OCS Study
MMS 88-0092

Ecological Research Associates

SYNTHESIS OF INFORMATION ON THE EFFECTS OF NOISE AND DISTURBANCE ON MAJOR HAULOUT CONCENTRATIONS OF BERING SEA PINNIPEDS

from

LGL Alaska Research Associates, Inc.
505 West Northern Lights Blvd., Suite 201
Anchorage, Alaska 99503

for

U.S. Minerals Management Service
Alaskan Outer Continental Shelf Region
U.S. Dept. of Interior
Room 603, 949 East 36th Avenue
Anchorage, Alaska 99508

Contract no. 14-12-0001-30361

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17 February 1989

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by

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ABSTRACT

This study investigated the use of terrestrial haulout sites in the eastern Bering Sea by four species of pinnipeds, northern fur seal, northern sea lion, harbor seal and Pacific walrus. Historical information on the use of each site was summarized. For a few sites there was little or no information about the number of animals present and consistency of use of the site, so we were unable to properly evaluate these.

Available information on the effects of airborne and waterborne noise, and human disturbance (from stationary and moving sources) was reviewed. We also conducted a detailed analysis of the acoustic environment of eight haulout sites. These eight sites were representative of others used by each of the four species studied. The analyses included investigations of (1) characteristics of airborne and underwater ambient noise, (2) characteristics of industrial noise sources, including aircraft, small boats, fishing trawlers and commercial cargo traffic, and (3) sound transmission loss in air, water and through the air-water surface.

Inter-site Population Sensitivity Index (IPSI)

As a means to evaluate the potential vulnerability of each haulout site to noise and disturbance, we developed a quantitative rating system (IPSI) whereby an index of sensitivity was assigned to each site. IPSI values were computed from rank scores assigned to eight categories associated with each site occupied by each of the four pinniped species. The eight categories were (1) the peak count of a particular species of pinniped recorded at a site since 1980, (2) the mean maximum number of animals recorded at a site during the past three decades and during the most recent count at the site, (3) the proportion of the current total estimated Bering Sea population present at a particular site, (4) the age and sex composition, and the kinds of behavioral activities that have been recorded at a site, (5) the duration of use of a haulout site, (6) consistency of use of a haulout site, (7) various physical characteristics of the site, including substrate type, local relief, water depth and proximity to airports, shipping lanes, human settlements, and (8) species characteristics, i.e. susceptibility of animals of this species to

noise and disturbance and the potential for mortality. Sites that rated high had high IPSI scores and were considered most sensitive.

Norton Basin Planning Area

There are 14 haulout sites in this planning area; they are used by two of the four species of pinnipeds studied. No northern fur seals or harbor seals haul out in significant numbers here. Twelve of the 14 sites are used by Pacific walrus. Two haulout sites, the one on North Punuk Island, and the one on King Island ranked high in our IPSI evaluation scheme. Northern sea lions have occasionally hauled out at Southwest Cape on St. Lawrence Island and on nearby South Punuk Island. However, there is no current information concerning the use of these sites by sea lions.

St. Matthew-Hall Planning Area

In this planning area 24 haulout sites are used by three of the four pinnipeds studied; there are no northern fur seal haulout sites in this area. Most of the sites (11) are used by northern sea lions, however none ranked high in the overall IPSI evaluation scheme. Pacific walrus sites were second in abundance (8) and four of these, all on St. Matthew or Hall islands, ranked high. Harbor seal sites were least abundant (5) in this planning area, but the site(s) in Kuskokwim Bay ranked relatively high. This area, and the areas to the east near Avinof Point, may be the most northerly major harbor seal pupping areas in the eastern Bering Sea.

North Aleutian Basin Planning Area

This planning area contains 44 haulout sites used by three of the four species studied; no northern fur seals haul out in this planning area. Harbor seals used 22 of the sites including 9 (20%) that rated high in our IPSI evaluation scheme. Twelve sites were occupied by northern sea lions, and at least six (14%) of these were ranked high. Ten sites are occupied by Pacific walrus, and five (11%) of these were ranked very high.

St. George Basin Planning Area

This planning area has 54 haulout sites used by three species; this is the largest number of haulout sites in any of the four planning areas in the eastern Bering Sea. There are no consistently used Pacific walrus haulout sites, but all 22 northern fur seal haulout sites in the eastern Bering Sea are found here (Pribilof Islands and Bogoslof Island). Seventeen sites are occupied by northern sea lions, and 6 (11%) of these were ranked very high in our IPSI evaluation scheme. At least 15 sites are used by harbor seals, and three (6%) of these (two in the Fox Islands and one on Otter Island) were ranked very high.

Overall, we evaluated 120 of 136 terrestrial haulout sites in four different OCS Planning Areas in the eastern Bering Sea. Of the 44 sites in the North Aleutian Basin Planning Area, almost half (20 sites; 45%) ranked high in our IPSI evaluation scheme. This number represents almost half of the total 41 most highly rated sites in the study area. Of the 54 sites in the St. George Basin Planning Area, 19 (35%) were rated high; this number was strongly influenced by 10 highly ranked northern fur seal sites on the Pribilof Islands. Of the 24 sites in the St. Matthew-Hall Planning Area, 5 (21%) rated high in our IPSI evaluation, and most (4 of 5; 80%) were sites occupied by Pacific walrus. Of the 14 sites in the Norton Basin Planning Area, only 2 rated high in our IPSI evaluation; both of these sites were occupied by Pacific walrus.

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Steve Treacy, Minerals Management Service (MMS), Anchorage, Alaska, helped set the geographical limits to the study area, and arranged for us to get official protraction diagrams of the coast and islands of the eastern Bering Sea. We thank Steve for his patience and cooperation throughout this study.

INTRODUCTION

Background

In Alaska four species of pinnipeds congregate, often by the thousands or tens of thousands, at specific terrestrial haulout sites along island and mainland coasts of the eastern Bering Sea. These species are the northern fur seal (Callorhinus ursinus), northern or Steller sea lion (Eumatopias jubatus), harbor seal (Phoca vitulina richardsi) and Pacific walrus (Odobenus rosmarus divergens). Except for the walrus, these species may occupy terrestrial haulout sites during pupping, nursing, mating and molting, which are all potentially times of elevated stress. (Mating, pupping and nursing by Pacific walruses occurs during January through June in the pack-ice rather than at terrestrial sites.) Consequently, acoustic and/or visual disturbance of animals at terrestrial haulout sites could adversely affect these and other functions, or could further decrease resistance to parasitic infection, thermoregulatory impairment, disease and other stress factors.

In recent years, the northern fur seal, northern sea lion and harbor seal populations in the North Pacific region including Bering Sea have experienced significant declines. These declines have been attributed to a variety of causes, e.g., entanglement in abandoned or discarded fishing gear, disease and parasitic infections, and reductions (principally through overfishing) in the abundance of principal prey species. However, there have been few studies of the potential sensitivity of these pinniped species to industrial disturbance near haulout sites. Additionally, although the Bering Sea population of the Pacific walrus has increased markedly in the past decades, mass mortality has occurred at some locations, and it has been suggested that this species may be sensitive to certain vessel and aircraft traffic.

Literature exists which identifies Bering Sea haulout locations for the four pinniped species. However, site-specific population information has not been combined with known behavioral and acoustic information to describe the potential for disturbance of these four pinniped species by oil and gas development activities in the Bering Sea. The present study was conducted on behalf of the U. S. Department of Interior, Minerals Management Service, in anticipation of eventual oil and gas exploration and development on the Outer Continental Shelf of the eastern Bering Sea. The purpose of this study was to provide an up-to-date and comprehensive synthesis of available information of the known and expected effects of (1) underwater noise, (2) nearby vessel traffic, (3) low-flying aircraft and (4) other associated human disturbances on major concentrations of northern fur seals, northern sea lions, harbor seals and walruses at rookeries and haulouts in the eastern Bering Sea.

Objectives

The principal objectives of this investigation were as follows:

1. Summarize the literature and compare the year-round utilization of major Bering Sea haulout sites by northern fur seals, northern sea lions, harbor seals and Pacific walruses. This objective included (a) a review of available literature on the distribution of the four pinniped species in the Bering Sea adjacent to Alaska, (b) the identification of the major haulout sites for these species, (c) an analysis of the use of major haulout sites by different age and sex cohorts, and (d) a summarization and estimation of the year-round use and relative biological value of each major haulout site to each species.

2. Summarize and quantify available information on the effects of industrial disturbances on the four major species being studied. This objective included (a) a summary and comparison of available information on the immediate and long-term effects of acoustic and visual disturbance on individuals and on concentrations (haulout sites) of the four species of pinnipeds, (b) a discussion of the applicability of information available for other pinniped species, and (c) a review of responses of marine mammals to various acoustic stimuli.

3. Based on data obtained in 1 and 2 above, estimate the relative vulnerability of the major haulout sites to industrial disturbances.

4. Assess whether disturbance to specific haulouts may have population-level effects on the above mentioned four species.

5. Conduct an analysis of the acoustic environment of representative pinniped haulout sites.

Study Area

The study area for this project is the Bering Sea adjacent to Alaska (Fig. 1) including the mainland coast from Cape Prince of Wales in the north to Cape Krenitzin at the tip of the Alaska Peninsula, in the south. It also includes all of the islands in the Bering Sea from Little Diomede Island in the north (in Bering Strait) to Unimak Island and the Fox Islands in the eastern Aleutian chain. Umnak Island is the most westerly island considered in detail in this review.

Some information from haulout sites on the Pacific Ocean sides of some of the Fox Islands (i.e., Ugamak I., Aiktak I.) are also considered. In general, however, we have restricted our investigations to haulout sites on the Bering Sea sides of the eastern Aleutian Islands.

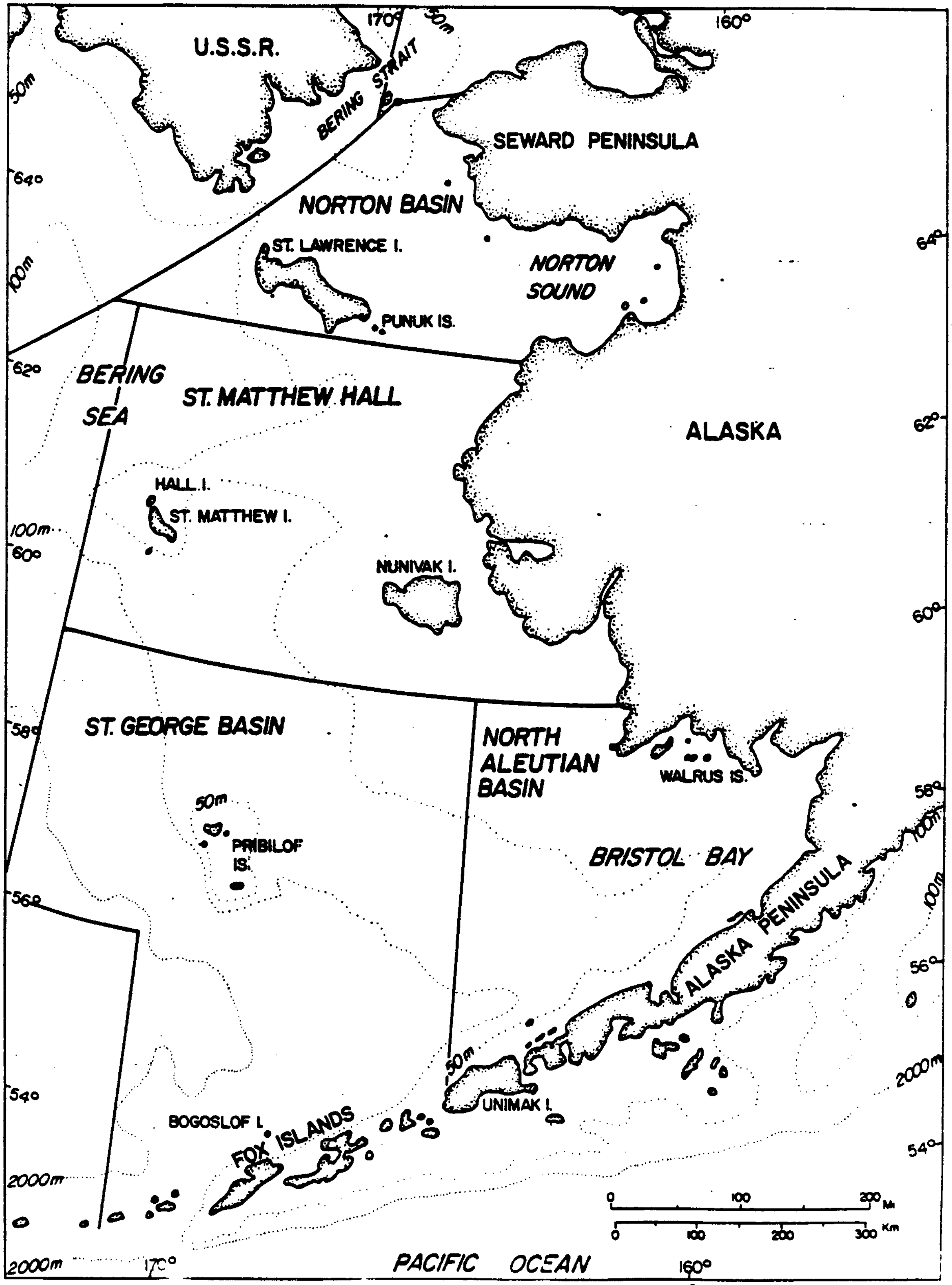


Figure 1. Map of Bering Sea, Alaska study area showing OCS planning areas.

METHODS

Terminology

Throughout this report we use the terms 'haulout site', 'rookery', and 'hauling ground' or 'haulout'. These terms refer to any site where pinnipeds traditionally haul themselves out of the water; however, the terms are not used synonymously. Haulout sites are composed of 'rookeries' and 'hauling grounds' (or 'haulouts'), which serve different biological functions for northern fur seals, northern sea lions, and other eared seals.

For northern fur seals, rookeries are areas generally near the water where females have their pups, where males and females congregate to breed, and where pups are raised. Hauling grounds are generally located near the rookeries but are more inland, and are occupied by non-breeding individuals during the breeding season. Some adult males may move to hauling grounds after the breeding season.

Similar to northern fur seals, northern sea lions give birth, nurture their pups, and breed at traditional, well established rookeries. Hauling grounds are often adjacent to the rookeries and are occupied by non-breeding or "bachelor" males (3+ years of age), and later by harem bulls. Bachelor bull northern sea lions aggregate at hauling grounds and spend much of their time mock-fighting or making occasional trips into the rookeries where they are chased by resident males. Unlike fur seals, northern sea lions haul out throughout the year, rather than only during the breeding season. In the present report we make a distinction between northern sea lion rookeries (breeding/pupping areas) and haulouts.

Harbor seals often congregate to feed and give birth at traditional sites, but these sites do not fit the definition of a rookery as described above, i.e., where males have well established territories in which females are defended and bred, and pups are born.

Walrus (mainly males in the present study) haul out at traditional terrestrial sites in the study area, but these sites are not rookeries; few females are present at terrestrial sites in the Bering Sea except in the far north during late fall. During this period, males may fight over females, but virtually all breeding and pupping occurs in the pack-ice during late winter through spring. The 'Glossary' provided in Appendix 9 gives more details and documentation of terminology used in this report.

Review and Summary of Information on Pinniped Populations and Disturbance

Initially we conducted a search of data bases such as ASFA (Aquatic Sciences and Fisheries Abstracts), ASTIS (Arctic Science and Technology Information Service), BIOSIS Previews (Biological Abstracts) and NTIS (National Technical Information Service). We also conducted thorough searches for relevant information in libraries at (1) the U. S. National Marine Mammal Laboratory (Nat. Mar. Fish. Serv., NOAA, Seattle, WA), (2) the Pacific Biological Station (Dept. Fish. and Oceans, Nanaimo, B.C.), (3) the University of British Columbia, Vancouver, B.C., (4) the various offices of LGL Limited (King City, Ontario; Sidney, B.C.) and LGL Alaska Research Associates (Anchorage and Fairbanks, Alaska), (5) office and staff libraries of the U. S. Fish and Wildlife Service in Alaska (Anchorage, Fairbanks, King Salmon, Cold Bay, Dillingham) and (6) office and staff libraries of the Alaska Dept. of Fish and Game (Anchorage, Fairbanks, King Salmon, Dillingham, Nome). Important sources of valuable information for this study have been personal communications from people who are currently working or have in the past worked extensively with pinnipeds in the Bering Sea and elsewhere.

We summarized pinniped population information for each major haulout site, i.e. with a few exceptions, a site where at least 1% of the total population had been recorded since 1950. Since populations of some species have fluctuated greatly in the past 2-3 decades, and no doubt will continue to do so in future years, we decided that it was not justifiable to exclude a haulout site because it had not been used in the past 10 years.

Counts at haulout sites may be influenced by a large number of factors, e.g., time of year, time of day, weather conditions, visibility, type of observation platform (aircraft, ship, boat, land), count procedure, observer ability, disturbance levels at sites, and nature of survey (opportunistic or otherwise). Counts at some sites on the same day may fluctuate from several thousands (or tens of thousands) of individuals to virtually none. As noted in most summary tables in this report, counts of northern sea lions, harbor seals and Pacific walruses are from many different sources, and many data have not been collected in a systematic or consistent manner (data for the northern fur seal are an exception). For this reason, in our main summary tables we present peak counts at each site for each of the four decades since the 1950's (Frost et al. 1983 used a similar approach), as well as the most current count and year of most current count for each site; details of all other individual counts are given in Appendices 6 through 8. In many cases, the most current count is often significantly lower than the peak count for the 1980's (because of recent regional population declines). When available, we give a breakdown by age and sex.

Inter-site Population Sensitivity Index (IPSI)

The importance and vulnerability to disturbance, i.e. the sensitivity of each haulout site used by each of the four species, was computed and an Inter-site Population Sensitivity Index (IPSI) was generated for each site using a series of variables or factors related to (1) the location and major physical characteristics of the haulout site being considered, (2) the status, composition and trend in numbers of the population being considered, and (3) the species being considered and its general response to disturbance (based on the literature). These variable factors and the way they fit into the Inter-site Population Sensitivity Index (IPSI) are described in more detail below.

The eight variables associated with each species and each site were ranked on an integer scale (1 through n) according to the total number of sites (n) considered for the species in question. Where variables (or factors) at two or more sites were of equal importance, they were treated as ties (ranked equally). In instances where two factors were highly interdependent, they were pooled into a single complex factor in order to reduce bias. It should be pointed-out, however, that most of the variables considered in this analysis were to some degree dependent on one or more of the other variables; it was not possible to eliminate all redundancy and/or bias in this ranking procedure. Thus, because of inherent unavoidable biases, the evaluation procedures that we used should not be considered a rigorous statistical treatment.

A mean rank was computed from the rank scores for each site. These means were then ranked again to determine the overall Inter-site Population Sensitivity Index (IPSI) for each site considered. For example, if there were 25 haulout sites described for a particular species of pinniped, then the site with the lowest overall mean rank (based on currently available information) had the highest IPSI score--i.e., was considered a site where severe disturbance could cause population-level effects.

Important variables or factors considered in evaluating each site were as follows:

1. The peak count of a particular species of pinniped recorded at a site since 1980. This peak emphasizes the most current counts (1980's count and the most current count) at a particular site. Peak count data for northern fur seal, northern sea lion, harbor seal and Pacific walrus are from Tables 3, 5, 6 and 7, respectively.

2. The mean maximum number of animals recorded at a site during the past three decades and during the most recent count at the site. This provides an indication (but only an indication) of the degree of use of the site over the past 30 years. The values given in Tables 8 through 11 are based on the average of peak counts for each of the 1960's, 1970's, 1980's, and the most current count at the sites given in Tables 3, 5, 6 and 7. Data from the 1950's, although presented in many of the review tables in order to provide historical perspective, have not been included in the evaluation scheme.

3. The proportion of the current total estimated Bering Sea population present at a particular site. A site that supports a large percentage of the population is considered more important than a site that supports only a small percentage. The values given in Tables 8 through 11 are the proportions based on current counts, i.e., the most current count recorded since 1980 and the most recent population estimate given in Tables 3, 5, 6 and 7, respectively.

4. Age and sex composition, and the kinds and amount of behavioral activities that have been recorded at a site. A large and complex site that is used for pupping and nursing, and for breeding was considered to be more important to a species and potentially more sensitive than a small site or a site used only for resting, or only by subadults. This factor therefore actually includes several important variables--(1) age/sex composition and complexity of the site, and (2) behavior--and both are highly interdependent. Information on the age/sex composition (and thus behavior), and complexity (number of subdivisions and areal extent) of the site are given in Tables 3, 5, 6 and 7, and in Figures 13, 14, 15 and 16, respectively.

5. Duration of use of a haulout site. A site that is used for a large part of the year is considered to be more important and more vulnerable than a site used only intermittently (e.g., only during migration). Since sites that are used for a large part of the year often are the rookeries, where various age and sex classes and a variety of different behaviors are exhibited, this variable is obviously related to several of the other variables. Duration of use was computed for each species using information given in the literature; e.g., Table 2 for northern fur seal where virtually all sites have rookeries and are occupied for about seven months (0.583 yr). Only some northern sea lion sites are rookeries or are near rookeries, which are occupied for an extensive period (0.500 yr, Table 3). Other southern Bering Sea sites may be used for about 0.250 yr and more northerly sites are used for only 0.167 yr (see Table 9). Harbor seal sites are also occupied for various durations depending on their geographic location and the average position of the ice front during winter. Southern sites are occupied by seals all year while the northerly sites are occupied for only about six months (0.500 yr, Table 10). Similarly, Pacific walrus occupy sites for various periods depending on the sex and age composition of the animals and the location of the site (Table 11). Southern sites are used almost exclusively by males for periods ranging from 2 to 7 months (0.167 to 0.580 yr). Northerly sites may be used by all ages and sexes for periods ranging from 2 to 4 months (0.167 to 0.333 yr).

6. Consistency of use of a haulout site. A site that is used every year is considered to be more important and more vulnerable than a site that is used only sporadically. Rookeries are used most consistently from one year to the next; thus, there is a strong relationship between consistency of use of a site and the age/sex classes, behaviors and duration of use of a site. Consistency of use of a site is determined by the frequency with which animals are recorded at sites during different surveys over a period of years.

7. Site characteristics, i.e., the physiography and associated susceptibility of the site to disturbance. This factor is based on the major physical characteristics of the site, e.g., the substrate, vertical relief, bathymetry, etc., in the immediate vicinity of the site, and its proximity to sources of disturbance. Any site located within 5 km of a source of noise or disturbance (shipping lanes, airports and/or air traffic lanes, settlements, etc.) was ranked high

in our evaluation scheme. Other sites not located close to noise or disturbance sources were ranked in accordance with the physical characteristics of the site.

8. Species characteristics, i.e., susceptibility of a species to disturbance. This factor is based on how the species responds to disturbances of different types (based largely on the literature presented in this report). It is dependent to a degree on the composition (age/sex, behavior) of the animals present at the site, how that segment of the population is affected by disturbances, and whether or not there is a high, medium or low probability of mortality as a direct or indirect result of noise/disturbance. Species that are known to have suffered mortality as a result of noise/disturbance (e.g., Pacific walrus, northern sea lion, harbor seal) were ranked high, and others (e.g., northern fur seal) were ranked lower (Tables 8 through 11).

Analysis of the Acoustic Environment

We also conducted a separate analysis of the acoustic environment of eight haulout sites (see Appendix 1). These sites were considered to be representative of those used by each of the four pinniped species considered in the present study. The physical conditions (location in the study area, proximity to noise sources, site substrate, slope of beach and sea bottom, bottom type), and pinniped use of these eight sites were included in our selection criteria. The analyses included investigations of the following topics:

1. Characteristics of airborne and underwater ambient noise.
2. Characteristics of industrial noise sources, including aircraft, small boats, fishing trawlers and commercial cargo traffic.
3. Sound transmission loss in air, water and through the air-water surface.

The ambient noise characteristics of the sites were estimated using data obtained from studies of similar areas. The noise source characteristics were obtained from data reported in the literature and data in the archives of BBN Systems and Technologies Corporation. Transmission loss characteristics for airborne and underwater sound were estimated using standard analytical procedures and computer models (see Appendix 1). An analytical procedure was developed for prediction of transmission of sound from aircraft into shallow water, since an existing procedure was not available. Procedures are described for using the information obtained in this study to predict noise exposure levels and to develop 'zone-of-influence' estimates for the various species of concern. All of these procedures are described and discussed in detail in Appendix 1.

RESULTS

The following results are presented in several sections, in accordance with the general objectives of the study. The first sections give descriptions of important background life-history information about each of the four species, information about patterns of occupancy and history of use of key haulout sites, and information about the location and status of haulout sites for each of the four species in the eastern Bering Sea. Later sections (1) review information on the effects of disturbance and noise on pinnipeds, and (2) review information on acoustic processes that may be relevant to OCS development near pinniped haulout sites in the eastern Bering Sea (Appendix 1). Specific descriptions of the physical characteristics and maps of each major haulout site are given in Appendices 2 through 5.

Northern Fur Seal (Callorhinus ursinus L.)

Background

The northern fur seal belongs to the family of eared seals (Otariidae); it is a medium-sized pinniped with adult bulls in prime condition on their breeding territories measuring about 2-3 m in length and weighing between 135 and 280 kg. Northern fur seals remain at sea for most of the year, often far from shore along the continental shelf and slope. The distribution of northern fur seals in the Pacific is from the Bering Sea to Southern California and Japan (Fowler 1985, In press). Figure 2 shows the general distribution of this species in the eastern Bering Sea.

No individual fur seal older than a neonate spends longer than 60-70 days of the year on shore (Gentry 1981). Males reach sexual maturity by about 6 years of age and females by 4-5 years of age; they give birth to a single pup (very rarely twins) weighing 4.5-5.5 kg each year. Adults may live to be almost 25 years of age (Fowler 1985, In press).

Northern fur seals are the most abundant marine mammal in the Bering Sea, but recent declines have occurred throughout its range. The current worldwide population of 1,173,000 is significantly less than the 1,765,000 individuals

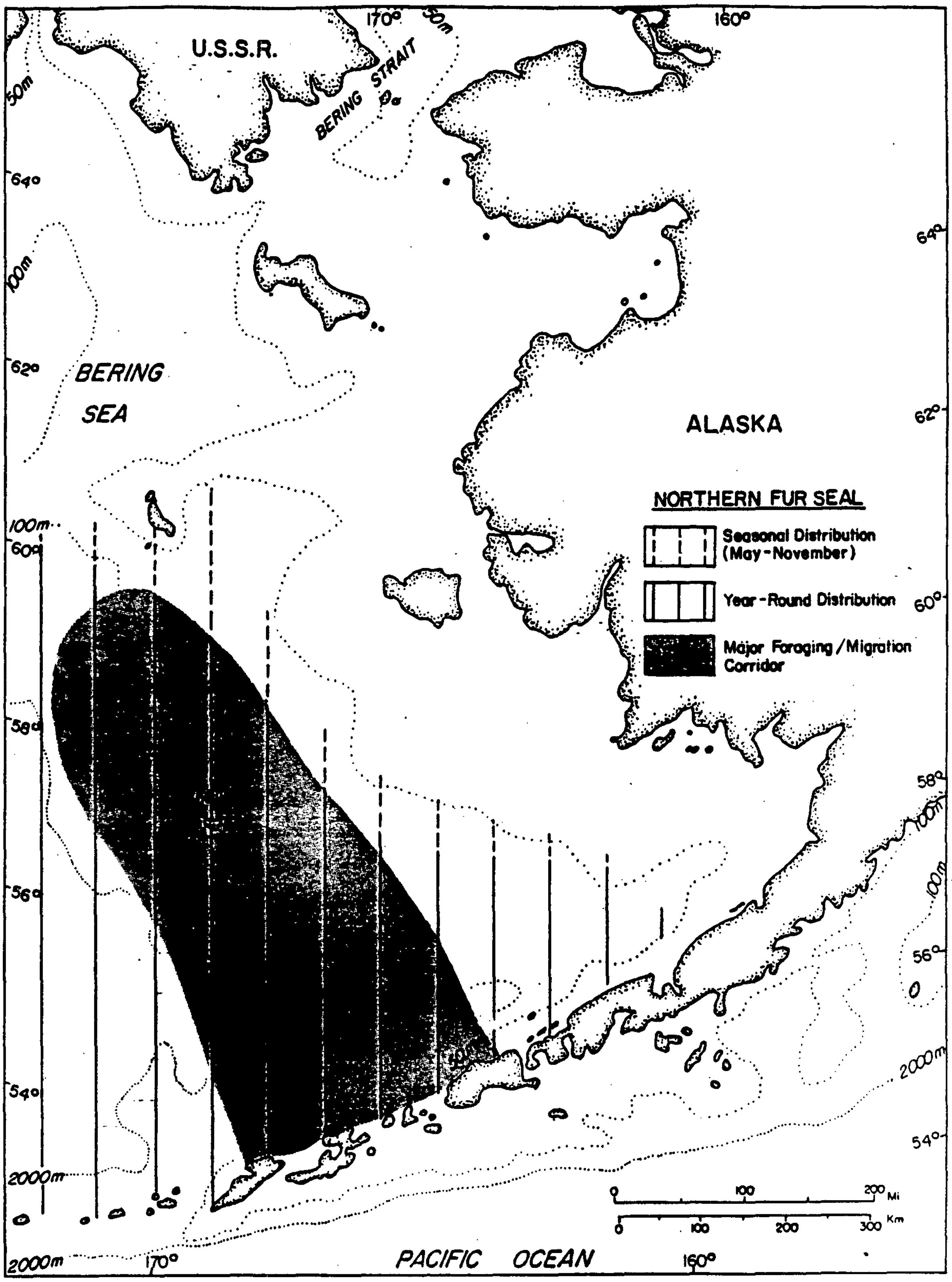


Figure 2. General distribution of the northern fur seal in the Bering Sea, Alaska.

reported in the mid 1970's by Lander and Kajimura (1982). Similarly, the number of fur seals estimated on the Pribilof Islands has declined from 1.3 million in the mid-1970's (Lander and Kajimura 1982), to 0.9 million in the mid-1980's (North Pacific Fur Seal Commission 1984, cited in Bigg 1986:383), to the current estimate of about 0.8 million individuals. This represents a decline since the mid- to late 1970's of about 4-8% per year (average = 6.1%; Fowler 1985). Recent studies indicate that the decline may in part be the result of increased mortality of younger age classes through entanglement in abandoned and lost fishing gear and other debris (Fowler 1984, 1985, 1987, In press; Yoshida and Baba 1985). Because of the decline, the National Marine Fisheries Service recently (May 1988) listed the Pribilof Islands population of northern fur seals as a 'depleted species' under terms of the Marine Mammal Protection Act of 1972 (MMPA).

Fur seals come ashore at several important locations in the North Pacific, Bering Sea and Sea of Okhotsk, though mainly during and after the breeding season (May-November). The distribution of northern fur seal haulout sites (rookeries and hauling grounds) in the eastern Bering Sea is limited to the Pribilof Islands including Sivutch (also known as Sea Lion Rock) and Bogoslof Island (Fig. 3 and Appendix 2) which are used by about 70-74% of the world population of this species. This relatively restricted distribution of haulout sites is thought to be related to nearby oceanographic features. Lloyd et al. (1981) speculated that the feeding habitats of all fur seals, not just those in the Bering Sea (Perez 1979, Perez and Bigg 1980), consist of the outer continental shelf and oceanic domains, and that "only islands in or immediately adjacent to the [very productive and food-rich] outer shelf domains are suitable for fur seal rookeries."

Patterns of Occupancy at Haulout Sites

Bigg (1986) conducted a detailed investigation of the rather complex patterns of arrival and departure of northern fur seals at haulout sites on St. Paul Island in the Pribilofs (see discussion above). Arrival and departure patterns on St. Paul probably are also representative of arrival and departure patterns on St. George Island, also in the Pribilofs (M. Bigg, pers. comm. 1987). Northern fur seals occupy haulout sites at different times depending on

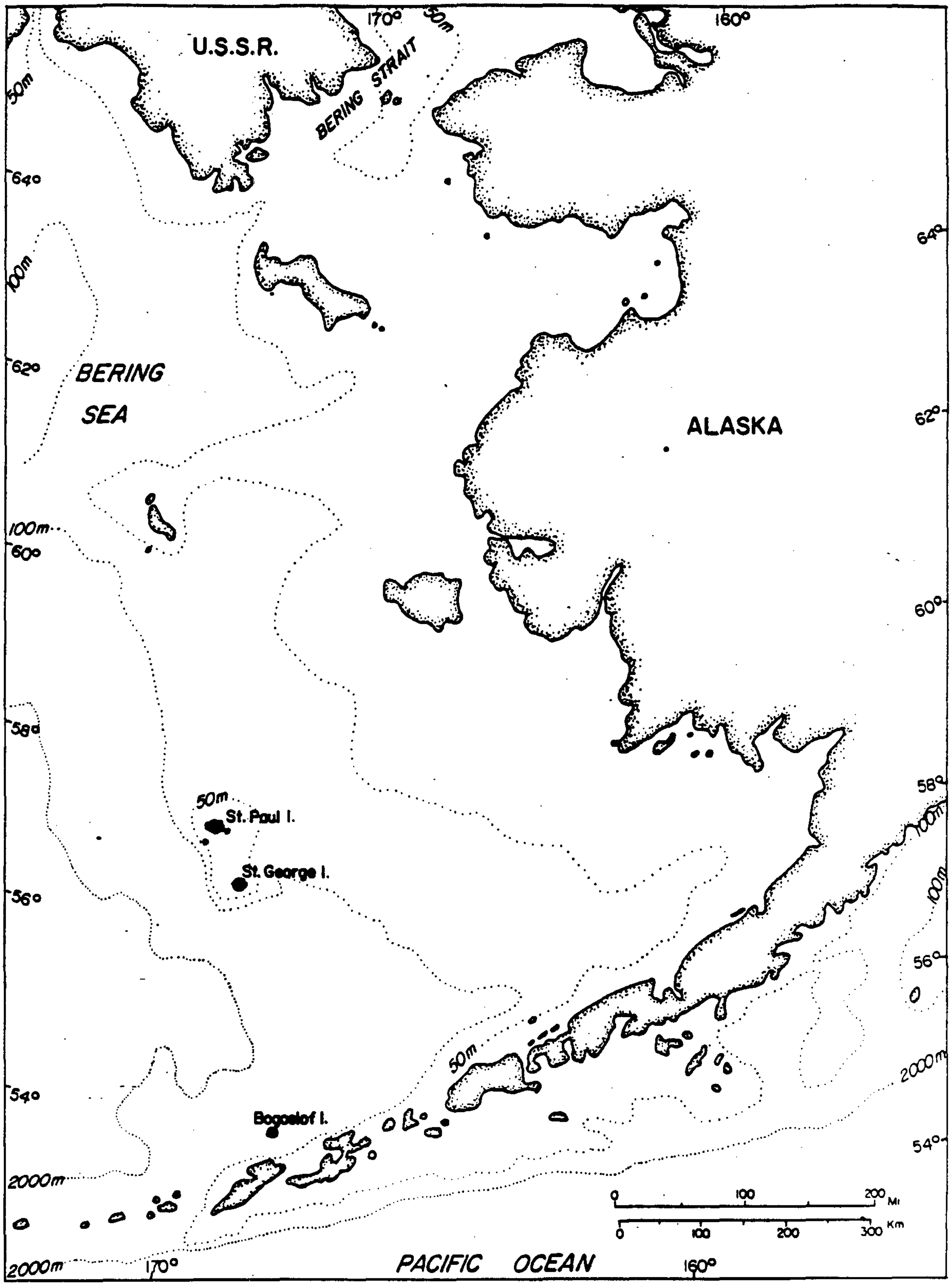


Figure 3. Locations of northern fur seal haulout sites in the Bering Sea, Alaska.

their sex and age. In general, the oldest and strongest bulls return first, followed by younger bulls and adult females, followed by even younger bulls and females (Table 1). The first bulls begin arriving at Pribilof Island rookeries in early to mid-May and usually abandon their territories by mid-August. Pregnant females begin arriving in mid-June. Females usually give birth within a day of arriving at the rookery, but it is not unusual for some females to give birth up to three days after arriving. The peak of pupping is in early July (Fiscus 1986). Pups are nursed until the female breeds 5-6 days after giving birth (Gentry and Holt 1986). Females then return to sea to feed for several days (mean 3.5 days, Loughlin et al. 1987). This is the first period of feeding by females after their arrival at the rookery. The female continues to come and go to and from the rookery for about 120 days (Gentry and Holt 1986). She travels to sea for periods averaging 5.7 days in July and 7.3 days in August; each feeding period is followed by two days of nursing (mean 1.9-2.2 days according to Loughlin et al. 1987 and Gentry and Holt 1986,

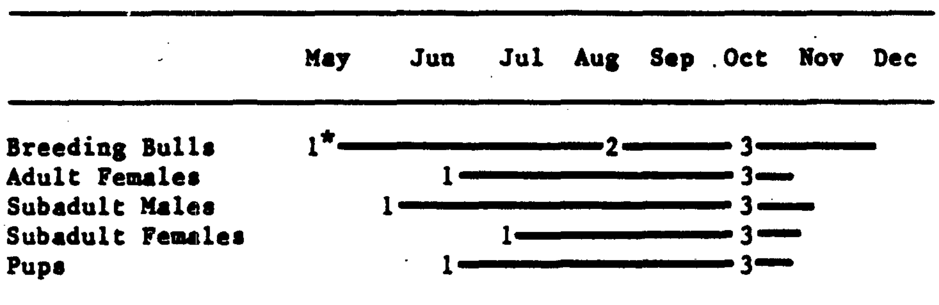
Table 1. Summary of the timing of arrival of hauling grounds and rookeries by northern fur seals of different ages and sexes, St. Paul Island, Bering Sea, Alaska (from Bigg 1986).

Sex	Site*	State**	Age	Date of Last Arrival***	Abundance
Male	R	-	1	Late Sep to early Oct	Few
	HG	-	2	Mid-to late Aug	2 yr >1 yr
	HG	-	3	Late Jul	3 yr >2 yr
	HG	-	4	Mid-Jul	all
	HG	-	5	Late Jun to early Jul	all
	HG	-	6	Late Jun	all
	R	-	>7	Late Jun	all
Female	R	NP	1	Oct to early Nov	Few
	HG,R	NP	2	Mid-to late Sep	2 yr >1 yr
	HG	NP	>3	Mid-Aug	3 yr >2 yr
	HG	P	>4	Mid-Aug	all
	R	P	>4	Mid-Jul	all

* R = rookery; HG = hauling ground.
** NP = not pregnant; P = pregnant.
*** Date when essentially all seals have arrived.

respectively). This process continues until the pups are weaned. Adult females start to leave the rookeries in early October (Gentry 1981) and departure continues into November (Table 2). Pups first enter the sea at about 4-6 weeks of age, but may remain at the rookery until early November (Fiscus 1986).

Table 2. A summary of the occupancy of haulout sites on the Pribilof Islands, Bering Sea, Alaska, by different age and sex classes of northern fur seals.



* '1' in the time line indicates the approximate earliest dates of arrival, '2' indicates the approximate date of abandonment of territories by adult bulls and breakdown of the social structure of the rookery, and '3' indicates the beginning of the departure of fur seals from the islands and the start of the southbound migration.

The 3 to 5-year-old males begin to haul out on the hauling grounds in late June, and younger animals continue to arrive well into September. The latest arrivals include many 2-year-olds. Although most yearlings remain at sea and do not return to haulout sites, a few yearling females may make brief visits to the periphery of rookeries or hauling grounds as late as early November.

Location and Status of Northern Fur Seal Haulout Sites

Pribilof Islands

St. Paul Island. There are 14 distinct haulout sites (rookeries with associated hauling grounds) on St. Paul Island (Table 3; Appendix 2; Kozloff 1985). The history of use of these haulout sites (Table 3) shows a general decline in the number of breeding bulls and pups since the 1950's. The most

Table 3. Peak numbers of northern fur seals at major haulout sites (all are rookeries) in the Bering Sea, Alaska.#

Haulout Site (Rookery)	19 50's*		19 60's*		19 70's*		19 80's**		Current	
	Breed. Bulls	Pups Born	Breed. Bulls	Live Pups	Breed. Bulls	Live Pups	Breed. Bulls	Pups (Est.)†	Breed. Bulls	Pups (Est.)†
St. George Island	1958*		1961*	1966*	1979*	1973*	1984**	1984**	1986**	1986**
Zapadni	370		363	8970	182	6821	157	5393	140	4809
South	276		335	7574	210	11164	247	8484	200	6870
North	985	No	1235	26507	674	19987	593	20370	599	20576
East Reef	212	Data	169	2645	132	2922	96	3298	92	3160
East Cliffs	350		366	10208	282	10290	279	9584	282	9687
Staraya-Artil	426		375	8854	236	6540	101	3469	81	2782
SUBTOTAL	2619		2843	64758	1716	57724	1473	50598	1394	47884
St. Paul Island	1959*	1955*	1961*	1961*	1978*	1975*	1984**	1984**	1987**	1987**
Lukanin	219		231	w/Kitovi	120	5704	119	4088	76	2611
Kitovi	600		609	24005	282	12965	236	8107	219	7523
Gorbatch	856		842	17103	810	17038	358	12297	280	9618
Ardiguen	119	No	153	w/Reef	93	2774	55	1889	57	1958
Reef	1663		1825	69246	455	27561	526	18068	427	14667
Morjovi	791		878	27628	518	21284	361	12400	245	8416
Vostochni	1568	Specific	1898	19899	1093	41356	811	27858	570	19579
Little Polovina	331		341	8794	107	3415	46	1580	19	653
Polovina Cliffs	740		870	w/Polovina	569	24870	404	13877	318	10923
Polovina	291	Data	356	21663	126	4355	70	2405	56	1924
Tolstoi	973		1149	34885	719	31108	614	21091	483	16591
Zapadni Reef	258		277	5850	203	7223	210	7213	145	4981
Little Zapadni	583		666	13294	519	21168	367	12606	280	9618
Zapadni	1011		1068	42102	882	36815	626	21503	443	15561
SUBTOTAL	10003	461000	11163	284469	6496	257636	4803	164982	3618	124623
Sivutch			1968* 166	1966* 17922	1979* 470	1970's†† 20000	1980's• 582	1980's†† 20000	1980's• 582	1980's†† 20000
Bogoslov Island	No Data	No Data	No Data	No Data	No Data	No Data	1980** 1	1980** 2	1984** 7	1984** 14
GRAND TOTAL	12622	461000	14172	367149	8682	335360	6859	235582	5601	192521

\# Note: data in this table are from many different years and may not have been collected in a systematic manner.
* 1950's, 1960's and 1970's data are from Lander (1980).
** 1980's and 'Current' data are from Lloyd et al. (1981), Kozloff (1986) and NMFS files.
† Estimates of pup production are based on the ratio--Breeding Bulls : Pups = 1 : 34.35 (Kozloff 1986:11).
†† Recent annual pup production on Sivutch (Lander and Kajimura 1982:322).
• Est. of recent annual Breeding Bulls on Sivutch are based on the ratio - Breeding Bulls:Pups =1:34.35 (Kozloff 1986:11).

current estimates indicate that about 124,500 pups (plus at least the same number of adult females) and about 3600 harem bulls used these 14 haulout sites during 1987 (NMFS file data).

Sivutch. This haulout site is located on a small island about 0.5 km S of St. Paul Island (S of the rookery at Reef; Appendix 2). Jordan and Clark (1898) reported about 6000 fur seals during investigations there late in the last century, and Lander and Kajimura (1982) indicated that the rookery at this haulout site produces about 20,000 pups each year.

St. George Island. There are six distinct haulout sites on St. George Island (Appendix 2; Kozloff 1985). A decline in the number of breeding bulls and pups similar to that recorded on St. Paul Island is also evident on St. George Island (Table 3). The most current estimates indicate that about 48,000 pups (plus at least the same number of adult females) and about 1400 harem bulls used these 6 haulout sites during 1986 (NMFS file data).

Bogoslof Island

Bogoslof Island is volcanic in origin; it rose from the sea about 65 km north of Umnak Island in the eastern Aleutians on 18 May 1796 (Orth 1967, Byrd et al. 1980; see Appendix 2). Today it is about 1.5 km long, and supports a very small number of reproductively active northern fur seals (Table 3). Nevertheless, the number of fur seals using this haulout site has grown since 1980 (Lloyd et al. 1981). The most current estimates indicate that 14 northern fur seal pups (plus the same number of adult females) and 7 harem bulls used this site during 1984 (NMFS file data) .

Northern Sea Lion (Eumatopias jubatus Schreber)

Background

The northern or Steller sea lion belongs to the family of eared seals (Otariidae). The northern sea lion is the largest of the eared seals, with some bulls exceeding 3 m in length and 1000 kg in weight. This species breeds along the west coast of North America from the southeastern Bering Sea and the

Aleutian Islands to southern California. It also breeds in Asia on the Kurile Islands, in the Sea of Okhotsk and on the Kamchatka Peninsula (Gentry and Withrow 1986, Loughlin et al. 1987; Hoover 1988a). Major breeding concentrations of this species in North America occur mainly in the northwest Gulf of Alaska and the Aleutian Islands; Forrester Island, off SE Alaska, is also a major rookery. Figure 4 shows the general distribution of this species in the eastern Bering Sea.

Similar to fur seals, the birth and the nurturing of pups and breeding by northern sea lions occurs on traditional, well established rookeries. As mentioned earlier, however, northern sea lions may haul out throughout the year (at different sites), rather than only during the breeding season. Nevertheless, there are definite seasonal peaks in haulout activity.

The annual distribution of northern sea lions is such that more males are seen along the north coast of North America during winter than during summer; individuals from California migrate northward during winter and return south in summer. Similarly, juvenile males from haulout sites in the Aleutian and Pribilof islands migrate north into the central and northern Bering Sea in late summer, then return south as ice begins to form.

The maximum size of the northern sea lion population for the 1974-1980 period was estimated to be about 290,000 individuals (some pups included); more than 196,000 (67.6%) of this total were counted in Alaska (Loughlin et al. 1984). The numbers of northern sea lions counted in Alaska during 1974-1980 apparently was unchanged since surveys in 1956-1960 by Kenyon and Rice (1961) and Mathisen and Lopp (1963). However, there had been a significant shift in their distribution. Fewer sea lions were using haulout sites in the eastern Aleutians (Braham et al. 1980), and more were using haulout sites in the central and western Aleutians (Fiscus et al. 1981). Since 1980 there have been further significant declines in the number of northern sea lions at most sites in Alaska.

The area from the central Aleutian Islands (Kiska Island eastward) to the central Gulf of Alaska (Sugarloaf and Marmot islands, north of Afognak Island) has been studied more systematically than most other areas of Alaska (see

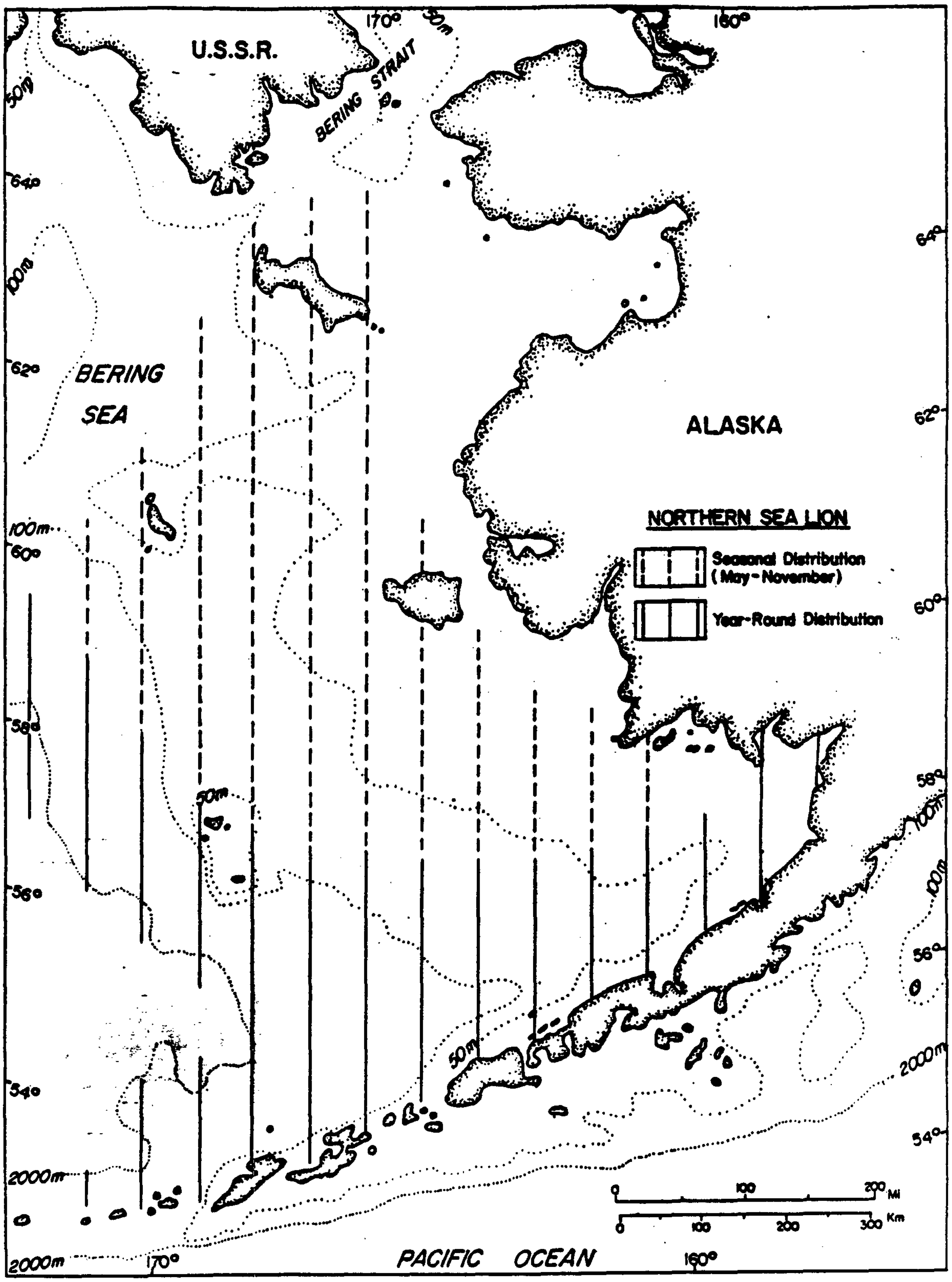


Figure 4. General distribution of the northern sea lion in the Bering Sea, Alaska.

Merrick et al. 1987), and best shows the recent declines in numbers. About 140,000 northern sea lions were counted in this area in 1958. Several different indicators confirmed that by 1985 the number had declined to less than 68,000; this represents a reduction of about 52% in 27 years or about -2.7% per yr (Merrick et al. 1987).

It is suspected that these declines may have occurred in two phases. The first decline probably was confined to the eastern Aleutian Islands and western Gulf of Alaska, and likely began in the early 1970s; it has not been possible to determine rates of decline earlier than 1969. Nevertheless, counts in the Central Aleutians to the Central Gulf of Alaska region as a whole declined by about 25% (-1.6% per yr) between 1958 and 1977 (Merrick et al. 1987). The second phase of the decline has occurred since 1977; all areas were apparently affected and the overall reduction in numbers was about 36% (-5.2% per yr) during this 8-yr period (Merrick et al. 1987). Results of counts at major haulout sites indicate that reductions may still be occurring in the southeastern Bering Sea as well as in the eastern Aleutian Islands and Gulf of Alaska.

Compared to the information available for northern sea lions in the Aleutian Islands and Gulf of Alaska, records for Bering Sea rookeries and haulout sites are less comprehensive. However, data given in Frost et al. (1983) indicate that significant declines in the numbers of northern sea lions also have occurred at Walrus Island and Dalnoi Pt. in the Pribilofs, and at Sea Lion Rock near Amak Island (North Aleutian Shelf).

The ultimate causes of the decline in the northern sea lion population in Alaska are unknown (Merrick et al. 1987). However, it has been postulated that disease (possibly Leptospira), changes in prey resources, mortality through shooting, and possible entanglement in nets and other debris may all be contributing factors. Some evidence suggests that changes in the quantity and size of walleye pollock (Theragra chalcogramma), the principal prey of northern sea lions, may be a significant factor in the decline (Frost and Lowry 1986, Loughlin 1987, Bakkala et al. 1987).

Patterns of Occupancy at Haulout Sites

Northern sea lions occupy haulout sites at different times depending on their sex and age. In general, the oldest and strongest bulls return to rookeries first, followed by adult females. The first bulls begin arriving at Aleutian Island rookeries in mid-May. They usually begin to abandon their territories in mid-July and move to nearby hauling grounds by mid-August (Table 4). Some pregnant females also begin arriving at rookeries in mid-May; pupping usually occurs within 2-3 days of arrival. Although pups are born at Alaskan rookeries from mid-May through mid-July, the peak of pupping is during the 10-20 June period (Calkins 1985).

Table 4. A summary of the occupancy of haulout sites on the Eastern Aleutian Islands and SE Bering Sea, Alaska, by different age and sex classes of northern sea lions.

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Breeding Bulls	1*	—	—	2	—	3	—	—
Adult Females		1	—	—	—	3	—	
Subadult Males	1	—	—	—	—	3	—	—
Subadult Females			1	—	—	3	—	
Pups		1	—	—	—	3	—	

* '1' in the time line indicates the approximate dates of arrival at rookeries, '2' indicates the approximate date of abandoment of territories by adult bulls and breakdown of the social structure of the rookery, and '3' indicates the beginning of the departure of sea lions from their haulout sites in the study area.

Pups begin nursing almost immediately after birth, and are nursed until the female breeds again, usually within two weeks of pupping. Females stay ashore with their pups for an average of 6.7 days (± 2 days) before making their first feeding trip to the sea (Higgins et al. 1988). This is the first period of feeding by females after they arrive at the rookery. They assume a schedule of feeding at night and suckling their young during the day. At about 14 days of age pups first enter the sea; for about two weeks they restrict their swimming activity to littoral zone pools (Sandegren 1970). Each day they spend more time in the water, and eventually join their mothers on 'tours' of deeper waters adjacent to the rookery. Pups are usually able to swim and dive quite well after about 28 days in pelagic waters with their mothers.

The number of sea lions at rookeries during the breeding season show diel fluctuations, with early morning lows and late afternoon highs resulting from the movement of females to and from the sea to feed (mostly nocturnally). The numbers of sea lions in some locations are also affected by tide and weather (Sandegren 1970; Withrow 1982). Calkins (1985) indicated that the areas over which sea lions forage are very broad, extending from the intertidal zone to the continental shelf break.

Males leave the rookeries immediately after the breeding aggregation breaks down in mid-July to August. Most adult females and young have left their rookeries by mid October. However, in the eastern Aleutian Islands the majority of the breeding population is still present at haulout sites through the end of October. As mentioned above, there is a general northward movement of sea lions (primarily immature bulls) into the central and northern Bering Sea. They usually occur in largest numbers on St. Lawrence Island (63°30'N) during September. In the central Bering Sea region, sea lions also may haul out on sea ice when it is present during winter and spring.

Location and Status of Northern Sea Lion Haulout Sites

There are approximately 15 rookeries and associated hauling grounds used by large numbers of northern sea lions in the eastern Bering Sea, and there are about 30 additional sites where smaller numbers have hauled out (Table 5; Fig. 5; Appendix 3). Only six of the total number of haulout sites are rookeries where more than one or two pups are born, and all but one of these sites are in the eastern Aleutian Islands or extreme southwestern part of Bristol Bay. The exception is Walrus Island, in the Pribilof Islands group (Table 5). Similar to the situation described for the northern fur seal (Lloyd et al. 1981), the locations of key northern sea lion haulout sites, especially the rookeries, may in part be determined by important oceanographic features

Table 5. Peak counts of northern sea lions at major haulout sites in the Bering Sea, Alaska.†

Haulout Sites	1950's	1960's	1970's	1980's	Current Estimate	Year of Curr. Est.
Bogoslof Island*						
Adults/Subads.	3707	2566	3300	1379	1287	1985
Pups	3106	2385	2328	–		1985
Fire Island	–	100	4	–	–	–
Unalaska Island						
Spray Cape	–	200	2	161	20	1985
Cape Starichkof	–	100	244	–	–	–
Bishop Point	–	300	501	549	549	1985
Cape Tebenkof	–	200	8	–	–	–
Akutan Island*						
Cape Morgan*						
Adults/Subads.	–	9000	5925	2840	1338	1986
Pups	1735	–	–	–	1130	1985
Akun Island*						
Billings Head*						
Adults/Subads.	–	–	2641	760	435	1985
Pups	–	–	–	–	60	1985
Akun Head	–	2008	10	–	–	–
Tanginak Island	–	600	470	–	61	1985
Tigalda Island	108	650	314	–	–	–
Rocks NE of Tigalda I.	–	750	190	225	82	1985
Ugamak Island Group*						
Adults/Subads.	14536	19400	5408	2035	1604	1986
Pups	1466	–	–	1635	1386	1986
Aiktak Island	–	600	1	0	0	1985
Unimak Island						
Cape Sarichef	–	200	4	40	128	1985
Cape Mordvinof Area	500	4000	2	–	–	–
Amak Island	3016	2000	2316	2400	599	1986
Unnamed Rocks	–	–	355	250	218	1986
Sea Lion Rock*						
Adults/Subads.	4694	4100	2530	1298	527	1986
Pups	424	–	–	–	–	–
Right Hand Point	–	–	–	50	50	1981
Hagemeister Island	–	–	150	–	0	1985
Twin Islands						
S. Twin Island	45	–	300	–	–	–
N. Twin Island	–	–	150	–	–	–
N. & S. Twin Islands	300	400	–	–	–	–
Round Island	–	0	500	1000	1000	1987
Cape Peirce	–	–	present	450	450	1981
Cape Newenham	250	–	800	1500	950	1987
Nunivak Island						
Binajoaksmiut Bay	–	–	49	–	–	–
Nalunagyagt Rock	–	–	35	–	–	–
Cape Mendenhall	–	–	–	50	50	1981
St. Matthew Island						
Sugarloaf Mtn.	–	–	–	30	30	1982
Cape Upright	–	100	–	90	90	1982
Rocks at Lunsdale Pt.	–	–	–	32	600	1983
Hall Island						
Arre Rock	–	–	–	150	150	1982
North Cove	–	–	–	75	4000	1983
S. Elephant Rock	350	–	–	–	–	–
Pinnacle Island	–	–	100	257	257	1985
Gull Islands	–	–	159	550	550	1986
St. George Island	–	1200	138	86	86	1989
St. Paul Island						
Northeast Point	490	71	50	–	–	–
Sivutch	500	500	100	–	–	–
Otter Island	1000	160	800	29	11	1984
Walrus Island*						
Adults/Subads.	3000	5000	1529	868	459	1987
Pups	3000	3000	–	304	114	1987
Otter Island	–	–	200	–	–	–
St. Lawrence Island						
Southwest Cape	–	1000	–	–	–	–
South Punuk I.	–	200	–	–	–	–
GRAND TOTAL	42222	60782	31613	19131	18371	

† Note: data in this table are from many different sources and years; they have not been collected systematically or consistently. Peak counts at different sites on the same island may be from different censuses; only counts of adults/subadults and pups at a rookery may be from the same census and may be summed. Unless otherwise indicated, counts are of adults/subadults.

Peak count data were taken from Kenyon and Rice (1961), Kenyon (1962;1965), Mathisen and Lopp (1963), Braham et al. (1980), Frost et al. (1983), Loughlin et al. (1984), Calkins (1985), Merrick et al. (1987), O'Neil and Hagglom (1987), Sherburne and Lipchak (1987), Envirosphere Co. file data, NMFS file data, USFWS file data, ADFG file data.

* Signifies that this haulout site is (or has been) a major rookery (breeding area) where a significant number of pups are (were) born. The Ugamak I. group includes Round I.

"–" signifies that no data are available.

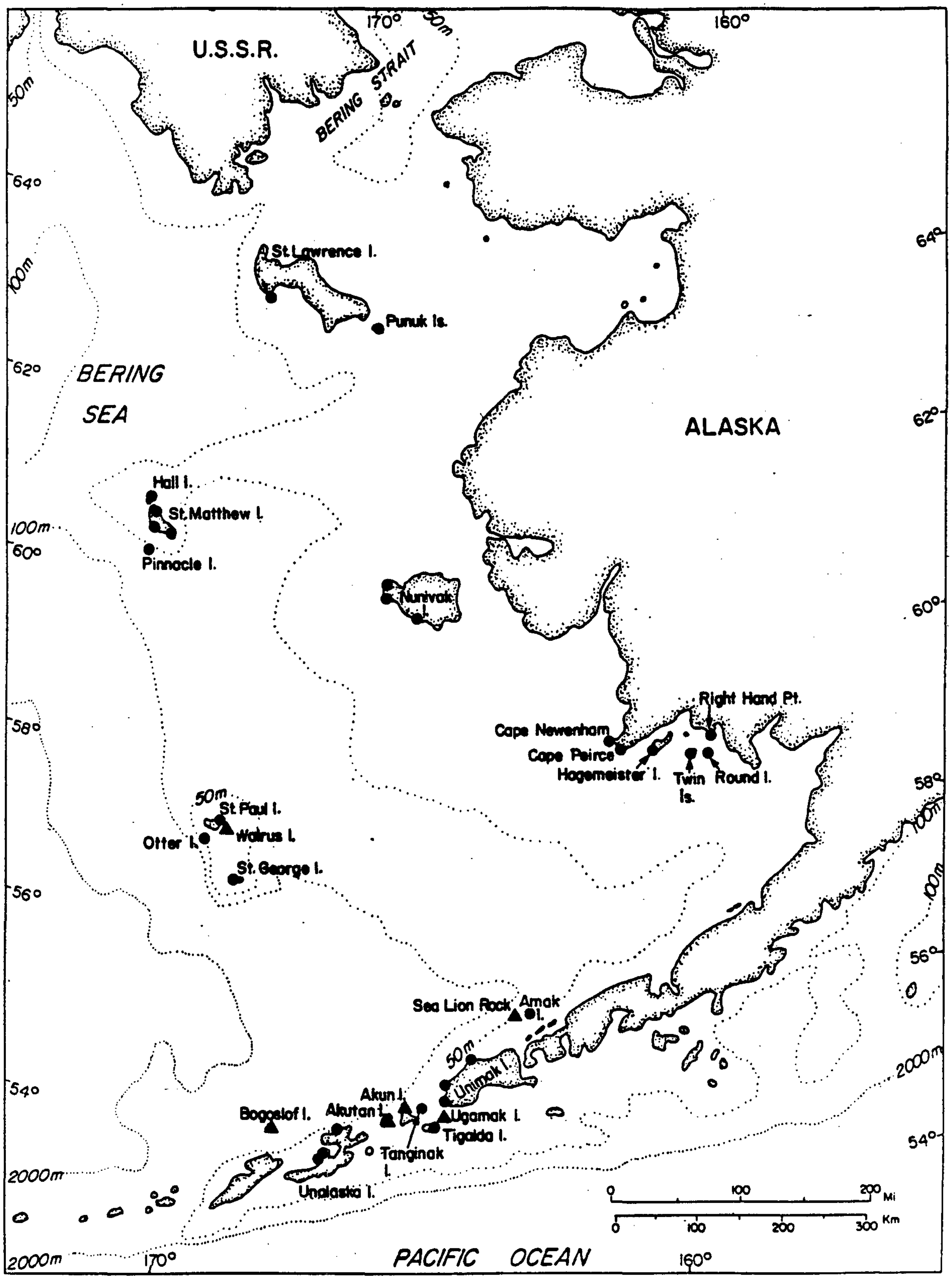


Figure 5. Locations of important haulout sites used by northern sea lions in the Bering Sea, Alaska. Sites designated by (▲) are rookeries.

which effect the distribution and abundance of principal prey (see earlier discussion of northern fur seal).

Sea lions occur irregularly and in small numbers (usually as singles) along the mainland coast of Alaska north of Cape Newenham; there are no known rookeries or haulouts used on a regular basis in this area. General comments of long-time residents indicate that single animals are known to have occurred on Besboro Island, Cape Denbigh, Cape Darby, Rocky Point, Cape Nome, Sledge Island and Cape Prince of Wales. During summer and autumn Nunivak Island is also regularly visited by relatively small numbers of northern sea lions, most of which are presumed to be juvenile males. The largest number that has been reported at any of these sites was 50 (Frost et al. 1983; Table 6.9). Lantis (in Kenyon and Rice 1961) indicated that sea lions were familiar to all of the Nunivak Island hunters, though they were not considered by them to be numerous. The sites near Cape Mendenhall and Cape Mohican are used most frequently (E. Shavings, pers. comm.).

At St. Lawrence Island, sea lions usually occur in small numbers (1-6 animals) in the autumn (Kenyon and Rice 1961). Reportedly sea lions are molting when they haul out on St. Lawrence Island. The two main haulout locations are at Southwest Cape and on South Punuk Island (F.H. Fay *in* Kenyon and Rice 1961). In one exceptional case, on 25 September 1953, Fay recorded about 1000 northern sea lions hauled out on the rocks and beach at Southwest Cape; three or four days later there were about 200 animals hauled out on South Punuk Island. Aside from this report, there have been no other sightings of more than 100 animals at haulouts in the St. Lawrence Island area. Farther north, at King and Little Diomede islands, sea lions occur irregularly, mostly as single animals during late summer and autumn.

Harbor Seal (Phoca vitulina L.)

Background

The harbor seal belongs to the family of true or earless seals (Phocidae). The distribution of the Pacific form (*Phoca vitulina richardsi*) extends as far south as the coast of Baja California and north to the Gulf of

Alaska, along the entire Aleutian Islands, and into the Bering Sea (Jeffries and Newby 1986; Hoover 1988b). Harbor seals are regularly found as far north in the Bering Sea as the Kuskokwim River mouth and Nunivak Island, and as far offshore as the Pribilof Islands where they are year-round residents (Frost et al. 1983). On the other hand, large-scale seasonal movements apparently occur in Kuskokwim Bay and northern Bristol Bay where many harbor seals are found in summer but few are found in winter when the area is largely covered with ice (Pitcher 1980; J.J. Burns, pers. comm. 1988). In general, the harbor seal is replaced north of Nunivak Island by the ice-breeding spotted seal (Phoca largha), whose pups are born much earlier and with white coats. Figure 6 shows the general distribution of the harbor seal in the eastern Beaufort Sea.

An interesting situation exists in the Pribilof Islands area where harbor seals occur in small numbers in all areas (especially when compared with the northern fur seals) except on Otter Island. Johnson (1974) estimated that about 1300 harbor seals were hauled out on Otter Island in 1974; Fiscus (cited in Johnson 1974) estimated that there were about 1500 harbor seals throughout the Pribilof Islands area. It should also be noted that the ice-associated spotted seal (Phoca largha) is abundant on the pack ice in heavy ice years when it extends as far south as the Pribilof Islands; a few of these seals, mainly pups, occasionally come ashore.

Harbor seals are more-or-less restricted to the coastal zone. Although they do not undertake regular seasonal migrations on a large scale, they are known to move considerable distances. One radio-tagged individual crossed a 75 km stretch of open water between two islands in the Gulf of Alaska. Other individuals have been seen up to 80 km from shore. Tagging studies have shown that young harbor seals move up to 250 km from their place of birth (Pitcher 1980). During the 1960's when the seals (primarily pups) were killed for the fur trade, hunters active at haulout sites on the Alaska Peninsula recognized that seals harassed and displaced from one site would move to another (e.g., from Port Heiden to the Seal Islands). Also, some harbor seals move northward along the Alaska mainland during summer and early autumn.

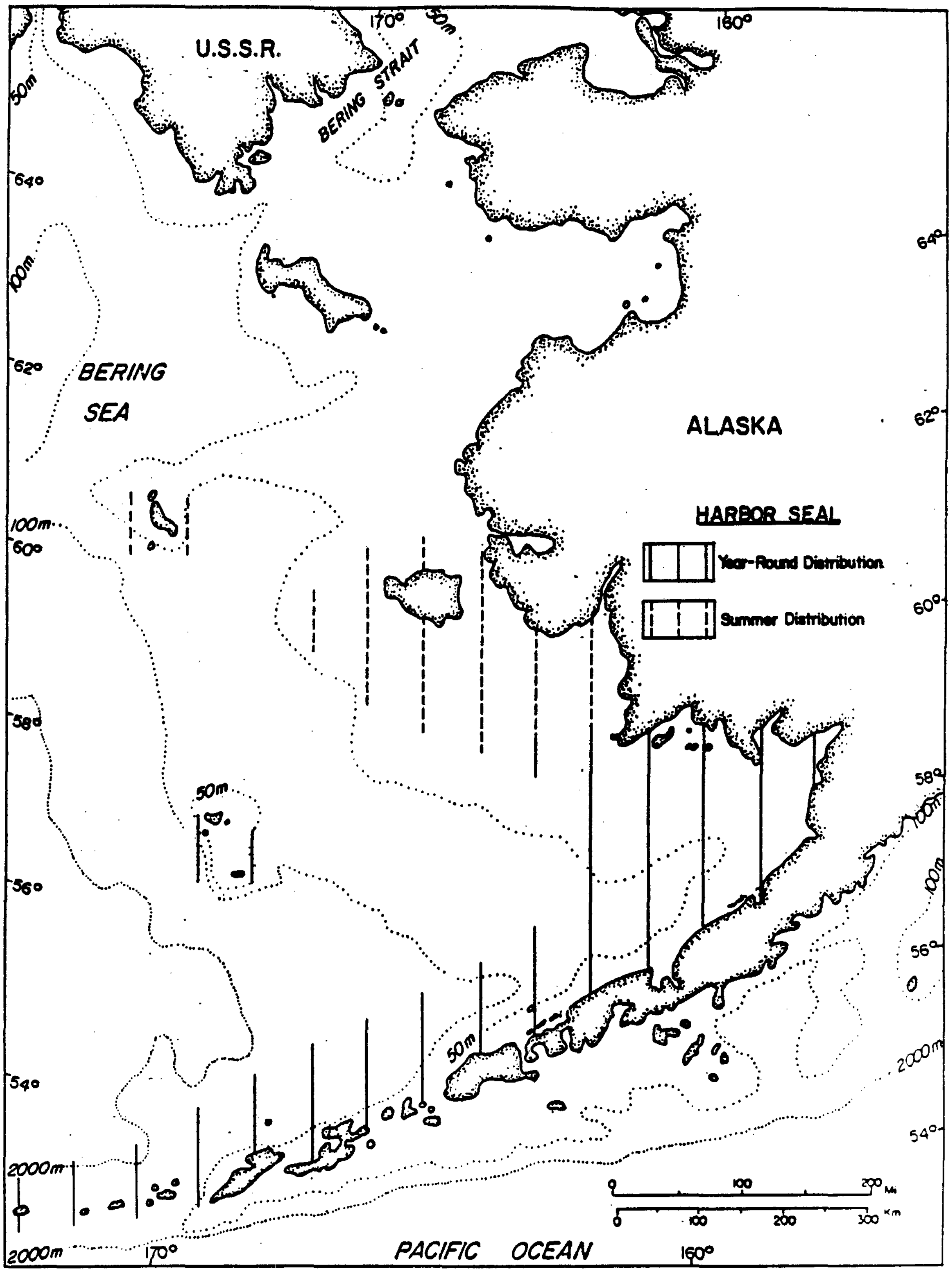


Figure 6. General distribution of the harbor seal in the Bering Sea, Alaska.

In general, most harbor seals haul out of the water to rest, give birth, and suckle their pups. However, it is not necessary for them to be hauled out to give birth; occasionally a pup is born and suckled in the water (J.J. Burns, pers. comm. 1988). Sand and gravel beaches, sand and mud bars, reefs, low lying rocks and ledges and pieces of ice are used as haulout areas. It is probably important for harbor seals to haul out during the molt period. The peak of the adult molt period on Otter Island (in the Pribilof Islands) was in late August (Johnson 1974); this period is probably the same throughout most of the Bering Sea. Access to food, freedom from disturbance, ready access to water, and protection from wind and wave action are among important criteria for haulout site selection by harbor seals.

Harbor seals reach sexual maturity at about 6 years of age, and may live for 30 years (Jeffries and Newby 1986; Hoover 1988b). In the Bering Sea mating takes place (in the water) mainly from mid-July to early August. As with other phocids, there is a period of arrested embryonic growth and delayed implantation, with implantation occurring in late October to early November (Burns and Gol'tsev 1984). Most pups are born during the early June to mid-July period. As a rule, pups are born on land. They enter the water shortly after birth, as most preferred haulout sites in the study area are awash during the twice-daily high tides. According to Lawson and Renouf (1987), prior to weaning, pups spend as much time in the water as out of it. They also found that the highly defensive behavior of mothers, together with the maternal bonding immediately after birth (especially during the first five minutes after birth), was responsible for maintaining early mother-pup contact. After that short time, pups followed their mothers. Mother-pup pairs went into the water about 50 minutes after birth. Some pups apparently remain with their mothers after weaning. In areas such as estuaries, where haulout habitat is limited, they may segregate into nursery groups composed almost exclusively of females with pups.

The population of harbor seals along the Pacific coast of North America is composed of about 330,000 individuals, of which almost 80%, or 260,000 individuals are found in Alaska (Jeffries and Newby 1986). The size of the eastern Bering Sea population was conservatively estimated to be about 30,000 in 1973. However, it was estimated that about 29,000 were present on sand and mud bars in the large estuaries on the north side of the Alaska Peninsula (Izembek Lagoon, Port Moller, Seal Islands, Cinder River, Port Heiden and Ugashik Bay) during the period 1975-1977 (Everitt and Braham 1980). Thus the overall estimate for the Bering Sea may have been in excess of 30,000. Harbor seals are difficult to census since the only time when they can be counted with any degree of accuracy is when they are hauled out. Although they haul out by the thousands in some locations, the proportion of the total population that may be hauled out at any one time is unknown, thus repeated counts usually represent trends in abundance rather than precise censuses.

Harbor seals and spotted seals reach the greatest degree of sympatry in the coastal zone from northern Bristol Bay (Nanvak Bay) to Kuskokwim Bay. Spotted seals occur in greatest numbers when the seasonal sea ice is present. Thus they move farthest south in greatest numbers during late winter and spring, although some occur in the coastal zone during summer and autumn; their abundance in this area increases from south to north. Arvey (1973) initiated a field study of sympatry in these seals and found that in summer, a small proportion of the seals hauled out in Nanvak Bay were spotted seals; the majority were harbor seals. Based on seals killed by subsistence hunters in Kuskokwim Bay during May and July, Arvey also found that one species replaced the other as the season progressed. All of the seals he examined in May were spotted seals, whereas those taken in July were harbor seals. The relative abundance of seals also showed a seasonal trend; seals were very abundant in May through early June and were much less abundant by July. These finding suggest that in the northern part of their range harbor seals are probably migratory; they occupy northern coastal areas in summer that are vacated by spotted seals in late spring after the ice disappears.

Harbor and spotted seals are also sympatric on coastal areas of the mainland from northern Bristol Bay northward, and around the central and northern Bering Sea islands. The actual number of harbor seals in this area is small and there are no known major haulout sites (i.e., where more than 100 have been reported to haul out). Nunivak Island seems to support the greatest number, and they may occur there year-round; the largest numbers of harbor seals recorded on Nunivak Island are at Ikookstakswak Cove, 5 km NE of Cape Mohican, at the west end of the island (<45 seals), in the bays around Ikook

Point at the extreme western end of the island (up to 70), and in the vicinity of Cape Mendenhall on the southern tip of the island (up to 80). They are present on islands of the St. Matthew group, though in small numbers, and they probably occur infrequently in the St. Lawrence Island area.

Burns (J.J. Burns and F. H. Fay, unpubl. data) was able to confirm the presence of harbor seals on St. Matthew Island based on definitive photographs taken by R. Johnson (Univ. of Alaska) on 20 August 1986. However, spotted seals are more abundant and they haul out in relatively large numbers (more than 100 in a herd) at several locations in this island group, as suggested in Frost et al. (1983). According to L.F. Lowry (ADFG, Fairbanks, AK) only the spotted seal was seen during observations on St. Matthew Island in mid-June 1986 when sea ice was still present. Few harbor seal pups are born on St. Matthew Island and St. Lawrence Island, and the few that biologists and native hunters have reported there are probably only seasonal residents during late summer through early autumn.

Records of harbor seals north of Kuskokwim Bay are particularly poor, although they are known to coastal residents as far north as St. Michael, on the southern shore of Norton Sound. They are usually referred to as "summer" seals or freshwater seals.

Patterns of Occupancy at Haulout Sites

Pitcher (1980) mentioned that studies in Washington State and San Francisco Bay have shown that harbor seals may adapt the timing of haulout to avoid human disturbance in some situations. Autumn haulout patterns by harbor seals on San Miguel Island, California, indicated that the largest proportion of individuals under observation hauled out between 13:00 and 15:00 h (Yochem et al. 1987). Most seals remained hauled out less than 12 h, and most seals were hauled out on fewer than 51% of the days sampled. Only about 40% of a sample of tagged seals hauled out each day; only 19% of tagged seals were hauled out during peak afternoon hours.

Renouf et al. (1981) found no recognizable diurnal pattern to harbor seal movements where harbor seals hauled out in a shallow bay on the French island of Michelon, in the Gulf of Saint Lawrence, Canada. They also found no relationship between the direction and intensity of seal traffic and various weather factors.

Johnson (1974, 1977) found more harbor seals hauled out on Otter Island, Alaska during his morning census (09:00 h) than during his evening census (21:00 h). In the southeastern Bering Sea, on the other hand, Everitt and Braham (1980:285) found a strong inverse correlation between the number of harbor seals hauled out and tide level. Significantly more seals were seen at lower tides than higher tides, regardless of whether the tides were rising or falling. This relationship has also been reported elsewhere (Scheffer and Slipp 1944, Fisher 1952, Bishop 1967, Newby 1971; all seen in Everitt and Braham 1980).

Repeat counts of harbor seals hauled out at Port Heiden in 1971 (data from Pitcher, in Frost et al. 1983; and Pitcher 1986) and on Otter Island in 1974 (data from Johnson 1974) illustrate the magnitude of day-to-day and week-to-week fluctuations in the number of individuals recorded at haulout sites (Fig. 7).

Location and Status of Harbor Seal Haulout Sites

Unlike the situation described for the northern fur seal and northern sea lion, births of harbor seal pups apparently are not restricted to a select few rookeries. As indicated by their broad distribution and occupation of habitats with many different physical characteristics, harbor seals are quite adaptable. It is thought that areas with adequate prey, especially in large expanses of shallow water, are necessary to support large harbor seal populations.

The number of harbor seals recorded at haulout sites in the Bering Sea, especially at some sites in the southeastern Bering Sea, has apparently declined dramatically during the recent decade (Pitcher 1986). Numbers of harbor seals may have been below carrying capacity during the early to mid

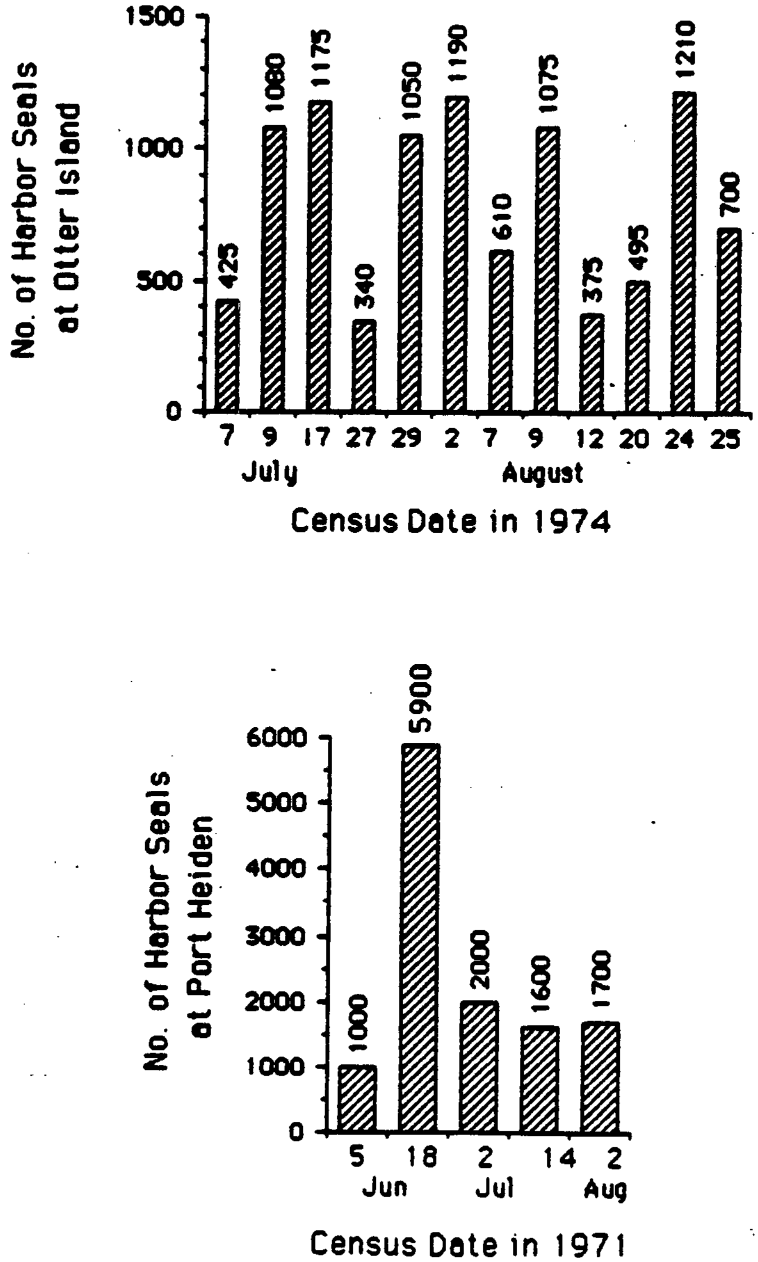


Figure 7. Variability in counts of harbor seals at two haulout sites in the Bering Sea, Alaska. Otter Island data are from Johnson (1974); Port Heiden data are from Pitcher (1986, in Frost et al. 1983).

1960's when as many as 50,000 individuals were harvested in Alaska in 1965 (Pitcher 1980). The harvest declined until the early 1970's when the Marine Mammal Protection Act of 1972 (MMPA) was passed. Currently, most of the harvest is taken by Alaskan Natives under the Native Exemption to the MMPA. Although several reasons have been given for the apparent recent decline of harbor seals (e.g., disease, over-exploitation in earlier years, increased predation, increased fouling in fishing gear, supposed reductions in principal prey [walleye pollock]), none of these suggestions have been clearly documented.

We have identified about 33 haulout sites that are or have been important for harbor seals in the Bering Sea and 9 other sites for which there is less complete information (Table 6; Fig. 8; Appendix 4). Except for the recent counts at several major haulout sites along the north side of the Alaska Peninsula, there is little current published information for several sites that were last censused and considered to be important in the 1970's. In general, the largest proportion of harbor seals in the Bering Sea occur along the north side of the Alaska Peninsula and in Bristol Bay (25,000-29,000), in Nanvak Bay (3,000), and at Otter Island (1,300; see Table 6). Smaller numbers are scattered along the coast of the Bering Sea, but no other major concentration areas have been recorded.

Walrus (Odobenus rosmarus (L.))

Background

The Walrus shares some characteristics with both the otariid or eared seals (fur seals and sea lions) and the phocids or earless seals (harbor seal, spotted seal, ringed seal and relatives). However, because of several distinct characteristics, such as its skin, method of sleeping at sea and feeding, and its distinctive tusks, it is placed in a separate taxonomic family--Odobenidae (Kenyon 1986). The walrus is among the largest of pinnipeds, with some males weighing almost 1600 kg; only the elephant seal (*Mirounga angustirostris*) is larger. The species has a discontinuous holarctic distribution; the widest gap is between the eastern Chukchi Sea and the central Canadian Arctic (Fay 1985). The range of the Pacific Walrus (*Odobenus rosmarus divergens*) is generally

Table 6. Peak counts of harbor seals at major haulout sites in the Bering Sea, Alaska†.

Haulout Site	1950's	1960's	1970's	1980's	Current Estimate	Year of Curr. Est.
Umnak Island	--	--	415	--	--	--
Bogoslof Island	--	--	56	--	--	--
Unalaska Island	--	40	612	--	-	--
Akutan Island	--	0	99	6	6	1980
Akun Island (incl. Tangik I)	--	--	179	23	23	1980
Tanginak Island	--	--	--	--	--	--
Avatanak Island	--	0	135	--	--	--
Tigalda Island	8	--	--	--	--	--
Kaligagan & islets NE of Tigalda I.	--	60	437	245	245	1980
Ugamak Island	--	50	30	--	--	--
Aiktak Island	--	150	149	94	94	1980
Unalga, Babies & rocks/islets	--	200	430	125	125	1980
Cape Lapin (Unimak I.)	--	200	40	--	--	--
North Creek (Unimak I.)	--	70	--	--	--	--
Unimak I. (all of N side)	--	550	125	--	--	--
Bechevin Bay	--	1500	--	--	--	--
Cape Krenitzin	--	1500	--	--	--	--
Isanotski Islands	--	--	511	--	--	--
Izembek/Moffet Lagoons	1142	1000	5000	1974	325	1987
Amak Island	--	13	61	2	2	1981
Cape Lieskof	--	100	199	--	--	--
Cape Seniavin	--	--	71	--	--	--
Port Moller	431	8000	7968	4010	4010	1985
Seal Islands (incl. Ilnik)	--	3200	1600	1521	75	1988
Port Heiden	1295	10000	10548	6196	800	1986
Cinder River	--	3000	4503	350	300	1988
Ugashik Bay	--	--	438	--	1000	1988
Egigik R. Flats	--	--	300	--	--	--
Deadman Sands	--	--	150	150	150	1988
Cape Constantine	--	--	--	100	100	1981
Tvativak Bay	--	--	--	77	77	1981
Hagemeister Island	--	--	200	100	100	1980
Black Rock	--	--	--	300	300	1981
Nanvak Bay*	--	--	3000	3100	221	1987
Cape Newenham	--	--	50	--	--	--
Chagvan Bay (Mouth)	--	--	150	--	--	--
Quinhagak (Middle Bar)	--	--	3000	--	--	--
Kongiganak (South Bar)	--	--	50	--	--	--
Kuskokwim Bay**	--	--	2000	--	--	--
Nunivak I. (Cape Mendenhall)	--	--	--	80	80	1981
St. George I. (Dalnoi Pt. area)	--	--	289	50	50	1982
Otter Island	--	--	1210	119	119	1981
TOTAL	2876	29633	44005	18622	8202	

† Note: data in this table are from many different sources and years and have not been collected in a systematic or consistent fashion. Sources of peak count data are Kenyon (1960, 1965; Mathisen and Lopp (1963); Johnson (1977); Everitt and Braham (1979, 1980); Frost et al. (1983); Pitcher (1986); NMFS file data; USFWS file data; J. J. Burns field notes.

* The Nanvak Bay haulout site is reported to be the most northerly pupping colony of harbor seals in the Bering Sea (Clarence Rhode Nat. Wildl. Refuge Rep. 1981, in Frost et al.1983).

** Adult harbor seals, many with pups, were seen on sandbars at the mouth of the Kuskokwim River on 4 July 1972 (R. Baxter pers. comm., in Frost et al. 1983). Hence, haulout sites in Kuskokwim Bay, rather than Nanvak Bay, actually may be the most northerly pupping colony of harbor seals in the Bering Sea.

"--" signifies that no data are available.

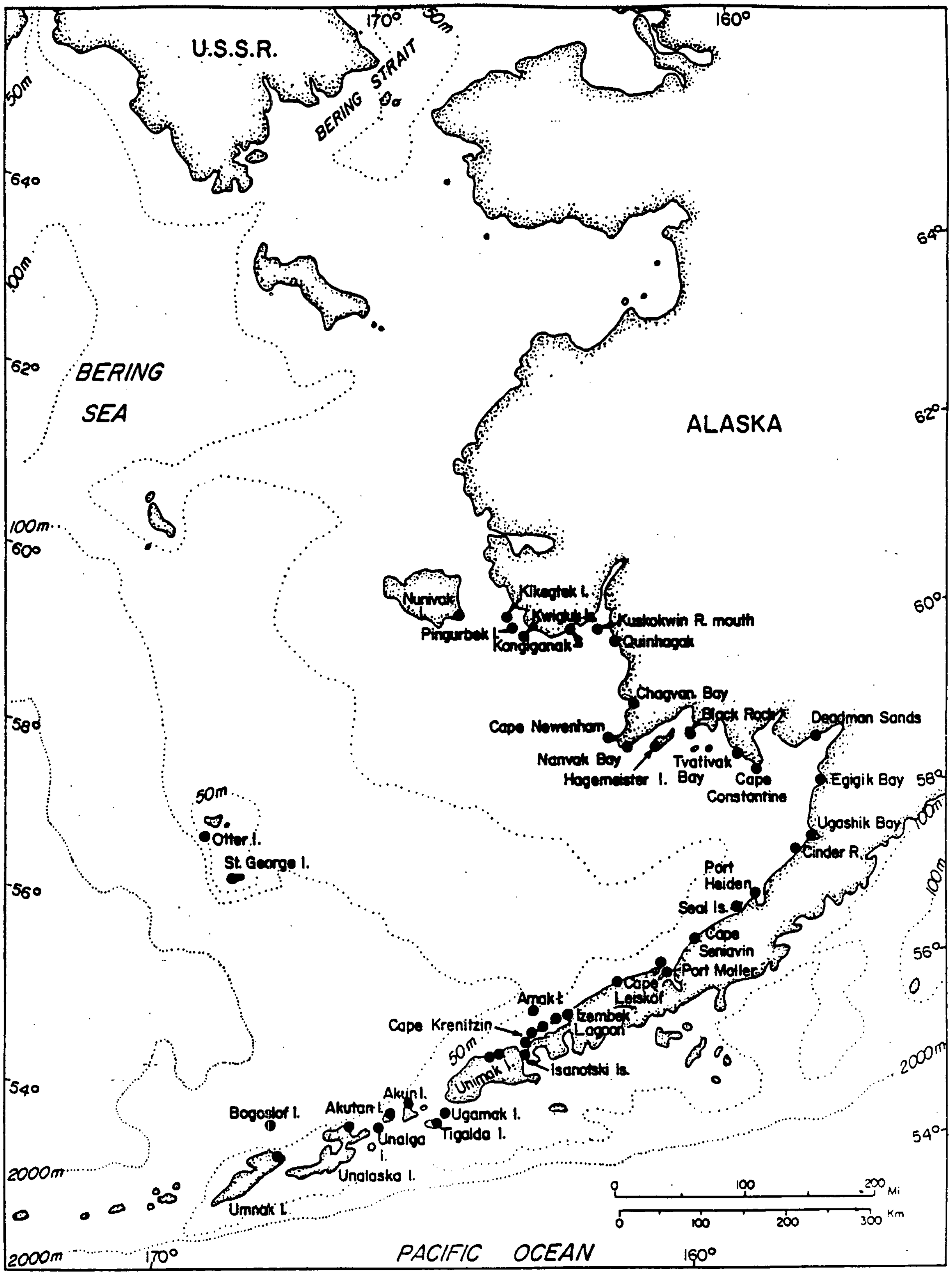


Figure 8. Locations of important haulout sites used by harbor seals in the Bering Sea, Alaska.

confined to the Bering and Chukchi seas. Aerial surveys conducted during 1960-1972 showed that when the Bering Sea ice pack is at its maximum, walruses though widely distributed were concentrated in two principal locations in the Bering Sea: north and south of St. Lawrence Island, and in southeastern Bristol Bay (Kenyon 1986; Sease and Chapman 1988). Figure 9 shows the general annual distribution of the species in the eastern Bering Sea.

Male walruses reach sexual maturity at 8-10 years but do not reach physical maturity (i.e. are not able to successfully compete for mates) until about 15 years of age. Females reach sexual maturity at about 6-8 years of age and may give birth to a single calf about every 2 years. Calves are born on the ice in April or May after a gestation period of 14-15 months. Walruses may live to be 35-40 years of age (Fay 1985).

Walruses feed primarily on bivalve molluscs which they obtain from bottom sediments in the shallow continental shelf waters of the Bering and Chukchi seas (Fay 1985, Nelson and Johnson 1987). The distribution and abundance of the walrus is thought to be closely tied to the availability of large volumes of molluscan crustaceans; captive walruses consume up to almost 30 kg of bivalves daily (Kenyon 1986).

The size of the Pacific walrus population was greatly reduced during the last half of the 19th century and again during the 1950's. The first of those major reductions resulted in the virtual extirpation of walruses from haulout sites in southeastern Bering Sea and the Pribilof Islands. Elliot (1882) indicated that walruses had formerly hauled out on the Pribilofs in large numbers, and he referred to the acquisition of considerable amounts of ivory from there (by early Russian hunters and traders) as proof of the former abundance. Jordon and Clark (1898) considered that walruses were practically extinct on the Pribilofs and True (1899) said that they had been exterminated there.

Pacific walruses have increased greatly since the 1950's; the population was estimated to be 250,000 animals in 1980 (Fay et al. 1984; Sease and Chapman 1988) and many experts believed that the walrus population had reached or exceeded the long-term carrying capacity of the habitat. The increase

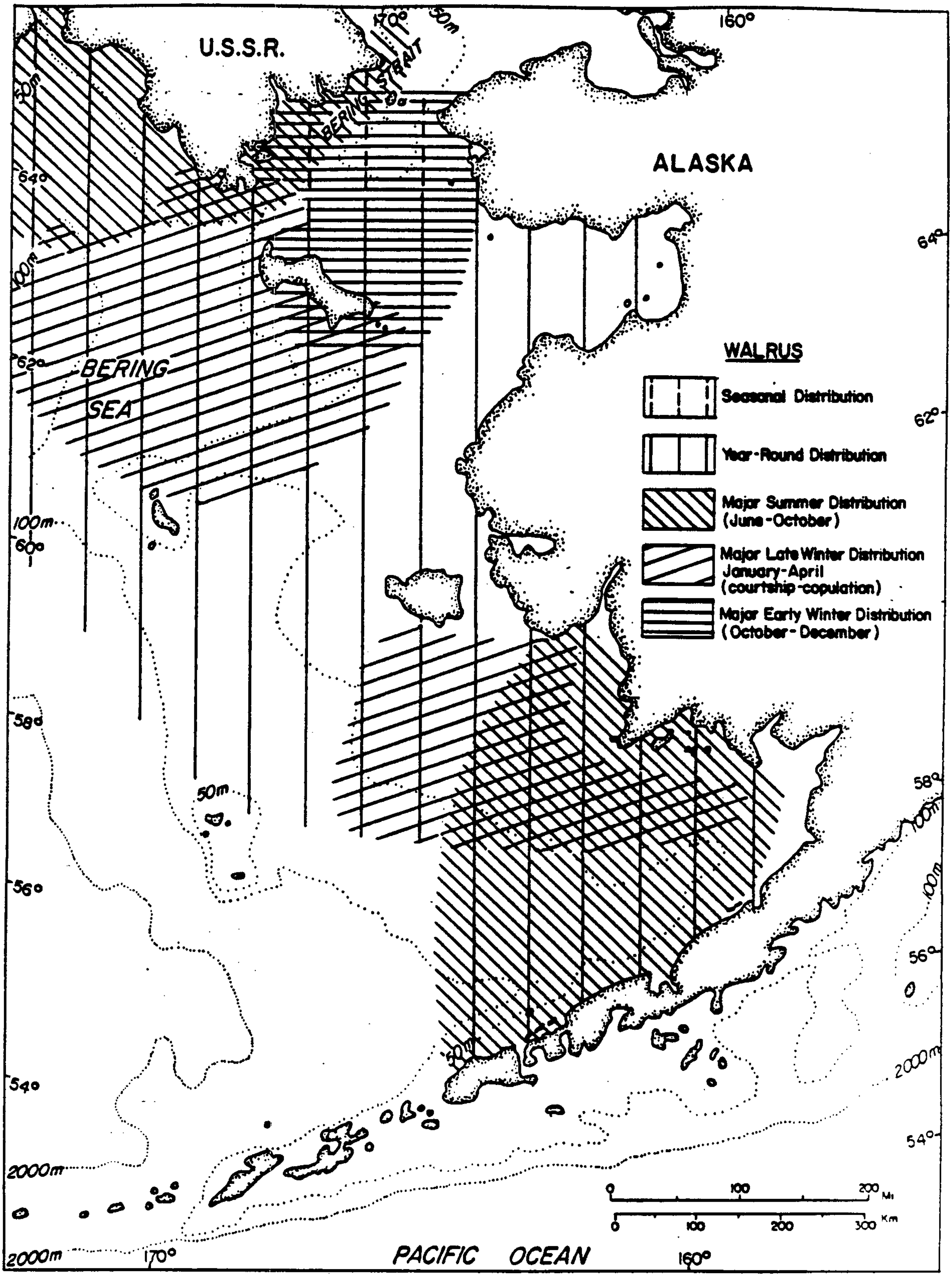


Figure 9. General distribution of the Pacific Walrus in the Bering Sea, Alaska.

resulted in the reoccupation of many former hauling grounds; so far, however, the Pribilof Islands remain a notable exception.

Patterns of Occupancy at Haulout Sites

The distribution of Pacific walruses varies considerably throughout the year. Males and females aggregate together in the pack ice as far north as St. Lawrence Island during late winter and early spring, which is when mating occurs; during some mild winters, many walrus may remain in the northern Bering Sea throughout the winter. As the ice pack breaks up and begins to move north (May-July), the population of walruses segregates; females with young stay with the ice and drift north through the Bering Strait into the Chukchi Sea. Virtually all males move toward the coast and south into Bristol Bay where they aggregate in large numbers at traditional haulout locations, principally along the north coast of Bristol Bay (Kenyon 1986; Sease and Chapman 1988). The largest and most regularly used summer haulout sites for these bull walruses are on the Walrus Islands (Round Island, N. Twin Island, High Island) and at nearby Cape Peirce (Fig. 10).

Bulls remain at these coastal haulout locations throughout the summer-early fall period, after which they begin moving west and north to rendezvous with the females and young that have drifted south with the advancing pack ice. Large numbers of walruses sometimes aggregate on St. Lawrence Island and regularly on the nearby Punuk Islands during October through December.

Walruses are known to be synchronous in their arrival at and departure from haulout sites on land and ice (Mazzone 1987; O'Neil and Haggblom 1987). To date that phenomenon, although important to the issue of protecting haulout sites, has not been adequately studied. All observations at haulout sites on land show generally alternate peaks of high and low numbers. At Cape Peirce, Mazzone (1987) reported that during the summer of 1985 and 1986 walruses were ashore for an average of 2.54 days and were away (presumably at sea) for an average of 8.5 days. O'Neil and Haggblom (1987) found that the mean duration of time ashore at Cape Peirce was 2.97 days and the time away from the haulout sites was 7.87 days. Counts of walruses hauled out at Cape Seniavin in 1987 and 1988 (data from S. Hills, USFWS pers. comm. 1988) illustrate the magnitude

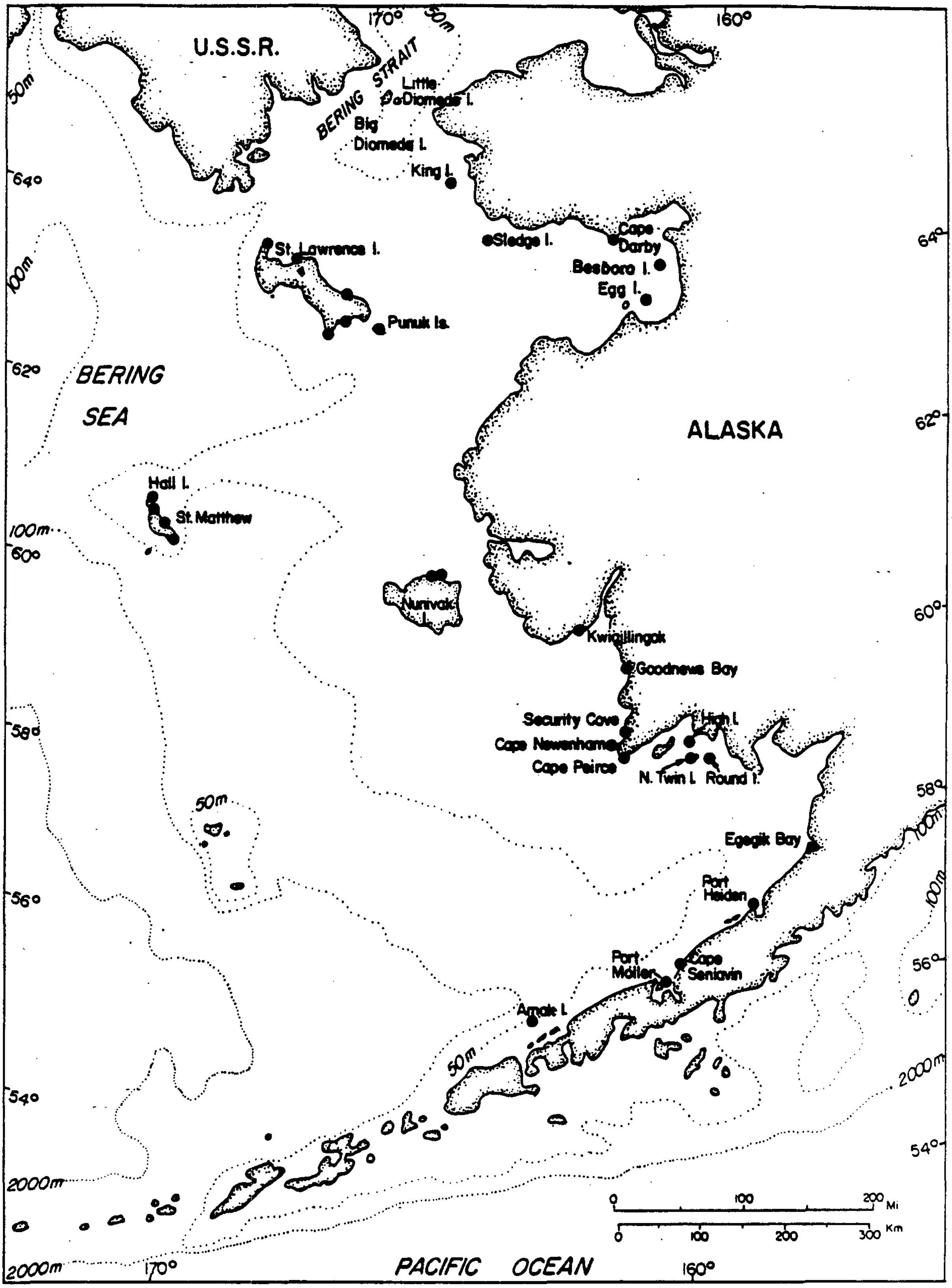


Figure 10. Locations of important haulout sites used by Pacific walruses in the Bering Sea, Alaska.

of day-to-day and week-to-week fluctuations in occupancy at haulout sites (Fig. 11).

Freedom from disturbance, particularly that associated with hunting and other types of harassment of hauled out walruses is required before reoccupancy of abandoned haulout sites is possible. Although walruses have been attempting to use former haulout sites and have been reported at many locations, relatively few places are protected from undue disturbance by man. An interesting comparison of successful vs. unsuccessful reoccupancy has occurred on the Diomede Islands. Big and Little Diomede islands are very similar to each other and are only 4 km apart. Walrus haulout sites were re-established on Big Diomede Island starting in about 1968. That island is now regularly used every year by several thousand walruses. In contrast, small numbers of animals have repeatedly attempted to haul out on Little Diomede Island, but are usually hunted and frightened away when discovered. As yet, there is no regularly used haulout site on that island.

Location and Status of Pacific Walrus Haulout Sites

Data from Frost et al. (1983) indicated that only 12 of 39 specific locations where walrus had been reported to haul out in the eastern Bering Sea were regularly used by substantial numbers of animals. Six of these major locations were in the North Aleutian Basin (Amak Island, Port Moller, Cape Seniavin, Big Twin Island, Round Island, Cape Newenham), one was in the St. Matthew Island-Hall Island area, and five were in Norton Basin (Besboro Island, St. Lawrence Island, Punuk Islands, King Island and Big Diomede Island (USSR)). Except for the addition of Cape Peirce, which is currently used by a large proportion of the walrus that historically have hauled out in the Walrus Islands area, we found the general trend given in Frost et al. (1983) to be generally consistent with our current review (Table 7; Fig. 10; Appendix 5); we evaluated about 30 different haulout sites for Pacific walrus.

It is noteworthy that the reoccupancy by significant numbers of walruses of haulout sites in the southern Bristol Bay area, and some sites in northern Bristol Bay (e.g., Cape Peirce), is a relatively recent event. It is thought that these sites were abandoned earlier in the century when walrus numbers

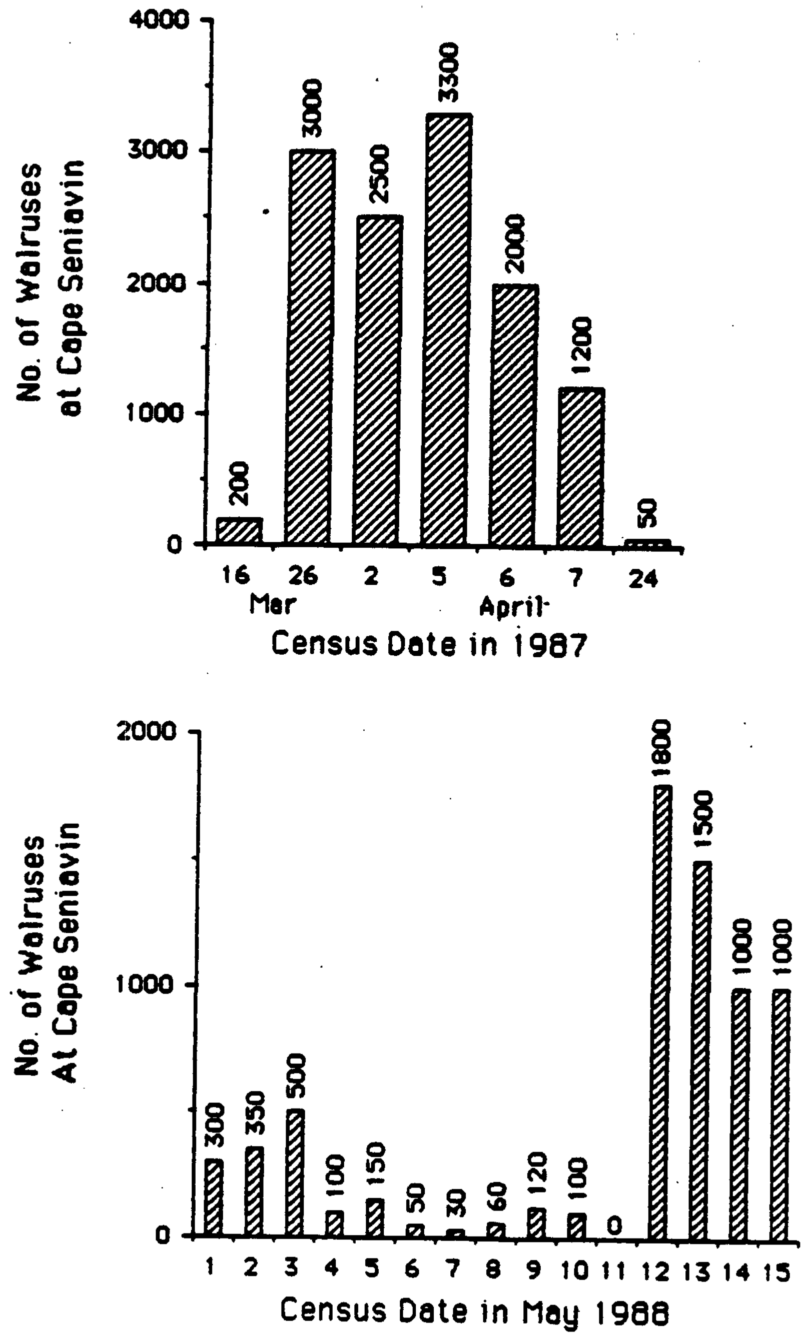


Figure 11. Variability in counts of Pacific walruses at Cape Seniavin, Alaska. Data are from S. Hills, USFWS (pers. comm. 1988).

Table 7. Peak counts of Pacific walruses at major terrestrial haulout sites in the Bering Sea, Alaska.† (This table does not include walruses that do not haul out in terrestrial habitats, i.e., many females and young.)

Haulout Site	1950's	1960's	1970's	1980's	Current Estimate	Date of Curr. Est.
Amak Island*	–	120	500	0	0	1982
Port Moller*	–	1000	4000	3250	3250	1983
Cape Seniavin*	–	–	140	3500	1800	1988
Port Heiden*	–	–	60	–	–	–
Egegik Bay*	–	–	–	1000	1000	1983
High Island*	250	–	–	–	–	–
North Twin Island*	1000	–	1000	–	–	–
Round Island*	3076	2000	10000	12400	5300	1987
Cape Peirce*	–	–	–	12500	6300	1987
Cape Newenham*	–	–	500	700	70	1987
Security Cove*	–	–	30	10000	10000	1983
Goodnews Bay*	–	–	250	–	–	–
Kwigillingok*	–	500	–	–	–	–
Nunivak Island*						
Cape Etolin*	–	–	200	–	–	–
Mekoryuk*	–	–	200	–	–	–
St. Matthew Island*						
Cape Upright*	–	–	–	160	160	1982
Cape Glory of Russia*	–	–	–	80	80	1980
Lunda Bay*	–	–	–	180	180	1982
Hall Island*	–	–	–	550	130	1986
Egg Island*	–	–	300	–	–	
Besboro Island*	–	400	–	100	100	1981
Cape Darby*	–	–	7	50	50	1981
Sledge Island	–	–	1050	3	3	1981
King Island	–	–	1000	5000	1000	1985
Punuk Islands						
North Island	100	1500	32000	15000	15000	1981
Middle Island	–	–	14000	–	–	–
South Island	–	–	11000	–	–	–
St. Lawrence Island						
Chibukak Pt.	5	100	100	100	100	1988
Salghat	–	–	19000	–	–	–
Maknik	–	–	35000	–	–	–
Kialegak Pt. Area	–	–	37000	–	–	–
TOTAL	4431	5620	167337	64573	44523	

† Note: data in this table are from many different sources and have not been collected in a consistent or systematic manner. Peak counts were taken from the following sources: Kenyon (1960); Fay and Kelly (1980); Kelly (1980); Fay (1982); Frost et al. (1983); Mazzone (1986); O'Neil and Haggblom (1987); Sherburne and Lipchak (1987); S. Hills (USFWS, pers. comm. 1988); ADFG files; Izembek NWR files; NMFS files; USFWS files.

* An asterisk indicates that this haulout site is occupied mostly by adult males. All other haulout sites (those without asterisks) are occupied mostly by male and female adults, subadults and calves.

"–" signifies that no data are available.

were considerably reduced. Some of the first relatively recent sightings in the southern Bristol Bay region were on Amak Island in spring 1962 (J.J. Burns files), near Ugashik Bay in spring 1962 and 1963 (Fay and Lowry 1981), and on ice in Herendeen Bay (Port Moller area) in late winter-early spring 1968 (Frost et al. 1983). Cape Seniavin apparently was reoccupied in the late 1970's. The largest number of walruses recorded along the north coast of the Alaska Peninsula was 6,750 individuals on 26 April 1983. About 3,500 of these were hauled out at Cape Seniavin and 3,250 were in the Port Moller area, including Herendeen Bay (USFWS file data).

Reactions of Pinnipeds to Disturbance

The following section of the report describes documented reactions of northern fur seal, northern sea lion, harbor seal and Pacific walrus to various types of noises and disturbances similar to those that may result from OCS development in the eastern Bering Sea. As mentioned in the 'Methods' Section, we have used published information as much as possible, but also have relied on relevant personal communications from experienced and knowledgeable biologists. We have also used relevant published and unpublished information concerning species or subspecies closely related to the four pinnipeds considered in this study, e.g., Guadalupe and Cape fur seals (*Arctocephalus townsendi* and *A. pusillus*), respectively, California sea lion (*Zalophus californianus*), spotted seal (*Phoca largha*), ringed seal (*P. hispida*), bearded seal (*Erignathus barbatus*), harp seal (*P. groenlandica*), and Atlantic walrus (*Odobenus rosmarus rosmarus*).

Our discussion of the effects of noise and disturbance is organized by the four species, but is further broken down into three additional categories, namely: airborne noise and disturbance (mainly aircraft), underwater noise and disturbance (mainly ships and boats), and human presence and disturbance. Airborne and underwater noises and disturbances are further subdivided into stationary sources and moving sources. Several recent observations suggest that animals are more likely to accommodate to stationary noise sources than moving sources (see Richardson et al. 1983 for review).

Northern Fur Seal

Airborne Noise and Disturbance

Moving Sources. A well documented example of aircraft disturbance to northern fur seals occurred at the Gorbatch hauling grounds on St. Paul Island (Pribilof Islands) in September 1981 (S. Swibold, pers. comm. 1988). Swibold was photographing from a blind near thousands of resting bachelor bull fur seals. As a large twin-engine aircraft passed overhead (at 300-500 feet altitude), the seals panicked and stampeded toward the water. Her film apparently shows the seals looking up (toward the low-flying aircraft) as they stampeded. No mortality was recorded as a result of this disturbance.

In contrast to the above observation, was an observation during July of a group of sleeping subadult male northern fur seals at a hauling ground adjacent to East Rookery, on St. George Island in the Pribilofs. As a twin-engine cargo plane flew directly overhead at low altitude (S. Zimmerman, NMFS, pers. comm. 1988), the seals responded by awakening and lifting their heads, but there was no mass movement, no milling behavior, nor any other obvious overt reaction to the aircraft.

In the opinion of C. Fowler (NMFS, pers. comm. 1988), the Little Polovina rookery/hauling ground may be the next fur seal haulout site to be abandoned in the Pribilof Islands--possibly within the next several years. This haulout site is within 5 km of the airport runway on St. Paul Island, and one fur seal biologist (A. York, NMFS, pers. comm. 1988) speculated that the decline in numbers of fur seals at the Polovina Complex (Polovina, Little Polovina and Polovina Cliffs; see Fig. 15, Appendix 2) of rookeries may be related to their close proximity to the St. Paul airport.

York tried to document the number of commercial aircraft using the St. Paul airport each year since its construction during WW II (1941-1943) in relation to the steady decline in the number of fur seals using the Polovina Complex of rookeries. Although the airport records showed a general increase over the years in the number of commercial flights to and from St. Paul, there were many more unrecorded military and charter flights that she was unable to document. Although her investigation was inconclusive, York felt there was no basis to completely discount the possible relationship between the level of aircraft overflights and the decline in use of the Polovina complex of rookeries/hauling grounds, especially at Polovina and Little Polovina.

York said that on several occasions during the past few years she has observed large helicopters flying over her study area at the Kitovi rookery on St. Paul Island. However, she has never noticed a stampede as a result of these overflights.

In the opinion of A. Antonelis (NMFS, pers. comm. 1988), fur seals respond differently to different types of aircraft. When he conducted photo-censuses using a single-engine, fixed-wing aircraft flying at 100-175 m over the fur seals, he saw no overt reaction by the seals to his aircraft. However, he was aware of severe disturbances caused by larger multi-engine aircraft flying low over rookeries/hauling grounds. Antonelis has seen the film by Swibold and noted that it is a clear example of severe aircraft disturbance to northern fur seals. He further pointed out that fur seals seem to be more easily disturbed (i.e., are more inclined to stampede) on hot rather than cool days. Antonelis reiterated that he was not aware of any instance where mortality has resulted from a low-level aircraft overflight.

Stationary Sources. A. Antonelis (NMFS, pers. comm. 1988) is currently conducting research and synthesizing information on the effects of sonic booms on fur seals at San Miguel Island, California. His research is primarily related to possible hearing impairment in the seals caused by sonic booms associated with activities at the nearby Pacific Missile Range (Vandenberg Air Force Base) in California. He has found no example in a fur seal of hearing impairment caused by a sonic boom. Based on his observations, fur seals usually respond to sonic booms by assuming an upright posture (they appear startled), and they sometimes stampede from the beach into the water. Antonelis has never seen a case where mortality has resulted from such disturbance.

Underwater Noise and Disturbance

Moving Sources. During his pelagic studies of northern fur seals, H. Kajimura (NMFS, pers. comm. 1988), has found them to be quite tame when first encountered at sea; they are curious and often approach the research vessel. However, after one or two days of collecting (hunting) northern fur seals in one area, it is often very difficult to maneuver the ship close to the seals. In some instances, sleeping fur seals were seen to respond to the approaching ship at distances up to about a mile; the seals apparently were awakened by the noise of the ship, and then rapidly swam away. Kajimura said that he thought the seals were responding to the sounds of the ships propellers and engine. He thought they could hear the prop and engine sounds, and that they associated those sounds with earlier collecting activities, and fled away from the source of the ship sounds. However, such a response could also, in part, be an artifact of removing (hunting) the least wary seals from an area.

Stationary Sources. Shaughnessy et al. (1981) reported on attempts to scare cape fur seals away from fishing nets in waters off southern Africa. The seals disturb shoals of fish and pursue fish into nets, causing damage to the nets. Fur seals remained in an area where they were subjected to 'firecrackers', killer whale playbacks, rifle shots and an arc-discharge transducer. The arc-discharge transducer produced pulses at 10-second intervals with a peak source level of 132 dB//1 μPa at 1 m. Fur seals did not appear to be deterred by any of the devices used in this study.

Human Presence and Disturbance

According to C. Fowler (NMFS, pers. comm. 1988), the abandonment of the 'Lagoon' rookery on St. Paul Island in the late 1940's may have been due to increased activities at the village of St. Paul, which is situated directly across the bay from the 'Lagoon' rookery. Fowler speculated that increased hunting, as well as increased general activity at the village of St. Paul, including the operation of the fur seal by-products processing plant, may have been responsible for the abandonment of this rookery.

A. York (NMFS, pers. comm. 1988) said that people (including biologists) walking near or through fur seal rookeries/hauling grounds also may cause major disturbances. In some cases, such disturbances may be as severe as aircraft overflights. According to York, one reason why there is so little documentation of mortal effects of aircraft overflights or other disturbances and consequent stampedes in breeding rookeries, is because observers are often too far away from the rookeries to be able to see dead or dying pups that may have been crushed during stampedes. Most of the observation blinds at the rookeries on the Pribilof Islands are far enough away to greatly reduce the possibility of human disturbance. Blinds near the hauling grounds may be closer to concentrations of seals, so there is a greater risk to the non-breeding animals concentrated at those locations.

Northern Sea Lion

Airborne Noise and Disturbance

Moving Sources. Calkins (1983) indicated that different types of aircraft appear to have substantially different effects on marine mammals. Reactions of northern sea lions to aircraft is varied and depends on several factors. At haulout sites where sea lions are not breeding and not pupping, approaching aircraft will usually cause some disturbance, frightening at least some animals into the water. On some occasions at haulouts (not rookeries), approaching aircraft can cause complete panic and stampede all sea lions to the water. The variability in reaction at haulouts (as opposed to rookeries) appears to depend on environmental conditions (weather, tide, etc.) as well as the type, speed and altitude of the approaching aircraft.

When sea lions are at rookeries during the breeding and pupping season, their reaction to aircraft is altered and appears to depend more upon the sex, age and reproductive status of the individual (R. Merrick, NMFS, pers. comm. 1988). Immatures and pregnant females may enter the water when aircraft approach, but territorial males and females with small pups generally remain hauled out, but may vocalize during the disturbance. In general, aircraft disturbance to sea lions appears to cause at least some panic stampedes into the water on most occasions. Merrick knew of very few examples of serious disturbance to northern sea lions in the Bering Sea by aircraft flying within several hundred meters.

Stationary Sources. Stewart (1981) reported that breeding California sea lions and elephant seals exposed to intense impulsive airborne noise from a carbide pest control cannon apparently were not greatly affected, although the details of this study are not available. Apparently 'Habitat use, population growth, and pup survival of both species were unaffected by periodic exposure to carbide cannon impulse noise' (Stewart 1981).

Underwater Noise and Disturbance

Moving Sources. Northern and California sea lions have been hauling out since 1978 on the Steveston jetty, adjacent to the middle arm of the Fraser River where it flows into Georgia Strait, in southwestern British Columbia (M. Bigg, DFO, pers. comm. 1987). They aggregate in this area in April and May to feed on smelt which move into the Fraser River. The haulout site is immediately adjacent (≤500 m) to the main shipping channel leading from Georgia Strait to New Westmininster, British Columbia. Bigg said there is no evidence that these seal lions have been affected by nearby heavy ship traffic or by tour boats that approach close to the hauled out sea lions.

Similarly, at Race Rocks, in Jaun de Fuca Strait, British Columbia, up to 800 California and northern sea lions haul out near a busy shipping lane leading to ports in Puget Sound, Washington, and Georgia Strait, British Columbia (M. Bigg, DFO, pers. comm 1987). This haulout site has been heavily used by sea lions in spite of increasingly heavy ship traffic over the past two decades. Bigg knows of no major disturbance to sea lions at the Race Rocks haulout site.

Bigg mentioned that northern and California sea lions aggregate (major "rafting area") in Active Pass, British Columbia, a narrow and heavily used shipping lane through the southern Gulf Islands of British Columbia. He is not aware of any disturbance to sea lions in this area, even though such shipping has been going on near "rafting" sea lions for many decades. J.J. Burns has observed northern sea lions actively congregating around and following vessels engaged in fishing and processing of fish in the Gulf of Alaska and the Bering Sea.

Human Presence and Disturbance

Lewis (1987) studied the effects of human disturbance on sea lions at rookeries in the northeast Gulf of Alaska. Here census procedures (by biologists) involved purposely flushing all animals except pups from the rookeries. Results indicated that there was little pup mortality as a result of this procedure, but that aggressive behavior and territorial behavior by breeding females increased significantly, and the rookery was much more easily disturbed (more stampedes) by natural events after such a disturbance. There was some abandonment of the rookery by non-pup sea lions immediately after the disturbance. The significant finding, however, was that there was markedly lower maintenance of female-pup contact (49% vs. 71%) in the year of disturbance compared to a year of no such disturbance. The female-pup bond during the early stages of pup development is critical to the survival of the pup; if this bond is broken, the pup is likely to die. It should be noted that natural mortality of pups during the first year of life may reach 50% (ADF&G 1973). The variety of natural mortality factors is not clearly understood, but young pups washed to sea during storms are presumed to drown.

Northern sea lions are generally less easily disturbed at rookeries early in the breeding season (June) during mating and pupping, and generally more sensitive later, after the breeding season (August), when most of the adult males and non-breeding females are hauled out at locations away from rookeries (R. Merrick, NMFS, pers. comm. 1988). During August, only the pups and productive females would still be present near rookeries; Merrick said that this is the period when sea lions are most reactive to disturbance.

According to Merrick (NMFS, pers. comm. 1988), the shooting of northern sea lions has caused severe disturbance in the Unimak Pass area of the Bering Sea. In the past, sea lion meat apparently was used as bait in certain commercial fishing operations (e.g., crab fishery, long-line halibut fishery); sea lion rookeries near fishing grounds traditionally were hardest hit by such activities. Although this practice is no longer common, the large rookery on Ugamak Island recently was affected by such a shooting. Similarly, Kenyon (1962) suggested that the large northern sea lion rookery near Northeast Point on St. Paul Island was abandoned because of excessive harvesting. Formerly, this was the largest sea lion rookery in the Pribilof Islands; no pups have been recorded there since 1957.

Harbor Seal

Airborne Noise and Disturbance

Moving Sources. Pinnipeds that haul out for molting or pupping probably are the most susceptible to adverse effects resulting from disturbance by aircraft. Johnson (1977) gave evidence that harbor seals may temporarily leave pupping beaches when aircraft fly over. Since harbor seals may not always haul out at the same site when returning to the beach, pups left behind at one site may be permanently separated from their mothers and may die. Low-flying aircraft may have been responsible for the deaths of more than 10% of the approximately 2000 pups born on Tugidak Island, Alaska, in 1976 (Johnson 1977). All types of aircraft flying below 400 ft (122 m) nearly always caused seals to vacate the beaches, sometimes for 2 h or more, with helicopters being particularly disturbing. Responses of harbor seals to overflights at altitudes between 400 and 1000 ft varied with weather, frequency of disturbance, altitude and aircraft type. Aircraft were more disturbing on calm days, after recent disturbance, and at lower altitudes. According to Johnson (1977), helicopters and large planes were more disturbing to harbor seals than small airplanes.

Pitcher and Calkins (1979) reported that harbor seals are susceptible to disturbance from low-flying aircraft and are noted for their mass exodus (stampedes) from hauling areas in the event of such disturbance. As mentioned earlier, Johnson (1977) has warned that one of the major negative consequences of such stampedes is the separation of mother-pup pairs, and the consequent reduction in pup survival.

Several thousand harbor seals haul out during May through October on the sand and mud bars at the entrance to Nanvak Bay, near Cape Peirce, Alaska (Johnson 1975; USFWS file data; LGL file data). Single-engine float planes and less frequently small amphibious aircraft land and take off near the beach about 2-3 times each month during this same period. During these aircraft activities, the seals appear to leave the beach as soon as the aircraft either land or take off.

M. Bigg (DFO, pers. comm. 1988) said that there are two major haulout sites for harbor seals on the sand bars and shoals near the entrance to the Sea Island Arm of the Fraser River, in British Columbia. One of these haulout sites (the northernmost) is fairly close to the main E-W runway at Vancouver International Airport. Aircraft frequently fly low over this haulout site with little or no reaction by the harbor seals, which Bigg thinks have habituated to the noise/disturbance. Hovercraft, on the other hand, do frighten these seals into the water. Bigg speculated that the noise from a hovercraft was "probably 10 times greater than the aircraft flying overhead". Since the hovercraft operates on the water, it is possible that the seals perceive it as more of a 'threat' than the more numerous aircraft overhead.

Spotted seals are closely related to harbor seals, and also haul out on beaches along the Bering Sea coast (Burns 1970). Burns and Harbo (1977, in Cowles et al. 1981) reported that spotted seals react to aircraft at rather great distances by 'erratically racing across [ice] floes and eventually diving off'. This type of 'panic' reaction also may be common during summer when spotted seals are hauled out on beaches. However, disturbance by aircraft at terrestrial haulout sites is unlikely to cause pup mortality because spotted seal pups are usually independent by summer when they might be hauled out at terrestrial sites. Nevertheless, Eley and Lowry (1978) speculated that spotted seals may abandon summer haulout sites if disturbed frequently.

Burns and Harbo (1977) found that reactions by ringed seals on fast ice to an aerial survey aircraft were variable depending on proximity to high headlands, position of the aircraft in relation to seals, and weather conditions. When transects were within 2 miles of a rock cliff, most seals hauled out adjacent to the cliffs dived through nearby holes and ice cracks as the aircraft came abreast or over them. Seals under the aircraft dived even when those to the side did not. Reactions on nice days were less severe than on marginal days for surveying, and seals overflown during optimal haulout conditions often shifted positions and looked upward at the aircraft but did not dive.

Burns and Frost (1983) reported that "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." "On a warm calm spring day when they are basking, they often show little concern for a low-flying aircraft." "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." In general, bearded seals appear to be only mildly affected by aircraft overflights, usually showing some reaction only at very low altitudes.

Stationary Sources. A small population of harbor seals resides in upper Kachemak Bay, Alaska, near where the Bradley Lake Hydroelectric Project is under construction. During 22 May to 17 June 1987, before construction activity had begun at the site, as many as 150-200 seals have been seen hauled out in groups of 50-75 on bars in the upper bay near the construction site (Roseneau 1988). The seals typically haul out at a location about 1.6 km from the project powerhouse site and permanent construction facilities. During construction activities in the area (late June through October) the seals appeared to ignore most project activities, and no marked changes in overall numbers or patterns of use were noted during construction activities or after project activities ceased during 1987 (D. Trugden, pers. comm., in Roseneau 1988).

Underwater Noise and Disturbance

Moving Sources. Ugashik Bay in upper Bristol Bay, Alaska, supports a relatively large population of harbor seals (about 400-500). The seals occupy the bay along with many diesel-powered commercial fishing boats and noises emanate from the processor, including noises from large compressors. Small outboard-powered skiffs from Pilot Point, Alaska, also operate throughout the bay. Harbor seals remain in Ugashik Bay despite these activities (R. Gill, USFWS, pers. comm. 1987).

J.J. Burns (pers. obs. 1988) observed two groups of harbor seals (200 to 400 seals in each group), many of which were pups hauled out during daytime low tides on 9, 11, 13 and 14 July 1988 in Ugashik Bay. This was during the peak of fishing operations in the area and numerous fishing boats continuously passed relatively close to the animals. Fishing activity had been going on since about mid-June. It was noted that the seals paid little attention to moving boats that were at least 200 m away. The seals became alert and agitated when boats stopped at that same distance and some animals slowly (not in a stampede) entered the water when boats approached closer than 150 to 200 m. All seals vacated the haulout site when boats approached closer than about 60 m. The haulouts were submerged at high tide and the seals became broadly scattered through the fishing fleet, occasionally feeding on salmon hanging in gill nets.

Thousands of harbor seals haul out near Port Moller (Pitcher 1986), on the north side of the Alaska Peninsula. In this area, a large fish-processing vessel is stationed for most of the summer fishing season; many fishing boats deliver catches to the processor vessel each day (R. Gill, USFWS, pers. comm. 1987). During these deliveries, the fishing boats, including outboard-powered skiffs and tenders, motor through a channel close to the hauled out seals, apparently causing little if any disturbance to the resting animals.

M. Bigg (DFO, pers. comm. 1988) said that there are two major haulout sites for harbor seals on the sand bars and shoals near the entrance to the Steveston Arm of the Fraser River, in British Columbia. According to Bigg, harbor seals at these sites have become habituated (do not respond) to nearby fishing boats that pass quite close to the haulout sites.

Few authors have described responses of seals to ships or boats. Kapel (1975) noted that hunters in one part of Greenland are opposed to the use of outboard motors because they think that they frighten seals away. In fact, pinnipeds may associate the boat noise with being hunted (H. Kajimura, NMFS, pers. comm. 1988), and thus they may be reacting to the threat of being hunted rather than the noise of the ship or boat.

Murphy and Hoover (1981) noted that "Disturbance may have considerable impact where haulout space is limited, since seals frightened from haulouts tend to search for new sites rather than use those they abandoned....".

In Bonner's (1982) review of human-related impacts on seals, he states that "Drescher (1978) has drawn attention to the need of harbor seals for an undisturbed nursing period. Disturbance by passing sailboats or power craft can seriously reduce the survival of pups".

Terhune et al. (1979) obtained qualitative information about the amount of harp seal vocalization before and after a 36.5 m stern trawler approached within 2 km of a pupping area in the offshore pack ice. There was little evidence of a decrease in vocalizations the first night after the ship arrived, but many fewer vocalizations were recorded after that. It was not known whether some seals moved away from the pupping area, or whether all remained but vocalized less often. The results were ambiguous because of temporal variation in vocalizations and varying levels of other disturbance, such as seal hunting. Ship sounds often were so intense that harp seal vocalizations (if any) were totally masked.

Brodie (1981a, 1981b) has pointed out that harp and hooded seals continue to return to traditional breeding and molting areas in the moving pack ice off Newfoundland each year despite centuries of disturbance by vessels and seal hunting. It should be pointed out that the seals have few options short of changing their habitat. Also, there are never any hunters present when the seals coalesce into the breeding herds on the ice in early March. The hunters wait until the herds have formed and pupping has begun before travelling to the floes for the hunt.

Stationary Sources. Anderson and Hawkins (1978) conducted a series of trials to study the effects of sound as a deterrent to predatory seals at an Atlantic salmon netting station. A feasibility trial and follow-up experiment were conducted on a captive harbor seal. A variety of sounds were used in the trials; pure tones, killer whale calls, and loud noises were transmitted and responses were recorded on videotape. Although one sound appeared to cause an alarm reaction, the seal appeared to accommodate rapidly. Further field trials were conducted where grey seals were eating salmon at a river netting station. Although a broad range of sounds were played, none was consistently effective in scaring seals from the nets. The results of this study led to the conclusion that an acoustic deterrent for feeding seals is not effective. Thus, it is probable that harbor seals and some other phocids are quite tolerant to underwater sounds, especially when they are feeding in areas where prey are abundant. This conclusion is supported by a variety of recent studies that are summarized in the proceedings of a symposium on acoustical deterrents in marine mammal (almost solely pinniped) conflicts with fisheries (Mate and Harvey 1987).

Cummings et al. (1986) broadcast man-made noises associated with on-ice seismic (Vibroseis) activity to ringed seals on two occasions during haulout periods in March and April. On two occasions early in the season, sound production by seals before and after the broadcasts were not significantly different. During two broadcasts later in the season, sound production by seals was higher than recorded earlier. However, this increase was thought to be related to the timing of the breeding cycle in ringed seals rather than the sound broadcasts. In general, sound production by ringed seals was probably not affected by seismic activity noise.

Human Presence and Disturbance

Allen et al. (1984) studied the effects of various types of disturbance on harbor seal haulout behavior in Bolinas Lagoon, California. Their results indicated that harbor seals were disturbed on 71% of days monitored; people in canoes were the principle source of disturbance. Human activities closer than 100 m caused seals to leave haulout sites more than activities at greater distances. On average, it took harbor seals 28 $\pm$ 21 minutes to haulout again after they were disturbed. After disturbances, the number of seals that hauled out again was lower than the original number. Based on results of other studies on the effects of human disturbance on harbor and monk seals, the authors speculated that disturbances near Marin County haulout sites could cause harbor seals to switch to nocturnal haulout behavior, increase pup mortality, and/or cause the haulout site to be abandoned.

Osborne (1985) studied the effects of disturbance on a local population of harbor seals that haul out in Elkhorn Slough, California. She found that recreational boating, primarily canoes and power boats, were the single largest source of disturbance to hauled-out seals. Boating caused two-thirds of the seal flight reactions; most of the disturbance was in summer when recreational activity was greatest. All flight reactions occurred when the boats were within 100 m of the haulout site; 74% were when the boats were less than 30 m.

Laursen (1982) reported that coastal areas of the Dutch Wadden Sea where harbor seals haul out were receiving increasing recreational pressures. As numbers of people using beach and water areas increased, more harbor seals were being displaced from loafing areas. Analysis of data on the distribution of humans and seals showed that the first disturbing event of the day determined where seals were or were not found. Loafing harbor seals were present only in areas where they had not been disturbed earlier in the day, indicating it may take only one such disturbance to keep seals away from otherwise adequate loafing habitat for that day. This indicates that the timing and frequency of disturbance may be an important aspect of short-term displacement.

Reijnders (1984) reported that "Direct effects of disturbance on reproductive success of pinnipeds are unlikely to occur, as only very dramatic events--such as collisions or injuries--will cause intrauterine mortality or abortion. This is concluded from reports on heavily-hunted seal populations in which any differences between the rate of ovulating and pregnant females, and the differences between numbers of half-term-pregnant and parturient animals, were neglectable [sic] (Bigg, 1969; Smith, 1973; Boulva, 1974). " Reijnders (1984) goes on to state that "This is not unexpected, because hunting of seals mainly takes place between birth and weaning, and stress involved with those activities is of short duration. It is assumed, however, that more frequent disturbance throughout the whole year might act indirectly to depress reproductive success through impairing reproductive performance."

During the daylight hours from 14-27 June 1980, Renouf et al. (1981) watched movements of harbor seals (and grey seals) through a narrow channel connecting their haulout sites with the sea. Seals used this channel to come and go from the sea after being forced from their haulout sites on nearby sand flats exposed at low tide. Before the study it was presumed that the seals returned to the sea to feed and/or to avoid disturbance. There was only a slight increase in seaward travel by seals after they were disturbed by humans at their haulout sites (automobile and boat traffic; tourists walking nearby and touching pups), and the seals did not always go to sea when the sand flats where they hauled out were flooded by the high tide.

It has been reported that hunting in the Shetland Islands (Scotland) has, in at least one place retarded the onset of the pupping season (Tickell 1970). However, even those stocks which were heavily hunted continued to pup on their traditional hauling grounds rather than move to a new area (Bonner et al. 1973).

Terhune (1985) noted that "The seals readily enter the water in response to a wide variety of disturbances. They react in essentially the same manner when shot at, approached by humans or dogs walking along a beach, or approached by boats or light aircraft."

Walrus

Airborne Noise and Disturbance

Moving Sources. Walruses at terrestrial haulout sites may show responses to aircraft disturbance that vary with distance, aircraft type, flight pattern and age-sex class of the animals. Brooks (1954) noted that walruses onshore were disturbed by an aircraft passing overhead at 300 m. In a more extensive study, Salter (1979) found that, at horizontal distances beyond 2.5 km, the only response elicited by aircraft was raising of the head by some of the hauled out animals. A Bell 206 helicopter 1.3 km from a haulout site and flying at an altitude of less than 150 m prompted orientation toward the water by 31 of 47 animals. When the helicopter veered suddenly causing an abrupt change in the pitch of the noise, 26 of 47 walruses rushed into the water (Salter 1979). Another flight by a Bell 206 helicopter at the same altitude but at a range less than 1 km elicited head raising and orientation toward the water by some animals but no escape reactions--presumably because there were no sudden changes in the flight pattern or noise. DeHavilland Otter aircraft, which have a piston-driven single engine, caused escape reactions by walruses at horizontal distances less than 1 km during overflights at altitudes of 1000 and 1500 m (Salter 1979). Disturbance observed by Salter never caused escape reactions in all the walruses at the haulout site. Adult females, calves and immatures were more likely than adult males to enter the water during disturbance. However, severe disturbance may cause stampedes into the water by all the walruses at a haulout site.

Loughrey (1959) reported that walruses started to scramble towards the water when an aircraft was still more than 400 m away, and had all reached the water by the time the aircraft passed overhead. The walruses were most disturbed by the noise of the aircraft when it flew overhead at low rather than high altitudes; he noted that some calves were crushed to death by walruses stampeding from low-flying aircraft. Tomilin and Kibal'chich (1975 in Fay 1981) reported that an overflight at 150 m by an IL-14 twin piston engine aircraft caused a stampede by walruses that resulted in 21 calves being crushed to death and two aborted fetuses.

Burns and Harbo (1977) found that walruses hauled out on ice floes at the Bering Sea ice front responded in a variable manner to aircraft overflights, depending on weather. Apparently the walrus were most sensitive to aircraft disturbance on cold, overcast days. They speculated that in general, aircraft disturbance was not anticipated to affect pup survival in the eastern Bering Sea, except under specific conditions at terrestrial sites on the Punuk Islands (J.J. Burns).

Salter (1979) observed no detectable response to six approaches by outboard-powered inflatable boats at distances of 1.8-7.7 km from walruses hauled out at a terrestrial site. Similarly, Brooks (cited in Fay 1981) said that walruses hauled out on ice floes appeared not to be disturbed by the sound of outboard engines on small boats at distances of 400 m.

Frost et al. (1986) reported that "Fay observed instances when walruses at Cape Seniavin were stampeded into the water by low-flying aircraft. When animals flee from the hauling areas some mortality of animals...will occur through injury or abandonment and subsequent starvation... . Regular human disturbance has prevented the long-term use of haulouts at Cape Newenham, Sledge Island, and to some extent King Island (ADF&G, unpub. data)". The 'regular human disturbance' at Cape Newenham was not specified in Frost et al (1986), nor were any data presented. However, we presume they were referring to disturbance associated with regular activities at the U.S. Air Force Radar Station at Cape Newenham. Disturbances at King and Sledge islands were probably associated with boat and aircraft traffic from nearby Nome, Alaska.

Fay et al. (1986) reported on a series of disturbances to a herd of about 1,000 male walruses that had been under observation at a terrestrial haulout site at Cape Seniavin, in southern Bristol Bay. In one day (8 April 1981), over the course of 8 hours, three fixed-wing aircraft and one helicopter passed the haulout site at altitudes of 60-80 m and flushed all of the animals into the water. The number of animals remaining at the site after each of these overflights was not mentioned. However, by early morning of the following day (9 April) about 100 animals had returned to the haulout site, but about half of them left when another fixed-wing aircraft passed them at less than 100 m. About 100 walrus were present when observations started on the following day (10 April), but those were stampeded into the water about an hour later by another passing aircraft.

Fay et al. (1986) reported on another aircraft disturbance to walruses hauled out on a beach on the Punuk Islands (near St. Lawrence Island) on 8 November 1981. During that episode a twin-engine aircraft (type unspecified) made three passes at an altitude of about 60 m over about 4,500 walruses. About 1,000 of the animals raised their heads when the aircraft passed, but fewer than 100 of them went into the water. Two other aircraft passed within hearing range of the Punuk Islands that same day, but caused no apparent response among the walruses.

Similarly, Roseneau (1988) reported that walruses hauled out along rocky beaches near the Air Force Station at Cape Lisburne often ignored low-flying aircraft. In one case, a group of about 50 sleeping walruses were not disturbed (did not respond) when a 4-engine Hercules C-130 cargo aircraft took off from the Air Force station and flew within 0.8 km of the resting animals. According to Roseneau (1988), "Noise from the climbing, departing aircraft flushed many seabirds, but the walruses did not respond to the disturbance." Roseneau also notes that "Some aircraft-related disturbances of walruses have almost certainly occurred at Cape Lisburne over the years. Site personnel have related several incidents...of groups flushing from landing aircraft when animals have been hauled out near the western end of the runway.... However, the arrival of varying numbers of summering and migrating walruses remains an annual event."

The consequences of aircraft disturbances to walruses is discussed by Fay et al. (1986), but most of their discussion relates to disturbances of females and calves hauled out on ice, or of disturbances to wintering or breeding animals. They do not discuss the consequences of disturbance to walruses hauled out at terrestrial sites. However, Fay and Kelly (1980) recorded a case of mass natural mortality apparently caused through injury during a stampede of several thousand walruses during late autumn 1978 at terrestrial haulout sites on eastern St. Lawrence Island and on the Punuk Islands (located southeast of St. Lawrence Island). Fay and Kelly (1980) estimated that about 148,000 walruses had hauled out at six major sites on St. Lawrence Island and the Punuk Islands during autumn 1978. They estimated the following spring (June 1979) that about 411-1134 walrus carcasses (range; based on aerial survey results) were present on the coast of St. Lawrence Island; most of the carcasses had apparently drifted away from the haulout sites and had washed up at 'non haulouts'.

The details of the above incident are best quoted from Fay and Kelly (1980:227-228). "...At the time when these events occurred, the weather was very stormy, with high winds and heavy seas from the south. The walruses, mainly adult females and young, were arriving from the northwest, presumably having swum from the edge of the pack ice which was then just north of Bering Strait, some 300 km away. The Eskimos remarked that the animals coming ashore appeared weak and physically exhausted, sleeping so soundly that it was possible to walk up and touch them without waking them. Observers on the Punuk Islands in early November estimated that there were at least 6000 walruses on the beach at one time. Hunters camped at Kialegak Point [about 40 km W of the Punuk Islands; on St. Lawrence Island] stated that the animals covered about 2.5 km of beach and, in some places, extended inland onto the tundra.

According to the reports from Eskimos camped on Punuk, a few adult bulls were present among the females. These bulls were extremely belligerent, rushing through the resting herd to engage other bulls in battle. On one occasion, two bulls fought with such vigour that one appeared to have mortally wounded the other. In their rushes through the herd, the bulls trampled and struck at other animals with their tusks, and some calves (about 6 months old) were believed to have been killed by them. One night, an entire herd stampeded off the beach into the sea, leaving behind about 25 dead and disabled animals at the water's edge, below a wave-cut terrace. ..."

According to biologists working at the Cape Peirce haulout sites since 1983 (D. Fisher, USFWS, pers. comm. 1988) low-flying (<500 ft ASL) single engined aircraft have disturbed walrus hauled out on the beach near the entrance to Nanvak Bay on several occasions. During one incident in summer 1986, an aircraft flew low (<500 ft ASL) over 4000-5000 hauled out animals several times and caused a stampede into the water that resulted in 2-3 animals being trampled and killed.

Human Presence and Disturbance

Frost et al. (1983) mentioned that "We have noted that ... walruses almost invariably flee into the water when approached by humans... ." Similarly, Kelly (1980) reported that walruses will leave haulout areas in response to the presence of man, and speculated that continued harassment may prevent recolonization.

Shooting of walrus at Cape Peirce by passing boaters and aircraft has been a chronic problem at this site (D. Fisher, USFWS, pers. comm. 1988). During summer 1983 at least 20-23 walruses were shot and killed on the beach near the entrance to Nanvak Bay by a passing boater or a low-flying aircraft (D. Fisher, USFWS, pers. comm. 1988).

DISCUSSION

We have evaluated haulout sites used by fur seals, sea lions, harbor seals and walruses in the eastern Bering Sea in an objective and quantitative manner in an attempt to determine which sites appear to be most sensitive to disturbance. Our IPSI evaluations were based on eight different (but sometimes related) criteria (see 'Methods') for each haulout site, and are presented and discussed here on a species-by-species basis.

Northern Fur Seal

This species differs from the other three pinnipeds considered because virtually all animals haulout in the study area at sites on the Pribilof Islands, although there is a relatively new and small haulout site on Bogoslof Island, in the eastern Aleutians. Lloyd et al. (1981) speculated that the feeding habitat of fur seals consists of outer continental shelf and oceanic domains, and that "only islands in or immediately adjacent to the [very productive] outer shelf domains are suitable for fur seal rookeries."

In addition, virtually all haulout sites are used by all age and sex classes of northern fur seals that haul out on an annual basis, even though these classes may be segregated in different sections of the site (see Appendix 2 for maps of haulout sites on the Pribilof Islands). The northern fur seal is also unique because it does not haul out except during the breeding and post breeding season; it is pelagic throughout most of the year.

There is considerable evidence that northern fur seals respond to various forms of disturbance in different ways (see 'RESULTS'). However, there is no direct evidence that significant mortality has resulted from any of the recent disturbances that have occurred at haulout sites. Most of the recent disturbances are similar to those that may accompany OCS development (e.g., aircraft overflights at altitudes <500 m, nearby ship traffic, human presence). It should be noted, however, that this subject has not been thoroughly investigated through field experiments (R. Gentry, NMFS, pers. comm. 1987).

There is circumstantial evidence that some formerly used historic sites were abandoned because of proximity to man. Overharvesting-overshooting and other chronic disturbances may have been significant factors in the abandonment of the Lagoon rookery on St. Paul Island and the Little Eastern rookery on St. George Island. Both of these haulouts were close to village sites (Jordan and Clark 1898). Also, some workers are concerned that there may be a relationship between low-level (<500 m) aircraft flights on St. Paul Island and the declining numbers of northern fur seals at the Polovina complex of rookeries which are located near the airport (A. Yorke, NMFS, pers. comm. 1988).

Based on all criteria considered in this study, including the general sensitivity of this species, and the susceptibility of the 22 haulout sites to disturbance, North Rookery on St. George Island, Vostochni, Zapadni, Tolstoi, Reef, Polovina Cliffs and Gorbatch rookeries on St. Paul Island, and Sivutch Rookery south of St. Paul Island rated highest in our IPSI evaluation scheme (Table 8). In particular, the Polovina Cliffs rookery is thought by some workers (C. Fowler, NMFS, pers. comm. 1988) to be a likely candidate for abandonment in the near future.

As mentioned earlier, there is some evidence that mortality of younger age classes at sea, through entanglement in abandoned fishing nets and other debris, is an important cause of the recent severe declines in numbers of northern fur seals (Fowler In press; 1985). Because of this decline, the National Marine Fisheries Service recently (May 1988) listed the Pribilof Islands population of northern fur seal as 'depleted' under terms of the Marine Mammal Protection Act of 1972.

Northern Sea Lion

Unlike northern fur seals, northern sea lions may haul out at terrestrial sites throughout the year. Nevertheless, there are definite seasonal peaks in haulout activity in the Bering Sea, especially at the breeding sites, or rookeries. Virtually all of the important rookeries in the study area, with the exception of Walrus Island in the Pribilofs, are in the eastern Aleutian Islands or southeastern Bristol Bay. Similar to northern fur seals (Lloyd et

Table 8. Inter-site Population Sensitivity Index (IPSI) for northern fur seal haulout sites in the Bering Sea, Alaska.

Haulout Site	Max. Count	Rank	Mean Max. Count	Rank	Propor. Pop.	Rank	Age/Sex Comp. x Activity	Rank	Duration of Use	Rank	Consist. of Use	Rank	Site Char.	Rank	Species Char.	Rank	Mean Rank (n=8)	IPSI Rating
St. George I.																		
Zapadni	157	15	211	14	0.025	15	3	14.5	0.583	11.5	1	11	4	18	2	11.5	14.6	18
South	247	12	248	13	0.036	13	3	14.5	0.583	11.5	1	11	4	18	2	11.5	13.6	15
North	593	4	775	3	0.107	1	2	4.5	0.583	11.5	1	11	1	3	2	11.5	4.4	1
East Reef	96	18	122	20	0.016	16	3	14.5	0.583	11.5	1	11	4	18	2	11.5	16.3	21
East Cliffs	282	11	302	12	0.050	9	3	14.5	0.583	11.5	1	11	3	11.5	2	11.5	11.5	11
Staraya-Artil	101	17	198	15	0.014	17.5	3	14.5	0.583	11.5	1	11	1	3	2	11.5	13.0	14
St. Paul I.																		
Lukanin	119	16	137	18	0.014	17.5	3	14.5	0.583	11.5	1	11	2	7.5	2	11.5	14.1	17
Kitovi	236	13	337	11	0.039	12	3	14.5	0.583	11.5	1	11	3	11.5	2	11.5	12.2	12
Gorbatch	358	10	573	6	0.050	9	3	14.5	0.583	11.5	1	11	2	7.5	2	11.5	9.7	8
Ardiguen	57	20	90	21	0.010	19.5	3	14.5	0.583	11.5	1	11	2	7.5	2	11.5	15.6	20
Reef	526	6	808	2	0.076	6	2	4.5	0.583	11.5	1	11	4	18	2	11.5	7.9	5
Morjovi	361	9	501	8	0.044	11	2	4.5	0.583	11.5	1	11	4	18	2	11.5	10.3	9
Vostochni	811	1	1093	1	0.102	3	1	1.5	0.583	11.5	1	11	4	18	2	11.5	5.9	2
Little Polovina	46	21	128	19	0.003	21	3	14.5	0.583	11.5	1	11	1	3	2	11.5	14.9	19
Polovina Cliffs	404	7	540	7	0.057	7	3	14.5	0.583	11.5	1	11	1	3	2	11.5	8.3	6
Polovina	70	19	152	17	0.010	19.5	3	14.5	0.583	11.5	1	11	1	3	2	11.5	14.0	16
Tolstoi	614	3	741	5	0.086	4	3	14.5	0.583	11.5	1	11	2	7.5	2	11.5	7.5	4
Zapadni Reef	210	14	209	15	0.026	14	2	4.5	0.583	11.5	1	11	4	18	2	11.5	12.8	13
Little Zapadni	367	8	458	9	0.050	9	3	14.5	0.583	11.5	1	11	3	11.5	2	11.5	10.5	10
Zapadni	626	2	755	4	0.079	5	1	1.5	0.583	11.5	1	11	4	18	2	11.5	6.9	3
Sivutch	582	5	450	10	0.104	2	3	14.5	0.583	11.5	1	11	3	11.5	2	11.5	9.0	7
Bogoslof I.	7	22	2	22	0.001	22	3	14.5	0.583	11.5	2	22	4	18	2	11.5	20.1	22

Max. Counts are Breed. Bulls only from either "1980's" or "Curr. Est." columns in Table 3.
Mean Max. Counts are Breed. Bulls only from "1960's", "1970's", "1980's" and "Curr. Est." columns in Table 3.
Proportion of Population is calculated from "Curr. Est." column in Table 3.
Age/Sex Composition x Activity values are based on whether all age/sex classes are present and whether breeding occurs regularly at the site (all=1, ad.=2, subad.=3), and the number of different locations at the site where fur seals haul out (1=many, 2=several, 3=few).
Duration of Use of site is the approximate proportion of the year that the site is occupied.
Consistency of Use categories are as follows :1 = annual and consistent, and 2 = inconsistent.
Site Characteristic values were based on topography and proximity to noise/disturb. near the haulout site (1=any site near noise/disturbance, 2=cliffs, 3=bluffs/slopes, 4=low or no relief).
Species Characteristics values were assigned based on the degree of sensitivity of the species and potential for mortality as a result of noise/disturbance (1=high, 2= medium, 3=low).

al. 1981), it may be possible that the locations of northern sea lion rookeries in part are determined by the distribution and abundance of their principal prey, walleye pollock (Frost and Lowry 1986; Loughlin 1987; Bakkala et al. 1987), which in turn may be affected by overfishing and/or oceanographic characteristics.

Consistently used haulout sites are generally located in the southern half of the Bering Sea, south of Cape Newenham and the Pribilof Islands. Haulout sites farther north are generally used for shorter durations and less consistently from one year to the next (J.J. Burns, pers. obs. 1988).

Northern sea lions respond to noise and human disturbance in a variety of ways. There have been instances where human disturbance at northern sea lion rookeries has caused mortality (Lewis 1987; R. Merrick, NMFS, pers. comm. 1988). Thus, human disturbance has the potential to significantly affect the health of the Bering Sea population. Our evaluation of the sensitivity of northern sea lions at their 26 terrestrial haulout sites in the study area has been influenced by the fact that mortality associated with disturbance is known to occur. Based on all criteria considered in this study (IPSI evaluation), including the general susceptibility of this species, and the susceptibility of the 26 haulout sites to disturbance, we determined that the rookeries and associated hauling grounds on Ugamak Island and nearby rocks and islets (incl. Round I.), at Cape Morgan on Akutan Island, on Sea Lion Rock near Amak Island, on Walrus Island in the Pribilofs, on Bogoslof Island, and at Billings Head on Akun Island rated the highest in our IPSI evaluation scheme (Table 9). Recent severe disturbances at the Ugamak Island rookery, and increased chronic disturbances from aircraft and ship traffic near Sea Lion Rock (close to the airport at Cold Bay, AK) and Bogoslof Island (increased fishing activity nearby) are of particular concern.

The history of use and disuse of haulout sites in the Pribilof Islands is of particular interest, considering that these islands are likely to be the focus of activity during possible OCS development in the St. George Basin. Of the eight historically used sea lion haulout sites in the Pribilofs (4 on St. George, 1 on St. Paul, and 3 on smaller surrounding islets), there is current information (1980's) for only 3 sites (Walrus I., Otter I. and Dalnoi Pt.

Table 9. Inter-site Population Sensitivity Index (IPSI) for northern sea lion haulout sites in the Bering Sea, Alaska.

Haulout Site	Max. Count	Rank	Mean Max. Count	Rank	Propor. Pop.	Rank	Age/Sex Comp. x Activity	Rank	Duration of Use	Rank	Consist. of Use	Rank	Site Char.	Rank	Species Char.	Rank	Mean Rank (n=8)	IPSI Rating
Bogoslof Island*	1379	5	2133	4	0.083	4	6	3.5	0.500	5	1	4.5	4	26	1	3.5	6.9	5
Unalaska Island																		
Spray Cape	161	17	96	22	0.001	25.5	4	12	0.250	14.5	2	13.5	2	14	2	16.5	16.9	18
Bishop Point	549	12	475	11	0.035	9.5	4	12	0.250	14.5	2	13.5	2	14	2	16.5	12.9	11
Akutan Island*																		
Cape Morgan*	2840	2	5996	2	0.110	2	1	3.5	0.500	5	1	4.5	2	14	1	3.5	4.6	2
Akun Island*																		
Billings Head*	760	9	1459	7	0.028	13	1	3.5	0.500	5	1	4.5	2	14	1	3.5	7.4	6
Tanginak Island	61	22	377	14	0.004	21	4	12	0.250	14.5	2	13.5	2	14	2	16.5	15.9	16
Rocks NE of Tigalda I.	225	15.5	312	16	0.005	20	4	12	0.250	14.5	2	13.5	2	14	2	16.5	15.3	15
Ugamak Island Group*	2033	3	7131	1	0.109	3	1	3.5	0.500	5	1	4.5	1	4	1	3.5	3.4	1
Unimak Island																		
Cape Sarichef	128	19	115	21	0.008	17	4	12	0.250	14.5	2	13.5	1	4	2	16.5	14.7	14
Amak Island	599	11	1379	8	0.039	7.5	4	12	0.500	5	1	4.5	1	4	2	16.5	8.6	7
Unnamed Rocks	225	15.5	266	17	0.014	15	4	12	0.500	5	1	4.5	1	4	2	16.5	11.2	9
Sea Lion Rock*	1298	6	1967	6	0.035	9.5	1	3.5	0.500	5	1	4.5	1	4	1	3.5	5.3	3
Right Hand Point	50	24	50	25	0.003	23	4	12	0.167	23	2	13.5	2	14	2	16.5	18.9	21
Round Island	1000	7	833	10	0.064	5	4	12	0.167	23	2	13.5	2	14	2	16.5	12.6	10
Cape Peirce	450	13	450	12	0.029	12	4	12	0.167	23	2	13.5	1	4	2	16.5	13.3	12.5
Cape Newenham	1500	4	1083	9	0.061	6	4	12	0.167	23	2	13.5	1	4	2	16.5	11.0	8
Nunivak Island																		
Cape Mendenhall	50	24	50	25	0.003	23	6	23	0.167	23	3	22.5	3	23	2	16.5	22.5	26
St. Matthew Island																		
Sugarloaf Mtn.	50	24	50	25	0.003	23	6	23	0.250	14.5	3	22.5	2	14	2	16.5	20.3	25
Cape Upright	90	20	93	23	0.006	18.5	6	23	0.250	14.5	3	22.5	2	14	2	16.5	19.0	22
East of Lunda Pt.	600	10	326	15	0.039	7.5	6	23	0.250	14.5	3	22.5	3	23	2	16.5	16.5	17
Hall Island																16.5		
Arre Rock	150	18	150	20	0.010	16	6	23	0.250	14.5	3	22.5	3	23	2	16.5	19.2	23
North Cove	4000	1	2038	5	0.258	1	6	23	0.250	14.5	3	22.5	3	23	2	16.5	13.3	12.5
Pinnacle Island	257	14	205	18	0.017	14	6	23	0.167	23	3	22.5	2	14	2	16.5	18.1	20
St. George Island	86	21	378	13	0.006	18.5	6	23	0.167	23	3	22.5	3	23	2	16.5	20.1	24
Walrus Island*	868	8	2392	3	0.031	11	1	3.5	0.500	5	1	4.5	2	14	1	3.5	6.6	4
Otter Island	–	26	200	19	0.000	25.5	6	23	0.500	5	2	13.5	2	14	2	16.5	17.8	19

Max. Counts are Ads./Subads. only from either "1980's" or "Curr. Est." (whichever is larger) in Table 5.
Mean Max. Counts are Ads./Subads. only from "1960's", "1970's", "1980's" and "Curr. Est." columns in Table 5.
Proportion of Population is calculated from "Curr. Est." column in Table 5.
Age/Sex Composition x Activity values are based on whether all age/sex classes are present and whether breeding took place at the site (all=1, adults and subad.=2), and the number of different locations at the site where sea lions haul out (1=many, 2=several, 3= 1 or 2).
Duration of Use is the approximate proportion of the year the site is occupied.
Consistency of Use categories are as follows: 1=annual and continuous, 2=annual but discontinuous, and 3=inconsistent.
Site Characteristic values were based on topography and proximity to noise/disturb. near the haulout site (1=any site near noise/disturbance, 2=cliffs, 3=bluffs/slopes, 4=low or no relief).
Species Characteristics values were assigned based on the degree of sensitivity of the species and potential for mortality as a result of noise/disturbance (high=1, medium=2, low=3).

* Asterisks indicate that the haulout site is a rookery.

area). Formerly there were four rookeries on the Pribilofs: Walrus Island; near Northeast Point; near East Rookery; and near Tolstoi Point. Currently only the site on Walrus Island is an active rookery. Kenyon (1962) noted that the haulout site near Northeast Point on St. Paul Island was formerly the largest rookery in the Pribilof Islands, however, no pups have been seen there since 1957, which is about when major declines in the numbers of northern sea lions apparently began.

The ultimate causes of the decline in the northern sea lion population in Alaska are unknown (Merrick et al. 1987). However, it has been postulated that disease (possibly Leptospira), changes in prey resources, increased mortality through shooting, and possible entanglement in nets and other debris may all be contributing factors.

Some evidence suggests that changes in the quantity and size of walleye pollock (Theragra chalcogramma), the principal prey of northern sea lions, may be a factor in their decline (Bakkala et al. 1987; Fowler In press; Loughlin 1987; Frost and Lowry 1986). It is also possible that increased mortality of pups that become separated from their mothers during some types of censuses at rookeries (Lewis 1987) may be a factor contributing to the decline. Away from the haulout sites, there is little evidence that noise from either airborne or underwater sources has serious detrimental effects on northern sea lions. In fact, some studies show that sea lions habituate well to some severe forms of noise (Shaughnessy et al. 1981, Mate and Harvey 1987).

Harbor Seal

Harbor seals are distributed throughout the portion of the study area south of Nunivak and the Pribilof islands. Harbor seals do not necessarily aggregate at large rookeries to breed, pup and suckle their young. Aside from the resident population on Otter Island in the Pribilofs, most harbor seals in the northern part of the study area probably move south (away from advancing ice) during winter. Of the 41 terrestrial haulout sites considered in detail in our study area, only about 6-8 appear to have consistently supported large fractions of the total eastern Bering Sea population of this species--most of these important sites are on the Alaska Peninsula.

Harbor seals respond to noise and human disturbance in a variety of ways. In some situations it is not possible to disperse them even using severe forms of disturbance; i.e., they appear to accommodate to noise and disturbance in some instances when they are actively feeding. However, there have been instances where human disturbance at harbor seal haulout sites have caused the sites to be abandoned and pups to be separated from their mothers, thereby causing mortality (Johnson 1977; see 'Results' section for details). Thus, our evaluation of the importance and vulnerability of harbor seals at 41 terrestrial haulout sites has been influenced by the fact that abandonment of sites and consequent mortality of pups has been shown to be associated with some kinds of noise and disturbance near such sites. Based on all criteria considered in this study, including the general susceptibility of this species, and the susceptibility of the 41 haulout sites to disturbance, we determined that the sites in Izembek/Moffet Lagoon, Port Heiden, Port Moller, Cinder River, Seal Islands and Ilnik (all on the Alaska Peninsula), and in Nanvak Bay near Cape Peirce, Ugashik Bay, and on Otter Island in the Pribilofs to be the most important and potentially most vulnerable to noise and disturbance associated with OCS development (Table 10).

The number of harbor seals recorded at haulout sites in the Bering Sea, especially at some sites in the southeastern Bering Sea, has apparently declined dramatically during the recent decade (Pitcher 1986). Although several reasons have been given for the apparent recent decline of harbor seals (e.g., disease, over-exploitation in earlier years, increased predation, increased fouling in fishing gear, reductions in principal prey [walleye pollock]), none of these suggestions have been clearly documented. At present, the sites that appear to have been most significantly reduced in size (fewer seals counted recently) are the Seal Islands, Cinder River, and Izembek/ Moffet Lagoon, on the Alaska Peninsula. However, as noted in the 'Results', counts at any one of these sites may be greatly influenced by such factors as the time of day, time of year, tide, weather, availability of prey, etc. Recommended programs designed to more carefully monitor the number of harbor seals at haulout sites in Bristol Bay could provide more of the data needed to determine the status of this species in the study area, prior to OCS development (Hoover 1988b).

Table 10. Inter-site Population Sensitivity Index (IPSI) for harbor seal haulout sites in the Bering Sea, Alaska.

Haulout Site	Max. Count	Rank	Mean Max. Count	Rank	Propor. Pop.	Rank	Age/Sex Comp. x Activity	Rank	Duration of Use	Rank	Consist. of Use	Rank	Site Char.	Rank	Species Char.	Rank	Mean Rank	IPSI Rating
Umnak Island	–	31	415	14	–	31.5	1	15	1.000	15.5	2	29.5	2	17.5	3	33	22.2	24
Bogoslof Island	–	31	56	34	–	31.5	1	15	1.000	15.5	3	41	4	35	3	33	29.2	41
Unalaska Island	–	31	326	15	–	31.5	1	15	1.000	15.5	2	29.5	2	17.5	3	33	22.4	26
Akutan Island	6	20	28	38	0.001	20	1	15	1.000	15.5	2	29.5	2	17.5	3	33	21.1	23
Akun Island (incl. Tangik I.)	23	19	75	30	0.003	19	1	15	1.000	15.5	2	29.5	2	17.5	3	33	19.9	20.5
Tanginak Island	–	31	–	41	–	31.5	1	15	1.000	15.5	2	29.5	2	17.5	3	33	26.1	37
Avatanak Island	–	31	68	33	–	31.5	1	15	1.000	15.5	2	29.5	2	17.5	3	33	24.9	34
Tigalda Island	–	31	8	40	–	31.5	1	15	1.000	15.5	2	29.5	2	17.5	3	33	25.9	36
Kaligagan & islets NE of Tigalda I.	245	9	247	18	0.030	7	1	15	1.000	15.5	2	29.5	2	17.5	3	33	17.2	12
Ugamak Island	–	31	40	37	–	31.5	1	15	1.000	15.5	2	29.5	1	5	3	33	23.7	29
Aiktak Island	94	15	122	25	0.012	12	1	15	1.000	15.5	2	29.5	1	5	3	33	17.3	13.5
Unalga, Babies, rocks & islets	125	11	220	19	0.015	10.5	1	15	1.000	15.5	2	29.5	2	17.5	3	33	17.6	15
Cape Lapin (Unimak I.)	–	31	120	26	–	31.5	1.5	31.5	1.000	15.5	2	29.5	1	5	3	33	24.5	31
North Creek (Unimak I.)	–	31	70	32	–	31.5	1.5	31.5	1.000	15.5	2	29.5	1	5	3	33	25.4	35
Bechevin Bay	–	31	1500	9.5	–	31.5	1.5	31.5	1.000	15.5	1	9.5	1	5	2	16.5	16.9	10.5
Cape Krenitzin	–	31	1500	9.5	–	31.5	1.5	31.5	1.000	15.5	1	9.5	1	5	2	16.5	16.9	10.5
Isanotski Islands	–	31	511	12	–	31.5	1.5	31.5	1.000	15.5	1	9.5	1	5	2	16.5	17.3	13.5
Izembek/Moffet Lagoon	1974	4	1888	7	0.040	4	0.5	3.5	1.000	15.5	1	9.5	1	5	1	4.5	6.1	1
Amak Island	2	21	20	39	0.000	21	1.5	31.5	1.000	15.5	2	29.5	1	5	2	16.5	19.8	19
Cape Leiskof	0	31	150	21	–	31.5	1.5	31.5	1.000	15.5	2	29.5	3	27	2	16.5	24.6	32.5
Cape Seniavin	–	31	71	31	–	31.5	1.5	31.5	1.000	15.5	2	29.5	2	17.5	2	16.5	24.6	32.6
Port Moller	–	2	4884	2	0.488	1	0.5	3.5	1.000	15.5	1	9.5	4	35	1	4.5	9.1	3
Seal Islands (incl. Ilnik)	1521	5	1599	8	0.009	16.5	0.5	3.5	1.000	15.5	1	9.5	4	35	1	4.5	10.1	5
Port Heiden	6196	1	5768	1	0.098	3	0.5	3.5	1.000	15.5	1	9.5	4	35	1	4.5	8.8	2
Cinder River	350	7	2038	5	0.037	5.5	0.5	3.5	1.000	15.5	1	9.5	4	35	1	4.5	10.0	4
Ugashik Bay	1000	6	719	11	0.121	2	1	15	1.000	15.5	1	9.5	4	35	2	16.5	13.6	6.5
Egigik R. Flats	0	31	300	16.5	–	31.5	1	15	1.000	15.5	1	9.5	4	35	2	16.5	19.9	20.5
Deadman Sands	–	10	150	21	0.018	9	1	15	1.000	15.5	1	9.5	4	35	2	16.5	15.3	9
Cape Constantine	100	14	100	27	0.012	13	1.5	31.5	0.075	31.5	2	29.5	2	17.5	2	16.5	20.9	22
Tvativak Bay	77	17	77	29	0.009	16.5	1.5	31.5	0.075	31.5	2	29.5	3	27	2	16.5	22.8	27
Hagemeister Island	100	14	133	23	0.012	13	1.5	31.5	0.580	33.5	1	9.5	2	17.5	2	16.5	18.1	16
Black Rock	300	8	300	16.5	0.037	5.5	1.5	31.5	0.580	33.5	2	29.5	2	17.5	2	16.5	19.1	18
Nanvak Bay (Mouth)	3100	3	2107	4	0.027	8	1	15	0.500	38	1	9.5	4	35	1	4.5	13.6	6.5
Cape Newenham	0	31	50	35.5	–	31.5	1.5	31.5	0.500	38	2	29.5	2	17.5	2	16.5	28.5	40
Chagvan Bay (Mouth)	–	31	150	21	–	31.5	1.5	31.5	0.500	38	1	9.5	4	35	1	4.5	24.4	30
Quinhagak (Middle Bar)	–	31	3000	3	–	31.5	1.5	31.5	0.500	38	1	9.5	4	35	2	16.5	23.5	28
Kongiganak (South Bar)	–	31	50	35.5	–	31.5	1.5	31.5	0.500	38	1	9.5	4	35	2	16.5	28.1	39
Kuskokwim Bay	–	31	2000	6	–	31.5	0.5	3.5	0.500	38	1	9.5	4	35	1	4.5	18.2	17
Nunivak I. (Cape Mendenhall)	–	16	80	28	0.010	15	2	40.5	0.500	38	2	29.5	3	27	3	33	26.5	38
St. George I. (Dalnoi Pt. area)	50	18	130	24	0.006	18	2	40.5	1.000	15.5	2	29.5	2	17.5	3	33	22.3	25
Otter Island	119	12	483	13	0.015	10.5	1	15	1.000	15.5	1	9.5	2	17.5	3	33	14.4	8

Max. Count is from either "1980's" or "Curr. Est." columns (whichever is greater) in Table 6.

Mean Max. Count is from "1960's", "1970's", "1980's" and "Curr. Est." columns in Table 6.

Proportion of Population is calculated from "Curr. Est." column in Table 6.

Age/Sex Composition x Activity values are based on whether all age/sex classes are present and whether pupping occurs regularly at or near the site (all=0.5, Ad. only=1), and the number of different locations where harbor seals haul out (1=many, 2=several, 3=few) associated with the site.

Duration of Use is based on the approximate proportion of the year that the site is used.

Consistency of Use categories are as follows: 1=annual and relatively consistent, and 2=inconsistent.

Site Characteristics values were based on topography and proximity to noise/disturb. source near the haulout site (1=any site near noise/disturb., 2=cliffs, 3=bluffs/slopes, 4=low or no relief).

Species Characteristics values were assigned based on the sensitivity of the species and associated potential for mortality as a result of disturbance (1=high, 2=medium, 3=low).

Pacific Walrus

Only male Pacific walruses haul out at terrestrial sites in the southern part of the study area, i.e., at island and mainland sites south of the St. Matthew-Hall Islands area (south of about 60°N). During fall, as the pack-ice advances south through Bering Strait, females with calves return to the northern part of the study area, where they are joined by males that have moved northward from southern sites. Haulout sites on St. Lawrence Island and on the nearby Punuk Islands are particularly important at this time of year (autumn); all age and sex classes may be found hauled out at these terrestrial sites in some years. Breeding occurs on the pack-ice in late winter-early spring and calves are born on the ice in spring. Females and newborn calves remain with the pack-ice as it retreats north out of the study area in early summer, whereas many males remain south and utilize haulout sites in Bristol Bay.

There is only a relatively small body of information concerning the effects on walruses of various kinds of noise and disturbance, however, some of this information is particularly relevant to this study. In general, walruses respond to noise and human disturbance by temporarily leaving the haulout site; if the disturbance persists, the site may be abandoned (Fay et al. 1986; for more details see 'RESULTS'). Natural mass mortality of walruses has occurred at a Punuk Island haulout site in at least one year, 1978 (Fay and Kelly 1980). Although it is unclear how mortality of this type has occurred, it does indicate the magnitude of such mortality (many hundreds of animals died) that can occur when large numbers of animals (tens of thousands) are hauled out at one site. At other sites (Cape Peirce), shooting and other types of harassment such as by aircraft and boats have caused severe disturbances.

Based on all criteria considered in this study, including the general susceptibility of this species, and the susceptibility of the 31 haulout sites to disturbance, we determined that the sites at (1) Port Moller and Cape Seniavin in southern Bristol Bay, (2) at Round Island, Cape Peirce and Cape Newenham in northern Bristol Bay, and (3) at St. Matthew and Hall islands, King Island, eastern St. Lawrence Island and North Punuk Island in the central and northern Bering Sea rate high in our IPSI evaluation scheme (Table 11).

Both the Amak Island and Cape Seniavin haulout sites have been disturbed in recent years by fishing boats and low-flying aircraft and beachcombers landing at the site; poachers have also frequently disturbed the Cape Seniavin site (J.J. Burns, pers. comm. 1988). It is probable that many of the walruses recorded in the Port Moller area have been displaced (through disturbance) from nearby Cape Seniavin (details given earlier in 'Results'). Further, there is evidence that walruses using the Cape Seniavin site are also associated with the Round Island site in northern Bristol Bay. At least one male walrus tagged at Round Island was recovered (dead) on the beach at Cape Seniavin.

The Cape Peirce haulout site has been reoccupied since the early 1980's. Significant numbers hauled out at this site in 1983, but shooting and other disturbances prevented a sustained reoccupancy that year (D. Fisher, USFWS, pers. comm. 1988). Large numbers of walrus (about 4,000-6,000 males) again reoccupied this site in 1984. Very large numbers of walrus (12,000 males) have been recorded at Cape Peirce in recent years, even though shooting of some animals has occurred at this site every year since 1986 (D. Fisher, USFWS, pers. comm. 1988). Daily surveillance at Cape Peirce during the summer haulout period began in 1984 and currently there is careful documentation of hunting and other disturbances.

Table 11. Inter-site Population Sensitivity Index (IPSI) for Pacific walrus haulout sites in the Bering Sea, Alaska.

Haulout Site	Max. Count	Rank	Mean Max. Count	Rank	Propor. Pop.	Rank	Age/Sex Comp. x Activity	Rank	Duration of Use	Rank	Consist. of Use	Rank	Site Char.	Rank	Species Char.	Rank	Mean Rank (n=8)	IPSI Rating
Amak Island*	0	18	155	26	0.000	14.5	3	25.5	0.580	1	2	22	1	4	2	16	15.9	18
Port Moller*	3250	7	2875	10	0.073	5	2	19.5	0.417	4.5	2	22	1	4	2	16	11.0	5
Cape Seniavin*	3500	6	1813	12	0.040	9.5	3	25.5	0.417	4.5	1	6.5	1	4	2	16	10.5	4
Port Heiden*	–	25	60	29	–	25	3	25.5	0.333	12.5	2	22	1	4	2	16	19.9	26
Egegik Bay*	1000	8	1000	14	0.022	8	3	26	0.333	12.5	2	22	1	4	3	27	15.2	13.5
High Island*	–	25	0	31	–	25	3	25.5	0.333	12.5	1	6.5	2	13.5	3	27	20.8	28
North Twin Island*	–	25	1000	13	–	25	3	25.5	0.333	12.5	1	6.5	2	13.5	3	27	18.5	23
Round Island*	12400	3	7425	8	0.119	4	1	9	0.333	12.5	1	6.5	2	13.5	3	27	10.4	3
Cape Peirce*	12500	2	9400	7	0.141	3	1	9	0.333	12.5	1	6.5	2	13.5	3	27	10.1	2
Cape Newenham*	700	9	423	16	0.002	13.5	2	19.5	0.333	12.5	1	6.5	2	13.5	2	16	13.3	8
Security Cove*	10000	4	6677	9	0.225	2	3	25.5	0.167	24.5	2	22	3	23	2	16	15.8	17
Goodnews Bay*	–	25	250	20	–	25	3	25.5	0.167	24.5	2	22	3	23	2	16	22.6	31
Kwigillingok*	–	25	500	15	–	25	3	25.5	0.167	24.5	2	22	3	23	2	16	22.0	30
Nunivak Island*																		
Cape Etolin*	–	25	200	22	–	25	3	25.5	0.167	24.5	2	22	1	3.5	2	16	20.4	27
Mekoryuk*	–	25	200	22	–	25	3	25.5	0.167	24.5	2	22	1	3.5	2	16	19.4	25
St. Matthew Island*																		
Cape Upright*	160	12	160	25	0.004	9.5	1	9	0.417	4.5	1	6.5	2	13.5	3	27	13.4	9
Cape Glory of Russia*	80	15	80	28	0.002	13.5	1	9	0.417	4.5	1	6.5	2	13.5	3	27	14.6	12
Lunda Bay*	180	11	180	24	0.004	9.5	1	9	0.417	4.5	1	6.5	3	23	3	27	14.3	10
Hall Island*	550	10	340	18	0.003	11	1	9	0.417	4.5	1	6.5	2	13.5	3	27	12.4	6
Egg Island*	–	25	300	19	–	25	1.5	16	0.167	24.5	2	22	3	23	2	16	21.3	29
Besboro Island*	100	14	200	22	0.002	13.5	1.5	16	0.167	24.5	2	22	2	13.5	2	16	17.7	20
Cape Darby*	50	16	36	30	0.001	16	1.5	16	0.167	24.5	2	22	2	13.5	2	16	19.3	24
Sledge Island	3	17	352	17	0.000	17.5	1.5	16	0.167	24.5	2	22	2	13.5	1	5	16.6	19
King Island	5000	5	2333	11	0.022	7.5	1.5	16	0.167	24.5	2	22	2	13.5	1	5	13.1	7
Punuk Islands																		
North Island	15000	1	15875	4	0.337	1	0.5	2.5	0.167	24.5	1	6.5	4	29	1	5	9.2	1
Middle Island	–	25	14000	5	–	25	1	9	0.167	24.5	2	22	4	29	1	5	18.1	21
South Island	–	25	11000	6	–	25	1	9	0.167	24.5	2	22	4	29	1	5	18.2	22
St. Lawrence Island																		
Chibukak Pt.	100	13	100	27	0.002	13.5	1	9	0.167	24.5	1	6.5	3	23	1	5	15.2	13.5
Salghat	–	25	19000	3	–	25	0.5	2.5	0.333	12.5	2	22	4	29	1	5	15.5	16
Maknik	–	25	35000	2	–	25	0.5	2.5	0.333	12.5	2	22	4	29	1	5	15.4	15
Kialegak Pt.	–	25	37000	1	–	25	0.5	2.5	0.333	12.5	2	22	3	23	1	5	14.5	11

Max. Count is from either "1980's" or "Curr. Est." columns (whichever is greater) in Table 7
Mean Max. Count is from "1960's", "1970's", "1980's" and "Curr. Est." columns in Table 7.
Proportion of Population is calculated from "Curr. Est." column in Table 7.
Age/Sex Composition x Activity values are based on whether all age/sex classes are present at the site (all=0.5, ad. males only=1), and the number of different locations at the site where walruses haul out (1=many, 2=several, 3= few).
Duration of Use is the approximate proportion of the year that the site is occupied.
Consistency of Use categories are as follows: 1 = annual and consistent, and 2 = inconsistent.
Site Characteristic values were based on topography and proximity to noise/disturb. near the haulout site (1 = any site near noise/disturb., 2 = cliffs, 3 = bluffs/slopes, 4 = low or no relief).
Species Characteristics values were assigned based on the degree of sensitivity of the species and associated potential for mortality as a result of noise/disturbance (high=1, medium=2, low=3).

* An asterisk indicates that this haulout site is occupied mostly by adult males. All other haulout sites (those without asterisks) are occupied by male and female adults, subadults and calves.

SUMMARY AND CONCLUSIONS

The following summary and concluding remarks are presented in relation to the four broadly defined OCS Planning Areas (Norton Basin, St. Matthew-Hall, North Aleutian Basin, and St. George Basin) in our study area (see Fig. 1). Each of these four planning areas contain haulout sites that are important to more than one of the pinniped species considered in this report. Many of these sites ranked high in our Inter-site Population Sensitivity Index (IPSI) evaluations.

Norton Basin Planning Area

There are 14 haulout sites in the Norton Basin Planning Area used by two of the four species of pinnipeds considered in this study; no northern fur seals or harbor seals haul out in significant numbers in this planning area. However, 86% (12) of the 14 sites in this planning area are used by one species, the Pacific walrus (Fig. 12). Two (14%) of these haulout sites, the one on North Punuk Island, and the one on King Island had high IPSI ratings (see Table 11). Northern sea lions have occasionally hauled out at Southwest Cape on St. Lawrence Island and on South Punuk Island; however, there is no current information concerning the use of these sites by this species, consequently, there was insufficient information to assign an IPSI value (compare Table 5 with Table 9).

St. Matthew-Hall Planning Area

In the St. Matthew-Hall OCS Planning Area 24 haulout sites have been used by three of the four pinniped species considered in this study; there are no northern fur seal haulout sites. The majority of the sites are used by northern sea lions (11 sites, 46%); however none of these 11 sites ranked high in the overall evaluation of importance or potential vulnerability (Table 9). Pacific walrus sites were second in abundance (8 sites; 33%) and four of these, all on St. Matthew or Hall islands, ranked high in our IPSI rating system (Table 11). Harbor seal sites were least abundant (5 sites; 21%) in this planning area. Nevertheless, the site(s) in Kuskokwim Bay had relatively high IPSI values (Table 10); this area , and the areas to the east near Avinof

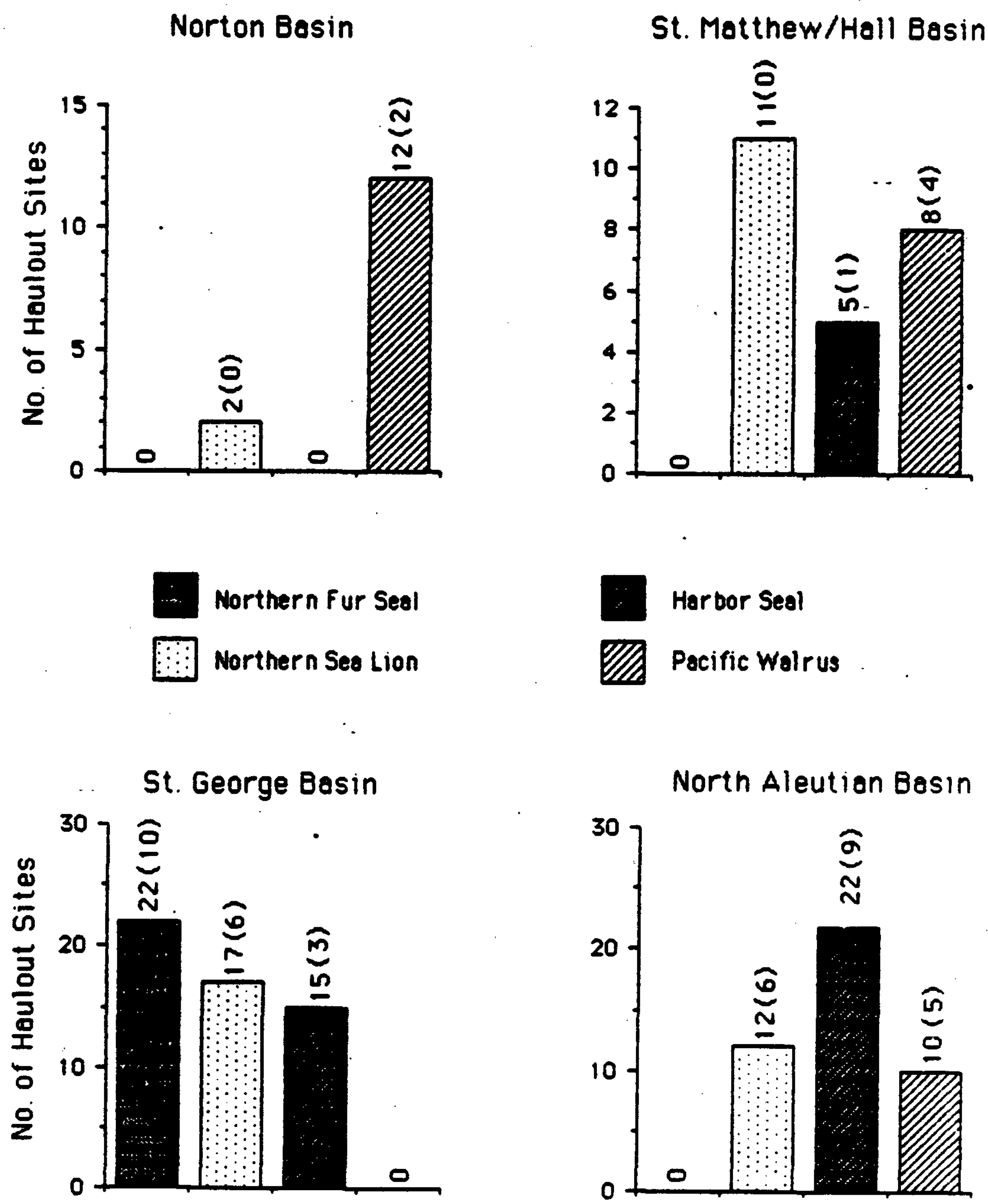


Figure 12. Summary of haulout sites in various OCS Planning Areas in the Bering Sea, Alaska. The number of sites that rated high in our IPSI evaluations are shown in parentheses.

Pt., may be the most northerly major harbor seal pupping areas in the eastern Bering Sea, and probably this is the least studied harbor seal habitat in the study area.

North Aleutian Basin Planning Area

The North Aleutian Basin Planning Area contains 44 haulout sites used by three of the four pinniped species considered in this study (Fig. 12). Harbor seals use 22 (50%) of these sites including 9 of the 13 sites that had the highest IPSI ratings for harbor seals in this study (see Table 10). Twelve (27%) sites were occupied by northern sea lions, and at least six (14%) of these sites had high IPSI ratings. Ten sites (23%) in the North Aleutian Planning Area are occupied by Pacific walrus; five (11%) of these sites had very high IPSI values (Table 11).

St. George Basin Planning Area

The St. George Basin Planning Area supports the largest number of haulout sites for the species considered in this study--a total of at least 54 sites for three species. There are no consistently used Pacific walrus haulout sites in the St. George Basin Planning Area. On the other hand, all 22 (100%) of the northern fur seal haulout sites in the eastern Bering Sea are in this planning area (Pribilof Islands and Bogoslof Island); these 22 sites represent about 40% of the total 54 sites used by the four species studied in this planning area (Table 10). Seventeen sites (32%) in this planning area are occupied by northern sea lions, and 6 (11%) of these had high IPSI ratings (Table 9). It was not possible for some sites to be evaluated (compare Table 5 with Table 9) because there was insufficient information on their current use. At least 15 sites (28%) in the St. George Basin Planning Area are used by harbor seals, and three (6%) of these sites (two in the Fox Islands and Otter Island) had very high IPSI ratings.

It should be remembered that we have not discussed rookeries/haulouts used by very small numbers of pinnipeds. With the exception of northern fur seals (which use only the Pribilofs and Bogoslof Island), hundreds of such sites are used by small groups (1-10 individuals) of Pacific walruses, northern sea lions, and especially harbor seals. The degree of fidelity to specific haulout sites (from greatest to least) by the four species we studied are: northern fur seal, walrus, northern sea lion and harbor seal. The last two species are most likely to haul out at sites not considered significant (far less than 1% of the study area population) and not considered in this study. This is especially true for harbor seals which are ubiquitous in most of the study area and haul out at hundreds of sites not considered here.

In summary, we evaluated 120 of 136 major terrestrial haulout sites in four different OCS Planning Areas to determine their overall importance and potential vulnerability, i.e. their sensitivity to possible OCS activities. It was not possible to evaluate some sites mentioned in the text and tables because of insufficient information on the number of animals currently using the sites and uncertainly about the consistency of use of the sites. Of the 44 sites in the North Aleutian Basin Planning Area, almost half (20 sites; 45%) were ranked high in our IPSI evaluations; this number represents almost half of the total 41 most highly rated sites for all four species in the study area. Of the 54 sites in the St. George Basin Planning Area, 19 (35%) were rated high; this number is strongly influenced by the 10 most highly rated northern fur seal sites on the Pribilof Islands. Of the 24 sites in the St. Matthew-Hall Planning Area, 5 (21%) were ranked high in our IPSI evaluations, and most (4 of 5; 80%) were sites occupied by Pacific walrus. Similarly, of the 14 sites in the Norton Basin Planning Area, only 2 were rated high in our IPSI evaluations; both of these sites were occupied by Pacific walrus.

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