NOAA Technical Memorandum NMFS-AFSC-77

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

August 1997

NOAA Technical Memorandum NMFS

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This document should be cited as follows:

> Chumbley, K., J. Sease, M. Strick, and R. Towell. 1997. Field studies of Steller sea lions (Eumetopias jubatus) at Marmot Island, Alaska, 1979 through 1994. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-77, 99 p.

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August 1997

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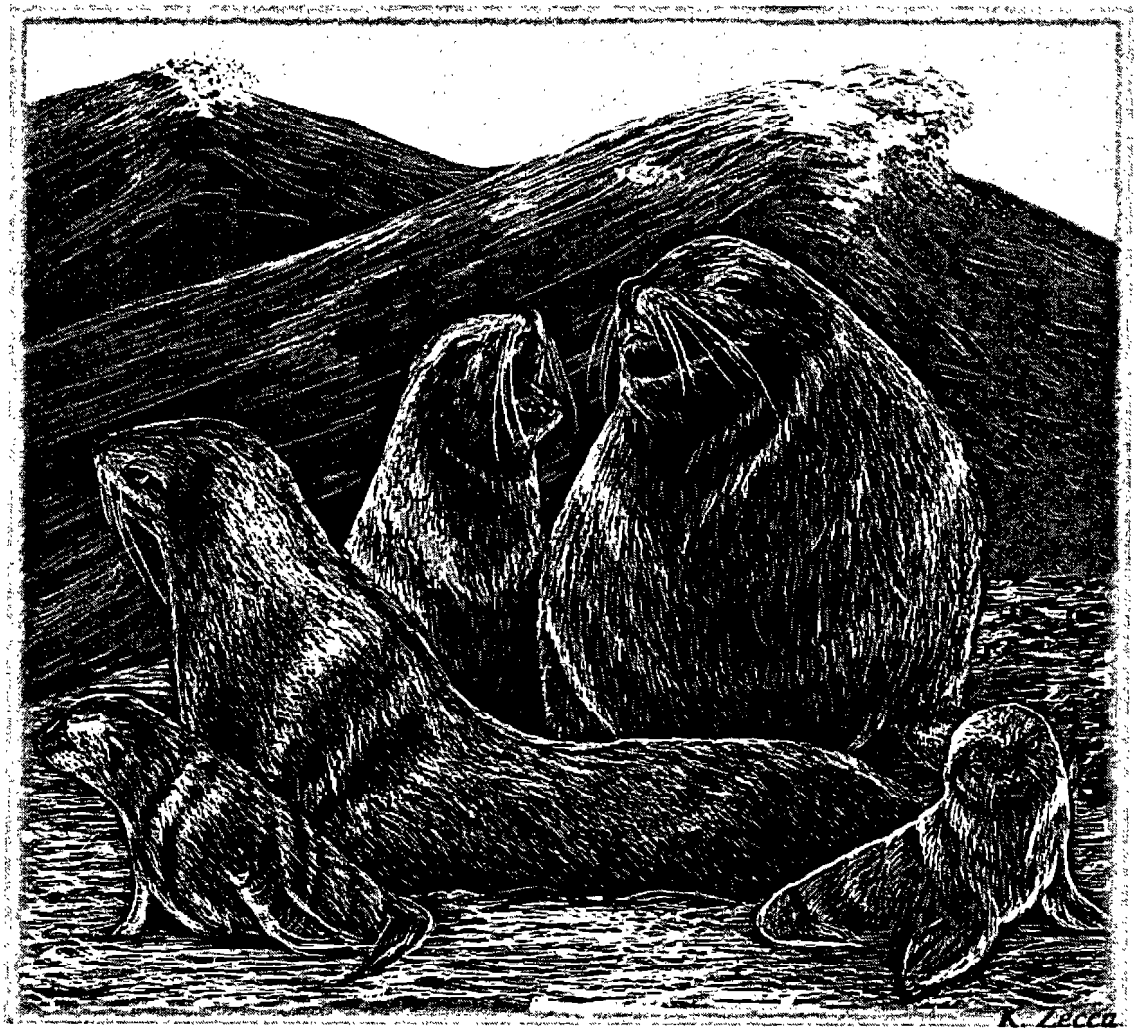
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ABSTRACT

The Alaska Department of Fish and Game and the National Marine Fisheries Service conducted field studies of Steller sea lions *(Eumeropias jubatus)* on Marmot Island, Alaska, from 1979 through 1994. Marmot Island is one of 15 trend sites and four trend rookeries used to identify population trends in the central Gulf of Alaska. Prior to the 1970s Marmot Island was one of the largest Steller sea lion rookeries in Alaska. Since the 1970s numbers of non-pup (adults, sub-adults, and juvenile) sea lions observed on Marmot Island during the breeding season declined dramatically: 87.1% since 1979. From 1976 to 1994, non-pups declined 76.9% at the 14 other trend sites and 79.1% at the three other trend rookeries in the central Gulf of Alaska. The proportion of juvenile sea lions on Marmot Island also declined, from 15 to 35% of all non-pups during 1979 and 1983, respectively, to 5% or less during 1987 through 1994. The decline in pup numbers were commensurate with those for non-pups. From 1979 to 1994, pup numbers declined 88.1% at Marmot Island and 84.4% at the other three trend rookeries in the central Gulf of Alaska. From 1991 to 1994, pup production declined by 50.1% at Marmot Island and by 40-50% at two of the other central Gulf rookeries. Since 1979, four rookery sites on Marmot Island have either become haulouts or have been abandoned entirely.

Non-pup counts were made from 12 through 29 June on Marmot Island since counts made during these dates were likely to be 90% or more of the maximum number of sea lions counted during the breeding season. The hours of 1100 to 1400 ADT or 0900 to 1700 ADT were optimal for observing 90% and 80%, respectively, of daily maximum counts. Optimal dates for counting pups were 29 June through 9 July. Beach 3Z, a rookery beach occupied by relatively few sea lions during the breeding season, was the preferred haul-out site from December through March or April. How and when sea lions make the fall and spring transitions between breeding season and non-breeding season distribution could not be determined.

During June and July of 1987 and 1988, 751 pups (390 females, 361 males) were branded and tagged on Marmot Island. Through December 1994, 151 (20.1%: 78 females and 73 males) of these animals were resighted on 204 occasions. Most resightings (116 of 204: 56.9%) were from Marmot Island; an additional 33 resightings (16.2%) were from within a radius of about

75 km. The resighting most distant from Marmot Island, approximately 1,700 km, was at Loretta Island, British Columbia, Canada. All resightings except five were of live animals. The observed numbers of resightings were significantly below the number expected to be alive (based on life tables) at any given age. Nine branded females (2.3%) were observed with pups during 1993 or 1994: five were on Marmot Island and three were on the Sugarloaf Island rookery, about 75 km north of Marmot Island. One female with a pup was seen during March 1994 on Latax Rocks, approximately 70 km north of Marmot Island. It is not known on which rookery that pup was born.

CONTENTS

INTRODUCTION

An overall decline of about 70% in the number of Steller sea lions *(Eumetopias jubatus)* has occurred throughout most of Alaska since the 1970s (Loughlin et al. 1992, Sease et al. 1993, NMFS 1992, NMML 1995). On 26 November 1990, Steller sea lions were listed as a threatened species under the U.S. Endangered Species Act (55 FR 49204). Data collected from surveys conducted since 1990 indicate that the decline is continuing in the Gulf of Alaska and Aleutian Islands (Merrick et al. 1991, Menick et al. 1992, Sease et al. 1993, NMML 1995). The Alaska population census data were gathered by aerial and ship-based surveys except at Marmot Island, where surveys were conducted from land. During the 1980s rookeries on Marmot and Sugarloaf Islands were the largest with respect to pup production, producing approximately 40% of the total number of pups born annually in the central Gulf of Alaska (Calkins and Pitcher 1982).

Marmot Island has been the site of land-based research on Steller sea lions since the 197Os, primarily as a cooperative effort between the Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS). Work conducted on the island included:

1. Daily counts by age and sex class.
2. Hourly counts of age and sex classes performed weekly from dawn to dusk.
3. Resighting of branded and tagged animals.
4. Collecting of scats for food habits data.
5. Recording of marine mammal/fishery interactions.
6. Recording presence of other marine mammals and wildlife.

Earlier research efforts consisted primarily of aerial surveys conducted in 1957 (Mathisen and Lopp 1963) and from 1965 to 1976 (Calkins and Pitcher 1982, ADF&G unpubl. data). During the summers of 1975 and 1976, ADF&G branded 598 and 3,669 sea lion pups, respectively. In 1979, ADF&G investigated population dynamics at Marmot Island under contract to the Outer Continental Shelf Environmental Assessment Program (OCSEAP). Although the purpose of this research was to assess the possible impact of pending offshore oil

and natural gas development in the Gulf of Alaska, it formed an important baseline for future work on the island.

Study Site

Marmot Island is located 45 km northeast of Kodiak Island and approximately 5 km off the easternmost shore of Afognak Island (Fig. 1). The Marmot Island rookery is defined as 58º14'N, 151º47'W to 58º10'N, 151º51'W (50 CFR 227.12). The island is 3800 hectares with the highest elevation rising to 385 m. There were no permanent human residents on the island during the years of this study. Fifty-one species of birds (Appendix A), five species of land mammals, and nine species of marine mammals are found on the island or in its environs (R. MacIntosh[1], ADF&G[2], and NMFS') (Appendix B). Domestic cattle *(Bos taurus)* were introduced to the island in the 1920s as were European boars *(Sus scrofa)* in 1985. Both species became feral, although cattle have not been seen in more than 10 years. Vegetation consists primarily of Sitka spruce *(Picea sitkensis)* interspersed with open meadows and alpine tundra (Appendix C).

Marmot Island includes several Steller sea lion rookery and haul-out beaches. Rookeries are sites where adult males defend territories, pups are born, and mating takes place. Haul-outs are sites where sea lions predictably rest, but where few pups are born and mating typically does not occur (Calkins and Pitcher 1982, Loughlin et al. 1984). On Marmot Island, rookery and haul-out areas are located along on the southeastern side of the island (Fig. 2). Steller sea lion. rookeries and haul-outs in Alaska often are located on isolated rocky islands or outcroppings. On Marmot Island, however, the rookery beaches are typically composed of black sand and cobble

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[1]R. Macintosh, National Marine Fisheries Service, P.O. Box 1638, Kodiak, AK 99615. Pers. commun., September 1996.

[2]ADF&G, unpubl. data. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518.

[3]NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way N.E., Seattle, WA 98115.

and are bordered by talus cliffs ranging in height from 50 m to over 300 m. In 1979, Aumiller and Orth (ADF&G[4]) described seven separate rookery and haul-out beaches on the island. Rookeries and haulouts were considered distinct sites if they were geographically isolated from adjoining beaches by natural barriers. Sea lion use of beaches has not remained constant over time; some rookeries have become haulouts while others have been abandoned altogether. Figures 2 through 6 describe Beaches 1, 2, 3, 3Z, and 4, which were the primary observation sites in this study.

Protective Measures

In June 1990, the state of Alaska designated Marmot Island a Special Use Area (ADL 225034) in order to minimize human disturbance of Steller sea lions. Activities prohibited under the special use designation include the use of ground transportation, aircraft or boats, access development, camping, introduction of domestic animals, permitting or leasing for facilities, timber harvest, mining, and material sales. In addition to the state regulations, NMFS enacted several protective measures pursuant to listing Steller sea lions as "threatened" under the Endangered Species Act (55 FR 49204). With few exceptions, vessels are not authorized to approach within 5.5 km of rookeries on Marmot Island and elsewhere in the Gulf of Alaska and the Aleutian Islands (Fig. 1). On land, unauthorized persons may not approach within 2.4 km or within sight of the Marmot Island rookeries. This ruling also prohibits the discharging of firearms near Steller sea lions. On 23 January 1992, under the authority of the Magnuson Fishery Conservation and Management Act, NMFS instituted year-round prohibition of trawl fisheries within 18.5 km of Steller sea lion rookeries in the Gulf of Alaska and the Aleutian Islands, including Marmot Island (57 FR 2683) (Fig. 7).

In 1993, NMFS designated critical habitat for Steller sea lions in Alaska to include both terrestrial and aquatic habitats (58 FR 45269). Terrestrial habitats include rookeries and haul-out sites where more than 200 sea lions have been counted. Aquatic habitats include nearshore waters around rookeries and haul-out sites. The boundaries of aquatic habitats are defined as the

[4]ADF&G, unpubl. rep. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518.

mean low-water mark, traditional rafting sites where resting occurs in tightly packed groups (e.g., Bigg 1985) and foraging areas. While no definitive description of sea lion foraging habitat has been developed (58 FR 45269) data from satellite telemetry studies indicate that the waters near rookeries and haulouts are important foraging zones for females with pups during the breeding season and yearlings during the non-breeding season (ADF&G[5], Merrick 1995). Critical habitat designations also require that aircraft fly higher than 914 m above rookeries and major haulouts.

Summary of Additional Studies

Many other Steller sea lion research projects have been conducted on Marmot Island. The following is a brief summary of these projects.

During the summer of 1980, Gisner (1985) conducted behavioral observations of adult male Steller sea lions at the Beach 3 rookery on Marmot Island (Fig. 4) and compared the results with observations from rookeries on Año Nuevo Island, California. Comparisons focused on differences in territorial behavior, boundary displays, and reproductive behavior between sea lions at the two sites.

In 1983, Merrick (1984) observed peaks in daily and hourly sea lion abundance trends at Marmot Island beaches (Fig. 2). He determined the best dates and times for conducting aerial surveys of the island to maximize total counts and pup counts. Additional research on the behavior of female Steller sea lions was conducted in 1987. This focused on courtship displays, maternal care, aggression, and differences in behavior between sites and time of day (Merrick 1987).

In 1984 and 1985, Lewis (1987) conducted studies of disturbance and pup mortality during pup counts on Beach 4 (Fig. 6) in conjunction with age group composition counts. Disturbance of the rookery during pup counts increased non-pup displacement, female aggression and territoriality, pup separation and abandonment, and frequency of stampede in response to

[5]D. G. Calkins, ADF&G, unpubl. data. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518.

natural events such as rock slides and low-flying bald eagles *(Haliaeetus leucocephalus).* Trampling by adult sea lions during pup counts accounted for only 0.03% of pup mortalities.

In 1987 and 1988, Laughlin and Spraker (1989) tested the effectiveness of the drug Telezo1[6] for immobilizing Steller sea lions. Drug dosages were determined relative to estimated body mass, based on curvilinear and standard lengths. Loughlin and Spraker (1989) recommended that Steller sea lions be injected with Telezol in or posterior to the shoulder region to maximize immobilization response and to minimize accidental mortality. Activity patterns and general behavior of injected and non-injected animals were monitored, by land-based observation or remote telemetry for at least 2 weeks after injection. No behavioral differences were observed between drugged and non-drugged animals 2 days after injection. Most behaved normally within 1 day of injection,

In 1987 and 1988, Laughlin and Merrick (1987) conducted counts of pups and non-pups as well as branding, weighing and measuring of pups on Marmot Island. Return trips to the island later in the season were made to assess the conditions of branded pups. Preliminary studies to determine the effectiveness of Telezol as an anesthetic for sea lions and the feasibility of attaching radio transmitters to drugged sea lions were conducted.

In June and July 1987 and 1988, Menick and Laughlin (in press) attached VHF radio transmitters to 14 adult female sea lions to monitor their patterns of occupancy on the rookeries. A VHF telemetry station on the bluff over Beaches 3Z and 4 (Fig. 6) recorded occupancy of the 14 sea lions. Average duration of trips to sea and stays on shore for eight of the 1988 females was approximately 20 hours.

In 1989, Laughlin et al. (1990) conducted aerial surveys and pup counts on Marmot Island to determine if the decline in abundance was continuing (NMFS').

In 1990 and 1991, Loughlin et al. (1992) deployed satellite transmitters (PTT) to study migration and foraging ecology of northern fur seals and Steller sea lions in Alaska. These studies

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[6]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[7]NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

were linked to their previous studies of interactions of pinnipeds with commercial fisheries. Data on location, dive depths and durations, and water temperatures were collected.

In 1990 and 1991, Castellini et al. (1993) studied the blood chemistry and body condition of Steller sea lion pups at Marmot Island. A series of blood indices that reflect hydration state, blood oxygen transport, the metabolism of protein, and lipid and carbohydrate metabolism were examined. These parameters are useful for detecting changes in health status. Animals were also measured for blubber thickness. The resulting blood chemistries and body condition of newborn pups at Marmot Island were within normal ranges for pinnipeds and had not changed compared with the control animals examined over the past 22 years. Davis et al. (1993) used isotope-labeled water to estimate metabolic rates of pups. Williams et al. (1993) estimated energetic costs of thermoregulation in pups based on measurements of blubber thickness, heat flow, and body surface temperature.

During January 1990, Merrick and Miller (NMFS*) deployed a satellite-linked radio transmitter on an adult female Steller. sea lion captured on Marmot Island to gather information on sea lion movement and dive patterns. The animal was anaesthetized using Telezol, tagged on the flippers, and fitted with a satellite transmitter (PTT) on the back and a VHF radio transmitter on the head.

Since 1991, NMML has been collecting sea lion scats from Marmot Island for food habits analyses. Because most of the rookery and haul-out beaches are inaccessible from land, scat collections typically are done during pup counts. Although there are potential biases associated with scat data analyses (Pitcher 1980, Harvey 1989, Harvey and Antonelis 1994) the advantage of using fecal material rather than sampling stomach contents is that numerous samples can be obtained with minimal disruption to the study animals. Basing prey identification on all recovered bones and hard parts, not only on fish otoliths and cephalopod beaks, reduces sampling bias (Merrick and Chumbley in press). In conjunction with National Marine Mammal Laboratory (NMML) food habits research, hydroacoustic and trawl surveys of potential sea lion prey species were conducted in the vicinity of Marmot Island during the summers (June-July) of 1992 through

[8]R. L. Merrick and R.V. Miller, NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

1994 and the winters (November-March) of 1992 and 1993 (NMFS[9]). These surveys were designed to assess the prey resources available to sea lions on the island.

During the summers of 1993 and 1994, Ono (1993) conducted behavioral studies at Beach 3Z (Fig. 6). Those studies focused on adult female feeding cycles and activity budgets, as well as other population and behavioral parameters that may reflect nutritional state and health of the animals. These data will be compared with similar data collected on Lowrie Island in Southeast Alaska and Año Nuevo Island in California.

Study Objectives

This report presents the results of field work conducted at Marmot Island from 1979 through 1994,

Primary objectives of the Marmot Island research included:

1. Census Steller sea lions by age group and sex (non-pups, juveniles, and pups)' during the breeding season.
2. Identify year-to-year trends in the numbers or composition of sea lions.
3. Describe seasonal and daily occupancy patterns.
4. Compare aerial survey counts to ground counts.
5. Identify optimal dates and hours for conducting aerial surveys and pup counts.

[9]R. L. Met-rick, NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

METHODS

Land-based Observation

Breeding Season

Counts and observations of Steller sea lions were made during the breeding season in 10 years from 1979 through 1994 (Table l), During the breeding season, count dates ranged from early May through mid-July, Of the 669 daily counts of non-pups, 649 included composition by age group and sex. There were also 647 counts of pups.

Daily or alternate day counts of sea lions were made at Beaches 1, 2, 3, and 4 during most years. Daily counts at Beach 3Z and approximately weekly counts at Beaches 5, 6, and 7 began in 1991.

Daily counts generally were made between 1000 and 1600 ADT in an effort to coincide with peak abundance, although some counts were made as late as 1800 ADT (Withrow 1982).

Hourly counts were made at Beaches 3 and 4 on six occasions. These counts were made each hour from dawn to dusk (0600 to 2300 ADT), weather permitting. Animals on the beach, as well as those lying or walking in the surf zone were counted; animals free-swimming in the water were not. Sea lions were tallied by the following age and sex classifications:

1. Territorial males - adult males (approximately age 8 years or older) actively maintaining a territory on a rookery.
2. Other adult males - adult or subadult males (approximately ages 5 to 8 years) not maintaining a territory on a rookery.
3. Adult females - (approximately age 4 years or older) based primarily on size, pelage color and characteristics, -and frequently confirmed by the presence of a pup.
4. Juveniles - animals of either sex, smaller than adults but older than pups of the year (ages 1 to 4 years), identified primarily by size, pelage color and characteristics, and behavior. The number of suckling juveniles was also recorded.

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5. Pups - live pups of the year.

6. Dead pups.

Observations were made from the edge of the cliffs overlooking each rookery or haul-out site. More than one overlook was required at several beaches due to natural obstructions or the length of the beach (Figs. 3-6). Counts were made using binoculars or variable-power spotting scopes and recorded on hand tally counters (Table 1). Generally, counts by age group and sex were made using binoculars while spotting scopes were used to look for branded and tagged animals. Spotting scopes also were used at beaches where counting was done from great distances (e.g., Beaches 6 and 7) especially for counting pups.

Because counts were made from cliff tops, fog and low-lying clouds were the greatest potential obstacle to successful counts, especially at the higher observation posts (e.g., Beaches 4 through 7). Counts were partially or completely compromised by fog or clouds on about 20% of all observation days in 1992 and 1994 and on 37% of the days in 1991. Weather was exceptionally favorable during 1993 when only two counts (6%) at Beach 4 were missed during 33 days of observation.

Non-Breeding Season

Cliff counts outside of the breeding season were made during only one non-breeding season, 18 November 1987 through 27 March 1988. Observers from ADF&G and NMFS made a total of 89 composition counts of sea lions. Of those, 79 counts included only Beaches 1 through 4, and 10 counts included all beaches on the island.

Pup Counts

Between 1979 and 1994, ADF&G and NMFS conducted nine pup counts on all rookery beaches at Marmot Island (Table 2). Counts took place in late June or early July, to maximize the chance of counting newborn pups but to minimize the number of pups old enough to flee into the

water. These counts are sometimes referred to as “spook counts.” Because pups blend in with the substrate and can hide behind rocks and in crevices, counts were made by walking through the rookery rather than attempting to count from the cliffs above or from aerial photographs. To perform pup counts, biologists landed on each rookery beach, typically by small boat or helicopter. As the older sea lions vacated the rookery beaches, two or three biologists walked along the beach and used hand counters to tally live and dead pups. The final count for each beach was the mean of all individual counts. Final beach counts were summed to provide an overall total for the island.

Aerial Surveys

The numbers of non-pups on Marmot Island during the breeding season have been counted by aerial surveys during June in 11 years from 1957 through 1994 (Table 3). Aerial surveys outside of the breeding season took place on 12 occasions (Table 3). Aerial surveys were conducted from IS June to 16 July between 1000 and 1600 ADT to coincide with peak abundance of non-pups on the beaches. Counts were made from oblique photographs (Braham et al. 1980, Withrow 1982, Loughlin et al. 1990, Menick et al. 1991, Menick et al. 1992, Sease et al. 1993). Most counts were generated from single overflights, although there were two flights during a 6-day period in 1992 (Sease et al. 1993). These aerial survey techniques are not appropriate for counting pups, primarily because pups are able to hide under cliffs, logs, and rocks, blend in with the substrate, and are too small to locate in the photographs. In addition, aerial surveys for non-pups frequently take place too early in the season to count peak numbers of pups.

Resighting of Branded and Tagged Animals

Steller sea lion pups were branded and tagged on Beach 3 during 29 June to 1 July 1987, and on Beach 3 and Beach 4 from 30 June to 1 July 1988 (Table 4). Sequential numbers were

branded on the right flank of each pup in 1987 (numbers 5l-401) and on the left flank in 1988 (numbers 401-800). Branding irons, with digits approximately 5 cm x 8 cm, were made from 1.0 cm rolled steel stock and heated in a propane-fueled forge (Merrick et al. 1996). Plastic identification tags (Allflex medium cattle ear tags) embossed with the same number as the brand were applied to both fore-flippers of each pup. The portion of the tag containing the identification number is approximately 2.5 cm x 4 cm. During 1987, the first 49 pups received tags but no brands. Most branded pups received a prophylactic injection of tetracycline (about 5 cc). One subadult male and 18 adult females were tagged (but not branded) during other research on Marmot Island during 1987 and 1988. Other sea lions tagged on Marmot Island since 1988 include 4 adult females and 9 pups in 1990, 51 pups in 1993, and 21 pups in 1994. Appendix D lists all sea lions branded and tagged on Marmot Island from 1987 through 1994.

Resight information on Marmot Island was gathered primarily during June and early July in conjunction with the daily census of Beaches 1 through 4 and weekly census of Beaches 5 through 7. Although branded animals were detected during counting, additional daily observation time was devoted solely to searching for branded or tagged animals, particularly beginning in 1991. Resightings at other locations and during other times of the year were opportunistic, reported by biologists from numerous state and federal agencies, and by the general p u b l i c .

Data Analysis

Analyses were restricted to composition counts made from 1000 to 1800 ADT (corrections were made for 1979 and 1983 to account for local time zone changes). In 1991, several counts of the non-territorial males at Beach 1 made after 1800 were included because poor weather conditions greatly reduced the total number of counts. For many of the analyses, count dates were converted to Day of Year (Appendix E).

A mean count was used in analyses whenever two or more counts were available within the acceptable time window. This included multiple counts made by a single observer as well as

counts made by different observers. Whenever possible, means were calculated for each age and sex group on each beach. For some days in 1979, morning and afternoon pup counts were available for a single day with no specific time reference. These morning and afternoon counts typically were made by different observers (L. Aumiller[10]). Accordingly, they were treated as separate counts of pup abundance and a mean was used in the analyses. On days when hourly counts were made at a given beach, the count between the hours 1000 to 1800 that included the maximum number of non-pups was used for the daily count. The count for each age and sex group From that time was used, whether or not each was the daily maximum (i.e., maximum counts for each different age and sex group were not selected from different hourly counts).

Analyses of trends in overall abundance and composition by age group and sex at rookeries focused on Beach 4. Beach 4 is one of the major rookeries containing animals on Marmot Island and the only one observed consistently from 1979 through 1994. Therefore, counts made at Beach 4 make up the longest and most continuous data set available for Marmot Island from 1979 through 1994. The Beach 2 rookery was abandoned in 1985 and Beach 3 changed from a rookery to a haul-out after 1988. Regular counts of Beach 32, a relatively small rookery, did not begin on a daily or weekly basis before 1991. Beach 7, a major rookery, was rarely counted during the breeding season before 1991, and only about once per week during 199l-94. During the 1980s some of the work focused at particular beaches and counts for the remaining beaches were not made on a daily basis, if at all.

Long-term trends in abundance of sea lions at Marmot Island during the breeding season were examined using cliff counts of pups and non-pups, beach pup counts, and aerial surveys. Two sets of analyses were derived from the cliff counts. The first used the maximum cliff count during each year for each age and sex group separately or for non-pups as a whole (all four non-pup groups combined). The second focused on a 10-day period of peak abundance for each group rather than on a single count per year. Ranges were selected by visually examining plots of abundance over time. The ranges were 24 June to 4 July (days 175-185) for pups, 29 June to 9 July (days 180-190) for juveniles, and 14 June to 24 June (days 165-l 75) for all non-pups,

[10]L. Aumiller, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518, Pers. commun., December 1994

including juveniles. Ten-day means and standard errors were calculated for each age group and each year. Beach counts of pups were made on a single visit to the rookery beaches in a given year and typically were a mean of two or more individual counts. Aerial survey counts were made for all non-pups, not for individual age or sex groups, on all rookery and haul-out beaches. A single count was available for most aerial surveys from 1976 to 1994; a mean of two counts was used for 1992. Aerial survey and beach pup counts were analyzed using simple linear regression in the same manner as were the cliff counts.

Trends in abundance for pups, juveniles, and all non-pups combined (including juveniles) were tested using three regression models. The first was simple linear regression of the natural log of counts on year for the 1970s to 1994 and for 1,991 to 1994. Slopes of the regressions were used as estimators of average annual rates of change. The second regression model (after Dennis et al. 1991) used the mean counts and standard errors for the l0-day periods of peak abundance for pups, juveniles, and all non-pups combined. The third was an iterative, or bootstrap, model that randomly picked one data point from within the 10-day period for each year and fit a linear regression. The final result for each age group was the mean of all outcomes from 1,000 repetitions.

Aerial survey and cliff counts of non-pups were compared by rookery beach to test for any systematic over- or under-counting by method. Accordingly, the comparison of greatest interest was between each aerial count and the cliff count made closest to it in time. Corresponding aerial and cliff counts were available for five aerial surveys: 9 June 1985, 11 June 1991, 17 and 23 June 1992, and 12 June 1994. Paired counts were analyzed only if both the cliff and aerial counts were made between 1100 and 1800 hours. Aerial survey photographs were re-examined to separate counts by beach. The difference between cliff and aerial counts was analyzed by simple linear regression of cliff counts on aerial counts. The resulting regression line was compared to the null hypothesis that counts from the two methods should be the same (i.e., Ho: slope = 1 and intercept = 0; H,: slope + 1 or intercept $\neq$ 0).

Assumptions about the days or hours of peak abundance at Marmot Island, as a guide for selecting survey dates and times, were tested by plotting daily and hourly counts as a percentage of the maximum count. Analyses included cliff counts for Beaches 1 through 4 combined, and

counts for Beaches 2, 3, and 4 separately. Date and time ranges were selected to include most of the counts that were 1) 90% or more or 2) 80% or more of the maximum count.

The number of branded/tagged sea lions resighted was compared to the numbers expected to be alive for each age class. Expected numbers were generated from the initial number of branded/tagged pups and age-specific survival rates, adapted from Calkins and Pitcher (1982) and York (1994). Animals with brands and tags are likely to be resighted more easily than animals with tags only. Accordingly, except where noted, the results reported below refer to branded animals, excluding those with tags only. Resightings from November 1987 through August 1989 also were excluded from the analyses, as there was a substantial effort to follow the survival of pups branded in 1987 that was not repeated the following year.

RESULTS

Abundance and Distribution During the Breeding Season

The number and composition of sea lions varied between beaches, Beach 1, the northernmost beach, was a haul out occupied by non-territorial, sub-adult and adult males during all years of observation. Numbers of animals were as high as 1,400 from 1979 through the early 1980s (Table 5). Since 1991, there have been fewer than 100 males there. Beach 2 was a rookery from 1979 through 1984 with 500-900 non-pups and about 100 pups. Beach 2 has been vacant since 1985. Since 1991, there have been occasional observations of one or two sea lions. Beaches 3 and 4 were rookery beaches of similar size from 1979 through 1987, with peak numbers from 1,000 to 2,000 non-pups. During that time, pup production was slightly greater at Beach 4 (l,000-1,800) than at Beach 3 (700-1,100). By 1991, Beach 3 had become a haulout. From 1991 through 1994, fewer than 100 males and from 1 to 10 females and pups occurred on Beach 3. From 1991 through 1994, Beach 4 was the largest rookery on Marmot Island, both in numbers of non-pups (574-93 1) and in pup production (498-855).

The maximum number of non-pups on Beaches 1 through 4 during the breeding season, as counted from cliffs, ranged from 6,391 in 1979 to 815 in 1994 (Table 5). Maximum counts for

the entire island (Beaches 1 through 7) range from 1,690 non-pups in 1991 to 1,161 in 1994, Counts of non-pups for the entire island, from June aerial surveys, ranged from 9,862 in 1976 to 1,091 in 1994 (Table 3).

Total pup counts for all Marmot Island rookeries ranged from 6,741 pups in 1979 to 804 pups in 1994 (Table 2). The number of pups counted from the cliff tops at all rookery beaches ranged from 1,244 in 1991 to 780 in 1994. Pup production on rookery Beaches 2, 3 and 4 combined, as estimated from cliff-top counts, ranged from 2,907 in 1979 to 552 in 1994 (Table 5).

Beaches 32, 5, 6, and 7 were observed weekly only since 1991. Prior to that time, counts at these beaches were opportunistic and infrequent. Beach 7 was the largest, with from 348 to 586 non-pups and from 291 to 586 pups (Table 5). From 1991 to 1994, peak numbers of sea lions on Beach 3Z ranged from 63 to 217 non-pups and from 38 to 128 pups. Beaches 5 and 6 rarely were observed with more than 100 non-pups and 25 pups.

Decline in Abundance from 1979 through 1994

The number of non-pups declined significantly, based on simple linear regression, from the late 1970s to 1994 for cliff counts at Beaches 1 through 4 combined (- 15.5% per year, $P < 0.001$) and for all island aerial survey counts (- 12.7% per year, $P < 0.001$) (Fig. 8, Tables 3, 5). From 1991 to 1994 the decline in the number of non-pups also was significant for cliff counts at Beaches 1 through 4 combined (- 14.6% per year, $P = 0.037$). Estimated annual rates of decline were derived from regression lines (i.e., slopes of - 0.155, - 0.127, and - 14.6, respectively). The decline in abundance from 1991 to 1994 was not significant for the aerial surveys ($P = 0.5$) or for cliff counts from Beaches 1 to 7 combined ($P = 0.09$). See Table 6 for detailed information on simple linear regressions.

Results from application of the Dennis et al. (199 1) regression method to 10-day mean counts of non-pups at Beach 4 were not significant for a single-regression model for 1979 to 1994 (slope = - 6.9%, $P = 0.153$). Differences between slopes for 1979 to 1987 (- 3.2%) and 1991 to

1994 (- 23.2%) in a two-regression model were not significant (P = 0.113). The decline from 1979 to 1994 was significant (P < 0.025) using the iterative, or bootstrap, method (Table 7).

At Beach 4, the number ofjuvenile sea lions decreased dramatically after 1979 (Fig. 9). During the 1990s from 10 to 40 juveniles were observed on any given day, almost an order of magnitude lower than during 1979. During June, juveniles represented about 5% of all non-pups at Beach 4 in 1987 through 1994, compared to 15 to 25% during 1979 (Fig. 10). At Beach 3, the percentage ofjuveniles decreased from 15 to 35% in 1979 and 1983 to 10 to 15% in 1987. The IO-day mean counts ofjuveniles at Beach 4 showed only marginal change from 1987 through 1994, but these means were significantly lower than the mean for 1979 (t-test, P < 0.01). The regression model of Dennis et al. (1991) did not detect a significant decline over the period 1979 to 1994 (P > 0.28), but there were no data points for years between 1979 and 1987.

The number of pups declined significantly (simple linear regression, P < 0.001) from 1979 through 1994, for cliff counts of rookery Beaches 2 through 4 and for beach pup counts of all rookery beaches (Fig. 11, Tables 2, 5, 6). Estimated annual rates of decline were 10.4% for cliff counts and 15.3% for pup counts. From 1991 through 1994, estimated annual rates of decline were 16.6% (P = 0.006) for combined cliff counts from Beaches 3, 3Z, and 4, 15.9% (p = 0.004) for combined cliff counts of all rookeries (Beaches 3 to 7), and 23.4% (P = 0.028) for pup counts of all rookery beaches. Using the regression model of Dennis et al. (1991) on mean cliff counts of pups at Beach 4, numbers of pups declined by 8.6% per year (P = 0.056) from 1979 through 1994. A two-regression model suggested that rates of decline for 1979 to 1987 (5.0%) and 1991 to 1994 (26.8%) were different (P = 0.021). The iterative regression method also detected a significant decline (7.5%) in pup numbers from 1979 to 1994 (P < 0.025) (Table 7).

Seasonal Distribution Patterns

In general, the number of non-pups on rookery beaches increased gradually during the early part of the breeding season, reached a peak during mid-June, and then slowly declined. This pattern was most apparent on Beaches 3 and 4, the larger rookery beaches (Fig. 12). There was daily variability in the number of non-pups on rookery beaches. The coefficient of variation

(standard deviation divided by the mean) was 8 to 12% for non-pup counts at Beaches 3 and 4 during the peak period of abundance in most years. The coefficient of variation was 15 to 40% for non-pup counts at Beach 2 during 1979, 1983, and 1984. Much of this variability was smoothed by plotting 5-day maximum counts.

Annual variability also was apparent. For example, the number of non-pups on Beach 4 in 1979 was high early in the season on 9 May. Non-pup numbers continued to increase until about 14 June (day 165), but the relative magnitude of the build-up was less than in other years (Fig. 12). At Beach 2, numbers of non-pups increased throughout the breeding season during 1979, 1983, and 1984 and daily variability appeared greater than at other beaches. Beach 2 was not used as a rookery after 1984.

The number of sea lions at Beach 7 (Fig. 13) appeared to continue building much later in the season than at Beaches 3 and 4; however, this was based on very few observations. The number of non-pups on Beach 3Z gradually increased to a peak in mid-season followed by a gradual decline in 1993 when there were 120 to 220 non-pups on the beach. In 1991, 1992, and 1994, when there were fewer than 50 non-pups at Beach 3Z, occupancy generally increased over the course of the observation period. During the last observations of 1992, in mid-July, the number of non-pups on Beach 3Z increased sharply and the observer noted an apparent immigration of sea lions from Beach 4.

The range of days when the greatest number of animals were hauled out was not constant in all years, Generally, the window between 12 and 29 June (days 163-180) appeared to maximize the chance of counts being at least 90% of the maximum counts (Fig. 14). This window of opportunity was the same for Beaches 3 and 4 combined or for Beach 4 separately. Even within this window, however, numerous individual counts fell below the 90% threshold. No optimal window for maximizing counts was apparent for either Beach 2 or 3.

Daily Distribution Patterns

Attempts to identify an optimal daily window for counting non-pups were inconsistent, Three dawn-to-dusk time series were available for Beach 3, all during 1987: 14 June, 18 June, and

8 July (Fig. 15). On 18 June and 8 July, counts were above 90% of the maximum counts from about 1100 to 1700 ADT, and above 80% from 0900 ADT until after 1700 ADT. Counts on 14 June never dropped below 92%. Three time series were available for Beach 4. On 12 June 1991, the number of non-pups was 90% or more of the day's maximum count from about 0900 to 1400 ADT. All counts were greater than 80% except at 1600 and 1800 ADT (79.7% and 77.9%, respectively). On 21 June 1993, counts were greater than 90% only from about 1100 to 1300 ADT, and greater than 80% from 0639 to 1400 ADT. On 9 June 1992, however, counts were above 90% intermittently from 0600 to 1800 ADT; none was below 80%.

Age and Sex Composition During the Breeding Season

Adult females -- Abundance curves for the number of adult females on rookery beaches during the breeding season were similar to those for all non-pups: increasing gradually during the early part of the breeding season, reaching a peak during mid-June, and then slowly declining. This relationship is understandable because adult females accounted for 75-95% of all non-pups on the rookery beaches during the breeding season.

There were approximately 15 to 20 adult females per territorial male at Beaches 3 and 4 from 1979 through 1988 (Fig. 16). The ratio dropped to 5 to 10 adult females per territorial male at Beach 4 during 1991 to 1994.

Territorial males -- The number of territorial males generally followed a pattern similar to those for adult females or for all non-pups. Territorial males appeared on the rookery beaches slightly earlier in the season, the peak in abundance was less pronounced, and the decline in numbers took place later. On Beach 4, the number of territorial males remained at or above 80% of the maximum number observed each year during most days in June. During 1984 and 1985, the number of territorial males increased substantially after 9 July, both on Beach 4 and on Beach 3.

No year-to-year trend was apparent in the numbers of territorial males. On Beach 4, for example, there were approximately 65 to 90 territorial males present during the peak of breeding

from 1979 to 1993. Some of the lowest counts of territorial males on Beach 4 were from 1993 and 1994, whereas the highest counts were from 1992.

Juveniles -- For Beach 4, counts of juveniles were available primarily during 1979 and 1991 through 1994. Very few counts were available from Beach 4 during 1987 (5 days) and 1988 (4 days). For Beaches 2 and 3, juvenile counts also were available from 1979 and 1983, and for Beach 3 from 1987. Observers did not attempt to differentiate juveniles from other non-pups during 1984 and 1985 at any beaches (J. Lewis").

Juveniles represented 20-50% of all non-pups early in the season at Beach 4 during 1979. This dropped to about 15% by early June, then slowly increased to about 20% by early July (Fig. 10). The proportion of juveniles was much lower during 1991 to 1994, but it still increased during the season, from 2% to 5% in early June to only 4% to 8% by early July (Fig. 10). Those within-season increases were significant in 1992 and 1993 ($P < 0.001$) and in 1994 ($P = 0.024$), but not in 1979 ($P = 0.23$) or 1991 ($P = 0.10$). On Beach 3 the proportion ofjuveniles in the population decreased significantly ($P < 0.001$) from 30% to 15% during 1983. No significant increasing or decreasing trend in the number ofjuveniles was demonstrated by simple linear regression during other years at Beaches 2 or 3. The proportion of juveniles on Beach 7 was calculated for only four occasions each year from 1991 through 1994. Compared with the other beaches, the proportion ofjuveniles was low (about 2.5% of non-pups) during 1991. About 5% of non-pups were juveniles early each season during 1992 through 1994, but that number increased to over 10% by July in 1992 and 1994.

Pups -- Birth of pups began on rookery beaches in mid- to late May (days 130-140). The number of pups generally increased rapidly during most of June and leveled off in late June or early July (days 180- 190). Median pupping dates were 10 to 13 June at Beach 4 (days 161 - 164: 1979-94), 11 to 15 June at Beach 3 (days 162-166: 1979-87), and 18 to 22 June at Beach 2 (days 168-173: 1979-83). On the smaller rookery beaches at Marmot Island (i.e., Beaches 2 and 32, with fewer

[11]J. Lewis, Alaska Department of Fish and Game, 802 3rd Street, Douglas, Alaska 99824. Pers. commun., June 1991.

than 200 pups), however, the median pupping date typically was a week later: 19 to 23 June. Phenology of pupping was similar at all rookeries, regardless of size, and during all years. Characterizing pupping at Beach 7 was difficult due to infrequent counts, but timing appeared to be comparable to other beaches in 1993 and 1994. However, in 1991 and 1992, perhaps earlier by 10 to 14 days.

Extended series of cliff pup counts during mid- to late July were available only for 1984 and 1985. At Beaches 3 and 4, numbers of pups declined dramatically after 9 July during both years (Fig. 17). The onset of the decline in 1984 coincided with pup counts, which were conducted on 8 and 10 July at Beach 4 and on 10 July at all other rookery beaches (Lewis 1987). At Beach 2 in 1984 however, numbers of pups increased for about 10 days after the pup count before beginning. to decline. There were no pup counts in 1985. During 1994, there was no apparent change in numbers of pups at Beach 4 after the pup count, which was conducted on 27 June. At Beach, 7, pup numbers appeared to increase after the pup count in 1994.

A decline in pup abundance may have begun at Beach 4 during mid-July 1992, a year with no pup counts. Pups were observed swimming to Beach 3Z, where a concurrent increase in pup numbers took place. The observer assumed these pups were immigrating from Beach 4, which is located only a few hundred yards to the south (S. Stanford"). Unfortunately, observations ended that year on 15 July, so the extent of this pup movement is not known.

The number of pups per adult female tended to increase linearly during the breeding season. By early July, when very few new pups were being born, the ratio of pups to adult females on Beach 4 ranged from 1.2 to 1.8. (Fig. 18). The ratio of pups to adult females was consistently lower (from 0.5 to slightly over 1.0) at Beach 3, and lowest (between 0.2 and 0.4) at Beach 2. No consistent difference was apparent between years at Beach 4 (Fig. 18). At Beaches 2 and 3, the number of pups per adult female appeared to decrease slightly from 1979 to 1983 and again from 1983 to later years. A ratio of pups to females greater than unity can be explained by adult females spending more time at sea as their pups grew older.

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[12]S. Stanford, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, Alaska 99501. Pers. commun., July 1992.

The number of pups per territorial male also increased linearly until early July at each of the rookery beaches, The greatest number of pups per male (approximately 35) were observed during 1979 at Beach 4 (Fig. 19). Pups per male declined consistently each year from 1979 through 1994, seldom more than 10 pups per male. Other rookery beaches had fewer pups per male than Beach 4. Peak numbers at Beach 3 were approximately 10 to 15 pups per territorial male from 1979 through 1987. The ratio of pups to territorial males was consistently lowest at Beach 2, typically well below 10 pups per male.

Comparison of Aerial Survey and Cliff Counts

Fifteen paired counts were available for comparing aerial to cliff counts. The range in time difference for the paired counts was between 43 minutes and 4.7 hours. On five occasions, the cliff count was made prior to the aerial survey count and on 10 occasions the cliff count was made later. The relative difference between the number of animals counted by the two methods ranged from 2.5% to 67.6% ($x = 21.8\%$). If the sign of the difference was retained (a negative value when the cliff count was smaller), the range was from -67.6% to +24.6% ($x = -16.1\%$). Thus, the cliff count averaged about 16% below the aerial survey count. Linear regression also indicated that the cliff counts were consistently lower than the aerial counts, as the observed slope of 0.781 (Fig. 20) was less than 1 ($P < 0.001$, $R^2 = 0.996$). By this method, the cliff counts averaged only 78.1% as many animals as the aerial survey counts. The intercept was not different from zero (t-test, $P = 0.56$). There was a direct relationship (simple linear regression, $P = 0.040$, $R^2 = 0.287$) between the relative numerical difference in the counts and the time difference between them (Fig. 21). That is, the earlier a cliff count was made in advance of the aerial count, the lower it was.

Observations During Non-Breeding Season

Land-based Counts

Cliff counts were made on a regular basis from 18 November 1987 through 27 March 1988, in conjunction with other research. Observers were able to follow the progress of pups that were branded and tagged during the previous June and July, assessing the survival of branded pups and the integrity of brands as they healed and pups molted. Observers also made counts of pups and .non-pups at each beach. These included 74 to 86 counts each at Beaches 1 through 4 and 9 to 10 counts at Beaches 5 through 7. All counts were dependent on weather conditions.

Day-to-day variability in counts was much greater during the non-breeding season than during the breeding season, even when the data is smoothed by plotting using 5-day maximum counts (Fig. 22). The total number of non-pups counted at all beaches ranged from 8 to 756. Pup cliff counts for all beaches ranged from 4 to 981. For Beaches 1 through 4, counts ranged from 7 to 873 for non-pups and 9 to 981 for pups. The numbers of sea lions on the beaches appeared to be governed primarily by weather conditions, with the fewest number of animals on the beach during stormy weather when water levels and surf were highest[13]. For the Beaches 1 through 4, which were surveyed on a regular basis, virtually all animals were observed on Beaches 3Z or 4. A total of 26 animals were seen on four occasions at Beach 3 and none were seen on Beaches 1 or 2.

Aerial Surveys

Aerial surveys, at times other than the breeding season (June and early July), were conducted on 12 occasions from July 1956 through December 1994 (Table 3). The largest estimate of sea lions from an aerial survey made outside of the breeding season was 8,819 non-

[13] L. Aumiller and C. Matt. 1988. Summary of data collected on Marmot Island, Alaska, November 17, 1987 - March 28, 1988. Unpubl. summ., avail. National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Seattle WA 98115.

pups in late July 1986. At that time of year, pups could be differentiated from older animals and excluded from the counts. Counts from the non-breeding season aerial surveys ranged from 114 in March 1993 to 6,790 in September 1957. These counts include all animals because pups had molted into adult-colored pelage and were not discernable from juveniles.

Distribution

Redistribution of animals was observed twice from November 1987 to March 1988. Prior to 5 December 1987, Beaches 3Z and 4 were usually occupied by several hundred sea lions each (Fig. 22). From 5 December 1987 through 21 March 1988, however, the number of sea lions on Beach 3Z increased while Beach 4 was virtually abandoned. Sea lions were observed at Beach 4 on only 7 occasions during the following 73 counts. Presumably, all or most of the Beach 4 animals moved to Beach 3Z during the non-breeding season. In fact, 45 branded pups moved from Beach 4 to Beach 32 during late November and early December. From 22 to 24 March, however, most of the sea lions on Beach 32 moved back to Beach 4, including 79 branded- pups. Of the pups observed to change beaches, 23 made both moves, from Beach 4 to Beach 3Z in the fall and back to Beach 4 in March.

For Beaches 5, 6, and 7, which were observed less frequently from November 1987 to March 1988, sea lions appeared to use all three early in the observation period. After late January, however, animals were seen only on Beach 5. Unfortunately, the low frequency of counts makes it impossible to identify when this change in haul-out use took place.

Counts made from a skiff on 31 July 1993 also detected substantial redistribution of sea lions along the Marmot Island beaches following the end of cliff counts in mid-July. No sea lions were observed on Beach 3 where there had been 50 to 70 males in mid-July. The total number of non-pups on Beach 3Z dropped from 150 or more to 40- 45. The number of sea lions on Beach 4 dropped from 400 non-pups to only 16-l8 males. Conversely, on Beach 5 the number of animals increased from no more than 14 animals during June and July to 135 to 144 on 31 July. The 225 to 240 animals on Beach 7 were only marginally below the June to July counts. On 31 July, pups

were observed to be present but could not be counted on Beaches 3Z, 5, 6, and 7. No pups were observed on Beach 4.

Aerial surveys during March 1993 and December 1994, as well as opportunistic observations made during February 1993, March 1994, and November-December 1994 support the supposition that Beach 3Z is a preferred haulout during the fall, winter, and early spring., On those occasions, virtually all of the sea lions hauled out on Marmot Island were at Beach 3Z.

Resighting of Branded and Tagged Animals

Of 49 Steller sea lion pups tagged (and not branded) on Beach 3 in 1987, 3 1 (63.3%) were females and 18 (36.7%) were males. An additional 751 pups were both branded and tagged during 1987 and 1988: 390 (5 1.9%) females and 361 (48.1%) males (Table 4). Through December 1994, 151 individual sea lions (20.1%: 78 females and 73 males) of the 751 branded pups were resighted on 204 occasions. Of the 151 resighted animals, 114 (77.6%) have been resighted only once, 19 (12.9%) have been resighted twice, 9 (6.1%) were seen three times, 3 (2.0%) were seen four times, and 1 each (0.7%) were resighted five and six times. Of the 49 pups that were only tagged, only one female was resighted on a single occasion. Considering all observations through December of 1994, there has been no apparent difference in the resighting rate for branded males and females or for the 1987 and 1988 cohorts (x^2, $P > 0.05$).

Branded sea lions were observed at 23 different locations through 1994 (Table 8). The greatest number of resightings (116 of 204: 56.9%) were from Marmot Island; an additional 33 resightings (16.2%) were from the Kodiak Archipelago or Sugarloaf Island, within a radius of about 75 km. The one female that was tagged without a brand was also resighted at Marmot Island, The resighting most distant (approximately 1,700 km) from Marmot Island was made at Loretta Island (53º45'N, 128º50’W), in the upper reaches of Douglas Channel, British Columbia, Canada (P. Olesiuk[14]). Tags from 13 (6 females, 7 males) animals, branded/tagged as pups, were

[14]P. Olesiuk, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, British Columbia, Canada V9R 5K6. Pers. commun., July 1995.

recovered from the stomach of a killer whale found dead on the beach in Prince William Sound, Alaska, and two animals were killed in gillnets. All other resight observations were of live animals.

The greatest number of resightings occurred when animals were about 1 -year-old (Fig. 23). Yearlings accounted for 72 of 187 (38.5%) or 71 of 186 (38.2%) resightings, depending on whether the analysis included animals that were tagged but not branded. For males, the frequency of resighting was low for 2- through 5-year-olds. Resighting generally was low for females 2 or more years old; the greatest frequency of resighting (10 individuals) was for 7-year-olds from the 1987 cohort. The observed number of females and males was significantly below the number of animals expected to be alive at any given age (x^2, $P \approx 0$) (Table 9).

By 1994, nine branded females were observed with pups. Two were seen with pups on Marmot Island during June 1993 (one pup was later abandoned) and one was seen with her pup on Latax Rocks, approximately 70 km from Marmot Island, in March 1994. During June 1994, three branded females were observed with pups on Marmot Island and three were observed on the rookery at Sugarloaf Island, approximately 75 km north of Marmot Island. The pup abandoned on Marmot in 1993 and one of the 1994 Sugarloaf pups did not survive.

DISCUSSION

Decline in Abundance

The most striking result to come from the many years of observation at Marmot Island is the overall decline in the number of Steller sea lions present during the breeding season. The decline was consistent from the 1970s to 1994, both for non-pups and pups. The population decline was not unique to Marmot Island, but rather reflected a trend that was observed from the Gulf of Alaska westward. However, the decline in abundance was more severe at Marmot Island than in the central Gulf of Alaska as a whole. From 1976 to 1994, the number of non-pups at Marmot Island declined by 88.9%. By comparison, the decline in abundance was about 76.9% (14,816-3,427) at the other 14 trend sites and 79.1% (9,617- 2,008) at the other three trend

rookeries (Sugarloaf, Chirikof, and Chowiet Islands). From 1991 to 1994, the decline in the number of non-pups at Marmot Island ranged from 25% to 33%,, depending on whether aerial surveys or cliff counts were compared. Based on aerial survey results, the decline from 1991 to 1994 was 28.8% for the other 14 trend sites and 30.2% for the other three trend rookeries in the central Gulf of Alaska (NMFS[15]). From 1976 to 1994, estimated annual rates of decline were 12.8% at Marmot Island, 8.8% for the other trend sites, and 8.9% for the other trend rookeries.

The decline in pup production at Marmot Island was also comparable to those observed for pups in the central Gulf of Alaska. From 1979 to 1994, the observed decline in pup numbers was 88.1% at Marmot Island and 84.4% for Sugarloaf, Chirikof, and Chowiet Islands combined. From 1991 to 1994, pup production declined by 50.1% at Marmot, 41.5% at Sugarloaf Island (1990-94), and 48.6% at Chirikof Island (1991-94) (NMFS[16]). Reliable counts were not available for Chowiet Island for 1990 or 1991,

The statistical significance of declines in the numbers of pups and non-pups at Marmot Island, as well as the estimated annual rates of decline, varied among the regression methods. The numbers of non-pups from 1979 to 1994 provide an example of this discrepancy. Simple linear regression indicated similar annual rates of decline in counts from Beaches 1 through 4 (- 15.5%, $P < 0.001$) and in aerial surveys (- 12.7%, $P < 0.001$). By the bootstrap method, the decline was still significant, but the rate was lower (- 5.9%, $P < 0.025$). The Dennis et al. (1991) model did not detect a significant decline (- 6.9%, $P = 0.153$). These differences arise from differences in the data points used in the analyses as well as in the way the model analyzes those data.

The simple linear regressions used a single data point for each year from the aerial surveys, beach pup counts, or the maximum cliff count. For any given count, an unknown proportion of all animals that use the beach are not present. Although aerial surveys are timed to maximize the likelihood of observing at least 90% of the maximum number of non-pups that use a particular rookery beach, daily counts may vary by 30% or more. Reliance on maximum annual counts

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[15]R. L. Merrick, NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way N.E., Seattle, WA 98115.

[16]NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way N.E., Seattle, WA 98115.

assumes that after several weeks of daily observation the maximum count should approach the actual number of animals that use the beach during a given year. The beach pup counts may be less problematic. If they are conducted at the correct time, the number of pups that have already left the beach or that have not been born should be negligible.

The Dennis et al. (1991) and iterative models, as applied to the Marmot Island data, avoid the problems associated with single counts by using all available counts from a l0-day period. Certainly, the selection of an interval is critical and a slight shift earlier or later in peak abundance could affect the results. The Dennis model also incorporated adjustments for count variability as well as for non-independence (i.e., the count in one year is not independent of the counts in previous or successive years). The bootstrap model handles count variability and non-independence by examining many solutions derived from data points randomly selected from all observations.

Given these differences, it is not surprising that the different regression methods may yield different results. Arguments could be made in favor for or against each method, but the important conclusion is that each presents a similar general trend: Steller sea lions, both pups and non-pups, have declined in number at Marmot Island from 1979 to 1994.

The one age/sex group that did not show any sign of a population decline at Marmot Island was the territorial males, The number of territorial males on a particular rookery beach appeared to be independent of population size. As the population of adult females decreased, territorial males either had fewer females in their territories or more males held territories containing no females. By the 1990s adult females and pups on Beach 4 were concentrated primarily on the northern half of the rookery. A number of adult males continued to occupy territories without females in the southern part of the rookery, however. The size and overall distribution of individual males appeared to be quite similar for the males at either end of the beach.

Juvenile Survival in Relation to the Population Decline

Juvenile Steller sea lions appear to have declined more precipitously than other groups, both in absolute numbers and relative to the numbers of all non-pups. This drop in the proportion ofjuveniles From 1979 to 1994 suggests either that unusually high numbers ofjuveniles were observed at Marmot during 1979 and 1983 or that the number ofjuveniles has decreased from 1987 through 1994. Based on observations during 1981, Smith (1988) noted that the relative numbers ofjuvenile sea lions were much greater on Marmot Island than on Sugarloaf Island, approximately 75 km to the north Physiography is perhaps the most significant difference between the rookery areas on the two islands. Smith (1988) suggested that the gently sloping, wide beaches on Marmot Island created a more favorable habitat for juveniles than did the steep-sided, rocky rookeries on Sugarloaf Island. If, in fact, Marmot Island has always been a preferred site-for juvenile sea lions, then the 1979-83 counts would not be inordinately high. Thus, the dramatic drop in observed numbers ofjuveniles at Marmot Island could suggest that their survival rate has decreased since the late 1970s or early 1980s.

The low return rate of branded sea lions also suggests low juvenile survival during recent years. For any given age group and sex, the number of branded animals that have been resighted was about an order of magnitude lower than the number expected to be alive, as estimated by age-specific survival rates (Table 8). Given the strong tendency of adult female sea lions to return to their natal rookery (Gentry 1970, Calkins and Pitcher 1982), however, most surviving females would be expected to return to Marmot Island as they recruit into the breeding population. Female Steller sea lions reach sexual maturity between 3 and 6 years of age (Calkins and Pitcher 1982). Females branded as pups on Marmot could have returned to breed for the first time in 1990 or 1991. By 1994,6 and 7 years after branding, almost all surviving females should have been sexually mature. The expected number of resighted 6-year-old females was 140 to 150, but through 1993 and 1994 only 10 of these animals were resighted.

The success for resighting branded or tagged animals is determined largely by observation effort. Since 1991, that effort has been uniform and extensive at Marmot Island only during the breeding season. Two of the 8 branded females observed with pups during June 1994 were

resighted on Sugarloaf Island, where there has been little observer effort since 1987-88. Presumably, the number of resighted branded females would have been greater with increased observer effort. Unless the number of branded/tagged females returning to rookeries is observed to increase substantially during 1995 or 1996, it would appear that recruitment into the breeding population is low.

In comparison, 380 California sea lion *(Zalophus californianus)* pups were branded on San Miguel Island, California, in 1987 (95 females, 111 males) and 1988 (85 females, 89 males). Since 1990, the proportion of the branded females that were resighted each year on San Miguel has been 5 to 10 times greater" than for the corresponding age groups of Steller females resighted at Marmot Island. The San Miguel Island and Marmot Island brand-resight work were for different, albeit closely related species, and took place on extremely different habitats separated by about 24 degrees of latitude. In addition, resight effort was not the same at the two islands and certain behaviors at San Miguel Island may enhance resighting ability (animals frequently travel from inland sites to the water to escape the afternoon heat, thus providing a convenient opportunity for a well-situated observer to search for brands[18]). Despite these differences, however, the extreme disparity between the observed numbers of females on the two islands suggests a much lower survival of juvenile sea lions at Marmot Island.

Timing of the Breeding Season

Timing of the breeding season for Steller sea lions is uniform throughout their range. This includes rookeries as geographically dissimilar as Año Nuevo Island off northern California (Evermann and Hanna 1925, Orr and Poulter 1965, Gentry 1970) several rookeries in British Columbia, Canada (Pike and Maxwell 1958), the Gulf of Alaska (Calkins and Pitcher 1982), and the Pribilof Islands in the Bering Sea (Scheffer 1945). Peak numbers of adult and juvenile sea

[17]R. DeLong and S. Melin, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way N.E., Seattle, WA 98115.

[18]S. Melin National Marine Mammal Laboratory, 7600 Sand Point Way N.E., Seattle, WA 98115. Pers. commun., October 1995.

lions on the rookery typically occur during late June and early July at Marmot Island, as well as at Año Nuevo Island (Gentry 1970) and at Ugamak Island in the eastern Aleutian Islands (Menick et al. 1988). The increases, peaks, and declines in the number of territorial males and adult females on Marmot Island's rookery (Beaches 3 and 4: Figs. 12 and 24) are simultaneous and parallel to those at Año Nuevo Island (Gentry 1970).

The range of dates for viable births, from mid-May to mid-July, also is uniform for Marmot Island, for Alaska in general (Calkins and Pitcher 1982), for Rogue Reef in Oregon (Merrick 1987) and for Año Nuevo Island (Gentry 1970). Slightly shorter seasons are described for the Pribilof Islands (23 May to 20 June: Scheffer 1945), Fish (also called Lewis or Wooded) Island, approximately 340 km northeast of Marmot Island (25-28 May to 29 June- 1 July: Sandegren 1970), and British Columbia (late May through late June or early July: Pike and Maxwell 1958). From 1979 through 1994, the median pupping date for the Marmot Island rookery (Beaches 3 and 4) was from 10 to 15 June. Dates within the same range were observed at Fish Island in 1967/68 (13- 16 June: Sandegren 1970), at Ugamak Island in 1977/78 and 1985/86 (12-15 June: Withrow 1982, Merrick 1987, Merrick et al. 1988) at Cape St. James, British Columbia in the 1970s (14 June: Edie 1977, cited in Menick 1987), and at Año Nuevo Island in 1968 (approximately 14 June: Gentry 1970).

Differences in Distribution Between the Breeding Season and Non-breeding Season

Beaches 4 and 7 have been the major rookeries on Marmot Island since 1991. Beaches 2 and 3 were also important rookeries prior to the mid-1980s. Beach 3Z, a small rookery during the breeding season, appears to be the primary haul-out beach during winter and early spring. Virtually all sea lions observed hauled out on the island during November through March have been on Beach 3Z.

There appears to be a variable transition period between distribution during the breeding and non-breeding seasons. In 1992, immigration of adult females and pups to Beach 3Z was observed beginning on 12 July. Presumably these sea lions arrived from Beach 4, which may have signaled the onset of the seasonal redistribution in that year. In 1993, observers detected no

appreciable movement away from Beach 4 to Beach 3Z by 9 July when observations ended for the season. A l-day visit on 3 1 July, however, revealed that a substantial redistribution had occurred sometime during the previous 3 weeks. The number of sea lions on Beach 7 remained essentially unchanged, but other rookeries were almost completely abandoned. More than 100 sea lions were on Beach 5, a beach used by few sea lions during the summer. By March 1994, the next time the island was visited, virtually all sea lions observed were on Beach 3Z. In 1987, the only year with continuous non-breeding season observations, the shift from Beach 4 to Beach 3Z took place during a l-or 2-day period around 5 December.

The transition back to breeding season distribution in the spring may be equally variable. In 1988, after spending most of the non-breeding season on Beach 3Z, most sea lions abruptly moved to Beach 4 From 24 to 28 March. Observations ended at that time, so we do not know if that marked the redistribution of sea lions from one beach to the other or merely marked the onset of a transition period characterized by large-scale movements. As late as 20 March in 1993 and 15 March in 1994, almost all sea lions were still located on Marmot Island on Beach 3Z. Certainly by May the animals began shifting back to a breeding season distribution, as numbers of territorial males increased on rookeries. The variable number of adult males and juveniles observed in 1979 during the last half of May suggests that animals are returning to the rookery beaches at that time but may not be remaining there for long periods of time. Stability of the rookery beaches probably does not occur until the adult females begin to return in significant numbers in June to give birth to their pups.

Comparison of Aerial Survey and Cliff Counts

Our results led us to reject the null hypothesis that cliff counts and aerial survey counts at Marmot Island yield the same results. In particular, cliff counts were systematically lower than aerial counts by 16% to 22%. Numbers of non-pups on rookery beaches tend to build during the day and earlier counts might be expected to be lower. However, all aerial and cliff counts were made during peak hours when higher numbers of animals are likely to be present on the beach. Even cliff counts that were made later in the day were lower than aerial counts.

There are several possible explanations for this observed difference: 1) aerial survey counts overestimated the number of animals on the beach; 2) cliff counts under-estimated the number of animals on the beach; 3) both counts were accurate but the number of animals changed between counts; 4) some combination of the above. Counters use a variety of cues to interpret aerial photographs. The head, flipper, or rump of a single sea lion conceivably could be interpreted as parts of two or more animals, particularly if there are many animals on a beach, animals are densely packed, and the photographic image is small. Such conditions may occur with photographs of the largest rookery beaches on Marmot Island (i.e., Beaches 4 and 7). During cliff counts, some animals certainly are obscured from view, as most beaches have some areas that are difficult or impossible to see from the observation sites above. Even though some animals may haul out high on the beach, particularly during cool weather, systematically missing 20% of the animals on a beach in this manner is unlikely. Alternatively, observers may just tend to under-count the number of animals on the beach.

Withrow (1982) compared ground counts of Steller sea lions with aerial survey counts from photographs taken at Ugamak Island during 1977 and 1978. and found no significant difference between them. Count data from Ugamak Island were less problematic than those from Marmot Island. At Ugamak Island, ground counts were made within 15 to 30 minutes of the aerial survey. Typically, the ground observer waited in position and started counting immediately after the aircraft passed overhead and observers could walk between outlooks in a few minutes (D. Withrow[19]). 'Under these circumstances there probably was little or no change in the number of sea lions counted by the two methods. Because of the distances between the different beaches on Marmot Island, a complete census requires 6 hours or more, guaranteeing a large time difference and increasing the likelihood that the number of animals on the beach changed between aerial and cliff counts. In addition, the view of beaches on Ugamak Island was unobstructed, leaving almost no blind spots for counters. The appropriate controls for analyzing the Marmot Island data, namely knowing exactly how many animals were available for either count or how much change occurred between counts, are unavailable.

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[19]D. Withrow, National Marine Mammal Laboratory, 7600 Sand Point Way, N.E., Seattle, WA 98115. Pers. commun., October 1995.

Optimal Survey Dates and Times

Based on his observations at Ugamak Island (54º12.5' N, 164º50.0' W) in the eastern Aleutian Islands during 1977 and 1978, Withrow (1982) determined that aerial surveys conducted between 18 June to I6 July should maximize the likelihood that at least 90% of the animals will be hauled out. Similarly, Menick (1987) identified the optimal survey window as 18 June through 7 July using observations at Rogue Reef, Oregon (1982), Marmot Island Beach 3 (1983) and Ugamak Island (1986 and 1987). Our observations at Marmot Island from 1979 through 1994, suggest that the optimal dates are from 12 to 29 June. A slightly wider survey window, 10 June to 4-5 July (days 161 to 185- 186) probably would yield satisfactory counts in most years. Survey dates after 9 July are unsatisfactory.

Identification of a specific hour window for surveys is less straightforward, possibly because of the limited number of observations. The three dawn-to-dusk count series at Beach 3 suggest that surveys should be conducted from 1100 to 1700 ADT (0900-1500 "local sun time"; i.e., when the sun is directly overhead at 1200) to maximize the likelihood that a survey count will be within 90% of the daily maximum. Survey times could be expanded to 0900-2 100 ADT if the threshold is reduced to 80% of the maximum. The three series of dawn-to-dusk observations from Beach 4 suggest a more narrow window to include 90% of the daily maximum: 1000- 1300 ADT. The likelihood of observing at least 80% of the daily maximum was high almost all day at Beach 4, but it may drop after about 1400 ADT.

Based on his observations in 1977 and 1978, Withrow (1982) determined that the optimal hours for aerial surveys at Ugamak Island are 1000-1800 BST (Bering Standard Time). In 1977 and 1978, BST coincided with local sun time. Using counts at Ugamak Island from 1986 and 1987, Merrick et al. (1988) identified the hours of 1000-2000 AST (Alaska Standard Time) as the best time to conduct an aerial survey. Because of the Alaska-wide, 2-hour time-zone shift in October 1983, 1000-2000 AST in 1986 and 1987 corresponded to 0800-1800 BST or local sun time, in 1977 and 1978. Thus, during our observations, the optimal window for counting sea lions on Marmot Island occurred two or more hours earlier on Marmot Island than on Ugamak, according to "local sun time."

Met-rick (1984, 1987) noted the lack of a well-defined daily peak in occupancy on Marmot Island Beach 3 during 1983. At that time, it appeared that a tidal effect obscured the hauling pattern typical of other rookeries, as a mid-day high tide restricted beach space and reduced the area available for sea lions to haul out. However, it is difficult to build a convincing argument that tides played a significant role in shaping daily hauling patterns on Beach 4 during 1991 and 1992. By 1991, only about one-half of Beach 4 was occupied by sea lions. Even during stormy conditions there appeared to be ample beach area for animals to haul out. At this time, there is no clear explanation for the lack of a clearly defined daily haul-out pattern on Marmot Island.

The optimal time for pup counts on Marmot Island was between 29 June and 9 July. Performing pup counts a week or 10 days earlier likely would not diminish the count results severely, but there is some evidence to suggest that pup numbers could decline precipitously after 9 July. Unfortunately, the number of late-season counts was too small to verify the extent of this decline.

Branded Animal Resights

The number of resights of branded or tagged animals is a function of observation effort. For Steller sea lions at Marmot Island and elsewhere in Alaska, that effort has not been uniform temporally or geographically. There was considerable resighting effort for branded/tagged pups on Marmot Island from November 1987 through March 1988. There was no significant difference in mortality between branded and unbranded pups[20]. During the summers of 1988, 1989, and 1990, however, resighting effort at Marmot Island and other locations came largely from opportunistic observations made during other research. Concerted effort to resight branded/tagged animals has taken place on Marmot Island during the breeding season each year since 1991. There was similar effort on Sugarloaf Island during the breeding seasons for 1994 and 1995. Observers at other locations and during other times of year continued to be opportunistic.

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[20]NMFS, unpubl. data. National Marine Mammal Laboratory, 7600 Sand Point Way N.E., Seattle, WA 98115.

Another complication with the resighting of marked animals is the potential confusion with animals marked at other locations. Three sea lions observed on four occasions in southern British Columbia, Canada, may have been marked at Marmot Island, but probably were Steller sea lions tagged at rookeries in Oregon, Those three Oregon animals were marked with different color tags and were not branded*‘. Potential confusion arises, however, because tag color can change as tags weather (i.e., white tags may appear yellow or blue tags may appear green) and brands may not be visible.

[21]R. Brown Oregon Department of Fish and Wildlife, Marine Region, Marine Science Drive, Bldg. No. 3, Newport, OR 97365. Pers. commun., July 1995.

ACKNOWLEDGEMENTS

We would like to thank L. Aumiller, G. Orth, J. Lewis, C. Matt, W. Cunningham, and S. Stanford from the Alaska Department of Fish and Game; L. Ferm, R. Merrick, C. Hutchinson, M. Strick, and J. Cesarone from the National Marine Mammal Laboratory; K. Ono from University of California Santa Cruz; L. Gerber from University of Washington; and. volunteers P. Lewis, L. Taylor and J. Waite who participated in this study. R. Menick (NMFS), T. Laughlin (NMFS), D. Calkins (ADF&G) and J. Lewis (ADF&G) participated in the design of the field studies. Pup branding work in 1987-1988 was directed by T. Loughlin (NMFS). P. Anderson, R. Otto, R. Macintosh, N. Terrell, and others at the National Marine Fisheries Service Kodiak Laboratory provided invaluable logistical support. R. Macintosh at National Marine Fisheries Service Kodiak Laboratory provided a comprehensive list of bird species on the island. D. Prokopowich and K. Brennan of the Commercial Fisheries Division, Alaska Department of Fish and Game, Kodiak, Alaska, provided much appreciated radio contact and logistical support. H. Reed and T. Walters of Maritime Helicopters, M. Machulsky and H. Downs of Alaska Helicopter, and various pilots of U.S. Coast Guard, Kodiak, Alaska, provided air transport of personnel and field gear to and from Marmot Island. P. Dyson of Kodiak provided valuable and reliable weather information. This work was authorized under Marine Mammal Protection Act permits 598 and 809. H. Huber (NMFS), D. Withrow (NMFS), T. Laughlin (NMFS), R. Merrick (NMFS), and H. Braham (NMFS) provided critical review of this manuscript. K. Zecca provided the front cover illustration. Finally, we thank our friends and families for their continued support.

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Table 1.--Range of dates, total number of counts, number of composition counts (by age/sex classes) for non-pups, and number of pup counts made during the breeding season by observation from cliff tops at five rookery beaches on Marmot Island, Alaska, 1979-94.

Year	Range of Dates	Number of Counts			Source[1]
		Total	Compos.	Pups	
Beach 2					
1979	8 May - 9 July	49	47	38	1
1983	4 June - 6 July	17	17	1	2
1984	26 May - 27 July	48	48[2]	38	1
Totals		114	112	93	
Beach 3					
1979	12 May - 9 July	50	49	51	1
1983	4 June - 7 July	16	16	32	2
1984	25 May - 27 July	47	47[2]	47	1
1985	26 May - 30 July	49	49[2]	49	1
1987	13 June - 8 July	17	17	11	2
Totals		179	178	190	
Beach 3Z					
1991	6 June - 2 July	16	16	17	2
1992	7 June - 30 June	33	33	33	2
1993 4	June - 9 July	36	36	36	2
1994	9 June - 16 July	36	28	29	2
Totals		121	113	115	
Beach 4					
1979	9 May - 8 July	45	38	43	1
1984	21 May - 27 July	26	26[2]	26	1
1985	26 May - 30 July	27	27[2]	27	1
1987	13 June - 5 July	5	5	5	2
1988	20 June - 27 June	4	4	3	2
1991	6 June - 2 July	16	16	16	2
1992	3 June - 15 July	35	35	34	2
1993	6 June - 8 July	33	33	33	2
1994	6 June - 16 July	33	31	30	2
Totals		223	214	217	

Table 1 .--Continued.

Year	Range of Dates	Number of Counts			Source[1]
		Total	Compos.	Pups	
Beach 6					
1991	7 June - 29 June	4	4	4	2
1992	7 June - 30 June	4	4	4	2
1993	9 June - 5 July	4	4	4	2
1994	11 June - 8 July	4	4	4	2
Totals		16	16	16	
Beach 7					
1991	7 June - 29 June	4	4	4	2
1992	7 June - 30 June	4	4	4	2
1993	9 June - 5 July	4	4	4	2
1994	11 June - 8 July	4	4	4	2
Totals		16	16	16	
Overall Totals		669	649	647	

[1] Sources: I-ADF&G, unpubl. data; 2-NMML, unpubl. data.
[2] Composition counts for territorial males and pups only.

Table 2.--Counts of Steller sea lion pups on Marmot Island, Alaska, 1979-94.

Year	Date	Number of Pups	Source*
1979	7 July	6,741	1
1984	7 July	5,751	1
1986	8 July	4,381	1
1987	2 July	2,910	1
1988	2 July	3,136	1
1989	28 June	2,199	2
1991	3 July	1,611	3
1993	9 July	986	4
1994	27 June	804	4

*Sources: I-ADF&G, unpubl. data; 2-Laughlin et al. 1990; 3-Merrick et al. 1992; 4-NMFS, unpubl. data.

Table 3.--Numbers of Steller sea lions on Marmot Island, Alaska, counted from aerial photographs, 1957-94. Counts for May though July are of non-pups only; counts for September through March include pups.

Year	Date(s)	Hour	Count	Source*
Surveys of non-pups during June				
1957	27-28 June		3,866	1
1976	June		9,862	2
1978	June		8,506	3
1979	29 June		8,450	3
1985	9 June		4,983	4
1985	26 June	0900	4,982	5,6
1989	14 June	1010	2,331	7
1990	13 June	1400	1,766	8
1991	11 June	1320	1,459	9
1992	17 June	1505	1,464	10
1992	23 June	1420	1,698	10
1994	12 June	1143	1,091	4
Surveys of non-pups other than during June				
1956	22-25 July		2,262	1
1957	27-29 July		5,077	1
1978	4 July		8,506	2
1979	6 July		6,381	2
1984	10 July	1500	6,947	5,6
1984	20 July	1000	8,054	5,6
1984	30 July	0930	9,366	5,6
1986	9 July	1030	6,248	4,6
1986	14 July	1750	7,281	4,6
1986	18 July	1030	5,912	4,6
1986	21 July	1615	8,819	4,6

Table 3 .--Continued.

Year	Date(s)	Hour	Count	Source*
Surveys of pups and non-pups				
1956	1-2 September		5,598	1
1956	10-14 December		1,445	1
1957	21 March		1,425	1
1957	29 September		6,790	1
1957	4-5 December		2,872	1
1975	October		8,256	2
1976	March		3,655	2
1993	12 March	1838	114	4
1993	13 March	1100	398	4
1993	20 March	1441	249	4
1994	7 December	1320	423	4

*Sources: 1-Mathisen and Lopp 1963; 2-Calkins and Pitcher 1982; 3-ADF&G, unpubl. data; 4-NMFS, unpubl. data.; 5-Lewis 1987; 6-Calkins and Goodwin 1988; 7-Laughlin et al. 1990; 8-Menick et al. 1991; 9-Merrick al. 1992; l0-Sease et al. 1993.

Table 4.--Steller sea lion pups marked with sequentially numbered flipper tags and hot brands at Marmot Island, Alaska, during 29 June to 1 July 1987, and 30 June to 1 July 1988. Flipper tags were applied to the posterior margin of both fore-flippers of each pup; hot brands were on the right (1987) or left (1988) flank.

Year	Tag/Brand Numbers	Tag Color	Brand Side	Females	Males	Total
1987	001-044[1] 046-050	yellow	none	31	18	49
1987	051-401[2]	yellow	right	186	165	351
1988	401[2]-800	blue	left	204	196	400
Total				421	379	800

[1] Tag/brand number 045 was not used.
[2] Two pups were tagged and branded with number 401.

Table 5.--Maximum counts of Steller sea lion non-pups and pups counted from cliff-top observation posts overlooking rookery and haul-out beaches on Marmot Island, Alaska, during the breeding season., 1979-94.

	Rookery or Haul-out Beach								Totals for Beaches	
Year	1	2	3	3Z	4	5	6	7	1-4	1-7
Non-pups										
1979	1100	935	2200	-	2440	-	-	-	6391	-
1983	680	544	2335	-	-	-	-	-	-	-
1984	775	778	2456	-	2230	-	-	-	5085	-
1985	1424	400[1]	1787	-	1329	-	-	-	3800[1]	-
1987	-	-	1476	-	1282	-	-	-	-	-
1988	-	-	-	-	1433	-	-	-	-	-
1991	163	0	115	63	931	45	113	586	1215	1690
1992	86	1	173	86	868	113	53	463	1104	1709
1993	35	2	106	217	574	14	32	348	848	1217
1994	10	2	130	133	591	4	27	493	815	1161
Pups										
1979	0	111	1071	-	1733	-	-	-	2907	-
1983	0	70	1069	-	-	-	-	-	-	-
1984	0	129	812	-	1423	-	-	-	2232	-
1985	0	0	761	-	1084	-	-	-	1845	-
1987	0	-	676	-	1185	-	-	-	-	-
1988	0	-	-	-	1173	-	-	-	-	-
1991	0	0	1	38	855	5	23	586	894	1244
1992	0	0	10	17[2]	737	93	10	336	759	1110
1993	0	0	0	128	522	1	8	291	616	916
1994	0	0	0	84	498	0	6	387	552	780

'Only approximate numbers available for Beach 2 in 1985.

'Pups were observed immigrating from Beach 4 on 12- 15 July. During the 4-day period the number of pups increased from 17 to 66.

Table 6.--Statistics for linear regressions of the natural log (In) of counts on year for aerial survey counts of non-pups and beach counts of pups for the entire island and for cliff counts of non-pups and pups for Beaches 1-4 and Beaches l-7, combined. The slope estimates the annual rate of decline during the interval.

Type of Count	Interval	Intercept	Slope	R^2	P
Non-pups					
aerial survey	1976-1994	259.9	- 0.1268	0.9858	< 0.001
	1991-1994	236.9	- 0.1153	0.7823	0.217
cliff, Beaches 1-7	1991-1994	299.3	- 0.1466	0.9127	0.087
cliff, Beaches 1-4	1979-1994	315.3	- 0.1548	0.9801	< 0.001
	1991-1994	298.1	- 0.1462	0.9625	0.0375
Pups					
beach counts	1976-1994	311.7	- 0.1528	0.9551	< 0.001
	1991-1994	472.6	- 0.2336	0.9990	0.028
cliff, Beaches 1-7	1991-1994	324.2	- 0.1593	0.9955	0.004
cliff, Beaches 1-4	1979-1994	212.9	- 0.1035	0.9559	< 0.001
	1991-1994	336.3	- 0.1655	0.9936	0.006

Table 7.--Statistics for the Dennis (after Dermis et al. 1991) and iterative (bootstrap) models for cliff counts of pup, juvenile, and all non-pup Steller sea lions at Beach 4, Marmot Island, Alaska. Type of model, interval (years), number of data points (n: one point per year), slope, standard error (SE), and probability value (P) are listed below.

Model Type	Interval	n	Slope	SE	P
Pups					
Dennis	1979-1994	8	- 0.086	0.046	0.056
Dennis	1979-1987	4	- 0.050	0.036	0.118
Dennis	1991-1994	4	- 0.268	0.072	0.033
Bootstrap	1979-1994	8	- 0.075	0.019	< 0.025
Juveniles					
Dennis	1979-1994	6	- 0.078	0.119	0.274
Bootstrap	1979-1994	6	- 0.032	0.103	0.384
Non-pups					
Dennis	1979-1994	9	- 0.069	0.063	0.153
Dennis	1979-1988	5	- 0.032	0.066	0.324
Dennis	1991-1994	4	- 0.232	0.133	0.011
Bootstrap	1979-1994	9	- 0.059	0.018	< 0.025

Table 8.--Location, approximate distance from Marmot Island, and number (n) of resightings of Steller sea lions branded as pups on Marmot Island, Alaska, in 1987 and 1988. Multiple resightings are included for individual sea lions from different years or from different locations in the same year.

Resight Location	General Region	Approx. Distance from Marmot I. (km)	n
Marmot Island	Kodiak Archipelago	0	116[1]
Seal Bay (Afognak Island)	Kodiak Archipelago	40	2
Sea Otter Island	Kodiak Archipelago	45	4
Long Island	Kodiak Archipelago	55	7
Kodiak Harbor	Kodiak Archipelago	60	3
Latax Rocks	Kodiak Archipelago	70	4
Sugarloaf Island	central Gulf of AK	75	13
Cape Douglas	central Gulf of AK	120	1
Outer Island	central Gulf of AK	150	1
Chiswell Islands	eastern Gulf of AK	215	6
Ressurection Bay	eastern Gulf of AK	250	2
Puale Bay	Shelikof Strait	280	2
The Needle	Prince William Sound	340	8
Montague Island	Prince William Sound	350	13[2]
Seal Rocks	eastern Gulf of AK	375	3
Chirikof Island	central Gulf of AK	375	1
Cape St. Elias	eastern Gulf of AK	460	10
The Whaleback	Shumagin Islands	665	1
Yakutat	eastern Gulf of AK	725	1[3]
Benjamin Island	Southeast Alaska	1,060	1
Tenakee Inlet	Southeast Alaska	1,075	2
Annette Island	Southeast Alaska	1,400	1[3]
Lorreta Island	British Columbia	1,700	1
unknown	-	-	1[4]
total resights			204[1]

[1]Does not include the resight of one female that was tagged but not branded.
[2]Tags recovered from the stomach of a beach-cast killer whale. Tags from 14 individual sea lions were recovered; 13 were positively identified as animals tagged on Marmot Island.
[3]Animals killed in gillnets.
[4]Animal released alive from gillnet, location not reported.

Table 9.--The number of Steller sea lions branded and tagged as pups on Marmot Island during 1987 and 1988 expected to be alive and the number observed at given ages. Expected numbers (Exp.) were generated from the initial number of branded or tagged pups and age-specific survival rates (SW-V.) adapted from CaIkins and Pitcher (1982) and York (1994). Observed numbers of animals (Obs.) were those resighted at all locations, excluding those for which age of death is unknown. One resighted female was tagged but not branded.

	Females			Males		
Age	Surv.	Exp.	Obs.	Surv.	Exp.	Obs.
A. Including 49 animals with tags only						
0	-	415	-	-	372	-
1	0.782	325	36	0.641	238	36
2	0.782	254	10	0.641	153	5
3	0.782	198	3	0.641	98	4
4	0.930	185	8	0.856	84	7
5	0.909	168	10	0.871	73	8
6	0.895	150	9	0.878	64	24
7	0.884	133	14	0.878	56	13
B. Excluding 49 animals with tags only						
0	-	384	-	-	354	-
1	0.782	300	35	0.641	227	36
2	0.782	235	10	0.641	145	5
3	0.782	184	3	0.641	93	4
4	0.930	171	8	0.856	80	7
5	0.909	155	10	0.871	70	8
6	0.895	139	9	0.878	61	24
7	0.884	123	14	0.878	54	13

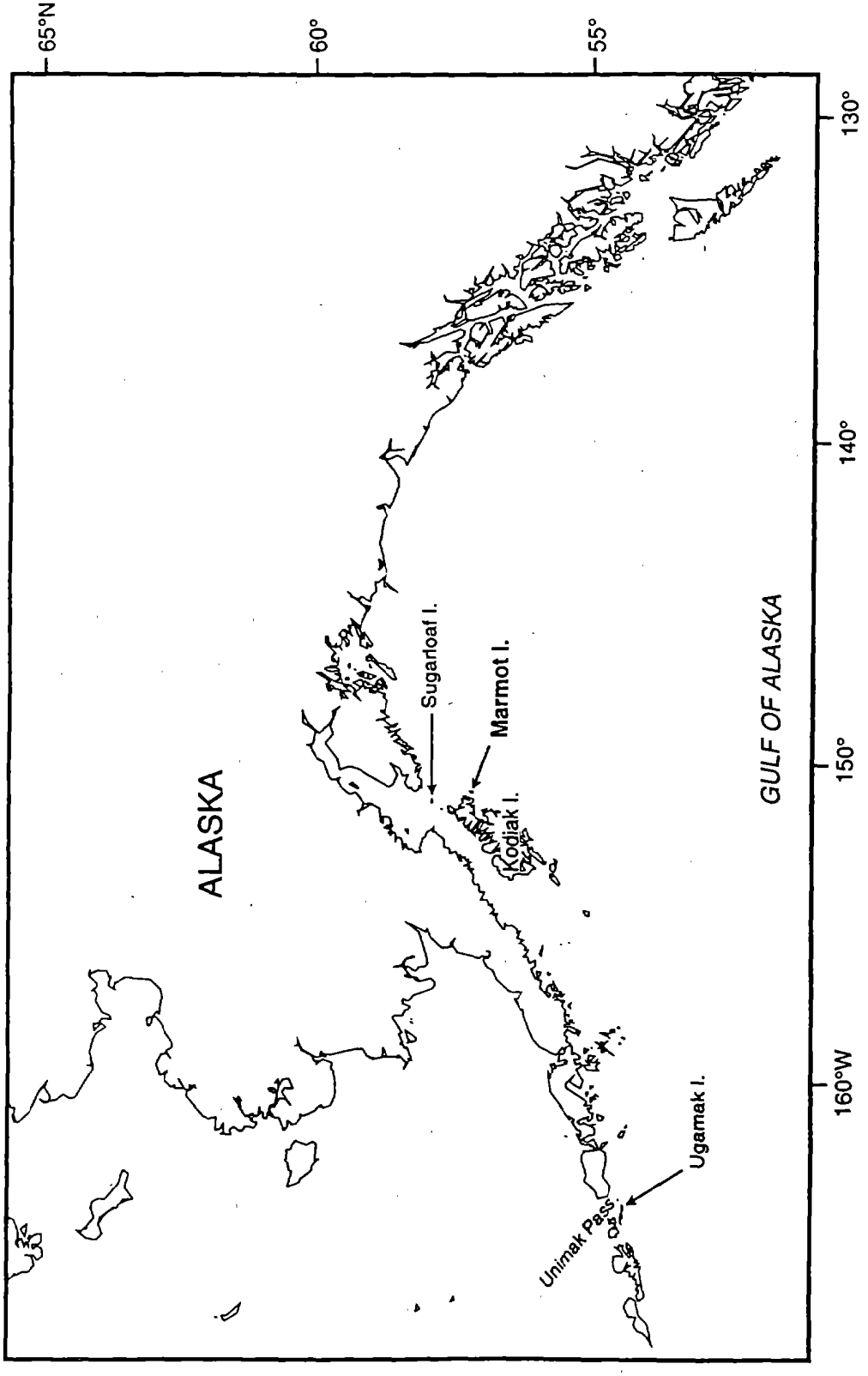

Figure 1. Map of the Gulf of Alaska showing locations of Marmot Island, Sugarloaf Island and Ugamak Island

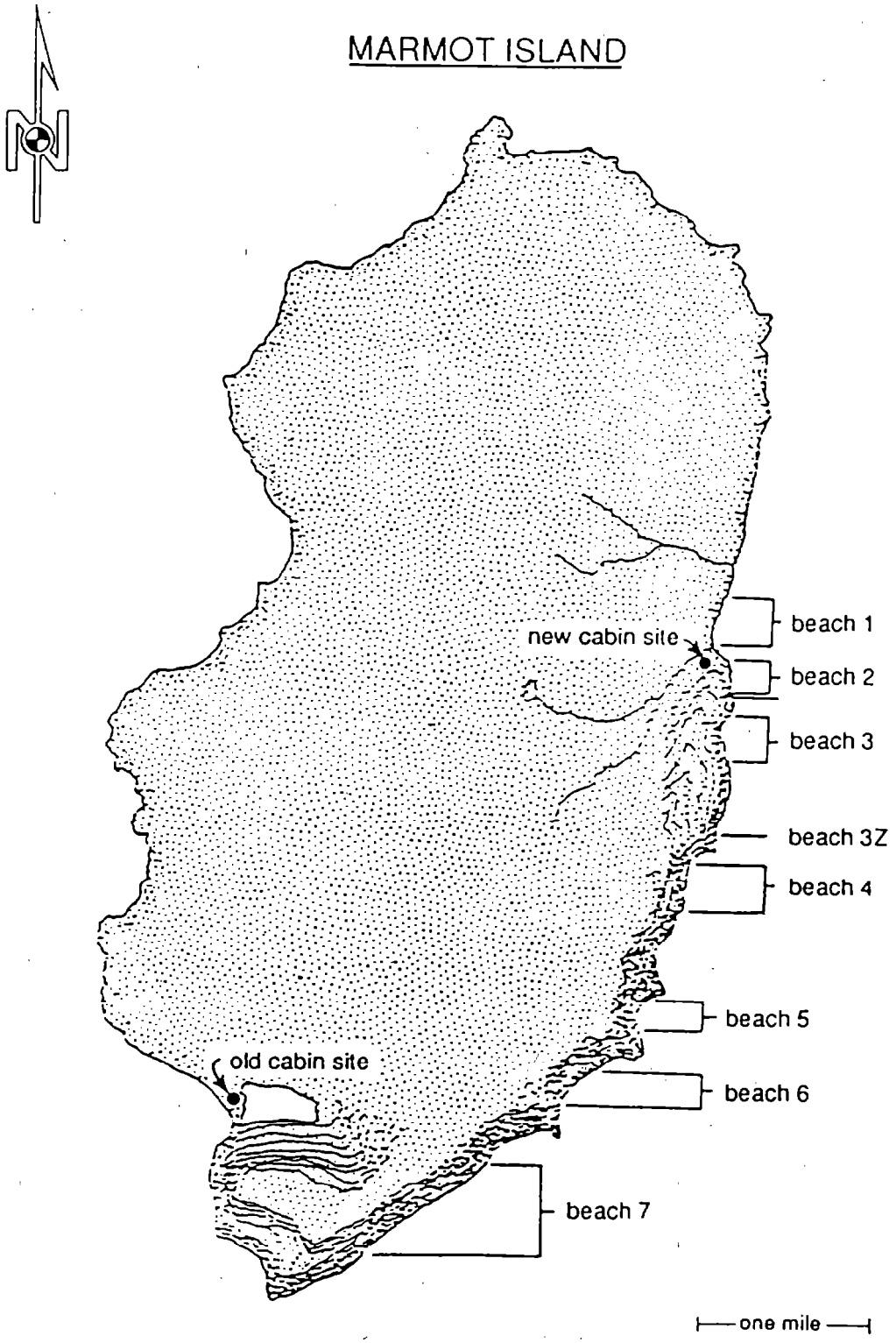

Figure 2

Source: Alaska Dept. Fish and Game, 1979.

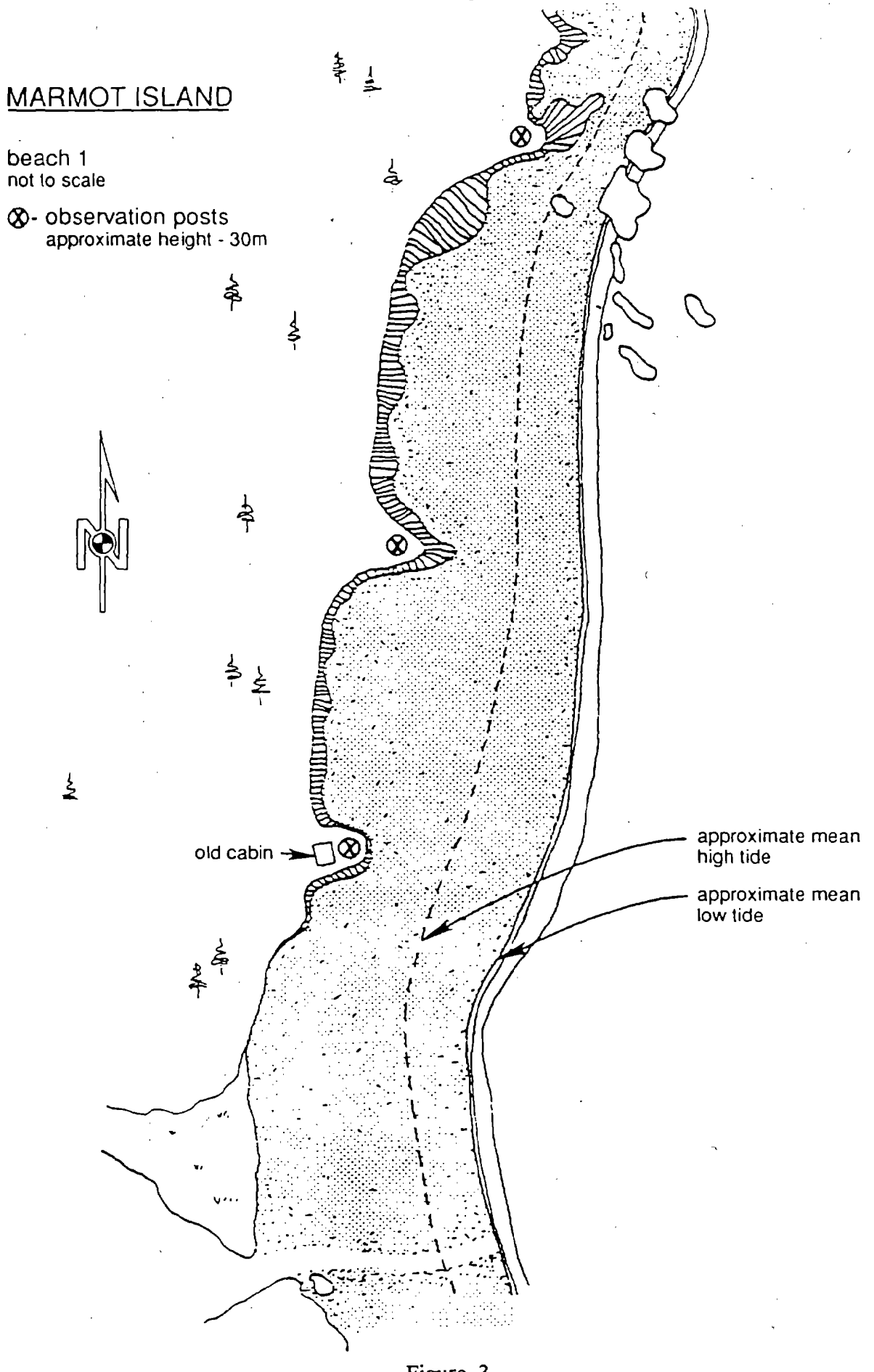
MARMOT ISLAND
beach 1
not to scale
⊗- observation posts
approximate height - 30m
old cabin
approximate mean high tide
approximate mean low tide

Figure 3

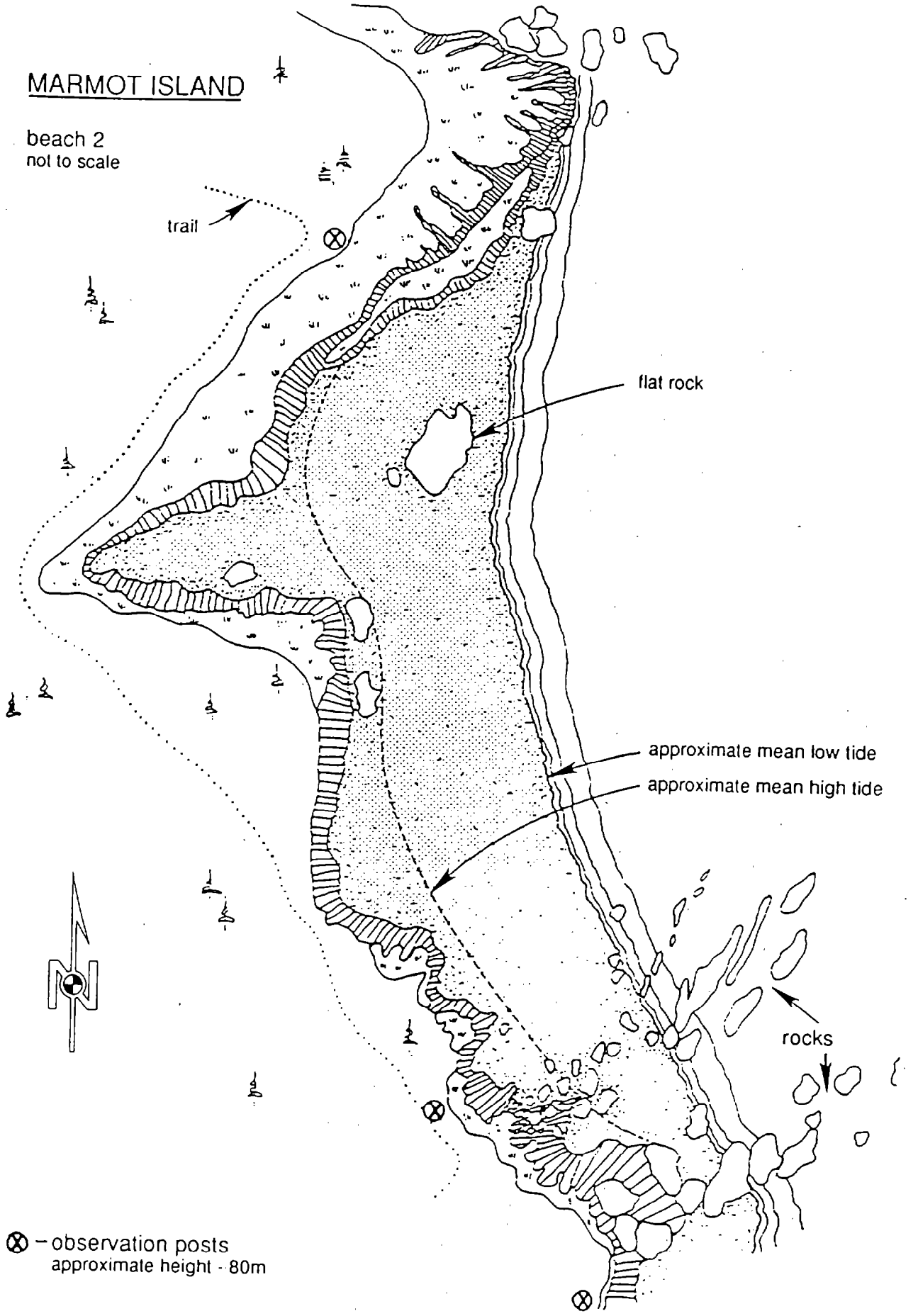

Figure 4

Source: Alaska Dept. Fish and Game, 1979

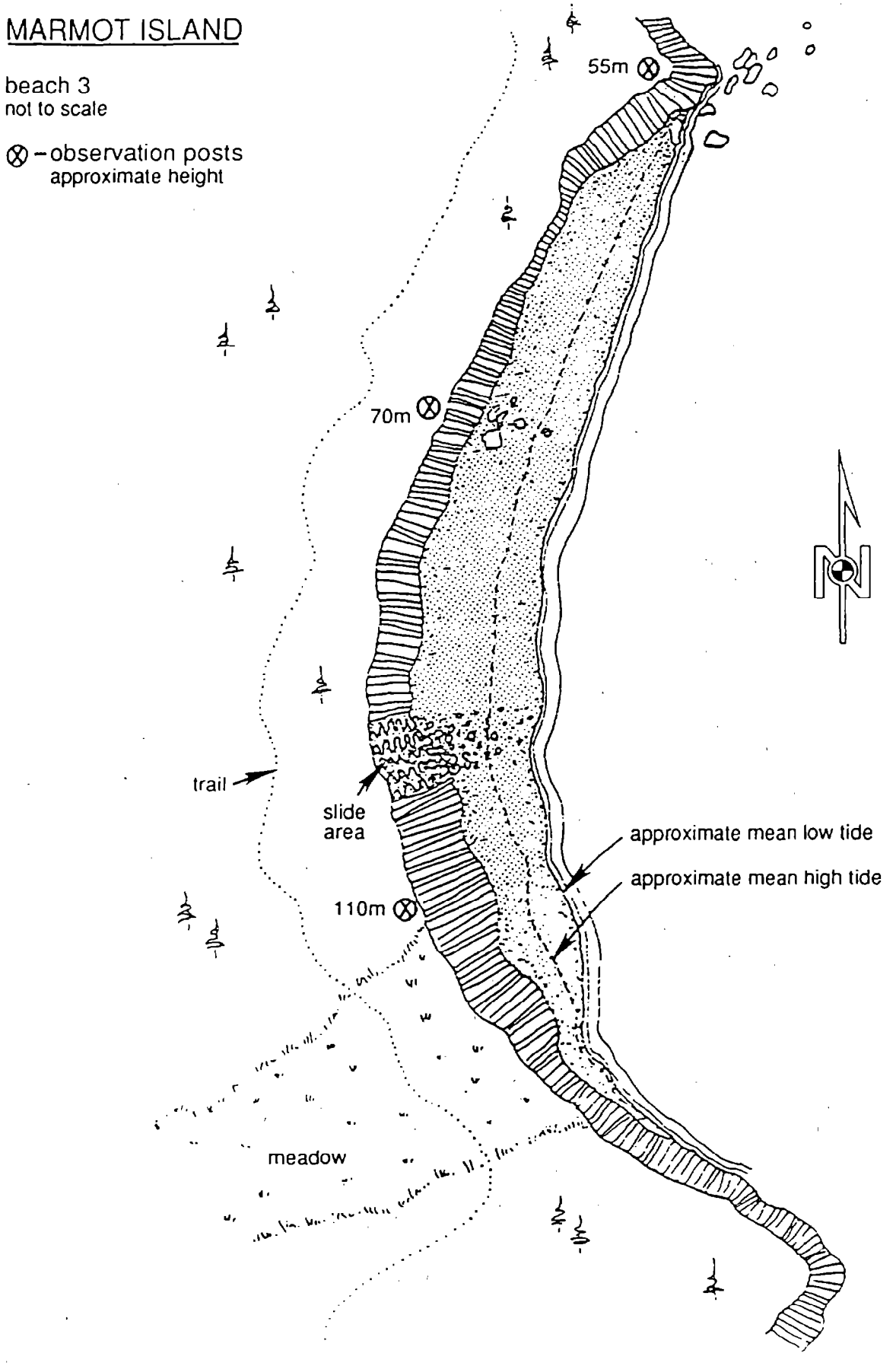

Figure 5

Source: Alaska Dept. Fish and Game, 1979

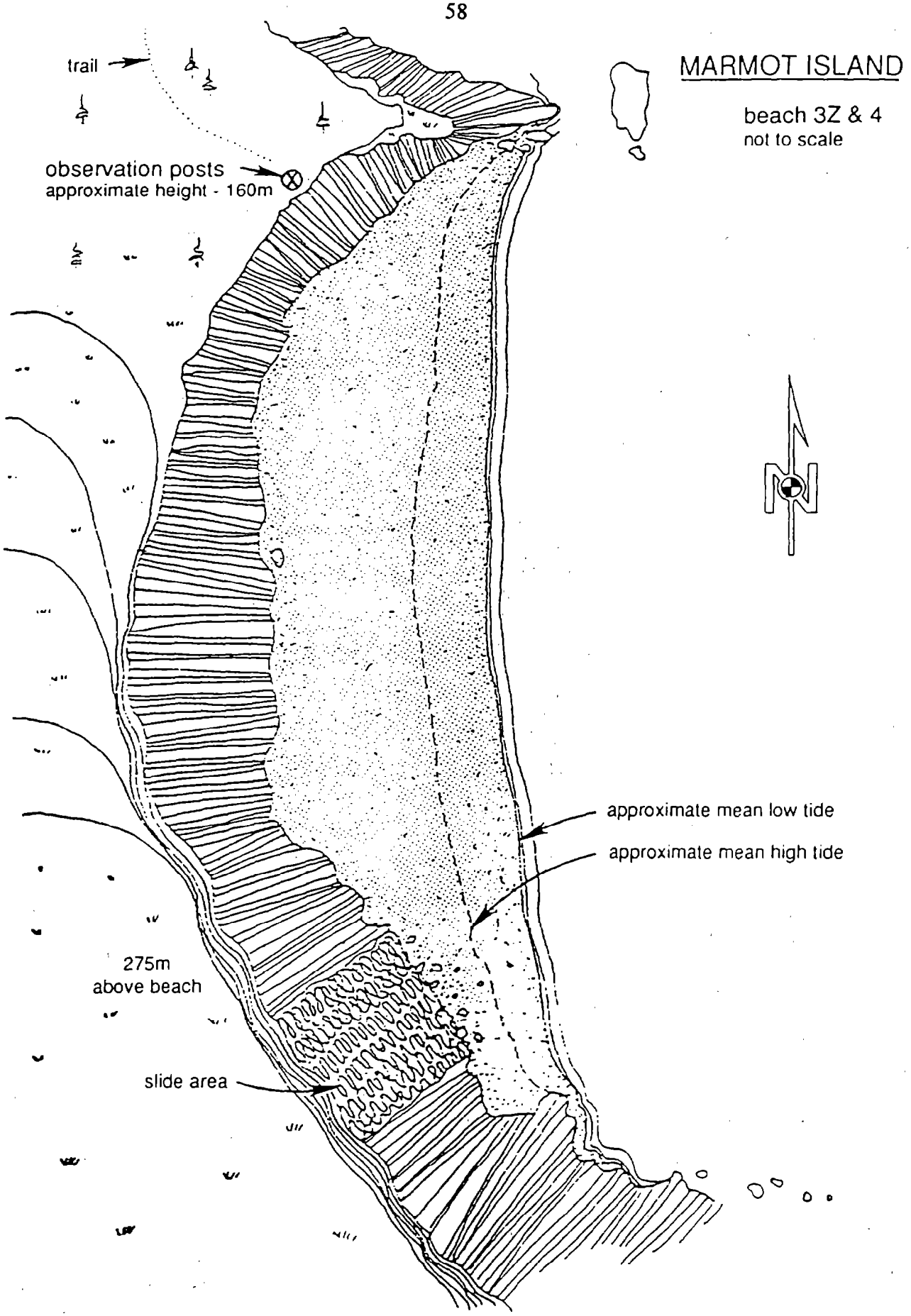

Figure 6

Source: Alaska Dept. Fish and Game, 1979

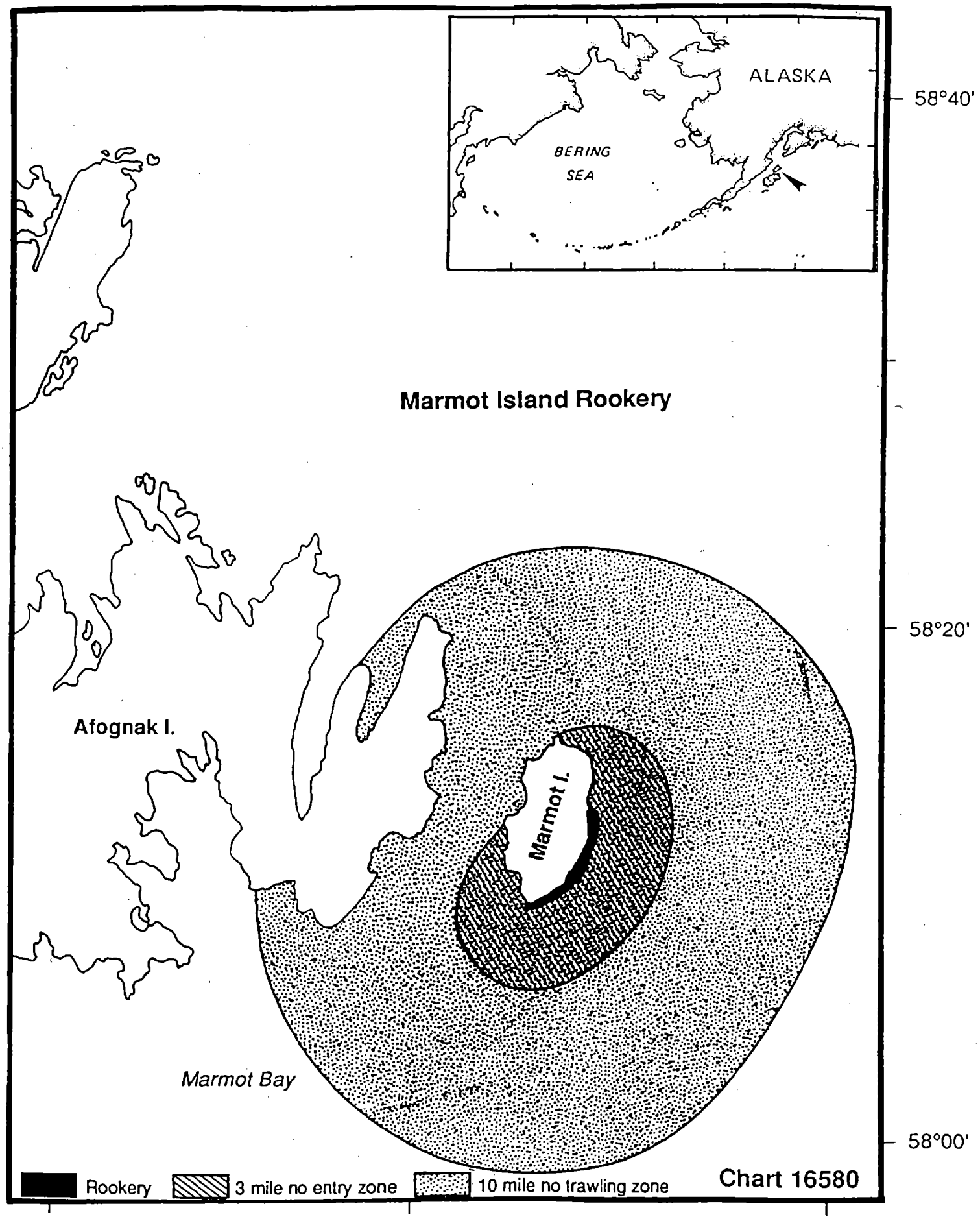
ALASKA
BERING SEA
Marmot Island Rookery
Afognak I.
Marmot I.
Marmot Bay
58°40'
58°20'
58°00'
Rookery
3 mile no entry zone
10 mile no trawling zone
Chart 16580
152°30' W
152°00
151°30'

Figure 7

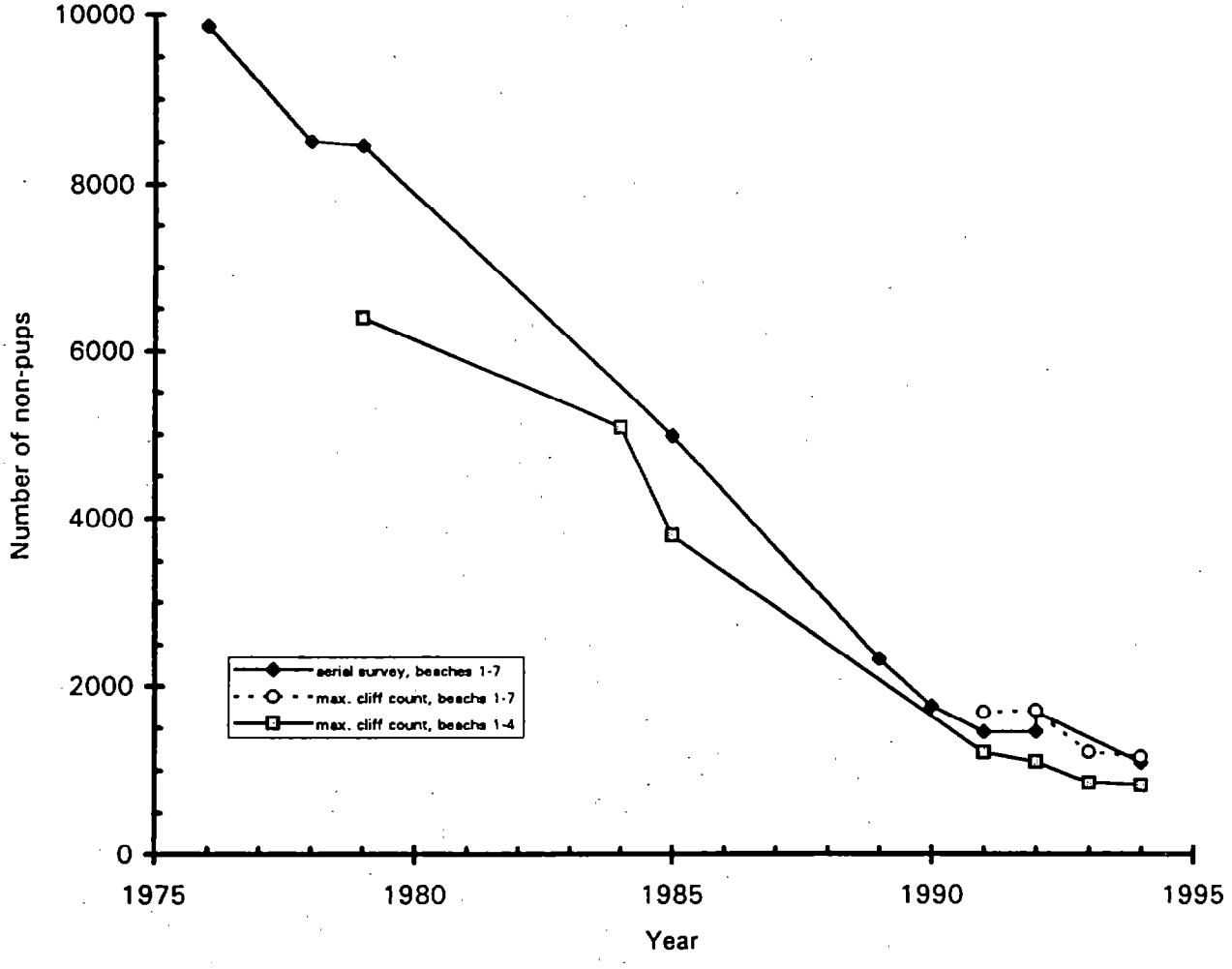

Figure 8.--Number of non-pup Steller sea lions counted on Marmot Island, Alaska, during aerial surveys (1976 to 1994), maximum counts from cliff-tops for Beaches 1 through 7 combined (1991 to 1994), and maximum counts from cliff-tops for Beaches l through 4 combined (1979 to 1994). Each maximum count represents the greatest number of non-pups counted on a single day during a particular year.

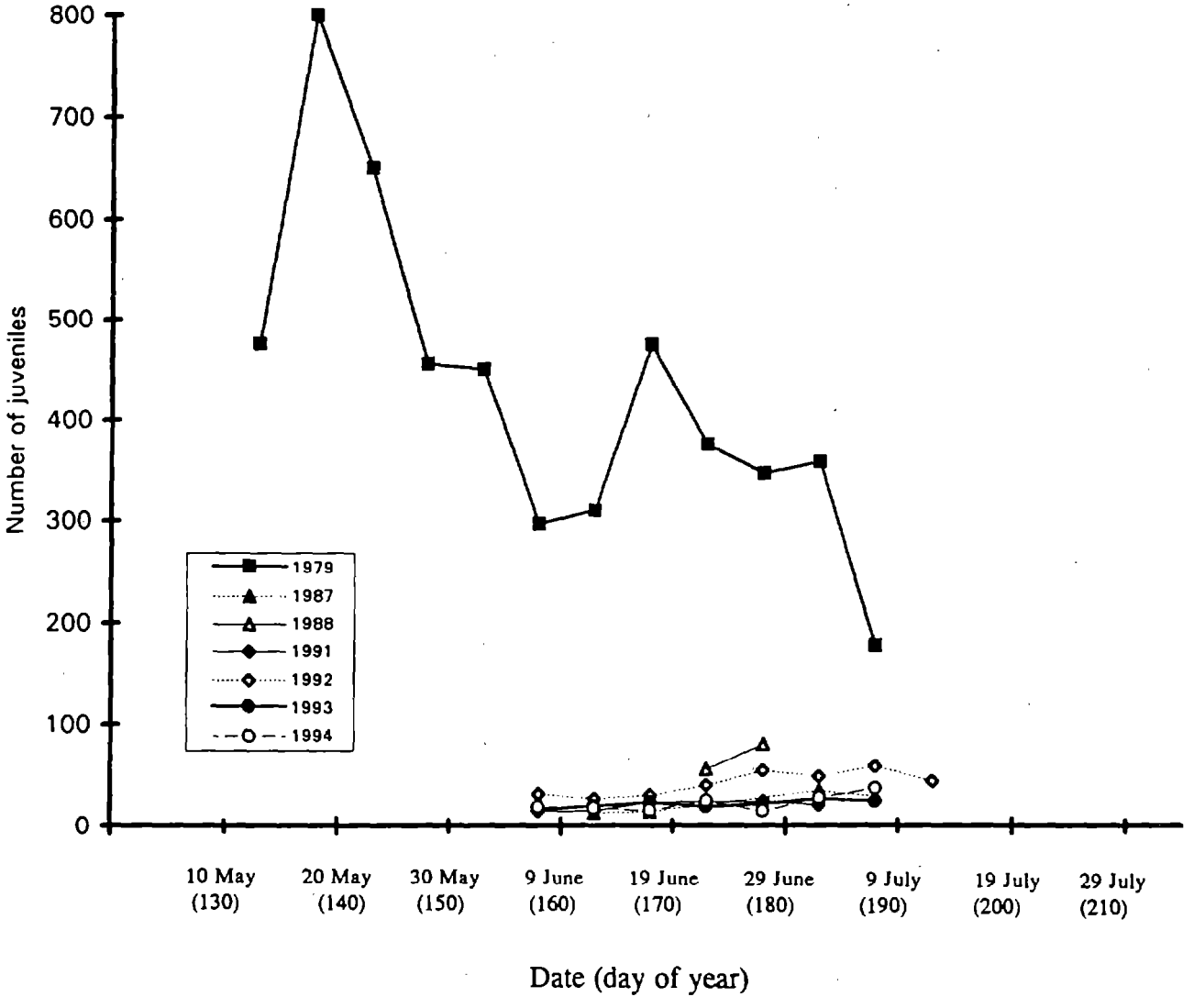

Figure 9.--Number of juvenile Steller sea lions counted on Beach 4, Marmot Island, Alaska, during the breeding season: 1979 to 1994. Data points represent maximum counts during 5-day intervals.

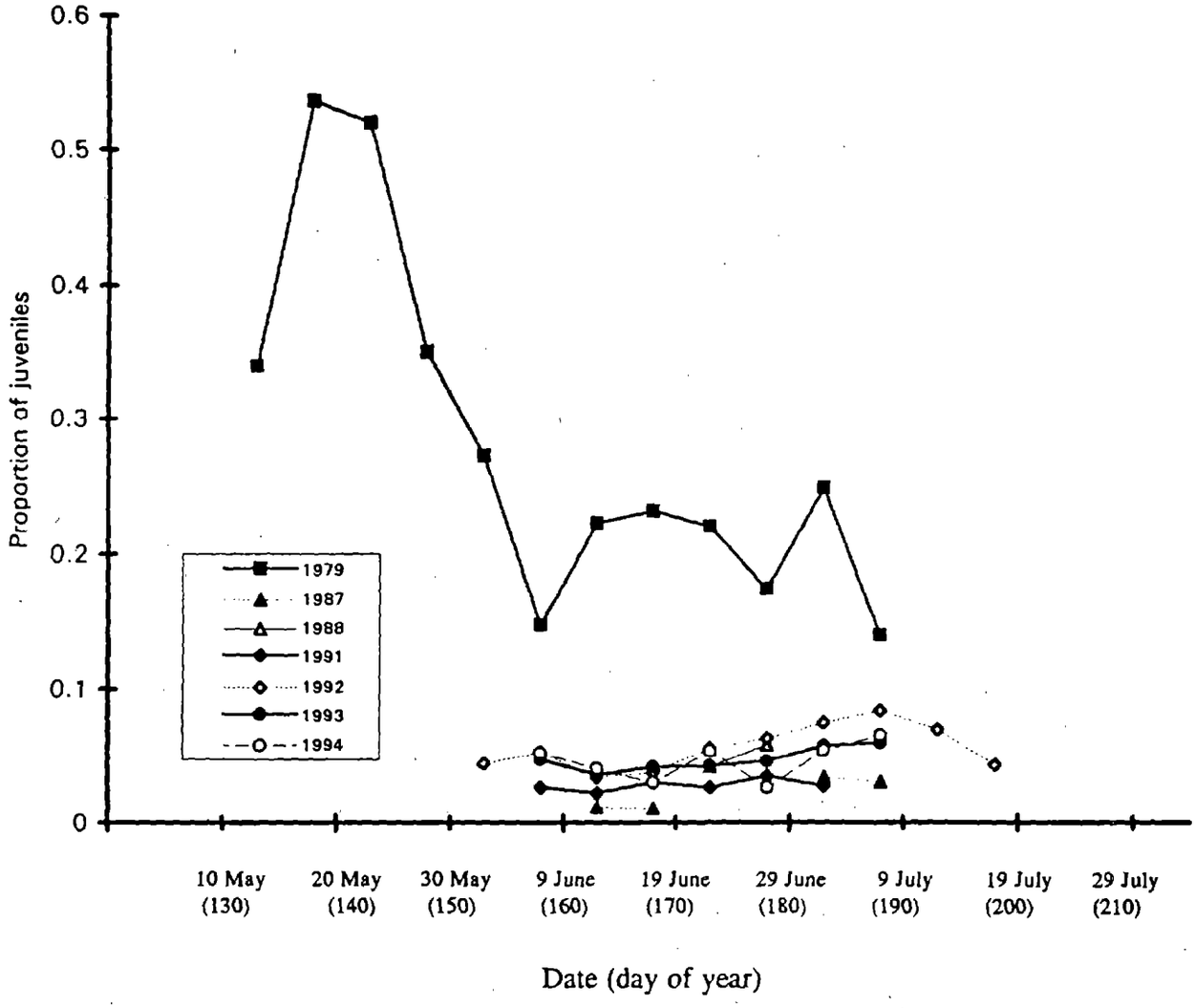

Figure l0.--Proportion of juvenile Steller sea lions, relative to the total number of non-pups, counted on Beach 4, Marmot Island, Alaska, during the breeding season: 1979 to 1994. Data points represent maximum counts during 5-day intervals.

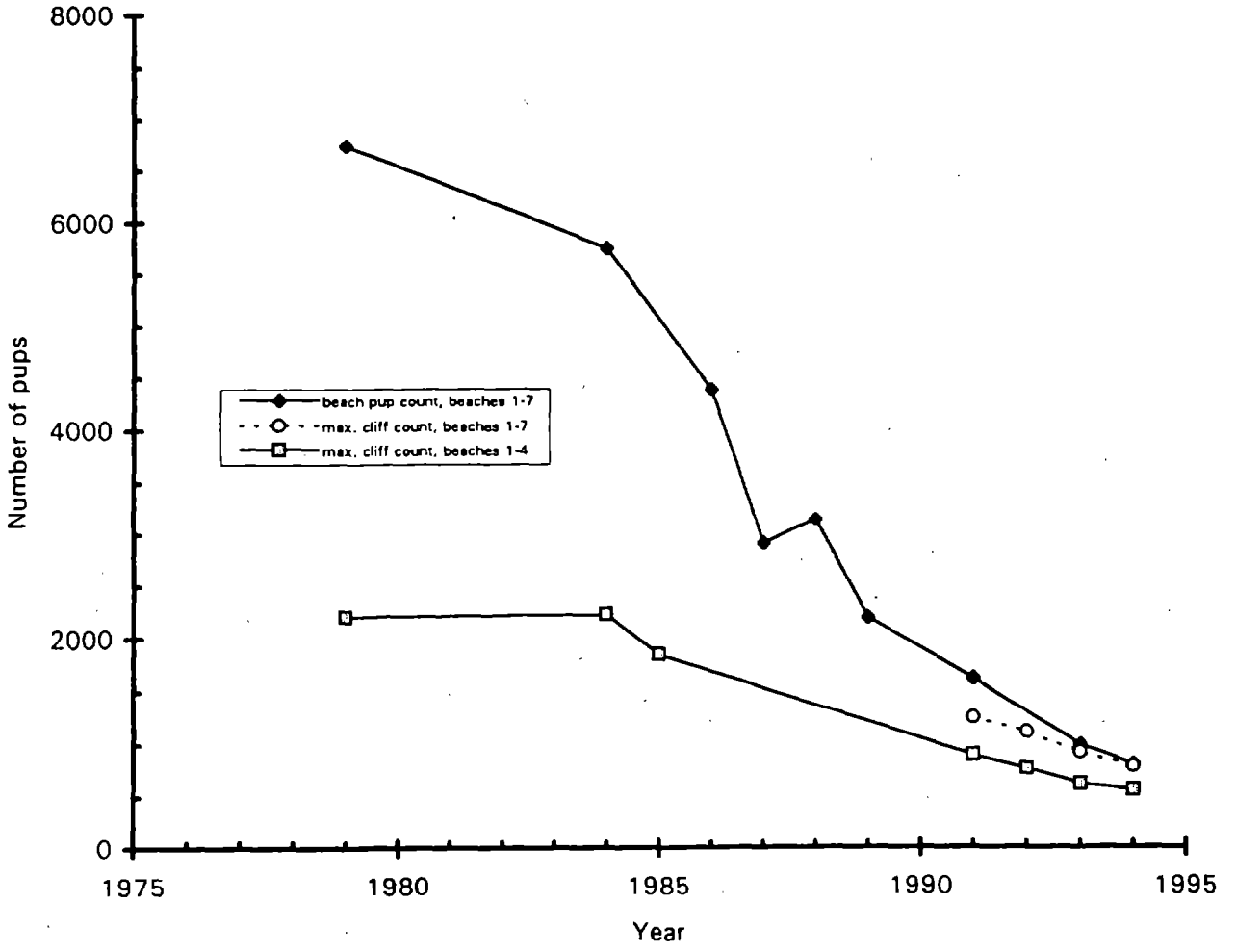

Figure 11 .--Number of Steller sea lion pups counted on Marmot Island, Alaska, during spook counts of all rookery beaches (1979 to 1994), maximum counts from cliff-tops for Beaches 1 to 7 combined (1991 to 1994), and maximum counts from cliff-tops for Beaches 1 to 4 combined (1979 to 1994). Each maximum count represents the greatest number of pups counted on a single day during a particular year.

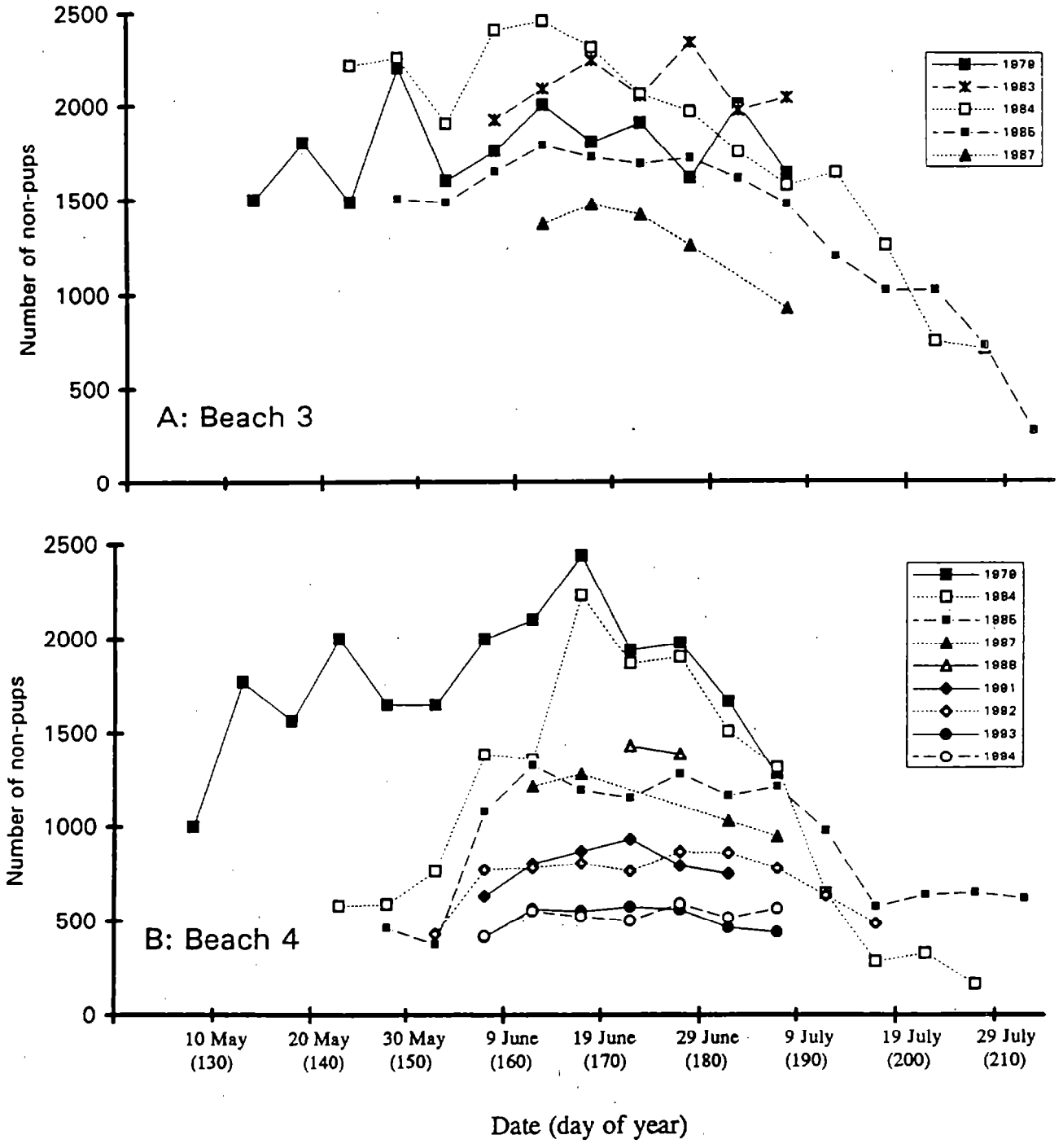

Figure 12.--Numbers of non-pup Steller sea lions counted during the breeding season on rookeries at (A) Beach 3 during 1979 to 1987 and (B) Beach 4 during 1979 to 1994, Marmot Island, Alaska. Data points represent maximum counts during 5-day intervals. Since 1987, sea lions have used Beach 3 as a haulout and very few pups have been born there.

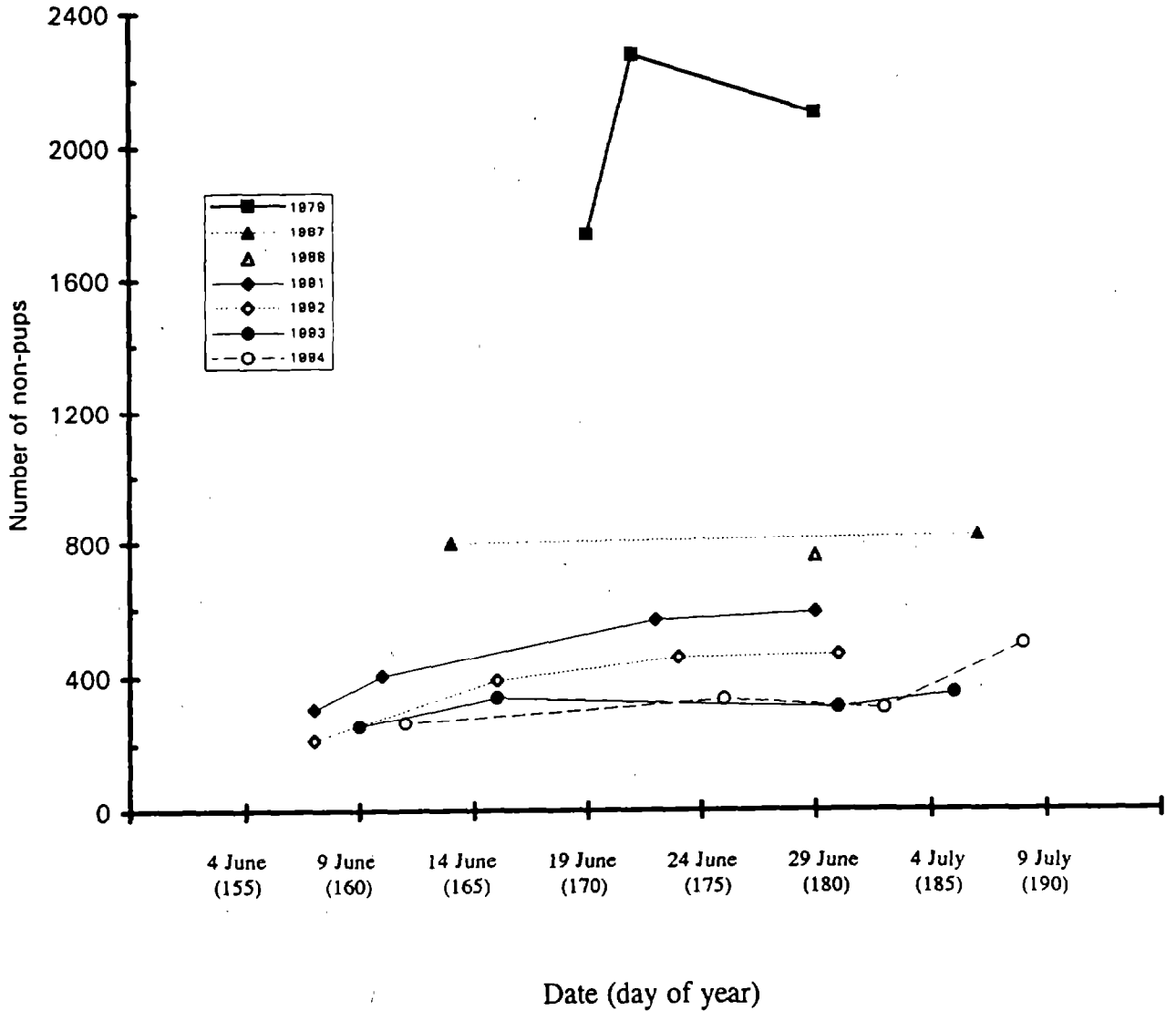

Figure 13.--Number of non-pup Steller sea lions counted on Beach 7, Marmot Island, Alaska, during the breeding season: 1987 to 1994. Counts were conducted about once per week during each year.

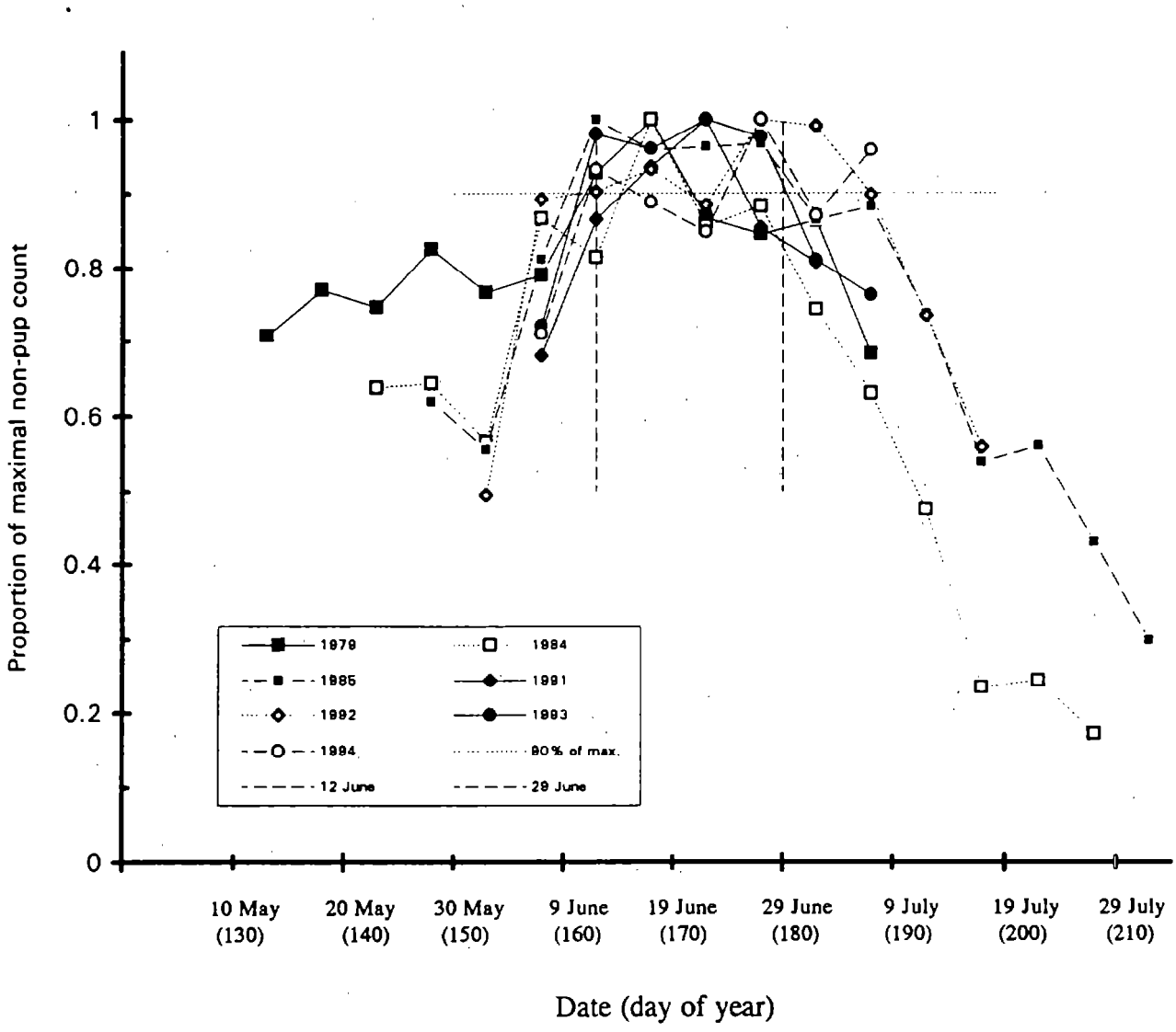

Figure 14.--Number of non-pup Steller sea lions for daily counts on Beaches 3 and 4 combined during 1979 to 1985 and on Beach 4 during 1991 and 1992, plotted as a proportion of the maximum count during that year. The horizontal dotted line represents 90% of the maximum count, vertical dashed lines represent 12 and 29 June (days 163 and 180, respectively).

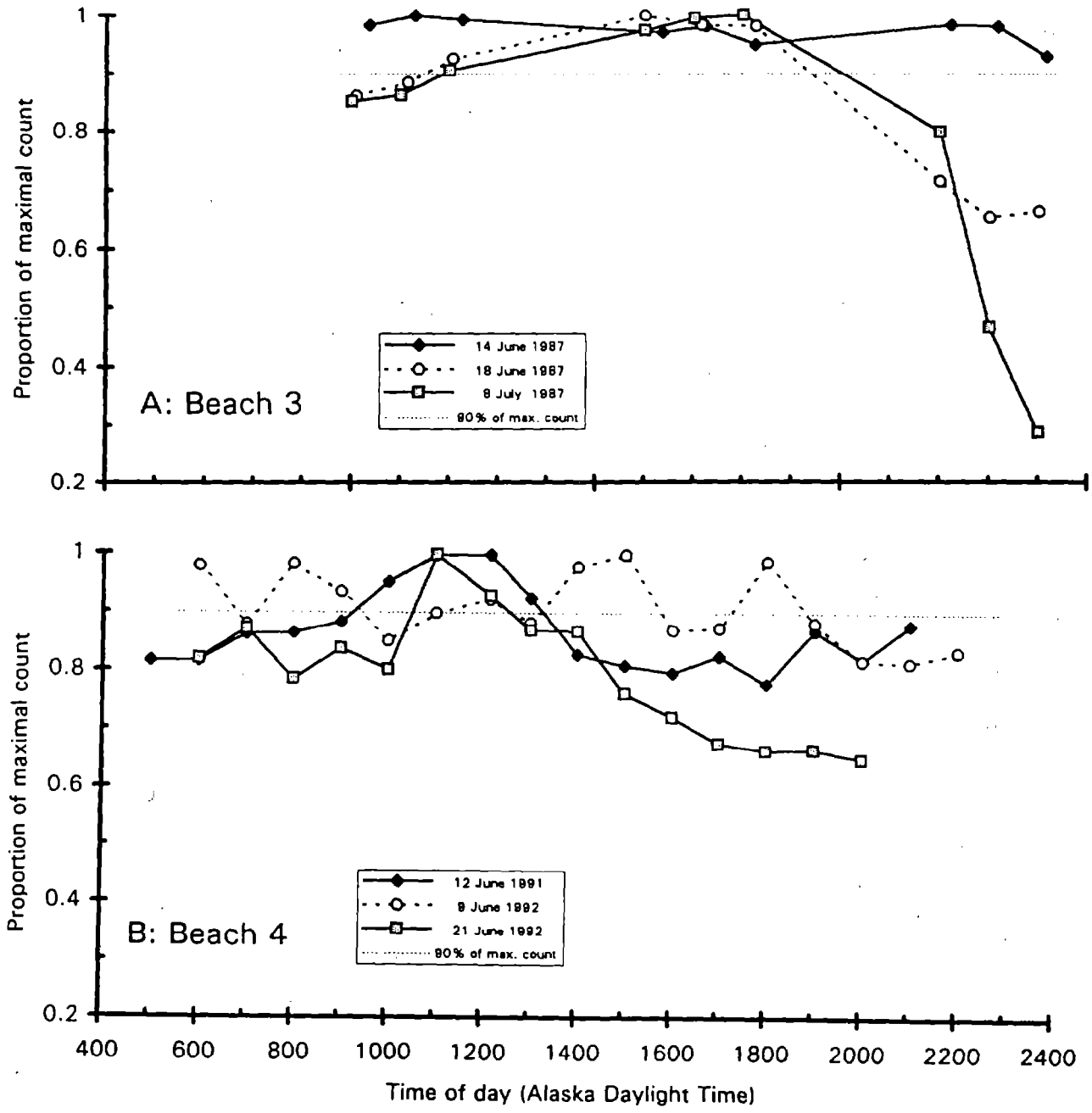

Figure 15.--Number of non-pup Steller sea lions for hourly counts (A) on Beach 3 during 1987 and (B) on Beach 4 during 1991 and 1992, plotted as a proportion of the maximum count during that day.

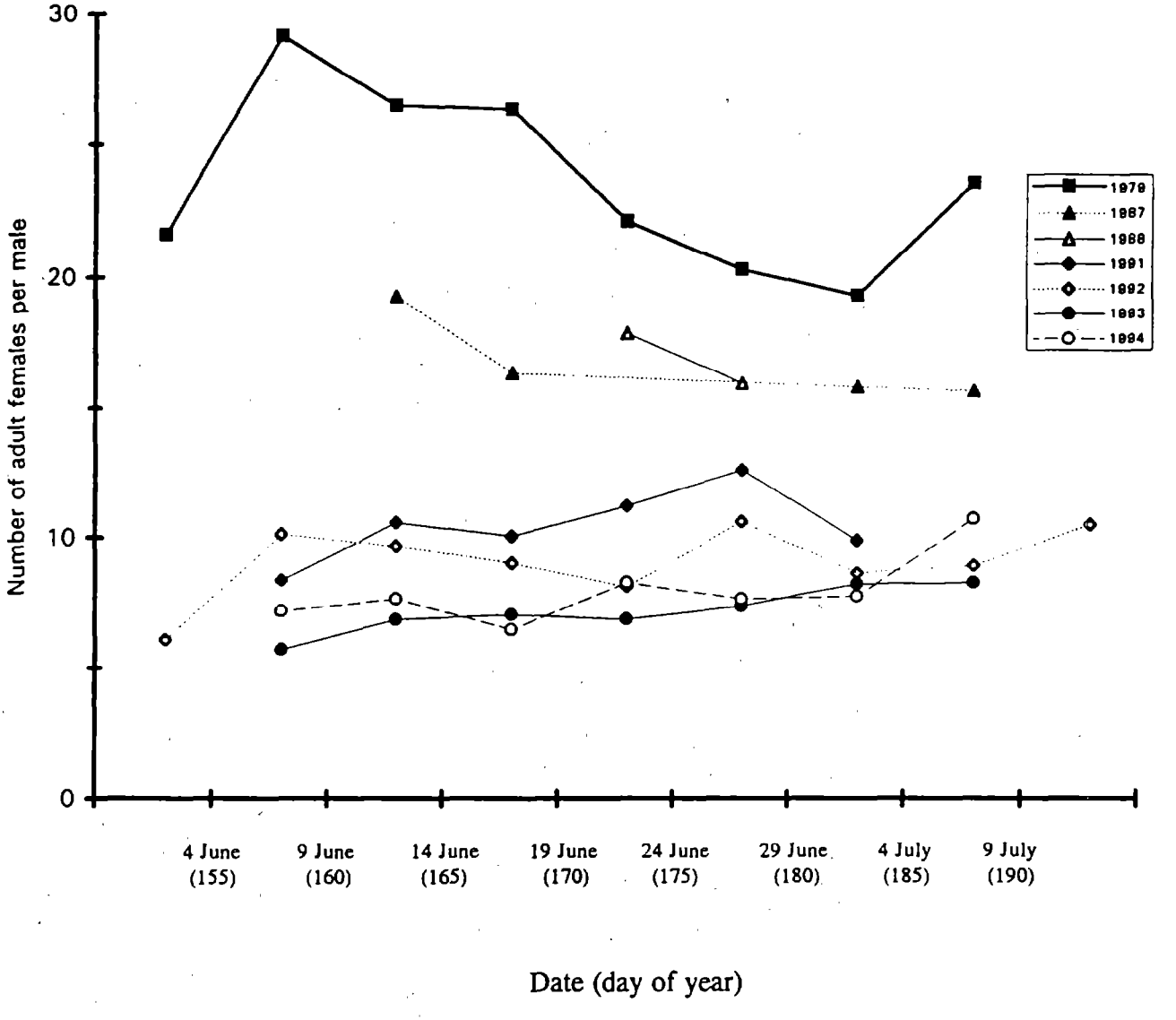

Figure 16.--Number of adult female Steller sea lions per territorial male on Beach 4, Marmot Island, Alaska, during the breeding season: 1979 to 1994. Each plotted point is the maximum number observed during a 5-day interval.

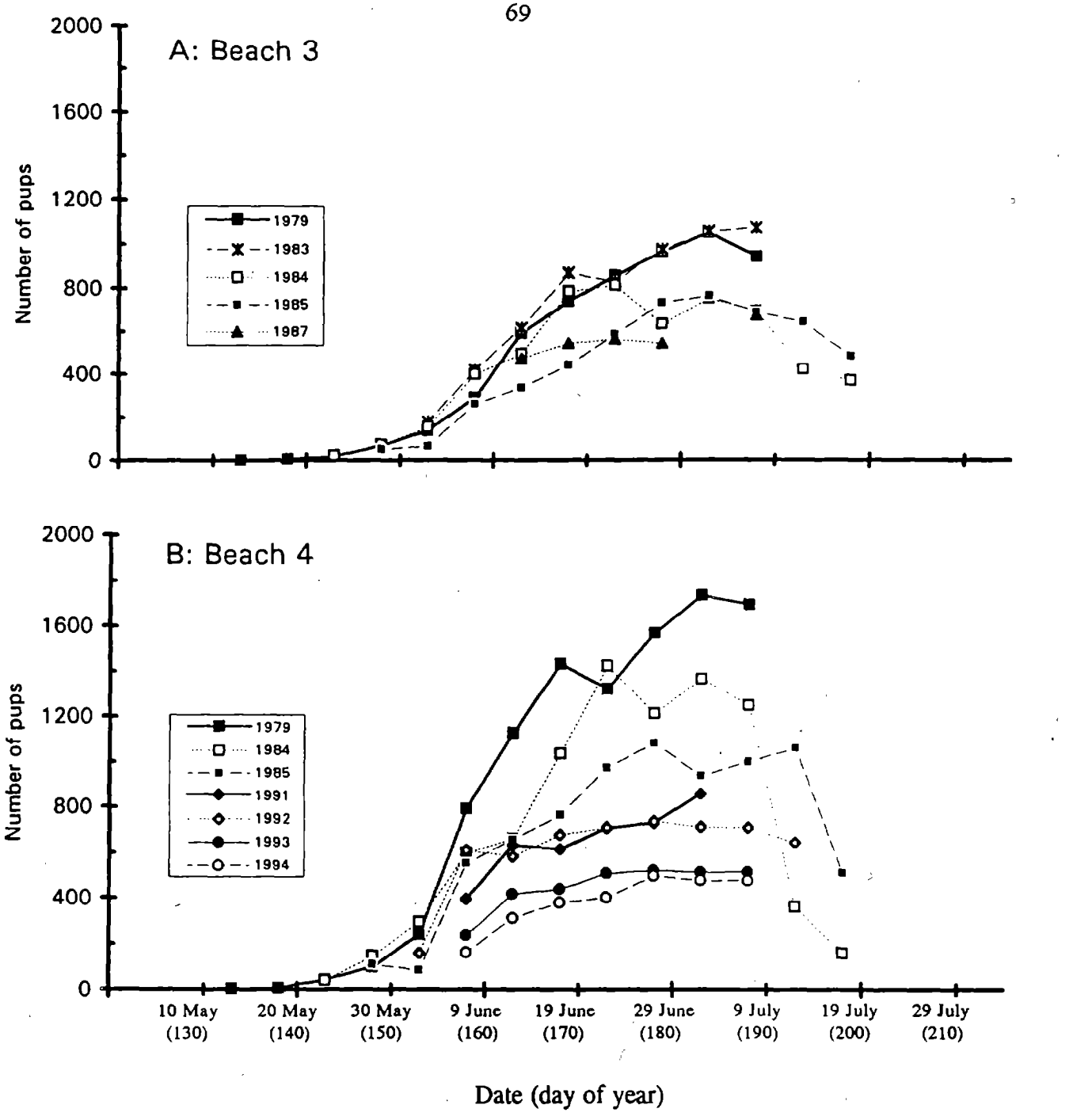

Figure 17.--Number of Steller sea lion pups counted (A) on Beach 3 from 1979 through 1987 and (B) on Beach 4 from 1979 through 1994. Data points represent maximum counts during 5-day intervals.

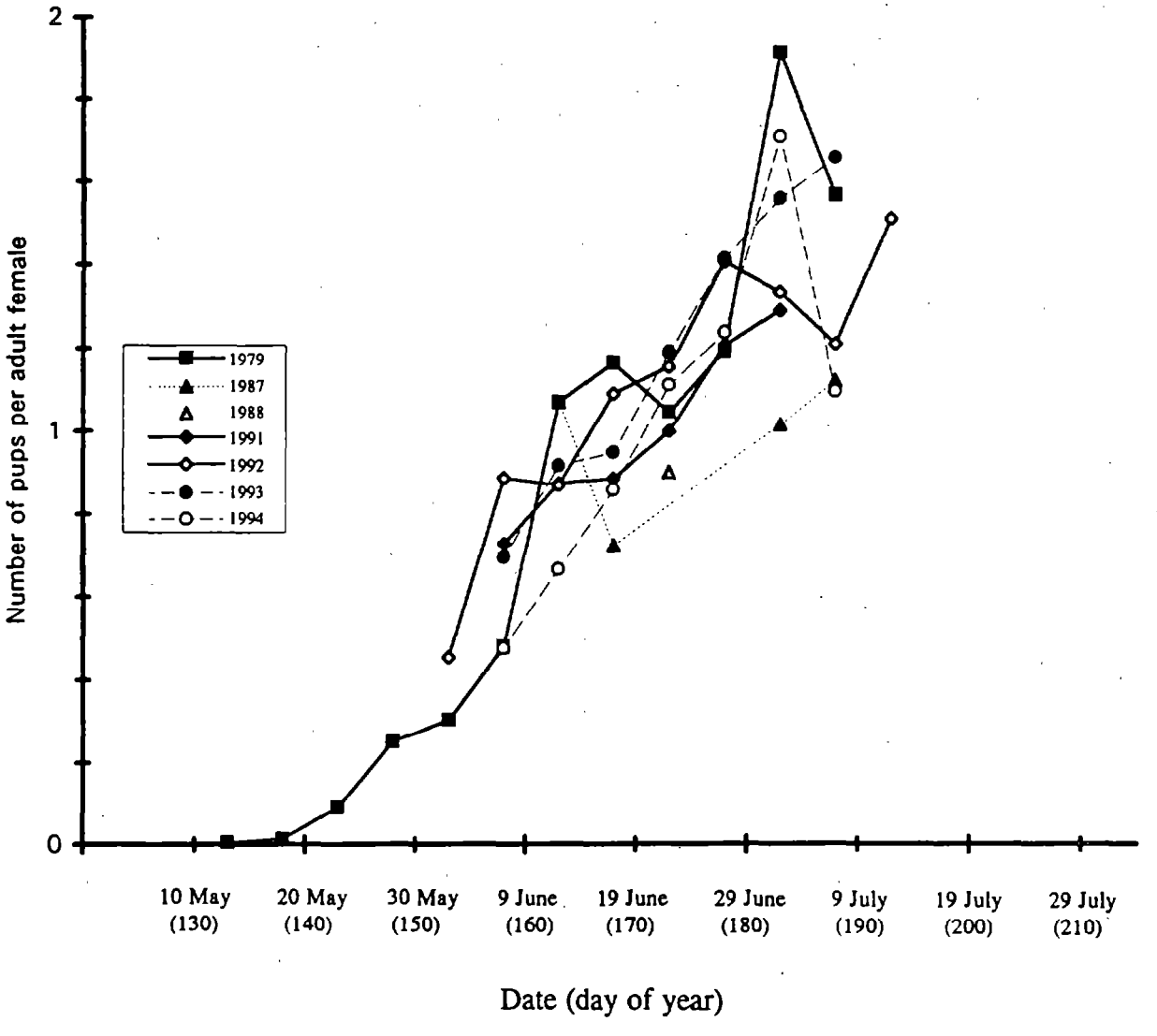

Figure 18.--Number of Steller sea lion pups per adult female on Beach 4, Marmot Island, Alaska: 1979 to 1994. Data points represent maximum counts during 5-day intervals.

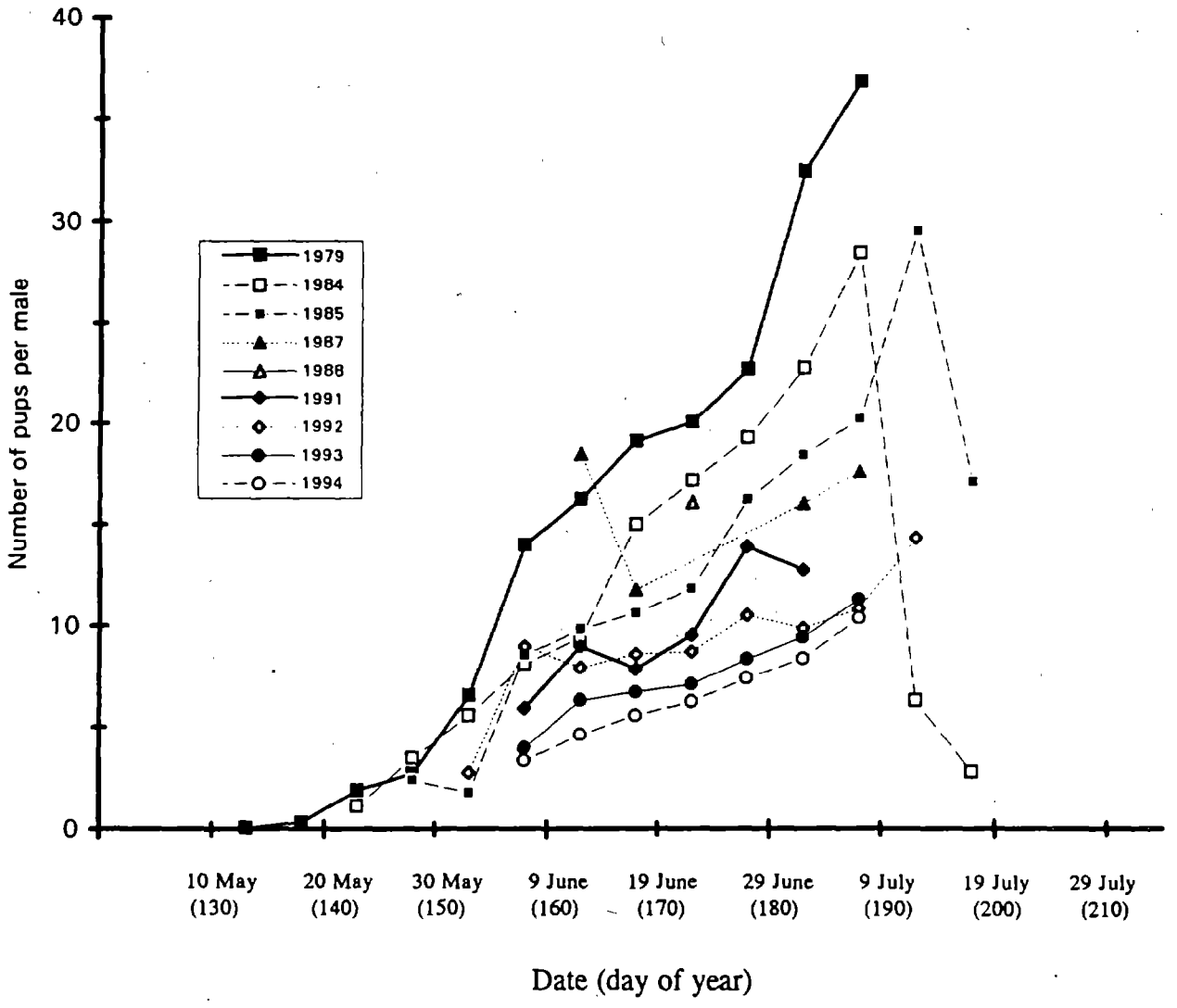

Figure lg.--Number of Steller sea lion pups per territorial male on Beach 4, Marmot Island, Alaska: 1979 to 1994. Each plotted point is the maximum number observed during a 5-day interval.

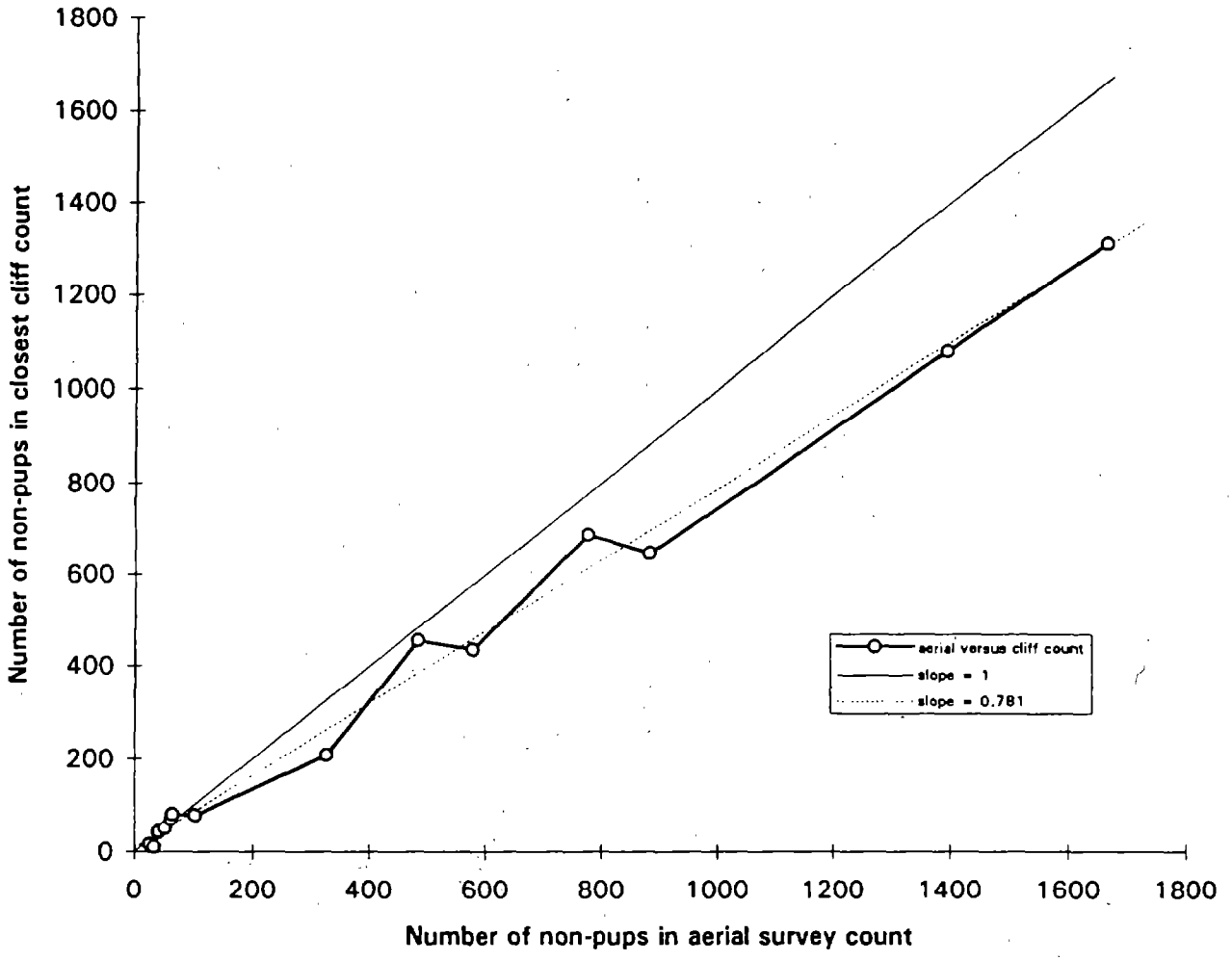

Figure 20.--Comparison of the number of non-pups counted from aerial survey photographs and from the cliff **count** made closest in time. Each point represents an individual rookery or haul-out beach for a particular aerial survey (e.g., Beach 3 - 1985 Beach 7 - 1994). The, solid line represents perfect concordance between the count methods (slope = 1.0). The dotted line represents the regression of cliff counts on aerial counts (slope = 0.789).

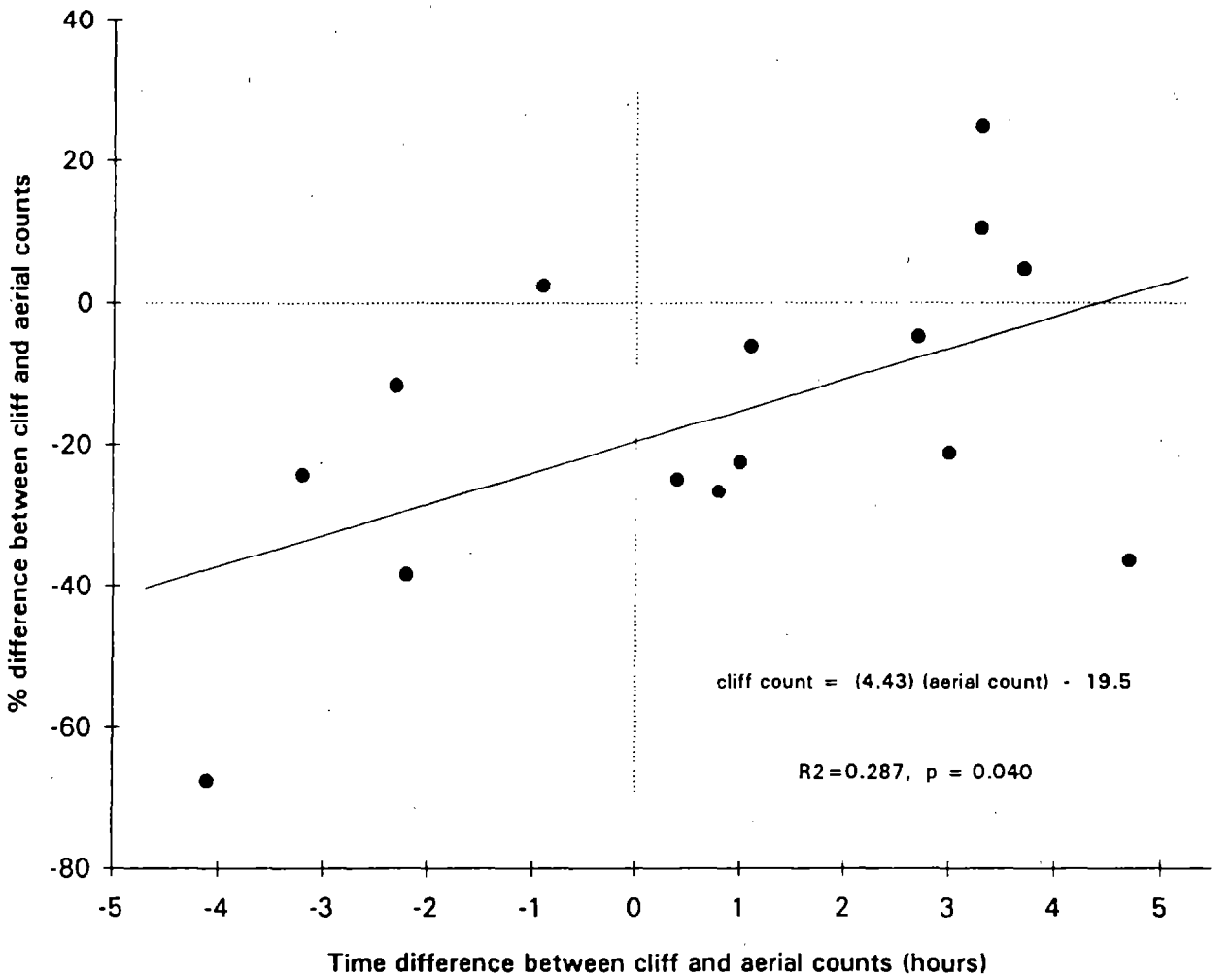

Figure 21 .--The relative difference between numbers of non-pups from cliff counts and from-aerial survey photographs, as a function of the time difference between the two counts. A negative time means the cliff count was made before the aerial survey; a negative difference means the cliff count was lower than the aerial survey.

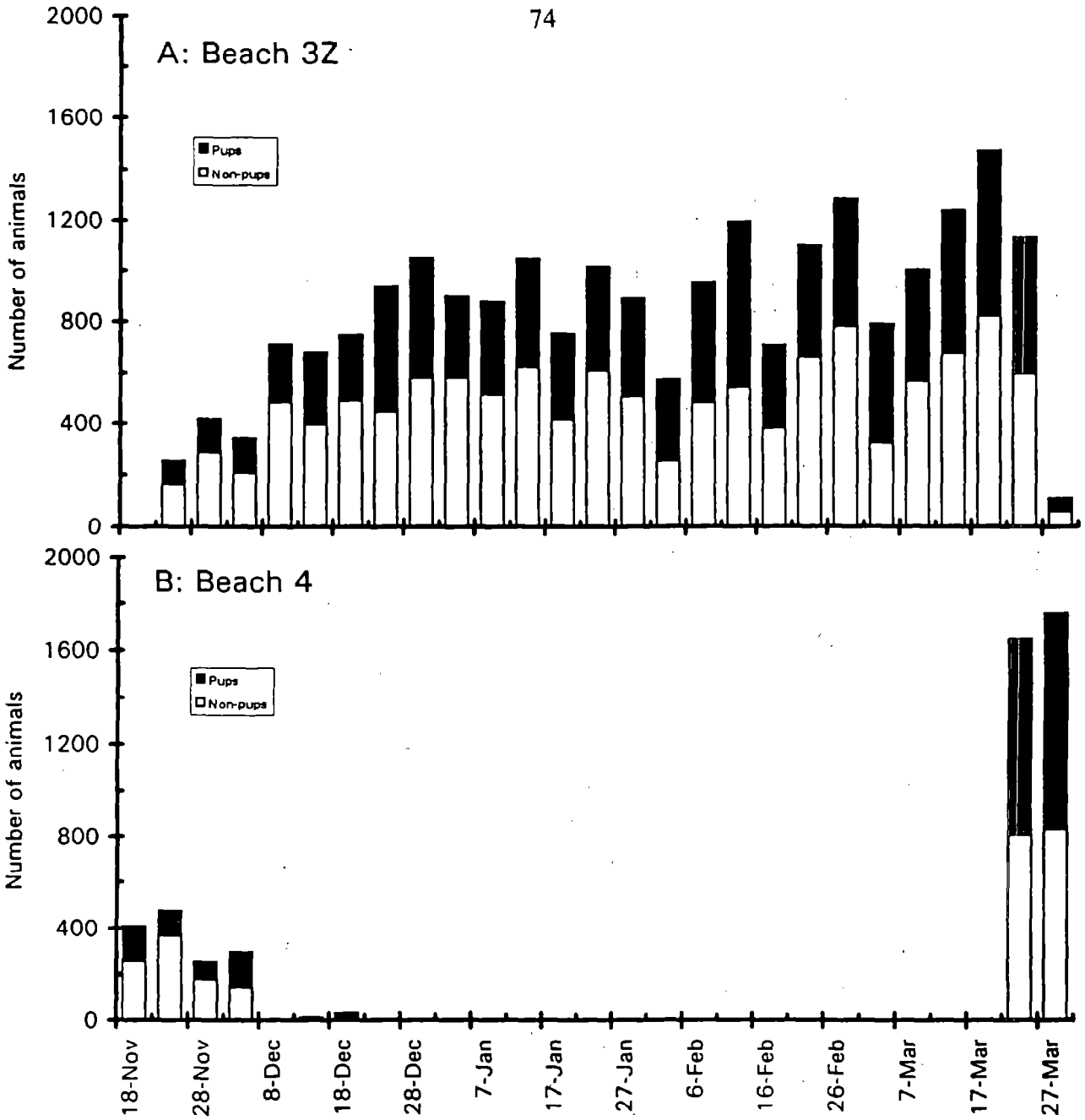

Figure 22.--Numbers of Steller sea lion pups (black bars) and non-pups (white bars) counted (A) on Beach 3Z and (B) on Beach 4, Marmot Island, Alaska, during November 1987 through March 1988. Each bar represents the maximum numbers observed during a 5-day interval.

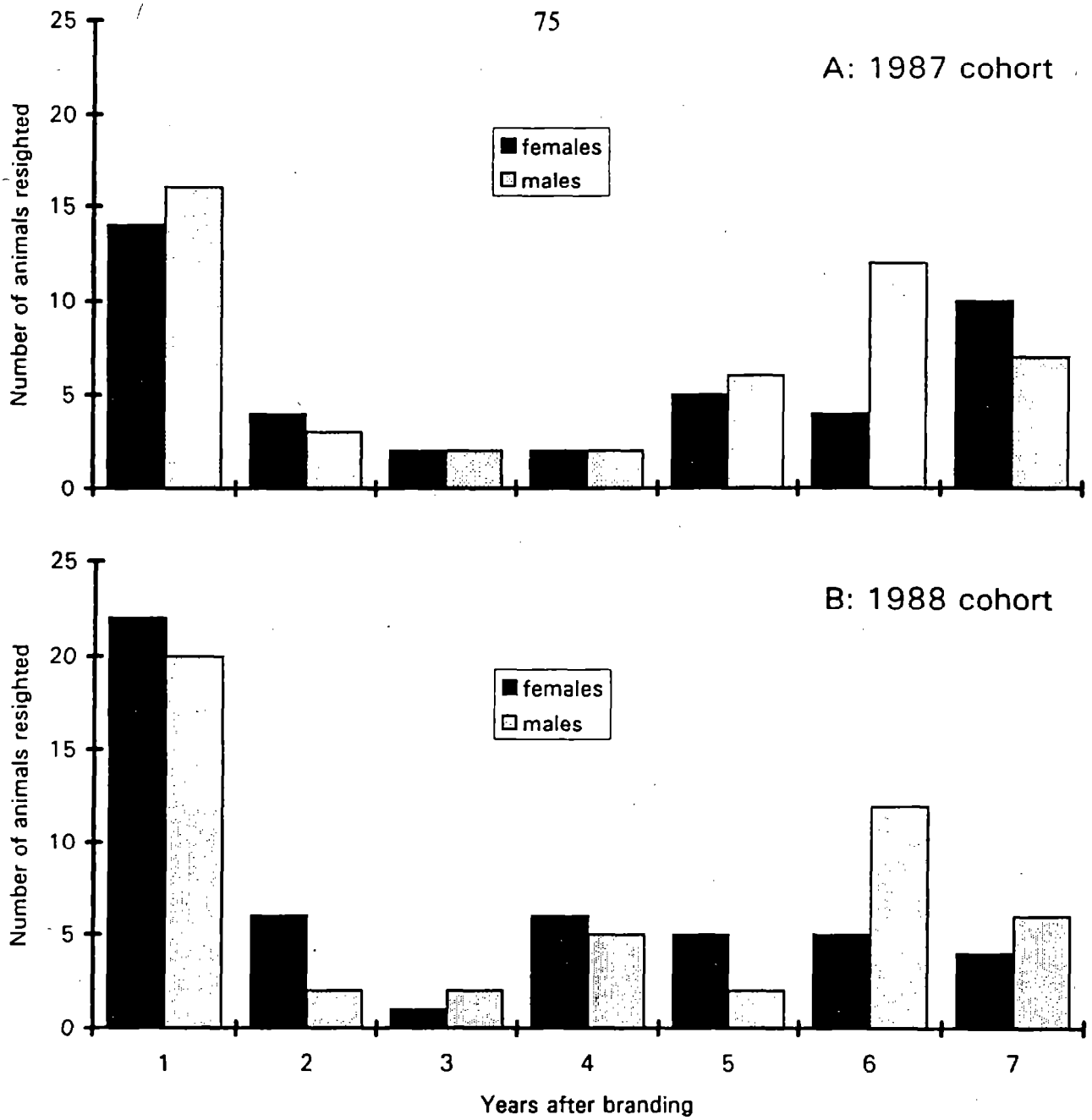

Figure 23.--Numbers of female (black bars) and male (gray bars) Steller sea lions branded and tagged as pups on Marmot Island, Alaska, during (A) 1987 and (B) 1988 resighted one to seven years after branding. Resightings are from all locations. Resightings of the 1988 cohort during June 1995 are included. These data must be interpreted with caution as resighting effort was not uniform during all years.

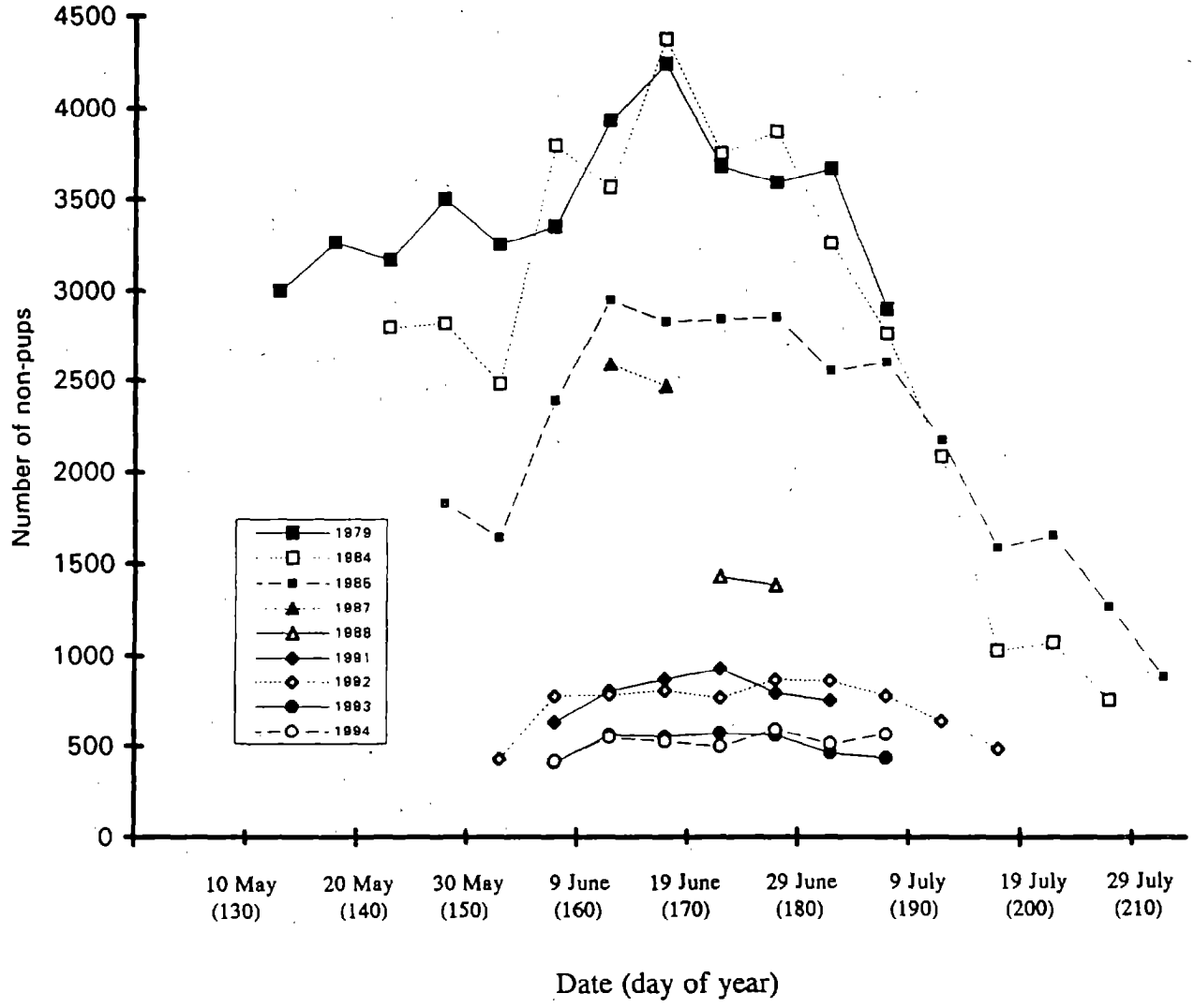

Figure 24.--Total number of non-pup Steller sea lions counted on rookery Beaches 3 and 4, Marmot Island, Alaska, during the breeding season: 1979 to 1994. Data points represent maximum counts during 5-day intervals. Counts for 1979 through 1987 , include both beaches, counts for 1988 through 1994 (after Beach 3 was abandoned as a rookery) are for Beach 4 only.

Appendix A.--Avian species sited at Marmot Island, 1979 through 1994.

Red-throated Loon	*Gavia stellata*
Common Loon	*Gavia immer*
Homed Grebe	*Podiceps auritus*
Red-necked Grebe	*Podiceps grisegena*
Sooty Shearwater	*Puffimus griseus*
Pelagic Cormorant	*Phalacrocorax pelagicus*
Red-faced Cormorant	*Phalacrocorax urile*
Green-winged Teal	*Anas crecca*
Mallard	*Anas platyrhynchus*
American Wigeon	*Anas americana*
scaup sp.	*Aythya sp.*
Harlequin Duck	*Histrionicus histrionicus*
Oldsquaw	*Clangula hyemalis*
Black Scoter	*Melanitta nigra*
White-winged Scoter	*Melanitta fusca*
goldeneye sp.	*Bucephala sp.*
Bald Eagle	*Haliaeetus leucocephalus*
Sharp-shinned Hawk	*Accipiter striatus*
Northern Goshawk	*Accipiter gentilis*
Peregrine Falcon	*Falco peregrinus*
Gyrfalcon	*Falco rusticolus*
Willow Ptarmigan	*Lagopus lagopus*
Rock Ptarinigan	*Lagopus mutus*
Black Oystercatcher	*Haematopus bachmani*
yellowlegs sp.	*Tringa sp.*
Surfbird	*Aphriza virgata*
Western Sandpiper	*Calidris mauri*
Common Snipe	*Gallinago gallinago*
Red-necked Phalarope	*Phalaropus lobatus*
Mew Gull	*Larus canus*
Herring Gull	*Larus argentatus*
Glaucous-winged Gull	*Larus glaucescens*
Black-legged Kittiwake	*Rissa tridactyla*
Pigeon Guillemot	*Cepphus columba*
Marbled Murrelet	*Brachyramphus marmoratus*
Tufted Puffin	*Fratercula cirrhata*
Homed Puffin	*Fratercula comiculata*
Short-eared Owl	*Asio flammeus*
Belted Kingfisher	*Cetyle alcyon*

Appendix A.--Continued

Downy Woodpecker	*Picoides pubescens*
Three-toed Woodpecker	*Picoides tridactylus*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachyciteta thalassina*
Bank Swallow	*Riparia riparia*
Black-billed Magpie	*Pica pica*
Northwestern Crow	*Corvus caurinus*
Common Raven	*Corvus corax*
Black-capped Chickadee	*Par-us atricapillus*
Brown Creeper	*Certhia americana*
Winter Wren	*Troglodytes troglodytes*
American Dipper	*Cinclus mexicanus*
Golden-crowned Kinglet	*Regulus satrapa*
Gray-cheeked Thrush	*Catharus minimus*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*
Varied Thrush	*Ixoreus naevius*
American Pipit	*Anthus rubescens*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Wilson's Warbler	*Wilsonia pusilla*
Savannah Sparrow	*Passerculus sandwichensis*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Dark-eyed Junco	*Junco hyemalis*
Gray-crowned Rosy Finch	*Leucoslicte tephrocotis*
Pine Grosbeak	*Pinicola enucleator*
Red Crossbill	*Loxia curvirostra*
White-winged Crossbill	*Loxia leucoplera*

Source: Compiled by R. McIntosh, NMFS Kodiak Laboratory, Kodiak, Alaska

Appendix B.--Mammal Species (relative abundance) at Marmot Island 1979 through 1994

Abundance catagories: A = abundant
C = common
U = uncommon
R = rare

Terrestrial:

River otter *(Lutra canadensis)* U
Red fox *(Vulpes fulva)* U
Arctic ground squirrel *(Spermophilus undulatus)* A
Sitka black-tailed deer *(Rama lemionus)* U
Feral cattle *(Bos sp.)* R
Wild boar *(Sus scrofa) C*
Snowshoe hare *(Lepus americanus) C*

Marine:

Sea otter *(Enhydra lutris)* A
Steller sea lion *(Eumetopias jubatus)* A
Harbor seal *(Phoca vitulina)* A
Gray whale *(Eschrichtius robustus)* U
Killer whale *(Orcinus orca)* R
Humpback whale *(Megaptera novaeangliae)* R
Minke whale *(Balaenoptera acutorostrata)* R
Dall's porpoise *(Phocoenoides dalli)* R
Harbor porpoise *(Phocoena phocoena)* R

Appendix C.--Plats identified on Marmot Island, 1979 through 1994

Sitka Spruce	*Picea sitchensis*
Salmonberry	*Rubus spectabilis*
Cow Parsnip	*Heracleum lanatum*
Devil's Club	*Echinopanax horridum*
Northern Marsh Violet	*Viola espisila*
Yellow Violet	*Viola glabella*
Wild Flag	*Iris setosa*
Northern Yarrow	*Achilles borealis*
Red-berried Elder	*Sam bucus racemosa*
Western Buttercup	*Ranunculus occidentalis*
Marsh Marigold	*Caltha palustris*
Kamchatka Dandelion	*Taraxacum kamtschaticum*
Alpine Shooting Star	*Dodecatheon frigidum*
Beach Cinquefoil	*Potentilla pacifica*
Villons Cinquefoil	*Potentilla villosa*
Marsh Fivefinger	*Potentilla palustris*
Silverweed	*Potentilla anserina*
Kamchatka Lily	*Fritillaria camschatcensis*
Wild Geranium	*Geranium erianthum*
Oak Fern	*Dryopteris linnaena*
Dwarf Cornel	*Cornus suecica*
Trailing Raspberry	*Rubus pedatus*
Nagoonbeny	*Rubus stellatus*
Narcissus-flowered Anemone	*Anemone narcissiflora*
Roseroot	*Sedum rosea*
Bog Cranberry	*Oxycoccus microcarpus*
Highbush Cranberry	*Viburum edule*
Butterwort	*Pinguicula vulgaris*
Large-leaved Avens	*Geum macrophyllum*
Oeder's Lousewort	*Pedicularis oederi*
Weasel Snout	*Lugotis glauca*
Alpine Bearberry	*Arctostaphylos alpina*
Kinnikinnik	*Arctostaphylos uva-ursi*
Alpine Azalea	*Loiseleura procumbens*
Siberian Phlox	*Phlox sibirica*
Seacoast Agelica	*Angelica lucida*
Seabeach Sandwort	*Honckenya peploides*
Siberian Spring Beauty	*Claytonia sibirica*
One-flowered Wintergreen	*Moneses unrflora*
Alaska Heather	*Cassiope stelleriana*

Appendix C.--Continued.

Yellow Paintbrush	*Castilleja unalaschensis*
Labrador Tea	*Ledum palustre decumbens*
Nootka Lupine	*Lupinus nootkatensis*
Beach Pea	*Luthyrus maritimus*
Dwarf Fireweed	*Epilobium latifolium*
False Hellebore	*Viride eschscholtzii*
Brook Saxifiage	*Saxifraga punctata*
Leather-leafed Saxifiage	*Leptarrhena pyrolifolia*
Pink Daisy	*Erigeron peregrinus*
Yellow Monkey Flower	*Mimulus gutlatus*
Groundsel	*Senecio atropurpureus*
Amica	*Arnica latifolia*

Source: Alaska Department of Fish and Game, 1979.

Appendix D.--Steller sea lions marked with flipper tags or brands on Marmot Island, Alaska, during 1987 through 1994, including the color of flipper tags, sex, age, weight (kg), standard length (cm), and date of marking. Brands, on the left or right flank, are the same number as on the flipper tags. Attachments of radio transmitters (VHF) or satellite- linked, platform terminal transmitters (PTT) are noted as comments. Tags from animals denoted as "dead, <1992" were found in the stomach of a beach-cast killer whale in 1992. All are presumed dead, but the date of death is unknown

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
1	yellow		m	pup	29	109	29	6	1987	
2	yellow		f	pup	20	94	29	6	1987	
3	yellow		f	pup	28	101	29	6	1987	
4	yellow		f	pup	19	96	29	6	1987	
5	yellow		f	pup	25	105	29	6	1987	
6	yellow		m	pup	25	100	29	6	1987	
7	yellow		m	pup	29	107	29	6	1987	
8	yellow		f	pup	25	108	29	6	1987	
9	yellow		f	pup	25	106	29	6	1987	
10	yellow		f	pup	25	101	29	6	1987	
11	yellow		f	pup	25	91	29	6	1987	
12	yellow		m	pup	21	101	29	6	1987	
13	yellow		f	pup	25	96	29	6	1987	
14	yellow		f	pup	25	93	29	6	1987	
15	yellow		f	pup	19	88	29	6	1987	
16	yellow		f	pup	26	104	29	6	1987	
17	yellow		f	pup	20	90	29	6	1987	
18	yellow		f	pup	24	99	29	6	1987	
19	yellow		f	pup	18	92	29	6	1987	
20	yellow		f	pup	23	89	29	6	1987	
21	yellow		f	pup	20	97	29	6	1987	
22	yellow		f	pup	21	96	29	6	1987	
23	yellow		m	pup	26	101	29	6	1987	
24	yellow		f	pup	23	93	29	6	1987	
25	yellow		m	pup	26	95	29	6	1987	
26	yellow		m	pup	27	102	29	6	1987	
27	yellow		m	pup	24	103	29	6	1987	
28	yellow		m	pup	28	105	29	6	1987	
29	yellow		m	pup	30	107	29	6	1987	
30	yellow		f	pup	21	97	29	6	1987	
31	yellow		m	pup	24	95	29	6	1987	dead, 3 July 1987
32	yellow		m	pup	29	101	29	6	1987	
33	yellow		m	pup	36	112	29	6	1987	
34	yellow		m	pup	28	102	29	6	1987	
35	yellow		f	pup	28	104	29	6	1987	
36	yellow		f	pup	33	102	29	6	1987	
37	yellow		m	pup	30	103	29	6	1987	
38	yellow		f	pup	26	107	29	6	1987	
39	yellow		f	pup	25	100	29	6	1987	
40	yellow		f	pup	21	92	29	6	1987	
41	yellow		f	pup	27	96	29	6	1987	
42	yellow		m	pup	29	105	29	6	1987	
43	yellow		f	pup	21	98	29	6	1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
44	yellow		f	pup	26	103	29	6	1987	
45	-		-	-	-	-	-	-	-	tag 45 not issued
46	yellow		m	pup	28	100	29	6	1987	
47	yellow		f	pup	28	100	29	6	1987	
48	yellow		m	pup	28	106	29	6	1987	
49	yellow		f	pup	27	93	29	6	1987	
50	yellow		f	pup	26	99	29	6	1987	
51	yellow	right	m	pup	30	105	30	6	1987	
52	yellow	right	f	pup	27	102	30	6	1987	
53	yellow	right	m	pup	29	110	30	6	1987	
54	yellow	right	f	pup	25	97	30	6	1987	
55	yellow	right	f	pup	27	98	30	6	1987	
56	yellow	right	m	pup	29	102	30	6	1987	
57	yellow	right	m	pup	23	95	30	6	1987	
58	yellow	right	f	pup	29	103	30	6	1987	
59	yellow	right	m	pup	27	106	30	6	1987	
60	yellow	right	m	pup	31	107	30	6	1987	
61	yellow	right	f	pup	21	94	30	6	1987	
62	white		m	subadult			26	6	1987	VHF
62	yellow	right	m	pup	24	99	30	6	1987	
63	white		f	adult			28	6	1987	VHF
63	yellow	right	m	pup	27	104	30	6	1987	
64	white		f	adult			28	6	1987	VHF
64	yellow	right	f	pup	23	90	30	6	1987	
65	white		f	adult			28	6	1987	VHF
65	yellow	right	m	pup	29	101	30	6	1987	
66	white		f	adult			29	6	1987	VHF
66	yellow	right	m	pup	27	106	30	6	1987	
67	white		f	adult			29	6	1987	VHF
67	yellow	right	f	pup	28	99	30	6	1987	
68	white		f	adult			29	6	1987	VHF
68	yellow	right	m	pup	27	102	30	6	1987	
69	yellow	right	f	pup	25	94	30	6	1987	
69	white		f	adult			13	10	1987	VHF
70	yellow	right	m	pup	30	108	30	6	1987	
70	white		f	adult			17	10	1987	VHF
71	yellow	right	f	pup	23	100	30	6	1987	
71	white		f	adult			17	10	1987	VHF
72	yellow	right	m	pup	37	110	30	6	1987	
73	yellow	right	f	pup	25	98	30	6	1987	
74	yellow	right	f	pup	30	102	30	6	1987	
75	yellow	right	m	pup	30	106	30	6	1987	
76	yellow	right	f	pup	29	102	30	6	1987	
76	white		f	adult			4	1	1990	PTT & VHF
77	yellow	right	f	pup	24	96	30	6	1987	
77	white		f	adult			6	1	1990	VHF
78	yellow	right	f	pup	31	110	30	6	1987	
79	yellow	right	m	pup	31	108	30	6	1987	
80	yellow	right	f	pup	20	95	30	6	1987	
81	yellow	right	m	pup	27	102	30	6	1987	
82	yellow	right	m	pup	31	104	30	6	1987	
83	yellow	right	f	pup	30	105	30	6	1987	
84	yellow	right	f	pup	23	99	30	6	1987	
85	yellow	right	f	pup	24	96	30	6	1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
86	yellow	right	m	pup	37	112	30	6	1987	
87	yellow	right	f	pup	30	108	30	6	1987	
88	yellow	right	f	pup	26	103	30	6	1987	
89	yellow	right	f	pup	27	101	30	6	1987	
90	yellow	right	f	pup	25	99	30	6	1987	
91	yellow	right	f	pup	24	96	30	6	1987	
92	yellow	right	m	pup	31	104	30	6	1987	
93	yellow	right	m	pup	28	100	30	6	1987	
94	yellow	right	m	pup	27	104	30	6	1987	
95	yellow	right	f	pup	27	102	30	6	1987	
96	yellow	right	f	pup	20	92	30	6	1987	
97	yellow	right	m	pup	28	101	30	6	1987	
98	yellow	right	f	pup	25	99	30	6	1987	
99	yellow	right	f	pup	32	96	30	6	1987	
100	yellow	right	f	pup	33	107	30	6	1987	
101	yellow	right	f	pup	19	94	30	6	1987	
102	yellow	right	m	pup	37	113	30	6	1987	
103	yellow	right	m	pup	32	102	30	6	1987	
104	yellow	right	m	pup	32	110	30	6	1987	
105	yellow	right	f	pup	27	101	30	6	1987	
106	yellow	right	m	pup	28	99	30	6	1987	
107	yellow	right	f	pup	27	95	30	6	1987	
108	yellow	right	f	pup	23	91	30	6	1987	dead, <1992
109	yellow	right	m	pup	31	108	30	6	1987	
110	yellow	right	f	pup	24	96	30	6	1987	
111	yellow	right	f	pup	30	102	30	6	1987	
112	yellow	right	f	pup	39	102	30	6	1987	
113	yellow	right	m	pup	28	106	30	6	1987	
114	yellow	right	f	pup	26	98	30	6	1987	
115	yellow	right	m	pup	28	106	30	6	1987	
116	yellow	right	f	pup	24	93	30	6	1987	
117	yellow	right	f	pup	30	98	30	6	1987	
118	yellow	right	f	pup	25	100	30	6	1987	
119	yellow	right	f	pup	27	104	30	6	1987	
120	yellow	right	f	pup	25	103	30	6	1987	
121	yellow	right	f	pup	29	104	30	6	1987	
122	yellow	right	f	pup	28	102	30	6	1987	
123	yellow	right	f	pup	25	97	30	6	1987	
124	yellow	right	m	pup	33	103	30	6	1987	
125	yellow	right	m	pup	29	108	30	6	1987	
126	yellow	right	f	pup	27	102	30	6	1987	
127	yellow	right	f	pup	22	98	30	6	1987	
128	yellow	right	m	pup	30	103	30	6	1987	
129	yellow	right	f	pup	25	99	30	6	1987	
130	yellow	right	m	pup	29	101	30	6	1987	
131	yellow	right	m	pup	26	106	30	6	1987	
132	yellow	right	f	pup	30	107	30	6	1987	
133	yellow	right	m	pup	34	107	30	6	1987	
134	yellow	right	f	pup	26	102	30	6	1987	
135	yellow	right	m	pup	30	102	30	6	1987	
136	yellow	right	f	pup	28	107	30	6	1987	
137	yellow	right	f	pup	30	105	30	6	1987	
138	yellow	right	m	pup	28	106	30	6	1987	
139	yellow	right	f	pup	31	107	30	6	1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date	Comments
140	yellow	right	m	pup	29	104	30 6 1987	
141	yellow	right	f	pup	26	99	30 6 1987	
142	yellow	right	f	pup	21	95	30 6 1987	
143	yellow	right	m	pup	26	105	30 6 1987	
144	yellow	right	m	pup	24	100	30 6 1987	
145	yellow	right	f	pup	20	97	30 6 1987	
146	yellow	right	m	pup	45	112	30 6 1987	
147	yellow	right	m	pup	42	116	30 6 1987	
148	yellow	right	f	pup	25	103	30 6 1987	
149	yellow	right	m	pup	33	108	30 6 1987	
150	yellow	right	f	pup	31	108	30 6 1987	
151	yellow	right	f	pup			30 6 1987	
152	yellow	right	f	pup			30 6 1987	
153	yellow	right	m	pup			30 6 1987	
154	yellow	right	f	pup			30 6 1987	
155	yellow	right	m	pup			30 6 1987	
156	yellow	right	f	pup			30 6 1987	
157	yellow	right	m	pup			30 6 1987	
158	yellow	right	f	pup			30 6 1987	
159	yellow	right	f	pup			30 6 1987	
160	yellow	right	m	pup			30 6 1987	
161	yellow	right	m	pup			30 6 1987	
162	yellow	right	m	pup			30 6 1987	
163	yellow	right	f	pup			30 6 1987	
164	yellow	right	m	pup			30 6 1987	
165	yellow	right	m	pup			30 6 1987	
166	yellow	right	m	pup			30 6 1987	
167	yellow	right	f	pup			30 6 1987	
168	yellow	right	m	pup			30 6 1987	
169	yellow	right	f	pup			30 6 1987	
170	yellow	right	m	pup			30 6 1987	
171	yellow	right	f	pup			30 6 1987	
172	yellow	right	f	pup			30 6 1987	
173	yellow	right	m	pup			30 6 1987	
174	yellow	right	m	pup			30 6 1987	dead, <1992
175	yellow	right	f	pup			30 6 1987	
176	yellow	right	m	pup			30 6 1987	
176	blue		f	pup	17	94	28 6 1994	
177	yellow	right	m	pup			30 6 1987	
177	blue		f	pup	21	98	28 6 1994	
178	yellow	right	m	pup			30 6 1987	
178	blue		m	pup	21	100	28 6 1994	
179	yellow	right	f	pup			30 6 1987	
179	blue		f	pup	24	98	28 6 1994	
180	yellow	right	f	pup			30 6 1987	
180	blue		f	pup	19	98	28 6 1994	
181	yellow	right	f	pup			30 6 1987	
181	blue		m	pup	22	103	28 6 1994	
182	yellow	right	m	pup			30 6 1987	
182	blue		f	pup	23	101	28 6 1994	
183	yellow	right	f	pup			30 6 1987	
183	blue		m	pup	23	103	28 6 1994	
184	yellow	right	f	pup			30 6 1987	
184	blue		f	pup	18	92	28 6 1994	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
185	yellow	right	f	pup			30	6	1987	
185	blue		m	pup	24	107	28	6	1994	
186	yellow	right	f	pup			30	6	1987	
186	blue		f	pup	20	101	28	6	1994	
187	yellow	right	f	pup			30	6	1987	
187	blue		f	pup	22	104	28	6	1994	
188	yellow	right	f	pup			30	6	1987	
188	blue		f	pup	22	103	28	6	1994	
189	yellow	right	m	pup			30	6	1987	
190	yellow	right	m	pup			30	6	1987	
190	blue		f	pup	22	103	28	6	1994	
191	yellow	right	m	pup			30	6	1987	
191	blue		f	pup	21	98	28	6	1994	
192	yellow	right	m	pup			30	6	1987	
192	blue		f	pup	21	101	28	6	1994	
193	yellow	right	m	pup			30	6	1987	
193	blue		m	pup	21	102	28	6	1994	
194	yellow	right	f	pup			30	6	1987	
194	blue		f	pup	20	97	28	6	1994	
195	yellow	right	m	pup			30	6	1987	
195	blue		m	pup	21	102	28	6	1994	
196	yellow	right	f	pup			30	6	1987	
196	blue		f	pup	19	94	28	6	1994	
197	yellow	right	f	pup			30	6	1987	
197	blue		f	pup	21	101	28	6	1994	
198	yellow	right	m	pup			30	6	1987	
199	yellow	right	m	pup			30	6	1987	
200	yellow	right	f	pup			30	6	1987	
201	yellow	right	m	pup			1	7	1987	
202	yellow	right	f	pup			1	7	1987	
203	yellow	right	m	pup			1	7	1987	
204	yellow	right	f	pup			1	7	1987	
205	yellow	right	m	pup			1	7	1987	
206	yellow	right	f	pup			1	7	1987	
207	yellow	right	m	pup			1	7	1987	
208	yellow	right	m	pup			1	7	1987	
209	yellow	right	m	pup			1	7	1987	
210	yellow	right	f	pup			1	7	1987	
211	yellow	right	f	pup			1	7	1987	
212	yellow	right	f	pup			1	7	1987	
213	yellow	right	m	pup			1	7	1987	
214	yellow	right	m	pup			1	7	1987	
215	yellow	right	f	pup			1	7	1987	
216	yellow	right	f	pup			1	7	1987	
217	yellow	right	m	pup			1	7	1987	
218	yellow	right	m	pup			1	7	1987	
219	yellow	right	f	pup			1	7	1987	
220	yellow	right	f	pup			1	7	1987	
221	yellow	right	m	pup			1	7	1987	
222	yellow	right	m	pup			1	7	1987	
223	yellow	right	f	pup			1	7	1987	
224	yellow	right	f	pup			1	7	1987	
225	yellow	right	m	pup			1	7	1987	
226	yellow	right	f	pup			1	7	1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date	Comments
227	yellow	right	f	pup			1 7 1987	
228	yellow	right	m	pup			1 7 1987	
229	yellow	right	m	pup			1 7 1987	
230	yellow	right	f	pup			1 7 1987	
231	yellow	right	f	pup			1 7 1987	
232	yellow	right	m	pup			1 7 1987	
233	yellow	right	m	pup			1 7 1987	
234	yellow	right	f	pup			1 7 1987	
235	yellow	right	m	pup			1 7 1987	
236	yellow	right	f	pup			1 7 1987	
237	yellow	right	f	pup			1 7 1987	
238	yellow	right	f	pup			1 7 1987	
239	yellow	right	m	pup			1 7 1987	
240	yellow	right	f	pup			1 7 1987	dead, <1992
241	yellow	right	f	pup			1 7 1987	
242	yellow	right	f	pup			1 7 1987	
243	yellow	right	m	pup			1 7 1987	
244	yellow	right	f	pup			1 7 1987	
245	yellow	right	f	pup			1 7 1987	
246	yellow	right	m	pup			1 7 1987	
247	yellow	right	m	pup			1 7 1987	
248	yellow	right	m	pup			1 7 1987	
249	yellow	right	m	pup			1 7 1987	
250	yellow	right	m	pup			1 7 1987	
251	yellow	right	f	pup			1 7 1987	
252	yellow	right	m	pup			1 7 1987	
253	yellow	right	m	pup			1 7 1987	
254	yellow	right	f	pup			1 7 1987	
255	yellow	right	f	pup			1 7 1987	
256	yellow	right	f	pup			1 7 1987	
257	yellow	right	f	pup			1 7 1987	
258	yellow	right	f	pup			1 7 1987	
259	yellow	right	m	pup			1 7 1987	
260	yellow	right	f	pup			1 7 1987	
261	yellow	right	m	pup			1 7 1987	
262	yellow	right	m	pup			1 7 1987	
263	yellow	right	m	pup			1 7 1987	
264	yellow	right	f	pup			1 7 1987	
265	yellow	right	m	pup			1 7 1987	
266	yellow	right	m	pup			1 7 1987	
267	yellow	right	f	pup			1 7 1987	
268	yellow	right	m	pup			1 7 1987	
269	yellow	right	m	pup			1 7 1987	
270	yellow	right	m	pup			1 7 1987	
271	yellow	right	f	pup			1 7 1987	
272	yellow	right	f	pup			1 7 1987	
273	yellow	right	m	pup			1 7 1987	
274	yellow	right	m	pup			1 7 1987	
275	yellow	right	f	pup			1 7 1987	
276	yellow	right	f	pup			1 7 1987	
277	yellow	right	m	pup			1 7 1987	
278	yellow	right	f	pup			1 7 1987	
279	yellow	right	f	pup			1 7 1987	
280	yellow	right	m	pup			1 7 1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
281	yellow	right	f	pup			1	7	1987	
282	yellow	right	m	pup			1	7	1987	
283	yellow	right	f	pup			1	7	1987	
284	yellow	right	f	pup			1	7	1987	
285	yellow	right	f	pup			1	7	1987	
286	yellow	right	m	pup			1	7	1987	
287	yellow	right	m	pup			1	7	1987	
288	yellow	right	f	pup			1	7	1987	
289	yellow	right	m	pup			1	7	1987	
290	yellow	right	m	pup			1	7	1987	
291	yellow	right	f	pup			1	7	1987	
292	yellow	right	m	pup			1	7	1987	
293	yellow	right	f	pup			1	7	1987	
294	yellow	right	f	pup			1	7	1987	"4" blurred
295	yellow	right	f	pup			1	7	1987	
296	yellow	right	f	pup			1	7	1987	
297	yellow	right	m	pup			1	7	1987	
298	yellow	right	m	pup			1	7	1987	
299	yellow	right	m	pup			1	7	1987	
300	yellow	right	f	pup			1	7	1987	
301	yellow	right	m	pup			1	7	1987	
302	yellow	right	f	pup			1	7	1987	
303	yellow	right	f	pup			1	7	1987	
304	yellow	right	m	pup			1	7	1987	
305	yellow	right	m	pup			1	7	1987	dead, <1992
306	yellow	right	m	pup			1	7	1987	
307	yellow	right	m	pup			1	7	1987	
308	yellow	right	m	pup			1	7	1987	
309	yellow	right	f	pup			1	7	1987	
310	yellow	right	m	pup			1	7	1987	
311	yellow	right	m	pup			1	7	1987	
312	yellow	right	f	pup			1	7	1987	
313	yellow	right	m	pup			1	7	1987	
314	yellow	right	m	pup			1	7	1987	
315	yellow	right	m	pup			1	7	1987	
316	yellow	right	f	pup			1	7	1987	
317	yellow	right	m	pup			1	7	1987	
318	yellow	right	f	pup			1	7	1987	
319	yellow	right	f	pup			1	7	1987	
320	yellow	right	f	pup			1	7	1987	
321	yellow	right	m	pup			1	7	1987	
322	yellow	right	m	pup			1	7	1987	dead, July 1988
323	yellow	right	f	pup			1	7	1987	
324	yellow	right	m	pup			1	7	1987	
325	yellow	right	f	pup			1	7	1987	
326	yellow	right	f	pup			1	7	1987	
327	yellow	right	m	pup			1	7	1987	
328	yellow	right	m	pup			1	7	1987	"8" blurred
329	yellow	right	m	pup			1	7	1987	
330	yellow	right	m	pup			1	7	1987	
331	yellow	right	m	pup			1	7	1987	
332	yellow	right	f	pup			1	7	1987	
333	yellow	right	f	pup			1	7	1987	
334	yellow	right	m	pup			1	7	1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
335	yellow	right	m	pup			1	7	1987	
336	yellow	right	f	pup			1	7	1987	
337	yellow	right	f	pup			1	7	1987	
338	yellow	right	f	pup			1	7	1987	
339	yellow	right	f	pup			1	7	1987	
340	yellow	right	f	pup			1	7	1987	
341	yellow	right	f	pup			1	7	1987	
342	yellow	right	f	pup			1	7	1987	
343	yellow	right	f	pup			1	7	1987	
344	yellow	right	f	pup			1	7	1987	
345	yellow	right	f	pup			1	7	1987	
346	yellow	right	f	pup			1	7	1987	
347	yellow	right	f	pup			1	7	1987	
348	yellow	right	m	pup			1	7	1987	
349	yellow	right	f	pup			1	7	1987	
350	yellow	right	f	pup			1	7	1987	
351	yellow	right	m	pup			1	7	1987	
352	yellow	right	f	pup			1	7	1987	
353	yellow	right	m	pup			1	7	1987	
354	yellow	right	f	pup			1	7	1987	
355	yellow	right	m	pup			1	7	1987	
356	yellow	right	m	pup			1	7	1987	
357	yellow	right	m	pup			1	7	1987	
358	yellow	right	m	pup			1	7	1987	
359	yellow	right	f	pup			1	7	1987	
360	yellow	right	f	pup			1	7	1987	
361	yellow	right	m	pup			1	7	1987	
362	yellow	right	m	pup			1	7	1987	
363	yellow	right	m	pup			1	7	1987	
364	yellow	right	f	pup			1	7	1987	
365	yellow	right	f	pup			1	7	1987	
366	yellow	right	f	pup			1	7	1987	
367	yellow	right	f	pup			1	7	1987	
368	yellow	right	m	pup			1	7	1987	
369	yellow	right	f	pup			1	7	1987	
370	yellow	right	m	pup			1	7	1987	
371	yellow	right	f	pup			1	7	1987	
372	yellow	right	m	pup			1	7	1987	
373	yellow	right	m	pup			1	7	1987	dead, 14 May 1988
374	yellow	right	f	pup			1	7	1987	
375	yellow	right	m	pup			1	7	1987	
376	yellow	right	m	pup			1	7	1987	
377	yellow	right	m	pup			1	7	1987	
378	yellow	right	m	pup			1	7	1987	
379	yellow	right	m	pup			1	7	1987	
380	yellow	right	m	pup			1	7	1987	
381	yellow	right	f	pup			1	7	1987	
382	yellow	right	f	pup			1	7	1987	
383	yellow	right	f	pup			1	7	1987	
384	yellow	right	f	pup			1	7	1987	
385	yellow	right	f	pup			1	7	1987	
386	yellow	right	f	pup			1	7	1987	
387	yellow	right	f	pup			1	7	1987	
388	yellow	right	f	pup			1	7	1987	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date	Comments
389	yellow	right	f	pup			1 7 1987	
390	yellow	right	f	pup			1 7 1987	
391	yellow	right	m	pup			1 7 1987	
392	yellow	right	m	pup			1 7 1987	
393	yellow	right	f	pup			1 7 1987	
394	yellow	right	f	pup			1 7 1987	
395	yellow	right	f	pup			1 7 1987	
396	yellow	right	m	pup			1 7 1987	
397	yellow	right	m	pup			1 7 1987	
398	yellow	right	m	pup			1 7 1987	
399	yellow	right	m	pup			1 7 1987	
400	yellow	right	f	pup			1 7 1987	
401	yellow	right	f	pup			1 7 1987	401 also used in 1988
401	blue	left	f	pup	26		30 6 1988	401 also used in 1987
402	blue	left	f	pup	24		30 6 1988	
403	blue	left	m	pup	27		30 6 1988	
404	blue	left	m	pup	23		30 6 1988	
405	blue	left	m	pup	35		30 6 1988	
406	blue	left	f	pup	23		30 6 1988	
407	blue	left	f	pup	21		30 6 1988	
408	blue	left	m	pup	25		30 6 1988	
409	blue	left	f	pup	29		30 6 1988	
410	blue	left	f	pup	29		30 6 1988	
411	blue	left	m	pup	30		30 6 1988	
412	blue	left	m	pup	32		30 6 1988	dead, <1992
413	blue	left	m	pup	30		30 6 1988	
414	blue	left	f	pup	16		30 6 1988	
415	blue	left	f	pup	29		30 6 1988	
416	blue	left	m	pup	28		30 6 1988	
417	blue	left	m	pup	29		30 6 1988	
418	blue	left	f	pup	20		30 6 1988	
419	blue	left	m	pup	32		30 6 1988	
420	blue	left	m	pup	21		30 6 1988	
421	blue	left	m	pup	27		30 6 1988	
422	blue	left	f	pup	26		30 6 1988	
423	blue	left	f	pup	31		30 6 1988	
424	blue	left	m	pup	32		30 6 1988	
425	blue	left	m	pup	29		30 6 1988	
426	blue	left	f	pup	36		30 6 1988	
427	blue	left	m	pup	32		30 6 1988	
428	blue	left	m	pup	34		30 6 1988	
429	blue	left	f	pup	26		30 6 1988	dead, <1992
430	blue	left	f	pup	21		30 6 1988	dead, <1992
431	blue	left	f	pup	25		30 6 1988	
432	blue	left	m	pup	36		30 6 1988	
433	blue	left	f	pup	26		30 6 1988	
434	blue	left	m	pup	33		30 6 1988	
435	blue	left	f	pup	30		30 6 1988	
436	blue	left	m	pup	33		30 6 1988	
437	blue	left	f	pup	26		30 6 1988	"3" blurred
438	blue	left	f	pup	31		30 6 1988	
439	blue	left	f	pup	30		30 6 1988	dead, <1992
440	blue	left	f	pup	27		30 6 1988	
441	blue	left	f	pup	28		30 6 1988	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date	Comments
442	blue	left	f	pup	26		30 6 1988	
443	blue	left	f	pup	32		30 6 1988	
444	blue	left	f	pup	24		30 6 1988	
445	blue	left	f	pup	27		30 6 1988	
446	blue	left	f	pup	24		30 6 1988	
447	blue	left	f	pup	25		30 6 1988	
448	blue	left	m	pup	33		30 6 1988	
449	blue	left	f	pup	28		30 6 1988	
450	blue	left	m	pup	23		30 6 1988	
451	blue	left	f	pup			30 6 1988	
452	blue	left	f	pup			30 6 1988	
453	blue	left	f	pup			30 6 1988	
454	blue	left	m	pup			30 6 1988	
455	blue	left	m	pup			30 6 1988	
456	blue	left	f	pup			30 6 1988	
457	blue	left	m	pup			30 6 1988	
458	blue	left	m	pup			30 6 1988	
459	blue	left	m	pup			30 6 1988	
460	blue	left	f	pup			30 6 1988	
461	blue	left	f	pup			30 6 1988	
462	blue	left	m	pup			30 6 1988	
463	blue	left	f	pup			30 6 1988	
464	blue	left	m	pup			30 6 1988	
465	blue	left	f	pup			30 6 1988	
466	blue	left	m	pup			30 6 1988	
467	blue	left	m	pup			30 6 1988	
468	blue	left	f	pup			30 6 1988	
469	blue	left	f	pup			30 6 1988	
470	blue	left	f	pup			30 6 1988	
471	blue	left	m	pup			30 6 1988	
472	blue	left	f	pup			30 6 1988	
473	blue	left	f	pup			30 6 1988	
474	blue	left	m	pup			30 6 1988	
475	blue	left	m	pup			30 6 1988	
476	blue	left	f	pup			30 6 1988	
477	blue	left	m	pup			30 6 1988	
478	blue	left	m	pup			30 6 1988	
479	blue	left	f	pup			30 6 1988	
480	blue	left	f	pup			30 6 1988	
481	blue	left	f	pup			30 6 1988	
482	blue	left	m	pup			30 6 1988	
483	blue	left	m	pup			30 6 1988	
484	blue	left	f	pup			30 6 1988	
485	blue	left	m	pup			30 6 1988	dead, <1992
486	blue	left	m	pup			30 6 1988	"8" blurred
487	blue	left	m	pup			30 6 1988	
488	blue	left	m	pup			30 6 1988	
489	blue	left	m	pup			30 6 1988	
490	blue	left	m	pup			30 6 1988	
491	blue	left	m	pup			30 6 1988	
492	blue	left	m	pup			30 6 1988	
493	blue	left	m	pup			30 6 1988	
494	blue	left	m	pup			30 6 1988	
495	blue	left	f	pup			30 6 1988	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date	Comments
496	blue	left	f	pup			30 6 1988	
497	blue	left	f	pup			30 6 1988	
498	blue	left	m	pup			30 6 1988	
499	blue	left	m	pup			30 6 1988	2nd "9" blurred
500	blue	left	f	pup			30 6 1988	
501	blue	left	f	pup			30 6 1988	no left tag
502	blue	left	m	pup			30 6 1988	no left tag
503	blue	left	f	pup			30 6 1988	no left tag
504	blue	left	f	pup			30 6 1988	no left tag
505	blue	left	f	pup			30 6 1988	
506	blue	left	m	pup			30 6 1988	no left tag
507	blue	left	f	pup			30 6 1988	dead, <1992
508	blue	left	m	pup			30 6 1988	no left tag
509	blue	left	f	pup			30 6 1988	no left tag
510	blue	left	m	pup			30 6 1988	no left tag
511	blue	left	f	pup			30 6 1988	no left tag
512	blue	left	m	pup			30 6 1988	no left tag
513	blue	left	m	pup			30 6 1988	no left tag
514	blue	left	f	pup			30 6 1988	no left tag
515	blue	left	f	pup			30 6 1988	no left tag
516	blue	left	f	pup			30 6 1988	no left tag, "5" blurred
517	blue	left	m	pup			30 6 1988	no left tag
518	blue	left	m	pup			30 6 1988	no left tag
519	blue	left	m	pup			30 6 1988	no left tag, "1" blurred
520	blue	left	f	pup			30 6 1988	no left tag
521	blue	left	m	pup			30 6 1988	no left tag
522	blue	left	f	pup			30 6 1988	no left tag
523	blue	left	m	pup			30 6 1988	no left tag
524	blue	left	m	pup			30 6 1988	"5" blurred
525	blue	left	m	pup			30 6 1988	no left tag
526	blue	left	m	pup			30 6 1988	
527	blue	left	m	pup			30 6 1988	
528	blue	left	f	pup			30 6 1988	
529	blue	left	m	pup			30 6 1988	
530	blue	left	f	pup			30 6 1988	
531	blue	left	f	pup			30 6 1988	
532	blue	left	f	pup			30 6 1988	
533	blue	left	m	pup			30 6 1988	
534	blue	left	f	pup			30 6 1988	
535	blue	left	f	pup			30 6 1988	"3" blurred
536	blue	left	m	pup			30 6 1988	
537	blue	left	m	pup			30 6 1988	
538	blue	left	m	pup			30 6 1988	
539	blue	left	m	pup			30 6 1988	
540	blue	left	m	pup			30 6 1988	
541	blue	left	f	pup			30 6 1988	
542	blue	left	m	pup			30 6 1988	
543	blue	left	f	pup			30 6 1988	
544	blue	left	f	pup			30 6 1988	
545	blue	left	m	pup			30 6 1988	dead, <1992
546	blue	left	f	pup			30 6 1988	
547	blue	left	f	pup			30 6 1988	
548	blue	left	f	pup			30 6 1988	
549	blue	left	f	pup			30 6 1988	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
550	blue	left	f	pup			30	6	1988	
551	blue	left	m	pup			30	6	1988	
552	blue	left	m	pup			30	6	1988	
553	blue	left	f	pup			30	6	1988	
554	blue	left	m	pup			30	6	1988	
555	blue	left	m	pup			30	6	1988	
556	blue	left	m	pup			30	6	1988	
557	blue	left	f	pup			30	6	1988	
558	blue	left	f	pup			30	6	1988	
559	blue	left	m	pup			30	6	1988	
560	blue	left	m	pup			30	6	1988	
561	blue	left	m	pup			30	6	1988	
562	blue	left	f	pup			30	6	1988	"6" blurred
563	blue	left	f	pup			30	6	1988	
564	blue	left	m	pup			30	6	1988	
565	blue	left	f	pup			30	6	1988	
566	blue	left	f	pup			30	6	1988	
567	blue	left	m	pup			30	6	1988	
568	blue	left	m	pup			30	6	1988	
569	blue	left	m	pup			30	6	1988	
570	blue	left	f	pup			30	6	1988	
571	blue	left	f	pup			30	6	1988	
572	blue	left	m	pup			30	6	1988	
573	blue	left	f	pup			30	6	1988	
574	blue	left	m	pup			30	6	1988	
575	blue	left	m	pup			30	6	1988	
576	blue	left	f	pup			30	6	1988	
577	blue	left	f	pup			30	6	1988	
578	blue	left	f	pup			30	6	1988	
579	blue	left	f	pup			30	6	1988	
580	blue	left	f	pup			30	6	1988	
581	blue	left	m	pup			30	6	1988	
582	blue	left	m	pup			30	6	1988	
583	blue	left	m	pup			30	6	1988	
584	blue	left	m	pup			30	6	1988	
585	blue	left	m	pup			30	6	1988	
586	blue	left	m	pup			30	6	1988	
587	blue	left	m	pup			30	6	1988	
588	blue	left	f	pup			30	6	1988	
589	blue	left	m	pup			30	6	1988	dead, <1992
590	blue	left	f	pup			30	6	1988	
591	blue	left	f	pup			30	6	1988	
592	blue	left	f	pup			30	6	1988	
593	blue	left	f	pup			30	6	1988	
594	blue	left	f	pup			30	6	1988	
595	blue	left	m	pup			30	6	1988	
596	blue	left	f	pup			30	6	1988	
597	blue	left	f	pup			30	6	1988	
598	blue	left	f	pup			30	6	1988	
599	blue	left	f	pup			30	6	1988	
600	blue	left	f	pup			30	6	1988	
601	blue	left	m	pup			1	7	1988	
602	blue	left	m	pup			1	7	1988	
603	blue	left	m	pup			1	7	1988	dead, <1992

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
604	blue	left	m	pup			1	7	1988	
605	blue	left	m	pup			1	7	1988	
606	blue	left	m	pup			1	7	1988	
607	blue	left	f	pup			1	7	1988	
608	blue	left	m	pup			1	7	1988	
609	blue	left	f	pup			1	7	1988	
610	blue	left	m	pup			1	7	1988	
611	blue	left	f	pup			1	7	1988	
612	blue	left	m	pup			1	7	1988	
613	blue	left	f	pup			1	7	1988	
614	blue	left	m	pup			1	7	1988	
615	blue	left	f	pup			1	7	1988	
616	blue	left	f	pup			1	7	1988	
617	blue	left	m	pup			1	7	1988	
618	blue	left	f	pup			1	7	1988	
619	blue	left	f	pup			1	7	1988	
620	blue	left	m	pup			1	7	1988	
621	blue	left	f	pup			1	7	1988	
622	blue	left	f	pup			1	7	1988	
623	blue	left	m	pup			1	7	1988	
624	blue	left	m	pup			1	7	1988	
625	blue	left	f	pup			1	7	1988	
626	blue	left	m	pup			1	7	1988	
627	blue	left	m	pup			1	7	1988	
628	blue	left	m	pup			1	7	1988	
629	blue	left	m	pup			1	7	1988	
630	blue	left	f	pup			1	7	1988	
631	blue	left	m	pup			1	7	1988	
632	blue	left	f	pup			1	7	1988	
632	white		f	pup	22	93	9	7	1993	
633	blue	left	f	pup			1	7	1988	
633	white		f	pup	17	94	9	7	1993	
634	blue	left	m	pup			1	7	1988	
634	white		m	pup	14	83	9	7	1993	
635	blue	left	f	pup			1	7	1988	
635	white		m	pup	34	112	9	7	1993	
636	blue	left	f	pup			1	7	1988	
636	white		m	pup	36		9	7	1993	
637	blue	left	f	pup			1	7	1988	
637	white		m	pup	34		9	7	1993	
638	blue	left	m	pup			1	7	1988	
638	white		m	pup	28	105	9	7	1993	
639	blue	left	f	pup			1	7	1988	
639	white		m	pup	38		9	7	1993	
640	blue	left	f	pup			1	7	1988	
640	white		f	pup	30		9	7	1993	
641	blue	left	f	pup			1	7	1988	
641	white		m	pup	41		9	7	1993	
642	blue	left	m	pup			1	7	1988	
642	white		f	pup	26		9	7	1993	
643	blue	left	f	pup			1	7	1988	
643	white		m	pup	29		9	7	1993	
644	blue	left	f	pup			1	7	1988	
644	white		m	pup	41		9	7	1993	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
645	blue	left	f	pup			1	7	1988	
645	white		f	pup	32		9	7	1993	
646	blue	left	f	pup			1	7	1988	
646	white		m	pup	41		9	7	1993	
647	blue	left	m	pup			1	7	1988	
647	white		m	pup	32	113	9	7	1993	
648	blue	left	m	pup			1	7	1988	
648	white		m	pup	41		9	7	1993	
649	blue	left	m	pup			1	7	1988	
649	white		m	pup	44		9	7	1993	
650	blue	left	m	pup			1	7	1988	
650	white		m	pup	43		9	7	1993	
651	blue	left	f	pup			1	7	1988	
651	white		f	pup	28		9	7	1993	
652	blue	left	f	pup			1	7	1988	
652	white		f	pup	29	105	9	7	1993	
653	blue	left	f	pup			1	7	1988	
653	white		f	pup	37		9	7	1993	
654	blue	left	m	pup			1	7	1988	
654	white		f	pup	30		9	7	1993	
655	blue	left	m	pup			1	7	1988	
655	white		f	pup	29	102	9	7	1993	
656	blue	left	m	pup			1	7	1988	
656	white		f	pup	37		9	7	1993	
657	blue	left	m	pup			1	7	1988	
657	white		m	pup	36		9	7	1993	
658	blue	left	f	pup			1	7	1988	
658	white		f	pup	34	114	9	7	1993	
659	blue	left	m	pup			1	7	1988	
659	white		m	pup	36		9	7	1993	
660	blue	left	m	pup			1	7	1988	"6" bad
660	white		m	pup	29		9	7	1993	
661	blue	left	f	pup			1	7	1988	
661	white		m	pup	38		9	7	1993	
662	blue	left	m	pup			1	7	1988	
662	white		m	pup	33	109	9	7	1993	
663	blue	left	f	pup			1	7	1988	
663	white		f	pup	30		9	7	1993	
664	blue	left	f	pup			1	7	1988	
664	white		m	pup	36		9	7	1993	
665	blue	left	m	pup			1	7	1988	
665	white		m	pup	36		9	7	1993	
666	blue	left	f	pup			1	7	1988	
666	white		f	pup	33		9	7	1993	
667	blue	left	m	pup			1	7	1988	
667	white		f	pup	20	101	9	7	1993	
668	blue	left	m	pup			1	7	1988	
668	white		f	pup	36		9	7	1993	
669	blue	left	f	pup			1	7	1988	
669	white		f	pup	31		9	7	1993	
670	blue	left	m	pup			1	7	1988	
670	white		f	pup	33		9	7	1993	
671	blue	left	f	pup			1	7	1988	
671	white		f	pup	32		9	7	1993	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
672	blue	left	f	pup			1	7	1988	
672	white		m	pup	43		9	7	1993	
673	blue	left	m	pup			1	7	1988	
673	white		m	pup	36		9	7	1993	
674	blue	left	f	pup			1	7	1988	
674	white		m	pup	35		9	7	1993	
675	blue	left	m	pup			1	7	1988	
675	white		m	pup	41		9	7	1993	
676	blue	left	m	pup			1	7	1988	
676	white		m	pup	34		9	7	1993	
677	blue	left	m	pup			1	7	1988	
677	white		m	pup	35		9	7	1993	
678	blue	left	m	pup			1	7	1988	
678	white		m	pup	41		9	7	1993	
679	blue	left	f	pup			1	7	1988	
679	white		m	pup	30		9	7	1993	
680	blue	left	f	pup			1	7	1988	"8" blurred
680	white		m	pup	32		9	7	1993	
681	blue	left	f	pup			1	7	1988	
681	white		m	pup	36		9	7	1993	
682	blue	left	m	pup			1	7	1988	
682	white		m	pup	37		9	7	1993	
683	blue	left	m	pup			1	7	1988	
684	blue	left	m	pup			1	7	1988	
685	blue	left	m	pup			1	7	1988	
686	blue	left	m	pup			1	7	1988	
687	blue	left	m	pup			1	7	1988	
688	blue	left	m	pup			1	7	1988	
689	blue	left	m	pup			1	7	1988	
690	blue	left	m	pup			1	7	1988	
691	blue	left	m	pup			1	7	1988	
692	blue	left	f	pup			1	7	1988	
693	blue	left	f	pup			1	7	1988	
694	blue	left	f	pup			1	7	1988	
695	blue	left	m	pup			1	7	1988	
696	blue	left	m	pup			1	7	1988	
697	blue	left	m	pup			1	7	1988	
698	blue	left	f	pup			1	7	1988	
699	blue	left	m	pup			1	7	1988	
700	blue	left	f	pup			1	7	1988	
701	blue	left	m	pup			1	7	1988	
702	blue	left	m	pup			1	7	1988	
703	blue	left	m	pup			1	7	1988	
704	blue	left	f	pup			1	7	1988	
705	blue	left	m	pup			1	7	1988	
706	blue	left	f	pup			1	7	1988	
707	blue	left	f	pup			1	7	1988	
708	blue	left	m	pup			1	7	1988	
709	blue	left	m	pup			1	7	1988	
710	blue	left	m	pup			1	7	1988	
711	blue	left	m	pup			1	7	1988	
712	blue	left	m	pup			1	7	1988	
713	blue	left	f	pup			1	7	1988	
714	blue	left	f	pup			1	7	1988	

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date			Comments
715	blue	left	f	pup			1	7	1988	
716	blue	left	m	pup			1	7	1988	
717	blue	left	f	pup			1	7	1988	
718	blue	left	f	pup			1	7	1988	
719	blue	left	f	pup			1	7	1988	
720	blue	left	m	pup			1	7	1988	
721	blue	left	f	pup			1	7	1988	
722	blue	left	m	pup			1	7	1988	
723	blue	left	f	pup			1	7	1988	
724	blue	left	m	pup			1	7	1988	
725	blue	left	f	pup			1	7	1988	
726	blue	left	f	pup			1	7	1988	
727	blue	left	m	pup			1	7	1988	
728	blue	left	f	pup			1	7	1988	
729	blue	left	m	pup			1	7	1988	
730	blue	left	f	pup			1	7	1988	
731	blue	left	f	pup			1	7	1988	
732	blue	left	m	pup			1	7	1988	
733	blue	left	m	pup			1	7	1988	
734	blue	left	f	pup			1	7	1988	
735	blue	left	m	pup			1	7	1988	
736	blue	left	f	pup			1	7	1988	
737	blue	left	f	pup			1	7	1988	
738	blue	left	m	pup			1	7	1988	
739	blue	left	f	pup			1	7	1988	
740	blue	left	m	pup			1	7	1988	
741	blue	left	f	pup			1	7	1988	
742	blue	left	m	pup			1	7	1988	
743	blue	left	f	pup			1	7	1988	
744	blue	left	m	pup			1	7	1988	
745	blue	left	f	pup			1	7	1988	
746	blue	left	f	pup			1	7	1988	
747	blue	left	m	pup			1	7	1988	
748	blue	left	m	pup			1	7	1988	
749	blue	left	f	pup			1	7	1988	
750	blue	left	f	pup			1	7	1988	
751	blue	left	f	pup			1	7	1988	
752	blue	left	f	pup			1	7	1988	
753	blue	left	f	pup			1	7	1988	"7" blurred
754	blue	left	f	pup			1	7	1988	
755	blue	left	f	pup			1	7	1988	
756	blue	left	f	pup			1	7	1988	"7" blurred
757	blue	left	m	pup			1	7	1988	
758	blue	left	f	pup			1	7	1988	"7" blurred
759	blue	left	f	pup			1	7	1988	
760	blue	left	f	pup			1	7	1988	
761	blue	left	m	pup			1	7	1988	
762	blue	left	m	pup			1	7	1988	
763	blue	left	f	pup			1	7	1988	
764	blue	left	f	pup			1	7	1988	
765	blue	left	m	pup			1	7	1988	
766	blue	left	m	pup			1	7	1988	
767	blue	left	m	pup			1	7	1988	
768	blue	left	m	pup			1	7	1988	"8" blurred

No.	Tag color	Brand	Sex	Age	Wt. (kg)	S.Ln. (cm)	Date	Comments
769	blue	left	f	pup			1 7 1988	
770	blue	left	f	pup			1 7 1988	
771	blue	left	f	pup			1 7 1988	
772	blue	left	f	pup			1 7 1988	
773	blue	left	m	pup			1 7 1988	
774	blue	left	m	pup			1 7 1988	
775	blue	left	f	pup			1 7 1988	1st "7" blurred
776	blue	left	f	pup			1 7 1988	
777	blue	left	m	pup			1 7 1988	
778	blue	left	f	pup			1 7 1988	1st "7" blurred
779	blue	left	m	pup			1 7 1988	
780	blue	left	f	pup			1 7 1988	"7" blurred
781	blue	left	m	pup			1 7 1988	
782	blue	left	f	pup			1 7 1988	
783	blue	left	f	pup			1 7 1988	
784	blue	left	f	pup			1 7 1988	
785	blue	left	f	pup			1 7 1988	"7" blurred
786	blue	left	f	pup			1 7 1988	
787	blue	left	f	pup			1 7 1988	
788	blue	left	f	pup			1 7 1988	
789	blue	left	f	pup			1 7 1988	
790	blue	left	m	pup			1 7 1988	
791	blue	left	f	pup			1 7 1988	
792	blue	left	m	pup			1 7 1988	
793	blue	left	f	pup			1 7 1988	"9" blurred
794	blue	left	f	pup			1 7 1988	
795	blue	left	f	pup			1 7 1988	
796	blue	left	m	pup			1 7 1988	
797	blue	left	m	pup			1 7 1988	
798	blue	left	m	pup			1 7 1988	
799	blue	left	m	pup			1 7 1988	
800	blue	left	m	pup			1 7 1988	
801			f	pup			26 6 1990	
802			m	pup			27 6 1990	
803			m	pup			27 6 1990	
804			m	pup			27 6 1990	
805			f	pup			27 6 1990	
806			f	pup			27 6 1990	
807			f	pup			27 6 1990	
808			m	pup			27 6 1990	
809			m	pup			27 6 1990	
987			f	adult			26 6 1988	VHF
988			f	adult			26 6 1988	VHF
989			f	adult			26 6 1988	VHF
990			f	adult			27 6 1988	VHF
991			f	adult			27 6 1988	VHF
992			f	adult			27 6 1988	VHF
993			f	adult			27 6 1988	VHF
994			f	adult			28 6 1988	VHF
995			f	adult			24 6 1988	VHF
996			f	adult			24 6 1988	VHF
997			f	adult			24 6 1988	VHF
998			f	adult			28 6 1988	VHF
999			f	adult			28 6 1988	VHF

Appendix E.--Dates and corresponding Day of the Year used in analyses. Day of the year was the same for leap years and non-leap years.

Date	Day of Year	Date	Day of Year	Date	Day of Year
1 May	121	1 June	152	1 July	182
2 May	122	2 June	153	2 July	183
3 May	123	3 June	154	3 July	184
4 May	124	4 June	155	4 July	185
5 May	125	5 June	156	5 July	186
6 May	126	6 June	157	6 July	187
7 May	127	7 June	158	7 July	188
8 May	128	8 June	159	8 July	189
9 May	129	9 June	160	9 July	190
10 May	130	10 June	161	10 July	191
11 May	131	11 June	162	11 July	192
12 May	132	12 June	163	12 July	193
13 May	133	13 June	164	13 July	194
14 May	134	14 June	165	14 July	195
15 May	135	15 June	166	15 July	196
16 May	136	16 June	167	16 July	197
17 May	137	17 June	168	17 July	198
18 May	138	18 June	169	18 July	199
19 May	139	19 June	170	19 July	200
20 May	140	20 June	171	20 July	201
21 May	141	21 June	172	21 July	202
22 May	142	22 June	173	22 July	203
23 May	143	23 June	174	23 July	204
24 May	144	24 June	175	24 July	205
25 May	145	25 June	176	25 July	206
26 May	146	26 June	177	26 July	207
27 May	147	27 June	178	27 July	208
28 May	148	28 June	179	28 July	209
29 May	149	29 June	180	29 July	210
30 May	150	30 June	181	30 July	211
31 May	151			31 July	212

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