422-432. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

[This report is Appendix 1 of Pitcher & Calkins (1977), found on pages 189-225, but the two have been accidentally separated.] Daily observations were made from May to September 1976 in large rookery area on southwest end of Tugidak Island. Major disturbances, and even minor ones, cause separations of mothers and pups which often result in starvation and death of the pup. Major natural disturbances: eagle landing nearby, massive rockslide. It is estimated that human disturbances such as hikers, all-terrain vehicles, and especially low-flying aircraft, caused the deaths of more than 10% of the pups born on Tugidak Island. 1 tab., 3 ref.

Johnson, Murray L., and Gordon D. Alcorn.
1962. The return of the sea otter. Outdoor Calif. 23(2):4-5.

Recounts history of exploitation since 1741. Present population is estimated as high as 40,000. Distribution includes Amchitka Island, Delarof, Andreanof and Fox island groups, Alaska Peninsula, Kodiak archipelago, and Kenai Peninsula to Cape St. Elias in Alaska, and the California coast.

Johnson, Murray L., Clifford H. Fiscus, Burton T. Ostenson, and Myron L. Barbour.
1966. Marine mammals. P. 877-923 in Norman J. Wilimovsky (ed.), Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission. (Avail. Natl. Tech. Inf. Serv., Springfield, Virginia.)

Authors studied at Point Hope and Kivalina, Alaska, August-September 1959 and November 1960-June 1961. Data were obtained on the following animals: 2,028 ringed seals, 208 bearded seals, 7 ribbon seals, 3 fur seals, 3 harbor seals, 2 walrus, 5 beluga whales, 3 bowhead whales and 3 polar bears. Quoting from authors' abstract: "The ringed seal is present in abundance from November through June. Pups are born in late March. Mating occurs in April and May; pregnancy rate 86.7%. Food is principally fish in the winter and invertebrates in the spring, and many species of both are used. The bearded seal is present in numbers only in June. Pups are born in late April and are completely molted. Food is principally invertebrates of many species. All marine mammals are migratory, and most of the animals used by the Eskimos are absent in the ice-free months."

Johnson, M.L., K.W. Kenyon, and C. Brosseau.
1967. Notes on a captive sea otter *Enhydra lutris*. Zool. Soc. London, Int. Zoo Yearb. 7:208-209.

Discusses knowledge of sea otter biology and history of attempts to keep in captivity; reports on behavior, size and food of a male sea otter brought to Tacoma, Washington, from Amchitka Island (Aleutian Islands) by Karl W. Kenyon in November 1965.

Jones, Robert D., Jr.
1963. An overland migration of fur seals. J. Mammal. 44(1):122.

A small number of fur seals have been observed in winter crossing the tip of the Alaska Peninsula from the Bering Sea to the Pacific Ocean. Author reports personal observations on 20 November 1960 (one young female) and 8 March 1962 (one old female). Distance of crossing was 3 miles. Other observers report crossings of 8 miles.

Jonsgård, Age.
1968a. A note on the attacking behaviour of the killer whale (*Orcinus orca*). Norsk Hvalfangst-Tid. 57(4):84-85.

A school of killer whales was observed feeding on a just dead bottlenosed whale *Hyperoodon ampullatus* while two of the killer whales kept the prey afloat. When the killer whales sounded the prey also sank. It was brought to the surface again later by the killer whales, which continued to feed as before. Another incident is related wherein killer whales attacked live bottlenosed whales tethered to a small whaling vessel. With reference to killer whale predation on a minke whale, author notes that "at any rate, in Norwegian coastal waters adult [minke] females, contrary to adult males, often migrate into inshore waters during their feeding migration in the summer, also visiting small bays." 4 ref.

1968b. Another note on the attacking behaviour of killer whale (Orcinus orca). Norsk Hvalfangst-Tidende 6:175-176.

It appears that under special circumstances, killer whales will attack and bite off the flippers of larger whales. It does not seem likely that they are able to kill species' like minke or bottlenose whales. These larger whales may dive deeply to escape when under attack.

Jonsgård, A., and P.B. Lyshoel.
1970. A contribution to the knowledge of the biology of the killer whale Orcinus orca (1). Nytt Mag. Zool. 18:41-48.

Data were collected on 1,413 killer whales caught in the northeastern North Atlantic 1938-1967. The distribution of killer whales in these waters is dependent on the herring distribution. Stomachs examined contained squid, large herring and marine mammals. Information on size at birth, sexual maturity and physical maturity is given.

Jonsgård, Age, and Per Oynes.
1952. Om bottlenosen (Hyperoodon rostratus) og spekkhoggeren (Orcinus orca). Fauna no. 1, Naturen 1:1-17. In Norwegian. (Transl. of p. 11-16, concerning killer whale, by O.A. Mathisen, 1967, Coll. Fish., Univ. Wash., Seattle, Wash., 4 p.)

Physical characteristics, behavior, and capture patterns of the killer whale are discussed. In the northeast Atlantic, killer whales are attracted to the herring schools, and tend to frequent shallow areas on the continental shelf. The primary food source is reportedly fish, although marine mammals are often taken.

Jurasz, Charles M., and Virginia Jurasz.
1977. Censusing of humpback whales, Megaptera novaeangliae, by body characteristics. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 54. (Avail. from authors, Sea Search, P.O. Box 93, Auke Bay, AK 99821.)

Fluke and dorsal fin characteristics permit visual identification of individual whales, and were used to discriminate transient and non-transient animals in Glacier Bay, Alaska.

Kajimura, Hiroshi, Michael Perez, Robert Lander, W. Bruce McAlister, Michael Bigg, Ian MacAskie, and Graham Ellis.
1977. The distribution and food of northern fur seals in the northeastern Pacific and Bering Sea. Abstr. only, in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 9. (Avail. from senior author, Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

Data collected by U.S. and Canadian scientists from 1958 to 1974 (as research for the North Pacific Fur Seal Commission) have been jointly analyzed to provide a comprehensive summary on fur seal food and distribution.

Kasuya, Toshio.
1971. Consideration of distribution and migration of toothed whales off the Pacific coast of Japan based upon aerial sighting record. Sci. Rep. Whales Res. Inst. 23:37-60.

Reports sightings recorded during aerial surveys 1959-1970 of whales (sperm, Baird's beaked, killer, pilot, and false killer), dolphins (Risso's, common, bottlenosed, northern right-whale, and striped) --and finless porpoise. Fifteen aerial photos show these species in the water.

Kawakami, Takehiko, and Tadayoshi Ichihara.
1958. Japanese whale marking in the North Pacific in 1956 and 1957. Norsk Hvalfangst-Tid. 47(6):285-291.

Japanese whale marking in the North Pacific was begun in 1949. In 1956 and 1957, 310 whales were marked. Over 34 of these were fin and humpback whales; the remainder were sperm, sei and blue whales. Marked whales recaptured in 1956 and 1957 by Japanese whalers were: 30 sperm, 2 sei, 18 fin and 3 blue whales. Six recaptures by Soviet whalers are also mentioned. Three humpback whales marked off Unalaska Island (central Aleutian Islands) in 1956 were recaptured in 1958 off Okinawa Island. All results are charted. 3 tab., 1 fig.

Kawamura, Akito.
1975. Whale distribution in Bering Sea and northern North Pacific in the summer of 1974: Results of a visual sighting study aboard the University of Hokkaido training vessel OSHORO MARU. Bull. Japan. Soc. Fish. Oceanogr. 25:119-128.

Cruise between 9 June and 29 July afforded 1,766 observation miles, and yielded the following cetacean sightings: 416 Phocoenoides (mostly dalli, but including 93 truei); 23 killer whales; 25 minke whales; 8 fin whales; 2 humpback whales, 2 large unidentified, 2 small unidentified. Figures show locations of sightings. (Dall porpoise was the only species sighted enough to provide really useful data.) Density of Dall porpoises was judged to be higher in the Amchitka Pass area and over the shelf slope in the Bering Sea than in the North Pacific, Bristol Bay and northern coasts of Aleutian Islands. Various evidence indicates that the center of distribution for large whales is over the shelf proper rather than along the shelf edge in the Bering Sea; none were seen in what used to be a good fin whale ground just south of the Aleutian Islands. Conspicuously absent was any sighting of sperm whales. Distributions of Dall's porpoises and pinnipeds often coincide, and are different from that of large whales. Killer whale sightings were to the north of Unalaska Island in the vicinity of Pribilof Canyon.

Kellogg, Remington.
1931. Whaling statistics for the Pacific coast of North America. J. Mammal. 12(1):73-77.

Catch data by species and location from 1919-1929 are tabulated. Species are blue, finback, humpback, sei, gray and sperm whales, plus "miscellaneous" whales including beluga, bowhead, right, bottlenose, sharp-headed finback (minke), Bryde's whales. Locations decribed include: Alaska, British Columbia, Washington and California. Discussion mentions migration, numbers of whales, biology (length and maturity) and conservation.

Kenyon, Karl W.
1952. Diving depths of the Steller sea lion and Alaska fur seal. J. Mammal. 33(2):245-246.

At the mouth of Sitka Sound, off Crawfish Inlet, and off Kruzof Island, all within 40 miles of Sitka, Herman Kitka, halibut fisherman, has been bothered by sea lions. Kitka's observations indicate that sea lions do not go below 100 fathoms; fur seals do not usually go below 30 fathoms.

1960a. Aerial surveys of marine mammals in the Bering Sea; 23 February to 2 March 1960 and 25-28 April 1960. Unpubl. manuscr., 39 p. U.S. Dep. Inter., U.S. Fish Wildl. Serv., Bur. Sport Fish. Wildl., Sand Point Nav. Air Stn., Seattle 15, Wash.

Includes copious material about walrus sightings (cf. Kenyon 1960b), plus short sections on whales sighted (1 bowhead, 27 beluga), and seals sighted (ringed seal, ribbon seal, bearded seal) with comments on other records of their occurrence. No polar bears were seen in 1960, but tracks were seen in 1958 between King Island and Little Diomede. Estimated populations were: (1) 30,000 to 60,000 bearded seals in the Bering Sea, (2) 70,000 to 100,000 walrus.

1960b. Aerial survey of walruses in northern Bering Sea, 23 February to 2 March 1960. Unpubl. manuscr., 23 p. U.S. Dep. Inter., U.S. Fish Wildl. Serv., Bur. Sport Fish. Wildl., Sand Point Nav. Air Stn., Seattle 15, Wash.

Survey included: Nunivak Island, St. Matthew Island, St. Lawrence Island and return to Bethel; area south of Nunivak; area south and southwest of St. Lawrence Island to St. Matthew Island; Kuskokwim Bay, northern Bristol Bay, and trip to Cold Bay. Greatest concentrations of walrus were seen on "close" and "very close pack ice", often near islands. Population computation methods are explained. Population computations are tabulated in 6 divisions of area, yielding grand total estimates ranging from 78,000 to 170,000, depending on the percentage presumed to have been overlooked. The majority were found south and southwest of St. Lawrence Island. On 1 March, group sizes were noted: 65% of groups were more than 10; 35% ten or less. Charts show track of survey, locations and numbers of walrus seen, and approximate position of the ice edge. Birth was evidenced 1 March. 3 charts, 10 photos.

1960c. A ringed seal from the Pribilof Islands, Alaska. J. Mammal. 41(4):520-521.

A dead _Pusa hispida_ was found on St. Paul Island in August 1951. It constitutes the first record from the Pribilofs.

1960d. The Pacific walrus. Oryx 5(6):332-340.

Eskimo hunting of walrus on St. Lawrence, Little Diomede, Round and Walrus Islands in 1958 is discussed. Walruses are killed for food and boat coverings, but the real economic motive for hunting is provided by ivory sales. Estimated annual take is 1,000 for the American side and 5,000 for the Soviet side. Females with calves are preferred kills because their ivory is easier to carve, their meat more tender, and their skin preferable as a boat cover. Of all walruses killed, at least half are lost.

1961a. Cuvier beaked whales stranded in the Aleutian Islands. J. Mammal. 42(1):71-76.

Two carcasses of *Ziphius cavirostris* found on Amchitka Island, apparently shot by rifle. Measurements, dentition, stomach contents and other biological data are reported. 2 tab., 1 fig., 2 pl., 9 ref.

1961b. Sleep...on the deep. Pac. Discovery 14(3):22-24.

Fur seals sleep very soundly at sea with 3 flippers above water forming a "jug handle". In choppy water they trail the hind flippers. Sea otters invariably sleep on their backs, in coastal waters. Pups sleep on the mother's chest. Six excellent photos illustrate.

1962a. History of the Steller sea lion at the Pribilof Islands, Alaska. J. Mammal. 43(1):68-75.

Author's abstract: "In 1786 the Pribilof Islands probably supported a sea lion population considerably in excess of 15,000 animals. These bred on 2 rookeries on St. George Island, one on St. Paul Island, and one on Walrus Island. A few may have bred also on Sea Lion Rock. The Walrus Island colony disappeared in 1827; between 1867 and 1914 both St. George rookeries were exterminated, and the St. Paul rookery was reduced to less than 150 animals. A measure of protection was given the sea lion in 1914. By 1960, the population had increased to 5,700-6,700 adults. The only breeding ground today on the Pribilofs is on Walrus Island, where about 3,000 young were born in 1960. Newborn pups were last seen on St. Paul Island in 1957. All extinct rookery sites are now regularly used as hauling grounds. Otter Island, never a breeding ground, is a regular winter hauling ground. Unregulated exploitation and harassment by man probably played an important role in the reduction of the Pribilof sea lion herd and the shifts in rookery locations. The failure of the Pribilof population to approach its aboriginal size and to reoccupy old breeding grounds during a 40-year period of moderate exploitation is unexplained. Unknown ecological factors are suggested as a contributing cause." 3 tab., 1 fig.,1 photo.

1962b. Notes on phocid seals at Little Diomede Island, Alaska. J. Wildl. Manage. 26(4):380-387.

Information was gathered during the spring of 1958 (11 May to 14 June) on the hunting and biology of ringed, bearded, ribbon and harbor [=larga?] seals. Most of the article concerns ringed and bearded seals, which are taken by the Eskimos of Ignaluk Village to supplement the kill of walrus, their primary subsistence species. Hunting efficiency, reproductive data (a few reproductive tracts were examined), behavior, body size, hauling out, movements and pelage are included, along with various information gained from resident Eskimos. Stomach contents were examined from 14 ringed seals and 17 bearded seals. Dominant food of ringed seals was shrimp; that of bearded seals was rock crabs and clams. 2 photos, 6 tab.

1965. Aerial survey of sea otters and other marine mammals, Alaska Peninsula and Aleutian Islands; 19 April to 9 May 1965. Unpubl. manuscr. P. 1-52 in K.W. Kenyon and J.G. King, Aerial survey of sea otters, other marine mammals and birds, Alaska Peninsula and Aleutian Islands, 19 April to 9 May 1965. U.S. Dep. Inter., U.S. Fish Wildl. Serv., Bur. Sport Fish. Wildl., Seattle, Wash.

Tabulates numbers and distribution of sea otters and (secondarily) sea lions and harbor seals. Survey area was: the length of the Aleutian chain and eastward along the north side of the Alaska Peninsula to Port Moller. Total counts in entire area were: sea otters - 12,687; sea lions - 63,933; harbor seals - 4,868. Total population of otters in survey area is estimated at about 17,000. Harbor seals may number twice the actual count. Present counts are compared with counts made in 1959 and/or 1962. Otters ranged several miles offshore into the shallow waters of Bristol Bay north of Unimak Island and the Alaska Peninsula east to Port Moller. Also mentioned are walrus, killer whale, and minke whale. 24 charts, 5 photos.

1972. Aerial surveys of marine mammals in the Bering Sea, 6-16 April 1972. Unpubl. manuscr., 79 p. U.S. Dep. Inter., U.S. Bur. Sport Fish. Wildl., Mar. Mammal Substation, Nav. Support Activity, Bldg. 192, Seattle, Wash.

Between 7 and 16 April 1972 flights were made over Bering Sea ice from Bering Strait to the Alaskan Peninsula and from Alaskan to Strait to the Alaskan Peninsula and from Alaskan to Siberian coastal waters. Sea otter (8), walrus (9,300), larga seal (79), ringed seal (29), ribbon seal (6), bearded seal (221), bowhead whale (1), and beluga whale (33) were observed in a 1-mile wide survey track of approximately 4,280 nautical miles in length. Two areas of abundance of walrus were observed: (1) north and south of the west end of St. Lawrence Island and (2) in central Bristol Bay. Abundance of Pacific walrus is estimated at 136,000 animals. (Statistical treatment yields estimate of 93,000 - 178,000 animals.) Survey methods, conditions and problems, and treatment of data are discussed. Field data given in Appendix 1, areas of high and low abundance in Appendix 2. 9 charts, 14 tab. (13 concerning walrus only). [Part of the above is adapted from summary and conclusions.]

1978a. Sea otter. P. 226-235 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

1978b. Walrus. P. 178-183 _in_ Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Kenyon, Karl W., and Dale W. Rice.
1961. Abundance and distribution of the Steller sea lion. J. Mammal. 42(2):223-234.

Authors' abstract in part: "Observations of the Steller sea lion, _Eumetopias jubata_, including hauling-out habits, seasonal movements, and aerial surveys in eastern Bering Sea from Bering Strait to and including the Aleutian Islands, are presented.... The total world population of this species, based on the present report and on previously published data, is estimated to be about a quarter of a million animals." 2 tab., 1 fig. (maps), 1 pl., 17 ref.

Kenyon, Karl W., and V.B. Scheffer.
1949. A long-snouted dolphin from the Washington coast. J. Mammal. 30(3):267-268.

A specimen was found dead in March 1948 near Westport, Washington. Although decayed, it appeared to be _Stenella euphrosyne_. This is the second report of this species in North America. Description and measurements are given.

1955. The seals, sea lions, and sea otter of the Pacific coast. U.S. Fish Wildl. Serv., Circ. 32 [revision of Wildl. Leafl. 344, 1953], 34 p.

A general guide to North Pacific pinnipeds and sea otter from Mexico to the Bering Sea. Brief descriptions of physical appearance, range and habits are given for each of 12 species.

Kenyon, Karl W., and Ford Wilke.
1953. Migration of the northern fur seal, _Callorhinus ursinus_. J. Mammal. 34(1):86-98.

Summary of existing knowledge. Three major breeding grounds are the Pribilof Islands, the Commander Islands, and Robben Island. Fur seals migrate southward in winter as far as 34°N Lat. along the California coast, and to about 39°N Lat. off Japan. Monthly summary of known occurrences of the northern fur seal at sea is given. Effects of water temperature, food and weather on distribution are evaluated. Arrival and departure schedule of the various age classes on Pribilof breeding grounds is summarized. Recoveries of tagged seals are summarized. A small fraction of Pribilof seals migrate to Japanese waters.

Kleinenberg, S.E., A.V. Yablokov, B.M. Bel'kovich, and M.N. Tarasevich.
1964. Belukha. Opyt monograficheskogo issledovaniya vida (Beluga. (Delphinapterus leucas). Investigation of the species). Izd. "Nauka", Moscow, 454 p. In Russian. (Transl. by Israel Program Sci. Transl., 1969, 376 p., avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 67-51345.)

A monograph on the beluga with comprehensive sections on morphology, distribution, classification, biological characteristics and whaling. The range of belugas is circumpolar, and they occur in the open sea as well as along the coast. From stomach analysis of whales taken in Soviet arctic seas, it appears the beluga has a broad feeding spectrum. Most of the organisms are shallow water forms. Food habits differ according to age and sex. The food items include arctic cod, capelin, salmonids, flat-fish, herring and crustacea. Explicit distribution patterns along Soviet coast shown. Belugas are found in the Bering Strait in February and May-June. No information offered for the Alaskan coast. It is believed that the beluga can winter in waters that freeze by remaining near large polynyas.

Klinkhart, Edward.
1966. The beluga whale in Alaska. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep., Vol. 7, 11 p.

A general article discussing knowledge of biology of beluga whales, drawing upon about 25 sources, some from outside Alaska. Nearly all concentrations of belugas occur in shallow bays or estuaries of large rivers north of 40°N Lat. (They have been seen up to 60 miles upstream from the mouth of the Yukon River.) Bristol Bay population (which appears to be resident throughout the year) is estimated at 1,000-1,500. Population in Cook Inlet is estimated at 300-400. Populations which winter in the Bering Sea may be those which summer in the western Canadian arctic and eastern Siberian arctic. Contains sections on: general description, range and movements, abundance, population dynamics, food habits, parasites and predators, underwater sound, utilization, and future research and management. 53 ref.

1967. Birth of a harbor seal pup. J. Mammal 48(8):677.

On 15 June 1967 a harbor seal gave birth at Tugidak Island, Alaska (56°33'N, 155°20'W). One half-hour of observation, from 12 minutes before the birth until 18 minutes afterward, is reported.

1969. The harbor seal in Alaska. Alaska Dep. Fish Game, Wildl. Notebook Ser., 2 p.

Both ice- and non-ice-inhabiting harbor seals are described. Natural history is given. Annual harvest in northern Alaska is given as 4,000, and as 30,000 in southern Alaska. A bounty was in effect from 1927 to 1967.

Klumov, S.K.
1962. Gladkiye (Yaponskiye) kity Tikhogo Okeana (The right whales in the Pacific Ocean). Tr. Inst. Okeanol., 58:202-297. English summary.

Whaling and research vessels conducted observations from 1952 to 1957 on the distribution of right whales in the northwest Pacific. The results of this work describe two stocks. The Pacific stock is larger than the Okhotsk stock and growth of the Pacific stock is faster. It is possible that puberty comes when the animals are 14-15m long. Weaning takes place after 6-7 months. All data are preliminary. The weight of adult whales is more than 100 tons at a length of 16-17m. Analysis of food showed that right whales are stenophagous. The main food of right whales in the Northern Hemisphere is Calanoida.

Kooyman, Gerald L., Roger L. Gentry, and W. Bruce McAlister.
1976. Physiological impact of oil on pinnipeds. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 23 p.

[This report was submitted as final report for Research Unit #71, Outer Continental Shelf Environmental Assessment Program, sponsored by U.S. Dep. Inter. and Bur. Land Manage.] Northern fur seals' major breeding grounds, the Pribilof Islands, are close to a major oil lease site, the St. George Basin. Objectives of this study were (A) to measure effects of oil fouling on northern fur seals in terms of: thermal conductance of pelts, and dive performance and metabolic rate of live animals, and (B) to compare thermal conductance of fur-bearing and non-fur-bearing pelts. From authors' summary: "The study has shown that small amounts of crude oil have large effects on thermal conductance of fur-bearing pelts, and no effect on nonfur-bearing pelts. [Oiled pelts tested were those of sea otter, bearded seal, Weddell seal, California sea lion, and northern fur seal.] In living animals [northern fur seals] light oiling of approximately 30% of the pelt surface area resulted in a 1.5-fold increase in metabolic rate while immersed in water of various temperatures. Furthermore, this effect lasted at least 2 weeks. Although normal diving was measured we did not obtain post-oiling data to show the effect of oil contact on dive performance. .... That death would inevitably follow such contact cannot be verified with the present effort; however, considering that (a) oiled animals have greatly increased maintenance costs, and (b) they are extremely reluctant to enter sea water (where their food is found), it is clear that the health of oiled animals would be in serious jeopardy." Light crude oils may be invisible on animals, so that attempts to wash fouled animals will be made ineffective. 5 tab., 3 fig., 16 ref.

Kooyman, G.L., R.L. Gentry, and D.L. Urquhart.
1976. Northern fur seal diving behavior: a new approach to its study. Science 193(4251):411-412.

Authors' abstract: "A new type of depth-time recorder was used to monitor behavior of fur seals at sea. During 608 hours, 2957 dives were recorded for four animals. The deepest dive was 190 meters, and the longest submersion was 5.6 minutes." 10 ref.

Kosygin, G.M.

1966a. Nekotorye materialy po pitaniyu lakhtaka v Beringovom more v vesenne-letnii period (Certain materials on the feeding of the bearded seal in the Bering Sea during the spring-summer period). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:153-157. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 78-82 in K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

In spring-summer of 1963, 37 adult bearded seal stomachs were collected during sealing. (Figure shows distribution of 75 bearded seals killed from Gulf of Anadyr to northwest Bristol Bay by squares of approximately 1^{o} Long. x 1^{o} Lat.) Knowledge of distribution of benthic species and knowledge of bearded seal feeding is reviewed. Stomach contents examined are discussed and tabulated. Decapods, gastropods and polychaetes predominated. 9 ref.

1966b. Raspredelenie i nekotorye cherty biologii lastonogikh Beringova morya - vesenne-letnii period 1963 g. (Distribution and certain biological features of Bering Sea pinnipeds - the spring-summer season of 1963). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:117-124. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 40-49 in K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Describes distribution of ribbon, harbor (Phoca vitulina largha) and bearded seals as observed during sealing in March-June 1962 and 1963. Two figures summarize these findings. Area covered was from western Bristol Bay northwestward to Anadyr Bay. Observations are given relating to the schedule of pupping, shedding of lanugo, and molting for these 3 phocids. Ice conditions are described.

1966c. Raspredelenie lakhtaka v Beringovom more v vesennii period 1962-1964 gg. (The distribution of the bearded seal in the Bering Sea in the spring period of 1962-1964). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:125-128. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 50-53 in K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Information was gathered in the course of hunting cruises, March-June. "Accumulations" were found between St. Lawrence Island, southeast of St. Matthew Island, south of Nunivak Island, and in Anadyr Bay. Notes young animals found, in summer, in region of Karagin Island. Contains two references to ribbon seals. 1 fig.

1971. Pitaniye lakhtaka Erignathus barbatus nauticus (Pallas) v Beringovom more v vesenny-letniy period (Feeding of the bearded seal Erignathus barbatus nauticus (Pallas) in the Bering Sea during the spring-summer period). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 75:144-151. In Russian. (Transl. by Fish. Mar. Serv. [Can.], Ste. Anne de Bellevue, Quebec, Can., 1976, Transl. Ser. 3747, 14 p.)

From March to June 1963-1965, 565 stomachs were collected from bearded seals across the Bering Sea. Crustaceans comprised the bulk of the diet, with snow crabs, visored shrimp and Pandalus spp. figuring prominently. Gastropod mollusks and octopuses were important. Polychaetes were significant only in 1963. Fish appears to be important, but the species vary greatly. Young seals forage in the morning, while mature individuals do so in the afternoon. It appears that the seals eat more in May than in June. 2 tab., 3 fig., 36 ref.

1975. K raspredeleniyu i migratsiyam lastonogikh Beringova i Chukotskogo morei (On the distribution and migration of pinnipedia in the Bering and Okhotsk* Seas). [*"Okhotsk" is a mistranslation; it should read "Chukchi".] P. 115-117 in Papers of the All-Union Conference, Vladivostok, Oct. 1975 - Biologicheskie resursy morei dal′nego vostoka (Biological resources of the Far East seas). Ichthyol. Comm., Min. Fish. USSR, Pac. Ocean Res. Inst. Fish. Oceanogr. [TINRO]. In Russian. (Transl. avail. Natl. Mar. Fish. Serv., Off. Int. Fish., Lang. Serv. Branch, Washington, D.C., 2 p.)

In May and June ribbon seals, predominantly age 5 and older, concentrated 30 to 200 miles east and southeast of Cape Navarin. Harbor [larga?] seals were found in Karaginskii Gulf and in Kolyuchinskaia Bay. Walruses were observed from July to September in western Chukotsk Sea: In September 1973, male groups were found on drifting ice from Cape Serdtse-Kamen′ to Cape Shmidt, while two groups including females and young were found south of Wrangel Island. In July 1973 on Rudder sand bar (Gulf of Anadyr), number of walrus was calculated at 5,000, and in September 1973 1500-2000 walrus were hauled out here plus many in the water. Ringed seals were seen by the thousands in June 1973 in Krest Bay (Gulf of Anadyr). Bearded seals were found in the western Bering Sea not only in the northern area and in Karaginskii Gulf as usual but also in Peter and Paul Bay (approx. 61°N). Passive migration on drifting ice by walrus and bearded seal in the Bering Sea is discussed.

Krogman, Bruce.
1977. Six bowhead whales in the arctic. Alaska 43(9):52-53.

Extraordinary photograph taken in early May 1977, 17 miles east of Pt. Barrow, shows whales engaged in reproductive activity, with penis of male extruded and highly visible.

Krogman, Bruce D., Howard W. Braham, Ronald M. Sonntag, and Richard G. Punsly.
1978. Seasonal distribution and abundance of the Pacific walrus (Odobenus rosmarus). Unpubl. manuscr., 47 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

[Submitted as the Final Report for subcontract R7120804, Research Unit 14, Outer Continental Shelf Environmental Assessment Program, sponsored by the Dep. Inter., Bur. Land Manage.] Fay′s (1957) historical analysis is summarized, describing distribution and abundance. Authors′ research is described. [Remainder of annotation is derived from "conclusions".] "From October to December southward migration occurs from the Chukchi Sea through the Bering Strait and into the Bering Sea. Walrus pass across the outer Kotzebue Basin as the ice front advances south. Much of the population reaches the St. Lawrence Island vicinity as early as late October and most of the population arrives by late December (Burns et al., 1977). During its southward movement through the Bering Strait large aggregations of walrus occur on hauling out areas in the Soviet sector.... During the December to March period a large proportion of the population is distributed in the St. Lawrence Island vicinity mainly to the west and more southwest and north than has occurred in the recent past. Results of this study are consistent with Burns et al. (1977) findings that few walrus occur in the Gulf of Anadyr, Norton Sound, or in the area north of Nunivak Island." Potential harm to this walrus population is assessed (with particular regard to oil lease site development): Walruses may be most vulnerable to harm through harm to the food supply on their winter range. Also, increased traffic of barges, tankers and aircraft may increase mortality of calves in the April-June period when the population is greatly confined in northward migration toward and through Bering Strait. 6 tab., 16 fig., 58 ref.

Krylov, V.I.

1962. Tempy razmnozheniya tikhookeanskogo morzha (Rate of reproduction of the Pacific walrus). Zool. Zhur. 41(1):116-120. In Russian. (Transl. by F.H. Fay, Univ. Alaska, College, Alaska, 12 p.)

Data were gathered from 600 walruses in July-October of 1960 in the Wrangel Island area. Pupping begins in April and ends in early June, copulation occurs immediately after birth. The greatest number of females bear young once every 3-4 years. Young individuals breed nearly twice as often as older females. The pregnancy rate is 18.8%. 2 tab.

1966. Vozrastnoi i polovoi sostav, plotnost′ zaleganiya tikhookeanskogo morzha na l′dakh i beregovykh lezhbishchakh (The age and sex composition and the density of the Pacific walrus on ice and shore hauling-out places). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:97-103. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 19-26 _in_ K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Observations were made from late July to September 1960. Walrus density on 92 ice grounds, mostly in the vicinity of Wrangel Island, was uneven and depended on the state of the ice surface as well as sex and age composition of animals. Three types of groups were found in this area: (1) sexually mature males with immature animals, (2) females with offspring, immature animals, and a few sexually mature males, and (3) old barren females and old males with a few young animals. Average density on ice grounds was 3.4 m^2 per animal. On 27 shore grounds, mostly at Rudder and Inchoun, walrus density tended to be lower when further from the water. Only males were found in these areas, and average density was 3.3 m^2 per animal. Highest density was found on hauling grounds occupied by females with young. Further detail on age of animals is given. 3 tab., 3 fig., 4 ref.

1968. O sovremennom sostoyanii zapasov tikhookeanskogo morzha i perspektivakh ikh ratsional′nogo ispol′zovaniya (Present condition of the Pacific walrus stocks and prospects of their rational exploitation). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 68 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 62):189-204. In Russian. (Transl. by Israel Program Sci. Transl., 1971, p. 185-200 in V.A. Arsen′ev and K.I. Panin (eds.), Pinnipeds of the North Pacific, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 70-54020.)

From aerial surveys of the western Chukchi Sea and Wrangel Island area in 1961, 30,000 walruses were counted. By 28 May, most had passed through the Bering Strait. Assuming over half the population travels on the western side of the Bering Strait, total population is estimated at 50,000. Of this, 70% are mature. Sex ratio is 1:1. Birth rate is calculated to be 11.2%. This is compensated for by a low natural mortality. It is suggested that the annual take be kept at 6%. 10 tab., 2 fig., 26 ref.

1971. O pitanii tikhookeanskogo morzha (Odobenus rosmarus divergens Ill.) [The feeding of the Pacific walrus (Odobenus rosmarus divergens Ill.)]. Tr. Atlant. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (AtlantNIRO) 39:110-116. In Russian. (Transl. by Fish. Mar. Serv. [Can.], Ste. Anne de Bellevue, P.Q. [Can.], 1974, p. 177-189 in K.K. Chapskii and (ed.) E.S. Mil′chenko, Research on marine mammals, Transl. Ser. 3185.)

Material was collected by author in 1960-1963 from the region of Wrangel Island. Out of 650 stomachs, 32 contained food in a state permitting determination of its composition. Contents of these 32 stomachs are tabulated. Mollusks predominated, followed by worms, ascidians, crustaceans, and fish. Existing literature is reviewed, including discussion of carnivorous walruses. Selective feeding related to sex and age of walruses was noted. 1 tab., 26 ref.

Kuzin, A.E.

1975. Sovremennoe sostoianie i perspektivy rosta populiatsii kotikov kuril′skikh ostrovov (Contemporary state and prospects for the growth of the Kuril Island fur seal population). Promysl. Ikhtiol. (7), Ref. Inf., Ser. 1, Min. Rybn. Khoz. SSSR: 15-16. In Russian. (Transl. avail. Natl. Mar. Fish. Serv., Off. Int. Fish., Lang. Serv. Branch, Washington, D.C., 2 p.)

Fur seals are found only on the Kamennye Lovushki and Srednego Islands, whereas in the 19th century they were found on nine islands in the Kuril archipelago. Total Kuril population was 24,482 (1,189 mature males, 12,277 females and 11,016 pups) in 1974. Three sites are mentioned as hauling-out grounds for both sea lions and fur seals. The two species get along well and numbers of fur seals continue to grow. Well-defined bachelor grounds are absent. Careful conservation is advised so that all former hauling grounds can be re-occupied.

Kuzin, A.E., M.K. Manimov, and A.S. Perlov.
1973. Dinamika chislennosti i perspektivy rosta stada morskikh kotikov na Kuril'skikh ostrovakh (Population dynamics and trends in the growth of a herd of fur seals on the Kurile Islands). Akad. Nauk SSSR, Ekologiya, No. 4:63-67. In Russian. (Transl. by Israel Program Sci. Transl., 1975, 7 p., avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 75-50064.)

Dramatic increases in Kurile Island fur seals have been observed since 1956. In the 1870's, 15,000 fur seals were counted on Raikoka Island, which was then the largest concentration in the Kurile Islands. No seals are found there now. However, they are found on several rocks in the Kamennye Lovushki and Srednev Islands, where counts totalled about 8,000 adults and 4,000 pups in 1971. From tagged seals caught, it appears that the majority of immigrants to the Kurile Islands come from the Pribilof Islands herd, though all of the major rookeries are represented. Increases are expected at various sites. At certain sites sea lions have decreased while fur seals have increased. Their hauling grounds are sometimes shared. 3 tab.

Kuz'min, A.A., and A.A. Berzin.
1975. Raspredelenie i sovremennoe sostoianie chislennosti gladkikh i serykh kotov v dal'nevostochnykh moriakh (Distribution and current numbers of right and gray whales in the far-east seas). P. 121-122 in Papers of the All-Union Conference, Oct. 1975, Vladivostok - Biologicheskie resursy morei dal'nego vostoka (Biological resources of the far-east seas). Ichthyol. Comm., Min. Fish. USSR, Pac. Ocean Res. Inst. Fish. Oceanogr. [TINRO]. In Russian. (Transl. avail. Natl. Mar. Fish. Serv., Off. Int. Fish., Lang. Serv. Branch, Washington, D.C., 2 p.)

Cruises were conducted August to October 1974. Greenland right whales in the Okhotsk Sea were concentrated near the Shantar Islands in areas of shore effluence. These whales apparently give birth from May to mid-July. Pacific right whales were found in an area of powerful rising movement of the water, northeastward from the Kashaverov shoal (40-45 whales). Only one gray whale was seen in the Okhotsk Sea (where four were seen in 1967). Two Greenland right whales were seen in the Bering Strait October 24, and three in the southern Chukchi Sea. From September to October gray whales were seen in the Bering and Chukchi Seas. Densest concentrations of gray whales were in the Gulfs of Anadyr and Mechigmen, in the widest opening of Laurentiya Gulf, and in the Chukchi Sea. Mass departure of gray whales from the Chukchi Sea occurs in mid-October. Total number of gray whales in Soviet waters is estimated to be 1,800-2,000. All whales were found in water with surface salinity of less than 30%. Gray whales confine themselves to shoal waters where wind agitation penetrates to the bottom, and where oxygenation is about 50%.

Lander. R.H.
1975. Method of determining natural mortality in the northern fur seal (Callorhinus ursinus) from known pups and kill by age and sex. J. Fish. Res. Board Can. 32(12)·2447-2452.

From known values of the number of northern fur seals born in a given year and the commercial kill of older animals by age and sex, a method is given for approximating natural mortality or survival (1) between times of birth and the first kill and (2) during the successive ages of kill. Applications of the present method to the 1961-1966 year classes of males indicate natural survival of 31-42% during ages 0-2 years and 84-89% annually during ages 2-5 years. [Author's abstract in part.]

Lander. R.H., and H. Kajimura.
In press. Status of northern fur seals [FAO ACMRR/MM/SC/34]. In Mammals in the seas, FAO [Food Agric. Org., U.N.] Fish. Ser. No. 5. Vol. 2, 50 p. [This volume will consist of documents of the Food Agric. Org. U.N., Advis. Comm. Mar. Resour. Res., Working Party on Mar. Mammals, from the Sci. Consultation on Mar. Mammals, Bergen, Norway. 31 Aug. - 9 Sep. 1976.]

Population on the Pribilof Islands given as 1,300,000. Birth, mortality and harvesting rates given with trends in abundance. Fur seals, considered opportunistic feeders, feed on fish over the continental shelf and squid beyond the shelf edge. The principal foods in Alaskan waters are capelin pollack. mackerel, sand lance and various squid (mostly deep water varieties).

Leatherwood, J.S., W.E. Evans, and D.W. Rice.
1972. The whales, dolphins, and porpoises of the eastern North Pacific -- a guide to their identification in the water. Nav. Undersea Res. and Develop. Cent., San Diego. Calif., 184 p.

Thirty cetaceans found in the North Pacific are grouped into 6 categories based on size and presence of dorsal fin. Members of each category are listed giving distinctive characteristics. (Drawings of surfacing and diving silhouettes are given for large whales.) Each species is then described in more detail (giving distribution, feeding), is shown at sea in photos, and is compared and contrasted with other animals with which it may be confused. Tags and marking methods currently in use are discussed and pictured. Sighting report forms are provided. 102 fig. + 6 app. fig., 11 ref.

Leatherwood. Stephen. and Randall Reeves.
1978. Porpoises and dolphins. P. 96-111 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle Wash.

[See Haley. 1978a.]

Lensink, Calvin J.
1960. Status and distribution of sea otters in Alaska. J. Mammal. 41(2):172-182.

A detailed report and review of census efforts from Cook Inlet to Amchitka Island from 1936 to 1957. "The present status of the otter is such that we can expect a rapid expansion in numbers from the Andreanof Islands eastward. West of the Andreanof Islands the habitat is limited and the population may already be near the carrying capacity. Here, sea otters are perhaps as abundant as they were before exploitation by the Soviets. On Amchitka Island the evidence indicates that a high population has resulted in increased mortality and a lowered reproductive rate." Estimates present Alaska population at 40,000. 1 fig. (map)

Lentfer, Jack W.
1970. Polar bear - sea ice relationships. P. 165-171 in Bears - their biology and management, publ. by Int. Union Conserv. Nat. Nat. Resour., Morges, Switz., New Series 23.

Sections: introduction; characteristics and movements of sea ice; polar bear distribution in relation to type of ice; harvest; denning related to ice movements and climate; discreteness of polar bear populations; influence of human activity. 2 fig., 12 ref.

1971. Polar bear movements as determined by mark and recovery. Science in Alaska. Proc. 22nd Alaska Sci. Conf., College, August 17-19, 1971, p. 133. [Abstr. only.]

Mark and recovery data from tagging of 283 bears as well as skull and body size, suggest that there are 2 discrete populations in Alaska. One population is to the west and one is to the north of Pt. Barrow. Bears sometimes appear to maintain their position relative to land, moving against ice drift.

1973. Occurrence of a northern fur seal near Wainwright, Alaska. Can. Field-Nat. 87(1):60.

A female northern fur seal was killed in early September 1969, 65km southwest of Wainwright, Alaska, at approximately 70°16'N, 161°42'W. Four other fur seal records from arctic coasts are reviewed: (1) Point Barrow, Alaska, in mid-August, (2) a Yukon Territory lake on 1 October, (3) near Letty Harbour, Northwest Territories, in mid-October, and (4) near Bathurst Inlet.

1974. Discreteness of Alaskan polar bear populations. Int. Congr. Game Biol. [Stockholm, Sweden, 1973] 11:323-329.

From author's abstract: "Recoveries of marked animals, differences in body and skull sizes, and differences in mercury levels thus indicate that bears to the west of Alaska and bears to the north of Alaska occur as partially discrete geographically isolated populations with only a limited amount of movement between them." 4 fig.

1975. Polar bear denning on drifting sea ice J. Mammal. 56(3):716-717.

Describes polar bear den found 168 km northwest of Pt. Barrow on drifting multiyear ice. Suggests that return of females to previously used dens minimizes interchange between populations· denning on drifting ice could increase the interchange. Bears may be forced to den on drift ice in the Barrow region due to human activity associated with oil development.

1978. Polar bear. P. 218-225 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Lentfer J.W.. J.R. Blum, S.N. Eide, and L.N. Miller.
1967. Report on 1966 bear studies. Alaska Dep. Fish Game, Div. Game, Fed. Aid Wildl. Restoration. Annu. Proj. Seg. Rep.. Vol. 8, 54 p.

[Only polar bear section is annotated.] Data from 399 bears taken in sport kills from July 1965 to June 1966. are presented. Skull and hide measurements as well as ovary and testis samples were taken from the harvested bears. Aerial surveys were conducted in late April. Of the 1,090 bears seen by airplane hunting guides in 1966. 33% were young. Bears are more numerous in lead areas, particularly those covered by young ice and bordered by rough, broken ice. Correlation was noted between the number of seals and seal holes, and the number of bears. No population estimate given. Section includes 7 tab., 1 fig.

Loeb, Valerie Jean.
1972. A study of the distribution and feeding habits of the Dall porpoise in Monterey Bay, California. M.A. Thesis, San Jose State Coll., San Jose Calif.. 62 p.

Previous literature on distribution, feeding, reproduction. and behavior is reviewed. Study period was from March 1970 through December 1971. Forty-six cruises were made for observation and collection of porpoises. Twenty-one animals were collected, and 10 beach-cast specimens were examined. Animals were found mostly in waters over the 100 fathom contour of the Monterey submarine canyon. Largest numbers and largest group sizes were found in January and July. Group size ranged from 2 to 50, most being 6 or less. Interactions with boats, breakaway stocking net, fin whale. and dolphins (Lagenorhynchus obliquidens) are described. Probable intraspecific agonistic behavior was observed. Variant coloration was noted. Food consisted mainly of hake, juvenile rockfish, and squid. Parturition occurred primarily in May and June. Sight records and length/weight of specimens are tabulated in appendices. 6 tab., 7 fig.. 27 ref.

Loken, Marty.
1977. 1977 - last year for bowhead-whale hunting? Alaska 43(9):11.

Outlines development of bowhead controversy from federal and international viewpoints, quoting liberally from William Aron, U.S. Commissioner to the International Whaling Commission and director of NOAA's Office of Ecology and Environmental Conservation.

Lowry. Lloyd F., Kathryn J. Frost, and John J. Burns.

1977a. Final report of Beaufort Sea activities -- Trophic relationships among ice inhabiting phocid seals. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 391-421. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder Colo.

In Beaufort Sea, only year-round marine mammal residents are ringed seal, bearded seal. and polar bear. Summer residents include spotted (larga) seal, walrus, beluga whale, and bowhead whale. Stomachs were collected from 21 ringed seals and 3 bearded seals, almost all from western Beaufort Sea. Ringed seal foods: primarily nektonic crustaceans, small benthic crustaceans, and small to medium size schooling pelagic fishes. Bearded seal foods: bivalve molluscs, crabs, shrimps and sculpins, plus a variety of other invertebrates and fishes. Foods of these prey species are described, where known. Interactions with other marine mammals: Diet of belukha whales and spotted seals overlaps with that of ringed seals, but foraging is usually separated in time and space; bowhead whales and ringed seals compete for zooplankton; polar bears eat ringed seals and, less often, bearded seals. Productivity and food chain: The bloom of epontic (under-ice) algae in May and June. and that of planktonic algae in August are the two best known sources of primary productivity; probable paths of consumption are outlined. 2 tab., 6 fig., 55 ref.

1977b. Trophic relationships among ice-inhabiting phocid seals. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 303-390. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Study area includes Beaufort, Chukchi and Bering Seas, and is broken down into 4 subareas. Results of this study have been presented in detail in earlier quarterly and annual reports, and are given only in general terms here. Stomach contents have been examined from 218 ringed seals, 110 bearded seals, 26 spotted seals, and 5 ribbon seals. most obtained at coastal seal-hunting native villages. Important prey species of these seals are tabulated by area. Potential effects of petroleum development are discussed. Four translations from the Russian are appended which concern feeding of ribbon and ringed seals, and seals of the east coast of Sakhalin and of the Okhotsk Sea. 21 tab., 5 fig., 54 ref., + app.

1978. Food of ringed seals and bowhead whales near Point Barrow, Alaska. Can. Field-Nat. 92(1):67-70.

Stomach samples were collected from 16 ringed seals and 2 bowhead whales taken in the vicinity of Point Barrow. Euphausiids (Thysanoessa inermis and T. raschii) made up over 3/4 of total combined volume of samples from ringed seal stomachs. Euphausiids (all identifiable material was T. raschii) made up 90.3% of total combined volume of samples from bowhead stomachs. In the northern portion of their range these two species show broad dietary overlap. In general, however, ringed seals utilize many species of fishes and crustaceans, while bowhead whales depend mostly on swarms of small to medium-sized zooplankton. (Previous literature concerning food and feeding of both species' is reviewed.) Extreme year-to-year variability in ice cover in the Beaufort Sea causes fluctuations in primary productivity. Consequences upon the higher trophic levels are considered. There is urgent need for data on the trophic interaction of major components of the arctic ecosystem since drastic environmental modifications such as offshore oil drilling are imminent. Questions about the ecological context of bowhead decline and possibility of recovery are raised. 1 tab., 17 ref.

In press. Potential competition in southeastern Bering Sea: Fisheries and phocid seals. Science in Alaska, Proc. 29th Alaska Science Conf., Fairbanks, Alaska, August 15-17, 1978, 15 p.

From authors' abstract "Harbor seals in the southeastern Bering Sea eat a variety of fishes, shrimps and octopus. In general the same is true for spotted and ribbon seals. Capelin are a dominant prey item in the diet of spotted seals. Pollock are the major food of ribbon seals. The prey of ringed seals in this region is poorly known. However, fishes, shrimps and zooplankton are all eaten. Bearded seals are benthic feeders eating mostly tanner crabs, spider crabs, and shrimps. Fishes and crustaceans of present or potential commercial value which are also major food items of these seals in southeastern Bering Sea include pollock, capelin, smelt, herring, various flat-fishes, tanner crabs, and pandalid shrimps." A balanced systems management approach for these marine mammal and fishery resources will be possible only when conflicts arising between the Marine Mammal Protection Act and the Fisheries Conservation and Management Act are resolved. 4 tab., 46 ref.

MacAskie, I.B.
1969. Report on Canadian pelagic fur seal research in 1969. Unpubl. manuscr., 35 p. Pac. Biol. Stn., Fish. Mar. Serv., P.O. Box 100, Nanaimo, B.C. V9R 5K6, Can.

(See Pike et al. 1958.) In April and May seals were hunted off southwestern Vancouver Island and Washington State and three cruises were made toward Cobb Seamount (located at 46°45'N, 130°50'W). Pituitary glands and tissue samples for DDT analysis were collected. 9 tab., 4 fig.

1970. Report on Canadian pelagic fur seal research in 1970. Unpubl. manuscr., 16 p. Pac. Biol. Stn.. Fish. Mar. Serv., P.O. Box 100, Nanaimo, B.C. V9R 5K6, Can.

(See Pike, Spalding, et al. 1958.) Seals were hunted from January to March off southwestern Vancouver Island (La Perouse Banks), and Washington State with a trip to Cobb Seamount. Pituitary glands and tissue samples for DDT analysis were again collected. 8 tab., 4 fig.

Machida. Masaaki.
1969. Parasites of the northern fur seal and their relationship to the breeding islands. Proc. Jpn. Soc. Syst. Zool., No. 5, p. 16-17. In Japanese with English summary.

Fur seals were taken off northern Japan and their parasites are listed. The only apparent differences among seals from the Pribilof, Commander, and Kurile Islands were in the occurrence of Unicaria lucasi. The precise nature of these differences is not included in the English summary.

1971. Survey on gastric nematodes of the northern fur seal on breeding islands. Jpn. J. Parasitol. 20(5):371-378. In Japanese with English abstract.

A survey was made on three islands: Robben. Bering (Commander Islands) and St. Paul (Pribilof Islands). These results and those of a previous study of fur seals caught near Sanriku (Pacific coast of northern Japan), are discussed. Infestation was found much higher in the more southern waters for several reasons. Though Delyamure (1955) described definite geographic distributions for each helminth, it was found that helminth infestation could not be used to identify the origin of seals because of intermixing of herds both on land and at sea.

Machida. Saburo.
1970. A sword-fish sword found from a North Pacific sei whale. Sci Rep. Whales Res. Inst. 22:163-164.

Sei whale was taken at 50°52′N, 169°12′W. Sword was enclosed in musculature of whale. Previous literature is reviewed (5 articles).

Maher. W.J.
1960. Recent records of the California grey whale (Eschrichtius glaucus) along the north coast of Alaska. Arctic 13:257-265.

Observations made during the summers of 1953 to 1959, coupled with information from Eskimos, show that grey whales can be found in arctic waters. Over years 1955-59 (on dates ranging from 18 July to 13 Sept.), nine grey whales were taken at Barrow, one at Wainwright. Knowledge of northern summer grounds is briefly reviewed. They are commonly seen in summer from Pt. Barrow to Icy Cape. but rarely east of Barrow. Migration appears to begin in August although some animals were in the Barrow vicinity in mid-September 1959. 1 tab., 2 fig.. 14 ref.

Maher. W.J., and N.J. Wilimovsky.
1963. Annual catch of bowhead whales by Eskimos at Pt. Barrow Alaska, 1928-1960. J. Mammal. 44(1):16-20.

The number of bowheads taken averages 5.8 whales per year. The early migrants are small and appear in early April off Barrow. Migration is thought to continue to June. Exact dates are unknown. Whales migrating south in the fall are first seen in mid- to late August.

Mansfield, A.W.
1970. Population dynamics and exploitation of some arctic seals. P. 429-466 in M W. Holgate (ed.), Antarctic ecology, Academic Press. London.

Article gives the life history of the harp and ringed seals. Population assessments made for the eastern Canadian arctic. Sustainable yields offered.

1971. Occurrence of the bowhead or Greenland right whale (Balaena mysticetus) in Canadian arctic waters. J. Fish. Res. Board Can. 28(12)·1873-1875.

Chart shows former known whaling grounds, and current distribution in Canadian arctic waters as reported in Annual Game reports from arctic detachments of Canadian Mounted Police, by ice observers. by other personnel aboard government ships and aircraft, and by pilots of light aircraft. Range of western Canadian arctic sightings extends through Amundsen Gulf to Coronation Gulf. Here herds of 20-30 bowheads have been seen and as many as 100 individuals have been sighted in one season. 2 fig.. 6 ref.

Marine Mammal Biological Laboratory.
1969. Fur seal investigations, 1966. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 584, 123 p.

Pribilof Is. harvest: 52,497 males, 391 females. Malnutrition, hookworm disease, infections and bite wounds were major causes of death among pups. Pups tagged in September seemed to have survived better than those tagged in mid-August. Number of pups born decreased steadily from 1960 to 1964. Pup nutrition and fur seal milk were studied. Implantation chambers appeared in adult female genital tracts on 4 November. Age determination process, using canine teeth, was tested.

Pelagic research conducted off central and southern California from 21 January to 25 March found seals most numerous near abrupt changes of depth. Of 444 seals collected, 428 were females, half of which were gravid. Stomach contents are reviewed.

1970a. Fur seal investigations, 1967. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 597, 104 p.

Pribilof Is. harvest: 55,720 males, 10,471 females. Information from Pribilof studies includes: counts of adult males; causes of death among pups· differing weights of pups depending on their rookery origin; tagging and freeze-branding of pups; recovery of U.S. and Soviet tags; population estimates for pups and young males for past years; feeding of captive pups; past and present predicted kills; counts of adult males, and reproductive information on females.

Pelagic activities included: collection of 131 fur seals, mostly off Cape Flattery and La Perouse Bank. Washington, in January and February; analysis of stomach contents, which included shrimp for the first time; distribution studies in the eastern Aleutian Islands area from 20 November to 4 December· observation of Japanese pelagic research, and study of pup feeding on rookery.

1970b. Fur seal investigations, 1968. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-617, 125 p.

Field investigations in 1968 were made on the Pribilof Islands from June to October, in Washington waters in November-December 1967 and January-February 1968, and in Alaska waters from May to August 1968. Pribilof Is. harvest: 45,625 males, 13,335 females. Collected at sea: 374 seals off Washington, 456 off Alaska. Report includes: causes of death among pups; counts of dead seals; weights; tagging and marking by removal of parts of flippers and results of same; counts of adult males; pregnancy rates; estimates of the number of yearling males for several year classes; two methods of estimating populations; predicted kills; attaching of transmitters to 10 seals, and age determination of males killed.

1971a. Fur seal investigations. 1969. U.S. Dep. Commer.. NOAA Tech. Rep. NMFS SSRF-628, 90 p.

Field investigations of the fur seal in 1969 were conducted on the Pribilof Islands from June to October, and in the eastern North Pacific off the State of Washington in February and March. The kill included 38.678 males and 230 females. Information includes: adult male counts; dead seal counts, pup weights; marking and tagging results; estimates of pups born in 1966 and 1969; forecasted kills; transmitters attached to young males; weights of bacula and testes; organochlorine pesticides found in tissues of fur seals, sea lions and marine birds; fur seals sighted and/or collected off Washington; pregnancy rates, and prey species.

1971b. Fur seal investigations, 1970. Unpubl. manuscr., 155 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Pribilof Is. harvest: 42,121 males, 120 females. Predicted kill of males had been 53,700. Information given includes: counts of adult males; counts of dead fur seals; causes of death among pups; pup weights; tagging program; pup population estimates for 1966 and 1970; estimates of survival to ages 1 and 2; fur seals sighted and/or collected off Washington; group size at sea; age and reproductive condition of seals collected, and prey species found.

1972. Fur seal investigations, 1971. Unpubl. manuscr.. 132 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Pribilof Is. harvest: 31,795 males. 103 females. Information from Pribilofs includes: counts of adult males· counts of dead fur seals; causes of death among pups: pup weights; marking of pups; pup population estimates. Reports on seals found off Washington in pelagic study. Appendix D concerns fur seal and sea lion observations in western Aleutian area [See Fiscus, 1972a]. 19 fig., 15 tab. + 35 app. tab.

Marine Mammal Division [new name for Marine Mammal Biological Laboratory].
1973. Fur seal investigations, 1972. Unpubl. manuscr., 93 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Pribilof Is. harvest: 37,314 males, 79 females. Activities on the Pribilof Islands included: counts of living adult males; counts of dead fur seals; continuation of marking program, and estimates of past pup populations based on mark-recapture data. Activities in other areas included the discovery of an additional rookery of northern fur seals on Castle Rock, a small rocky islet near San Miguel Island. Counts of the colony at Adams Cove and the one at Castle Rock show a population of over 600 animals. Seals were sighted and collected off Washington. Prey species are reported.

1974. Fur seal investigations, 1973. Unpubl. manuscr., 96 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div.. Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Pribilof Is. harvest: 28,457 males, 25 females. Information from the Pribilof studies includes: counts of adult males; counts of dead seals; marking, and population estimates. Beginning this year on St. George Island no killing was done and observational studies were conducted relating to abundance and distribution, sex ratio, reproduction, survival, behavior and activity patterns. Northern sea lions were observed attacking fur seal pups. At San Miguel Island, off southern California, an observational study begun in 1969 was continued. Two rookeries, one on the main island and the other on a small islet nearby, accounted for at least 261 pups born in 1973. Pelagic collection of 675 seals (of 1,765 sighted) was conducted within a 20 to 100 mile radius of the Pribilof Islands.

1975a. Birds and mammals observed at sea 1958-1974. Unpubl. data listing. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

A compilation of marine mammal sightings made during pelagic fur seal research cruises, concerning 25 different species. Sightings of each species are broken down by geographical area (e.g., Gulf of Alaska, Bering Sea). Location is given for each sighting.

1975b. Fur seal investigations, 1974. Unpubl. manuscr., 125 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Pribilof Is. harvest: 32,976 males, +51 females. Pribilof Islands research included: age determination of some killed males, counts of dead seals, and marking. A new method of estimating natural survival rates was developed. Natural survival rate from birth to age 2 appears significantly lower than in 1929-1933. Causes of death of pups were studied. The second year of behavior research was conducted on St. George Island. There, 27 females were radio-tagged, and sea lions were again seen preying on fur seal pups - 86 kills were observed. Off California, at San Miguel Island fur seal rookeries, influx of Pribilof Island and other northern fur seals continued. Pelagic research involved collection of 323 female and 53 male seals in the vicinity of the Pribilof Islands in the Bering Sea to obtain age-specific pregnancy and ovulation rates of females and to study feeding. Walleye pollock was the predominant prey species found.

1976. Fur seal investigations, 1975. Unpubl. manuscr., 115 p. Northwest and Alaska Fish. Cent., Mar. Mammal Div., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Pribilof Islands: Age was determined for 20% of 29.093 male fur seals harvested. The 55 females unintentionally killed were not examined; dead seals were counted; marking was done; an experiment to determine the abundance of subadult males on St. George Island was attempted; causes of pup death were studied. Estimations of pups born in 1967-68 and 1972-74 are explained in detail; homing to island of origin is discussed. St. George Island: The third year of observational research involved investigation of female feeding cycles, female estrus cycle, pup predation by northern sea lions, behavior of fur seals at sea, onshore-offshore movements of subadult males, and female/male interactions. Techniques included bleach-marking, radio tagging and the attachment of depth-time recorders to 5 lactating females, as well as visual observation. San Miguel Island and Castle Rock: the pup count showed 725 pups, a 39% increase over 1974· nocturnal behavior and vocal activity were investigated. Pelagic study· Data collected during cruises 1958-1974 were compiled and preliminary analysis made with emphasis on consumption of walleye pollock.

1977. Fur seal investigations, 1976. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin.. Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div. Seattle, Wash., Processed Rep., 92 p.

Population assessment, Pribilof Islands. Commercial harvest consisted of 23,081 male seals taken on St. Paul Island. Size limit of 47" was imposed. Two hundred male seals were killed for native subsistence on St. George Island. Marked animals recovered during harvest included 3 animals tagged on Bering Island (Commander Islands). Number of pups born on St. Paul Island is estimated at 291,000. Natural survival rates of male fur seals from birth to age 5 are estimated. Alternative harvesting strategies discussed. Counts were made on both islands. Physiology and medicine. Medical staff examined dead pups (main causes of death

were hookworm disease and emaciation syndrome), did bacteriological, immunological, virological, and thermoregulation studies. Behavior and biology, Pribilof Islands. Stages and duration of estrus, management-caused disturbances (possible disruption of mother-young suckling cycle), female feeding cycles (a 12-year comparison), and the effects of oil pollution were subjects of study on St. George Island. Population growth and behavior - San Miguel Island (Adams Cove and Castle Rock). In Adams Cove, female population was estimated at 1200; 417 pups were born. Research included tagging, investigation of pup mortality (heat prostration due to unusually high temperatures took 41 lives). general activity patterns, vocalization, reproduction, and activity as related to light intensity. On Castle Rock, 18 territorial males, 516 adult females, and 521 pups (including 27 dead) were counted; pups were tagged. Pelagic ecosystem. Analysis of data gathered pelagically by U.S. and Canadian scientists 1958-74 continued, correlating age, sex, location, and feeding habits. 13 tab. (+20 app. tab.), 10 fig.

1978. Fur seal investigations, 1977. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 94 p.

Population assessment - Pribilof Islands. On St. Paul Island, 28,396 males of maximum length 47" (and 48 females killed unintentionally) were taken in commercial harvest. On St. George Island, 350 males were taken for local subsistence. Age breakdown is given of males harvested 1963-75. Counts were made of adult males (expected increase on both islands found), dead pups, dead older seals, and of pups born. Twelve seals tagged on the Commander Islands were recovered in harvest. Behavior and biology - Pribilof Islands. Increase of adult males and decrease of adult females on St. George Island are discussed. Site fidelity in pups and in mothers was studied. Physiology and medicine. On St. Paul Island, studies were done in pathology, virology, bacteriology, immunology, parasitology, and physiology. On St. George Island, pup mortality was studied. Population growth - San Miguel Island. In Adams Cove, 681 females were counted and 421 pups born. Of 64 pups that died on land, 54 died during abnormally hot periods. Tagging records discussed. At Castle Rock, 617 pups were counted. Pelagic ecosystem. Studies of distribution, migration, growth/age, and feeding have been begun, using data and specimens collected pelagically by U.S. and Canadian scientists 1958-74. 9 tab (+25 in app.), 10 fig. (+5 in app.).

Marquette, Willman M.

1976. Bowhead whale field studies in Alaska, 1975. MFR Paper 1195. Mar. Fish. Rev. 38(8):9-17.

In spring 1975 bowhead whaling activities occurred at these villages for the time periods indicated: Gambell and Savoonga (St. Lawrence Is.) --25 April to 30 May; Kivalina --similar to Point Hope; Point Hope --19 April to 1 June; Wainwright --similar to Barrow; Barrow --21 April to 4 June. Fifteen bowheads were caught (1 at Gambell, 4 at Point Hope, and 10 at Barrow); 2 were killed but lost (1 at Gambell, 1 at Barrow); and 26 were struck but lost (3 at Gambell, 13 at Point Hope, and 10 at Barrow). (No bowheads were taken in autumn in the autumn whaling locations, Barrow, Nuiqsut. and Kaktovik.) Length and sex of bowheads caught, and sightings of 132 bowheads at Point Hope and 63 at Barrow between April 20 and May 31 are tabulated. Whaling methods, whaling effort, utilization, migration, and other mammals and birds are discussed. Bowhead migration: "Three distinct runs of the bowhead occurred at Point Hope in the spring of 1974. In 1975, only two runs were noted, probably because during late May several open leads existed far offshore from Point Hope, within which the whales may have traveled instead of migrating through the nearshore lead. The first run occurred 20-30 April and the second 10-17 May. Two distinct runs were all that were observed at Barrow this spring, but as at Point Hope additional runs could have moved through large open leads far offshore." Belukha migration: "Although belukha were occasionally observed from 30 April to 1 June, three noticeable waves of these animals migrated past Point Hope whaling camps - the first prior to 30 April, the second 10-15 May, and a third from 22 to 26 May." Marine mammals taken at Point Hope in spring were: 13 belukha (244 sighted), 17 ringed seals, 1 walrus, and 3 polar bears; 2 bearded seals were seen. Marine mammals taken at Barrow in spring were: 17 ringed seals and 1 polar bear. 9 tab., 1 map, 12 photos, 6 ref.

1977. The 1976 catch of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos, with a review of the fishery, 1973-1976, and a biological summary of the species. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Cent., Mar. Mammal Div., Seattle, Wash., Processed Rep., 79 p. +app.

Pt. I. The 1976 catch (25 p.): A total of 48 bowhead whales were butchered in spring and fall 1976 at nine different villages; at least 43 were struck and lost.
Pt. II. Review and biological summary (62 p.): Author discusses legal status of the bowhead whale, history of fishery, breakdown of recent fishery statistics, biological specimens obtained (including stomachs), measurements, reproduction and growth, abundance, historical catch, sightings, counts, current population estimates (ranging from high 100's to 1,000 - 3,000), recent increase in Eskimo harvest, and future research. 29 tab., 12 fig.. 65 ref.

1978. Bowhead whale. P. 70-81 *in* Delphine Haley (ed.). Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press. Seattle, Wash.

[See Haley, 1978a.]

In press. The 1977 catch of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos [SC/30/Doc. 35]. Rep. Int. Whaling Comm. 29. 26 p.

Residents of Gambell and Savoonga (both on St. Lawrence Island), Wales, Kivalina, Pt. Hope, Wainwright, and Barrow engaged in spring whaling. Twenty-six bowhead whales were killed and recovered, 3 were killed and lost, and 79 were struck and lost. Residents of Barrow, Nuiqsut, and Kaktovik killed and recovered 3 bowhead whales in the autumn hunt. Stomach contents of one whale consisted mainly of copepods. Biological samples collected are reported. Fifty-two belukha whales were taken by residents of Point Hope, with 3 killed but lost. Two belukha whales were taken by residents of Barrow, with 4 killed and lost. Other marine mammals taken at Barrow were: one bearded seal, 3 ringed seals, 6 polar bears and one walrus, with one bearded seal killed but lost. 9 tab., 1 fig., 6 ref.

Masaki, Yasuaki.
1976. Biological studies on the North Pacific sei whale. Bull. Far Seas Fish. Res. Lab. [Jpn.], No. 14, Dec. 1976. 104 p.

Study was done with intention of clarifying life history and discriminating stocks of sei whales in North Pacific. Adult female reproductive cycle: conception in late December· gestation lasting 10-1/2 months; lactation lasting 7 months; resting period lasting 6-1/2 months. Sex ratio among single births approx. 1:1, rate of twinning 0.52%. Length at sexual maturity: 13.4m for females, 12.9m for males. Length at physical maturity: 15.2m for females, 14.3m for males. Mature testis weight .9kg. Age at sexual maturity: 7 years for both sexes. Ovulation rate: Different calculation methods yield rates of from 1.00 to 0.30; reasonable mean annual rate 0.604. Data from whale marking, whale sighting, and specimen data from catch show three different migration and movement patterns in waters (1) west of 180^{o}, (2) between 180^{o} and 160^{o}W, and (3) east of 160^{o}W. Migration is northward in spring and southward in autumn, with discernible segregation by sex and age. Three separate stocks with borders of 175^{o}W and 155^{o}W are identified using whale marking, catch distribution, whale sighting and shape of baleen plates. 12 tab., 72 fig., 121 ref., 1 pl.

Mathisen, Ole A.
1959. Studies on Steller sea lion (Eumetopias jubata) in Alaska. Trans. 24th North Am. Wildl. Conf.:346-356. Wildl. Manage. Inst., Washington, D.C.

Sea lions were studied with special reference to salmon predation. Film types used in aerial surveys conducted from 1953-55 are discussed. From March to December 1956-58 surveys were made in the Gulf of Alaska, Aleutian Islands and Bristol Bay. Counts given: Aleutian Islands - 73,090; Gulf of Alaska - 76,027; Bristol Bay - 147 (includes information from earlier sources). In 1958 the Chernabura Island (Shumagin Islands) rookery was studied. Mating took place 31 May - 10 July; births 25 May - 27 June; pups managed alone by end of July. Reduction of sea lions is suggested because of their predation on salmon (and halibut). 1 tab., 4 fig., 10 ref.

Mathisen, Ole A., Robert T. Baade, and Ronald J. Lopp.
1962. Breeding habits, growth and stomach contents of the Steller sea lion in Alaska. J. Mammal. 43(4):469-477.

Observations of Chernabura rookery, May - July 1958. (See Mathisen, 1959.) From authors' abstract: "... Harem boundaries were indistinct, and the size of a harem varied from day to day as did the number of unattached males near a harem. ... A cow nursed only her own pup or yearling. Harem groups slowly disbanded as pups learned to swim.

Lengths of pups, yearlings, cows and bulls are summarized. Only non-commercial fishes, with the exception of one pink salmon, were found in 114 stomachs. Invertebrates were more frequent than fishes." 3 tab., 3 fig., 8 ref.

Mathisen, Ole, A., and Ron J. Lopp.
1963. Photographic census of the Steller sea lion herds in Alaska, 1956-58. (Contr. No. 83, College of Fisheries, Univ. Wash.), U.S. Fish Wildl. Serv.. Spec. Sci. Rep. Fish. 424, 20 p.

Authors' abstract: "An aerial photographic technique for censusing herds of Steller sea lions (Eumetopias jubata) in Alaska is described. The minimum number of sea lions from Cape St. Elias to the Islands of the Four Mountains was estimated to be about 110,000, based on photographic censuses of rookeries and hauling grounds in 1957. The heaviest population density was recorded in an area between the entrance of Cook Inlet and Unimak Pass. Pronounced seasonal variations were observed, with a peak population on the rookeries from July to September. A partial aerial photo census of the harbor seals (Phoca vitulina) in Alaska is discussed in the appendix."

Mercer, Roger, Howard Braham, and Clifford Fiscus.
1977. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 100-133. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

[This report follows Fiscus, Braham, Mercer, et al. (1976) which addressed the northeastern Gulf of Alaska.] Study area was approximately from Prince William Sound (145°W) to Umnak Island (169°W), i.e., the western Gulf of Alaska. Sightings were gathered through the Platforms of Opportunity program (involving collection of observations from NOAA ships and other sources), OCSEAP contract vessels, and data from pelagic fur seal cruises (1958-73). Computer plots map these sightings of northern sea lion, humpback whale, Dall propoise, killer whale, and blue, fin, and sei whales (3 species together) in different seasons, from 145°W to 158°W (Prince William Sound to Alaska Peninsula). Absence of information from Unimak Pass to the Aleutian oil lease area is noted. Summary of 4th quarter operations presented. 3 tab., 17 fig., 4 ref.

Miller, E.H.
1975. Walrus ethology. I. The social role of tusks and applications of multidimensional scaling. Can. J. Zool. 53:590-613.

Male Pacific walrus were observed for 2 summers on Round Island in Bristol Bay. Land interactions are mostly agonistic. Visual threats and actual strikes with tusks commonly characterize interactions. Dominance accrues to those with larger bodies and longer tusks. Smaller animals receive most of the threats and strikes. 5 tab., 25 fig., 87 ref.

1976. Walrus ethology. II. Herd structure and activity budgets of summering males. Can. J. Zool. 54(5)· 704-715.

Observations during two summers on Round Island, Bristol Bay. Walrus haul out on all kinds of terrain; however, they seem to prefer those beaches that are wind sheltered. Herd structure on land was arranged so that the small walrus or those with broken tusks were on the seaward periphery. Centrally-located walrus sleep more. Activity budget given. Author believes gregariousness facilitates search for food and mates as well as creating an advantage in thermoregulation. 5 tab., 9 fig, 45 ref.

Mitchell, Edward.
1968. Northeast Pacific stranding distribution and seasonality of Cuvier's beaked whale (Ziphius cavirostris). Can. J. Zool. 46:265-279.

Author's abstract: "Previously known and new strandings of Ziphius cavirostris are tabulated for the coast of western North America and found to range between Alaska and the tip of Baja California. Strandings are most numerous between February and September, and whales less than about 18 ft long have not usually stranded north of 42°N. Adults and juveniles strand singly, not in mass, but there is evidence for recurrent, single strandings near the same spot at different times."

Mitchell, Edward (ed.).
1975. Review of biology and fisheries for smaller cetaceans -- report and papers from a meeting of the Subcommittee on Small Cetaceans, Int. Whaling Comm., Montreal, April 1-11, 1974. J. Fish. Res. Board Can. 32(7):875-1240 [entire special issue].

Contents: Meeting report -- Research and information, review of smaller cetacea, identity and status of species and stocks, regional accounts, types of fisheries, relationships between cetaceans and other fisheries, catch statistics, biological investigation - methods and techniques, recommendation to the Scientific Committee and other business, appendices. Invited papers -- Biology and current status of species (10); regional accounts of fisheries (7); types of fisheries for cetaceans (6); and incidental capture of cetaceans in fisheries (3).

1978a. Finner whales. P. 36-45 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.] Concerns whales of the genus Balaenoptera: blue, fin, sei, Bryde's and minke whales.

1978b. Origins of eastern North Pacific sea mammal fauna. P. 13-20 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

"All in all, this [present] fauna of sea mammals is large and diverse when compared with others throughout the world. ...About one sixth of these thirty-eight species are found nowhere else in the world but in the North Pacific." Article focusses on assemblages found in California dating from the Miocene period. 9 drawings.

Miyazaki, N., T. Kusaka, and M. Nishiwaki.
1971. Food of Stenella caeruleoalba. Sci. Rep. Whales Res. Inst. 25:265-275.

The stomach contents of 27 dolphins collected from 2 schools off the Japanese coast were examined. Myctophids (lantern fish) and Bentheogennema borealis (shrimp) were the dominant food items, but squid were also found. All food items were pelagic or semi-pelagic species; 74% had luminous organs. The size of fish ranged from 60-300 mm, shrimp from 38-130 mm and squid from 95-190 mm (mantle length).

Mizue, Kazuhiro, Kazumoto Yoshida.
1965. On the porpoises caught by the salmon fishing gillnet in the Bering Sea and the North Pacific Ocean. Fac. Fish., Nagasaki Univ., Bull. 19, 21 p. In Japanese with English summary.

Phocoenoides dalli is found in greater abundance east of 175°W, but Japanese fishermen do not fish that far east. West of 175°W, eleven Japanese salmon fleets caught more than 10,000 (Dall) porpoises yearly in the areas north and south of the Aleutian and Commander Islands. Fifty-four specimens were examined. Comments are included on stomach contents, reproductive condition, and taxonomy.

Mizue, Kazuhiro, Kazumoto Yoshida, and Akiro Takemura.
1966. On the ecology of the Dall's porpoise in the Bering Sea and the North Pacific Ocean. Fac. Fish., Nagasaki Univ., Bull. 21, 21p. In Japanese with English summary.

From Dall's porpoises caught from late May to early August, 1964 and 1965 (during salmon gill netting) in the Bering Sea and North Pacific, researchers studied 148 stomachs and 103 gonads. Stomach contents were not large though food was apparently abundant; squid predominated in stomach contents; and pregnant animals showed less quantity and more diversity than other animals. All infants' stomachs contained only mothers' milk. Length at birth was about 1 m. Gestation seemed to be under one year. Parturition occurred in late July and early August. Since no ripe testes were found, fertilization was presumed to occur later in the year. Fetuses were found in the left uterine cornu in all cases; the left ovary was found to be larger than the right, and of 84 females, 83 ovulated from the left ovary. The corpus albicans apparently remains visible in the ovary throughout life. Most females are sexually mature at two years of age, with length around 170 cm. Additional information on ovaries and ovulation is given. One Baird's beaked whale and one common dolphin were also caught in 1965. Exact locations of captures are not given.

Moiseev, P.A., ed.
1972. Morskie mlekopitayushchie (spravochnik) (Marine mammals (a reference book)), by M.V. Ivashin, L.A. Popov, and A.S. Tsapko. Izd. "Pishch. Prom." (Food Industry Press), Moscow. 303 p. illus. In Russian. (Abstract, introduction and appendices #1,5-19 transl. by Natl. Mar. Fish. Serv., Off. For. Fish.. Lang. Serv. Branch, Washington, D.C., 1974, 28 p.)

Describes marine mammals of the world from order to species, with illustrations. Distribution, migration, and general biology of animals in northern Atlantic and Pacific Oceans and contiguous portions of the Arctic Ocean, and southern hemisphere are discussed. History of exploitation, present condition of stocks, and regulation of kills are given. Hunting and processing are described briefly. Leading commercial species are emphasized. Appendices: Names of pinnipeds in Russian, Latin, and English; names of cetaceans in Russian, Latin, English, Norwegian and Japanese; and various whaling industry statistics, some going back to 1910. 4 whale migration charts.

Moore, Joseph Curtis.

1963. Recognizing certain species of beaked whales of the Pacific Ocean. Am. Midl. Nat. 70(2):396-428.

By examining 18 skulls found along Pacific coasts, the author sorts the animals into 3 species of the genus Mesoplodon. They separate morphologically and geographically into a subarctic species, M. stejnegeri; a south temperate animal, M. bowdoini; and a north temperate species, M. carlhubbsi. Records of all the specimens are reviewed, and measurements are given.

1966. Diagnoses and distributions of beaked whales of the genus Mesoplodon known from North American waters. In K.S. Norris (ed.), Whales, dolphins and porpoises, p. 32-61, Univ. California Press, Berkeley.

Examination of 42 skulls brought out taxonomic differences within 6 species of Mesoplodon, two of which are found in the North Pacific. The distribution of the Bering Sea beaked whale (M. stejnegeri), as judged by stranded specimens, is between 50^{o} and 60^{o}N Lat., but extends as far south as 45^{o}N. In 1944 an arch-beaked whale (M. carlhubbsi) was found in Grays Harbor, Washington; its distribution is usually considered to be the temperate Pacific, south of the range of M. stejnegeri.

1968. Relationships among the living genera of beaked whales, with classifications, diagnoses and keys. Fieldiana: Zool. 53(4).

From the study of 292 skulls, 2 dichotomous keys to the genera were drawn, one based on skulls. the other on teeth. Six genera are diagnosed.

Morejohn, G.V., and D.M. Baltz.

1970. Contents of the stomach of an elephant seal. J. Mammal. 51(1):173-174.

A dead male specimen (Mirounga angustirostris) was found on Sunset Beach, California. Otoliths found in the stomach were primarily from benthic or epibenthic species of teleost fish, supporting the belief that elephant seals are deep diving bottom feeders. Also, the species taken were not the most common species in the area suggesting the seals are selective feeders.

Morgan, Lael.
1977. A new look at subsistence whaling. Alaska 43(9):8-10.

Article focusses on differing viewpoints among Alaskan natives on bowhead whaling. In Barrow, inlanders and others with no apprenticeship in the art of Eskimo whaling are now outfitting their own boats and hunting bowheads. Tradition-oriented subsistence hunters (including many from other areas with less access to paying jobs) worry about abuses of subsistence whaling since they are dependent on it: They may not qualify for high-paying jobs; families are large (Barrow population now 2,500); in Barrow prices of store food are very high; caribou hunting and duck hunting have been outlawed; and fishing lakes have been "killed" by oil exploration activities. Lack of good bowhead census is noted; difficulty of censusing is emphasized. Recent OCSEAP [Outer Continental Shelf Environmental Assessment Program] report is quoted, concluding that one could argue that bowhead population is healthy and increasing. At Inuit Circumpolar Conference in June, Eskimos voted for strong self-regulation.

Murdoch, John.
1885. "Natural history." Part IV, p. 89-200 in Rep. of the international polar expedition to Point Barrow. Alaska (695 p.), Gov. Print. Off., Washington, D.C.

Author lived at Pt. Barrow 8 September 1881 to 29 August 1883. Accounts given of mammals, birds, fishes, insects and marine invertebrates, including a section on mollusks by W.H. Dall, and a short section on plants by Prof. Asa Gray. Appendices are on: surface life - 1) under sea-ice, 2) during voyage from San Francisco to Pt. Barrow, and 3) during season of open water at Pt. Barrow (approx. July - Sept.); and birds observed at Plover Bay, Eastern Siberia, August 1881. Marine mammals at Point Barrow: Polar bear - present year round on ice but not common; harbor seal - occasional at Elson Bay (Pergniak); ringed seal (major subsistence species) - year-round, abundant during season of ice; bearded seal - occurs all year but abundant only in summer and autumn (in loose ice); ribbon seal - rare; walrus - never very abundant, but frequently seen during open or partially open water (whalemen report increasing scarcity in ice field just north of Bering Strait); white whale - occasional large schools during season of open water; narwhal - none seen; killer whale - none seen; bowhead - beginning mid-April (natives killed 3 during 2 seasons). 113 ref.

Murie, J.
1872. On the walrus. Trans. Zool. Soc. London 7:411-464.

The anatomy of a juvenile walrus is carefully described. The skeletal system, locomotion, dentition, viscera, and reproductive organs are reported. Musculature noted in detail.

Murie, Olaus J.
1959. Fauna of the Aleutian Islands and Alaska Peninsula. In O.J. Murie and V.B. Scheffer, Fauna of the Aleutian Islands and Alaska Peninsula, with notes on invertebrates and fishes collected in the Aleutians, 1936-1938 (406 p.), U.S. Fish Wildl. Serv., North Am. Fauna 61:1-364.

Based on survey done in 1936 and 1937. Marine mammals covered are: sea otter - Aleutian population, 2,000; Steller sea lion - seen on 10 islands; northern fur seal - author mentions report of breeding on Buldir Island; harbor seal - small groups seen; ringed seal - none seen; harp seal - Alaskan occurrence questioned; bearded seal - none seen; walrus - none seen. Author notes his lack of experience in observing cetaceans, notes possibility of missing some animals. Right whales and bowheads - none seen; gray whale - none identified; finback whale - several seen; sei whale - several seen; blue whale - tentatively identified; humpback whale - several seen; sperm whale - one seen; killer whale - common; Pacific blackfish (Globicephala scammoni), Pacific striped porpoise (Lagenorhynchus obliquidens), right-whale porpoise, white whale and beaked whales - none seen; harbor porpoise - 5 seen; Dall porpoise - seen twice. Published and unpublished information is reviewed. Aleut and Russian names are given when known.

Naito, Y.
In press. Harbor seal in the North Pacific [FAO ACMRR/MM/SC/44]. In Mammals in the seas, FAO [Food Agric. Org., U.N.] Fish. Ser. No. 5, Vol. 2, 13 p. [This volume will consist of documents of the Food Agric. Org. U.N., Advis. Comm. Mar. Resour. Res., Working Party on Mar. Mammals, from the Sci. Consultation on Mar. Mammals, Bergen, Norway. 31 Aug. - 9 Sep. 1976.]

A review of the taxonomy, distribution and growth of the harbor seal. The distribution of Phoca vitulina largha is given as the Bering, Chukchi and Okhotsk Seas where ice prevails. P. v. richardsi is found from Alaska to Mexico, widely distributed along the coast where they haul out on tidal sand bars or exposed rocks. Population estimates given for the eastern North Pacific are those made by Scheffer in 1958.

Nakashim, Leslie.
1977. Fall whaling in Barrow. Alaska 43(9):97.

Whalemen go 10 to 15 miles out to sea for fall whaling. Dangers, difficulties, and waste are described.

Nasu, Keiji.
1960. Oceanographic investigation in the Chukchi Sea during the summer of 1958. Sci. Rep. Whales Res. Inst. 15:143-158.

Nineteen stations were occupied in the area between Point Hope and the Kolyuchin Gulf and southward to the Bering Strait during 5 days in August. Oceanographic data are presented. Marine productivity appears to increase in the western part and decrease in the eastern part. A map shows sightings of gray whales, 2 right [bowhead] whales, a fin whale, and an unidentified whale, and also shows some previous sightings of gray whales in the Bering Sea. 11 fig.

1963. Oceanography and whaling ground in the subarctic region of the Pacific Ocean. Sci. Rep. Whales Res. Inst. 17:105-155.

Data were obtained by whaling factory and whale marking boats in the North Pacific Ocean and Bering and Chukchi Seas. Extensive oceanographic data were collected. Usual whaling grounds for blue, fin, humpback, sei and sperm whales are discussed. Annual catch by species 1940-1962 is tabulated. "Centers" of 2 fin-whaling grounds (south of Commander Is. and northwest of Unalaska Is.) 1954-1960, are mapped. Areas north and south of Unalaska are particularly productive for all species except perhaps blue whale. 51 fig.

1966. Fishery oceanographic study on the baleen whaling grounds. Sci. Rep. Whales Res. Inst. 20:157-210.

Discusses the Bering Sea, northern North Pacific, and Gulf of Alaska "pelagic" grounds. In the subarctic Pacific, distribution of whaling grounds for blue, fin, sei, and humpback whales is roughly mapped. In the Gulf of Alaska, Japanese catch of baleen whales is tabulated for 1961-64, fin whale catch is mapped in detail. Section on whale movements includes fin whales in subarctic Pacific. 10 tab., 52 fig., 59 ref.

National Marine Fisheries Service [NMFS]/National Oceanic and Atmospheric Administration [NOAA].

1977. Current status of stocks of marine mammals. Part III, p. 38992-39026, in Administration of the Marine Mammal Protection Act of 1972; April 1, 1976 through March 31, 1977. Federal Register 42(147):38982-39030.

Reports are given on 69 species of whales, porpoises, seals and sea lions. Each species report consists of the following sections: distribution and migration, abundance and trends, general biology, ecological problems, allocation problems, and current research.

Nemoto, Takahisa.

1957. Foods of baleen whales in the northern Pacific. Sci. Rep. Whales Res. Inst. 12:33-89.

Presents analysis of stomach samples collected 1954-56. Whaling grounds along Aleutian chain are discussed. Tabulates catch 1952-56 of blue, fin, sei, and humpback whales in Aleutian waters. Discusses: food preference among whale species; hour of feeding as related to diurnal migration of plankton; depth of whale dives; effect of chasing time on stomach contents; fluctuation of food abundance from year to year and corresponding presence of whales, and feeding by "skimming" (sei and right whales) versus "gulping" (blue, fin and humpback whales). Foods include euphausiids, copepods, fish, squid. Zooplankton biology discussed. 26 fig., 74 ref.

1959. Food of baleen whales with reference to whale movements. Sci. Rep. Whales Res. Inst. 14:149-290.

Mentions blue, sei, Bryde's, fin, right, Greenland, gray, humpback and little piked whales. Data come from whales caught in 3 areas: northern North Pacific, waters adjacent to Japan, and Antarctica. In addition to food items found in stomachs of each species, author discusses: "feeding apparatus" in relation to food preference; hours of feeding; natural history of Euphausia superba; yearly fluctuations in abundance and location of foods in North Pacific; quantity of stomach contents; previous publications on feeding; "swallowing" and "skimming" types of feeding; congregation, diurnal migration and depth of food species; weights of stomach contents of fin and sei whales; distribution of whales in North Pacific (especially migrations of fin, sei and Bryde's whales); results of marking research; "dispersive movements" of fin whales, and parasites found as related to whale migration. Appendix gives data on whale marks recovered from fin, sei and Bryde's whales in the North Pacific. One plate, picturing 17 prey species. 43 tab., approx. 40 charts, 149 ref.

1963. Some aspects of the distribution of Calanus cristatus and C. plumchrus in the Bering and its neighboring waters, with reference to the feeding of baleen whales. Sci. Rep. Whales Res. Inst. 17:157-170.

Distributions of the 2 Calanus species were studied using whale stomach contents from 1952-1961, and plankton net studies. Spring and summer concentrations of C. cristatus coincide with fin whale feeding grounds; C. plumchrus likewise corresponds to sei whale. Total catches of fin and sei whales 1952-1961 are mapped. (Includes Gulf of Alaska.)

Nemoto, Takahisa, and Toshio Kasuya.
1965. Foods of baleen whales in the Gulf of Alaska of the North Pacific. Sci. Rep. Whales Res. Inst. 19:45-51.

Stomach contents were examined of blue, fin and sei whales caught in the Gulf of Alaska in 1961, 1962 and 1963. Catch distributions of 1963 are mapped. Right whales are mentioned in coastal waters of Kodiak Island.

Nemoto, T., and K. Nasu.
1963. Stones and other aliens in the stomachs of sperm whales from the Bering Sea. Sci. Rep. Whales Res. Inst. 17:83-91.

Stone and rock fragments found in the stomachs of whales collected from the Aleutians and Bering Sea suggest that sperm whales plow the sea bottom with their lower jaw while chasing food items such as crabs or rays. Such alien materials also indicate sperm whales dive deeper than 200 m.

Newby. Terrell C.
1978. Pacific harbor seal. P. 184-191 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Newman, Murray A.
1978. Narwhal. P. 138-144 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Nichols, G., Jr.
1975. Eschrichtius robustus. Oceans 8(3): 60-65.

Records observations on the maternal behavior of the grey whale made during January 1965 from Isla Magdalena, Baja California.

Nichols, J.T.
1950. Additional data on the occurrence of Dall's porpoise. J. Mammal. 31(1):99.

Report of six sightings from the summer of 1926: 5 July, Queen Charlotte Strait; 6 July, inside passage, south of Ketchikan, Alaska; 8-9 July, Cross Sound, Gulf of Alaska; 5 August, at 53°36'N, 145°37'W; 6 August, at 52°19'N, 137°42'W.

Niggol, Karl, Clifford H. Fiscus, Jr., Thomas P. O'Brien, and Ford Wilke.
1960. Pelagic fur seal investigations -- Alaska, 1960. U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Biol. Lab., Seattle, Wash., Processed Rep., 61 p.

The third year of pelagic research, under the Interim Convention on Conservation of North Pacific Fur Seals, was conducted from March to May from near Sitka into the Gulf of Alaska, in June between Kodiak and Unalaska, and in July and August from Unimak Pass to Pribilof and St. Matthew Islands. Of 1,495 seals collected, 25 bore tags. Ages and reproductive condition were determined. One seal carried twin fetuses. Pregnancies develop more often in the left uterine horn than the right. The numbers of male and female fetuses found were approximately equal. Stomach contents are reported. One killer whale, taken in Chiniak Bay, Kodiak, had fed on halibut.

Niggol, Karl, Clifford H. Fiscus, Jr., and Ford Wilke.
1959. Pelagic fur seal investigations -- California, Oregon, and Washington, 1959. U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Res., Seattle, Wash., Processed Rep., 92 p.

The second year of pelagic research, under the Interim Convention on Conservation of North Pacific Fur Seals, was carried out from January to April. Concentrations were found west of Point Buchon, south to Point Sur, California, and near the Farallon Islands, California. Of 1,548 seals collected, 37 were males. Age and reproductive condition were determined. Nineteen tagged seals were recovered. Two seals carrying twins were collected. Stomach contents are reported.

Nikolaev, A.M.
1960. O dinamike chislennosti kalanov v SSSR (Change in the number of sea otter in the USSR). Tr. Sakhalinsk. Kompleksn. Nauchno-issled. Inst. 9:108-121. In Russian. (English abstr. in Biol. Abstr., 1963, 72(1):45.)

Describes former and present range in the USSR. Movements occur between Kamchatka and the Kuriles, between the northern and southern Kuriles, and from the Commander Islands to the Aleutian Islands.

1961. (The distribution, quantity and biology of the sea otter). Akad. Nauk SSSR, Tr. Soveshch. Ikhtiol. Komm. 12:24-217. (Transl. by Natl. Mar. Fish. Serv., Off. Int. Fish., Lang. Serv. Branch, Washington, D.C., 1970, Transl. 520.)

Tabulates population estimates for years 1912 to 1939 from Kurile Islands, Kamchatka, Aleutian Islands, Alaska and California. Otter habitat analyzed. Suggests possibility that sea otters give birth only once every two years.

1965. O pitanii Kuril'skikh kalanov i nekotorykh osobennostyakh ikh povedeniya v ledovyi period (On the feeding of the Kurile sea otter and some aspects of their behavior during the period of ice). Izd. Akad. Nauk SSSR, Ikhtiol. Komm., Moscow. In Russian. (Transl. by Bur. Sport Fish. Wildl., Div. Wildl. Res., Seattle, Washington, 1966, 11 p., in E.N. Pavlovskii, B.A. Zenkovich et al. (eds.), Marine Mammals.)

Food species studied by visual observations and inspection of excrement. Species tabulated and broken down by areas: Uruppu Island, Kurile Islands, Commander Islands and Momoren Island. Spherical urchins, loricate mollusks, the wrinkled crab, and the common mussel were apparently most commonly consumed.

1971. Migratsii i lokal'nye peregruppirovki kuril'skogo kalana (Migrations and local regroupings of the Kuril sea otter). Tr. Atlant. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (AtlantNIRO) 39:171-178. In Russian. (Transl. by Fish. Mar. Serv., Ottawa, Canada, 1974, p. 274-283 in K.K. Chapskii and E.S. Milchenko (eds.), Research on marine mammals, Transl. ser. 3185.)

Otters move to the leeward (Pacific) side of the islands when ice is blown down to the Kuriles in autumn. Similar movements occur in the Aleutians. Also, there are known mass migrations of sea otters, occurring under the influence of intensive hunting or severe volcanic activity.

Nikulin, P.G.
1941. Chukotskii morzh (Chukotsky walrus). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 20:21-59. In Russian. (Transl. by Bur. Commer Fish., Seattle, Washington, 1953, 52 p.)

Observations were made in 1934, 1935 and 1937-1939 on nearly 1,000 animals from waters near the Chukot peninsula. Distribution is briefly described as are morphological characteristics and reproductive biology. The walrus is believed to be polygamous. Stomach contents indicate mollusks are the primary food source, and bottom fauna from 30-50 m depth are preferred. Predation by killer whales and polar bears is discussed.

1946. O raspredelenii kitoobraznykh v moryakh, omyvayushchikh Chukotskiy poluostrov (Distribution of cetaceans in seas surrounding the Chukchi Peninsula). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 22:255-257. In Russian. (Transl. by U.S. Nav. Oceanogr. Off., Washington, D.C., 1969, Transl. 428, 3 p.)

Species are listed, noting abundance and the season(s) when each occurs. Data from seven years of irregular observation (1937-1943) are tabulated by month (usually between June and October), species, and point of observation (predominantly from land along Bering Strait). Species, listed in descending order of total number observed, were: gray whale, fin whale, humpback whale, "species not determined", killer whale, beluga, little piked whale, and Greenland (bowhead) whale.

1947. Biologicheskaya kharakteristika beregovykh lezhbisheh morzha na Chukotskom poluostrove (Biological characteristics of shore aggregations of the walrus in the Chukotka Peninsula). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 25:226-228. In Russian. (Transl. by Fish. Res. Board Can., Arctic Unit, Montreal, 1957, Transl. ser. 115, 4 p.)

Using observations from 1934-1941, the author explains shore aggregations. The walruses prefer ice haul-outs, but will remain in ice-free, shallow water areas with abundant benthic fauna during the summer. This necessitates the usage of shore hauling grounds. With the reappearance of drifting ice, the walrus leave the shore.

Nishiwaki, Masaharu.

1962. Aerial photographs show sperm whales' interesting habits. Norsk Hvalfangst-Tid. 51(10):395-398.

Six photographs of sperm whales: (1) a swimming herd, (2) resting herd, (3) group playing with piece of timber, (4) solitary bull, (5) catcher boat shooting into a pod which had formed a circle head-inward "like a marguerite flower" around a whale which had been shot, and (6) a group formed likewise in a circle, from directly overhead.

1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. P. 171-191 in K.S. Norris (ed.), Whales, dolphins and porpoises, Univ. Calif. Press, Berkeley.

Whaling catches reported for 1945-1962 for blue, fin, humpback, sei, Bryde's and sperm whales. Table and map for each species. Area includes North Pacific, Gulf of Alaska, and Bering Sea. Catches are analyzed by 10^{o} squares of area. Months of whaling activity are noted. Population estimates offered.

1967. Distribution and migration of marine mammals in the North Pacific area. Bull. Univ. Tokyo, Ocean Res. Inst. 1:1-64.

Maps and short discussions on present knowledge of distribution of each species of marine mammal (excluding polar bear) found in the North Pacific, Bering Sea and waters north of Bering Strait. Thirteen pinnipeds, 53 cetaceans. Illus.

1975. Ecological aspects of smaller cetaceans, with emphasis on the striped dolphin (Stenella coeruleoalba). J. Fish. Res. Board Can. 32(7):1069-1072.

Author's abstract: "The striped dolphin (Stenella coeruleoalba) is captured by drive fisheries as it migrates along the coast of Japan. The largest school of striped dolphins captured contained 2,838 individuals. Annual catches have reached approximately 20,000 striped dolphins, and it is estimated that the population fished must number 400,000-600,000 animals. Recent variations in catch levels have resulted from economic and environmental fluctuations, not from a decrease in population size."

Nishiwaki, M., T. Hibiya, and S. Kimura.
1956. On the sexual maturity of the sperm whale (Physeter catodon) found in the North Pacific. Sci. Rep. Whales Res. Inst. 11:39-46.

In the Aleutian Islands, 1,060 male sperm whales were caught in 1954 and 1955. The testes were examined and it was found that most individuals over 38 feet in body length have attained sexual maturity. The sperm whales found in the Aleutians were lone bulls.

North Pacific Fur Seal Commission.
1965. North Pacific Fur Seal Commission report on investigations from 1958 to 1961. Kenkyusha Print. Co., Tokyo, 183 p.

Scientists from the U.S., the U.S.S.R., Japan and Canada conducted both land and pelagic research on North Pacific fur seals throughout their range. Areas of study were: population dynamics, distribution and intermixture of seals of different origins, food habits and management needs. 137 tab.

1969. North Pacific Fur Seal Commission report on investigations from 1964 to 1966. Kenkyusha Print. Co., Tokyo, 161 p.

Scientists from the US, the USSR, Japan and Canada conducted both land and pelagic research on the North Pacific fur seal throughout its range. Areas of study were: population dynamics, distribution and intermixture of seals of different origins, segregation at sea, food habits, management and utilization. 161 tab.

1971. North Pacific Fur Seal Commission report on investigations in 1962-63. Kenkyusha Print. Co., Tokyo, 96 p.

Scientists from the US, the USSR, Japan and Canada conducted both land and pelagic research on the North Pacific fur seal throughout its range. Areas of study were: population dynamics, distribution and intermixture of seals of different origins, and food habits. 118 tab.

1975. North Pacific Fur Seal Commission report on investigations from 1967 through 1972. Dependable Print. Co., Inc., Hyattsville, Maryland, 212 p.

Scientists from the US, the USSR, Japan, and Canada conducted both land and pelagic research on the North Pacific fur seal throughout its range. Areas of study were: distribution and intermixture of seals of different origins, segregation at sea, feeding habits, population dynamics, management, utilization, and impact of fur seals on fisheries. 194 tab.

Ohsumi, Seiji.
1966. Sexual segregation of the sperm whale in the North Pacific. Sci. Rep. Whales Res. Inst. 20:1-16.

Very few females are found in Bering Sea and Aleutian area. Those found are associated with warmer water masses. Forty to sixty percent of mature males segregate to high latitudes.

Ohsumi, S.
1975. Incidental catch of cetaceans with salmon gillnet. J. Fish. Res. Board Can. 32(7):1229-1235.

Reports data from salmon research vessels, 1962-1971. Species caught were Dall porpoise, True's porpoise, harbor porpoise, pilot whale and Baird's beaked whale. Many animals were not identified to species. The area fished included northwestern North Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan. 6 fig.

1976. Population assessment of the Californian gray whale [SC/27/Doc 19]. P. 350-359 in Rep. and papers of the Sci. Committee of the Commission - 1975, Int. Comm. Whaling. [By the prior procedure, the material in this volume would have been published in the 26th report of the Int. Whaling Commission.]

Author makes a simple population model, using best available population parameters, to reconstruct history of stock size and to consider exploitation. According to his calculations, the present population of 11,000 is 30% higher than the maximum sustainable yield population level. 2 tab., 4 fig., 6 ref.

Ohsumi, S., and Y. Fukuda.
1975. A review on population estimates for the northern Pacific sei whales. Rep. Int. Comm. Whaling 25:95-101.

Whaling ground has extended southward and eastward to to north of 20°N Lat. (in middle North Pacific) during past 15 years. Catch per unit effort increased until 1968, but has been decreasing yearly since then. Modified De Lury equation, Ohsumi's previous approach, and other estimates are compared and discussed. 1 tab., 2 fig.

Ohsumi, Seiji, and Yasuaki Masaki.
1977. Stocks and trends of abundance of the sperm whale in the North Pacific. Rep. Int. Whaling Comm. 27·167-175.

Catch per unit effort records 1954-75, and differential pregnancy rates indicate a separation of stocks of females with a boundary line at approximately 160°W. Catch records and tagging records show a congregation of males from both east and west stocks in the Aleutian Island area ("intermingling males") which are taken to be surplus males. Catch of sperm whales 1949-75 in North Pacific is newly analyzed by these stocks: western, eastern, and intermingling. Charts show catches of each sex 1949-1975, movements of tagged whales, schematic figure of distribution for each sex and stock. Estimated current population sizes of mature females are: western stock -- 84,900-137,900; eastern stock -- 56,700-83,300. 2 tab., 11 fig., 7 ref.

Ohsumi, Seiji, Yasuaki Masaki, and Shiro Wada.
1976. A note on the distribution of some smaller cetaceans in the North Pacific. Int. Whaling Comm., Scientific Comm. London, 1976. IWC/SC/28/20. 2 p. + figs.

Maps show average density distribution during spring-summer, by 5°x5° squares, of Baird's beaked whales, killer whales, and "other small cetaceans" (could be mostly Phocoenoides dalli in the north and mostly Stenella spp. in the south, and includes some pilot whales), using whale sighting data from years 1965-1975, the reliability of which is considered lower for small cetaceans than for commercial species. Area surveyed is North Pacific, Bering Sea, and Gulf of Alaska (approximately Lat. 25°-65°N, Long. 150°E-125°W). 4 fig.

1977. Seasonal distribution of sperm whales sighted by scouting boats in the North Pacific and southern hemisphere. Rep. Int. Whaling Comm. 27:308-323.

Areas surveyed were predominantly waters of latitude greater than 30°. Seven charts show density distribution of sighted whales in North Pacific by month, April - September 1965-74. Others show Antarctic similarly. Same data are also shown in graphs and tables. 2 tab., + 4 app. tab., 6 fig.

Ohsumi, S., M. Nishiwaki, and T. Hibiya.
1958. Growth of fin whales in the Northern Pacific. Sci. Rep. Whales Res. Inst. 13:97-133.

Data were collected on whales caught from 1952 to 1957, in the North Pacific from 48°N to the Bering Sea. The process of growth was divided into 6 stages: fertilization, birth, weaning, pre-puberty, sexual maturity and physical maturity. At four years, fin whales approach sexual maturity, at which time males average 58 feet and females 61 feet. Physical maturity occurs at 24 years, when the average length is 62 feet in females. Shrinkage of about 1 foot occurs after physical maturity is attained. Maximum life expectancy is estimated to be 50 years.

Ohsumi, S., Y. Shimadzu, and T. Doi.
1971. The seventh memorandum on the results of Japanese stock assessment of whales in the North Pacific. Rep. Int. Comm. Whaling 21:76-89.

Index of abundance tables presented using CPUE (catch per unit effort) and whale sightings for fin, sei, sperm, blue, humpback and right whales. Estimations on population size given for each species. Maximum sustainable yield and changes in population size offered.

Ohsumi, S., and S. Wada.
1972. Stock assessment of blue whales in the North Pacific. Int. Whaling Comm., Scientific Committee paper, IWC/SC/24/13, 20 p. (Avail. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

Population sizes estimated using population model, whale sighting and marking. Figure shows Japanese catch of blue whales (per 1° square) 1952-1965. Biological parameters used are described. Boundary between stocks is taken to be 175°E-180°. Population size in 1972 is estimated at 1,500, or 30% of initial level and 65% of MSY level. Main whaling grounds were Gulf of Alaska, south side of eastern Aleutian Islands, and east side of Kamchatka Peninsula. 14 fig., 1 tab. [Copy seen may be incomplete.]

1974. Status of whale stocks in the North Pacific, 1972. Rep. Int. Comm. Whaling 24:114-126.

Gives catch of large whales by 3 Japanese and 2 Soviet expeditions, and 8 Japanese land stations in 1972. Indices of abundance were calculated from (1) Japanese catch and effort data, 1966-1972, for fin, sei, and sperm whales, and (2) Japanese sighting data, 1965-1972, for fin, sei, sperm, minke, blue, humpback, and right whales. North Pacific area of operation used for these calculations is roughly from 35°-65°N (including the Bering Sea and Gulf of Alaska), excluding certain northwest Pacific areas. Indices of abundance of fin whale and sei whale derived from catch/effort data, sightings, and a population model are compared; shortcomings are discussed. Indices of abundance are tabulated by species and area. 2 fig., 8 tab., + app.'s.

Okutani, Takashi, and Takahisa Nemoto.
1964. Squids as the food of sperm whales in the Bering Sea and Alaskan Gulf. Sci. Rep. Whales Res. Inst., 18:111-122.

Seven genera of squid were found in stomachs of sperm whales from Aleutian Island waters, Bering Sea and Alaskan Gulf. Distribution of whales caught is mapped, according to (1) whether they contained fish or squid, and (2) what kind of squid they contained. Squids predominated over fish in stomachs from the western part of the Aleutian chain, while fish predominated in those from the Gulf of Alaska. 5 pl., 5 fig.

Omura, Hideo.
1955. Whales in the northern part of the North Pacific. Norsk Hvalfangst-Tid. 44(6):323-345, 44(7):395-405.

Describes history of whaling in the North Pacific and compiles catch statistics since beginning of commercial whaling. Recent Japanese catches on each of 3 whaling grounds, (1) south of Commander Islands, (2) north of the eastern Aleutian Islands, and (3) south of the eastern Aleutian Islands, are analyzed for each species by sex, length and sexual maturity. Composition of catch in Alaska region is given for 1912-1939. Blood group studies of fin whales are discussed. Also reports on 2 marking cruises. 17 tab., 18 fig.

1958. North Pacific right whale. Sci. Rep. Whales Res. Inst. 13:1-52.

Black right whales appear in the Bering Sea in June and stay all summer. Sightings from 1941-57 are mapped by months; April, May, June and July-September. Numerous sightings occurred between Pribilof Islands and Aleutian Islands in July. In June and July a few were seen as far east as the Shumagin Island region. Whales sighted near the Aleutian Islands are thought perhaps to belong to a "Kodiak Ground" stock. Of all sightings, 68% were of single individuals. Largest group seen was four. Exhaustive physical description given of 2 right whales taken near Japan. 8 pl., 27 fig., including 25 photos.

Omura, Hideo, and Seiji Ohsumi.
1964. A review of Japanese whale marking in the North Pacific to the end of 1962, with some information on marking in the Antarctic. Norsk Hvalfangst-Tid. 53(4):90-112.

Reports on marking of blue, fin, humpback, sei (and Bryde's), and sperm whales from 1949 to 1962. Of 3,343 whales marked, 282 were recaptured, 80% of which were fin and sperm. Area included waters east of Japan to Long. 160°E, waters south of the Aleutian chain, the Gulf of Alaska and the Bering Sea. Maps show movements of recaptured whales summarized by species. Appendix gives sex, length, date and locations of marking and recapture of each whale. 12 tab., 5 maps.

1974. Research on whale biology of Japan with special reference to the North Pacific stocks. P. 196-208 in W.E. Schevill, ed., The whale problem: a status report, Harvard University Press. Cambridge, Massachusetts.

Stock assessments for the North Pacific were derived from 5 sources: whaling statistics, whale sightings, whale marking, biological investigations of whale carcasses, and stock identification. The object was to determine the maximum sustainable yield for 4 species of whale (fin, sei, sperm and blue). Attempted derivation of reproductive relationships from catch-per-unit-effort data is discussed. Uncertainty of age determination by ear plugs is mentioned. Table of stock assessment provided. 2 tab., 2 fig., 26 ref.

Omura, H., S. Ohsumi, T. Nemoto, K. Nasu, and T. Kasuya.
1969. Black right whales in the North Pacific. Sci. Rep. Whales Res. Inst. 21:1-78.

Thirteen right whales were collected from the coast of Japan, Kodiak waters, the Bering Sea and the Okhotsk Sea. A detailed morphology is presented that includes coloration, bonnet, hair, osteology and body proportions. In May, right whales appear north of 57°N, and by June they have moved into the Bering Sea. The northern limit was thought to be 63°N but some have been sighted in the Chukchi Sea. Their principal food items are calanoid copepods and euphausiids. Data of Klumov (1962) are summarized. 38 tab.+ 4 app. tab., 27 fig., 18 pl., 64 ref.

Øritsland, N.A.
1975. Insulation in marine mammals: the effect of crude oil on ringed seal pelts. Appendix A, p. 48-66, in Thomas G. Smith and Joseph R. Geraci, The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea, Dep. Environ. [Can.], Beaufort Sea Project, Victoria, B.C., Beaufort Sea Tech. Rep. #5 (66 p.).

Thermal and optical measurements were made on dead pelt samples using Norman Wells crude oil (of low viscosity). Insulation conditions in nature are described. From discussion: "The major effect of Norman Wells crude oil on the fur of the ringed seal is to increase the solar heating of the animal's skin." 2 tab., 7 fig., 12 ref.

Orr, Robert T.
1966. Risso's dolphin on the Pacific coast of North America. J. Mammal. 47(2):341-343.

On 11 June 1963 a specimen was found on the beach near Princeton, California. The stomach contained 3 squid jaws from *Dosidicus gigas*. Description and body measurements are given. Summary of the records of *Grampus griseus* on the Pacific coast is provided.

Osgood, Wilfred H., Edward A. Preble, and George H. Parker.
1951. The fur seals and other life of the Pribilof Islands, Alaska, in 1914. U.S. Bur. Fish., Bull. 34, 168 p.

Reports on observations from 21 June to 30 August 1914. Fur seals totalled about 300,000. Contains extensive discussion of Pribilof fur-sealing, including sealing history; age structure of population; recommendations for management, legal and social aspects. Among other animals covered are Steller sea lion and sea otter. Sea lions, which formerly numbered in thousands, were estimated at "a few hundred on both islands". They are present the whole year, being "more scattered in winter". Sea otters, discovered in the Pribilofs in 1786 were scarce by 1811, "extinct" by 1840. No current Pribilof population is known, though a handful of sightings of single individuals were reported beginning in 1889.

Panina, G.K.
1966a. O pitanii sivucha i tyulenei na Kuril'skikh ostrovakh (On the feeding of the sea lion and seals on the Kurile Islands). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:235-236. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 140-141 in K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Sea lions, harbor seals and island seals (Phoca insularis, described by Belkin in 1964, as a new species) were taken from 18 islands of the Kuril Ridge in 1963 and 1964. Stomach contents are briefly reported and tabulated. Contents included fishes, cephalopods, crustaceans, milk, rocks and sand.

1966b. Pitanie morskikh kotikov v zapadnoi chasti Tikhogo okeana (Food of fur seals in the western part of the Pacific Ocean). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:23-40. In Russian. (Prelim. transl. by Fish. Res. Board Can., Biol. Stn. Nanaimo, British Columbia, Transl. Ser. 766, 15 p.)

Investigations were conducted from 1958 to 1963 (March to June) in winter-spring settlements and during seal migrations. Most seal collections were made 250 miles east of Honshu Island. Contents of 2,611 stomachs were analyzed. Prey species are described and pictured. In June occurrences of lantern fish dropped off steeply, while squid increased to 90%. Time of feeding depends on availability of prey. Fish and squid habitats and migrations are discussed. Fur seal's food consumption was calculated to be 17g per day: 1,020g fish, 680g squid (live weight). Qualitative differences in stomach contents for different age and sex groups were not detected. 6 tab., 6 fig.

1971. Kharakter raspredeleniya kotikov, zimuyushchikh v Yaponskom more (Distribution of fur seals wintering in the Sea of Japan). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 82:14-24. In Russian. (Transl. by Fish. Res. Board Can., Arctic Biol. Stn., Ste. Anne de Bellevue, Quebec, Canada, 1973, Transl. Ser. 2571, 18 p.)

From 1959 to 1968, between January and May, 1,743 seals were collected in the Sea of Japan. Females outnumbered males overall in a ratio of 1:1.3, and 85% of all females caught were 7 years of age or older. Of males caught, most were aged 3-4 years; 23.2% were mature. One- and two-year-olds of both sexes were sparse. The main regions of habitat are the Gulf of Korea and the Yamato Shallows in the central part of the sea. Age and sex composition of seals caught is is tabulated by month. Concentrations and apparent movements of different groups are shown in figures. Food plays a part in determining locations of different age and sex groups.

Peterson, R.S., and B.J. LeBoeuf.
1969. Population studies of seals and sea lions. Trans. 34th North Am. Wildl. Nat. Resour. Conf.:74-79. Wildl. Manage. Inst., Washington, D.C.

Authors report on two years of study, concentrating on northern elephant seals and California sea lions, but including the Steller sea lion and the two fur seals of California, Callorhinus ursinus and Arctocephalus townsendi. Techniques were censusing, marking and behavioral observation. Study areas were the islands of South Farallon, Ano Nuevo, San Miguel, San Nicolas (California) and Guadalupe (Baja California). Total world population of northern elephant seals is estimated at 30,000. Population of California sea lions at two centers, San Miguel and San Nicolas Islands, is estimated at 40,000.

Peterson, R.S., B.J. LeBeouf, and R.L. DeLong.
1968. Fur seals from the Bering Sea breeding in California. Nature 219(5157):899-901.

One hundred fur seals, including 40 newborn pups, were discovered on San Miguel Island, off southern California. Behavior is described. 3 photos.

Pike, G.C.
1953. Two records of _Berardius bairdi_ from the coast of British Columbia. J. Mammal. 34(1):98-104.

Documents two catches by whalers off Vancouver Island. First taken 5 July 1950, 10 miles off Kains Island; second taken 9 August 1951, 20 miles east southeast of Cape St. James. Measurements given. Stomachs contained squid parts and small rockfish. British Columbia whalers report that schools of Baird's whale are commonly seen in July and August.

1960. Pacific striped dolphin, _Lagenorhynchus obliquidens_ off the coast of British Columbia. J. Fish. Res. Board Can. 17(1):123-124.

Records encountering a school of 1000 striped dolphins 25 miles off Queen Charlotte Islands (53°30'N, 133°40'W) in June 1959. The school was travelling at about 20 knots and was accompanied by three fur seals.

1961. The northern sea lion in British Columbia. Can. Audubon 23:1-5.

Describes distribution from southern California to the arctic. Estimates Alaska populations at 150,000; British Columbia, 12,000; Oregon, 1,000; Washington, 500; California, 3,000. Of the total British Columbia population, 70% is found on 2 rookeries, west of Cape Scott and south of Cape St. James. Seasonal food intake and food species are discussed.

1962. Migration and feeding of the gray whale (_Eschrichtius gibbosus_). J. Fish. Res. Board Can. 19(5):815-838.

Observations of gray whales from the coasts of British Columbia, Washington and Alaska are combined with published accounts in an effort to define the timing and route of migration, and feeding areas in the Bering and Chukchi Seas. Route between British Columbia and Bering Sea is still unconfirmed. Feeding observations, particularly around St. Lawrence Island, are given. 4 fig. (incl. 2 maps)

Pike, G.C., and I.B. MacAskie.
1966. Report on Canadian pelagic fur seal research in 1966. Fish. Res. Board Can., Pac. Biol. Stn. Nanaimo, British Columbia, Manuscr. Rep. Ser. (Biol.) 875, 20 p.

(See Pike, Spalding, et al., 1958.) From March to June, seals were hunted off Washington and British Columbia, with two trips to Cobb Seamount. 8 tab., 5 fig.

1967. Report on Canadian pelagic fur seal research in 1967. Unpubl. manuscr., 15 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From late March to June, seals were hunted off Washington and Vancouver Island, with one trip to Cobb Seamount. Pituitary glands were collected. 8 tab., 2 fig.

1968. Report on Canadian pelagic fur seal research in 1968. Unpubl. manuscr., 20 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From March to July, seals were hunted along the North American coast from the mouth of the Columbia River to Kodiak Island. Pituitary glands were again collected. 9 tab., 3 fig.

1969. Marine mammals of British Columbia. Fish. Res. Board Can., Bull. 171, 54 p.

Records of cetaceans and pinnipeds in British Columbia and into the Gulf of Alaska up to 1967 were compiled from published and unpublished records. An account is given for each species with information on distribution, measurements, and incidental observations of interesting phenomena. A photograph or drawing is also given for each species. No abundance information is included except the occasional comment that a species is rare.

Pike, G.C., I.B. MacAskie, and A. Craig.
1965. Report on Canadian pelagic fur seal research in 1964. Unpubl. manuscr., 16 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From April to June, seals were hunted off Vancouver Island. 9 tab., 3 fig.

1966. Report on Canadian pelagic fur seal research in 1965. Unpubl. manuscr., 17 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From April to June, seals were hunted off British Columbia, Washington, Oregon, and northern California. From 10 November to 12 December, a cruise was made from Victoria to the Pribilof Islands and back, carrying scientists from both Canada and the U.S. Reproductive data were compared among seals taken by the U.S., the U.S.S.R., Japan and Canada. 7 tab., 1 fig.

Pike, G.C., and B.E. Maxwell.
1958. The abundance and distribution of northern sea lions (*Eumetopias jubata*) on the coast of British Columbia. J. Fish. Res. Board Can. 15(1):5-17.

Abundance and distribution of the northern sea lion in British Columbia waters are described on the basis of aerial surveys made in 1956-57. Compared with similar surveys made in 1913, 1916, 1938 and 1955, the number of sea lions had not changed significantly: Estimated population in 1913 was 12,000-13,000; estimate in 1956 was 11,000-12,000. Major changes over this period were in distribution and use of different rookeries. Efforts to reduce population, present rookeries, and some reproductive biology are also discussed. Annual destruction of over 1,000 sea lions is shown to be ineffective in reducing the population in general, but has eliminated some accessible rookeries.

Pike, G.C., D.J. Spalding, I.B. MacAskie, and A. Craig.
1959. Preliminary report on Canadian pelagic fur seal research in 1959. Unpubl. manuscr., 51 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From March to July seals were hunted from the mouth of the Columbia River to Kodiak Island, Alaska. 11 tab., 5 fig., 17 charts.

1960. Report on Canadian pelagic fur seal research in 1960. Unpubl. manuscr., 92 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From March to May seals were hunted from the mouth of the Columbia River to Hecate Strait (Queen Charlotte Islands). Reproduction study is presented in detail. 15 tab., 16 fig., 8 pl.

1961. Report on Canadian pelagic fur seal research in 1961. Unpubl. manuscr., 35 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) From late January to May, seals were hunted in Knight Inlet, Hecate Strait, off southwestern Vancouver Island, and off Cape Flattery, Washington. Known accumulations were sampled repeatedly. 15 tab., 5 fig.

1962. Report on Canadian pelagic fur seal research in 1962. Unpubl. manuscr., 35 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) Seals were hunted from February to June in Hecate Strait, off the west coast of Vancouver Island, and in the Gulf of Alaska. 10 tab., 9 fig.

1963. Report on Canadian pelagic fur seal research in 1963. Unpubl. manuscr., 29 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) Seals were hunted off the west coast of Vancouver Island in April and May, and on Portlock Banks, Gulf of Alaska, in June and July. Information on reproductive condition of females taken from the western North Pacific is included. 15 tab., 4 fig.

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Pike, G.C., D.J. Spalding, I.B. MacAskie, and A. Craig.
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(See Pike, Spalding, et al., 1958.) From March to July seals were hunted from the mouth of the Columbia River to Kodiak Island, Alaska. 11 tab., 5 fig., 17 charts.

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(See Pike, Spalding, et al., 1958.) From late January to May, seals were hunted in Knight Inlet, Hecate Strait, off southwestern Vancouver Island, and off Cape Flattery, Washington. Known accumulations were sampled repeatedly. 15 tab., 5 fig.

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(See Pike, Spalding, et al., 1958.) Seals were hunted from February to June in Hecate Strait, off the west coast of Vancouver Island, and in the Gulf of Alaska. 10 tab., 9 fig.

1963. Report on Canadian pelagic fur seal research in 1963. Unpubl. manuscr., 29 p. Pac. Biol. Stn., Fish. Res. Board Can., P.O. Box 100, Nanaimo, B.C., V9R 5K6, Can.

(See Pike, Spalding, et al., 1958.) Seals were hunted off the west coast of Vancouver Island in April and May, and on Portlock Banks, Gulf of Alaska, in June and July. Information on reproductive condition of females taken from the western North Pacific is included. 15 tab., 4 fig.

Between July 1972 and November 1975, 199 seals were collected and measurements and specimens taken, for age determination, reproductive analysis and food habit studies. Results showed: 10.5 months gestation including 2.5-month delay of implantation; pupping May 20 - early July; lactation 3-6 weeks followed by ovulation; sexual maturity attained by males by age seven, females at age 3-5; ample blubber reserves in winter, less by mid-summer; 1:1 sex ratio, average annual mortality rate of 24% for ages 4-21, gross annual productivity of 18.8%; dominant food items pollock, herring and cephalopods (Prince William Sound), and eulachon (Copper River Delta). 12 tab., 7 fig., 52 ref.

Pitcher, Kenneth, and Donald Calkins.
1977. Biology of the harbor seal, _Phoca vitulina richardi_, in the Gulf of Alaska. _In_ Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. 1, Receptors - mammals, p. 189-225. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Environ. Res. Lab., Boulder, Colo.

Aerial survey on 2 September 1976 indicated a minimum population of 13,000 on Tugidak Island, the largest known single concentration of harbor seals. Locations of harbor seal concentrations observed are tabulated, with dates and numbers of animals. From Kodiak area to Kayak Island, 154 seals were collected. Age, length, and weight are correlated in tables. Principal prey species identified are _Theragra_, _Octopus_, _Gadus_, _Ammodytes_, _Mallotus_, and families Cottidae and Pleuronectidae, in some areas. Reproductive cycle is described as in Pitcher (1977) except that age of onset of female sexual maturity is given as 5-8 years. It is recommended that disturbances to the outer continental shelf be restricted during pupping season (15 August - 15 October), and molting season (15 May - 15 July). Appendix on human disturbance. [See Brian W. Johnson, 1977.] 11 tab., 7 fig., 17 ref.

Polar Record.
1966. The status of the polar bear. Polar Rec. 13(84):327-336.

Distribution is said to be between 88°N and 60°N. Estimates of world population have ranged from 19,000 to 5,000. Gives reports submitted by delegations to the conference in 1965, at the University of Alaska. In Alaska, bears are found on sea ice south to St. Lawrence Island. They do not regularly come ashore in Alaska and no denning places are known.

Popov, L.A.
In press. Status of main ice forms of seals inhabiting waters of the USSR and adjacent to the country marine areas [FAO ACMRR/MM/SC/51]. _In_ Mammals in the seas, FAO [Food Agric. Org., U.N.] Fish. Ser. No. 5, Vol. 2, 17 p. [This volume will consist of documents of the Food Agric. Org. U.N., Advis. Comm. Mar. Resour. Res., Working Party on Mar. Mammals, from the Sci. Consultation on Mar. Mammals, Bergen, Norway, 31 Aug.-9 Sep. 1976.]

For North Pacific seals, a brief description of the seal, its distribution, reproductive capacity, exploitation, census and trophic relationships are given. Population estimates for the Bering Sea are: ringed seal - 70,000-80,000; ribbon seal - 60,000 in 1969; bearded seal - 250,000; larga seal - 135,000. The predominant food item of the ringed seal was cod in May and June, but this seal exhibits a seasonal shift in food items. The ribbon seals feed primarily on crustaceans and to a lesser extent on fish and cephalopods. They can exploit food resources to a depth of 200 m. Bearded seals feed in water less than 200m deep on benthic crab, shrimp (Gragonidae), mollusks (Gastropods) and polychaetes. The larga seal feeds primarily on fish, cephalopods and crustaceans. Principal food items vary with the age of the seal. Young take amphipods, shrimp and shoaling fish; immatures and adults feed on pelagic fish (flounder, pollack, cod), octopus and crustaceans, and in autumn on salmonids.

Potelov, V.A.
1975. Biological background for determining the abundance of bearded seals (*Erignathus barbatus*) and ringed seals (*Pusa hispida*). *In* K. Ronald and A.W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:553.

Discusses the problem of estimating populations based on vessel counts of swimming seals.

Prasil, R.G.
1971. Distribution of sea mammals and associated land mammals found along the Katmai coast, Katmai National Monument. Science in Alaska, Proc. 22nd Alaska Sci. Conf., College, August 17-19, 1971, p. 132. [Abstr. only.] [Additional material on this presentation has been consulted, and is avail. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, Washington 98115.]

Ten flights and 25 hours of observation from a boat were conducted by Park Service personnel from July 1969 to June 1971, along the Katmai coast, surveying for marine mammals in the area. General seasonal distribution and maximum numbers observed are given for sea otter, sea lions and hair seals. A brief description of the different habitat types available to each species is given by coastal zone.

Rainey, Froelich G.
1940. Eskimo method of capturing bowhead whales. J. Mammal. 21(3):362.

Letter dated 19 April 1940 is printed. Author, doing anthropological study at Tigara (vicinity of Pt. Hope), participated in whale-hunt, and describes experiences. Failure of bombs to explode, and premature explosions of bombs and shells (involving one death) are reported. Number of whales seen is reported at 20 or more per day. "Sometimes there are three together and then they seem to be playing. We got right in the middle of one of these games but could not get over top of any one even though they rose all around us."

1947. The whale hunters of Tigara. Am. Mus. Nat. Hist., Anthropological Papers 41 (part 2):231-283.

Author spent most of 1940 (plus several previous summers doing archeological work) at Tigara, an ancient Eskimo village at the western tip of Pt. Hope with a population of 250 Eskimos. "Social structure of Tigara village in the 19th century" and "the yearly cycle before 1900" (reconstructed from conversations with the old men of the village) are explained. Included are descriptions of hunting of seal, bearded seal, walrus, beluga (with nets), birds, fish, and above all, bowhead whale, together with associated customs, rituals and ceremonies. As many as 15 to 18 bowhead whales might be taken in the spring season by the combined crews of the village in the days before American whalers came (before 1850). Whales were abundant and only young ones (ingutuk) were pursued. Now 3 or 4 whales represent a very successful season. A brief description of "Tigara today" concludes.

Ramsey, D.H.
1968. Diurnal fluctuations in censuses of migrating California gray whales. Norsk Hvalfangst-Tid. 57(5):101-105.

Data collected in 1954-1955 and 1967-1968 from California counting stations are used to determine fluctuations in the number of migrating whales. Fewer whales are sighted during the middle of the day than either in the morning or evening.

Rasmussen, R.A., and N.E. Head.
1965. The quiet gray whale (<u>Eschrichtius robustus</u>). Deep Sea Res. 12(6):869-877.

Author's abstract: "Studies conducted during the period December 22, 1964 - March 7, 1965 near San Diego, California and at several locations in Baja California failed to confirm the use of acoustic signals by the gray whale. It is concluded that this cetacean rarely transmits subsurface sounds, and that it utilizes methods other than echolocation for navigation in shallower areas during the day."

Ray, Dorothy Jean.
1975. The Eskimos of Bering Strait, 1650-1898. Univ. Washington Press, Seattle, Washington. 305 p.

This scholarly account treats the Eskimos of the area of Seward Peninsula and southward to the southern coast of Norton Sound. Tribal organization and political organization of traditional Eskimo culture are reconstructed from eighteenth and nineteenth century reports and author's field notes. Descriptions of Eskimo subsistence include various information about sea mammals. Walrus arrived in early part of May, largest number being killed in June, they being harder to kill in fall. Wales was reported to have taken 600-700 walrus annually before commercial whaling began (mid-1800's). In 1890, 322 walrus were taken at Wales. The writings of the first white teachers at Wales contain the following records of Eskimo bowhead whaling at Wales: 1888 - one whale taken; 1889 - 3 taken, 12 struck and lost; 1890 - 0 taken, 2 struck and lost; 1891 - one taken, 29 struck and lost; 1895 - 0 taken. Good hunting areas for bearded seals were Tapkak stretch near Shishmaref; around Sledge and King Islands; the mouth of the Solomon River; and in Port Clarence. Beluga whales were caught in shallow water where they were chased toward land by men in kayaks and speared. "The best known beluga shallows were Eschscholtz Bay, at Koyuk, at Inglutalik in Golovin Bay and near Pastolik.... Cape Nome long ago was supposed to have been a rich beluga area, and an old village there, still occupied during the gold rush days, was called Setuk (seto'ak) or 'white whale.' (Another beluga shallows on the north shore of Kotzebue Sound is called 'Sheshalik', from 'sesualik', meaning 'where there are white whales.')" The seal was the most important sea mammal to almost all Eskimos. "In the 1890's, the Wales Eskimos annually captured between four and five thousand 'common seals,' besides a few other species, between 15 September and 15 June by shooting or netting, usually through the ice." Beluga and spotted seals were netted near the mouth of Tuksuk Channel (Grantley Harbor). Shaktoolik Eskimos went at all times of the year to Besboro Island for spotted seals. Seal hunting was conducted at Stuart Island, Pt. Spencer, and Atnuk. At Kikiktuak seals were caught in nets during July and September. 5 maps, 28 photos and drawings.

Ray. G. Carleton.
In press. Conservation of marine mammals. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 7 p.

Walrus serves as an illustrative example of "systems analytic modelling" which involves mapping and overlay techniques and aims to provide an objective overall view of the schedules and activities of man and of nature in a given realm. Areas of interference can be identified and an appreciation gained of what may be involved in making the doings of man and of nature compatible. Agencies with jurisdictions over the various aspects of a system are taken into account. The need for information about natural history, ecology, and behavior of marine mammals for intelligent management and conservation is emphasized. 1 ref.

Ray, G. Carleton, and Douglas Wartzok.
1977. Insights into the natural history of the Pacific walrus. Abstr. only. in Proc. (abstracts), Second Conf. Biol. Mar. Mammals, San Diego, California, 12-15 December 1977, p. 22. (Avail. from first author, Dep. of Pathobiol., The Johns Hopkins Univ., 615 Wolfe St., Baltimore, MD 21205.)

Team conducted behavioral and ecological studies in the Chukchi Sea 10-31 July, remaining with one "focal group" of 1,000-2,000 animals continuously for 12 days. Pattern of dispersal and reassociation was discerned. Benthic feeding area of "focal group" was calculated at 500 square nautical miles. Polar bear predation on walrus was observed and judged to be possibly a significant factor in mortality of young. Behavioral and ecological research is advocated for walrus and other ice-inhabiting marine mammals.

Ray, G. Carleton, and W.A. Watkins.
1975. Social function of underwater sounds in the walrus *Odobenus rosmarus*. *In* K. Ronald and A.W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:524-526.

Observations were made from the ice 30-70 nautical miles south of St. Lawrence Island in the Bering Sea, on 8-10 March 1972. From conclusion: "Male walruses exhibit a display pattern in the vicinity of mixed herds of cows, subadults, and young at the time of year when courtship and reproductive behavior are presumably at ther height. The acoustical portion of the display ... fits the ... criteria of a "song" as used to described animal sounds: stereotyped and repetitive, seasonally produced (though part of this "song" may be heard through May or later), apparently sexually distinctive, and with territorial and courtship functions. The function of the sounds described appears to be primarily in advertising the presence of a bull in breeding condition and perhaps the establishment of an underwater territory or dominance hierarchy as well." 3 fig., 5 ref.

Ray, P.H.
1885. "Narrative" and "Ethnographic sketch of the natives of Pt. Barrow." P. 19-88 in Report of the international polar expedition to Point Barrow, Alaska. Govt. Print. Office, Washington, D.C.

Author's party lived just southwest of Point Barrow from 8 September 1881 to 29 August 1883. "Narrative" notes previous history of white men at Pt. Barrow, recounts entire expedition including voyages to and from Pt. Barrow, recounts seasonal appearances of birds and marine mammals, encounters with whaling ships, weather, a week's trek inland, etc. "Ethnographic Sketch" describes general human ecology, technology, and social characteristics of Pt. Barrow Eskimos. Population declined by more than 1/3 since the 1850's. Seals a mainstay of diet. "Over one hundred [mostly ringed] seal are sometimes taken at a single air-hole within twenty-four hours..."; however, seals occasionally desert the area for a season. Twenty-four bowhead whales were taken during 2 or 3 years in the early 1850's whereas only 2 were taken during the 1882 and 1883 whaling seasons. American whalers had greatly reduced bowhead numbers during the previous 20 years.

Reeves, Randall.
1977. The walrus not exactly thriving. North 24(4):2-5.

History and present status of the species *Odobenus rosmarus* are discussed. Four stocks are: (1) Pacific walrus, *O. r. divergens*, numbering perhaps 130,000-140,000, principally in the Bering and Chukchi Seas; (2) Atlantic walrus, *O. r. rosmarus*, numbering about 10,000 in the Canadian arctic, (3) Atlantic walrus in the northeast Atlantic and Barents and Kara Seas (north of Russia), especially Franz Josef Land, numbering in the hundreds, and (4) Laptev walrus, *O. r. laptevi*, numbering at least 3,000 in the Laptev Sea, north of central Siberia. Management, protection, and threats to the species are emphasized.

Reilly, Stephen B.
1978. Pilot whale. P. 112-119 *in* Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Rice, Dale W.
1963. Pacific coast whaling and whale research. Trans. 28th North Am. Wildl. Nat. Resour. Conf.:327-335. Wildl. Manage. Inst., Washington, D.C.

Complete catch data (1956-1962) from the 3 U.S. whaling stations is tabulated. The average annual catch was less than 300 whales, which was less than 3% of the total North Pacific catch. Hunting from the two San Francisco Bay stations was conducted in the area within about 125 nautical miles of the Golden Gate. The third station, in Oregon, had taken only 6 whales. In descending order of total numbers caught, whales were: humpback. fin, sperm, sei, blue, and giant bottlenose. Relevant characteristics of each species (e.g. usual distance from shore) are noted. Captures and flensing described; quantity and value of whale products tabulated. Current research on large whales in North Pacific outlined. 2 tab., 2 fig.

1965. Synopsis of the biology and history of the gray whale. Unpubl. manuscr., 14 p. U.S. Dep. Inter., U.S. Fish Wildl. Serv., Mar. Mammal Biol. Lab., Seattle, Washington.

A synopsis offering information on distribution, migration, life history and ecology of the gray whale. Appendix recommends further research topics. Population size estimated at 6,000 in 1959-1960, with a rate of increase of 10% per year. From June to October gray whales are found in the northern Bering Sea and Chukchi Sea from the mouth of the Yukon River north to Wrangel Island and Point Barrow.

1968. Stomach contents and feeding behavior of killer whales in the eastern North Pacific. Norsk Hvalfangst-Tid. 57(2):35-38.

Remains of California sea lions, Steller sea lions, elephant seals, harbor porpoises, Dall porpoises, minke whale, opah (Lampris regius), Pacific halibut, carcharinid sharks, and squid were found in the stomachs of 10 killer whales collected between Kodiak Island, Alaska, and San Miguel Island, California. In Puget Sound, marine mammal populations are too small to support killer whale population, so fish proportion of diet is undoubtedly larger than elsewhere on the Pacific coast.

1974a. 1972-73 studies on the gray whale by the National Marine Fisheries Service. Rep. Int. Comm. Whaling 24:177-184.

Population was estimated by shore censuses at about 11,000, which may be close to the original size of the eastern Pacific stock. Low altitude light plane observations confirm that a negligible number of whales pass too far from shore to be observed by shore counters at Yankee Point, and that shore counters are probably correct in their estimates of pod sizes. Remote sensing was carried out at high altitude on 23 January 1973. The four remote sensor systems tried are listed in detail. Only the RC-8 aerial camera using 9x9 in. aerial color film at 2,000 ft. altitude proved useful for locating gray whales.

1974b. Whales and whale research in the eastern North Pacific. P. 170-195 in W.E. Schevill (ed.), The whale problem, Harvard Univ. Press, Cambridge, Mass.

The 11 large cetaceans of the eastern North Pacific are discussed, with particular regard to distribution and population. Five of the species are considered endangered; their populations are estimated as follows: black right, a few dozen; humpback, a few hundred; blue, 2,000; bowhead, a few thousand; gray 11,000. Three species are being commercially harvested under the jurisdiction of the International Whaling Commission. Their estimated numbers: fin, 9,000 recruited; sei, 28,000 recruited; sperm, several hundred thousand. Bryde's, minke, and giant bottlenose whales have unknown population sizes and are unexploited. Population data are summarized from catch statistics and other authors.

1975. Status of the eastern Pacific (California) stock of the gray whale. Food Agric. Organ. U.N., Adv. Comm. Mar. Resour. Res. ACMRR/MM/SC/14, 9 p.

Gives review of distribution, reproduction and exploitation of gray whale. Notes population size change from 1846. Present population has remained stable at about 11,000 (± 2,000) for the past 8 years.

1977a. A list of the marine mammals of the world. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-711, 15 p.

Author's abstract: "Listed are the 116 species of recent marine mammals, including freshwater species of the predominantly marine groups. The numbers of species are: Order Carnivora--36 (polar bear, sea otter and 34 pinnipeds); Order Sirenia--5; Order Mysticeti--10, and Order Odontoceti--65. The geographic distribution of each species is indicated."

1977b. Synopsis of biological data on the sei whale and the Bryde's whale in the eastern North Pacific. Rep. Int. Whaling Comm., Special Issue 1 - Rep. Spec. Meet. Sci. Comm. Sei and Bryde's whales, La Jolla, California, December 1974, p. 92-97.

Draws on data from 284 sei whales captured from 1959-1970, data from whale marking cruises in 1962-1971 off Mexico and California, and California catch statistics from 1956-1971. Sei whales: The dominant food varied seasonally. From June to August, northern anchovy (Engraulis mordax) predominated; in September to October the major catch was a krill (Euphausia pacifica). They are also known to feed on sauries and jack mackerel as well as copepods. High incidence of a disease resulting in shedding of baleen plates was found in sei whales. Reproductive cycles are given. Parasites listed. Bryde's whales: Are found year-round from 26°12'N to 21°N; have been observed feeding on the red crab (Pleuroncodes planipes) and on anchovies.

1978a. Beaked whales. P. 88-95 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

1978b. Blue whale. P. 30-35 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

1978c. Gray whale. P. 54-61 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

1978d. Sperm whales. P. 82-87 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Rice, Dale W., and Allen A. Wolman.

1969. Progress report on gray whale studies. Unpubl. manuscr., submitted to Int. Whaling Comm., 19 p. U.S. Fish Wildl. Serv., Mar. Mammal Biol. Lab., Seattle, Wash.

Whale counts were made from Point Loma and Yankee Point, California, for 10 hours a day. Extrapolations were made for night migration, poor visibility and offshore migration. Estimated population for 1968-69 was 10,000 animals.

1971. Life history and ecology of the gray whale, Eschrichtius robustus. Am. Soc. Mammal. Spec. Publ. No. 3. 142 p.

Monographic account of existing knowledge, incorporating results of authors' research, 1959-1970, which involved collection of 316 gray whales, mostly from California. Offers good descriptions of methods currently used in biological research on large whales (with exception of marking). Includes food and feeding, predators, parasites, etc. From late May to October gray whales can be found in the northwest Bering Sea, and in the Chukchi Sea as far north as 69°N. Along the northern Alaska coast, they are found from Cape Thompson to Point Barrow. A few have been seen in the Beaufort Sea as far east as Barter Island. A few animals can be found south of the Yukon Delta down the coast. 48 tab., 38 fig., 172 ref.

Robbins, L.L., F.K. Oldham, and E.M. Geiling.
1937. The stomach contents of sperm whales caught off the west coast of British Columbia. Rep. British Columbia Mus. 1937:19-20.

The stomachs of whales caught in 1936 and 1937 off Queen Charlotte Islands were examined. The most common fish was the rag-fish (*Acrotus willoughby*) [=*Icoteus aenigmaticus*], a deep sea animal. Another food item of importance was a species of giant squid (possibly *Moroteuthis robusta*). Sperm whales frequent the area off Rose Harbor, Queen Charlotte Islands, from the end of May until mid-September, with the greatest abundance in July and August.

Roest, A.I., R.M. Storm, and P.C. Dumas.
1953. Cuvier's beaked whale (*Ziphius cavirostris*) from Oregon. J. Mammal. 35(2):251-252.

On 21 February 1952 a Cuvier's beaked whale was found on the beach at Roads End, north of Oceanlake, Oregon. Measurements given.

Roppel, Alton Y., and Stuart P. Davey.
1965. Evolution of fur seal management on the Pribilof Islands. J. Wildl. Manage. 29:448-463.

Management of the northern fur seal (*Callorhinus ursinus*) and development of techniques (from indiscriminate killing to present day harvesting of specific sex and age groups) are traced.

Roppel, Alton Y., Ancel M. Johnson, Raymond E. Anas, and Douglas G. Chapman.
1965. Fur seal investigations, Pribilof Islands, 1964. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 502, 46 p.

In 1964, 48,980 male seals and 16,452 females were killed. Majority of males killed were age 3. Predicted kills of certain age classes were compared with actual kills. Reproductive studies were conducted. Skins were collected for experimentation relating economic value to age and sex. Tagging program continued. Pup mortality was investigated. Tagged pups weighed consistently less than untagged pups.

1966. Fur seal investigations, Pribilof Islands, Alaska, 1965. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 536, 45 p.

In 1965, 40,367 male seals, mostly ages 3 and 4, and 10,432 females, mostly ages 2 to 5, were killed. Females under 5 were usually not impregnated. Theoretically predicted kills for different age classes are compared with actual kills. Larger, older males were also killed to test the commercial value of their skins. Pup mortality was investigated. Tagging continued, and results are discussed at length. Male kills for 1966 are predicted. Female seals will not be intentionally killed in 1966.

Roppel, Alton Y., Ancel M. Johnson, Richard D. Bauer, Douglas G. Chapman, and Ford Wilke.
1963. Fur seal investigations, Pribilof Islands, Alaska, 1962. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 454, 101 p.

A description of research activities in 1962 is presented. Numbers and year classes of seals harvested from 2 July to 19 September are given. Data includes estimates on males, females, pups, tags and tag recovery; mortality; parasites.

Roppel, Alton Y., Ancel M. Johnson, and Douglas G. Chapman.
1965. Fur seal investigations, Pribilof Islands, Alaska, 1963. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 497, 60 p.

In the summer of 1963, 42,386 male seals and 43,952 females were killed. Ninety percent of males killed were 3 and 4 years of age. Reproductive studies were conducted. Tagging program was continued. Pup mortality is discussed. Tagged pups weighed consistently less than untagged pups.

Rovnin, A.A.
1968. Vstrechi kotikov Tikhom okeane (Frequency of occurrence of fur seals in the Pacific). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 68 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 62):87-88. In Russian. (Transl. by Israel Program Sci. Transl., 1971, p. 83-84 in V.A. Arsen'ev and K.I. Panin (eds.), Pinnipeds of the North Pacific, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 70-54020.)

Sightings of fur seals north of the Hawaiian Islands in March of 1966. There were 11 sightings in 6 days between latitudes 37°06'N and 39°06'N.

Rugh, David J., and Howard W. Braham.
In press. California gray whale (*Eschrichtius robustus*) fall migration through Unimak Pass, Alaska, 1977 [SC/30/Doc 46]. Rep. Int. Whaling Comm. 29. 20 p. + 3 fig.

From abstract: "California gray whales were censused from 20 November to 9 December 1977 as they passed Cape Sarichef, Unimak Island, Alaska, on their fall migration out of the Bering Sea. During 82.5 hours of systematic observation, 2,055 southbound whales were counted." By extrapolation from this count, it was estimated that 15,099 ±2,341 gray whales left the Bering Sea through Unimak Pass. 2 tab., 3 fig.

Ruud, J.T.
1956. The blue whale. Sci. Am. 195:46-50.

A general treatment of the blue whale which briefly discusses taxonomy, whaling methods and biology. Migration patterns are unknown, but the whales congregate in polar regions in the summer to feed.

Saario, Doris J., and Brina Kessel.
1966. Human ecological investigations at Kivalina. P. 969-1039 in N.J. Wilimovsky (ed.), Environment of the Cape Thompson region, Alaska, U.S. Atomic Energy Comm. (Avail. Natl. Tech. Inform. Serv., Springfield, Va.)

Describes seasons and ice conditions in which ringed seals and bearded seals occur. Eskimo take of these two species is tabulated by month from September 1959 to April 1961. Ringed seals begin to be seen in late October or early November. Peak occurrence is in February. In March, seals bask and can be taken on the ice. Also in March, bearded seals (ugruks) begin to appear with regularity. In May and June seals are found on large pan ice or floes, and they continue here until late June or early July, when ice is blown out to sea. Peak of ugruk hunting is in May and June. Beluga whales appear in March or April, just preceding bowhead whales; beluga kill (estimated) is tabulated for 1955-1960. Bowhead whaling was instituted in 1960, but none had yet been taken. Dead walrus are regularly found; seldom live animals. Appendix gives specimen data for 35 bearded seals and 34 ringed seals. Investigation covered a 22-month period from August 1959 to May 1961, and considered social structure and means of subsistence of Eskimos at Kivalina. 8 photos.

Sakiura, H., K. Ozaki, and K. Fujino.
1953. Biological investigation of the Northern Pacific baleen whales caught by the Japanese whaling fleet in 1952. Fish. Agency Jpn. Gov., issued by Jpn. Whaling Assoc., printed by Kokusai Bunken Insatsusha, Chiyoda-ku, Tokyo, Japan. 64 p.

Fifty-five blue, 213 fin, 37 humpback and 14 sei whales were caught from July to September 1952, in the North Pacific south of the Aleutians. Observations of external characters, external parasites, white scars, blubber thickness, mammary glands, foetus, stomach contents, genitalia condition and body measurements were recorded. The primary food items for blue, fin and humpback whales included _Thysanoessa_ and _Calanus_. Sei whales consumed mainly squid and saury. 12 tab., 21 fig., 22 ref.

Sampson, W.F.
1970. _Stenella coeruloealba_ in the northern Pacific Ocean. J. Mammal. 51(4):809.

Reported range is from the Bering Sea to southern California. In August of 1969, about 12 animals were seen at 34°N, 138°W (1,000 miles west of Los Angeles). This is the first report of the species in the open sea of the northern Pacific.

Sandegren, Finn.
1975. Sexual-agonistic signalling and territoriality in the Steller sea lion (_Eumetopias jubatus_). In K. Ronald and A.W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:195-204.

About 3,000 hours of observation were carried out on Lewis Island, Gulf of Alaska, in summers of 1967-1969, and on Año Nuevo Island, north of Santa Cruz, California, in summers of 1970 and 1971. Author describes "display" of the female, analyzing components of the display. Female display does not always lead immediately to copulation, but occurs in several situations, both before and after copulation. Male response to display discussed. Functions of various components of display are considered and compared with other species of pinnipeds. Author hypothesizes that display serves to synchronize breeding cycles of male and female. 11 photos, 2 graphs.

Sandegren, Finn E., Ellen W. Chu, and Judson E. Vandevere.
1973. Maternal behavior in the California sea otter. J. Mammal. 54(3):668-679.

Females with young were observed for a total of 300 hours, from Point Lobos to Lucia, California. Behavior is broken down into nursing, grooming young, grooming selves, feeding, swimming, and resting. Includes description of parturition, and sonograms of vocalizations between mother and pup. Describes swimming, aggression, feeding, and nursing-suckling.

Scammon, Charles M.
1870. Sea otters. Overland Monthly 4(1):25-30.

Describes appearance and behavior of sea otters. Notes distribution from Lower California to Washington in some detail. Alaskan distribution noted as abundant in the Aleutian Islands and Fox Islands. Describes methods of hunting sea otters used by Indians and whites. [Also found in Am. Nat. 4(2):65-74.]

1871. About sea-lions. Overland Monthly 9(3):266-272.

Describes several varieties of pinnipeds, including "Eumetopias stelleri, which inhabits the coasts and islands of the North Pacific, from California and southern Kamtchatka northward..." [It may be that Scammon thought of northern (Steller) and California sea lions as one species.] Describes annual drive of sea lions and their utilization by Aleuts on St. Paul Island, Pribilof Islands. Also describes ice-sealing and "net-sealing".

1872. The orca. Overland Monthly 9(1):52-57.

Brief article. Notes presence in Bering Sea and into Arctic Ocean. Mentions predation on gray whale, beluga whale and walrus calves. Mentions occasional taking by Makah Indians of Cape Flattery, Washington.

1874. The marine mammals of the northwestern coast of North America. John H. Carmany and Co., San Francisco, 320+v p., illus., 30cm. [Reprinted 1968, Dover Publications, New York, 319 p. Facsimile edition, 1969, Manessier Publishing Co., Box 5517, Riverside, Calif. 92507, XLVI+320+v p., with Scammon's charts of Baja Calif. lagoons.]

Provides a description of 24 species of cetacea, 6 pinnipeds and the sea otter. The descriptions are general and of a behavioral nature, interspersed with hunting anecdotes. The volume provides an important contribution to the history of whaling.

Scattergood, L.W.
1949. Notes on the little piked whale. Murrelet 30(1):3-16.

Review article on the minke whale. Encompasses body measurements, world distribution, reproduction, food and taxonomy. Minke whales are commonly found along the North Pacific coast. Areas of lesser abundance are off the British Columbia coast and southeastern Alaska. The primary food items are thought to be fish in the northern waters. 89 ref.

Scheffer, Victor B.
1939. Organisms collected from whales in the Aleutian Islands. Murrelet 20(3):67-69.

"Three species of crustacea and one species of nematode were collected from sperm and humpback whales at the whaling station on Akutan Island, Alaska, August 6, 1938."

1942. A list of the marine mammals of the west coast of North America. Murrelet 23(2):42-47.

There are 43 species of marine mammals listed as inhabitants of the west coast, one of which is extinct (Steller sea cow).

1945. Growth and behavior of young sea lions. J. Mammal. 26(4):390-392.

Northern sea lions were observed seven times from 23 May to 7 August 1944 on St. Paul Island, Pribilof Islands. Pupping began 23 May and continued until 20 June. Sizes and weights of 11 pups are tabulated. Newborn pups averaged 38 lbs. and 979 mm. Six- to ten-week-old pups averaged 88 lbs, and 1,250 mm. Eleven or 12 teeth were erupted in newborns. Mating occurs in June. On 23 June a pup was observed "learning to swim". 1 photo.

1949a. Notes on 3 beaked whales from the Aleutian Islands. Pac. Sci. 3(4):353.

On 6 June 1947 a specimen of Ziphius cavirostris was found on Samalga Island. On 12 November 1947 a tooth from a species of Mesoplodon was found on Amchitka Island. A specimen of Berardius bairdii was stranded in the fall of 1948 near Unalaska.

1949b. The Dall porpoise, Phocoenoides dalli, in Alaska. J. Mammal. 30(2):116-121.

Reports on observations during two cruises in 1947 and 1948. Describes range in southern Bering Sea, Aleutian Island waters, Gulf of Alaska and southeast Alaska. No seasonality was observed. Anatomical measurements given for 5 specimens. Liver analyzed for vitamin A content. 2 pl.

1950a. Porpoises assembling in the North Pacific Ocean. Murrelet 31(1):16.

Two sightings are reported: (1) On 13 July 1949 at 43°N, 139°03'W, over 5,000 unidentified porpoises (6-8 feet long, black) were reported by ship's officer. (2) In summer, about 1920 or 1930, between Seward and Cape Spencer, several thousand porpoises (probably Phocoenoides dalli) were reported by a passenger on a commercial steamer.

1950b. The striped dolphin, Lagenorhynchus obliquidens (Gill, 1865), on the coast of North America. Am. Midl. Nat. 44(3):750-758.

The range off the North American coast is from Ballenas Bay, Mexico, to Valdez, Alaska. There are three records of the striped dolphin in Alaska: Valdez, June 1901; Montague Strait, September 1905, and Sitka, September 1895. Off the British Columbia coast there was one sighting in July 1901 in Hecate Strait. There are 8 records off the Washington coast. Also included are records of sightings off the coasts of California and Oregon, as well as a description of the dolphin. Food items found in specimens include sardines and large and small squid.

1951. Measurements of sea otters from western Alaska. J. Mammal. 32(1):10-14.

Skulls and some skins of 120 otters were assembled from 1947-49, all but 19 from Amchitka Island. Upper canine of the adult male is over 10mm wide and is consistently larger than adult female's, and thus a possible means of sexing unidentified skulls.

1953a. Measurements and stomach contents from eleven dephinids from the northeast Pacific. Murrelet 34(2):27-30.

The 11 animals examined included 1 Phocaena vomerina, 8 Phocoenoides dalli, 1 Lagenorhynchus obliquidens and 1 Stenella styx. The sole food item for the P. vomerina was capelin. P. dalli contained mostly squid, but hake, horse mackerel and capelin were also present. The Lagenorhynchus was found with squid remains and jellyfish. All the specimens except 3 P. dalli and L. obliquidens were taken north of 45°N.

1953b. Otters diving to a depth of sixty feet. J. Mammal. 34(2):255.

Notes a report of otters found in crab pots in Fish Bay and Deep Bay, Sitka, Alaska, at a depth of about 10 fathoms. Quotes one other reference to otters caught in crab pots.

1958. Seals, sea lions and walruses: a review of the Pinnipedia. Stanford Univ. Press, Stanford, California. 179 p.

Gives biological characteristics, species evolution, taxonomy and systematic account of the pinnipeds. World populations estimates offered by subspecies.

1960. A dolphin Stenella from Washington state. Murrelet 41(2):23.

In February 1960 a specimen of Stenella caeruleo-albus [sic] was received anonymously from an unknown locality. If the dolphin is from Washington waters, it represents the third record for the state.

1967. Alaskan seals and sea otters: a partial bibliography. Unpubl. manuscr., 7 p. U.S. Dep. Inter., U.S. Fish Wildl. Serv., Mar. Mammal Biol. Lab., Seattle, Wash.

Includes publications from 1955-1967 that deal with distribution and population of seals and sea otters in Alaskan waters as well as methods of capturing and restraining.

1972. Marine mammals in the Gulf of Alaska. P. 175-207 in Donald H. Rosenberg (ed.), A review of the oceanography and renewable resources of the northern Gulf of Alaska. Inst. Mar. Sci., Univ. Alaska, Fairbanks.

Discusses history of regulations, uses of marine mammals and threats to particular species. Population estimates are tabulated: sea otter - 5,000; sea lion - 40,000; fur seal - 20,000; harbor seal - 20,000; walrus - rare; sperm whale - 600; sei whale - 300; fin whale - 1,000; humpback - 20; gray whale - 1,100; blue whale - 120; right whale - 50; minke whale - 200; beluga whale - 350; killer whale - 100; harbor porpoise - 1,000; Dall porpoise - 2,000; right whale dolphin, pilot whale, white-sided dolphin and beaked whales - rare. Large whale estimates are rough; procedure used to arrive at them is explained. Smaller cetaceans are estimated mainly from miscellaneous records. 66 ref.

1977. Newborn harbor seals on the Pribilof Islands, Alaska. Murrelet 58(2):44.

Four specimens (collected 1944-1950) are described and other reports are reviewed. Conclusion: that harbor seal pups on the Pribilof Islands are born between mid-May and mid-July, weigh about 25-30 lb. (11-14kg), and are about 90cm long.

1978a. Conservation of marine mammals. P. 242-244 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

1978b. Killer whale. P. 120-127 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

Scheffer, V.B., and K.W. Kenyon.
1963. Elephant seal in Puget Sound, Washington. Murrelet 44(2):23-24.

On 21 April 1963 an adult male northern elephant seal was seen swimming in Puget Sound. The observers took motion pictures of the animal for positive identification. This is the first record from Washington state.

Scheffer, V.B., and J.W. Slipp.
1948. The whales and dolphins of Washington state with a key to the cetaceans of the west coast of North America. Am. Midl. Nat. 39(2):257-337.

Records sightings or strandings for each of the 20 species (13 odontocetes, 7 mysticetes) found in Washington waters. A key to cetaceans along the west coast is provided.

Scheffer, Victor B., and Ethel I. Todd.
1967. History of scientific study of the Alaskan fur seal, 1786-1964. Unpubl. manuscr., 377 p. U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Biol. Lab., Seattle, Wash. [This work is currently in preparation for publication.]

The period is subdivided into the following parts: Russian period, 1786-1867; the interregnum, 1868-1869; Alaska Commercial Co., 1870-1889; North American Commercial Co. and the first international treaty, 1890-1909; transition years, 1910-1911; the period of population recovery, 1912-1939; the modern period, 1940-1964. "Literature cited" section consists of 84 pages and over 400 references.

Scheffer, V.B., and Ford Wilke.
1950. Validity of the subspecies _Enhydra lutris nereis_, the southern sea otter. J. Wash. Acad. Sci. 40(8):269-272.

Authors examined 56 specimens and conclude that "neither on the basis of demonstrable variation nor on the grounds of geographical isolation is there support for a southern subspecies of the sea otter."

Schiller, Everett L., and Robert Rausch.
1956. Mammals of the Katmai National Monument, Alaska. Arctic 9(3):191-201.

Information on occurrence and distribution of mammals, obtained in summer 1953 at Katmai National Monument. Survey areas included the Shelikof Strait, where harbour seals were common (especially in Kukak, Katmai and Portage Bays). The carcass of a young male northern fur seal washed ashore in May 1954 at Kanatak. Two carcasses of Steller's sea lions were found on the beach at Kukak Bay in July 1953.

Schneider, Karl B., and James B. Faro.
1975. Effects of sea ice on sea otters (_Enhydra lutris_). J. Mammal. 56(1):91-101.

Discusses offshore sea otter population in southern Bristol Bay during the winters of 1971 and 1972, when ice penetrated unusually far south along the Alaska Peninsula. Otter mortality in 1971 is estimated at at least 200. Mortality in 1972, when the onset of ice was not so sudden, was apparently negligible. Aerial surveys were made in March of both years along the north shore of the Alaska Peninsula. Authors also note expansion of known range of sea otters northeastward to Port Heiden by 1970.

Scott, R.F., K.W. Kenyon, J.L. Buckley, and S.T. Olson.
1959. Status and management of the polar bear and Pacific walrus. Trans. 24th North Am. Wildl. Conf.:366. Wildl. Manage. Inst., Washington, D.C.

From the number of bears sighted per flying hour, the Alaskan population was calculated by Tovey and Scott, 1957, to be 2,000-2,500. Walruses are said to number 45,000. Half of the walrus killed are thought to be lost through non-recovery. Mortality is estimated at twice the recruitment.

Sergeant, D.E., and P.F. Brodie.
1969. Body size in white whales, Delphinapterus leucas. J. Fish. Res. Board Can. 26:2561-2580.

Authors' abstract: "Measurements of length, girth, and weight show that male white whales grow larger than females. The smallest white whales come from western Hudson Bay, the White Sea, and Bristol Bay, Alaska. Animals of intermediate size inhabit all other arctic Canadian localities sampled and also the St. Lawrence River and the Kara and Barents seas. The largest white whales inhabit West Greenland waters, the Okhotsk Sea, and the coast of Sakhalin. Extreme differences in body weight of adult males are about threefold. Nonoverlapping differences in size indicate isolation of some adjacent populations of white whales; equal or overlapping sizes suggest, but cannot prove mixing of other populations. Size can be positively correlated with marine productivity, being lowest in the arctic and in estuaries and highest in subarctic seas. Since white whales most often grow largest at the southern ends of their range, their restriction to the arctic is attributed either to competition with certain of the Delphinidae or to predation from killer whales, Orcinus orca L., or to both. Both putative competitors and predators lack adaptations for arctic life."

1975. Identity, abundance, and present status of populations of white whales, Delphinapterus leucas, in North America. J. Fish. Res. Board Can. 32:1047-1054.

"White whales, Delphinapterus leucas, in the North American arctic number at least 30,000 animals. Largest herds identified are about 10,000 animals in western Hudson Bay, at least as many in Lancaster Sound, and at least 5000 summering in the Beaufort Sea." Around Alaska, white whales are found in Cook Inlet (150-300) and Bristol Bay (1,000-1,500), with greater numbers further north. 2 tab., 3 fig.

Sergeant, D.E., and W. Hoek.
1974. Seasonal distribution of bowhead and white whales in the eastern Beaufort Sea. P. 705-719 in J.C. Reed and J.E. Sater (eds.), The coast and shelf of the Beaufort Sea, Arctic Inst. North Am., Arlington, Va.

Authors' abstract: "Bowhead (Balaena mysticetus) and white whales (Delphinapterus leucas) migrate into the eastern Beaufort Sea from the west, arriving in May or June through leads in the pack ice. They depart westward again during September in open water. Present numbers of bowheads are not accurately known, but are probably in the low hundreds in this sector of the species' range. Groups of up to thirty have been seen on migration. Numbers of white whales are at least 3,500. Bowheads

spend the summer in oceanic water around Banks Island and off the mainland coast in the neighborhood of Cape Parry and Cape Bathurst. Many white whales are found in the same waters, but in July they move to the warm estuarine water off the Mackenzie River where calving is believed to occur and where feeding intensity is low. There is a hunt for white whales off the Mackenzie delta which for many years has taken an average of about 200 animals per year, but bowheads are not now taken from the Canadian coast of the Beaufort Sea." 1 tab., 9 fig., 13 ref.

Shaughnessy, P.D.
1975. Biochemical comparison of the harbor seals _Phoca vitulina richardi_ and _P. v. largha_. _In_ K. Ronald and A.W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:70-73.

Blood samples from 126 _Phoca vitulina richardi_ (from California, Washington, and Alaska) and 56 _P. v. largha_ seals (from the Bering Sea) were analyzed. Similarity of proteins in the two groups suggests that (a) there is still genetic interchange _or_ (b) separation was recent. Genetic homogeneity in all groups suggests past decimation of stock or the possibility that they are descended from a small number of colonizers from Atlantic stock.

Sherrod, Steve K., James A. Estes, and Clayton M. White.
1975. Depredation of sea otter pups by bald eagles at Amchitka Island, Alaska. J. Mammal. 56(3):701-703.

Three observations are given of eagles taking live pups from the water. Based on eagle nest contents (tabulated for 1969-1973), eagle predation on otter pups is variable.

Shurunov, N.A.
1970. Nekotorye gidrologicheskie kharakteristiki raionov kontsentratsii kitov v severo-vostochnoi chasti Tikhogo Okeana, Beringovom i Chukotskom moryakh (Some hydrological characteristics of whale grounds in the northeastern Pacific and Bering and Chukchi Seas). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 72:89-92. In Russian. (Transl. by Israel Program Sci. Transl., 1972, p. 83-86 _in_ P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Pt. 5, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 71-50127.)

Surveys were conducted on two vessels in 1962 along the Pacific side of the Aleutian Islands east of 170°W, and the western part of the Gulf of Alaska, to the Kenai Peninsula; the southeastern Bering Sea; the northern Bering Sea and the southern Chukchi Sea. It appears that whales form feeding concentrations in regions of contact between bodies of water of different characteristics. Hydrological information on the southeastern Bering Sea is from July; that on northern Bering and southern Chukchi is from July-August. In mid-March 1961, finbacks and sperm whales arrived in the western Gulf of Alaska and eastern Aleutian Islands waters. In about June, sei whales arrived. Concentrations of gray whales were noted in northern Bering Sea and southern Chukchi Seas.

Shustov, A.P.

1965a. Nekotorye cherty biologii i temp razmnozheniya krylatki (Some biological features and reproductive rates of the ribbon seal (Histriophoca fasciata) in Bering Sea). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 59:183-192. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1968, 17 p.)

Biological specimens were taken from 1,567 ribbon seals collected from Anadyr Inlet and in the area from St. Matthew Island to the Pribilof Islands from 1961 to 1963. From examination of sexual organs of both sexes, mating time was determined to be from the end of April through the beginning of May. Parturition occurred from the end of March through the end of April. Claw layers were used to determine age. Most females attained sexual maturity at age 2-3 and most males at age 4. Life-span remains unknown; the oldest animal examined was 26 years old. Author states that ribbon seals do not form permanent unions and assumes that one male may impregnate several females. Includes detailed discussion of appearance and size of Graafian follicles and yellow bodies in the ovary, and the reproductive conditions inferred from them.

1965b. O vliyanii promysla na sostoyanie beringomorskoi populyatsii krylatki (The effect of sealing on the state of the population of Bering Sea ribbon seals). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 59:173-178. In Russian. (Transl. by U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Mar. Mammal Div., Seattle, Wash., 11 p.)

This study was undertaken from 1960-1963, Anadyr Gulf to St. Lawrence Island. The ages of the harvested seals were determined by the dentine layers on the teeth and horny layer on the claws. Because ribbon seals are easy to hunt, their population had dropped by 1964, and it became uneconomical to hunt them over most of the Bering Sea. In addition to a population reduction, there was a clear tendency towards juvenescence in the schools after 1962. This changes the reproductive rate of the population.

1965c. Pitanie krylatki v Beringovom more (The food of ribbon seal in Bering Sea). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 59:178-183. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1968, 10 p.)

The stomachs of ribbon seals collected in the Bering Sea during the springs of 1961-1963 were analyzed. Males and females show no difference in feeding, and they feed regularly during ice rookery formation. Shrimps, crabs, and mysids were found with the greatest frequency in the seal stomachs with various fish and cephalopods of lesser importance. The majority of food was from the nektobenthos. The water depth where the seals were harvested was 60-100 m. Since the ocean bottom, and thus the food supply, is accessible to the ribbon seal in the Bering Sea, distribution is probably governed by presence of ice formations suitable for rookeries.

1965d. Raspredeleniye krylatki v beringovom more (The distribution of ribbon seal (Histriophoca fasciata) in the Bering Sea). P. 118-121 in E.N. Pavlovskii, B.A. Zenkovich, S.E. Kleinenberg, and K.K. Chapskii (eds.), Morskiye mlekopitayushchiye, Izd. "Pishch. Prom.", Moscow. In Russian. (Transl. by U.S. Nav. Oceanogr. Off., Washington, D.C., 1970, Transl. 474, 6 p.)

Information gathered by sealing and research ships in the springs of 1961 and 1962 was combined with other reports. Ribbon seals occur in the Bering Sea from the beginning of November until mid-July, where they are found mostly along the ice edge, and occasionally as far as 30-40 miles back from the edge of the ice. Animals were seen as far south as Cape Goven(a) in Olyutorskiy Gulf (mid-February) and east of the Pribilof Islands (April). Concentrations formed in St. Matthew Island area in early March. Pupping was observed 29 March - 27 April; breeding occurs around May; molting has often begun by that time. In the second half of May, concentrations were noted on three large ice fields; (1) northern Gulf of Anadyr, (2) south of St. Matthew Island (where ribbon seals were outnumbered by harbor seals), and (3) southeast of King Island. Density of seals increases with increasing concentration of ice. From July to November distribution is poorly known. Seals may inhabit the permanent ice edge north of Alaska. Single seals do occur on northeastern side of Chukchi Peninsula from November to July. Author concludes that Okhotsk and Bering populations are separate.

1967. K voprosu o ratsional'nom ispol'zovanii zapasov lastonogikh beringova morya (Rational utilization of the populations of Pinnipedia in the Bering Sea). Probl. Severa 11:182-185. In Russian. (Transl., 1968, in Problems of the North 11:219-224, Natl. Res. Council, Ottawa, Can.)

Relative abundance of ribbon, larga and bearded seals in the Bering Sea noted. Hunting methods and times given for each species.

1969. Opyt kolichestvennogo aerovizual'nogo ucheta tiulenei v severo-zapadnoi chasti Beringova moria (Experiments in quantitative aero-visual survey of seals in the northwestern part of the Bering Sea). P. 111-116 in V.A. Arseniev, B.A. Zenkovich, and K.K. Chapskii (eds.), Morskie mlekopitayushchie (Marine mammals) [a collection of articles containing materials from the 3rd All-Union Conf. on Marine Mammals], Akad. Nauk SSSR, Min. Rybn. Khoz. SSSR, Ikhtiol. Kom., Izd. "Nauka", Moscow. In Russian. (Transl. by Fish. Res. Board Can., 1970, Transl. Ser. 1510, summary only.)

Article discusses methods of aerial surveying in detail. Information is given about the placement of seals depending on the type of ice and approximate numbers of those species seen. Concludes that ribbon seal population has decreased. 2 tab., 10 ref.

1972. O sostoyanii zapasov i raspredelenii nastoyashchikh tyulenei i morzha v severnoi patsifike (On the condition of the stocks and the distribution of true seals, and walruses in the North Pacific). P. 146-147 in Tezisy Dokladov Pyatogo Vsesoyuznogo Soveshchaniya po Izucheniyu Morskikh Mlekopitayushchikh (Abstr. Papers 5th All-Union Conf. Studies Mar. Mammals) 19-21 Sept., 1972, Makhachkala. Makhachkala: Minist. Rybn. Khoz. SSSR, Ikhtiol. Kom. VNIRO, KaspNIRKh, Akad. Nauk SSSR, Zool. Inst., Inst. Evol. Morfol. Ekol. Zhivotn. im. A.N. Severtsova, Inst. Biol. Razvit. In Russian. (Transl. by F.H. Fay, Univ. Alaska, Fairbanks, 1974, 2 p.)

Centers of species concentrations remain fairly stable over the years. Local redistributions occur with yearly variations in ice cover. Aerial surveys in 1964 and 1968 show reduction in ribbon seals in the Bering Sea. Other ice seal populations remain stable. From aerial surveys in 1969 and 1970, populations are estimated. Bering Sea: ringed seal - 50,000; larga - 135,000; bearded seal - 90,000; ribbon seal - 60,000; walrus - 101,000. Okhotsk Sea: ringed seal - 800,000; larga seal - 130,000; bearded seal - 180,000· ribbon seal - 140,000. After 10-year protection, walrus stock has increased from 50,000 to 101,000-103,000.

Sleptsov, M.M.

1955. Biologiya i promysel kitov dalnevostochnykh morei (Biology of whales and the whaling fishery in Far Eastern seas). "Pishch. Prom.", Moscow. In Russian. (Transl. by Fish. Res. Board Can., Transl. Ser. 118, 6 p. Contents and conclusions only.)

Contains species composition of cetaceans in far eastern seas and in the northwestern part of the Pacific Ocean; food of whales; studies of the regions in which whales feed; distribution of Cetacea; migrations of whales; reproduction of toothed and whalebone whales; analysis of dynamics of age and sex composition of whale stocks. Includes contour maps of plankton abundance seaward from the Kurile Islands, at various times in 1953. These are compared with the distribution of cephalopod mollusks, sauries and the various whales. The North Pacific whale catch is given by species and region, with data on mean length and size distribution. Main attention is given to food. Blue whales eat fish as well as krill. Right whales have increased in the Sea of Okhotsk and northwestern Pacific. Sperm, fin and sei whale populations are said to be adequate for whaling; blue and humpback whale populations are said to be low, requiring study.

1961a. O kolebanii chislennosti kitov v Chukotskom more v raznyye gody (Fluctuations in the number of whales of the Chukchi Sea in various years). Tr. Inst. Morfol. Zhivotnykh 34:54-64. In Russian. (Transl. by U.S. Nav. Oceanogr. Off., Washington, D.C., 1970, Transl. 478, 18 p.)

The number of whales in the Chukchi Sea and their distribution, summer-autumn, depends upon the ice conditions and food supply. Most of the author's observations were from 1948. Mixing of cold and warm water occurs in the south and southwest Chukchi. This creates favorable conditions for zooplankton, biomass of which was estimated as 450-800 mg/m^3 in September 1948. Predominant species were _Calanus cristatus_, _C. finmarchicus_, _Thysanoessa rashii_, and _T. inermis_. The small cetaceans occurring in the Chukchi include: Phocoena phocoena vomerina, Phocoenoides dalli, Orcinus orca and Berardius bairdii. Delphinapterus leucas, Balaena mysticetus, and Monodon monoceros are believed to be permanent residents. Other species occasionally present include Rhachianectes glaucus [gray whale], Balaenoptera acutorostrata, Balaenoptera borealis, Balaenoptera physalus, Sibbaldius musculus [blue whale], and Megaptera nodosa.

1961b. Raiony nagula kitov v Beringovom more (Feeding regions of whales in the Bering Sea). Akad. Nauk SSSR, Tr. Inst. Morfol. Zhivotnykh 34:65-78. In Russian. (Engl. abstr., Biol. Abstr. 43(1), entry 551.)

Information from expeditions during 1947-1956 and 23 years of whaling data are used to provide a picture of the Bering Sea productivity. The highest surface concentrations of plankton occur near the Commander and Aleutian Islands and other areas of temperature flux. This attracts shoaling fish which are consumed by Phocaena phocaena, Globicephalus malus, Tursiops tursio, Orca orca, Ziphius spp., Berardius sp. and Mesoplodon sp. Large cetaceans consist of the finback whale and lesser rorqual. The time and appearance of the whales is determined by the food aggregations.

Slipp, J.W., and F. Wilke.
1953. The beaked whale Berardius on the Washington coast. J. Mammal. 34(1):105-113.

Authors examined the partially decomposed carcass of a Berardius bairdi [sic] stranded in July 1950 at Ocean City, Washington. This is the first specimen recorded for the coast of that state. Detailed measurements are given. It is noted that squid and octopus are the foods commonly found in stomachs of these animals in Japan, but that Berardius is occasionally found gorged with herring (Clupea pallasi). Authors argue that certain specimens taken in the North Pacific which have been identified as the Atlantic species of Hyperoodon were actually B. bairdi. So, such records of Hyperoodon may be transferred to the literature on Berardius in the North Pacific. 4 tab., 2 pl., 26 ref.

Small, George L.
1971. The blue whale. Columbia Univ. Press, New York. 248 p.

A general book on the blue whale. Includes some biology, but major emphasis is on whaling policies and the control of whaling, past and present.

Smith, Thomas G.
1973a. Censusing and estimating the size of ringed seal populations. Fish. Res. Board Can., Tech. Rep. 427, 18 p.+ figs.

Methodology of aerial surveys is discussed. From author's abstract: "A higher number of seals are seen along complex coastlines and different densities are observed in closely adjacent ice areas with different stability and ice cover. The latter appears to be directly related to the suitability of the ice as birth lair habitat." Other factors affecting counts are discussed. 3 tab., 4 fig., 10 ref.

1973b. Population dynamics of the ringed seal in the Canadian eastern arctic. Fish. Res. Board Can., Bull. 181, 55 p.

Two populations of ringed seals, from Cumberland Sound and Home Bay (Baffin Island, approx. 65^{o}-70^{o}N Lat.) were studied. Contents include: age determination and tooth structure; growth; reproduction; counts and behavioral observations on fast ice; estimates of population size; vital statistics of the population; dynamics of the population; management considerations. Subadult seals generally disperse offshore in winter and breeding adults remain in the fast ice. Peak haul-out is near the end of June. Aerial surveys described. 16 tab., 31 fig., 120 ref.

1974. Biology of the Beaufort region. Northern Perspectives, Can. Arctic Resour. Comm. 2(2):11-12.

There are 2 biological habitats of the southern Beaufort Sea: one is estuarine, influenced by the Mackenzie River outflow; the other is marine. The primary and secondary productivity of the area is low; this is reflected in the paucity of marine mammals of which ringed seals are the most abundant. The author estimates the summer population of bowhead whales to be several hundred animals, and beluga to be 4,000.

Smith, Thomas G., and Joseph R. Geraci.
1975. The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea. Dep. Environ. [Can.], Beaufort Sea Project, Victoria, B.C., Can., Beaufort Sea Tech. Rep. #5, 66 p.

Studies were conducted on the effects of both immersion in oil and ingestion of oil on wild and captive ringed seals and on harp seal whitecoat pups. Appendix reports effect of crude oil on ringed seal pelts (See Øritsland, 1975). 27 tab., 5 fig., 33 ref.

Smith, T.G., and I. Stirling.
1975. The breeding habitat of the ringed seal (Phoca hispida). The birth lair and associated structures. Can. J. Zool. 53:1297-1305.

Authors' abstract: "The subnivean lairs of the ringed seal (Phoca hispida) were studied in the Amundsen Gulf and Prince Albert Sound areas from 1971 through 1974. The structure of several different types of lairs are described. The existence of a birth-lair complex consisting of several closely adjacent lairs appears likely. The spacial distribution of lairs and lair types found on refrozen leads and in pressure ridges is described. Lairs were more abundant in inshore ice than in offshore ice. The function of subnivean lairs appears to be to provide thermal shelter, especially for neonate seals, and protection from predation by arctic foxes (Alopex lagopus) and polar bears (Ursus maritimus)."

Spalding, D.J.
1964. Comparative feeding habits of the fur seal, sea lion, and harbor seal on the British Columbia coast. Fish. Res. Board Can., Bull. 146, 52 p.

The stomach contents from 113 fur seals, 393 sea lions and 126 harbor seals were examined. British Columbia coastal waters support 6,000 Steller sea lions and 17,000 harbor seals. An unknown number of fur seals migrate offshore. No interspecific competition was found. Predation on commercial fish was deemed negligible. Distribution and migration are discussed.

Spotte, Stephen.
1976. Seeking the unknown. Animal Kingdom 79(2):21-25.

Author spent 5 weeks (Feb.-March 1974) in Catalina Channel area on an unsuccessful pilot whale capturing cruise. Informal discussion of biology, live capture method, behavior, appearance, taxonomy and feeding. Range in eastern Pacific is said to extend northward to Kanatak, Alaska. 2 photos + cover photo.

Stirling, Ian.
1974a. Midsummer observations on the behavior of wild polar bears (Ursus maritimus). Can. J. Zool. 52:1191-1198.

Bears were observed in the Canadian arctic in the summer of 1973. Two types of hunting were observed, stalking (23%) and still-hunting (77%). A diurnal rhythm appeared wherein the animals slept most of the latter 1/3 of the day and hunted most in the early morning hours.

1974b. Polar bear research in the Beaufort Sea. P. 721-733 in J.C. Reed and J.E. Sater (eds.), The coast and shelf of the Beaufort Sea, Arctic Inst. North Am., Arlington, Virginia.

Distribution of polar bears follows that of the pack ice. The bears move south in autumn and are found in the southeast Beaufort in winter and spring, where they concentrate in areas that are likely to have periodic open water. In summer, the bears recede north with the pack ice. They feed mainly on ringed seals and occasionally on bearded seals. Usually only the skin and blubber are eaten.

Stirling, Ian, and W. Ralph Archibald.
1977. Aspects of predation of seals by polar bears. J. Fish. Res. Board Can. 34:(8):1126-1129.

Data were gathered, as part of mark and recapture programs conducted 1971-1975, from 227 ringed and bearded seals killed by polar bears in the Canadian high eastern arctic and western arctic in spring, and 17 killed in summer and fall. Tables show analysis of data by age of killed seals, percent utilization of carcasses, and success rate of bears at subnivean breathing holes and birth lairs. Seal remains left by bears probably support large numbers of arctic foxes. 4 tab., 12 ref.

Stirling, I., R. Archibald, and D. DeMaster.
1975. Distribution and abundance of seals in the eastern Beaufort Sea. Dep. Environ. [Can.], Beaufort Sea Project, Victoria, B.C., Can., Beaufort Sea Tech. Rep. #1, 58 p.

The two main seals in the Beaufort Sea are the ringed seal (Phoca hispida) and the bearded seal (Erignathus barbatus). In a 1974 aerial survey east of 140°W, and south of 78°N, 41,982 ringed seals and 2,759 bearded seals were counted. An identical census in 1975 yielded 21,661 ringed and 1,197 bearded seals.

Stroud, S.K.
1968. Risso's dolphin in Washington state. J. Mammal. 49(2):347-348.

Records the second known specimen found north of California. The carcass was found in April, 1967, on Makkaw Beach (48°19'N, 124°40'W) at which time animal had been on beach about 1 month. Stomach contained beaks from 7 species of squid. Body measurements given.

Sund, Paul N.
1975. Evidence of feeding during migration and of an early birth of the California gray whale (Eschrichtius robustus). J. Mammal. 56(1):265-266.

Two observations were recorded in an aerial survey. (1) Southward-bound whales were feeding off Monterey on 17 and 20 January 1973. (2) On 23 January 1973 a young calf was observed making a southward migration with its apparent mother. It is inferred that the calf must have been premature because the pair was still 700 miles north of the nearest calving lagoon.

Sund, P.N., and J.L. O'Connor.
1974. Aerial observations of gray whales during 1973. Mar. Fish. Rev. 36(4):51-52.

Gray whales were observed from an airplane during January 1973 off the California coast. Apparently aircraft observations are more accurate than shore stations, but are limited by sea conditions. This study confirms the belief that 95% of migrating whales pass within 1.2 miles of Yankee Pt. in California.

Tarasevich, M.N.
1963. K biologii morskogo zaitsa (Erignathus barbatus) (Biology of the bearded seal (Erignathus barbatus). Tr. Akad. Nauk SSSR, Inst. Okeanol. 71:223-225. In Russian. (Transl. by Fish. Mar. Serv., Ste. Anne de Bellevue, Quebec, Can., 1976, Transl. Ser. 3774, 4 p.)

From the end of September to October 1958, 54 seals taken from the Kara Sea were examined. The predominant food items were the crustaceans, Mesidothea sabini, Crangon spp., and gammarid amphipods. Sexual distribution of the seals is uneven and determined by oceanic depths. Females frequent shallower inshore waters.

Taylor, F.H.C., M. Fujinaga, and F. Wilke.
1955. Distribution and food habits of the fur seals of the North Pacific Ocean - Report of cooperative investigations by the governments of Canada, Japan, and the United States of America, February - July 1952. U.S. Dep. Inter., Fish Wildl. Serv., Washington, D.C. Gov. Print. Off. 86 p.

Six vessels operated off the coast of northeastern Japan 19 February to 17 June, and off southern Hokkaido 6-17 June (2,329 seals were collected). One vessel operated off California, Oregon and Washington 8 February to 30 April. One vessel operated off Alaska 4 June to 13 July: 686 seals were collected off North America; most work was done within 30 miles of shore. Location of winter concentrations of seals is noted; distribution by sex and age is discussed. Stomach contents are discussed area by area noting proportions made up by commercial species. 50 fig., 30 tab., 9 app.

Thomas, Rex, and V.B. Scheffer.
1940. Records of ringed seals from the Pribilof Islands. J. Mammal. 43(3):428.

On 21 June 1961, one Pusa hispida was seen basking on St. Paul Island. On 26 June 1961, one specimen was found dead on St. George Island.

Thompson, R.J.
1940. Analysis of stomach contents of whales taken during the years 1937 and 1938 from the North Pacific. M.Sc. Thesis, Univ. Washington, Seattle, 82-p.

The stomachs from 237 whales of 5 species taken off the Alaskan coast were analyzed along with 37 stomachs taken from animals off the California coast. Four species of euphausiids (Thysanoessa), 5 copepod species and the surf smelt (Hypomesus pretious) comprised the bulk of the food of the Alaskan baleen whales. Sperm whales took principally squid, octopus and fish.

Thorsteinson, Fredrik V., Richard W. Nelson and Dexter F. Lall.
1961. Experimental harvest of the Steller sea lion in Alaskan waters. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 371, 15 p.

Authors' abstract: "During the summer of 1959, a commercial fishing company, under contract to the Bureau of Commercial Fisheries, conducted an experimental harvest of the Steller sea lion (Eumetopias jubata) in Alaska. During the expedition, 616 sea lions were killed of which 464 were ultimately processed. The yield was 200 tons of ground meat and 9 tons of whole livers, which was packaged in 50-pound bags, frozen, and sold through established commercial channels to fur farmers for feeding mink." 9 photos, 1 map.

Thorsteinson, Fredrik V., and Calvin J. Lensink.
1962. Biological observations of Steller sea lions taken during an experimental harvest. J. Wildl. Manage. 26(4):353-359.

Between May 27 and July 15, 1959, 464 sea lions, almost all breeding bulls, were harvested from five rookeries from Kodiak Island to the Krenitzen Islands: Marmot Island, Chowiet Island, Atkins Island, Jude Island, and Ugamak Island. Discussion includes sea lion behavior and reaction to hunting, reproduction, growth, sex and age composition of population, natural mortality of pups, and food habits.

Tikhomirov, E.A.

1959. K voprosu o pitanii sivucha teplokrovnymi zhivotnymi (The question of the use of warm-blooded animals as food by sea lions). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 47:185-186. In Russian. (Transl. by Bur. Commer. Fish., Seattle, Washington, 1963, 3 p.)

Remains of a white-coated ringed seal pup _Phoca hispida_ were found in stomach of a large adult male sea lion _Eumetopias jubatus_, killed on the ice at 58°53′N, 155°30′E (Gulf of Shelekhov, Sea of Okhotsk), 2 May 1956. Three other adult male sea lions were taken in the region; alimentary tracts were empty. Author reviews literature on sea lion food habits.

1961. Raspredelenie i migratsii tyulenei v vodakh dal′nego vostoka (Distribution and migration of seals in waters of the far east). Tr. Soveshchanii Ikhtiologicheskoi Komissii Akad. Nauk SSSR (Reports of Conferences, The Ichthyological Commission of the Academy of Sciences of the USSR), Vol. 12:199-210, Soveshchanie po morskim mlekopitayushchim, 1959 e. (Conference on pelagic mammals, 1959). (Transl. by Leda Sagen for U.S. Fish Wildl. Serv., Mar. Mammal Biol. Lab., Sand Point Nav. Air Sta., Seattle 15, Wash., 26 p.)

Most data in this paper come from the Sea of Okhotsk. Some information is included on seals in the Bering and Chukchi Seas (obtained from hunting ship captains of 1957 and 1958 and from previous literature). Largha, bearded, ringed and ribbon seals are discussed individually with detailed information on biological cycles and movements of each. 3 fig., 12 ref.

1964a. O raspredelenii i biologii lastonogikh beringova morya (materialy 1-go ekspeditsionnogo reisa v 1962 g.) (Distribution and biology of Pinnipeds in the Bering Sea). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (TINRO) 52):277-285. In Russian. (Transl. by Israel Program Sci. Transl., 1968, p. 272-280 _in_ P.A. Moiseev (ed.), Soviet fisheries investigations in the northeast Pacific, Part 3, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 67-51205.)

The Bering Sea, from Bristol Bay to the Bering Strait was surveyed for seals from 2 March to 1 July 1962. For harbor, ribbon and bearded seals, pupping takes place on the ice edge, and appears to occur simultaneously in all parts of the Bering Sea (mid-April). The nursing period continues until mid-May. Molting occurs from late May to mid-June; species differences in feeding needs at this time explain the distribution. The mechanism of reproduction is similar in all seal species, but maternal behavior is varied. For sea lions, parturition occurs in mid-June on coastal ground. Stomach dissections suggest herring is a staple food item at this time. Walruses winter in the southeastern Bering Sea. In March 1962 the population in this region numbered 10,000-15,000. Stomach dissections showed a predominance of shrimp and crab in the diet.

1964b. O raspredelenii i promysel sivucha beringovom more i sopredel'nykh raionakh tikhogo okeana (Distribution and hunting of the sea lion in the Bering Sea and adjacent parts of the Pacific). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (TINRO) 52):287-291. In Russian. (Transl. by Israel Program Sci. Transl., 1968, p. 281-285 <u>in</u> P.A. Moiseev (ed.), Soviet fisheries investigations in the northeast Pacific, Part 3, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 67-51205.)

Author estimates the sea lion stock of the entire North Pacific and Bering Sea to be 250,000 animals. The consumption of food by this population, based on a daily ration of 1/5 the body weight, is calculated to be 2,250,000 tons of food annually. The sea lions of Olyutorskii Bay and St. Matthew Island are said to consume 400-500 tons of herring daily. In Bristol Bay, sea lions concentrate near crab fisheries presumably because crab is a prominent item in their diet. The sea lion is also accused of destroying fishing nets and competing with fur seals for space on coastal rookeries. The article concludes that the population of sea lions should be reduced.

1966a. O razmnozhenii tyulenei semeistva <u>Phocidae</u> severnoi chasti tikhogo okeana (Reproduction of seals of the family <u>Phocidae</u> in the North Pacific). Zool. Zh. 45(2):275-281. In Russian. (Transl. by Fish. Res. Board Can., Ste. Anne de Bellevue, Que., 1971, Transl. Ser. 1889, 19 p.)

Data were collected from 1287 ringed, ribbon, harbor and bearded seals in the Okhotsk and Bering Seas in 1959-1962. Information on sexual maturity, whelping and reproductive biology show that the reproductive cycle is identical in all four species. Females reach sexual maturity earlier than males except in harbor seals, where the reverse is true. Mass pupping occurs in mid-April. Lactation lasts for 3-4 weeks. Mating occurs immediately after lactation ends, and implantation begins near the end of June. Since all the Far Eastern seals are found on ice, it is suggested the optimal period for births is at the time of maximum ice extension.

1966b. Opredelenie vidov dal'nevostochnykh tyulenei s samoleta (Identifying the species of Far Eastern seals from an airplane). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:163-172. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 87-97 <u>in</u> K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Discusses ringed, harbor, ribbon and bearded seal as observed in the Okhotsk, Bering and Chukchi Seas. For each species, notes distribution, degree of gregariousness, type of ice favored, usual placement on ice, appearance, and behavior. Many useful details. Optimum flying altitude felt to be 600 meters. 5 fig.

1968. Rost tela i razvitie organov razmnozheniya severotikhookeanskikh nastoyashchikh tyulenei (Body growth and development of reproductive organs of the North Pacific phocids). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 68 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 62):216-243. In Russian with English summary. (Transl. by Israel Program Sci. Transl., 1971, p. 213-241 in V.A. Arsen'ev and K.I. Panin (eds.), Pinnipeds of the North Pacific, avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 70-54020.)

In 1959-1961, in the Sea of Okhotsk, and in 1962 and 1964 in the Bering Sea, 1,521 seals were examined, including ringed, ribbon, common and bearded seals. Growth rates, weights, age at sexual maturity and life expectancy are given for each species. A table of ecological description is offered with food distribution and migratory patterns. 10 tab., 20 fig., 29 ref.

1975. Research on Pacific pinnipeds carried out by TINRO during the last decades. In K. Ronald and A. W. Mansfield (eds.), Biology of the seal. Rapp. P.-v. Réun. Cons. int. Explor. Mer 169:552. [Abstr.]

Before 1950's, research was confined to earless seals in Okhotsk Sea, and walrus. In 1958 new laboratories were organized and pinniped research staff was increased. Since then, distribution and abundance surveys, including aerial surveys, have been carried out in Bering Sea as well as Okhotsk Sea and Kuril Islands. Discreteness of populations has been investigated and physiological research is noted. Monographs on fur seal, bearded seal, and ringed seal are in preparation.

Tikhomirov, E.A., and G.M. Kosygin.

1966a. O mechenii tyulenei v Okhotskom i Beringovom moryakh (On the tagging of seals in the Sea of Okhotsk and Bering Sea). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:159-162. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 1966, p. 83-86 in K.I. Panin (ed.), Soviet research on marine mammals of the Far East.)

Tagging began with 16 seals in 1961 in Okhotsk Sea. In 1962, 35 seals were tagged in the Bering Sea, and 1 in the Chukchi Sea. In the Bering Sea, 204 were tagged in 1963 and 71 in 1964. Authors discuss pros and cons of tagging method and materials. Six out of a total of 327 tagged seals have been recovered. A figure shows movements of 4 ribbon seals between St. Matthew Island and St. Lawrence Island, and the northwestward movement of one ringed seal northwest of Cape Cezhneva.

1966b. Perspektivy promysla lastonogikh v Beringovom more (Prospects for commercial sealing in the Bering Sea). Rybn. Khoz. 42(9):25-28. In Russian. (Transl. by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Wash., 6 p.)

Data were collected March-June 1962-1965 in the Bering Sea. Ice and meteorological conditions are discussed. Most ribbon and bearded seals are found between St. Lawrence and St. Matthew Islands. The majority of ringed seals occur in Anadyr Bay. Large number of harbor seals are found in Anadyr Bay, St. Matthew, Nunivak and the Pribilof Islands. Notes pupping and molting. Steller sea lions found on ice edge in region of St. Matthew Island.

Tillman, Michael F.

1975. Assessment of North Pacific stocks of whales. Mar. Fish. Rev. 37(10):1-4.

Modern whaling in the North Pacific is reviewed. Stocks of commercial whales are assessed as follows, giving "original population", "maximum sustainable yield level", and "current population" (in that order): fin whale - 44,000, 27,000, 17,000; Bryde's whale - "unknown", 10-15,000, 20-30,000; male sperm whales - 166,000, 58,000, 72,000; female sperm whales - 152,000, 79,000, 125,000; sei whales - 50,000, 28-29,000, 20,600. (Sei whale stock was only recently assessed, by Marine Mammal Division.) Gray whales are stable at 11,000. Black right whales are severely depressed, fluctuating near 200. Blue whales and humpback whales have been protected through the International Whaling Commission since 1966. Blue whales had declined to 1,500 in 1966 from an estimated original population of 5,000. Humpback whales now number a few hundred and may be showing some recovery (originally numbering in the thousands). Recent research, IWC action on proposed whaling moratorium, and future research needs are discussed. 2 tab., 4 fig., 2 ref.

1977a. Progress report on gray and bowhead whale research. Paper prepared for US-USSR meeting, La Jolla, California, January, 1977. 4 p. + tab. (Avail. Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.)

Gray whale census activities are described and counts from California 1952/53-1975/76 are tabulated. Monitoring of the Eskimo harvest of bowhead whales beginning 1973 is discussed. Increase in number of whaling crews has brought an increased catch, and change in whaling methodology has resulted in larger numbers of whales killed-and-lost, and those struck-and-lost. Average annual catches of bowhead whales by Alaskan Eskimos, 1852-1976 are tabulated. 4 tab.

1977b. Trends in abundance of sperm whales in three areas of the North Pacific. Rep. Int. Whaling Comm. 27:343-350.

Available catch per unit effort (CPUE) data from Soviet and Japanese whaling through 1975 are analyzed by three longitudinal sectors: west of 170°E (including coastal waters of Japan, Kuril Islands, Kamchatka), east of 150°W (including Gulf of Alaska and North American coastal waters), and 180°-160°W (including central North Pacific and Aleutian Islands). Sexes are considered separately. From this analysis, "central" males and "Asian" females appear to be the most severely reduced. Implications for management are stated. 4 tab., 7 fig.

Tomilin, A.G.

1957. Kitoobraznye (Cetacea). Vol. IX of Zveri SSSR i prilezhashchikh stran (Mammals of the USSR and adjacent countries). Izd. Akad. Nauk SSSR, Moskva, 756 p. In Russian. (Transl. by Israel Program Sci. Transl., 1967, 717 p., avail. Natl. Tech. Inf. Serv., Springfield, Va.)

Encyclopedic account of species', including: nomenclature, external appearance, geographical distribution and migrations, biology, and whaling industry and its products (when applicable). Includes abundant citations from literature, author's recorded observations (largely from cruise in mid-1930's), plus information gleaned from natives of coastal areas (e.g. Siberian coast). Stomach contents are given for specific regions when known. Gives bibliography of "most important pictures" for each species; however there is no comprehensive bibliography. Illustrations and photos.

1960. O migratsiyakh, geograficheskikh rasakh, termoregulyatsii i vliyanii temperatury sredy na rasprostranenie kitoobraznykh (The migrations, geographical races, the thermo-regulation and the effect of the temperature of the environment upon the distribution of the cetaceans). P. 3-25 in Migratsii zhivotnykh (Animal migrations), no. 2, Akad. Nauk SSSR, 1960. (Transl. by Fish. Res. Board Can., 1962, Transl. Ser. 385, Biol. Sta. Nanaimo, British Columbia, 24 p.)

It is shown by marking data that whale populations do not migrate freely, but are confined to an area of the ocean. Size differences between whales of the northern and southern hemispheres are attributed to the greater cold and more abundant food of the southern hemisphere. Research on thermoregulation in cetacea is reviewed.

Tomilin, A.G., and A.A. Kibal'chich.

1975. Morzhi raiona ostrova Vrangelya (Walruses of the region of Wrangel Island). Zool. Zh. 54(2):266-272. In Russian. (Transl. by Dep. Environ., Fish. Mar. Serv., 1976, Transl. Ser. 3721, Arctic Biol. Sta., Ste. Anne de Bellevue, Quebec, Canada, 15 p.)

A study of the walrus in the Wrangel Island area during 1972 and 1973. In 1972, the population on one rookery was 36,000. The timing of hauling out and numbers of animals using this site depend on hydrological conditions and the ice situation. Animals haul out there only when the sea is ice free. Age structure of the population is mixed. Data are also provided on the feeding, reproduction and behavior of the walrus. Stomach contents included Mya, Priapulus and Ampelisca macrocephala. 1 tab., 1 fig., 10 ref.

Tomilin, A.G., and D.A. Morozov.

1968. (Sucking in of food - a previously unknown method of Phocaena phocaena feeding). Tr. Vses. Sel'skokhozyaystvennogo Inst. Zaochnogo Obrazovaniya 31:201-202. In Russian. (Transl. by Joint Publ. Res. Serv., 1970, p. 18-19 in Soviet studies on cetaceans, avail. Natl. Tech. Inf. Serv., Springfield, Va., as JPRS 49777.)

Records feeding mechanism of 2 harbor porpoises in captivity. In addition to seizing prey with their teeth, they can suck in food from 10 cm away. Skipjack was preferred, then sea bass and anchovy. Suction may be possible because of the blunt, spatulate teeth, and the broad, short snout.

Tomilin, A.G., and M.I. Smyshlyayev.
1968. O nekotorykh faktorakh smertnosti kitov (k voprosu o boleznyakh kitoobrazykh) [Some factors affecting whale mortality (diseases of cetaceans)]. Byulleten′ Moskovskogo Obshchestva Ispylateley Prirody, Otdek Biologicheskiy, 3:5-12. In Russian. (Transl. by Joint Publ. Res. Serv., 1970, p. 1-9 in Soviet studies on cetaceans, avail. Natl. Tech. Inf. Serv., Springfield, Va., as JPRS 49777.)

(In addition to human factors) Whales are subject to at least 17 species of ectoparasites and 117 species of endoparasites. Toothed whales are most affected by parasites of the digestive system whereas baleen whales are afflicted in the genitourinary system. The article recounts other possible ailments including bone fractures, skin diseases, and tumors. A new disease is described that weakens the gums to the extent that baleen plates fall out. The effects of radioactivity on cetaceans are speculated upon.

Townsend C.H.
1912. The northern elephant seal Macrorhinus angustirostris (Gill). Zoologica 1:159-173.

Elephant seal found only on Guadalupe Island (150 animals). Ten animals were collected in 1911. The largest males were 16 feet in length. They appear to be lethargic and not easily disturbed. Fighting described. No stomachs contained food. Remarkable flexibility of elephant seals is noted and attitudes described.

1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19(1):3-50.

Compilation of the records from 744 vessels and 1,665 voyages carried out from 1785 to 1916. Tables made of the catches of 6 species of whale (sperm, bowhead, northern right, southern right, humpback and California grey) in 3 oceans (Atlantic, Pacific and Indian). Whaling in the North Pacific and Bering Sea involved the right and bowhead whales and occurred almost exclusively during the summer months. Maps included showing seasonal catches.

Uda, Michitaka.
1954. Studies of the relation between the whaling grounds and the hydrographical conditions (I). Sci. Rep. Whales Res. Inst. 9:179-187.

Data from 1910-1951 were collected from all catcher boats to plot yearly whaling grounds off the Japanese coast. These have been examined with respect to the oceanographic conditions, primarily the surface temperature. Mixing areas between cold and warm water masses seem to correspond to the centers of the most productive whaling grounds. The currents off Japan and the Kurile Islands are examined in detail.

Uda, Michitaka, and Keiji Nasu.
1956. Studies of the whaling grounds in the northern sea-region of the Pacific Ocean in relation to the meteorological and oceanographic conditions (Part I). Sci. Rep. Whales Res. Inst. 11:163-179.

Concerns two whaling areas: (1) Sea-region adjacent to and northeast of Japan. Six charts show blue, fin, sei and sperm whales caught, with sea and weather conditions, during July and August 1953. Influence of cyclones is analyzed. (2) Waters of Aleutian chain. Two charts of Aleutian waters show blue, fin, sei, sperm and humpback whales caught May-September 1954. Weather and sea conditions are discussed. Good whaling is found where water masses of different temperatures meet, and in foggy conditions.

Ulmer, F.A.
1943. Two records of Dall's porpoise (Phocoenoides dalli). J. Mammal. 24(3):394.

One museum specimen was captured in Chatham Strait, southeast Alaska, summer 1933; another in the inside passage, 50 mi. north of Prince Rupert, British Columbia, August, 1939. Measurements given.

U.S. Fish and Wildlife Service.
1976. Species status report. Part II (p. 56723-56736) in Administration and status report of the Marine Mammal Protection Act of 1972; June 22, 1975 to June 21, 1976. Federal Register 41(251):56718-56736.

For each species, the following topical outline is followed: distribution and migration; abundance and trends (and harvest); general biology; ecological problems; allocation problems; regulations; and current research. Polar bear: There are six geographically isolated populations in the main polar basin. One centers in western Alaska and another in northern Alaska. Alaskan bears can winter as far south as St. Matthew Island. In summer, bears occur with the pack ice edge between 71°N and 72°N latitude. World population is estimated at 10,000-20,000 but abundance of bears off Alaskan coast coupled with sustained harvest suggest this estimate may be low. A significant number of bears are believed to den on the north slope of Alaska. Sea Otter: Distribution is described as central California north to Prince William Sound and westward along the Aleutian Chain and Commander Islands, and along southern Kamchatka Peninsula and Kuril Islands. In 1973, Alaska Department of Fish and Game estimated total Alaskan population of sea otters at 101,050-121,050. California sea otter population has been estimated at 1,600-1,800. Transplant efforts, pesticide residues, and the threat of oil pollution are mentioned. Pacific Walrus: Population winters in seasonal pack ice of Bering Sea, from Bristol Bay to St. Lawrence Island area. Most begin to migrate northward into the Arctic Ocean in April (though about 5,000 males remain on or near Round Island, Bristol Bay), and then disperse along the ice edge from about Pt. Barrow west to the Kolyma River (East Siberian Sea). From aerial survey efforts by the U.S.S.R. and U.S., very crude measures of walrus population were

obtained: 96,000 were counted along Soviet coastline; and it was estimated that along the ice edge in the Arctic Ocean, 30,000-40,000 occur west of the International Date Line, and 75,000 occur east of that line. Other Species: Atlantic walrus, manatees, dugong, and marine otter.

Uspensky, S.M., and V.I. Shilnikov.
1969. Raspredelenie i chislennost′ belykh medvedei v arktike po dannym arianablyudenii ledovoi razvedki (Distribution and numbers of the polar bear in the arctic according to the data of aerial ice surveys). P. 89-102 in A.G. Bannikov, A.A. Kishchinskii and S.M. Uspensky (eds.), The polar bear and its conservation in the Soviet arctic. Izd. Gidrometeorologicheskoe, Leningrad. In Russian with English summary.

Aerial surveys were flown in the Soviet arctic and the Barents Sea in 1962. Bears appeared to be more common on young ice fields. Density of bears seen in surveyed areas is utilized to give a world population estimate of 10-15,000 animals. [This collection of papers also contains an annotated bibliography of the Russian polar bear literature.]

Vania, John, and Edward Klinkhart.
1967. Marine mammal report. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 8, 24 p.

Reports work done in 1966. Sea lions: female reproductive tracts examined (delay of implantation found to be 3 months); pup pelage examined; molt at Lat. 58^{o}-59^{o}N found to last from last week July until beyond 25 October; total harvest 3,907, from Sugarloaf, Marmot and Akutan Islands. Sea otter: Thirty otters transplanted from Prince William Sound to Klag Bay (southeast Alaska) and Yakutat Bay; breeding success not confirmed. 2 fig. Hair seals: 300 harbor seals tagged on Tugidak Island - 45 recovered; aerial surveys of Tugidak Island, Port Heiden - Port Moller, Sitkinak Island, Seal Island, and Cinder River. Beluga whales: Belugas moved away from killer whale sounds transmitted underwater in Naknek River (Bristol Bay); measurements and stomach contents given of 11 belugas collected in Kvichak River, 1965-66.

Vania, John, Edward Klinkhart, and Karl Schneider.
1968. Marine mammal report. Alaska Dep. Fish Game, Fed. Aid Wildl. Restoration Proj. Rep. Vol. 9, 46 p.

Reports work done in 1967. Sea lions: Monitored harvest - hunters took 4,855 pup pelts; harvesting activity caused several thousand sea lions to shift from one area of rookery to another. Sea otter: Sighted transplanted otters near Klag Bay; made experimental harvest of 300 from Adak Island, 205 from Amchitka Island; sold pelts with 500 from previous experimental harvests in 1962-63; tabulated external measurements, dates and locations of collection. Harbor seals: From pelage specimens, it was found that molt occurs from late August to late October; 1,106 pups were tagged on Tugidak Island, 180 at Port Heiden; aerial surveys were made of these areas in June, July and August. Beluga whales: Killer whale noises were broadcasted underwater in Naknek and Kvichak Rivers (Bristol Bay); belugas responded at a distance of about 1 mile, changing previously observed daily movements to avoid area of transmitter.

Vladimirov, V.A.

1972. O pereselenii morskikh kotikov s o-va Tyulenii (The resettlement of fur seals from Tyuleni Island.) Rybn. Khoz. (11):27-28, November 1972. In Russian. (Transl. by For. Fish. (Transl.), Int. Activities Staff, Natl. Mar. Fish. Serv., Natl. Oceanic Atmos. Admin., U.S. Dep. Commer., Page Bldg., 3300 Whitehaven St. NW, Washington, D.C. 20235. 3 p.)

All hauling and rookery space on Tiuleny [Robben] Island is now utilized by fur seals and population has ceased to grow. Suitable site was found on the southern part of the Terpenia Peninsula on Sakhalin Island to relocate 300 fur seals. Criteria for site selection, and plans for transplant operation are covered in detail. 2 fig.

Wada, Shiro.

1975. Indices of abundance of large-sized whales in the North Pacific in 1973 whaling season. Rep. Int. Comm. Whaling 25:129-165.

Effort and catch for 1973 are tabulated by species and area. Indices of abundance, calculated from (1) Japanese catch and effort data and (2) Japanese sighting data, and presented the previous year, are updated and revised. Area of operation was extended southward to about 25^{o}N. In addition to indices, appendices give raw species data from Japanese catch 1966-1974 and Japanese sightings 1965-1974 tabulated by 10^{o} squares, and 5^{o} (Lat.) x 10^{o} (Long.) squares respectively. 4 tab. + 4 app. tab., 2 fig.

1976. Indices of abundance of large-sized whales in the North Pacific in the 1974 whaling season [SC/27/Doc 28]. P. 382-391 in Rep. and papers of the Scientific Committee of the Commission - 1975, Int. Comm. Whaling. [By the prior procedure, the material in this volume would have been published with the 26th report of the International Commission on Whaling.]

Effort and catch for 1974 are tabulated by species and area. Japanese catch and sighting data and indices of abundance from 1974 are tabulated, updating previous tabulations. 4 tab. + 2 app. tab., 2 fig.

1977. Indices of abundance of large-sized whales in the North Pacific in the 1975 whaling season. Rep. Int. Whaling Comm. 27:189-194.

Effort and catch for 1975 are tabulated by area. Japanese catch and sighting data and indices of abundance for 1975 are tabulated, updating previous tabulations. An index for Bryde's whales is included for the first time. Distance covered in sighting activities has decreased steadily since 1972. 4 tab. + 2 app. tab., 2 fig.

Watkins, William A., and G. Carleton Ray.

1977. Underwater sounds from ribbon seal, *Phoca* (*Histriophoca*) *fasciata*. Fish. Bull. 75(2):450-453.

Recordings were made 16-18 and 23 May 1967, in waters off Savoonga, St. Lawrence Is., Alaska (Bering Sea). Ribbon seals were unusually plentiful in 1967. Two types of sounds - a relatively intense prolonged downward sweep in frequency and a broadband puffing sound - were attributed to ribbon seals, for reasons which are explained. Acoustic characteristics of calls are described. 3 fig.

Whales Research Institute.
1967. Summarized result of the whale marking in the North Pacific. Rep. Int. Comm. Whaling 17:116-119.

By the end of 1965, 4,907 whales had been marked by Canada, Japan, USA and USSR. The marks from 13 blue, 166 fin, 49 sei-or-Bryde's, 18 humpback and 130 sperm whales were recovered. The North Pacific was broken into 13 areas extending from the Bering Strait to 10°N. Figures are given for each species with the number of animals marked and recaptured in each area.

Wilke, Ford, and Clifford H. Fiscus.
1961. Gray whale observations. J. Mammal. 42(1):108-109.

Reports observations off Washington, off Kodiak Is. and in the Chukchi Sea, Bering Sea and Gulf of Alaska. Includes thoughts on route of migration (favoring use of eastern Aleutian passes), and observations of feeding.

Wilke, Ford, and Karl W. Kenyon.
1952. Notes on the food of fur seal, sea-lion, and harbor porpoise. J. Wildl. Manage. 16(3):396-397.

Contents of 148 fur seal stomachs, collected in West Crawfish Inlet, near Sitka, Alaska, in winters of 1950 and 1951, were 99.5% herring. Fur seals disgorge otoliths of gadid fishes (including pollack) on Pribilof Island rookeries in summer. Three northern sea lions from the Pribilof Islands yielded sand lance, flounder, other fish and one squid beak. One harbor porpoise, taken near Port Townsend, Washington, yielded remains of five herring.

1954. Migration and food of the northern fur seal. Trans. 19th North Am. Wildl. Conf.:430-440. Wildl. Manage. Inst., Washington, D.C.

Reviews history of pelagic studies of northern fur seal. Summarizes U.S. pelagic research 1947-1952. Includes some findings of joint research project done in spring of 1952 by scientists of Canada, US, and Japan, in which seals were taken from waters off Japan and North America. Tag recoveries indicate that 1-5% of Pribilof seals winter off Japan, comprising 27% of an estimated 137,000 fur seals wintering there. Upon leaving the Pribilofs, those seals bound for the North American coast are thought to fan out southward and eastward into the eastern North Pacific, arrive in coastal waters 10-30 miles from shore anywhere from southern California to southeastern Alaska, and later work their way gradually back to the Pribilofs, in the same coastal zone. Age and sexual segration patterns, sites of winter concentrations, and food are discussed.

Wilke, Ford, Karl Niggol, and Clifford H. Fiscus.
1958. Pelagic fur seal investigations - California, Oregon, Washington, and Alaska, 1958. U.S. Fish Wildl. Serv., Section of Marine Mammal Research, Seattle, Wash., Processed Rep., 96 p.

The first year of pelagic research, under the terms of the Interim Convention on Conservation of North Pacific Fur Seals, was conducted from 1 February to 1 July, from California waters to the Bering Sea. Off Alaska, concentrations of fur seals were found at Portlock Bank, off Kodiak, and between Sanak Island and Unimak Pass. Of 1,503 seals collected, 168 were male. Age and reproductive condition were determined and stomach contents reported. Water temperature was recorded.

Wolman, Allen A.
1972. Humpback whale. P. 38-43 in A. Seed (ed.), Baleen whales in eastern North Pacific and arctic waters, Pacific Search Books, Seattle, Wash.

A general article concerning the morphology and life history of Megaptera novaeangliae. A northward migration occurs in March-April from California and Mexico to the Bering Strait and the Chukchi Sea. The whales spend about 5-1/2 months on these feeding grounds. They feed primarily on euphausiids, but are known to take anchovies occasionally. A total of fewer than 2,000 humpbacks in the North Pacific is estimated.

1978. Humpback whale. P. 46-53 in Delphine Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters, Pacific Search Press, Seattle, Wash.

[See Haley, 1978a.]

York, Anne E.
In press. Age at first reproduction of the northern fur seal: A preliminary report. Science in Alaska, Proc. 29th Alaska Sci. Conf., Fairbanks, Alaska, August 15-17, 1978, 14 p.

Author's abstract: "Pelagic collections of northern fur seals, Callorhinus ursinus, were made by the United States off the Pacific coasts of Canada and the United States between 1958 and 1974. This report concentrates on the primiparous pregnant animals from those year classes in which a sufficient range of ages is represented in the collections. Mean age at first reproduction is estimated for the 1954-1964 year classes. These range from 5.53 for the 1964 year class to 6.98 for the 1956 year class. A strong relationship between the mean age at first reproduction and the early survival rate of the year class is discussed along with the relationship between the age at first reproduction and the commercial harvest of females on the Pribilof Islands between 1958 and 1968." 1 tab., 5 fig., 8 ref., app.

Zenkovich, B.A.
1955. O migratsiiakh kitov. Promyslove raiony v dal′nevostochnykh vodakh (The migration of whales, whale fishing in the waters of the Soviet far east). P. 51-68 in S.E. Kleinenberg and T.I. Makarova (eds.), Kitoboiny Promysel Sovetskogo Soyuza (The whaling industry of the Soviet Union) (107 p.), Vses. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. [VNIRO] Izdatel′stvo, Part One, Chapter III. (Transl. by Israel Program Sci. Transl., 1968, for U.S. Dep. Inter. and Sci. Found., 14 p.)

According to evidence and records here cited, sperm whales crossed the equator in substantial numbers, and have crossed from Pacific to Atlantic and from Atlantic to Indian Oceans; bowheads have moved from Greenland waters to Pacific waters; sei whales may travel from Antarctic waters to north Pacific waters. Whale migrations are regulated by food accumulations and hydrological conditions appropriate for rearing young. Effect of a weakening of the warm Japan current in the 1940′s upon abundance of whales′ prey species and thence upon distribution of whales is described. Segregation by age during migration reported. Baleen whales of Soviet far eastern seas move south in mid-September, gravid females leaving first. Sperm whales tend to migrate south earlier. These regions are discussed individually: (1) The "southern" region, i.e., Pacific shore of southern Kamchatka Peninsula. (2) Commander Islands. (3) Olyutorski Gulf. (4) "The region of the young of the gray California whales," i.e., Glubokaya-Severnaya Bay north to Cape Navarin. Of this area author writes, "We used to count over a thousand gray whales during our observations over 7-8 days in the season." (This coastal region is unsuitable for whaling but establishment of an observation station there is contemplated.) (5) Anadyr Gulf. (6) Bering Strait. (7) Kurile Islands. Whales discussed are: sperm, fin, blue, sei, minke, bottlenose (Berardius) and killer. At Cape Olyutorsk, ringed seal and sea lion rookeries, and walruses are mentioned.

1971. Uchast′ kitov (The fate of whales). Izv. Atlant. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (AtlantNIRO) 39:7-27. In Russian. (Transl. by Fish. Mar. Serv., Quebec, Can., 1974, p. 4-41 in K.K. Chapskii and (ed.) E.S. Mil′chenko, Research on marine mammals, Transl. Ser. 3185 [562 p.]).

World oceans are divided into 4 areas: North Pacific, North Atlantic, Antarctic and Southern hemisphere. Article provides catch statistics on the blue, fin, humpback, sei, sperm and grey whales from 1900-1967, in each area. Anecdotal information offered on external parasites as they occur in different waters. Plea is made for stringent quotas in all 4 areas on the three remaining commercial species (fin, sei, sperm). 4 tab., 12 ref.

Zhirnov, L.V., A.A. Vinokurov, and V.A. Bychkov.
1975. Redkie mlekopitayushchie, ptitsy i ikh okhrana v SSSR (Rare mammals, birds and their protection in the USSR). Moscow: Ministry of Agriculture. 82 p. In Russian. (Chapter 3, Marine Mammals, p. 27-38 plus accompanying references, translated by Francis H. Fay, Univ. Alaska, Fairbanks, 1977, 17 p.)

Over the years 1968-1973, fourteen species of marine mammals have been identified as rare and vanishing, including the following from the vicinity of Alaska: spotted seal (Phoca vitulina richardi Gray, = P. kurilensis Inukai, = P. insularis Belkin); bowhead whale; Japanese right whale; gray whale; northern humpback whale; northern blue whale; northern fin whale; sea otter; polar bear. For the pinnipeds and carnivores residing in USSR territory, various population estimates made over recent decades are cited. Statuses of cetacean stocks are briefly described. In many cases recommendations include refuge areas and/or complete protection from harvesting.

Zimushko, V.V.

1969a. Materialy po razmnozheniyu serykh kitov (Data on the reproduction of gray whales). P. 24-28 in Fourth All-Union Conference on the study of marine mammals, Kaliningrad, 16-18 September 1969. Akad. Nauk SSSR, VNIRO, AtlantNIRO, Moscow, 1969. In Russian. (Transl. by Leda V. Sagen, Fish. Res. Inst., Univ. Washington, Seattle, 4 p.)

Conclusions regarding correlation of length and sexual maturity [given in Zimushko 1969b] are recapitulated. Examination of whales caught in 1967-1968 included earplugs, as well as reproductive condition and body length. The assumption is that two layers in the earplug are formed per year. These data indicate that gray whales mature during the fifth to sixth year of life, and begin to reproduce when they have 9-11 layers in their earplugs. Examination of ovaries of 20 gray whales, combined with their ages (determined as above) showed 2 different sexual cycles: About 25% of these females seemed to calve once every 2 years; about 75% seemed to calve once every year for 2-4 years and then have a period of rest. By way of partial confirmation of the existence of this latter cycle, author relates that he has encountered 7 female whales simultaneously pregnant and lactating. By consideration of the ratios between males and females, the proportion of sexually mature females, and number of females participating in reproduction, the birth rate for this population of gray whales is calculated at about 23%.

1969b. Nekotorye dannye po biologii serogo kita (Some data on the biology of the gray whale). P. 93-97 in V.A. Arsen′ev, B.A. Zenkovich, and K.K. Chapskii (eds.), Morskie mlekopitayushchie (Marine mammals) [a collection of articles containing materials from the 3rd All-Union Conf. on Marine Mammals], Akad. Nauk SSSR, Min. Rybn. Khoz. SSSR, Ikhtiol. Kom., Izd. "Nauka", Moscow. In Russian. (Transl. by Leda V. Sagen, Assoc., Coll. Fish., Univ. Washington, Seattle, 10 p.)

Biological samples were examined from the gray whales harvested from waters of the Chukot Peninsula in 1965 (summer-fall) and 1966 (July-August). Data from 29 males (size and weight of testes and condition of seminal ducts) indicated that males attain sexual maturity when body length is about 11.5m. Data from 34 females (on presence of fetus or corpora lutea or corpora albicantia) indicated that they attain sexual maturity at a body length of about 12 m. Size composition of the catches indicates increase in population of whales. 2 tab, 2 fig.

1970a. Aerovizual'nyi uchet chislennosti i nablyudeniya za raspredeleniem serykh kitov v pribrezhnykh vodakh Chukotki (Aero-visual censusing of population and observations on the distribution of grey whales in coastal waters of the Chukchi Sea*). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 71:289-294. In Russian. (Transl. by Fish. Res. Board Can., 1973, Transl. Ser. 2391, 13 p.) *[Title is inaccurately translated, and should read "...in coastal waters of the Chukot Peninsula".]

History of grey whale population estimates is reviewed. The author and A.V. Yevzerov conducted aerial surveys of grey whales in coastal waters of the Chukot Peninsula from 10 to 30 July 1968. (Humpback, minke, and beluga whales were also seen but are not discussed here.) Coastal waters were surveyed from the shore out to at least 50 km offshore, and as far as 100 km offshore where shallows extended that far. Abundance of grey whales in the survey area is calculated to be 2 times the number of animals observed (or, about 4,800 animals), and total California-Chukchi stock is estimated at slightly over 5,000. Critical comments on this initial aerial census are offered. 1 tab., 1 fig.

1970b. K voprosu ob opredelenii vozrasta serogo kita (Eschrichtius gibbosus, Erx. 1777) [Age determination of the grey whale (Eschrichtius gibbosus, Erx. 1777)]. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 71:295-300. In Russian. (Transl. by Fish. Res. Board Can., 1973, Transl. Ser. 2426, 9 p.)

The lengths of 136 gray whales, collected from June through October in recent years, were plotted. Growth of males and females was shown to proceed at roughly the same rate until the onset of sexual maturity. Peaks in the length curves are apparent, and whales fall into the following length groups: (1) less than 8.0m, (2) average length 8.9m, (3) average length 10.4m, (4) average length 11m, (5) average length 12.2m, and (6) length 12.5m and more. These groups are interpreted as being, respectively: the young of the current year; yearlings; 2-year-olds; 3-year-olds; 4-year-olds; and senior age groups. The third group showed an average of 5 earplug layers; the fourth group showed an average of 8 earplug layers. (Recent reports are cited which show that only one layer per year is formed in earplugs of fin whales rather than two layers as is generally believed to be the case in gray whales.) Length and number of earplug layers (ranging from 4 to 56) are tabulated for 50 animals. 2 tab., 2 fig. [Note: In this translation the word for earplug is mistranslated as "otolith".]

1970c. Opredelenie sledov zheltykh tel no yaichnikakh u serogo kita - Eschrichtius gibbosus (cetacea, eschrichtiidae) [Detection of corpora lutea traces in the ovaries of the gray whale - Eschrichtius gibbosus (cetacea, eschrichtiidae)]. Zool. Zhurnal 49(7):1073-1080. (Transl. by S. Pearson, 1973, for Mar. Mammal Biol. Lab., Natl. Mar. Fish. Serv., Seattle, Wash., 11 p.)

The ovaries of 70 mature gray whales were examined. Two types of corpus luteum traces were found, which differ both macroscopically and in microstructure. These are described in detail and are identified as traces of pregnancy, and traces of ovulation. Atretic follicles and atretic corpora are described. 1 tab., 2 fig.

1971. Materialy po razmnozheniyu serykh kitov (Data on the reproduction of gray whales). _In_ Issledovaniya Morskikh Mlekopitayushchikh (Research on marine mammals). Tr. Atlant. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (AtlantNIRO) 39:44-53. (Transl. by S. Pearson, 1973, for Mar. Mammal Biol. Lab., Natl. Mar. Fish. Serv., Seattle, Wash., 13 p.)

Data on length, age (assuming two layers per year in earplugs), and reproductive condition are combined. Data come from harvests during summers of 1965-1968 by coastal villages on the Chukot Peninsula. After build-up of 8-10 layers in the earplug (roughly the age of onset of sexual maturity), growth rate is reduced. It was concluded that gray whales attain sexual maturity at an age of five to six years, and that most males attain it at an age of five years. Analysis of ovaries indicated that younger females became pregnant after ovulation more often than older ones, and that the first ovulation usually results in pregnancy. It was determined that roughly 40% of the females give birth every other year and roughly 60% give birth yearly 2-4 times in succession, with a one- or two-year resting period following such a series. Birth rate is calculated at 18%. 4 tab., 3 fig.

Zimushko, V.V., and S.A. Lenskaya.
1970. O pitanii serogo kita (_Eschrichtius robustus_ Erx.) na mestakh nagula [Feeding of the gray whale (_Eschrichtius robustus_ Erx.) at foraging grounds]. Ekologia, Akad. Nauk SSSR, 1(3):26-35. (Transl. by Consultants Bur., Div. of Plenum Publ. Corp. 227 W. 17th St., N.Y., N.Y. 10011, 1971, for sale upon request.)

Gray whale feeding studies are reviewed. Present article is based on materials and observations 1965-1969 in coastal waters of the Chukot Peninsula. Figure shows density of benthos and of gray whales in part of the Bering and Chukchi Sea. Regular gatherings of gray whales are observed in food-rich regions of the Gulf of Anadyr, Bering Strait, and the Chukchi Sea, but not in the food-poor southeastern Bering Sea. Absence of gray whales in certain areas of high density of benthos is explained by the low proportion of that benthos comprised by amphipods - the whales' primary food. Samples from 41 cows and 29 bulls were collected. List of foods found in stomachs includes 71 species. Dominant food items were amphipods of six species. It was noted that smaller animals kept closer to the shore than larger ones. No substantial differences were found between stomach contents of young and old animals, that of males and females, or that of whales taken from different areas. Seasonal changes in prey are noted, and also yearly differences in feeding. Calculations are given of quantity of food consumed by one animal per feeding (about 300 kg), per day (about 1200 kg), and per year (170 tons during 130-140 days of summer feeding). Estimating the total number of gray whales feeding in this area to be 5,000, food consumed would be 850,000 tons per year.

INDEX

SECTION

KEY TO INDEX CODES

In Species Index:

A	= Abundance
D	= Distribution
F	= Feeding
BF	= Beaufort Sea
CH	= Chukchi Sea
BR	= Bering Sea
AL	= Aleutian Ridge
GA	= Gulf cf Alaska

In Area Index and Subject Index:

BA	= *Balaenoptera acutorostrata* - minke whale
BB	= *Berardius bairdii* - giant bottlenose whale
BG	= *Balaena glacialis* - black right whale
BM	= *Balaenoptera musculus* - blue whale
Bow	= *Balaena mysticetus* - bowhead whale
BP	= *Balaenoptera physalus* - fin whale
Cet	= Cetaceans (general) - whales, dolphins, and porpoises
CU	= *Callorhinus ursinus* - northern fur seal
DL	= *Delphinapterus leucas* - beluga whale
EB	= *Erignathus barbatus* - bearded seal
EJ	= *Eumetopias jubatus* - northern (Steller) sea lion
ER	= *Eschrichtius robustus* - gray whale
GG	= *Grampus griseus* - Risso's dolphin
GM	= *Globicephala macrorhynchus* - shortfin pilot whale
HG	= *Hydrodamalis gigas* - great northern sea cow
LB	= *Lissodelphis borealis* - northern right whale dolphin
LO	= *Lagenorhynchus obliquidens* - Pacific white-sided dolphin
MN	= *Megaptera novaeangliae* - humpback whale
Mon	= *Monodon monoceros* - narwhal
MS	= *Mesoplodon stejnegeri* - sabertooth whale
OO	= *Orcinus orca* - killer whale
PD	= *Phocoenoides dalli* - Dall porpoise
PF	= *Phoca fasciata* - ribbon seal
PH	= *Phoca hispida* - ringed seal
Phoc	= Phocid seals (general) - true (earless) seals
Pinn	= Pinnipeds (general) - seals, sea lions, and walruses
PL	= *Phoca largha* - larga seal
PM	= *Physeter macrocephalus* - sperm whale
PP	= *Phocaena phocaena* - harbor porpoise
PV	= *Phoca vitulina* - harbor seal
SC	= *Stenella coeruleoalba* - striped dolphin
Sei	= *Balaenoptera borealis* - sei whale
UM	= *Ursus maritimus* - polar bear
ZC	= *Ziphius cavirostris* - goosebeak whale
Ziph	= Ziphiid whales (general) - beaked whales

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SPECIES INDEX

AREA INDEX

SUBJECT INDEX

SPECIES INDEX

M A R I N E   M A M M A L S   [MM]
(general)

1874	Scammon		D						
1920	Hanna		D				Br		
1923	Hanna		D				Br		
1926	Bailey & Hendee		D			Ch	Br		
1938	Barabash-Nikiforov		D					Al	
1942	Scheffer								
1956	Bee & Hall		D		Bf	Ch			
1957	Brooks								
"	Clarke		D						
1959	Murie		D				Br	Al	GA
1960	Kenyon	A	D				Br		
1963	Brooks								
1966	Fedoseev	A	D			Ch	Br		
"	Johnson, M.L. et al.		D			Ch			
1967	Nishiwaki		D			Ch	Br	Al	GA
"	Scheffer								
1969	Pike & MacAskie		D						GA
1972	Burgess		D				Br		
"	Kenyon	A	D				Br		
"	Moiseev		D						
1973	Burns & Morrow		D		Bf	Ch			
"	Scheffer	A							GA
1974	Fay		D				Br		
1975	Calkins et al.	A	D						GA
" a	Fay	A					Br		
" b	Fay					Ch	Br		
" a	Mar. Mammal Biol. Lab.		D				Br	Al	GA
"	Zhirnov et al.								
1976	Amer. Soc. Mammal.								
1977	Amer. Soc. Mammal.								
"	Berg						Br		
"	Braham, Everitt, et al.	A	D				Br		
"	Braham, Fiscus & Rugh					Ch	Br		
"	Fay						Br		
"	Lowry et al.			F	Bf				
"	Mercer et al.	A	D						GA
"	Natl. Mar. Fish. Serv.	A	D	F					
"	Rice		D						
1978a	Haley	A	D	F					
" b	Mitchell								
" a	Scheffer								
1979	Braham, Krogman et al.		D			Ch	Br		
in press	Brooks	A	D						
"	Chapman								
"	Fay								
"	Fay et al.						Br		GA
"	Ray								

P I N N I P E D S
(seals, sea lions, and walruses)

Callorhinus ursinus [CU] - (northern fur seal)

1915	Osgood et al.	A	D				Br		
1920	Hanna		D				Br		
1952	Kenyon			F					GA
"	Wilke & Kenyon		D	F					GA
1953	Alexander			F			Br		GA
"	Kenyon & Wilke		D						
1954	Wilke & Kenyon		D	F			Br	Al	GA
1955	Taylor et al.	A	D	F			Br	Al	GA
1956	Bee & Hall		D		Bf	Ch			
"	Schiller & Rausch		D						GA
1957	Brooks								
1958	Pike et al.	A	D	F					GA
"	Wilke et al.		D	F			Br		GA
1959	Murie		D				Br	Al	GA
"	Niggol et al.		D	F					
"	Pike et al.		D						GA
1960	Niggol et al.		D	F			Br	Al	GA
"	Pike et al.		D						GA
1961	Fiscus et al.		D	F					GA
"	Kenyon								
"	Pike et al.		D						GA
1962	Pike et al.		D						GA
1963	Jones		D				Br		GA
"	Pike et al.		D						GA
"	Roppel et al.	A							
1964	Fiscus et al.		D	F			Br	Al	
"	Spalding			F					GA
1965	Fiscus et al.		D	F			Br		
"	Fiscus & Kajimura		D	F			Br		GA
"	N. Pac. Fur Seal Comm.		D	F					
"	Pike et al.		D						GA
"	Roppel & Davey								
"	Roppel et al.	A							
"	Roppel Johnson & Chapman	A							
1966	Chugunkov & Prokhorov		D	F			Br		
"	Johnson, M.L. et al.		D			Ch			
" b	Panina			F					
"	Pike & MacAskie		D						GA
"	Pike et al.		D				Br		GA
"	Roppel et al.	A							
1967	Fiscus & Kajimura		D	F					GA
"	Pike & MacAskie		D						GA
"	Scheffer & Todd	A	D	F					
1968	Peterson et al.		D						
"	Pike & MacAskie		D						GA
"	Rovnin		D						
1969	Arsen'ev								
"	MacAskie		D						GA
"	Machida		D				Br	Al	
"	Mar. Mammal Biol. Lab.		D	F					
"	N. Pac. Fur Seal Comm.		D	F					
"	Peterson & LeBoeuf	A	D						
1970	Baker, Wilke & Baltzo	A	D	F					
"	MacAskie		D						GA
" a	Mar. Mammal Biol. Lab.	A	D	F			Br	Al	GA
" b	Mar. Mammal Biol. Lab.		D						GA
1971a	Arsen'ev		D						
" b	Arsen'ev		D						
"	Bigg & MacAskie								GA
"	Machida		D				Br	Al	
"	Harry	A							
" a	Mar. Mammal Biol. Lab.		D	F					GA
" b	Mar. Mammal Biol. Lab.	A	D	F					GA
"	N. Pac. Fur Seal Comm.		D	F					
"	Panina		D	F					
1972	Arsen'ev	A	D						
"	Bigg & MacAskie								GA
" a	Fiscus		D	F				Al	
" b	Fiscus	A	D	F			Br		GA
"	Ichihara & Yoshida			F					
"	Mar. Mammal Biol. Lab.	A	D						GA
"	Vladimirov		D						
1973	Chapman	A							
"	Kuzin et al.	A	D						
"	Lentfer		D			Ch			
"	Mar. Mammal Div.	A	D	F					GA
"	Scheffer	A							GA
1974	Anas								
"	Bigg & MacAskie								GA

C. ursinus (cont.)

"	Mar. Mammal Div.	A	D		Br		
1975	Bigg & MacAskie						GA
"	Borodin & Vladimirov	A				Al	
"	Johnson, A.M.	A					
"	Kuzin	A	D				
"	Lander	A					
"	Mar. Mammal Div.		D	F	Br		
"	N. Pac. Fur Seal Comm.		D	F			
"	Pitcher		D				GA
1976	Kooyman,Gentry&McAlister						
"	Kooyman,Gentry& Urquhart	9		F			
"	Lander & Kajimura	A	D	F			
"	Mar. Mammal Div.	A		F			
1977	Bogdanov et al.				Br		
"	Gentry			F			
"	Kajimura et al.		D	F			
"	Mar. Mammal Div.	A		F	Br		
1978	Fiscus						
"	Mar. Mammal Div.	A		F	Br		
in press	York				Br		

Erignathus barbatus [EB] - bearded seal

1885	Murdoch	A	D		Bf	Ch	
1923	Hanna		D				Br
1926	Bailey & Hendee		D			Ch	Br
1947	Rainey		D			Ch	
1956	Bee & Hall		D		Bf	Ch	
1957	Brooks						
1960	Fay						
" a	Kenyon	A	D				Br
1962b	Kenyon		D	F			Br
1963	Brooks			F			
"	Tarasevich		D	F			
1964a	Tikhomirov		D	F			Br
1965a	Burns						
" c	Burns		D				
"	Foote					Ch	
1966	Burns						
"	Fedoseev		D			Ch	
"	Johnson, M.L. et al.		D	F		Ch	
" a	Kosygin		D	F			Br
" b	Kosygin		D				Br
" c	Kosygin		D				Br
"	Saario & Kessel		D			Ch	
" a	Tikhomirov		D				Br
" b	Tikhomirov		D			Ch	Br
" b	Tikhomirov & Kosygin		D				Br
1967a	Burns	A	D	F		Ch	Br
" b	Burns		D				
"	Shustov	A					Br
1968	Tikhomirov		D	F			Br
1970	Burns		D			Ch	Br
1971	Kosygin			F			Br
1972	Burgess		D				Br
"	Kenyon	A	D				Br
"	Shustov	A	D				
1973	Burns		D				
1974b	Stirling				Bf		
1975	Kosygin	A	D				Br
"	Potelov						
"	Ray, D.J.		D			Ch	Br
"	Stirling et al.	A	D		Bf		
1976	Kooyman,Gentry&McAlister						
"	Popov	A	D	F			Br
1977	Braham, Everitt et al.	A	D				Br
"	Braham, Krogman & Fiscus		D		Bf	Ch	
"	Burns & Eley	A	D		Bf	Ch	Br
"	Burns, Shapiro & Fay		D				
"	Eley				Bf	Ch	
" a	Lowry et al.			F	Bf		
" b	Lowry et al.			F	Bf	Ch	Br
"	Stirling & Archibald				Bf		
1978	Burns						
in press	Lowry et al.			F			Br
"	Marquette				Bf	Ch	

Eumetopias jubatus [EJ] - northern (Steller) sea lion

1871	Scammon		D		Br		
1915	Osgood et al.	A	D		Br		
1945	Scheffer		D		Br		
1947	Imler & Sarber	A	D	F			GA
1952	Kenyon			F			GA
"	Wilke & Kenyon		D	F	Br		
1956	Schiller & Rausch		D				GA
1957	Brooks						
1958	Fay		D		Br		
"	Pike & Maxwell	A	D				GA
1959	Daetz		D				GA
"	Mathisen	A	D	F	Br	Al	GA
"	Murie		D		Br	Al	GA
"	Tikhomirov			F			
1961	Kenyon & Rice	A	D		Br	Al	GA
"	Pike	A	D	F			GA
"	Thorsteinson et al.						
1962	Fiscus & Scheffer		D	F		Al	GA
" a	Kenyon	A	D		Br		
"	Mathisen et al.			F			GA
"	Thorsteinson & Lensink		D	F			GA
1963	Brooks	A		F			
"	Mathisen & Lopp	A	D			Al	GA
1964	Spalding			F			GA
" a	Tikhomirov		D	F	Br		
" b	Tikhomirov	A	D	F	Br		
1965	Kenyon	A	D		Br	Al	
1966	Chugunkov & Prokhorov		D	F	Br		
"	Fiscus & Baines		D	F	Br		GA
" a	Panina			F			
" b	Tikhomirov & Kosygin		D		Br		
1967	Vania & Klinkhart		D				GA
1968	Rice						
"	Vania et al.		D				GA
1969	Peterson & LeBoeuf	A	D				
1971	Branson				Br		
"	Prasil	A	D				GA
1972	Burgess		D		Br		
" a	Fiscus		D	F		Al	
1973	Kuzin et al.		D				
"	Scheffer	A					GA
1974	Mar. Mammal Div.			F			
1975	Barr	A		F			
"	Calkins et al.	A	D				GA
"	Carlson						GA
" b	Mar. Mammal Div.			F			
"	Pitcher	A	D				GA
"	Sandegren						GA
1976	Mar. Mammal Div.			F			
1977	Braham et al.	A	D		Br	Al	
"	Braham, Everitt et al.	A	D			Al	
" a	Calkins & Pitcher	A	D	F			GA
"	Gentry			F			
"	Mercer et al.	A	D				GA
1978	Gentry & Withrow						

Mirounga angustirostris [MA] - northern elephant seal

1912	Townsend				
1924	Anthony	A	D		
1945	Cowan & Carl		D		GA
1952	Bartholomew				
1960	Bartholomew & Hubbs	A	D		
1963	Brooks	A			
"	Scheffer & Kenyon		D		
1968	Rice				
1969	Peterson & LeBoeuf	A	D		
1970	Morejohn & Baltz			F	
"	Calkins & Pitcher		D		GA
1977	Gogan	A	D	F	GA
1978	DeLong				

Odobenus rosmarus [OR] - walrus

1872	Murie, J.								
1872	Scammon								
1885	Murdoch	A	D		Bf	Ch			
1920	Hanna		D				Br		
1923	Hanna		D				Br		
1926	Bailey & Hendee		D			Ch	Br		
1941	Nikulin		D	F		Ch	Br		
1947	Nikulin		D			Ch	Br		
"	Rainey		D			Ch			
1952	Fay		D	F			Br		
1953	Fay						Br		
1954	Brooks	A	D	F		Ch	Br		
"	Fay		D						
1955	Fay	A	D	F		Ch	Br		
1956	Bee & Hall		D		Bf	Ch			
1957	Brooks								
"	Fay	A							
1958	Fay						Br		
1959	Murie		D	F			Br	Al	GA
"	Scott et al.	A							
1960	Fay			F					
" b	Kenyon	A	D				Br		
" d	Kenyon						Br		
1962	Fedoseev	A	D			Ch	Br		
"	Krylov					Ch			
1963	Burns & Croxton	A	D						
1964a	Tikhomirov		D	F			Br		
1965a	Burns								
" b	Burns	A	D	F		Ch	Br		
" c	Burns	A	D						
"	Foote					Ch			
"	Kenyon		D				Br	Al	
1966	Burns		D						
"	Fedoseev	A	D			Ch	Br		
"	Johnson, M.L. et al.		D			Ch			
"	Krylov		D			Ch	Br		
"	Saario & Kessel		D			Ch			
1967b	Burns	A	D				Br		
1968	Branson		D						GA
"	Gol'tsev	A	D			Ch	Br		
"	Krylov	A	D			Ch			
1970	Burns		D			Ch	Br		
1971	Frame		D	F	Bf	Ch			
"	Krylov			F		Ch			
1972	Burgess		D				Br		
"	Gol'tsev	A	D			Ch	Br		
"	Kenyon	A	D				Br		
"	Shustov	A	D						
1973	Scheffer	A							GA
1975a	Fay			F					
" b	Fay								
"	Fiscus & Marquette				Bf	Ch			
1975	Kosygin	A	D			Ch	Br		
"	Miller		D				Br		
"	Ray, D.J.		D			Ch	Br		
"	Ray, G.C. & Watkins						Br		
"	Tomilin & Kibal'chich	A	D	F		Ch			
1976	Fedoseev								
"	Marquette					Ch			
"	Golt'sev	A	D			Ch	Br		
"	Miller		D				Br		
"	U.S. Fish Wildl. Serv.	A	D			Ch	Br		
1977	Braham et al.	A	D				Br		
"	Braham, Krogman & Fiscus		D		Bf	Ch			
"	Burns								
"	Burns, Shapiro & Fay		D						
"	Estes	A							
"	Fay						Br		
"	Fay et al.	A		F			Br		
" a	Lowry et al.			F	Bf				
"	Ray, G.C. & Wartzok		D	F		Ch			
"	Reeves	A				Ch	Br		
1978	Estes & Gilbert					Ch			
" b	Kenyon								
"	Krogman et al.	A	D			Ch	Br		
in press	Brower								
"	Fay & Ray						Br		
"	Fay et al.						Br		
"	Marquette				Bf	Ch			
"	Ray								

Phoca fasciata [PF] - ribbon seal

1873	Gill		D					
1885	Murdoch	A	D		Bf	Ch		
1928	Bailey		D				Br	
1941	Arsen'ev		D	F				(Okh.)
1956	Bee & Hall		D		Bf	Ch		
1957	Brooks							
1960a	Kenyon	A	D				Br	
1963	Brooks	A						
1964a	Tikhomirov		D	F			Br	
1965a	Shustov		D				Br	
" b	Shustov	A					Br	
" c	Shustov		D	F			Br	
" d	Shustov		D			Ch	Br	
1966	Johnson, M.L. et al.		D			Ch		
" b	Kosygin		D				Br	
" c	Kosygin		D				Br	
" a	Tikhomirov		D				Br	
" b	Tikhomirov		D			Ch	Br	
" a	Tikhomirov & Kosygin		D				Br	
" b	Tikhomirov & Kosygin		D				Br	
1967	Shustov	A					Br	
" b	Burns		D					
1968	Tikhomirov		D	F			Br	
1969	Shustov	A	D				Br	
1970	Burns		D			Ch	Br	
1972	Burgess		D				Br	
"	Kenyon	A	D				Br	
"	Shustov	A	D					
1973	Burns		D					
"	Fedoseev	A	D				Br	(Okh.)
1975	Kosygin	A	D				Br	
1976	Fedoseev & Shmakova		D				Br	
"	Popov	A	D	F			Br	
1977	Braham et al.	A	D				Br	
"	Burns, Shapiro & Fay		D					
" b	Lowry et al.			F	Bf	Ch	Br	
"	Watkins & Ray	A	D				Br	
1978	Burns							
in press	Lowry et al.			F			Br	

Phoca hispida [PH] - ringed seal

		A	D	F	Bf	Ch	Br	
1885	Murdoch	A	D		Bf	Ch		
"	Ray, P.H.	A	D		Bf	Ch		
1926	Bailey & Hendee		D			Ch	Br	
1946	Pikharev			F				
1947	Rainey		D			Ch		
1956	Bee & Hall		D		Bf	Ch		
1957	Brooks							
1959	Tikhomirov							
1960	Fay							
" a	Kenyon	A	D				Br	
" c	Kenyon		D				Br	
1962b	Kenyon		D	F			Br	
"	Thomas & Scheffer		D				Br	
1963	Brooks			F				
1965	Foote					Ch		
1966	Burns							
"	Fedoseev		D			Ch		
"	Johnson, M.L. et al.		D	F		Ch		
"	Saario & Kessel		D			Ch		
" a	Tikhomirov		D				Br	
" b	Tikhomirov		D			Ch	Br	
" a	Tikhomirov & Kosygin		D			Ch		
" b	Tikhomirov & kosygin		D				Br	
1967b	Burns		D					
1968	Tikhomirov		D	F			Br	
1970	Burns		D			Ch	Br	
"	Fedoseev & Nazarenko						Br	
"	Mansfield	A						
1972	Burgess		D				Br	
"	Burns & Harbo	A	D		Bf	Ch		
"	Kenyon	A	D				Br	
"	Shustov	A	D					
1973	Burns		D					
" a	Smith		D					
" b	Smith		D					
1974	Smith	A			Bf			
" b	Stirling				Bf			
1975	Fedoseev		D			Ch	Br	(Okh.)
"	Fiscus & Marquette				Bf	Ch		
"	Kosygin	A	D				Br	
"	Øritsland							
"	Potelov							
"	Ray, D.J.		D			Ch	Br	
"	Smith & Geraci				Bf			
"	Smith & Stirling		D					
"	Stirling et al.	A	D		Bf			
"	Zhirnov et al.							
1976	Geraci & Smith				Bf			
"	Marquette					Ch		
"	Popov	A	D	F			Br	
1977	Braham et al.	A	D				Br	
"	Braham, Krogman & Fiscus		D		Bf	Ch		
"	Burns & Eley	A	D		Bf	Ch	Br	
"	Burns, Shapiro & Fay		D					
"	Eley				Bf	Ch		
"	Engelhardt et al.							
"	Fay						Br	
" a	Lowry et al.			F	Bf			
" b	Lowry et al.			F	Bf	Ch	Br	
"	Stirling & Archibald				Bf			
1978	Burns							
"	Lowry et al.			F	Bf	Ch		
in press	Lowry et al.			F			Br	
"	Marquette				Bf	Ch		

Phoca largha [PL] - larga seal, spotted seal
and/or
Phoca vitulina [PV] - harbor seal, common seal

		A	D	F	Bf	Ch	Br	Al	GA
1885	Murdoch	A	D		Bf	Ch			
1926	Bailey & Hendee		D			Ch	Br		
1928	Bailey		D				Br		
1947	Imler & Sarber	A	D	F					GA
1956	Bee & Hall		D		Bf	Ch			
"	Schiller & Rausch		D						GA
1957	Brooks								
1958	Fay		D				Br		
1959	Murie		D				Br	Al	GA
1963	Brooks			F					
"	Mathisen & Lopp								GA
1964	Spalding			F					GA
" a	Tikhomirov		D	F			Br		
1965	Foote					Ch			
"	Kenyon	A	D				Br	Al	
1966	Burns								
"	Johnson M.L. et al.		D			Ch			
" b	Kosygin		D				Br		
" a	Panina			F					
" a	Tikhomirov		D				Br		
" b	Tikhomirov		D			Ch	Br		
" b	Tikhomirov & Kosygin		D				Br		
1967	Bishop	A	D	F					GA
" b	Burns		D						
"	Chapskii						Br		
"	Klinkhart								GA
"	Shustov	A					Br		
"	Vania & Klinkhart		D				Br		GA
1968	Tikhomirov		D	F			Br		
"	Vania et al.	A	D				Br		GA
1969	Bigg	A	D	F					GA
"	Klinkhart	A	D				Br		GA
1970	Burns		D			Ch	Br		
1971	Prasil	A	D						GA
1972	Burgess		D				Br		
"	Burns, Ray et al.		D				Br		
"	Kenyon	A	D				Br		
"	Shustov	A	D						
1973	Burns		D						
"	Burns & Fay		D		Bf	Ch	Br	Al	
"	Scheffer	A							GA
1974	Anas								
1975	Calkins et al.	A	D						GA
"	Gol'tsev et al.		D				Br		
"	Kosygin	A	D			Ch	Br		
"	Pitcher	A	D						GA
"	Ray, D.J.		D			Ch	Br		
"	Shaughnessy								
"	Zhirnov et al.								
1976	Fedoseev & Shmakova		D				Br		
"	Naito		D			Ch	Br		GA
"	Popov	A	D	F			Br		
1977	Beier & Wartzok								
"	Braham, Everitt et al.	A	D				Br		
"	Burns & Harbo	A	D				Br		
"	Burns, Shapiro & Fay		D						
"	Fay						Br		
"	Jeffries et al.								
"	Johnson, B.W.								GA
" a	Lowry et al.			F	Bf				
" b	Lowry et al.			F	Bf	Ch	Br		
"	Pitcher		D	F					GA
"	Pitcher & Calkins	A	D	F					GA
"	Scheffer						Br		
1978	Burns								
"	Newby								
in press	Brower								
"	Everitt & Braham	A	D				Br	Al	
"	Lowry et al.			F			Br		

Phocidae [Phoc] - true (earless) seals

1920	Hanna		D				Br		
1961	Tikhomirov		D			Ch	Br		(Okh)
1962b	Kenyon		D				Br		
1966b	Kosygin		D				Br		
" a	Tikhomirov		D				Br		
" b	Tikhomirov		D			Ch	Br		
" b	Tikhomirov & Kosygin		D				Br		
1968	Tikhomirov		D	F			Br		
1970	Burns		D			Ch	Br		
1972	Shustov	A	D						
1973	Burns		D						
"	Sergeant								
1976	Fedoseev								
"	Popov	A	D	F			Br		
1977	Burns								
" a	Lowry et al.			F	Bf				
" b	Lowry et al.			F	Bf	Ch	Br		
1978	Burns								
in press	Lowry et al.			F			Br		

Pinnipedia (general) [Pinn] - seals, sea lions, & walruses

1935	Barabash-Nikiforov		D					Al
1955	Kenyon & Scheffer							
1958	Scheffer	A	D	F				
1964a	Tikhomirov		D	F			Br	
1975	Kosygin	A	D			Ch	Br	
"	Tikhomirov						Br	
1977	Burns, Shapiro & Fay		D			Ch	Br	

O T H E R   C A R N I V O R E S
(polar bear, sea otter)

Ursus maritimus [UM] - polar bear

1885	Murdoch	A	D		Bf	Ch	
1920	Hanna	A	D				Br
1926	Bailey & Hendee		D			Ch	Br
1956	Bee & Hall		D		Bf	Ch	
1959	Scott et al.	A					
1960	Fay			F			
" a	Kenyon	A	D				Br
1963	Brooks						
1965	Foote					Ch	
1966	Fedoseev		D			Ch	
"	Johnson, M.L. et al.		D			Ch	
"	Polar Record	A	D		Bf	Ch	Br
1967	Lentfer et al.	A	D	F	Bf	Ch	
1969	Uspensky & Shilnikov	A	D				
1970	Lentfer		D		Bf	Ch	
1971	Frame	A	D		Bf	Ch	
"	Lentfer	A	D		Bf	Ch	
"	Nikulin			F		Ch	Br
1974	Lentfer		D		Bf	Ch	
" a	Stirling			F			
" b	Stirling		D	F	Bf		
1975	Lentfer		D		Bf	Ch	
"	Zhirnov et al.						
1976	Heyland & Hay			F			
"	Marquette					Ch	
"	U.S. Fish Wildl. Serv.	A	D		Bf	Ch	Br
1977	Braham, Krogman & Fiscus		D		Bf	Ch	
"	Burns						
"	Burns & Eley			F			
"	Eley			F	Bf	Ch	
" a	Lowry et al.			F	Bf		
"	Ray & Wartzok		D	F		Ch	
"	Stirling & Archibald			F	Bf		
1978	Lentfer						
in press	Brower						
"	Marquette				Bf	Ch	

Enhydra lutris [EL] - sea otter

1870	Scammon		D			Al	
1915	Osgood et al.	A	D		Br		
1923	Hanna		D		Br		
1935	Barabash-Nikiforov	A	D	F		Al	
1950	Scheffer & Wilke						
1951	Scheffer						
1953b	Scheffer			F			GA
1955	Kenyon & Scheffer						
1959	Murie		D	F	Br	Al	GA
1960	Lensink	A	D			Al	GA
"	Nikolaev	A	D			Al	
1961b	Kenyon						
"	Nikolaev	A	D	F		Al	GA
1962	Johnson, M.L. & Alcorn	A	D			Al	GA
1963	Brooks						
1965	Burns & Croxton					Al	
"	Kenyon	A	D		Br	Al	
"	Nikolaev			F		Al	
1967	Johnson, M.L. et al.						
"	Vania & Klinkhart		D				GA
1968	Vania et al.	A	D			Al	
1971	Nikolaev		D			Al	
"	Prasil	A	D				GA
1972	Kenyon	A	D		Br		
1973	Sandegren et al.			F			
"	Scheffer	A					GA
1975	Calkins & Lent						GA
"	Calkins et al.	A	D				GA
"	Pitcher	A	D				GA
"	Sherrod et al.					Al	
"	Zhirnov et al.						
1976	Kooyman, Gentry & McAlister						
"	Schneider & Faro		D		Br		
"	U.S. Fish Wildl. Serv.	A	D			Al	GA
1977	Amer. Soc. Mammal.						
"	Fay				Br		
1978a	Kenyon						
in press	Fay et al.				Br		

S I R E N I A N S

Hydrodamalis gigas [HG] - great northern sea cow

1963	Berzin et al.	Br
1978b	Haley	

C E T A C E A N S
(whales, dolphins, and porpoises)

<u>Balaena glacialis</u> [BG] - black right whale

1931	Kellogg									
1935	Townsend		D			Br	Al	GA		
1955	Sleptsov	A	D							
"	Zenkovich		D				Al			
1956	Gilmore		D			Br		GA		
1958	Omura	A	D			Br	Al	GA		
1959	Nemoto		D	F						
1960	Nasu		D		Ch					
1962	Klumov	A	D	F						
1965	Nemoto & Kasuya		D	F				GA		
1966	Berzin & Rovnin		D							
1967	Ivashin & Rovnin		D							
1969	Omura et al.	A	D	F	Ch	Br	Al	GA		
1971	Ohsumi et al.	A								
1973	Scheffer	A						GA		
1974	Allen	A								
"	Ohsumi & Wada	A	D							
" b	Rice	A	D							
1975	Berzin & Kuz'min		D						(Okh.)	
"	Kuz'min & Berzin		D						(Okh.)	
"	Tillman	A								
"	Wada	A	D							
"	Zhirnov et al.									
1976	IWC - (Japan)		D							
"	Wada	A	D							
1977	Wada	A	D							
"	IWC - (Japan)		D							
1978a	Gilmore									

<u>Balaena mysticetus</u> [BOW] - bowhead whale; Greenland right whale

1885	Murdoch	A	D		Bf	Ch		
"	Ray, P.H.	A	D		Bf	Ch		
1920	Hanna		D				Br	
1926	Bailey & Hendee		D			Ch	Br	
1931	Kellogg							
1935	Townsend		D		Bf	Ch	Br	
1940	Rainey	A	D			Ch		
1946	Nikulin	A	D			Ch	Br	
1947	Rainey	A	D			Ch		
1956	Bee & Hall		D		Bf	Ch		
1957	Brooks							
1959	Nemoto		D	F				
1960c	Kenyon	A	D				Br	
1961a	Sleptsov	A	D			Ch		
1963	Maher & Wilimovsky		D		Bf	Ch		
1965	Foote					Ch		
1966	Fedoseev		D			Ch		
"	Johnson M.L. et al.		D			Ch		
"	Saario & Kessel		D			Ch		
1968	Heizer							
1971	Mansfield		D					
1972	Burgess		D				Br	
" a	Durham							
" b	Durham							
" c	Durham							
"	Kenyon	A	D				Br	
1973	Durham							
1974b	Rice	A	D					
"	Smith	A			Bf			
1975	Berzin & Kuz'min		D					(Okh.)
"	Bockstoce				Bf			
"	Durham							
"	Kuz'min & Berzin		D			Ch	Br	
"	Ray, D.J.	A	D			Ch	Br	
"	Zhirnov et al.							
1976	Marquette				Bf	Ch	Br	
1977	Bockstoce				Bf	Ch	Br	
"	Braham & Krogman	A	D		Bf	Ch	Br	
"	Braham, Krogman & Fiscus	A	D		Bf	Ch	Br	
"	Burns							
"	Krogman		D		Bf			
"	Loken							
" a	Lowry et al.			F	Bf			
"	Marquette	A	D	F	Bf	Ch	Br	
"	Morgan							
"	Nakashim		D		Bf	Ch		
"	Tillman	A						
1978	Braham & Leatherwood							
"	Fraker et al.	A	D	F	Bf			
"	Lowry et al.			F	Bf	Ch		
"	Marquette							
1979	Braham, Krogman et al.	A	D		Bf	Ch	Br	
"	Durham				Bf	Ch		
in press	Braham et al.	A	D		Bf	Ch	Br	
"	Brower							
"	Everitt & Krogman				Bf			
"	Marquette			F	Bf	Ch	Br	

Balaenoptera acutorostrata [BA] - minke whale; little piked whale; lesser rorqual

1931	Kellogg								
1939	Cowan								
1946	Nikulin		D			Ch	Br		
1949	Scattergood		D	F		Ch	Br	Al	GA
1955	Zenkovich		D						
1959	Nemoto		D	F					
1961a	Sleptsov	A	D			Ch			
" b	Sleptsov		D	F			Br	Al	
1965	Kenyon		D				Br	Al	
1968a	Jonsgard		D						
"	Rice								
1973	Scheffer	A							GA
1974	Doroshenko et al.								
"	Ohsumi & Wada	A	D						
" b	Rice	A	D						
1975	Fiscus & Marquette		D		Bf	Ch	Br		
"	Kawamura		D				Br	Al	
"	Mitchell								
"	Pitcher		D						GA
"	Sergeant			F					
"	Wada	A	D				Br	Al	GA
1976	Wada	A	D				Br	Al	GA
1977	Braham, Everitt et al.		D				Br		
"	Fay						Br		
"	Hall & Tillman	A	D						GA
"	Wada	A	D				Br	Al	GA
1978a	Mitchell								
1979	Braham, Krogman et al.		D				Br		

Balaenoptera borealis [SEI] - sei whale

1931	Kellogg							
1940	Thompson			F			Al	
1953	Sakiura et al.		D	F			Al	
1955	Omura	A	D			Br	Al	
"	Sleptsov	A	D					
"	Zenkovich		D					
1956	Uda & Nasu		D				Al	
1957	Nemoto		D	F			Al	
1958	Kawakami & Ichihara		D					
1959	Murie		D			Br	Al	GA
"	Nemoto		D	F				
1961a	Sleptsov	A	D		Ch			
1963	Nasu		D					
"	Nemoto		D	F		Br	Al	GA
"	Rice		D					
1964	Omura & Ohsumi		D			Br	Al	GA
1965	Nemoto & Kasuya		D	F				GA
1966	Nasu		D			Br	Al	GA
"	Nishiwaki	A	D			Br	Al	GA
1967	Doi et al.	A						
"	Ivashin & Rovnin		D					
"	Whales Research Inst.		D					
1970	Machida						Al	
"	Shurunov		D	F			Al	GA
1971	Gill & Hughes			F				
"	Ohsumi et al.	A						
"	Zenkovich	A	D					
1973	Scheffer	A						GA
1974	Int. Comm. Whaling		D					
"	Ohsumi & Wada	A	D					
"	Omura & Ohsumi	A	D					
" b	Rice	A	D					
1975	Brown		D					
"	Ohsumi & Fukuda	A						
"	Tillman	A						
"	Wada	A	D			Br	Al	GA
1976	Masaki		D					
"	Wada	A	D			Br	Al	GA
1977	Braham, Everitt et al.		D			Br		
"	Hall & Tillman	A	D					GA
"	Mercer et al.	A	D					GA
"	Rice		D	F				
"	Wada	A	D			Br	Al	GA
1978a	Mitchell							

Balaenoptera musculus [BM] - blue whale

1920	Hanna		D			Br		
1931	Kellogg							
1940	Thompson			F			Al	
1953	Sakiura et al.		D	F			Al	
1955	Omura	A	D			Br	Al	
"	Sleptsov	A	D					
"	Zenkovich		D					
1956	Ruud							
"	Uda & Nasu		D				Al	
1957	Nemoto		D	F			Al	
1958	Kawakami & Ichihara		D					
1959	Murie		D			Br	Al	GA
"	Nemoto		D	F				
1960	Fujino							
1961a	Sleptsov	A	D		Ch			
1963	Nasu		D					
"	Rice		D					
1964	Omura & Ohsumi		D			Br	Al	GA
1965	Nemoto & Kasuya		D	F				GA
1966	Berzin & Rovnin		D					
"	Nasu		D			Br	Al	GA
"	Nishiwaki	A	D			Br	Al	GA
1967	Doi et al.	A						
1967	Ivashin & Rovnin		D					
"	Whales Res. Inst.		D					
1971	Doroshenko							GA
"	Ohsumi et al.	A						
"	Small							
"	Zenkovich	A	D					
1972	Ohsumi & Wada	A	D				Al	GA
1973	Scheffer	A						GA
1974	Ohsumi & Wada	A	D					
"	Omura & Ohsumi	A	D					
" b	Rice	A	D					
1975	Tillman	A						
"	Wada	A	D			Br	Al	GA
"	Zhirnov et al.							
1976	Int. Whaling Comm.		D					GA
"	Wada	A	D			Br	Al	GA
1977	Int. Whaling Comm.		D					GA
"	Mercer et al.	A	D					GA
"	Wada	A	D			Br	Al	GA
1978a	Mitchell							
" b	Rice							

__Balaenoptera__ __physalus__ [BP] - fin whale

1909	Andrews			F				GA
1930	Howell & Huey			F				
1931	Kellogg							
1940	Thompson			F			Al	
1946	Nikulin		D		Ch	Br		
1953	Sakiura et al.		D	F			Al	
1954	Fujino							
1955	Omura	A	D			Br	Al	
"	Sleptsov	A	D					
"	Zenkovich		D			Br	Al	
1956	Uda & Nasu		D				Al	
1957	Nemoto		D	F			Al	
1958	Kawakami & Ichihara		D					
"	Ohsumi et al.						Al	
1959	Murie		D			Br	Al	GA
"	Nemoto		D	F		Br	Al	GA
1960	Fujino							
"	Nasu		D		Ch			
1961a	Sleptsov	A	D		Ch			
" b	Sleptsov		D	F		Br	Al	
1963	Nasu		D					
"	Rice		D					
1964	Omura & Ohsumi		D			Br	Al	GA
1965	Nemoto & Kasuya		D	F				GA
1966	Berzin & Rovnin		D					
"	Fedoseev		D			Br		
1966	Nasu		D			Br	Al	GA
"	Nishiwaki	A	D			Br	Al	GA
1967	Doi et al.	A						
"	Ivashin & Rovnin		D					
"	Whales Res. Inst.		D					
1970	Shurunov		D	F			Al	GA
1971	Doroshenko							GA
"	Ohsumi et al.							
"	Zenkovich	A	D					
1973	Scheffer	A						GA
1974	Allen	A						
"	Int. Comm. Whaling		D					
"	Ohsumi & Wada	A	D					
"	Omura & Ohsumi		D					
" b	Rice	A	D					
1975	Brown		D					
"	Kawamura		D			Br	Al	
"	Tillman	A						
"	Wada	A	D			Br	Al	GA
"	Zhirnov et al.							
1976	Wada	A	D			Br	Al	GA
1977	Braham, Everitt et al.		D			Br		
"	Hall & Tillman	A	D					GA
"	Mercer et al.	A	D					GA
"	Wada	A	D			Br	Al	GA
1978a	Mitchell							
1979	Braham, Krogman et al.		D			Br		

__Berardius__ __bairdii__ [BB] - Baird's beaked whale; giant North Pacific bottlenose whale

1920	Hanna		D			Br		
1923	Hanna		D			Br		
1931	Kellogg							
1949a	Scheffer		D				Al	
1953	Pike		D	F				GA
"	Slipp & Wilke		D	F				
1955	Zenkovich		D				Al	
1961a	Sleptsov	A	D		Ch			
" b	Sleptsov		D	F		Br		
1963	Rice		D					
1971	Kasuya							
1974b	Rice	A	D					
1975	Ohsumi		D					
1976	Ohsumi. Masaki & Wada		D			Br	Al	GA
1977	Hall & Tillman		D					GA
1978a	Rice							

Cetacea (general) [Cet]

1931	Kellogg		D					
1935	Townsend		D					
1940	Thompson			F			Al	
1946	Nikulin		D		Ch	Br		
1948	Scheffer & Slipp		D	F				
1954	Uda		D	F				
1955	Omura	A	D			Br	Al	
"	Sleptsov	A	D					
"	Zenkovich		D			Br	Al	
1956	Uda & Nasu		D				Al	
1957	Nemoto		D	F			Al	
"	Tomilin		D	F				
1958	Kawakami & Ichihara		D					
1959	Murie		D			Br	Al	GA
"	Nemoto		D	F				
1960	Tomilin		D					
1961a	Sleptsov	A	D		Ch			
" b	Sleptsov		D	F		Br	Al	
1962	Gudkov			F		Br		
1963	Nasu		D		Ch	Br	Al	
"	Rice		D					
1964	Omura & Ohsumi		D			Br	Al	GA
1966	Berzin & Rovnin		D	F	Ch	Br	Al	GA
"	Nasu		D			Br	Al	GA
"	Nishiwaki	A	D			Br	Al	GA
1967	Doi et al.	A						
1967	Ivashin & Rovnin		D					
"	Whales Res. Inst.		D					
1968	Tomilin & Smyshlyayev							
1970	Shurunov		D	F				
1971	Kasuya							
"	Ohsumi et al.	A						
"	Zenkovich	A	D					
1972	Ivashin et al.							
"	Leatherwood		D	F				
1973	Chapman	A						
1974	Allen	A						
"	Brown		D					
"	Gulland		D	F				
"	Int. Comm. Whaling		D					
"	Ohsumi & Wada	A	D					
"	Omura & Ohsumi	A	D					
" b	Rice	A	D					
1975	Brown		D					
"	Kawamura		D			Br	Al	
"	Mitchell							
"	Tillman	A						
"	Wada	A	D			Br	Al	GA
1976	Wada	A	D			Br	Al	GA
1977	Hall & Tillman	A	D					GA
"	Wada	A	D			Br	Al	GA

<u>Delphinapterus</u> <u>leucas</u> [DL] - beluga whale

1872	Scammon							
1885	Murdoch		D		Bf	Ch		
1926	Bailey & Hendee		D			Ch	Br	
1931	Kellogg							
1946	Nikulin		D			Ch	Br	
1947	Rainey		D			Ch		
1956	Bee & Hall		D		Bf	Ch		
1957	Brooks							
1960a	Kenyon	A	D				Br	
1961a	Sleptsov	A	D			Ch		
1963	Brooks	A	D	F			Br	
1964	Kleinenberg et al.	A	D	F		Ch	Br	
1965	Foote					Ch		
1966	Fedoseev		D			Ch		
"	Johnson, M.L. et al.		D			Ch		
"	Klinkhart	A	D	F	Bf	Ch	Br	GA
"	Saario & Kessel		D			Ch		
1967	Vania & Klinkhart		D	F			Br	
"	Vania et al.	A	D				Br	
1969	Sergeant & Brodie		D					
1972	Burgess		D				Br	
"	Kenyon	A	D				Br	
1973	Addison & Brodie	A	D	F	Bf			
"	Scheffer	A						GA
1974	Smith	A			Bf			
1975	Fiscus & Marquette				Bf	Ch		
"	Mitchell							
"	Ray, D.J.		D			Ch	Br	
"	Sergeant & Brodie	A	D		Bf		Br	GA
1976	Heyland & Hay							
"	Marquette					Ch		
1977	Braham & Krogman	A	D		Bf	Ch	Br	
"	Braham, Krogman & Fiscus	A	D		Bf	Ch	Br	
"	Burns							
"	Calkins & Pitcher		D					GA
"	Fay						Br	
"	Hall & Tillman	A	D					GA
"	Lowry et al.			F	Bf			
1978	Fay							
"	Fraker et al.	A	D	F	Bf			
1979	Braham, Krogman et al.					Ch	Br	
in press	Brower							
"	Marquette				Bf	Ch		

<u>Eschrichtius</u> <u>robustus</u> [ER] - gray whale

1872	Scammon									
1926	Bailey & Hendee		D			Ch	Br			
1930	Howell & Huey			F						
1931	Kellogg									
1935	Townsend		D							
1946	Nikulin		D			Ch	Br			
1955	Zenkovich		D				Br	Al		
1956	Bee & Hall		D		Bf	Ch				
1957	Brooks									
1958	Ichihara		D				Br	Al		
1959	Gilmore	A	D			Ch	Br			
"	Nemoto		D	F						
1960	Maher		D		Bf	Ch				
"	Nasu		D			Ch	Br			
1961a	Sleptsov	A	D			Ch				
"	Wilke & Fiscus		D			Ch	Br		GA	
1962	Pike		D	F		Ch	Br		GA	
1963	Fay						Br			
1965c	Burns		D		Bf	Ch				
"	Rasmussen & Head									
"	Rice	A	D	F		Ch	Br			
1966	Berzin & Rovnin		D							
"	Fedoseev		D	F		Ch				
1967	Ivashin & Rovnin		D							
1968	Ramsey									
1969	Rice & Wolman	A								
" a	Zimushko									
" b	Zimushko									
1970	Shurunov		D	F				Al	GA	
" a	Zimushko	A	D			Ch	Br			
" b	Zimushko									
" c	Zimushko									
"	Zimushko & Lenskaya	A	D	F		Ch	Br			
1971	Rice & Wolman	A	D	F	Bf	Ch	Br		GA	
"	Zenkovich	A	D							
"	Zimushko									
1972	Baldridge									
"	Burgess		D				Br			
1973	Arsen'ev et al.		D	F						
"	Scheffer	A							GA	
1974	Allen	A								
"	Hatler & Darling		D	F					GA	
" a	Rice	A								
" b	Rice	A	D							
"	Sund & O'Connor		D							
1975	Berzin & Kuz'min		D							(Okh.)
"	Brown		D							
" a	Fay			F						
"	Kuz'min & Berzin	A	D			Ch	Br			
"	Nichols									
"	Rice	A	D							
"	Sund			F						
"	Tillman	A								
"	Zhirnov et al.									
1976	Ohsumi	A								
1977	Braham		D				Br	Al	GA	
"	Braham, Everitt et al.		D				Br			
"	Braham, Krogman & Fiscus		D		Bf	Ch				
"	Brownell	A	D							
"	Fay						Br			
"	Hall et al.		D					Al	GA	
"	Hall & Tillman	A	D						GA	
"	Hart		D						GA	
"	Tillman	A								
1978b	Gilmore		D					Al	GA	
" c	Rice									
1979	Braham, Krogman et al.		D				Br			
in press	Fay et al.						Br			
"	Rugh & Braham	A	D				Br	Al		

Globicephala macrorhynchus [GM] - pilot whale

1961b	Sleptsov		D	F			Br	Al	
1971	Bree								
"	Kasuya								
1975	Mitchell								
"	Ohsumi		D						
1976	Spotte		D	F					GA
1978	Reilly								

Grampus griseus [GG] - Risso's dolphin

1965	Guiguet & Pike		D	F					GA
1966	Orr		D	F					
1968	Stroud			F					
1971	Hatler		D	F					GA
"	Kasuya								
1975	Mitchell								
1978	Leatherwood & Reeves								

Lagenorhynchus obliquidens [LO] - Pacific white-sided dolphin

1950b	Scheffer		D	F					GA
1952	Cowan & Guiguet		D						GA
1953a	Scheffer			F					
1960	Pike		D						GA
1961	Houck			F					
1975	Mitchell								
1977	Hall & Tillman	A	D						GA
1978	Leatherwood & Reeves								

Lissodelphis borealis [LB] - northern right whale dolphin

1971	Kasuya
1975	Mitchell
1978	Leatherwood & Reeves

Megaptera novaeangliae [MN] - humpback whale

1909	Andrews			F					GA
1920	Hanna		D				Br		
1930	Howell & Huey			F					
1931	Kellogg								
1935	Townsend		D						
1939	Scheffer			F				Al	
1940	Thompson			F				Al	
1946	Nikulin		D			Ch	Br		
1953	Sakiura et al.		D	F				Al	
1955	Omura	A	D				Br	Al	
"	Sleptsov	A	D						
"	Zenkovich		D				Br		
1956	Uda & Nasu		D					Al	
1957	Nemoto		D	F				Al	
1958	Kawakami & Ichihara								
"	Murie		D				Br	Al	GA
"	Nemoto		D	F					
1960	Fujino								
1961a	Sleptsov	A	D			Ch			
1963	Nasu		D						
"	Rice		D						
1964	Omura & Ohsumi		D				Br	Al	GA
1966	Berzin & Rovnin		D						
"	Dawbin		D						
"	Fedoseev		D				Br		
"	Nasu		D				Br	Al	GA
"	Nishiwaki	A	D				Br	Al	GA
1967	Doi et al.	A							
"	Ivashin & Rovnin		D						
"	Whales Res. Inst.		D						
1971	Ohsumi et al.	A							
"	Zenkovich	A	D						
1972	Wolman		D	F		Ch	Br		GA
1973	Scheffer	A							GA
1974	Allen	A							
"	Ohsumi & Wada	A	D						
" b	Rice	A	D						
1975	Kawamura		D				Br	Al	
"	Pitcher		D						GA
"	Tillman	A							
"	Wada	A	D				Br	Al	GA
"	Zhirnov et al.								
1976	Int. Whaling Comm.		D						GA
"	Wada	A	D				Br	Al	GA
1977	Hall & Tillman	A	D						GA
"	Int. Whaling Comm.		D						GA
"	Jurasz & Jurasz								GA
"	Mercer et al.	A	D						GA
"	Wada	A	D				Br	Al	GA
1978	Wolman								

Mesoplodon stejnegeri [MS] - sabertooth whale

1949a	Scheffer		D					Al	
1953	Jellison		D				Br		
1961b	Sleptsov		D	F			Br		
1963	Moore		D						
1966	Moore		D				Br		
1969	Fiscus et al.		D						GA
1977	Hall & Tillman		D						GA
1978a	Rice								

Monodon monoceros [MON] - narwhal

1952	Huey		D		Bf				
1956	Bee & Hall		D		Bf	Ch			
1960	Geist et al.		D			Ch	Br		
1961a	Sleptsov	A	D			Ch			
1969	Bruemmer	A	D		Bf	Ch			
1975	Mitchell								
1978	Newman								

Orcinus orca [OO] - killer whale; orca

1872	Scammon		D	F		Ch	Br		
1920	Hanna		D				Br		
1923	Hanna		D				Br		
1926	Bailey & Hendee		D			Ch	Br		
1941	Nikulin			F		Ch	Br		
1946	Nikulin		D			Ch	Br		
1952	Jonsgard & Oynes			F					
1953	Alexander			F					
1956	Bee & Hall		D		Bf	Ch			
1959	Murie		D				Br	Al	GA
1960	Niggol et al.			F					
1961	Fiscus et al.			F					
"	Ivanova			F					
" a	Sleptsov	A	D			Ch			
" b	Sleptsov		D	F			Br	Al	
1965	Kenyon		D				Br	Al	
1967	Ivashin & Rovnin		D						
1968a	Jonsgard			F					
" b	Jonsgard			F					
"	Rice		D	F					GA
1970	Jonsgard & Lyshoel			F					
1971	Branson			F			Br		
"	Kasuya								
1972	Baldridge			F					
"	Barr & Barr			F					
1973	Scheffer	A							GA
1975	Kawamura		D				Br	Al	
"	Mitchell								
"	Pitcher		D						GA
"	Zenkovich		D					Al	
1976	Ohsumi, Masaki & Wada		D				Br	Al	GA
1977	Braham, Everitt et al.		D				Br		
"	Hall & Tillman	A	D						GA
"	Mercer et al.	A	D						GA
1978b	Scheffer								
1979	Braham, Krogman et al.		D				Br		
in press	Fay et al.			F			Br		

Phocaena phocaena [PP] - harbor porpoise

1923	Hanna		D				Br		
1926	Bailey & Hendee		D			Ch	Br		
1952	Wilke & Kenyon		D	F					
1953a	Scheffer			F					
1954	Hall & Bee		D	F	Bf	Ch			
1956	Bee & Hall		D		Bf	Ch			
1959	Murie		D				Br	Al	GA
1961a	Sleptsov	A	D			Ch			
" b	Sleptsov		D	F			Br	Al	
1968	Rice								
"	Tomilin & Morosov			F					
1973	Scheffer	A							GA
1974	Gaskin et al.		D						
1975	Mitchell						Br		
"	Ohsumi		D						
1977	Braham, Everitt et al.		D				Br		
"	Fay								
1978	Leatherwood & Reeves								

Phocoenoides dalli [PD] - Dall porpoise

1942	Benson & Groody							
1943	Ulmer		D					GA
1944	Cowan		D	F				GA
1949b	Scheffer		D			Br	Al	GA
1950	Nichols		D					GA
" a	Scheffer		D					GA
1953a	Scheffer			F				
1959	Murie		D			Br	Al	GA
1961a	Sleptsov	A	D		Ch			
1965	Mizue & Yoshida	A	D	F		Br	Al	
1966	Mizue et al.			F		Br	Al	
1968	Rice							
1972	Barr & Barr							
1972	Loeb		D	F				
1973	Scheffer	A						GA
1975	Kawamura		D			Br	Al	
"	Ohsumi		D					
"	Mitchell							
"	Pitcher		D					GA
1976	Ohsumi, Masaki & Wada		D			Br	Al	GA
1977	Braham, Everitt et al.		D			Br		
"	Hall & Tillman	A	D					GA
"	Mercer et al.	A	D					GA
1978	Leatherwood & Reeves							

Physeter macrocephalus [PM] - sperm whale

1923	Hanna		D		Br		
1931	Kellogg						
1935	Townsend		D				
1937	Robbins et al.		D	F			GA
1939	Scheffer			F		Al	
1940	Thompson			F		Al	
1955	Omura	A	D		Br	Al	
"	Sleptsov	A	D				
"	Zenkovich		D		Br	Al	
1956	Nishiwaki et al.		D			Al	
"	Uda & Nasu		D			Al	
1958	Kawakami & Ichihara		D				
1959	Berzin			F	Br	Al	
"	Murie		D		Br	Al	GA
1960	Fujino						
1962	Nishiwaki						
1963	Nasu		D				
"	Nemoto & Nasu			F	Br	Al	
"	Rice		D				
1964a	Berzin		D		Br	Al	GA
" b	Berzin						
"	Okutani & Nemoto		D	F	Br	Al	GA
"	Omura & Ohsumi		D		Br	Al	GA
1966	Berzin & Rovnin		D				
"	Caldwell et al.		D	F			
"	Nishiwaki	A	D		Br	Al	GA
"	Ohsumi		D				
1967	Doi et al.	A					
"	Ivashin & Rovnin		D				
"	Whales Res. Inst.		D				
1970	Berzin	A	D	F			
"	Shurunov		D	F		Al	GA
1971	Int. Whaling Comm., SC		D				
"	Kasuya						
"	Ohsumi et al.	A					
"	Zenkovich	A	D				
1973	Scheffer	A					GA
1974	Allen	A					
"	Gulland		D				
"	Int. Whaling Comm.		D				
"	Ohsumi & Wada	A	D				
1974	Omura & Ohsumi	A	D				
" b	Rice	A	D				
1975	Brown		D				
"	Tillman	A					
"	Wada	A	D		Br	Al	GA
1976	Wada	A	D		Br	Al	GA
1977	Ohsumi & Masaki	A	D		Br	Al	GA
"	Ohsumi, Masaki & Wada		D		Br	Al	GA
"	Tillman	A	D			Al	GA
"	Wada	A	D		Br	Al	GA
1978d	Rice						

Stenella coeruleoalba [SC] - striped dolphin

1949	Kenyon & Scheffer	D				
1952	Cowan & Guiguet	D				GA
1953a	Scheffer		F			
1960	Scheffer	D				
1970	Sampson	D		Br		
1971	Kasuya					
1973	Miyazaki et al.		F			
1975	Mitchell					
1978	Leatherwood & Reeves					

Ziphiids [Ziph] - beaked whales, general

1968	Moore
1975	Mitchell
1978a	Rice

Ziphius cavirostris [ZC] - goosebeak whale; Cuvier's beaked whale

1940	Cowan & Hatter	D				GA
1945	Cowan	D				GA
1949a	Scheffer	D			Al	
1952	Cowan & Guiguet	D				GA
1953	Roest et al.	D				
1961a	Kenyon	D			Al	
" b	Sleptsov	D	F	Br		
1968	Mitchell	D				
1969	Fiscus et al.	D			Al	
1973	Balcomb	D				
1977	Braham, Everitt et al.	D		Br		
"	Hall & Tillman	D				GA
1978a	Rice					

AREA INDEX

BEAUFORT SEA

1885	Ray. P.H.	Bow,PH
1935	Townsend	Bow
1952	Huey	Mon
1954	Hall & Bee	PP
1956	Bee & Hall	MM
1960	Maher	ER
1963	Maher & Wilimovsky	Bow
1965c	Burns	ER
1966	Klinkhart	DL
"	Polar Record	UM
" a	Tikhomirov & Kosygin	PF
1967	Lentfer et al.	UM
1969	Bruemmer	Mon
1970	Lentfer	UM
1971	Frame	UM
"	Lentfer	UM
"	Rice & Wolman	ER
1972	Burns & Harbo	PH
1973	Burns & Morrow	MM
"	Addison & Brodie	DL
1974	Lentfer	UM
"	Smith	Bow,DL,PH
" b	Stirling	UM.PH,EB
1975	Bockstoce	Bow
"	Fiscus & Marquette	Bow,DL,OR.PH
"	Lentfer	UM
"	Sergeant & Brodie	DL
"	Smith	PH
"	Stirling et al.	PH,EB
1976	Geraci & Smith	PH
"	Marquette	BOW
"	U.S. Fish Wildl. Serv.	UM
1977	Bockstoce	Bow
"	Braham & Krogman	Bow,DL
"	Braham, Krogman & Fiscus	Bow,DL,MM
"	Burns & Eley	PH,EB
"	Eley	UM,PH,EB
"	Krogman	Bow
" a	Lowry et al.	MM
" b	Lowry et al.	Phoc
"	Marquette	Bow
"	Nakashim	Bow
"	Stirling & Archibald	UM.EB,PH
1978	Fraker et al.	Bow.DL
"	Lowry et al.	PH.Bow
1979	Braham. Krogman et al.	Bow
"	Durham	Bow
in press	Braham et al.	Bow
"	Everitt & Krogman	Bow
"	Marquette	Bow.DL,OR, PH,EB,UM

CHUKCHI SEA

1872	Scammon	OO
1885	Ray. P.H.	Bow.PH
1926	Bailey & Hendee	MM
1935	Townsend	Bow
1940	Rainey	Bow
1941	Nikulin	OR,OO,UM
1946	Nikulin	Cet
1947	Nikulin	OR
"	Rainey	Bow,DL.PH,EB.OR
1949	Scattergood	BA
1954	Brooks	OR
"	Hall & Bee	PP
1955	Fay	OR
1956	Bee & Hall	MM
1959	Gilmore	ER
1960	Geist et al.	Mon
"	Maher	ER
"	Nasu	ER,BP,BG
1961a	Sleptsov	Cet
"	Wilke & Fiscus	ER
"	Tikhomirov	Phoc
1962	Fedoseev	OR
"	Krylov	OR
"	Pike	ER
1963	Maher & Wilimovsky	Bow
"	Nasu	Cet
1964	Kleinenberg et al.	DL
1965b	Burns	OR
" c	Burns	ER
"	Foote	MM
"	Rice	ER
" d	Shustov	PF
1966	Berzin & Rovnin	Cet
"	Fedoseev	MM
"	Johnson et al.	MM
"	Klinkhart	DL
"	Krylov	OR
"	Polar Record	UM
"	Saario & Kessel	PH,EB OR,DL.Bow
" a	Tikhomirov & Kosygin	PH
1967a	Burns	EB
"	Lentfer et al.	UM
"	Nishiwaki	MM
1968	Gol'tsev	OR
"	Krylov	OR
1969	Bruemmer	Mon
"	Omura et al.	BG
1970	Burns	OR,Phoc
"	Lentfer	UM
"	Shurunov	ER
" a	Zimushko	ER
"	Zimushko & Lenskaya	ER
1971	Frame	UM,OR
"	Krylov	OR
"	Lentfer	UM
"	Rice & Wolman	ER
1972	Burns & Harbo	PH
"	Gol'tsev	OR
"	Wolman	MN
1973	Burns & Fay	PL
"	Burns & Morrow	MM
"	Lentfer	CU
1974	Lentfer	UM
1975b	Fay	MM
"	Fedoseev	PH
"	Fiscus & Marquette	Bow.DL,OR,PH
"	Kosygin	OR,PL
"	Kuz'min & Berzin	Bow.ER
"	Lentfer	UM
"	Ray. D.J.	MM
"	Tomilin & Kibal'chich	OR
1976	Golt'sev	OR
"	Marquette	Bow,DL,PH OR,UM
"	Naito	PL
"	U.S. Fish Wildl. Serv.	OR,UM
1977	Bockstoce	Bow
"	Braham, Fiscus & Rugh	MM
"	Braham & Krogman	Bow,DL
"	Braham, Krogman & Fiscus	Bow,DL,MM
"	Burns & Eley	PH,EB
"	Burns, Shapiro & Fay	Pinn
"	Eley	UM,PH,EB
" b	Lowry et al.	Phoc
"	Marquette	Bow
"	Nakashim	Bow
"	Ray & Wartzok	OR,UM
"	Reeves	OR
1978	Estes & Gilbert	OR
"	Krogman et al.	OR
"	Lowry et al.	PH,Bow
1979	Braham, Krogman et al.	Bow,MM,DL
"	Durham	Bow
in press	Braham et al.	Bow
"	Marquette	Bow,DL,OR, PH,EB.UM

BERING SEA

1871	Scammon	EJ
1872	Scammon	OO
1915	Osgood et al.	CU,EJ,EL
1920	Hanna	MM
1923	Hanna	MM
1926	Bailey & Hendee	MM
1928	Bailey	PF,PL
1935	Townsend	Bow,BG
1941	Nikulin	OR,UM OO
1945	Scheffer	EJ
1946	Nikulin	Cet
1947	Nikulin	OR
1949	Scattergood	BA
" b	Scheffer	PD
1952	Fay	OR
"	Wilke & Kenyon	EJ
1953	Alexander	CU
"	Fay	OR
"	Jellison	MS
1954	Brooks	OR
"	Wilke & Kenyon	CU
1955	Fay	OR
"	Omura	Cet
"	Taylor et al.	CU
1956	Gilmore	BG
1958	Ichihara	ER
"	Omura	BG
"	Wilke et al.	CU
1959	Berzin	PM
"	Gilmore	ER
"	Mathisen	EJ
"	Murie	MM
"	Nemoto	Cet
1960	Geist et al.	Mon
" a	Kenyon	MM
" b	Kenyon	OR
" c	Kenyon	PH
" d	Kenyon	OR
"	Nasu	ER
"	Niggol et al.	CU
1961	Kenyon & Rice	EJ
" b	Sleptsov	Cet
"	Tikhomirov	Phoc
"	Wilke & Fiscus	ER
1962	Fedoseev	OR
"	Gudkov	Cet
" a	Kenyon	EJ
" b	Kenyon	Phoc
"	Pike	ER
"	Thomas & Scheffer	PH
1963	Fay	ER
"	Jones	CU
"	Nasu	Cet
"	Nemoto	Cet
1964a	Berzin	PM
"	Fiscus et al.	CU
"	Kleinenberg et al.	DL
"	Okutani & Nemoto	PM
"	Omura & Ohsumi	Cet
" a	Tikhomirov	Pinn
" b	Tikhomirov	EJ
1965b	Burns	OR
"	Fiscus,Baines & Kajimura	CU
"	Fiscus & Kajimura	CU
"	Fiscus & Marquette	Bow
"	Kenyon	MM
"	Mizue & Yoshida	PD
"	Rice	ER
" a	Shustov	PF
" b	Shustov	PF
" c	Shustov	PF
" d	Shustov	PF

1966	Berzin & Rovnin	Cet
"	Chugunkov & Prokhorov	CU.EJ
"	Fedoseev	MM
"	Fiscus & Baines	EJ
"	Klinkhart	DL
" a	Kosygin	EB
" b	Kosygin	Phoc
" c	Kosygin	EB,PF
"	Krylov	OR
"	Mizue et al.	PD
"	Moore	MS
"	Nasu	Cet
"	Nishiwaki	Cet
"	Polar Record	UM
" a	Tikhomirov	Phoc
" b	Tikhomirov	Phoc
" a	Tikhomirov & Kosygin	PF
" b	Tikhomirov & Kosygin	Phoc,EJ
1967a	Burns	EB
" b	Burns	OR,Phoc
"	Chapskii	PL
"	Nishiwaki	MM
"	Shustov	PL,PF.EB
"	Vania & Klinkhart	PV,DL
1968	Gol'tsev	OR
"	Tikhomirov	Phoc
"	Vania et al.	PV.DL
1969	Klinkhart	PV,PL
"	Machida	CU
"	Omura et al.	BG
"	Shustov	PF
1970	Burns	OR,Phoc
"	Fedoseev & Nazarenko	PH
"	Mar. Mammal Biol. Lab.	CU
"	Sampson	SC
"	Shurunov	ER
" a	Zimushko	ER
"	Zimushko & Lenskaya	ER
1971	Branson	OO,EJ
"	Kosygin	EB
"	Machida	CU
"	Rice & Wolman	ER
1972	Burgess	MM
"	Burns, Ray, et al.	PL
" b	Fiscus	CU
"	Gol'tsev	OR
"	Kenyon	MM
"	Wolman	MN
1973	Burns	Phoc
"	Burns & Fay	PL,PV
"	Fedoseev	PF
1974	Fay	MM
"	Mar. Mammal Div.	CU
"	Ohsumi & Wada	Cet
1975a	Fay	MM
" b	Fay	MM
"	Fedoseev	PH
"	Gol'tsev et al.	PL
"	Kawamura	Cet
"	Kosygin	PF.PH PL,OR,EB
"	Kuz'min & Berzin	Bow,ER
" a	Mar. Mammal Div.	MM
" b	Mar. Mammal Div.	CU
"	Miller	OR
"	Ohsumi	PD.PP,GM,BB
"	Ray, G.C. & Watkins	OR
"	Ray, D.J.	MM
"	Sergeant & Brodie	DL
"	Tikhomirov	Pinn

1976	Fedoseev & Shmakova	PL,PF
"	Marquette	Bow
"	Miller	OR
"	Naito	PL,PV
"	Ohsumi, Masaki & Wada	OO,BB PD,Cet
"	Popov	Phoc
"	Schneider & Faro	EL
"	U.S. Fish Wildl. Serv.	OR,UM
"	Wada	Cet
1977	Berg	MM
"	Bockstoce	Bow
"	Braham	ER
"	Braham, Everitt et al.	MM
"	Braham, Fiscus & Rugh	MM
"	Braham & Krogman	Bow.DL
"	Braham, Krogman & Fiscus	Bow.DL
"	Burns & Eley	PH,EB
"	Burns & Harbo	PL
"	Burns, Shapiro & Fay	Pinn
"	Fay	MM
"	Fay et al.	OR

1977	Lowry et al.	Phoc
"	Mar. Mammal Div.	CU
"	Marquette	Bow
"	Ohsumi, Masaki & Wada	PM
"	Ohsumi & Masaki	PM
"	Reeves	OR
"	Scheffer	PV
"	Wada	Cet
"	Watkins & Ray	PF
1978	Mar. Mammal Div.	CU
"	Krogman et al.	OR
1979	Braham. Krogman et al.	Bow,MM,DL
in press	Braham et al.	Bow
"	Everitt & Braham	PV
"	Fay & Ray	OR
"	Fay et al.	OR,EL,ER,OO
"	Marquette	Bow
"	Lowry et al.	Phoc
"	Rugh & Braham	ER

ALEUTIAN RIDGE

1870	Scammon	EL
1935	Barabash-Nikiforov	EL,Pinn
"	Townsend	BG
1938	Barabash-Nikiforov	MM
1940	Thompson	Cet
1949	Scattergood	BA
" a	Scheffer	ZC,BB.MS(?)
" b	Scheffer	PD
1953	Sakiura et al.	Cet
1954	Wilke & Kenyon	CU
1955	Omura	Cet
"	Taylor et al.	CU
1956	Nishiwaki et al.	PM
"	Uda & Nasu	Cet
1957	Nemoto	Cet
1958	Ichihara	ER
"	Ohsumi	BP
"	Omura	BG
1959	Berzin	PM
"	Mathisen	EJ
"	Murie	MM
"	Nemoto	Cet
1960	Lensink	EL
"	Niggol et al.	CU
"	Nikolaev	EL
1961a	Kenyon	ZC
"	Kenyon & Rice	EJ
"	Nikolaev	EL
" b	Sleptsov	Cet
1962	Fiscus & Scheffer	EJ
"	Johnson & Alcorn	EL
1963	Burns & Croxton	EL
"	Mathisen & Lopp	EJ
"	Nasu	Cet
"	Nemoto	Cet
1964a	Berzin	PM
"	Fiscus et al.	CU
"	Okutani & Nemoto	PM
"	Omura & Ohsumi	Cet
1965	Kenyon	MM
"	Mizue & Yoshida	PD
1966	Berzin & Rovnin	Cet
"	Fiscus & Baines	EJ
"	Mizue et al.	PD
"	Nasu	Cet
"	Nishiwaki	Cet
1967	Nishiwaki	MM
1968	Vania et al.	EL
1969	Fiscus et al.	ZC
"	Machida	CU
"	Omura et al.	BG
1970	Machida	Sei
" a	Mar. Mammal Biol. Lab.	CU
"	Shurunov	BP,PM,Sei
"	Machida	CU
1971	Nikolaev	EL
1972	Fiscus	CU,EJ
"	Ohsumi & Wada	BM
1973	Burns & Fay	PV
1974	Ohsumi & Wada	Cet
1975	Bigg & MacAskie	CU
"	Borodin & Vladimirov	CU
"	Kawamura	Cet
" a	Mar. Mammal Biol. Lab.	MM
"	Ohsumi	PD,PP,GM,BB
"	Sherrod et al.	EL
"	Wada	Cet
1976	Ohsumi, Masaki & Wada	OO,BB,PD,Cet
"	U.S. Fish Wildl. Serv.	EL
"	Wada	Cet
1977	Braham	ER
"	Braham, Everitt et al.	EJ
"	Braham, Everitt & Rugh	EJ
"	Hall et al.	ER
"	Ohsumi & Masaki	PM
"	Ohsumi, Masaki & Wada	PM
"	Tillman	PM
"	Wada	Cet
1978b	Gilmore	ER
in press	Everitt & Braham	PV
"	Rugh & Braham	ER

GULF OF ALASKA

(1892)1953	Alexander	CU
1935	Townsend	BG
1937	Robbins et al.	PM
1940	Cowan & Hatter	ZC
1943	Ulmer	PD
1944	Cowan	PD
1945	Cowan	ZC
1945	Cowan & Carl	MA
1947	Imler & Sarber	PV,EJ
1949	Scattergood	BA
1949b	Scheffer	PD
1950	Nichols	PD
" a	Scheffer	PD
" b	Scheffer	LO
1952	Cowan & Guiguet	LO,SC,ZC
"	Kenyon	EJ,CU
"	Wilke & Kenyon	CU,EJ,PP
1953	Pike	BB
" b	Scheffer	EL
1954	Wilke & Kenyon	CU
1955	Taylor et al.	CU
1956	Gilmore	BG
"	Schiller & Rausch	CU,EJ,PV
1958	Omura	BG
"	Pike & Maxwell	EJ
"	Pike et al.	CU
"	Wilke et al.	CU
1959	Daetz	EJ
"	Mathisen	EJ
"	Murie	MM
"	Pike et al.	CU
1960	Lensink	EL
"	Niggol et al.	CU
"	Pike	LO
"	Pike et al.	CU
1961	Nikolaev	EL
"	Pike	EJ
"	Pike et al.	CU
"	Thorsteinson et al.	EJ
"	Wilke & Fiscus	ER
1962	Fiscus & Scheffer	EJ
"	Johnson & Alcorn	EL
"	Mathisen et al.	EJ
"	Pike	ER
"	Pike et al.	CU
"	Thorsteinson & Lensink	EJ
1963	Jones	CU
"	Mathisen & Lopp	EJ,PV
"	Nemoto	Cet
"	Pike et al.	CU
1964a	Berzin	PM
"	Okutani & Nemoto	PM
"	Omura & Ohsumi	Cet
"	Spalding	PV,EJ,CU
1965	Fiscus & Kajimura	CU
"	Guiguet & Pike	GG
"	Nemoto & Kasuya	Cet
"	Nikolaev	EL
"	Pike et al.	CU
1966	Berzin & Rovnin	Cet
"	Fiscus & Baines	EJ
"	Klinkhart	DL
"	Nasu	Cet
"	Nishiwaki	Cet
"	Pike & MacAskie	CU
"	Pike et al.	CU
1967	Bishop	PV
"	Fiscus & Kajimura	CU
"	Klinkhart	PV
"	Nishiwaki	MM
"	Pike & MacAskie	CU
"	Vania & Klinkhart	EJ.EL,PV
1968	Branson	OR
"	Pike & MacAskie	CU
"	Rice	OO
"	Vania et al.	PV,EJ
1969	Bigg	PV
"	Fiscus et al.	MS
"	MacAskie	CU
"	Omura et al.	BG
"	Pike & MacAskie	MM
1970	MacAskie	CU
" a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
"	Shurunov	BP,PM,Sei
1971	Bigg & MacAskie	CU
"	Doroshenko	BM,BP
"	Hatler	GG
" a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
"	Prasil	EL,EJ,PV
"	Rice & Wolman	ER
1972	Bigg & MacAskie	CU
"	Fiscus	CU
"	Mar. Mammal Biol. Lab.	CU
"	Ohsumi & Wada	BM
"	Wolman	MN
1973	Mar. Mammal Div.	CU
"	Scheffer	MM
1974	Bigg & MacAskie	CU
"	Hatler & Darling	ER
"	Ohsumi & Wada	Cet
1975	Bigg & MacAskie	CU
"	Calkins & Lent	EL
"	Calkins et al.	MM
"	Carlson	EJ
" a	Mar. Mammal Biol. Lab.	MM
"	Pitcher	EL,EJ,PV,Cet,CU
"	Sandegren	EJ
"	Sergeant & Brodie	DL
"	Wada	Cet
1976	Int. Whaling Comm.	BM,MN
"	Naito	PV
"	Ohsumi, Masaki & Wada	OO,BB,PD,Cet
"	Spotte	GM
"	U.S. Fish Wildl. Serv.	EL
"	Wada	Cet
1977	Braham	ER
" a	Calkins & Pitcher	EJ
" b	Calkins & Pitcher	DL,MA
"	Gogan	MA
"	Hall et al.	ER
"	Hall & Tillman	Cet
"	Hart	ER
"	Int. Whaling Comm.	BM.MN
"	Johnson	PV
"	Mercer et al.	MM,A,D
"	Ohsumi & Masaki	PM
"	Ohsumi, Masaki & Wada	PM
"	Pitcher	PV
"	Pitcher & Calkins	PV
"	Tillman	PM
"	Wada	Cet
1978b	Gilmore	ER

OKHOTSK SEA

1941	Arsen'ev	PF
1961	Tikhomirov	Phoc
1973	Fedoseev	PF
1975	Berzin & Kuz'min	BG,Bow,ER
"	Kuzin	CU
"	Kuz'min & Berzin	BG.Bow,ER
"	Fedoseev	PH

SUBJECT INDEX

AGE/GROWTH, AGE DETERMINATION

1945	Scheffer	EJ
1952	Fay	OR
1953	Fay	OR
1954	Fay	OR
1955	Fay	OR
"	Omura	Cet
"	Sleptsov	Cet
1956	Nishiwaki et al.	PM
1958	Ohsumi et al.	BP
"	Pike et al.	CU
"	Scheffer	Pinn
"	Wilke et al.	CU
1959	Niggol et al.	CU
1960	Niggol et al.	CU
1962	Klumov	BG
"	Mathisen et al	EJ
"	Thorsteinson & Lensink	EJ
1964a	Berzin	PM
" b	Berzin	PM
"	Fiscus et al.	CU
1965b	Burns	OR
"	Fiscus et al.	CU
"	Fiscus & Kajimura	CU
"	Rice	ER
"	Roppel & Davey	CU
" a	Shustov	PF
" b	Shustov	PF
1966	Burns	OR
"	Mizue et al.	PD
1967	Bishop	PV
" a	Burns	EB
"	Scheffer & Todd	CU
1968	Tikhomirov	Phoc
1969	Bigg	PV
"	Mar. Mammal Biol. Lab.	CU
"	Omura et al.	BG
" a	Zimushko	ER
" b	Zimushko	ER
1970	Baker, Wilke & Baltzo	CU
"	Berzin	PM
"	Burns	OR,Phoc
"	Fedoseev & Nazarenko	PH
"	Jonsgard & Lyshoel	OO
" b	Zimushko	ER
1971	Int. Comm. Whaling. SC	PM
"	Panina	CU
"	Rice & Wolman	ER
"	Zimushko	ER
1973	Arsen'ev et al.	ER
"	Fedoseev	PF
" b	Smith	PH
1974	Omura & Ohsumi	BP.BM,PM, Sei
1975	Fedoseev	PH
"	Mar. Mammal Div.	CU
1976	Masaki	Sei
1977	Burns & Eley	PH
" a	Calkins & Pitcher	EJ
"	Mar. Mammal Div.	CU
"	Marquette	Bow
"	Natl. Mar. Fish. Serv.	MM
"	Pitcher	PV
"	Pitcher & Calkins	PV
"	Rice	Sei
1978	Braham & Leatherwood	BOW
"	Fraker et al.	DL
"	Mar. Mammal Div.	CU

BEHAVIOR

1870	Scammon	EL
1874	Scammon	MM
(1892)1953	Alexander	CU
1909	Andrews	MN,BP
1912	Townsend	MA
1928	Bailey	PF.PL
1935	Barabash-Nikiforov	EL
1940	Rainey	Bow
1947	Nikulin	OR
1952	Bartholomew	MA
"	Jonsgard & Oynes	OO
1957	Nemoto	Cet
1959	Daetz	EJ
"	Gilmore	ER
"	Nemoto	Cet
1960b	Kenyon	OR
1961b	Kenyon	CU,EL
1962b	Kenyon	PH,EB
"	Mathisen et al.	EJ
"	Nishiwaki	PM
1963	Fay	ER
"	Jones	CU
"	Tarasevich	EB
1965b	Burns	OR
"	Nikoleav	EL
"	Rasmussen & Head	ER
1966	Caldwell et al.	PM
"	Klinkhart	DL
"	Krylov	OR
1967	Bishop	PV
" a	Burns	EB
"	Vania & Klinkhart	DL
1968	Gol'tsev	OR
" a	Jonsgard	OO,BA
" b	Jonsgard	OO
"	Peterson et al.	CU
"	Vania et al.	DL
1970	Berzin	PM
"	Burns	OR,Phoc
" b	Mar. Mammal Biol. Lab.	CU
1971	Kosygin	EB
" a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
"	Nikolaev	EL
"	Rice & Wolman	ER
1972	Burns, Ray et al.	PL
"	Ichihara & Yoshida	CU
"	Leatherwood et al.	Cet
"	Loeb	PD
1973	Arsen'ev et al.	ER
"	Burns & Fay	PV,PL
"	Kuzin et al.	CU,EJ
"	Sandegren et al.	EL
" b	Smith	PH
1974	Gaskin et al.	PP
"	Mar. Mammal Div.	CU
1975	Barr	EJ
"	Calkins & Lent	EL
"	Carlson	EJ
"	Lentfer	UM
"	Mar. Mammal Div.	CU
"	Miller	OR
"	Nichols	ER
"	Ray & Watkins	OR
"	Sandegren	EJ
"	Smith & Stirling	PH
"	Tomilin & Kibal'chich	OR
1976	Kooyman et al.	CU
"	Mar. Mammal Div.	CU
"	Miller	OR
1977	Beier & Wartzok	PL
"	Gentry	CU,EJ
"	Hart	ER
"	Jeffries et al.	PV
"	Johnson, B.W.	PV
"	Krogman	BOW
"	Mar. Mammal Div.	CU
"	Ray & Wartzok	OR
"	Watkins & Ray	PF
1978	Mar. Mammal Div.	CU
1979	Braham, Krogman et al.	Bow,ER
in press	Braham et al.	Bow
"	Everitt & Krogman	Bow
"	Fay & Ray	OR

MARKING, TAGGING

1953	Kenyon & Wilke	CU
1958	Kawakami & Ichihara	Cet
"	Pike et al.	CU
1959	Nemoto	Cet
"	Niggol et al.	CU
1960	Fujino	BP
"	Niggol et al.	CU
1961	Fiscus et al.	CU
1963	Roppel et al.	CU
1964	Omura & Ohsumi	Cet
1965	Fiscus & Kajimura	CU
"	Roppel et al.	CU
1966	Chugunkov & Prokhorov	CU
"	Roppel et al.	CU
" a	Tikhomirov & Kosygin	PF,PH
1967	Ivashin & Rovnin	Cet
"	Scheffer & Todd	CU
"	Vania & Klinkhart	PV
"	Whales Res. Inst.	Cet
1968	Vania et al.	PV
1969	Mar. Mammal Biol. Lab.	CU
1970a	Mar. Mammal Biol Lab.	CU
1970b	Mar. Mammal Biol. Lab.	CU
1971a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
1972	Leatherwood et al.	Cet
"	Mar. Mammal Biol. Lab.	CU
"	Ohsumi & Wada	BM
1973	Burns	PL,PF,PV
"	Kuzin et al.	CU
"	Mar. Mammal Div.	CU
1974	Brown	BG,OO,GM,Cet
"	Int. Whaling Comm.	Cet
"	Mar. Mammal Div.	CU
"	Omura & Ohsumi	Cet
1975	Brown	Cet
"	Mar. Mammal Div.	CU
1976	Mar. Mammal Div.	CU
1977a	Calkins & Pitcher	EJ
"	Estes	OR
"	Mar. Mammal Div.	CU
"	Ohsumi & Masaki	PM

POLLUTANTS

1967	Pike & MacAskie	CU
1968	Pike & MacAskie	CU
1969	MacAskie	CU
1970	MacAskie	CU
1971	Bigg & MacAskie	CU
" a	Mar. Mammal Biol. Lab.	CU,EJ
1973	Addison & Brodie	DL
"	Burns & Morrow	PP.PL,DL
1974	Anas	CU,PV
1975	Øritsland	PH
"	Smith & Geraci	PH
1976	Geraci & Smith	PH
"	Kooyman.Gentry&McAlister	CU,EL,EB
1977	Engelhardt et al.	PH
" b	Lowry et al.	Phoc
"	Mar. Mammal Div.	CU
1978	Fraker et al.	Bow,DL
"	Krogman et al.	OR
"	Lowry et al.	PH,Bow

PARASITES, DISEASE

1935	Barabash-Nikiforov	EL
1939	Scheffer	MN,PM
1953	Sakiura et al.	Cet
1958	Scheffer	Pinn
1959	Daetz	EJ
"	Nemoto	Cet
1960	Fay	OR
1963	Roppel et al.	CU
1965	Fiscus & Kajimura	CU
"	Rice	ER
"	Roppel et al.	CU
"	Roppel,Johnson & Chapman	CU
1966	Klinkhart	DL
"	Roppel et al.	CU
1967	Scheffer & Todd	CU
1968	Tomilin & Smyshlyayev	Cet
1969	Machida	CU
"	Mar. Mammal Biol. Lab.	CU
1970	Baker et al.	CU
"	Berzin	PM
" a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
1971	Machida	CU
" b	Mar. Mammal Biol. Lab.	CU
"	Rice & Wolman	ER
"	Zenkovich	Cet
1972	Mar. Mammal Biol. Lab.	CU
1974	Rice	Sei
1975	Gol'tsev et al.	PL
"	Mar. Mammal Div.	CU
1976	Mar. Mammal Div.	CU
1977	Burns & Eley	PH
"	Gogan	MA
"	Mar. Mammal Div.	CU
"	Nat. Mar. Fish. Serv.	MM
1978	Mar. Mammal Div.	CU

POPULATION DYNAMICS (including mortality, birth rates, etc.)

1955	Fay	OR
"	Sleptsov	Cet
1959	Scott et al.	OR
1960	Lensink	EL
1962	Thorsteinson & Lensink	EJ
1963	Roppel et al.	CU
1965	N. Pac. Fur Seal Comm.	CU
"	Roppel & Davey	CU
"	Roppel, Johnson & Chapman	CU
"	Roppel. Johnson et al.	CU
1966	Burns	OR
"	Klinkhart	DL
"	Roppel et al.	CU
1967a	Burns	EB
" b	Burns	OR
"	Bishop	PV
"	Doi et al.	Cet
"	Scheffer & Todd	CU
1968	Krylov	OR
"	Tomilin & Smyshlyayev	Cet
1969	Arsen'ev	CU
"	Bigg	PV
"	N. Pac. Fur Seal Comm.	CU
" a	Zimushko	ER
" b	Zimushko	ER
1970	Baker et al.	CU
"	Mansfield	PH
" b	Mar. Mammal Biol. Lab.	CU
1971	Harry	CU
"	Int. Comm. Whaling	PM
" b	Mar. Mammal Biol. Lab.	CU
"	N. Pac. Fur Seal Comm.	CU
"	Ohsumi et al.	Cet
"	Omura & Ohsumi	BM, BP, Sei, PM
1972	Arsen'ev	CU
"	Ohsumi & Wada	BM
1973b	Smith	PH
1974	Allen	Cet
"	Ohsumi & Wada	Sei, BP
1975b	Fay	MM
"	Fedoseev	PH
"	Johnson, A.M.	CU
"	Lander	CU
"	Mar. Mammal Div.	CU
"	N. Pac. Fur Seal Comm.	CU
"	Ohsumi & Fukuda	Sei
"	Wada	Cet
1976	Fedoseev	Phoc, OR
"	Lander & Kajimura	CU
"	Mar. Mammal Div.	CU
1977a	Calkins & Pitcher	EJ
"	Fay	MM
"	Gogan	MA
"	Mar. Mammal Div.	CU
"	Pitcher	PV
1978	Mar. Mammal Div.	CU
in press	Chapman	MM
"	Fay & Ray	OR
"	Fay, Shults & Dieterich	MM
"	York	CU

REPRODUCTION

1935	Barabash-Nikiforov	EL
1941	Nikulin	OR
1945	Scheffer	EJ
1949	Scattergood	BA
1952	Bartholomew	MA
1953	Sakiura	Cet
1954	Brooks	OR
1955	Fay	OR
"	Omura	Cet
"	Sleptsov	Cet
1956	Nishiwaki et al.	PM
1958	Ohsumi et al	BP
"	Pike & Maxwell	EJ
"	Pike et al.	CU
"	Scheffer	Pinn
"	Wilke et al.	CU
1959	Mathisen	EJ
"	Niggol et al.	CU
1960	Niggol et al.	CU
"	Pike et al.	CU
1961	Fiscus et al.	CU
"	Nikolaev	EL
"	Tikhomirov	Phoc
1962b	Kenyon	PH, EB
"	Klumov	BG
"	Krylov	OR
"	Mathisen et al.	EJ
"	Thorsteinson & Lensink	EJ
1963	Fay	ER
"	Pike et al.	CU
1964	Fiscus et al.	CU
"	Sund	ER
" a	Tikhomirov	Pinn
1965b	Burns	OR
" c	Burns	OR, EB
1965	Fiscus et al.	CU
"	Mizue & Yoshida	PD
"	Rice	ER
"	Roppel & Davey	CU
"	Roppel, Johnson & Chapman	CU
"	Roppel et al.	CU
" a	Shustov	PF
" b	Shustov	PF
" d	Shustov	PF
1966	Burns	OR
"	Johnson, M.L. et al.	PH, EB
" b	Kosygin	Phoc
"	Mizue et al.	PD
"	Pike et al.	CU
"	Roppel et al.	CU
" a	Tikhomirov	Phoc
1966b	Tikhomirov & Kosygin	Phoc
1967	Bishop	PV
" a	Burns	EB
"	Doroshenko et al.	BA
"	Fiscus & Kajimura	CU
"	Klinkhart	PV
"	Scheffer & Todd	CU
"	Vania & Klinkhart	EJ
1968	Krylov	OR
"	Tikhomirov	Phoc
1969	Bigg	PV
"	Mar. Mammal Biol. Lab.	CU
"	Omura et al.	BG
" a	Zimushko	ER
" b	Zimushko	ER
1970	Baker et al.	CU
"	Berzin	PM
"	Burns	OR, Phoc
"	Jonsgard & Lyshoel	OO
" a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
" c	Zimushko	ER

1971	Int. Comm. Whaling, SC	PM
"	Doroshenko	BM,BP
" a	Mar. Mammal Biol. Lab.	CU
" b	Mar. Mammal Biol. Lab.	CU
"	Panina	CU
"	Rice & Wolman	ER
"	Zimushko	ER
1972b	Fiscus	CU
"	Loeb	PD
1973	Arsen'ev et al.	ER
"	Burns & Fay	PV,PL
"	Fedoseev	PF
" b	Smith	PH
1974	Mar. Mammal Div.	CU
"	Omura & Ohsumi	BP,BM.PM.Sei
1975	Calkins & Lent	EL
"	Fedoseev	PH
"	Kuz'min & Berzin	Bow
"	Mar. Mammal Div.	CU
"	Rice	ER
"	Smith & Stirling	ER
"	Tomilin & Kibal'chich	OR
1976	Fedoseev	Phoc,OR
"	Masaki	Sei
"	Popov	Phoc
1977	Beier & Wartzok	PL
"	Burns & Eley	PH
"	Calkins & Pitcher	EJ
"	Gogan	MA
"	Hart	ER
"	Krogman	Bow
"	Marquette	Bow
"	Natl. Mar. Fish. Serv.	MM
"	Pitcher	PV
"	Pitcher & Calkins	PV
"	Rice	Sei
"	Scheffer	PV
1978	Fraker et al.	Bow,DL
"	Krogman et al.	OR
in press	Everitt & Krogman	Bow ER
"	Fay & Ray	OR
"	York	CU

SURVEY/CENSUS METHODOLOGY

1959	Gilmore	ER
"	Mathisen	EJ
"	Scott et al.	OR,UM
1960a	Kenyon	MM
" b	Kenyon	OR
1961	Kenyon & Rice	EJ
1962	Fedoseev	OR
1963	Mathisen & Lopp	EJ,PV
1965	Kenyon	EL,MM
1966	Fedoseev	MN
" b	Tikhomirov	Phoc
1967	Vania & Klinkhart	PV
1968	Gol'tsev	OR
"	Krylov	OR
"	Vania et al.	PV
"	Ramsey	ER
1969	Rice & Wolman	ER
"	Shustov	PF
"	Uspensky & Shilnikov	UM
1970a	Zimushko	ER
1971	Rice & Wolman	ER
1972	Burns & Harbo	PH
"	Gol'tsev	OR
"	Kenyon	MM OR
"	Shustov	Phoc,OR
1973a	Smith	PH
" b	Smith	PH
1974a	Rice	ER
"	Sund & O'Connor	ER
1975	Potelov	EB PH
"	Wada	Cet
1976	Gol'tsev	OR
"	Wada	Cet
1977	Braham	ER
"	Braham, Everitt et al.	MM
"	Braham, Everitt & Rugh	EJ
"	Braham, Fiscus & Rugh	MM
"	Braham & Krogman	Bow.DL
"	Braham,Krogman & Fiscus	Bow,DL,MM
"	Burns & Eley	PH,EB
"	Burns & Harbo	PL
"	Burns, Shapiro & Fay	Pinn
"	Estes	OR
"	Jeffries et al.	PV
"	Jurasz & Jurasz	MN
"	Pitcher & Calkins	PV
"	Wada	Cet
1978	Estes & Gilbert	OR
"	Fraker et al.	Bow,DL
"	Krogman et al.	OR
1979	Braham, Krogman et al.	Bow,OO
in press	Braham, Krogman et al.	Bow
"	Everitt & Braham	PV
"	Rugh & Braham	ER

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TROPHIC RELATIONSHIPS AMONG ICE-INHABITING PHOCID SEALS AND FUNCTIONALLY RELATED MARINE MAMMALS IN THE CHUKCHI SEA

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 232, Contract Number 03-5-022-53

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I. Summary

A total of 41 spotted seal, 581 ringed seal, and 243 bearded seal stomachs containing food and collected in the Chukchi Sea were analyzed. In addition, we examined 83 belukha whale and 4 walrus stomachs containing food. Most of the specimens were obtained from Eskimo subsistence hunters at three coastal villages: Shishmaref, Point Hope, and Wainwright. Most of the belukhas were collected in Eschscholtz Bay (inner Kotzebue Sound). Samples were collected at several times of year in order to assess seasonal changes in feeding patterns. The best sample coverage was near the coast in spring and summer when native hunting activity is greatest. Poorest sample coverage was in winter, and in offshore areas that are not accessible to coastal based hunters.

The diet of ringed seals in the Chukchi Sea shows pronounced seasonal variation. In most seals collected in fall, winter, and early spring, arctic cod were the main food. Near Shishmaref saffron cod were important in the fall and spring periods, with arctic cod most important in midwinter. During spring and summer crustaceans, mostly shrimps, amphipods and mysids, were the major prey. Age-related differences in diet were found in seals from Shishmaref. Almost one-third of the diet of pups was comprised of small crustaceans such as mysids, amphipods, and euphausiids, and the fish they ate were entirely cod. Older seals ate proportionately less crustacean material and a much greater variety of fishes.

Bearded seals are primarily benthic feeders, eating mostly crabs, shrimps, and clams. The vast Chukchi Platform provides extensive shallow water feeding habitat for them. Clams are found in the diet only during summer months. Pup bearded seals eat more shrimps and isopods than do older seals which eat more clams, crabs, and echuiroid worms.

Based on very limited samples, spotted seals and belukhas forage primarily on several species of coastal and anadramous fishes including herring, saffron cod, capelin, and rainbow smelt.

Clams comprised most of the contents of the four walrus stomachs exmained.

During much of the year the distribution of marine mammals is determined by the distribution and abundance of their prey. In order to assess the probable effects of OCS development on marine mammals, data must be available on the distribution, abundance, and hydrocarbon sensitivity of their principal prey species. Available data are reviewed in this report and found to be inadequate. Recommendations for further studies of the foods and feeding habits of marine mammals as well as the biology and hydrocarbon sensitivity of prey species are given.

II. Introduction

During the last 5 years there has been a continually changing series of oil and gas leasing schedules proposed for areas of "promising" oil and gas potential on the continental shelf off Alaska. Among these areas are the nearshore waters of the Chukchi Sea. The present leasing schedule calls for sale #85 (Chukchi Sea) in February 1985 and sale #86 (Hope Basin) in May 1985. Final Environmental Impact Statements for those areas are due in July and October 1984, respectively.

Since 1975, as a part of the Alaskan Outer Continental Shelf Environmental Assessment Program (OCSEAP), this research unit has been investigating trophic relationships of ice-associated marine mammals, primarily phocid seals, of western and northern Alaska. This final report presents the information collected in the Chukchi Sea during a 4-year field program in order to make it available to resource managers for consideration during tract selection, EIS preparation, and policy formulation.

The waters off the coast of Alaska support a tremendous abundance and diversity of marine mammals. Some species occur only during ice-free months while others are more or less dependent on sea ice as a habitat in which to whelp, breed, molt, and feed. The relationship between northern marine mammals and sea ice has been well summarized by Burns (1970) and Fay (1974).

Several species of marine mammals regularly occur in the Chukchi Sea. From April to June bowhead whales pass through leads in the nearshore ice of the Chukchi Sea on their way from wintering areas in the Bering Sea to their summer feeding grounds in the eastern Beaufort Sea. These whales leave the Beaufort.Sea when ice reforms in September and October and once again pass through the Chukchi on their way to overwintering areas. Belukha or white whales accompany the bowheads north in spring. Some of these small whales may bear their young in coastal lagoons and estuarine systems of the Chukchi. They, too, usually leave in autumn as the ice forms. Belukhas winter primarily in areas of moving ice. Occasionally they are trapped in polynyi where they overwinter or perish as the ice cover becomes complete.

As the pack ice disintegrates and recedes north in the spring, most of the Pacific walrus population leaves its wintering grounds in the Bering Sea and moves north. The majority of these animals summer in the northern Chukchi Sea and off the coast of northeast Siberia. Some walruses penetrate the western and central Beaufort Sea. They move south in the early autumn, passing through the Bering Strait mainly in the months of October, November, and December.

Spotted seals utilize the ice front of the Bering Sea for whelping and molting in late winter and spring. They move north and toward the coast as the ice recedes in May and June. Many are found along the Chukchi coast during summer and early fall. They are not adapted to wintering in this area, and so move south in early fall with the onset of freezeup.

Only three species of marine mammals can be considered year-round residents of the Chukchi Sea. These are ringed seals, bearded seals, and polar bears. Although arctic foxes range widely over all types of sea ice, it is debatable whether they can be considered truly marine.

Polar bears are distributed throughout ice-covered arctic waters. In summer they are found on the pack ice, with greatest densities along the edge. They are primarily found in areas of high abundance and availability of ringed and bearded seals which are their main prey.

Bearded seals are year-round residents of the Chukchi Sea. They are able to maintain breathing holes in ice, but appear to do so only rarely, and are thus largely excluded from the fast ice zone. Rather, they are most common in the transition zone and offshore pack ice (Burns 1967, Burns and Harbo 1972, Stirling et al. 1975). The Chukchi Sea is underlain by the Chukchi Platform, a vast area of continental shelf with water depths less than 100 m. As bearded seals can feed at depths up to 100 m, the Chukchi Sea offers an extensive foraging area. During the summer there is an influx of bearded seals from the Bering Sea as the ice there melts and recedes north. Although some seals move into the Beaufort Sea in summer, the majority appear to remain over the shallow Chukchi Platform.

Ringed seals are found almost throughout ice-covered seas of the northern hemisphere, and they are overall the most common species of seal in the Chukchi Sea. Their density in any given area and at any given time is closely related to ice conditions. In late March and early April ringed seal pups are born in lairs excavated in snow-covered ice (McLaren 1958, Burns 1970, Smith and Stirling 1975). Although stable landfast ice is the preferred area for pupping, and the greatest density of seals occurs there, some pups are born on drifting ice. There are some indications that older, more experienced females may occupy the preferred breeding habitat (McLaren 1958, Burns 1970). Subadult animals are often found congregated along transient lead systems (Stirling et al. 1975; Burns, unpubl.).

Subsequent to pupping and breeding, ringed seals undergo a period of molting during which they spend a large amount of time hauled out on the ice. During this period feeding intensity is quite low (McLaren 1958, Johnson et al. 1966). As the ice melts in the Bering Sea in May and June, seals move into the Chukchi and Beaufort Seas where they spend the summer dispersed throughout ice-covered areas. With the onset of winter and the increase in ice cover, the area occupied by ringed seals expands accordingly. Specific details of these movements are largely unknown.

Ringed, spotted, and bearded seals, as well as the other species of marine mammals, are of cultural and economic importance to residents of the Chukchi coast. Seal hunting occurs regularly at the villages of Shishmaref, Point Hope, and Wainwright where seals are hunted for human and dog food, and for the skins which have traditionally been used for clothing, equipment, and crafts. National interest in these animals and the habitats they utilize is high. This interest is perhaps best exemplified by the Marine Mammal Protection Act of 1972 (Public Law 92-522) passed by the Congress of the United States which states that "marine mammals have proven themselves to be resources of great international significance, esthetic and recreational as well as economic, and it is the sense of the Congress that they should be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management."

These factors and others make it imperative that the potential effects of oil and gas exploration and development in the Chukchi Sea on ice-inhabiting marine mammals be anticipated and minimized to whatever degree possible. Such an evaluation requires an understanding of the biology of the species involved, as well as how they affect and are affected by their environment. This study of the trophic relationships of ice-inhabiting phocid seals of the Chukchi Sea will contribute to such an understanding. We have dealt in greatest detail with the two resident and most abundant species, ringed seals and bearded seals. In addition, preliminary data are presented for three summer residents, spotted seals, walruses, and belukha whales.

The intricacy of biological systems is such that even gross simplifications are difficult to render verbally and/or graphically. However, through this study of trophic relationships of marine mammals we have attempted to identify key species, those organisms which are the most tightly woven into the web of trophic interdependencies. It is our hope that identification of these key species and important interdependencies will provide a focus of attention and contribute to the assessment of anticipated ecological effects. When integrated with other OCSEAP research it should be possible to identify potential differential sensitivity of parts of the system and to evaluate which times, places, or species appear to be most or least vulnerable.

In the discussions that follow it will be necessary to give the names of many species of marine animals. The authors realize that there are advantages to the use of either common or scientific names. In this report we will use common names whenever such are available and appropriate. For purposes of clarity and ease of reference, the accepted scientific names of most species for which we will use common names are given in Table 1. For species mentioned seldom in this report, both common and scientific names are given at the first mention of that species.

Table 1. Common and scientific names of species commonly mentioned in this report.

Common Name	Scientific Name
Pollock	Theragra chalcogramma
Arctic cod	Boreogadus saida
Saffron cod	Eleginus gracilis
Herring	Clupea harengus
Rainbow smelt	Osmerus mordax
Sand lance	Ammodytes hexapterus
Capelin	Mallotus villosus
Sculpin	Family Cottidae
Flatfish	Family Pleuronectidae
Tanner crab	Chionoecetes opilio
Spider crab	Hyas coarctatus

III. Current State of Knowledge

We know of only two accounts of the food habits of marine mammals in the Chukchi Sea published prior to this OCSEAP study. An extensive study was conducted as a part of Project Chariot by Johnson et al. (1966) at Point Hope and Kivalina from November 1960 through June 1961. They examined 1,923 stomachs from ringed seals. During the months of November, December, January, and February, fishes (mostly sculpins, arctic cod, and saffron cod) made up 90 percent or more of the contents. During March, April, May, and June, invertebrates, mostly shrimp and amphipods, were the predominant food, making up more than half and occasionally more than 80 percent of total stomach contents.

The stomach contents of 164 bearded seals were examined in that study. The only month in which a large sample (129) was obtained was June. Shrimp, crabs, and clams were the most common food items with other benthic invertebrates found in small quantities and fishes (sculpins and arctic cod) usually comprising less than 10 percent of the total volume.

Burns (1967), in his summary of the biology of the bearded seal, reported on his examination of stomachs from seals collected at Nome, Gambell, and Wainwright. In May he found that brachyuran and anomuran crabs (Hyas coarctatus alutaceus and Pagurus sp.) accounted for 57 percent of the contents with shrimp, fishes (saffron cod, arctic cod, and sculpins), and sponges comprising most of the remainder. In July and August clams (Serripes groenlandicus, Spisula sp. and Clinocardium sp.) were the most abundant food item, with shrimp, crabs, and isopods also quite commonly found.

Results of our OCSEAP studies of the food habits of bearded seals in the Bering and Chukchi Seas have been compiled and are currently in press (Lowry et al. 1980).

There are no published accounts of the foods of spotted seals, walruses, or belukha whales in the Chukchi Sea.

Published accounts of the food habits of ringed, bearded, and spotted seals, as well as belukha whales, in other parts of the world have been reviewed in 1978 and 1979 annual reports for this research unit (Lowry et al. 1978a, Lowry et al. 1979a).

IV. Study Area

The study area encompasses the Alaskan sector of the Chukchi Sea from Bering Strait to Point Barrow (Figure 1). Data we have collected from the Bering Strait (Wales and Diomede) will be presented in a future report dealing with the Bering Sea. In the Chukchi Sea we collected specimens from the villages of Shishmaref, Point Hope, and Wainwright. The region between Bering Strait and Point Hope is referred to as Hope Basin. The region between Cape Lisburne and Wainwright is referred to simply as "the Chukchi," or Sale #85.

V. Sources, Methods, and Rationale of Data Collection

Field Collections

OCSEAP sponsored collection efforts began in 1975 and intensified in 1976-1979. Collectors were sent to the coastal hunting villages during predictably good hunting periods. Specimen material, including jaws and claws for age determination, reproductive tracts, and stomachs were purchased from hunters. Sampling was done by the principal investigators and other ADF&G employees. A schedule of field activities and summary of specimens obtained is presented in Table 2.

Whenever possible seals from which specimen material was taken were weighed, sex was determined, and a series of standard measurements was made for use in this and other ongoing studies of ice-inhabiting seals. Tissue and blood samples were collected in some cases and made available to other investigators for heavy metal, hydrocarbon, PCB, and pathogen analysis. (See methods section in RU #230, Annual Report, for detailed description of standard measurements and collection of additional specimen material.)

Only stomachs containing food were collected. Stomachs were tied at the cardiac and pyloric sphincters and severed from the remainder of the alimentary canal near these ties. They were then either injected with 10 percent formalin, labeled and placed intact in plastic bags

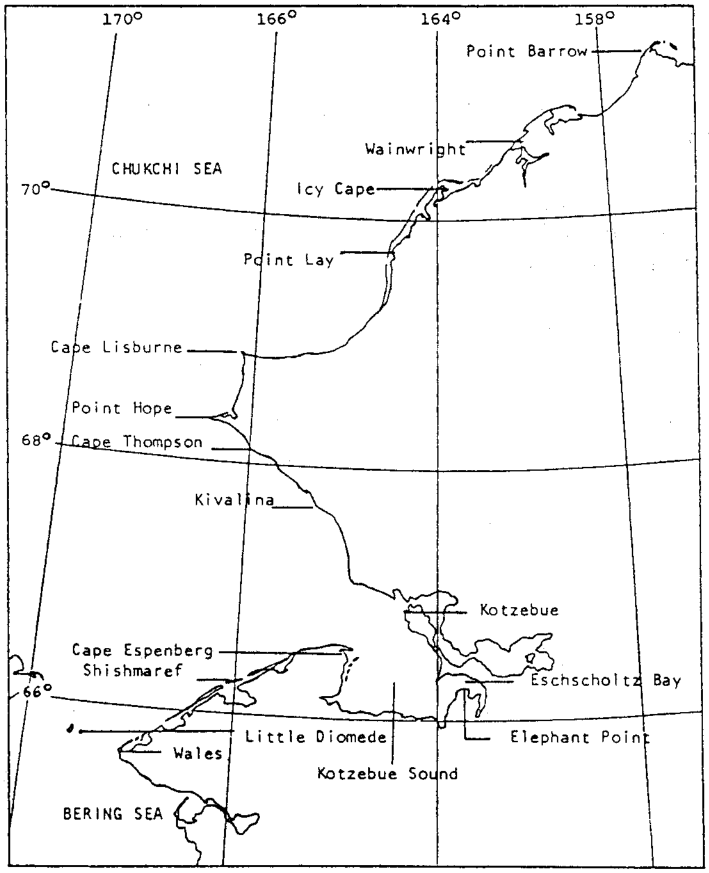

Table 2. Schedule of field activities in the Chukchi Sea and summary of specimens obtained. Only stomachs with food are included.

		Specimens Obtained				
Location/Platform	Dates	Spotted Seals	Ringed Seals	Bearded Seals	Belukha Whales	Walrus
Wainwright	24 July-11 Aug 1975	3	17	22		
Cape Lisburne	10 Mar-20 Apr 1976		3			
Point Hope	19 Apr-1 June 1976		33			
Shishmaref	22 June-15 July 1976	3	106	40		
Wainwright	22 July-1 Aug 1976			7		
DISCOVERER	17 Aug-3 Sept 1976		2	1		
Point Hope	15 Apr-2 June 1977		26		5	
Shishmaref	24 June-21 July 1977	10	235	112		3
Wainwright	22 July-24 July 1977			3		
GLACIER	1 Aug-5 Aug 1977			2		
Shishmaref	15-31 October 1977	14	6	13		
Shishmaref	4-11 November 1977	1	7			
Shishmaref	6 Jan-10 Feb 1978		24			
Kotzebue	February 1978		3			
Point Hope	10-28 Apr 1978		15	1	9	
Wainwright	25 Apr-22 May 1978		4	1		
Shishmaref	20 May-21 June 1978	10	56	17		
Elephant Point	13-18 June 1978		3		62	
Wainwright	1-12 July 1978		24	4		
Point Hope	6-8 May 1979				2	
Shishmaref	24 May-8 June 1979		12	4		
Wainwright	25 June-13 July 1979		5	16	2	1
Elephant Point	16-23 June 1979				3	
Totals		41	581	243	83	4

containing 10 percent formalin, or placed in bags and frozen. All stomachs were shipped to the ADF&G lab in Fairbanks. Upon arrival in the lab those stomachs containing large numbers of small otoliths, which degrade rapidly in formalin, underwent a preliminary sort in which the otoliths were removed and stored in 95 percent ethanol.

Laboratory Procedures and Identification

The preserved contents of stomachs were washed onto a 1.0-mm mesh screen. Contents were sorted and identified to the lowest taxonomic level permitted by their condition, using appropriate taxonomic keys and reference specimens. In the majority of cases identifications entailed the sorting and recognition of small bits and pieces of organisms. Crustaceans were frequently identified by claws, carapaces, or abdomens. Fishes were identified on the basis of otoliths and bone fragments. The volume and number of each type of prey item were determined by water displacement and counts of individuals or otoliths. Size ranges of various prey items were determined when possible.

Virtually all identifications were made by project personnel. Necessary taxonomic keys and references, both published and unpublished, were accumulated. Much use was made of the University of Alaska Marine Museum/Sorting Center reference collection and of the expertise of Sorting Center personnel. A reference and voucher collection of invertebrates and fishes was established at ADF&G. In addition, an otolith collection was compiled. Considerable interchange of specimen material and ideas occurred among personnel of this project, Dr. James Morrow, OCSEAP RU# 285, and John Fitch, California Department of Fish and Game (retired).

VI. Results

Spotted Seals

Most of the spotted seal specimens we have examined were from seals taken at Shishmaref. Foods found in specimens collected in the spring-summer varied widely among the 3 years sampled (Table 3). Largest volumes of food were found in seals taken 8-19 July 1977 which had eaten mostly herring. Our results are obviously influenced by the timing of seal collections in relation to the appearance of schools of spawning herring. Barton (1979) reported schools of herring off Shishmaref on 25 July 1976. Herring were obviously abundant in the vicinity from 8-19 July 1977 when our spotted seal samples were collected, but apparently had not yet arrived when seals were taken in early July 1976 and June 1978. Spotted seals taken at Shishmaref in October 1977 had also eaten mostly herring (Table 4). A seal taken there in early November had eaten only arctic cod. Three spotted seals taken at Wainwright in summer 1975 had eaten small amounts of sculpins and cod (arctic or saffron) and traces of shrimp and isopods.

Ringed Seals

Most of the ringed seal specimens we examined were collected at Shishmaref, Point Hope, and Wainwright. Foods eaten by ringed seals during the late spring-early summer period at Shishmaref were similar in 1976, 1977, and 1978 (Table 5). Fishes (mostly saffron cod) and shrimps (mostly Crangon septemspinosa) were the major foods in all 3 years with amphipods, mysids, euphausiids, and isopods also eaten. Seals taken at Shishmaref in spring 1979, slightly earlier than previous years, had eaten almost entirely fishes: saffron and arctic cods, and rainbow smelt. Seals collected at Shishmaref in October had eaten mostly hyperiid amphipods while arctic cod were the primary food item in November, January, and February (Table 6).

Four ringed seal stomachs containing food were collected at Point Hope during January-March. Foods eaten included arctic cod, sand lance, gammarid amphipods (mostly Ampelisca spp.), and hyperiid amphipods (Table 7). Stomach contents of seals collected in April varied widely among the 3 years sampled. Overall during April, fishes (several species), Ampelisca spp., and shrimps (primarily Pandalus goniurus) were the main foods (Table 8). Foods eaten by seals collected in May 1976 and 1977 were similar (Table 9). Several types of prey were identified from the stomachs including shrimps (mostly Argis lar), gammarid amphipods (mostly Ampelisca spp., some Anonyx nugax), mysids (Mysis litoralis and Neomysis rayi), euphausiids (Thysanoessa spp.), and several species of fishes, mainly saffron cod and sand lance.

Four seals collected at Wainwright during winter and spring 1978 had eaten small amounts of primarily gammarid amphipods (mostly Anonyx nugax, some Ampelisca spp.) and shrimps (Argis lar, Sclerocrangon boreas, and Pandalus goniurus). Seals taken in winter had eaten arctic cod also. Stomach contents varied greatly in seals collected during summer 1975, 1978, and 1979 (Table 10). Overall the stomach contents consisted mostly of fishes (primarily arctic cod), gammarid amphipods (Gammarus sp. and Onisimus sp.), and shrimps (Eualus gaimardii and Sclerocrangon boreas).

Stomach contents of 11 ringed seals collected at miscellaneous locations in the Chukchi Sea were examined (Table 11). The presence of herring in seals taken near Kotzebue in February was of interest since overwintering of herring in that area was not previously documented. The two seals collected on the DISCOVERER cruise provided the only data collected on summer foods of ringed seals in offshore waters of the northern Chukchi Sea. Those seals had eaten mostly shrimps (Eualus gaimardii, E. macilenta, and Pandalus goniurus) and arctic cod.

The large samples of ringed seals collected at Shishmaref during June-July 1976-1978 were examined for age- and sex-related differences in foods (Table 12). Foods of male and female seals were very similar. Small crustaceans (amphipods, mysids, and euphausiids) make up 28 percent of the stomach contents of pups but only 4-9 percent of the contents of older seals. The proportion of fish in the stomach contents increased

Table 3. Spotted seal stomach contents data from Shishmaref. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Shishmaref	Shishmaref	Shishmaref		
Dates:		4-6 July 1976	8-19 July 1977	6-21 June 1978	All years combined 1976-1978	
Sample Size:		3	10	10	23	
Mean Volume (ml)		402.9	632.0	49.7	359.7	
Food Items	1	Shrimp 87	Fish 99 Herring 96 Saffron cod 4	Fish 80 Sand Lance 94 Saffron cod 3 Sculpins 2	Fish 85 Sand Lance 48 Herring 36 Saffron cod 8 Flatfish 7	
	2	Fish 13 Flatfish 62 Saffron cod 38	Shrimp 1	Shrimp 8	Shrimp 14	
	3			Hyperiid amphipod 7		
	4			Mysid 3		
	5			Gammarid amphipod 1		

Table 4. Spotted seal stomach contents data from Shishmaref. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Shishmaref	Shishmaref			
Dates:		10-24 Oct 1977	4 Nov 1977			
Sample Size:		14	1			
Mean Volume (ml)		432.9	751.0			
Food Items	1	Fish 99 Herring 83 Saffron cod 17	Fish 100 Arctic cod 100			
	2					
	3					
	4					
	5					

Table 5. Ringed seal stomach contents data from Shishmaref. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Shishmaref	Shishmaref	Shishmaref	Shishmaref	Shishmaref
Dates:		4 June-12 July 1976	10 June-19 July 1977	9-21 June 1978	24 May-8 June 1979	All years combined 20 May-19 July
Sample Size:		106	235	56	12	409
Mean Volume (ml)		96.1	97.6	104.2	102.4	98.3
Food Items	1	Shrimp 47	Fish 57 Saffron cod 83 Arctic cod 8 Sand lance 4 Flatfish 3	Fish 44 Saffron cod 89 Sand lance 8 Arctic cod 1	Fish 95 Saffron cod 77 Rainbow smelt 13 Arctic cod 8	Fish 52 Saffron cod 86 Arctic cod 5 Sand lance 4 Flatfish 3
	2	Fish 41 Saffron cod 91 Flatfish 6 Herring 1	Shrimp 31	Shrimp 27	Shrimp 2	Shrimp 29
	3	Mysid 4	Euphausiid 3	Hyperiid amphipod 16	Echiuroid worm 2	Mysid 4
	4	Isopod 4	Mysid 3	Mysid 6	Mysid 1	Hyperiid amphipod 2
	5	Gammarid amphipod 2	Gammarid amphipod 2	Gammarid amphipod 3		Gammarid amphipod 2

Table 6. Ringed seal stomach contents data from Shishmaref. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Shishmaref	Shishmaref	Shishmaref		
Dates:		23-28 Oct 1977	4-5 Nov 1977	6 Jan-2 Feb 1978		
Sample Size:		6	7	24		
Mean Volume (ml)		122.0	272.7	314.9		
Food Items	1	Hyperiid amphipod 88	Fish 100 Arctic cod 86 Saffron cod 14	Fish 99 Arctic cod 83 Saffron cod 10 Sculpins 3		
	2	Fish 7 Saffron cod 100				
	3	Shrimp 5				
	4					
	5					

Table 7. Ringed seal stomach contents data from Point Hope. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Point Hope	Point Hope	Point Hope		
Dates:		January 1977	February 1978	March 1976		
Sample Size:		2	1	1		
Mean Volume (ml)		149.5	140.0	15.6		
Food Items	1	Fish 84 Arctic cod 96 Sand lance 4	Gammarid amphipod 100	Gammarid amphipod 59		
	2	Hyperiid amphipod 16		Fish 32 Sand lance 100		
	3			Shrimp 5		
	4					
	5					

Table 8. Ringed seal stomach contents data from Point Hope. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Point Hope	Point Hope	Point Hope	Point Hope	
Dates:		April 1976	April 1977	April 1978	Combined April 1976-78	
Sample Size:		12	17	15	44	
Mean Volume (ml)		118.9	42.3	59.9	67.3	
Food Items	1	Fish 75 Arctic cod 78 Sculpins 9 Sand lance 6 Saffron cod 5	Hyperiid Amphipod 52	Gammarid Amphipod 32	Fish 46 Arctic cod 49 Sand lance 29 Sculpins 16 Saffron cod 3	
	2	Hyperiid amphipod 16	Shrimp 36	Fish 33 Sand lance 64 Sculpins 26 Arctic cod 6 Saffron cod 2	Gammarid amphipod 29	
	3	Shrimp 4	Fish 7 Arctic cod 64 Sand lance 16 Sculpins 12 Pricklebacks 8	Shrimp 27	Shrimp 19	
	4	Echiuroid worm 3	Euphausiid 4	Hyperiid amphipod 8	Hyperiid amphipod 2	
	5				Echiuroid worm 1	

Table 9. Ringed seal stomach contents data from Point Hope. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Point Hope	Point Hope	Point Hope		
Dates:		May 1976	May 1977	Combined May 1976-77		
Sample Size:		20	7	27		
Mean Volume (ml)		27.9	55.8	35.1		
Food Items	1	Shrimp 36	Shrimp 42	Shrimp 38		
	2	Gammarid amphipod 30	Gammarid amphipod 22	Gammarid amphipod 27		
	3	Euphausiid 11	Mysid 22	Mysid 11		
	4	Fish 8 Sand lance 69 Arctic cod 19	Fish 13 Saffron cod 65 Sand lance 17 Arctic cod 14 Sculpins 4	Fish 10 Saffron cod 42 Sand lance 37 Arctic cod 16 Sculpins 5		
	5			Euphausiid 7		

Table 10. Ringed seal stomach contents data from Wainwright. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Wainwright	Wainwright	Wainwright	Wainwright	
Dates:		8 July-7 August 1975	1-2 July 1978	25 June-13 July 1979	All years combined 25 June-7 August 1975-1979	
Sample Size:		17	24	5	46	
Mean Volume (ml)		26.3	117.7	63.8	78.1	
Food Items	1	Shrimp 42	Fish 71 Arctic cod 99 Sand lance 1	Gammarid amphipod 75	Fish 61 Arctic cod 96 Sculpin 2 Sand lance 1	
	2	Fish 22 Sculpins 50 Cod 25 Capelin 17	Gammarid amphipod 27	Fish 21 Arctic cod 93 Sculpin 7	Gammarid amphipod 29	
	3	Gammarid amphipod 8	Shrimp 1	Mysid 1	Shrimp 6	
	4	Isopod 5			Isopod 1	
	5	Hyperiid amphipod 2			Mysid 1	

Table 11. Ringed seal stomach contents data from misc. areas in the Chukchi Sea. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area: Dates: Sample Size:		Kotzebue February 1978 3	Elephant Point June 1978 3	Cape Lisburne March-April 1976 3	DISCOVERER 27-28 August 1976 2	
Mean Volume (ml)		212.3	21.9	36.6	75.9	
Food Items	1	Fish 100 Herring 51 Saffron cod 37 Smelt 6 Arctic cod 3	Fish 62 Saffron cod 71 Sculpins 29	Fish 31 Arctic cod 96 Sculpins 4	Shrimp 84	
	2		Mysid 17	Shrimp 29	Fish 13 Arctic cod 100	
	3		Shrimp 15	Gammarid amphipod 20	Gammarid amphipod 2	
	4		Isopod 2	Mysid 1		
	5		Gammarid amphipod 1			

Table 12. Major food items of ringed seals collected at Shishmaref in June-July 1976-1978. Results are presented by age and sex categories. Numbers indicate percent of total volume for invertebrates and total fish, and percent of total number for species of fishes.

	Sexes Combined				Seals ≥5 yrs old	
Food Item	Pups N=99	Yrlgs N=24	2-4 yrs old N=36	≥5 yrs N=212	Males N=100	Females N=126
Shrimp	19	37	38	30	31	33
Hyperiid Amphipod	9	*	*	2	1	*
Gammarid Amphipod	8	*	1	2	2	2
Mysid	7	6	3	3	4	3
Euphausiid	4	-	*	2	3	1
Total Fish	45	42	48	52	49	53
Saffron Cod	92	60	75	90	85	93
Arctic Cod	7	38	11	3	2	3
Sand Lance	1	-	-	2	*	-
Sculpin	*	*	1	*	1	*
Flatfish	-	1	1	4	11	3
Mean Volume of Contents (ml)	39.3	98.9	111.6	121.9	120.7	111.1

* Indicates values less than 1 percent.

slightly with age. Pups ate almost exclusively cod while other fishes occurred more frequently in stomachs of older seals. The mean volume of stomach contents showed a steady increase with age.

Bearded Seals

Most of the bearded seal specimens we examined were collected at Shishmaref and Wainwright. At Shishmaref during June and July shrimps (mostly *Crangon septemspinosa* and some *Argis lar*) were the main food in all 4 years sampled (Table 13). Brachyuran crabs (mostly *Telmessus cheiragonus*), clams (mostly *Spisula polynyma* and *Serripes groenlandicus*), isopods (*Saduria entomon*), and fishes were also major foods. In 13 bearded seals taken at Shishmaref 16-30 October 1977, the stomach contents averaged 631.8 ml and was comprised of 87 percent shrimps and 13 percent fishes (flatfish, sculpins, and saffron cod).

Stomachs of bearded seals were collected at Wainwright during five summers (Table 14a). Clams (*Spisula* and *Serripes*) were the primary prey during 1975-1977. Shrimp (*Sclerocrangon boreas* and *Eualus gaimardii*) were the major food in 1978 and 1979. Overall for the 5 years sampled, clams were the major food followed by shrimp, crabs (*Chionoecetes opilio* and *Hyas coarctatus*), fishes, and *Saduria* (Table 14b). The stomach of one bearded seal collected at Wainwright on 18 May 1978 contained 1171.7 ml of food consisting of 52 percent shrimp, 34 percent fishes (98% sculpins, 2% arctic cod), 9 percent gammarid amphipods, and 2 percent clams (*Musculus* sp.).

Only four bearded seal stomachs containing food were obtained from other locations in the Chukchi Sea (Table 15). Little can be said about those small, scattered samples. It is interesting and perhaps significant that three types of prey which were not important foods at Shishmaref and Wainwright (eelpout, priapulids, and snails) were major foods of seals collected in the northern Chukchi Sea ice edge in August.

Age- and sex-related differences in the bearded seal diet were examined using data from seals collected at Shishmaref in June-July 1976-1978 (Table 16). Foods of males and females were generally similar although shrimp and isopods were proportionately more important in the diet of females while males ate more echiuroid worms. The importance of clams, brachyuran crabs, and echiuroid worms in the diet increased with age while shrimp and isopods were of lesser importance in the diet of older seals.

Walruses

We obtained and examined stomach contents of only four walruses taken in the Chukchi Sea. Small amounts of food (mean volume 48.5 ml) were found in three walruses taken at Shishmaref on 25 October 1977. The contents consisted of 75.7 percent clams (*Siliqua* sp. and *Tellina* sp.), 11.7 percent priapulid, 6.5 percent shrimp (*Crangon septemspinosa*), and 4.2 percent snail (*Natica* sp. and *Polinices* sp.). One walrus taken at Wainwright on 28 June 1979 contained 2039 ml of food comprised of 99.7 percent clam and trace amounts of priapulids and polychaete worms. Of the identifiable clams in that walrus, 50.3 percent (by volume) were *Mya truncata*, 48.6 percent were *Spisula polynyma*, and 1.1 percent were *Serripes groenlandicus*.

Belukha Whales

Stomach contents of 62 belukhas collected at Elephant Point (eastern Kotzebue Sound) in June 1978 were examined (Table 17). Small amounts of shrimp (*Crangon septemspinosa*), isopods (*Saduria entomon*), snails (*Polinices* sp.), polychaetes, and octopus were found in the stomachs. Most of the stomach contents consisted of bones and otoliths of fishes, primarily saffron cod and sculpins. Stomachs of three whales taken in Kotzebue Sound in June 1979 contained food. Two were taken in Eschscholtz Bay and contained numerous saffron cod otoliths and traces of shrimp and snails. The third was taken near the village of Buckland and contained 5810 ml of partially digested fish, most of which was remains of 11 arctic char up to 50 cm long. Otoliths and bones representing 7 whitefish, 5 suckers, 50 sculpins, 22 smelt, and 1 arctic cod were also present in that stomach.

At Point Hope we found food remains in stomachs of five belukhas taken in May 1977 and 9 taken in April 1978 (Table 18). Most of the stomach contents in April was fragments of crangonid shrimps and arctic cod otoliths. Octopus beaks were very common in stomachs collected in May 1977, occurring in all five stomachs containing food. Stomachs of two belukhas taken on 6 and 8 May 1979 at Point Hope contained food. One stomach contained otoliths from 3 arctic cod; the other contained 1 octopus beak, 1 saffron cod otolith, and 2 small unidentifiable fishes.

One belukha taken at Wainwright on 22 July 1976 contained beaks from three octopus and four gonatid squids. Two belukhas taken at Wainwright on 18 July 1979 contained 12 partially digested rainbow smelt, otoliths from 2 saffron cod, and trace amounts of snails and isopods.

Possible age- and sex-related differences in belukha foods were examined using data from whales collected at Elephant Point in June 1978. The composition of the stomach contents in young and older belukhas was quite similar (Table 19). The composition of the stomach contents of male and female whales was slightly different (Table 20). Shrimp accounted for a greater proportion of the contents and occurred more frequently in females while the converse was true for isopods. The most obvious difference occurred in the consumption of sculpins which were eaten by 4 of 28 females and 21 of 29 males.

VII. Discussion

A. Foods of Marine Mammals

We investigated the foods utilized by marine mammals in the Chukchi Sea based on stomachs collected during 1975-1979. During 1975-1977,

Table 13. Bearded seal stomach contents data from Shishmaref. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Shishmaref	Shishmaref	Shishmaref	Shishmaref	Shishmaref
Dates:		4 June-11 July 1976	24 June-20 July 1977	9-21 June 1978	3-8 June 1979	3 June-20 July 1976-1979
Sample Size:		40	112	17	4	173
Mean Volume (ml)		415.2	460.4	407.9	433.8	444.5
Food Items	1	Shrimp 51	Shrimp 35	Shrimp 41	Shrimp 65	Shrimp 40
	2	Brachyuran Crab 19	Brachyuran Crab 21	Clam 17	Isopod 17	Brachyuran Crab 20
	3	Clam 16	Clam 14	Echiuroid 16	Echiuroid 4	Clam 14
	4	Isopod 4	Isopod 13	Brachyuran Crab 13	Snail 3	Isopod 10
	5	Fish 3 Flatfish 54 Saffron cod 15 Sculpins 14 Sand lance 7	Echiuroid worm 6	Fish 4 Sculpins 45 Flatfish 34 Sand lance 14 Saffron cod 6	Clam 3	Fish 6 Sculpins 34 Saffron cod 32 Flatfish 30

Table 14a Bearded seal stomach contents data from Wainwright. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Wainwright	Wainwright	Wainwright	Wainwright	Wainwright
Dates:		24 July- 7Aug 1975	28-29 July 1976	23 July 1977	8 July 1978	27 June-1 July 1979
Sample Size:		22	7	3	4	16
Mean Volume (ml)		530.7	848.3	367.6	761.0	593.4
Food Items	1	Clam 55	Clam 66	Clam 75	Shrimp 81	Shrimp 39
	2	Shrimp 12	Shrimp 25	Shrimp 13	Isopod 9	Clam 32
	3	Fish 10 Sculpin 96 Cod 4	Brachyuran Crab 5	Brachyuran Crab 7	Brachyuran Crab 5	Brachyuran Crab 12
	4	Brachyuran Crab 4	Isopod 2	Snail 2	Clam 4	Gammarid amphipod 3
	5	Snail 4	Fish 1 Sculpin 60 Sand lance 26 Arctic cod 14			Fish 1 Sculpin 77 Arctic cod 21 Saffron cod 1

Table 14b. Bearded seal stomach contents data from Wainwright. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Wainwright				
Dates:		All years combined 27 June-7 August 1975-1979				
Sample Size:		52				
Mean Volume (ml)		601.1				
Food Items	1	Clam 46				
	2	Shrimp 29				
	3	Brachyuran Crab 7				
	4	Fish 4 Sculpin 74 Arctic cod 15 Sand lance 10				
	5	Isopod 2				

Table 15. Bearded seal stomach contents data from misc. areas in the Chukchi Sea. Numbers in parentheses indicate percent of the total stomach contents volume made up by that taxon, except for fish taxa which are percent of the total number of fishes identified which belonged to that taxon.

Area:		Point Hope	DISCOVERER	GLACIER		
Dates:		16 April 1978	27 August 1976	1-5 August 1977		
Sample Size:		1	1	2		
Mean Volume (ml)		1172.4	655.5	454.5		
Food Items	1	Shrimp 88	Fish 29 Eelpout 91 Sculpins 9	Snails 48		
	2	Fish 6 Sculpins 100	Brachyuran Crabs 26	Shrimp 9		
	3	Brachyuran Crab 5	Shrimp 6	Priapulids 6		
	4		Priapulids 3	Amphipods 4		
	5			Brachyuran Crabs 3		

Table 16. Major food items of bearded seals collected at Shishmaref in June-July 1976-1978. Results are presented by age and sex categories. Numbers indicate percent of total volume for invertebrates and total fish, and percent of total number for species of fishes.

Food Item	Sexes Combined			Seals ≥3 yrs old	
	Pups N=38	1&2 yrs old N=21	≥3 yrs old N=91	Males N=27	Females N=64
Shrimp	59	30	30	26	32
Isopod	18	18	8	2	11
Clam	4	11	19	20	18
Brachyuran Crab	6	20	24	23	25
Echiuroid Worm	*	*	9	19	4
Total Fish	7	11	6	6	5
Saffron Cod	51	18	30	28	31
Sculpin	28	55	25	24	25
Flatfish	20	25	37	46	38
Mean Volume of Contents (ml)	324.8	462.4	492.4	539.7	472.5

* Indicates values less than 1 percent.

collection efforts concentrated only on seals. In 1978 and 1979 we systematically attempted to collect stomachs from belukha whales also. Stomach contents of belukhas and walruses were obtained on an opportunistic basis throughout the collection period.

Virtually all marine mammal stomachs were obtained from animals killed by Eskimo subsistence hunters. The distribution of our sample collections reflects locations and times where active subsistence marine mammal hunting occurs. Most of the seal specimens were collected at Shishmaref and Wainwright in the late spring-summer period. Most of the belukha specimens were collected at Point Hope in spring and Elephant Point in June. Therefore, our results cannot be extrapolated to and should not be considered representative of the entire Chukchi Sea. Rather, they represent the feeding patterns of marine mammals in localized areas of the nearshore zone. This is unfortunate since marine mammals occur and feed throughout the vast area of the Chukchi Sea. In order to allow a broader interpretation of our findings and a description of overall feeding patterns in the Chukchi Sea, many more animals (ringed and bearded seals and walruses) must be collected from offshore areas and systematic collections of spotted seals must be made in certain coastal areas. Offshore collections can be made from ice-strengthened vessels and shore-based helicopters. Adequate ship and helicopter support have not yet been provided by OCSEAP in the Chukchi Sea, although in the Bering and Beaufort Seas we have had great success in using such logistics. With the background data presented in this report, an adequate understanding of feeding of marine mammals in the Chukchi Sea can be developed when appropriate support and logistics are made available.

Spotted Seals

Spotted seals forage in coastal waters of the Chukchi Sea primarily during June-October. Major concentrations of spotted seals occur in Kotzebue Sound and the coastal lagoons and barrier islands between Point Lay and Point Barrow. Based on our samples from Shishmaref, herring are a major food of spotted seals at least in July and October. Other fishes and shrimps may be the main foods earlier and later in the year. Concentrations of herring have not been documented north of Kotzebue Sound and the few seal specimens we obtained at Wainwright do little to identify major prey in the northern Chukchi. Based on results from other areas (Bukhtiyarov et al. in press), capelin, smelt, arctic cod, saffron cod, and sculpins, in addition to herring, are probably all significant prey of spotted seals in the Chukchi Sea. Identification of specific seasonal and geographical prey utilization patterns will require systematic sampling.

Ringed Seals

Ringed seals are abundant throughout the Chukchi Sea, particularly in coastal waters, from late October through July. During August through mid-October when much of the Chukchi Sea is ice-free, many ringed seals are thought to be associated with the pack ice in the northern Chukchi.

Table 17. Stomach contents of belukha whales collected at Eschscholtz Bay, 13-18 June 1978 (N=62).

Prey Item	% of total volume	% of total number	% frequency of occurrence
Shrimp	4	--	76
Isopod	6	--	34
Octopus	<1	--	52
Other Invertebrate	<1	--	41
Total Invertebrate	11	--	90
Rocks and Pebbles	1	--	66
Total Fishes	87	--	94
Saffron Cod	--	88	94
Sculpins	--	11	42
Rainbow Smelt	--	<1	29
Pacific Herring	--	<1	3
Eelpout	--	<1	2
Mean Volume of Contents (ml)		47.2	
Total # Identified Fishes		4346	

Table 18. Stomach contents of belukha whales collected at Point Hope.

Prey Item	22-27 May 1977, N = 5			25-26 April 1978, N = 9		
	% of total volume	% of total number	% frequency of occurrence	% of total volume	% of total number	% frequency of occurrence
Shrimp	<1	--	20	99	--	67
Squid	0	--	0	<1	--	11
Octopus	75	--	100	<1	--	78
Other Invertebrate	<1	--	60	<1	--	11
Total Invertebrate	75	--	100	100	--	100
Rocks and Pebbles	25	--	40	<1	--	22
Total Fishes	0	--	0	<1	--	11
Arctic Cod	--	0	0	--	100	11
Mean Volume of Contents (ml)		53.3			48.4	
Total # Identified Fishes		0			43	

Table 19. Stomach contents of belukha whales collected at Eschscholtz Bay, June 1978, separated by age categories.

Prey Item	Less than 6 years old, N = 9			6 or more years old, N = 47		
	% of total volume	% of total number	% frequency of occurrence	% of total volume	% of total number	% frequency of occurrence
Shrimp	15	--	78	5	--	77
Isopod	7	--	22	7	--	38
Octopus	3	--	56	<1	--	47
Other Invertebrate	<1	--	44	<1	--	30
Total Invertebrate	25	--	100	12	--	89
Rocks and Pebbles	2	--	67	1	--	68
Total Fishes	72	--	100	86	--	94
Saffron Cod	--	92	100	--	89	94
Sculpins	--	7	44	--	10	40
Rainbow Smelt	--	<1	33	--	<1	32
Pacific Herring	--	0	0	--	<1	4
Eelpout	--	0	0	--	<1	2
Mean Volume of Contents (ml)		9.9			44.3	
Total # Identified Fishes		571			3562	

Table 20. Stomach contents of belukha whales collected at Eschscholtz Bay, June 1978, separated by sex.

Prey Item	Females, N = 28			Males, N = 29		
	% of total volume	% of total number	% frequency of occurrence	% of total volume	% of total number	% frequency of occurrence
Shrimp	11	--	82	2	--	72
Isopod	2	--	25	8	--	48
Octopus	<1	--	64	<1	--	34
Other Invertebrate	<1	--	21	<1	--	38
Total Invertebrate	14	--	93	10	--	86
Rocks and Pebbles	<1	--	64	1	--	69
Total Fishes	85	--	89	88	--	97
Saffron Cod	--	98	89	--	82	97
Sculpins	--	<1	14	--	17	72
Rainbow Smelt	--	2	39	--	<1	24
Eelpout	--	<1	4	--	0	0
Mean Volume of Contents (ml)		24.8			73.0	
Total # Identified Fishes		1648			2588	

At Shishmaref, arctic cod and some saffron cod were the main foods of ringed seals in November-February. Saffron cod and several types of crustaceans were the primary foods in late spring and early summer as were hyperiid amphipods in October. A similar pattern was documented at Point Hope by Johnson et al. (1966) based on 1,432 stomachs containing food. Fishes were the main food there in November-February. Arctic cod were eaten throughout that period but were proportionately most important in December-February. Saffron cod were most commonly eaten in November, December, April, and June. Crustaceans (amphipods, shrimp, and mysids) were the primary food in March-June. The results of our limited collections from Point Hope generally agree with those of Johnson et al. The foods eaten at Wainwright in summer were slightly different from those found further south. Arctic cod were overall the dominant food. This is probably due to the fact that the pack ice edge usually remains close to Wainwright during the summer. Our data from Wainwright at other times of year are inadequate. However, it seems likely that the seasonal pattern of food utilization would be similar to other areas, i.e. primarily arctic cod in winter and mostly crustaceans in spring.

The feeding pattern of ringed seals near coastal villages in the Chukchi Sea is similar to what we observed in the Beaufort Sea (Lowry et al. 1979b) with the following exceptions: 1) more species of fishes are regularly eaten, and saffron cod are of considerable importance in the diet especially at Point Hope and Shishmaref; 2) shrimp (*Crangon septemspinosa*, *Eualus gamardii*, *Pandalus goniurus*, and *Sclerocrangon boreas*) are proportionately more important in the spring-early summer diet in the Chukchi Sea. In general, more species are of importance in the diet in the Chukchi Sea than in the Beaufort Sea. In August-October in the Beaufort Sea, ringed seals forage intensively on nektonic crustaceans (euphausiids and hyperiid amphipods) associated with pack ice. The only two seals we examined from the summer pack ice of the northern Chukchi had eaten mostly shrimp. That is not surprising since nektonic crustaceans appear to occur in patches, perhaps related to oceanographic conditions. Relatively large amounts of hyperiids in ringed seal stomachs collected in October at Shishmaref indicate that patches of nekton do occur in the Chukchi. The distribution and causes of such concentrations of nekton are of great interest since they appear to be of major importance in the annual feeding cycle of ringed seals (Lowry et al. in prep.).

Bearded Seals

Bearded seals forage throughout the Chukchi Sea. During winter months they are most common in areas of regular ice movement. They are generally absent from open water areas in summer.

The foods of bearded seals in the late spring-summer period at Shishmaref and Wainwright were generally similar to those found at other locations (Lowry et al. 1980). Shrimp, brachyuran crabs, and clams made up the majority of the stomach contents. The composition of the diet was relatively stable over the several years sampled; however, clams made up a smaller proportion of the diet at Wainwright in 1978 and 1979 than in previous years.

There are very few data available on foods of bearded seals nearshore during fall, winter, and early spring or offshore at any time of year. Distinct seasonality was observed in foods of bearded seals collected at Point Hope; clams were important in the diet only in June (Johnson et al. 1966). A similar seasonal pattern occurs in the Bering Sea (Lowry et al. 1980).

Walruses

A large portion of the Pacific walrus population summers and feeds along the pack ice edge in the northern Chukchi Sea (Estes and Gilbert 1978). Walruses are not common in the Chukchi Sea during winter months.

Foods of walruses in the Chukchi Sea are poorly documented. The stomach contents of the four walruses we examined was mostly clams. Clams appear to make up most of the walrus diet in all areas of the Bering and Chukchi Seas (Fay et al. in press).

Belukha Whales

Belukha whales migrate through the Chukchi Sea in spring and fall. Some belukhas spend summer months in and near coastal lagoons and estuaries in Kotzebue Sound and between Point Lay and Wainwright and along the edge of pack ice in the northern Chukchi Sea.

The intensity with which belukhas feed during migration is not known. Our results from Point Hope indicate that some feeding does occur during the spring migration: octopus, shrimps, and arctic cod are eaten.

Belukhas taken at Elephant Point (which had probably fed in the Eschscholtz Bay portion of Kotzebue Sound) had eaten saffron cod, sculpins, shrimps, isopods, snails, polychaetes, and octopus. Based on food remains in stomachs, saffron cod were the major prey. Belukhas we examined were taken in mid-June. Interviews with local residents indicated that later in the summer (July and August) belukhas in the area feed extensively on herring and occasionally on salmonids. Less is known about the foods of belukhas summering in the Point Lay-Wainwright areas. The few stomachs we have examined contained mostly rainbow smelt, saffron cod, octopus, and squids. Belukhas observed near Point Lay in summer appeared to be feeding on capelin (Seaman and Lowry, in prep.).

There are no data available on foods of belukhas in the summer Chukchi Sea pack ice. Based on other studies (Kleinenberg et al. 1964), arctic cod may be a major food in that region.

B. Biology of Major Prey Species

The probable effects of OCS exploration and development on marine mammals in the Chukchi Sea will depend to a large degree on the effects such activities may have on populations of prey species. In this section we review the available information on the biology of major marine mammal prey with particular respect to distribution and abundance, reproductive strategy, and food habits. Since little data for most species have been collected in the Chukchi Sea, we have had to draw on data collected in other areas in many instances.

Arctic Cod

Arctic cod is the single most important forage fish in far northern waters (Klumov 1937, Tomilin 1957, Tuck 1960, Lowry et al. 1979a&b). In the southeastern Chukchi Sea in September-October, Wolotira et al. (1977) found them to be the most widely distributed of all species of fishes, with the greatest abundance in the Hope Basin area, excluding Kotzebue Sound. Alverson and Wilimovsky (1966) noted that arctic cod were the most common species near Point Hope in August 1959. Over a thousand individuals were caught at a single station approximately 80 km northeast of Cape Lisburne. Lowry et al. (1978a) found arctic cod to be the most numerous fish in 10 trawls conducted in the northeastern Chukchi Sea in August. Quast (1974) sampled surface and mid-depth waters between Cape Lisburne and Icy Cape at night during September and October 1970 and found juvenile arctic cod to be ubiquitous and at least 10 times more numerous than sand lance, the only other species caught. Quast estimated an average density of 28 juvenile cod/1000 m^3.

The distribution of adult arctic cod is closely related to low temperatures and/or the presence of sea ice, with much of the population believed to stay under or near the edge of compact ice for most of the year (Svetovidov 1948, Andriyashev 1954, Ponomarenko 1968). Andriyashev (1954) indicated that in autumn large schools may be found nearshore, especially in warm, relatively fresh water near river mouths. Recent OCSEAP research in the Beaufort Sea has also documented large concentrations of arctic cod in nearshore areas in late summer and autumn (Bendock 1979, Craig and Haldorson 1979). The precise time and location of spawning for arctic cod in Alaska is unknown. In the Beaufort Sea individuals caught nearshore during November were gravid, and by the next sampling period in February all individuals had spawned. This coincides closely with spawning periods in the Barents and Kara Seas and eastern Siberia (Moskalenko 1964, Rass 1968, Ponomarenko 1968). Spawning probably occurs in coastal areas.

Arctic cod have the largest and fewest eggs of all cods (Svetovidov 1948, Andriyashev 1954). The eggs develop in surface waters under the ice and probably hatch in May or June. Larvae live in surface waters until August or September when transition to the juvenile stage takes place and the fry descend to the bottom (Rass 1968, Baranenkova et al. 1966). Association with the ice is thought to begin after the first year. Individuals mature at 3 to 4 years and probably do not live much longer than 6 years (Gjosaeter 1973).

Arctic cod eat a variety of euphausiids, copepods, benthic amphipods, shrimps, mysids, hyperiid amphipods, and small fish (Lowry and Frost unpubl., Klumov 1937, Craig and Haldorson 1979). Planktonic forms--

copepods (mostly Calanus hyperboreas, C. glacialis, and Euchaeta glacialis) and gammarid amphipods (Apherusa glacialis)--were the major prey of arctic cod from the northeastern Chukchi Sea (Lowry et al. 1978a).

Saffron Cod

Saffron cod are important prey of seals, belukha whales, and seabirds (Lowry et al. 1978a, 1979a; Tomilin 1957; Springer and Roseneau 1978). Alverson and Wilimovsky (1966) and Wolotira et al. (1977) found them to be much less abundant in central and southeastern Chukchi Sea and Kotzebue Sound than in the northern Bering Sea and Norton Sound. Greatest densities were in relatively shallow water near the mouth of Kotzebue Sound, offshore from the northern Seward Peninsula, and in waters less than 25 m deep between Cape Lisburne to Point Hope. Most saffron cod caught north of Bering Strait were small (less than 10 cm in length).

Saffron cod are thought to reside in the coastal zone coming close to shore in the fall to spawn in river mouths, bays, and inlets, and moving into deeper water (30-50 m) in summer to feed (Svetovidov 1948, Andriyashev 1954). Such movements may not occur in the Chukchi Sea. Saffron cod are present and abundant in nearshore shallow waters in June and July, as indicated by their importance in the diets of seals and belukhas at Shishmaref and Eschscholtz Bay at that time. No trawl surveys have been conducted in offshore waters in June and July, but by August-October saffron cod are not numerous there. It is probable that they remain nearshore throughout the year. Spawning probably takes place between December and February (February in Norton Sound) at subzero temperatures (-1.0 to -1.8°C). The eggs are demersal and are spawned on clean sandy or pebbly bottoms (Andriyashev 1954). Most larvae hatch in April. Normal embryonic development occurs at temperatures of -3.8° to 8°C and salinities of 28-30 ppt. Development is suspended below -3.8°C; however, eggs will resume growth even after freezing in ice once temperatures are greater than -3.8°. Larvae perish en masse in water warmer than 8°C (Mukhacheva 1959). Larvae stay near the surface after hatching and are often associated with the jellyfish Cyanea sp. (they live inside the protection of the mantle and tentacles). Growth is probably very slow until August when larvae are fully transformed into fry and descend to the bottom to assume a demersal life similar to the adults. Maximal growth occurs in the first 3 years of life, and almost all of each year's growth occurs in September-October. Sexual maturity occurs at 2-3 years and individuals probably live at least 12 years (Svetovidov 1948). Saffron cod eat a variety of benthic organisms including polychaetes, shrimps, crabs, mysids, and amphipods.

Herring

Herring are present and locally abundant in nearshore areas of the southern Chukchi Sea. Barton (1979) reported peak herring abundance along the northern coast of the Seward Peninsula and southern Kotzebue Sound (Eschscholtz Bay) in late July and August. Both pre- and post-spawning segments of the population remain nearshore during spring and summer. Barton also noted that herring were present in autumn and winter near Shishmaref (October, March, April) and in Kotzebue Sound (November). We have found herring in the stomachs of spotted and ringed seals from Shishmaref in October, January, and February. Wolotira et al. (1977) reported that herring made up 22 percent of the total catch of fish in the southeastern Chukchi and Kotzebue Sound. Catch rates were highest in outer Kotzebue Sound and lowest in inner Kotzebue Sound. Relatively few herring were caught by Alverson and Wilimovsky (1966) in their 1959 trawl survey. Highest relative abundance was near Cape Thompson. In all of the Chukchi trawl surveys very few young fish (less than 2 years) were caught. In the Bering Sea herring make large scale onshore-offshore movements in summer and winter. Major wintering concentrations occur northwest of the Pribilofs and at the seasonal ice edge. Herring move to the coast in summer to spawn and feed (Barton 1979). It is unknown whether Chukchi and Bering Sea herring are part of the same stocks. Barton suggests that there may be an overwintering population in Kotzebue Sound. Percy (1975) working in the MacKenzie Delta found herring to congregate nearshore during winter and spawn in spring and summer in coastal bays and river mouths.

Herring spawn in late July or August in the Chukchi Sea (spawning occurs earlier farther south). Most spawning occurs subtidally in relatively shallow bays, lagoons, or inlets such as Shishmaref Inlet and Kugruk and Kiwalik lagoons in Kotzebue Sound (Barton 1979). Spawning is also known to occur along rocky headlands of eastern Eschscholtz Bay. Eggs develop in about 23 days at 6-8°C (Andriyashev 1954). Barton found Chukchi Sea herring to be euryhaline and believed they are also eurythermal if they in fact overwinter north of Bering Strait. Sexual maturity probably occurs between 3 and 6 years of age. Herring feed on euphausiids, copepods, hyperiids, mysids, amphipods, and fish fry (Andriyashev 1954, Percy 1975, Rumyantsev and Darda 1970). Feeding is probably most intensive during the period following spawning.

Sand Lance

The distribution and abundance of sand lance in the Chukchi Sea are poorly known. Alverson and Wilimovsky (1966), Wolotira et al. (1977), and Barton (1979) make no mention of them in any of their Chukchi Sea fish surveys. They were one of two species caught by Quast (1974) in a midwater survey of the eastern Chukchi Sea in 1970. In that survey sand lance were taken mostly near the surface and were about one-tenth as abundant as arctic cod. Swartz (1966) reported sand lance as a major food of murres, kittiwakes, and gulls in the Cape Thompson region. They did not appear in the diets, however, until mid-June or early July. According to Andriyashev (1954) sand lance form schools near the bottom in sandy areas, sometimes burrowing into the sand. They inhabit deep water in winter and move close to the coast in June. Spawning occurs from November-February at 50-75 m on sandy bottoms. Sand lance mature in their third year of life. Their main foods include copepods, barnacle larvae, euphausiids, and amphipods.

Sculpins

Many species of sculpins are present in the Chukchi Sea. Five species were among the 20 most abundant fishes caught in the southeastern Chukchi and Kotzebue Sound (Wolotira et al. 1977). They were, in relative order of abundance, Myoxocephalus scorpius, Gymnocanthus tricuspus, Enophrys diceraus, Triglops pingeli, and Megalocottus platycephalus. Myoxocephalus (averaging 25 g in weight) were most abundant slightly north of Bering Strait in water deeper than 25 m, and farther north near Kivalina and Point Hope. Alverson and Wilimovsky (1966) listed the genera Gymnocanthus, Artediellus, Triglops, and Myoxocephalus among the 10 most common fishes near Cape Lisburne and Point Hope. Together they comprised almost 20 percent of the total catch.

Sculpins are demersal and most prefer water temperatures around 0°C. Most species spawn in fall or winter (Andriyashev 1954). In general they feed on benthic or epibenthic organisms such as shrimps, amphipods, polychaete worms, isopods, mysids, and molluscs.

Flatfishes

Flatfishes (F. Pleuronectidae) were the most abundant group of fishes in southeastern Chukchi Sea and Kotzebue Sound, comprising 30 percent of the total fish biomass (Wolotira et al. 1977). They were less abundant in Kotzebue Sound (10%) than in offshore waters (42%). Starry flounder (Platichthys stellatus), mostly large, older fish, was the most abundant species in this group in the southern portion of the Chukchi Sea. Alaska plaice (Pleuronectes quadrituberculatus) were locally abundant along the north coast of the Seward Peninsula, with small individuals closest to shore and larger fish offshore. Yellowfin sole (Limanda aspera) were most abundant in inner Kotzebue Sound (mostly small fish) and along the north coast of the Seward Peninsula. They were absent farther north. Bering flounder (Hippoglossoides robustus) were found mostly north of Kotzebue Sound. None were caught in inner Kotzebue Sound. Arctic flounder (Liopsetta glacialis) were restricted to very shallow waters in Kotzebue Sound, and near Kivalina. Mean size of individuals was quite small (less than 14 cm). Flatfishes feed on a variety of benthic organisms including polychaetes, molluscs, and small crustaceans, and on small fishes.

Hyperiid Amphipods

Parathemisto libellula is very common in arctic waters. According to Dunbar (1942) "P. libellula is without doubt one of the most important organisms in the Arctic, in any habitat, terrestrial or aquatic." He later stated (Dunbar 1957) that "it forms the most important link in the food chain between the copepods and other smaller planktonic forms on the one hand, and the vertebrates on the other, and in fact it takes the place, in cold water, of the euphausiids in this respect." Although Parathemisto is probably somewhat less "important" in more southern waters, it is nonetheless a major food of ringed seals at some locations and during certain times. It may be relatively more important in far northern Chukchi waters than in more southern areas with warmer water. Information on the distribution and relative abundance of Parathemisto in the Chukchi Sea is virtually nonexistent, except by inference from stomach contents of predators.

Parathemisto is a pelagic species which spends its life in the water column. It is often considered to be an indicator of cold arctic waters. Individuals are found closer to the surface during the day due to a positive phototropic response (Tencati and Leung 1970). The young develop directly in brood pouches in the female rather than as free swimming larvae. Individuals probably breed only once in their 18-month to 2-year lifetime (Dunbar 1957). Breeding takes place over an extended period lasting from September until April. There may be two breeding periods during this time: September-October and March-April. Foods include small crustaceans such as copepods and barnacle, crab, and shrimp larvae.

Gammarid Amphipods

Gammarid amphipods are a diverse element of the Chukchi Sea fauna. They are the predominant food of many demersal fishes, and regular prey of seabirds, arctic cod, ringed and bearded seals, and bowhead and gray whales. Although primarily benthic, several species make use of the inverted substrate provided by the undersides of ice floes (Barnard 1959, George and Paul 1970, Tencati and Leung 1970). Ampelisca, Anonyx, and Gammarus are all important genera to seals and whales. Based on scattered samples collected in the Chukchi Sea, Anonyx is widespread though apparently not present in large numbers. We found Ampelisca to be much less abundant, but because they are tube dwellers, trawls probably do not provide a true reflection of their abundance. Stoker (pers. comm.) found Anonyx, Rhacotropis, and Stegocephalus to be the most ubiquitous genera in the Chukchi Sea. Sparks and Pereyra (1966) also found Stegocephalus to be very abundant in the Point Hope region. This species is large and heavily armored and is probably poorly suited as food.

Ampelisca is probably the single most important species to marine mammals. Ampelisca macrocephala lives 1-1/2 to 2 years, with some females living to age 3 and reproducing a second time (Kanneworff 1965). Maximum growth occurs in spring and early summer and breeding takes place in the fall (October). Females carry eggs in a brood pouch until the young are released in about April when feeding conditions are good. Ampelisca is both an active predator and a detritus feeder. Prey includes copepods, other small crustaceans, and various detrital plant and animal material. Feeding (as well as growth and gonad development) is most intense during spring and summer when phyto- and zooplankton are abundant.

Mysids

Mysids (*Mysis litoralis* and *Neomysis rayii*) occurred as major prey in samples from May and June near Shishmaref, Point Hope, and Elephant Point. Redburn (1974) encountered mysids only rarely in his collections from the Chukchi Sea near Point Barrow. Geiger (1969) did not catch mysids in 13 tows from the southwestern Chukchi, but cautioned that this should not be interpreted as complete absence of the group from the Chukchi Sea. Broad (1978) listed *Mysis* as one of the principal genera at 4 of 18 nearshore stations between Point Hope and Point Barrow and at 2 of 23 between Bering Strait and Point Hope. *Neomysis* was one of the principal genera at 13 of 23 more southern stations. In general *Mysis* and *Neomysis* are found throughout shallow waters of the Alaskan continental shelf. *Mysis* is tolerant of low salinities and is often found nearshore (Geiger 1969). They live on or near the bottom and are probably detritus feeders.

Isopods

The isopod *Saduria entomon* is locally abundant in shallow nearshore waters of the continental shelf (McCrimmon and Bray 1962, Mohr and Geiger 1968). This species is extremely euryhaline (0-31.6 ppt) and eurythermal (-1.4-11.0°C) (Bray 1962). Sparks and Pereyra (1966) reported cosmopolitan distribution of *Saduria* in the eastern Chukchi. The life cycle probably requires 2-3 years; individuals spawn once and then die. Spawning activity takes place throughout the summer in the western Canadian Arctic, with females moving inshore to release the young. Young are borne in a brood pouch and released when 3-4 mm long. *Saduria* is an omnivorous scavenger, eating a variety of plant and animal material and occasionally preying on small crustaceans (Green 1957).

Shrimps

Three families of shrimps are present and important as marine mammal prey in the Chukchi Sea: F. Hippolytidae, F. Crangonidae, and F. Pandalidae. The pandalids are of commercial importance in the Gulf of Alaska and Bering Sea, but no species are commercially harvested in the Chukchi. Information on the distribution and abundance of shrimps in the Chukchi Sea is scarce.

Eualus gaimardii is the most widespread and abundant of the hippolytids. MacGinitie (1955) found it to be the most numerous shrimp near Point Barrow. We caught this species throughout the Chukchi, both nearshore and offshore, in depths of 5-55 m on muddy and rocky bottoms. It was usually the most numerous shrimp species in our trawls. In the Canadian arctic individuals probably spawn biennially (Squires 1969). Spawning frequency in the Chukchi is unknown. Many ovigerous females were found in spring-summer when most of our trawls were made. *Eualus* eat ostracods, euphausiids, copepods, and phytobenthos.

Pandalus goniurus is the most abundant pandalid shrimp in the Chukchi Sea. We caught them in trawls from Bering Strait to Barrow.

Most individuals we caught were small, and none were ovigerous. Pandalid shrimps are protandrous hermaphrodites, that is they reproduce first as males (probably during the first year), then become females and produce eggs when large (1-1/2 to 2-1/2 years) (Butler 1964). Breeding takes place in the fall and the eggs are carried until they hatch in spring. Larvae are planktonic during summer and settle to the bottom in late summer or early fall (Charnov 1979). Adult shrimps eat small crustaceans, polychaete worms, and detritus.

Crangonid shrimps which are major prey of seals include *Crangon septemspinosa*, *Argis lar*, and *Sclerocrangon boreas*. *Crangon septemspinosa* is euryhaline and eurythermal, and is especially common in very shallow waters (Price 1962). Broad (1978) found them to be abundant between Wales and Point Hope in water 0-5 m deep. *Argis lar* is one of the most abundant and widespread shrimps throughout the Chukchi Sea (Feder and Jewett 1978, Lowry et al. 1978a, Stoker unpublished). *Sclerocrangon boreas* is apparently less abundant there, being found at only a few stations, mostly in the northeastern Chukchi near Wainwright (Lowry and Frost unpublished, Stoker unpublished). It is a relatively large, heavily armored shrimp which occurs at temperatures of -1.5 to -5°C (Squires 1967). Spawning in the three species may occur over a broad time span, although all probably carry eggs through the winter and hatch them in spring-summer. *Sclerocrangon* and *Argis* females carrying eggs were caught in October (Feder and Jewett 1978). During June-July very few *Crangon* females had eggs, whereas many *Argis* and *Sclerocrangon* either had large eggs ready to hatch, recently hatched eggs, or recently extruded eggs (Squires 1968, Lowry and Frost unpublished). Crangonid shrimps eat a variety of organisms including phytobenthos and detritus, polychaete worms, small crustaceans, crustacean eggs and larvae, and to a lesser degree foraminiferans, gastropods, and ophiuroids (Squires 1967).

Crabs

Brachyuran crabs are widely distributed in the Chukchi Sea. Three species are important to bearded seals--*Hyas coarctatus*, *Telmessus cheiragonus*, and *Chionoecetes opilio*. Feder and Jewett (1978) and Wolotira et al. (1977) found *Chionoecetes* and *Hyas* to be nearly ubiquitous in southeastern Chukchi Sea and outer Kotzebue Sound. *Telmessus* was found mostly nearshore and in Kotzebue Sound. *Chionoecetes* was over 4 times more abundant than either of the other two species. Sparks and Pereyra (1966) listed *Chionoecetes* as one of the dominant organisms in trawls near Point Hope/Cape Lisburne. Lowry et al. (1978a) found both *Hyas* and *Chionoecetes* in the northeastern Chukchi. *Hyas* was the most abundant of the two.

Watson (1970) found that *Chionoecetes* males mature at about 5.7 cm and females at about 5.0 cm. Since most individuals caught in the Chukchi Sea were smaller than 5 cm, the number of reproductively mature specimens there is probably very low (Feder and Jewett 1978, Lowry and Frost unpublished). In contrast, reproductively mature *Hyas* are common in the Chukchi. Many females with eggs were found in July-August and

October. In Canada Squires (1957) found eggs only in July and August. Telmessus were ovigerous in June-July but not in October (Feder and Jewett 1978, Frost and Lowry unpublished).

Brachyuran crabs are scavengers or predators. They eat a variety of detritus, phytobenthos, crustaceans such as amphipods, euphausiids, copepods, and shrimps, molluscs, ophiuroids, polychaetes, hydroids, and in some cases, fishes (Feder and Paul 1979, Squires 1967).

Clams

Two genera of clams, Serripes and Spisula, are especially important as food for bearded seals and walruses in the Chukchi Sea. Virtually nothing is known about the distribution or abundance of either species there. Filatova (1957) lists Serripes as one of the abundant bivalves in the southwestern Chukchi and Spisula as common along the Alaska shore from Bering Strait to the MacKenzie River. Neither of these clams was mentioned in his biomass calculations, perhaps because of sampling difficulties and patchy distribution.

Serripes is hermaphroditic and probably spawns in spring after the phytoplankton bloom has begun (Petersen 1978). Settling of larvae probably occurs in late summer-autumn. In Greenland waters some examples of size at age are as follows: 1 yr, 3-10 mm; 11 yrs, 53.4 mm; 14 yrs, 58.3 mm. They probably grow as large as 10 cm (Clench and Smith 1944).

Little is known about the life history of Spisula. They seem to prefer medium grade sediments of sand and gravel mixture. In southeastern Bering Sea they are found primarily in coastal waters 24-33 meters deep. Spisula is probably patchy in distribution, with given patches consisting of clams of a single year class (due to favorable larval settlement and survival in specific areas in a particular year). They are active burrowers, sometimes living as deep as 22 cm. Individuals reach about 13.5 cm, or 16 years of age, with growth until age 8 occurring at a rate of 10-12 mm/year (North Pacific Fishery Management Council, in preparation). There is no information on reproduction of Spisula in Alaska. Spisula in the North Atlantic are dioecious (sexes separate), unlike Serripes, and spawning probably occurs in summer. Larvae are planktonic for some unknown period of time, then settle to the bottom as miniature adults.

Spisula and Serripes are both filter feeders, removing small particles from seawater.

C. Food Webs and Trophic Relationships

The food webs which support marine mammal populations in the Chukchi Sea are considerably more complex than in the Beaufort Sea. More species of marine mammals regularly feed in the Chukchi Sea and they utilize a greater number of prey species. Major prey dependencies of the marine mammals we have studied are summarized in Table 21.

Table 21. Major prey of marine mammals in nearshore waters of the Chukchi Sea. Items which are probably major prey but have not occurred in samples examined during this project are followed by a question mark.

SEASON	SPOTTED SEALS	RINGED SEALS	BEARDED SEALS	WALRUSES	BELUKHA WHALES
SPRING	Not present	Gammarid Amphipods Shrimps Mysids Arctic Cod Saffron Cod	Shrimps Brachyuran Crabs? Sculpins	Not present	Octopus Shrimps Arctic Cod
SUMMER	Herring Saffron Cod Sand Lance Shrimps Rainbow Smelt? Capelin?	Hyperiid Amphipods? Euphausiids? Shrimps Gammarid Amphipods Arctic Cod	Clams Shrimps Brachyuran Crabs Isopods Sculpins	Clams Snails Priapulids Polychaetes	Saffron Cod Herring Rainbow Smelt Sculpins Salmonids Arctic Cod? Shrimps
AUTUMN	Herring Saffron Cod Arctic Cod Rainbow Smelt?	Hyperiid Amphipods Saffron Cod Arctic Cod	Shrimps Brachyuran Crabs? Sculpins Flatfish	Clams Priapulids Shrimps Snails	Saffron Cod? Arctic Cod? Rainbow Smelt? Shrimps?
WINTER	Not present	Arctic Cod Saffron Cod Sculpins Gammarid Amphipods Shrimps	Shrimps? Brachyuran Crabs? Sculpins?	Not present	Not present

Bearded seals and walruses feed primarily on benthic organisms. Much of the bearded seal diet is comprised of epifauna (shrimp and crabs) while infaunal species, particularly clams, are the most important foods of walruses. In some areas clams are a major component of the bearded seal diet, and in such instances seals compete with walruses for food since the species of clams eaten by the two are the same (Serripes groenlandicus, Clinocardium ciliatum, Spisula polynyma). Available information is not adequate to address the magnitude and effects of such competition in detail. However, it presently appears that competition may have a greater effect on walruses than on more euryphagous bearded seals (Lowry et al. 1980). The prey utilized by walruses and bearded seals are generally benthic omnivores (crabs and shrimps), detritus feeders (some clams and polychaetes), or filter feeders (priapulids and some clams). A relatively small portion of the diet is made up of predators of other benthic organisms (snails, sculpins, and some polychaetes).

Based on our samples belukhas and spotted seals in coastal waters utilize very similar prey, the majority of which are small to medium sized forage fishes. It appears that aggregations of the forage fishes which occur in coastal waters in summer and fall are of major importance in the diet of spotted seals and belukhas and influence their summer distributions. The distribution, abundance, and phenology of forage fishes in the Chukchi, and their importance in marine mammal diets, warrants considerable further study. The food habits of forage fishes in the Chukchi Sea have not been studied.

Ringed seals also eat considerable quantities of the same fish species consumed by spotted seals and belukhas. However, they also feed to a large extent on crustaceans and therefore have a more diverse food resource base, and utilize organisms from more points in the trophic structure. Nektonic crustaceans eaten by ringed seals feed on other, smaller crustaceans and phytoplankton, while benthic crustaceans consumed are detritivores, predators, and omnivores.

Bowhead whales migrate through the Chukchi Sea in spring and autumn. While it is known that they seldom feed during the spring migration, the extent of their summer and autumn foraging in the Chukchi is not known. In some areas of the Beaufort Sea, ringed seals and bowhead whales feed on the same prey (Lowry et al. 1978b, Lowry and Burns 1980).

In summer grey whales forage throughout the Chukchi Sea. Foods of grey whales in the Chukchi are poorly documented. In the Bering Sea they feed primarily on benthic crustaceans, mostly gammarid amphipods (Zimushko and Lenskaya 1970). They may be significant trophic competitors with ringed seals which also feed considerably on gammarid amphipods in some areas.

Seabirds compete to some extent with marine mammals for food. In particular, murres (Uria spp.) which are very abundant near Cape Lisburne feed on many of the fish species which are consumed by marine mammals (Swartz 1966).

In some areas such as the Bering Sea, commercial fisheries harvest considerable quantities of the same species eaten by marine mammals (Lowry et al. 1979c). In the Chukchi Sea, few species of marine mammal prey are of potential commercial value. The primary exception is herring which in the Bering Sea have been harvested at increased levels in recent years. Considering the importance of herring to marine mammals, any commercial fishing of stocks occurring in the Chukchi Sea should be approached very cautiously.

D. Potential Effects of Petroleum Development

This study was designed to develop an understanding of the feeding and trophic interactions of marine mammals, particularly ringed, bearded, and spotted seals, in the Chukchi Sea and to assess the possible and/or probable effects of petroleum exploration and development on the ability of those animals to meet their nutritional requirements. Possible effects fall into two categories: 1) those directly affecting the seals and their access to feeding habitat and 2) those affecting the availability of prey. The potential for and severity of any effects will vary by season and geographic area. For that reason we have organized the following discussion of effects by time period and, when appropriate, by area.

Winter exploration and development activities are likely to include such things as seismic profiling, construction and operation of drilling facilities, and maintenance activities such as supply and service of facilities. In the immediate future most activity will probably occur nearshore using landfast ice as a stable platform from which to operate. During this time period ringed and bearded seals and polar bears are the only resident marine mammals. Bearded seals and polar bears are found mostly offshore in areas of moving broken ice. Ringed seals are also present in the offshore area; however, preferred breeding habitat is the shorefast ice. It is this nearshore area where direct effects on feeding seals are most likely to occur and be of significance.

Prime ringed seal habitat coincides with and may be determined by the availability of arctic cod which are abundant nearshore under the fast ice during winter. Spilled oil or high noise levels which may displace ringed seals from this area would in fact be excluding them from their major food source at a time of year when energetic requirements are high and alternate prey are least available.

The nearshore area is important in winter, not only to ringed seals but to several major prey species. Arctic cod aggregate in autumn-winter and move onshore to spawn during January-February. The schooling of adult arctic cod at spawning time, particularly near narrow cracks in the ice and in slushy "frazil" ice, places them in areas most likely to be contaminated by winter oil spills. It also suggests that in the event of a catastrophic spill or blowout a large proportion of the breeding segment of the population might be affected. Preliminary toxicity studies have shown adult arctic cod to be very sensitive to crude oil at less than 2 ppm (NAFC 1979).

Both the eggs and larvae of arctic cod are pelagic, developing near the undersurface of the ice. The egg stage lasts 1.5-3.0 months, and the larval stage lasts about 2 months. Because the eggs and larvae are in the upper portion of the water column, they are likely to be exposed to surface and under ice spills, emulsions, and dispersions. Studies of other members of the cod family have shown eggs and larvae to be highly sensitive to even short-term exposure (5-30 hrs) to crude oil and crude oil extracts (Mironov 1967, Kuhnhold 1970).

Saffron cod also spawn nearshore under the ice in winter. Spawning aggregations form in autumn-early winter near river mouths, bays, and inlets in such places as Shishmaref, Kotzebue Sound, and the area near Point Hope. Unlike arctic cod the eggs are demersal and are laid on clean, sandy gravel bottoms. The presence of sinking oil in areas where saffron cod spawn could kill or cause abnormal development of eggs and larvae. Adult mortality occurs within 24 hours when individuals are exposed to the soluble fractions of crude oil at less than 2ppm at 3°C (Devries 1976).

Other major prey species reproduce in deeper offshore waters during autumn-winter. Sand lance spawn then as do many species of sculpins. Percy and Mullin (1975) found fry of the sculpin _Myoxocephalus quadricornis_ to be the most sensitive organisms they tested, with 100 percent mortality occurring after 24 hours in a heavy dispersion of oil. _Parathemisto_ breeds in autumn-winter and broods its eggs until spring. A similar pattern occurs in many gammarid amphipods, including _Ampelisca_ and _Gammarus_, and some shrimps such as _Pandalus_, _Argis_, and _Sclerocrangon_. The crabs _Hyas_ and _Chionocetes_ carry eggs in autumn and perhaps winter. Time of hatching in the Chukchi is unknown. Water soluble fractions of crude oil can cause loss of eggs by gravid female amphipods (Busdosh and Atlas 1977) and may cause similar effects in shrimps and crabs.

The spring-summer period is a time of increased biological activity. Ringed and bearded seals bear their pups in April. As the ice melts in the Bering Sea there is an influx of ringed, bearded, and spotted seals, as well as walruses and belukhas, into the Chukchi. Walruses remain associated with pack ice in the northern Chukchi while belukhas move inshore to calve and feed in nearshore lagoons, bays, or inlets. Some prey species also undergo major movements at this time, moving into or out of nearshore areas to feed and/or reproduce.

The two major forage fishes of ringed seals, arctic and saffron cod, have already spawned. Larvae of both species develop in surface waters where exposure to toxic pollutants is most likely, then descend to the bottom in late summer and assume a demersal life similar to adults. Adult arctic cod disperse offshore during spring/summer and are probably least sensitive to oil spills and pollutants at this time. Most saffron cod apparently remain nearshore in areas where exploration and development are likely to occur.

Herring form pre-spawning concentrations in spring and move en masse into lagoons, bays, and inlets (for example the north coast of the Seward Peninsula, Shishmaref Inlet, Eschscholtz Bay, and outer Kotzebue Sound) to spawn at about the time the ice breaks up. After spawning they remain aggregated and feed intensively throughout the remainder of the summer.

Spawning takes place in two very different habitats: on kelp growing near exposed rocky headlands (such as Cape Espenberg in Kotzebue Sound) and on eelgrass (*Zostera* sp.) growing in shallow, brackish bays, lagoons, or inlets (such as the inlets near Shishmaref). The latter of these types is probably the most important spawning habitat in the Chukchi and the most vulnerable to either large or small scale discharges of pollutants. Rocky headlands are quite rapidly cleansed of oil as a result of wind and wave action. Such cleansing action occurs more slowly in lagoons, bays, or inlets where wind and wave action are more moderate and hydrocarbons can become entrained in sediments.

In herring, hydrocarbons cause reduced survival of ovarian eggs prior to spawning, of embryos from the time of fertilization to hatching, and of larvae through the yolk absorption stage (Struhsaker 1977; Kuhnhold 1970; Mironov 1970; Eldridge et al. 1978; Smith and Cameron 1977). In addition, hatching may be delayed and a significant proportion of the larvae may develop abnormally. In the natural environment only 5-10 percent of the herring are estimated to survive beyond the larval stage. The presence of hydrocarbons may aggravate a natural tendency toward embryonic mortality, and it is possible that an entire year class could be eliminated in localized areas. In addition to effects on eggs and larvae, benzene has been shown to cause aberrant swimming and disequilibrium in adults (Struhsaker 1977).

Many invertebrates release their young during spring and summer. Among the major species are the amphipods *Ampelisca* and *Gammarus*, the isopod *Saduria*, the shrimps *Eualus*, *Pandalus*, *Crangon*, *Argis*, and *Sclerocrangon*, and the clams *Serripes* and *Spisula*. The eggs of *Hyas* and *Chionocoetes* crabs may also hatch then. Growth and molting of crab larvae are impaired by hydrocarbons even in species in which adults are highly resistant (Mironov 1970; Parker and Menzel 1974; Rice et al. 1976). Pandalid and hippolytid shrimp larvae are sensitive to hydrocarbons. Low concentrations (1-5ppm) of water soluble fractions cause mortality and cessation of swimming activity (Malins et al. 1977; Brodersen et al. 1977; Craddock 1977).

Water soluble fractions of crude oil cause reduced fertilization of eggs, decreased survival of eggs, sperm, and larvae, and abnormal development of embryos in bivalve molluscs (Scarratt and Zitko 1972; Renzoni 1975). Growth, survival, and recruitment rates in local clam populations remained depressed for 3-6 years after the occurrence of oil spills in Nova Scotia and Maine (Gilfillan and Vandermeulen 1978).

Young amphipods may not colonize oiled sediments. Atlas et al. (1978) found that arctic amphipods occurred less frequently in oiled sediments than in unoiled (control) sediments. Although contaminated sediments were later recolonized, species composition was quite different. If colonization of a species such as Ampelisca, which is a major food not only of ringed seals but also of grey whales and numerous fishes, were discouraged it could have major implications for predators.

In general the literature indicates that many of the fishes, crustaceans, and bivalves (especially their eggs and larvae) which are important prey species in the Chukchi are sensitive to the presence of hydrocarbon in water. Summer is probably the period when reproductive products are most abundant; however, it is also the time of open water and warmer temperatures, which may facilitate dispersal, dilution, and degradation of contaminants. Consequently, the occurrence of an oil spill in summer may be less critical from the standpoint of prey species than a similar spill in winter. The probable exception is a summer spill in areas such as bays, inlets, and lagoons, where water circulation is sluggish, flushing time slow, and abundance of spawning and/or juvenile organisms is very high. Such spawning/nursery areas are very important to maintenance of prey species populations.

Fewer species reproduce during winter but many of the ones that do are major prey of marine mammals. The winter ice cover and accompanying colder water act to reduce dispersion rates, evaporative loss of toxic fractions, and biodegradation rates, and may concentrate pollutants in places of high biological activity such as leads and slush ice.

Pollutant levels high enough to cause large-scale die-offs of individuals will probably occur only on a very localized basis (except where oil or pollutants are trapped under the ice and transported long distances in a relatively unweathered state). The greatest concern may not be with local catastrophic events but with long-term sublethal effects of pollutants. Individuals may not be killed directly, but instead very low concentrations of pollutants may affect locomotion, metabolism, or reproduction and lead to substantial reduction of populations over several generations (Percy and Mullin 1975). These long-term reductions are of special concern in considering food availability to consumers.

VIII. Conclusions

Spotted seals are summer residents in the Chukchi Sea. They feed mostly on fishes, although at certain times and places shrimps are a major food. Among the fishes eaten are herring, arctic and saffron cods, sculpins and sand lance, and probably capelin and rainbow smelt.

Belukha whales are also summer residents in the Chukchi Sea. Based on our samples from coastal waters they utilize much the same prey as spotted seals; small to medium-sized forage fishes make up most of the diet. Aggregations of those fishes which occur in coastal waters during summer and fall probably influence the distribution of both spotted seals and belukhas.

Bearded seals are abundant year round residents in the Chukchi They eat mostly shrimps, brachyuran crabs, and clams. The diet appears to vary on a seasonal basis with clams important only during summer Young seals eat more shrimps and isopods while older seals eat more clams, crabs, and echiuroid worms.

A large proportion of the Pacific walrus population summers and feeds in the Chukchi Sea but they are not common there during winter. Foods of walruses in the Chukchi are poorly documented. They probably eat mostly clams, as they do elsewhere in their range. Walruses may compete for food with bearded seals in areas such as Wainwright where clams are a major component of the bearded seal diet.

Ringed seals are the most abundant marine mammal in the Chukchi Sea and they compete with and provide food for other marine species. Arctic cod and some saffron cod (at Shishmaref) are their main foods in winter. Crustaceans (amphipods, shrimps, and mysids) are the main food in March through June. Ringed seal pups eat more small crustaceans (amphipods, mysids, and euphausiids) than older seals, while older seals eat slightly more fish. Ringed seals eat many of the same fish species consumed by spotted seals and belukhas. However, they also utilize crustaceans in significant quantities and therefore have a more diverse food resource base.

Available information on the distribution, abundance, and natural history of most major prey species is inadequate. Information on hydrocarbon sensitivity of all but a few species is totally lacking. Without such information the potential effects of OCS development in the Chukchi Sea on marine mammals cannot be quantified. However, based on what information is available, a real potential for detrimental effects on prey populations exists. Changes in the abundance of prey can be expected to influence populations of marine mammals.

IX. Needs for Further Study

The data summarized in this report pertain almost exclusively to the nearshore waters of the Chukchi Sea in spring and summer. Virtually nothing is known about foods of marine mammals in offshore waters in either summer or winter, or about winter food habits in coastal areas. With adequate logistic support the necessary data could be obtained.

The Chukchi Sea is the major summering and feeding area for much of the Pacific walrus population yet virtually nothing is known of either food habits or distribution of potential prey in that region. Of particular interest are areas where bearded seals and walruses are found together and appear to compete for the same major prey (clams). Very little is known about utilization of the Chukchi coast by belukha whales. Although many belukhas migrate through the Chukchi to other areas, some spend summer months in and near coastal lagoons and estuaries in Kotzebue

Sound and between Point Lay and Wainwright. Future studies should address the distribution of whales in relation to available food resources such as herring, saffron cod, capelin, and anadromous fishes.

Distribution and abundance of arctic cod are virtually unknown in the Chukchi Sea. Spawning time and locations are unknown. Very limited data are available on arctic cod foods. Prey specificity, seasonal variation in prey, availability of alternate prey items and sensitivity of prey to hydrocarbons should be studied. Arctic cod are one of the most important forage species in the Chukchi Sea. Research should be undertaken immediately to fill these data gaps.

Data are needed on a seasonal basis on the distribution and abundance of other important prey species, the factors determining their presence or absence and the timing of important life history events. Some information on these species is available in the literature. It should be compiled and analyzed in light of questions pertaining to petroleum development. Critical feeding areas for marine mammals in the Chukchi Sea will be determined in part by the distribution of these organisms. The species include:

Fishes - Herring, saffron cod, sand lance
Gammarid amphipods - *Ampelisca* spp.
Mysids - *Mysis litoralis*, *Neomysis rayii*
Shrimps - *Crangon septemspinosa*, *Argis lar*, *Sclerocrangon boreas*, *Pandalus goniurus*, *Eualus gaimardii*
Brachyuran crabs - *Hyas coarctatus*, *Chionoecetes opilio*, *Telmessus cheiragonus*
Clams - *Serripes groenlandicus*, *Spisula polynyma*
Hyperiid amphipods - *Parathemisto libellula*

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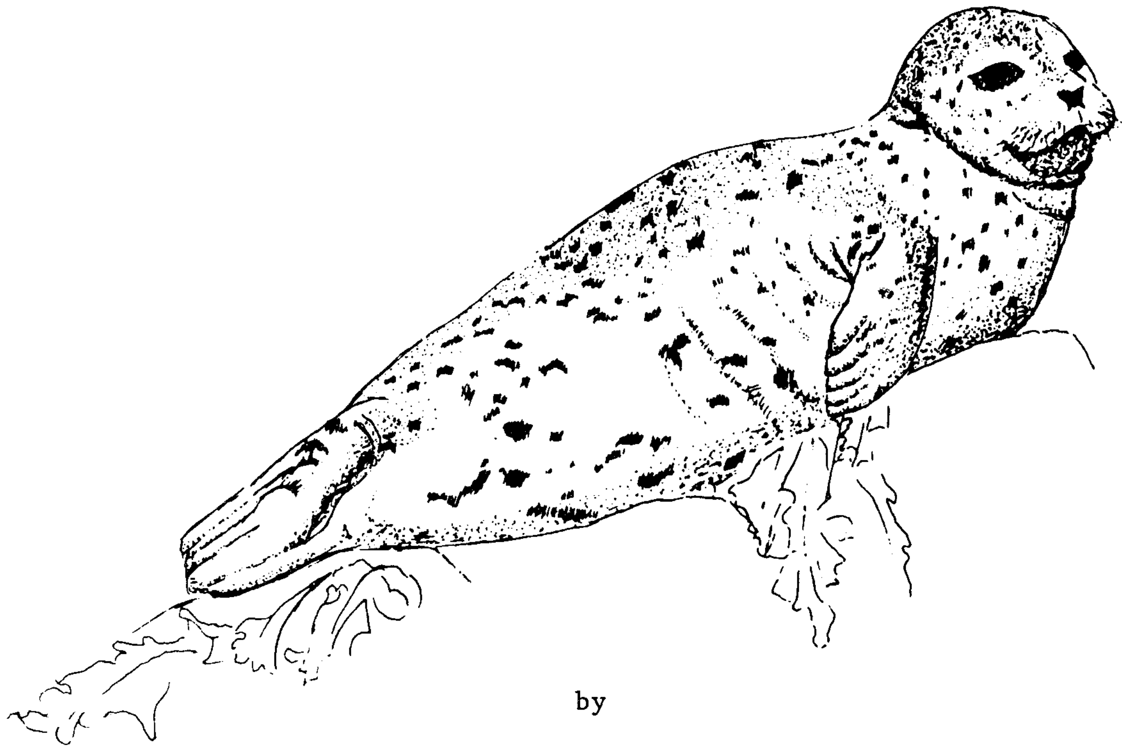
BIOLOGY OF THE HARBOR SEAL, PHOCA VITULINA RICHARDSI, IN THE GULF OF ALASKA



by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 229, Contract Number 03-5-002-69

September 1979

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INTRODUCTION

Land breeding harbor seals, *Phoca vitulina richardsi*, (Shaughnessy and Fay 1977) are an abundant and ubiquitous resident pinniped along the coast of the Gulf of Alaska. Exploration for and development and transportation of petroleum reserves in the Gulf of Alaska appear to have a number of potentially harmful effects on harbor seal populations. Field studies were conducted from 1975 through 1978 on diverse aspects of harbor seal biology to obtain information which would be of value in guiding developmental activities in a direction which would minimize adverse impacts on harbor seal populations. These data would also serve as baselines against which future information could be compared. Our general strategy was to conduct a basic, ecological life history study of the harbor seal focusing on several specific areas which appeared to have the greatest potential for development related impacts. Explicit objectives included: (1) determination of food habits and identification of important prey items, (2) measurement of growth and physical condition and (3) delineation of the reproductive cycle with estimates of basic parameters including age specific pregnancy rates and age of sexual maturity. Secondary objectives included accumulation of data on distribution, locations of major haulout areas, population composition, mortality rates, timing of molting activities and effects of disturbance. During FY 1978 several additional aspects of harbor seal biology were examined including range of individual movements, haulout area fidelity, haulout patterns and counts of seals at key haulout areas in each lease area.

Bishop (1967) conducted the first life history study of harbor seals in the Gulf of Alaska. He combined a cementum annuli age determination technique with reproductive tract analyses to obtain information on the reproductive cycle of harbor seals. Bishop also collected information on behavior, population composition and productivity during observational studies on Tugidak Island. From 1956 to 1958 Mathisen and Lopp (1963) photographed and counted concentrations of harbor seals in conjunction with a census of Steller sea lions (*Eumetopias jubatus*). Imler and Sarber (1947) reported on stomach contents of seals collected on the Copper River Delta during the months of June and July. The Alaska Department of Fish and Game (ADF&G) conducted harbor seal studies on Tugidak Island from 1965-1972. Although the main emphasis of this work was monitoring a commercial harvest, over 4,000 pups were tagged providing information on dispersal and providing known age specimens used to evaluate age determination techniques. Seasonal distribution surveys were conducted in the Prince William Sound area by ADF&G in 1973 and 1974 (Pitcher and Vania 1973; Pitcher 1975). Additional studies provided information on population productivity, growth, condition and food habits in Prince William Sound (Pitcher 1977). The latter provided the first sizable sample of data from any area in the Gulf of Alaska and is useful for comparative purposes. A general discussion and maps of harbor seal distribution and abundance in the Gulf of Alaska were presented by Calkins et al. (1975). Fiscus et al. (1976) reported offshore observations of harbor seals in the Gulf of Alaska.

Broad limits of the study area were Yakutat Bay to the southeast and Sanak Island to the southwest (Figure 1). Little work was done in Prince William Sound or in Cook Inlet north of Kachemak and Kamishak Bays.

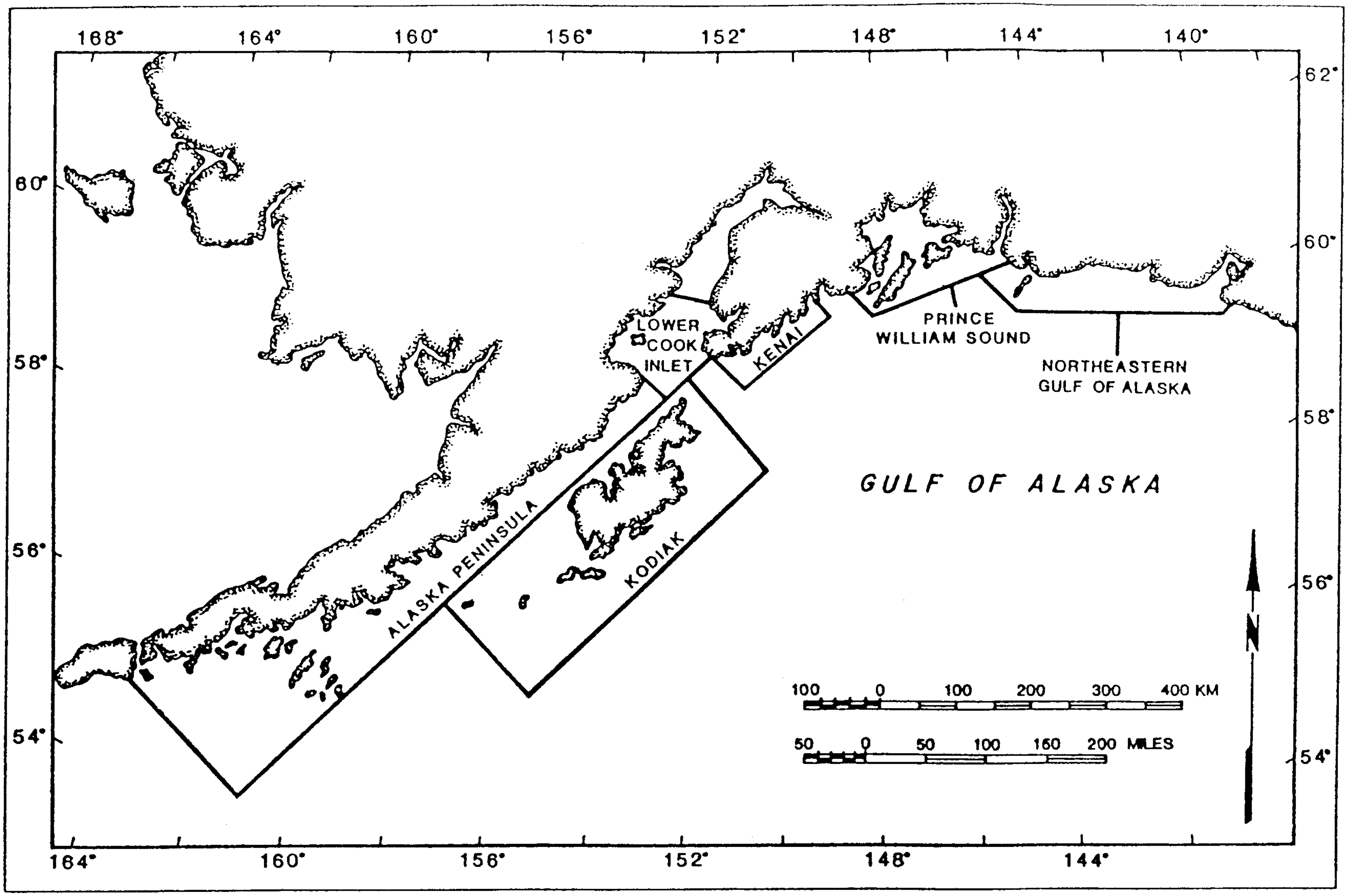

FIGURE 1. GULF OF ALASKA STUDY AREA SHOWING GEOGRAPHIC SUBDIVISIONS.

METHODS

Harbor seals were collected by shooting. Collections were scheduled to obtain representative seasonal and geographic coverage. Total weights and the following measurements were taken from collected animals: standard length, curvilinear length, axillary girth, hind flipper length and blubber thickness. All measurements except standard length were made as detailed by Scheffer (1967). Standard length measurements were made with the "back" or dorsal surface up rather than the "belly" or ventral surface up. A sample of 100 animals was measured using both methods and the paired measurements were subjected to linear regression analysis. There was a highly significant correlation between the two measurements ($r = 0.99$, $P<0.001$) and a formula ($Ye = 2.35 + 1.0(X)$ was derived to estimate "belly up" (Ye) from "back up" (X) standard length. All standard lengths in this report are the "back up" measurement. Persons wishing to compare data can use the formula for conversions.

Ages of collected animals were estimated by counts of cementum annuli in canine teeth. Teeth were decalcified, sectioned (about 48 microns) and stained with hematoxylin (Johnson and Lucier 1975). Annual deposition of cementum annuli was confirmed by examination of teeth from four known age seals (tagged as pups during the 1960's and collected on Tugidak Island during this study).

The ovaries and uterus from each female seal were preserved in formalin. Each uterus was opened and the presence of an embryo, fetus or placental scars was recorded. Ovaries were sectioned with a scapel at about 1 mm. The number and size of graffian follicles, corpora lutea and corpora albicantia were recorded thus allowing reconstruction of a partial reproductive history for each female. Testes and epididymides were taken from male seals and preserved in formalin. Microscopic examinations were made of epididymal fluid to determine whether sperm were present.

Stomach contents were preserved in a 10% formalin solution. In the laboratory, total volume was determined by water displacement. The contents were sorted by species when possible and volumes were determined for each taxon. Identifications were made by examination of recognizable individuals and skeletal materials, particularly fish otoliths (sagittae) and cephalopod beaks.

Pelage samples for analysis of progression of the molt were taken from the mid-dorsal line between the front flippers and preserved in formalin. Laboratory procedures followed Scheffer and Johnson (1963) in which thin slices were cut parallel to the lay of the roots in a plane midway between frontal and horizontal. Each slice was about 2/3 mm thick and 10 mm wide. Sections were allowed to dry then cleared with a drop or two of cedarwood oil. Stage of molt was determined by examining sections with a dissecting microscope at about 10x.

Concentrations of harbor seals seen during collecting cruises and radio tracking surveys were recorded. Personnel of other marine mammal projects and sea bird projects provided additional observations.

A field camp was manned on Tugidak Island from 15 May to 29 September 1976. Periodic censuses were made on the southwest hauling area. Instances of disturbances, both man-related and natural, were documented. Progression of life history events (i.e. birth, lactation, weaning and molting) was determined. A field camp was also manned on Tugidak Island from 15 April to 12 July and 31 July to 6 September 1978. Radio transmitters were attached around the ankles of the hind flippers of 35 seals. Daily checks were made on the southwest hauling area to determine how frequently the radio-tagged seals hauled out. Concurrent counts of total numbers of hauled out seals were made and notes on disturbances and observations on life history events taken. Periodic radio tracking surveys were flown from 8 June to 9 September 1978 to locate radio-tagged animals which had moved from their capture location on Tugidak Island.

Short term field camps were established on Elizabeth Island (LCI) and Channel Island (NEGOA), both of which are major harbor seal hauling areas. Daily counts of seals were made at low tide. From this series of counts, means and associated standard deviations were calculated.

Standard statistical techniques (Snedecor and Cochran 1967) were used in data analysis. Confidence intervals for proportions were calculated for pregnancy rates and for occurrences of prey species. Confidence intervals for means were calculated for weights, standard lengths and blubber thickness. One-way analysis of variance and t-tests were used to test for differences in independent samples of measurement data. A modified t-test was employed for comparing ages of sexual maturity. Statistical comparisons of frequency of occurrences of prey and of sex ratios were made with chi-square analysis when sample sizes were adequate. Linear regression analysis was used to derive a formula for estimating "belly up" standard length from "back up" standard length measurements and to estimate the amount of variance within counts of hauled out seals associated with stage of tide.

To consolidate the food habits data from both frequency of occurrence and volumetric analyses and to provide a single ranking of prey species a modified Index of Relative Abundance (IRI) was calculated (Pinkas et al. 1971). Because of the vast differences in size of harbor seal prey items the numerical analysis was eliminated. Therefore, the modified IRI was calculated as percentage of occurrences x percentage of volume.

DISTRIBUTION OF HARBOR SEALS IN THE GULF OF ALASKA

Harbor seals have a continuous distribution along the coastal Gulf of Alaska. They occupy virtually all nearshore marine habitats and seasonally are found in certain rivers and lakes. Although harbor seals are generally considered a coastal species, sightings of animals up to 100 km offshore (Wahl 1977; Fiscus et al. 1976; Spalding 1964) suggest pelagic distribution of at least some individuals.

Collection of accurate and meaningful data on distribution is difficult because the only time harbor seals are easily seen is when they are hauled out. Surveys of hauled out animals do not provide information on aquatic distribution which is a critical component of their life history.

Because of this problem a formal program to collect distributional data was not conducted. Nevertheless, concentrations of harbor seals encountered during field operations were recorded. Observations by other workers, particularly Sears and Zimmerman (1977) and Arneson RU-003[1] were also compiled. Files of the Alaska Department of Fish and Game were searched for appropriate sightings. Because virtually all sightings were of hauled out animals and because there are thousands of haulout areas in the Gulf of Alaska, only major sites (where 25 or more seals were seen) are reported. Commonly used haulout substrates in the Gulf included offshore reefs, rocks and ledges, beaches of isolated islands, mainland or island beaches backed by cliffs, sand and mud bars (often located in estuaries), ice floes calved from tidewater glaciers and sea ice.

Geographical coverage included the coastal Gulf of Alaska north and west of Ocean Cape (Yakutat Bay) to Chirikof Island. Prince William Sound is not included since detailed results of surveys in that area were previously reported by Calkins et al. (1975). Cook Inlet north of Anchor Point and Chinitna Bay also is not included.

Attempts to classify critical habitat may not be appropriate for harbor seals in the Gulf of Alaska. The fact that harbor seals are widely distributed and are not restricted to a few limited localities in obtaining requirements for successful culmination of their life cycle reduces the value of critical habitat classification. On the basis of our current level of knowledge, the only criterion we could use to assign and rate critical habitats would be the number of animals observed at particular locations.

Figures 2-4 show the locations of major harbor seal concentrations in the Gulf of Alaska. Tables 1-5 summarize information on each of the concentration areas. It must be emphasized that the catalog of concentration areas is incomplete. No attempt should be made to relate the number hauled out at any particular site to total population for that area. Available information indicates that only a relatively small proportion of the total is hauled out at any given time (see discussion on haulout patterns in this report and Summers and Mountford 1975).

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1 Arneson, P. A. OCSEAP RU 003. Identification, Documentation and Delineation of Coastal Migratory Bird Habitat in Alaska.

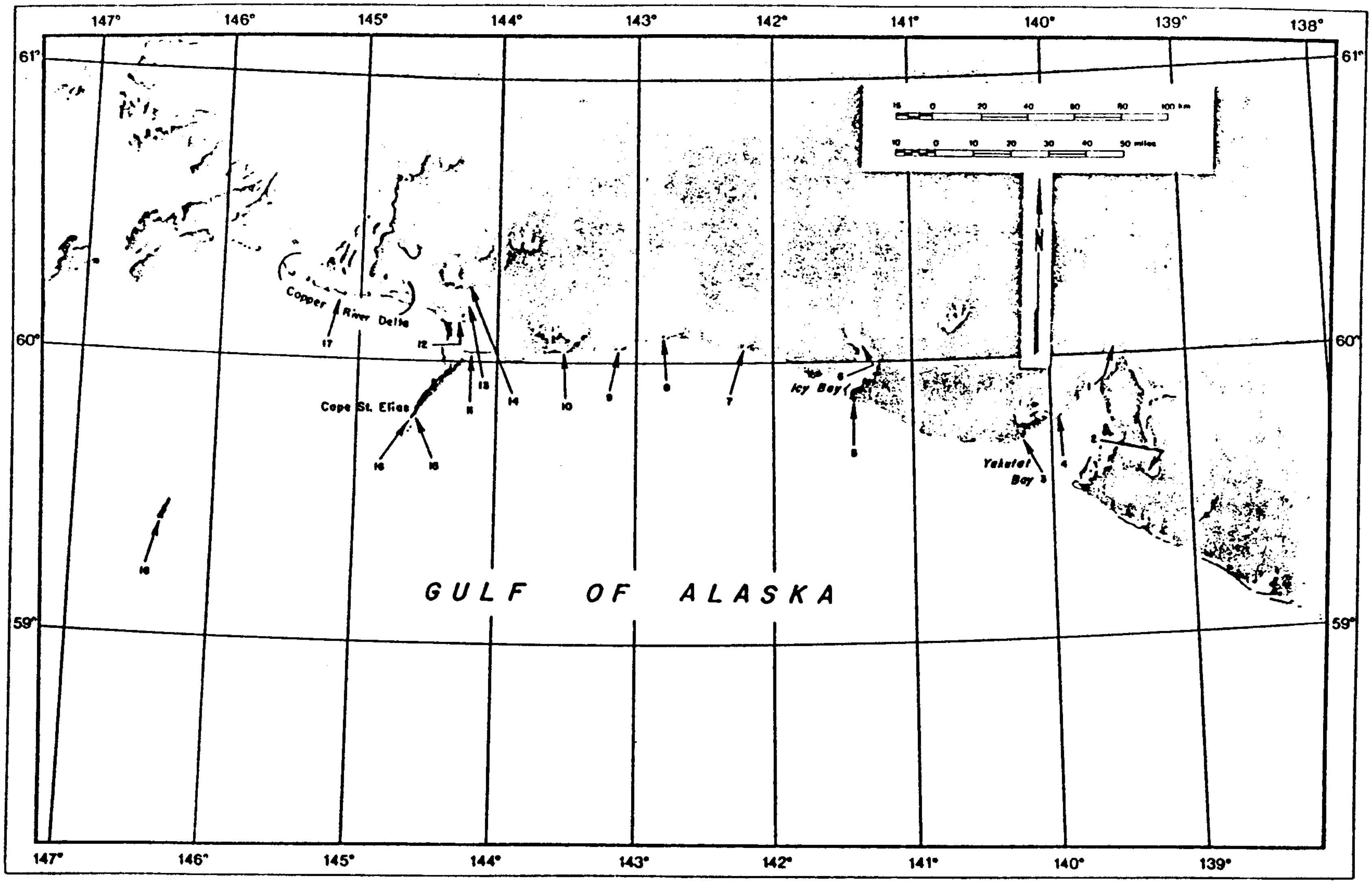

FIGURE 2. LOCATIONS OF MAJOR (≥ 25 SEALS) HARBOR SEAL CONCENTRATIONS ALONG THE NORTHEASTERN COAST OF THE GULF OF ALASKA: YAKUTAT BAY TO THE COPPER RIVER DELTA.

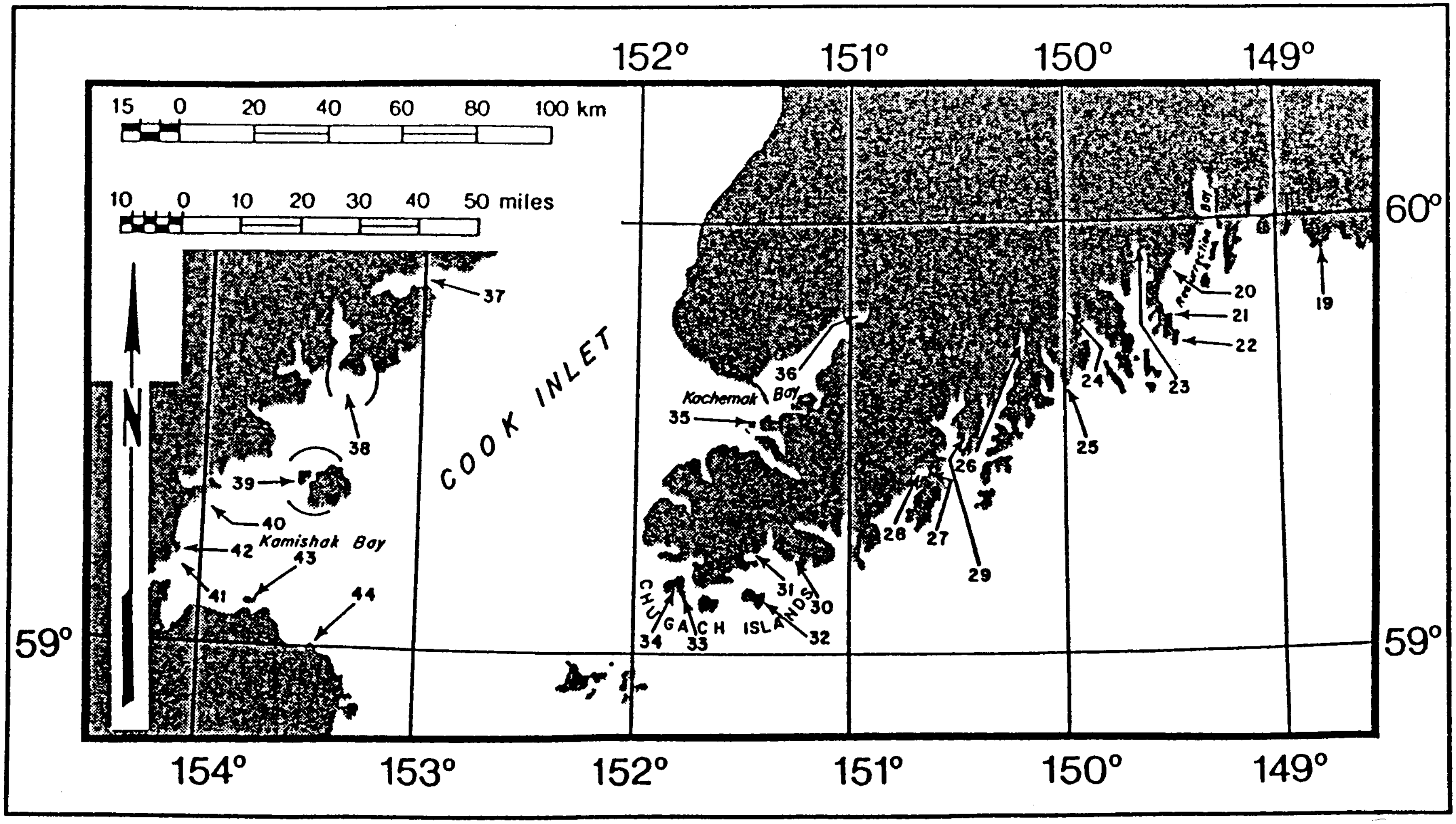

FIGURE 3. LOCATIONS OF MAJOR (≥ 25 SEALS) HARBOR SEAL CONCENTRATIONS ALONG THE KENAI COAST AND IN LOWER COOK INLET.

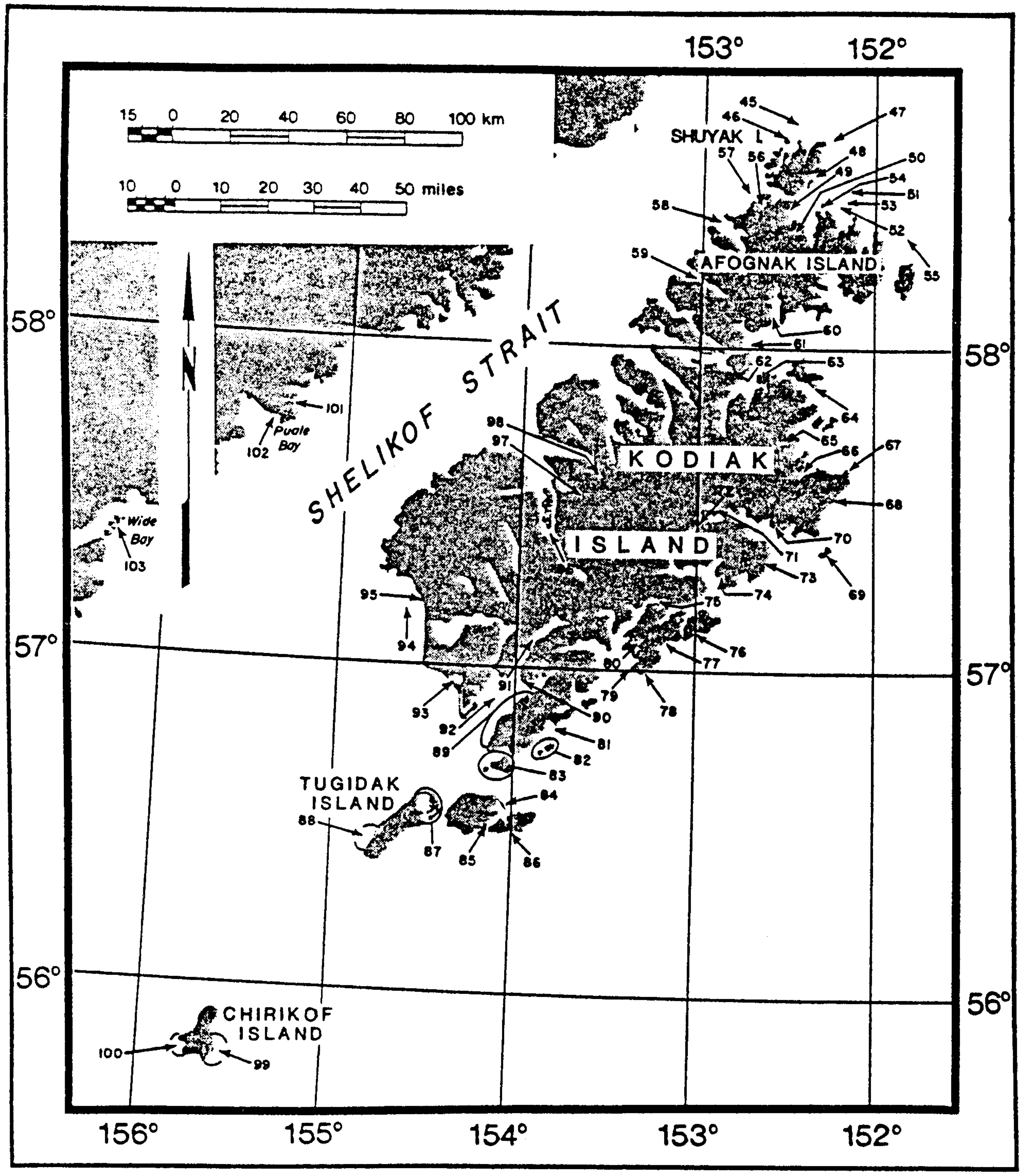

FIGURE 4. LOCATIONS OF MAJOR (≥25 SEALS) HARBOR SEAL CONCENTRATIONS IN THE KODIAK ISLAND - SHELIKOF STRAIT AREA.

Table 1. Listing of major harbor seal concentrations along the northeastern coast of the Gulf of Alaska; Yakutat Bay to the Copper River Delta.

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Disenchantment Bay 60 01 10 N 139 31 53 W	(1)	331	31 May 1976	Hauled on glacial ice floes, ADF&G survey
Russell Fiord 59 34 57 N 139 18 31 W	(2)	75	26 June 1975	Hauled on rock islet, ADF&G survey
Manby Stream 59 41 35 N 140 18 41 W	(3)	45	29 May 1976	Stream mouth, ADF&G survey
Sudden Stream 59 46 13 N 140 02 20 W	(4)	40+	29 May 1976	Stream mouth, ADF&G survey
Yahtse River 59 51 49 N 181 22 58 W	(5)	41	24 July 1976	Arneson (RU 003)
Icy Bay 60 00 00 N 141 19 40 W	(6)	5,000	Summer 1975	Hauled on glacial ice floes, Sears & Zimmerman (1977)
Duktoth River 60 05 32 N 142 35 57 W	(7)	25+	6 June 1975	Hauled on sandbar at river mouth, USGS pers. comm.
Kaliakh River 60 06 21 N 142 44 03 W	(8)	200	28 May 1976	Hauled on sandbars at river mouth, ADF&G survey
Tsiu River 60 03 59 N 143 05 57 W	(9)	25+		Hauled on sandbars at river mouth, ADF&G report
Seal River 60 02 50 N 143 00 21 W	(10)	25+		Hauled on sandbars at river mouth, ADF&G report
Controller Bay 60 00 26 N 144 08 30 W 60 06 35 N 144 15 29 W	(11,12)	186	26 July 1973	Hauled on sandbars, ADF&G survey

Table 1. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Bering River 60 15 25 N 144 10 36 W 60 13 54 N 144 11 29 W	(13,14)	68	26 July 1973	Hauled on sandbars, ADF&G survey
Cape St. Elias 59 47 20 N 144 36 02 W 59 47 43 N 144 34 18 W	(15,16)	350	March-June 1977, 1978	Hauled on tidal rocks, ADF&G field camp
Copper River Delta 60 22 00 N 144 59 00 W	(17)	1,571	late August 1975	Hauled on sandbars, ADF&G survey
Middleton Island 59 24 25 N 146 20 10 W	(18)	125	26 May 1976	Hauled on tidal rocks, ADF&G survey

Table 2. Listing of major harbor seal concentrations along the Kenai coast; Cape Puget to Flat Island.

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Cape Fairfield 59 55 53 N 148 49 15 W	(19)	200-300	20 July 1970	ADF&G survey
Bear Glacier 59 53 44 N 149 32 50 W	(20)	70	31 Aug. 1976	Arneson (RU 003)
Cheval Island 59 46 56 N 149 31 08 W	(21)	200	31 Aug. 1976	Arneson (RU 003)

Table 2. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Pony Cove 59 45 04 N 149 32 50 W	(22)	40	31 Aug. 1976	Arneson (RU 003)
Aialik Bay 59 56 45 N 149 43 40 W	(23)	400	14 Aug. 1970	Hauled on glacial ice floes, ADF&G survey
Harris Bay 59 47 06 N 150 01 33 W	(24)	200-300	Nov. 1970	Hauled on glacial ice floes, ADF&G survey
Surok Point 59 36 50 N 150 01 33 W	(25)	25	4 Oct. 1975	ADF&G survey
McCarty Arm 59 43 06 N 150 13 25 W	(26)	100	12 Nov. 1970	Hauled on glacial ice floes, ADF&G survey
Division Island 59 25 23 N 150 41 50 W	(27)	50	6 June 1978	Hauled on intertidal rocks, ADF&G survey
Nuka Island, NW 59 23 24 N 150 42 00 W	(28)	37	31 Aug. 1976	Hauled on intertidal rocks, Arneson (RU 003)
Suprise Cove 59 31 40 N 150 28 32 W	(29)	25	21 March 1977	ADF&G survey
No Name Bay 59 14 07 N 151 17 25 W	(30)	176	24 June 1976	Arneson (RU 003)
Windy Bay 59 13 42 N 151 26 50 W	(31)	26	24 June 1976	Arneson (RU 003)
East Chugach Island 59 06 55 N 151 25 47 W	(32)	40	1 Oct. 1976	Hauled on sand beach, Arneson (RU 003)
Elizabeth Island 59 08 15 N 151 47 37 W 59 08 37 N 151 50 25 W	(33,34)	619	22 Aug. 1978	Hauled on gravel-cobble beach and intertidal rocks, ADF&G field camp, daily counts

Table 3. Listing of major harbor seal concentrations in lower Cook Inlet; Kachemak Bay, Chinitna Bay and Kamishak Bay.

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Yukon Island 59 31 37 N 151 30 20 W	(35)	250	30 Sept. 1976	Hauled on gravel beach, Arneson (RU 003)
Bradley-Fox River Flats 59 46 45 N 151 00 43 W	(36)	140	-	Arneson (RU 003)
Gull Island 59 50 29 N 152 59 15 W	(37)	400	1 Oct. 1976	Arneson (RU 003)
Mouth Oil Bay to Mouth Iniskin Bay 59 37 32 N 153 24 15 W	(38)	200	Summer	Arneson (RU 003)
Augustine Island 59 20 08 N 153 32 55 W	(39)	850-1,500	30 Sept. 1976	Hauled out in many locations along shore, Arneson (RU 003)
No Name Reef (Kamishak Bay) 59 17 30 N 153 53 07 W	(40)	200	8 April 1978	ADF&G survey
Nordyke Island 59 10 57 N 154 05 22 W	(41)	109	15 July 1978	Arneson (RU 003)
Juma Reef 59 11 45 N 154 04 02 W	(42)	150	8 April 1978	ADF&G survey
Douglas River Reefs 59 05 09 N 153 44 03 W	(43)	200		Sears and Zimmerman (1977)
Shaw Island 59 00 35 N 153 22 18 W	(44)	500-1,000	23 June 1978	ADF&G survey

Table 4. Listing of major harbor seal concentrations in the Kodiak Island Group.

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Latax Rocks 58 40 15 N 152 30 45 W	(45)	175	26 July 1978	Hauled on rocky beach, ADF&G survey
Dark Island 58 39 00 N 152 31 50 W	(46)	45	12 June 1978	ADF&G survey
NE Shuyak Island, offshore rocks 58 35 31 N 152 16 43 W	(47)	25	12 June 1978	ADF&G survey
Andreon Bay 58 30 36 N 152 23 33 W	(48)	25	April 1976	ADF&G survey
Big Waterfall Bay 58 25 46 N 152 28 15 W	(49)	50	21 May 1977	ADF&G survey
Phoenix Bay 58 22 07 N 152 28 20 W	(50)	25	22 May 1977	ADF&G survey
Sea Otter Island area 58 30 33 N 152 10 25 W 58 29 48 N 152 16 28 W	(51)	30	12 June 1978	ADF&G survey nearby tidal rocks
Seal Island 58 26 19 N 152 16 07 W	(52)	40	12 June 1978	ADF&G survey
Seal Bay-offshore rocks 58 24 13 N 152 12 04 W 58 23 35 N 152 10 14 W	(53)	35	22 May 1977	ADF&G survey

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Posliedni Pt. offshore rocks 58 26 48 N 152 18 08 W	(54)	60	14 June 1978	ADF&G survey
Sea Lion Rocks 58 21 00 N 151 47 45 W	(55)	34	6 Oct. 1975	ADF&G survey
Blue Fox Bay 58 26 03 N 152 40 44 W	(56)	25	22 April 1976	ADF&G survey
Alligator Island 58 29 40 N 152 46 33 W	(57)	30	26 July 1978	ADF&G survey
Foul Bay 58 21 45 N 152 52 00 W	(58)	40	30 July 1978	ADF&G survey
Malina Bay 58 11 35 N 152 59 35 W	(59)	50	30 July 1978	ADF&G survey
Kazakof Bay-offshore rocks 58 04 48 N 152 34 30 W	(60)	45	12 June 1978	ADF&G survey
Hog Island group 58 00 15 N 152 41 01 W	(61)	160	12 June 1978	ADF&G survey
Whale Passage 57 55 58 N 152 50 04 W	(62)	35	20 May 1977	ADF&G survey
Anton Larsen Bay 57 53 15 N 152 39 27 W	(63)	25	20 May 1977	ADF&G survey
Spruce Island-rocks off southeast tip 57 53 22 N 152 20 20 W	(64)	25	12 June 1978	ADF&G survey

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Womens Bay 57 42 40 N 152 31 42 W	(65)	31	1 March 1978	Arneson (RU 003)
Kalsin Bay 57 38 35 N 152 21 02 W	(66)	200	-	Sears and Zimmerman (1977)
Cape Chiniak 57 37 50 N 152 08 10 W	(67)	100	10 June 1978	ADF&G survey, hauled on tidal rocks
Sacramento River- mainland beach 1 mile north 57 32 17 N 152 14 35 W	(68)	140	11 June 1978	ADF&G survey hauled on gravel beach
Ugak Island 57 22 18 N 152 16 15 W	(69)	1,600	29 July 1978	ADF&G survey hauled on gravel beach
NE Ugak Bay-offshore rocks 57 25 50 N 152 33 50 W	(70)	410	24 July 1978	ADF&G survey
Hidden Basin- entrance 57 30 12 N 152 54 40 W	(71)	107	1 March 1976	Arneson (RU 003)
Ugak Bay-head 57 26 43 N 153 01 04 W	(72)	200+	10 Nov. 1976	ADF&G survey
Ugak Lagoon 57 20 06 N 152 38 15 W	(73)	50	6 Sept. 1978	ADF&G survey, hauled on sand bar
NE Kiluda Bay 57 18 48 N 152 54 17 W	(74)	160	24 July 1978	ADF&G survey

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Sitkalidak Straits 57 12 07 N 153 10 37 W	(75)	35	2 May 1977	ADF&G survey, hauled on tidal rocks
NE Sitkalidak-mouth lagoon 57 07 32 N 153 00 43 W	(76)	125	27 Aug. 1978	ADF&G survey, hauled on sand bar
Ocean Beach 57 05 30 N 153 07 18 W	(77)	40	-	Sears and Zimmerman (1977)
Sitkalidak Island, Ocean Beach to Black Point 57 00 00 N 153 15 54 W	(78)	48	-	Sears and Zimmerman (1977)
Puffin Island 57 00 25 N 153 21 11 W	(79)	90	27 Aug. 1978	ADF&G survey
Natalia Bay 57 05 48 N 153 17 47 W	(80)	30	-	Sears and Zimmerman (1977)
Flat Island 56 49 53 N 153 44 20 W	(81)	100	27 July 1978	ADF&G survey
Geese Islands 56 43 42 N 153 54 03 W	(82)	670	27 July 1978	ADF&G survey
Aiaktalik-Sundstrom Islands 56 41 53 N 154 07 45 W	(83)	635	27 July 1978	ADF&G survey
Sitkinak Bar 56 33 04 N 154 01 10 W	(84)	250	9 Sept. 1978	ADF&G survey, hauled on sand bar
Sitkinak Lagoon 56 31 27 N 154 07 20 W	(85)	200	1 July 1978	ADF&G survey, hauled on sand bar

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Sitkalidak Straits 57 12 07 N 153 10 37 W	(75)	35	2 May 1977	ADF&G survey, hauled on tidal rocks
NE Sitkalidak-mouth lagoon 57 07 32 N 153 00 43 W	(76)	125	27 Aug. 1978	ADF&G survey, hauled on sand bar
Ocean Beach 57 05 30 N 153 07 18 W	(77)	40	-	Sears and Zimmerman (1977)
Sitkalidak Island, Ocean Beach to Black Point 57 00 00 N 153 15 54 W	(78)	48	-	Sears and Zimmerman (1977)
Puffin Island 57 00 25 N 153 21 11 W	(79)	90	27 Aug. 1978	ADF&G survey
Natalia Bay 57 05 48 N 153 17 47 W	(80)	30	-	Sears and Zimmerman (1977)
Flat Island 56 49 53 N 153 44 20 W	(81)	100	27 July 1978	ADF&G survey
Geese Islands 56 43 42 N 153 54 03 W	(82)	670	27 July 1978	ADF&G survey
Aiaktalik-Sundstrom Islands 56 41 53 N 154 07 45 W	(83)	635	27 July 1978	ADF&G survey
Sitkinak Bar 56 33 04 N 154 01 10 W	(84)	250	9 Sept. 1978	ADF&G survey, hauled on sand bar
Sitkinak Lagoon 56 31 27 N 154 07 20 W	(85)	200	1 July 1978	ADF&G survey, hauled on sand bar

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Womens Bay 57 42 40 N 152 31 42 W	(65)	31	1 March 1978	Arneson (RU 003)
Kalsin Bay 57 38 35 N 152 21 02 W	(66)	200	-	Sears and Zimmerman (1977)
Cape Chiniak 57 37 50 N 152 08 10 W	(67)	100	10 June 1978	ADF&G survey, hauled on tidal rocks
Sacramento River- mainland beach 1 mile north 57 32 17 N 152 14 35 W	(68)	140	11 June 1978	ADF&G survey hauled on gravel beach
Ugak Island 57 22 18 N 152 16 15 W	(69)	1,600	29 July 1978	ADF&G survey hauled on gravel beach
NE Ugak Bay-offshore rocks 57 25 50 N 152 33 50 W	(70)	410	24 July 1978	ADF&G survey
Hidden Basin- entrance 57 30 12 N 152 54 40 W	(71)	107	1 March 1976	Arneson (RU 003)
Ugak Bay-head 57 26 43 N 153 01 04 W	(72)	200+	10 Nov. 1976	ADF&G survey
Ugak Lagoon 57 20 06 N 152 38 15 W	(73)	50	6 Sept. 1978	ADF&G survey, hauled on sand bar
NE Kiluda Bay 57 18 48 N 152 54 17 W	(74)	160	24 July 1978	ADF&G survey

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
SE Sitkinak 56 30 28 N 154 01 30 W	(86)	1,000	27 July 1978	ADF&G survey, hauled on gravel beach
NE Tugidak Island 56 36 05 N 154 28 55 W 56 31 35 N 154 27 25 W	(87)	4,660	2 Sept. 1976	ADF&G survey, hauled on gravel beaches and sand bars, many locations
SW Tugidak Island 56 27 04 N 154 46 35 W	(88)	9,300	31 Aug. 1976	ADF&G field camp, ground count, hauled on gravel beach
Aliulik Peninsula-west side 56 51 35 N 154 01 05 W	(89)	200	10 June 1978	ADF&G survey, hauled on tidal rocks, many locations
Cape Hepburn 56 52 25 N 154 05 08 W	(90)	50	2 May 1977	ADF&G survey, hauled on tidal rocks
Deadman Bay 57 04 18 N 154 56 38 W	(91)	100	-	Sears and Zimmerman (1977)
Middle Reef 56 54 36 N 154 02 28 W	(92)	150	2 May 1977	ADF&G survey, hauled on tidal rocks
Sukhoi Lagoon 56 56 52 N 154 20 43 W	(93)	350	28 Aug. 1978	ADF&G aerial survey, hauled on sand bar
Ayakulik Island 57 13 03 N 154 35 00 W	(94)	75	-	Sears and Zimmerman (1977)
Ayakulik River 57 12 17 N 154 32 30 W	(95)	100	9 Oct. 1976	Hauled on mainland gravel beach, ADF&G survey
Alf Island-Uyak Bay 57 24 45 N 153 49 50 W	(96)	250	1 Sept. 1978	Hauled on gravel spit, ADF&G survey

Table 4 (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Cape Hepburn 56 52 25 N 154 05 08 W	(90)	50	2 May 1977	ADF&G survey, hauled on tidal rocks
Deadman Bay 57 04 18 N 154 56 38 W	(91)	100	-	Sears and Zimmerman (1977)
Middle Reef 56 54 36 N 154 02 28 W	(92)	150	2 May 1977	ADF&G survey, hauled on tidal rocks
Sukhoi Lagoon 56 56 52 N 154 20 43 W	(93)	350	28 Aug. 1978	ADF&G aerial survey, hauled on sand bar
Ayakulik Island 57 13 03 N 154 35 00 W	(94)	75	-	Sears and Zimmerman (1977)
Ayakulik River 57 12 17 N 154 32 30 W	(95)	100	9 Oct. 1976	Hauled on mainland gravel beach, ADF&G survey
Alf Island-Uyak Bay 57 24 45 N 153 49 50 W	(96)	250	1 Sept. 1978	Hauled on gravel spit, ADF&G survey
Zachar Bay-Head 57 32 31 N 153 42 18 W	(97)	30	5 Nov. 1976	ADF&G survey
Spiridon Bay-Head 57 36 50 N 153 35 41 W	(98)	50	5 Nov. 1976	ADF&G survey
SW and SE Chirikof Island 155 32 45 W 55 48 16 N 155 43 50 W	(99,100)	353	30 June 1978	ADF&G survey, hauled on offshore rocks, many locations

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Zachar Bay-Head 57 32 31 N 153 42 18 W	(97)	30	5 Nov. 1976	ADF&G survey
Spiridon Bay-Head 57 36 50 N 153 35 41 W	(98)	50	5 Nov. 1976	ADF&G survey
SW and SE Chirikof Island 155 32 45 W 55 48 16 N 155 43 50 W	(99,100)	353	30 June 1978	ADF&G survey, hauled on offshore rocks, many locations

Table 5. Listing of major harbor seal concentrations along the Alaska Peninsula coast of Shelikof Strait; Cape Douglas to Wide Bay*.

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Alinchak Bay 57 45 50 N 155 15 00 W	(101)	200	16 June 1976	ADF&G survey
Puale Bay 57 41 40 N	(102)	150	24 June 1978	Hauled on tidal rocks, ADF&G survey
Wide Bay 57 23 40 N 155 12 00 W	(103)	117	24 June 1978	Hauled on rocks and islands at mouth of bay, ADF&G survey

* Coverage of this area was extremely sparse.

REPRODUCTION

Pupping

Pupping activities of harbor seals in the Gulf of Alaska were not restricted to large discrete rookeries. Pupping seemed to take place at nearly all locations where animals hauled out. Major hauling areas where many pups were born included: Disenchantment Bay, Icy Bay, Copper River Delta, Aialik Bay, Harris Bay, McCarty Arm, Augustine Island, Seal Island, Ugak Island and Tugidak Island.

Observations on Tugidak Island in 1976 and 1978 showed that most pups were born between 5 and 25 June. The height of pupping activity was about 15 June. Collecting activities in other areas of the western Gulf of Alaska supported these observations. Between 20 and 27 May 1977, 23 reproductive females were collected. Twenty-one were pregnant and two were postpartum. All 19 mature females collected from 21 June to 1 July 1978 had already given birth. Pupping in the eastern Gulf of Alaska may be about one week earlier. Numerous mother-pup pairs were seen in the Yakutat-Icy Bay area between 28 May and 1 June 1976. In the Prince William Sound-Copper River Delta area pupping began about 20 May, peaked during the first week of June and was completed by early July (Pitcher 1977).

Premature pupping was documented in the Gulf of Alaska. The remains of a pup were found in Kamishak Bay on 8 April 1978. Another dead, premature pup was found in Alitak Bay on 2 May 1977. Premature pups were seen on Tugidak Island on 28 April, 2 May and 8 May 1978. It appeared that all early pups were abandoned by the female and died. Premature pupping was observed on Tugidak Island in 1964 by Bishop (1967) who believed that desertion by the female was the rule in instances of early pupping.

Lactation and Weaning

Seventeen of 19 postpartum females collected between 21 June and 1 July were lactating. The other two had apparently completed lactation. An adult female collected on 30 July 1978 had produced a pup earlier in the summer and was not lactating. These data are not sufficient to determine the length of the lactation period, but do appear to fit within the ranges presented in the literature: Bishop (1967), 3 weeks; Bigg (1969), 5-6 weeks; Knudtson (1974), 5-6 weeks and Johnson (1976), 3-5 weeks. Johnson (1976) reported a gradual weaning period of about 1 week.

Ovulation

Ovulation in harbor seals reportedly takes place shortly after weaning in reproductive females (Fisher 1954, Bishop 1967 and Bigg 1969). None of 25 lactating females collected during this study had ovulated. A postpartum female collected on 21 June 1978 was not lactating and had a newly formed corpus luteum. The rupture site on the outside of the ovary was visible. Another nonlactating, postpartum female collected on

28 June had a single large follicle (16 mm in diameter) and was apparently nearing ovulation. Four females which had never pupped (4-6 years old) were collected between 21 and 23 June. All had large follicles (7, 14, 18 and 19 mm in diameter) and appeared to be nearing ovulation. Two mature females collected on 30 July 1974 had ovulated. From these observations it appears that ovulation occurs between mid-June and mid to late July.

Delay of Implantation

Thirteen mature females collected between 30 July and 9 September were apparently all in the delay of implantation as each had an ovary with a corpus luteum but no visible evidence of embryos or implantation sites in the uteri. Five of 6 mature females collected between 6 and 12 October either had newly implanted embryos (<0.1 g) or developing implantation sites. A female collected on 6 October was apparently still in the delay as no sign of an implantation site was visible, while a large, normal appearing corpus luteum was present in one ovary. Four of 5 mature females taken between 29 and 31 October had implanted embryos. The other appeared to be in the process of implantation as there was a small swelling in one uterine horn. All twelve mature females collected between 5 and 10 November had implanted embryos. These observations indicated that implantation occurs during October, primarily early in the month. It appears that the period of delayed implantation is approximately 11 weeks.

Literature reports for length of delay of implantation in harbor seals are: Fisher (1954), 11 weeks; Harrison (1960), 2 to 3 months; Bishop (1967), 1.5 to 2 months; and Bigg (1969), 2 months.

Female Age of Sexual Maturity

Age at first ovulation (Bigg 1969) and age at which a female first produces offspring (McLaren 1958) are the two criteria commonly used to assign age of sexual maturity. The age at which offspring are first produced (productive maturity) is more meaningful when population dynamics are the primary concern. Nonetheless age of first ovulation can be more accurately determined (it requires less interpretation during ovarian analysis) and this parameter may have value as an indicator of population status.

Female harbor seals collected during this study ovulated for the first time between the ages of 3 and 7 years. The average age (with 95% confidence limits) of first ovulation was estimated at 4.96 ± 0.43 years using the technique of DeMaster (1978). Productive maturity, or the average age of first pregnancy, was calculated at 5.51 ± 0.46 years. Initial pregnancies occurred between 4 and 9 years of age.

Average ages of first ovulation and initial pregnancy calculated from data presented by Bigg (1969) for harbor seals in British Columbia and Pitcher (1977) for seals in Prince William Sound were significantly lower ($P<0.05$) than for those collected in the Gulf of Alaska during this study (Figure 5). The reasons for these differences are not known, but they may be related to differences in population status at the times the collections were made. Age of sexual maturity in many species generally drops when population levels are reduced and may serve as an indicator of population status (Sergeant 1966, 1973; Eberhardt 1977; Laws 1959).

Ovulation and Pregnancy Rates

Age specific ovulation and pregnancy rates were calculated after examination of 194 female reproductive tracts (Table 6). Pregnancy rates were based only on those animals collected between implantation and ovulation because of the findings of Bigg (1973) who demonstrated that a normal appearing corpus luteum persisted for several months after ovulation even if fertilization did not occur.

Ovulation rates increased from 7% at 3 years to 100% by 7 years. Every female 7 years old and older had ovulated during the reproductive year in which it was collected. Pregnancy rates increased from 17% at 4 years to 100% at 8 years old. The pregnancy rate for females 8 years old and older was 92%. Bigg (1969) reported a pregnancy rate of 97% for animals of comparable ages from British Columbia. Pitcher (1977) found that all 15 females, 8 years old and older, taken in Prince William Sound were pregnant. These rates did not differ significantly ($P>0.10$) from those in this study.

Reproductive Failures

Reproductive failures in pinnipeds have been classified in three categories (Craig 1964; 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 in which the fetus was expelled from the uterus.

Reproductive failures were found in 14 (10.6%) of 132 reproductive females collected between implantation and birth (Table 7). The most common reason for failure was abortions (6) followed by missed pregnancies (4) and resorptions (1). Seven (50%) of these failures occurred during initial pregnancies. Of five initial failures which could be classified to cause, four were missed pregnancies. This appears to follow the same pattern described by Craig (1964) in northern fur seals (*Callorhinus ursinus*). Craig found that missed pregnancies were most common in young females whereas abortions and resorptions occurred in all ages.

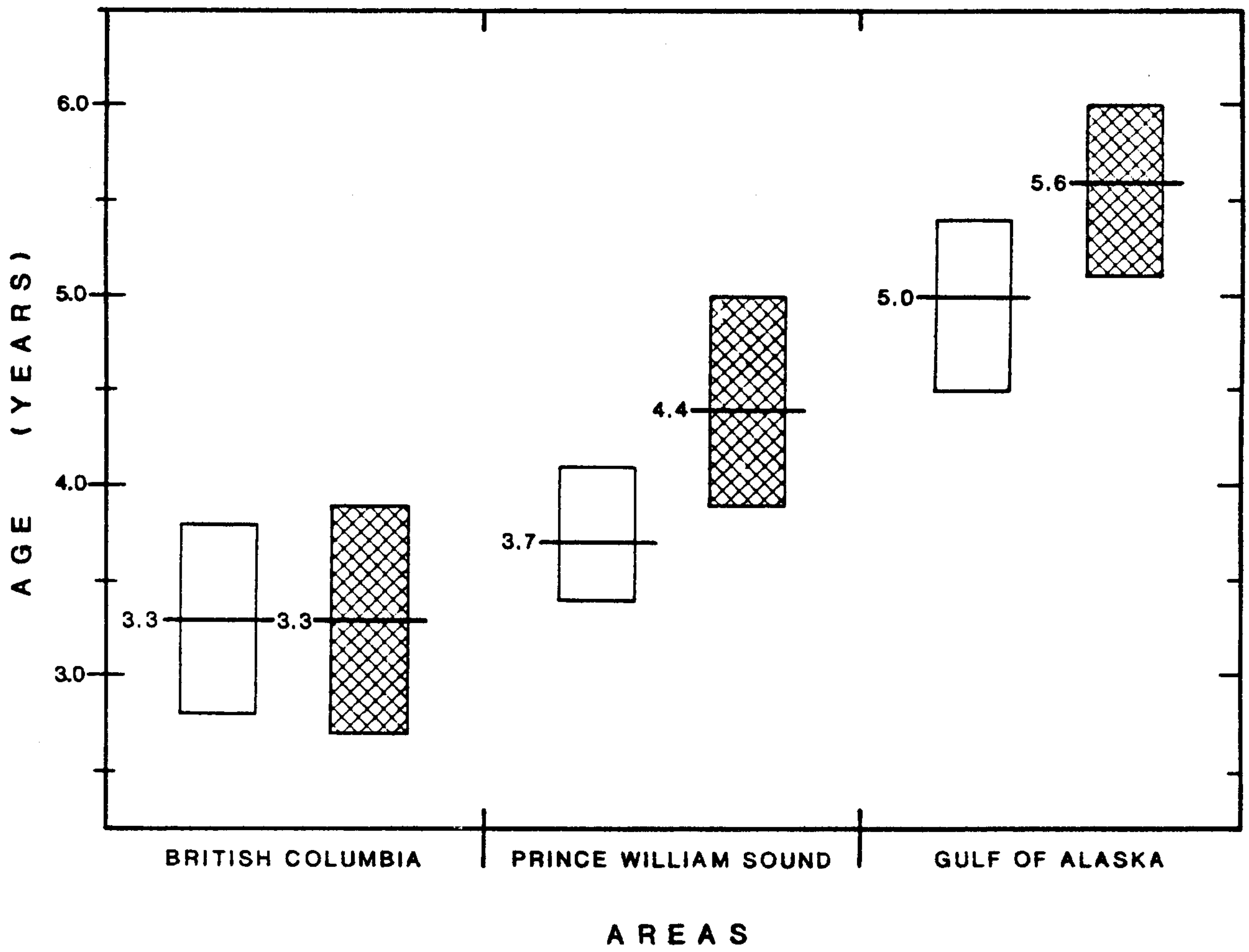

FIGURE 5. MEAN AGES OF FIRST OVULATION AND FIRST PREGNANCY OF HARBOR SEALS COLLECTED IN BRITISH COLUMBIA (BIGG 1969), PRINCE WILLIAM SOUND (PITCHER 1977) AND THE GULF OF ALASKA. HORIZONTAL LINE, MEAN; BOX, 95% CONFIDENCE INTERVAL; ▭, OVULATION; ▩, PREGNANCY.

Table 6. Ovulation and pregnancy rates for female harbor seals collected in the Gulf of Alaska.

Age	Number in Sample	Number Ovulated	Ovulation Rate (%)	Number in Sample	Number Pregnant	Pregnancy Rate (%)
0-12 months	14	0	0	14	0	0
1 year	11	0	0	11	0	0
2	4	0	0	4	0	0
3	14	1	7	13	0	0
4	12	6	50	12	2	17
5	10	8	80	8	5	63
6	8	7	88	8	7	88
7	9	9	100	9	8	89
8	6	6	100	6	6	100
9	17	17	100	17	15	88
10	14	14	100	14	11	79
11-15	35	35	100	33	32	97
16-20	20	20	100	16	15	94
21-25	16	16	100	15	15	100
26-30	4	4	100	3	2	67
TOTALS	194	143		183	119	

Table 7. Summary of reproductive failures in female harbor seals collected in the Gulf of Alaska.

Age of Female	Initial Pregnancy	Missed Pregnancy	Resorption	Abortion	Indeterminable
4 yrs.	yes	X			
4	yes	X			
4	yes	X			
4	yes	X			
5	yes			X	
7	yes				X
9	no				X
9	yes			X	
10	no			X	
10	no			X	
10	no				X
12	no			X	
18	no		X		
30	no			X	

Male Age of Sexual Maturity and Seasonal Spermatogenic Activity

Sexual maturity in males was defined as the presence, in quantity, of epididymal sperm (Hewer 1964; Bigg 1969). During adolescence small quantites of sperm are present. However, because high concentrations of sperm are necessary for fertilization (Laws 1956) these animals cannot be considered mature.

Males were considered mature if abundant epididymal sperm were present during the period of 20 May through 31 July which brackets the normal ovulation period of female harbor seals in the area. The youngest mature male was 5 years old (Table 8). Thirty of 31 males older than 6 years had abundant epididymal sperm. The one exception was a 22 year old animal collected on 27 May. In Prince William Sound males matured between 3 and 7 years of age (Pitcher 1977); in British Columbia they matured between 3 and 6 years, most by 5 years (Bigg 1969).

Sperm were not found in the epididymides of mature (7 years old or older) males between 9 October and 11 February (Table 9). All but one of 31 mature males had abundant sperm from 20 May through 31 July. Considerable individual variation was apparent in both initiation and cessation of sperm production. Most males were apparently capable of breeding in advance and probably somewhat beyond the normal ovulation period of females.

Table 8. Age of sexual maturity in 54 male harbor seals based on the presence of abundant epididymal sperm during the period of 20 May-31 July.

Age	No. of Males	(Epididymal sperm) Absent	Trace	Abundant	Mature %
0-12 mos.	3	3			0
1 year	1	1			0
2	7	7			0
3	4	4			0
4	4	2	2		0
5	1		1		0
6	3	1	1	1	33
7	3			3	100
8	2			2	100
9	1			1	100
10	1			1	100
11-15	16			16	100
16-20	5			5	100
21-26	3			2	67

Table 9. Seasonal spermatogenic activity in male harbor seals, 7 years and older, collected in the Gulf of Alaska.

Time Period	No. of Animals	(Epididymal Sperm) None	Trace	Abundant	Percentage with Abundant Sperm
7-11 February	2	2			0
18-25 March	18	11	4	3	17
8-25 April	32	4	4	24	75
20 May-31 July	31	1		30	97
28 Aug.-9 Sept.	4	3		1	25
9-12 October	3	3			0
5-10 November	6	6			0

GROWTH

Birth Size

Weights and measurements were obtained from 23 near-term fetuses and newly born pups in the Kodiak Island area which were collected between 20 May and 10 June. Mean standard lengths were 78.6 $\pm$ 2.7 cm (95% C.L.) for males and 76.5 $\pm$ 1.9 cm for females. Mean weights were 12.0 $\pm$ 1.0 kg for males and 11.5 $\pm$ 0.6 kg for females. No significant differences were apparent (P>0.1) between sexes for either length or weight. With both sexes combined, mean standard length was 77.7 $\pm$ 1.7 cm and mean weight was 11.7 $\pm$ 0.61 kg.

Weights and measurements were also obtained from seven near term fetuses and newly born pups collected between 28 May and 1 June in NEGOA, primarily the Icy Bay area. Average standard length (both sexes) was 73.0 $\pm$ 4.7 cm and average weight was 10.0 $\pm$ 1.7 kg. A t-test was used to test for differences between this sample and that obtained from Kodiak. Both mean weight and length were significantly less (P<0.05) for the NEGOA sample.

Bigg (1969) presented a summary of birth lengths and weights from his research and a literature review. Average length and weight for males and females combined from his British Columbia sample were 81.6 $\pm$ 6.2 cm and 10.2 $\pm$ 1.5 kg, respectively.

Postnatal Growth

Insight into growth during the first year of life was gained through examination of weights and measurements from 20 seals between the ages of birth and 12 months collected in the Kodiak area (Figure 6). Initial rapid growth occurred. Bigg (1969) found that pups more than doubled their weight during the suckling period. Rate of growth then decreased, possibly reflecting difficulty associated with nutritional independence (Pitcher 1977).

Growth patterns of harbor seals collected in Kodiak waters are portrayed in Figures 7 and 8. Growth, as measured by standard length, was rapid for both sexes through 4 to 5 years of age. Growth slowed after this and by 7 years of age skeletal growth appeared to be completed. Weight increased rapidly through about 5 years of age and then more slowly until 10 years. Little if any weight gain occurred after this.

The average standard length for adult male harbor seals (7 years old and older) for all areas of the Gulf of Alaska was 155.4 $\pm$ 1.4 cm (95% C.L.). The average length for females was 144.8 $\pm$ 1.1 cm. Adult males were significantly longer than adult females (P<0.001). The same pattern persisted in all geographic areas where adequate samples sizes were available (Tables 10 and 11).

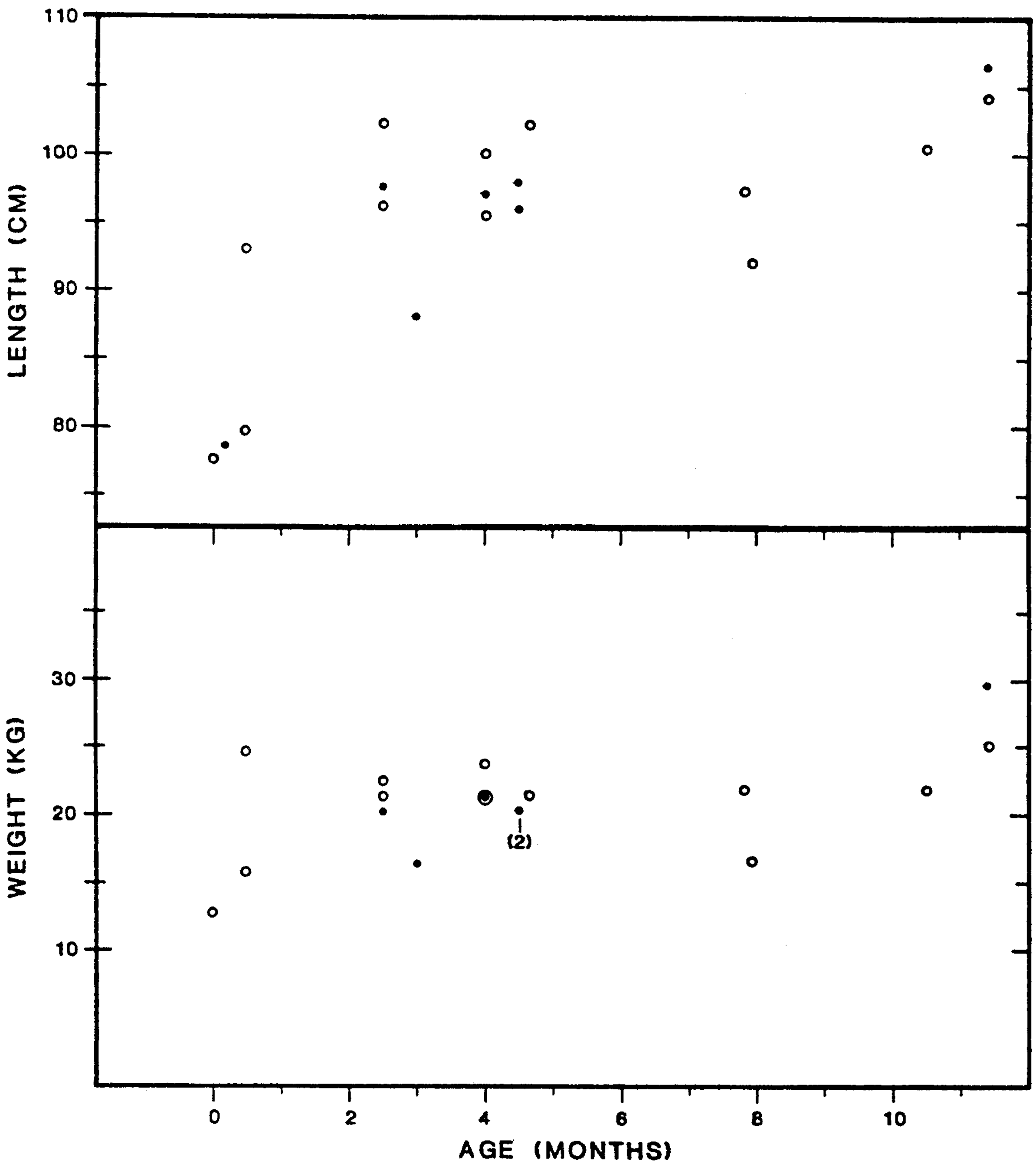

FIGURE 6. FIRST YEAR BODY GROWTH IN STANDARD LENGTH AND WEIGHT FOR 20 HARBOR SEALS COLLECTED IN THE KODIAK ISLAND AREA. •, MALE; o, FEMALE.

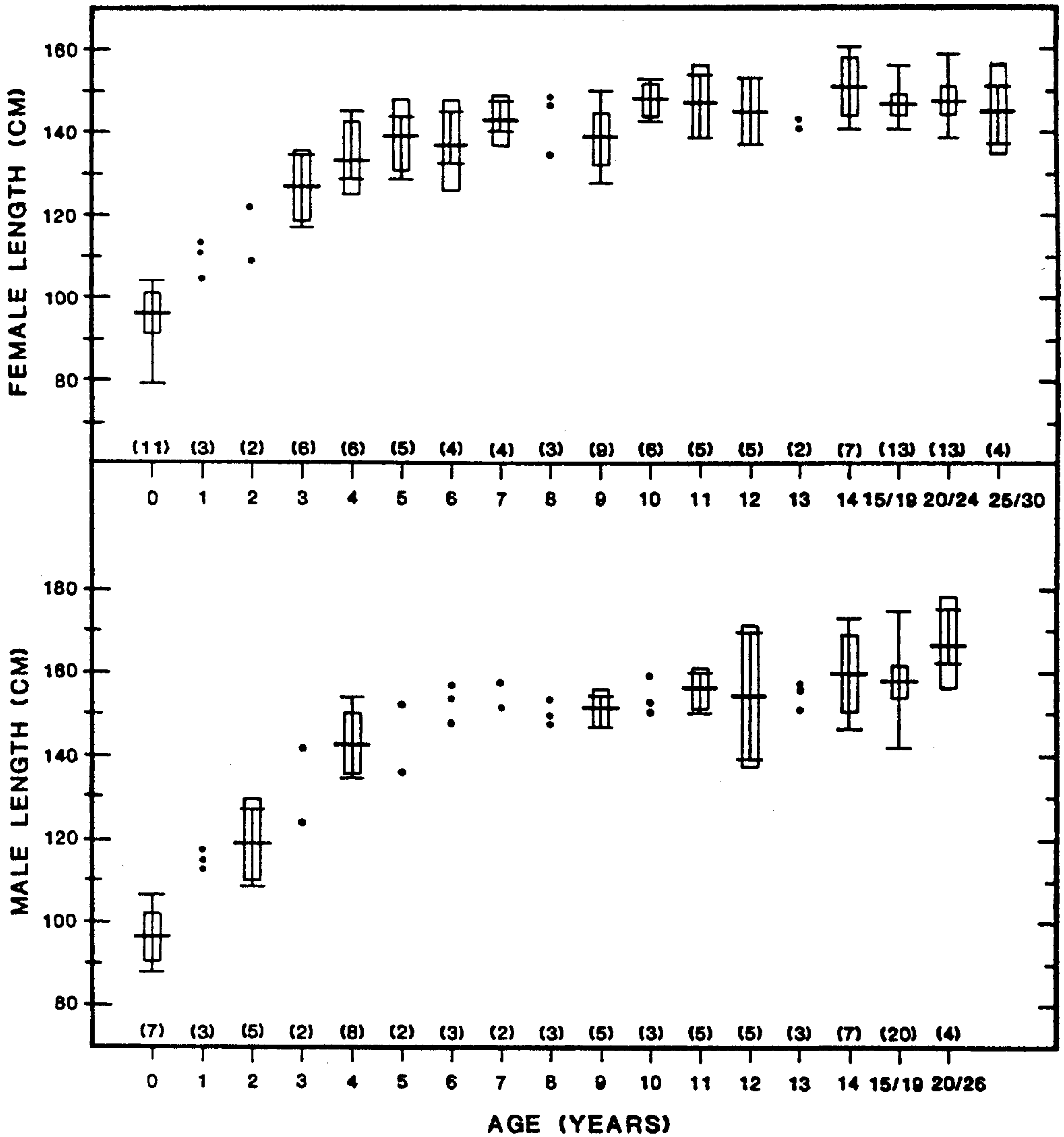

FIGURE 7. STANDARD LENGTHS OF MALE AND FEMALE HARBOR SEALS FROM THE KODIAK AREA BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE INTERVAL; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL LENGTHS OF SAMPLE SIZE <4.

Table 10. Comparison of standard lengths of adult harbor seals (7 years old and older) collected in various localities in the Gulf of Alaska. Data points are means with 95% confidence limits.

Area	Sample Size MM	Sample Size FF	Standard Length (cm) MM	Standard Length (cm) FF
Icy and Yakutat Bays	*	8	*	138.2 ± 4.4
Prince William Sound	30	20	154.4 ± 2.8	144.0 ± 2.5
Kenai coast	17	19	156.0 ± 2.0	146.4 ± 2.7
Lower Cook Inlet	8	9	148.9 ± 5.5	138.9 ± 2.6
Kodiak area	57	71	157.1 ± 2.1	145.8 ± 1.5
Alaska Peninsula	*	7	*	147.9 ± 5.8
TOTAL	112	134	155.4 ± 1.4	144.8 ± 1.1

* N < 4

Table 11. Summary of statistical comparisons between male and female standard lengths and weights. Results are from t-tests. Tests indicating significant differences ($P < 0.05$) are underlined.

Area	Statistical Significance Standard Length	Statistical Significance Weight
Prince William Sound	<u>P < 0.001</u>	P > 0.10
Kenai coast	<u>P < 0.001</u>	P > 0.10
Lower Cook Inlet	<u>P < 0.001</u>	P > 0.05
Kodiak	<u>P < 0.001</u>	<u>P < 0.01</u>
All areas combined	<u>P < 0.001</u>	<u>P < 0.001</u>

Mean weights were also significantly greater ($P<0.01$) for adult male harbor seals (10 years old and older) than those for females; at 84.6 ± 2.1 kg and 76.5 ± 3.0 kg, respectively. However, the heaviest seal weighed during this study was a pregnant female at 127.5 kg. Significant differences in weights between sexes did not persist for most geographic areas (Tables 11 and 12) because of the large variance and small sample sizes.

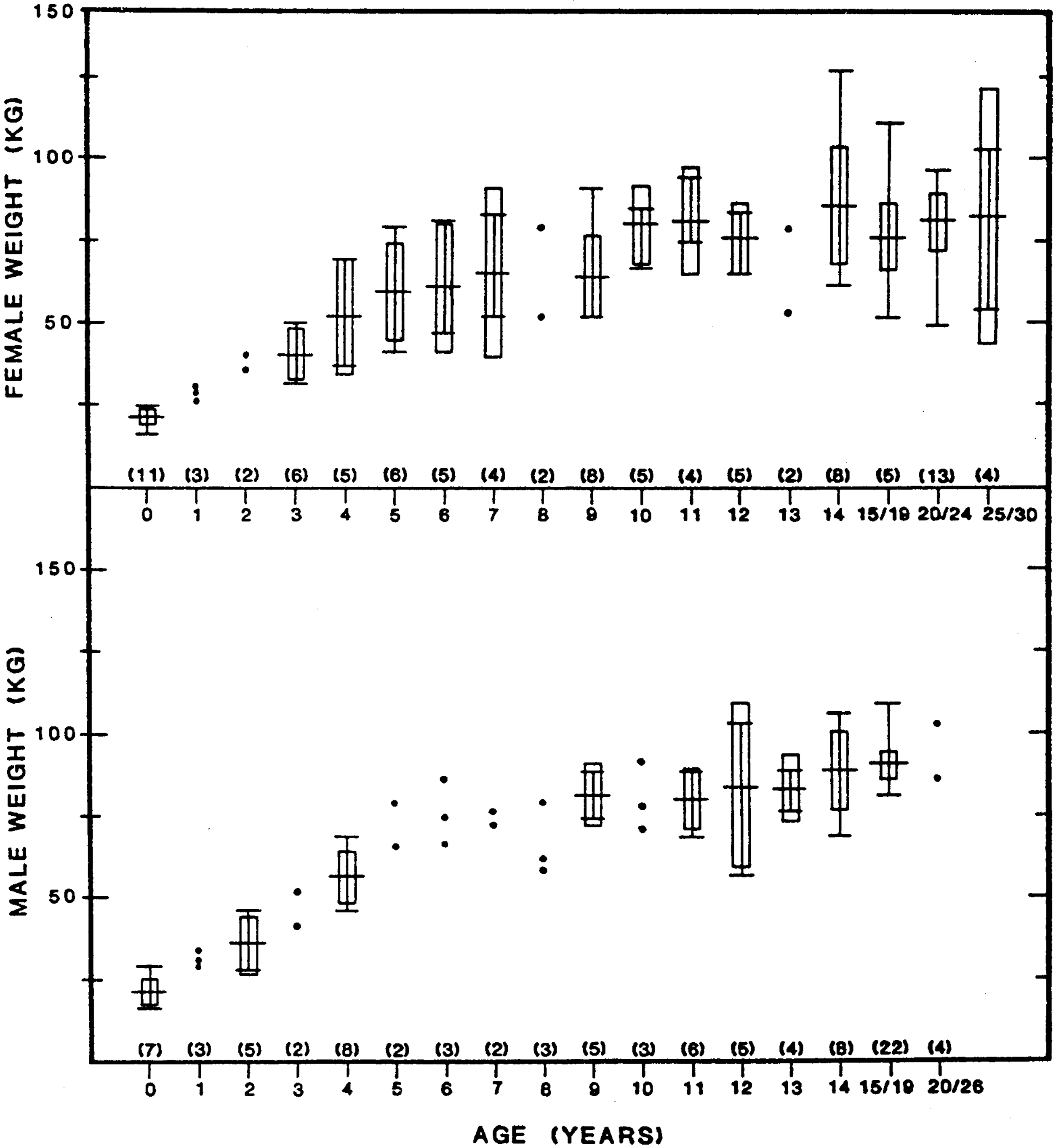

FIGURE 8. WEIGHTS OF MALE AND FEMALE HARBOR SEALS FROM THE KODIAK AREA BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE INTERVAL; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL WEIGHTS OF SAMPLE SIZE <4.

Table 12. Comparision of weights of adult harbor seals (10 years old and older) collected in various localities in the Gulf of Alaska. Data points are means with 95% confidence limits.

Area	Sample Size MM	Sample Size FF	Weight (kg) MM	Weight (kg) FF
Icy and Yakutat Bays	*	6	*	64.4 ± 19.2
Prince William Sound	9	8	78.2 ± 7.4	72.9 ± 12.5
Kenai coast	12	11	80.4 ± 6.1	80.5 ± 5.6
Lower Cook Inlet	6	8	83.6 ± 10.8	69.4 ± 10.8
Kodiak area	50	54	87.2 ± 3.1	79.8 ± 4.0
Alaska Peninsula	*	6	*	64.9 ± 14.8
TOTAL	77	93	84.6 ± 2.1	76.5 ± 3.0

* N < 4

Geographic comparisons of adult body size showed some distinct differences (Figure 9). Standard lengths (Table 10) of adult males showed significant differences among some areas ($P<0.05$). Males from Kodiak, Kenai and Prince William Sound were similar in size and did not differ significantly ($P>0.10$). Males from lower Cook Inlet were significantly shorter than males from Kodiak and Kenai ($P<0.05$). Females from Prince William Sound, Kenai, Kodiak and the Alaska Peninsula were of similar size while those from Icy and Yakutat Bays and lower Cook Inlet were considerably smaller ($P<0.01$).

Weights (Table 12) of adult males were significantly different ($P<0.05$) among some areas. Kodiak males were the heaviest and Prince William Sound animals were the lightest. The only significant differences were between these extremes. Weights of adult females were also significantly different ($P<0.05$) among areas. The lightest animals were from Icy and Yakutat Bays and the heaviest were from Kodiak and Kenai.

Length appears to be a much better measure of physical size than weight. Fatness, and consequently weight varies seasonally but length changes only with skeletal growth. Individual variation is much greater with weight than with length, making statistical comparisons of weight less precise.

PHYSICAL CONDITION

Blubber thickness was measured for each collected animal. The amount of blubber was assumed to be an indicator of physical condition. In order to compare populations over time and between areas it was necessary to consider the effects of sex, age and season on blubber thickness. To eliminate confounding effects of attaining nutritional independence and sexual maturity, analyses were restricted to animals $\geq$ 7 years old which formed the largest segment of our sample. Blubber thickness for males and females was examined separately because females were significantly

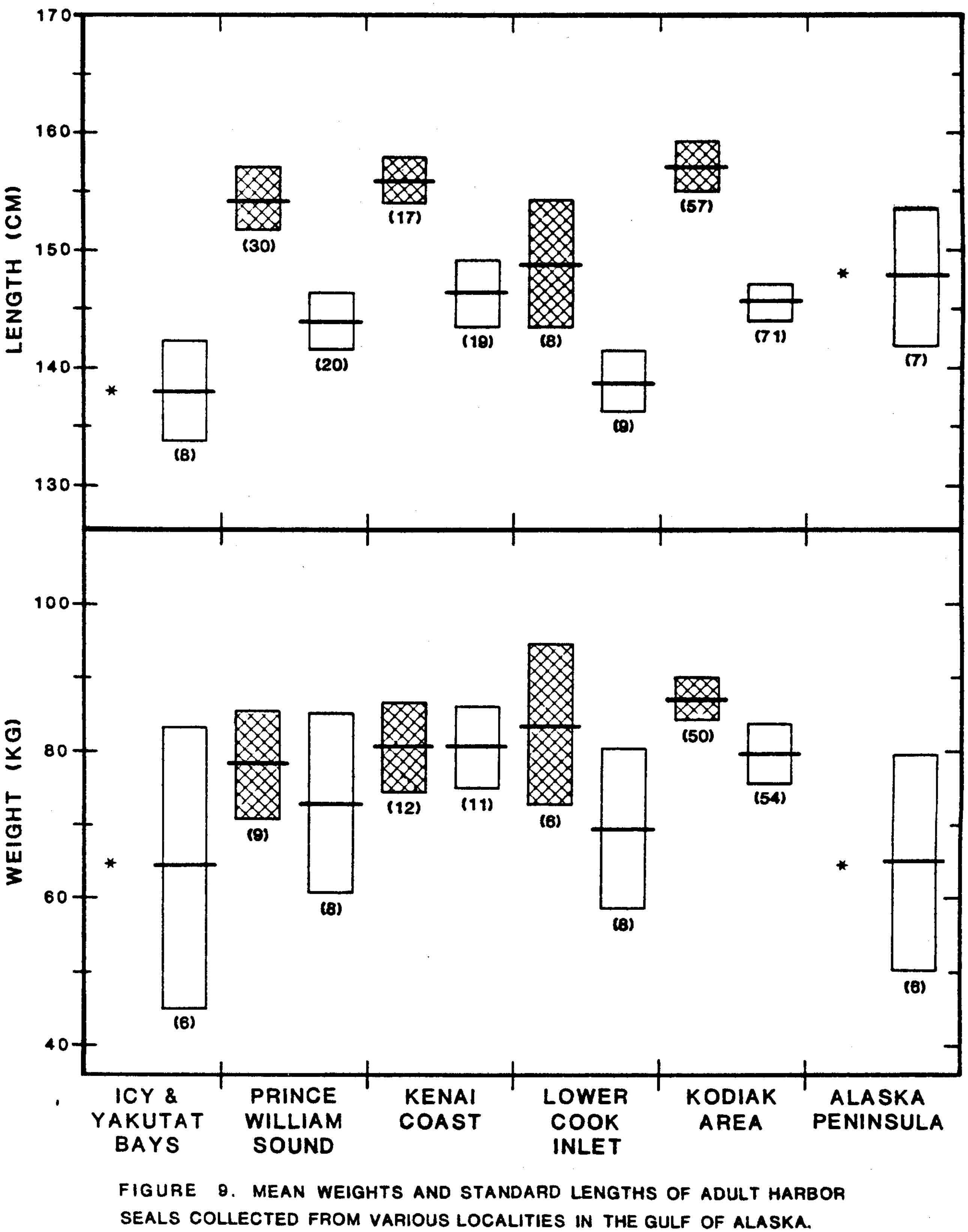

FIGURE 9. MEAN WEIGHTS AND STANDARD LENGTHS OF ADULT HARBOR SEALS COLLECTED FROM VARIOUS LOCALITIES IN THE GULF OF ALASKA. ▨, MALE; ▭, FEMALE; BOX, 95% CONFIDENCE INTERVAL; HORIZONTAL LINE, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; *, SAMPLE SIZE <4.

(P<0.05) fatter than males. Seasonal patterns of blubber thickness showed high and relatively stable levels from November through mid-May (Figure 10), therefore samples from this period were combined for comparative purposes. Seals were thinner during summer months, probably as a result of the demands of lactation, breeding and molting. Lowest levels were reached during the period 15 July to 14 September when many animals were molting.

Analysis of variance tests were performed on blubber thickness of adult male and female harbor seals collected between 1 November and 15 May from various geographic areas and during different years (Table 13). Significant differences were found for both males (P<0.05) and females (P<0.001). These differences were solely the result of low values from animals collected in the Kodiak area during 1977. The cause of this difference is unknown, however, it demonstrates that year to year natural variation occurs.

Table 13. Comparison of blubber thickness of mature (≥ 7 years) male and female harbor seals collected from 1 November through 15 May from different areas and during different years in the Gulf of Alaska. Blubber thickness is presented as means with 95% confidence limits. Sample size in parenthesis.

Area	Year	Blubber Thickness (cm) Male	Blubber Thickness (cm) Female
Prince William Sound	1975	3.1 ± 0.48 (11)	3.9 ± 0.39 (10)
Kenai coast	1976	2.9 ± 0.51 (9)	3.8 ± 0.86 (4)
Kenai coast	1977	3.1 ± 0.45 (8)	3.7 ± 0.24 (15)
Lower Cook Inlet	1978	3.1 ± 0.87 (5)	3.4 ± 0.53 (5)
Kodiak	1976	3.0 ± 0.24 (22)	3.6 ± 0.33 (17)
Kodiak	1977	2.3 ± 0.26 (11)	2.3 ± 0.28 (14)

MOLT

Pelage samples from 325 harbor seals collected in the Gulf of Alaska were microscopically examined to determine stage of molt. Classification followed Scheffer and Johnson (1963) and the stages are described below.

Resting stage (telogen): Hair roots nearly colorless, little or no pigment in the bottom two-thirds of the follicles, club shaped hair roots. The early portion of the resting stage is considered "prime."

Beginning molt (anagen): Bulbs at bases of follicles are very dark. The highly pigmented new hair shafts do not extend beyond the skin surface.

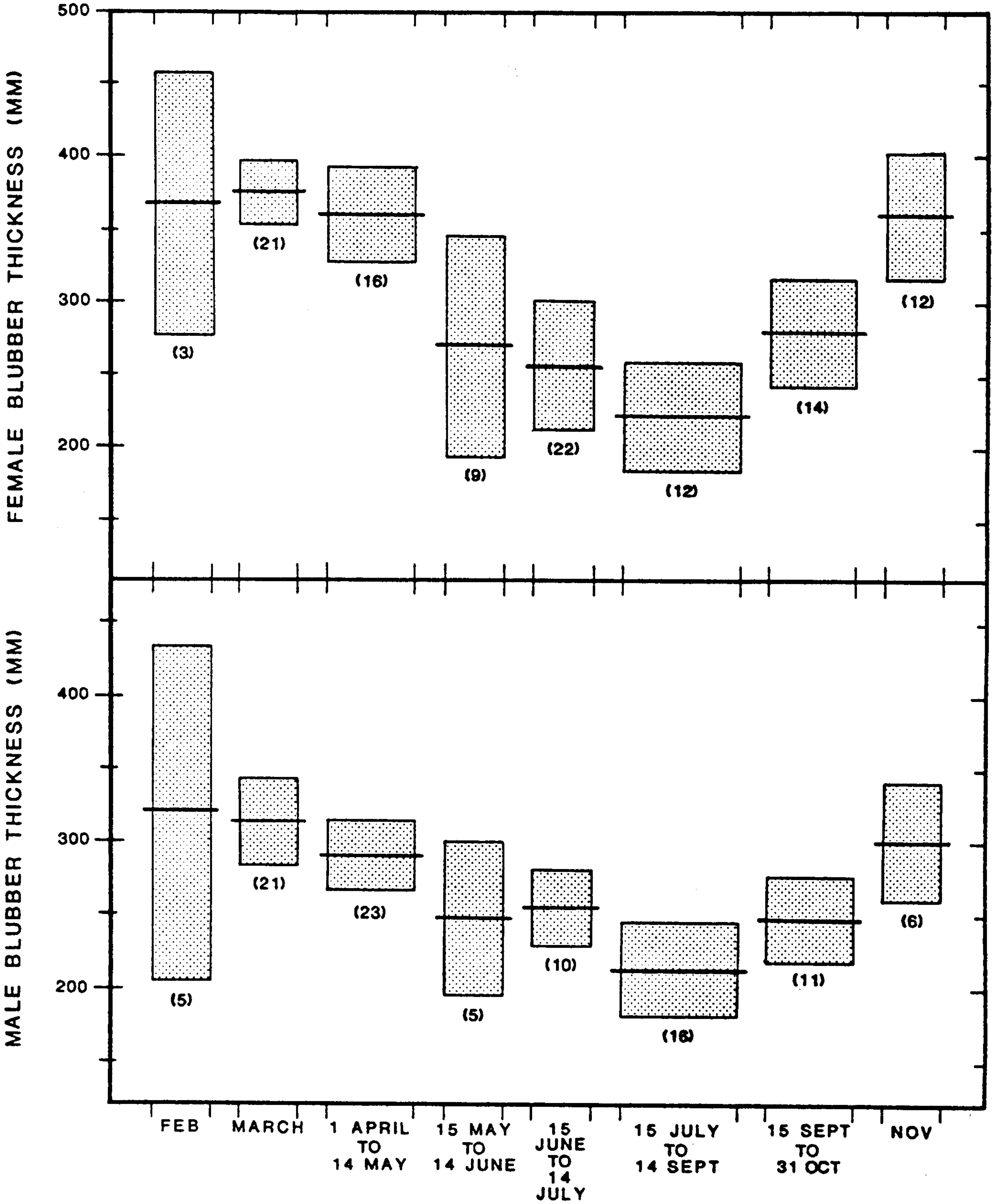

FIGURE 10. SEASONAL PATTERNS OF BLUBBER THICKNESS OF ADULT ($\geq$ 7 YEARS) HARBOR SEALS COLLECTED IN THE GULF OF ALASKA, EXCLUDING ANIMALS TAKEN IN THE KODIAK AREA IN 1977. HORIZONTAL LINE, MEAN; BOX, 95% CONFIDENCE INTERVAL; NUMBER IN PARENTHESIS, SAMPLE SIZE.

Early molt (anagen): Characterized by heavy pigmentation throughout the follicle. New guard hair shafts have grown beyond the skin surface, but do not extend beyond the underfur layer. Both old and new guard hairs present in many follicles.

Late molt (anagen): Pigment throughout the follicle, however, less dense than during early molt. New guard hairs nearly as long as old guard hairs. Rapid shedding of old guard hairs.

Ending molt (catagen): Follicles with light, but even distribution of pigment. No old guard hairs remaining.

The period of active molt began about 2 June and extended into early October (Table 14). The highest proportion of molting animals was found in late July (Figure 11). Sample sizes were too small and the sampling schedule inadequate to analyze timing of the molt by sex and age class and by geographic area. The one animal classified as being in end molt during the 20 June-2 July period was a pup less than 1 month old and obviously was completing the lanugo molt. The only animal found to be actively molting during October was a 15 year old male.

Table 14. Progression of the molt in 325 harbor seals of all ages and both sexes collected in the Gulf of Alaska.

Time Period	Stage of Molt									
	Resting		Beginning		Early		Late		End	
	#	%	#	%	#	%	#	%	#	%
7-11 Feb.	4	100	0	0	0	0	0	0	0	0
18-26 March	46	100	0	0	0	0	0	0	0	0
7 Apr.-10 May	75	100	0	0	0	0	0	0	0	0
20 May-1 June	69	100	0	0	0	0	0	0	0	0
20 June-2 July	37	73	11	22	2	4	0	0	1	2
29-30 July	1	14	5	71	0	0	0	0	1	14
27 Aug.-9 Sept.	18	82	2	9	0	0	1	5	1	5
6-14 Oct.	16	94	0	0	0	0	1	6	0	0
4-10 Nov.	29	100	0	0	0	0	0	0	0	0

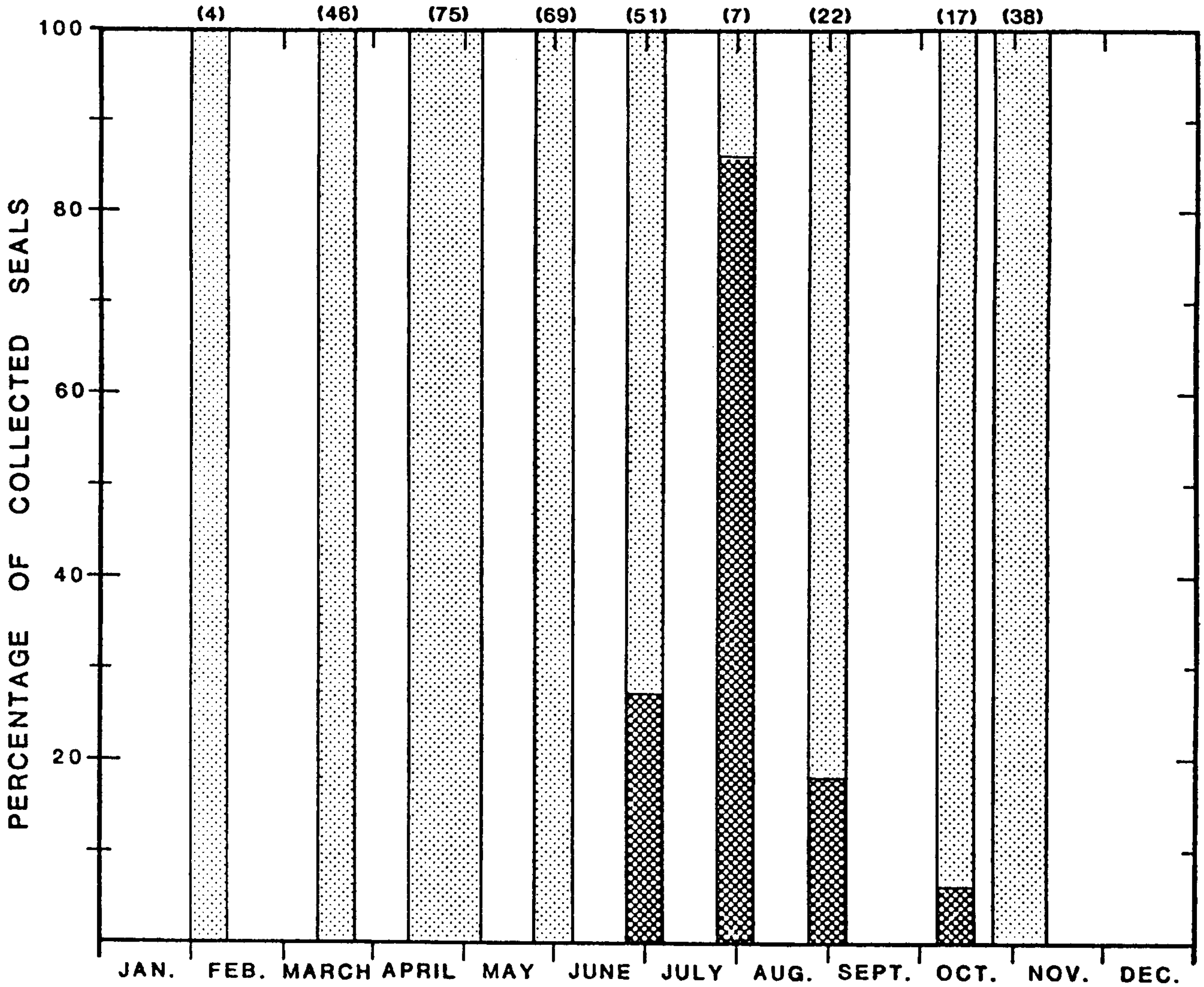

FIGURE 11. PROPORTIONS OF MOLTING HARBOR SEALS BY COLLECTING PERIOD IN THE GULF OF ALASKA. ALL AGES AND BOTH SEXES COMBINED. ▩ , MOLTING STAGE; ⬚ , RESTING STAGE; NUMBER IN PARENTHESIS, SAMPLE SIZE.

POPULATION CHARACTERISTICS

Sex Ratio

Sex ratios for various age categories of seals collected during this study are presented in Table 15. The only age category which had a significant deviation ($P<0.05$) from an even sex ratio was the oldest group (21-31 years) where 25 of 32 seals (78%) were females. These data agree closely with those of Bigg (1969); females comprised 53% of the postnatal seals and few males over 20 years were collected.

Table 15. Sex ratios of various age classes of harbor seals collected in the Gulf of Alaska

Age Classes	MM:FF Sex Ratio	Chi square	(P)
Fetal	41 : 51	0.55	>0.10
0 - 5 years	132 : 130	0.01	>0.90
5 - 10 years	63 : 86	1.79	>0.10
11 - 20 years	68 : 63	0.10	>0.10
21 - 31 years	7 : 25	5.50	<0.05
0 - 31 years	270 : 304	1.01	>0.10

Age Structure of the Sample

It appears that our sample did not accurately reflect age structure of the population below about 4 years of age (Figure 12). Young seals were particularly vulnerable to collecting and were therefore deliberately selected against. The oldest female was 31 years old and the oldest male was 26 years.

Mortality

KL_x series life tables (Caughley 1966) were constructed to examine mortality patterns. Because it appeared that animals were not fully represented in our sample until 4 years of age we deleted age classes 1-3 years in the analyses. Initial pup production was estimated from age specific pregnancy rates and age frequency distribution. Age frequencies were smoothed using probit regression (Caughley 1977). Assumptions basic to these life table analyses are that the initial size of each age class is equal and that age specific mortality and reproductive rates have remained constant over the range of age classes present. Neither assumption can be conclusively demonstrated, nevertheless we felt they were approximated and that it was valid to proceed. When frequency values for an age class dropped below five, life table calculations were stopped.

Mortality rates for both sexes were high from birth to 4 years; estimated at 74.2% for females and 79.2% for males (Tables 16 and 17). The mean annual mortality rate for females between 4 and 19 years was 11.4% and for males between 4 and 17 years, 12.7%. Mortality rates for both sexes reached minimal levels between about 8 and 13 years and then appeared to increase slightly. By combining sexes, the life table was extended to 23 years (Table 18) and an increase in mortality rate was apparent after 18 years. Although not shown by the life tables there is evidence that males in the older age classes have a considerably higher mortality rate than females. In a sample of 32 seals, between 21 and 31 years of age, only seven were males.

Table 16. Life table for male harbor seals collected in the Gulf of Alaska.

Age	Frequency*	Survival	Mortality	Mortality rate
0	89.30**	1.000	0.792	0.792
4 years	18.60	0.208	0.022	0.106
5	16.57	0.186	0.019	0.102
6	14.89	0.167	0.016	0.096
7	13.47	0.151	0.014	0.093
8	12.24	0.137	0.012	0.088
9	11.14	0.125	0.011	0.088
10	10.16	0.114	0.010	0.088
11	9.27	0.104	0.009	0.087
12	8.45	0.095	0.009	0.095
13	7.70	0.086	0.008	0.093
14	7.00	0.078	0.007	0.090
15	6.35	0.071	0.007	0.099
16	5.74	0.064	0.006	0.094
17	5.16	0.058		
>17	26.13			

* Age frequencies ≥ 4 years smoothed by probit curve.

** Estimated value based on age frequencies and age specific fecundity rates.

Bigg (1969) estimated average annual mortality of harbor seals between 5 years and the end of life at 29% for males and 15% for females. Values in the literature for adult mortality in other phocid seals are 14% for bearded seals, *Erignathus barbatus*, (Benjaminsen 1975); 8-10% for harp seals, *Pagophilus groenlandicus*, (Sergeant 1976); and Weddell seals, *Leptonychotes weddelli*, 15-20% for females and perhaps as high as 50% for males (Siniff et al. 1977).

Table 17. Life table for female harbor seals collected in the Gulf of Alaska.

Age	Frequency*	Survival	Mortality	Mortality rate
0	89.30**	1.000	0.742	0.742
4 years	23.04	0.258	0.028	0.109
5	20.55	0.230	0.023	0.100
6	18.50	0.207	0.019	0.092
7	16.76	0.188	0.017	0.090
8	15.24	0.171	0.015	0.088
9	13.90	0.156	0.014	0.090
10	12.70	0.142	0.012	0.085
11	11.60	0.130	0.011	0.085
12	10.60	0.119	0.011	0.092
13	9.68	0.108	0.009	0.083
14	8.83	0.099	0.009	0.091
15	8.03	0.090	0.008	0.089
16	7.28	0.082	0.008	0.098
17	6.58	0.074	0.008	0.108
18	5.91	0.066	0.007	0.106
19	5.28	0.059		
>19	23.80			

* Age frequencies $\geq$ 4 years smoothed by probit curve.

** Estimated value based on age frequencies and age specific fecundity rates.

FOOD HABITS

Stomachs from 357 seals were examined for food during this study. Food was present in 172 stomachs. Data previously collected on harbor seal food habits from Prince William Sound (Pitcher 1977) were also included in these analyses to expand coverage of geographic variations.

All Areas and Seasons Combined

Analysis of prey utilization with all areas and all seasons combined (Table 19) showed that fishes comprised 73.8%, cephalopods 22.2% and decapod crustaceans 4.1% of the occurrences of prey items. Cephalopods included both octopus (*Octopus* sp.) and squids of the family Gonatidae. Decapod crustaceans were primarily shrimps with one occurrence of a crab. A minimum of 27 species of fishes were eaten belonging to 13 families. Major prey items were ranked (Table 20) using a modified Index of Relative Importance. The top three prey taken by harbor seals in the Gulf of Alaska were walleye pollock (*Theragra chalocogramma*), octopus and capelin (*Mallotus villosus*).

Area Comparisons of Prey Utilization

Table 21(A-F) is a presentation of prey utilization by harbor seals according to area of collection. In all areas except Kodiak and Prince William Sound, sample sizes were small and the collections did not have

Table 18. Life table for harbor seals, both sexes combined, collected in the Gulf of Alaska.

Age	Frequency*	Survival	Mortality	Mortality rate
0	178.60**	1.000	0.767	0.767
4 years	41.65	0.233	0.025	0.107
5	37.12	0.208	0.021	0.101
6	33.40	0.187	0.018	0.096
7	30.23	0.169	0.015	0.089
8	27.48	0.154	0.014	0.091
9	25.05	0.140	0.012	0.086
10	22.86	0.128	0.011	0.086
11	20.87	0.117	0.010	0.085
12	19.06	0.107	0.010	0.093
13	17.38	0.097	0.008	0.082
14	15.83	0.089	0.008	0.090
15	14.38	0.081	0.008	0.099
16	13.02	0.073	0.007	0.096
17	11.74	0.066	0.007	0.106
18	10.53	0.059	0.006	0.102
19	9.38	0.053	0.007	0.132
20	8.30	0.046	0.005	0.109
21	7.26	0.041	0.006	0.146
22	6.27	0.035	0.005	0.143
23	5.32	0.030		
>23	14.02			

* Age frequencies $\geq$ 4 years smoothed by probit curve.
** Estimated value based on age frequencies and age specific fecundity rates.

complete seasonal coverage, therefore, caution must be applied when making comparisons. Either walleye pollock or octopus was the top ranked food item in all areas. Walleye pollock was the top ranked item in the three eastern areas i.e., Northeastern Gulf of Alaska, Prince William Sound and Kenai coast. In the three western areas i.e., Lower Cook Inlet, Kodiak Island and Alaska Peninsula, octopus had the highest ranking. In lower Cook Inlet, invertebrates (i.e. octopus and shrimps) made up over 60% of both occurrences and volumes.

In two areas, Kodiak Island and Prince William Sound, where larger samples and fairly complete seasonal coverage were obtained we statistically compared occurrences of some major prey species between these areas (Table 22). In Prince Willian Sound more pollock ($P<0.001$) were eaten while in Kodiak higher utilization of capelin ($P<0.05$) occurred. Octopus and Pacific cod (*Gadus macrocephalus*) were not utilized at significantly different rates ($P>0.05$). While samples were too small for statistical testing, it appeared that a higher proportion of squids and herring were eaten in Prince William Sound and more Pacific sandlances (*Ammodytes hexapterus*), flatfishes and sculpins were preyed upon in the Kodiak area (Table 22).

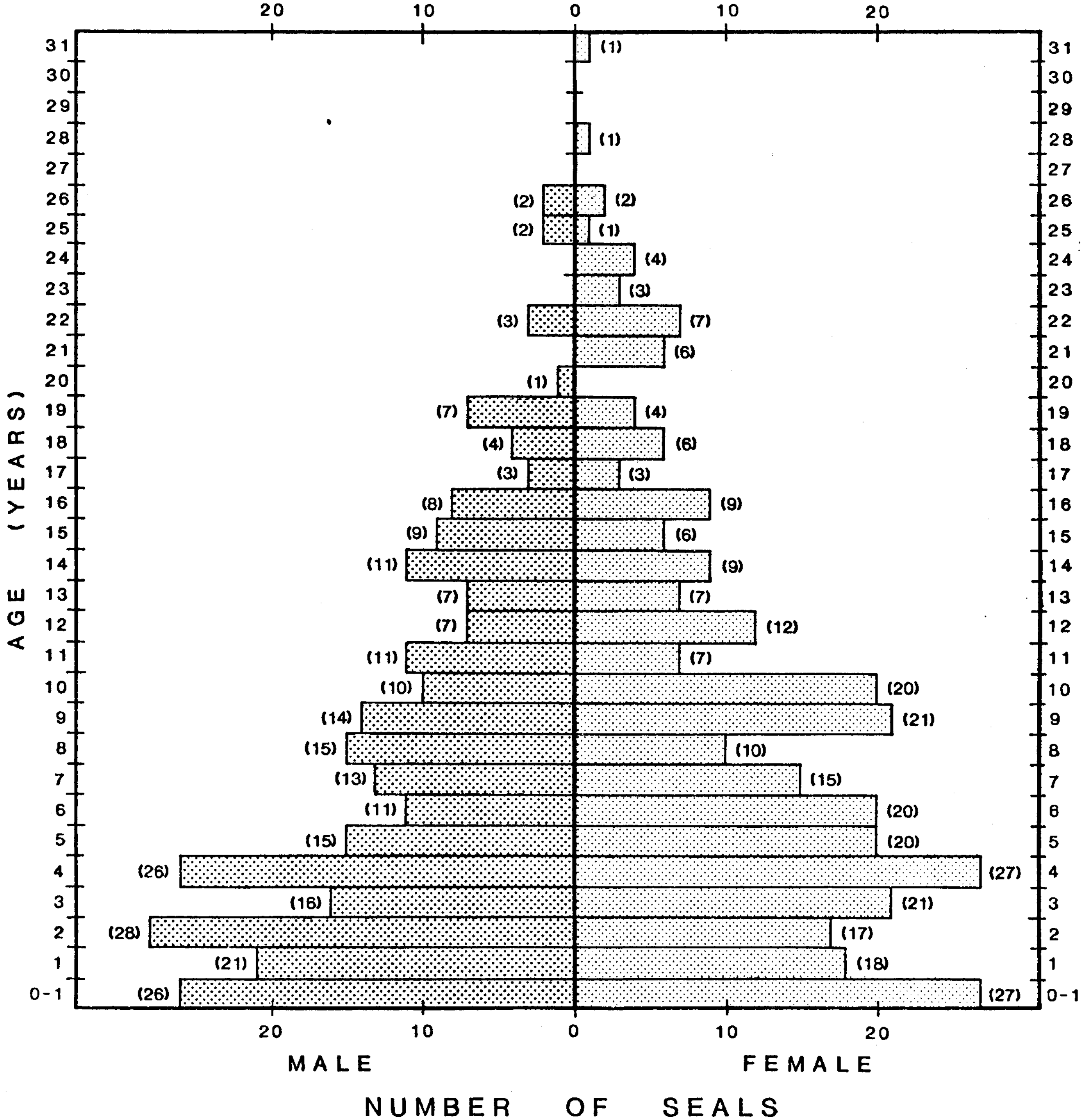

FIGURE 12. SEX AND AGE COMPOSITION OF 574 HARBOR SEALS COLLECTED IN THE GULF OF ALASKA. NUMBER IN PARENTHESIS, NUMBER OF SEALS IN AGE CLASS.

Table 19. Summary of composition of stomach contents from 255 harbor seals collected in the Gulf of Alaska, all areas and all seasons combined.

Prey	Occurrences No.	Occurrences % ± 95% C.L.(%)	Volume cc	Volume %
Cephalopoda	97	22.2 ± 4.0	20,433	21.7
Octopus sp. (octopus)	77	17.7 ± 3.7	18,753	19.9
Gonatidae (squids)	20	4.6 ± 2.1	1,680	1.8
Decapoda	18	4.1 ± 2.0	3,800	4.0
Shrimps	17	3.9 ± 1.9	3,400	3.6
Crabs	1	0.2 ± 0.6	400	0.4
Rajidae				
Raja spp. (skates)	3	0.7 ± 0.9	2,780	3.0
Clupeidae				
Clupea harengus (herring)	29	6.7 ± 2.5	6,560	7.0
Salmonidae				
Oncorhynchus spp. (salmon)	8	1.8 ± 1.4	4,037	4.3
Osmeridae	53	12.2 ± 3.2	15,359	16.3
Mallotus villosus (capelin)	40	9.2 ± 2.8	10,687	11.3
Thaleicthys pacificus (eulachon)	8	1.8 ± 1.4	4,162	4.4
Hypomesus pretiosus (surf smelt)	4	0.9 ± 1.0	460	0.5
Unid. osmeridae (smelts)	1	0.2 ± 0.5	50	0.1
Gadidae	134	30.7 ± 4.4	26,603	28.2
Eleginus gracilis (saffron cod)	5	1.1 ± 1.1	395	0.4
Gadus macrocephalus (Pacific cod)	28	6.4 ± 2.4	3,240	3.4
Microgradus proximus (Pacific tomcod)	7	1.6 ± 1.3	1,030	1.1
Theragra chalcogramma (walleye pollock)	94	21.6 ± 4.0	21,938	23.3
Zoarcidae				
Lycodes spp. (eelpouts)	6	1.4 ± 1.2	60	0.1
Scorpaenidae				
Sebastes spp. (rockfishes)	4	0.9 ± 1.0	810	0.9
Hexagrammidae				
Hexagrammos spp. (greenlings)	2	0.5 ± 0.7	400	0.4

Table 19. Continued.

Prey	Occurrences No.	Occurrences % ± 95% C.L.(%)	Volume cc	Volume %
Cottidae	10	2.3 ± 1.5	1,912	2.0
Dasycottus setiger (spinyhead sculpin)	2	0.5 ± 0.7	--	--
Enophrys bison (buffalo sculpin)	1	0.2 ± 0.6	240	0.3
Myoxocephalus spp. (sculpins)	2	0.5 ± 0.7	1,430	1.5
Unid. cottidae (sculpins)	5	1.1 ± 1.1	242	0.3
Trichodontidae				
Trichodon trichodon (Pacific sandfish)	10	2.3 ± 1.5	3,025	3.2
Bathymasteridae				
Bathymaster signatus (searcher)	3	0.7 ± 0.9	40	<0.1
Ammodytidae				
Ammodytes hexapterus (Pacific sandlance)	19	4.4 ± 2.0	463	0.5
Pleuronectidae	23	5.3 ± 2.2	2,615	2.8
Atheresthes stomias (arrowtooth flounder)	3	0.7 ± 0.9	--	--
Eopsetta jordani (petrale sole)	1	0.2 ± 0.5	--	--
Glyptocephalus zachirus (Rex sole)	1	0.2 ± 0.5	150	0.2
Hippoglossoides elassodon (flathead sole)	5	1.2 ± 1.1	130	0.1
Lepidopsetta bilineata (rock sole)	1	0.2 ± 0.5	--	--
Limanda aspera (yellowfin sole)	6	1.4 ± 1.2	1,650	1.8
Lyopsetta exilis (slender sole)	2	0.5 ± 0.7	--	--
Parophrys vetulus (English sole)	2	0.5 ± 0.7	65	0.1
Unid. pleuronectidae	2	0.5 ± 0.7	620	0.7
Unid fish remains	17	3.9 ± 1.9	5,320	5.6
Totals	436	100.4	94,217	100.1

Table 20. Rankings of major prey of harbor seals collected in the Gulf of Alaska. Modified Index of Relative Importance = percentage of occurrences X percentage of volumes. Only those prey with modified I.R.I. ≥ 2 are included.

Prey	Modified I.R.I.	Percent of Occurrences	Percent of Volume
Walleye pollock	503	21.6	23.3
Octopus	352	17.7	19.9
Capelin	104	9.2	11.3
Herring	47	6.7	7.0
Pacific cod	22	6.4	3.4
Flatfishes	15	5.3	2.8
Shrimps	14	3.9	3.6
Squids	8	4.6	1.8
Eulachon	8	1.8	4.4
Salmon	8	1.8	4.3
Pacific sandfish	7	2.3	3.2
Sculpins	5	2.3	2.0
Skates	2	0.7	3.0
Pacific sandlance	2	4.4	0.5
Pacific tomcod	2	1.6	1.7

Table 21. A-F. Major prey of harbor seals from six geographic areas in the Gulf of Alaska. Prey are ranked by order of modified Index of Relative Importance. Only prey with modified I.R.I. values ≥ 2 are included.

A. Northeastern Gulf of Alaska; Yakutat Bay to Middleton Island. Total stomachs with contents=17, total occurrences=39, total volumes=2,420 cc.

Prey	Modified I.R.I.	Percent of Occurrences with 95% C.L.	Percent of Volume
Walleye pollock	640	28.2 ± 15.4	22.7
Surf smelt	196	10.3 ± 10.8	19.0
Capelin	143	23.1 ± 14.5	6.2
Shrimps	131	2.6 ± 6.3	50.4

Continued

Table 21 (cont.)

B. Prince William Sound. Total stomachs with contents=83, total occurrences=122, total volumes=28,290 cc.

Prey	Modified I.R.I.	Percent of Occurrences with 95% C.L.	Percent of Volume
Walleye pollock	1,375	29.5 ± 8.5	46.6
Herring	166	14.8 ± 6.7	11.2
Squids	77	13.1 ± 6.4	5.9
Octopus	75	13.9 ± 6.6	5.4
Salmon	33	3.3 ± 3.6	10.0
Capelin	16	4.1 ± 3.9	3.8
Pacific tomcod	5	1.6 ± 2.7	3.3
Pacific cod	4	4.9 ± 4.2	0.9
Saffron cod	3	2.5 ± 3.2	1.3
Eulachon	3	1.6 ± 2.7	1.9

C. Kenai Coast. Resurrection Bay to Pt. Adam. Total stomachs with contents=30, total occurrences=52, total volumes=7,225 cc.

Prey	Modified I.R.I.	Percent of Occurrences with 95% C.L.	Percent of Volume
Walleye Pollock	1,503	40.4 ± 14.3	37.2
Herring	247	11.5 ± 9.6	21.5
Pacific sandfish	44	7.7 ± 8.2	5.7
Capelin	19	5.8 ± 7.3	3.3
Pacific tomcod	4	3.8 ± 6.2	1.0

D. Lower Cook Inlet. Kachemak and Kamishak Bays. Total stomachs with contents=17, total occurrences=23, total volumes=5,412 cc.

Prey	Modified I.R.I.	Percent of Occurrences with 95% C.L.	Percent of Volume
Octopus	1,697	39.1 ± 23.3	43.4
Eulachon	532	17.4 ± 18.6	30.6
Shrimps	501	21.7 ± 20.0	23.1
Capelin	17	8.7 ± 14.4	1.9

Table 21. Continued.

E. Alaska Peninsula. Puale Bay, Shumagin Islands and Sanak Island. Total stomach with contents=6, total occurrences=9, total volumes=8,185 cc.

Prey	Modified I.R.I.	Percent of Occurrences with 95% C.L.	Percent of Volume
Octopus	929	33.3 ± 41.8	27.9
Walleye pollock	824	22.2 ± 37.5	37.1
Pacific sandfish	342	11.1 ± 29.7	30.8
Pacific cod	40	22.2 ± 37.5	1.8
Sculpins	26	11.1 ± 29.7	2.3

F. Kodiak Island; The Barren Islands to Chirikof Island. Total stomachs with contents=102, total occurrences=192, total volumes=42,685 cc.

Prey	Modified I.R.I.	Percent of Occurrences with 95% C.L.	Percent of Volume
Octopus	631	21.4 ± 6.1	29.5
Capelin	323	10.9 ± 4.7	21.3
Walleye pollock	70	12.0 ± 4.9	5.8
Flatfishes	63	10.9 ± 4.7	5.8
Pacific cod	55	8.3 ± 4.2	6.6
Pacific sandlance	9	8.3 ± 4.2	1.1
Herring	9	2.1 ± 2.3	4.2
Shrimps	8	3.6 ± 2.9	2.2
Salmon	6	2.1 ± 2.3	2.9
Sculpins	3	4.2 ± 3.1	0.7
Eulachon	2	0.5 ± 1.3	4.6

Table 22. Area differences in major prey occurrences ($N \geq 4$) among harbor seals collected in Prince William Sound and the Kodiak Island area.

Prey	Kodiak Occurrences		Prince William Sound Occurrences		Chi-Square Significance
	Number	Percentage ± 95% C.L.	Number	Percentage ± 95% C.L.	
Octopus	41	21.4 ± 6.1	17	13.9 ± 6.5	>0.10
Squids	2	1.0 ± 1.7	16	13.1 ± 6.4	*
Shrimps	7	3.6 ± 2.9	1	0.8 ± 2.0	*
Herring	4	2.1 ± 2.3	18	14.8 ± 6.7	*
Salmon	4	2.1 ± 2.3	4	3.3 ± 3.6	*
Capelin	21	10.9 ± 4.7	5	4.1 ± 3.9	<0.05
Pacific cod	16	8.3 ± 4.2	6	4.9 ± 4.2	>0.10
Walleye pollock	23	12.0 ± 4.9	36	29.5 ± 8.5	<0.01
Sculpins	8	4.2 ± 3.1	0	0.0	*
Pacific sandlance	16	8.3 ± 4.2	0	0.0	*
Flatfishes	21	10.9 ± 4.7	1	0.8 ± 2.0	*
Total occurrences	192		122		

* Sample too small for testing.

Seasonal Variations in Occurrence of Prey

Table 23 is a presentation of prey utilization by season for both Prince William Sound and Kodiak. Samples were too small in nearly all instances for statistical testing, however, several probable seasonal differences were apparent. Salmon were found only during the summer period in both areas. In the Kodiak area, capelin occurred more frequently during summer and Pacific sandlance more frequently during fall than during other seasons.

Table 23. Seasonal variations in occurrences of principal prey ($N \geq 4$) of harbor seals. Winter (W)=1 February-9 May, Summer (S)= 10 May-30 September and Fall (F)=1 October - 30 November.

Kodiak Island Area

Prey	(W) Occurrences Number	(W) Percentage ± 95% C.L.	(S) Occurrences Number	(S) Percentage ± 95% C.L.	(F) Occurrences Number	(F) Percentage ± 95% C.L.
Octopus	17	30.4 ± 12.9	13	17.6 ± 9.4	11	17.7 ± 10.3
Salmon	0	0.0	4	5.4 ± 5.8	0	0.0
Capelin	3	5.4 ± 6.8	15	20.3 ± 9.8	3	4.8 ± 6.1
Pacific cod	6	10.7 ± 9.0	5	6.8 ± 6.4	5	8.1 ± 7.6
Walleye pollock	8	14.3 ± 10.1	9	12.2 ± 8.1	6	9.7 ± 8.2
Pacific sandlance	0	0.0	3	4.1 ± 5.2	13	21.0 ± 10.9
Total Occurrences	56		74		62	

Prince William Sound

Prey	(W) Occurrences Number	(W) Percentage ± 95% C.L.	(S) Occurrences Number	(S) Percentage ± 95% C.L.	(F) Occurrences Number	(F) Percentage ± 95% C.L.
Octopus	10	14.1 ± 8.8	2	15.4 ± 27.1	5	13.2 ± 12.1
Squids	9	12.7 ± 8.4	2	15.4 ± 27.1	5	13.2 ± 12.1
Herring	14	19.7 ± 10.0	2	15.4 ± 27.1	2	5.3 ± 8.4
Salmon	0	0.0	4	30.8 ± 33.5	0	0.0
Capelin	4	5.6 ± 6.1	1	7.7 ± 21.0	0	0.0
Walleye pollock	20	28.2 ± 11.2	1	7.7 ± 21.0	15	39.5 ± 16.9
Total Occurrences	71		13		38	

Prey of Harbor Seal Pups

Prey items were found in the stomachs of 13 harbor seals between the ages of 2.5 and 11 months (Table 24). Small fishes were the primary food. The sample size was too small, as shown by the large confidence limits, to make many valid statistical comparisons with animals of older age classes. Nevertheless, chi-square analysis of occurrence of prey eaten by pups and prey eaten by all other age classes showed one significant ($P<0.01$) difference. A higher proportion of capelin (35.7% compared to 9.2%) was eaten by pups than by all other age classes combined. Specialized feeding on shrimps by newly-weaned harbor seal pups has been reported by Havinga (1933), Fisher (1952) and Bigg (1973) but was not reflected in our data.

Table 24. Prey of harbor seal pups, 0-12 months of age, collected in the Gulf of Alaska.

Prey	Occurrences	
	Number	Percentage ± 95% C.L.
Shrimps	1	7.1 ± 19.4
Capelin	5	35.7 ± 32.1
Pacific tomcod	1	7.1 ± 19.4
Walleye pollock	5	35.7 ± 32.1
Pacific sandlance	1	7.1 ± 19.4
Unidentified fish	1	7.1 ± 19.4
TOTAL	14	99.8

Discussion

Other studies of harbor seal food habits in the eastern North Pacific reflected diets with similar compositions to that found in this study. In Washington, principal prey were members of the families Gadidae, Pleuronectidae, Clupeidae, Cottidae, Batrachoididae and Embiotocidae (Scheffer and Sperry 1931 and Calambokidis et al. 1978). In British Columbia, Spalding (1964) observed that stomachs of harbor seals collected mainly during the summer and fall contained primarily octopus, squids, herring and salmon. Imler and Sarber (1947), working in Southeastern Alaska, found that Gadidae, herring, Pleuronectidae, salmon and shrimps were major food items. Prey reported for harbor seals in the Aleutian Islands included octopus, walleye pollock, rock greenling, *Hexagrammos lagocephalus*, and Atka mackerel, *Pleurogrammus monopterygius*, (Wilke 1957; Kenyon 1965).

The high ranking of walleye pollock (Table 15) may have been a direct reflection of their abundance. Pereyra and Ronholt (1976) found that pollock were the dominant fish species in the Gulf of Alaska, comprising 45% of total fish stocks. They also found that pollock had increased proportionately from 5% of the fish stocks in 1961 to a 1973-75 level of 45%.

The major differences in prey utilization between Prince William Sound and the Kodiak area may be the result of differing habitats. Water depths and bottom topography are considerably different in these areas. Kodiak waters have a large, shallow shelf area, particularily east and south of the Island, while Prince William Sound generally has a precipitous coast with depths reaching 740 meters. These features may influence prey composition, abundance and availability to harbor seals.

Seasonal variations in utilization of certain prey appeared to be explained by seasonal availability of the prey. Salmon were taken only during the summer periods in both Prince William Sound and the Kodiak area. In both areas, salmon are available in nearshore waters only during this period. Capelin were utilized to a greater extent during summer in the Kodiak area which probably reflects nearshore distribution associated with reproductive activities. Also in the Kodiak area, sandlance were utilized to a much greater extent during the fall period. No reason for this is known.

RADIO-TELEMETRY STUDIES

Radio-tracking studies of harbor seals were conducted in the Tugidak Island area between 8 May and 9 September 1978. Objectives of this research were to determine the range of individual movements, extent of haulout area fidelity and haulout patterns. Thirty-five harbor seals (Table 25) were captured on the large haulout area on southwest Tugidak Island and radio transmitters were attached by means of a bracelet around a hind flipper. Signals from the transmitters could be received only when the seals were hauled out. Twenty-one seals were captured between 8 May and 2 June. Capture operations were then suspended until 3 July in order to avoid disturbance during pupping. Fourteen additional seals were equipped with transmitters during 3-9 July. Two backup marking techniques were used to detect radio loss and failure. These included individually recognizable color combinations of Temple cattle ear tags placed in the hind flippers and color combinations of plastic flagging attached to the radio transmitters.

Total numbers of seals and radio-tagged seals ashore on the southwest hauling area were monitored visually and with a radio receiver from 30 m bluffs abutting the beach. Nearly every day from 1-30 June and 1-August-5 September. Counts and radio checks were timed to coincide with daylight low tides, a period when maximum numbers were usually hauled out. Visual searches were conducted to locate radio-tagged individuals and the results were compared with the radio checks to detect transmitter failures.

Table 25. Sex and age composition of 35 radio-tagged harbor seals captured on the southwestern hauling area of Tugidak Island.

Sex and Age Classification	Number of Seals
Mature females	24
Immature females	5
Mature males	5
Immature males	1
Total	35

A total of 27 aerial radio-tracking surveys were flown to locate animals which had moved from their site of capture and were hauled out at other areas. A Bell 206 helicopter and a Bellanca Scout fixed-wing aircraft were used for the surveys. Coverage by these surveys included most of the shoreline and all of the known major hauling areas in the Kodiak Island group. The coast between Wide Bay and Amalik Bay on the Alaska Peninsula was surveyed one time, however, weather conditions prevented thorough coverage.

Movements

Eight seals were located a total of 17 times at hauling areas other than the site of capture (Figure 13). The longest movement was by a mature female, TR-18, which moved to Ugak Island, a minimum distance of 194 km. This seal was captured on 17 May, then was found hauled out on Tugidak again on 1 June. Nine days later she was found on Ugak Island. She was located three additional times, all on Ugak. The final contact was on 9 September during the last survey. TR-18 was pregnant when captured and probably had not given birth before moving to Ugak as she was not accompanied by a pup when last observed on Tugidak.

TR-5, another pregnant female, was captured on 11 May. She was not located again until 30 June when a radio tracking survey was flown around Chirikof Island, 74 km southwest of Tugidak Island. TR-5 was next relocated back on Tugidak Island on 3 August. The radio had failed so it was impossible to determine if she was hauled out any place except Tugidak where visual observations were made. She was seen periodically on Tugidak the remainder of the study period.

Another pregnant female, TR-4, was captured on 10 May. She was observed three times through 27 May on Tugidak and then was located with a pup on a sand bar just north of Sitkinak Island on 10 and 11 June. This represented a minimum movement of 56 km. From 1-5 September she was back on Tugidak. On 9 September she was found at the same hauling area north of Sitkinak where she had been on 10 and 11 June.

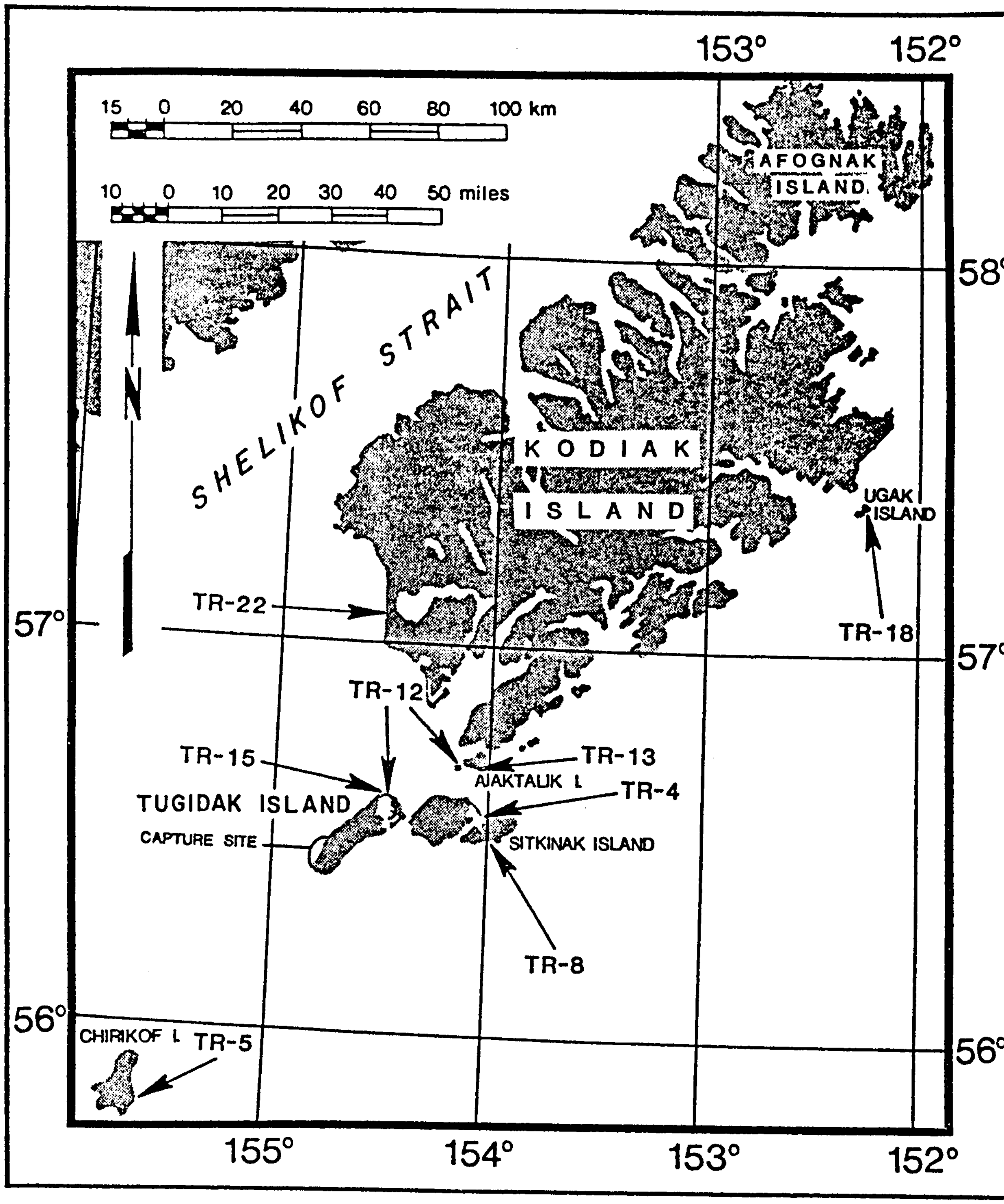

FIGURE 13. LOCATIONS OF RADIO TAGGED HARBOR SEALS FOUND AT HAULING AREAS OTHER THAN THEIR SITE OF CAPTURE ON SOUTHWEST TUGIDAK ISLAND.

TR-8, a pregnant female, was captured on 11 May then seen on Tugidak on 12 May and on 2 June, without a pup on either occasion. No contacts were made until 24-27 August on Tugidak. On 9 September she was found on southeastern Sitkinak, 56 km away.

Another pregnant female, TR-12 was captured on 12 May. She was observed again on southwest Tugidak on 16 and 21 May. On 8 June she was found on northern Tugidak, 26 km distant. On 1, 2 and 24 July she was located on Sundstrom Island an additional 24 km to the northeast.

TR-22, captured on 3 July, was accompanied by a pup. On 28 August she was located on the west coast of Kodiak, 74 km from southwest Tugidak. Her hind flipper was badly abraded at the transmitter attachment site so the radio was removed.

An immature male, TR-13, was captured on 13 May. He hauled out on southwest Tugidak on 21, 22, 24, 25 and 26 May and then was next located on Aiaktalik Island about 54 km away on 10 June. Three days later, TR-13 was back on Tugidak and was observed there frequently throughout the summer.

TR-15, an adult male, was captured on 8 May. He was located a total of nine times, all but one time on southwest Tugidak. On 30 June he was hauled out on the southwestern hauling area and the next day was found on northern Tugidak a minimum movement of 26 km.

Although only eight seals were found at hauling areas other than the capture site it was probable that additional movements occurred. Many of the other seals didn't haulout on southwest Tugidak for extended periods of time and only occasional surveys of other hauling areas were flown. Seals which were not hauled out at the time of the surveys would not have been detected. Five of the eight animals found on other hauling areas were in the northern Tugidak, Sitkinak, Aiaktalik Islands areas (Figure 13) which are the nearest major hauling areas to southwestern Tugidak. Other than this, no obvious pattern of movement was apparent.

One animal, TR-18, moved from Tugidak and appeared to use another hauling area for the remainder of the study period. Two seals, TR-4 and 13, appeared to alternate between two hauling areas. TR-5 made a major move and then returned and appeared to stay at Tugidak. TR-12 was located at three different hauling areas. Three seals, TR-8, 15 and 22, were found only one time at a hauling area other than Tugidak. We could not discern any correlation between sex or age of the animals and degree of movement, however, samples of all groups except adult females were small (Table 25).

Hauling Area Fidelity

Twenty-three of 35 (66%) of the radio-tagged harbor seals were found only at the hauling area where they were captured. Four seals were never relocated after their capture. They either died, moved beyond the range of the surveys or were not hauled out during aerial surveys. Also, if the radios failed or were lost they would not have been located during aerial surveys. Of the eight animals which were located at hauling areas other than Tugidak, three were found on the same hauling area more than one time. It is obvious from these observations that while fidelity to a single hauling area was not complete there was a strong tendency to use one or in some instances two hauling areas repeatedly.

Haulout Patterns

Haulout patterns of individual radio-tagged seals are presented in Figure 14. It was impossible to quantify with complete confidence frequency of haulout because some individuals used more than one hauling area and it was impossible to monitor more than the primary site regularly. Two extended periods with near daily monitoring were used to examine hauling patterns. These were 3-30 June and 1 August-5 September. Animals were arbitrarily classified as "residents" by excluding those found hauled out at other locations and those absent for extended periods. Estimates of the proportion of days hauled out were based on these animals and were undoubtedly biased upward because animals which might have been "residents" but hauled out infrequently were deleted from the analysis. During the June period "resident" seals hauled out on an average of 49.6% of the days (Table 26) and during the August-September period they hauled out on 41.3% of the days (Table 27).

Haulout patterns varied tremendously between individuals (Figure 14). Several animals (TR-7, 14, 15, 19 and 34) hauled out frequently throughout the study period without extended absences. Other seals (TR-3, 6, 10, 11, 21 and 27) had extended absences from Tugidak, were never located at other hauling areas and appeared to haulout infrequently. Some animals (TR-5, 16, 34 and 35) hauled out in somewhat regular patterns while other (TR-6, 14, 15 and 17) appeared more haphazard in their hauling habits.

Table 26. Proportion of days which "resident" radio-tagged harbor seals hauled out on southwest Tugidak Island from 1-30 June 1978.

Animal	Proportion of Days	Animal	Proportion of Days
TR-2	11/25	TR-17	9/25
TR-7	16/25	TR-19	20/25
TR-14	16/25	TR-20	4/25
TR-16	11/25		

$\bar{x}$ number of days = 12.4 (49.6%)
Standard deviation = 5.3

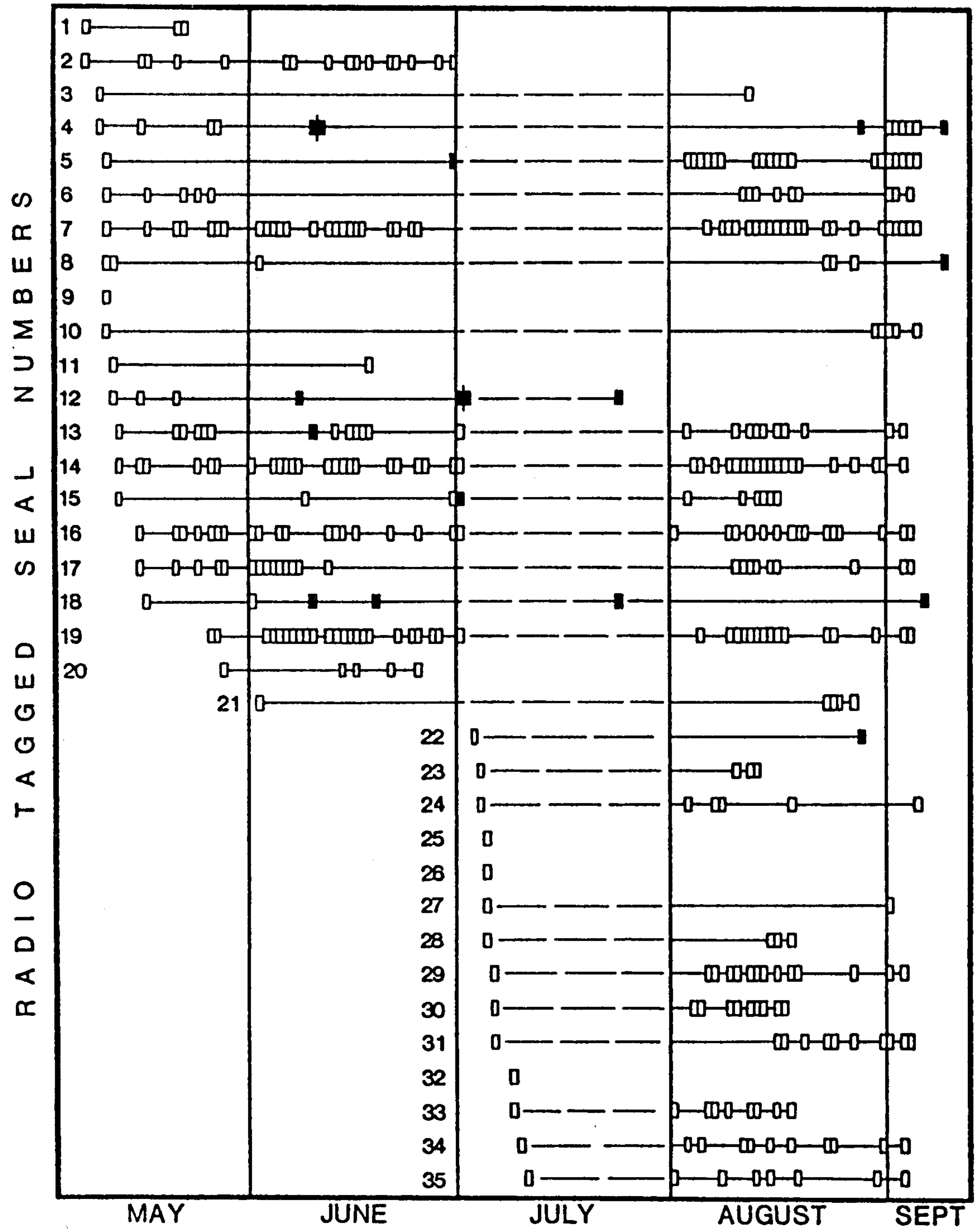

FIGURE 14. HAULOUT PATTERNS OF RADIO TAGGED HARBOR SEALS ON SOUTHWEST TUGIDAK ISLAND SHOWING THE PRESENCE OR ABSENCE OF EACH INDIVIDUAL DURING DAILY RADIO CHECKS. OPEN BOX, PRESENT; DARK BOX, FOUND ON OTHER HAULING AREA; FROM 8 MAY TO 2 JUNE CAPTURE OPERATION CAUSED DISTURBANCE; 25 VALID RADIO CHECKS BETWEEN 1 AND 30 JUNE; NO ONSITE RADIO CHECKS 2-31 JULY; 31 VALID RADIO CHECKS BETWEEN 1 AUGUST AND 5 SEPTEMBER.

Table 27. Proportion of days which "resident" radio tagged harbor seals hauled out on southwest Tugidak Island from 1 August through 5 September 1978.

Animal	Proportion of Days	Animal	Proportion of Days
TR-5	19/31	TR-17	9/31
TR-6	9/31	TR-19	15/31
TR-7	22/31	TR-24	5/31
TR-13	10/31	TR-29	13/31
TR-14	19/31	TR-34	10/31
TR-16	15/31	TR-35	7/31

$\bar{x}$ number of days = 12.8 (41.3%)
Standard deviation = 5.3

Movement Rates

Limited data were collected on movement rates by dividing the minimum distances between locations where an animal was found by the number of days elapsed between sightings. The rates were minimums in all instances because the actual route traveled was unknown and the time taken to travel was probably less than observed in most cases. Minimum movement rates for four animals were 24 km/day, 19 km/day, 27 km/day and 26 km/day.

Discussion

Harbor seals have generally been considered sedentary animals with perhaps limited seasonal movements (Havinga 1933; Scheffer and Slipp 1944; Fisher 1952). Previous studies which have documented movements of harbor seals have involved young animals which were tagged at their birthplaces (Vania et al. 1969; Bonner and Witthames 1974). These studies documented dispersal of juveniles up to 250 km from large pupping areas. Mansfield (1967) and Knudtson (1974) both mentioned wandering or dispersal of young animals and referred to them as "rangers." Boulva (1971) felt that the Sable Island harbor seal colony was isolated from the mainland because of distance (165 km).

In Puget Sound it was suggested that both long distance movements and year around site loyalty occurred (Calambodkis et al. 1978). The results of our work appear to agree with this as considerable individual variation was obvious. Knudtson (1974) and Reijnders (1976) reported observations of the same animals returning repeatedly to the same hauling area. Their results are similar to our findings of considerable hauling area fidelity by some individuals.

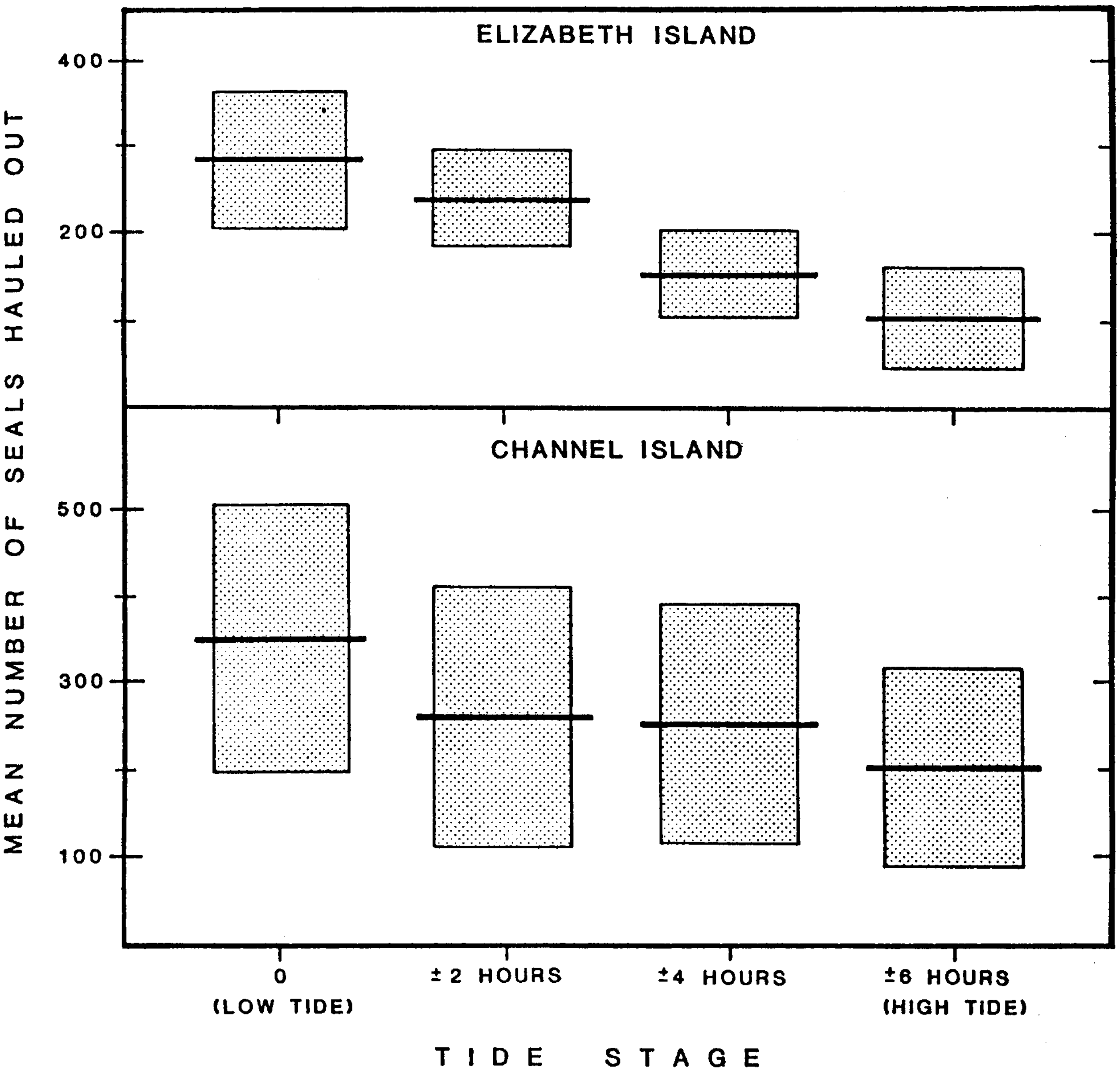

FIGURE 15. MEAN NUMBERS OF HARBOR SEALS HAULED OUT ON ELIZABETH ISLAND AND CHANNEL ISLAND IN RELATION TO STAGE OF TIDE. HORIZONTAL LINE, MEAN; BOX, 95% CONFIDENCE INTERVAL.

Additional information on the range of harbor seal movements comes from offshore sightings. Fiscus et al. (1976) reported observations of seals up to 100 km from land in the Gulf of Alaska and Wahl (1977) observed a harbor seal 80 km off the coast of Washington. The movement of one of our radio-tagged animals across 74 km of open ocean to Chirikof Island and back to Tugidak further demonstrated use of offshore waters.

INDEX COUNT SITES

Because of difficulties associated with censusing an ubiquitous marine mammal such as the harbor seal it appeared more feasible to monitor population status utilizing index count sites and following trends rather than by attempting total enumerations. To accomplish this a major hauling site was selected in each of the three lease areas in the Gulf of Alaska. These included Channel Island (60 14 35 N; 147 22 00 W) in the northeastern Gulf of Alaska, Elizabeth Island (59 08 20 N; 151 48 10 W) in lower Cook Inlet and southwest Tugidak Island (56 27 04 N; 154 46 35 W) in the Kodiak lease area. Data where available from Tugidak Island from previous years. We selected the period from 20 August through 10 September to conduct the counts because previous observations indicated that maximum numbers of seals hauled out then. Daily counts were made of seals hauled out during daytime low tides. Regression analyses indicated that stage of tide was the major explainable variable associated with numbers of seals hauled out ($r^2 = 0.18$ at Elizabeth Island and $r^2 = 0.08$ at Channel Island). Maximum counts were usually obtained at low tide (Figure 15). Counts were made from the ground with the aid of binoculars and spotting scopes. Counts of large groups of seals on Tugidak Island were made from polaroid prints. Counts were made at Channel Island from 25 August to 10 September 1978, at Elizabeth Island from 21 August to 10 September 1978 and at Tugidak Island from 1-30 June 1976 and 1978 and 20 August to 5 September 1976 and 1978.

Data from Channel Island and Elizabeth Island are summarized in Tables 28 and 29. These are the first counts made at these locations and will serve as a baseline for future comparisons. On Tugidak Island, data were collected for June and August-September of both 1976 and 1978 (Tables 30 and 31). The mean count for June 1978 was 54% of the average June count for 1976. The average August-September count for 1978 was 70% of the 1976 average. These reductions were both highly significant ($P<0.01$). The reason for the apparent decline is not evident. However, considerable disturbance was documented and could be a factor.

Table 28. Channel Island harbor seal count data, 25 August-10 September 1978.

Number of Seals	Number of Seals	Number of Seals
258	559	118
251	498	254
178	453	520
138	141	358
183	237	477
209	280	122
296	180	

$\bar{x}$ with 95% confidence limits = 285.5 ± 68.4
Range = 118 - 559
Standard Deviation = 142.7

Table 29. Elizabeth Island harbor seal count data, 21 August-10 September 1978.

Number of Seals	Number of Seals	Number of Seals
282	99	262
88	110	472
220	114	264
184	539	279
250	619	59
123	336	294
241	41	291
237	269	615

$\bar{x}$ with 95% confidence limit 262.0 $\pm$ 69.8
Range = 41 - 619
Standard Deviation = 161.7

Table 30. Summary of 1-30 June 1976 and 1978 harbor seal counts on Tugidak Island.

1976		1978	
Number of Seals	Number of Seals	Number of Seals	Number of Seals
2819	2278	731	1460
2574	1974	981	1773
1824	2785	715	851
1304	3566	1332	1148
1039	2525	1725	909
1335		1439	893
		812	1637
		892	1348
		714	939
		1078	927
		1965	765
		2086	853
		1570	

	1976	1978
$\bar{x}$ with 95% Confidence Limits	2183.9 $\pm$ 517.4	1181.7 $\pm$ 176.2
Range	1039 - 3566	714 - 2086
Standard Deviation	770.2	419.0

Table 31. Summary of 20 August-5 September 1976 and 1978 harbor seal counts on Tugidak Island.

1976		1978	
Number of Seals	Number of Seals	Number of Seals	Number of Seals
8716	6437	2532	5599
2800	9042	2587	5758
7645	9300	3983	5257
3700	7785	4814	6817
6735	6904	5966	4576
6781	7182	5372	4805

	1976	1978
$\bar{x}$ with 95% Confidence Limits	6918.9 $\pm$ 1301.8	4838.8 $\pm$ 854.7
Range	2800 - 9300	2532 - 6817
Standard Deviation	1962.5	1288.5

EFFECTS OF DISTURBANCE

Observations on Tugidak Island during the summers of 1976 and 1978 provided information on disturbance events and some insight into their possible effects on the population. All observations were of hauled out animals. A disturbance event was classified as any event which caused hauled out seals to rush into the water. Information on disturbance was descriptive rather than quantitative and interpretation of the effects is speculative.

Disturbances generally could be categorized as either major or minor based on the reaction of the seals. Major disturbances sent all the seals into the water and were often followed by a long period before they rehauled. Minor disturbances sent only a portion of the seals into the water and they returned rapidly to the haulout. Naturally occurring disturbances included earth slides and actions of birds and other seals. Earth slides caused both major and minor disturbances depending on their proximity and magnitude. Gulls (Laridae), ravens (*Corvus corax*) and bald eagles (*Haliaeetus leucocephalus*) all caused disturbances of varying intensities, usually when the birds were foraging for placentas, fetal membranes or feces. Agonistic behavior of seals and actions associated with parturition sometimes caused surrounding animals to go into the water. Occasionally, for no apparent reason, a single animal dashed into the water alarming other animals which followed.

Human related disturbances observed on Tugidak included: aircraft overflights, and disturbances caused by all terrain vehicles, hikers, domestic animals and research activities. Although boat traffic was not a disturbing factor on Tugidak, it was in many locations. Seals on Tugidak seemed to be particularly sensitive to aircraft. During aerial radio tracking surveys we noted that seals on Tugidak went into the water when a small, fixed-wing airplane passed over at 2,000 feet while in other areas they remained undisturbed when the aircraft was only 1,000 feet or less in altitude. Helicopters were particularly disturbing, probably because they usually flew at low altitudes and were loud. Occasionally, a large jet flying at high altitude (probably >30,000 feet) would cause animals to go into the water although the noise level was low. Certain research activities, particularly capturing hauled out seals to attach radio transmitters, were major disruptive factors. These were timed to avoid sensitive periods such as pupping and molting and were one time occurrences rather than continuing activities. The other disturbing activities including all terrain vehicle use, hikers and domestic animals were comparatively limited and at present are not serious.

Although it was difficult to evaluate overall effects of disturbance on harbor seal populations it appeared that disturbance during pupping contributed to neonatal mortality. Observations indicated that the first several hours following birth were critical to formation of the mother-pup bond. During this period the pups appeared disoriented and the females initiated "nose-to-nose" contacts. Usually within an hour after birth the pup and female went into the water for a short while. The first nursing took place within about two hours. The mother-pup association continued for about 4 weeks until the pup was weaned. It appeared that if a disturbance separated the mother and pup shortly after birth, before a strong bond was formed, permanent separation often occurred resulting in the death of the pup. By way of illustration, on 22 May 1978 a radio-tagged female was seen with a new pup (probably only hours old). There was considerable "nose-to-nose" contact and a short nursing bout. The female attempted to get the pup into the water, but a moderate surf washed the pup back ashore and the female returned to the pup on the beach. A helicopter then flew directly over the hauling area at less than 200 feet altitude scaring all the seals into the water. The female went into the water followed sometime later by the pup. We did not see them reunite and eventually lost track of them. Two days later the female was seen hauled out without her pup and it appeared that permanent separation had occurred. Disturbance did not appear to adversely affect older pups which had formed strong bonds with their mothers. Two females which were accompanied by pups were captured and separated late in June 1977. The following day both pairs were seen reunited. Burton et al. (1975), studying grey seals (*Halichoerus grypus*) found that the female smelling the pup immediately after birth and at intervals thereafter allowed her to establish the identity of her pup. They concluded that the more times a cow can smell the pup soon after birth the firmer the bond becomes. Disturbance by gulls, other seals or human intrusion may lead to a failure in bond establishment and result in abandonment of the pup.

During the molt seals are thinner than at any other time (see section on physical condition). Ronald et al. (1970) and Geraci and Smith (1976) found that stress occurred in molting seals. Findings of Feltz and Fay (1966) suggested that hauling out during the molt was important in warming the skin thus promoting growth of epidermal cells. Conceivably, disturbances during the molt which cause hauled out animals to enter the water could be detrimental to their health.

Effects of disturbance on harbor seals during other seasons are largely unknown. Kenyon (1972) presented evidence that repeated human disturbance caused Hawaiian monk seals, *Monachus schauinslandi*, to desert beaches offering preferred habitat as well as increasing juvenile mortality. Loughlin (1974) felt that disturbance factors such as boat traffic lessened use by harbor seals of some portions of Humboldt Bay. Nocturnal haulout cycles (in response to daytime disturbances) were reported for harbor seals in portions of Puget Sound and San Francisco Bay (Paulbitski 1975; Calambokidis et al. 1978). Streveler (1979) speculated that three periods of the harbor seals' life cycle were particularly sensitive and that the added stresses of human disturbance might increase mortality. His observations of the impact of disturbance on the mother-pup bond were similar to ours and further emphasize the importance of minimizing disturbance during pupping and suckling. He also felt that the breeding season and the period immediately following might be critical because animals are quite thin and adult males often have numerous wounds. Streveler said that winter weather was most severe and might be stressful. However, blubber reserves are greatest during this period which may indicate that it is not a critical period.

POTENTIAL IMPACTS OF OCS ACTIVITIES

OCS activites appear to have the potential to adversely affect harbor seal populations in at least four major ways: (1) death or physical impairment resulting from exposure to and/or ingestion of oil, (2) reduction in prey availability because of oil related mortality of organisms lower on the food chain, (3) loss of habitat due to development, and (4) stress imposed by disturbance.

The effects of direct oiling of harbor seals, or phocid seals in general, are not well known. Insulation is provided by a subcutaneous fat or "blubber" layer which is unaffected by oil. Field observations of elephant seal, *Mirounga angustirostris*, pups and grey seal pups which had been oiled did not indicate there was increased mortality (LeBoeuf 1971; Davis and Anderson 1976). Geraci and Smith (1976) experimentally coated harp seal, *Phoca groenlandica*, pups and immersed ringed seals, *Phoca hispida*, in a tank of sea water with a surface layer of crude oil. No mortality or reduction in thermoregulatory ability took place but eye irritation and behavioral changes occurred. In a later experiment, three "stressed" ringed seals died within 71 minutes after contact with oil. This may indicate that seals are more vulnerable during stressful periods such as the molt.

Engelhardt et al. (1977) found that ringed seals rapidly absorbed hydrocarbons into body tissues and fluids when exposed by immersion or ingestion. They did not determine concentrations necessary to kill the animals. It appears from the limited information available that phocid seals are not nearly as vulnerable to direct contact with oil as are sea otters (*Enhydra lutris*) and northern fur seals which depend on their pelage for insulation. Nevertheless, exposure to oil may be harmful because of absorption of hydrocarbons and increased stress.

Several studies have indicated that oil pollution might affect abundance of forage species (Evans and Rice 1974; DeVries 1975; Struhsaker 1977; Craddock 1977; Patten 1977). Extensive reductions in stocks of major prey such as walleye pollock, octopus, capelin, herring and Pacific cod would certainly have detrimental impacts on harbor seal populations.

Loss of habitat resulting from development does not appear to be a major problem. The amount of development that would take place in important harbor seal habitat would probably be negligible. Lease restrictions limiting development near major hauling or feeding areas would minimize potential conflicts.

Disturbance is an impact of OCS activities which is probably as great during the preliminary or exploratory phase as during the developmental and production stages. Low flying aircraft, both fixed wing and helicopters, are primary disturbing factors. Observations on Tugidak Island showed that helicopters transporting field geologists were a key disturbing factor. Vessel traffic appears to be a minor problem as most activities are not close enough to hauling areas to be disruptive. Disturbance impacts could be minimized by restrictive time and space zoning during both exploratory and developmental activities.

RECOMMENDATIONS

Restrictions on Disturbance

All phases of OCS development should be regulated in such a manner as to avoid disturbing major concentrations of harbor seals. Particular emphasis should be placed on avoiding disturbance during the pupping and suckling period (20 May-10 July) and the molting period (15 July-1 October). Aircraft are the most severe disturbing factor because of their speed and mobility and because they are the prevalent form of transportation. Minimum limits on altitude, perhaps 2000 feet, and horizontal distance, about 2 miles, should be placed on their use near major concentrations of seals.

Restrictions on Development

Major concentrations of harbor seals, particularly hauling areas, should be avoided as sites for development of facilities. Any planned development should be evaluated with consideration of harbor seal habitat.

Trophic Considerations

Maintenance of a large harbor seal population in the Gulf of Alaska will depend largely on the perpetuation of adequate stocks of prey organisms. We found that the major prey of harbor seals were walleye pollock, octopus, capelin, herring and Pacific cod. Relatively little is known about the life histories, distribution and key habitats of these species. The literature suggests (see previous section - Potential Impacts of OCS Activities) that harbor seal prey species may be more vulnerable to oil in the marine system than the seals themselves.

Research Needs

Improvement is needed in our ability to monitor trends in harbor seal abundance. It is impractical to census large populations of harbor seals spread over a wide geographic area. The index count areas established in 1978 were initial efforts to establish "baselines" of abundance. These should be continued for two additional years to evaluate year to year variation in numbers.

Age specific information on juvenile mortality rates i.e., between birth and 4 years of age, is not available. These age classes, particularly the first year, may be most susceptible to impacts of OCS development and it would be valuable to know the range of predevelopment juvenile mortality rates.

Research should be conducted on major prey species to provide information needed to insure their protection.

SUMMARY

Biological studies of harbor seals in the Gulf of Alaska were conducted from 1975 through 1978 with the major objective of gathering information which could be used to regulate OCS developmental activities in such a manner to minimize adverse effects on harbor seal populations. Data were obtained through observations and counts of hauled out seals, by relocating radio tagged animals and through analysis of specimens from collected seals.

A partial catalog of major harbor seal concentrations was developed. This listing is composed primarily of haulout areas and is weak in aquatic distribution.

Pupping appeared to occur at nearly all locations where seals hauled out and took place between about 20 May and 25 June. Weaning occurred 3-5 weeks after birth. Ovulation and breeding took place shortly after weaning in mature females. Breeding was followed by a period of delayed implantation lasting about 11 weeks, followed by an active gestation period of about 36 weeks. The average age of first ovulation was estimated at 5.0 years and the average age of first pregnancy at 5.5 years. Age specific pregnancy rates were: 0-3 years, 0%; 4 years, 17%; 5 years, 63%; 6 years, 88%; 7 years, 89%; 8 years old and older, 92%. Reproductive failures were found in 10.6% of the mature females. Male harbor seals became sexually mature at from 5 to 6 years of age. All males were spermatogenically inactive between early October and early February.

Birth weights and lengths were greater for seals from the Kodiak area than for those from the Icy-Yakutat Bay areas. Seal pups grew rapidly during the nursing period then slowly for the remainder of their first year. Growth was rapid between 1 and 5 years then slowed. Skeletal growth was completed by about 7 years and maximum weight attained at about 10 years. Adult male harbor seals were both longer and heavier than females. Geographic variations in adult body size were apparent, with the larger animals found in the Kodiak, Kenai, Prince William Sound and Alaska Peninsula areas and the smaller seals occurring in Lower Cook Inlet and the Icy-Yakutat Bay areas.

Physical condition, as reflected by blubber thickness, was good and relatively stable between early November and mid-May. Poorer condition occurred during summer, probably associated with lactation, breeding and molting. During winter 1977, seals from the Kodiak area were thinner than those collected from other areas and from Kodiak the previous year.

Molting seals were encountered between late June and early October with the highest proportion occurring in late July.

Sex ratios did not deviate significantly from 50:50 except in the 20 year plus category which was predominately females. Seals were not fully represented by our sample until about four years of age because of selection against younger animals. The oldest female collected was 31 years old and the oldest male was 26 years old. Mortality from birth to 4 years of age was estimated at 74.2% for females and 79.2% for males. Mean annual mortality for females from 4 to 19 years was calculated at 11.4% and for males from 4 to 17 years, 12.7%.

Major prey of harbor seals in the Gulf of Alaska were walleye pollock, octopus, capelin, herring and Pacific cod. Some seasonal and geographic variations in prey utilization were found. Small fishes were the main food of harbor seal pups.

Movements up to 194 km by radio-tagged seals were documented, including those of an individual which crossed 74 km of open ocean. There appeared to be a strong tendency for seals to use a single, or in some instances, two hauling areas repeatedly. Minimum movement rates ranged between 19 and 27 km/day.

It appeared that disturbance during pupping caused separation of mother-pup pairs thereby increasing neonatal mortality. Molting seals may be particularly vulnerable to the stress of disturbance because of poor physical condition and a possible physiological requirement of hauling out to warm the skin during the molt.

Index count sites were established at major haulouts in each of the lease areas and included Channel Island (NEGOA), Elizabeth Island (LCI) and southwest Tugidak Island (Kodiak). Repetitive counts were obtained at each site to form a "baseline" for future comparisons.

Potential impacts of OCS development include: (1) death or impaired health resulting from exposure to and/or ingestion of oil, (2) reduction in prey availability because of oil related mortality of organisims lower on the food chain, (3) loss of habitat due to development, and (4) stress imposed by disturbance. Recommendations to minimize these impacts include: (1) limiting activities around major harbor seal concentrations particularly during pupping, suckling and molting; (2) preventing habitat usurpation by not allowing development in the vicinity of major hauling or feeding areas; (3) research on the life histories, distribution and key habitats of major prey species; (4) research into juvenile mortality rates of harbor seals; and (5) continuation of "baseline" abundance studies at the index count sites.

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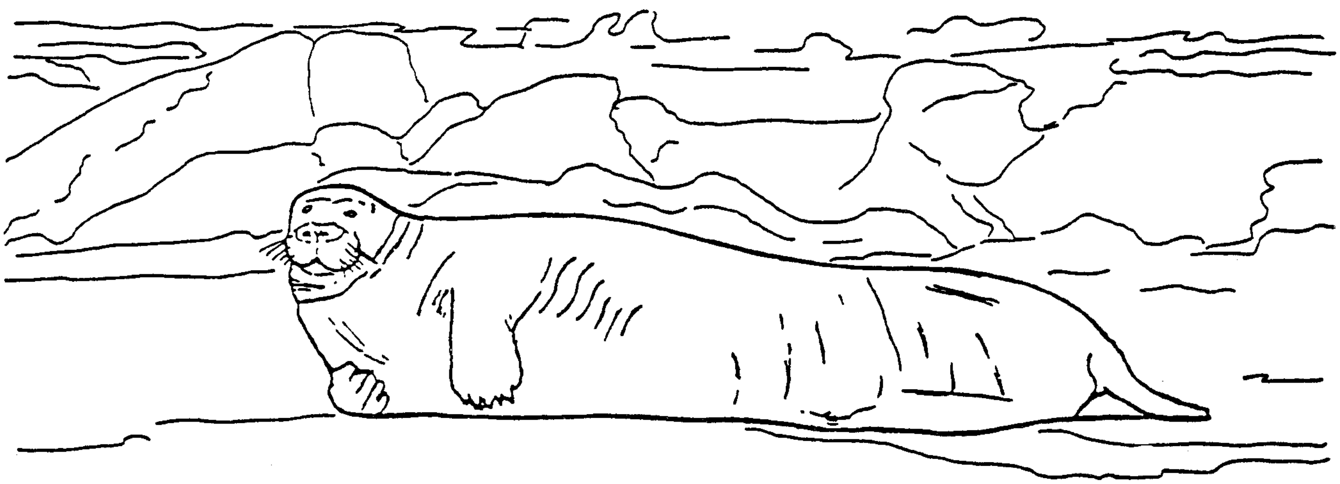
NATURAL HISTORY AND ECOLOGY OF THE

BEARDED SEAL, *ERIGNATHUS BARBATUS*



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Final Report
Outer Continental Shelf Environmental Assessment Program*
Research Unit 230, Contract Number 02-5-022-53

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I. Summary

A study of the natural history and ecology of bearded seals (Erignathus barbatus) was undertaken from June 1975 through April 1979. Of the proposed OCS lease areas which are north of the Alaska Peninsula, the Bristol, Norton and Hope Basins seasonally support the greatest numbers of bearded seals. The Beaufort Basin supports relatively low numbers of these seals but on an almost year round basis. St. George Basin and Bristol Bay are important for the direct support of these seals during years of extensive ice cover and the Navarin Basin is beyond the normal limit of bearded seal distribution. The continental shelf underlying the Bering and Chukchi Seas provides the largest continuous area of favorable bearded seal habitat in the world.

For the most part bearded seals maintain an association with drifting, relatively disturbed, sea ice during all months. As a result, these seals move extensively, being most numerous in Bering Sea during winter-spring and in the northern Chukchi Sea during summer-fall. It appears that seasonal movement into and out of the Beaufort Sea occurs but is not great except in the western part. The seasonal extremes of range vary considerably depending on annual variation in ice conditions.

Age composition of harvested seals was strongly biased toward pups. Thus, direct evaluation of harvest characteristics was not possible. After evaluation of biases influencing composition of the harvest, it was concluded that during early summer pups comprise 22-25 percent of the population, subadults (ages 0 through 3) 40-45 percent and animals 4 years and older 55-60 percent. The sex ratio was close to unity in pups and favored females in older age classes. Analysis of harvest data for individual collection years indicated variation in survival of pups born in different years. Age structure of the harvest was fitted into a "smoothed" age frequency distribution for the populations. This fitted age structure indicated that in early summer the population included 22 percent pups, 44 percent juveniles (ages 0 through 3) and 56 percent 4 years or older. These findings were in agreement with those derived through our understanding of factors which biased age composition of harvests.

A preliminary life table was developed and presented. Mean mortality rate for all ages (0-27) was found to be 219/1000 individuals. It was 96/100 individuals for age classes 6-27. The mean mortality rate for males was higher than for females and may account for the greater proportion of females in older, harvested animals.

Recent harvests are reported. In 1976 the American catch of bearded seals was 2,125 and 4,750 were taken in 1977. The contribution of bearded seals to village economies was estimated based on a reported harvest of 6,308 bearded seals landed between January 1977 and June 1978. The model age of a seal in that harvest was 5.1 years. Weight was 156.9 kg and its "equivalent monetary contribution" to a village was $285.62. The equivalent monetary contribution of this resource to Alaskans during the 18 months indicated above was $1,801,682. Bearded seals are an important resource to residents of northern Alaska.

Parameters of growth in these seals are presented. At birth pups averaged 131.3 cm long and weighed 33.6 kg. Mean length of all seals 9 years or older was 219.7 cm. Weights varied seasonally. Weight of adult females averaged 250.3 kg in spring and 228.6 kg in midsummer. The average weight of two adult males taken in winter was 390.0 kg. It was 244.4 kg in males taken during summer. These seals are heaviest during fall through early spring. Girth of bearded seals varies seasonally and is between 71 and 83 percent of the standard length. Thickness of the skin and blubber layer also varies with season between an average of 7.2 cm in winter and 4.4 cm in summer. Hide and blubber account for between 29 and 39 percent of total body weight.

Males attain sexual maturity at 6 or 7 years of age, females at 4 to 7 years (average age was 6 years). Breeding is mainly in May and implantation is mainly in July. The pregnancy rate for all females in our samples, ages 4 and older, was 77 percent. It was 83 percent in females 6 years and older. The latter value was the same as that derived in the same manner for females examined between 1962 and 1966. We found no evidence of reproductive senility in females.

Some behavioral characteristics of bearded seals are reported. These seals occupy areas of drifting ice. Pups are born on the ice floes with little shelter. The mother-pup bond is strong, pups can swim shortly after birth and lactation lasts for 12 to 18 days. Some pups probably begin independent feeding during the late stages of nursing. They feed as soon as they are weaned and therefore do not undergo a fasting period immediately after weaning occurs.

Bearded seals are relatively tolerant of aircraft and boats. Their tolerance to noise is unknown. They are highly vocal.

Major foods of these seals include crabs, shrimps, mollusks (including clams during summer) and some fishes (mainly cods and sculpins) on a year round basis. Shrimps were important to bearded seals in their first year of life. The specific prey species utilized varied with time and location.

Information on pathology and contaminant burdens was summarized from available literature. Pesticides found in bearded seal tissues included DDT, DDD, DDE, dieldrin and PCB's. Bearded seals had the highest levels of DDT of the Bering Sea phocids examined. Mercury, selenium, cadmium, nickel, copper and zinc were also present in bearded seal tissues. Mercury and cadmium were concentrated in the liver.

Direct effects of OCS development, excluding major accidents such as spills, will probably not be significant to bearded seals and will mainly involve short-term dislocation of animals in areas of exploration and production activity. Indirect effects of OCS development will be much more significant. Accumulations of petrochemical pollutants, under normal conditions of operation, will increase and the possibility of major introductions of contaminants is real.

Organisms eaten by bearded seals (or similar species to those utilized) have been shown to be sensitive to and significantly disadvantaged by petrochemical contamination. Extensive OCS development, in itself, will reduce the carrying capacity of habitats for bearded seals, especially if major accidental releases of fuel, crude oil or other pollutants occur.

II. Introduction

The distribution of bearded seals, _Erignathus barbatus_, Gill 1866, is circumpolar. These seals are boreoarctic and their effective range is restricted to regions within which seasonal sea ice occurs over relatively shallow waters, less than 200 m (Fig. 1). They are bottom feeders.

Two subspecies have been recognized: _E. b. barbatus_ (Erxleben 1777) in the region extending from the Laptev Sea westward to about Hudson Bay, and _E. b. nauticus_ (Pallas 1811) in the remaining range from central Canada westward to the Laptev Sea (King 1964). Boundaries of these supposedly different forms are unknown and, in view of the ecological strategy of this animal, probably do not exist. Manning (1974) examined 260 skulls from both forms and concluded that recognition of the two subspecies is justified. Conversely, Kosygin and Potelov (1971) concluded, based on examination of 416 skulls, that the subspecific differentiation is not warranted. Their findings suggest a single, wholearctic species.

Since we are not in a position to draw a definitive conclusion in this matter, we use the traditional concept of two subspecies--_nauticus_ being the subject of this report.

In the North Pacific region bearded seals occur in the Japan (Tartar Strait), Okhotsk, Bering, Chukchi, Beaufort and East Siberian Seas. The Bering-Chukchi population, which extends into the Beaufort Sea, is the subject of this report. In the Bering and Chukchi Seas these seals are extensively hunted for human food and byproducts by Alaskan and Siberian Natives. Commercial Soviet sealers, operating from large ships, also hunt them in the Bering and Chukchi Seas.

Of the six proposed OCS lease areas in waters of western and northern Alaska (Fig. 2), the St. George and Navarin Basins are on the southern fringes of the winter range of bearded seals. The remaining four (Bristol Bay, Norton, Hope and Beaufort Basins) are all within the range of these seals.

Common Names of the Seal

Some common names of _E. barbatus_ used in the Bering-Chukchi Sea region include: bearded seal (English), morski zaits (Russian, meaning sea hare, commonly used in the western portion of the USSR), laktak (from the Kamtschatdal term, now generally used throughout the Soviet far east), mukluk (Upik Eskimo term used in southwest Alaska, St. Lawrence

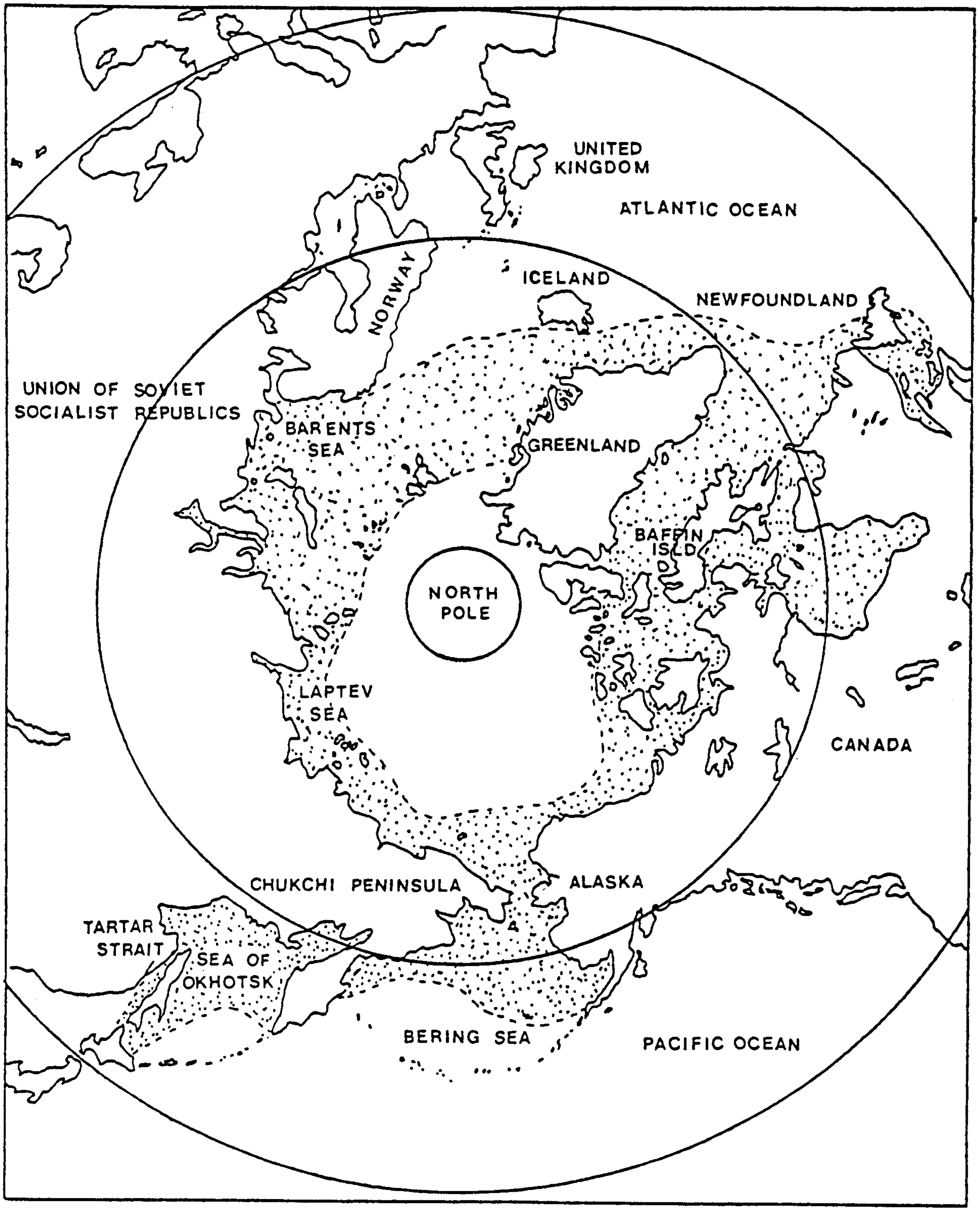


Figure 1. World distribution of the bearded seal, *Erignathus barbatus*.

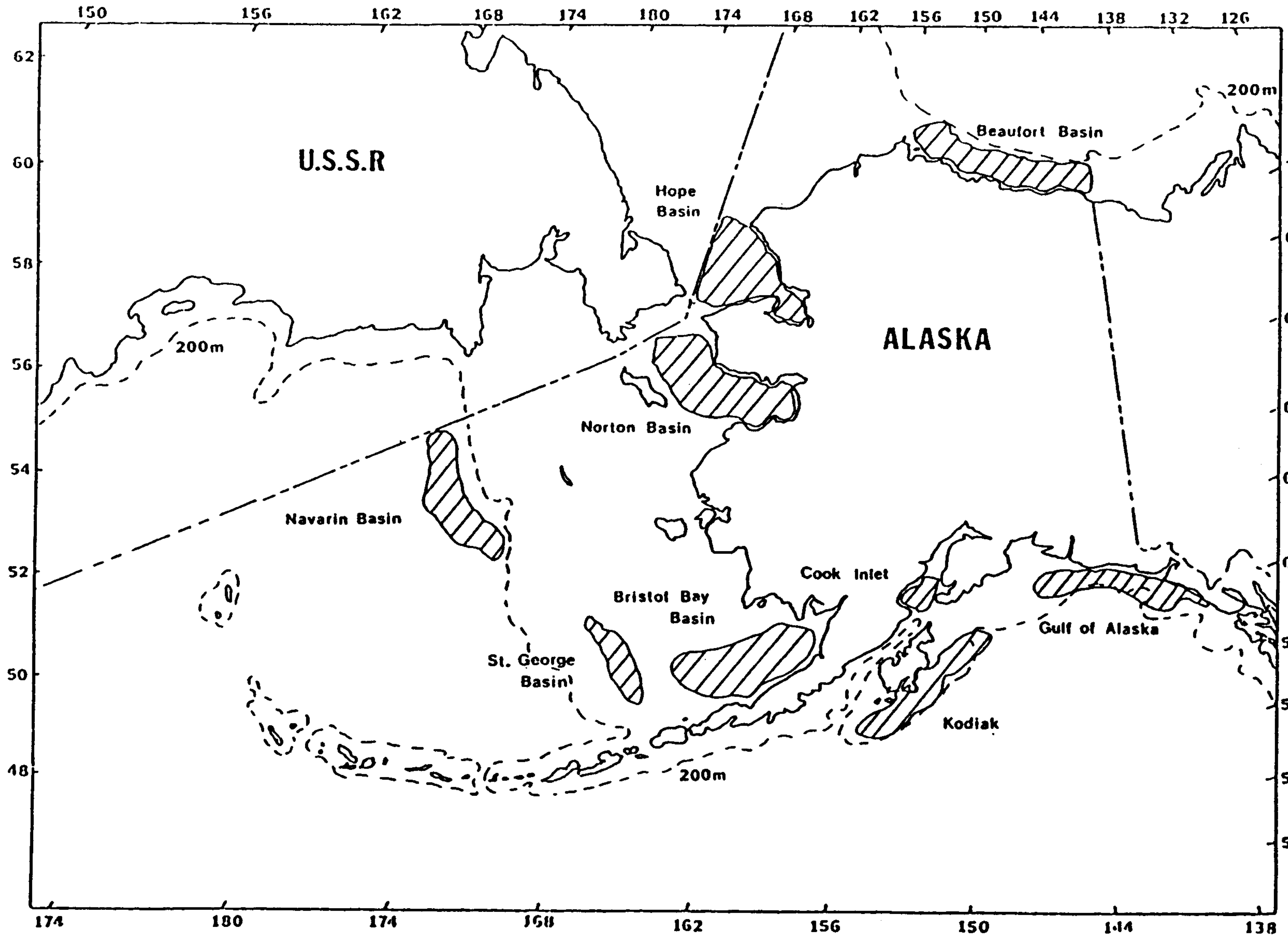


Figure 2. Map of Alaska showing proposed OCS lease areas. In this figure the range of bearded seals roughly coincides with location of the 200 m isobaths.

Island and southern Chukchi Peninsula) and oogruk (Inupiat Eskimo term, a close approximation of which is used by these Eskimos from the Chukchi Peninsula east to Greenland).

External Characteristics and Morphology

The scientific name is descriptive of two prominent features of bearded seals. As indicated by King (1964), the generic name, *Erignathus*, is from Greek and refers to the deep jaw. The specific name, *barbatus*, is derived from Latin and refers to the relatively long and numerous moustachial vibrissae. Obviously, the English common name, bearded seal, is aptly applied. The Norwegian sealer's term, square flipper, is in reference to the shape of the distal portion of the foreflippers, on which the third digit is slightly longer than the others, giving the appendage a blunt, squared appearance. This is in marked contrast to the other northern phocids in which the first digit is the longest.

Bearded seals are the largest of the northern phocids. However, they have a disproportionately small head. This characteristic was noted by Allen (1880) who wrote, "I find that the lower jaw of a very old male *P. vitulina* just fits an adult skull of *Erignathus barbatus*, except that the latter is slightly longer."

These seals have four retractable teats (the other northern phocids have two) which are evenly spaced, two on each side of the midline near the navel.

Coloration

Color of bearded seals is variable. Most adults are basically light to dark gray, slightly darker down the middle of the back. Other individuals vary from tawny-brown to dark brown, also being darkest on the dorsal surface. The sexes are similarly colored. Some younger animals, especially weaned pups, have faint irregularly shaped blotches which are unevenly distributed on the entire body. In general, however, these seals have none of the distinct and diagnostic color patterns such as the spots, rings or bands found in other species. The hair is relatively short and straight. On many animals the face and foreflippers have a rust or reddish brown color.

Term fetuses and newborn pups have dark (usually brown), dense, slightly wavy hair with light coloration on the facial region and one to four broad, transverse light bands on the crown and back. By the time these pups are weaned the pelage resembles that of older seals. Prior to Chapskii's (1938) excellent study of this species, there was considerable confusion in the literature about the pelage coloration of fetal and newborn bearded seals. It was thought that they, like other ice-associated phocids of the north, were white.

General Anatomical Characteristics

The following resumé of some anatomical characteristics of bearded seals was adapted from Burns (in press).

The skull of these seals is wide, comparatively short and more massive than those of other ice-associated phocids of the North Pacific region. Bearded seals commonly break through thin ice with their heads. There is no saggital crest. Teeth are comparatively large, and, except for the upper canines, are weakly rooted. The dental formula is typical of phocids: I $\frac{1\text{-}2\text{-}3}{0\text{-}2\text{-}3}$, C $\frac{1}{1}$, PC $\frac{1\text{-}2\text{-}3\text{-}4\text{-}5}{1\text{-}2\text{-}3\text{-}4\text{-}5}$, on each side for a complete complement of 34. Anomalies are not uncommon and usually involve lack of an incisor or presence of supernumerary postcanines. Teeth are mostly worn down or missing in adults.

The palate is more arched and higher than in other phocids and the mandibles are deep. These features result in a comparatively large buccal cavity, an adaptation for a modified type of suction feeding (presumed).

Mean condylobasal length for 63 adult Pacific bearded seals was 222.8 mm and zygomatic breadth was 130.3 mm (Manning 1974).

The rostrum is broad and rounded, supporting fleshy nasal pads with a large number of vibrissae, the feature on which the English common name of this seal is based.

Fay (1967) reported that a bearded seal he examined had 15 thoracic vertebrae and pairs of ribs, typical of the order Pinnipedia.

The trachea of bearded seals is different from that of other North Pacific phocids in that most of the rings are incomplete. On the average there are 69 rings (64-81) of which only the first 6 to 12 are complete. In the remainder there is a broad elastic membrane between the ends of the flattened rings. Ends of the rings are most widely separated in the central portion of the trachea (Sokolov et al. 1968, Burns unpubl.). The function or functions of this type of trachea are unknown but may be related to production of the unique vocalizations in this animal. The hyoid arch is complete.

Lungs in the bearded seal are multilobular and generally resemble those of ringed seals, having apical, cardiac, diaphragmatic and post-cardiac lobes on the right lung and lacking the postcardiac on the left. These are different from the unlobulated lungs of ribbon seals (Sokolov et al. 1968).

In five large bearded seals average length of the intestine was 2,502 cm. The duodenum averaged 33.6 cm, small intestine 2,164.6 cm and large intestine 303.8 cm.

Average heart weight in adults was found to be about 1,110 g.

III. Objectives

The objectives of this study were as follows:

1. To summarize and evaluate existing literature about bearded seals, particularly that population which occurs in the study area and in the six proposed lease areas within the range of these seals.

2. To determine population structure, dynamics and productivity of these seals as indicated mainly by specimens obtained from Eskimo subsistence hunters.

3. To compare current parameters of species productivity with similar measures determined in the recent past.

4. To determine important aspects of bearded seal natural history including prenatal and postnatal growth, condition, timing of major biological events, habitat requirements and behavior.

5. To determine the magnitude and distribution of annual harvests of these seals by residents of coastal Alaska villages and estimate the contribution of these harvests to village economies.

6. To acquire specimen material, mainly from subsistence harvests, necessary for the successful completion of related studies, particularly that of food habits and trophic relationships.

7. To predict, if possible, the potential effects of various stages of petroleum development on bearded seals.

Collectively, the objectives stated above were intended to provide information required for an assessment of the susceptibility of bearded seals to proposed OCS development, to acquire base line information about these seals against which future findings can be compared, and to provide a species account of use to the general public.

IV. Current State of Knowledge

The bearded seal has been important to man since he first occupied the Arctic and Subarctic regions. Every culture that utilized these large seals developed a body of knowledge about them that was based on observation during generations of hunting, examination of killed animals and a first-hand exposure to part of the environment in which the seals live and interact. Some of this knowledge has found its way into scientific literature, mostly through investigators who recorded the opinions and facts reported to them by Native peoples. Unfortunately, a large body of the information known to local residents of the North has not been recorded and much of it may be lost.

There are numerous references to bearded seals in a large number of publications dealing with various aspects of the Far North. Earliest accounts of northern explorers often indicate the importance of bearded seals to local peoples encountered during expeditions, and occasionally describe details of the natural history of the seals. Many of these accounts are in Russian and stem from an early interest in the Far North by the Russian Empire.

There have been relatively few scientific studies directed specifically toward bearded seals. Most scientific information about them has been obtained as an adjunct to work on other marine mammals such as the more abundant ringed (Phoca hispida) and harp (Phoca groenlandica) seals.

The following references are those which include significant contributions to our knowledge of bearded seals. An interested reader could obtain a general understanding of the species from them, although they are by no means the only sources of information. As an example, a listing of publications on regional faunas, which included references to bearded seals, would, in itself, be very long.

Accounts of the natural history of bearded seals include the pioneering work of Chapskii (1938), based on studies in the Kara and Barents Seas; Vibe (1950) who worked in northwest Greenland; Johnson et al. (1966) from the eastern Chukchi Sea; and Burns (1967) from the Bering and Chukchi Seas.

Plekhanov (1933) described a method for determining the age of seals based on examination of claws. Sleptsov (1943), McLaren (1958), Tikhomirov (1966) and Potelov (1975) studied growth and/or reproduction in bearded seals, relying mainly on Plekhanov's method for determining age of seals in their samples. Benjaminsen (1973) found that although the teeth of bearded seals are largely lost or reduced in adults, the root of upper canine teeth could be used for more precise determination of age in adult seals. His paper describes age and growth in these seals from the North Atlantic and Barents Seas. Benjaminsen's method was utilized in this study.

Feeding of bearded seals was studied by Pikharev (1940) and Fedoseev and Bukhtiyarov (1972) in the Okhotsk Sea; Dunbar (1941) in the eastern Canadian Arctic; Kosygin (1966a) in the Bering Sea; Kenyon (1962) in the Bering Strait; and Lowry et al. (1977, 1978, 1979a&b) in the Bering, Chukchi and Beaufort Seas. Delyamure (1955) reported on the helminth parasites of seals, including bearded seals. Fay et al. (1977, 1978, 1979) reported results of their studies on various aspects of morbidity and mortality in Alaskan marine mammals including bearded seals.

The taxonomy and/or systematics of bearded seals are included in papers by Chapskii (1955), Burns and Fay (1970), Kosygin and Potelov (1971) and Manning (1974).

Distribution of bearded seals in the study area was reported by Tikhomirov (1961), Kosygin (1966b&c), Burns (1970), Stirling et al. (1977) and Braham et al. (in press).

Relationships of marine mammals, including bearded seals, to sea ice in the study area were described by Burns (1970) and Fay (1974).

V. The Study Area

The study area includes the Bering, Chukchi and Beaufort Seas (Fig. 3). Although almost all of the data and samples were obtained in the

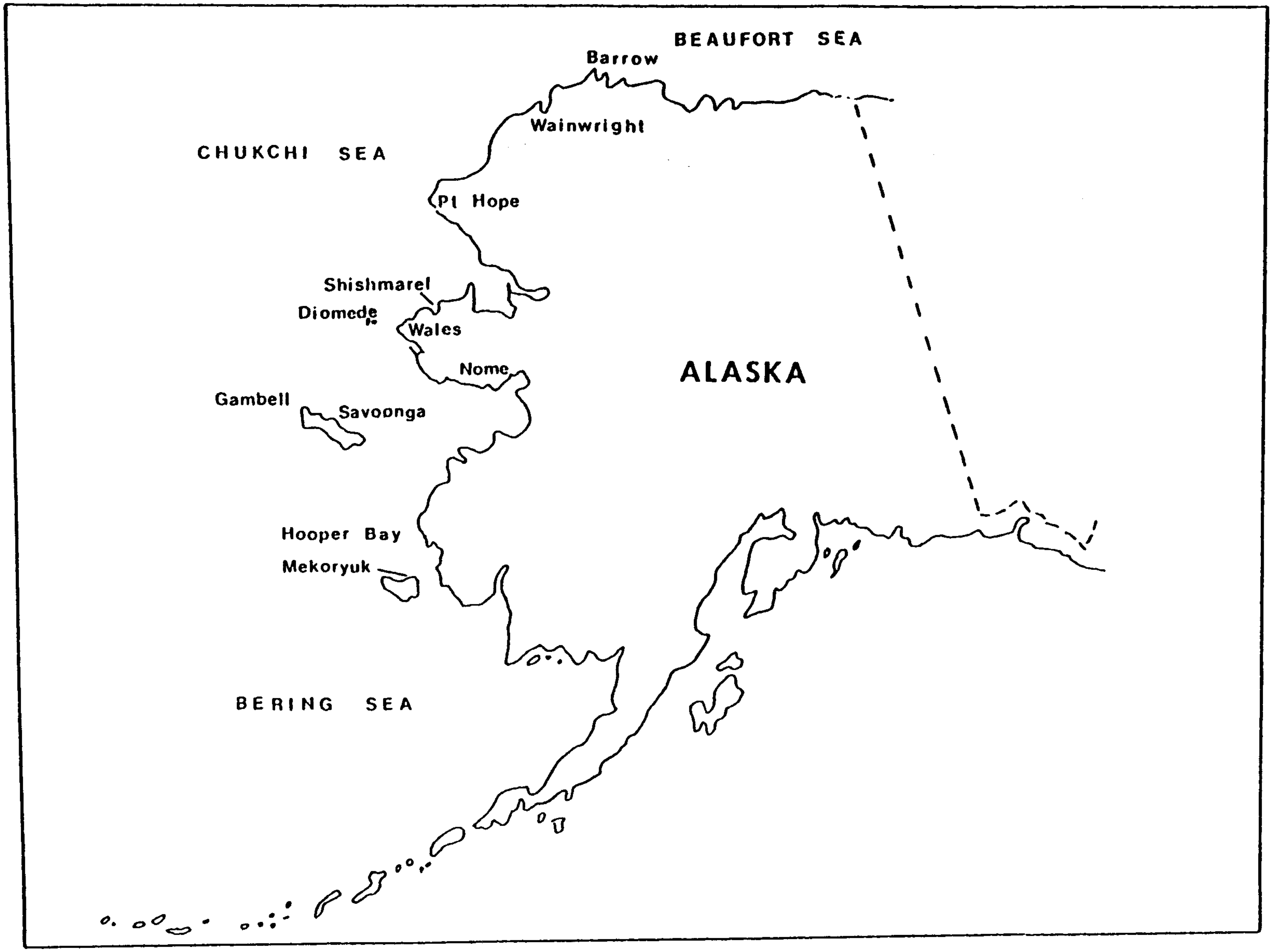


Figure 3. Locations where the major collections of specimen material and data were obtained during this investigation.

American "sector" of these seas, they were derived from what appears to be a single population whose range and seasonal movements occur mainly within (and between) these seas. The eastern part of the Beaufort Sea may be an exception in that nothing is presently known about movements of bearded seals between that region and the areas west and south.

The Bering Sea is a well-defined body of water which is almost completely surrounded by land. Zenkevich (1963) presents a very useful resumè of some major characteristics of this sea, as follows.

The surface approximates 2,304,000 km^2 and its volume approximates 3,683,000 km^3. Greatest depth is in the region of Kamchatka Strait, reaching 4,420 m. Mean depth for the entire sea is 1,598 m. Of great importance, from the standpoint of bearded seals, is the fact that the Bering Sea is divided by the 200 m isobath into two approximately equal parts; the southwestern part with depths greater than 3,500 m and the northern and eastern shelf regions of less than 200 m depth. Bearded seals occur in the shelf region.

The few soundings available suggest that the continental shelf of the northeastern Bering Sea is a flat plain with gentle slope gradients (Creager and McManus 1966). Minor relief features are present. Major relief features in the Bering Sea are the fjords of the Chukchi Peninsula and the discontinuous trough paralleling the Chukchi Peninsula north of Northwest Cape, St. Lawrence Island (Udintsev et al. 1959).

Of the confined seas, the Bering Sea is exceeded in size only by the Mediterranean Sea. It is connected with the Pacific Ocean by the deep Kamchatka Strait (4,420 m) as well as by numerous, deep passages through the Aleutian Islands.

In the north, Bering Strait connects the Bering and Chukchi Seas. This Strait is very shallow (not exceeding 55 m, according to U. S. Coast and Geodetic Survey, chart number 9400) with a width of 85 km and a cross-section of approximately 2.5 km^2 (Zenkevich 1963). Throughout most of the year movement of water is north through Bering Strait. Zenkevich (1963) indicates that about 20,000 km^3 of Bering Sea water passes north through Bering Strait each year. South setting currents have been recorded (Bloom 1964, pers. comm.) and are usually produced by meteorological factors. The magnitude and occurrence of such currents are only poorly known as they occur mainly during the late fall and winter months. South setting surface currents dominate during November through March and result in a net southward transport of ice during that period.

The Chukchi Sea is somewhat more difficult to delineate as it is not completely surrounded by land. It is frequently considered, especially in the Soviet literature, as an embayment of the Arctic Ocean which is bounded on the south by the Bering Strait; on the west by the Chukchi Peninsula and the eastern shores of Wrangell Island (approximately 176°42'W longitude); on the north by the edge of the continental shelf and on the east by the shores of Alaska as far as a line extending north from Point Barrow (approximately 156°13'W longitude). All of this area is underlain by the Chukchi Platform.

According to Zenkevich (1963), the area of the Chukchi Sea is 582,000 km^2. The continental shelf of the Chukchi Sea is a flat, almost featureless plain having average depths of 45 to 55 m and regional slope gradients ranging from 2 minutes to immeasurably gentle slopes (Creager and McManus 1966). Local maximum gradients range up to 1°55'. Excluding the slope between the land and the sea floor, the major relief features in the Chukchi Sea are Herald Shoal, Hope Sea Valley and the Cape Prince of Wales Shoal (Udintsev et al. 1959).

The Bering-Chukchi Platform underlying the northern and eastern half of the Bering Sea and all of the Chukchi Sea comprises the largest continuous area of bearded seal habitat in the world.

The Beaufort Sea is a less discrete body of water than either the Bering or the Chukchi Sea. Generally, it is considered as an integral part of the Arctic Ocean extending from Banks and Prince Patrick Islands in northwest Canada to Point Barrow in Alaska. Its southern margin is the shoreline of mainland Canada and Alaska. There is no discrete northern boundary. The portion of the Beaufort Sea presently under discussion extends from Point Barrow to Demarcation Point and from the Alaska Coast north to the 200 m isobath (i.e. the continental shelf). This is a narrow region which falls mostly within about 45 nautical miles of shore. The shelf break in the Beaufort Sea is abrupt.

The study area is shown in Figure 2. In this figure distribution of bearded seals can be considered to coincide with location of the 200 m isobaths.

Biological and physical features of bearded seal habitat within the three seas are different. The Bering Sea is a northern extension of the North Pacific Ocean. It is a biologically rich and diverse region within which upwelling of nutrient rich deep water, forced upward by the Aleutian Chain of islands and the continental shelf edge, is a major contributor to the high biological productivity which occurs. Several major rivers also contribute significantly to the nutrient regime. Climate in the Bering Sea (strongly influenced by the Pacific Ocean) is temperate, grading into subarctic in the northern one-third. Prevailing winds are out of the south (mainly southeast) during May through September and from the north (mainly northeast) during November through April. There are great annual differences in climate which result in major annual differences in, for instance, extent and characteristics of the seasonal ice cover. Ice is normally present from late November through June. It includes two major components--ice which forms during winter in the Bering Sea, and ice which is transported south through the Bering Strait. It appears that most ice is of the former component.

On the average the southern extent of ice, at the time of maximum coverage (March-April), coincides with the edge of the continental shelf. However, annual differences in location of the southern ice margin in the central Bering Sea are as much as 450 nautical miles (from approximately 60 nm south of St. George Island to about 60 nm south of St. Lawrence Island). Shifting and movement of the relatively thin ice cover is significant and produces extensive areas where the ice is fragmented and openings are present. This shifting, together with the extensive leeward coastlines of several large islands as well as the coasts of Alaska and Siberia, produce conditions which accommodate a relatively high abundance of bearded seals during winter. A high biomass of food species, which is present, supports these seals.

The Chukchi Sea is mainly subarctic in its characteristics. Much of the North Pacific influence is lost, as water flowing north through the narrow constriction of Bering Strait has become altered in the Bering Sea. Biological productivity of the Chukchi Sea is less than that of the Bering Sea.

Ice conditions are more severe due to average lower winter temperatures, a longer freezing period, incursions of multi-year ice during the fall-spring period, constraints of surrounding land masses which are largely exposed to prevailing winter winds (mainly northeast) and the frequent occurrence of persistent "arctic" high pressure systems.

Water depths in all parts of the Chukchi Sea are suitable for bearded seals feeding. These seals occur throughout this sea in winter. However, ice conditions are such that highest densities occur in the limited regions of persistent shear and flaw zones such as occur immediately north of Bering Strait and parallel to the Alaska and Siberian coasts. The abundance of bearded seals in the Chukchi Sea during winter is much less than in the Bering Sea.

The Beaufort Sea is a transition area between the subarctic and arctic provinces. The northward trend of decreasing biological productivity continues and, in comparison to the Chukchi Sea, productivity is significantly lower.

Multi-year ice is a significant feature of the northern part of this sea and the areal coverage of this ice shows extreme annual variations. Seasonal sea ice develops near shore, its extent depending on the amount of multi-year ice which is present. The coastline of the Beaufort Sea north of Alaska has a northeasterly exposure and is therefore ice stressed. Prevailing winds are northeast and, at least in the eastern part, there are weak cyclonic surface circulations of air and water (Wilson 1974).

Seasonal and multi-year ice can occur in the Beaufort Sea throughout the year. In most years the nearshore zone is ice free during August through October but there is great annual variation in the extent of open water. It is mostly ice covered from late October through mid-July. During the late summer-early fall "open water" period multi-year ice is present at varying distances from shore. Usually it is situated north of the shelf break and therefore beyond depths suitable for bearded seals. These seals occur in open water overlying the continental shelf or in association with nearshore ice remnants which sometimes persist through late summer. In winter ice conditions are such that bearded seals, in low numbers, are restricted to the narrow flaw zone which roughly parallels the coast. Compared to the Bering and Chukchi Seas, the Beaufort Sea is marginal winter habitat for bearded seals. They are restricted in distribution to a rather narrow zone and occur in low densities.

The requirements of bearded seals for suitable ice conditions over waters shallow enough to permit feeding on the sea floor result in an annual cycle of movements in which the majority of these seals move south into the Bering Sea with the buildup and advance of seasonal ice, and north with the retreat and disintegration of this ice cover. Many areas, especially in the Chukchi and Beaufort Seas, which do not support high densities of bearded seals during the winter or summer are important during the transition periods.

VI. Sources, Methods and Rationale of Data Collection

A. Field Processing of Seals

Data and specimens were obtained mainly from two sources: 1) a program to assess species, age and sex composition of the seal harvest in northern Alaska (funded by the Alaska Department of Fish and Game) and 2) the OCSEAP programs undertaken to investigate the ecology of bearded and ringed seals (RU #230) and the trophic relationships among ice-associated phocid seals (RU #232). Most of our data and specimens were obtained from bearded seals taken by Eskimo subsistence hunters. Locations of major hunting villages at which specimens were collected are shown in Figure 3. Some bearded seals were collected in the course of OCSEAP studies, mainly during research cruises of the NOAA ship SURVEYOR. Collections by project personnel were undertaken in regions or during times of the year when these seals were not available to coastal-based subsistence hunters.

Sampling procedures varied depending upon facilities available when bearded seals were examined, objectives of the program being conducted and on the number of seals being landed when investigators were present.

During sampling programs in villages, undertaken by ADF&G, notation of date, location, species and sex of the seal was always obtained. Minimum specimen requirements included upper jaws and claws of the foreflipper. When possible, seals were measured (see below) and reproductive tracts (mainly from female seals) and stomachs were obtained. Bearded seals were usually not weighed because of their size and the difficulty of moving them on the beaches.

During OCSEAP funded programs undertaken in the villages, specific effort was devoted to bearded seals. These seals were processed as completely as possible. Specimen material obtained included jaws, claws, female reproductive tracts and stomachs. Supporting data from each seal, including measurements, were obtained.

Seals collected by OCSEAP investigators, mainly with the support of ships, were photographed, weighed, measured and necropsied. A variety of organs and tissues were saved including skulls or jaws, claws, reproductive tracts, digestive tracts and samples of heart, liver, kidney, muscle and blubber. Blood samples were obtained when feasible. Weights obtained included that of the whole seal (no estimate of blood loss), the hide and blubber and a limited series of organ weights.

A series of 12 measurements were taken. Those utilized in this report include:

Standard length - the straight line distance measured from the tip of the nose to the tip of the tail with the head and neck in a natural position. Seals were placed on a flat surface (back down), the appropriate points marked, the seal moved aside and the distance between points measured.

Girth immediately behind foreflippers - measured with a flexible tape around the body, under the foreflippers, at the level of the axillae.

Skin and blubber thickness - the thickness of skin and blubber immediately overlying the sternum at the level of the xiphoid process. An incision was made and a knife inserted down to the bone. The skin and blubber thickness was marked on the knife blade and measured.

Occasionally dead seals were found. These were processed as indicated above and, if possible, cause of death was determined.

B. Laboratory Examination of Specimens

Age determinations were based on examination of claws and/or upper canine teeth. Tooth wear in bearded seals is rapid and in the majority of animals older than about 8 years teeth are missing or worn down to the gum line. Therefore, in several previous studies teeth were not examined to determine age (i.e. Chapskii 1938, McLaren 1958, Johnson et al. 1966, Burns 1967). In most of these earlier studies growth ridges on claws of the foreflippers were used, as described by Plekhanov (1933). However, Benjaminsen (1973) found that the roots of the upper canine teeth remained throughout life in most bearded seals. The remaining portions of these teeth could be sectioned and the age determined on the basis of annuli in the cementum layer. In our continuing studies of bearded seals we adopted a combination of the two methods. Initial determination of age was based on claw annuli. If the determined age was doubtful because annuli extended out to the tip of the claw, the roots of the upper canine teeth were sectioned. In most animals age 0 to 8 years results of both methods were in close agreement. The change in procedure has resulted in minor difficulties when comparing, for instance, growth curves from studies conducted prior to 1973.

Female reproductive tracts were preserved in 10 percent formalin for later study. In the laboratory the uterine horns were externally examined for signs of current or previous pregnancy, indicated by external size, conformation and degree of rugosity.

Uterine horns were then opened and examined for placental scars, fetuses, or other indications of recent pregnancy. These indications included shape and size of each horn, condition of the uterine walls, presence of hemorrhagic tissue, and the kinds and amount of debris in the lumen.

Ovaries were weighed and serially sectioned with a scalpel, parallel to the longest axis. Sections were 1-2 mm thick. Each section was examined macroscopically for follicles, corpora lutea or corpora albicantia. On these bases females were classified as nulliparous, primaparous or multiparous. Drawings were made of each ovary for later reference. The presence or absence of a fetus was noted at necropsy.

Testes were weighed to the nearest 0.1 g with and without epididymides. Length and width at the middle of the testes were measured to the nearest millimeter. Testes volume (nearest cc) was determined by water displacement. Bacula were cleaned by boiling, air dried and then measured (nearest mm) and weighed (nearest 0.1 g).

Samples (about 125 cm^3) of heart, liver, kidney, skeletal muscle and skin and blubber were wrapped in aluminum foil, labeled and frozen. These tissue samples were stored and/or provided to other investigators for microbiological, hydrocarbon, pesticide and heavy metal analyses.

C. Surveys and Observation of Seals

Seasonal migration patterns were determined through observations at coastal hunting sites and from surveys. Aerial and small boat surveys were used to determine the distribution and densities of pinnipeds in the ice-covered Bering, Chukchi and Beaufort Seas.

Aerial surveys were flown in fixed-wing aircraft and in helicopters. Aircraft used for surveys were a Cessna 180, Cessna 185, DeHavilland Twin-Otter and Lockeed P2V (all fixed-wing aircraft) and a Bell 206B helicopter. Strip transects were flown. Transect width varied, depending upon conditions, from 0.05 to 0.5 nm on one or both sides of the aircraft. Reported densities of seals were expressed as animals per nm^2. Transect width was maintained with fixed reference points on the aircraft windows and wing struts or floats. Surveys were usually flown at altitudes of 91.5 m (300 feet). All seals (by species) and polar bears observed on these flights were enumerated.

Locations and distances traveled along flight tracts were determined by standard aerial navigation techniques, by radar fixes from various DEW-Line stations, or with the aid of a GNS-500 system (very low frequency, Omega navigation system).

Some surveys were conducted from small boats. In these surveys general locations and numbers of seals seen per boat hour were recorded. It was not possible to reduce these data to densities per nm^2. However, these surveys did indicate relative abundance of seals in the different areas studied.

Natural history and behavioral observations were obtained from several sources: 1) field observations by the principal investigators, 2) unpublished field observations of other investigators and 3) reports from Eskimos. The bulk of the natural history and behavioral observations were recorded by the principal investigators while they were on the sea ice, or aboard ships, skin boats or aircraft. These observations are usually made with the aid of field glasses or spotting scopes and are recorded as field notes with appropriate ecological and behavioral notations.

Because of the amount of time they spend on the ice pursuing marine mammals, Eskimo hunters are able to provide a wealth of information concerning behavior and natural history. Their observations were recorded and, as appropriate, are presented.

D. Data Management

Data obtained in the course of OCSEAP funded programs were entered, as contractually required, into standardized data management programs. Two data sets were prepared--one being submitted to the National Oceanic Data Center and the second retained and used for analysis. We utilized a VT/78 micro-computer (Digital Equipment Corporation) for data entry and analysis.

The age structure of bearded seal harvests for the years 1971 through 1974 and 1975 through 1978 each consisted of two components: 1) those seals for which age determinations based on claws (young animals) and teeth were acceptable and 2) older aged seals for which only a minimum age, based on examination of claws, was known. The sample size in each category was:

Sample Series	No. for which age determinations were acceptable	No. for which only minimum age was known (claws)	Range of minimum known ages
1971-1974	306	55	6-16
1975-1978	1160	151	5-18

We combined the two components for each series by redistributing the seals of known minimum age in accordance with the age distribution of the larger sample for which age determinations were acceptable. In the minimum age component seals were not younger than the minimum age assigned to them. However, they were either of the minimum assigned age or of some older age class.

The mathematical procedure for incorporating the minimum age component into the larger series was based on the following calculations:

$$N_A \text{ total} = N_A \left[1 + \sum_{j=0}^{A} \left(\frac{M_j}{\sum_{i=j}^{26} N_i} \right) \right]$$

where

N_A total	=	number in age class A (exact + minimum)
N_A	=	number in age class A (exact only)
A	=	age class being analyzed
M_j	=	numbers that are at least j years old
N_i	=	numbers that are exactly i years old
26	=	oldest age class in known distribution

VII. & VIII. Results and Discussion

A. Distribution and Movements

The shelf regions of the study area are mostly covered by sea ice during late winter and spring and are mostly ice free by late summer and fall. The southern margin of multi-year ice which persists through the melting period is usually south of the northern limit of the Chukchi platform and extends completely across it. In most years multi-year ice is situated north of the Beaufort Sea shelf in August through October.

Bearded seals can and do make and maintain breathing holes in relatively thin ice. They avoid regions of continuous, thick shorefast ice (unlike ringed seals, *Phoca hispida*) and are not common in regions of unbroken, heavy, drifting ice. These seals mainly utilize areas of shallow water where the ice is in constant motion, producing leads, polynya and other openings. In the Chukchi Sea during winter and spring such conditions occur as extensive "flaw zones" which occur where heavy drifting ice, influenced by winds and currents, interacts with coastal features. The extent of such favorable winter habitat in the Chukchi Sea is relatively limited. It is most restricted in the Beaufort Sea. In comparison, this combination of suitable ice conditions and water depths occurs over a much broader area in the more temperate Bering Sea. Most of the population moves south through Bering Strait in late fall-early winter and "winters" in the Bering Sea. During the winter and early spring bearded seals are widely, though not uniformly, distributed throughout the drifting ice of the Bering Sea. Highest densities occur in the northern part of the ice-covered Bering Sea shelf. Relationships of marine mammals to sea ice in the region under discussion are described by Burns (1970) and Fay (1974).

As implied by the remarks above, most bearded seals move great distances during the year, mostly maintaining an association with ice. These movements are directly related to the seasonal advance and retreat (as well as the growth and degeneration) of the ice cover. During winter most of them are in the Bering Sea; in summer they are near the wide, fragmented margin of multi-year ice in the Chukchi Sea. The northward spring migration through Bering Strait, occurring from mid-April through June, is more marked and noticeable than the southward movements in late fall through winter. Spring migration past St. Lawrence Island, as indicated by hunting success, is shown in Figure 4.

Bearded seals do not resort to coastal hauling areas in the Bering-Chukchi region. This is probably because they are able to maintain their association with ice on a year-round basis, in water depths suitable for bottom feeding.

In other parts of their circumpolar range they regularly come ashore during summer. This has been reported to occur in the Okhotsk Sea (Tikhomirov 1961; Fedoseev, pers. comm.), the White Sea (Heptner 1976) and the Laptev Sea (Tavrovskii 1971). In these regions ice either melts in summer or recedes beyond limits of suitably shallow water.

Some bearded seals, perhaps a significant proportion of juveniles, occur in the open sea during summer. They also enter small bays and ascend some rivers. In Imuruk Basin on the south coast of the Seward Peninsula pups were occasionally taken in nets at the time of fall freeze-up. This basin is separated from a larger bay by a long, narrow channel. There are several reports of seals becoming trapped by freeze-up of this brackish body of water and seeking escape by traveling over ice or land. In two reported instances pups were tracked down in the snow and were dead when found (Kugzruk, pers. comm.). A similar occurrence in the Canadian Arctic was noted by Smith and Memogana (1977).

The seasonal occurrence of bearded seals in the proposed lease areas and the vital biological functions which occur while they are there vary with location.

Bristol Bay is normally occupied by ice to some extent from December through April. The annual extent of coverage is variable, from virtually complete (almost reaching the Alaska Peninsula) to ice free. Except for the extreme eastern part, seals occur throughout the drifting ice. This lease area supports a moderate but unknown number of wintering bearded seals in most years. The number of seals is directly related to extent and duration of the ice cover. In April 1971 and 1976, as examples, Bristol Bay was completely ice covered. In April 1979 it was ice free. Bearded seals begin migrating north in early April.

In heavy ice years pups are born, nursed, weaned and deserted within this lease area. Newly independent pups are less migratory than older seals and remain with the disintegrating ice until it is gone. Some probably remain in the bay during summer but, based on the abundance of pups in the Yukon-Kuksokwim Delta area during May and early June, most move north with the receding ice.

St. George Basin, like Bristol Bay, is on the southern boundary of bearded seal range. Importance of this lease area to the seals is directly related to annual ice conditions. In "average" years sea ice reaches the northern part while in heavy ice years much of this lease area is covered during late January through early May. When ice is present, bearded seals are moderately abundant through late March and begin to migrate northward in April. This lease area is particularly

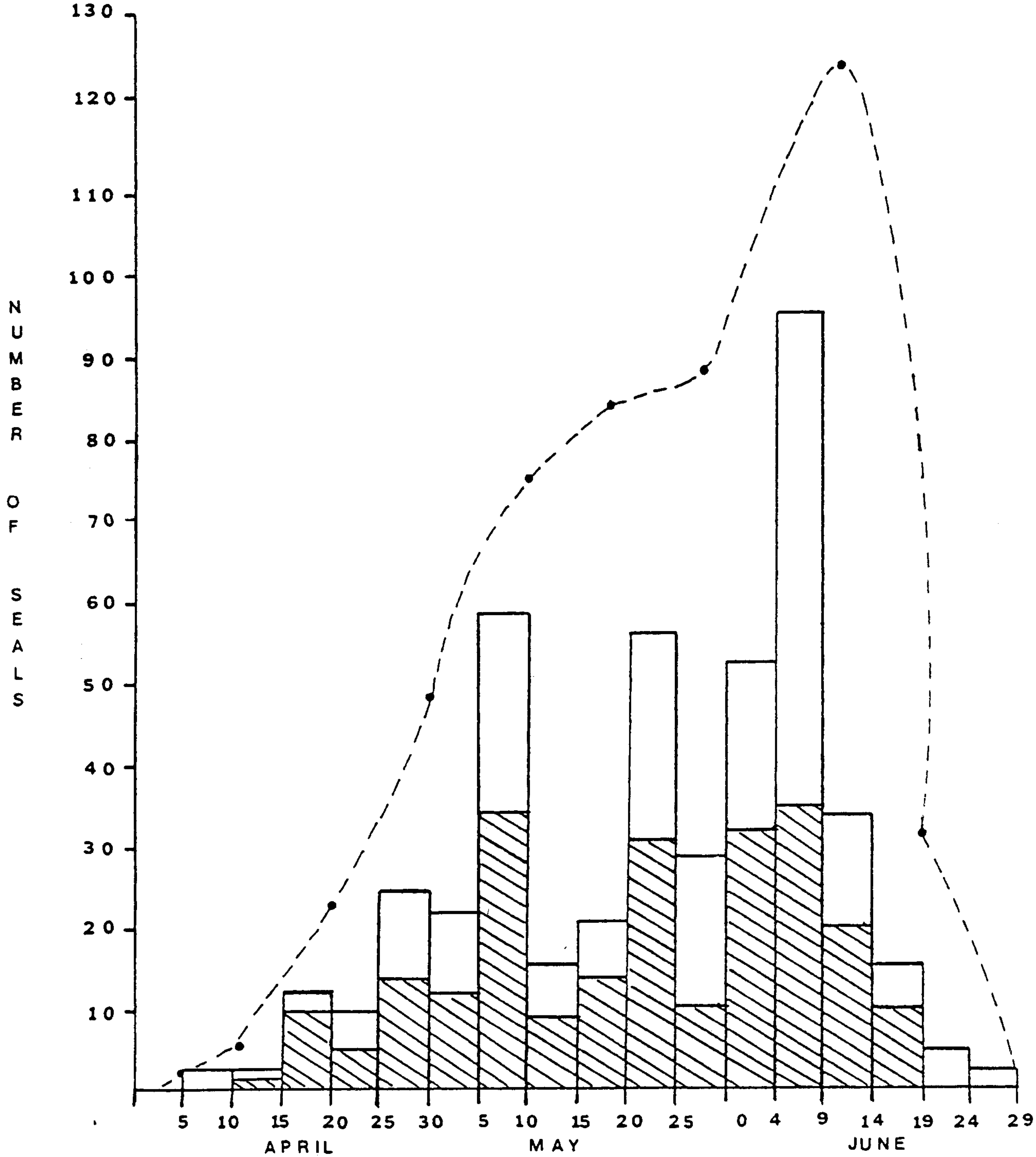


Figure 4. Spring migration timing of bearded seals past St. Lawrence Island as indicated by recorded hunting success from 1963-1966. The bars indicate harvest by five day intervals, with the female component indicated by stippling. The dots connected by a broken line indicate the harvest by ten day intervals, starting with the period from April 5 to 15. Total sample was 471 seals.

favorable habitat during late winter because of the high abundance of potential food (crabs and shrimps). As in Bristol Bay, birth, nursing and weaning of pups occurs in this proposed lease area. If ice persists into May, breeding adult seals are also present.

Navarin Basin is south of the limit of seasonal sea ice and probably does not support significant numbers of bearded seals.

Norton Basin is important bearded seal habitat. Shorefast ice is limited in extent while drifting ice of suitable characteristics for seals occurs throughout this lease area from late November through about 20 to 25 June. It is a region through which large numbers of seals migrate during spring and fall and in which they are abundant residents whenever ice is present. This lease area is one of seasonally high seal densities. Major biological events which occur in this lease area include birth, nursing, weaning, breeding and molting. Large numbers of newly independent pups are present in the area during May through June and some pups and subadults remain throughout the open water season. However, most seals pass north, through Bering Strait, by late June.

Hope Basin, like Norton Basin, is a very important area for bearded seals. They are present for a longer period of time because ice is present a little earlier and persists significantly longer. Ice is usually present from mid-November through mid- to late July. Bearded seals migrate through the Hope Basin in spring and fall. These seals are also abundant in suitable areas of drifting ice from late fall to summer. Extensive landfast ice occurs along the northern coast of the Seward Peninsula and in Kotzebue Sound. The fast ice zone is not utilized by bearded seals until it begins to disintegrate.

Hope Basin has several important features which contribute to its great importance for bearded seals. During winter prevailing winds are northeast. Thus, the northeastern part of this lease area (except Kotzebue Sound) is leeward of the coast. Polynya and lead systems occur throughout winter and spring. Similarly, disturbed ice conditions predominate in the vicinity of Bering Strait, caused by strong currents in that region. The conditions in Hope Basin, which maintain numerous openings in the winter ice cover, are favorable for bearded seals.

A shoal extending more than 100 km north of Cape Prince of Wales produces a gyre which, during the process of ice disintegration, entrains floes producing a large remnant. This ice remnant, consisting mainly of thick floes from the former shorefast zone, persists along the northwestern coast of the Seward Peninsula, as late as the end of July. Kotzebue Sound, on occasion, also traps drifting ice. Bearded seals congregate in these ice remnants for as long as they persist. Some subadults, mainly pups, remain in Hope Basin during the open water season.

From the standpoint of the bearded seals, major biological events which occur in the Hope Basin include all of those indicated for Norton Sound. Additionally, large numbers of seals are in the ice remnants of this lease area when implantation and early prenatal growth occur (i.e. mainly during July). It is noteworthy that two of the more successful seal hunting villages, Shishmaref and Point Hope, border the Hope Basin.

The Beaufort Basin has a relatively narrow shelf and is influenced by more severe ice conditions than the Chukchi or Bering Seas. The ice cover is more complete in winter through late spring and movement of the drifting ice is significantly less. A schematic representation of ice zonation and interaction with the shelf is shown in Figure 5.

A narrow flaw zone of varying width occurs where drifting ice interacts with fast ice, creating leads and other openings distributed generally parallel to the coast. The location of this broken ice zone changes in relation to meteorological conditions, usually being farther off shore as the freezing process continues. In the Beaufort Sea the late winter flaw zone is comparatively narrow and located near the northern edge of the shelf. Bearded seals are most numerous in the flaw zone but their density in most of the Beaufort Sea during winter is low. We have seldom seen bearded seals in open water areas north of Prudhoe Bay during February and March. Conversely, ringed seals were numerous.

The density of bearded seals increases in the extreme western Beaufort Sea. This is directly correlated with greater instability of ice and a wider shelf in the vicinity of Point Barrow.

Extent of open water during the ice-free period of the year is highly variable (Fig. 6). In most years the southern margin of multi-year ice (seasonal ice disappears) is over or slightly north of the shelf and therefore available to bearded seals. These seals are not associated with the ice margin when it occurs over deep water. Highest densities of bearded seals during summer occur in the western Beaufort Sea and in ice remnants which persist close to shore. The summering population is augmented by seals moving into the western Beaufort Sea from the Chukchi Sea. Density of bearded seals in the eastern Beaufort Sea seems to remain relatively low, suggesting that eastward movement from the Chukchi Sea is not great. A similar situation prevails with another benthic feeder, the Pacific walrus. There are more sightings of bearded seals in ice-free waters of the Beaufort Sea shelf during summer than in ice-free areas of either the Chukchi or Bering Seas (Burns, unpubl. data).

Annual differences in ice conditions influence the number of bearded seals in the Beaufort Basin and the region approaches being marginal habitat for these seals. Some are present at all times, thus all events in the annual and life cycles take place there. Nearshore ice remnants support the highest densities. These remnants occur and are utilized at the time when seals are completing the molt, resuming intensive feeding and when implantation and early fetal growth are occurring.

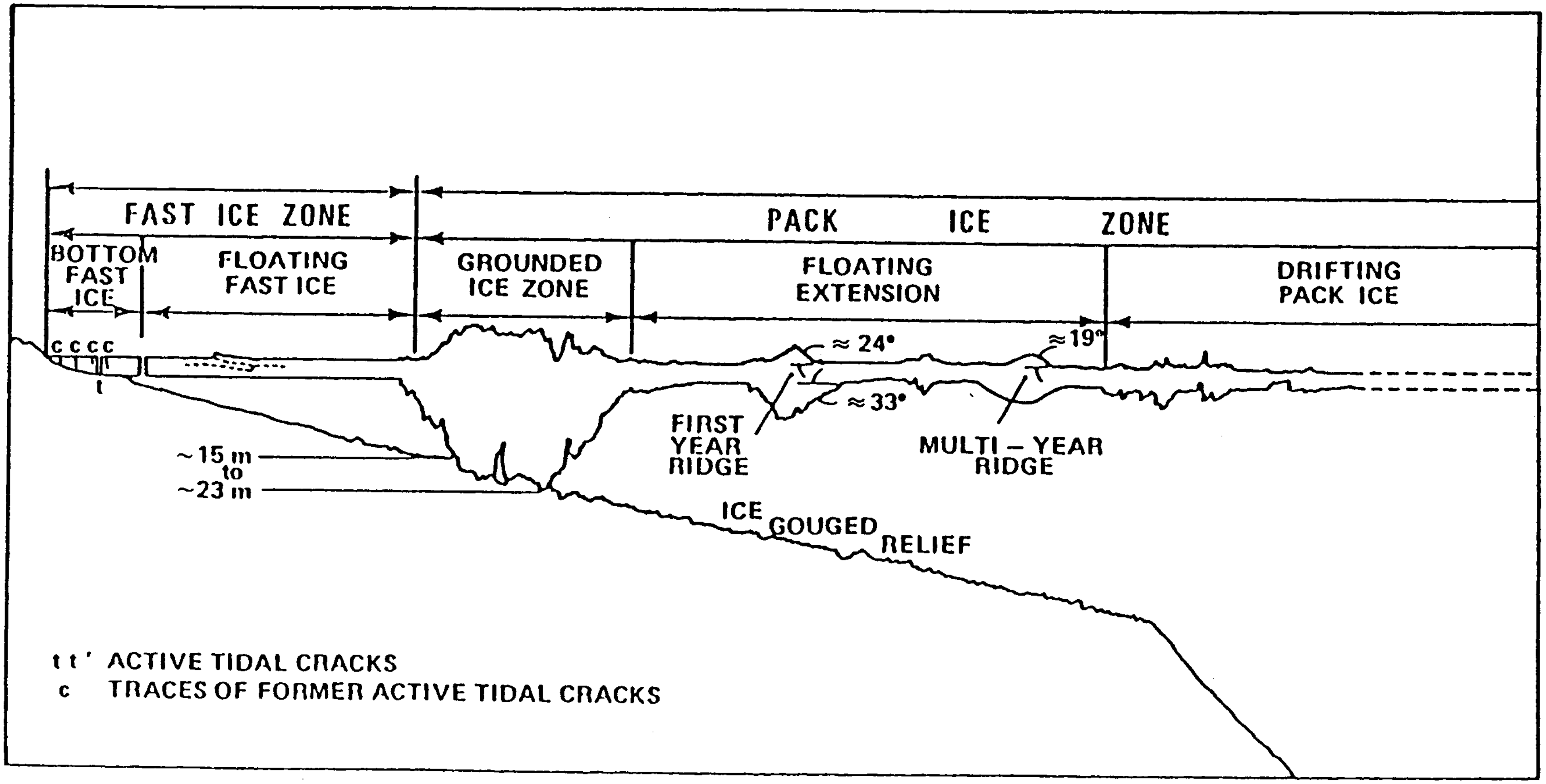
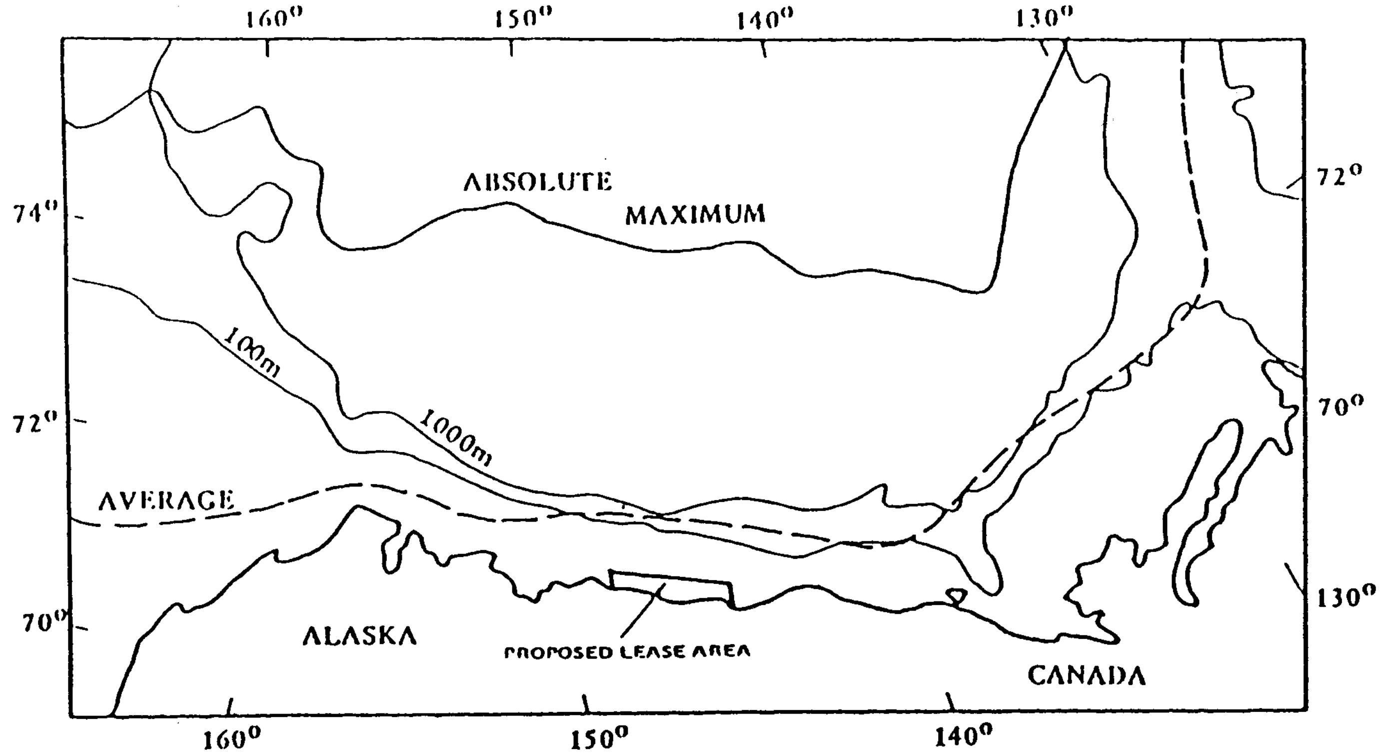


Figure 5. Schematic illustration of ice features in the coastal zone of the Beaufort Sea. The interaction of ice, shallow water and the coast are apparent. Similar features develop in the Bering and Chukchi Seas although their extent varies. (From Shapiro and Barry 1978.)



SOURCE: MODIFIED FROM AMERICAN GEOGRAPHICAL SOCIETY MAP OF THE ARCTIC REGION, 1975.

Figure 6. Average and absolute maximum retreat of multi-year ice during summer-early fall in the Beaufort Sea.

B. Regional Abundance

Many aerial and ship surveys for marine mammals have been undertaken in the study area. None of these have been specifically designed to assess bearded seal numbers and most have been conducted in the Bering Sea during spring, mainly April and May. Although these surveys could not be used as a basis for estimating the total number of seals present in areas surveyed, they did provide information on the relative abundance of seals in various parts of the study area and in different seasons.

Kosygin (1966b) graphically illustrated the relative abundance of ice-associated pinnipeds in those areas of the ice front where sealing by the Soviets was undertaken in March through June 1962 and April through June 1963. The front disintegrated and receded northward during these time periods. In general, highest densities of bearded seals in the front during April were: 1) near the Pribilof Islands, 2) southwest of St. Matthew Island and 3) in the southern Gulf of Anadyr. Movements were northward during May and June, commensurate with retreat of ice.

Extensive aerial surveys of marine mammals were conducted in the Bering Sea during April 1976 (Braham et al., in prep.). This effort involved three independent but coordinated programs; one was in the western and northern Bering Sea by Soviet investigators and two were in the eastern Bering Sea conducted by American scientists. Relative abundance of bearded seals in different regions is shown in Figures 7 and 8.

These extensive surveys confirmed previous findings (Burns 1970) that bearded seals are the most widely distributed species occurring in the drifting seasonal ice of the Bering Sea. In April 1976 highest numbers were seen in the northern Bering Sea, near St. Lawrence Island; in ice 60-100 km north of the front zone; west of St. Matthew Island; and in the southern Gulf of Anadyr (Braham et al., in prep.).

In March 1970, during a cruise of the icebreaker NORTHWIND, bearded seals were found to be abundant in northwestern Bristol Bay (Muktoyuk, pers. comm.).

Surveys by helicopter from the research vessel SURVEYOR were conducted in the eastern Bering Sea during spring 1977, 1978 and 1979. In 1977 these surveys were in the ice front. In 1978 and 1979 they were farther north in the receding and disintegrating ice. Results of these surveys are presented in Table 1. Location of the surveys and observed density of seals are shown in Figure 9.

An aerial survey from a single-engine fixed-wing aircraft (Cessna 180) was conducted in Norton Basin on 20 April 1967. The winter of 1966-1967 was unusually mild with frequent strong winds from the south. Ice was restricted mainly to the northern Bering Sea and the southern terminus was slightly south of St. Lawrence Island. Thus, the various ice-associated pinnipeds were more concentrated. The survey was undertaken to determine the relative abundance of marine mammals in western Norton Sound under the conditions existing at that time.

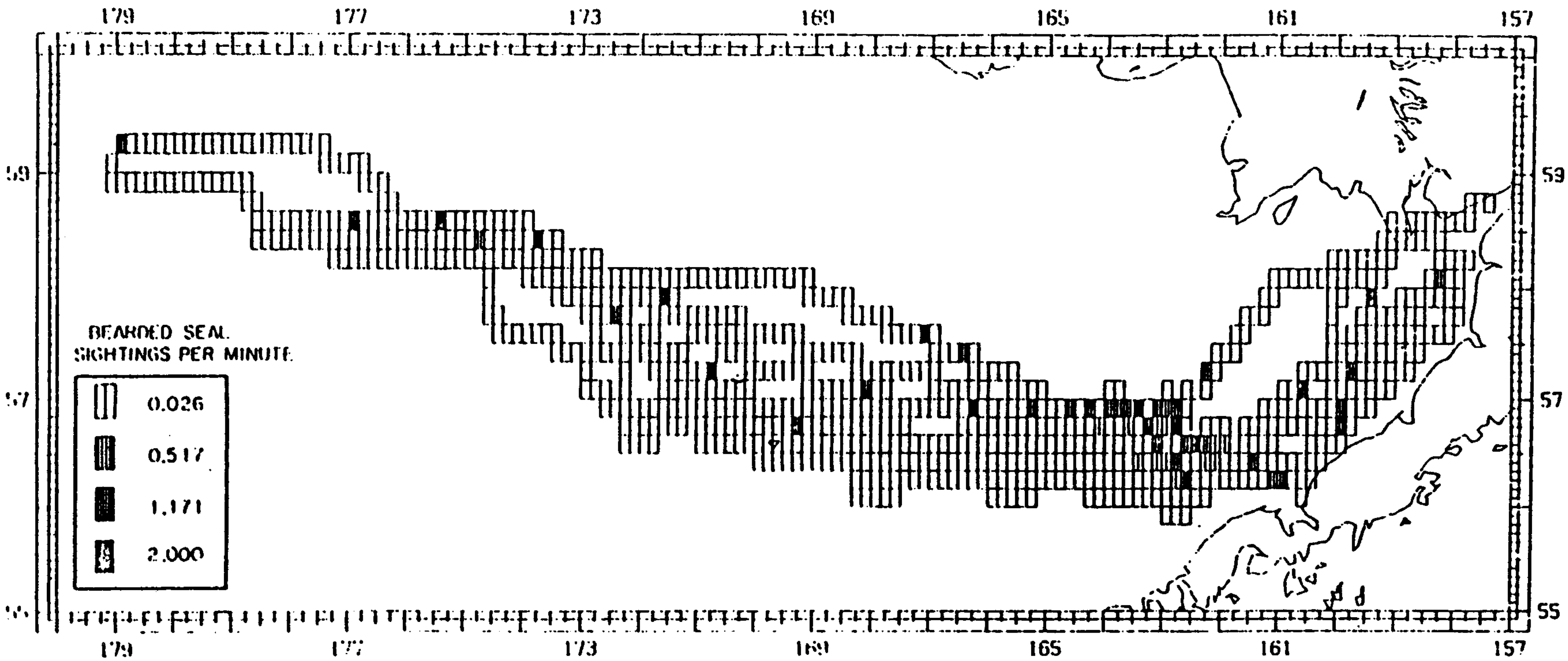


Figure 7. Density of bearded seals in the Bering Sea ice front during April 8-23, 1976. (Figure prepared by B. Krogman, NMFS, Seattle, from data obtained by Burns and Harbo, 1977.)

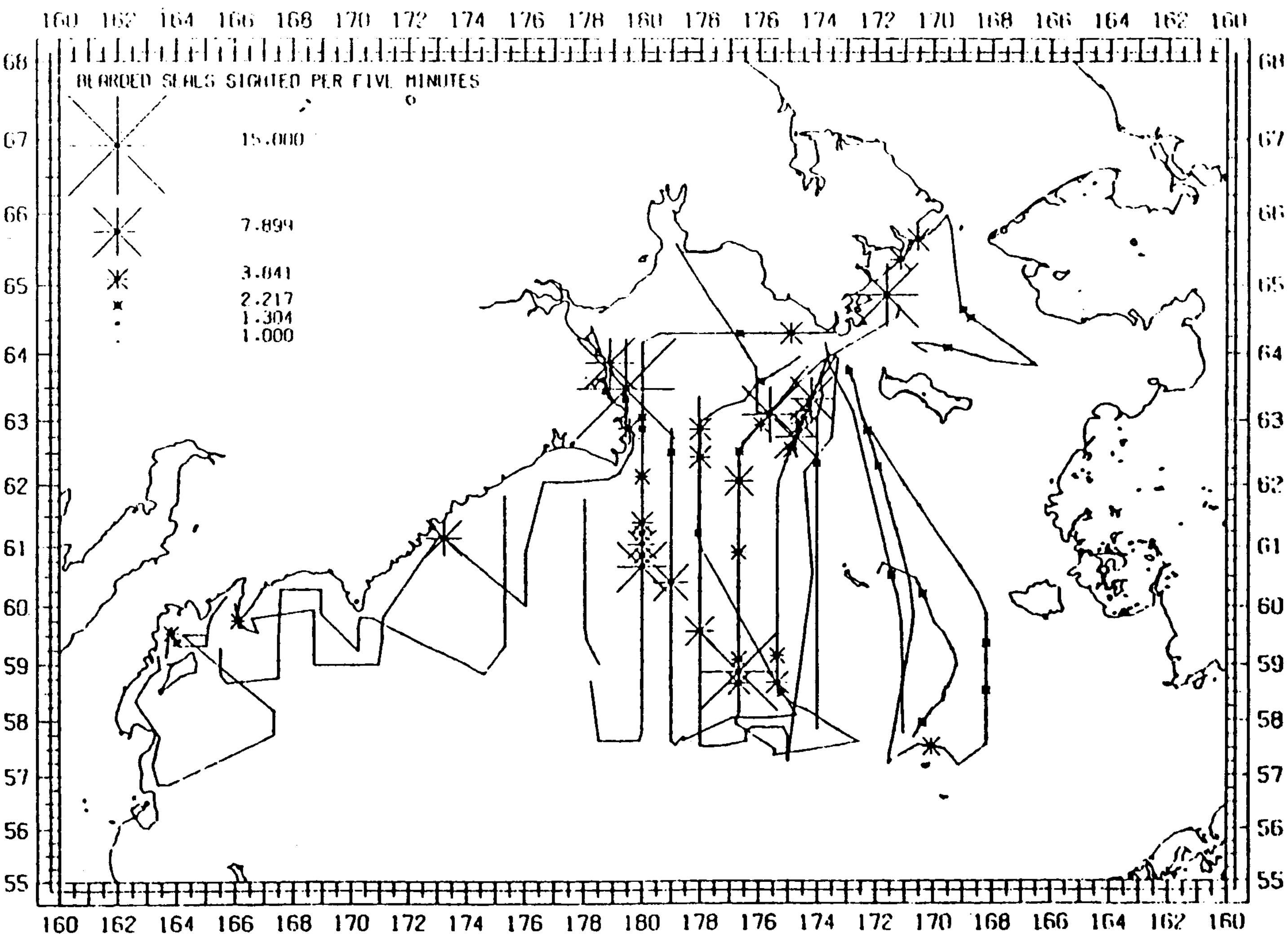


Figure 8. Density of bearded seals in western Bering Sea during April 1976. (Figure prepared by B. Krogman, NMFS, Seattle, from data provided by G. Fedoseev and included in Braham et al., in press).

Table 1. Results of aerial surveys conducted in spring 1977 and 1978 in eastern Bering Sea. Surveys were made using a Bell 206 helicopter operating from the research vessel SURVEYOR.

Date	Survey Number	General Position	Area Surveyed (nm^2)	Bearded Seals Seen	Density Seals $/nm^2$
March 1977					
27	1	55°49' 164°25'	82.7	0	0.00
28	2	59°08' 169°35'	103.3	68	0.66
30	3	58°20' 164°50'	81.2	16	0.20
April 1977					
21	4	57°40' 164°55'	40.6	9	0.22
23-25	5	58°45' 169°30'	289.3	11	0.04
27	6	59°40' 174°20'	55.9	0	0.00
May 1978					
5-6	7	61°40' 176°00'	94.5	0	0.00
7-9	8	61°45' 172°00'	211.0	26	0.12
10-13	9	61°35' 168°00'	180.0	70	0.39
29-31	10	64°45' 170°00'	218.7	293	1.34
June 1978					
1-3	11	62°45' 169°30'	51.5	16	0.31
4-6	12	63°15' 167°00'	51.1	0	0.00
7-9	13	64°45' 167°00'	75.6	66	0.87
May 1979					
15	14	61°46' 168°10'	67.0	15	0.22
18	15	63°58' 166°32'	51.0	8	0.16
20	16	62°10' 170°16'	60.0	60	1.00
21	17	62°16' 171°02'	59.0	51	0.86
22	18	62°16' 171°05'	44.0	17	0.39
24	19	62°50' 173°10'	49.0	79	1.61
25	20	62°50' 173°20'	49.0	108	2.20
27	21	62°50' 174°30'	48.0	65	1.35

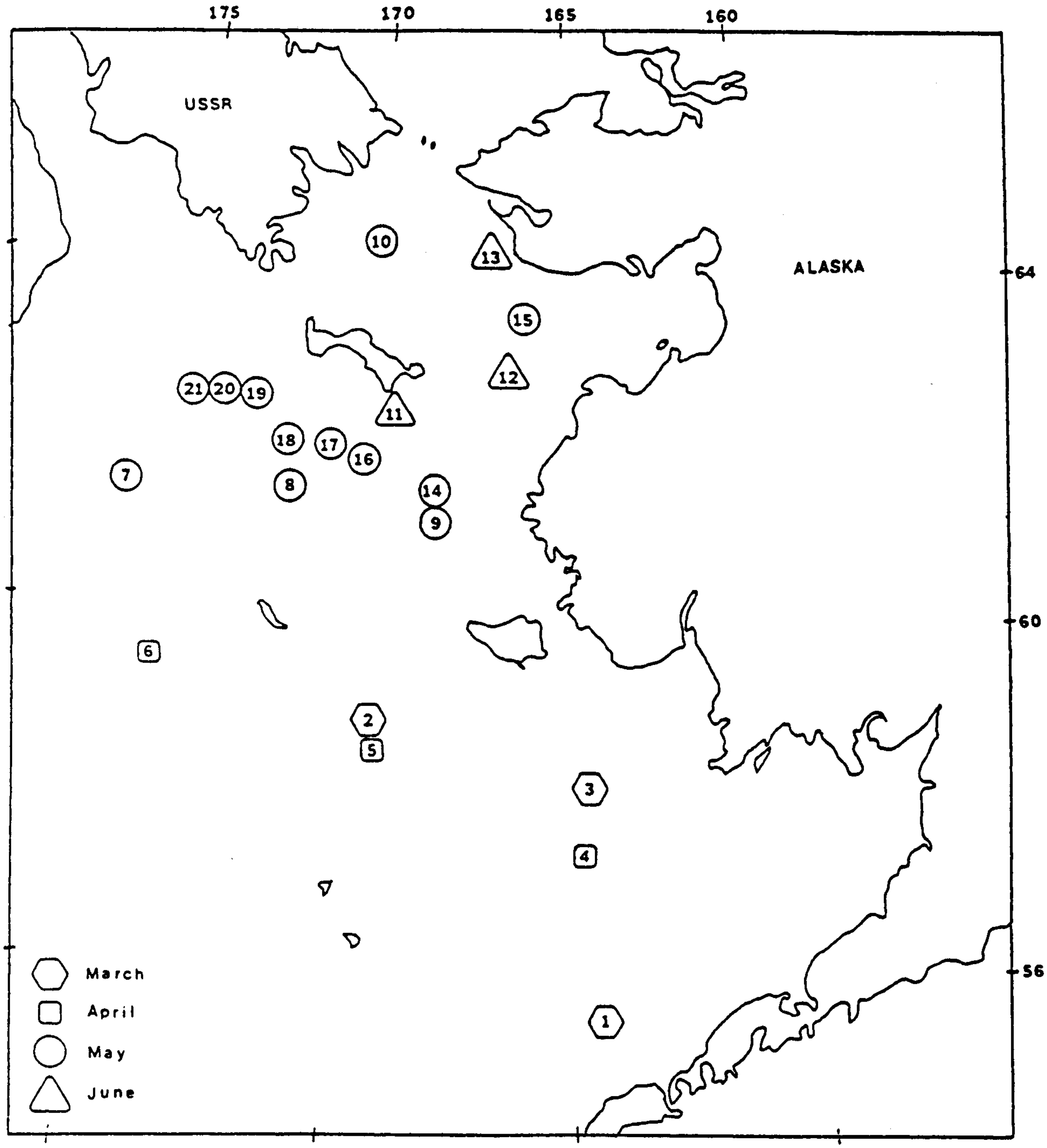


Figure 9. Locations where aerial surveys of seals were made in the spring seasons of 1977-1979.

The area surveyed was 314 nm^2 along a flight line generally from Nome to King Island to Diomede Island and return to Nome. Bearded seals were the most numerous marine mammals seen and the observed density of these seals was 0.72 per nm^2. Walruses were the next most abundant and the observed density was 0.52 per nm^2. Walruses were mainly in the vicinity of Bering Strait while bearded seals were rather evenly distributed throughout the area surveyed.

Johnson et al. (1966, Fig. 1, p. 885) conducted aerial surveys in parts of the Hope Basin between 19 April and 28 June 1963. They did not derive estimates of density. However, bearded seals were regularly observed in association with the flaw ice zone from Point Hope southeast toward Kotzebue Sound.

We conducted surveys in the northeastern Chukchi and Beaufort Seas during August and September 1977. A small boat working from the icebreaker GLACIER was employed. Weather conditions were generally marginal because of persistent fog. We recorded the number of seals seen per hour of travel by small boat at each of the stations occupied during the cruise. Results of those surveys are presented in Table 2. The stations occupied are shown in Figure 10. Bearded seals were most numerous in the Chukchi Sea and in the ice remnants of the Beaufort Sea. Some animals were seen in the offshore pack ice in the Beaufort Sea well north of the continental shelf.

Stirling et al. (1975) conducted systematic aerial surveys of marine mammals in the eastern Beaufort Sea and Amundsen Gulf during the peak period of molt (mid- to late June) during 1974 and 1975. The study area was divided into four strata based on depth, ice conditions and water characteristics. Bearded seals were strongly associated with the shallow water areas although they also occurred over deep water. The densities of bearded seals in the stratum over shallow areas with annually occurring lead systems was 0.091 per mi^2 in 1974 and 0.040 in 1975. Total population estimates in their study area, based only on seals sighted, were 2,759 $\pm$ 729 in 1974 and 1,197 $\pm$ 235 in 1975. The decline between years was significant.

C. Population Structure and Dynamics

Parameters of population structure and dynamics were investigated on the basis of harvest composition. The harvests are probably not representative of the population. Two approaches were taken in our analyses: 1) determination of population structure based on our perceptions of factors which bias the data base and 2) mathematical procedures of fitting or "smoothing" the available data. Each of these will be discussed separately.

The sex ratio in the population, as indicated by harvests, appears to change with age. At birth males may predominate, although the ratio is close to unity. It was 50 percent males in the sample of pups obtained between 1962 and 1966 (N=185), 49 percent males in 1971-1974 (N=172) and 55 percent males in 1975-1978 (N=434). In harvested animals older than

Table 2. Stations where small boat operations were conducted during the August-September 1977 cruise of the GLACIER, and the observed densities of bearded and ringed seals seen from the small boats.

Station No.	Position	Small Boat Hours	Bearded Seals /Boat Hour	Ringed Seals /Boat Hour	Total Seals /Boat Hour
1	71°18' 157°48'	2.0	4.5	0.5	5.0
2	71°19' 160°01'	5.0	0.6	0.2	0.8
3	71°28' 163°47'	3.7	1.1	0.5	1.6
4	71°17' 161°10'	2.5	1.2	0.4	1.6
5	71°12' 158°45'	4.0	0.0	0.0	0.0
6	71°45' 155°43'	6.3	0.2	0.9	1.1
7	72°24' 154°37'	7.2	0.0	0.3	0.3
8	71°13' 151°23'	2.3	0.0	0.9	0.9
9	71°47' 150°49'	3.9	0.0	0.8	0.8
10	71°09' 150°09'	7.5	0.4	1.2	1.6
11	71°00' 150°45'	3.0	0.3	2.3	2.6
12	70°40' 147°46'	6.5	0.6	1.1	1.7
13	72°48' 146°28'	2.0	0.0	0.0	0.0
14	72°46' 146°15'	4.0	0.0	0.2	0.2
15	72°58' 143°30'	5.9	0.0	0.0	0.0
16	70°11' 145°38'	2.0	0.0	0.0	0.0
17	70°22' 146°26'	2.2	0.0	0.9	0.9
18	70°32' 147°42'	2.0	3.0	8.5	11.5
19	70°47' 149°03'	8.1	0.5	2.8	3.3
20	70°45' 148°58'	10.8	0.3	4.2	4.5

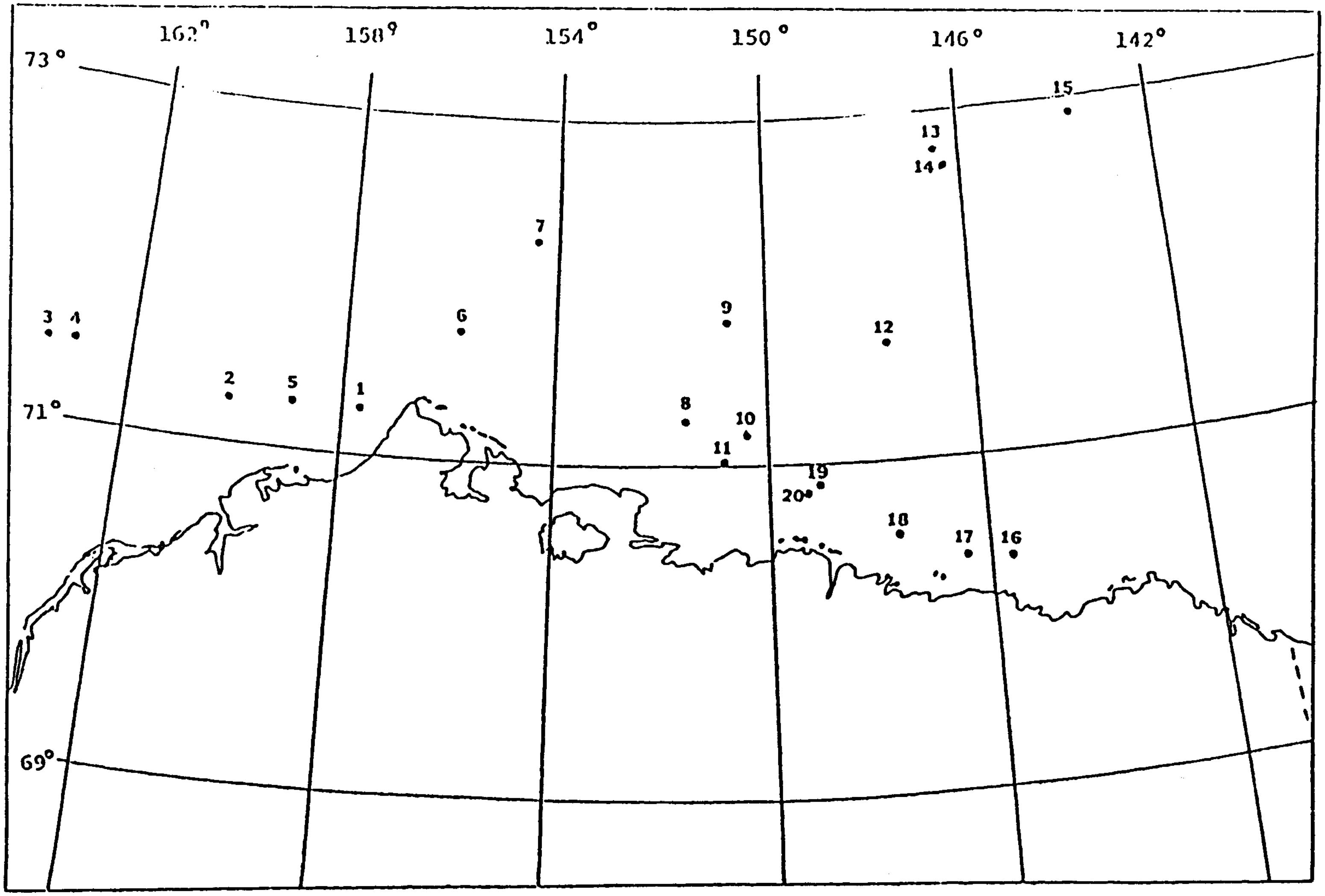


Figure 10. General locations of stations at which small boats were used to observe and collect seals during the August-September 1977 cruise of the GLACIER. Information for each station is presented in Table 2.

pups, females comprised 53 percent in 1962-1966 (N=205) and 55 percent in 1975-1978 (N=727). This change may be indicative of higher mortality in older males--a suggestion supported by calculated mortality rates (discussed below).

Data on age composition of harvests have been obtained over many years. They were grouped into three data sets, based on chronology, as follows: 1) for years 1962-1966, from seals taken mainly in Bering Strait (N=390); 2) for years 1971-1974 (N=361), from seals taken primarily during June near the villages of Hooper Bay (N=109), Shishmaref (N=103) and Savoonga (N=85); and 3) for the years 1975-1978 (N=1311), from seals mainly taken during May through July near the villages of Hooper Bay (N=382), Shishmaref (N=357), Gambell (N=122), Savoonga (N=91) and Wainwright (N=50).

Claws were used for determining age of seals in data set 1, while both claws and teeth were used to determine age of seals in data sets 2 and 3. In data sets 2 and 3 those seals for which only a minimum age was determined (i.e. claws but not teeth collected) were redistributed among age classes by the mathematical procedure previously indicated. Fifty-five reassignments were made in data set number 2 (minimum determined ages were 6 to 16 years) and 151 reassignments in data set 3 (minimum determined ages ranged from 5 to 18 years). The age frequency distribution as determined from harvests is illustrated in Figure 11. Data from 1971-1974 were considered poor as hunting conditions produced harvests of primarily pups. Table 3 indicates composition of the harvest for 1975-1978.

Differences in the proportion of pups taken in the major sampling areas are large and indicate a significant bias which may result from age segregation in the population due to differences in movement patterns and perhaps due to high mortality in pups. The proportion of pups was significantly lower at more northerly hunting sites. Table 4 shows this difference based on samples from Hooper Bay (southeastern Bering Sea), Shishmaref (southeastern Chukchi Sea) and Wainwright (northeastern Chukchi Sea). This bias must be considered in any effort to determine age structure of the population.

The proportions of pups in harvests as a whole were 27.4 percent for 1962-1966 and 36.9 percent for 1975-1978. The sample from 1962-1966, obtained from the island villages in and near Bering Strait, is probably more representative of the actual population.

In our samples seals of age classes 0 through 3 (those younger than the youngest breeding females) comprised 47 percent of the seals examined in 1962-1966 and 56 percent of those examined in 1975-1978. Again, disproportionate representation of pups in the harvest results in a higher than actual proportion of pre-breeding age animals in our samples.

Based on available data from harvested animals and our perceived understanding of biases which affect these harvests, we suggest that the proportion of pups in the population during summer is 22 to 25 percent,

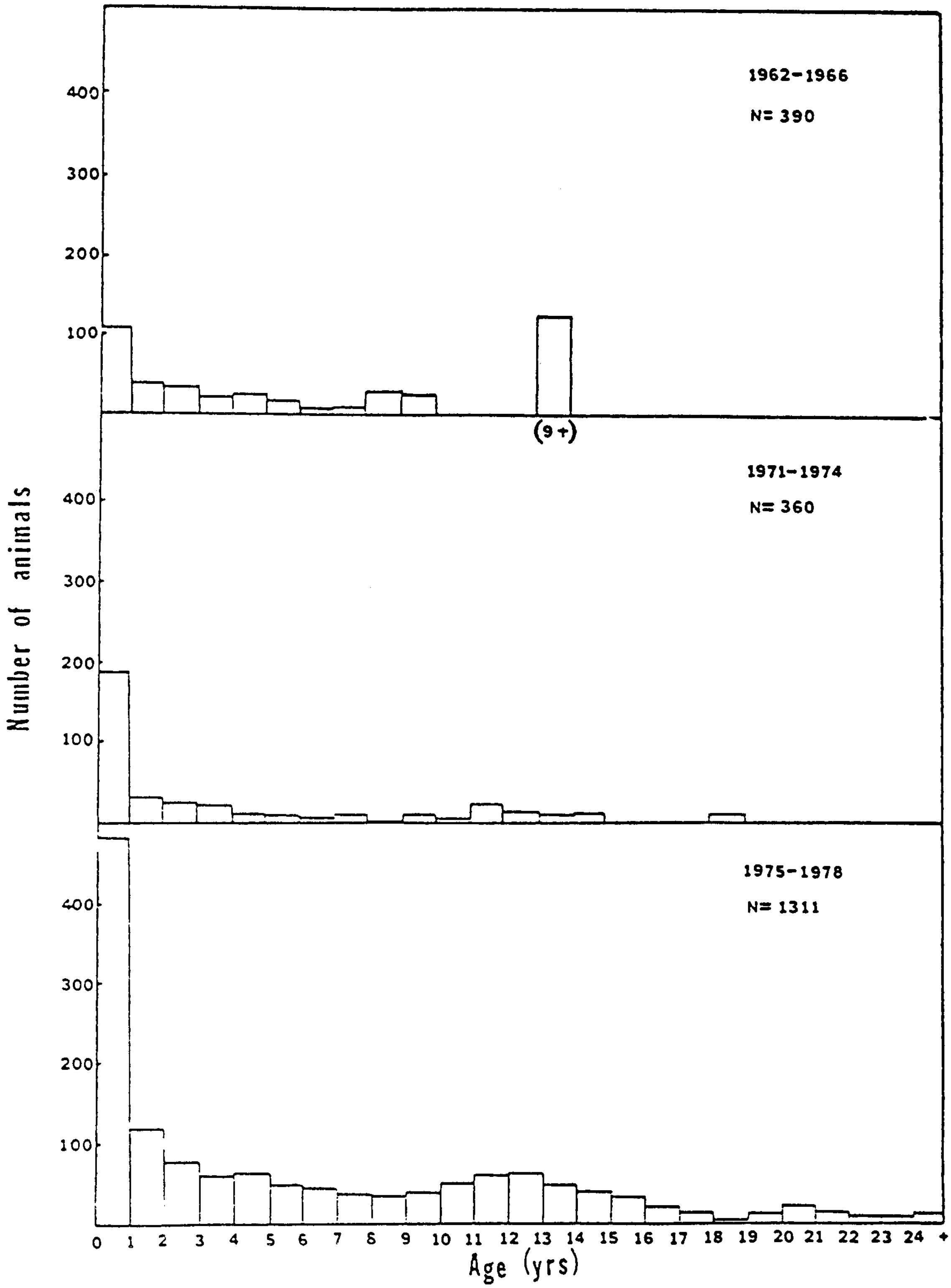


Figure 11. Age frequency distributions of sampled harvests of bearded seals taken in Alaska during 1962-1966, 1971-1974 and 1975-1978.

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Table 3. Age and sex composition of the sampled bearded seal harvest, 1975-1978.

Age (yrs)	Sex Undetermined #	Sex Undetermined %	Males #	Males %	Females #	Females %	Total #	Total %
0	50	34.7	237	45.1	197	31.0	484	36.9
1	10	6.9	49	9.3	56	8.8	115	8.8
2	10	6.9	32	6.1	33	5.2	75	5.7
3	5	3.5	25	4.8	24	3.8	54	4.1
4	12	8.3	21	4.0	24	3.8	57	4.3
5	2	1.4	17	3.2	28	4.4	47	3.6
6	3	2.1	17	3.2	20	3.1	40	3.1
7	5	3.5	7	1.3	17	2.7	30	2.3
8	6	4.2	6	1.1	16	2.5	28	2.1
9	2	1.4	10	1.9	21	3.3	33	2.5
10	6	4.2	12	2.3	21	3.3	40	3.1
11	10	6.9	18	3.4	30	4.7	58	4.4
12	6	4.2	20	3.8	34	5.4	60	4.6
13	7	4.9	7	1.3	33	5.2	48	3.7
14	1	0.7	13	2.5	19	3.0	33	2.5
15	3	2.1	11	2.1	14	2.2	28	2.1
16	1	0.7	2	0.4	12	1.9	15	1.1
17	1	0.7	4	0.8	6	0.9	12	0.9
18	0	0.0	0	0.0	2	0.3	2	0.2
19	0	0.0	2	0.4	8	1.3	10	0.8
20	3	2.1	0	0.0	12	1.9	16	1.2
21	1	0.7	4	0.8	6	0.9	12	0.9
22	0	0.0	4	0.8	0	0.0	4	0.3
23	0	0.0	2	0.4	2	0.3	4	0.3
24	0	0.0	2	0.4	0	0.0	2	0.2
25	0	0.0	2	0.4	0	0.0	2	0.2
26	0	0.0	2	0.4	0	0.0	2	0.2
27	0	0.0	0	0.0	0	0.0	0	0.0
Totals	144		526		635		1311	

Table 4. Proportion of pups in harvests of bearded seals sampled at Hooper Bay, Shishmaref and Wainwright in 1975-1978.

Year	Hooper Bay			Shishmaref			Wainwright		
	Sample Size	No. Pups	% Pups	Sample Size	No. Pups	% Pups	Sample Size	No. Pups	% Pups
1975	137	88	64.2	103	23	22.3	25	7	28.0
1976	128	63	49.2	69	14	20.3	18	2	11.1
1977	107	75	70.1	135	36	26.7	4	1	25.0
1978	10	7	70.0	50	7	14.0	3	2	66.7
Total	382	233	61.0	357	80	22.4	50	12	24.0

animals 3 years or younger (including pups) comprise 40 to 45 percent and those 4 years or older 55 to 60 percent. These values are similar to those reported by Burns (1967).

Mathematical procedures were applied to the harvest data obtained from 1975-1978 by Mr. Lloyd Lowry (ADF&G).

Age composition of annual samples, excluding pups, obtained during this time period are shown in Figure 12. These data suggest the occurrence of differential survival of year classes. For example, in the 1975 harvest, age classes 3, 11 and 20 are strongly represented. In 1976, the 4, 12 and 21-year-olds are strongly represented, as are the 6, 15 and 23-year-olds in 1978. Presuming that mortality is greatest during the first year of life, there was good survival (and perhaps production) of pups in 1955, 1964 and 1972.

Conversely, poor survival of pups is suggested in 1968 and 1973. Age class 2 was poorly represented in our 1975 sample. As 3, 4 and 5-year-olds this cohort continued to be poorly represented in the subsequent harvests. Similarly, 7-year-olds which occurred in low numbers in the 1975 harvest continue to be underrepresented in successive years through 1977.

The age frequency of sampled animals older than pups was "smoothed," using the probit regression (Caughley 1977) in order to generate a probable age structure of the population. The fitted age distribution was used to construct a life table and examine age specific mortality. Figure 13 shows the age frequency distribution of animals in the harvest and the age frequency distribution of the fitted data.

The probit curve results in a sample size of 804 animals older than pups. The number of pups in the population was calculated based on age specific reproductive rates (see section on Reproduction) and the fitted age frequency distribution. This produced an estimated 225 pups and gives a total sample size in the hypothetical population of 1,029 individuals.

Thus 22 percent of the hypothetical population was pups, 451 (44%) were in age classes 0 through 3 and 578 (56%) were 4 years or older. The probit curve generated estimates very similar to those derived from intuitive evaluation of biases affecting age composition of the harvest. We consider these values to be realistic.

A life table for bearded seals in the study area, based on the fitted age distribution of the 1975-1978 sample, is presented in Table 5. Procedures employed follow those as presented by Caughley (1966, 1977) and Smith (1973). Parameters included are age, smoothed age frequency, survivorship (l_x), mortality rate (q_x) and mean life expectation (e_x). Age specific mortality rates (q_x) for males, females and for the sample as a whole are shown in Figure 14. The mortality rate for males is higher than for females. This is significant and may account for the higher proportion of adult females in the harvest (see below). For the

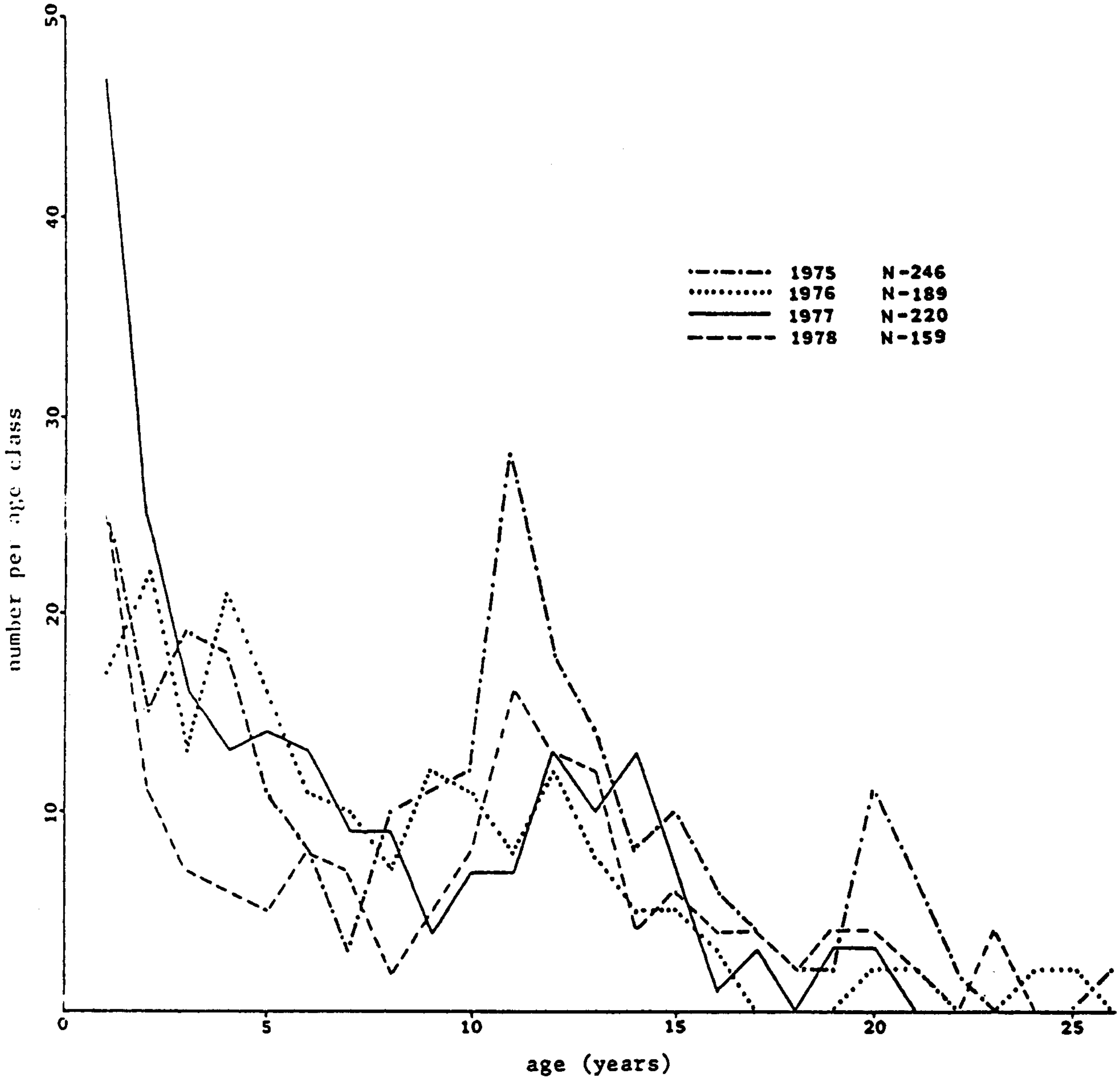

Figure 12. Age distributions of sampled bearded seal harvests, excluding pups, taken in Alaska during each year from 1975 through 1978.

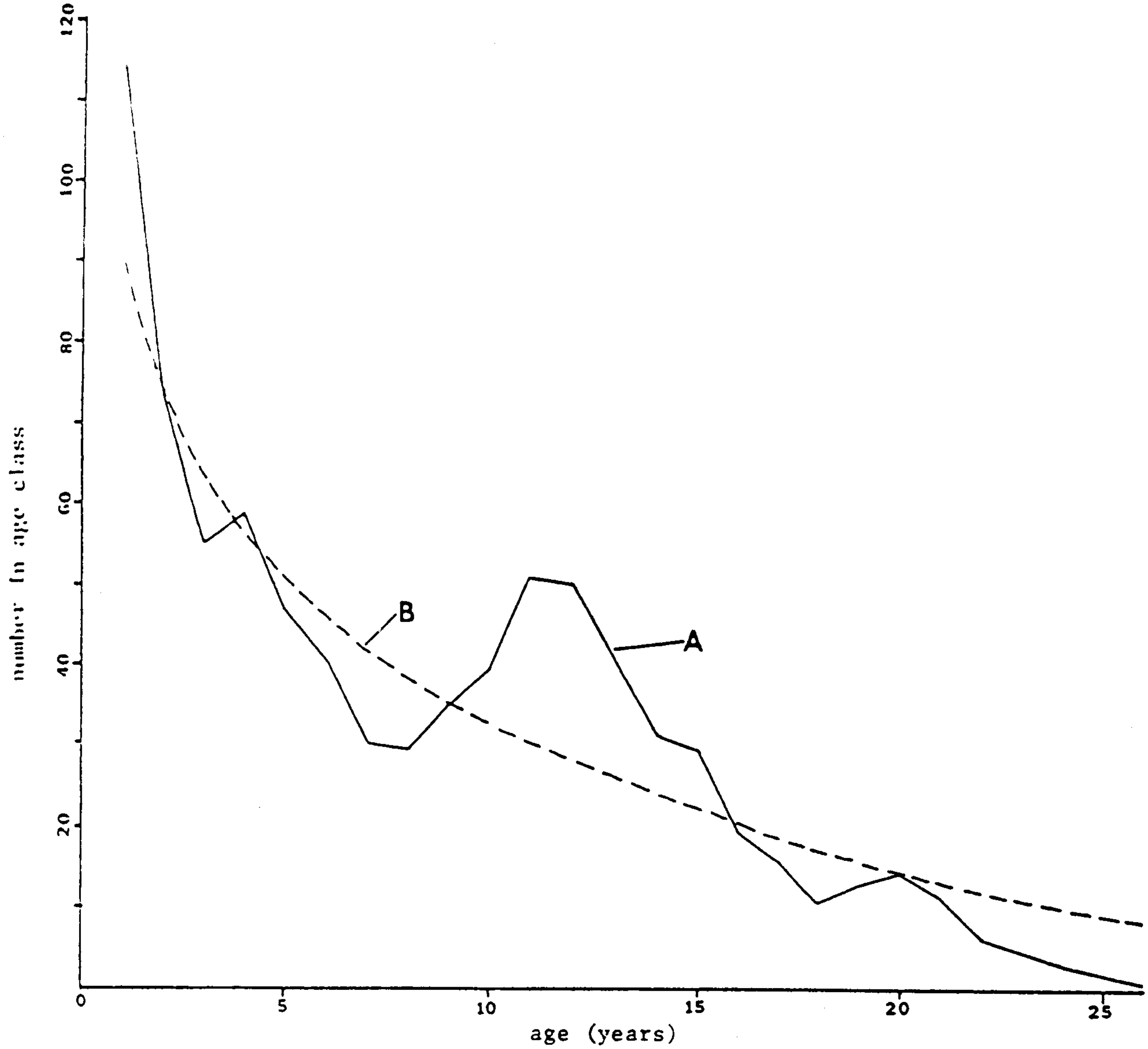

Figure 13. Age distribution of bearded seals older than pups based on all specimens collected in the Bering, Chukchi and Beaufort Seas 1975-1978; A - age structure of the sampled harvest (N=827) and B - data smoothed by probit equation (N=804, Caughley 1977).

Table 5. Life table for bearded seals based on specimens obtained in the Bering, Chukchi and Beaufort Seas, 1975-1978.

Age in Years	Fitted Age Frequency	Number per 1000 per Age Class	1000 l_x	1000q_x	1000e_x
0	225	219	1000	599	4.06
1	90	88	401	190	8.38
2	73	71	325	139	9.23
3	63	61	280	115	9.63
4	56	54	248	101	9.82
5	50	49	223	92	9.87
6	46	44	202	86	9.82
7	42	40	185	82	9.71
8	38	37	170	79	9.53
9	35	34	156	77	9.31
10	32	32	144	76	9.05
11	30	29	133	75	8.75
12	28	27	123	75	8.42
13	26	25	114	75	8.05
14	24	23	105	75	7.67
15	22	21	97	76	7.25
16	20	20	90	78	6.81
17	19	18	83	80	6.34
18	17	17	76	82	5.85
19	16	15	70	85	5.33
20	14	14	64	88	4.77
21	13	13	59	92	4.19
22	12	12	53	97	3.56
23	11	10	48	103	2.89
24	10	9	43	110	2.17
25	9	8	38	119	1.38
26	8	7	34	1000	0.50
27	0	0	0	0	0.00

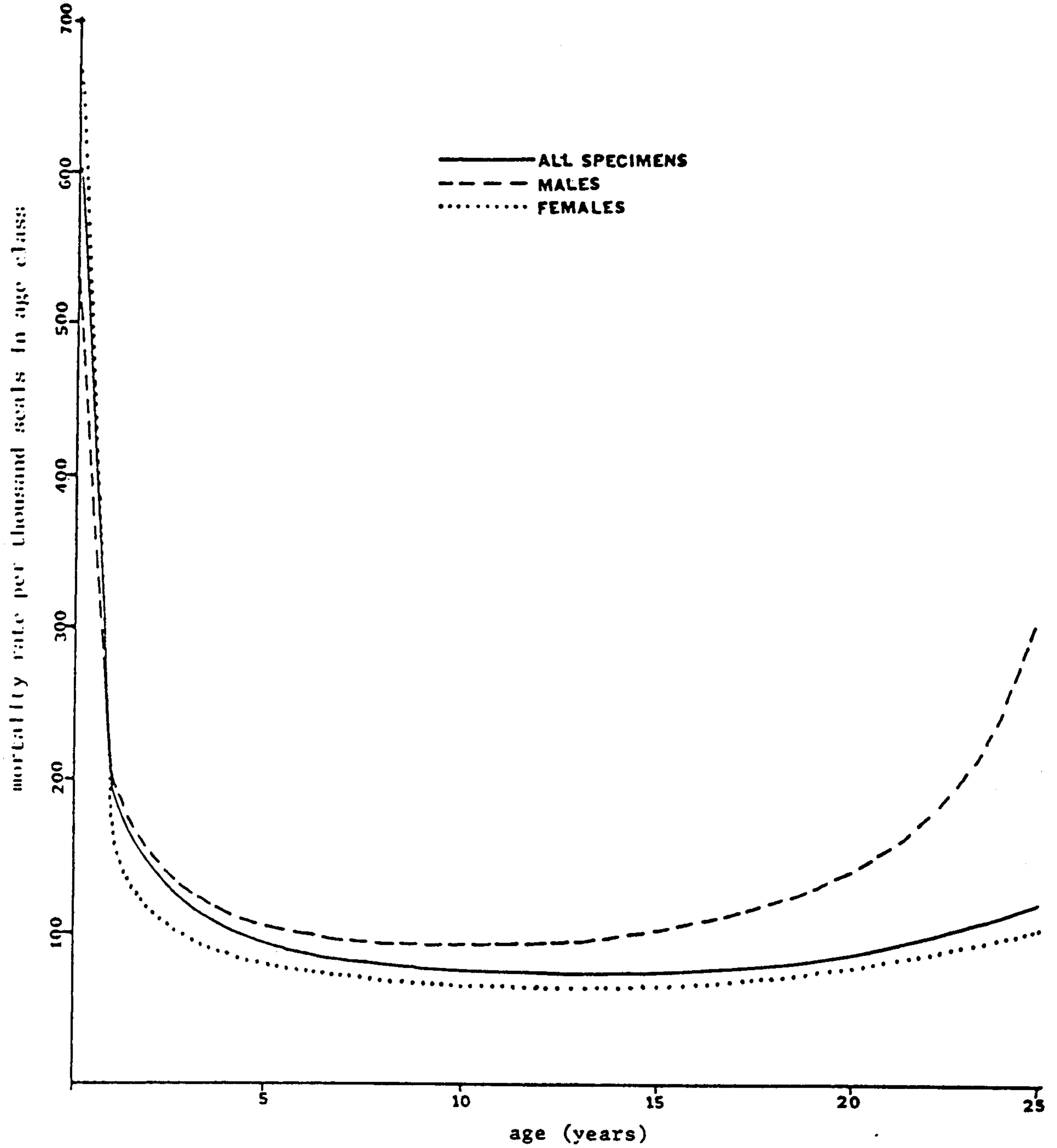

Figure 14. Age specific mortality rates (q_x) derived from life table of bearded seals in the Bering and Chukchi Seas. Data was obtained in 1975-1978.

entire sample the mean annual mortality rate for all age classes (0 to 27) was 219/1000 individuals. The mean annual mortality rate for age classes 6 to 27 was 96/1000 individuals.

D. Harvest Levels and Utilization

Bearded seals have been hunted in the Bering, Chukchi and Beaufort Seas since the earliest occupation of these regions by man. At present they are still hunted wherever they occur and are accessible. They are taken by shore-based subsistence hunters of Alaska and Siberia and by Soviet commercial sealers employing modern ships. Harvests during recent years are indicated below:

Year	American Harvest	Soviet Harvest	Total Annual Harvest
1966	1,242	6,230	7,472
1967	1,300	7,009	8,309
1968	1,050	4,577	5,627
1969	1,772	1,986	3,758
1970	1,759	2,533	4,292
1971	1,754	1,490	3,244
1972	1,353	1,428	2,781
1973	1,500	1,293	2,793
1974	1,600	1,256	2,856
1975	1,200	1,220	2,420
1976	2,125	1,644	3,769
1977	4,750	1,204	5,954

This seal is of great importance to coastal residents of Alaska as a dependable and significant source of food and necessary byproducts. Foot gear, boat covers (skin boats), lines, harnesses and other items are made from their very durable skins. Formerly, implements were made from their bones, rain gear and translucent windows from their intestines, fuel from their blubber, and waterproofing compounds and dyes from their blood. Although the methods used by coastal residents to hunt these seals and some of the traditional uses of byproducts have changed, the major uses of meat and hides remain the same.

Coastal-based hunters of Alaska use small, outboard motor-powered boats to hunt in open leads and among the scattered ice floes relatively near shore. Most bearded seals are taken in late spring-early summer as they migrate north and are basking on the ice. During spring they are specifically sought. Other species of seals are often passed up at this time of year as the large bearded seals require a great deal of effort and time to process. A small proportion of the annual catch is taken during winter-early spring. At the island villages, use of small boats during these seasons is sometimes possible. Also, bearded seals are occasionally taken in leads which occur at the fast ice boundary during winter. In these instances the seals are returned to shore with the aid of dog teams or snow machines, or dragged by men.

Hunting success varies with annual differences in ice conditions. Extensive ice cover usually results in availability of more seals for a longer period of time in the Yukon-Kuskokwim Delta area. A rapid spring "break-up" in which ice quickly leaves the coastal zone results in a truncated season. Frequent storms may eliminate a significant number of potential hunting days, etc. Loss is relatively low during the main (spring) hunting season, averaging about 25 percent (1 animal lost out of each 4 killed). It occasionally exceeds 50 percent during seasons when most animals are shot in the water.

The harvest of bearded seals in Alaska was determined for the periods 1 January to 31 December 1977 and 1 January to 30 June 1978 (Matthews 1978). These harvests were recorded by Alaska Game Management Units (GMU). Those units in which bearded seals are taken include GMU's 18, 22, 23 and 26. Coastal settlements in these units from which bearded seals are taken are as follows: 1) GMU 18, Kinegnak, Platinum, Goodnews Bay, Quinhagak, Eek, Akulrak, Tuntululiak, Kwigillingok, Kipnuk, Nightmute, Toksook Bay, Tanunak, Mekoryuk, Chevak, Hooper Bay, Scammon Bay, Akulurak, Sheldon Point, Alakanuk, Emmonak, Emanguk and Kotlik (22 villages); 2) GMU 22, Stebbins, St. Michael, Unalakleet, Shaktolik, Koyuk, Elim, Golovin, Solomon, Nome, Savoonga, Gambell, Teller, Brevig Mission, Wales, Diomede and Shishmaref (16 villages); 3) GMU 23, Deering, Candle, Buckland, Kotzebue, Kivalina and Point Hope (6 villages); and 4) GMU 26, Point Lay, Wainwright, Barrow, Nuiqsut and Kaktovik (5 villages).

We have estimated the yield of meat, hides and oil from the reported harvests and the dollar equivalent of that yield to the local economies in each of the Game Management Units. Assumptions made and procedures used in our determination of the yield derived from harvests of bearded seals were:

1. Age structure of the sample harvest approximated that indicated in Table 3.

2. Mean weight of seals in each age group through 6 years was derived from the growth curve and all seals older than 7 years were considered to weigh 242 kg.

3. Weight of hide and blubber was estimated to be 29 percent of whole weight.

4. 70 percent of the carcass (not including hide and blubber) was usable meat.

5. 80 percent of the combined weight of hide and blubber was oil.

Harvests of bearded seals in Alaska are almost entirely for human food, oil and hides which are consumed or utilized in rural villages. It is therefore difficult to place a monetary value on the harvest. However, the cost of purchasing bearded seal meat, oil and hides, or in some cases the cost of purchasing substitute items (i.e. beef), can be used as a basis for determining monetary value (= equivalent cash contribution) of the harvest. This dollar value was estimated based on the following, very conservative prices.

1. Oil valued at $.22 per kg ($.10 per lb).
2. Meat valued at $3.30 per kg (1.50 per lb).
3. Hides valued at $20.00 each.

From 1 January 1977 through 30 June 1978, 6,308 bearded seals were estimated to have been taken by Alaska residents (Matthews 1978). The derived yield and value of that harvest are given in Table 6. Based on the calculations included in that table, the average weight of a seal in that harvest was 156.9 kg and the equivalent monetary value of that "average" seal was $285.62. The total "equivalent" monetary contribution of the sample harvest was $1,801,682.

Geographic distribution of the sample harvest, as well as yield and equivalent monetary contribution to the regions, are presented in Table 7. The average harvest of bearded seals per village in the four Game Management Units was 89 in Unit 18, 169 in Unit 22, 161 in Unit 23 and 135 in Unit 26.

Clearly, the bearded seal is a very important resource to residents of the Bering, Chukchi and Beaufort Sea coasts. Largest catches are made from villages situated in the northern Bering and southern Chukchi Seas.

E. Age and Growth

In describing age and growth of bearded seals in the Bering-Chukchi population, mean birth date is considered to be 20 April. Standard length and weight of seals at birth, determined from 13 full-term fetuses, was 131.3 cm and 33.6 kg (Burns 1967, in press). However, the mean standard length and weight of newborn pups obtained during this study was slightly less. This may be due to small sample size. The nursing period was found to be short and was estimated to last 12 to 18 days (Burns 1967). Growth during the first few months of life is rapid. By 11 months of age maximum standard length was 165 cm. Increase in standard length and weight of pups is indicated in Table 8.

Growth of bearded seals throughout life is shown in Table 9. The average standard length of all seals 9 years and older was 219.7 cm. Using this mean value as the length of physically mature adults, the proportional length of younger year classes was as follows: pups, 66 percent of adult length; 1-year-olds, 73 percent; 2-year-olds, 83 percent; 3-year-olds, 88 percent; 4-year-olds, 94 percent; 5-year-olds, 96 percent and 9-year-olds, 100 percent.

Maximum recorded standard lengths of bearded seals from the Bering-Chukchi region were 243 cm for a female (Burns 1967) and 233 cm for a male (Johnson et al. 1966). In this study mean standard length of adult females was found to be 221.3 cm (N=20). In males it was 216.8 cm (N=11). These maximum values from the Bering Sea compare with a maximum standard length of 252 cm (sex of animal unknown) reported for the eastern North Atlantic (Benjaminsen 1973) and 253 cm for a female from the eastern Canadian Arctic (McLaren 1958). Maximum and mean standard lengths for mature seals from the Kara and Barents Seas were 238 cm ($\bar{X}$ = 215.4 cm) for males and 232 cm ($\bar{X}$ = 209.3 cm) for females (Chapskii 1938).

Table 6. Estimated yield from and "equivalent monetary value" of 6,308 bearded seals taken in Alaska from 1 January 1977 through 30 June 1978*.

Age Group	No. in Group	Mean Wt.	Collective Wt. All Seals in Age Group (kg)	Collective Wt. of Hide and Blubber (29% whole wt. kg)
0	2,337	68.2	159,383	46,221
1	555	112.4	62,382	18,091
2	359	155.6	55,860	16,199
3	259	196.9	50,997	14,789
4	261	210.0	54,810	15,895
5	227	230.0	52,210	15,141
6	195	242.2	47,229	13,696
7	145	242.0	30,090	8,726
8	132	242.0	31,944	9,264
9	158	242.0	38,236	11,088
10	195	242.0	47,190	13,685
11	277	242.0	67,034	19,440
12	290	242.0	70,180	20,352
13	233	242.0	56,386	16,352
14	158	242.0	38,236	11,088
15	132	242.0	31,944	9,264
16	69	242.0	16,698	4,842
17	57	242.0	13,794	4,000
18	12	242.0	2,904	842
19	50	242.0	12,100	3,509
20	76	242.0	18,392	5,334
21	57	242.0	13,794	4,000
22	19	242.0	4,598	1,333
23	19	242.0	4,598	1,333
24	12	242.0	2,904	842
25	12	242.0	2,904	842
26	12	242.0	2,904	842
Totals	6,308		989,701	287,010

* The number of bearded seals harvested is from Matthews (1978). Age structure of the harvest, yield and equivalent monetary value were derived as indicated in the text.

Table 6. Continued.

Age Group	Collective Weight Carcass Less Hide and Blubber (kg)	Collective Weight Usable Meat (70% carcass, kg)	Collective Weight Oil (80% hide and and blubber, kg)
0	113,162	79,213	36,977
1	44,291	31,004	14,473
2	39,661	27,763	12,959
3	36,208	25,346	11,831
4	38,915	27,241	12,716
5	37,069	25,948	12,113
6	33,533	23,473	10,957
7	21,364	14,955	6,981
8	22,680	15,876	7,411
	27,146	19,002	8,870
10	33,505	23,454	10,948
11	47,594	33,316	15,552
12	49,828	34,880	16,282
13	40,034	28,024	13,082
14	27,148	19,004	8,870
15	22,680	15,876	7,411
16	11,856	8,299	3,874
17	9,794	6,856	3,200
18	2,062	1,443	674
19	8,591	6,014	2,807
20	13,058	9,141	4,267
21	9,794	6,856	3,200
22	3,265	2,286	1,066
23	3,265	2,286	1,066
24	2,062	1,443	674
25	2,062	1,443	674
26	2,062	1,443	674
Totals	702,689	491,885	229,609

Table 6. Continued.

Age Group	Value of Usable Meat ($3.30/kg)	Value of Oil ($.22/kg)	Value of Hides ($20 ea)
0	$261,402	$8,135	$46,740
1	102,312	3,184	11,100
2	91,617	2,851	7,180
3	83,641	2,603	5,180
4	89,894	2,798	5,220
5	85,629	2,665	4,540
6	77,461	2,410	3,900
7	49,351	1,536	2,900
8	52,391	1,630	2,640
9	62,707	1,951	3,160
10	77,397	2,409	3,900
11	109,942	3,421	5,540
12	115,103	3,582	5,800
13	92,479	2,878	4,660
14	62,712	1,951	3,160
15	52,391	1,630	2,640
16	27,387	852	3,180
17	22,624	704	1,140
18	4,763	148	240
19	19,845	618	1,000
20	30,164	939	1,520
21	22,624	704	1,140
22	7,542	235	380
23	7,542	235	380
24	4,763	148	240
25	4,763	148	240
26	4,763	148	240
Totals	1,623,209	50,513	127,960

Table 7. Geographic distribution of the bearded seal harvest taken in Alaska from 1 January 1977 through 30 June 1978: the estimated yield and the "equivalent monetary contribution" of this harvest to each of the four Alaska Game Management Units involved.*

GMU No.	No. of Coastal Villages in GMU	Seals Harvested	Yield of Usable Meat (kg)	Yield of Oil (kg)	Value of Meat ($3.30/kg)	Value of Oil ($.22/kg)	Value of Hides ($20.00/ea)	Dollar Value to GMU
18	22	1963	153,075	71,453	505,147	15,720	39,260	560,127
22	16	2706	211,014	98,498	696,346	21,670	54,120	772,136
23	6	964	75,172	35,090	248,068	7,720	19,280	275,068
26	5	675	52,636	24,570	173,698	5,405	13,500	192,603

* The number of bearded seals taken and the geographic distribution of this harvest are from Matthews (1978). Yield and value were derived from Table 6.

Table 8. Growth in bearded seal pups from the Bering and Chukchi Seas during their first year of life. Specimens were obtained during the period 1975-1979.

Month of life	Standard Length (cm)				Weight (kg)			
	N	Mean	Range	Std. Dev.	N	Mean	Range	Std. Dev.
1	1	120.0	-	-	2	28.6	27.2-30.0	2.0
2	8	137.8	123.0-145.0	7.7	5	76.5	57.7-90.9	12.8
3	30	144.4	129.0-173.0	12.0	4	69.8	56.3-79.5	9.7
4	6	163.6	148.0-179.0	12.1	0	-	-	-
5	3	153.1	147.0-160.1	6.6	0	-	-	-
6	0	-	-	-	0	-	-	-
7	1	156.2	-	-	0	-	-	-
8	2	147.7	146.2-149.2	2.1	2	84.0	76.3-91.6	10.8
9	0	-	-	-	0	-	-	-
10	0	-	-	-	0	-	-	-
11	1	165.0	-	-	0	-	-	-
Totals	52				13			

Table 9. Age, standard length and weight of bearded seals from the Bering and Chukchi Seas. Specimens were obtained during the period 1975-1979.

Age (yrs)	Standard Length (cm)				Weight			
	N	Mean	Range	Std. Dev.	N	Mean	Range	Std. Dev.
0	52	146.4	120.0-179.0	13.4	13	68.2	27.2- 91.6	20.5
1	17	159.0	127.5-188.0	17.0	5	112.5	64.0-152.2	31.6
2	10	182.8	164.7-199.0	10.0	4	155.7	86.2-204.5	50.6
3	7	193.8	158.8-215.7	20.3	4	197.0	160.9-243.1	35.6
4	7	207.2	180.0-233.0	17.1	0	--	--	--
5	4	210.1	200.0-226.0	12.1	0	--	--	--
6	5	208.3	197.0-221.0	9.1	2	242.3	222.7-261.8	27.6
7	3	211.9	204.5-222.3	9.3	1	215.7	--	--
8	3	213.0	200.0-220.0	11.2	1	244.5	--	--
9	8	219.7	205.8-235.1	8.2	2	242.0	222.7-261.3	27.3
10	2	229.5	227.0-232.0	3.5	0	--	--	--
11	6	224.4	215.0-240.0	10.5	1	240.9	--	--
12	9	214.5	204.0-222.0	6.3	2	261.4	206.8-315.9	77.2
13	4	219.9	215.0-231.0	7.5	0	--	--	--
14	1	227.0	--	--	0	--	--	--
15	2	218.2	217.2-219.1	1.3	1	220.2	--	--
16	1	233.0	--	--	0	--	--	--
17	0	0	--	--	0	--	--	--
18	0	0	--	--	0	--	--	--
19	0	0	--	--	0	--	--	--
20	1	224.3	--	--	1	268.2	--	--
20+	7	214.1	202.0-232.0	9.7	0	--	--	--
Total	149				37			

In the Bering-Chukchi population females were, on the average, 2 percent longer than males. In other studies females were also found to be slightly longer than males (Johnson et al. 1966, Burns 1967, Benjaminsen 1973). Maximum recorded weights of seals from the study area were 318 kg for a male (this study) and 360.5 kg for a female (Johnson et al. 1966). The heaviest female examined in this study was a 316 kg pregnant female. She had a 32.3 kg fetus (10.2% of her total weight) and was taken on 29 March 1977. The mean weight of five adult females, all taken during late winter-spring, was 250.3 kg. This compares with a weight in summer of 228.6 kg (N=14, Burns 1967). Only two adult males, taken during late winter, were weighed during this study. Their average weight was 390.0 kg. Average weight of 11 adult males taken during summer was 244.4 kg (Burns 1967).

Bearded seals are heaviest in fall through spring. On the average, adult females are heavier than males during this period, especially in early spring when they are supporting a large fetus. Females lose considerable weight during lactation and both sexes undergo weight losses during the molt. By summer the average weight of adult females is less than that of males.

The robust body form of bearded seals is indicated by comparison of standard length and girth immediately behind the foreflippers. In a series of 40 seals 4 years and older, girth was between 71 and 83 percent of standard length. This relationship changes seasonally, lowest values occurring during summer and highest values during late fall through early spring. Seasonal changes in thickness of the blubber layer which account for the changes in girth are marked. Thickness of the blubber layer varies from an average of about 7.2 cm in late fall through early spring to about 4.4 cm during summer. Similarly, the hide and blubber layer account for an average of about 39 percent of total body weight when these seals are fattest and about 29 percent when they are lean.

F. Reproduction

Our investigation of the various aspects of reproduction in bearded seals was directed mainly toward females as it is this group which determines the various aspects of productivity. Most of our samples (about 90%) were obtained between mid-May and late July.

Reproduction in males has previously been investigated. A general resumé of findings is as follows.

McLaren (1958) examined growth in baculum size, seasonal changes in size of testes and in diameter of testis tubules. He concluded that in seals of the eastern Canadian Arctic sexual maturity is obtained at age 7 and that the peak breeding period is during mid-May. Based on his data, males appear to be in breeding condition through early June. Tikhomirov (1966) investigated reproduction in North Pacific bearded seals. He recorded presence of sperm in tubules of the testis and epididymis and changes in testis weight. His findings indicated that sexual maturity in males was obtained between ages 5 and 7 with 50 percent of the 5-year-olds, 66 percent of the 6-year-olds and 100 percent of the 7-year-olds being mature. The main period of breeding was indicated as 20 April to 20 May. Burns (1967) investigated baculum growth, growth and annual variation in size of testes and seasonal presence of sperm in tubules of the epididymis. He concluded that males from the northern Bering and Chukchi Seas attained sexual maturity at ages 6 and 7 and that males were capable of breeding from early April through early June. The peak breeding period was found to be during May.

In the present study we found that baculum length of 8-year-olds approximated the mean for all males older than 8 and that the mean weight of testes for 7-year-olds was within the range of weights for older age animals.

Investigation of reproduction in females has been based mainly on examination of ovaries. Both McLaren (1958) and Tikhomirov (1966) considered the presence of a corpus luteum to indicate ovulation (which it does) and pregnancy (which it may). These authors considered the age at which initial ovulation occurs to be the age at which sexual maturity is obtained.

McLaren (1958) suggested that in the eastern Canadian Arctic females attain sexual maturity, on the average, at 6 years of age. This conclusion was based on findings of follicles up to 10 mm in maximum diameter in a 6-year-old and a 7-year-old. An animal in her eighth year had been pregnant in her seventh year.

Tikhomirov (1966) working in the North Pacific region found that ovulation occurred in 8 percent of 3-year-olds, 21 percent of 4-year-olds, 83 percent of 5-year-olds and 100 percent of 6-year-olds. Ovulation was equated with sexual maturity.

In this study we obtained uteri and ovaries from 260 seals. Examinations of both were employed to correlate presence of a corpus luteum with pregnancy. A corpus albicans and characteristics of the uterus, including placental scars, indicated pregnancy during the reproductive cycle preceding collection. We considered sexual maturity to be obtained at the age of first pregnancy, not the age of first ovulation. As will be seen, this difference in interpretation is significant in estimating population productivity.

Our findings are summarized in Table 10. Interpretation of several important aspects of reproduction is possible from this table. Presence of a corpus luteum was indicative of ovulation and possible pregnancy. A corpus albicans indicated previous ovulation and possible previous pregnancy. These ovarian structures were correlated with characteristics of the uterus including placental scars.

Ovulation occurred in 67 percent of our sample of 3-year-olds. The frequency increased to about 93 percent in 4- and 5-year-olds and 100 percent in 7-year-olds. In order to determine incidence of pregnancy compared to ovulation, we examined the age distribution of animals which had definitely been pregnant during the reproductive cycle prior to

Table 10. Reproductive activity in 260 female bearded seals from the Bering and Chukchi Seas. Eleven seals were taken in 1969 through 1973 and 249 from 1975 through 1978.

Age (yrs)	N	Ovulated and perhaps pregnant in reproductive cycle when taken (corpus luteum) N	%	Pregnant in reproductive cycle preceding collection (large C.A.&Plac. Scar)[1] N	%	Pregnant in any preceding year (uterus & C.A.'s)	Previously ovulated (corpora albicantia)
0	61	0	0	0	0	0	0
1	23	0	0	0	0	0	0
2	13	0	0	0	0	0	0
3	9	6	67	0	0	0	0
4	15	14	93	0	0	0	7
5	12	11	92	2	17	2	6
6	10	9	90	5	50	6	8
7	10	10	100	8	80	8	10
8	16	16	100	13	81	15	16
9	9	9	100	9	100	9	9
10	10	10	100	9	90	10	10
11	18	16	89	15	83	17	18
12	16	15	94	16	100	16	16
13	10	10	100	8	80	10	10
14	4	4	100	2	50	4	4
15	8	7	88	6	75	8	8
16	3	3	100	2	67	3	3
17	2	2	100	2	100	2	2
18	1	1	100	1	100	1	1
19	1	1	100	1	100	1	1
20	2	2	100	2	100	2	2
21	2	2	100	2	100	2	2
22	1	1	100	1	100	1	1
adult	4	4	100	3	75	4	4
Totals	260	153					

[1] C.A. means corpus albicans and Plac. Scar means placental scar.

collection. Pregnancy was indicated by a recent placental scar and a large corpus albicans in the associated ovary. The youngest pregnant animals were 4-year-olds (in their fifth year of life), based on the finding of 2 out of 12 (17%) 5-year-olds that had apparently given birth during the reproductive cycle preceding collection. Thus, in our sample, first pregnancy occurred 1 year after first ovulation. The incidence of pregnancy steadily increased to 50 percent in 5-year-olds, 80 percent at age 6 and 100 percent at age 8. Most females apparently become sexually mature at age 6.

The average age at attainment of sexual maturity was also estimated according to procedures described by DeMaster (1978). In these, ovulation and pregnancy rates increase with each succeeding age class, to a maximum rate. In our calculations we used the ovulation rates indicated in Table 10 for ages 0 to 3 and the mean ovulation rate of 96 percent for ages 6 and older. Rates for age classes 4 and 5 were determined by linear interpolation, between the rates for 3- and 6-year-olds. The interpolated ovulation rate for 4-year-olds was 77 percent and for 5-year-olds 86 percent. For pregnancy rates the values indicated in Table 10 for seals which were pregnant in any preceding year were used for age classes 0 to 6. In age classes older than 6 the mean pregnancy rate of 83 percent was used. Sample sizes in the calculations were the number of animals in each age class from the "fitted" age distribution (see section on Population Structure and Dynamics). If attainment of sexual maturity was based solely on ovulation (indicated by the presence of a corpus luteum) the average mathematically derived age of sexual maturity was found to be 3.4 years ($N=753$, $S^2 = 0.137$). When the attainment of sexual maturity was based on successful pregnancy the average age of sexual maturity was found to be 5.6 years ($N=753$, $S^2 = 0.478$). We found that sample sizes and variances had little apparent meaning when fitted data were used, as both changed depending on the number of age classes included. We consider 5.6 years to be the best derived estimate of the average age of sexual maturity in bearded seals.

Once females begin to ovulate, they do so almost every year. In 127 seals 6 years and older, 122 (96%) contained a corpus luteum. The number which were pregnant could not be determined. However, 105 of these 127 seals (83%) had supported a fetus in the year preceding collection. Also, of 17 sexually mature females taken in 1975-1978 between mid-August and early April, when fetuses are present, 14 (82%) were pregnant. Since earlier estimates of the pregnancy rate were derived in this manner (i.e. Burns 1967), we have continued to use this procedure in order to have a basis for comparison.

Similar pregnancy rates in the Bering-Chukchi population have prevailed for some time. Johnson et al. (1966) studied these seals in 1959-1961. Five of six adult females (83%) taken between January and April were pregnant. Burns (1967) examined 133 sexually mature females between 1962 and 1966. In that study the pregnancy rate, based on examination of uteri and ovaries, was 83 percent. In 20 sexually mature females taken between mid-August and early April, 17 (85%) supported a fetus.

The incidence of pregnancy can also be calculated by determining the reproductive performance of all age classes which included any pregnant animals. In our sample all females 4 years and older would be included. On this basis the pregnancy rate in 139 females was 77 percent.

We determined the breeding period of bearded seals based on the time of ovulation in females. Approximate time of ovulation can be inferred from the presence of large follicles or the presence of corpora lutea in the early stages of development. A large follicle was one greater than 17 mm in diameter and an early stage corpus luteum was one less than one-fourth developed. Based on the 1975-1978 sample the breeding period was approximately 25 April to 30 May with the peak from 5 to 25 May. Females with large follicles (considered gravid) were taken between 29 April and 28 May (N=8). Presence of gravid follicles indicates imminent ovulation. Females containing corpora lutea in the earliest stages of development (only the periphery of the follicular cavity luteinized) were taken between 8 and 30 May (N=11). May 29 was the earliest date on which a female with a completely formed corpus luteum was taken. Fully mature follicles exceed 22 mm on the longest axis before erupting. We found two cases which suggest that ovulation may occur while the female is still nursing a pup. One seal taken on 12 April was supporting a full-term fetus and the ovary of the nongravid uterine horn contained a follicle 16 x 13 mm. The other seal, taken on 14 May, was lactating and accompanied by a pup. She had a follicle which was 22 x 18 mm. However, it appears that in most instances ovulation occurs after lactation has ceased and the females have left their pups. According to Tikhomirov (1966) ovulation is spontaneous.

Implantation was found to occur mainly in July, but apparently extended from early June through about 8 August. The delay between breeding and implantation is 2 months. The implantation site begins to swell and is obvious prior to presence of an embryo which was recoverable by us under existing field conditions. Figure 15 shows the time during which implantation occurred and early prenatal growth. Fetal growth from implantation to birth is illustrated in Figure 16. The duration of implanted fetal growth is 9 months. Total gestation is 11 months.

We found no evidence of reproductive senility in our samples, nor has evidence for such been reported in other studies.

G. Behavior

The following comments are from Burns and Harbo (1977) and Burns (in press).

Behavior including escape response is often important in the identification of seals from aircraft, as during surveys. Bearded seals usually react mildly to an airplane, even at close range. They almost always raise their heads, frequently look up at the plane and usually remain on the ice unless the plane passes directly over them. They do not form herds nor, with the exception of females with pups, do they rest next to each other with bodies touching. Pups in association with

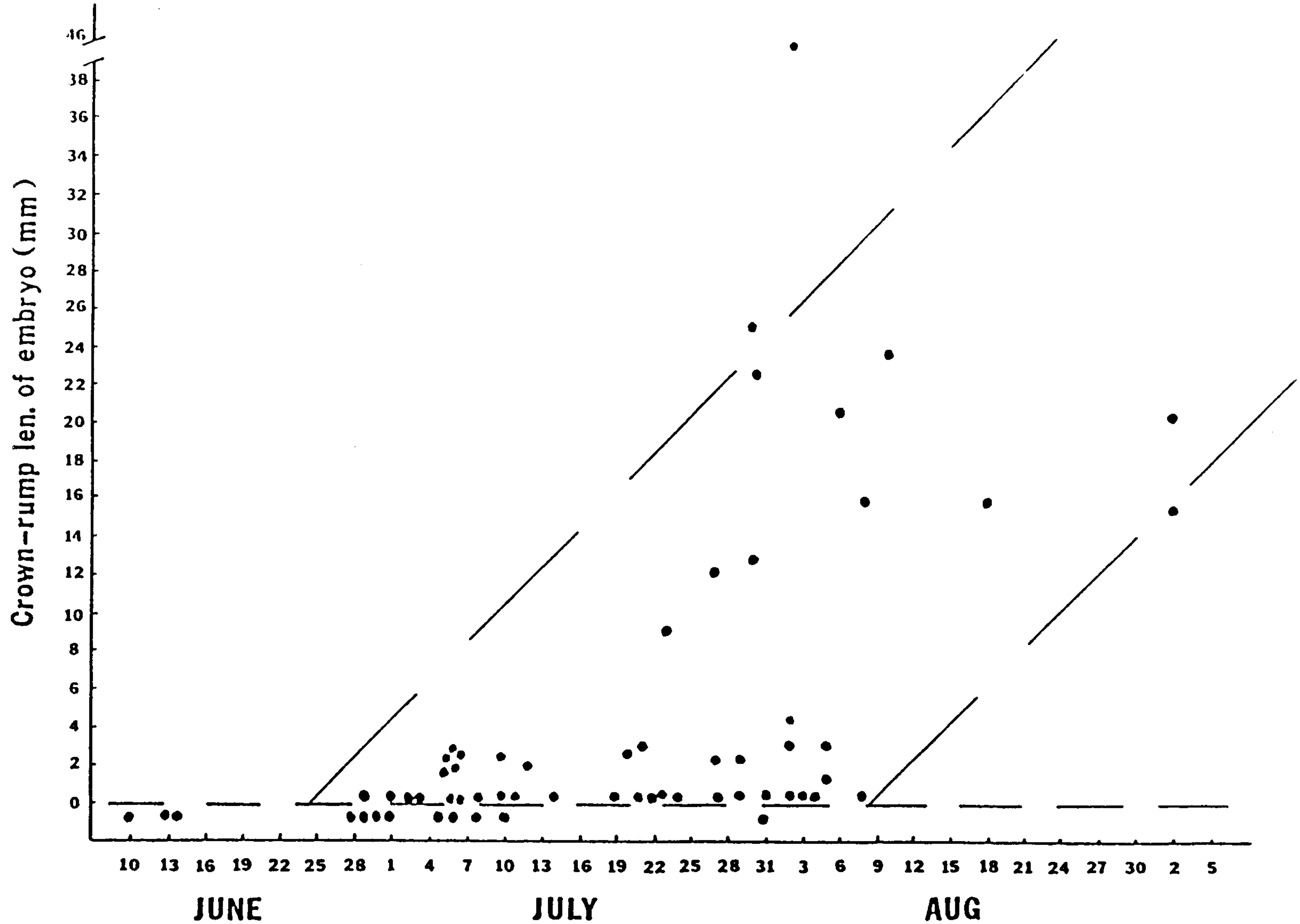

Figure 15. Time of implantation and early growth of embryos in bearded seals taken in the Chukchi Sea between 1964 and 1978 (N=62). Points below the 0 line indicate preimplantation sites, recognized by an obvious swelling in the uterus wall.

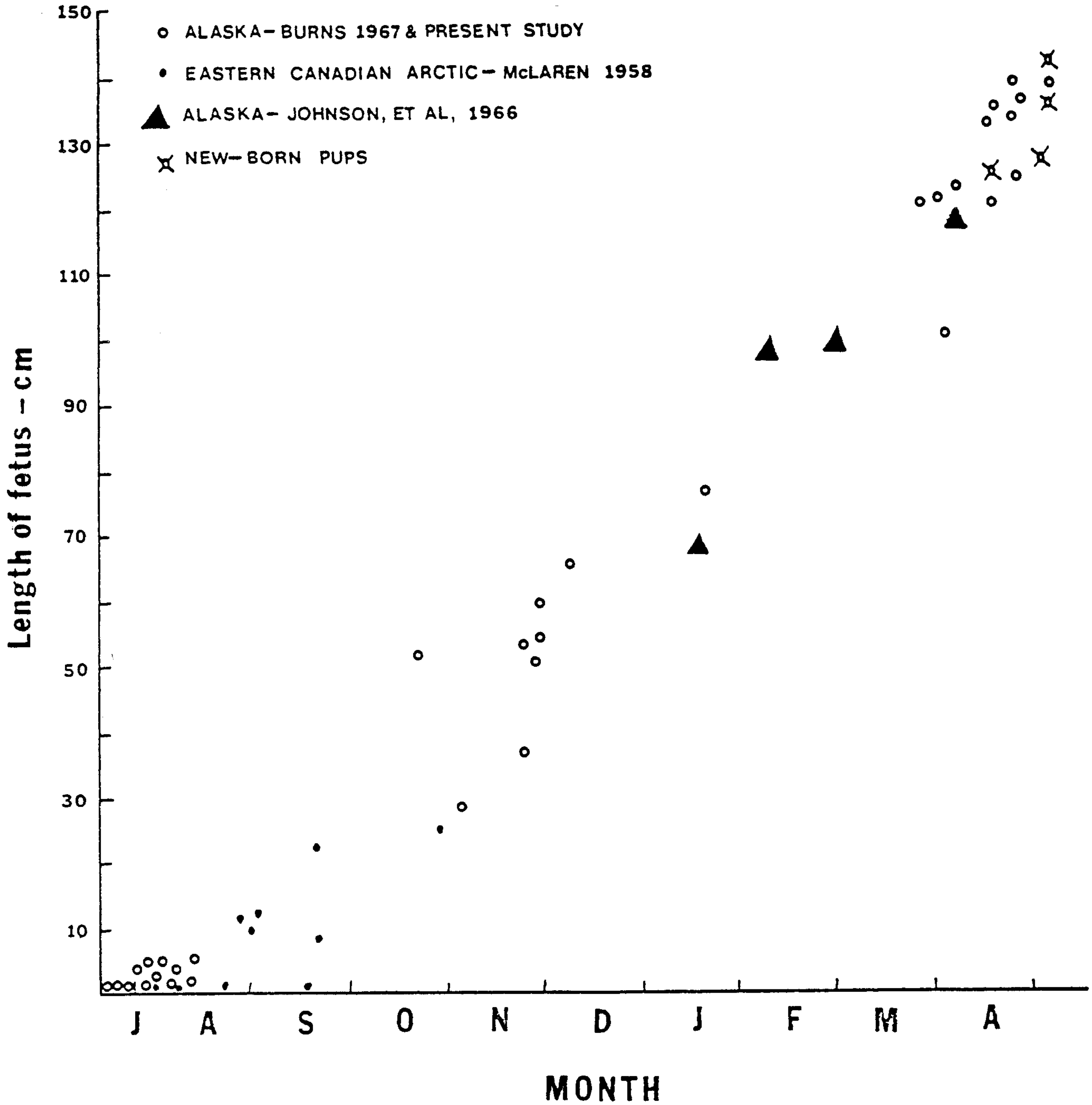

Figure 16. Growth of bearded seal fetuses from implantation to birth as indicated by 51 specimens from Alaska and Canada.

adult females (mainly in April) appear dark. Bearded seals are encountered mostly as single animals, although several may rest on a single floe. They lie on their bellies and, almost without exception, their heads are within a few feet of water. When several bearded seals are lying on a single ice floe they position themselves around the edge and appear as if facing away from each other. If animals are resting on both sides of a narrow lead they also face the water and orient themselves perpendicular to the axis of the lead. They rarely rest farther than a few feet from water and, when alarmed, move toward it in a wriggling gait using both foreflippers in unison. They slide head first into the water, frequently raising their hind end high in the air as they dive. The hindflippers do not rotate forward and are not used for locomotion over the ice. Fore- and hindflippers are not obvious except at close range. When sufficiently alarmed they bolt into the water raising and propelling their bodies by the simultaneous movement of both foreflippers. This leaping, forward movement of alarmed animals escaping from the ice is the behavioral basis for the Russian common name of sea hare (Kaitkulov, pers. comm.). Bearded seals rarely move away from water when disturbed, as will spotted and ribbon seals.

The capability of pups to swim shortly after birth, the habit of resting on the ice immediately adjacent to a route of escape and the explosive escape response of alarmed animals are thought to be adaptations which have evolved in the face of continuous predation by bears over a significant portion of their range.

The senses of sight, hearing and smell are difficult to evaluate as the responses of these seals to disturbance are so varied. On a warm, calm spring day when they are basking they often show little concern for a low-flying aircraft, or the close presence of men or boats. With care it is sometimes possible to crawl across the ice and touch one. This is in marked contrast to responses of these seals in winter when the slightest sound-producing movement of a man on the ice will cause a basking seal to flee, or entice a swimming seal to surface several hundred yards from the sound source. An undisturbed bearded seal will characteristically swim with its head and back above the water. One would conclude that when alert they have good senses of sight and hearing and a fair sense of smell.

The mother-pup bond is strong during the early nursing period. Females often remained near pups which were being marked, occasionally coming out on the ice in an attempt to frighten the intruder or defend the pup. Similarly, they will remain in the water near a pup killed by hunters on the ice, or assist a wounded pup in its attempts to escape.

Young animals have been observed engaged in what appeared to be play. In one instance two small bearded seals kept up a constant chase which involved a repetition of riding swells into the beach, active rolling, mock fighting with the foreflippers and tail-chasing back out through the surf. This activity continued for 37 minutes. In another situation two small seals moved along with a small outboard-powered boat and engaged in active tail-chasing, rolling, jumping partially clear of the water, slapping the water surface with their foreflippers and swimming from one side to the other immediately beneath the boat.

Formerly, hunters using kayaks in the open sea were especially successful in harpooning these seals during fall. On moderately windy days the seals could be approached very closely. It is thought that seals remaining at the surface for long periods of time were sleeping and could not hear an approaching kayak over the noises of wind and waves. Unlike swimming seals which expose both head and back, these "sleeping" seals are vertical in the water (Koezuna, pers. demonstration).

Mothers and pups frequently nose and gently scratch each other. Mutual nosing was part of every encounter observed in which a female rejoined her pup on the ice. It was similar to that reported by Burns et al. (1972) for spotted seals.

Use of foreflippers is probably important in social interactions among adults. Adults often bear deep, parallel scratch marks or scars on the posterior third of the body, particularly the abdomen. These marks are usually attributed to polar bears. However, although the distance between the parallel marks is about the same as that between the claws of a small to medium-sized bear, it is also similar to that between the claws of a flexed foreflipper. Additionally, it is difficult to imagine that a significant number of bearded seals struck on the abdomen by bears could escape the strong curved claws relatively unscathed.

In the only killing of a bearded seal by a bear which was observed, the seal's head was crushed by a single blow as it lay on the ice. The bear then grasped the seal's neck in its mouth and pulled it away from the edge of the ice floe. Tooth marks have not been found on seals we examined which had scratch marks.

Bearded seals are very vocal and produce a distinctive song. The long, musical underwater sounds are well known to Eskimo hunters who, in the days when kayaks were extensively used for spring hunting, tried to locate animals by listening for them. Although parts of the song are audible at close range in air, it can easily be heard by placing a paddle in the water and pressing an ear against the butt of the handle. The Alaskan Eskimo terms <u>aveloouk</u> (Upik Eskimo) and <u>ayuktuk</u> (Inupik Eskimo) specifically refer to bearded seals singing in the water.

The production of sounds by these seals has been referred to by several earlier workers. Chapskii (1938) summarized the available information up to the time of his studies. He and others, notably Dubrovskii (1937), associated these sounds with the mating period (Dubrovskii referred to the nuptial whistle) and stated that, "it cannot be explained otherwise than being a sound expression of sexual excitement." Some of Chapskii's informants apparently indicated that both males and females made these sounds.

In the Bering Sea the bearded seal song can be heard from March through July. There is definitely a marked peak in "singing" during April and May.

Analysis of these songs showed them to be complex, long, oscillating frequency-modulated warbles that may be longer than a minute in duration, followed by a short unmodulated low-frequency moan. These sounds are stereotyped and repetitive (Ray et al. 1969). Once located, the singing animals are easy to approach, apparently being inattentive to minor disturbances. They dive slowly, apparently in a loose spiral (judged by the rhythmic changes in strength of the sounds), release bubbles (which signal their general location to the seal hunters) and surface in the center of their area of activity. This behavior is repeated many times.

All of the "singing" bearded seals taken by Eskimo hunters, which we subsequently examined, were adult males. It was suggested that the song is produced by mature males during the spring breeding season and that it is a proclamation of territory or of breeding condition or both (Ray et al. 1969). Future studies will probably show that females also produce these songs. This is suggested by the number of songs that have been heard simultaneously at some locations. It seems that most of the seals observed had to be participating in the singing and it does not seem probable that they would all be males (Burns, in press).

H. Food Habits

Bearded seals are primarily benthic feeders. As a result their distribution is largely restricted to the shallow continental shelf waters which are seasonally covered by sea ice. Their diet is diverse. Epifaunal animals comprise most of the food; however, infaunal organisms and demersal fishes are also consumed. Feeding depths of up to 200 m are reported by Kosygin (1971). Chapskii (1938) indicates feeding depths of up to 50 m. Vibe (1950) found that at depths greater than 100 m bearded seals had not eaten benthic organisms, but instead bentho-pelagic fishes. Based on observed distribution of these seals in the southeastern Bering Sea, they are restricted to waters of 130 m or less.

Although the total array of food items consumed by bearded seals is quite large, relatively few types of organisms comprise the bulk of the food. These are bivalve molluscs, crabs, shrimps, sculpins and sometimes arctic or saffron cod. Geographical variation in diet is largely a reflection of local faunal differences. Major prey types remain the same among areas, however the species eaten may change.

Prior to OCSEAP studies initiated in 1975 (Trophic relationships of ice-inhabiting seals, OCSEAP RU #232) there were only five published accounts of the food habits of bearded seals in the Alaskan sectors of the Bering, Chukchi and Beaufort Seas. Kosygin (1966a, 1971) reported on the foods of bearded seals in the Bering Sea collected in spring and early summer 1963-1965. In 152 stomachs containing food, tanner crab (*Chionocetes* spp.) made up from 53 to 76 percent of the food. Shrimp (particularly *Argis lar*) were the second most important food. Snails, octopus, priapulids and fishes (particularly pricklebacks and flatfishes) were eaten regularly.

Kenyon (1962) examined 17 specimens from Little Diomede Island collected in May-June 1958. Shrimps, crabs and clams comprised most of the stomach contents. Other benthic invertebrates (sponges, annelid worms and snails) and several species of fishes were found in small amounts.

Johnson et al. (1966) examined the stomach contents of 164 bearded seals taken at Point Hope and Kivalina in the Chukchi Sea. The only month in which a large sample (129) was obtained was June. Shrimp, crabs and clams were the most common food items with other benthic invertebrates found in small quantities, and fishes (sculpins and arctic cod (Boreogadus saida)) usually comprising less than 10 percent of the total volume.

In his summary of the biology of the bearded seal, Burns (1967) reported on stomachs from seals collected at Nome, Gambell and Wainwright. In May he found that crabs accounted for 57 percent of the contents with shrimp, fishes (saffron cod (Eleganus gracilis), actic cod and sculpins) and sponges comprising most of the remainder. In July and August clams were the most abundant food item, with shrimp, crabs and isopods also quite common.

Prior to the OCSEAP program there were no published accuonts of feeding in bearded seals of the Beaufort Sea north of Alaska.

The following discussion of bearded seal food habits, by lease area, is summarized from Lowry et al. (1978, 1979a, 1979b).

Bristol Bay and the St. George Basin are at the southern limit of the normal bearded seal range. As stated previously, the importance of these lease areas to the seals is directly related to ice conditions, and may vary from one year to the next. In general, seals in the southeastern Bering Sea appear to rely on tanner crabs, Chionoecetes spp., as their primary food source. Gravid female tanner crabs (those with eggs) were eaten more frequently than males. Spider crabs (Hyas coarctatus), crangonid shrimps (Argis spp. and Crangon spp.) and sculpins were important food items in some areas. Differences in consumption of food species probably reflect the patchy distribution of concentrations of tanner crabs. The importance of tanner crabs to bearded seals is indicated by the large volumes found in stomachs of seals which had eaten primarily that species ($\bar{X}$ = 1000 ml), as opposed to much smaller volumes found in seals eating spider crabs, shrimp and sculpins ($\bar{X}$ = 150 ml). Tanner crabs are the most abundant epifaunal invertebrate in the offshore waters of the southeastern Bering Sea (Feder 1978, Lowry and Frost unpubl.).

In Norton Basin and the northern Bering Sea shrimps, crabs (Chionoecetes and Hyas) and slams (mostly Serripes groenlandicus) were the most important food items. They amde up from 59 to 93 percent of the stomach contents at various locations. Clams were of particular importance in the diet of beared seals taken at Nome where they accounted for 69 percent of the total stomach contents of seals taken in June. Fishes were usually of minor importance in the diet. Sculpins, saffron cod and arctic cod were the fishes most commonly eaten.

Seasonal variations in diet were found at Gambell and Nome. At Gambell sculpins were of major importance in the diet in March and were much less common in stomachs of seals taken in May and June. At Nome shrimps (mostly Pandalus hypsinotus) were the main food in January-April. In May-June shrimps were of lesser importance in the diet and consisted mostly of Argis lar. A major seasonal difference at both Gambell and Nome was in the importance of clams in the diet. They were rarely found in the stomachs of seals collected during winter months. In stomachs collected during spring-summer they were frequently present in large quantities. A similar lack of clams in the winter diet of bearded seals was noted by Burns (1967).

The Hope Basin lease sale area occupies a large portion of the southern Chukchi Sea. Large numbers of bearded seals feed in this area during much of the year. Most of the information on feeding in this area was from seals collected at Shishmaref. Foods of bearded seals taken near that locality in June-July were similar in 1976, 1977 and 1978. Shrimps (Crangon septemspinosa and some Argis lar), crabs (Telmessus cheiragonus) and clams (Serripes groenlandicus) made up 65-76 percent of the total stomach contents in all years. The predominance of the crab Telmessus, rather than Hyas or Chionocetes, at Shishmaref, and its infrequent occurrence in other samples, is due to the fact that these crabs are generally restricted to waters less than 10 m deep. Such shallow waters extend much farther off shore at Shishmaref than they do at other coastal hunting villages.

In October at Shishmaref shrimps and fishes (flatfish and sculpins) were the only foods eaten. The absence of clams in the fall diet is consistent with observations in the northern Bering Sea.

Point Hope is at the northern edge of the Hope Basin. Johnson et al. (1966) present the most complete account of feeding in bearded seals from this area. As at Shishmaref, crabs (Hyas and Telmessus), shrimp, clams and fishes (saffron cod, arctic cod and sculpins) were the major foods. In May crabs were the major food item whereas in July and August clams predominated.

Bearded seals collected at Wainwright ate clams, shrimp and lesser quantities of sculpins and crabs. Clams were eaten in large quantities, probably reflecting the presence of large clam beds in the Wainwright area.

The Beaufort Sea is an area of relatively low bearded seal abundance. Unlike the Chukchi and northern Bering Seas, it has a relatively narrow continental shelf. The 100 m contour is mostly within 40 km of shore. Since this depth is probably close to the maximum feeding depth for bottom foraging bearded seals, the Beaufort Sea does not include a very large area of favorable habitat for these seals. This is true in winter when landfast ice extends 20-40 km from shore (resulting in a very narrow band in which appropriate ice and water depths occur) and in summer when ice is mostly over deep water.

Data from stomach contents are available for 20 bearded seals taken in the Beaufort Sea. Sixteen of those seals were collected in the Barrow region. As at other locations along the coast of Alaska, crabs and shrimps were primary prey items. Clams, hermit crabs, octopus, gammarid amphipods, isopods and fish were also eaten.

During spring and summer invertebrates comprised over 95 percent of the stomach contents. Clams were an important component near Barrow in August. Large clam beds are known to occur off shore in that region (Carey 1978). In samples from Barrow, taken during November and February, fish were of greater importance than at other times of year. Although shrimps and crabs were still eaten, arctic cod were taken in substantial quantities. The importance of arctic cod is probably a result of the abundance of this fish in the Beaufort Sea, and its appearance in the winter diet may coincide with an onshore spawning migration during early winter.

The overall most important food species at Barrow were tanner crabs, spider crabs and the shrimp Sclerocrangon boreas. In the Prudhoe Bay area spider crabs and the shrimp Sabinea septemcarinata were the most important components of the diet. The absence of tanner crabs and the change in shrimp species reflect faunal differences between the areas. East of Barrow tanner crabs occur only rarely and Sabinea is more abundant than Sclerocrangon (Lowry et al. 1978).

Age-related differences in diet were found in bearded seals from both the Bering and Chukchi Seas. Table 11 presents data from all our Bering Sea samples combined and from June-July 1976-1978 at Shishmaref. Whereas the prey types were similar in all age classes, there were significant differences in the proportions of those types in pups, yearlings and older animals. The proportion of shrimps in the diet decreased with age while the proportion of crabs and clams increased. Capture of these last two prey types may depend on learned behavior acquired by the seal in the first few years of life. The species composition of fish included in the diet also changes with age. Saffron cod was most important as a food for pups, whereas flatfish and sculpins were most utilized by yearlings and adults. Sculpins, in both the Bering Sea and Shishmaref samples, were eaten in greatest number by yearlings. It may be that saffron cod are slow swimming and aggregated and are thus easy prey for pups.

Table 12 presents a summary of major prey species of bearded seals in each of the proposed Alaskan OCS lease sale areas in which the seals occur. This table makes it readily apparent that a very few species are extremely important to seals throughout Alaskan waters. In all five lease areas crabs are the primary food item. Crangonid shrimps were also of major importance in every area. Geographical distribution and abundance of the different species in these two groups determines which particular species will predominate as bearded seal food. Tanner crabs are most abundant in the Bering Sea and are most common in bearded seals from that area, whereas spider crabs (Hyas) are most numerous in both the fauna and in bearded seal diets in the Chukchi and Beaufort Sea. Shrimps show a similar pattern.

Table 11. Major foods of bearded seals collected in 1975-1978 in the Bering Sea and at Shishmaref. Results are reported by age group of seals. Numbers are the percent of total volume for invertebrates, and total fish. For species of fishes, numbers are the percent of the total number of identified fishes.

Food Item	Bering Sea Pups N=52	Bering Sea Yearlings N=23	Bering Sea ≥2 yrs old N=58	Shishmaref Pups N=38	Shishmaref Yearlings N=14	Shishmaref ≥2 yrs old N=87
Shrimp	45	23	28	58	36	31
Isopod	*	-	*	18	17	8
Clam	2	4	22	4	16	18
Brachyuran crab	28	42	27	6	12	23
Echuiroid worm	*	*	*	*	*	11
Total Fish (% volume)	13	27	11	7	17	6
Identified Fish (% number)						
Saffron cod	41	4	5	51	15	36
Sculpin	47	90	78	28	60	27
Flatfish	*	*	2	22	21	35
Mean Volume Contents (ml)	213	589	653	325	346	526

* Trace amounts present (less than 1 percent).

Table 12. Major prey species of bearded seals in 5 proposed OCS lease areas in the Bering, Chukchi and Beaufort Seas.

Area	Relative Ranking of Importance*			
	1	2	3	4
St. George Basin	*Chionocetes opilio*	*Hyas coarctatus*	*Argis lar*	*Crangon dalli*
Bristol Bay	*Chionocetes opilio*	*Hyas coarctatus*	*Argis lar*	*Crangon dalli*
Norton Basin	*Chionocetes opilio*	*Hyas coarctatus*	*Serripes groenlandicus*	*Argis lar*
Hope Basin	*Hyas coarctatus*	*Serripes groenlandicus*	*Crangon septemspinosa*	*Argis lar*
Beaufort Basin	*Hyas coarctatus*	*Sabinea septemcarinata*	*Boreogadus saida*	

* Decreasing importance (1 to 4).

I. Pathology

Pathology was not investigated by us. Readers are referred to reports of Fay et al. (OCSEAP project #194) for information on specimens jointly available to our respective studies. The following account is mainly summarized from Burns (in press).

An exhaustive list of the helminth parasites in bearded seals is beyond the scope of this report. Interested readers can refer to the various writings of K. I. Skriabin, S. L. Delyamure (1955) and King (1964). Current studies of the helminth parasites and other pathologies in bearded seals in the Bering-Chukchi region are being conducted by American and Soviet investigators.

Fay et al. (1978, 1979) reported that the causes of natural mortality in these seals, other than predation by polar bears, are essentially unknown. Lowry (pers. comm.) reported two cases of apparent predation on pups by Pacific walruses found during April 1979. The only major pathological findings in samples from the living population included helminthiasis of the liver and associated secondary bacterial invasion. This occurred in 5 of 96 specimens examined. They reported other conditions including acute dermato-mycosis, focal necrosis of the liver, trauma from unknown causes, biliary fibrosis, hepatitis and gastro-duodenal ulcers.

The most commonly occurring helminth parasites in eight seals from the Bering-Chukchi region examined by Fay et al. (1978) included *Diphyllobothrium cordatum*, *D. lanceolatum*, *Pyramicocephalus phocarum* and *Corynosoma validum* which occurred in all; *Diphyllobothrium* sp. and *Phocanema dicipiens* which occurred in five; *Orthosplanchnus fraterculus* in four; and *Contracaecum osculatum* in two. San Miguel sea lion virus/VESV was not found in 1 tested beared seal and 11 seals were negative in tests for *Leptospira*.

A total of three bearded seal pups, one stillborn and two newborn, with injuries resulting in death from internal hemmorhage were reported by Fay et al. (1978). Between 1962 and 1969 we found four dead pups, three stillborn and one newborn, which had apparently died of similar causes. The incidence of death from trauma in term fetuses (during birth?) and shortly after birth seems high in relation to the limited opportunities we have had to detect this type of natural mortality.

Pesticides and heavy metals are present in tissues of bearded seals. Galster and Burns (1972) reported DDT, DDD, DDE, dieldrin and PCB's in adipose tissues of polar bear, ringed seal, spotted seal, walrus, bearded seal and Steller sea lion (*Eumetopias jubata*) from the Bering-Chukchi region. Small concentrations of pesticides were present in nearly all samples and only PCB's occurred in what were thought to be high concentrations. The contaminant burden of the different species was greater than differences between areas. Of the pinnipeds, bearded seals had the highest concentrastions of DDT residues (0.330 μg/g) and sea lions the lowest (0.026 μg/g). Levels of dieldrin were low and varied from one-half to one-tenth the levels of DDT. Concentrations of PCB's were similar in all the pinnipeds and averaged $1.78 \pm 0.52\ \mu g/g$.

Accumulations of mercury were present in samples of liver, muscle and fat of the Bering Sea pinnipeds. The average concentration of mercury in the examined tissues from bearded seals was $0.95\ \mu g/g$. It was four times more concentrated in the liver than in muscle or adipose tissue (Galster 1971). Mercury and selenium were present in bearded seals from the Canadian Arctic (Smith and Armstrong 1978).

Cadmium, nickel, copper and zinc were present in tissues of four bearded seals from Bering Sea analyzed by Burrell (1978). Concentrations of cadmium were mainly in the liver and kidney. On the average, highest concentrations in the various tissues were as follows: nickel in muscle, copper in the kidney and liver, and zinc in the liver and kidney. Bearded seals had the highest metal loads of the marine mammals examined (walrus, spotted seal, ribbon seal and bearded seal), perhaps because of their food habits. It was advised that in light of the high concentrations of cadmium found in liver and kidney, these organs not be used as human food.

Petrochemical contaminant levels in seals from the Bering-Chukchi region have, as yet, not been determined.

J. Potential Effects of Development

The effects of petrochemical development on bearded seals will be of two general kinds, direct and indirect. Direct effects include such things as disturbance which may result in displacement of seals (short-term abandonment of formerly favorable habitat), the direct physical effects of exposure to fuel and crude oil spills, and the occasional death of seals struck by vessels.

Bearded seals live in the regions of drifting ice. The pup can swim shortly after birth (it can remain with the mother if she is disturbed), they can leave areas of intolerable disturbance (tolerance levels are unknown) and can probably avoid areas of chronic low-level fuel or crude oil spills.

It is anticipated that drilling rigs and production installations will be serviced by vessels and aircraft. Based on our experiences aboard icebreakers, some seals would be struck and killed by large ships, mainly during April-June. The magnitude of this kind of mortality will probably be small and obviously in proportion to the extent of vessel support required. Low flying aircraft, especially helicopters, frighten seals resting on the ice. This kind of disturbance can be minimized by requiring normal flight altitudes higher than 2,000 feet, by short climbs and descents from installations in bearded seal habitat, and by use of the shortest, most direct flight routes.

Disturbance caused by noises transmitted through the water may affect bearded seals. This possibility is based on the proven importance of vocalization in this species. However, there are no data which indicate the effects of noise on these seals. Based on their occurrence near large settlements such as Nome and Barrow, it appears that constant background noise levels from exploration or production installations will probably not cause significant dislocation of seals. However, periodically recurring loud noises such as explosions probably would.

It is not known whether bearded seals will avoid the small spills of fuel or crude oil which are inevitable. Observations of Eskimo hunters suggest that they, as well as ringed seals and walruses, will. A chronic fuel spill at Wainwright, Alaska, which produced a slick more than 3 miles long, was reported to have resulted in low numbers of seals and very poor hunting near that village, until the fuel leak was stopped. Hunters from Diomede Island, Alaska pour gasoline in the water if they think a skin boat may be imperiled by milling walruses. We have no data on which to evaluate avoidance of limited spills by bearded seals.

One can expect year round vessel and aircraft support of OCS development in Bristol Bay. This lease area has annual variations from being essentially ice free to having extensive thin ice during December through May. Helicopter support of installations in Bristol Bay will also be extensive, as the lease area is within range of shore.

St. George and Navarin Basins will, if developed, be serviced almost entirely by ships. As indicated previously, the occurrence of bearded seals in the St. George Basin lease area is irregular depending on extensiveness of ice. These seals can be considered as not normally present in the Navarin Basin.

Norton and Hope Basins are in areas where bearded seals are abundant for a major part of the year. It is anticipated that year round vessel traffic will be practical in Norton Sound and feasible in Hope Basin from May through December. Helicopter support will be extensive in these areas as development will be mostly within the range of shore bases. Shorefast ice is neither extensive nor thick enough to provide reliable access to nearshore installations except under unusual conditions. The effects of human presence and activities in these two lease areas has potential for the largest number of encounters with bearded seals.

The Beaufort Basin is marginal bearded seal habitat. It is extensively covered by fast ice in winter and the open water season is relatively short. It can be expected that vessel traffic will be limited and most access to development sites will be by fixed-wing aircraft landing on prepared ice strips, by helicopters and by surface travel over ice roads. The region occupied by bearded seals in winter is beyond the limits where petroleum development is now technologically practical (although it is feasible). Development of the Beaufort Basin, free of major accident, will probably have little direct impact on bearded seals.

Some direct impact of seals will occur if a major release of fuel or crude oil were to occur in any area when seals were present. The significance will vary with time, location and volume of the release. Seals swimming in slicks can be expected to suffer from eye irritation which is probably reversible (Geraci and Smith 1976). All seals hauling out on the ice through surface water containing fuel or crude oil would be completely covered. This would disadvantage newborn pups with an insufficient layer of blubber for insulation, and would also result in the ingestion of oil by nursing pups. In grey seals, growth of oiled pups was slower than growth of unoiled pups (Davis and Anderson 1976).

Indirect effects of petroleum development on bearded seals are of much greater concern than are the probable direct effects. They also have the greatest potential for adversely affecting marine systems. Indirect effects will derive mainly from introduction of toxic compounds into the system on a continuous, low volume basis or as the result of a major accident. The former is likely to occur in conjunction with any development while occurrence of the latter cannot be predicted.

Carrying capacity of bearded seal habitat is likely to be reduced as a result of large or long-term releases of toxic compounds. This reduction in carrying capacity is likely to be caused by decreased survival of important components in the food web as discussed by Lowry et al. (1979a).

Hydrocarbon pollution was found to result in mortality of saffron cod (DeVries 1976), eggs of the cod Gadus morhua (Kuhnhold 1970) and eggs of other cods (Mironov 1967). For a closely related fish, the Atlantic pollock (Pollachius virens), 70 percent of the eggs within a slick from the "Argo Merchant" spill were moribund. There was a high incidence of abnormal egg development in areas adjacent to this spill (Grose 1977 in Clark and Finley 1977).

Crabs are important to bearded seals and may be highly susceptible to oil pollution as suggested by Karinen and Rice (1974), Parker and Menzel (1974), Smith (1976), Rice et al. (1976) and Mironov (1970). These investigators demonstrated a variety of effects including sensitivity of larvae, abnormal growth, delayed and unsuccessful molting, retarded growth and morbidity.

Bivalve mollusks, another important food item of bearded seals, were reported to assimilate hydrocarbons (Scarratt and Zitko 1972), and still retained 40 percent of the initially introduced concentrations after 75 days (Vandermeulen and Penrose 1978). Effects of oil on mollusks included reduced breeding success, reduced survival of gametes and abnormal embryos and larvae (Renzoni 1975). Significant reductions in populations have been reported. Dow (1975) indicated a 20-percent decline on oil-contaminated mud flats. Gilfillan and Vandermeulen (1978) recorded a 60-percent reduction in clam stocks 6 years after the "Arrow" spill. Other moderately long-term reductions in clam stocks after oil spills have been documented.

Some shrimps ingest oil and apparently suffer behavioral or physiological changes making them more susceptible to predation by fishes (Blackman 1974, in Johnson 1977). Other effects similar to those found in crabs can also be expected.

It is probable that organisms comprising the food web of bearded seals would be significantly impacted by large spills and, as a result, the bearded seal population would be disadvantaged.

It is noteworthy that in the Baltic Sea, where every effort has been made to protect ringed seals from direct killing by man, the population of these animals continues to decline and is now at a dangerously low level. The continuing decline is ascribed to pollution (Popov, pers. comm.). Likewise, in Puget Sound harbor seals seem unable to increase in numbers in spite of complete protection from hunting.

IX. Conclusions

1. Bearded seals occur throughout the seasonally ice-covered regions of the Bering, Chukchi and Beaufort Seas. They mostly maintain a year round association with drifting ice undertaking major seasonal movements.

2. The oldest seal in our samples was 26 years. Age composition of the harvest is strongly biased toward pups. The proportion of pups in the population during early summer approximates 22-25 percent and the proportion of seals 4 years or older (those classes in which pregnancy occurs) was estimated at 55 to 60 percent, based on consideration of biases affecting the harvest.

3. In harvested animals the sex ratio of pups was approximately even. In older age classes there were more females taken than males.

4. A preliminary life table for bearded seals in the Bering and Chukchi Seas indicated an age frequency distribution in the population which included 22 percent pups, 44 percent juveniles (ages 0 through 3) and 56 percent animals 4 years and older. Mortality was higher for males than for females and may account for the discrepancy observed in harvests. Mean mortality rate for all ages (027) was 219/1000 individuals. For age classes 6-27 the mean mortality rate was found to be 96/100 individuals.

5. The harvest of bearded seals in Alaska between January 1977 and June 1978 was 6,308. Yield of products and the equivalent cash value of this harvest were estimated. A seal in this harvest was the equivalent of 5.1 years old, weighed 156.9 kg and had an equivalent cash value of $285.62. The total estimated value of this harvest was $1,801,682.

6. The mean date of birth for bearded seals was 20 April. At birth pups average 131.3 cm long and weigh 33.6 kg. During the 12-18 day nursing period they increase in weight to between 72 and 95 kg. Average length of seals 9 years or older was 219.7 cm. Weights varied seasonally. Weight of adult males in winter and early spring averaged 290.0 kg. In summer it was 244.4 kg. Adult females averaged 250.3 kg in late winter and early spring and 228.6 kg in summer. There were commensurate changes in girth, thickness of blubber and proportional weight of the hide and blubber layer.

7. Sexual maturity was attained at 6 to 7 years in males and at 4 to 7 years in females. The average age of sexual maturity in females was 6 years. Sexual maturity was based on pregnancy rather than ovulation.

Pregnancy rates were 77 percent for age classes 4 and older and 83 percent for females 6 years and older. The latter value was the same as that found in 1962-1966. Breeding occurs mainly in May and implantation mainly in June. The complete reproductive cycle in females is slightly more than 11 months.

8. Bearded seals may be less sensitive to disturbance by aircraft and vessels than other marine mammal species. The mother-pup bond is initially strong and pups can swim from shortly after birth. Thus, separation of mothers and pups may not be a significant problem.

9. Some pups apparently begin to feed while still nursing. In pups there is no indication of a post-weaning fasting period as in several other seals. The main food of newly independent pups are shrimps. Foods of bearded seals include mainly crabs, shrimps, mollusks (including clams during summer) and some fishes (mainly cods and sculpins).

10. These seals were shown to have a variety of pesticide and heavy metal residues in their tissues. Mercury and cadmium are concentrated in the liver to the extent that this organ should probably not be consumed for human food.

11. Predators of bearded seals include man, polar bears and, in some instances, walruses.

12. Bearded seals regularly occur in the Bristol, Norton, Hope and Beaufort Basins. Of these the Norton and Hope Basins support the largest numbers in most years. Bristol Bay is important during "average" and severe ice years. Beaufort Basin supports relatively low numbers of bearded seals on a year round basis. St. George Basin is utilized by these seals during occasional years of extensive ice while the Navarin Basin is south of the normal range of bearded seals.

13. Development, particularly for petroleum, will have an impact on bearded seals. The impact will range from minor to significant depending on occurrences during petroleum exploration and production phases. Direct effects on bearded seals are expected to be relatively minor. Indirect effects, mainly resulting from reduced productivity and survival of prey species could be significant if routine operating procedures are poor or if large accidental spills of fuel or crude oil occur.

X. Acknowledgments

Many individuals have significantly contributed to this study. We wish to especially acknowledge Mr. Carl Grauvogel of Nome who organized many of the village collections of seal specimens. Our assistants included Dan Strickland, Glenn Seaman, Richard Tremaine and Pamela Field. Edward Muktoyuk and Larry Shults accompanied us on ship expeditions and provided willing hands and encouragement. Lloyd Lowry assisted in all aspects of this and other marine mammal projects and was especially helpful in analyzing population data, preparing figures and editing the text. Larry Miller assisted in the task of data management and did our computer programming. Laura McManus suffered through the task of typing this report and providing editorial assistance. Francis H. Fay, as usual, provided specimen material and shared his knowledge and advice.

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MEASUREMENTS AND LOCALIZATION OF UNDERWATER SOUNDS FROM THE PRUDHOE REGION, ALASKA, MARCH 1981

A Report to OCSEAP, Arctic Project Office,
and the Alaska Eskimo Whaling Commission

by

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Final Report
Outer Continental Shelf Environmental Assessment Program

15 December 1981

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1.0 INTRODUCTION

This project consisted of an underwater acoustics feasibility study that was designed with the following objectives:

(1) Record and analyze ambient and man-made underwater sound during winter seismic profiling (Vibroseis®) at a given time and location.

(2) Investigate certain elements of sound propagation losses during winter conditions at a given location with a specified source.

(3) Record and analyze sounds encountered from ringed seals.

(4) Test a method of localizing under-ice/water transient sounds.

We previously submitted an interim report of this work (Cummings and Holliday, 1981).

1.1 Background

Because of the development of industrial operations in coastal and offshore regions of Alaska, federal and local authorities are concerned about impacts on Arctic and sub-Arctic wildlife (Brower, 1981; LGL, 1981). Consequently, several studies have been addressed to the various associated environmental problems. Related to the present undertaking of acoustical measurements, there have been other recent studies of man-made underwater sounds (e.g., Malme and Miawski, 1979; Ellison et al., 1980; Cummmings et al.,

[1] Trade or patented names are given in this report only for clarification of methodology and do not imply endorsement of products.

1981,a, b; Cummings and Holliday, 1981; Holliday, et al., 1981; Ellison and Cummings, 1980; Ellison et al., 1980; LGL, 1981; Fraker, 1981; Greene, 1981; Malme et al., 1981; unavailable reports to BLM by the Naval Ocean Systems Center (R. S. Gales, personal communication); and several others (see ASA, 1981).

At the request of the Alaska Eskimo Whaling Commission (AEWC) a fact-finding workshop was held by the Acoustical Society of America's (ASA) Coordinating Committee on Environmental Acoustics (CCEA). The report of this meeting clearly revealed a lack of sufficient acoustics data on ambient and man-made noise in the potentially affected Arctic regions and inadequate bioacoustic data on the animals involved (Acoustical Society of America, 1980). This report gave a rank of greatest need for measurements of seismic profiling noise.

The present report is primarily related to the winter habitat of the ringed seal, *Phoca hispida*, although the data may also apply to other species. Ringed seals utilize areas of ongoing and planned offshore petro-industrial operations. The seals maintain breathing holes in relatively stable areas of the ice (in addition to areas of shifting ice) where they excavate lairs for giving birth, nursing, and resting (Smith and Stirling, 1975). In the 1980 report by ASA, John J. Burns (Alaska Department of Fish and Game, ADFG) reported that "Preliminary studies indicate significant displacement of ringed seals in the fast ice from (winter, ed.) seismic exploration." He also reported that "Ringed seals appear susceptible to man-made acoustic disturbances in the fast ice zone." In cooperation with ADFG, NOAA's OCSEAP Arctic Project Office, in co-sponsorship with AEWC, solicited Oceanographic Consultants and Tracor, Inc. to conduct a brief pilot/feasibility study with the aforementioned objectives.

In addition to specified measurements of man-made and ambient underwater sound, we were asked to explore certain techniques (e.g., sound localization) that could be employed in research then being planned by OCSEAP and ADFG. For example, the ability to determine the location of vocalizing ringed seals could lead to a host of informative data on subjects such as short range movements, seal sound source levels, recognition of individual callers, and possible effects of man-made noise. It was anticipated that this method may also be used to localize certain kinds of nearby man-made sounds.

1.2 Acknowledgement

We are indebted to numerous persons and organizations for their assistance: Dave Norton and W. M. Sackinger (OCSEAP), then Mayor Jacob Adams (NSB), Chairman Eugene Brower and Marie Adams (AEWC) sponsored the study and helped with logistics; John Burns, Brendan Kelly, Larry Moulton (ADFG), and John Craighead (OCSEAP) considerably assisted the liaison and field operations; William Harrigan, Eric Davis, and Roy De Hart piloted NOAA's helicopter and they assisted with ice operations; Lonnie Brooks, Mike Roberts, Marty Hall, C. W. "Bill" Hayes, Juan Gomez, and Mike Tesch (Geophysical Services, Inc.) provided valuable information and coordination concerning Vibroseis® operations; John Mortigan (Sohio) conducted a tour and offered technical information on the Vanguard II rig as it drilled from man-made island No. 8; Ron Scheidt, Cleve Coles, Dale Kinney, and Esther Wunnicke (BLM) provided useful information; I. Palmer and Jon Neuman (USGS) made arrangements for us to work with GSI's seismic profiling crews; Margie Richardson and Tanya Rydlinski produced the finished text; and W. T. Ellison commented on the manuscript.

2.0 METHODS

2.1 Locations and Materials

The work described in this report was conducted on the ice off Prudhoe Bay, Alaska, during 5 - 12 March, 1981. Dates and location had been assigned to the investigators. John Burns and his group established an ice camp for us (Station 1) that included a Parcoll structure at which the field operations were based and where sound localization, velocity, and propagation measurements took place. A total of nine widespread stations were used to record 33 reels of tape. In addition to the acoustics work at the base camp, acoustic data on Vibroseis® operations were obtained at Stations 5, 6, 7, and 8. Station 9, situated off the Sagavanirktok Delta was used to obtain recordings in the presence of offshore drilling. The other stations were for listening to seals and obtaining underwater ambient noise data. Fig. 1 illustrates the positions of the various recording stations, and Table 1 gives the coordinates of their locations. Reported bearings are in degrees magnetic, corrected for local variation, and the time of day is in local time.

2.2 Environmental Conditions

All recordings were made through hydroholes bored in shorefast ice that varied in thickness from 1.2 to 1.5 m. Low ridges and scattered rubble fields occurred near most of the 9 stations. Unlike our previous work at Prudhoe Bay during the spring and fall months, the nearshore ice was very stable during the present measurements. The water temperature was about -2.2^{o}C; air temperature varied from -29 to -20^{o}C (-20.2 to -4^{o} F), not considering the chill factor. Wind speed varied from 0 to 12.9 m/sec (25 kts). The prevailing wind direction was east by northeast, but occasionally it came from the southwest. Water depths varied from 2.7 to 18.3 m, depending upon location (Table 1). Although current measurements were not taken, there was no detectable current as evidenced by cable strum, movement of suspended particles and plankton, or associated low-frequency noise. White-outs (atmospheric ice crystallization) were common and several flights had to be postponed.

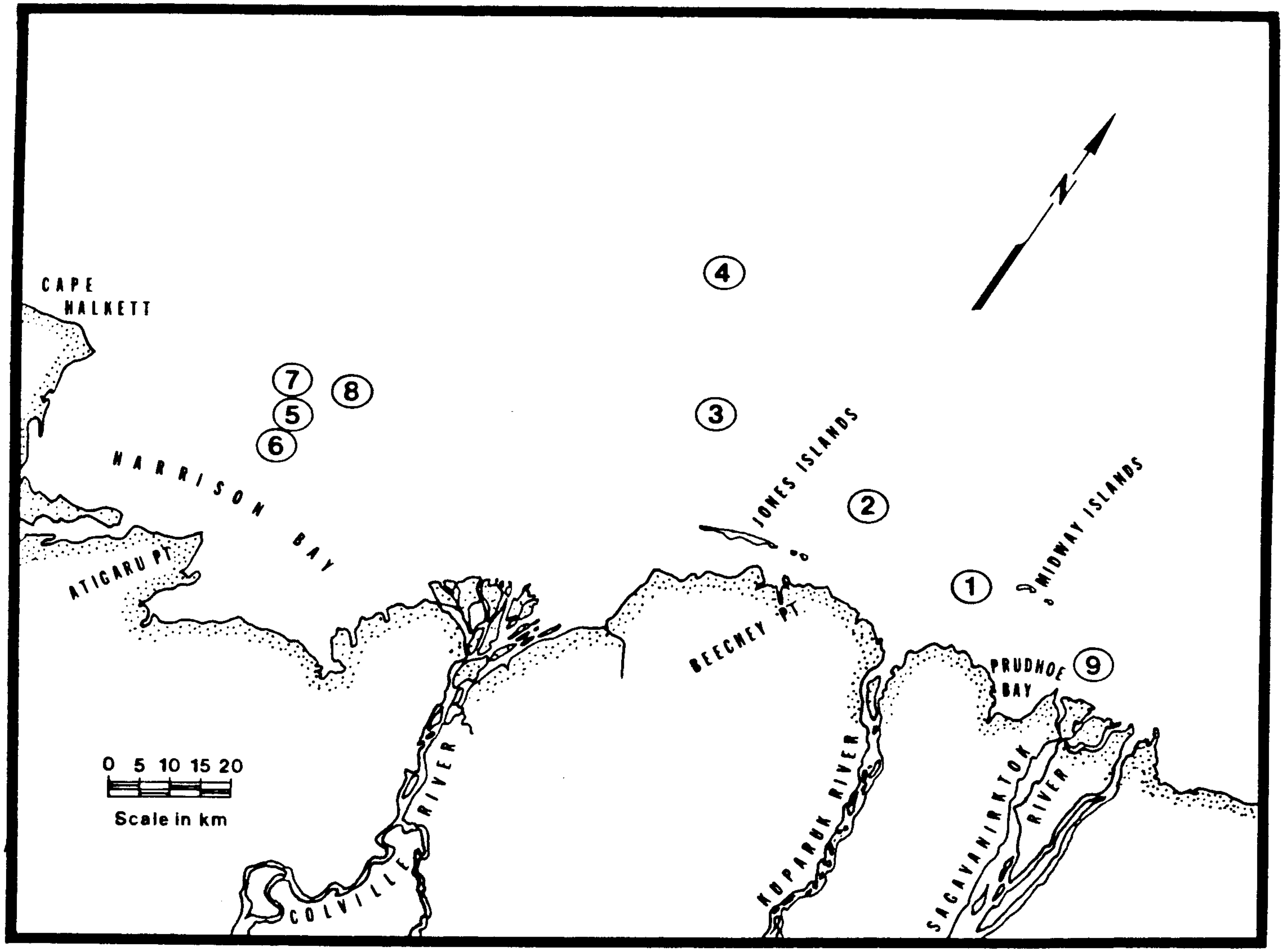


Figure 1. Location of 9 stations from which under-ice/water sound measurements were made in the Prudhoe region.

Table 1. Stations, Recording Numbers, and Supporting Data

STATION	RECORDING	LOCATION (Deg., Min., N,W)		DATE	TIME (HRS)	AIR TEMP (C)	WIND SPEED (m/sec)	DIRECTION	WATER DEPTH(m)	HYDROPHONE DEPTH(m)
1	21, total	70 148	29.3 35.0	3/05/81- 3/11/81	varied	-19 to -28	0 to 6.6	30° to 210°	9.5	5
2	2	70 149	36.8 0.4	3/06/81	1230	-27.5	4.9	35°	18	9
3	3	70 149	43.9 39.5	3/06/81	1342	-28	5.2	205°	18	10
4	4	70 149	55.4 37.3	3/06/81	1445	-29	2.1	72°	18.3	9
5	8,9	70 151	42.5 21.5	3/07/81	1320	-20	6.4	76°	9	5
6	11	70 151	41.5 24.0	3/07/81	1551	-20.5	6.4	76°	9	5
7	13-16	70 151	43 21	3/08/81	1512	-20	0		9	5
8	26	about 5 miles E. of Stat. 7		3/10/81	1610	-21	2.6	70°	10	5
9	33	70 148	22 3	3/12/81	1530	-24	6.2	250°	2.7	2.1

One of the anticipated problems was keeping the three exposed permanent hydroholes near the base camp free of ice so that hydrophone cables would not freeze in during long recording sessions or extended experiments. Although we were prepared with hole liners and an ample supply of gelatinized kerosene, these precautions were unnecessary. Tops of the hydroholes in the ice were below 0.2 to 1 m of snow cover, and we simply cut blocks of snow and piled them on and around the holes as an insulating cover. An ice ladle was used to remove ice that quickly formed in the holes. When holes did freeze up overnight, they were re-bored the next morning. The fourth hydrohole at the base camp (Station 1) was inside of the heated Parcoll, and it stayed open most of the time with the help of an ice chisel.

The only animals observed on the ice were a polar bear, its cub, and Arctic foxes. The bears had a den on the north edge of Pingok Island. The foxes were most active at night. They were attracted to our activities at the base camp where they became a nuisance by chewing on cables and a hydrophone.

2.3 Recordings and Analysis

Recordings were made in the Parcoll shelter or in NOAA's helicopter (Bell 204). Hydrophones usually were lowered to about mid-depth, depending upon circumstances.

The hydrophones (InterOcean, R130) terminated 90-m lengths of shielded cable, and were connected, via 20, 40, or 60-dB preamplifiers, to a portable, 3-channel tape recorder (Nagra IV SJ). As in our previous operations, we deployed a ground connection from the topside instrumentation to the water in order to reduce RF interference. At some of the sites high- and low-gain channels were recorded simultaneously for increased dynamic range in the recordings. Occasionally, FM and direct recordings were made simultaneously, on separate channels, to achieve a greater overall frequency response. One hydrophone was used at a time at the 8 outlying stations, but the localization and propagation studies at the base camp were accomplished with three hydrophones in a triangular array, 157 x 141 x 152.5 m, and one hydrophone in the center of the array. In all cases calibration signals and voiced commentary were provided for each recording. The most optimum setup provided a useful frequency response from 10 Hz - 40 kHz with corrections for low- and high- frequency roll off (Fig. 2). A more detailed description of the recording system has already been reported (Holliday, et al., 1980; Cummings et al., 1981).

Recording sessions were aurally monitored and accompanying meteorological and other supporting data were noted (Table 1). Representative samples were chosen for spectral analyses, a procedure that mainly utilized a real-time spectrum analyzer (Spectral Dynamics 345, with options), a video printer (Axiom EX 850), and a continuous recorder (Spectral Dynamics 4633A). Data were displayed and recorded in the time (waveform) or frequency (spectrum) domains, Fig. 3, or as updated spectra from the continuous recorder.

A writing oscillograph (Sanborn, 4500) was used to obtain waveform traces from each of the three hydrophones in triangular array, and time delays were determined with a digital oscilloscope (Nicolet, Explorer III A). Computer programs were developed to localize underwater acoustic signals, based on either time delays at three hydrophones or time delays and received sound pressure levels on two of the three hydrophones.

For a more informative display of relatively stable or continuous man-made noise, data were linearly averaged over time periods from 0.6 to 20 sec (e.g., 16 to 512 averages, using the 10 kHz range). Averaging enhances the detection of narrowband sound energy, such as tonals from man-made noise. When averaging was used, the number of averages appears in the lower right corner of the spectrogram, 17 in Figure 3.

The analyzing filter bandwidth can be determined by calculation: analysis frequency range/400 x 1.5. Total duration of the averaged data is the number of averages/analyzing filter bandwidth for a given spectrogram. For brevity, the analyzing filter bandwidth and the duration of averaged data are not given for every spectrogram; these values may be calculated from the information given, if desired.

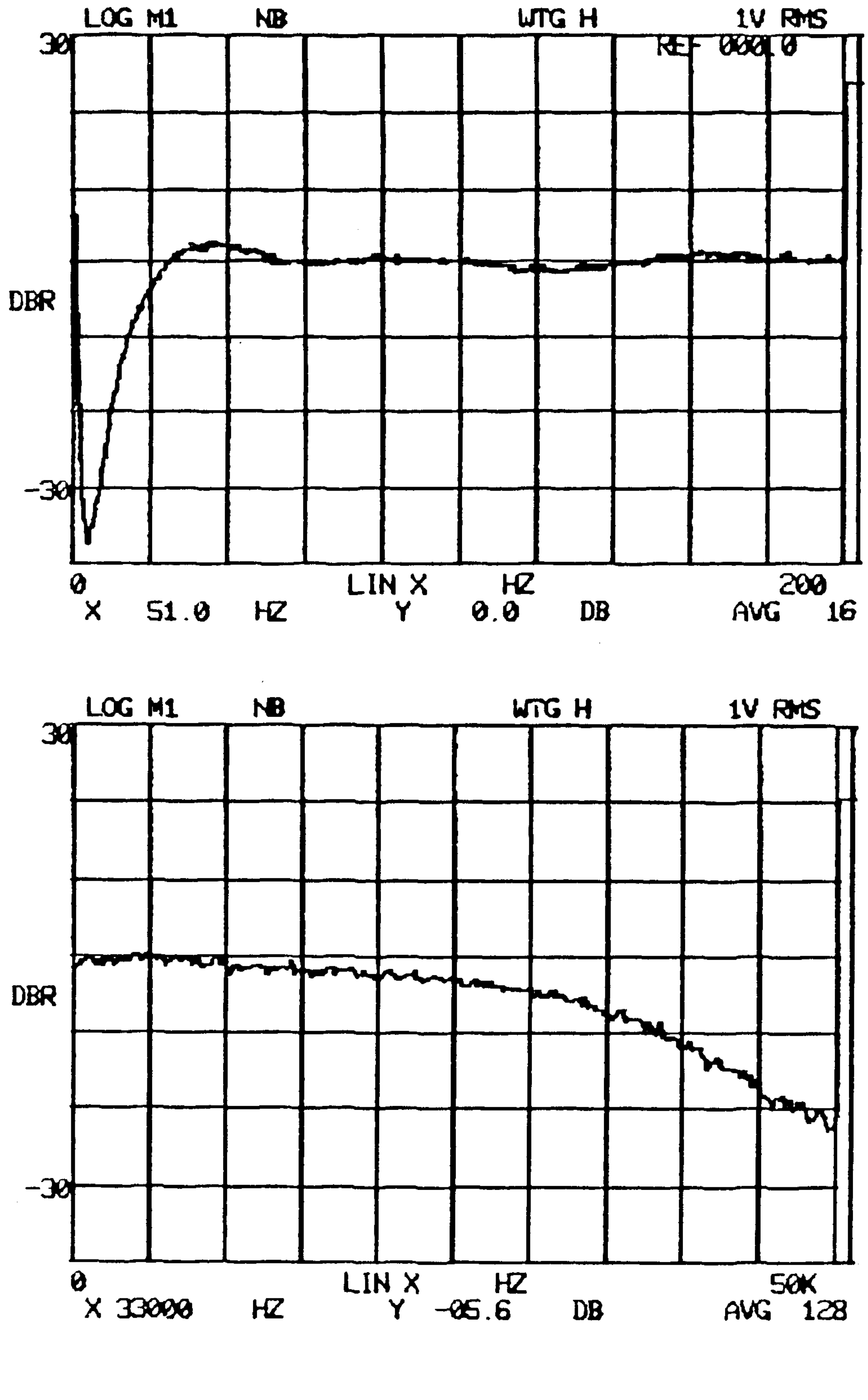


Figure 2. System response, excluding hydrophone crystals, and indicated corrections for 0 - 200 Hz and 0 - 50 kHz regions.

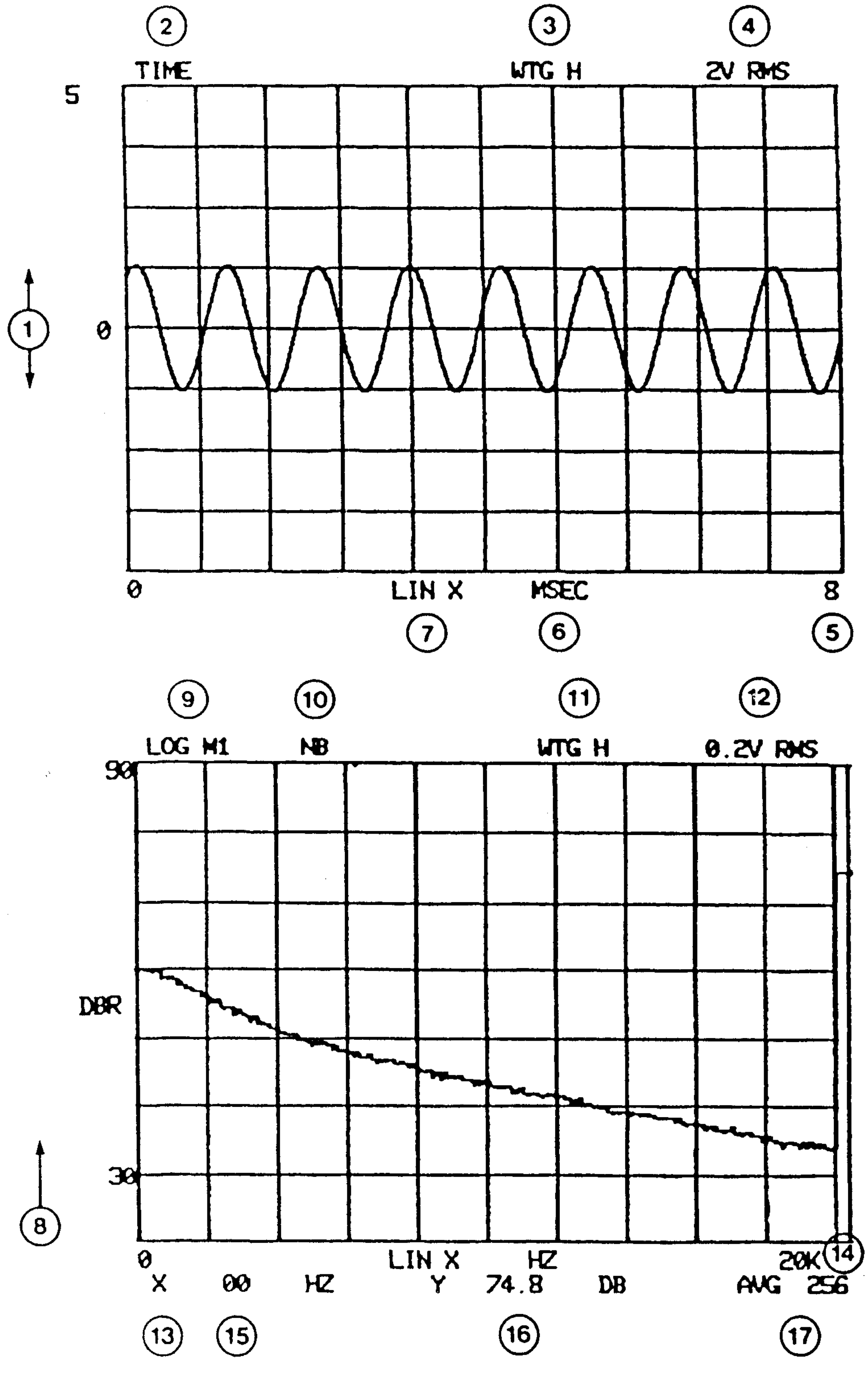


Figure 3. Together with Table 2, an explanation of the computer-derived notations accompanying the data in this report--time domain (waveform) of a 1,000 Hz sine wave, upper; frequency domain representation (spectrum) of random noise passed through an RC filter, lower.

Table 2. Explanation of notations on spectrographs in this report (See Fig. 3)

WAVEFORM DISPLAY		REAL TIME SPECTRUM	
1	Relative Amplitude	8	Calibrated sound pressure level (dB re 1μPa) corrected to an equivalent 1-Hz band, i.e., power spectral density.
2	Waveform Display	9	Log dB scale, memory no. 1
3	Hanning Window Weighting (pertains to spectrum only)	10	Narrowband
4	Reference Voltage	11	Hanning Window Weighting (used in computing spectrum)
5	Duration of Sample Window	12	Reference Voltage
6	Units of Time in Sample	13 - 14	Frequency Scale
7	Linear Spacing of Time Samples	15	Position of Cursor (Hz), 00 Hz is at bar, offscale to right.
		16	Sound pressure level at position of cursor. At extreme right margin, cursor and bar read overall rms level, as here. Bar always shows rms level
		17	Number of Averages (when used)

All received sound pressure levels are reported in dB re 1μPa, either as spectrum level (in a 1-Hz band) or as rms level (integrated spectrum levels over the entire analysis frequency range). Source levels are referenced to 1 m distance. Time of day is given in local time.

An underwater sound velocimeter (NUS, Model 1000-113) was used to measure the speed of underwater sound at Station 1.

For the purpose of this report acoustical energy is discussed in three specific categories: (1) man-made noise, man's contribution of noise to the underwater environment; (2) bioacoustic signals, sounds made by animals, and (3) ambient noise, the natural noise background due to physical processes, excluding outstanding man-made or animal sounds.

3.0 RESULTS

3.1 Sound Speed

The sound speed profile is a graphic depiction of the speed of sound with respect to depth, and it is used (among other parameters) to interpret the behavior of an advancing wavefront (e.g., upward or downward refraction). Speed through water alone is a function of changes in salinity, temperature, and depth, with the latter two being the most important determinants under normal conditions. Under melting ice, salinity differences and suspended material may be more dominant (Urick, 1975). Depending upon conditions, the substrate and ice cover also influence the overall speed of sound. To help interpret arrival time differences at the hydrophone array and transmission losses, sound speed was measured with respect to depth at Station 1 on two occasions, 5 and 10 March 1981.

An average of the resulting sound speed profiles appears in Fig. 4. Differences in sound velocity of the 38 measurements (in 0.5 m steps) between the two dates averaged only 0.34 m/sec in the range of differences of 0.9 to 0.1 m/sec. The sound speed varied from 1437.6 m/sec near the surface to

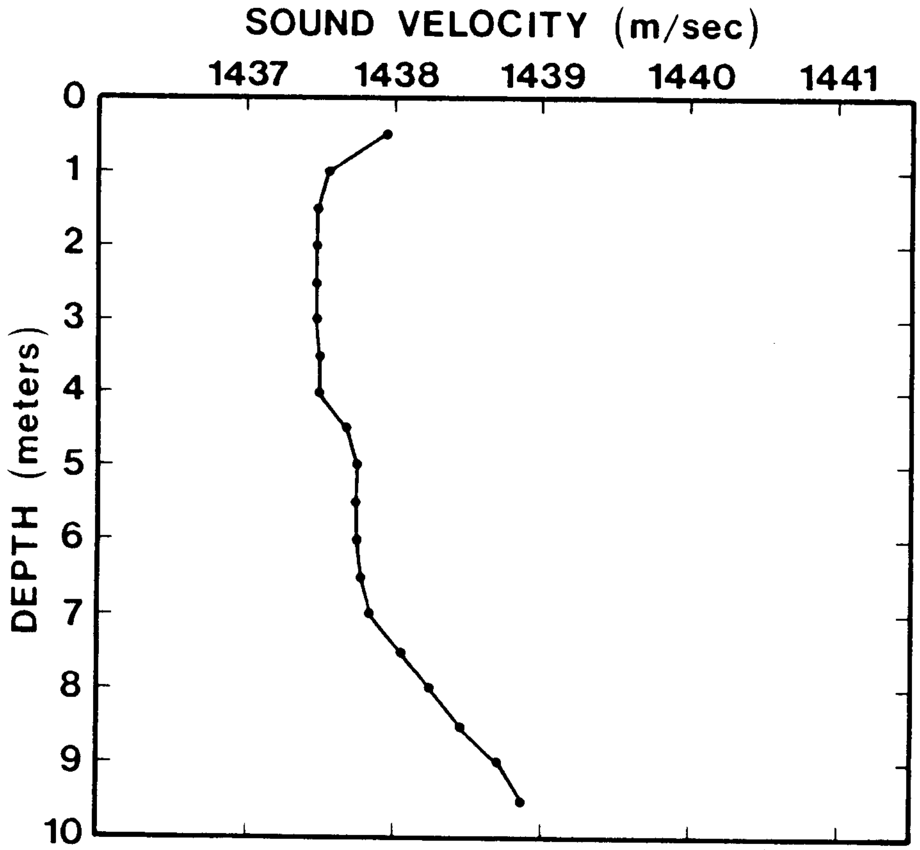


Figure 4. An average of two sound speed profiles from measurements taken at the base camp, about 17 km northwest of Prudhoe Bay (Station 1).

1438.3 m/sec at 8.5 m. However, it increased rapidly at a position 0.5 m from the bottom and at the bottom (Fig. 4). A sharp discontinuity of increasing velocity may be seen at the 4-m depth.

The expected overall effect of such a profile would be upward refracted paths (as a function of increasing speed with depth) with sound propagation enhanced from downward reflections off overlying ice. Such is the usual case in ice-covered Arctic regions where emphasis is placed on the importance of the ice's under-surface topography.

3.2 Propagation re Depth/Range

Based on the sound speed profile and bottom depth at the base camp, a computer program was designed to yield theoretical propagation loss contours as a function of sound frequency and range. Fig. 5 illustrates the extreme variability of losses with respect to depths down to the bottom (9 m) out to a range of 1.5 km. Depth was measured from the bottom surface of the ice cover. Note that the vertical/horizontal position of a receiver or sound source, such as a seal underwater, greatly affects the received level of the sound in this illustration which is based upon a sinusoid at 1 kHz. For example, at a distance of 0.78 km, losses at this frequency theoretically will vary from as much as 72 dB (25 log R(m)) near the bottom (contour no. 8) to as little as 42 dB (14.5 log R(m)) at 3.37 m depth. Source/receiver perspectives are reciprocal in the interpretation of this model.

This variability, along with the other factors already mentioned, clearly points out the uncertainty of estimating MDA's based on limited data.

3.3 Seismic Profiling

Seismic profiling is a method of using intense acoustical energy for the identification of underlying strata in petro-industrial exploration. Two basic methods are used off the North Slope of Alaska. One utilizes powerful impulses of underwater sound from gas guns that are towed by vessels during open water conditions. Barger and Hamblen (1980) reported sound source levels for gas guns that varied in size from 120 - 1200 $in.^3$ to be in the order of 200 to 220 dB over the effective bandwidth of the fundamental frequencies. More recently, Johnston (1981) surveyed a number of more powerful seismic profiling sources (see that reference for other authors on this subject). For comparison, the overall level of a typical World War II Navy Cruiser was about 185 dB. Cummings et al., (1981) have described seismic profiling sounds from a gas gun recorded in September, 1980 off Prudhoe. Another method of seismic profiling is used during solid ice cover in a permitted period from about 15 October to about 15 March, after bowhead whales have left the Beaufort and before they arrive the following spring. The patented term for winter profiling is Vibroseis®. We have been unable to determine underwater source levels of Vibroseis® from the open literature, but in a recent report by the Acoustical Society of America (1980) the maximum source level was estimated to be 230 dB, that of the gas gun was 240 dB.

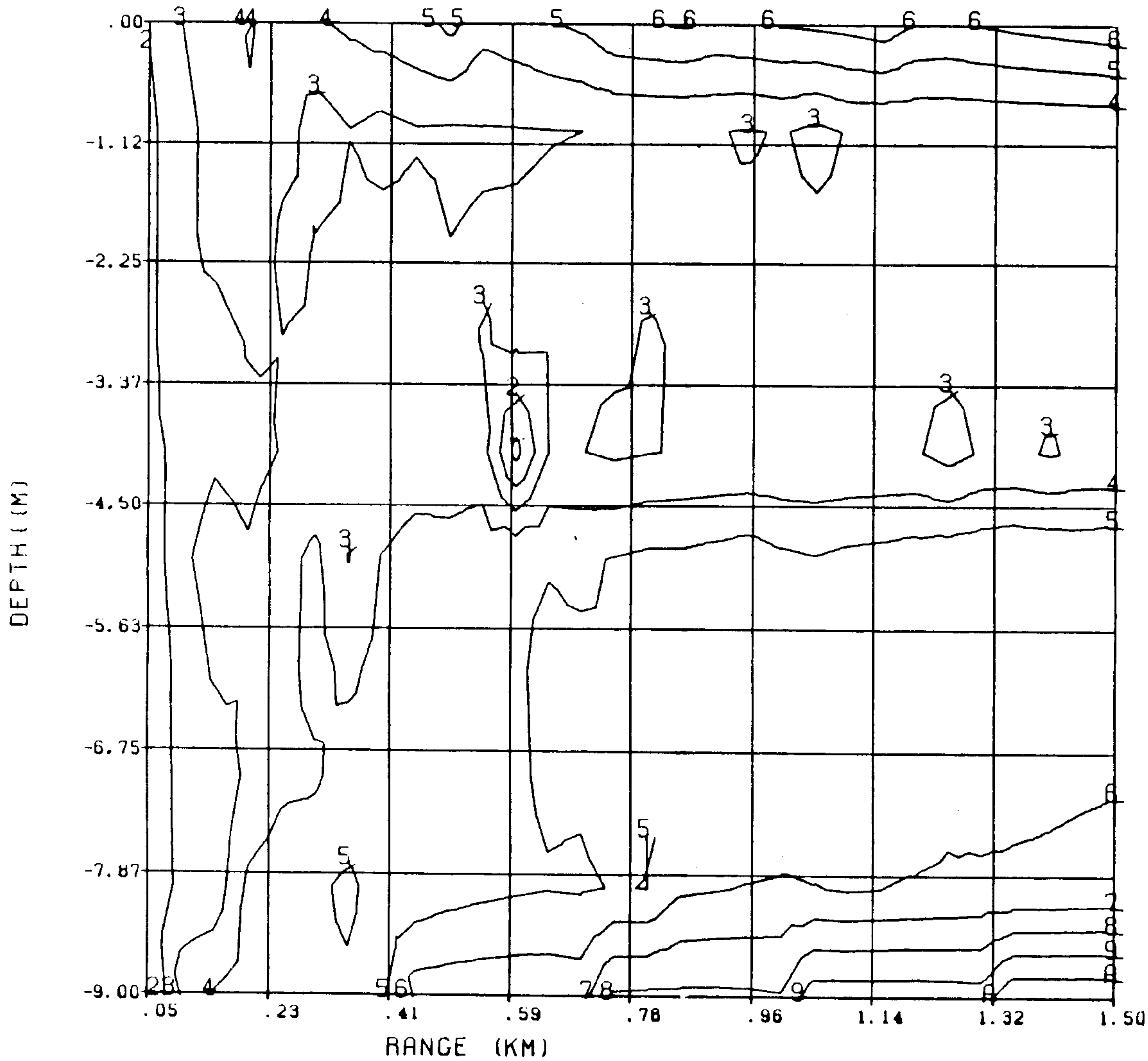


Figure 5. Propagation loss contours modeled from sound speed profile data and depth at the base camp using a sinusoid of 1 kHz and 20 log R(m) spreading. The model includes surface and bottom reflection effects as well as the effect of the sound speed variation with depth. Contour no. 1 represents a loss of 30 dB with each successive contour adding an additional 6 dB of loss out to no. 9 where the total is 78 dB. Contour "A" represents 84 dB loss.

As used by Geophysical Services, Inc., one of two such services off the North Slope, the Vibroseis® method begins with energizing the ice by vibrating it with powerful, hydraulically operated pads. One pad is situated below each of four trucks, the four units being driven in phase. The operation we viewed spaced the four trucks 6.9 m (22.5 ft) apart. The four pads were about 15.2 m (50 ft) apart. After vibrating for 16 sec, using a linear fundamental frequency sweep of 10 to 70 Hz, the convoy moved 6.9 m and repeated the sequence. After 10 such repetitions, the convoy moved 67 m (220 ft) and began 10 more repetitions. While vibrating, each truck is jacked up in order to put the vehicle's weight on the vibrating pad.

Because a similar operation was being conducted by another geophysical service company several miles away, GSI conducted its seismic profiling for 12 hrs and then was silent while the other company operated its system for an equal length of time. The reason for the work shifts was potential acoustic signal interference between the two operations. We were told that, when the two systems were far enough apart, they could be carried out simultaneously, 24 hrs each day. Since the entire procedure entails more than vibrating and recording, the activities are not continuous. For example, calibrations, geophone positioning, troubleshooting, and repairs occupy significant time periods.

The four-truck convoy proceeded along a snow plowed road on the ice. Alongside the road was a very long array of geophones planted on the snow and ice. These sensors received the reflected sound, the recordings being made in a special recording truck ahead of the convoy. It was reported to us that the digital recordings are processed at a computer center in Texas.

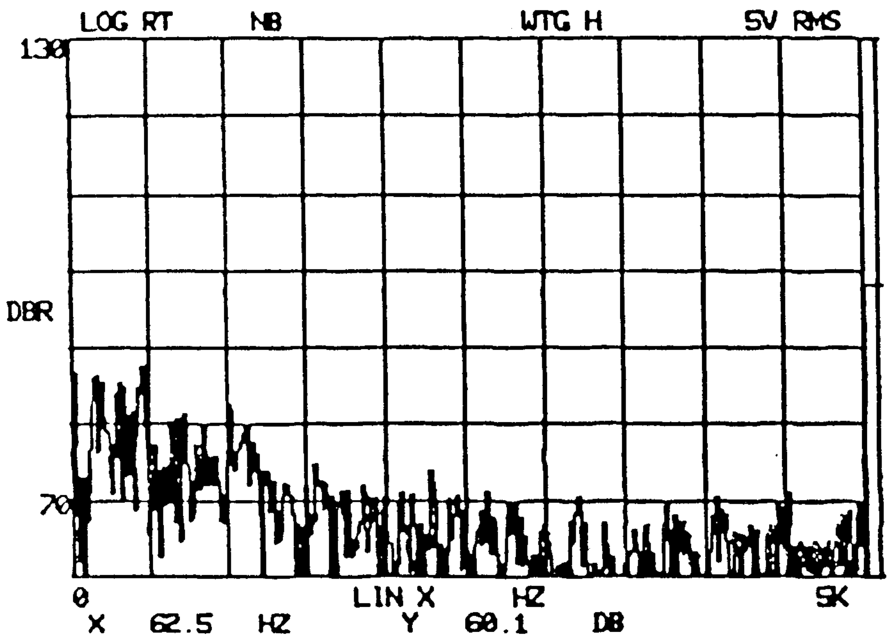
It had been reported at ASA's San Diego meeting that most of the sound is directed downward with little horizontal propagation, and that the energy was virtually confined to the band from 10 - 70 Hz. The statement regarding propagation is undoubtedly true in a relative sense, with levels exceeding even those we measured at a point horizontally displaced from the main beam. However, we found appreciable horizontal propagation in an effective band that extended to about 2500 Hz, towards the end of the sweep, e.g., when the fundamental was at 62.5 Hz (Fig. 6). On a lower frequency scale, the spectra revealed strong line structure as a result of harmonics (Fig. 7). Fig. 8 shows the harmonic relation to the fundamental as the latter was swept from 10 Hz (near 3 sec) to about 70 Hz (near 19 sec). The harmonic structure can also be seen in the waveforms of the Vibroseis® sound (Fig. 9, 10). Considerable care was taken to assure that the harmonics observed were not generated in the measuring instrumentation due to overloading (clipping or non-linear distortion). The recorded waveform was well within the linear range of the instrumentation used. The observed waveform distortion is similar to that which would be caused by non-elastic deformation of the ice during the transmission cycles, or by non-linearity in the driving mechanism.

The operation of Vibroseis® on ice results in the generation of harmonics which can be easily detected above ambient Arctic underwater noise at frequencies higher than the intended fundamental.

Primarily due to the close proximity of sound reflecting boundaries in such a shallow-water location (overlying ice and bottom) and the beamforming characteristics of the Vibroseis® array, propagation of the underwater sound is a complicated process that warrants more analysis than the task allowed. However, the following illustrate basic points.

(1) The horizontal beam pattern around the array of four trucks consists of major lobes of sound energy extending out in a direction normal to the array's orientation. Secondary lobes are situated in the end-fire positions. Horizontal propagation was maximum out to the sides and approximately 20 dB down in the forward and backward directions.

(2) Over the duration of the transmission, the overall received level in the band to 2 kHz, at a distance of 328 m, broadside to the array was 144 dB (rms level integrated over the indicated



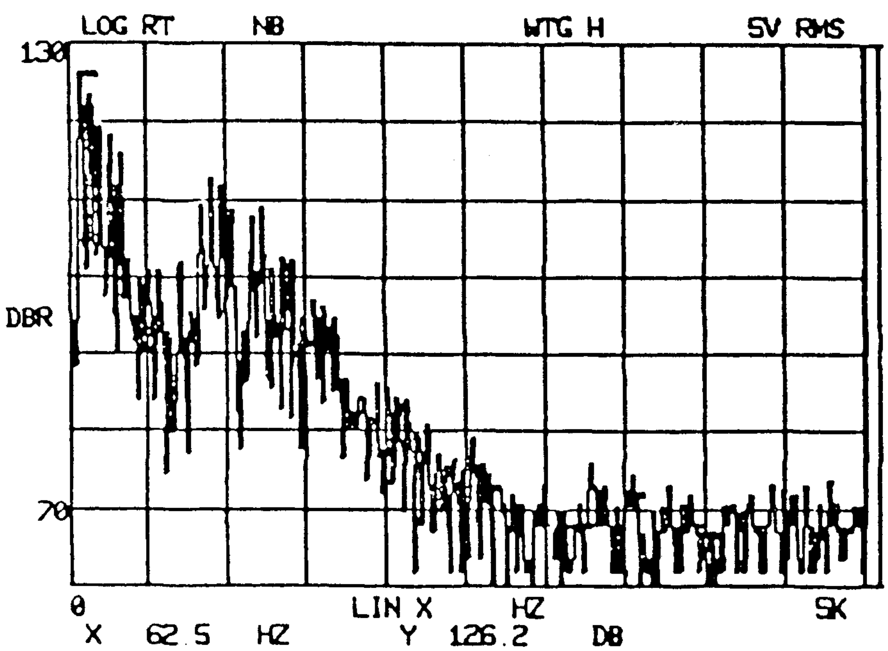


Figure 6. Spectrographs showing the overall addition of 66 dB of noise from Vibroseis mostly over frequencies to 2,500 Hz when the fundamental was at 62.5 Hz (below) compared to "ambient" conditions (above) that contained truck and other noises just before the Vibroseis sound (Station 8).

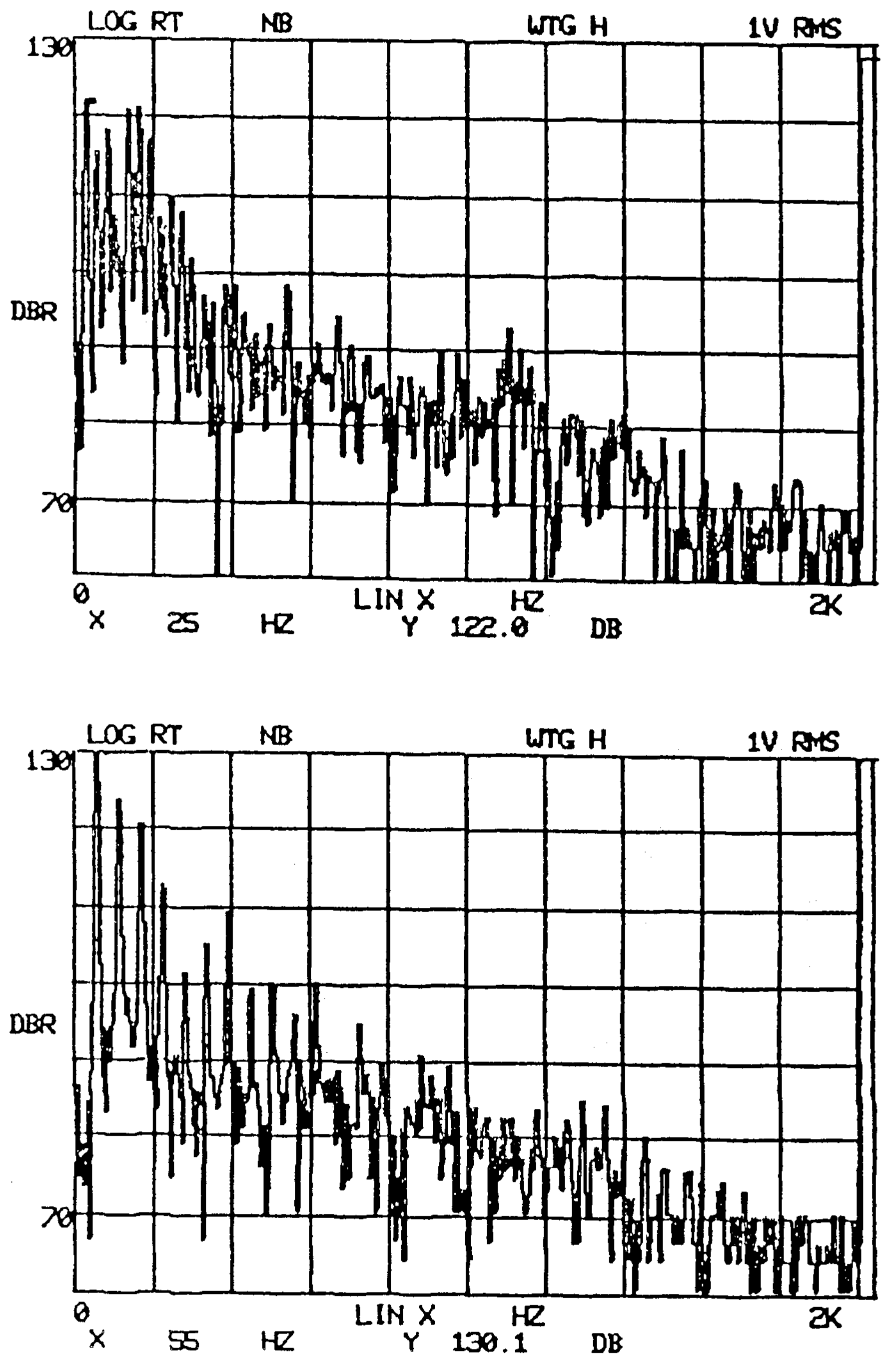


Figure 7. Spectrographs of Vibroseis with the fundamental at 25 Hz (above) and 55 Hz (below). Notice strong line structure from harmonics nearly throughout the frequency range, Rec. 11, N-8.

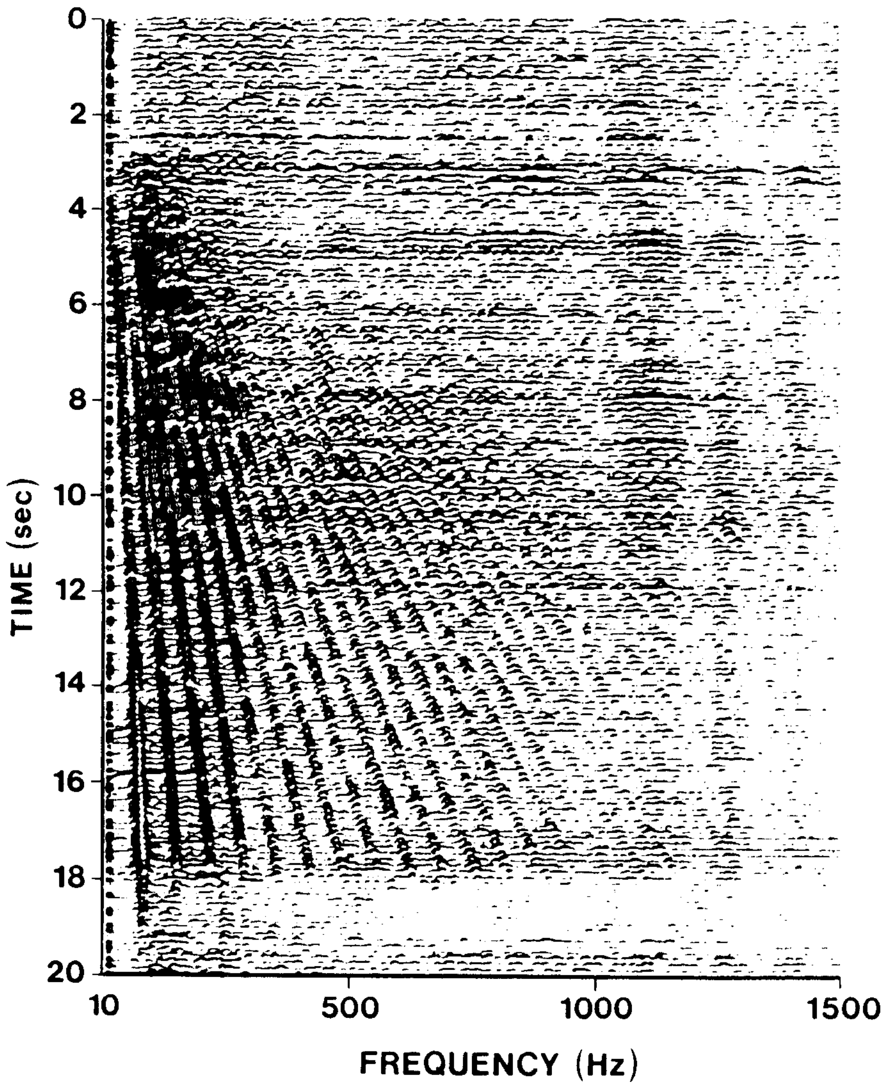


Figure 8. Time-history spectrogram of the underwater noise from Vibroseis recorded at a distance of about 800 m from the center of the array. Note the linear sweep of the fundamental from 10 to 70 Hz and its strong harmonics (Station 6).

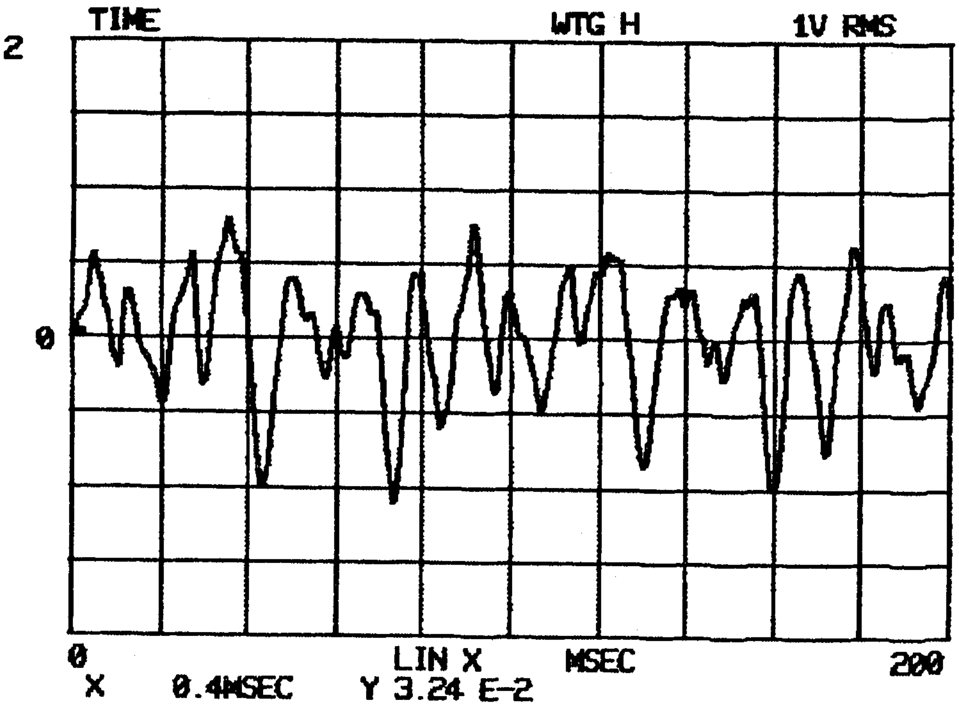


Figure 9. Waveform of Vibroseis in 200 msec duration.

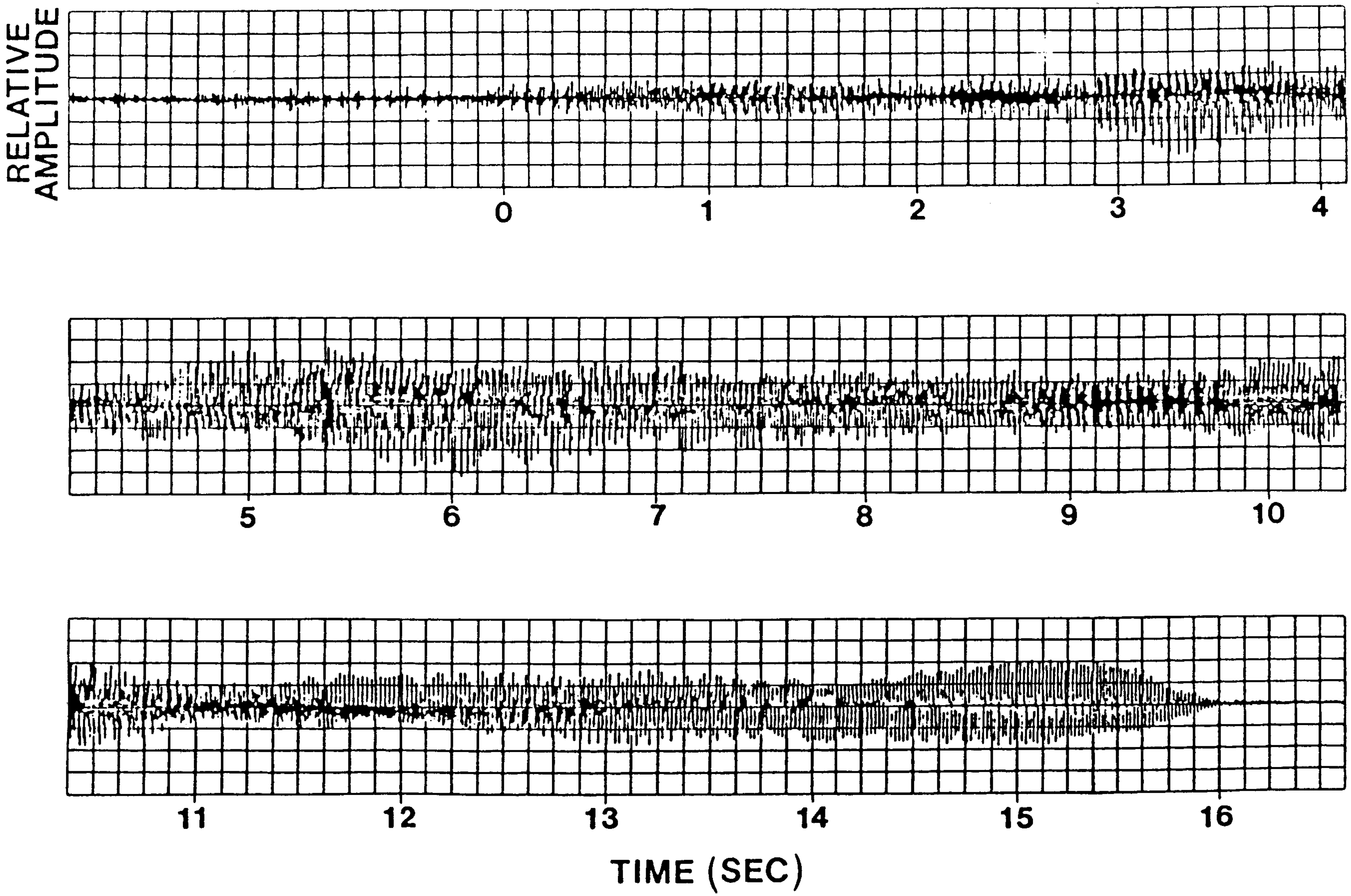


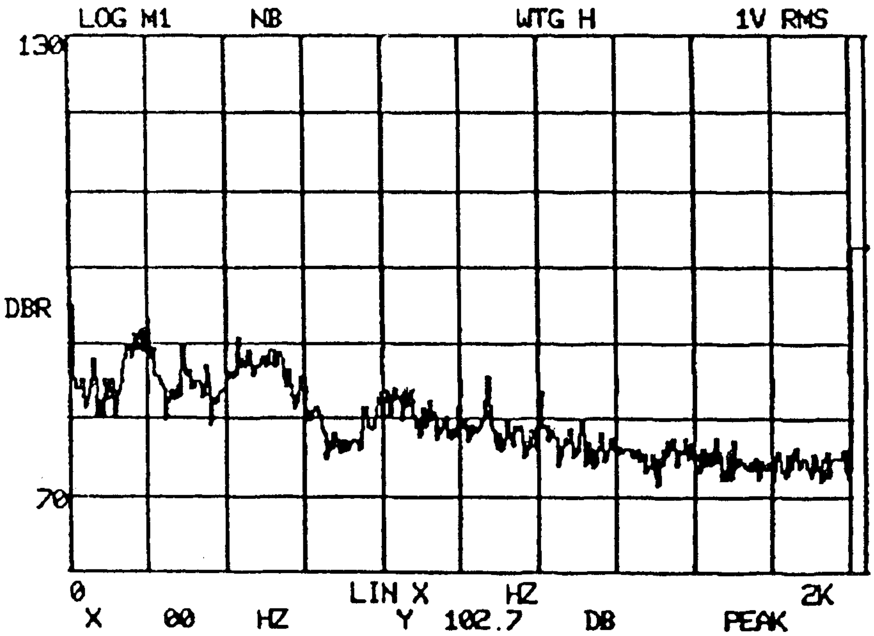
Figure 10. Continuous waveform of Vibroseis over the duration of the signal.

band). This was 41 dB above background noise consisting of elements of the convoy moving on the ice (Fig. 11), and at least 85 dB above overall ambient noise level as measured out to 10 kHz.

(3) As the vibrators moved away from our receiver, acoustic beamforming effects became relatively less (propagation loss being equal), because the hydrophone was increasingly in an end-fire position. It is important to note that background noise in this area is increased from track and other vehicles in conjunction with other associated industrial noise, such as generators, aircraft, and snow plowing.

(4) Because of the hydrophone's orientation with respect to the convoy and the path taken by the frequently moving trucks, most data were obtained in the end-fire mode. Based upon beamforming calculations (e.g., Figs. 12, 13) and allowing for resultant differences in received level at equivalent ranges, it appears that maximum source level of Vibroseis, as measured from horizontal propagation in the location studied, exceeded 184 dB. The source level of the downward propagated sounds undoubtedly was much higher due to the focusing inherent in array phasing and the directivity of the moving surface. A more specific estimate will depend upon additional analysis that would profit from more data.

Based on certain assumptions, masking of seal communication or other behaviorally important acoustic signals may be expected when the signal-to-noise ratio is less than 0 dB. The maximum distance for audibility (MDA) of Vibroseis® sounds by seals will be primarily background noise limited. Based on the simplest possible model, the MDA in the vicinity of our operations theoretically would be 3000 km, based upon a maximum source level of 185 dB, a propagation loss in dB of 19.3 log R(m), and an overall ambient level of 60 dB. However, we emphasize that this value should not be taken out



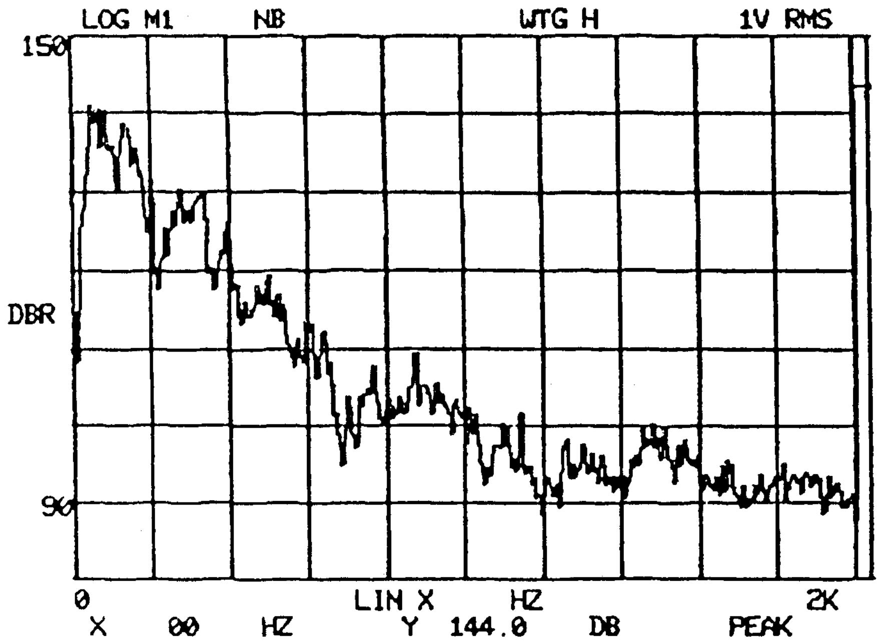


Figure 11. Spectrographs of noise from the Vibroseis convoy moving over the ice 400 m away (102.7 dB, peak level), above, and from the operating Vibroseis recorded 328 m away (144 dB, peak level), below. The latter shows maximum spectrum levels (peak) over the entire 16-sec sweep (Station 8).

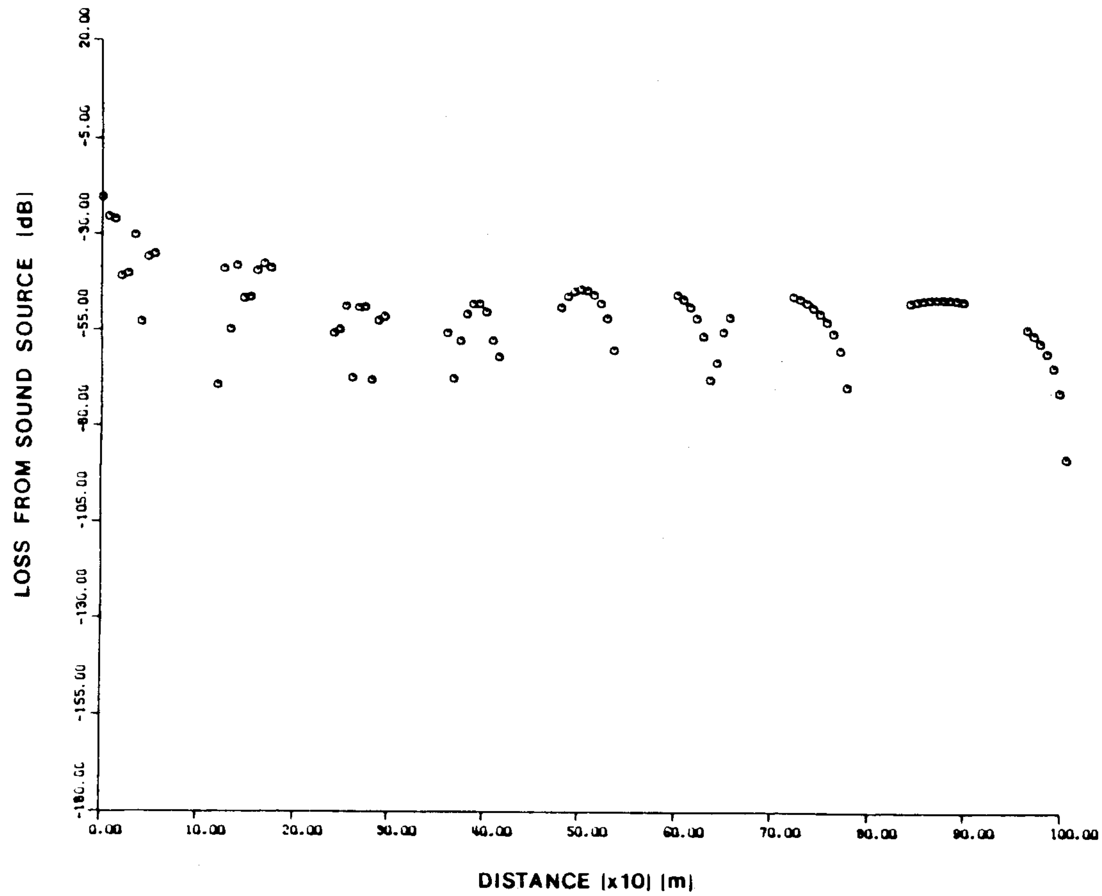


Figure 12. A simulation of the Vibroseis beamforming superimposed on a 20 log R spreading loss for a 70-Hz sinuosid beginning with near-field broadside aspect ("0" distance) out to 1000 m as the convoy moved to an almost end-fire position. Note lobed characteristics of the transmit beam superimposed on the assumed propagation loss. Points are computed only for those positions at which the convoy transmitted a pulse.

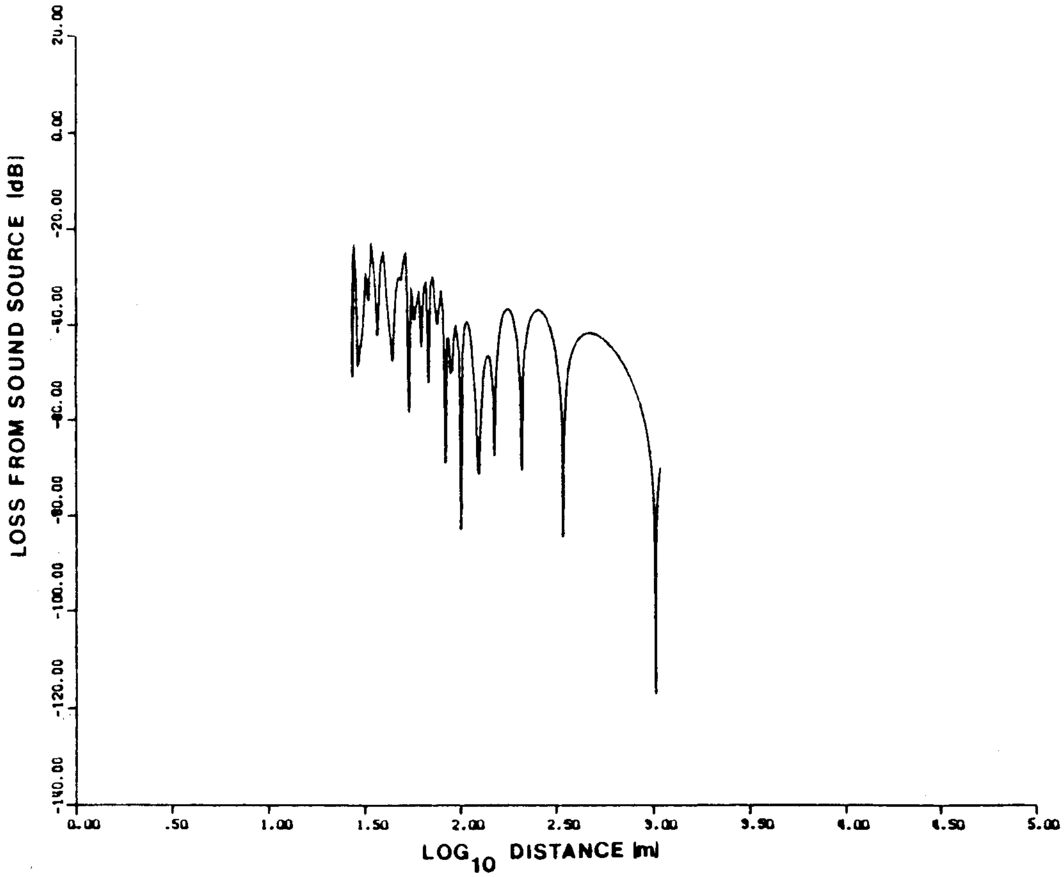


Figure 13. This plot combines the beamforming inherent in driving a 4-element phased array and a 20 log R spreading loss to simulate the sound intensity at 10-Hz. Both "look" angle and range from the source are varied, as in the actual measurement, beginning with near-field broadside aspect and moving the source out to 1,000 m when the convoy was near an end-fire position. Note the lobed characteristics of the beamforming process. The uneven spacing at close ranges is characteristic of the complex pattern of the near field of the Vibroseis array in the horizontal plane.

of context or misconstrued. It is mentioned only to stress the relatively high potential of masking by noise such as that from Vibroseis®

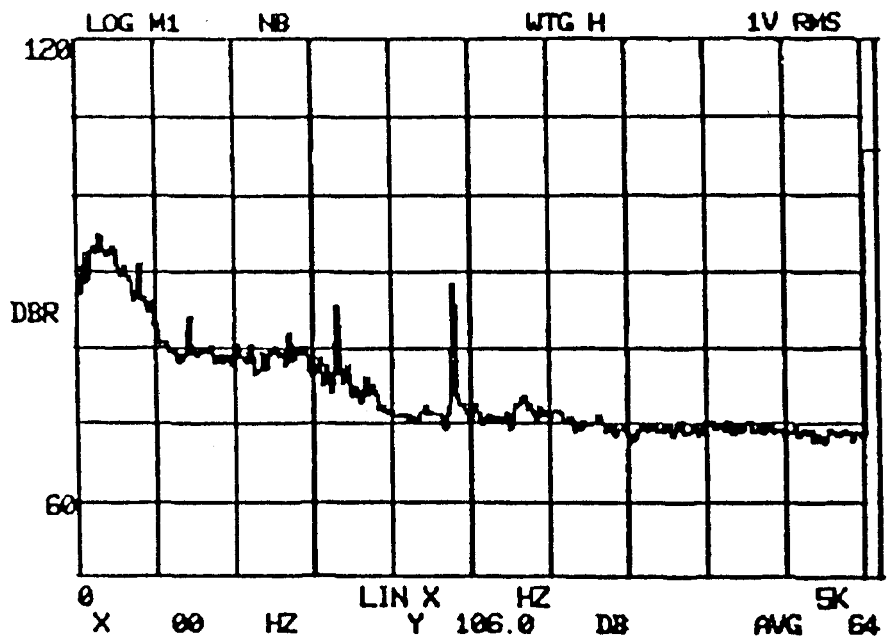
In reality, MDA will be much less than 3000 km due to several factors primarily as a result of the relative depth and position of the receiver (as indicated by the enclosed contours of propagation loss, Fig. 5), critical hearing bands and ratios, characteristics of the masked signal, instantaneous spectrum of a Vibroseis® sweep at the time of potential masking, ambient noise characteristics, and attenuation losses. The seals' audiogram is not expected to be an important limiting factor considering Vibroseis® noise. Behavioral or other biological consequences of the seals' reception of Vibroseis® sounds are unknown, and they exceed the purview of the task.

3.4 Other Man-Made Noise

In addition to the spectra of the moving convoy (above) we measured the sound from our Bell 204 helicopter as it warmed up on the ice (e.g., see Fig. 14). Line spectra were outstanding and overall received levels were as high as 110 dB over an effective bandwidth of 2 kHz.

The peak of noise received from a Caterpillar tractor at a distance of 3.7 km was 66 dB at a frequency of 800 Hz (Fig. 15).

We also took the opportunity to record near SOHIO's Vanguard No. 2 drill rig on 12 Mar. This rig contained a drill motor (1500 HP) and 2 mud pumps (500 HP each). Power generation plants were operating. The bit was 3.57 km (11,700 ft) below the surface, and the recording platform was located 480 m from the rig. The ice was 1.5 m thick, under which there was only 1.2 m of water. Such conditions could be virtually described as a worse case for low-frequency waterborne sound; however, line spectra were noted that apparently originated at the drill site, i.e., high signal/noise ratio, not found in other study sites, close resemblance to sounds known to be from drill rigs (described by Malme and Miawski, 1979). Some of the lines were harmonically related, such as those based on the 10-Hz line seen in Fig. 16.



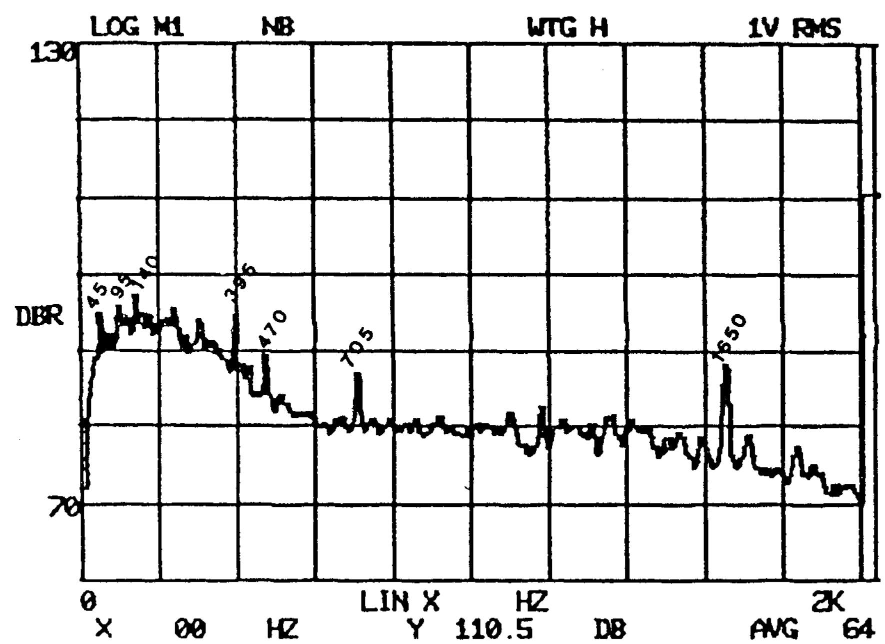


Figure 14. Spectrographs of noise from the helicopter as it warmed up on the ice adjacent to the hydrohole (Station 7).

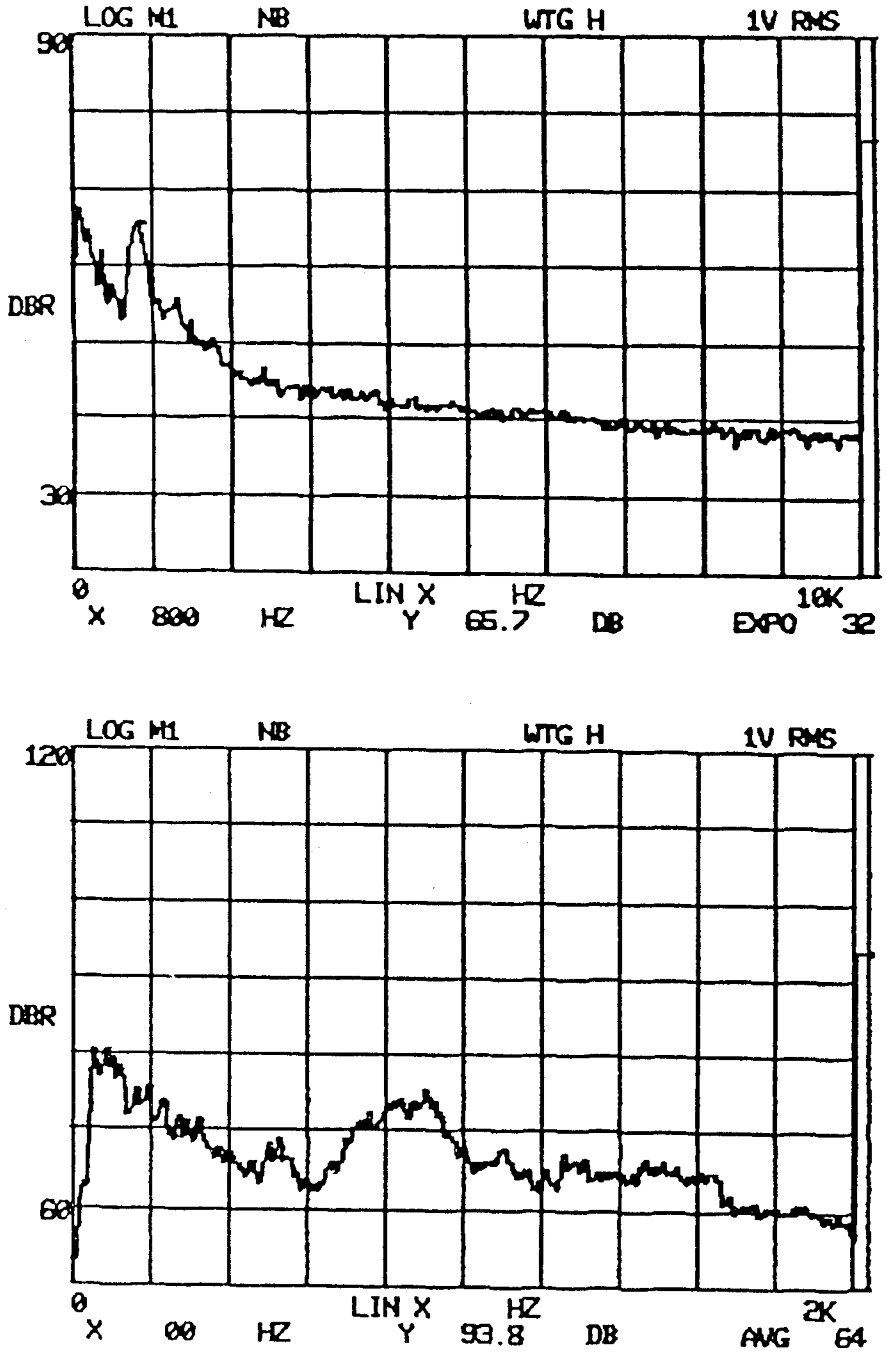


Figure 15. Spectrographs of noise from a Caterpillar tractor on the ice at a distance of 3.7 km, principal energy at 800 Hz (Rec. 15, Sta 5).

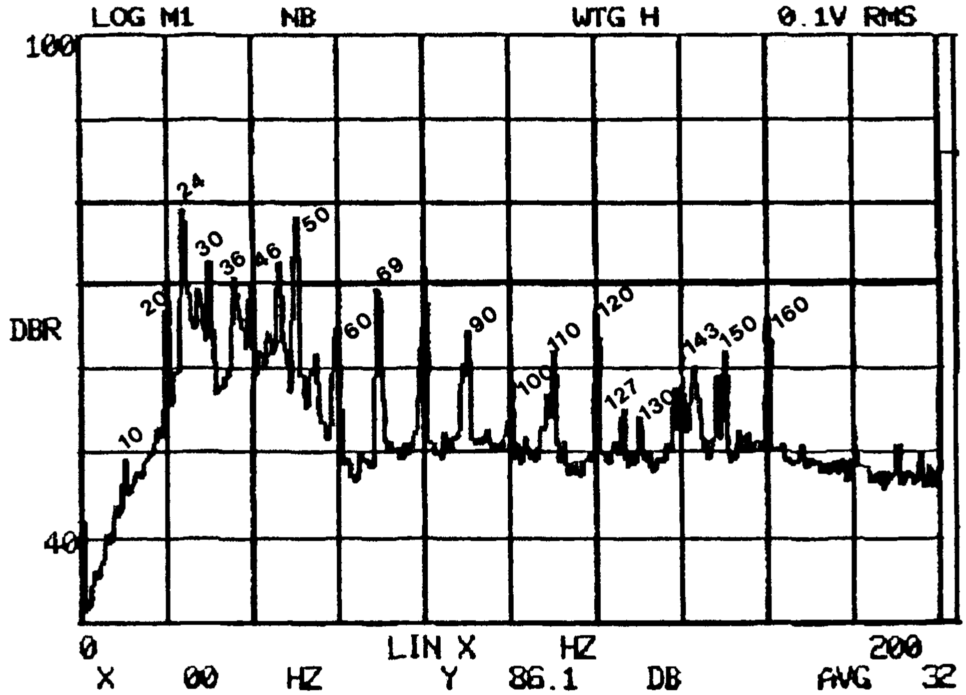


Figure 16. Spectrographs of noise from Vanguard II drill rig as recorded 480 m away when the bit was 3.57 km deep, note heavy line spectra (Station 9).

The overall received level was 86.1 dB with the dominating line spectra distributed in the first 200 Hz.

3.5 Animal Sounds

Sponsors chose the dates and position of our operation to assure that the main objective be met--recording and measuring Vibroseis®, before the cutoff date. Only a few ringed seal sounds were encountered, possibly because most of the animals were not yet actively courting. Growl, gargle, rubbing, bubbling, and scratching sounds believed to be from ringed seals were heard sporadically over the operating period (e.g., see Figs. 17-20).

Of special note were the last 2 categories where a specific behavior is indicated. According to Smith and Stirling (1975) ringed seals partially exhale just before surfacing. The occurrence of these sounds (Fig. 18) near our base camp would indicate that lairs and/or breathing holes were in this region and that they were being used. Smith and Stirling also reported that ringed seals actively scratch the ice to keep holes open and to prepare and maintain dens (Fig. 20). Stirling (1973) describes low-frequency barks, high-frequency yelps and yowls, low and high frequency growls, and a short descending chirp from ringed seals. It was interesting to learn that Stirling was unable to identify sounds that were peculiar to the breeding season.

An Arctic fox was responsible for the scratching sounds shown in Fig. 21. Its sounds were distinctly different from the scratching sounds believed to be from seals, which consisted of a rhythmically occurring series sometimes accompanied by growls or other seal-like sounds. The hydroholes and cables were attractive to the fox. One scratching episode ended in chewing sounds that abruptly terminated with high-frequency NAVAID radio signals--the result of the fox having chewed into hydrophone cable "C" and destroying the shield.

3.6 Ambient Noise

For the purpose of this work, we define ambient noise as background

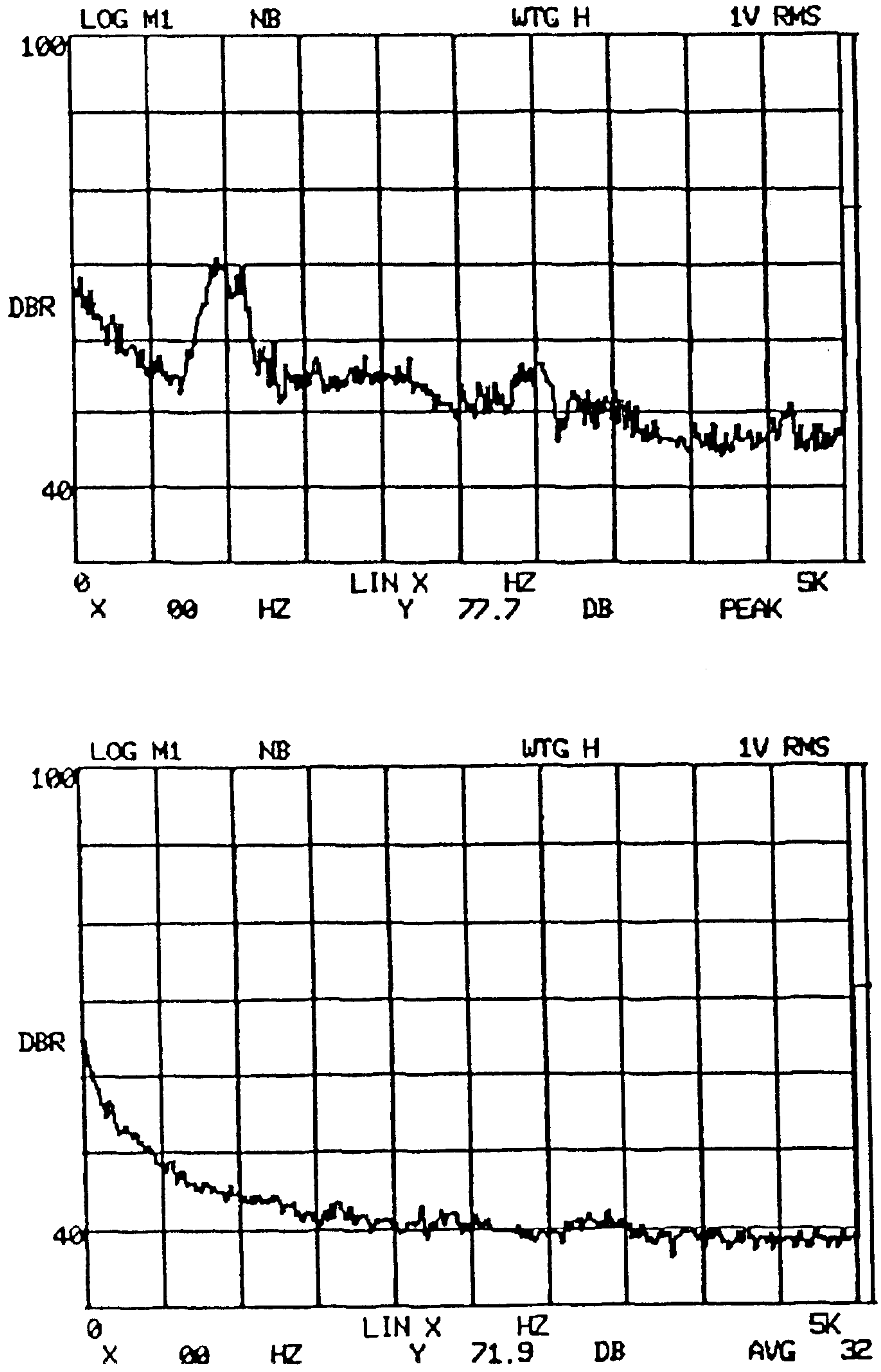


Figure 17. Spectrograph of gargle sound believed to be from a ringed seal (above) compared to preceding ambient noise (below), Station 1.

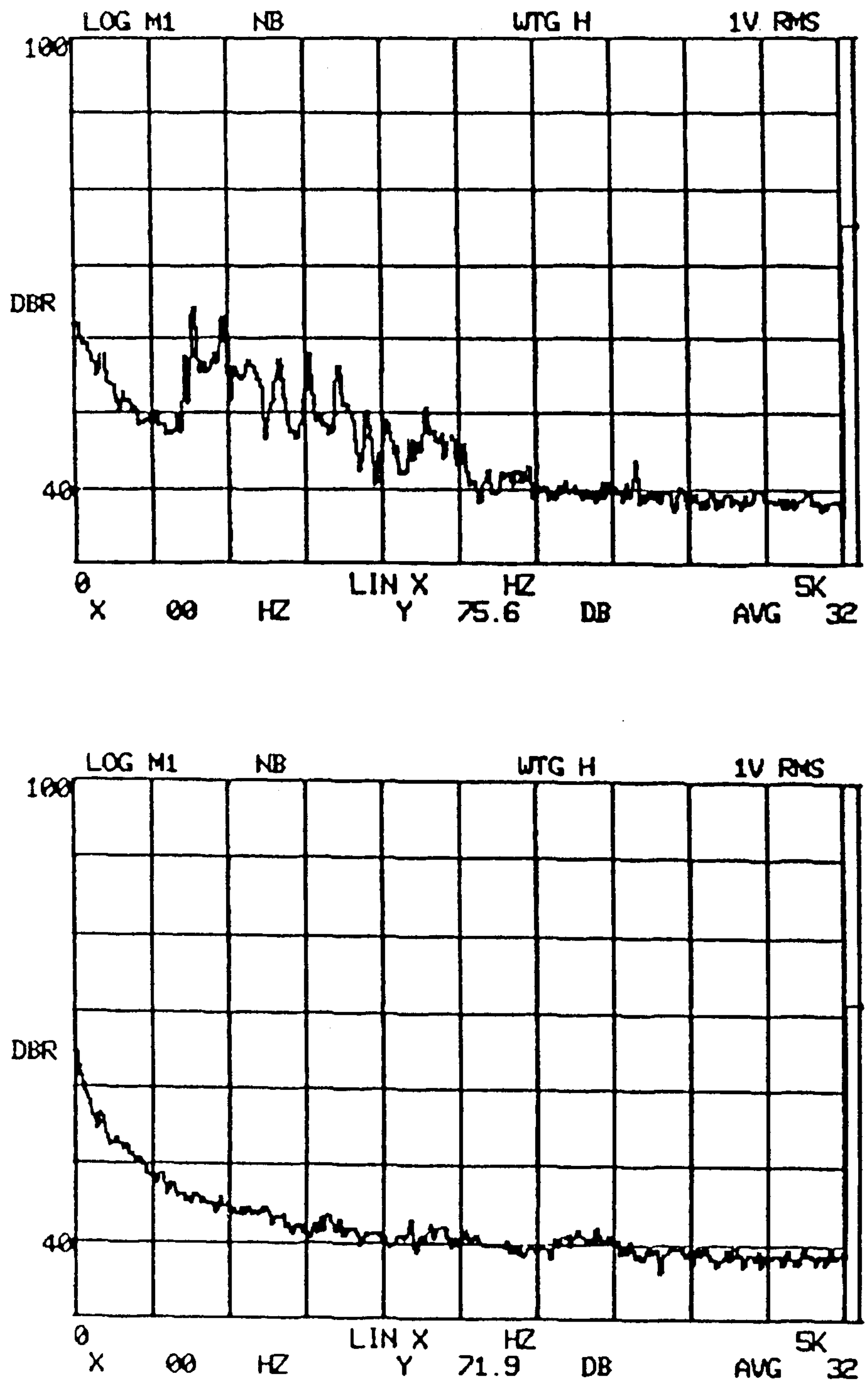
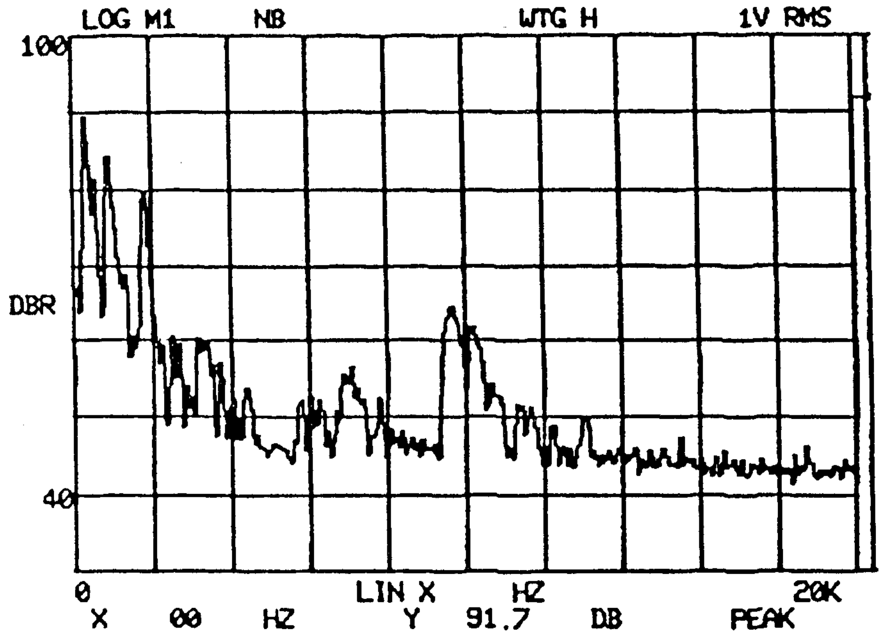


Figure 18. Spectrograph of rubbing sound believed to be from a ringed seal (above) compared with preceding ambient noise (below), Station 1.



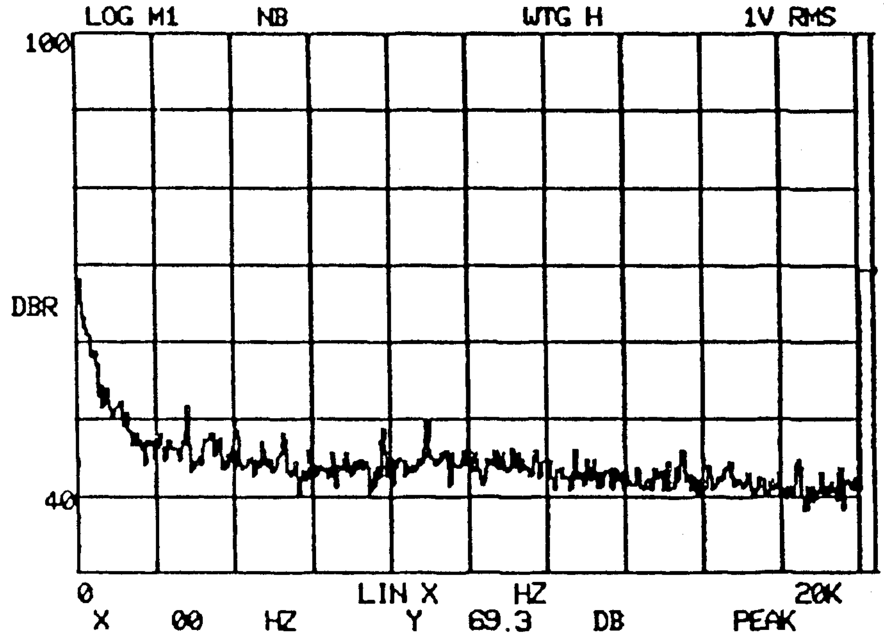
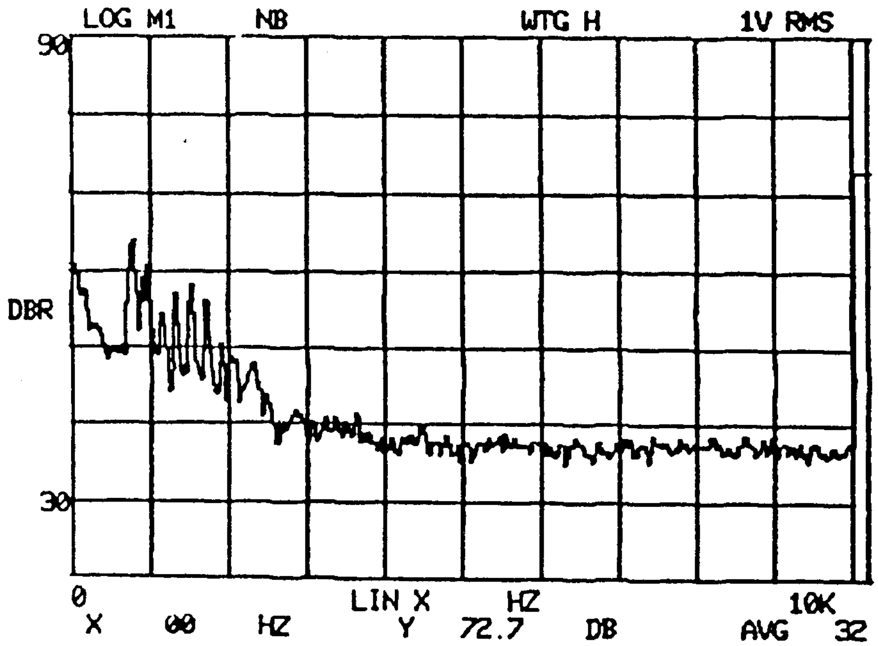


Figure 19. Spectrograph of bubbling sound believed to be from a ringed seal (above) compared to preceding ambient noise (below), Station 1.



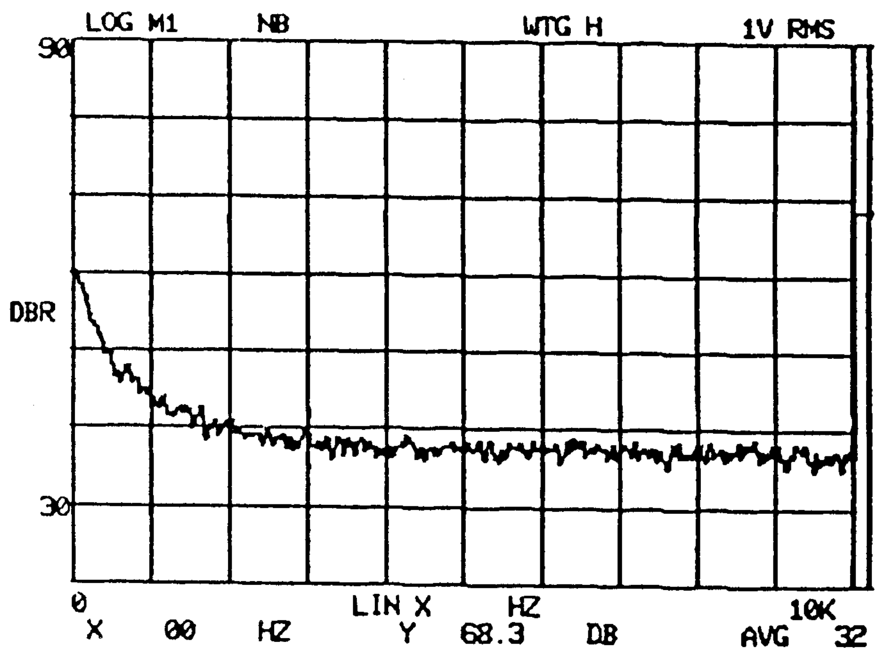
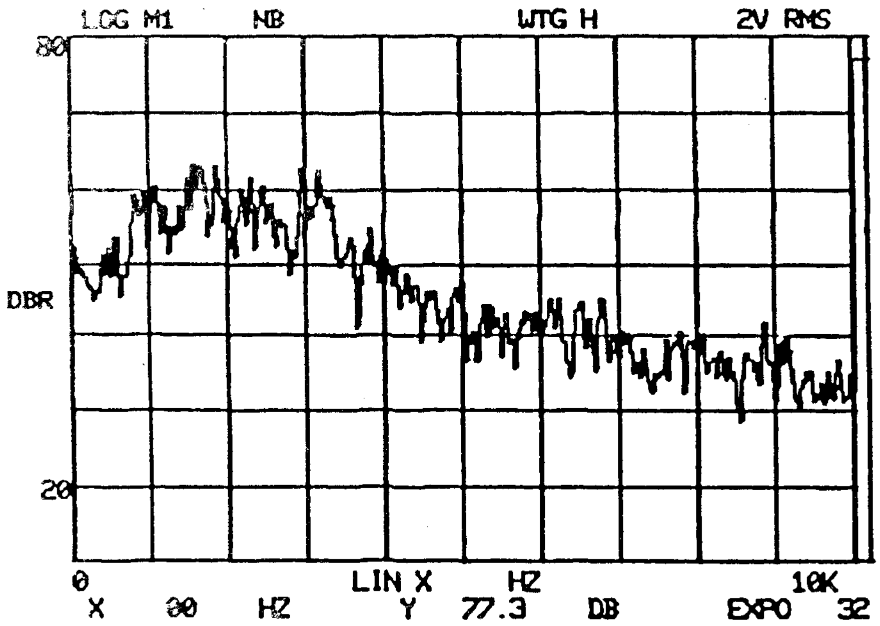


Figure 20. Spectrograph of a scratching sound believed to be from a ringed seal working on its breathing hole or lair (above), compared with preceding ambient noise (below), Station 1.



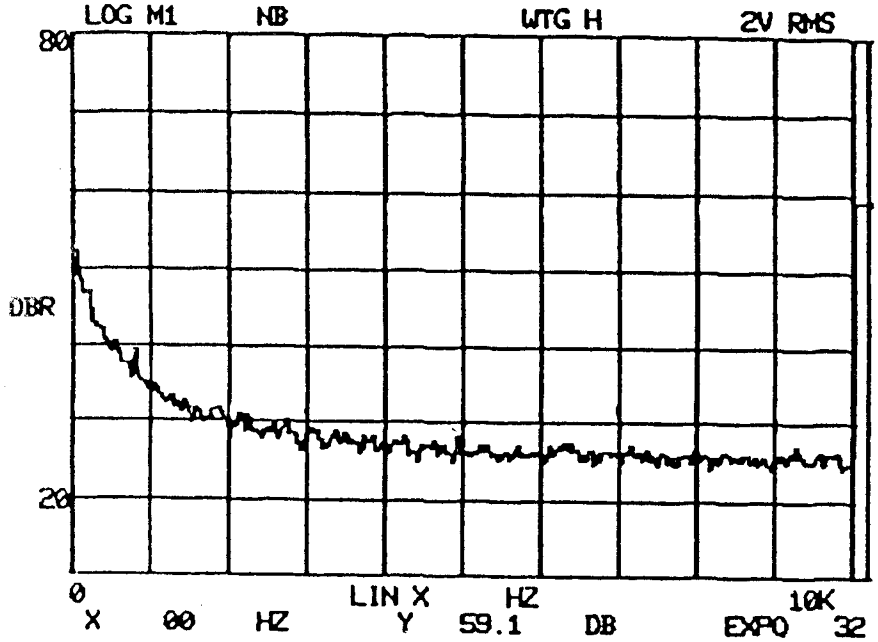


Figure 21. Spectrograph of sounds from a fox scratching the frozen snow near a hydrohole (above) and the preceding ambient noise (below), Station 1.

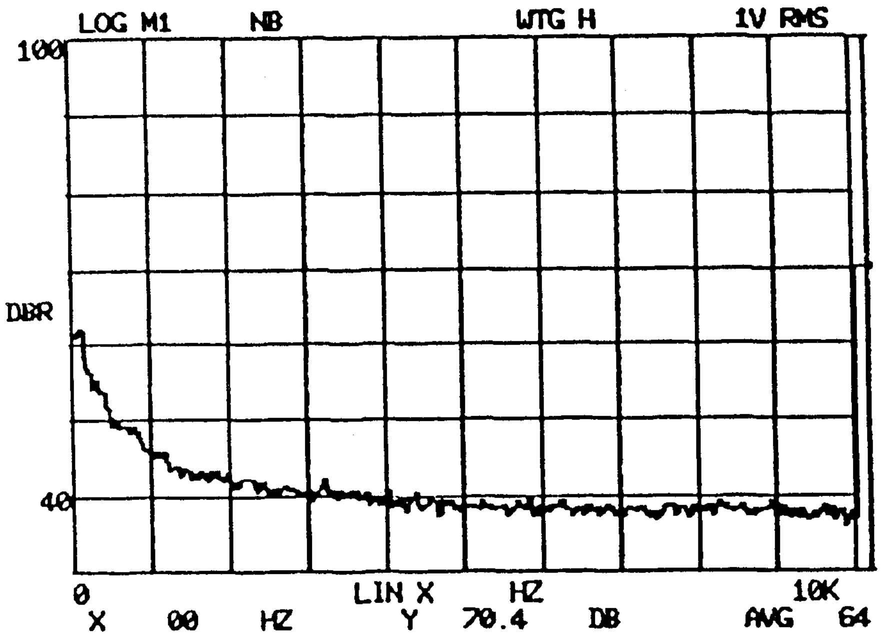
underwater noise that does not contain an obvious large contribution of discrete sounds from animals or man-made sources. In addition to the ambient spectra already presented in conjunction with man-made or animal sounds, spectra from Stations 1, 4, and 5 show rather uniform levels out to 10 kHz with the normal high contribution of low-frequency energy (Figs. 22-24). From 1 to 10 kHz, slopes varied between -3 and -10 dB. An average of 5 overall ambient noise levels from different locations was 63.4 dB in a range of 50 to 66.8 dB (1 - 10 kHz) during these winter conditions.

As explained in previous reports ambient noise levels contain the effect of distant man-made and animal sounds, but it is not possible to distinguish their effects when non-discrete. Although the ranges of values in the present study were less than those experienced during the preceding fall, partially open-water conditions (Cummings et al., 1981) the means were comparable. If anything, slightly higher average levels were encountered during the present study. There was no attempt to obtain sufficient data in either case to account for or suitably describe the large degree of variability of ambient noise data.

3.7 Sound Localization

Numerous test sounds consisting of impacts on the ice from a steel rod, ball drops onto a steel plate frozen into the ice, and metallic impulses in the water were used to test the feasibility of a horizontal array for sound localization. Equations were written that utilized knowns consisting of X, Y coordinates of hydrophone locations, first and second time delays in msec, and a measured sound speed of 1437.5 m/sec. The use of first-arrival times generally precluded the multipath problem, and a single horizontal plane was assumed for the source and receiver. The computer program printout occupies 3 pages, and, once data are entered, processing time is in the order of 1 sec. A few examples of localizations are given in Fig. 25.

A second technique of using absolute received levels on only 2 hydrophones and the arrival-time difference was unsatisfactory because of the



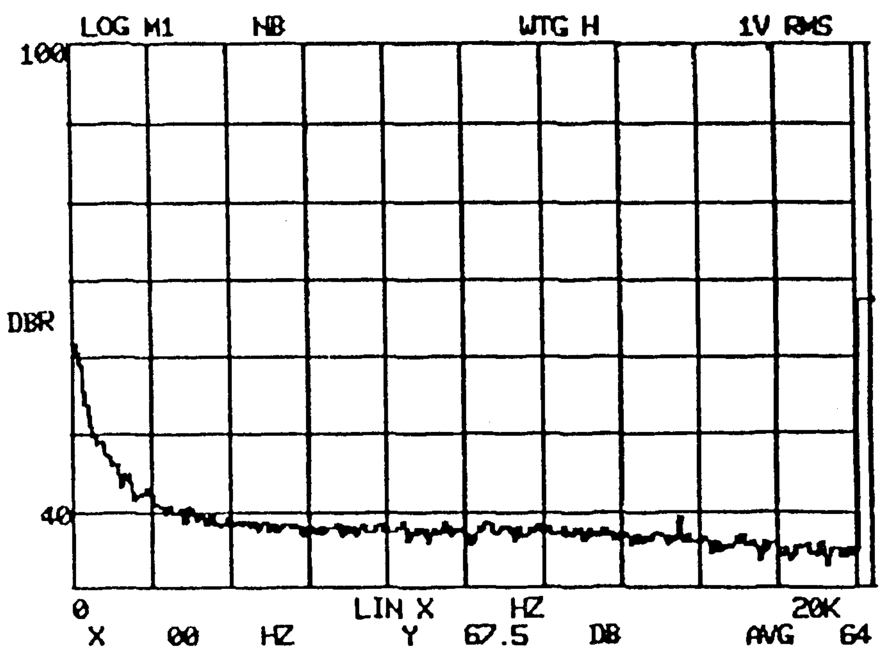
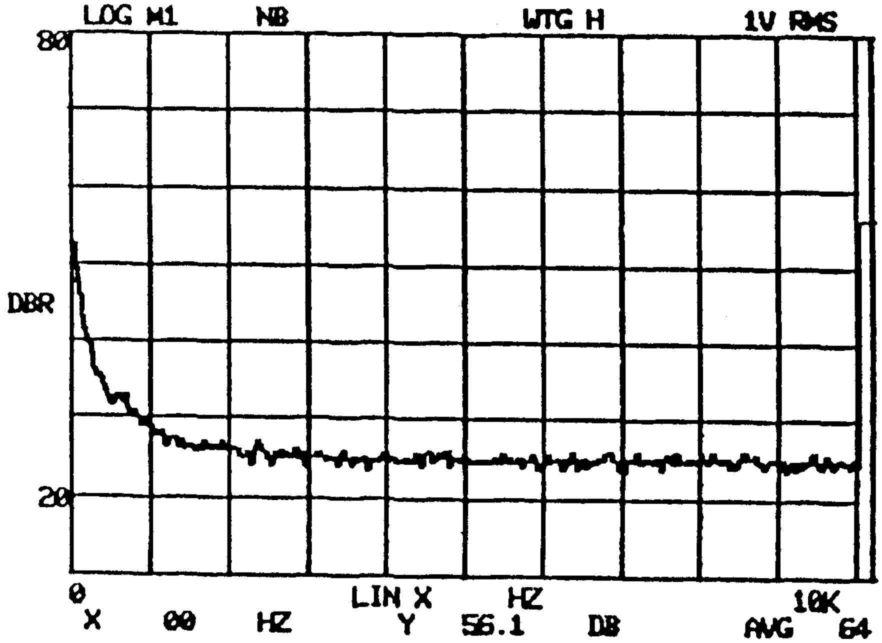
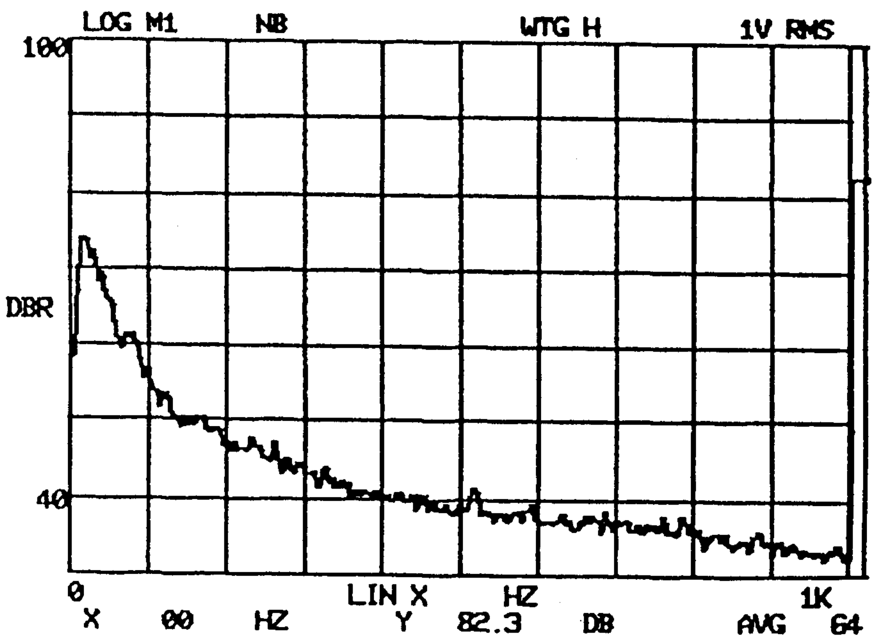
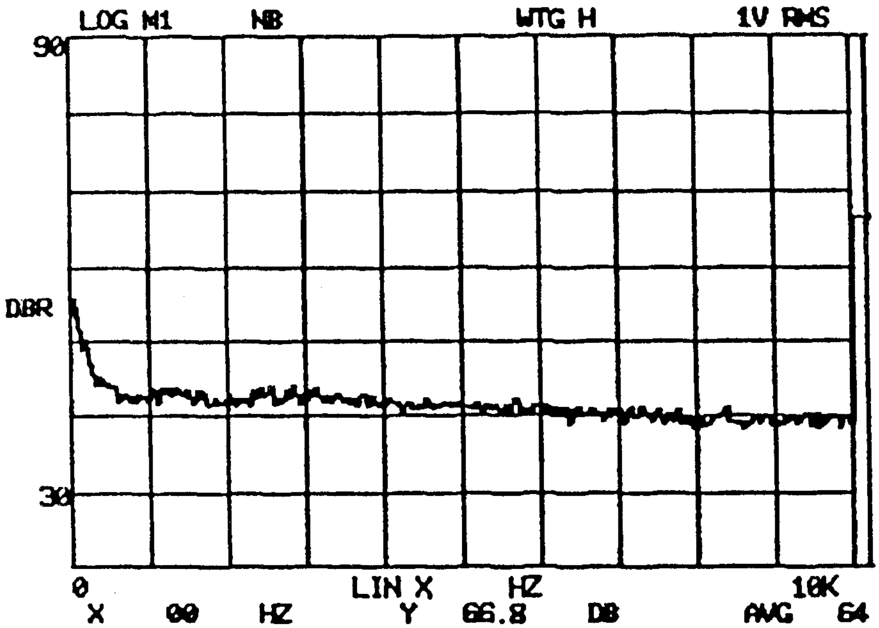


Figure 22. Spectrographs of ambient noise recorded in the presence of variable wind velocity (Station 1.).





Figured 23. Spectrographs of ambient noise from Station 4 (wind 2.1 m/sec) located about 68 km north of the Colville River delta (Rec. 4, Sta. 4).



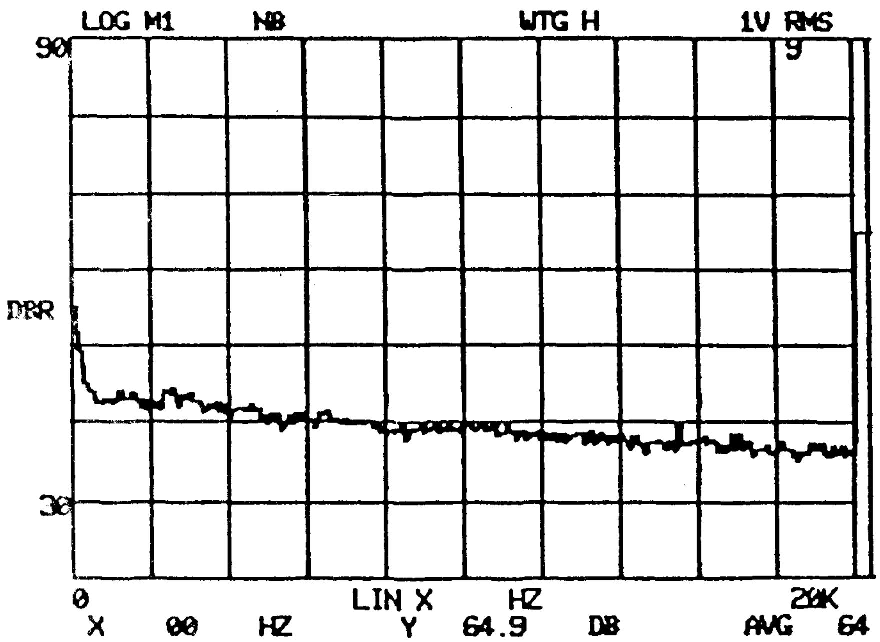


Figure 24. Spectrographs of ambient noise (wind, 6.4 m/sec) from an area about 25 km north of Antigaru Point off Harrison Bay (Station 5).

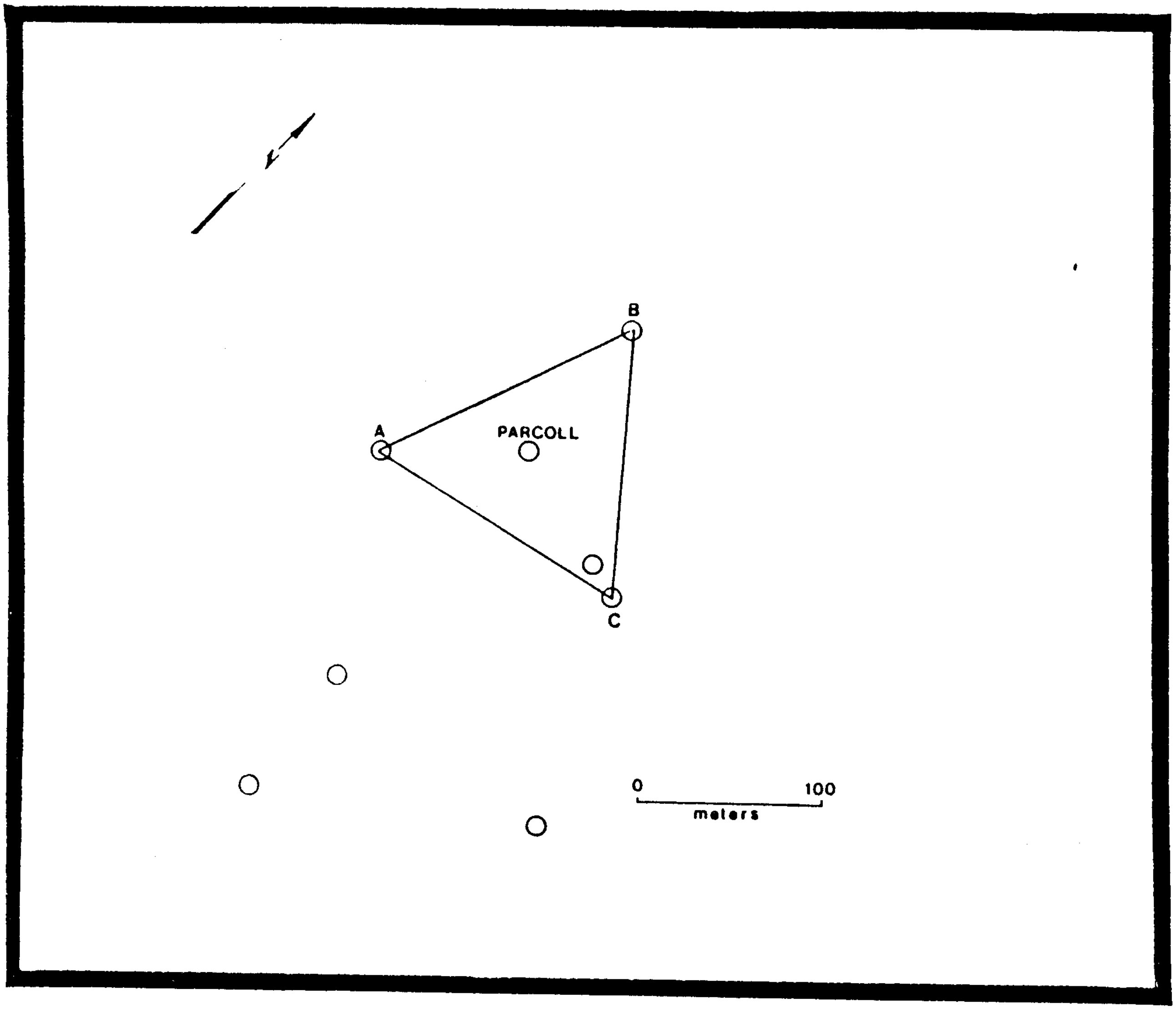


Figure 25. Location of the 3-hydrophone array (A, B, C) in relation to the base camp which also contained a hydrohole. The circles represent examples of test sounds located by triangulation.

complexity and variability of perturbations in propagation losses in the shallow water (e.g., see Fig. 5).

The data obtained with the hydrophone array at the base camp can be used to make an estimate of water/ice propagation losses, under those conditions; however, this was beyond the scope of the present task.

4.0 RECOMMENDATIONS

4.1 Seismic Profiling

Although the present work concentrated on measurements of winter seismic profiling noise, with a result of considerably more data than had been available, additional data should be taken from several distances along the beam aspect. The power of the horizontally propagated sound and the effective frequency bandwidth would indicate a strong potential of impact upon Arctic marine mammals, especially the ringed seal.

Research should be undertaken to predict the transfer functions and expected acoustical ramifications in the underwater and lair environments of this species. Vibration and acoustic noise should be measured and characterized using appropriate instrumentation in and below lairs under controlled sound source conditions. Infrasound should receive special consideration. This would provide a means for predicting sound and vibration spectra expected from powerful man-made sources such as Vibroseis® and the planned ice-breaking LNG carriers (Peterson, ed., 1981).

Such quantitative data are necessary for making informed management decisions. The data, in turn, would lead to a more intelligent assessment of possible effects, such as masking of communication signals of the animals. A considerable advantage from the standpoint of research is present in the case of the ringed seal, because much is known about its auditory capacity (Terhune and Ronald, 1975a, b, 1976), and only a modest effort is required to augment the already existing data on sound production by this species, especially during the courtship season (Stirling, 1973). Methods should be developed for telemetering neuro-physiological responses.

4.2 Sound Propagation

We do not recommend extrapolations of propagation losses based on deep-water, free-field data to shallow Arctic regions. This is especially true in the low-frequency region of the spectrum. Nonetheless, good data resulted from measurements taken at numerous distances from the source. The effective distances for sound detection were much greater than surmised from information available prior to this undertaking. Predicted "zones of influence" can and should be modeled for at least the ringed seal.

4.3 Animal Sounds

Signals such as scratching and bubbling that are known to be from seals, in addition to any peculiar calls during courtship season, could be used to obtain important behavioral data. Although more sound recording should be undertaken, preferably in areas of high concentrations of ringed seals during the height of breeding season, ringed seals may not be very much more loquacious in courtship (Stirling, 1973). Source levels of ringed seal sounds are needed and are very important in the prediction of masking and effective masking distances of man-made noise.

4.4 Ambient Noise

It is not possible to take an over-abundance of ambient noise data. First, this is "ground truth" and as such a very important parameter in any consideration of man-made noise. Secondly, it is important to obtain these data as soon as possible to minimize the contribution of man-made noise (as apart from naturally occurring noise sources) in ambient noise data. Normally, ambient noise in temperate and tropical waters which are frequented by ships and other man-made sources are so affected that spectra of natural noise, without contamination, are almost nonexistent. Thus, it is already impossible to separate the two in most other areas of the world.

4.5 Sound Localization

The 2-hydrophone, absolute received sound level method of localization (Cummings, 1968) proved to be inappropriate for shallow ice-covered areas. However, the method utilizing only the arrival times proved to be feasible for localizing frequent sources of sound over distances approximately 3 to 5 times the array dimension, depending upon conditions. Deployment and maintenance of a cable-connected system for regular use in sound localization is not recommended. Instead, expendable sonobuoys should be used to minimize equipment bulk, chances of damage, and overall effort.

Unmodified sonobuoys are not satisfactory for determining absolute levels of sound, but slightly modified off-the-shelf units would be ideal because our recommended method uses only arrival time differences and an estimation of sound speed. Methods that utilize absolute received levels are not recommended for the shallow Arctic regions. Techniques involving the measurement of phase must be studied further before a recommendation can be made on the practicality of this type of procedure. The ability to localize sounds opens up unlimited possibilities for undertaking bioacoustic and behavioral research.

Several unpublished reports and recent meetings have placed emphasis on sightings of marine mammal species in areas of underwater man-made noise as being indicative of "adaptation." Caution of such intrepretations is urged in the light of abundant data that show insidious or outward harm to noise-exposed humans who really had no choice in the matter (Kryter, 1970). The possibility exists that marine mammals in the presence of underwater man-made noise may be so affected. This condition may occur undetected for want of better diagnostic indicators. It is doubtful that behavioral methods presently in use can indicate communication masking, gradual loss of hearing, interruption of food finding, or long-term reduction of reproduction potential or population size. Stated in another way, the "price" marine mammals may have to pay for having to inhabit areas affected by man-made noise is unknown at this time.

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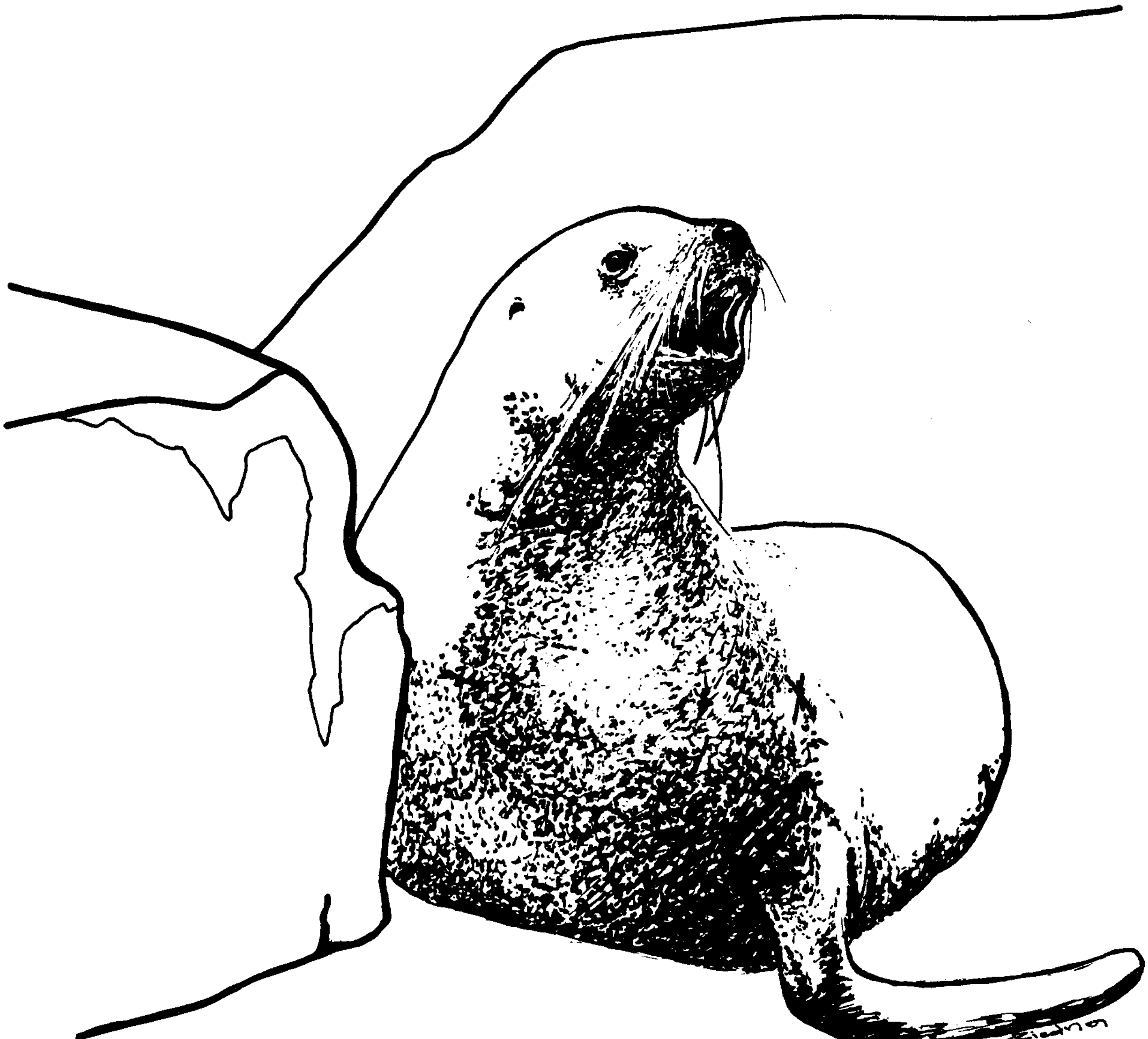
POPULATION ASSESSMENT, ECOLOGY, AND TROPHIC RELATIONSHIPS OF STELLER SEA LIONS IN THE GULF OF ALASKA



by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 243, Contract Number 03-5-022-69

18 April 1982

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INTRODUCTION

Steller sea lions (*Eumetopias jubatus* Schreber) are large, conspicuous pinnipeds 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 aspects 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.

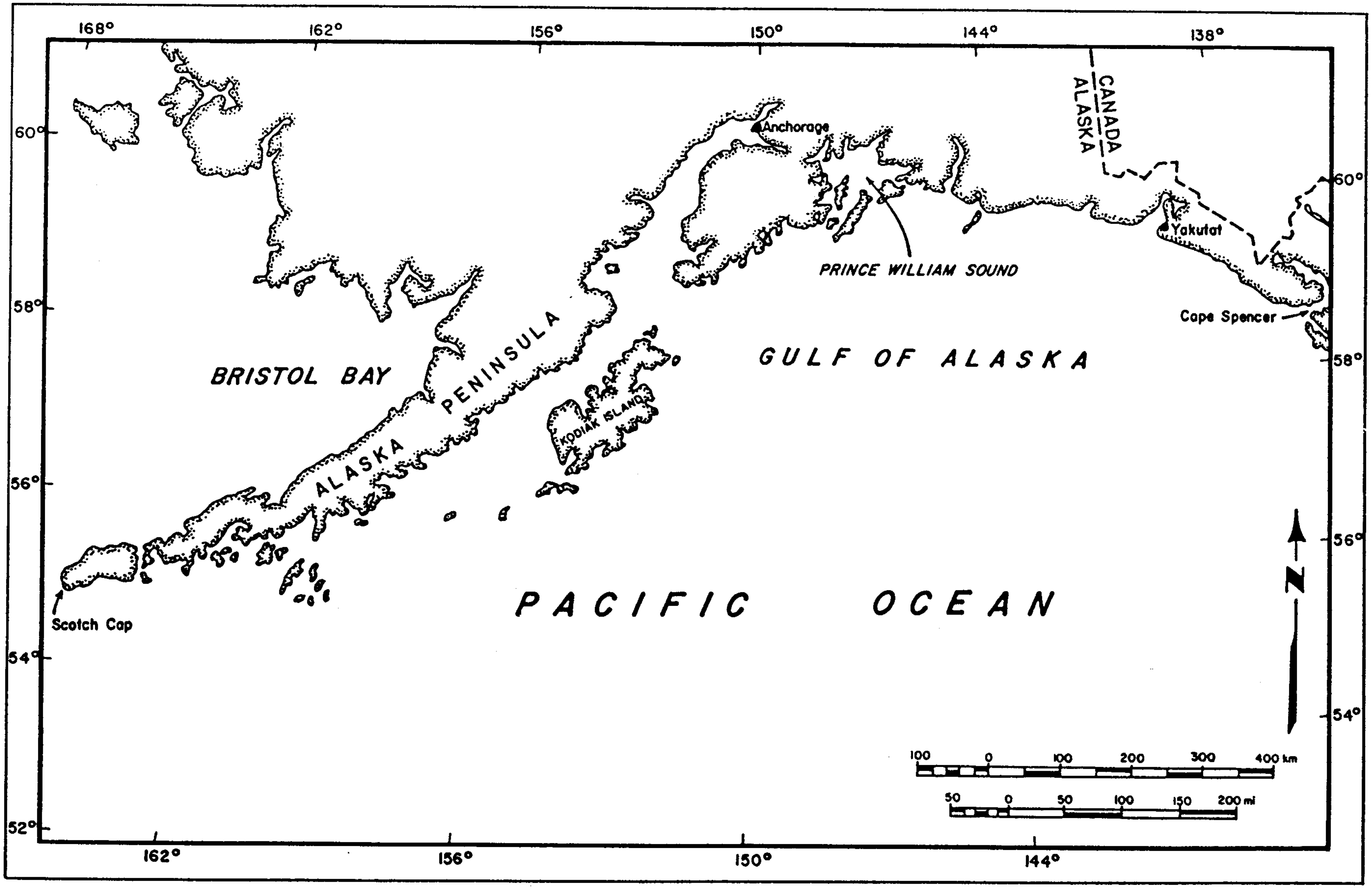

FIGURE I. GULF OF ALASKA STELLER SEA LION STUDY AREA.

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 ekta-chrome 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.

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.

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

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.

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
Cape Lazaref	54@37'00"N,	163@35'07"W

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.

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.

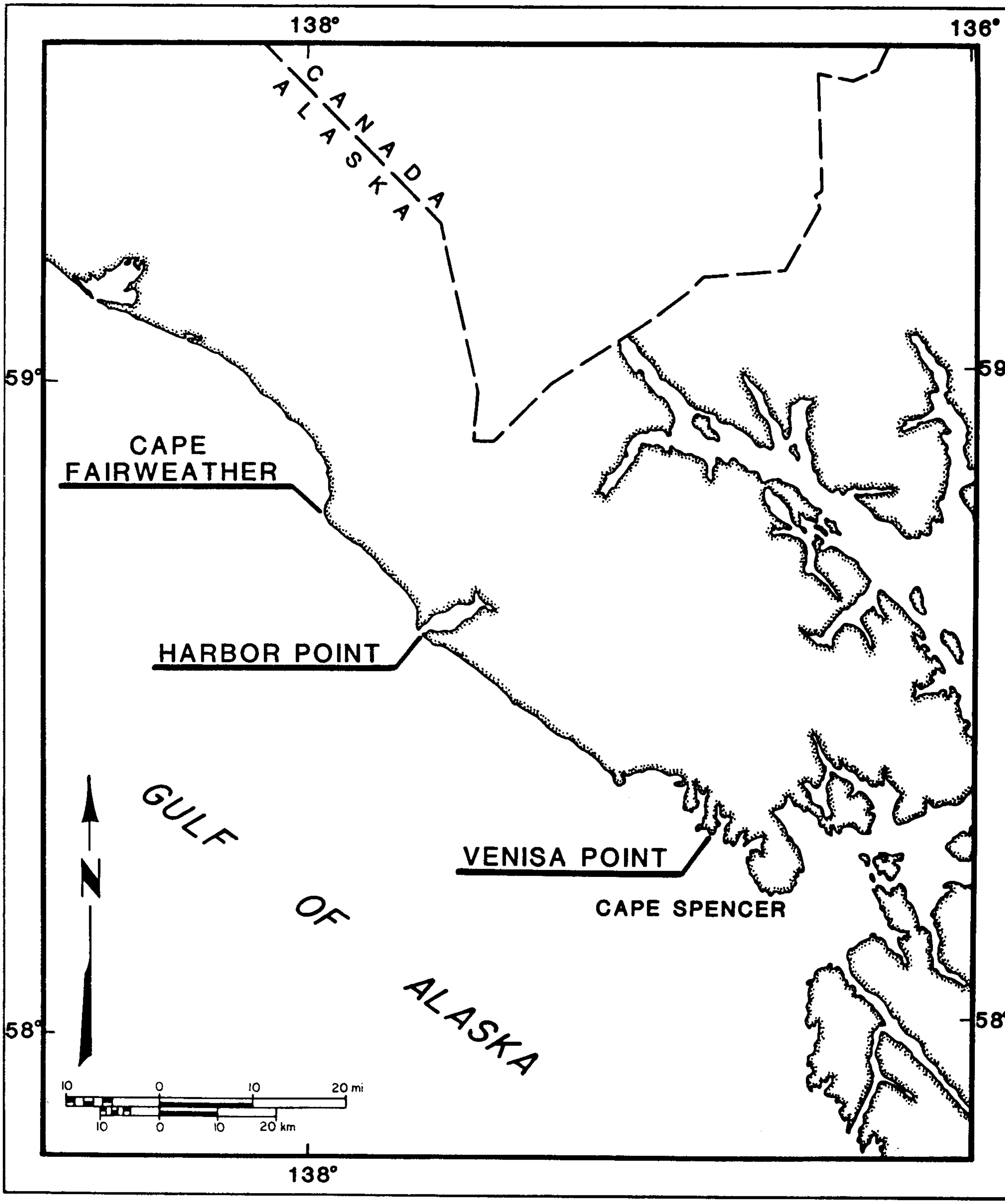

FIGURE 2. STELLER SEA LION HAULOUTS AND ROOKERIES FROM CAPE SPENCER TO CAPE FAIRWEATHER.

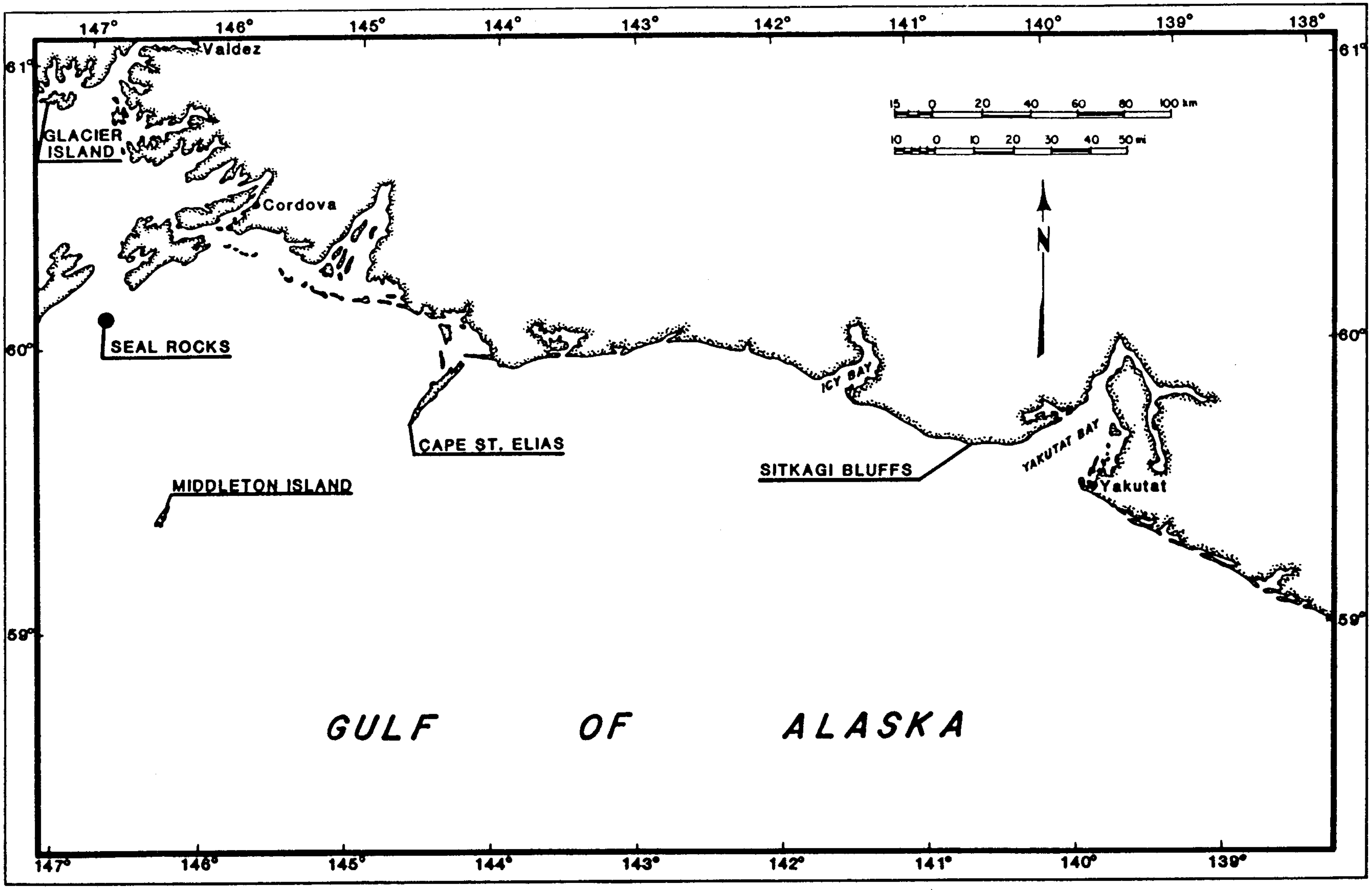

FIGURE 3. STELLER SEA LION HAULOUTS AND ROOKERIES FROM YAKUTAT BAY TO PRINCE WILLIAM SOUND. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

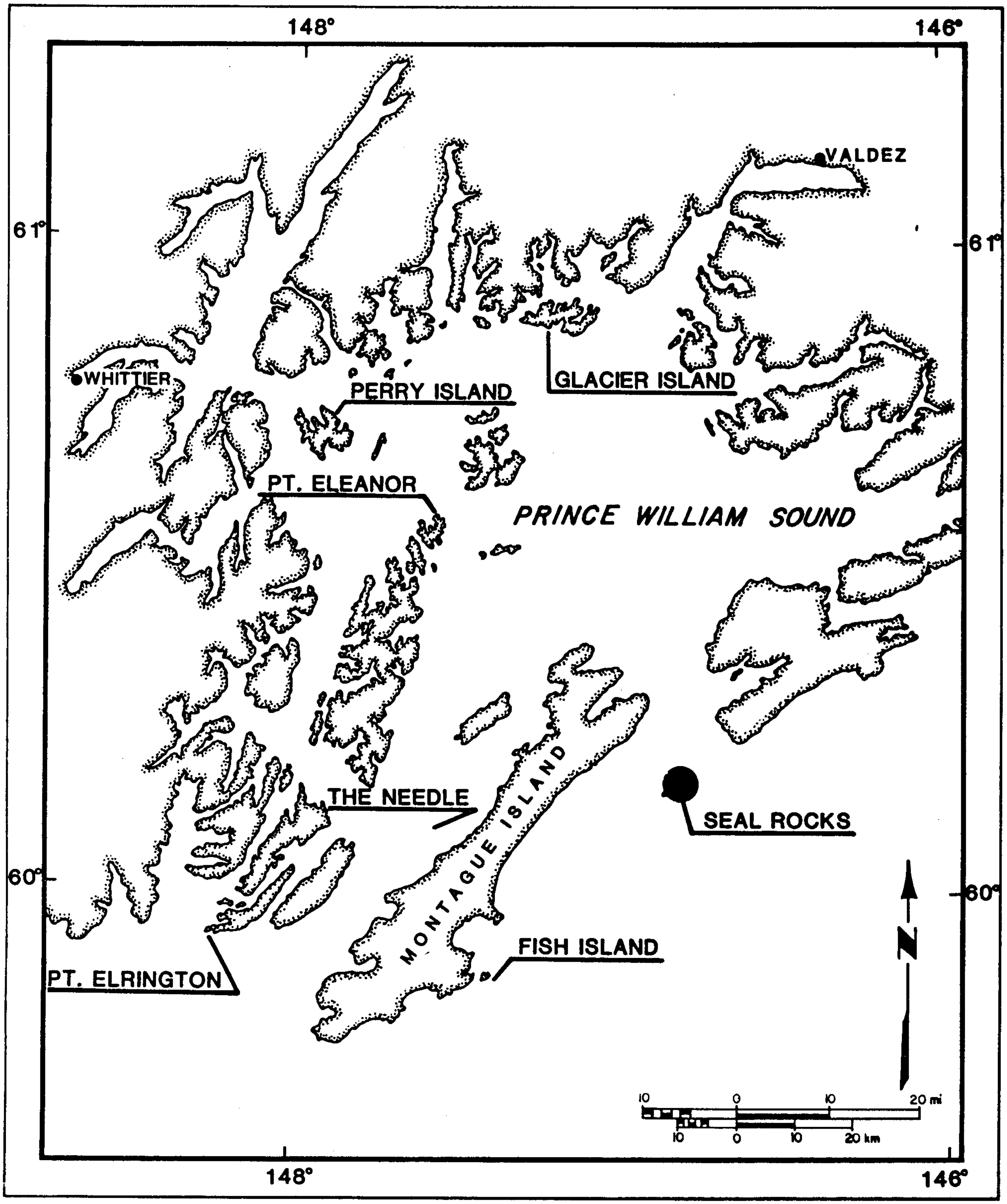

FIGURE 4. STELLER SEA LION HAULOUTS AND ROOKERIES IN PRINCE WILLIAM SOUND. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

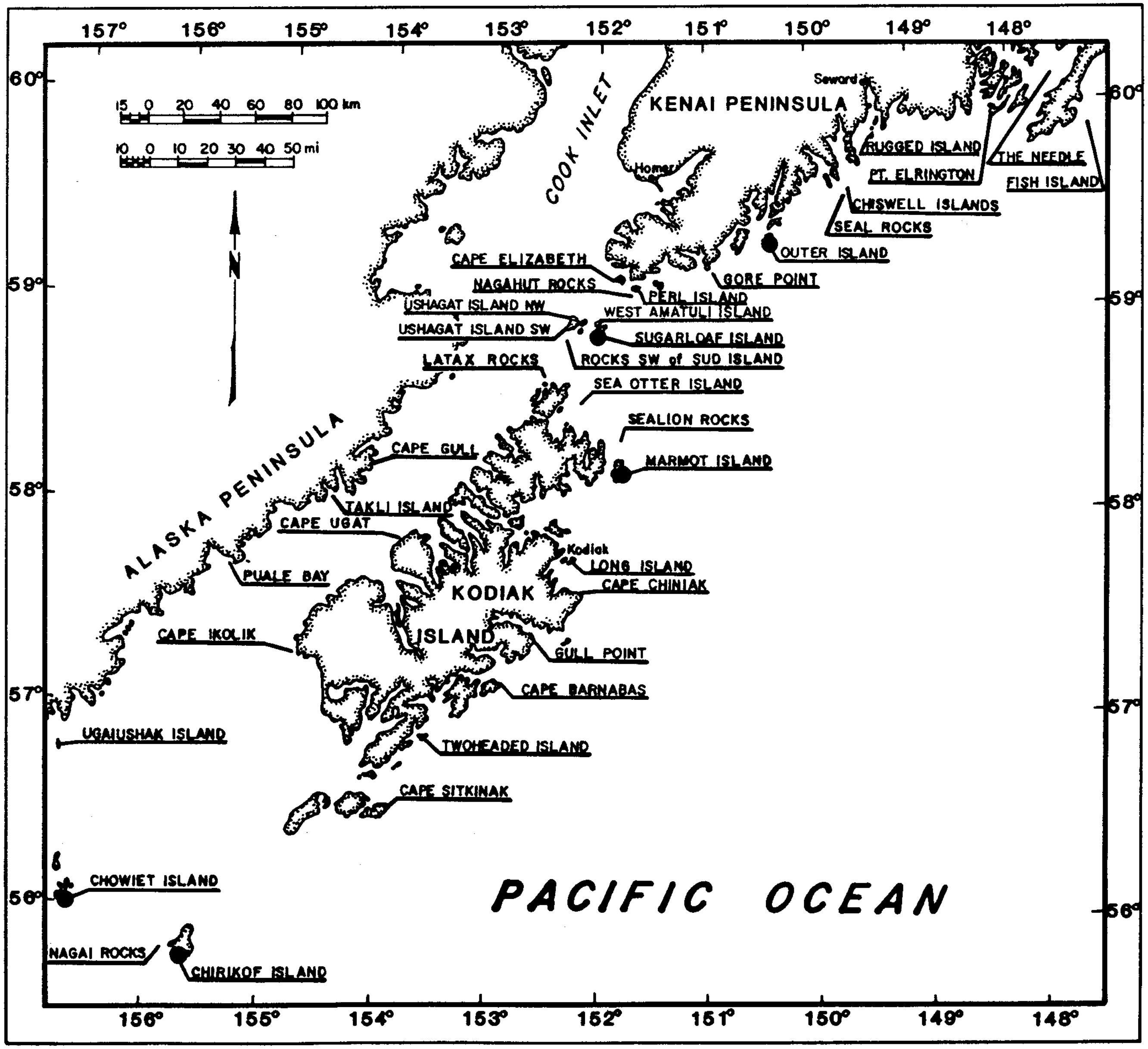

FIGURE 5. STELLER SEA LION HAULOUTS AND ROOKERIES FROM PRINCE WILLIAM SOUND TO CHIRIKOF ISLAND. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

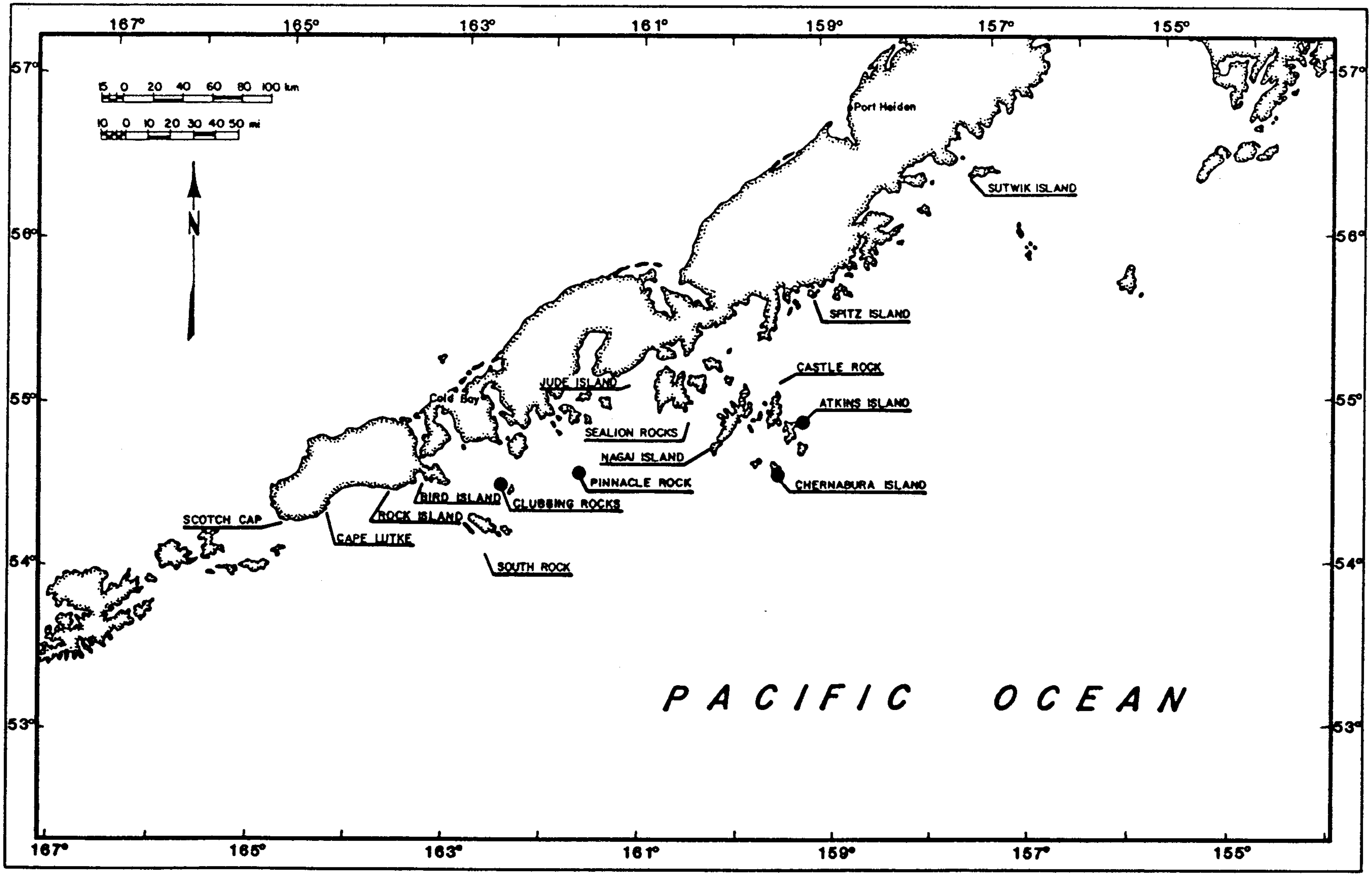

FIGURE 6. STELLER SEA LION HAULOUTS AND ROOKERIES FROM CHIRIKOF ISLAND TO SCOTCH CAP. BLACK DOT (●) DENOTES MAJOR PUPPING ROOKERY.

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, 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, 51 in March 1976, and 541 in June 1976. 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, 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, 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, 343 in June 1957 (Mathisen and Lopp 1963), and was reported to have 470 by Alaska Department of Fish and Game (1973). 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, 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 Peninsula, 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 and 250 pups in 1978. 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 (1973) 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

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

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 exclu-

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

Sugarloaf Island Date	Pup count	Marmot Island 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 Date	Pup count	Marmot Island Date	Pup count
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

ded completely from the rookery areas and most appeared to congregate on "bachelor" areas adjacent to the rookeries.

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.

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 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 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 con-

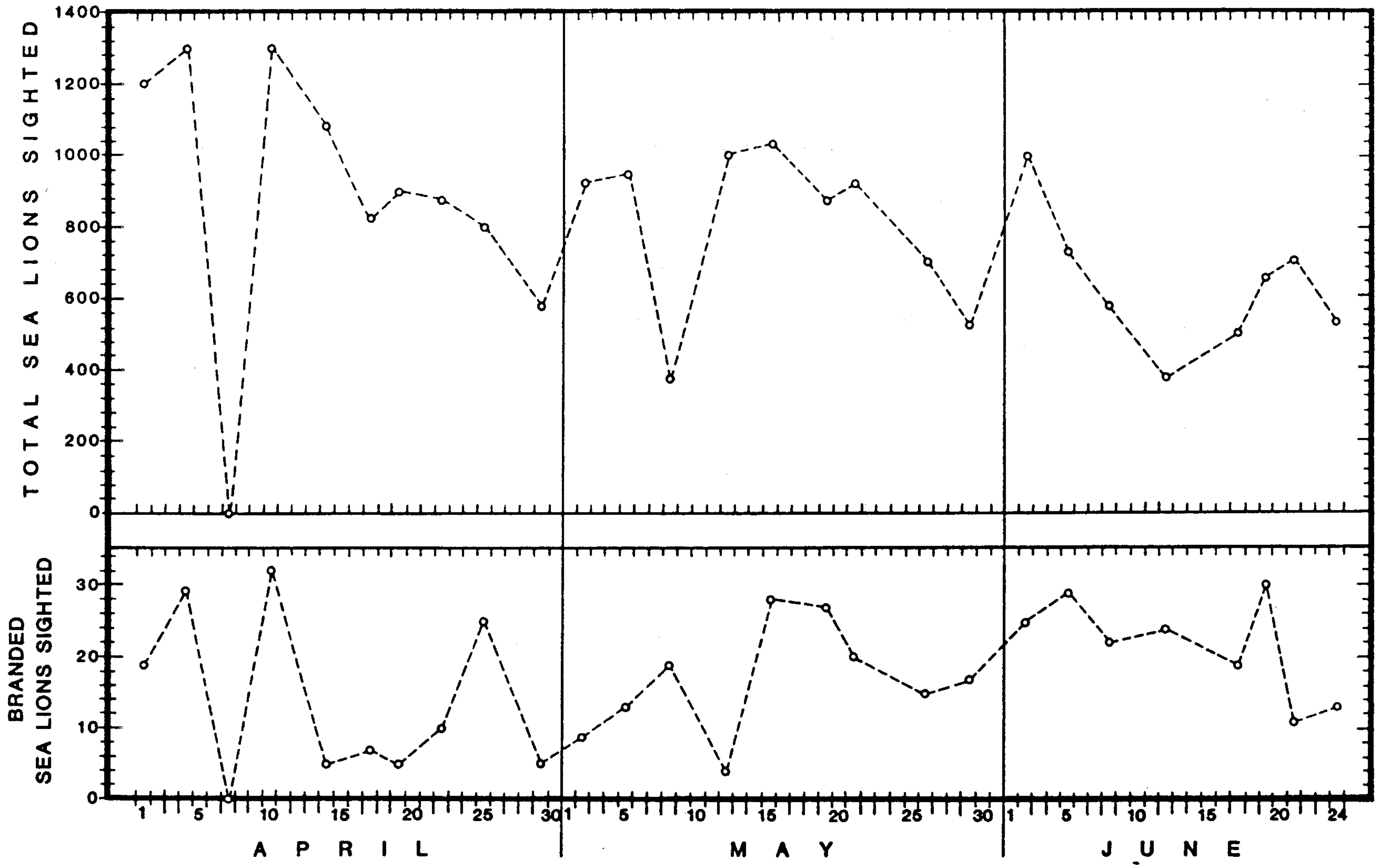

FIGURE 7. NUMBER OF BRANDED SEA LIONS SIGHTED AND TOTAL NUMBER PRESENT AT CAPE ST. ELIAS, KAYAK ISLAND, 1978.

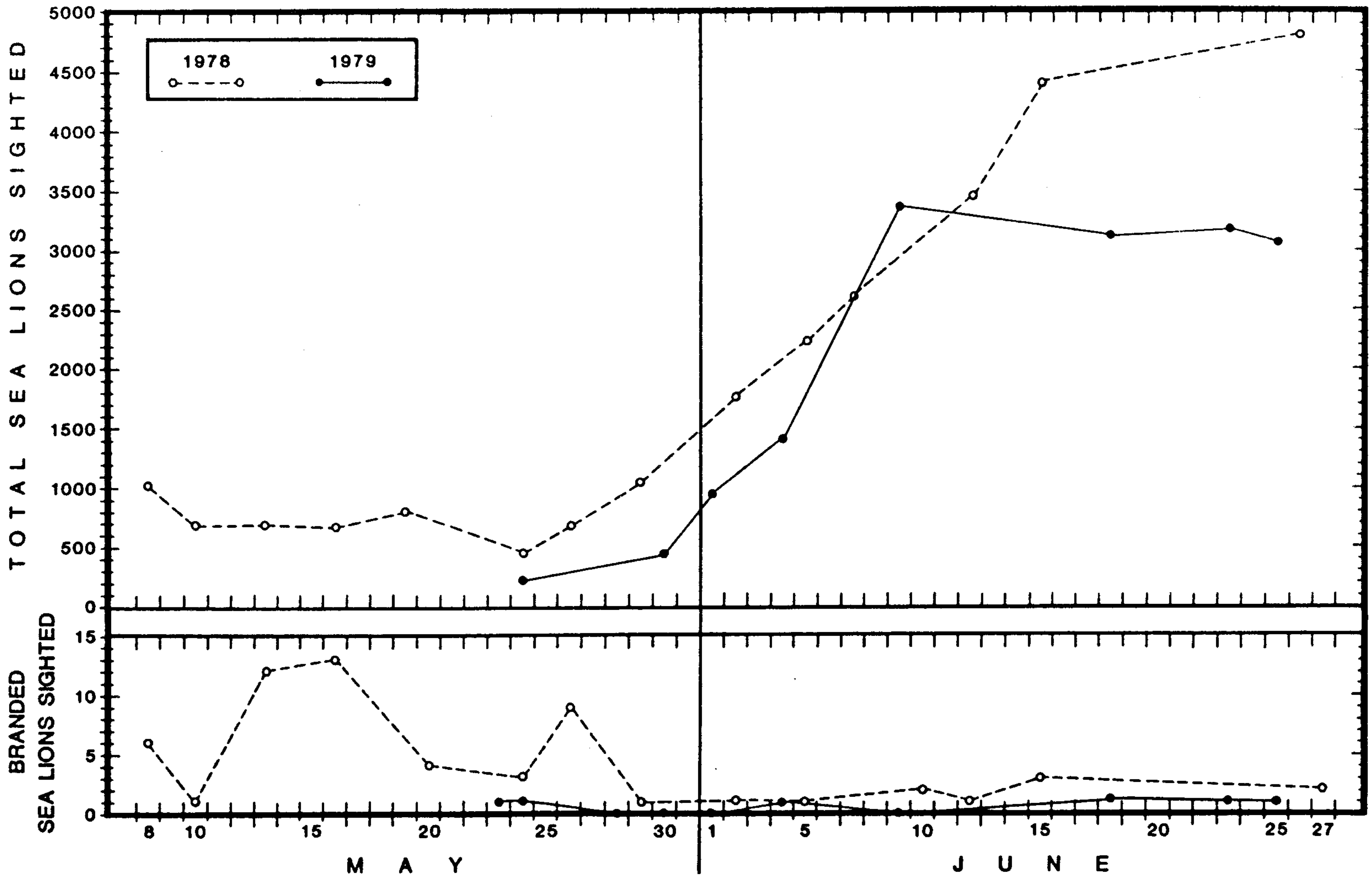

FIGURE 8. NUMBER OF BRANDED SEA LIONS SIGHTED AND TOTAL NUMBER OF SEA LIONS COUNTED, MAY AND JUNE 1978 AND 1979, SUGARLOAF ISLAND.

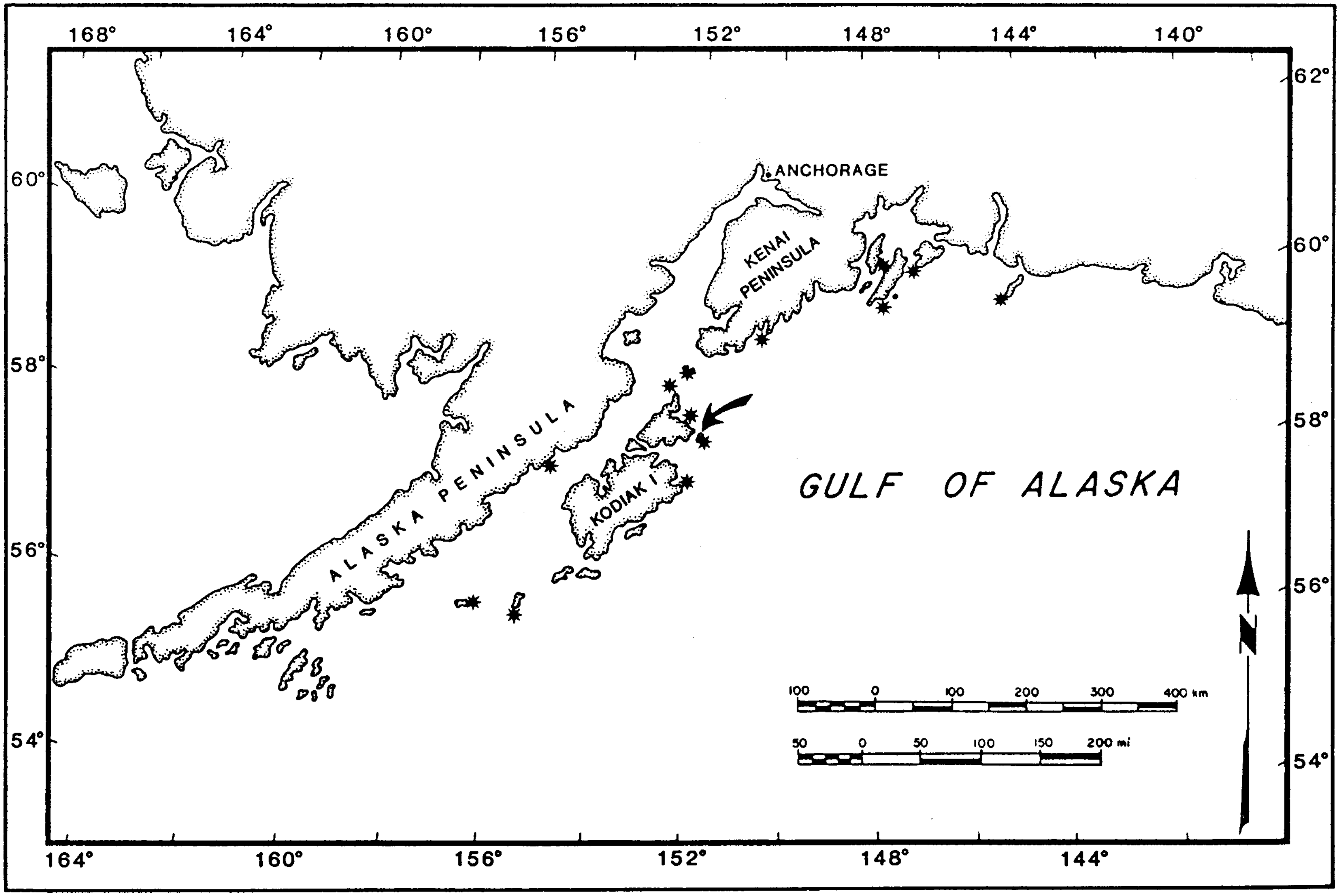

FIGURE 9. HAULOUTS WHERE SEA LIONS BRANDED AT MARMOT ISLAND (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

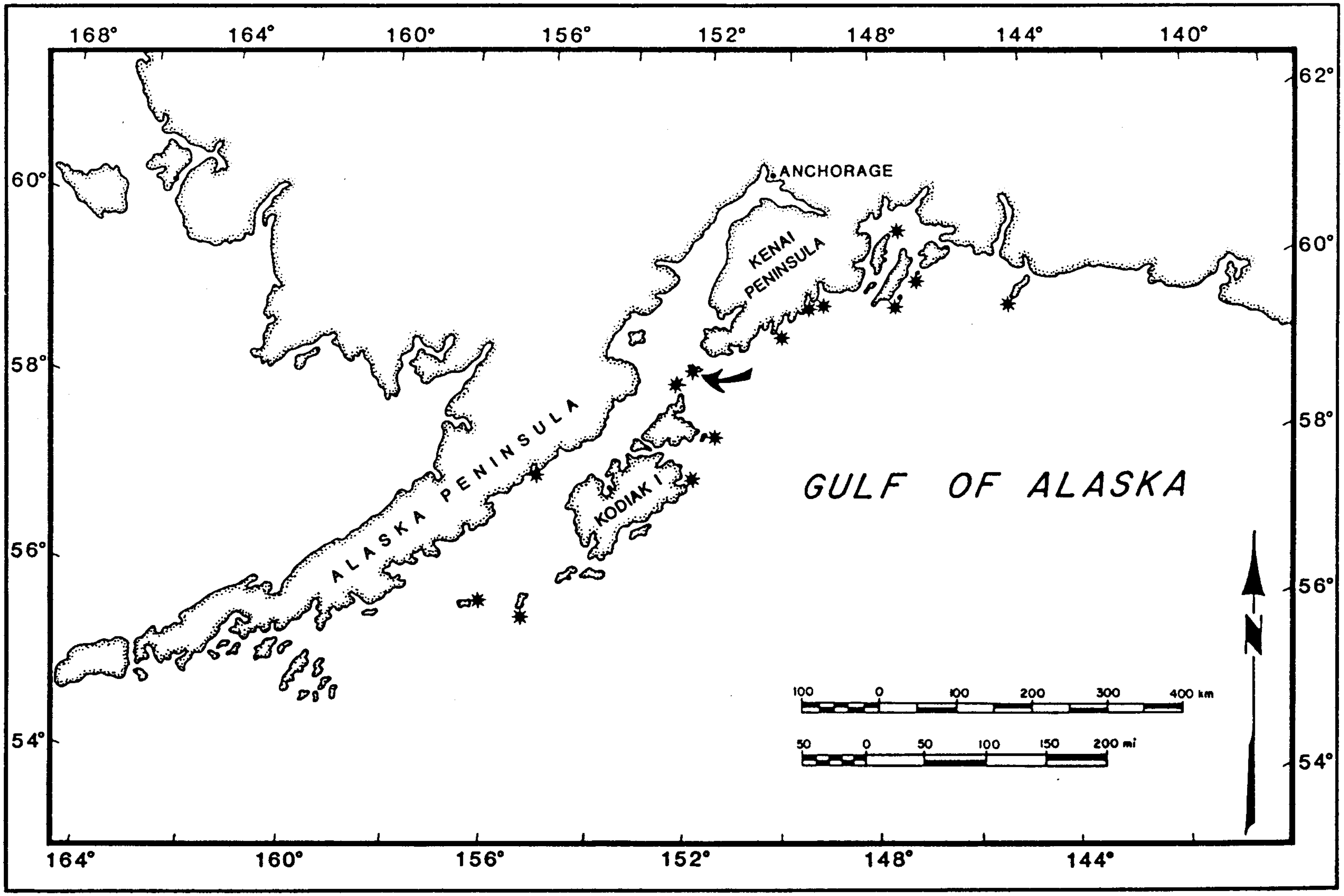

FIGURE 10. HAULOUTS WHERE SEA LIONS BRANDED AT SUGARLOAF ISLAND (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

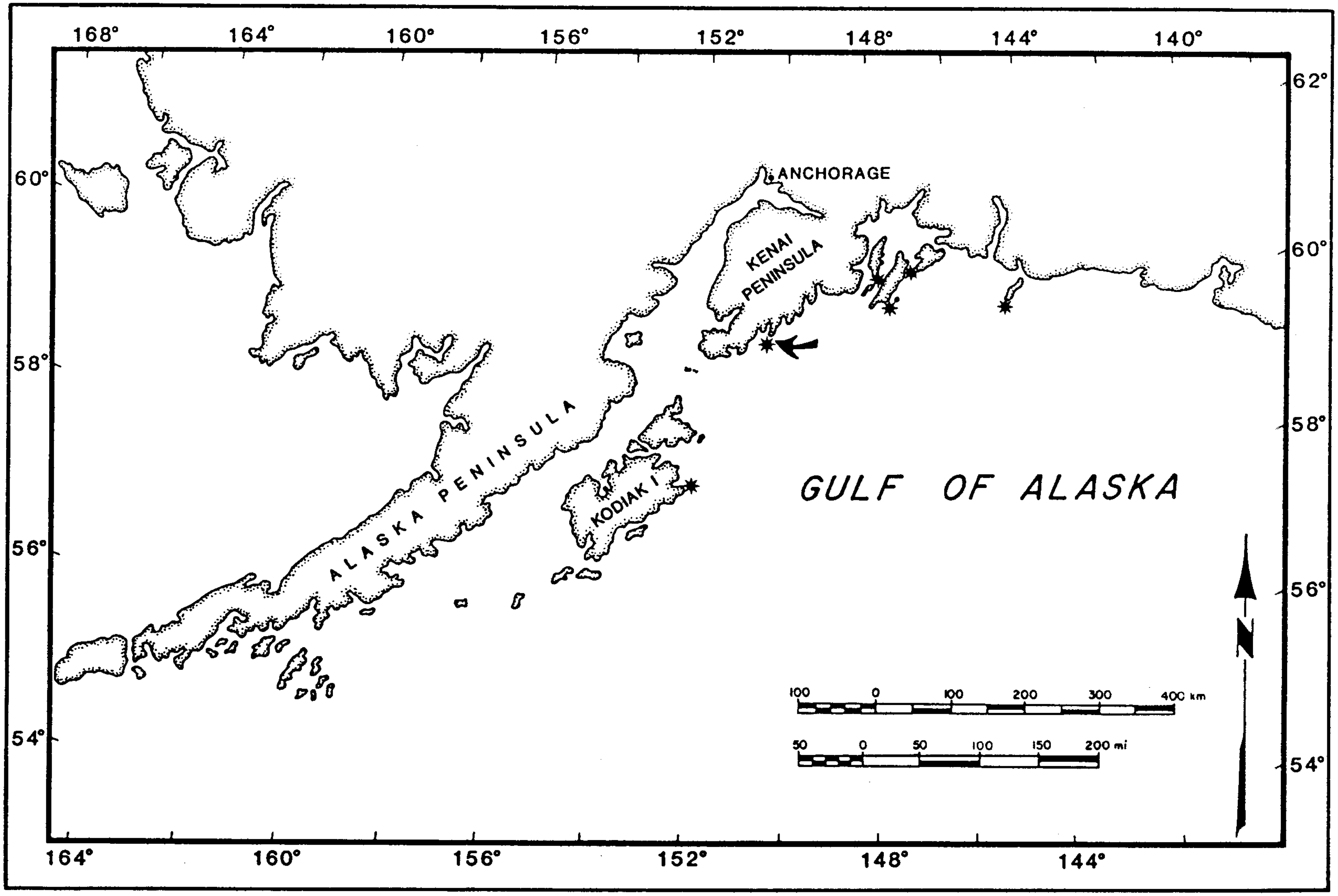

FIGURE 11. HAULOUTS WHERE SEA LIONS BRANDED AT OUTER ISLAND (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

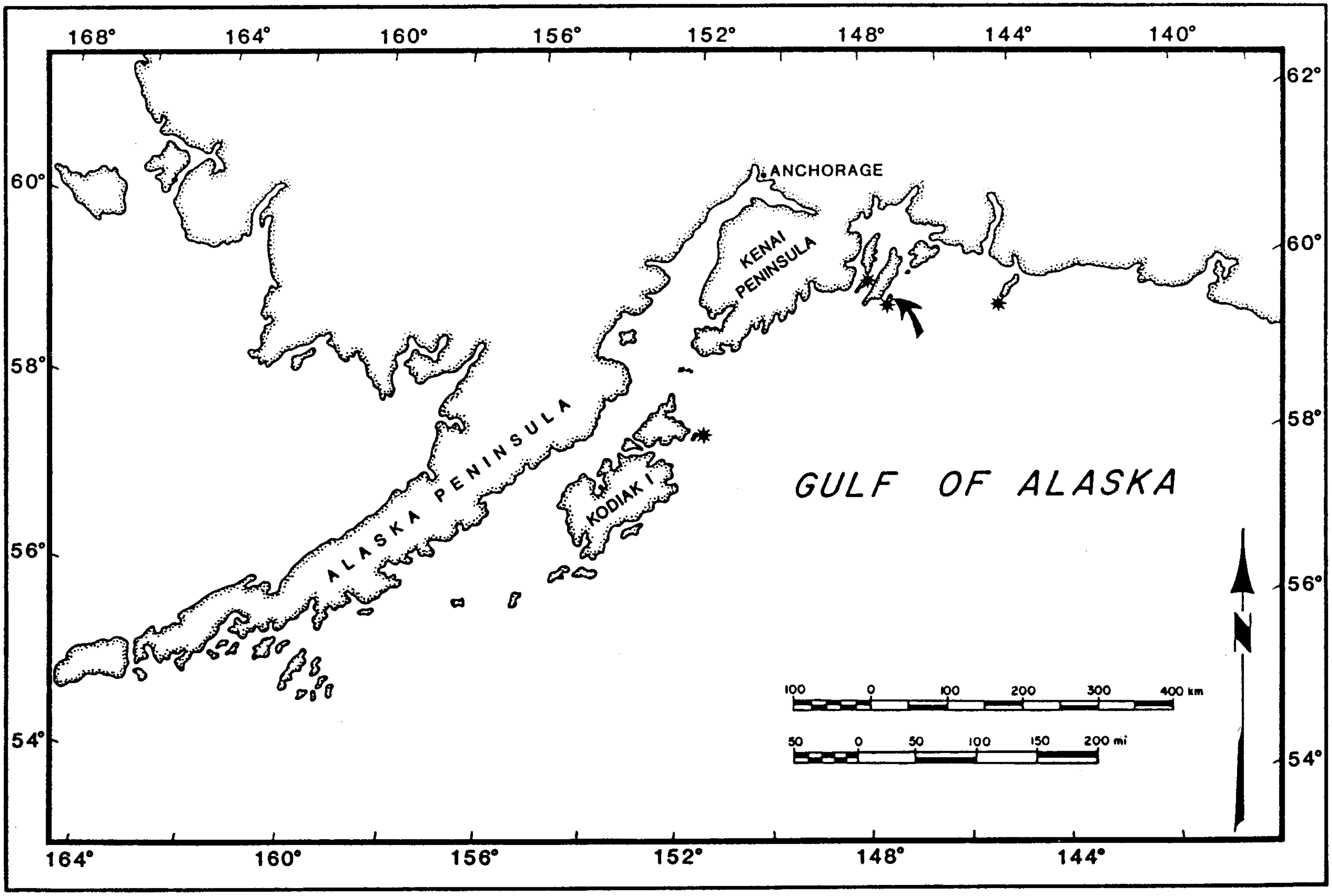

FIGURE 12. HAULOUTS WHERE SEA LIONS BRANDED AT THE WOODED ISLANDS (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

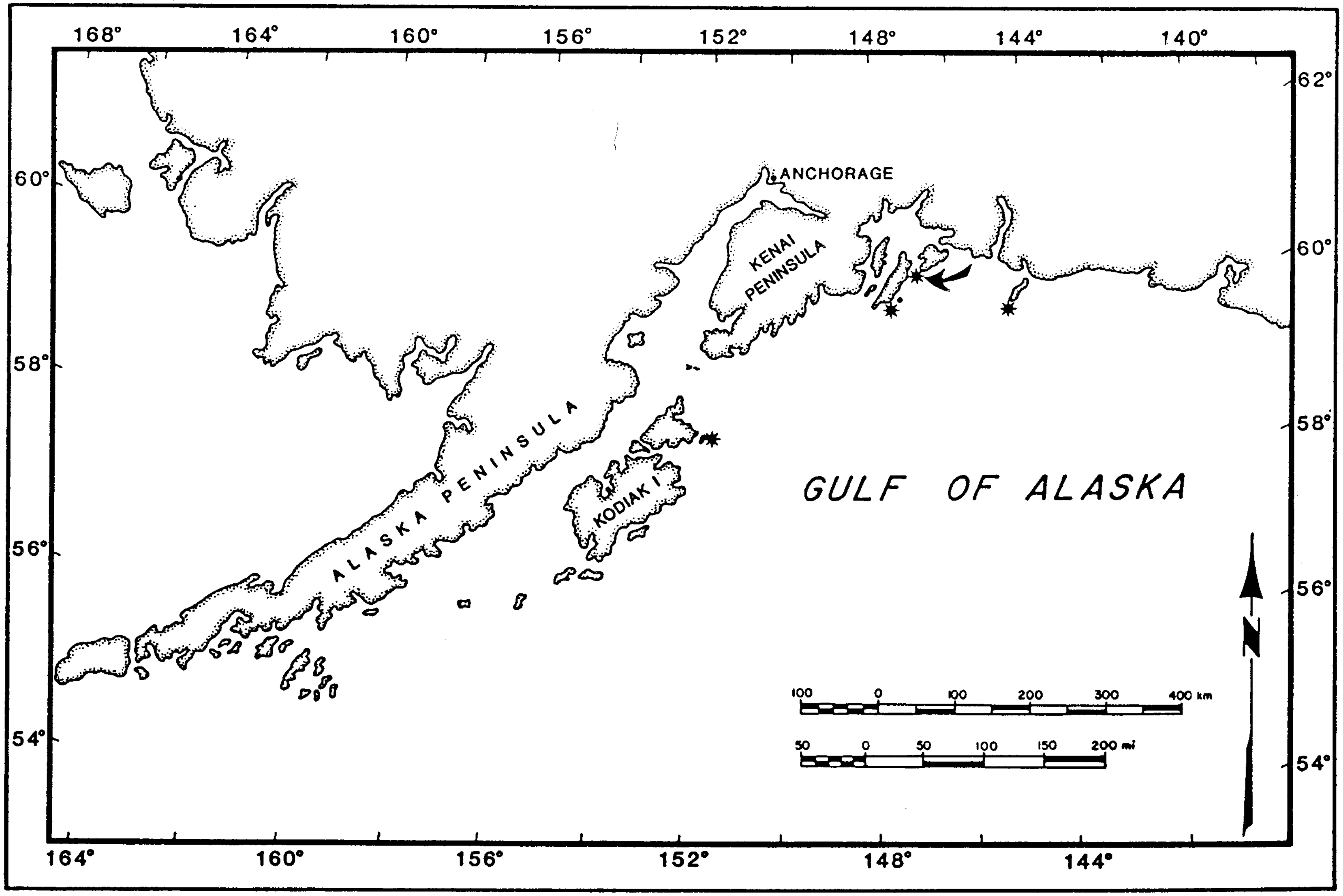

FIGURE 13. HAULOUTS WHERE SEA LIONS BRANDED AT SEAL ROCKS (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

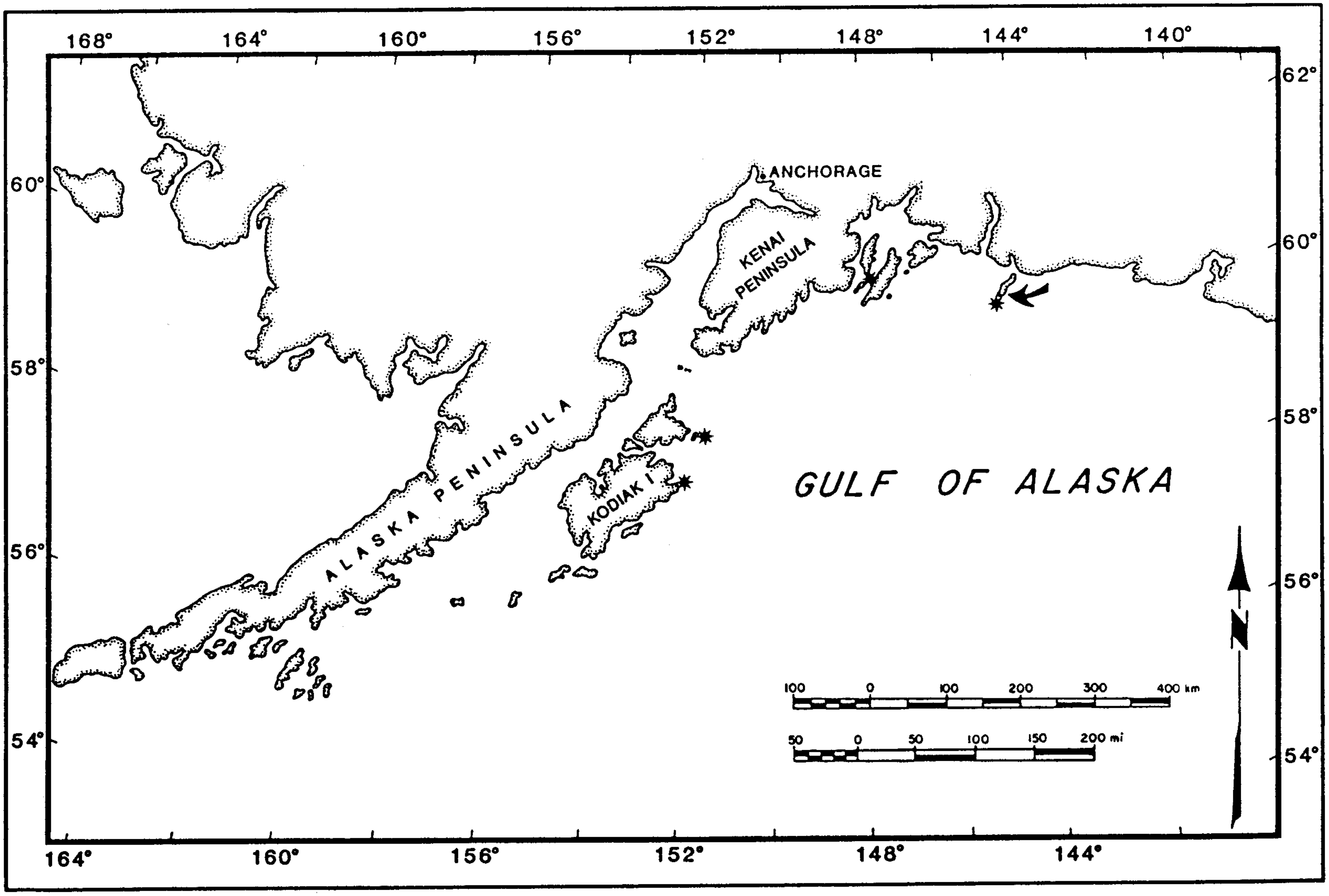

FIGURE 14. HAULOUTS WHERE SEA LIONS BRANDED AT CAPE ST. ELIAS (DENOTED BY ARROW) HAVE BEEN SIGHTED THROUGHOUT THE GULF OF ALASKA, 1976 THROUGH 1980.

clude 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 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 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.

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

Prey	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 ≥ 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.L.
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	

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.

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

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.

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

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.

	1975-1978 Occurrences			1945-1960[1] Occurrences		
Prey	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.

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 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).

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.

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.

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=0.60, 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 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 (average of 11.4 days) while Sandegren found that breeding occurred from 10 to 14 days after birth (average of 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.

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.

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%

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

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.

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	

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 gestation (Table 18). Missed pregnancies occurred most frequently in younger 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

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

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

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 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.

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

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.

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 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 Absent	Epididymal Sperm Trace	Epididymal Sperm Abundant	Percentage Sexually Mature
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

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	(Epididymal Sperm) Trace	(Epididymal Sperm) 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		

GROWTH AND CONDITION

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 Krenitzin 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 ($P \geq 0.2$).

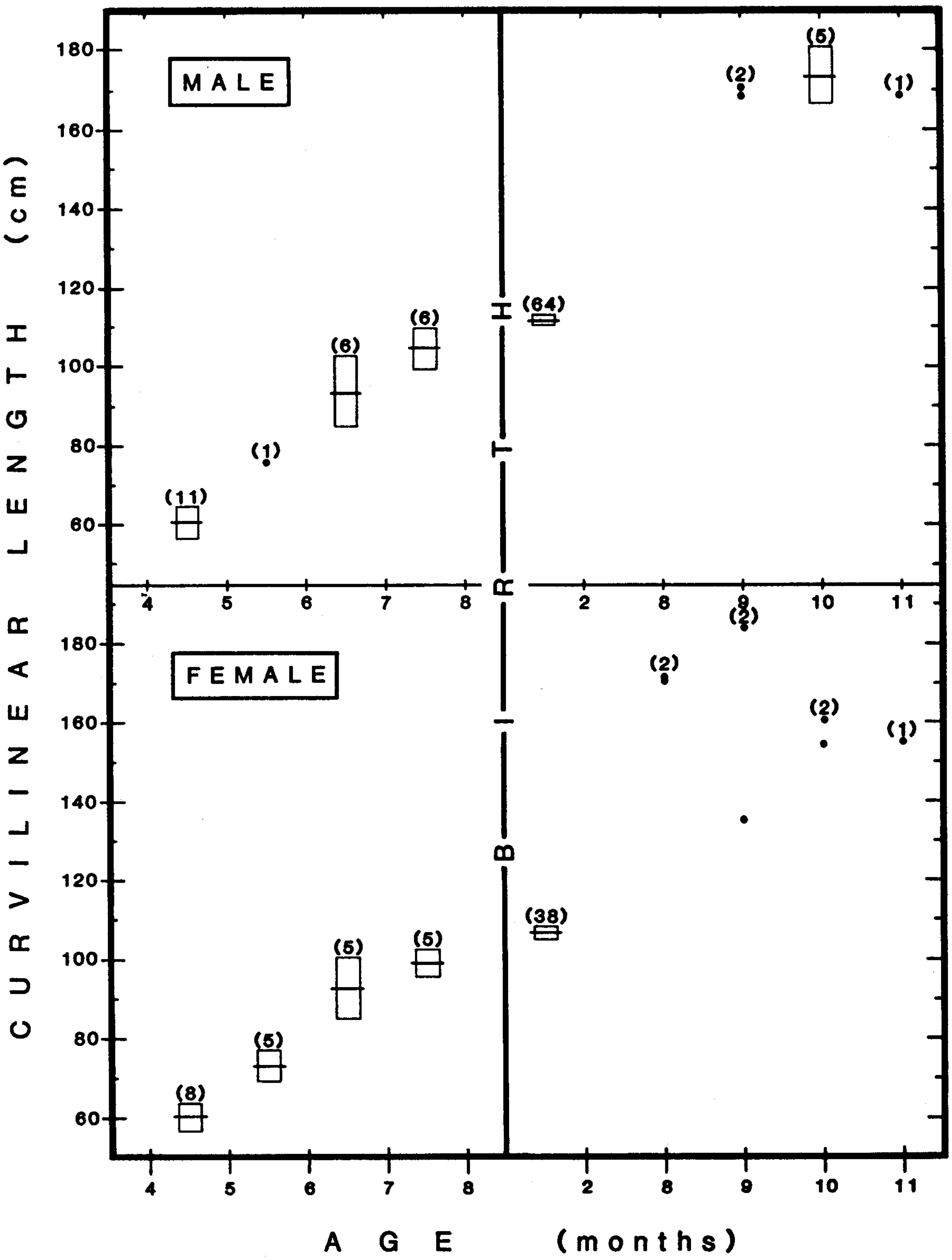

FIGURE 15. CURVILINEAR LENGTH OF MALE AND FEMALE STELLER SEA LIONS FROM THE FOURTH MONTH AFTER IMPLANTATION (FEBRUARY) UNTIL THE ELEVENTH MONTH AFTER BIRTH. BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, SAMPLE SIZE <4.

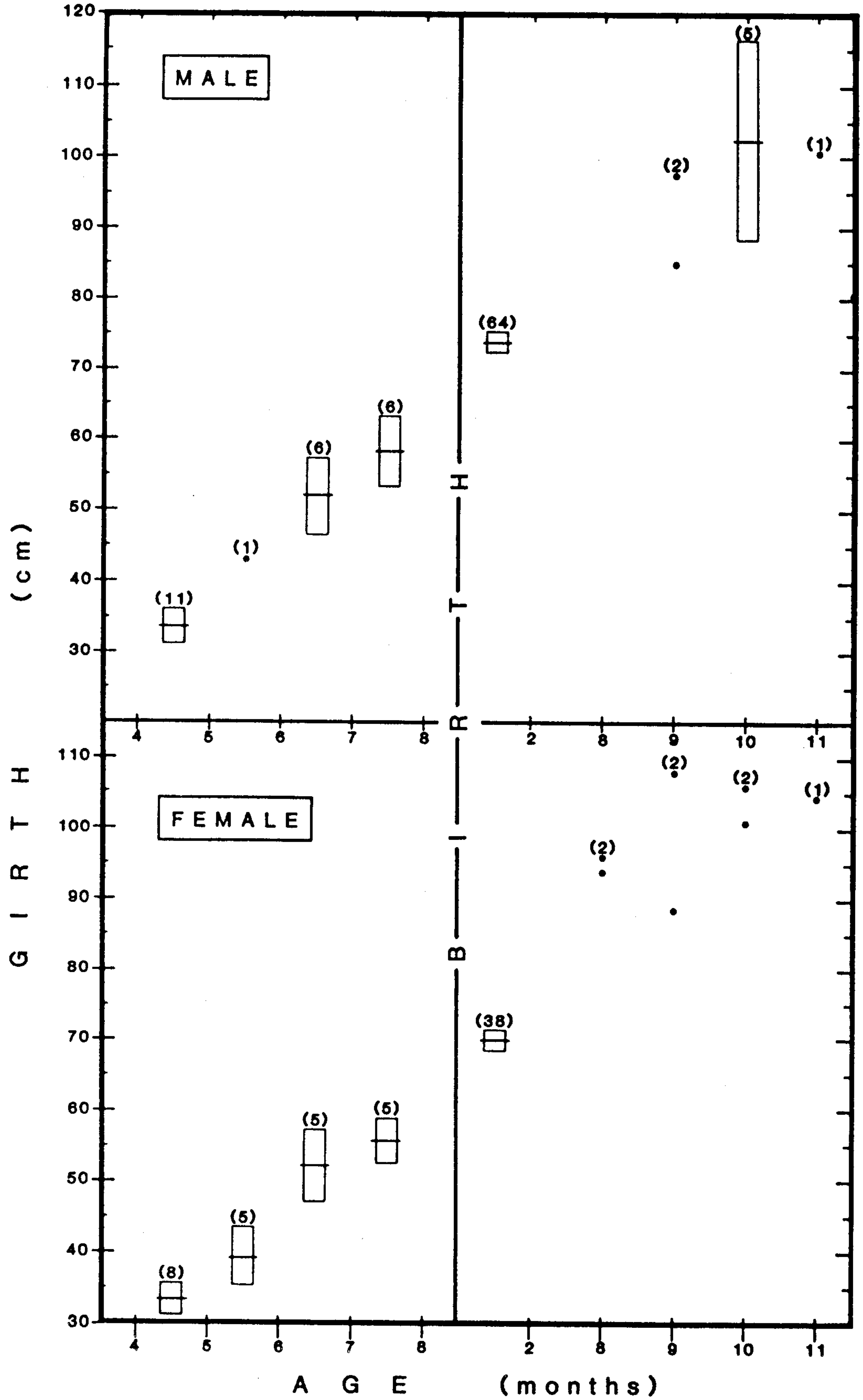

FIGURE 16. GIRTH OF MALE AND FEMALE STELLER SEA LIONS FROM THE FOURTH MONTH AFTER IMPLANTATION (FEBRUARY) UNTIL THE ELEVENTH MONTH AFTER BIRTH. BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, SAMPLE SIZE <4.

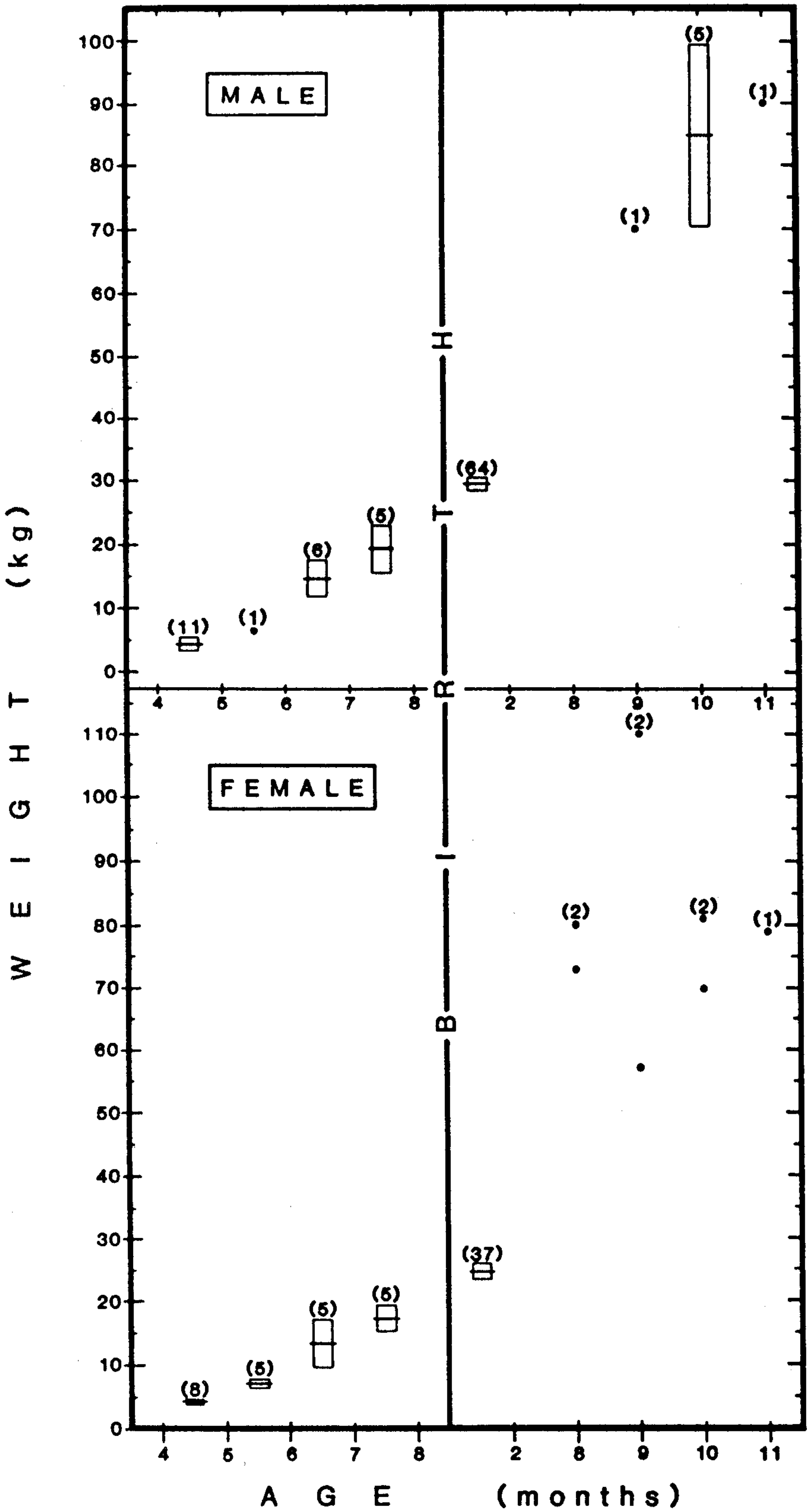

FIGURE 17. WEIGHT OF MALE AND FEMALE STELLER SEA LIONS FROM THE FOURTH MONTH AFTER IMPLANTATION (FEBRUARY) UNTIL THE ELEVENTH MONTH AFTER BIRTH. BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; ●, SAMPLE SIZE <4.

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.

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.

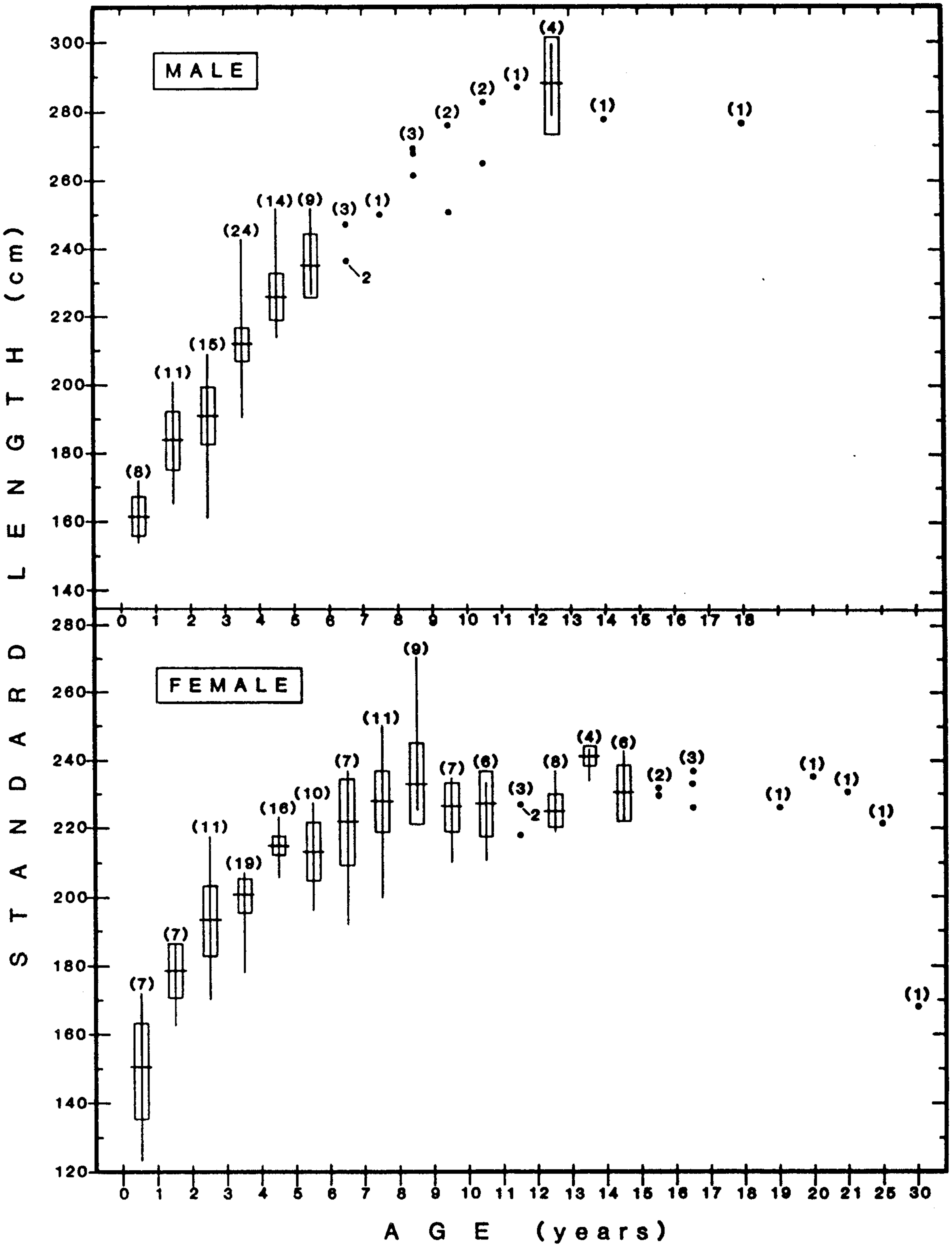

FIGURE 18. STANDARD LENGTHS OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL LENGTHS OF SAMPLE SIZE <4.

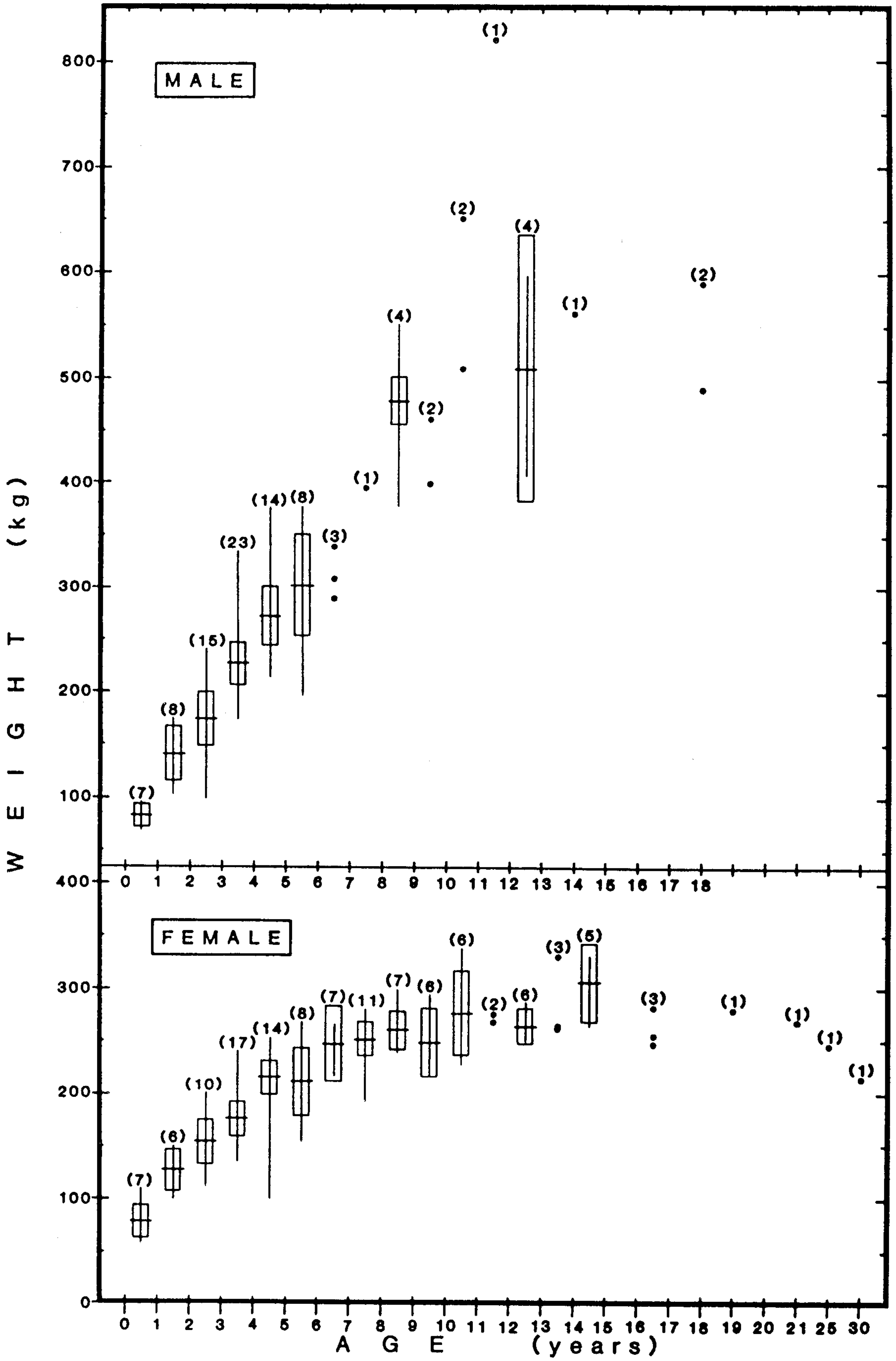

FIGURE 19. WEIGHTS OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL WEIGHTS OF SAMPLE SIZE<4.

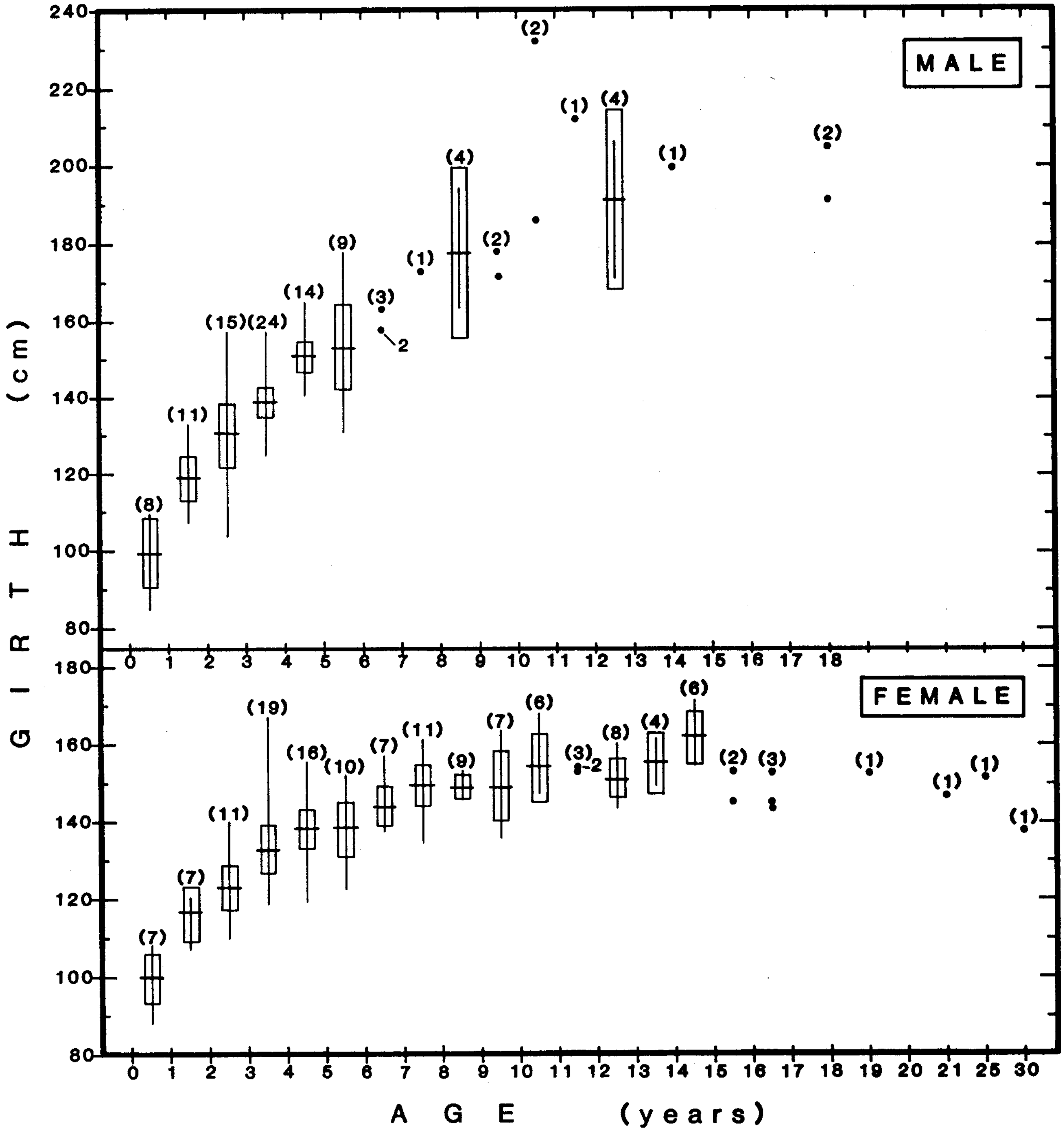

FIGURE 20. GIRTHS OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL GIRTHS OF SAMPLE SIZE <4.

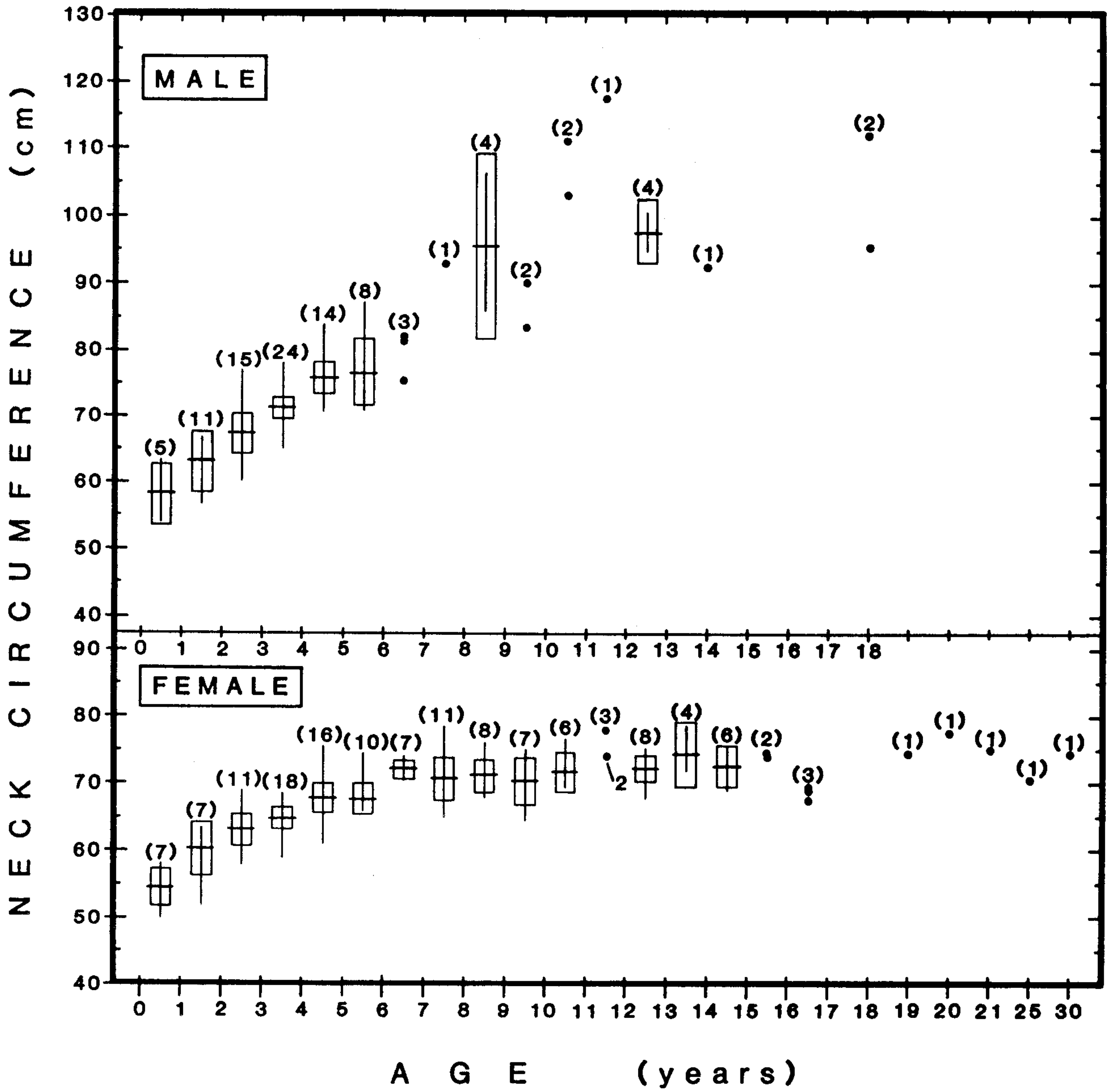

FIGURE 21. NECK CIRCUMFERENCES OF MALE AND FEMALE STELLER SEA LIONS TAKEN IN THE GULF OF ALASKA, 1975 THROUGH 1978, BY AGE CLASS. VERTICAL LINE, RANGE; BOX, 95% CONFIDENCE LIMITS; HORIZONTAL LINE IN BOX, MEAN; NUMBER IN PARENTHESIS, SAMPLE SIZE; •, INDIVIDUAL CIRCUMFERENCES OF SAMPLE SIZE<4.

The mean 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 ($P \geq 0.2$). No difference in weight was detected until after the first 3 years ($P \geq 0.2$). After the third year significant differences were detected between male and female weights ($P \leq 0.001$) and after the fourth year, differences were detected between male and female lengths ($P \leq 0.01$). 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 ($P \leq 0.05$) and by the end of the fourth year the difference had become highly significant ($P \leq 0.001$).

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.

POPULATION CHARACTERISTICS

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 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).

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.

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

Table 24. Life table for female Steller 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 ≥3 years smoothed by probit curve.
** Estimated value derived from age frequencies, maturation rates and birth rates.

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

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

of mature females surviving in each age class and estimated annual production of 27,462 pups (Table 26). This was reasonably close to our total count of 30,000 pups thus lending confidence to our estimates.

Male estimates were more difficult and less precise because: mortality data were more limited, 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 Lensink (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).

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

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 ≥3 years = 22,383
Total males ≥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 pinnipeds 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 include 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 term 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 have 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 investigated 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 and extensive scale , 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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THE HARVEST OF PACIFIC WALRUSES BY THE PELAGIC WHALING INDUSTRY, 1848-1914

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by John R. Bockstoce and Daniel B. Botkin

ABSTRACT

The most important agent in the historical reduction of the Pacific walrus population in the nineteenth century was the pelagic whaling industry. From 1848, when the whaling grounds of Bering Strait were discovered, to 1914, by which time the industry had collapsed, whaling vessels made more than 2,700 cruises seeking bowhead whales in the waters of the western Arctic. Large numbers of walruses also were taken during those voyages.

We present here the results of the first systematic attempt to determine the size of the pelagic whaling industry's walrus harvest. Our data are drawn from the best extant records: the logbooks of the whaling vessels. Our data indicate that in the course of their voyages, the whalers captured approximately 140,000 walruses.

INTRODUCTION

Recently there has been popular speculation that the Pacific walrus population has reached such a high level that it may be approaching a crash (Jones 1979). It has been suggested that this dramatic increase may be the result of a severe suppression of the population by commercial harvesting in the nineteenth and early twentieth centuries. The population may have been reduced to such a low level that large areas of the animal's former feeding range were undisturbed for as long as a century. These unexploited areas apparently allowed an abundance of food for the recovering population when the commercial harvest ended. Like some terrestrial mammal populations that have been introduced to a new food supply, this walrus population, because of time lags in its birth and death rates, may have increased beyond the carrying capacity of its ecosystem.

To help assess this possibility it would be useful to know the size of this historical commercial harvest, but heretofore only Fay (1957) has attempted such a study. Fay's important, pioneering analysis was based on data derived from published sources, the best information then available. Recently, however, we have been able to refine our understanding of the majority of the reduction--the harvest carried out by the pelagic whaling fleets--by analyzing the data in the logbooks of the whaling vessels.

Our data begin in 1849. It is unlikely that whaling vessels took Pacific walruses before this date, for until 1848 no whaling vessel had passed far north of the Aleutian and Commander islands. In 1848 one ship reached Bering Strait, but there is no evidence that it captured any walruses; however, in 1849 and the years immediately following, several ships took a few walruses, more out of curiosity than a desire for economic gain. It was not until the 1860's that a relatively steady market price for animal oils and a severe reduction in the bowhead whale population brought about the development of a deliberate walrus hunt.

The pattern of the bowhead's annual migration was a third factor in the development of the harvest. From mid-June to early August the bowheads, traveling in the safety of the ice in the Chukchi and Beaufort seas, were generally inaccessible to the whaleships, which could only move north with the retreating margin of the pack ice. Although the ships were kept from the bowheads, they were within easy reach of vast herds of Pacific walruses. Because the costs of a whaling voyage were fixed, regardless of whether the crew was whaling, it was logical to harvest walruses for their oil and ivory and thus to derive revenue from an otherwise unproductive period of time.

Although some ships made a concerted effort to hunt walruses in the early 1860's, the majority did not begin walrusing until after the Civil War. This intensive hunt continued until the early 1880's when a severely depleted walrus population and a declining price for oil made the hunt unprofitable. From the mid-1880's onward, walrusing was all but abandoned by the whaling fleet which had again turned its attention solely to bowheads.

METHODS

We gathered the data on the walrus harvest in the course of a larger project on the historical reduction of the bowhead whale population (Bockstoce and Botkin 1980).

The first step in our investigation was to identify all whaling vessels that cruised in the Bering Strait region and Chukchi and Beaufort seas, to determine both the size of the fleet in each year and the names of those vessels for which logbooks might have survived. The basic sources for this phase of the study were the several newspapers published in New Bedford, San Francisco, and Honolulu that reported marine news. We also gathered data from more than 500 books, magazine articles, manuscripts, and government documents. These resources allowed us to expand our purview beyond the American whaling industry to include vessels of the other nations operating in the western Arctic: Hawaii, Germany, France, and Great Britain (Australia).

In all, more than 25,000 reports were processed, giving us a record of more than 2,700 annual cruises. Significantly, as our work advanced, fewer and fewer new cruises were found to add to our list; during the extraction of data from the last hundred or so documents, no new cruises were identified. Thus we believe that our list of whaling vessels operating annually in the western Arctic is accurate to within at least 99 percent.

When we had completed our preliminary list of cruises, we were then able to locate the surviving logbooks and in turn extract the primary data from them. We extracted data for 516 complete cruises (approximately 19 percent of the total number of cruises) from logbooks spanning this entire period of whaling history. We compiled more than 66,000 days of observations and recorded the following information for each day: the ship's name; the date and geographical coordinates; the weather, ice conditions, and visibility; and the species and number of marine mammals sighted, chased, mortally wounded, wounded and escaped, captured, or found dead. The result was a continuous, representative sample of information on the activities of whaleships in the western Arctic from 1849 to 1914.

The primary information for an analysis of the whaling fleet's walrus harvest appears in Table 1 and includes the total voyages we identified (column A), the total documents we read (column B), the number of these documents that reported a walrus harvest (column C), and the number of walruses reported caught (column D).

The question arises as to the best method for extrapolating from these data to obtain a figure for the total walrus catch by the entire whaling fleet. (In our analysis, we assume that the extant documents have no consistent bias toward or against ships that sought walrus.)

By grouping the data in 5-year periods to obtain a larger sample per period, we calculated (Table 2) standard statistics for these data, including a mean catch, standard error, and confidence interval. It may be argued, however, that the data are best treated as a case study not open to an error estimate; consequently, we made a simple extrapolation, weighting the catch observed by the inverse of the fraction of the voyages read in each year. This weighting

Table 1.--Column A lists the total known voyages for each year, B the documents read, C the number of documents read that reported a walrus harvest, and D the total number of walrus caught as reported by the documents in column C.

YEAR	A WHALING VOYAGES	B TOTAL DOCUMENTS	C WALRUS DOCUMENTS	D CATCH
1849	50	7	3	4
1850	136	25	2	33
1851	176	33	9	20
1852	224	39	9	19
1853	168	27	4	11
1854	45	9	5	22
1855	7	3	1	1
1856	9	1	0	0
1857	12	2	1	29
1858	97	19	9	108
1859	86	20	14	220
1860	49	10	6	22
1861	45	10	7	310
1862	20	6	4	39
1863	35	9	3	15
1864	80	19	11	143
1865	84	19	5	54
1866	81	24	9	81
1867	83	28	18	386
1868	60	15	10	575
1869	42	11	7	1571
1870	55	15	14	3939
1871	43	10	8	1552
1872	35	9	8	1485
1873	35	5	4	645
1874	19	3	3	1455
1875	20	3	2	1962
1876	19	1	1	1877
1877	23	5	4	2890
1878	24	3	3	1641
1879	29	1	1	231
1880	23	3	3	349
1881	22	1	0	0

TABLE 1 (CONTINUED)

YEAR	A WHALING VOYAGES	B TOTAL DOCUMENTS	C WALRUS DOCUMENTS	D CATCH
1882	32	2	1	164
1883	39	3	3	271
1884	38	2	2	35
1885	41	4	2	83
1886	41	4	1	2
1887	36	3	1	12
1888	39	5	1	36
1889	42	4	1	1
1890	39	4	1	1
1891	39	7	1	2
1892	44	5	0	0
1893	44	5	0	0
1894	33	7	1	2
1895	30	7	0	0
1896	25	6	2	9
1897	23	6	3	20
1898	20	5	0	0
1899	16	4	0	0
1900	16	4	1	6
1901	13	4	1	1
1902	12	3	1	1
1903	15	3	1	1
1904	17	3	1	1
1905	16	5	1	10
1906	16	4	0	0
1907	11	3	1	14
1908	11	3	0	0
1909	5	1	1	10
1910	4	1	1	17
1911	5	1	0	0
1912	5	1	1	6
1913	5	1	1	4
1914	4	1	1	2

Table 2.--Estimated total walrus catch using standard statistical methods. Data are grouped by 5-year periods to obtain a larger sample. The mean catch per vessel, standard error, and confidence interval are calculated. Of those documents read, the percentage reporting a walrus catch is given in column B. Column C--the estimated total number of cruises on which walruses were caught--is calculated by multiplying the entry in column B by the total number of voyages for that period (column A). Column D--the mean catch per voyage--is the average catch per vessel among those vessels reporting a walrus catch. In column E, the estimated total catch is obtained by multiplying column C by column D.

	A	B	C	D	E
YEARS	TOTAL WHALING VOYAGES	% THAT CAUGHT WALRUS	EST. TOT. WALRUS VOYAGES	MEAN CATCH/ VOYAGE	ESTIMATED TOTAL CATCH
1849-53	754	20.6	155	3.22 ± 2.25	499.1 ± 349.5
1854-58	170	47.0	80	10.00 ± 6.63	800.0 ± 530.8
1859-63	235	61.8	145	17.82 ± 8.03	2583.9 ± 1165.0
1864-68	388	50.5	196	23.37 ± 10.54	4581.9 ± 2067.8
1869-73	210	82.0	172	224.19 ± 58.11	38561.5 ± 9996.6
1874-78	105	86.7	91	755.76 ± 269.69	68775.0 ± 25542.2
1879-83	145	80.0	116	126.87 ± 69.73	14717.5 ± 8088.7
1884-88	195	38.9	76	24.00 ± 13.43	1824.0 ± 1021.0
1889-93	208	12.0	25	1.33 ± .65	33.2 ± 16.2
1894-98	131	19.4	25	5.16 ± 3.01	129.2 ± 75.4
1899-03	72	22.2	16	2.25 ± 2.45	36.0 ± 39.2
1904-08	71	16.7	12	8.33 ± 7.53	100.0 ± 90.4
1909-14	28	83.3	23	7.80 ± 5.20	179.4 ± 119.8
TOTALS 66	2712		1132		132820.7 ± 48102.6

assumes that our 19 percent sample of all whaling voyages is sufficiently large to provide a trustworthy assessment of walrusing activities by the whaling fleet. The estimated catch extrapolated by this method is given in Table 3, column D.

Our sample extrapolation method (Table 3) yields an estimate of 148,250 walrus caught for the entire period 1849-1914. The standard statistical method yields an estimate of 133,000 ± 48,000 (Table 2). Therefore the two statistical methods yield results that are close and suggest that a reasonable estimate of the total number of walrus caught is approximately 140,000.

DISCUSSION

As Table 3 shows, the vast majority of the whalers' walrusing activities took place in the 17 years from 1867 to 1883 when about 90% of the total harvest was made. The catch statistics from our data sample have been segmented further in Table 4. It shows that the walrus were taken primarily during the months of June and July (while the whaleships, impeded by ice, moved slowly northward toward the northwest coast of Alaska to be ready to intercept the bowheads on their return migration from the Beaufort Sea in August and September).

We also subdivided the Bering, Chukchi, and Beaufort seas into 19 regions which we constructed empirically to segregate areas where the greatest concentrations of ships'

Table 3.--Estimated total walrus catch. This table uses a simple extrapolation from documents read to total number of voyages.

CATCH .... number of walruses caught in documents read
CUMCAT .... cumulative catch
WFACTOR .... weighting factor (total number of voyages/ number of documents read)
WCATCH .... weighted catch (CATCH x WFACTOR)
WCUMCAT .... weighted cumulative catch

YEAR	A CATCH	B CUMCAT	C WFACTOR	D WCATCH	E WCUMCAT	YEAR
1849	4	4	7.14	29	29	1849
1850	33	37	5.44	180	208	1850
1851	20	57	5.33	107	315	1851
1852	19	76	5.74	109	424	1852
1853	11	87	6.22	68	492	1853
1854	22	109	5.00	110	602	1854
1855	1	110	2.33	2	605	1855
1856	0	110	9.00	0	605	1856
1857	29	139	6.00	174	779	1857
1858	108	247	5.11	551	1330	1858
1859	220	467	4.30	946	2276	1859
1860	22	489	4.90	108	2384	1860
1861	310	799	4.50	1395	3779	1861
1862	39	838	3.33	130	3909	1862
1863	15	853	3.89	58	3967	1863
1864	143	996	4.21	602	4569	1864
1865	54	1050	4.42	239	4808	1865
1866	81	1131	3.38	273	5081	1866
1867	386	1517	2.96	1144	6226	1867
1868	575	2092	4.00	2300	8526	1868
1869	1571	3663	3.82	5998	14524	1869
1870	3939	7602	3.67	14443	28967	1870
1871	1552	9154	4.30	6674	35641	1871
1872	1485	10639	3.89	5775	41416	1872
1873	645	11284	7.00	4515	45931	1873
1874	1455	12739	6.33	9215	55146	1874
1875	1962	14701	6.67	13080	68226	1875
1876	1877	16578	19.00	35663	103889	1876
1877	2890	19468	4.60	13294	117183	1877
1878	1641	21109	8.00	13128	130311	1878
1879	231	21340	29.00	6699	137010	1879
1880	349	21689	7.67	2676	139685	1880
1881	0	21689	22.00	0	139685	1881

TABLE 3 (CONTINUED)

YEAR	A CATCH	B CUMCAT	C WFACTOR	D WCATCH	E WCUMCAT	YEAR
1882	164	21853	16.00	2624	142309	1882
1883	271	22124	13.00	3523	145832	1883
1884	35	22159	19.00	665	146497	1884
1885	83	22242	10.25	851	147348	1885
1886	2	22244	10.25	21	147368	1886
1887	12	22256	12.00	144	147512	1887
1888	36	22292	7.80	281	147793	1888
1889	1	22293	10.50	11	147804	1889
1890	1	22294	9.75	10	147814	1890
1891	2	22296	5.57	11	147825	1891
1892	0	22296	8.80	0	147825	1892
1893	0	22296	8.80	0	147825	1893
1894	2	22298	4.71	9	147834	1894
1895	0	22298	4.29	0	147834	1895
1896	9	22307	4.17	38	147872	1896
1897	20	22327	3.83	77	147948	1897
1898	0	22327	4.00	0	147948	1898
1899	0	22327	4.00	0	147948	1899
1900	6	22333	4.00	24	147972	1900
1901	1	22334	3.25	3	147976	1901
1902	1	22335	4.00	4	147980	1902
1903	1	22336	5.00	5	147985	1903
1904	1	22337	5.67	6	147990	1904
1905	10	22347	3.20	32	148022	1905
1906	0	22347	4.00	0	148022	1906
1907	14	22361	3.67	51	148074	1907
1908	0	22361	3.67	0	148074	1908
1909	10	22371	5.00	50	148124	1909
1910	17	22388	4.00	68	148192	1910
1911	0	22388	5.00	0	148192	1911
1912	6	22394	5.00	30	148222	1912
1913	4	22398	5.00	20	148242	1913
1914	2	22400	4.00	8	148250	1914

cruising had occurred (Fig. 1). The ships had their greatest successes in July (Table 4) in the waters immediately north of Bering Strait (Fig. 1, division G), a time and place when the walrus were found in great numbers and the ice had disintegrated sufficiently to allow the ships relatively easy access to the herds.

Our data do not indicate whether the whalemen suppressed a particular subpopulation or age group because of the ships' proximity to certain segments of the populations at regular times of the year; nor have we found any evidence within the documents to suggest that the whalers practiced selective harvesting during the hunt.

Apart from estimating whalers' total catch, it is far more difficult to estimate the total walrus kill. After the Civil War, when the hunters began using large caliber rifles (before then they had used harpoons and lances) to kill the animals, the loss no doubt increased dramatically through the escape of large numbers of mortally wounded animals. Although the records of the walrus that were caught and processed were faithfully kept, it is regrettable that few records were kept of the total kill. The four that we have found are:

<u>Northern Light</u>:

June 3, 1876: retrieved 59 of 82 shot.

June 21, 1876: lost all 24 walrus shot.

July 26, 1877: retrieved 118 of 130 shot.

Lucretia:

June 21, 1883: retrieved 18 of 40 or 50 shot. Although insufficient for use in statistical procedures, these data suggest that no more than 60 to 70 percent of the walruses shot were retrieved and processed.

Beyond the question of the size of the whalers' catch and kill lies the more difficult, if not insoluble, problem of estimating the total commercial catch and kill. Although the pelagic whaling fleet killed the greatest proportion of walruses in the nineteenth century and left a detailed body of data from which to reconstruct their harvest, vessels engaged in trade for walrus ivory left few records, and it is unlikely that their activities can be accurately measured.

The nineteenth century trade for walrus ivory took several forms: small trading vessels, personal trade by whaling captains and officers, and trade both at posts near Chukotka and by the Russian American Company and its successors. In the first case a number of schooners and brigs sailed annually from Honolulu, Hong Kong, Sydney, Hobart, and San Francisco (and after 1900, from Nome) to the Bering Strait region to trade alcohol and manufactured goods to the natives for baleen, furs, and ivory. Occasionally these vessels also hunted walruses for a short time when they had finished trading. Except in rare cases their logbooks have not survived, nor were their activities regularly reported in newspapers.

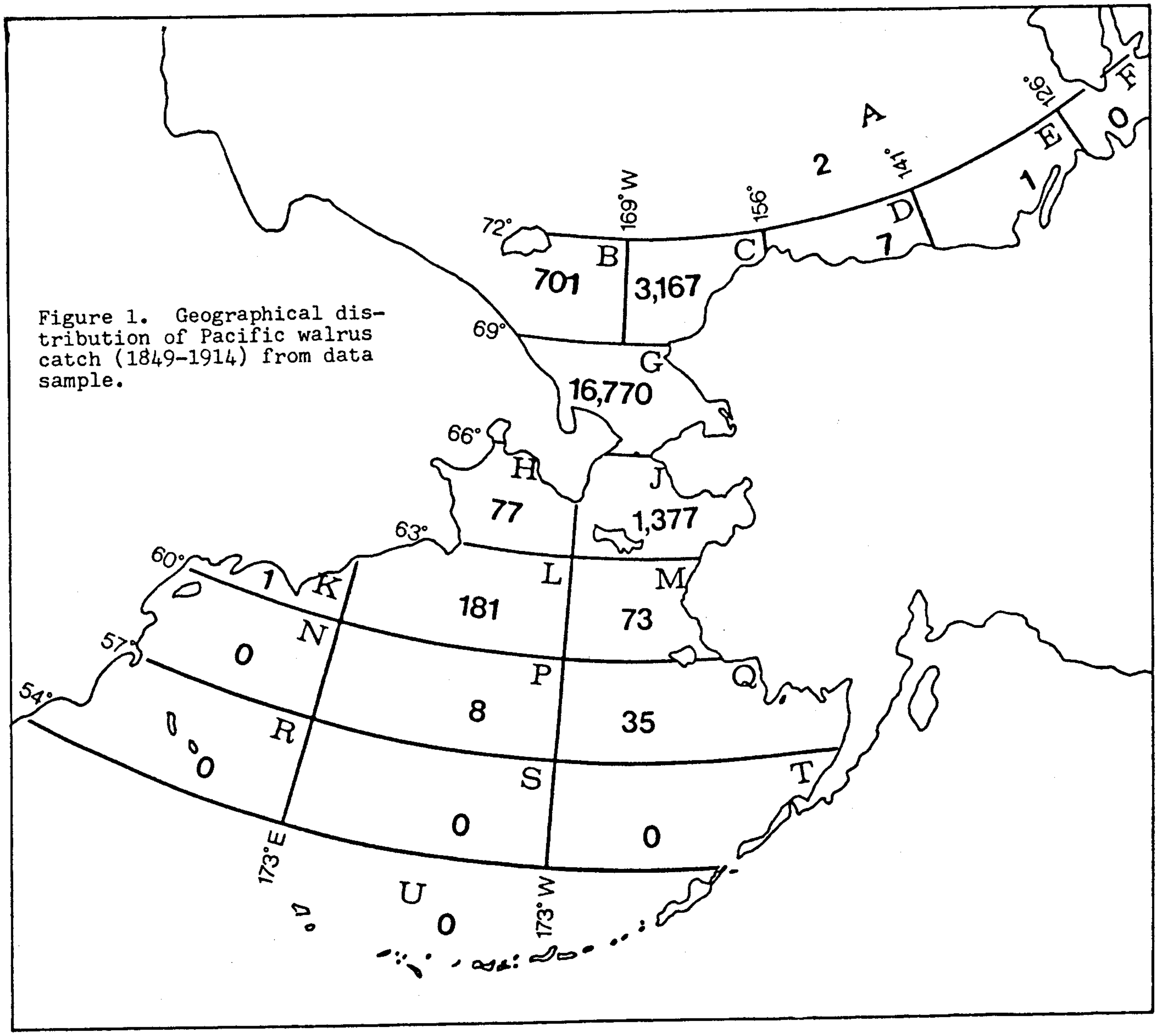

Figure 1. Geographical distribution of Pacific walrus catch (1849-1914) from data sample.

Table 4. Summary of the sample Pacific walrus catch per month and 10-year period, 1849-1914.

	total	May	June	July	August	September
1849 - 58	247	10	40	130	54	13
1859 - 68	1,845	16	267	1,027	480	55
1869 - 78	19,017	514	4,462	12,750	1,221	70
1879 - 88	1,183	77	242	768	74	22
1889 - 98	35	0	13	3	18	1
1899 - 08	34	1	7	2	21	3
1909 - 14	39	0	4	15	10	10
total	22,400	618	5,035	14,695	1,878	174

Similarly, there is no documentation for the ivory trade carried on by whalemen with the natives for personal gain, and furthermore, surviving records of the trading companies are sparse. But even if these documents had survived, one would be faced with the possibly insoluble problem of estimating the factor by which the natives increased their subsistence hunt to provide raw materials for the trade market.

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