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Annual Reports of research carried out on the population biology of marine mammals by the National Marine Mammal Laboratory to meet the 1994 amendments to the Marine Mammal Protection Act and the Endangered Species Act

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Preface

Beginning in 1991, the National Marine Mammal Laboratory (NMML) has been partially funded by the National Marine Fisheries Service's (NMFS) Office of Protected Resources to determine the abundance of selected species in U.S. waters of the eastern North Pacific Ocean. On 30 April 1994, Public Law 103-238 was enacted allowing significant changes to provisions within the Marine Mammal Protection Act (MMPA). Interactions between marine mammals and commercial fisheries are addressed under three new Sections. This new regime replaced the interim exemption that had regulated fisheries-related incidental takes since 1988. The 1994 MMPA amendments continue NMFS' responsibility to carry out population studies to determine the abundance, distribution and stock identification of marine mammal species that might be impacted by human-related or natural causes.

The following report, containing 11 papers, is a compilation of studies carried out with fiscal year 2000 (FY00) funding as part of the NMFS MMPA/ESA Implementation Program. The report contains information regarding studies conducted on beluga whales, cetaceans, gray whales, harbor seals, humpback whales, ice seals, and Steller sea lions.

This report does not constitute a publication and is for information only. All data herein are to be considered provisional. Further, most of the papers included in this report may be published elsewhere. Any question concerning the material contained in this document should be directed to the authors, or ourselves. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Anita L. Lopez
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AERIAL SURVEYS OF BELUGAS IN COOK INLET, ALASKA, JUNE 2000

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Abstract

The National Marine Fisheries Service (NMFS) conducted an aerial survey of the beluga population in Cook Inlet, Alaska, during 6-13 June 2000. The 43 hr survey was flown in a twin-engine, high-wing aircraft at an altitude of 244 m (800 ft) and speed of 185 km/hr (100 kt), consistent with NMFS' annual surveys conducted each year since 1993. The flights in June 2000 included one or more surveys of coastal areas (flown 1.4 km offshore) around the entire Inlet and 1,841 km of transects across the Inlet. Paired, independent observers searched on the coastal (right) side of the plane, where virtually all beluga sightings occur, while a single observer and a computer operator/data recorder were on the left side. In addition, on each day a representative of the Cook Inlet Marine Mammal Council observed from the right side. After finding beluga groups, a series of aerial passes were made to allow at least two pairs of primary observers to make four or more counts of each group. Median counts made in optimal viewing conditions were 114 beluga in the Susitna Delta (between the Beluga and Little Susitna Rivers), 42 in Knik Arm, and 28 in Chickaloon Bay, but no beluga were found in lower Cook Inlet in spite of ideal sighting conditions. This is consistent with the sighting distributions observed each June or July since 1996. The sum of the aerial estimates (not corrected for missed whales) for June 2000 is 184, which is the lowest index count made by NMFS observers since these surveys began in 1993, but it is essentially the same as counts made in 1998 (193) and 1999 (217).

Introduction

Beluga whales (*Delphinapterus leucas*) are distributed around most of Alaska from Yakutat Bay to the Alaska/Yukon border (Hazard 1988). Five stocks are recognized in this region: Cook Inlet, Bristol Bay, Eastern Bering Sea, Eastern Chukchi Sea, and the Beaufort Sea

(Hill and DeMaster 1998; O'Corry-Crowe et al. 1997). The most isolated of these is the Cook Inlet stock, separated from the others by the Alaska Peninsula (Laidre et al. in press). Beluga in Cook Inlet are very concentrated in a few river mouths during parts of the year (Rugh et al. in press). The geographic and genetic isolation of the whales in Cook Inlet, in combination with their strong site fidelity, makes this stock vulnerable to impacts from large or persistent harvests.

NMFS's National Marine Mammal Laboratory (NMML) and the Alaska Regional Office have conducted annual aerial surveys to study the distribution and abundance of beluga in Cook Inlet each June/July since 1993 (Withrow et al. 1994; Rugh et al. 1995, 1996, 1997a, 1997b, 1999a, 1999b) in cooperation with the Alaska Beluga Whale Commission (ABWC) and the Cook Inlet Marine Mammal Council (CIMMC). A letter from the Alaska Regional Scientific Review Group (ASRG) to S. Pennoyer, NMFS, dated 13 May 1997, strongly urged NMFS to continue these surveys every year. Aerial surveys are proven to be the most efficient method for collecting distribution and abundance data for beluga in Cook Inlet (Klinkhart 1966; Calkins et al. 1975; Murray and Fay 1979; Calkins 1984). The most recent studies have been some of the most thorough and intensive (Rugh et al. in press).

Methods

The survey aircraft, an Aero Commander 680 FL (*N7UP*), has twin-engines, high-wings, 10-hr flying capability, and is equipped with seating for five passengers and one pilot. There are bubble windows at each of the four observer positions, maximizing the search area. An intercom system provided communication among the observers, data recorder, and pilot. A selective listening control device was used to aurally isolate the observer positions. Location data were collected from a portable global positioning system (GPS) interfaced with the laptop computer used to enter sighting data. Data entries included routine updates of locations, percent cloud cover, sea state (Beaufort scale), glare (on the left and right), and visibility (on the left and right). Visibility was documented in five subjective categories from excellent to useless; conditions rated poor or worse were considered unsurveyed. Each start and stop of a transect leg was reported to the recorder. Observer seating positions were recorded each time they were changed, generally every 1-2 hrs to minimize fatigue.

There was an attempt to synchronize flight timings with low tides in the upper Inlet. This was primarily to minimize the effective survey area (at low tide, large areas of mudflats are exposed that would otherwise have to be surveyed). However, the broad geographical range of these surveys in conjunction with highly variable tide heights made it impractical to survey at specific tidal conditions throughout the Inlet.

Coastal surveys were conducted on a trackline approximately 1.4 km offshore. The objective was to search nearshore, shallow waters where beluga are typically seen in summer (Rugh et al. in press). The trackline distance from shore was monitored with an inclinometer such that the waterline was generally 10° below horizontal while the aircraft was at the standard altitude of 244 m (800 ft). Ground speed was approximately 185 km/hr (100 knots). This coastal survey included searches up rivers until the water appeared to be less than 1 m deep, based on the appearance of rapids and riffles.

In addition to the coastal surveys, systematic transects were flown across the Inlet. A sawtooth pattern of tracklines was designed to cross over shore at points approximately 30 km apart starting from Anchorage and zigzagging to the southern limits of Cook Inlet, between Cape Douglas and Elizabeth Island (Fig. 1). This sawtooth pattern was offset from previous years to reduce resampling among years.

Immediately upon seeing a beluga group, each observer reported the sighting to the recorder. As the aircraft passed abeam of the whales, the observer informed the recorder of the inclinometer angle, whale travel direction, and notable behaviors but not group size. With each sighting, the observer's position (right front, right center, etc.) was also recorded. An important component of the survey protocol was the independence of the observers on the right (i.e., that they not cue each other to their sightings). They had visual barriers between them, and their headsets did not allow them to hear each other. When a group of whales was first seen, the aircraft continued on until the group was out of sight; then the aircraft returned to the group and began the circling routine. This allowed each observer full opportunity to independently sight the whale group. The pilot and data recorder did not call out whale sightings or in any way cue the observers to the presence of a whale group until it was out of sight. The whale group location was established at the onset of the aerial counting passes by flying a criss-cross pattern over the group, recording starts and stops of group perimeters.

The flight pattern used to count a whale group involved an extended oval around the longitudinal axis of the group with turns made well beyond the ends of the group. Whale counts were made on each pass down the long axis of the oval. Because groups were circled at least four times (four passes for each of two pairs of observers on the right side of the aircraft), there were typically eight or more separate counting opportunities per whale group. Counts began and ended on a cue from the right front observer, starting when the group was close enough to be counted and ending when it went behind the wing line. This provided a precise record of the duration of each counting effort. The paired observers made independent counts and wrote down their results along with date, time, pass number, and quality of the count. The quality of a count was a function of how well the observers saw a group, rated A (if no glare, whitecaps or distance compromised the counting effort) through F (if it was not practical to count whales on that pass). Only quality A and B estimates were used in the analysis. Only whales that were at the surface during the counting period were included; whale tracks in the muddy water or ripples were not included in the analysis. Count records were not exchanged with anyone else on the aerial team until after all of the aerial surveys were completed. This was done to maximize the independence of each observer's estimates.

Two digital video cameras were operated on each counting pass. The pair of cameras were mounted together on a common board: one camera was kept at maximum zoom; the other was adjusted to keep the entire group in view. Later, the images will be studied in the laboratory, and counts of whales will be compared to the infield counts. Analysis of both the aerial counts and counts from the video tapes are detailed in Hobbs et al. (In press [a]) for 1994-98 data.

Results

A total of 43 hrs of aerial surveys were flown around Cook Inlet from 6 to 13 June 2000. All of these surveys (11 flights ranging from 2.5 to 5.1 hrs) were based out of Anchorage, sometimes with refueling stops in Homer. Systematic search effort was conducted for 26.5 hrs, not including time spent circling whale groups, deadheading without a search effort, or periods with poor visibility. Visibility and weather conditions interfered with the survey effort during 0.8 hrs (3% of the effective search time) when the right-front observer considered the visibility poor or worse. All of the primary observers (the authors of this report) who flew with this project in 1998 and 1999 returned in 2000. Three of the four observers have participated in this project almost every season since it began in 1993.

On 6 June, a test flight was conducted to be sure all onboard systems were operational, and calibration targets were circled and videoed in Goose Bay of Knik Arm. The targets–inflated inner tubes colored with various shades of white to gray–provided a test of sightability of beluga under different lighting conditions and on video tape. The methods were kept similar to those used to count beluga, so the abundance analysis can include a correction for whales missed because they are not white. During the aerial surveys of Cook Inlet, a pair of video cameras were operated over whale groups during counts. One camera had its lens magnification adjusted to include the full width of the group (but kept constant throughout a pass), and the other camera was held at maximum zoom to provide a sampling of color ratios within the respective groups. This research is a part of a master's study being conducted by L. Litzky.

On 7 June, an aerial survey was conducted, but only the waters of Knik Arm were calm enough for a reasonable search effort. Two groups of beluga were found, and a full counting protocol was applied. The next day, 8 June, conditions were more favorable such that a survey could be conducted around much of upper Cook Inlet north of the Forelands; however, Chickaloon Bay and Turnagain Arm had marginal conditions due to high winds. In the Susitna area, a large group of beluga was found and counted. The only whales found in Chickaloon Bay were in the relatively calm waters of Chickaloon River. Other whales may have been offshore, but they were too hard to find among the whitecaps of the Inlet, so the effort there was abandoned. A flight was made into Knik Arm to confirm the location of the beluga groups counted there on the previous day (the sightings on these 2 days were only 1 km apart); therefore, the combination of survey results from 7 and 8 June provided partial or complete coverage of all primary areas where beluga have usually been found in the past.

With improved weather conditions after 8 June, surveys were conducted in the lower Inlet as far south as the Gulf of Alaska, where it is more challenging to find calm seas. On 9-11 June, coastal and offshore areas of Lower Cook Inlet (south of East Foreland and West Foreland) plus the Susitna area, were surveyed (Fig. 1). Survey conditions were generally good to excellent. No beluga were found except in the Susitna area (Table 2), although many other marine mammals were seen (2 gray whales, 11 humpback whales, 17 Dall's porpoise, 29 harbor porpoise, 10 sea lions, 236 sea otters, and over 1,800 harbor seals). This lack of beluga sightings in the lower Inlet is in contrast to the fact that beluga groups were seen virtually every time the survey passed through the Susitna or Knik areas, even when making approaches to the airport or during the calibration test of the floating targets.

Optimal survey conditions were experienced in the upper Inlet on 12 June. The survey on this day included all coastal areas north of North Foreland and offshore transects north of East and West Forelands. Beluga groups were found in Chickaloon Bay, Knik Arm, and the Susitna Delta–consistent with previous sighting locations.

In an attempt to recount the whale groups of upper Cook Inlet, an additional survey was made on 13 June. However, the beluga in Chickaloon Bay were farther offshore than usual, and white caps made it difficult to count them, so this effort was abandoned. At the mouth of the west side of the Susitna River, a group of whales was found again and counted, but the density of the group and reflective lighting conditions made the whales hard to count. Although Knik Arm had good conditions, a high volume of air traffic precluded the option to circle whale groups near Anchorage. Therefore, counts made on 12 June were considered the best for subsequent analysis.

The composite of these aerial surveys provided a thorough coverage of the coast of Cook Inlet (1,388 km) for most of the area within approximately 3 km of shore (Fig. 1). In addition, there were 1,841 km of systematic transects flown across the Inlet. Assuming a 2.0 km transect swath (1.4 km on the left plus 1.4 km on the right, less the 0.8 km blind zone beneath the aircraft), the cumulative survey tracklines covered roughly 6,500 km^2, which is approximately 33% of the 19,863 km^2 surface area of Cook Inlet; however, these surveys covered virtually 100% of the coastal areas. All of upper Cook Inlet was surveyed at least once, and areas where large groups of beluga have consistently been found in the past–such as the Susitna Delta, Knik Arm, and Chickaloon Bay–were surveyed at least three times.

Counts of beluga are shown in Table 1, and sighting locations are shown in Figure 1. These counts are the medians of each primary observers' counts on multiple passes over a group. Ideal counting conditions and thorough coverage of the upper Inlet occurred on 12 June. Therefore, only the counts made on that date were used in summary calculations (which is consistent with methods used in the past). Observers' counts ranged from 173 to 191, depending on observer, and the median index count was 184. This sum was not corrected for missed whales. Calculations for whales missed during these aerial counts and an estimate of abundance will be developed in a separate document (e.g., Hobbs et al. in press [b]). The median index of counts in June 2000 (184) is lower than any previous year, but it is essentially the same as counts in 1998 (193) and 1999 (217) (Table 2).

Discussion

In Cook Inlet, beluga concentrate near river mouths during spring and early summer across the northernmost portion of upper Cook Inlet, especially in the Susitna Delta, Knik Arm, and Chickaloon Bay (Fig. 1). Fish also concentrate along the northwest shoreline of Cook Inlet, mostly in June and July (Moulton 1994). These concentrations of beluga apparently last from mid-May to July or later and are very likely associated with the migration of anadromous fish, particularly eulachon (*Thaleichthys pacificus*) (Calkins 1984; 1989) and several species of Pacific salmon.

Historically many beluga were seen in lower Cook Inlet (Rugh et al. in press), but since 1993, when the NMFS surveys began, only 0-4% of the annual sightings have occurred there (Table 2). Furthermore, since 1996 only single or dead whales have been seen south of North Foreland, and none were seen in the lower Inlet in 1999 and 2000. Sighting conditions were ideal during the searches of coastal and offshore waters in June 2000, but no beluga were seen except in the northern Inlet (Table 1, Fig.1) at locations where they have been found during June or July most years (Rugh et al. in press). Many sea otters, harbor seals, harbor porpoise, gray, and humpback whales were seen in the lower Inlet, so the lack of beluga sightings was not simply a function of visibility.

The uncorrected sum of median estimates made from the June 2000 aerial observations in Cook Inlet was 184 beluga. Using the same procedure of summarizing median estimates from the highest seasonal counts at each site for each year 1993-99, there were, respectively, 305, 281, 324, 307, 264, 193, and 217 beluga (Table 2). The process of using medians instead of maximum numbers reduces the effect of outliers (extremes in high or low counts) and makes the results more comparable to other surveys which lack multiple passes over whale groups. Medians are also more appropriate than maximums when counts will be corrected for missed whales. Not until the respective correction factors have been applied will absolute abundances or inter-year trends be calculated. The average abundance estimate for the period 1994-98 is 505 beluga (SE = 81, CV = 0.16; Hobbs et al. in press [b]), including corrections for whales missed within the viewing range of observers and whales missed because they were beneath the surface.

Although the low abundance index that occurred in June 2000 might at first be interpreted as a decline in the true abundance, the precision of the index is not good enough to be a true reflection of such a small change (33 fewer whales than in 1999 and 9 fewer than in 1998). The abundance estimate for 1998 (347 beluga) had a CV of 0.29 (Hobbs et al. in press [b]); therefore, a large change in counts would be necessary to show a statistically significant difference.

Acknowledgments

Funding for this project was provided by the Marine Mammal Assessment Program, NMFS, NOAA. Douglas DeMaster and Sue Moore served as Program Leaders of the Cetacean Assessment and Ecology Program over the past several years; their dedicated support made this project possible. Rod Hobbs oversees the beluga project in Cook Inlet, including directing studies on tagging and establishing correction factors for aerial counts of beluga. Our pilot, Dave Weintraub of Commander NW, Ltd., very capably carried out the complex flight protocol. Visitors on the flights, representing the Cook Inlet Marine Mammal Council, included Leslie Green, Perry Dimmick, Daniel Alex, Floyd Kakaruk, and Gilbert Paniptchuk. We are grateful for their insights and help with this project. The survey map and data on distances flown were provided by Kristin Laidre (NMML). This survey was conducted under MMPA Scientific Research Permit No. 782-1438.

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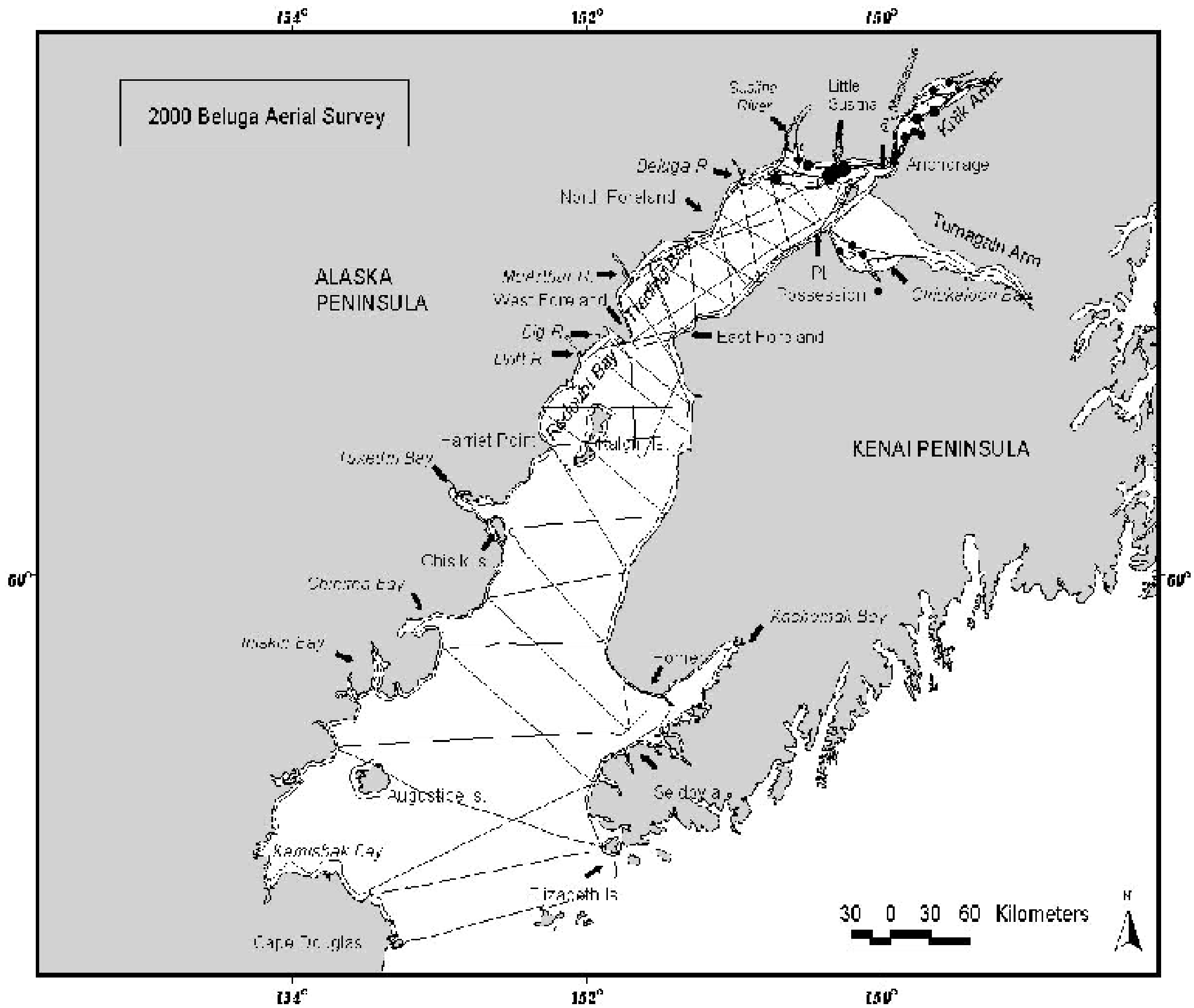
Table 1. Summary counts of beluga made during aerial surveys of Cook Inlet in June 2000. Medians from primary observers' counts were used from aerial passes where observers considered visibility good or excellent (conditions B or A). Dashes indicate no survey, and zeros indicate that the area was surveyed but no whales were seen. Sites are listed in a clockwise order around Cook Inlet.

Location	7-8 June		9-11 June		12 June		13 June		2000
	median	high	median	high	median	high	median	high	Highest medians
Turnagain Arm (East of Chickaloon)	---	---	---	---	0	0	---	---	0
Chickaloon Bay/ Pt. Possession	6	12	---	---	28	51	---	---	28
Pt. Possession to East Foreland	0	0	0	0	0	0	---	---	0
Mid-Inlet east of Trading Bay	---	---	0	0	0	0	---	---	0
East Foreland to Homer	---	---	0	0	---	---	---	---	0
Kachemak Bay	---	---	0	0	---	---	---	---	0
W side of lower Cook Inlet	---	---	0	0	---	---	---	---	0
Redoubt Bay	---	---	0	0	---	---	---	---	0
Trading Bay	---	---	0	0	---	---	---	---	0
Susitna Delta (N Foreland to Pt. Mackenzie)	100	179	104	145	114	167	67	96	114
Fire Island	0	0	---	---	0	0	0	0	0
Knik Arm	24	58	---	---	42	65	25	55	42
								3 =	**184**

Table 2. Summary of beluga sightings made during aerial surveys of Cook Inlet in June or July 1993-2000. Medians were used when multiple counts occurred within a day, and the high counts among days were entered here.

			Percent Sightings		
Year	Dates	Counts	Lower Cook Inlet	Susitna Delta	Elsewhere in Upper Cook Inlet
1993	June 2-5	**305**	0	56	44
1994	June 1-5	**281**	4	91	5
1995	July 18-24	**324**	4	89	7
1996	June 11-17	**307**	0	81	19
1997	June 8-10	**264**	0	28	72
1998	June 9-15	**193**	0	56	44
1999	June 8-14	**217**	0	74	26
2000	June 6-13	**184**	0	62	38

Fig. 1. Aerial survey tracklines and beluga groups seen 6-13 June 2000 during aerial surveys of Cook Inlet.



FIELD REPORT FOR TAGGING STUDY OF BELUGA WHALES IN COOK INLET, ALASKA, SEPTEMBER 2000

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Abstract

Two beluga whales (*Delphinapterus leucas*) were captured and satellite tagged in Cook Inlet, Alaska by researchers from the National Marine Mammal Laboratory and the Alaska Region National Marine Fisheries Service during 7-14 September 2000. Fourteen net sets were made on belugas using a modified encirclement technique with three successful captures. Of the three whales caught, satellite tags were attached to two; the first whale was released as it was judged to be too small. The tag on a juvenile female (CI-DL-02-00) transmitted for 126 days. The tag on an adult male (CI-DL-03-00) transmitted for 112 days. A time depth recorder (TDR) was attached to the juvenile female. The TDR stayed on for at least 90 hours and recorded 55 hours of data. Biopsies of skin were taken from all three animals for genetic analysis.

Introduction

This report describes tagging operations conducted by researchers from the National Marine Mammal Laboratory (NMML) and National Marine Fisheries Service - Alaska Region, (NMFS-AKR) in Cook Inlet, Alaska from 7-14 September 2000. NMFS worked in cooperation with Cook Inlet Marine Mammal Council (CIMMC) and Alaska Beluga Whale Commission (ABWC).

Beluga whales, *Delphinapterus leucas*, live year-round in the Northern Hemisphere's arctic and subarctic seas (Hazard 1988). Five discrete stocks are recognized around Alaska, designated by both their primary summer time locations (Frost and Lowry 1990) and by genetic differentiation (O'Corry-Crowe et al. 1997). Of these stocks, Cook Inlet belugas are the most isolated, both geographically and genetically, making them particularly vulnerable to both anthropogenic and environmental impacts (Hill 1996). The distribution and abundance of Cook Inlet belugas has been monitored annually by NMML since 1993. The results of this monitoring indicate a significant decline in abundance from 653 whales in 1994 to as low as 347 whales in 1998. The 1999 and 2000 estimates are 357 and 435 whales, respectively (Hobbs et al. in press).

Due to the decline in numbers, the stock was designated as depleted under the Marine Mammal Protection Act (Fed. Regist. 65:34590-34597) on May 31, 2000 and monitoring of its status continues.

Since 1993, information has accumulated regarding the summer distribution of the Cook Inlet belugas (Rugh et al. in press), while relatively little has been learned about distribution in other seasons, particularly winter distribution. Attachment of satellite tags that would transmit beluga locations during winter months could further validate the contention that the Cook Inlet stock is isolated from the four other Alaska beluga stocks.

Abundance estimates for the Cook Inlet stock are produced each year from aerial survey counts made by observers and from video imagery. One of the key components of the estimation process is applying a correction factor for belugas not at the surface during counts. To determine this correction factor, data collected on beluga dive intervals is used (Hobbs et al. in press). Dive data has been collected from the attachment of three suction cup tags (Lerczak et al. in press) and one satellite tag (Ferrero et al. in press). Such a small sample size of individual whales necessitates the collection of more dive information to improve population abundance estimates.

Belugas have been successfully captured and tagged in Point Lay and Cook Inlet, Alaska (Suydam et al., in review, Ferrero et al. in press), as well as in the Canadian Arctic (Martin and Smith 1992, Heide-Jorgensen et al. 1998, Orr et al., in review). As technology has improved**,** the size of the tags has decreased while the possible transmission time has increased. In addition to providing data on seasonal distribution and dive intervals, satellite tags can collect information on the daily movements of whales, which can then be related to ice cover, tides, surface water temperature and anthropogenic activities.

Study Area

The study took place in the northern waters of Cook Inlet known as Knik Arm. An emphasis was placed on Eagle Bay, about 25 km (15.5 mi) north of Anchorage, for three reasons. First, results from the 1999 Cook Inlet satellite tagging study showed the tagged whale frequented this part of the Inlet during September. Second, Eagle Bay provides an environment conducive to operations used for whale capture. A deeper water channel follows the contour around this bay while the center, known as Eagle Flats, is shallower with sandbars and mud flats that are exposed during low tides. Eagle Bay is also protected from the strong winds that come out of Turnagain Arm. Third, the proximity to Anchorage facilitated crew transport to and from the area. All operations were based out of Anchorage with daily trips made to the study site.

Methods

Four vessels were used for tagging operations. The boat that carried and deployed the net for whale captures was a 6.4 m (21 ft) Boston Whaler (referred to as net boat). The primary boat used to locate and isolate whales was an 5 m (17 ft) rigid hull inflatable (referred to as NOAA-08). Another, smaller rigid hull inflatable (referred to as NOAA-13), length 3.9 m (13 ft) was used to herd whales into the deployed net and to carry supplemental crew required for tag attachment. Lastly, a small 3.7 m (12 ft), inflatable Zodiac was also used to herd whales and carry additional crew members. Boats were on the water from sun up to sun down as permitted by tides and weather.

Net deployment techniques were similar to those used in Cook Inlet in 1999 (Ferrero et al. in press); however, a longer net of larger mesh size was used. The net was composed of 16 panels each 15 m (50 ft) in length by 4.6 m (15 ft) in depth for a total net length of 240 m (800 ft). The net was composed of a 0.64 cm (0.25 in) lead line, 3.8 cm (1.5 in) cork line and 53 cm (21 in) stretch mesh of size 30 twine. The main modification made to net deployment from the previous year's technique was the construction of a ramp that led the net out of a storage box and over the net boat engine.

Tag design was also similar to tags used in 1999 (Ferrero et al. in press) with the difference being the protrusion of wire cables for bolt attachment instead of a flexible material saddle. The wire cables require three bolts for tag attachment (versus four needed for saddle tags) and create less drag. These tags, known as 'spider tags', were constructed by Wildlife Computers of Redmond, Washington. They were composed of four C-cell batteries, a computer, a satellite transmitter with antenna, a pressure sensor, and a conductivity sensor all encased in a rigid polyurethane block with three wire cables extending from each side.

The TDR used was a MK-6, also built by Wildlife Computers. It consisted of a 3.5 V battery, VHF radio transmitter, and sensors for velocity, light levels, temperature, and depth. With half a megabyte of memory, the TDR was not duty cycled and sensed depth every one second. A flotation unit, built by Robin Baird, was attached to the TDR along with a suction cup. The suction cup, when lubricated with silicon grease, was used to secure the TDR to the animal.

Beluga captures followed a set routine. After crew on the boats spotted whales, the animals were approached slowly by NOAA-08 with the net boat close behind on the port side. Whales were followed with the intent to identify and isolate mature individuals that were not part of a cow/calf pair. When this was done, NOAA-08 continued to follow the selected animal and attempted to herd it into shallow water. When the beluga was ideally located, NOAA-08 gave a signal to the net boat, which then rapidly deployed the net, encircling both NOAA-08 and the whale. At the same time, the two small boats would speed to the location of the set to prevent the whale from leaving the net before the circle was closed. The net was then systematically checked for whales. If the set had been successful, the captured animal was measured and assessed to determine if it was suitable for tagging. If not, a biopsy of the skin was taken and the animal quickly released. If suitable for tagging, the animal was slowly towed to shore where attachment of the satellite tag occurred.

Tags were attached as quickly as possible. Holes were bored through the dorsal ridge using a coring device 1 cm (0.4 in) in diameter. Biopsy samples of skin and blubber were extracted from the corer and stored in DMSO, 10% formalin, and an RNA extraction solution. Flexible nylon rods with threaded ends were then pushed through the holes, attached to the wire cable of the satellite tags and secured with nylon nuts melted onto the ends. The wire cables allowed the tag to be cinched against the back of the animal to minimize tag movement and drag. All equipment was kept in cold sterile solution prior to its use.

Morphometric measurements, blowhole and blood samples were taken while the satellite tag was being attached. Mucous samples from the blowhole were collected using sterile cotton tipped swabs. When the whale lifted its head for a breath, a swab was quickly inserted into the blowhole before it was shut and gently swiped around inside. When the animal opened its blowhole for the next breath the swab was removed. The swab was wrapped in tin foil, then placed in a labeled zip lock plastic bag and stored with ice. Blood samples were taken using 18 or 19¾ gauge needles with a syringe or a vacutainer equipped with a butterfly. Two types of collection tubes were used: 'purple tops' containing EDTA for complete blood count, and 'red tops' with serum separators for blood chemistry. Purple topped tubes were rocked gently for 2-3 minutes after blood collection and then stored with ice. After collection into red topped tubes, blood was allowed to coagulate for 4-5 minutes and then stored with ice. The red tops were later centrifuged.

In addition to vessel operations, daily flights were made over the northern portion of Cook Inlet to identify whale group locations and (after its attachment) monitor TDR signals. A single observer, with pilot, flew in a Cessna 182 prior to vessel launchings. Communications between the aerial and shipboard contingencies were made via cell phone. A two-element strut mount radio antenna (Telonics) was used with a VHF radio receiver (Advanced Telemetry Systems, Inc., Isanti, Minn.) to detect signals from the TDR for tracking in the air and a whip antenna or two element YAGI antenna was used with the same receiver to track from the boat.

Results and Discussion

A total of 77 hours in eight days were spent on the water during this study. The net used for whale capture was deployed 16 times with two initial practice sets and 14 sets on belugas. Out of the 14 sets on whales, three were successful in capturing animals. There was also evidence of whales being encircled in the net on four other sets, but due to tangles formed during net deployment, and one instance where the animal apparently broke through the net, none of these belugas were captured.

Whales appeared to ignore vessels that were at a distance greater than 46 m (150 ft) away. They also did not seem to change their behavior when approached slowly, but would consistently move in a direction away from the boats. When approached rapidly whales tended to make a series of quick surfacings and then would disappear by submerging for extended periods of time. When in shallow water, their underwater movements could be tracked by the appearance of a surface wake. Upon deployment of the capture net, which coincided with a burst of speed and engine noise from the net boat, whale behavior became erratic. Usually, the isolated whale would race away from the vessels in a straight line. In one instance a whale essentially made a U-turn and ran into the NOAA-08. The whale then surfaced a number of times and was observed to have a cut about 40 cm (16 in) long on the left side of its body, just forward of the peduncle. The cut appeared to be superficial as there was minimal bleeding. The animal was followed at a distance and observed to return to the group from which it was initially isolated.

The first successful net deployment occurred on 8 September around 1100 hours. The length of the beluga, identified as CI-DL-01-00, was measured in the water at 274 cm (9 ft). The skin was light gray in color and very smooth with no visible scarring. Since the focus of the study was to tag mature whales, this apparently young animal, caught early on in the study, was not tagged. A small skin biopsy was taken and the whale was released at 1115 hours.

The second successful capture occurred near the end of the study on 13 September at 1220 hours. The beluga, identified as CI-DL-02-00, was slightly darker gray than the first captured whale but still considered light gray. There were some light scars visible on the animal's back. Measurements taken in the water found this beluga suitable for tagging and it was slowly towed, fluke first, to shore with the aid of a hoop net and tail rope. On shore measurement of whale length was 272 cm (8 ft 11 in). Tagging began at 1330 hours using satellite tag #30719. Due to the falling tide, the whale was continually moved down shore during the tagging process to keep it in shallow water. A total of four holes were made through the blubber of the dorsal ridge. Nylon rods were put through three of these holes for tag attachment. The first hole made was not used because it was high on the dorsal ridge. During tag attachment two mucous samples were taken from the whale's blowhole. Blood samples were also taken from the left side of the dorsal surface of the beluga's fluke using an 18 gauge needle. About 25 ml of blood were taken filling two purple capped tubes and four red caps. Lastly, a TDR was attached to the left dorsal side of the whale with a suction cup. The animal was released at 1415 hours.

The third successful capture of this study occurred on 13 September at 1745 hours. The large white beluga, identified as CI-DL-03-00, was clearly suitable to tag. It was towed to shore head first, again utilizing a hoop net and two tail ropes. Shore was reached around 1810 hours, where the animal was sexed as male and measured to be 413 cm (13 ft 7 in). A deep, old scar was evident on the forward portion of the dorsal ridge. Attachment of satellite tag # 25850 occurred just behind this scar and required the boring of three holes through the ridge. Again, two mucous samples were taken from the blowhole. About 16 ml of blood were taken from the dorsal surface of the fluke using a 19 ¾ gauge needle and filling two purple tops and 2 ½ red tops. During tagging, the beluga was continually moved up shore with the rising tide to keep it at the water's edge. The whale was released at 1900 hours.

Signals from the TDR attached to CI-DL-02-00 were monitored daily from both the water and air. Manual recordings of surfacing intervals were made for comparison with electronic recordings made by the instrument. On 17 September a continuous signal from the TDR was heard from the air, indicating its release from the whale. The TDR was recovered on the morning of 18 September. It had been attached to the whale for at least 90 hours and recorded 55 hours of data.

Transmissions from the two satellite tags began immediately after their attachment. Tag #25850 on CI-DL-03-00 stopped transmitting on 3 January, providing 113 days of transmissions. Tag # 30719 on CI-DL-02-00 stopped transmitting on 16 January, providing 126 days of transmissions. This information will provide the first scientific look at winter movements of the Cook Inlet belugas and additional information on surfacing intervals.

Analyses of skin samples indicated CI-DL-02-00 is a female and confirmed CI-DL-03-00 is a male. Swabs with mucous samples taken from the two belugas were highly saturated with salt water and were thus unable to be processed. Although it would be useful to have whales completely out of the water to prevent saturation of swabs during blowhole sampling, the resulting stress to the animal, and difficulty in then returning the animal to the water, prevent the recommendation of such a technique. Due to improper storage of blood samples, it is unclear if analyses for complete blood count and blood chemistry will yield results. A disease screening, however, is planned to be conducted on the blood. In the future it is recommended to use needles of size 18 gauge or lower for blood collection as the 19¾ gauge needles were too thin and tended to clog.

Groups of belugas were seen every day during this study, both in the study area from the research vessels, and further south in Turnagain Arm via aerial observations. Group sizes varied from greater than 50 animals down to less than five animals. Movements seemed to be related to tidal cycles but were difficult to predict. A directional hydrophone may have been useful when whales were out of sight to determine their location.

In addition to belugas, other species of marine mammals observed during this study include: numerous harbor seals (*Phoca vitulina*), one harbor porpoise (*Phocoena phocoena*), and two minke whales (*Balaenoptera acutorostrata*). The minke whales were spotted mid-Inlet, half way between Anchorage and Eagle Bay on 8 September.

Acknowledgments

This project could not have happened without the help and participation of many people. Thanks to: Doug Baird for field assistance; Matt Eagleton for driving the NOAA-08 and supplying his knowledge about Cook Inlet; Carolyn Goode for daily aerial observations; William Gossweiler for acting as official net thrower and videographer; Kristin Laidre for collection of TDR data; Nancy Lord for field assistance; Greg O'Corry-Crowe for driving the Zodiac and contributing his knowledge regarding tagging; Charles Saccheus for driving the Zodiac and providing expert knowledge on the behavior of belugas and tagging; Dana Seagars for driving the NOAA-13; Robert Suydam for his knowledge regarding tagging; Dan Vos for driving the net boat and providing useful input on capture techniques; and Bill Walker for aiding in drawing blood from the animals. We would also like to thank Sue Moore for her helpful review of this report. Funding for this project was provided by NMFS, Office of Protected Resources.

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CETACEAN DETECTION AND ASSESSMENT VIA PASSIVE ACOUSTICS, 2000

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Abstract

During FY00, the first of a three year study to advance the use of passive acoustics for detection of large whales, the National Marine Mammal Laboratory (NMML) collaborated with researchers from three institutions to leverage their expertise in underwater acoustics and apply it to cetacean research. Four autonomous recorders were built and deployed in the eastern Bering Sea to monitor waters where critically endangered North Pacific right whales (*Eubalaena japonica*) have been seen each July since 1996. Two additional recorders, fabricated by NOAA/PMEL, were deployed southeast of Kodiak Island near an area where one North Pacific right whale was seen in July 1998. In addition, NMML collaborated with researchers using the U.S. Navy's SOund SUrveillance System (SOSUS) assets to locate blue whales in the North Pacific to conduct a provisional seasonal habitat analysis by integrating the call location data with bathymetry and remotely sensed data (i.e., sea surface temperature (SST), chlorophyl a, altimetry) using a geographic information system (GIS). Results of these analysis were presented at the 13th Biennial Marine Mammal Conference and have been submitted to a referred journal. Finally, calls recorded near humpback whales (*Megaptera novaeangliae*) on their feeding ground in Southeast Alaska were analyzed to determine their type and character for comparison to the better-known calls (songs) described for the breeding ground; results of these analyses have been accepted for publication by the journal *BioAcoustics*.

Introduction

Throughout FY00, the National Marine Mammal Laboratory collaborated with scientists at the NOAA Pacific Marine Environmental Laboratory (PMEL) in Newport, OR, Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA, and Scripps Institution of Oceanography (SIO), La Jolla, CA to leverage their expertise in underwater acoustic techniques and analysis. Initial focus of acoustic studies at NMML was on long-term deployment of autonomous acoustic recorders to monitor specific areas for mysticete whale calls.

North Pacific right whales were a species of particular focus due to their status as a critically endangered species and the on-going photo-identification studies conducted by the Southwest Fisheries Science Center (SWFSC) in the eastern Bering Sea. The sighting of a lone right whale among humpback whales southeast of Kodiak Island in 1998 provided impetus for placement of two recorders there also. In addition, NMML was able to collaborate on an on-going acoustic study of blue whales in the North Pacific basin using the U.S. Navy's SOSUS, and to augment that work though application of GIS technology. Finally, collaboration with a graduate student at the University of Michigan provided an opportunity to analyze recordings of humpback whale calls recorded in Southeast Alaska. A brief synopsis of each collaborative project is provided below.

Acoustic Monitoring for Right Whales in the eastern Bering Sea: Collaboration with SIO

Early in FY00, NMML transferred funds to SIO to build four acoustic recording packages (ARPs). The autonomous recorders were fabricated during the winter, field tested in late spring and deployed on 1 October 2000, in the eastern Bering Sea at locations where SWFSC researchers have photographed North Pacific right whales (*Eubalaena japonica*) during aerial surveys each July since 1998 (Fig. 1: NMML/SIO). The ARPs sample acoustic data at 500 Hz and have 36 Gbytes of data storage capacity. The recorders will remain in place until approximately 1 September 2001, when they will be recovered and four replacement recorders deployed. ARPs, deployed in series, will provide roughly two years of continuous monitoring of the eastern Bering Sea for right whale and other mysticete whale calls. Data analysis will commence upon recovery of the first four recorders, via contract to Dr. Mark McDonald, and SIO graduate student Lisa Munger (under the direction of Dr. John Hildegrand). Dr. McDonald will use calls recorded from North Pacific right whales in 1999 (McDonald and Moore, in review) to aid in the detection and enumeration of recorded calls.

North Pacific Right Whales in the Gulf of Alaska: Collaboration with NOAA/PMEL

After a North Pacific right whale was sighted off Kodiak Island in July 1998, an acoustic search for right whales was conducted (Waite et al., in review). In May 2000, an autonomous recorder, similar to instruments used by PMEL for seismicity detection (Fox et al. 2001), was placed on the seafloor at the location of the sighting, 57° 08.20 N and 151° 51.00 W A second recorder was deployed farther offshore to listen for right whales and to complement a broad array of six recorders deployed in the Gulf of Alaska by PMEL (Fig. 1: NMML/PMEL). The first instrument was recovered in early September 2000, but sea conditions have thus far prevented recovery of the second recorder. The first instrument recorded sound continuously to a magnetic disk from 26 May to 11 September, 2000. After recovery of the instrument, all sounds that could potentially be right whale calls were detected by a computer. This was done by measuring energy in the frequency band of right whale calls, 50 Hz to 400 Hz. Whenever the total energy was above the background noise level for at least 0.6 sec (so short thumps and clicks would not be detected), but not more than 3 sec (so long tones would not be detected), the sound was extracted and saved as a separate sound file.

A total of 10,729 potential right whale sounds were detected and extracted using this method. Next, a spectrogram of each sound file was examined visually to determine whether it was similar to other up-type calls that have been recorded from North Pacific right whales (McDonald and Moore, in review). Upon examination, 6,364 (59%) were found to be humpback whale (*Megaptera novaeangliae*) sounds, with most of the rest being various sounds from fish and other, unknown sources. A few sounds were somewhat similar to right whale calls but could not be identified with certainty because some of the calls made by humpbacks that summer were very similar to right whale up-type calls. This made it difficult to determine with certainty what species produced these calls - especially since the right whale seen in 1998 was among humpbacks. We took a conservative view and said that any up-like call heard when humpback calls were heard near the same time were ambiguous, and could not be positively identified. Perhaps some of the up-like calls we heard really were right whales, but we cannot say with certainty that this was so.

Blue Whales in the Northwest Pacific Ocean: Collaboration with WHOI

Dr. Bill Watkins at WHOI heads an on-going study (since 1995) of mysticete whale calls in the North Pacific, based upon SOSUS signal reception at the U.S. Navy NAVFAC/Whidbey Island (Watkins et al. 2000a & b). In FY00, NMML contracted with GIS-analyst Jeremy Davies to construct call-maps for blue whales in the North Pacific (e.g., Fig. 2) and collate call location and seasonal occurrence with bathymetry and remotely-sensed data (e.g., SST, chlorophyl a). Preliminary results of this analysis were first provided in an oral presentation at the 13th Biennial Marine Mammal Conference, December 1999. More recently, a manuscript has been prepared for submission to Oceanography (Moore et al., in review). Here, the focus is on blue whale call detection in the Northwestern Pacific, an area of the ocean virtually un-surveyed for large whales since the era of commercial whaling. The strong seasonal signal of blue whale calling corresponds with seasonal changes in SST and chlorophyl a, although it is the association with ocean height (altimetry) and eddys that appear the strongest. This paper is designed to augment an earlier presentation of seasonal occurrence of blue, fin and humpback whales in the North Pacific, as derived by SOSUS reception of calls (Watkins et al., 2000a).

Feeding Calls of Humpback Whales in Southeast Alaska: Collaboration with S. Cerchio

Numerous publications exist describing calls produced by humpback whales on their breeding grounds. Information on calls produced by humpback whales on their feeding grounds is more limited. The accurate identification of the calling species is enhanced when the full repertoire of calls can be described and catalogued. Calls of feeding humpback whales from Southeast Alaska were analyzed to quantitatively characterize the predominant vocalization associated with feeding and assess variation among vocalizations. Whales uttered series of cries similar in acoustic structure to those described previously as stereotyped, rhythmic ‘feeding calls’. Individual cries ranged in duration from 0.4 to 8.2 sec (median = 2.6 sec). Cries had relatively little frequency modulation (FM) over the main body of the call which ranged in fundamental frequency from 360 to 988 Hz (median = 553 Hz) and sometimes exhibited a frequency oscillation over a bandwidth of approximately 16 to 65 Hz. Calls typically had a short, strongly FM introductory and ending component. Principle components analysis indicated that most variation in the data-set (over 35%) could be attributed to measures of absolute frequency, however a substantial amount of variation was also due to other acoustic parameters such as duration, frequency oscillation and average slope of call sections. Within series, cries were stereotyped and varied little, whereas there was statistically significant variation in cries among series. Furthermore, overlapping cries, which are considered to represent vocalizations of different individuals, varied significantly. These results suggest that whales may have individually specific cries, and these differences can be ascribed to either individual signature information, or alternatively, active mismatching of calls by simultaneously vocalizing animals. Accepted for publication in BioAcoustics (International Journal of Animal Sound and its Recording). Authors: Cerchio, S. and M. Dahlheim.

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Figure 1. Locations of autonomous acoustic recorders deployed to monitor areas for North Pacific right whale (and other mysticete whale) calls in the eastern Bering Sea (NMML/SIO) and in the northern Gulf of Alaska (NMML/PMEL). The two recorders in the Gulf of Alaska complement six recorders deployed by PMEL to monitor deep-water areas for blue whales.

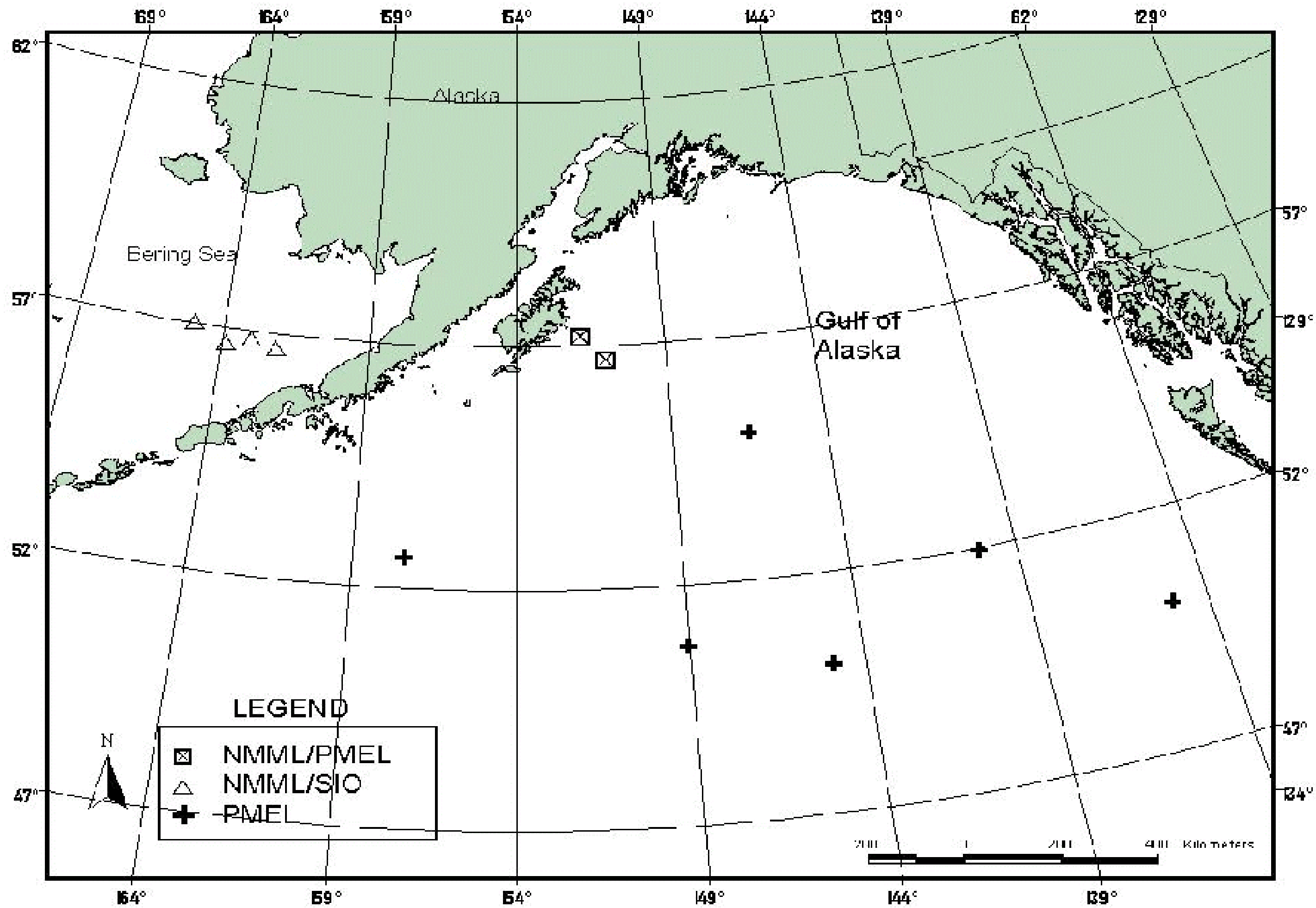
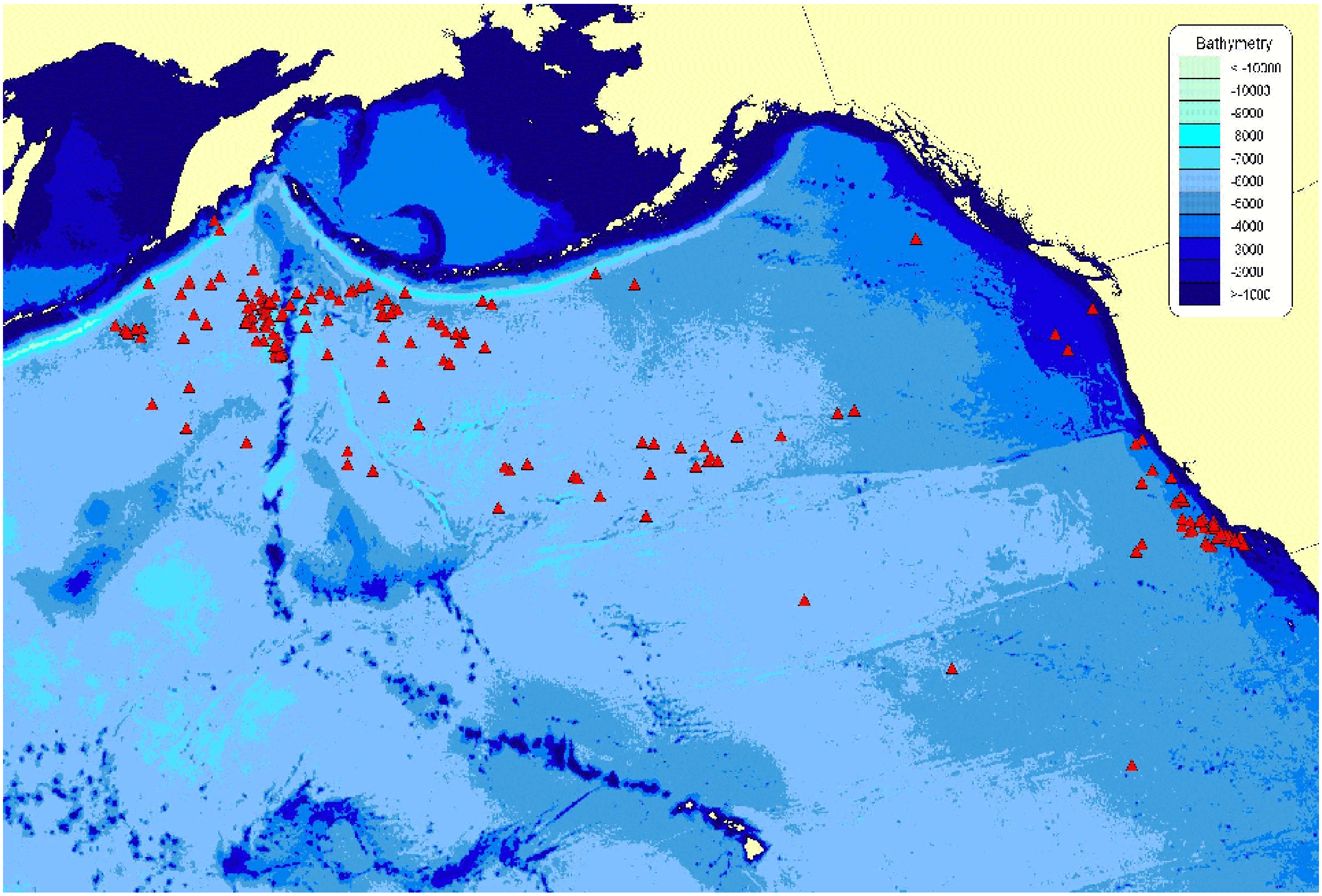


Figure 2. Blue whale call locations for the month of July with reference to bathymetry in the North Pacific basin. Call locations provided by WHOI using Navy SOSUS and other assets (ref. Watkins et al. 2000a).



CETACEAN VESSEL SURVEY IN THE SOUTHEASTERN BERING SEA, JUNE 2000

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Abstract

A line-transect vessel survey for cetaceans was conducted 12 June to 3 July 2000 in the southeastern Bering Sea aboard the NOAA ship *Miller Freeman* in association with a groundfish stock assessment. Survey effort totaled 2,598 km. The most common mysticete and odontocete were the fin whale (*Balaenoptera physalus*) and the Dall's porpoise (*Phocoenoides dalli*). Sightings in the Bering Sea included 48 fin whales, two sei whales (*Balaenoptera borealis*), 35 minke whales (*Balaenoptera acutorostrata*), five humpback whales (*Megaptera novaeangliae*), 11 gray whales (*Eschrichtius robustus*, one Baird's beaked whale (*Berardius bairdii*), 12 killer whales (*Orcinus orca*), one Pacific whitesided dolphin (*Lagenorhynchus obliquidens*), 85 Dall's porpoise and 53 harbor porpoise (*Phocoena phocoena*). Abundance estimates were calculated for five species: 481 fin whales (CV = 0.31), 1,036 minke whales (CV = 0.31), 408 killer whales (CV = 0.41), 6,343 Dall's porpoise (CV = 0.26), and 1,662 harbor porpoise (CV = 0.22). Fin whales, found throughout the Bering Sea shelf, were spread across the shelf break near the Pribilof Islands and were clustered near the 50 m isobath in Bristol Bay, where fish and invertebrate species were aggregated. Minke whales had no apparent association with fish aggregations, and were distributed broadly across the shelf. Killer whales were found throughout the survey area, although they tended to be close to the Alaska Peninsula and the Pribilof Islands. The distribution of harbor and Dall's porpoise differed by depth, with most Dall's porpoise found deeper than the 75 m isobath and most harbor porpoise in waters shallower than the 85 m isobath.

Introduction

Most of the information on large whale distribution and abundance in the Bering Sea comes from catch records (e.g., Springer et al. 1996, 1999). Northern right whales (*Eubalaena japonica*), fin whales (*Balaenoptera physalus*), and humpback whales (*Megaptera novaeangliae*) were harvested predominantly south of the Aleutian Islands in the North Pacific (Miyashita et al. 1995), but takes were also substantive in the Bering Sea. Minke whales (*Balaeanoptera acutorostrata*) were harvested most heavily in the western Pacific and Sea of Okhotsk, with comparatively few whales taken in the central Bering Sea. Surveys conducted in the southeastern Bering Sea in the 1980s (Leatherwood et al. 1983; Brueggeman et al. 1989) found few large whales. From the little historical information about whale abundances, and sparse research in recent years, it is impossible to assess if populations of mysticete whales are recovering from the commercial harvests of the 20th century, and whether they are resuming an important role in the ecology of the Bering Sea.

Information has also been sparse for small cetaceans in the southeastern Bering Sea. A photo-identification study for killer whales (*Orcinus orca*) was conducted in 1992 and 1993 (Dahlheim and Waite 1993, Dahlheim 1994, Dahlheim 1997) which resulted in a total of 170 individual killer whales. These surveys were conducted primarily along the eastern Aleutian Islands and shelf from Unalaska Island to the Pribilof Islands and so represent only a small portion of the Bering Sea, but also include areas where large groups of killer whales are known to frequent. Tynan (2001) produced killer whale abundance estimates for two years of surveys in the southeastern Bering Sea. The abundance estimates had low precision with 5,333 (CV = 95%; 95% CI = 949–29,972) killer whales in 1997 and 414 (CV = 60%; 95% CI = 130–1,315) killer whales in 1999. A Dall's porpoise (*Phocoenoides dalli*) abundance estimate of 9,000 (CV = 91%; 95% CI = 1,960 - 41,400) was calculated for in the Bering Sea by Hobbs and Lerczak (1993) (using data from 1987-1991), but the large confidence interval makes it impractical for looking at trends. No estimates have been made for harbor porpoise (*Phocoena phocoena*) in the southeastern Bering Sea, however, Dahlheim et al. (2000) calculated an abundance estimate of 3,531 (CV = 24%; 95% CI = 2,206-5,651) for harbor porpoise in Bristol Bay from aerial surveys conducted in 1991.

In 2000, scientists from the Alaska Fisheries Science Center/Resource Assessment and Conservation Engineering (AFSC/RACE) Division conducted another in a series of acoustic-trawl surveys for walleye pollock (*Theragra chalcogramma*) on the Bering Sea shelf. Biologists from the AFSC/National Marine Mammal Laboratory (NMML) were able to join the first leg of that cruise and conduct a visual cetacean survey along the lines RACE had developed for the pollock assessment. This opportunity provided a means to assess the southeastern Bering Sea shelf for cetaceans and begin developing baseline information against which future research can be compared for trend assessment.

Methods

A line-transect survey for cetaceans was conducted in the southeastern Bering Sea from the flying bridge of the NOAA ship *Miller Freeman* (66 m in length) along predetermined tracklines of the acoustic pollock survey. The height of the platform was 12 m and the ship traveled at approximately 22 km/hr. A survey conducted during the transit from Kodiak Island to the southeastern Bering Sea was considered a training session and not included in abundance estimates, except for killer whales (see below). The cetacean survey included 18 north-south transect lines proceeding from east (160/ 20'W) to west (171/ 20'W), the east-west lines connecting the transect lines, and a small portion of the transit at the end of the survey to Dutch Harbor. The transect lines were 37 km apart and ranged from approximately 85 km to 290 km in length and covered the southwestern portion of Bristol Bay and across the shelf (with the southern ends of the lines along the shelf edge) to just west of the Pribilof Islands (Fig. 1).

Line-transect methodology was used with three observers; two using 25x150 power binoculars on port and starboard stations, and a data recorder. The port observer surveyed from 10E right to 90E left of the trackline and the starboard observer surveyed 10E left to 90E right of the trackline. The data recorder scanned the entire 180E area forward of the ship with the naked eye using Fujinon 7x50 reticled binoculars to confirm sightings. The ship's global positioning system (GPS) unit was connected directly to a portable computer (Compaq Lte) at the recorder's station. The date, time, and position of the vessel were automatically entered into the survey program every ten minutes and whenever data were entered by the recorder. At the start of each trackline, waypoint numbers, observer positions, and environmental conditions were entered. Environmental conditions included sea state (Beaufort scale), weather (rain, fog, no rain or fog, both rain and fog), visibility (an overall determination from excellent to unacceptable of how well each observer felt they could see a cetacean), and glare (no glare, minor glare, bad glare, or reflective glare). When a sighting was made, the recorder entered it in the computer, which automatically input the time and position from the GPS unit. The observer then reported the species, vertical distance (taken from reticles in the binoculars), angle relative to the ship's heading (from an angle ring on the binocular mount), and group size. The observers rotated positions every 30 min during a 2 hr shift, followed by a 30 min break. The survey was suspended when the ship stopped for fishing operations, during inclement weather, and when light levels were too low for efficient observations.

Throughout the cruise, the ship's survey technician collected continuous oceanographic data including temperature and salinity and the acoustic trawl survey collected data on pollock biomass and other fish and invertebrate species (Honkalehto et al., in prep). Cetacean sightings from the survey were plotted in ArcView™ (3.1) and compared to maps of fish and invertebrate distribution. Further analysis will be completed relating the possible influence of oceanographic features and fisheries distribution to cetacean distribution.

Cetacean abundance was estimated using line-transect analysis for each species that had 12 or more on-effort sightings. Due to the small number of killer whale sightings (12), sightings from the Gulf of Alaska transit and a 1999 cruise using identical methods (Moore et al. 2000) were included for the estimation of the detection function as in Waite et al. (in review). Effective strip width, group size, density, and abundance were estimated using the program DISTANCE (Thomas et al. 1998). Abundance, *N*, was calculated as:

$$N = \frac{A\bar{s}\,n}{WL},$$

where, *A* is the size of the study area, *ÿ* is the average number of whales per useable, on-effort sighting, *n* is the number of useable on-effort sightings, *W* is the effective strip width, and *L* is the total length of the useable effort segments. The study area was defined as the area enclosed by a boundary 10 km beyond the limits of the survey tracklines (Fig. 1), calculated as 158,561 km^2 using ArcView™ (3.1).

The perpendicular distance between a sighting and the trackline was estimated as the product of the radial distance to sightings and the sine of the radial angle of the sighting. The distribution of perpendicular distances was examined for each species to determine the appropriate truncation point which provided the best data for estimating the detection function. Sightings beyond the truncation point were removed from the analysis. Perpendicular sighting distances were grouped into bins of equal width, the number and width of which varied depending on the distribution of perpendicular distances. The exception to this procedure was killer whales, for which unequal bin widths were used because of the small number of sightings.

The probability of sighting with respect to perpendicular distance from the trackline was modeled using the uniform and half-normal key functions, with either the cosine or simple polynomial series expansion, and the hazard rate key function, with either the cosine or Hermite polynomial series expansion. The probability of sighting a group on the trackline was assumed to be one. Akaiki Information Criteria (AIC) were used to determine both the number of expansion terms for each model and the best-fit of the six models. The strip width was estimated as twice the integral of this curve over the perpendicular distance from the trackline to the truncation point. Tracklines began and ended whenever there was a significant shift in survey effort as indicated by changes in sighting conditions (visibility, Beaufort sea state), personnel, or vessel direction. Expected group size was computed as the regression of the log of the observed group sizes on the detection probability unless the regression was not significant at the 0.15 level, at which time the mean group size was used.

Results

The survey began in the Gulf of Alaska, west of Kodiak Island and ended at Dutch Harbor, Alaska, extending from 10 June to 3 July 2000. The transit from Kodiak Island through the Gulf of Alaska to Unimak Pass (10 - 11 June) was treated as a training/practice survey. Sightings during this transit are included in species totals and maps but are not used in abundance estimation, except for killer whales (see above). A total of 2,598 km of trackline was surveyed, 402 km during training and 2,194 km of survey used for abundance estimation (Fig. 1). There was a total of 264 on-effort identified cetacean sightings, of which 109 were mysticetes and 155 were odontocetes (Table 1; Figs. 2 and 3).

Fin whales were the most common mysticete whale during the survey with 36 sightings in the southeastern Bering Sea (and 12 in the Gulf of Alaska) (Fig. 2). Sightings were made throughout the survey area, but they were more densely clustered where fish and invertebrate species were aggregated (Honkalehto et al., in prep). Abundance was estimated using a truncation distance of 6 km (Fig. 4) which included only 29 of the 36 on-effort sightings. Perpendicular distances were grouped into bins 1 km wide, and the best-fit model for the detection curve was the uniform key function with one simple polynomial series expansion term (AIC = 98.16, goodness-of-fit Chi-square test probability = 0.87). Because larger group sizes were seen further from the trackline, the expected group size was computed as the regression of the log of the group size on the detection probability ($P = 0.003$). The estimated abundance of fin whales was 481 (CV = 31%; 95% CI = 264-879) (Table 2).

Minke whales were also common with 35 sightings in the southeastern Bering Sea and one in the Gulf of Alaska. They had no apparent association with fish aggregations, and were distributed broadly across the shelf, with clustering near the Pribilof Islands and the Alaska Peninsula (Fig. 2). Because of a bimodal distribution in the perpendicular distances for minke whales sightings which made fitting the detection function problematic, a truncation distance of 1 km (Fig. 5) was used. This extreme truncation distance resulted in the use of only 19 of the 34 on-effort sightings in the estimation of abundance. Perpendicular distances were grouped into bins 0.25 km wide, and the best-fit model for the detection curve was the uniform key function with one cosine series expansion term (AIC = 51.85, goodness-of-fit Chi-square test probability = 0.78). Because the one pair of animals used in the analysis was sighted at 0.82 km from the trackline, the expected group size was computed as the regression of the log of the group size on the detection probability (P = 0.05). The estimated abundance of minke whales was 1,036 (CV = 31%; 95% CI = 567-1,891) (Table 2).

Twelve killer whales were sighted in the southeastern Bering Sea (2 in the Gulf Alaska/Unimak Pass) and were scattered throughout the survey area, although most were sighted in the vicinity of either the Alaska Peninsula or the Pribilof Islands (Fig. 3). For abundance estimation, a truncation distance of 7.5 km (Fig. 6) was used which resulted in 19 of the 20 useable sightings (by including the Gulf of Alaska and the 1999 sightings) to fit the detection function and 11 of the 12 on-effort sightings for the rest of the abundance estimation procedure. Perpendicular sighting distances were grouped into nine bins such that the first three bins were 0.5 km wide and the remaining bins were 1 km wide. Unequal bins widths were chosen over equal widths because they more accurately represented the data. However, seven bins 1km wide produced comparable results. The best-fit model for the detection curve was the uniform key function with one cosine series expansion term (AIC = 83.33, goodness-of-fit Chi-square test probability = 0.89). The expected group size was computed as the average of the observed group sizes because the regression of the log of the group size on the detection probability was not significant (P = 0.53). The estimated abundance of killer whales was 408 (CV = 41%; 95% CI = 185-904) (Table 2).

Dall's porpoise were the most common odontocete with 84 sightings in the southeastern Bering Sea (one in the Gulf of Alaska). Harbor porpoise were also fairly common with 53 sightings. The two porpoise species appeared to be segregated by depth at about the 75 m isobath, with Dall's porpoise in deeper waters (Fig. 3). The distribution of perpendicular distances for Dall's and harbor porpoises were such that manual truncation was not needed, with all on-effort sightings used in the estimation of abundance. For Dall's porpoise, perpendicular distances were grouped into bins 0.5 km wide, which resulted in a maximum perpendicular distance of 5 km (Fig. 7). For harbor porpoise, perpendicular distances were grouped into bins 0.75 km wide, which resulted in a maximum perpendicular distance of 3.75 km (Fig. 8). The best-fit model for the detection curve for both species was the hazard rate key function with no series expansion terms (Dall's porpoise: AIC = 312.33, goodness-of-fit Chi-square test probability = 0.93; harbor porpoise: AIC = 128.24, goodness-of-fit Chi-square test probability = 0.24). The expected group size was computed as the average of the observed group sizes since larger groups were not seen further from the trackline, and the regression of the log of the group size on the detection probability was not significant (Dall's porpoise: P = 0.89 ; harbor porpoise: P = 0.83). The estimated abundances of Dall's and harbor porpoise were 6,343 (CV = 26%; 95% CI = 3,833-10,497) and 1,558 (CV = 24%; 95% CI = 981-2,473), respectively (Table 2).

Too few sightings were made for other species to estimate abundance although sighting locations were interesting for distributional information. The two sei whale sightings were made at very different depths, 75 m and over 1,000 m. Given that there were only two sightings of sei whales and that they were dissimilar, it is difficult to speculate on the characteristics of their distribution. Five humpback whales sightings were made in the southeastern Bering Sea, all in the eastern and shallow end of the study area. The acoustic trawl survey showed a high biomass of a fish-invertebrate mixture on which the humpback whales may have been feeding. The eleven gray whales sighted in the study area were all along the north Alaska Peninsula coast. They were likely feeding in the benthic zone of the shallow coastal waters. The Baird's beaked whale sighting was made at a depth of over 1,000 m, as would be expected for the deep diving species. One sighting of Pacific whitesided dolphins was made outside of Port Moller on the

Alaska Peninsula. Occasional Pacific whitesided dolphin sightings are made throughout the southern Bering Sea, so this sighting is not unusual.

Discussion

The 2000 cruise aboard the NOAA ship *Miller Freeman* allowed for a line-transect survey for marine mammals in the southeastern Bering Sea. This survey complements the 1999 survey conducted in the central Bering Sea (Moore et al. 2000); together they cover most of the Bering Sea shelf. Sufficient sighting data provided the estimation of preliminary abundance estimates for fin whales, minke whales, killer whales, Dall's porpoise and harbor porpoise presented here. Moore et al. (2000) presents abundance estimates for fin, humpback and minke whales for the central Bering Sea. Both year's estimates are uncorrected for animals missed on the trackline, animals missed while submerged, and for attraction or avoidance of the survey vessel.

No abundance estimates exist for the Northeast Pacific stock of fin whales (Ferrero et al. 2000) except for a small portion of their range in the central Bering Sea calculated by Moore et al. (2000). The 4,951 fin whales (CV = 29%; 95% CI = 2,833-8,653) estimated by Moore et al. (2000) is much higher than the 481 (CV = 31%; 95% CI = 264-879) estimated here, which indicates that fin whales are more abundant in the central Bering Sea, assuming distribution was similar between 1999 and 2000. The survey area in the central Bering Sea included more tracklines over the shelf break than the southeastern Bering Sea survey. This area has been termed the Bering Sea Green Belt (Springer et al. 1996), because of its high productivity of zooplankton and fish, which should attract large whales. In support, Nasu (1974) reported that fin whales in the Bering Sea were commonly associated with the oceanic front that occurs between water masses at the shelf break. Springer et al. (1999) also reported fin whale distribution in subarctic North Pacific (based on whaling records) to coincide with zooplankton biomass. For this survey, fin whale sightings were found throughout the study area, but with few large concentrations of whales. A cluster of sightings were made along the shelf edge, but the largest concentration was found near the 50 m isobath in the eastern portion of our survey area where the acoustic trawl survey detected large concentrations of invertebrate-fish species mixtures (Honkalehto et al. in prep).

Few humpback whales were seen on this survey, making it unfeasible to produce an abundance estimation. The few that were seen in the southeastern Bering Sea (five sightings, seven animals) were in the eastern portion of our survey area. Their locations, near the concentration of fin whale sightings, also coincide with large invertebrate-fish species mixtures found concurrently on the acoustic survey (Honkalehto et al. in prep). An abundance estimate was calculated for humpback whales (1,175 whales; CV = 113%; 95% CI = 197-7,009) in the central Bering Sea (Moore et al. 2000), from sightings clustered around Unimak Pass and far north on the shelf, but it is very imprecise due to few sightings. It is interesting that in both years, humpback whales were not found throughout most of the survey areas, comprising much of the middle and outer Bering Sea shelf. The scarcity of humpback whales in much of the Bering Sea raises uncertainty of their recovery there. Because of low occurrence and clumped distribution of sightings, mark-recapture methods may be more suitable than line-transect methods for abundance estimation of humpbacks in this region. Photo-identification and genetic studies are also needed to identify stocks that are present in the Bering Sea.

Minke whales in the eastern North Pacific are separated into the Alaska stock and the California, Oregon and Washington stock based on distribution; no abundance estimates are available for either stock (Ferrero et al. 2000). During this survey, minke whales were distributed throughout the study area, including nearshore regions (e.g., Pribilof Islands) and the upper shelf, suggesting widespread use of the Bering Sea. There are also reports of minke whale aggregations elsewhere in the Bering Sea, such as along the Chukotka coastline (e.g., Melnikov et al. 2000). The estimate of 1,036 minke whales (CV = 31%; 95% CI = 567-1,891) presented here for the southeastern Bering Sea together with the central Bering Sea estimate of 936 whales (CV = 35%; 95% CI = 473-1,852) (Moore et al. 2000), provides a baseline minimum estimate for this population.

Killer whales stocks are distinguished by killer whale type, resident or transient, and geography (Bigg et al. 1990, Ford et al. 1994). Killer whales in the Bering Sea are considered to be either from the eastern North Pacific northern resident stock or the eastern North Pacific transient stock (Ferrero et al. 2000). However, the 408 (CV = 41%; 95% CI = 185-904) killer whales calculated here cannot be distinguished as residents or transients. Behavioral, morphological, and genetics data are necessary to assess the difference, both of which require focused research including photo-identification. We did make two attempts at photo-identification, one for an on-effort sighting and one for an off-effort sighting. Interestingly, both were groups of three whales involved in predation on a marine mammal (one Dall's porpoise and one northern fur seal), which distinguishes them as transient killer whales. We found the killer whale distribution from this survey to be associated with the Alaska Peninsula and the Pribilof Islands, with scattered sightings around the 100 m depth contour of the shelf. However, because killer whales are highly mobile, and we do not know if their distribution changes among years, it is difficult to know whether the distribution reported here is typical. Our estimate of 408 (CV = 41%; 95% CI = 185-904) killer whales is comparable to the 414 (CV = 60%; 95% CI = 130–1,315) killer whales that Tynan (2001) estimated from a 1999 survey in the same region using the same survey platform, but much lower than her 1997 estimate of 5,333 (CV = 95%; 95% CI = 949–29,972). However, the imprecision of her 1997 estimate makes it difficult to compare.

The Dall's porpoise has been considered the most abundant cetacean species in the Bering Sea (Leatherwood et al. 1983) and this survey also supports that conclusion. The abundance estimate of 6,343 (CV = 26%; 95% = 3,833-10,497) is the largest estimate of the cetacean species found during our survey. Hobbs and Lerczak (1993) calculated an abundance estimate for Dall's porpoise (using data from 1987-1991) of 9,000 in the Bering Sea, but this was based on only three sightings and the CV (91%) and 95% confidence interval (1,960 - 41,400) are very large. Leatherwood et al. (1983) calculated Dall's porpoise density estimates from aerial surveys in 1982-1983. For survey blocks representing the Bering Sea shelf region, Dall's porpoise densities were 0.0023 (0.00173 -0.00287) individuals/km^2. This compares to densities calculated in our surveys of 0.0383 individuals/km^2 (95% CI = 0.0297–0.0494). It is likely that our estimate is higher due to the probability of sighting porpoise from a vessel vs. an aerial platform (more time to see surfacings), and the increase of Dall's porpoise sightings on ships due to their attraction to vessels. It is unknown whether our abundance estimate is comparable to historical Dall's porpoise abundance as no historical estimates are available. Dall's porpoise were primarily found in deep waters, with most sightings occurring in waters deeper than the 75 m isobath. Many were found over the shelf break.

Harbor porpoise in Alaska have been separated into three stocks: Southeast Alaska, Gulf of Alaska and the Bering Sea stocks (Ferrero et al. 2000). At this time, the population size of the Bering Sea stock is based only on an aerial survey in Bristol Bay conducted in 1991 (Dahlheim et al. 1999). Their uncorrected abundance estimate is 3,531 (CV = 24%; 95% CI = 2,206-5,651). Our estimate of 1,558 (CV = 24%; 95% CI = 982-2,473) is somewhat lower, but includes area with deeper waters where harbor porpoise are less likely to occur. Leatherwood et al. (1983) calculated harbor porpoise density estimates from aerial surveys in 1982-1983. For survey blocks representing the Bering Sea shelf region, harbor porpoise densities were 0.0038 (0.0027 - 0.0049) individuals/km^2. We calculated a density of 0.0242 (95% CI = 0.0041-0.0336). The higher density calculated in our study may indicate an increase in harbor porpoise abundance in the southeastern Bering Sea, although differences in survey platform, study area, and methods may account for some of the difference in porpoise density. Harbor porpoise were found primarily in shallow waters, mostly shallower than the 85 m isobath.

The opportunistic survey aboard the NOAA ship *Miller Freeman* provided a snapshot of fundamental information about cetacean populations in the southeastern Bering Sea. It appears that substantial numbers of fin whales, minke whales, killer whales, Dall's porpoise and harbor porpoise occur there. These preliminary abundance estimates provide a baseline for comparison to data we hope to obtain in subsequent surveys.

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Table 1. Number of marine mammal sightings and individuals observed during the survey aboard the NOAA ship *Miller Freeman* (including transit/training survey). Off effort sightings are in parentheses.

Species	Number of sightings	Number of individuals
Fin whales	48 (2)	123 (27)
Sei whales	3	4
Humpback whales	11 (1)	16 (1)
Gray whales	12	24
Minke whales	35	37
Baird's beaked whales	1	18
Killer whales	14 (1)	67 (3)
Pacific whitesided dolphins	2	10
Dall's porpoise	85 (2)	233 (4)
Harbor porpoise	53	68
Unidentified balaenopterid whales	10	10
Unidentified whales	9	10
Unidentified dolphin/porpoise	5	8
Steller sea lion	1	1
Northern fur seal	67	72
Harbor seal	10	11
Unidentified pinniped	2	2
Walrus	25	42
Sea otter	33	40

Table 2. Abundance estimates for fin whales, minke whales, killer whales, Dall's porpoise and harbor porpoise.

	Point Estimate	Standard error	% CV	95% Confidence Interval	
Fin Whales				(Upper)	(Lower)
Number of sightings	29				
Truncation distance (km)	6				
Effective strip width (km)	3.9	0.3	9	3.3	4.7
Sightings per km	0.0132	0.0036	27	0.0079	0.0222
Average group size	1.8	0.2	13	1.4	2.4
Animals per km^2	0.0030	0.0010	31	0.0017	0.0055
Estimated abundance	481	151	31	264	879
Minke Whales					
Number of sightings	19				
Truncation distance (km)	1				
Effective strip width (km)	0.7	0.1	20	0.4	1.0
Sightings per km	0.0087	0.0021	24	0.0055	0.0137
Average group size	1.0	0.04	4	1.0	1.07
Animals per km^2	0.0065	0.0020	31	0.0036	0.0119
Estimated abundance	1,036	322	31	567	1,891
Killer Whales					
Number of sightings [1]	11 (19)				
Truncation distance (km)	7.5				
Effective strip width (km)	4.4	0.7	15	3.2	6.1
Sightings per km	0.0050	0.0013	25	0.0031	0.0082
Average group size	4.5	1.3	28	2.4	8.4
Animals per km^2	0.0026	0.0011	41	0.0012	0.0057
Estimated abundance	408	167	41	185	904
Dall's Porpoise					
Number of sightings	84				
Truncation distance (km)	5				
Effective strip width (km)	1.3	0.3	20	0.9	1.9
Sightings per km	0.0383	0.0050	13	0.0297	0.0494
Average group size	2.7	0.3	11	2.2	3.4
Animals per km^2	0.0400	0.0104	26	0.0242	0.0662
Estimated abundance	6,343	1,648	26	3,833	10,497
Harbor Porpoise					
Number of sightings	53				
Truncation distance (km)	3.75				
Effective strip width (km)	1.6	0.2	14	1.2	2.1
Sightings per km	0.0242	0.0041	17	0.0174	0.0336
Average group size	1.3	0.1	10	1.1	1.6
Animals per km^2	0.0098	0.0023	24	0.0062	0.0156
Estimated abundance	1,558	371	24	981	2,473

[1] Number in parentheses is the number of sightings used to fit the detection function

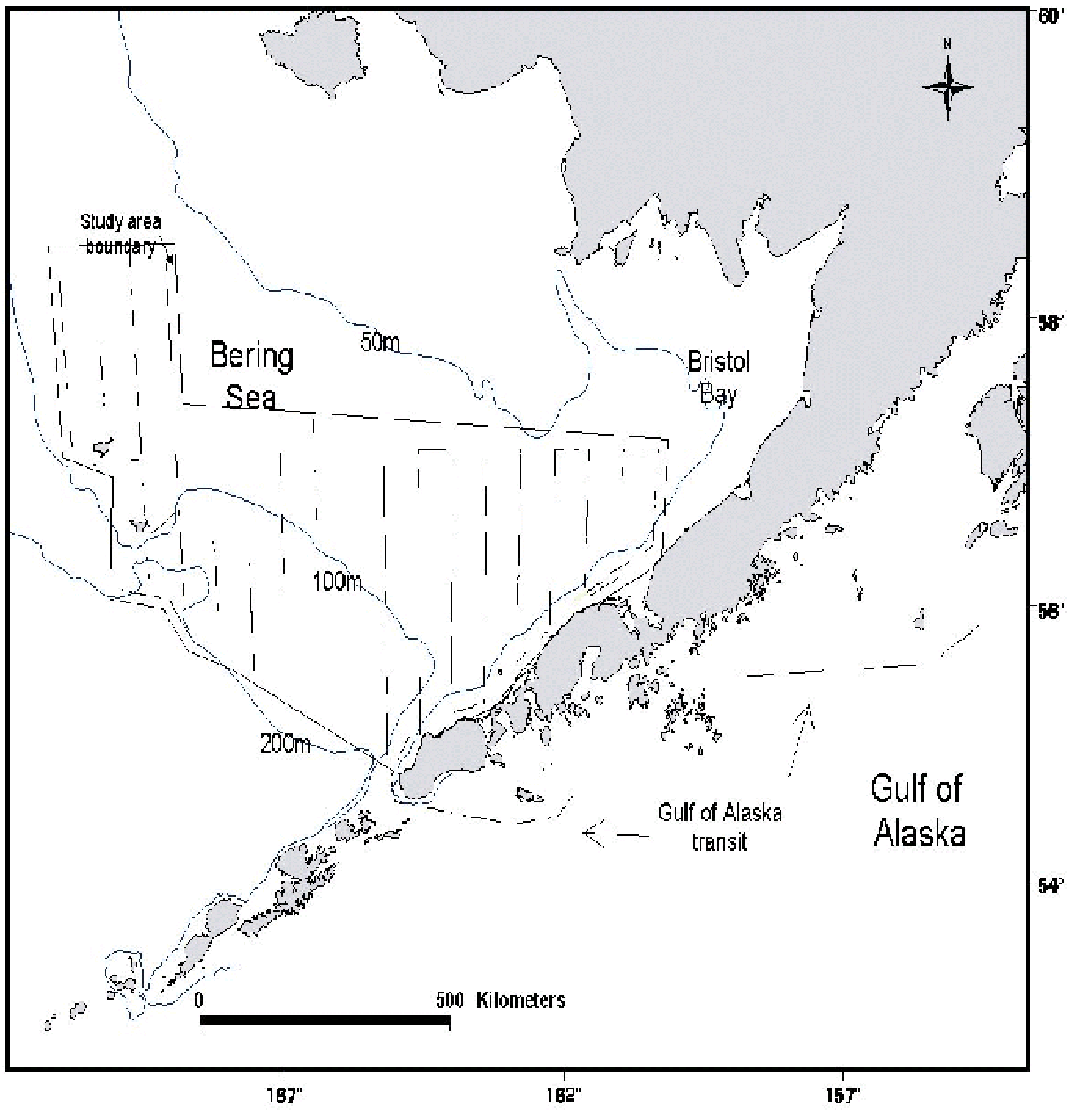

Figure 1. Completed trackline for the 2000 cetacean survey in the southeastern Bering Sea aboard the NOAA ship *Miller Freeman*.

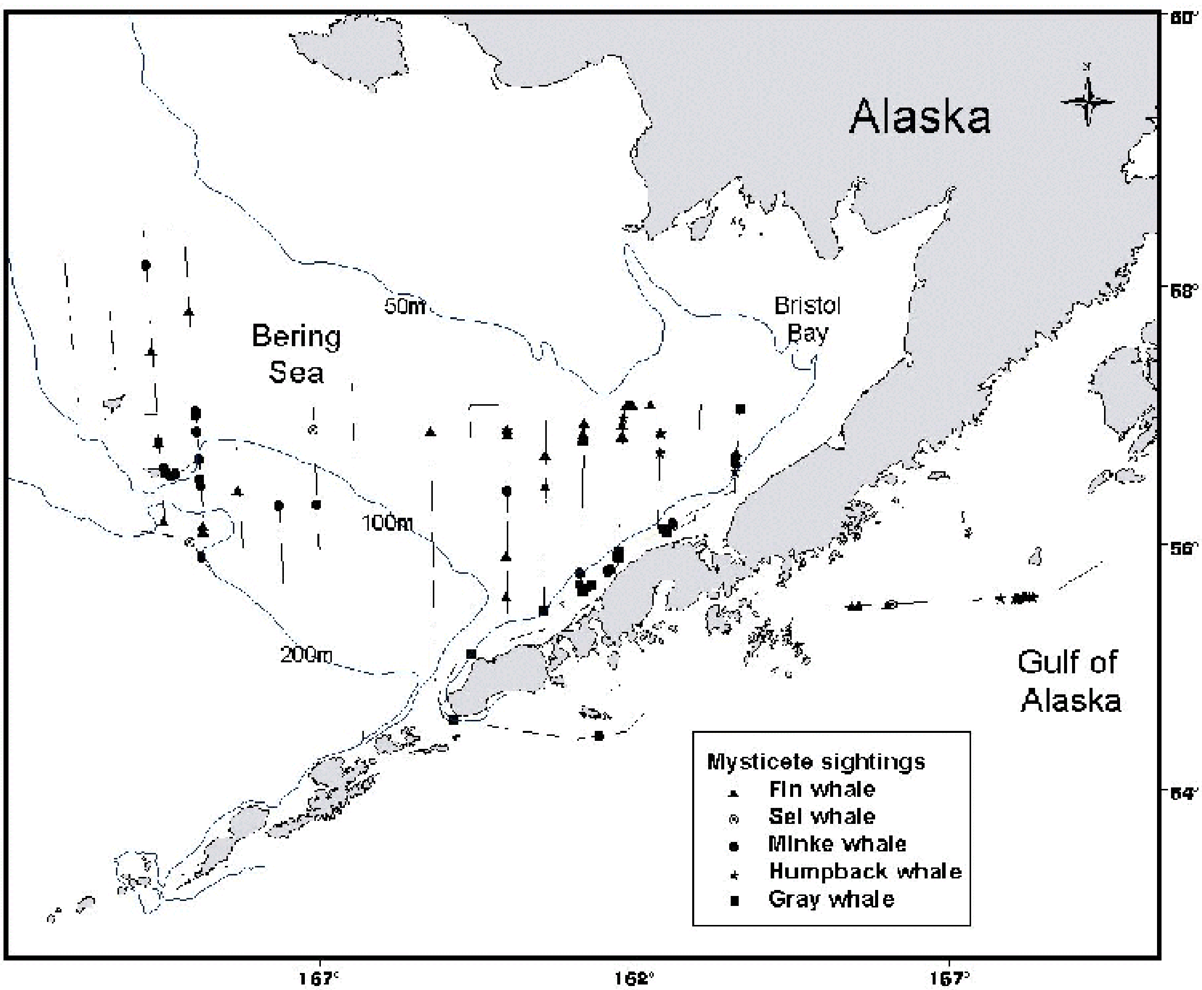

Figure 2. Mysticete whale sighting locations during the 2000 cetacean survey in the southeastern Bering Sea.

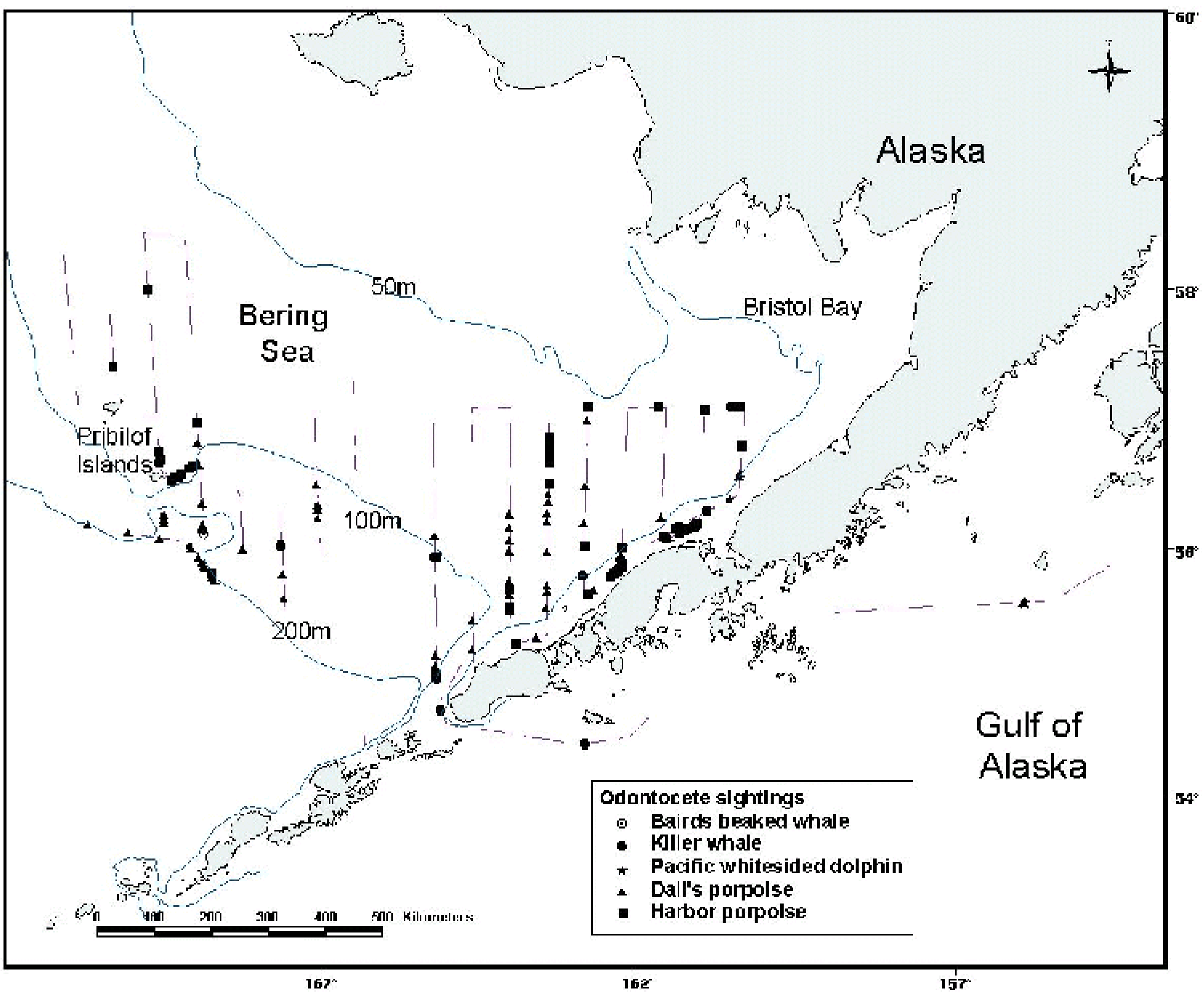

Figure 3. Odontocete sighting locations during the 2000 cetacean survey in the southeastern Bering Sea.

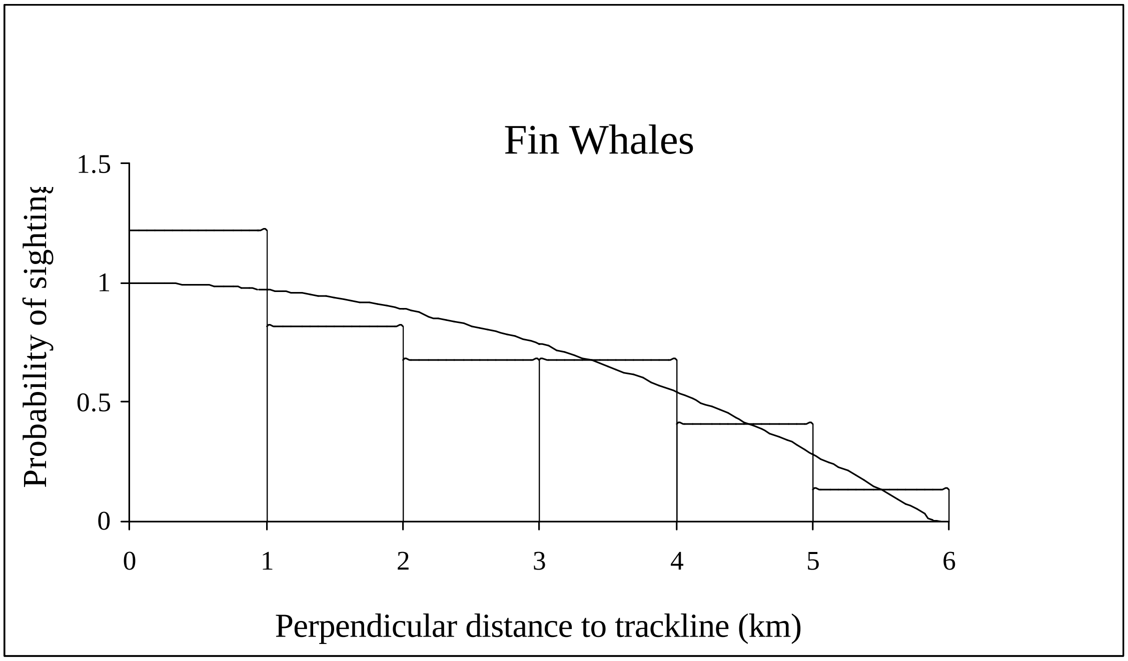

Figure 4. Distribution of perpendicular distances for fin whales with the best-fit detection function [G(x)] curve.

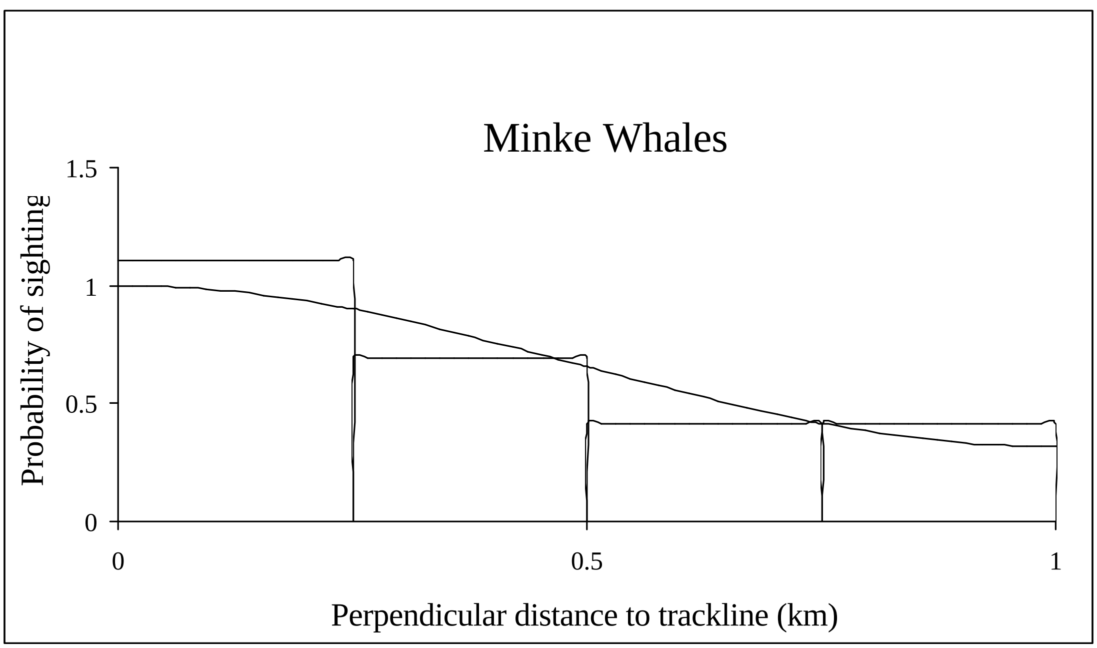

Figure 5. Distribution of perpendicular distances for minke whales with the best-fit detection function [G(x)] curve.

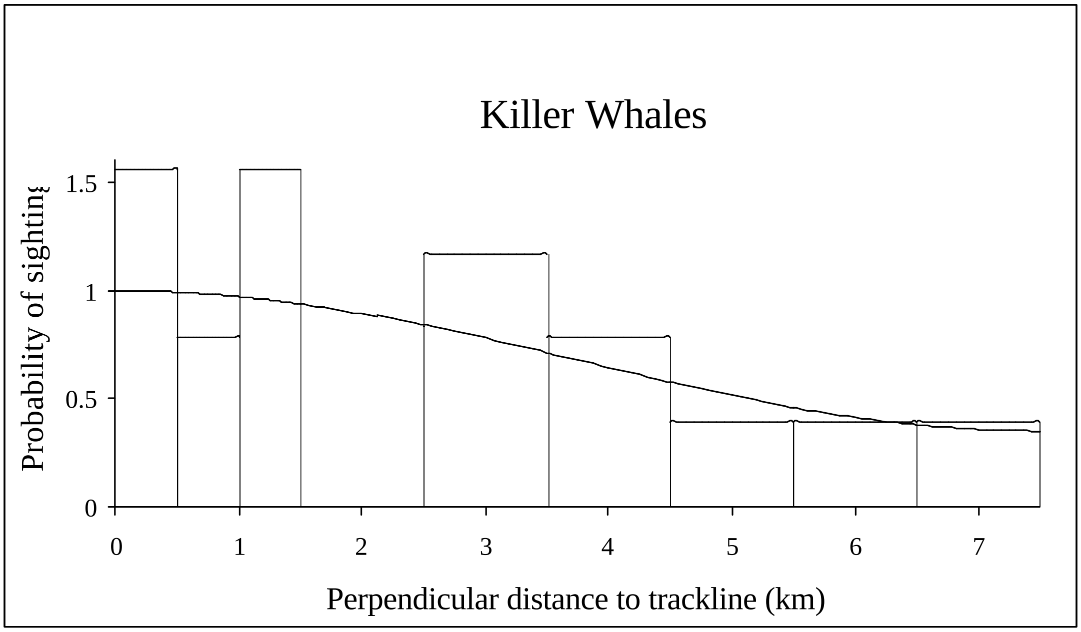

Figure 6. Distribution of perpendicular distances for killer whales with the best-fit detection function [G(x)] curve.

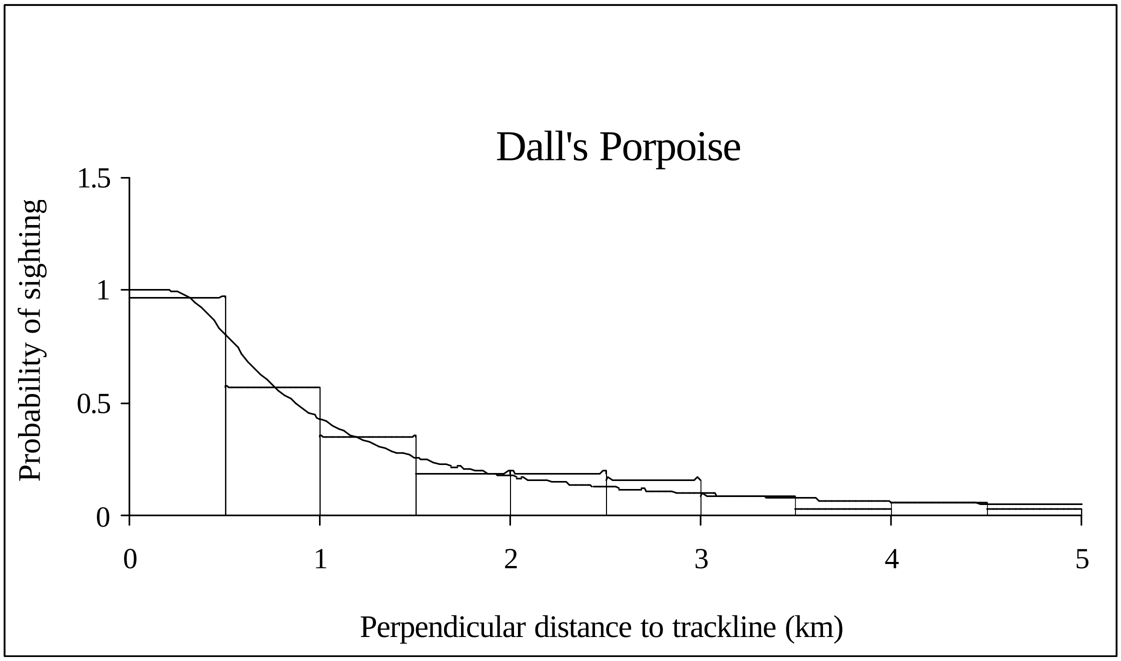

Figure 7. Distribution of perpendicular distances for Dall's porpoise with the best-fit detection function [G(x)] curve.

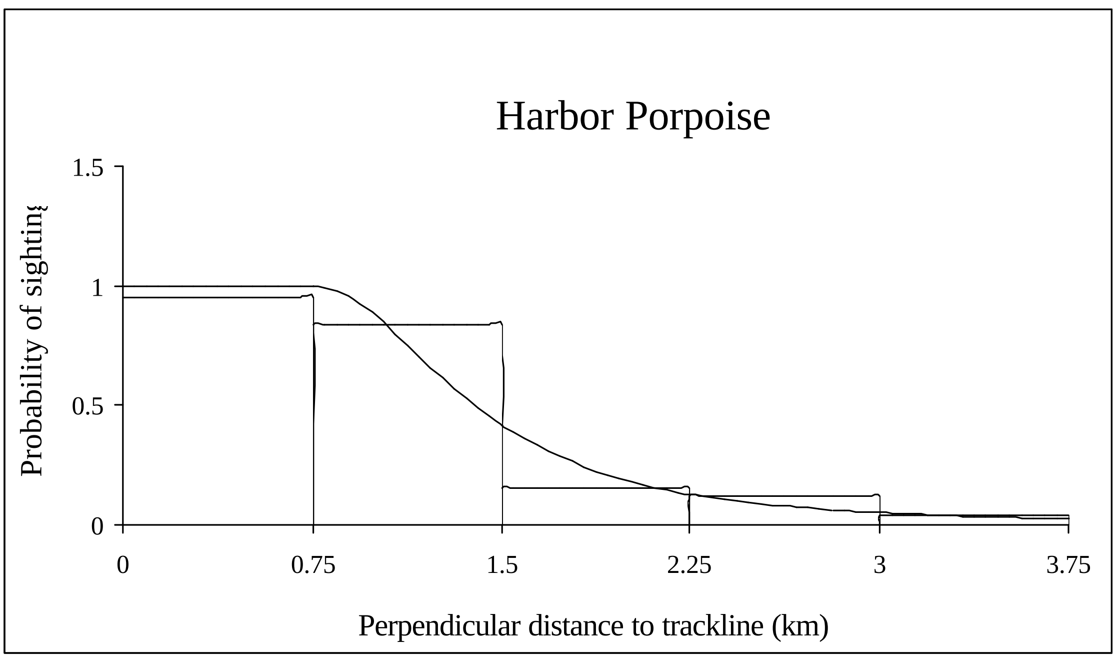

Figure 8. Distribution of perpendicular distances for harbor porpoise with the best-fit detection function [G(x)] curve.

REGIONAL MOVEMENTS OF GRAY WHALES OFF THE COASTS OF NORTHERN WASHINGTON AND SOUTHERN VANCOUVER ISLAND, 1996 - 2000

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Abstract

The National Marine Mammal Laboratory conducted gray whale (*Eschrichtius robustus*) surveys in the Strait of Juan de Fuca, and along the northern Washington coast, and southern Vancouver Island from 1996 to 2000. Most gray whales occurred off the northern Washington coast in 1996, in the Strait of Juan de Fuca in 1997, and off southern Vancouver Island in 1998. In 1999 and 2000, most whales were seen in the water off western and southern Vancouver Island. The largest number of photographically identified whales occurred in different areas in different years, in some cases changing by season within a year. Animals seen at least two years were more likely to be seen in several areas rather than in the same area. Since sites used by gray whales change, we should try to determine the broader home range of these animals.

Introduction

The eastern North Pacific stock of gray whales (*Eschrichtius robustus*) migrates between calving grounds in Baja California, Mexico and feeding grounds in the northern and western Bering Sea, Chukchi Sea, and western Beaufort Sea (Wolman 1985). Although the majority are feeding in the northern grounds from late May to October, a small but unknown portion of the stock remains in various locations along the west coast of North America. Summer sightings of gray whales have been reported from Mexican waters (Patten and Samaras 1977), off northern California (Mallonee

1991), off the Oregon coast (Sumich 1984), off the west side of Vancouver Island, Canada (Darling 1984), southeast Alaska (Calambokidis et at., 2000) and off Kodiak Island, Alaska (Kate Wynn, pers. comm.)

The northbound migration of gray whales through Washington and British Columbia waters occurs from March to May with a peak from mid-March to mid-April (Pike 1962). Gray whales have been seen in Washington waters throughout the year well outside the migratory period (Flaherty, 1983; Calambokidis et al. 1994). Photographic identification of these animals has revealed that some whales spend extended periods feeding in these waters and that some have returned to these areas numerous times over the past few years (Calambokidis et al. 1994; Calambokidis and Quan, 1997; Calambokidis and Schlender, 1998).

In 1996, the National Marine Mammal Laboratory (NMML) initiated a study of these local feeding aggregations to better understand the occurrence, distribution, and abundance of gray whales in northwest Washington waters where the Makah Tribe has resumed a subsistence hunt for these animals.

Methods

Gray whale surveys were conducted in three areas: Strait of Juan de Fuca, northern Washington coast, and southern Vancouver Island coast. The Strait of Juan de Fuca study area extended from Tatoosh Island at the northwest tip of Washington State to Sekiu (Fig. 1). On the northern Washington coast, the study area extended from Tatoosh Island south to Carroll Island. Off southern Vancouver Island, the study area extended from Port San Juan on the Canadian side of the Strait of Juan de Fuca north to Barkley Sound.

Surveys were conducted using two NOAA vessels: a 24 ft Almar (Aluminum Marine Company) powered by a 200 HP outboard and a 22 ft Boston Whaler powered by a 225 HP outboard. Both vessels were equipped with radio, radar, global positioning system (GPS) and depth sounder. A differential GPS and portable computer was set up inside the cabin of the Almar to record vessel position every 60 seconds. Position was recorded manually on the Boston Whaler.

Gray whale surveys were conducted at speeds between 10 and 15 kt approximately 1/4 to 1/2 nautical miles (nm) from the shoreline. In most cases, two people were on board searching for whale blows. Once whales were sighted and counted, the survey would be interrupted while the whales were approached to be photographed. After an adequate number of photographs were taken, the survey would be resumed. The time taken to photograph the whales was not included in the survey time. Whenever possible, the depth of the water in which whales were present as well as whale behavior was noted.

Photographs were taken from the Almar using a Nikon 8008 single-lens reflex camera equipped with a 300 mm lens. The camera used aboard the Whaler was a Canon EOS equipped with an 70-210 mm zoom lens. Fuji Neopan 1600 black and white print film was used in both cameras. The film was developed commercially, but the best photographs were cropped and reprinted at the National Marine Mammal Laboratory (NMML).

Gray whales were individually identified by Cascadia Research based on photographs of the natural markings on the right and left sides of the whale, especially in the vicinity of the dorsal hump. Custom prints were made of the best photographs of individuals in each sighting. All photographs were compared by at least two matchers. An independent aid to matching was used as a final check that was based on the relative spacing between the knuckles along the dorsal ridge behind the dorsal hump. All photographs for each year were compared internally and then compared to a catalog of gray whales identified in Washington State and British Columbia in past years maintained by Cascadia Research (Calambokidis et al. 1994).

The identifications of gray whales photographed in 2000 which were checked with Cascadia Research's catalog were just recently received and have not yet been analyzed.

Results

Survey Effort

In 1996, NMML conducted gray whale surveys covering 816 nm, representing 91 hr of survey effort. These numbers increased to 1,821 nm and 195 hr in 1997 and peaked at 2,594 nm and 228 hr in 1998. Survey effort decreased to 2,001 nm and 150 hr in 1999 and to 1,397 nm and 125 hr in 2000. The monthly effort by area is given in Tables 1 to 5.

Gray Whale Sightings

Whenever a gray whale was seen during a survey, it was recorded as a sighting. Although an attempt was made to get close enough to the whale for a photographic identification, this was not always successful. Furthermore, the identification of the whale was usually not made for several weeks or even until the end of the season. Consequently, multiple sightings of the same whale occurred. For example, whale number 187 was sighted 11 times from 24 July 1998 to 18 November 1998 all on the northern Washington coast. Although this was just one whale, it was listed as 11 sightings.

In 1996, most (88%) of the whale sightings occurred off the northern Washington coast. These were greatest in August and September (Table 1). However, the area of concentration changed in 1997 when 70% of the sightings occurred in the Strait of Juan de Fuca. Gray whales were consistently sighted in the Strait from June to September (Table 2).

In 1998, the distribution of gray whales was mixed between southern Vancouver Island (44%), the northern Washington coast (30%), and the Strait of Juan de Fuca (25%). Gray whales were present in greatest numbers from July to September in both southern Vancouver Island and the northern Washington coast (Table 3). In the Strait of Juan de Fuca, the greatest number were sighted in October and November.

In 1998, six surveys were also conducted in offshore waters (5 to 15 nm off the northern Washington coast) in fall and early winter in an attempt to detect southbound migrating gray whales. Only one gray whale was sighted.

In 1999, the study area was expanded to the northwest of Barkley Sound along the west coast of Vancouver Island. In addition, the northern end of Vancouver Island and the area up to Cape Caution on the British Columbia mainland was surveyed. (This area is referred to as part of northern British Columbia although it is more central British Columbia). A large number of whales were sighted along west Vancouver Island (51%) from Clayoquot Sound to Esperanza Inlet when it was surveyed in August and September. Around 25% of the gray whales were sighted along southern Vancouver Island (Table 4).

In 2000, the study area extended along the west coast of Vancouver Island to Nootka Island. The majority (44%) of gray whales were sighted along western Vancouver Island, while 25% were sighted along southern Vancouver Island (Table 5). Sightings in the Strait of Juan de Fuca comprised 17%, while that along the northern Washington coast was 15%.

The total number of surveys, number of hours surveyed, distance covered, and whales sighted for each year by area is given in Table 6. The number of gray whales sighted was divided by the number of nautical miles surveyed and also by the number of hours surveyed to provide a measure of relative density of whales in each area. These numbers are represented in Figures 2 and 3 as whales seen per nautical mile and per hour.

In both representations, the relative density of whales was greatest off the northern Washington coast in 1996, in the Strait of Juan de Fuca in 1997, and off southern Vancouver Island in 1998. In 1999, the relative density of whales along the coasts of southern Vancouver Island and west Vancouver Island appeared to be very similar (Figs. 2 and 3).

Movements of Identified Whales

The number of whales sighted is typically larger than the number of whales present because sometimes the same whales are sighted several times. Table 7 shows the number of whales sighted, the number photographed, and the number of identified individual whales. In 1996, 101 gray whales were sighted and 34 were photographed. From these photographs, only 18 individual gray whales were identified. Similarly, 28 individual gray whales were identified in 1997, 54 in 1998, and 72 in 1999.

The areas where these individually identified whales were seen each year is given in Table 8. Only the northern Washington coast, Strait of Juan de Fuca, and southern Vancouver Island coast were used because only those areas had comparable sighting effort from 1996 to 1999. The number of identified gray whales for 1999 decreased to 24 when the whales identified in western Vancouver Island and northern British Columbia were excluded. The sightings of identified whales were divided into summer (June to August) sightings in Table 9 and fall (September to November) sightings in Table 10.

In 1996, one-half of the identified gray whales were on the northern Washington coast and an additional 17% moved between the coast and the Strait of Juan de Fuca (Table 8). Their presence on the Washington coast was not only high in the summer, but persisted into the fall (Tables 9 and 10).

Although many identified individual whales occurred in the Strait in 1997, there was a significant movement of animals between the Strait and the northern Washington coast in the summer (Table 9). In the fall of 1997, most (61%) of the identified whales occurred in the Strait (Table 10).

In the summer of 1998, almost 62% of the identified gray whales occurred off southern Vancouver Island. A significant number occurred off the northern Washington coast (26%) and 10% of the whales moved between the two areas (Table 9). In the fall of 1998, the whales appeared to be evenly distributed between the three areas (Table 10).

Since western Vancouver Island had not been surveyed by NMML before 1999, the number of identified gray whales in this area could not be compared with previous years. The remaining data showed that most of the identified gray whales occurred off southern Vancouver Island in the summer of 1999 (Table 9). In the fall, most of the whales occurred off the northern Washington coast (Table 10).

Movements Between Areas

Although Table 8 shows the number of identified animals seen in only one area and those moving between areas, it is biased towards the former because it contains animals which were only sighted once. A better estimate of the magnitude of movement between areas was obtained by pooling all identified gray whales which were sighted over at least two years (Table 11). Of the 31 whales, 6 (19%) were only seen in one area. Twenty-five whales (81%) were seen in more than one area.

Another example is the resightings of the 18 gray whales which were identified in 1996 (Table 12). Of these 18 whales, 15 (83%) were resighted in subsequent years. Only three whales were seen only in 1996 and were not seen again during all the surveys conducted from 1997 to 1999.

Of the 18 whales, ten were resighted in 1997, ten in 1998, and 13 in 1999. The number increased in 1999 because the study area was increased to include western Vancouver Island. Half of the original 18 whales were seen in western Vancouver Island in 1999. Six of these animals were seen only in the western Vancouver Island area in 1999.

The three whales which were only seen in 1996 were all seen only on the northern Washington coast. One additional whale (No. 174) was seen on the northern Washington coast in both 1996 and 1997. All of the remaining 14 whales (78%) visited different areas from 1996 to 1999.

Discussion

Concentrations of gray whales off the northern Washington coast, in the Strait of Juan de Fuca, and off southern Vancouver Island occur in different areas in different years. Changes in distribution patterns even occurred between seasons during the same year. Darling et al. (1998) found that gray whales off Vancouver Island used different locations and habitats at different times within one season and from year to year based on the different prey species upon which they were feeding.

Gray whales were present in different areas within the same year as well as visited different areas between years. They appear to roam between areas rather than to return year after year to specific areas. Rather than thinking of certain areas as gray whale habitat, we should think in terms of the home range of these feeding aggregations.

Resighting identified whales also has its problems. When an animal is not resighted, it is not known whether the animal has left the study area or was missed during the survey. Expanding the study area to include western Vancouver Island in 1999 resulted in a large number of resights and identifications of new whales. Some gray whales identified in 1998 in northern California, Oregon, and southeast Alaska had previously been identified in Washington waters and off southern Vancouver Island (Calambokidis et al., 2000) which suggests a much larger home range.

Darling (1984) found that some gray whales returned annually to Vancouver Island waters, while others spent only one summer there. He speculated that the animals that did not return had joined the full migration.

Surveys need to be carried out over many years to generate the information needed concerning the return of gray whales to specific areas.

The home range of Pacific coast gray whales may be too large for NMML to survey alone. Identifying the home range of gray whales can be accomplished in the future through the cooperation of all gray whale researchers in other areas.

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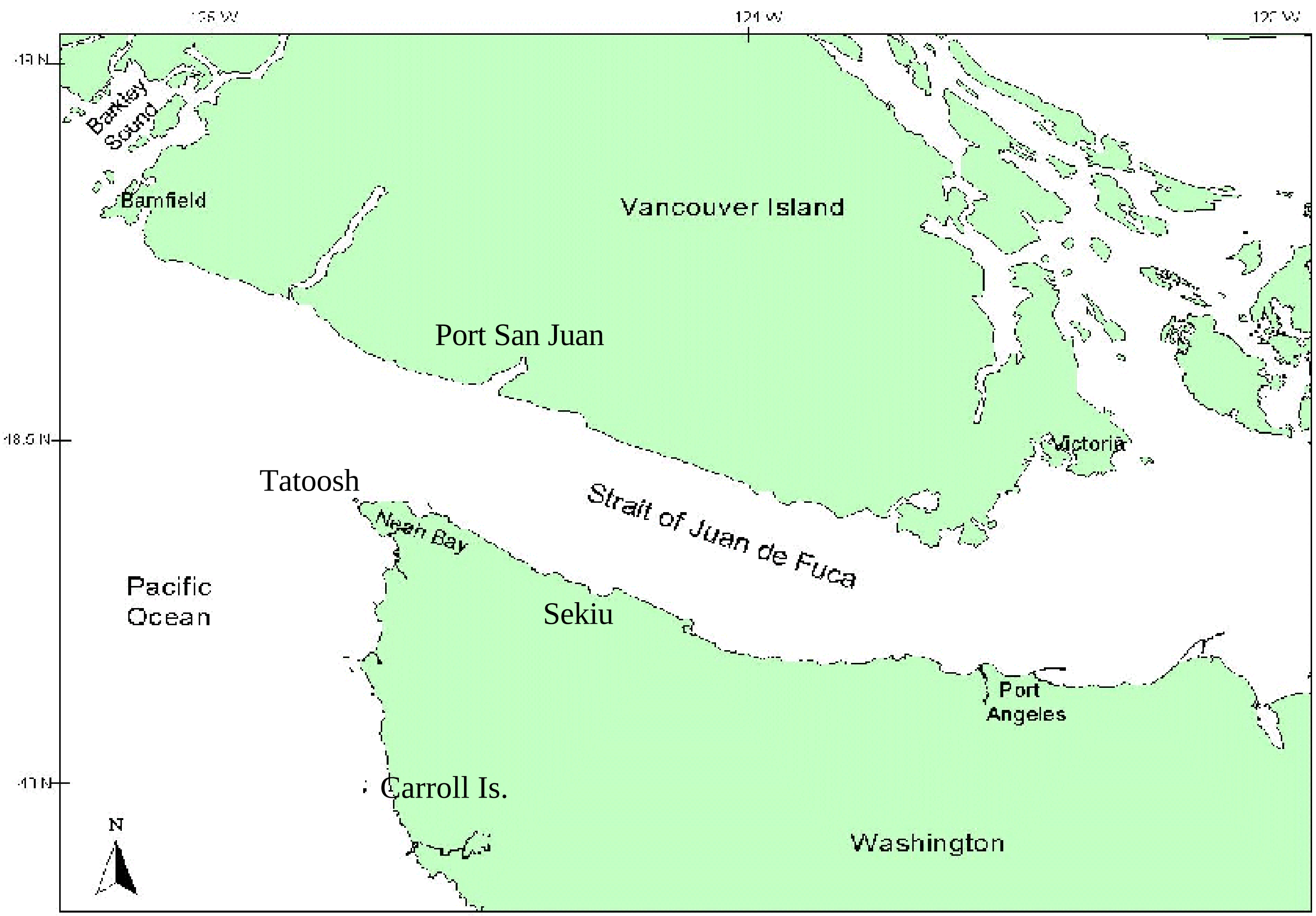

Figure 1. Gray whale survey area.

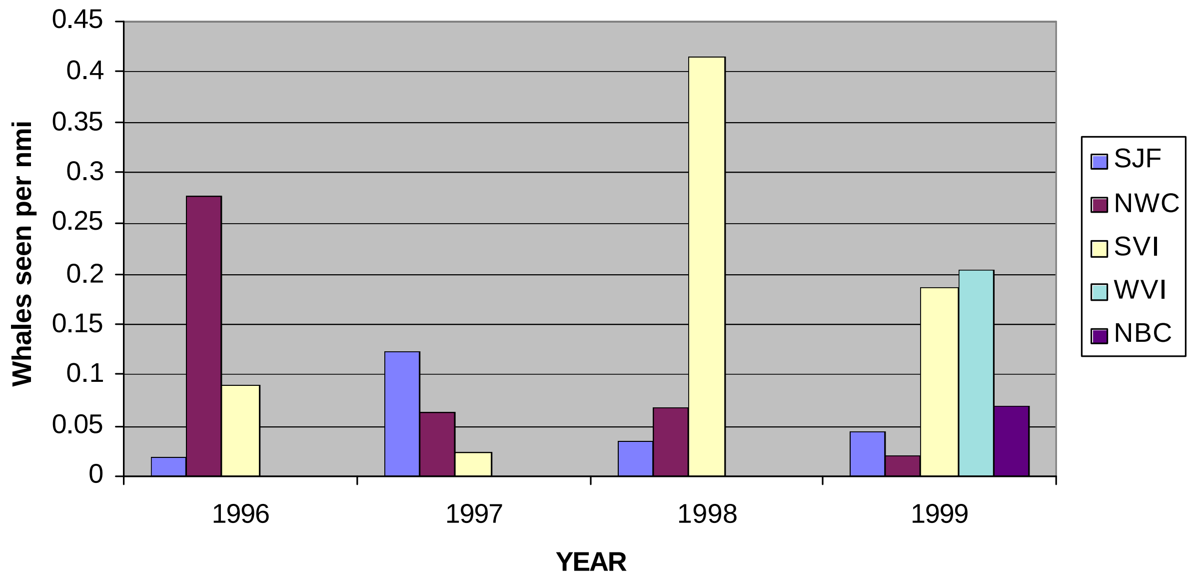

Figure 2. Number of gray whales sighted per nautical mile.

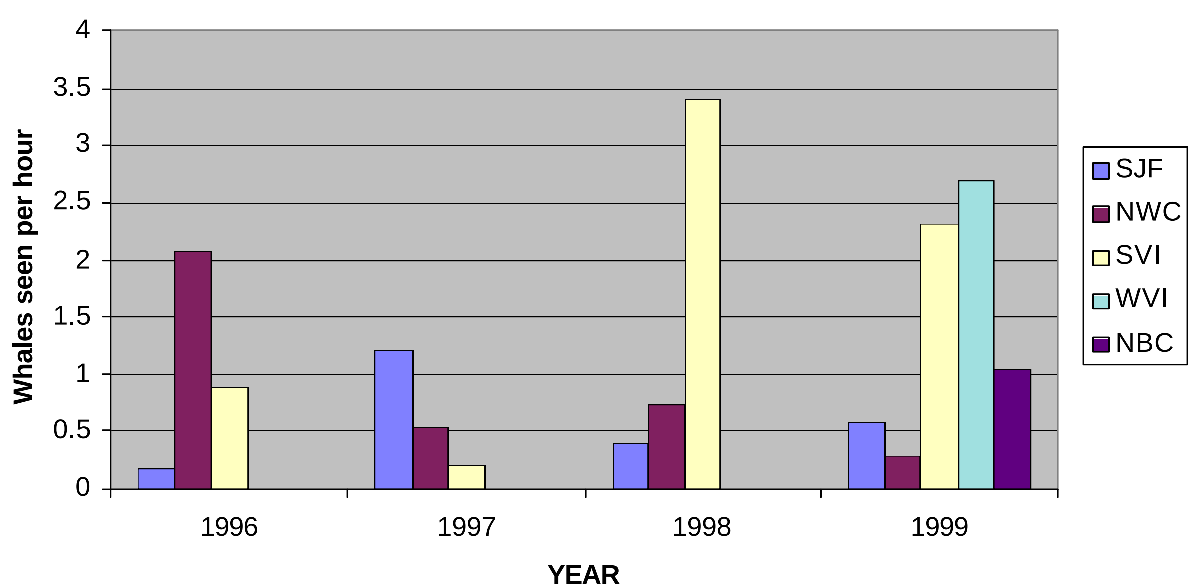

Figure 3. Number of gray whales sighted per hour.

Table 1. 1996 Gray whale surveys by month

	JUNE	JULY	AUGUST	SEPT	OCT	NOV	TOTAL
Strait of Juan de Fuca	3						
No. of Surveys:		11	12	11	1	1	39
No. of Hours:	5.97	17.26	10.49	7.38	0.50	2.08	43.68
No. of Nautical miles:	52.0	152.0	111.5	102.0	6.0	27.0	450.5
No. of Whales sighted:	**3**	**2**	**1**	**2**	**0**	**0**	**8**
Northern WA Coast							
No. of Surveys:	1	7	8	8	0	0	24
No. of Hours:	3.58	10.86	15.15	13.23			42.82
No. of Nautical miles:	31.8	91.0	93.0	105.5			321.3
No. of Whales sighted:	**0**	**2**	**20**	**67**			**89**
South Vancouver Is.							
No. of Surveys:	0	1	0	1	0	0	2
No. of Hours:		2.88		1.67			4.55
No. of Nautical miles:		24.0		20.0			44.0
No. of Whales sighted:		**4**		**0**			**4**
Total Surveys:	4	19	20	20	1	1	65
Total Hours:	9.55	31.00	25.64	22.28	0.50	2.08	91.05
Total Nautical Miles:	83.8	267.0	204.5	227.5	6.0	27.0	815.8

Total Whales Sighted:	**3**	**8**	**21**	**69**	**0**	**0**	**101**

Table 2. 1997 Gray whale surveys by month

	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	TOTAL
Strait of Juan de Fuca No. of Surveys:	1	6	12	13	16	8	1	57
No. of Hours:	2.33	9.93	21.30	18.35	24.92	14.00	2.62	93.45
No. of Nautical miles:	15.2	63.2	219.1	207.0	235.0	141.7	39.0	920.2
No. of Whales sighted:	**2**	**15**	**27**	**29**	**36**	**4**	**0**	**113**
Northern WA Coast No. of Surveys:	1	3	5	7	8	2	1	27
No. of Hours:	2.33	7.42	19.47	17.85	25.77	6.12	2.42	81.37
No. of Nautical miles:	18.0	73.6	142.3	166.5	211.8	80.0	24.0	716.2
No. of Whales sighted:	**0**	**1**	**5**	**27**	**12**	**0**	**0**	**45**
South Vancouver Is. No. of Surveys:	0	1	1	0	4	2	0	8
No. of Hours:		0.67	3.00		10.67	5.48		19.82
No. of Nautical miles:		11.0	19.0		102.1	53.0		185.1
No. of Whales sighted:		**0**	**1**		**2**	**1**		**4**
Total Surveys:	2	10	18	20	28	12	2	92
Total Hours:	4.67	18.02	43.77	36.20	61.35	25.60	5.03	194.63

Total Nautical Miles:	33.2	147.8	380.4	373.5	548.9	274.7	63.0	1821.5
Total Whales Sighted:	**2**	**16**	**33**	**56**	**50**	**5**	**0**	**162**

Table 3. 1998 Gray whale surveys by month

	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	TOTAL
Strait of Juan de Fuca No. of surveys:	14	11	12	13	16	9	2	2	79
No. of hours:	16.58	11.16	21.47	20.25	24.66	16.25	4.00	3.36	117.73
No. of nautical miles:	184.7	117	248	251.4	295.75	196	62	40	1394.85
No. of whales sighted:	0	0	1	2	32	12	0	0	47
Northern Washington Coast No. of surveys:	11	8	7	8	4	3	0	1	42
No. of hours:	16.34	14.06	14.19	13.42	7.07	7.23	0	2.5	74.81
No. of nautical miles:	184	154.5	156.75	142.0	96	78	0	28	839.25
No. of whales sighted:	1	15	9	18	8	5	0	0	56
Off-shore No. of surveys:	-	-	-	-	4	1	-	1	6
No. of hours:					7.39	3		1.5	11.89
No. of nautical miles:					114	26		23	163
No. of whales sighted:					0	1		0	1
South Vancouver Island No. of surveys:	-	4	3	4	-	-	-	-	11

No. of hours:		9.87	8.63	5.57					24.07
No. of nautical miles:		74.25	76.25	46					196.50
No. of whales sighted:		46	16	20					82
	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	TOTAL
Total Surveys:	25	23	22	25	24	13	2	4	138
Total Hours:	32.92	35.09	44.29	39.24	39.12	26.48	4.00	7.36	228.50
Total Nautical Miles:	368.7	345.8	481.0	439.4	505.8	300.0	62.0	91.0	2593.7
Total Whales Sighted:	1	61	26	40	40	18	0	0	186

Table 4. 1999 Gray whale surveys by month

	JUNE	JULY	AUGUST	SEPT	OCT	NOV	TOTAL
Strait of Juan de Fuca							
No. of Surveys:	4	8	6	3	7	5	33
No. of Hours:	2.75	9.00	5.38	2.53	8.78	6.28	34.72
No. of Nautical miles:	43.5	112.0	69.0	41.0	109.5	87.0	462.0
No. of Whales sighted:	0	1	3	2	10	4	20
Northern WA Coast							
No. of Surveys:	3	5	3	3	3	2	19
No. of Hours:	6.68	9.88	11.20	7.63	9.35	4.28	49.02
No. of Nautical miles:	89.5	135.5	109.0	114.0	136.0	80.0	664.0
No. of Whales sighted:	1	0	2	6	3	2	14
South Vancouver Is.							
No. of Surveys:	1	1	4	2			8
No. of Hours:	3.08	2.85	11.41	3.33			20.67
No. of Nautical miles:	35.0	35.0	137.0	50.0			257.0
No. of Whales sighted:	8	15	24	1			48
West Vancouver Is.							
No. of Surveys:			6	2			8
No. of Hours:			24.84	11.17			36.01
No. of Nautical miles:			316.0	160.0			476.0

No. of Whales sighted:			63	34			97
	JUNE	JULY	AUGUST	SEPT	OCT	NOV	TOTAL
North. British Columbia No. of Surveys:			2				2
No. of Hours:			9.51				9.51
No. of Nautical miles:			142				142
No. of Whales sighted:			10				10
Total Surveys:	8	14	21	10	10	7	70
Total Hours:	12.51	21.73	62.34	24.66	18.13	10.56	149.93
Total Nautical Miles:	168.0	282.5	773.0	365.0	245.5	167.0	2001.0
Total Whales Sighted:	9	16	102	43	13	6	189

Table 5. 2000 Gray whale surveys by month

	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	TOTAL
Strait of Juan de Fuca No. of Surveys:	6	5	6	1	3	8	3	32
No. of Hours:	9.5	4.65	6.34	2.37	2.0	10.53	4.82	40.21
No. of Nautical miles:	133	68	101	36	24	117.4	52.5	531.9
No. of Whales sighted:	6	1	2	0	2	5	0	16
Northern WA Coast No. of Surveys:	1	4	4		2	3	1	15
No. of Hours:	2.5	6.03	8.63		6.0	10.37	2.0	35.53
No. of Nautical miles:	40	80	107		44	100	16	387
No. of Whales sighted:	1	0	1		2	13	1	18
South Vancouver Is. No. of Surveys:				2	3			5
No. of Hours:				2.87	11.5			14.37
No. of Nautical miles:				46	110			156

No. of Whales sighted:				8	23			31
West Vancouver Is. No. of Surveys:				4	2			6
No. of Hours:				9.62	17.0			26.62
No. of Nautical miles:				114	136			250
No. of Whales sighted:				34	20			54
	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	TOTAL
Total Surveys:	7	9	10	7	10	11	4	58
Total Hours:	12.0	10.68	14.97	14.86	36.5	20.9	6.82	116.73
Total Nautical Miles:	173	148	208	196	314	217.4	68.5	1324.9
Total Whales Sighted:	7	1	3	42	47	18	1	119

Table 6. Summary of NMML Vessel Surveys from Neah Bay from 1996 to 2000.

YEAR	AREA	NO. OF SURVEYS	DISTANCE (n.miles)	DURATION (hours)	WHALES SIGHTED	Whales per n.mi	Whales per hr
1996	Strait of Juan de Fuca	39	450.5	43.68	8 (7.9%)	0.018	0.18
	Northern Washington Coast	24	321.3	42.82	89 (88.1%)	0.277	2.08
	South Vancouver Island	2	44.0	4.55	4 (4.0%)	0.091	0.88
	TOTAL	65	815.8	91.05	101	0.124	1.11
1997	Strait of Juan de Fuca	57	920.2	93.45	113 (69.8%)	0.123	1.21
	Northern Washington Coast	27	716.2	81.37	45 (27.8%)	0.063	0.55
	South Vancouver Island	8	185.1	19.82	4 (2.5%)	0.022	0.20
	TOTAL	92	1821.5	194.64	162	0.089	0.83
1998	Strait of Juan de Fuca	79	1394.9	117.73	47 (25.3%)	0.034	0.40
	Northern Washington Coast	42	839.3	74.81	56 (30.1%)	0.067	0.75
	Offshore	6	163.0	11.89	1 (0.5%)	0.006	0.08
	South Vancouver Island	11	196.5	24.07	82 (44.1%)	0.416	3.41

	TOTAL	138	2593.7	228.49	186	0.072	0.81

	AREA	NO. OF SURVEYS	DISTANCE (n. miles)	DURATION (hours)	WHALES SIGHTED	Whales per n. mi	Whales per hour
1999	Strait of Juan de Fuca	33	462.0	34.72	20 (10.6%)	0.043	0.58
	Northern Washington Coast	19	664.0	49.02	14 (7.4%)	0.021	0.29
	South Vancouver Is	8	257.0	20.67	48 (25.4%)	0.187	2.32
	West Vancouver Is	8	476.0	36.01	97 (51.3%)	0.204	2.69
	Northern British Columbia	2	142.0	9.51	10 (5.3%)	0.070	1.05
	TOTAL	70	2001.0	149.93	189	0.094	1.26
2000	Strait of Juan de Fuca	34	587.4	45.71	21	0.0358	0.4594
	Northern Washington Coast	15	403.0	38.53	18	0.0447	0.4672
	South Vancouver Is	5	156.3	14.37	31	0.1984	2.1573
	West Vancouver Is	6	250.0	26.62	54	0.2160	2.0285
	TOTAL	60	1396.7	125.23	124	0.0888	0.9902

Table 7. Gray whale photo-identifications.

YEAR	NO. SIGHTED	NO. PHOTOGRAPHED	NO. OF INDIVIDUALS
1996	101	34	18
1997	162	122	28
1998	186	146	54
1999	189*	186	72
2000	124*	103	-

* Does not include northern Puget Sound surveys

Table 8 . Occurrence of identified gray whales by area by year.

	NWC only	SJF only	SVI only	NWC & SJF	NWC & SVI	SJF & SVI	NWC&SJF&SVI	Total
1996	9 (50.0%)	2 (11.1%)	4 (22.2%)	3 (16.7%)	0	0	0	18 (100%)
1997	6 (21.4%)	10 35.7%)	1 (3.6%)	10 (35.7%)	1 (3.6%)	0	0	28 (100%)
1998	13 (24.1%)	10 (18.5%)	24 (44.4%)	0	5 (9.3%)	1 (1.9%)	1 (1.9%)	54 (100%)
1999	5 (20.8%)	1 (4.2%)	13 (54.2%)	0	2 (8.3%)	3 (12.5%)	0	24 (100%)
All Years	10 (13.5%)	15 (20.3%)	21 (28.4%)	8 (10.8%)	9 (12.2%)	3 (4.1%)	8 (10.8%)	74 (100%)

Table 9. Summer occurrence of identified gray whales by area by year.

	NWC only	SJF only	SVI only	NWC&SJF	NWC&SVI	SJF&SVI	Total
1996	5 (38.5%)	2 (15.4%)	4 (30.8%)	2 (15.4%)	0	0	13 (100%)
1997	5 (23.8%)	7 (33.3%)	0	8 (38.1%)	1 (4.8%)	0	21 (100%)
1998	10 (25.6%)	1 (2.6%)	24 (61.5%)	0	4 (10.3%)	0	39 (100%)
1999	2 (9.5%)	1 (4.8%)	16 (76.2%)	0	0	2 (9.5%)	21 (100%)

Table 10. Fall occurrence of identified gray whales by area by year.

	NWC only	SJF only	SVI only	NWC&SJF	NWC&SVI	SJF&SVI	Total
1996	6 (75.0%)	1 (12.5%)	0	1 (12.5%)	0	0	8 (100%)
1997	4 (22.2%)	11 (61.1%)	1 (5.6%)	2 (11.1%)	0	0	18 (100%)
1998	7 (25.0%)	10 (35.7%)	10 (35.7%)	1 (3.6%)	0	0	28 (100%)
1999	6 (60.0%)	3 (30.0%)	1 (10.0%)	0	0	0	10 (100%)

Table 11. Number of identified gray whales sighted in each area.

	NWC only	SJF only	SVI only	NWC & SJF	NWC & SVI	SJF & SVI	NWC, SJF & SVI	TOTAL
Number of whales	2	0	4	7	8	2	8	31
Percentage	6.5%	0	12.9%	22.6%	25.8%	6.5%	25.8%	100%

Table 12. Number of times the 18 gray whales identified in 1996 were resighted in each area.

	1996			1997			1998			1999					
ID #	NWC	SJF	SVI	NWC	SJF	SVI	NWC	SJF	SVI	NWC	SJF	SVI	WVI	NBC	TOTAL
37			1				1						1		3
41			1						2			1		1	5
68	5				3										8
80	4	1							5	2		1			13
83	1			1			1						1		4
87	1												1		2
88	1														1
92			1	1			1		3			1	3		10
145	1														1
166		1		2	2		2					2			9
174	1			3											4
175	3	2		1	7		3						3		19
178		1		1	4								1		7
185	1			1	7						4	1	1		15
186			1						1				1		3
187	1	2		2	2		11					2	1		21
210	2														2
212	2				3				5			2			12

ABUNDANCE AND DISTRIBUTION OF HARBOR SEALS (*Phoca vitulina*) IN BRISTOL BAY AND ALONG THE NORTH SIDE OF THE ALASKA PENINSULA DURING 2000

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Abstract

Minimum population estimates were obtained for harbor seals, (*Phoca vitulina)*, in Bristol Bay and along the north side of the Alaska Peninsula during August molt surveys in 2000. Surveys were divided into three zones; Zone 1 from Unimak Pass to Port Moller, Zone 2 from Port Moller to Kvichak Bay, and Zone 3 from Nushagak Bay to Goodnews Bay. Zone 1 is a new survey area which was not censussed in our surveys in 1990 or 1995. The mean number of seals counted in Zone 1 was 2,452 (95% confidence interval between 1,966 and 2,937). The CV of the mean was equal to 10.02%. Most of the seals were located in the Izembek Lagoon National Wildlife Refuge. Zone 2 data was not included since counts from ADF&G are not complete. The mean number of seals counted in Zone 3 was 1,164 (95% confidence interval between 1,030 and 1,299). The CV of the mean was equal to 5.84%. In Zone 3, observers counted 209 (18%) more seals in 2000 than in 1995.

Introduction

Background

Declines in harbor seal, *Phoca vitulina richardsi*, abundance have been observed in several locations throughout Alaska (e.g., Pitcher 1990). Amendments to the Marine Mammal Protection Act (April 30, 1994, Public Law 103-238) required the Secretary of Commerce to reduce the overall mortality and serious injury to marine mammals caught incidental to commercial fisheries, to levels below a zero mortality rate goal. In order to evaluate the status of incidentally caught marine mammals, certain key parameters are required for each stock. These parameters include an estimate of population size and CV of abundance, net productivity rates, and current takes by commercial fisheries and subsistence hunters. The purpose of our study is to provide an estimate of the population size of seals throughout Alaska.

Harbor seals range from throughout coastal Alaska from southern Kuskokwim Bay southward (Frost et al. 1982). We have arbitrarily subdivided the state into five regions for census purposes: northern southeast Alaska, southern southeast Alaska, the Gulf of Alaska (from Prince William Sound to the Shumagin Islands), the Aleutian Islands, and the north side of the Alaska Peninsula to southern Kuskokwim Bay. These regions roughly follow the putative stock management areas, but logistical constraints were also considered. The National Marine Mammal Laboratory (NMML), with funding from the NMFS Office of Protected Resources, has censused each of these regions twice since 1991: Loughlin (1992) [Bristol Bay, Prince William Sound, and Copper River Delta], Loughlin (1993) [Gulf of Alaska and Prince William Sound], Loughlin (1994) [Southeastern Alaska], Withrow and Loughlin (1995) [Aleutian Islands], Withrow and Loughlin (1996) [Gulf of Alaska], Withrow and Loughlin (1997) [northern southeast Alaska], and Withrow and Cesarone (1998) [southern southeast Alaska]. This report describes the results of the second abundance survey of the Aleutian Islands. Previous to 1994, data on harbor seal abundance (along the Aleutian Islands) were collected incidental to Steller sea lion and sea otter studies. The objective of this study was to derive a minimum population estimate of harbor seals along the Aleutian Islands chain from Unimak Pass to Attu Island.

Methods

Study Area

Aerial surveys were flown from 21-27 August 2000 from Unimak Pass in the south to Goodnews Bay in the north. This time of year corresponds to the harbor seal's annual molt period when most animals are thought to be hauled out on land and visible to observers. The study area was subdivided into three zones (Figs. 1-3) such that each section was surveyed by separate observers at about the same time. Table 1 lists the observers, dates and aircraft used to survey each area. All known harbor seal haul-out sites in each area were surveyed.

Survey Methods

Fixed-wing aircraft were used to photograph harbor seals while they were on land. The molt period is the optimal period to obtain minimum population estimates because that is when the greatest number of harbor seals spend the greatest amount of time hauled out (Pitcher and Calkins 1979; Calambokidis et al. 1987).

At locations that are affected by tides, harbor seals haul out in greatest numbers at and around the time of low tide. Aerial surveys were timed such that haul-out sites were flown within 2 hours on either side of low tide, when available daylight and weather permitted. At least four repetitive photographic counts were planned for each major haul-out site within each study area over the 2 week survey period. Four or more repetitive surveys are necessary to obtain estimates of coefficient of variation (CV; standard deviation of the counts divided by the mean count) less than 30%. Four to five surveys resulted in the desired results in past harbor seal surveys in Alaska and have proven to be an effective way of counting the maximum number of animals (Loughlin 1992, 1993; Pitcher 1989, 1990).

Harbor seals on land or in the water adjacent to the haul-out sites were photographed with 35 mm cameras with a 70-210 mm or 35-135 mm zoom lens using ASA 200 or 400 color slide film. Transparencies were later projected onto a white background and the number of seals counted. Generally, two counters score the number of seals on the photographs for each site and the arithmetic mean is calculated. This year, one counter scored each slide twice and then took the average count. The largest arithmetic mean obtained for each area was used as the minimum population estimate. Visual estimates of abundance were also recorded at the time of the survey.

Small groups of seals (generally less than ten) were counted as the plane passed by (no photographs were taken), while larger groups were circled and photographed.

Most surveys were flown between 175 to 300 m (wind permitting) at about 90 knots. The survey area was divided into three zones with a plane and observer dedicated to each section. Zone 1 included the area along the north side of the Alaska Peninsula from Unimak Pass in the south to Port Moller in the north, including Izembek Lagoon (Fig. 2, Table 2). Zone 2 ran along the north side of the Alaska Peninsula from Port Moller to Kvichak Bay. This zone is the new Alaska Department of Fish and Game (ADF&G) Bristol Bay Trend Route and was flown by ADF&G personnel. Zone 3 ran from Nushagak Bay to Goodnews Bay (Fig. 3, Table 3).

Two additional zones were also surveyed along the south side of the Alaska Peninsula from Unimak Pass in the west to Chignik Bay in the east. These zones are in our Gulf of Alaska region and results will be reported next year as part of our Gulf of Alaska range-wide surveys.

Data Analysis

The maximum number of animals counted on one day for each zone was accepted as that area's minimum number of seals, which were then summed for a minimum population estimate for the Aleutian Islands. The maximum number for each zone did not occur on the same day, resulting in the possible double counting of some animals if they moved from one area to another. The number of seals moving between areas was assumed to be small considering each area's large geographic size.

The mean and standard deviation (SD) of the mean for each zone were also calculated. Estimates of the number of animals hauled out during the survey were calculated by summing the mean number of harbor seals ashore at each site. The CVs were calculated for all sites with two or more counts. The SD for sites with only one count was estimated to be 1.0 (based on the average maximum of the calculated CVs of the mean multiplied by the count for that site). The variance of the total for the Aleutian Islands was calculated as the sum of the individual variances and the SD as the square root of that variance. This method of estimating the expected total and its variance assumes that there is no migration between sites and that there was no trend in the number of animals ashore over the survey period. The assumption that seals did not move between sites may not be valid (as mentioned above) and a small number of seals may have been counted twice. All areas that could be surveyed were censussed, given weather and safety constraints.

Results

Zone 1

John Jansen surveyed from Unimak Pass in the south up to Port Moller in the north, including Izembek Lagoon and Amak Island. On this route, Port Moller includes only those sites not covered in Zone 2, such as Herendeen Bay, thus there are no duplicate coverages between Zones 1 and 2. This area contained 35 sites. Six surveys were flown from 21 to 27 August 2000 resulting in three or more surveys for most sites. A maximum count of 5,160 harbor seals was obtained by combining the maximum count for each area regardless of day censussed (Fig. 2, Table 2). The sum of means was **&** = 2,452 harbor seals (SD = 61.32), with a CV = 10.02%.

Zone 2

Bob Small surveyed from Port Moller in the south to Kvichak Bay in the north. This area is the ADF&G Trend Route. As of this writing (September 2001), ADF&G reports that photos (digital) have not yet been counted, but should be shortly. Therefore we are unable to report results for these surveys at this time.

Zone 3

Jack Cesarone and Dave Withrow surveyed from Nushagak Bay (Dillingham) in the southeast to Goodnews Bay in the north. This area contained 37 sites. Six surveys were flown from 21 to 27 August 2000. The maximum count of 2,005 was obtained by combining the maximum count for each area regardless of day censussed (Fig. 3, Table 3). The sum of means was **&** = 1,164 harbor seals (SD = 67.99), with a CV = 5.84%.

Discussion

The 2000 harbor seal census surveys were conducted in a similar manner to those of 1995 (Withrow and Loughlin 1996) and 1990 (Loughlin 1992). One additional region (Zone 1), however, was added in 2000 which was not covered in earlier surveys. This region was believed to be only sparsely populated with seals. The Zone 1 observer took over responsibility of the outlying areas of Port Moller (Herendeen Bay) which allowed the observer in Zone 2 to more thoroughly cover his area during the 4 hour low tide window. Zone 1 also included the Izembek Lagoon National Wildlife Refuge. This area turned out to be densely populated with harbor seals. Of the 2,452 seals counted in Zone 1, approximately 1,800 were regularly found in the greater Izembek Lagoon area (Table 2).

For Zone 3 (Nushagak Bay to Goodnews Bay) seals were located at 37 sites, compared to 24 recorded sites during the 1995 surveys. Area coverage is the same between the 1995 and 2000 surveys, but with the advent of Global Positioning System (GPS) navigational receivers, seal haulouts can now be more precisely delineated. We now instruct our observers to record haulouts in as fine a detail as possible. If necessary, sites can be combined later for comparisons with previous surveys. Observers counted 1,164 seals in Zone 3 in 2000 compared with 955 seals in 1995. Table 4 illustrates this comparison by area. Individual haulout sites have been combined in an area (i.e., all sites on High Island combined) to simplify the comparisons. Most sites showed a slight increase. There are two exceptions, Cape Peirce was lower in 2000 and Hagemeister Island was much higher. In addition to these aerial surveys, we tagged 32 seals at Cape Peirce with VHF radio transmitters and recorded the number of tagged seals hauled out daily during our flights and tracked the movements of the seals in the region. The purpose of this tagging study was to estimate the proportion of seals in the water or away from the haulout, which might not be included during our census surveys. We often found more than 314 seals at Cape Peirce (while tagging) and that several of the tagged seals temporarily relocated at Hagemeister Island. It is likely that these two events are related.

Acknowledgments

This report is a summary of surveys conducted by the people listed in Table 1 and who are gratefully acknowledged for their time and effort. Tom Tucker from Tucker Aviation and Dave Weintraub from Commander NW piloted our aircrafts. Their expertise and attention to safety were greatly appreciated.

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Table 1. Zone number, city from which surveys originated, name of observer, dates, and aircraft type for harbor seal surveys in Bristol Bay and along the north side of the Alaska Peninsula during August 2000.

Zone	City	Name	Dates	Aircraft
1	Cold Bay	John Jansen	21-27 August	Aero Commander
2	King Salmon	Bob Small	21-27 August	Cessna 185 on floats
3	Dillingham	Jack Cesarone Dave Withrow	21-27 August	Cessna 185 on floats

Table 2. The number of seals counted for each site for Zone 1. [Jansen]

Location Name	Latitude	Longitude	Substrate	Max	Mean	8/21	8/22	8/23	8/24	8/26	8/27
Amak I.-S rocks	55.3929	163.1416	Rock	35	18			35	0		
Bechevin Bay 1	55.0251	163.3769	Rock	93	23		0	93	0		0
Bechevin Bay 2	55.0382	163.3758	Rock	259	139		0	80	216		259
Bechevin Bay 3	55.0434	163.3746	Rock	243	138		39	197	243		74
Bechevin Bay-Traders Cove	54.9185	163.2898	Rock	8	4		8	4	0		
Cape Krenitzin	55.0773	163.4398	Rock	35	30		32	35	23		
Cape Lapin	54.9802	164.1245	Rock	10	8		7	10	6		
Cathedral River mouth	55.6245	162.3416	Sand	215	98	5	115	28	126		215
Herendeen Bay S-Arm W of Pinnacle Peak	55.7414	160.8082	Rock	12	6		12	4	9		0
Herendeen Bay-Arm E of Pinnacle Peak 1	55.7339	160.7003	Rock	102	47	100	102	0	0		35
Herendeen Bay-Arm E of Pinnacle Peak 2	55.7628	160.6996	Sand	68	32	18	18	40	68		18
Herendeen Bay-Arm E of Pinnacle Peak 3	55.7591	160.7245	Rock	9	5	3	0	7	9		7
Herendeen Bay-Arm E of Pinnacle Peak 4	55.7307	160.6633	Rock	10	5	0	0	10	6		8
Herendeen Bay-E of Black Pt. 1	55.8873	160.9085	Rock	2	0	0	0	2	0		0
Herendeen Bay-E of Black Pt. 2	55.8963	160.8762	Rock	1	0	0	0		1		0
Herendeen Bay-Halftide Rock	55.8247	160.7655	Rock	20	10	8	20	12	10		1
Izembek Lagoon- SE of Cape Glazenap	55.2325	162.9724	Sand	773	604	189	721	773	668	635	635
Izembek Lagoon-Applegate Cove 1	55.1964	162.8944	Sand	11	2	11	0	0	2	0	0
Izembek Lagoon-Applegate Cove 2	55.2132	162.8971	Sand	13	4	0	0	4	0	13	6
Izembek Lagoon-between Blaine Pt. and Neuman I. 1	55.4015	162.6270	Sand	190	34	190	1	0	0	0	11
Izembek Lagoon-between Blaine Pt. and Neuman I. 2	55.4064	162.6224	Sand	525	153	36	15	168	176	0	525
Izembek Lagoon-between Blaine Pt. and Neuman I. 3	55.4076	162.6340	Sand	227	87		227	20	0	0	186
Izembek Lagoon-between Blaine Pt. and Neuman I. 4	55.4154	162.6336	Sand	481	118	0	0	225	0	0	481
Izembek Lagoon-E of Cape Glazenap	55.2457	162.9687	Sand	24	12		18	16	0	0	24
Izembek Lagoon-E of Norma Bay	55.1784	162.9782	Sand	14	6	0	0	6	10		14
Izembek Lagoon-N of Norma Bay	55.2229	162.9984	Sand	37	22	6	35	20	37	0	36
Izembek Lagoon-S Open I.-e end	55.3922	162.7059	Sand	7	3	3	7	5	0	0	5
Izembek Lagoon-W of Blaine Pt.	55.3953	162.6712	Sand	34	11	0	0	34	10	0	24
Kudiakof I.-between Glen and Open I. 1	55.3350	162.8978	Sand	474	145	10	474	0	385	0	0
Kudiakof I.-between Glen and Open I. 2	55.3288	162.8876	Sand	250	129	250	0	195	141	23	162
Kudiakof I.-between Glen and Open I. 3	55.3395	162.8981	Sand	109	24	37	0	0	0	0	109
Kudiakof I.-between Glen and Open I. 4	55.3331	162.8708	Sand	205	124	78	149	175	0	205	135
Mud Bay-W of Black Pt.	55.8939	160.9700	Sand	2	1	2	2		0		0
Neuman I.-W of	55.4310	162.6478	Sand	650	400	650	640	538	571	0	0
Unimak I.-W of Scotch Cap	54.3954	164.7541	Rock	12	10		8	12			

MAX	MEAN
5,160	2,452

95 % Confidence Interval			
1,966	=LOW	2,937	=HIGH

Table 3. The number of seals counted at each site for Zone 3. [Cesarone/Withrow]

Location Name	Latitude	Longitude	Substrate	Max	Mean	8/21	8/22	8/23	8/24	8/25	8/27
Castle Rock	58.6631	161.9414	Rock	13	5	0	3	5	13	2	
Black Rock	58.7058	160.1894	Rock	76	51	76	75	56	47	33	20
Calm Point	58.5464	161.0694	Rock	160	37	160	0	61	0	0	0
Cape Newenham	58.6399	162.1644	Rock	9	7			9	3	8	
Oracle SE	58.6239	161.9944	Rock	9	5			5		0	9
Oracle NE	58.6266	161.9952	Rock	4	4			4			
Chagvan Bay W	58.7680	161.7942	Sand	61	40				61	28	32
E Crooked	58.6652	160.2469	Rock	39	23		1	30	39	28	17
E Hagemeister	58.6828	160.7964	Rock	8	6			6	8	8	0
E High N	58.7322	160.3861	Rock	168	70	0	33	92	60	66	168
E High S	58.6900	160.4044	Rock	12	8		12			0	12
Estes Pt.	58.7892	161.1761	Rock	10	3	0	0			0	10
High Is S	58.6809	160.4257	Rock	13	8				13	7	4
Metervik Bay	58.8378	159.7864	Rock	119	95	80	119	100	86	88	94
N Hagemeister	58.7775	160.7772	Rock	51	33	24	12	28	38	45	51
Nanvak Bay	58.5800	161.7500	Sand	438	314	225	345	278	285	311	438
Nunavakchak Bay	58.8669	159.9994	Rock	13	6	1	5	7	6	13	4
Oracle	58.6561	162.1353	Rock	6	3	0	0	0	6	6	3
Pyrite 2	58.6200	161.5400	Rock	4	2		3		4	0	0
Pyrite Pt.	58.6156	161.5431	Rock	45	37	37	34	43	45	27	33
Rocky Point	58.8892	160.2289	Rock	2	0	0	0	0	2	0	0
Rugged Point	58.5556	161.7108	Rock	8	5		0	8	6	4	5
S Hagemeister	58.5493	161.0506	Rock	17	4			17	0	0	0
Oracle S.	58.6156	162.0042	Rock	12	12						12
Oracle W.	58.6221	162.0403	Rock	5	5						5
Cape Newenham S.	58.6299	162.1315	Rock	20	20						20
Summit Island	58.8386	160.2356	Rock	41	30	4	35	41	38	26	35
W Crooked 1	58.6474	160.2779	Rock	71	33		16	19	23	71	37
W Crooked 2	58.6528	160.2758	Rock	83	46	28	15	83	55	41	54
W Hagemeister 1	58.5454	161.0787	Rock	30	28		30			25	29
W Hagemeister 2	58.5493	161.0804	Rock	78	45		61	78	78	6	2
W Hagemeister 3	58.5588	161.0842	Rock	101	71		60	98	101	62	35
W Hagemeister 5	58.5675	161.0802	Rock	40	16		40		0	24	0
W Hagemeister N	58.5892	161.0886	Rock	190	76	18	10	73	96	71	190
W High Island	58.7003	160.4331	Rock	20	4		20	1	0	0	0
W High N	58.7361	160.4259	Rock	29	15		26	1	8	29	12

MAX	MEAN
2,005	1,164

95 % Confidence Interval			
1,030	=LOW	1,299	=HIGH

Table 4. Summary comparison between 1995 and 2000 harbor seal counts

Site Name		Means 1995	Means 2000
Oosik Bay		1	0
Metervik Bay		38	95
Nunavakchak Bay		3	6
E. Neguthlik Bay		3	0
Rocky Point		6	0
Summit Island		15	30
Black Rock		48	51
Crooked Island		45	102
High Island		50	105
Owens Bay		1	0
Hagemeister Island		129	279
Calm Point		78	37
Estes Point		17	3
Pyrite Point		29	39
Rugged Point		6	5
Bird Rock		6	5
Castle Rock		3	9
Chagvan Bay		32	40
Nanvak Bay		436	314
Oracle		10	17
Cape Newenham		-	27
Totals		955	1164

Figure 1. Bristol Bay and northside Alaska Penninsula, 2000 harbor seal aerial survey by zone.

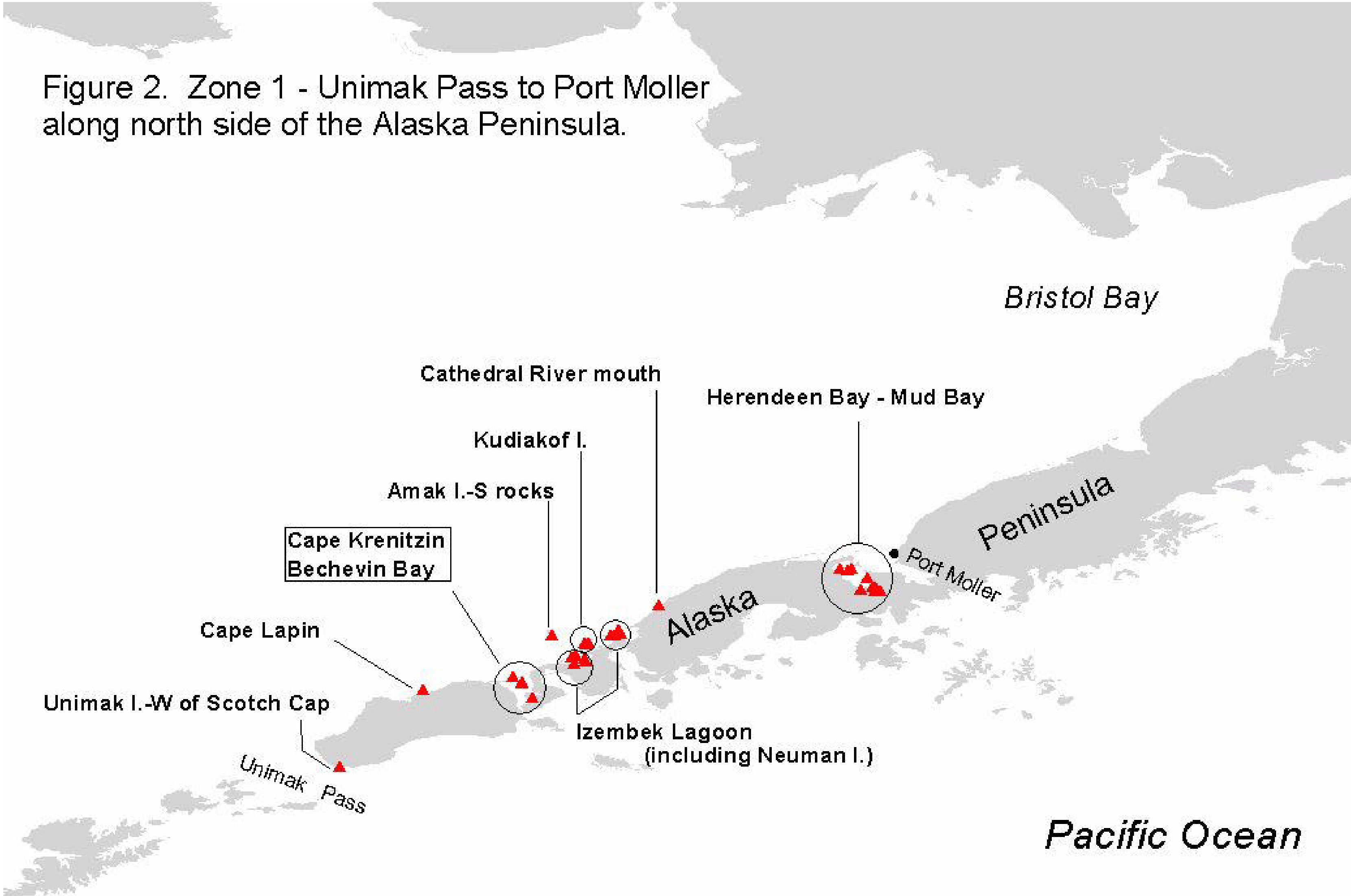

Figure 2. Zone 1 - Unimak Pass to Port Moller along north side of the Alaska Peninsula.

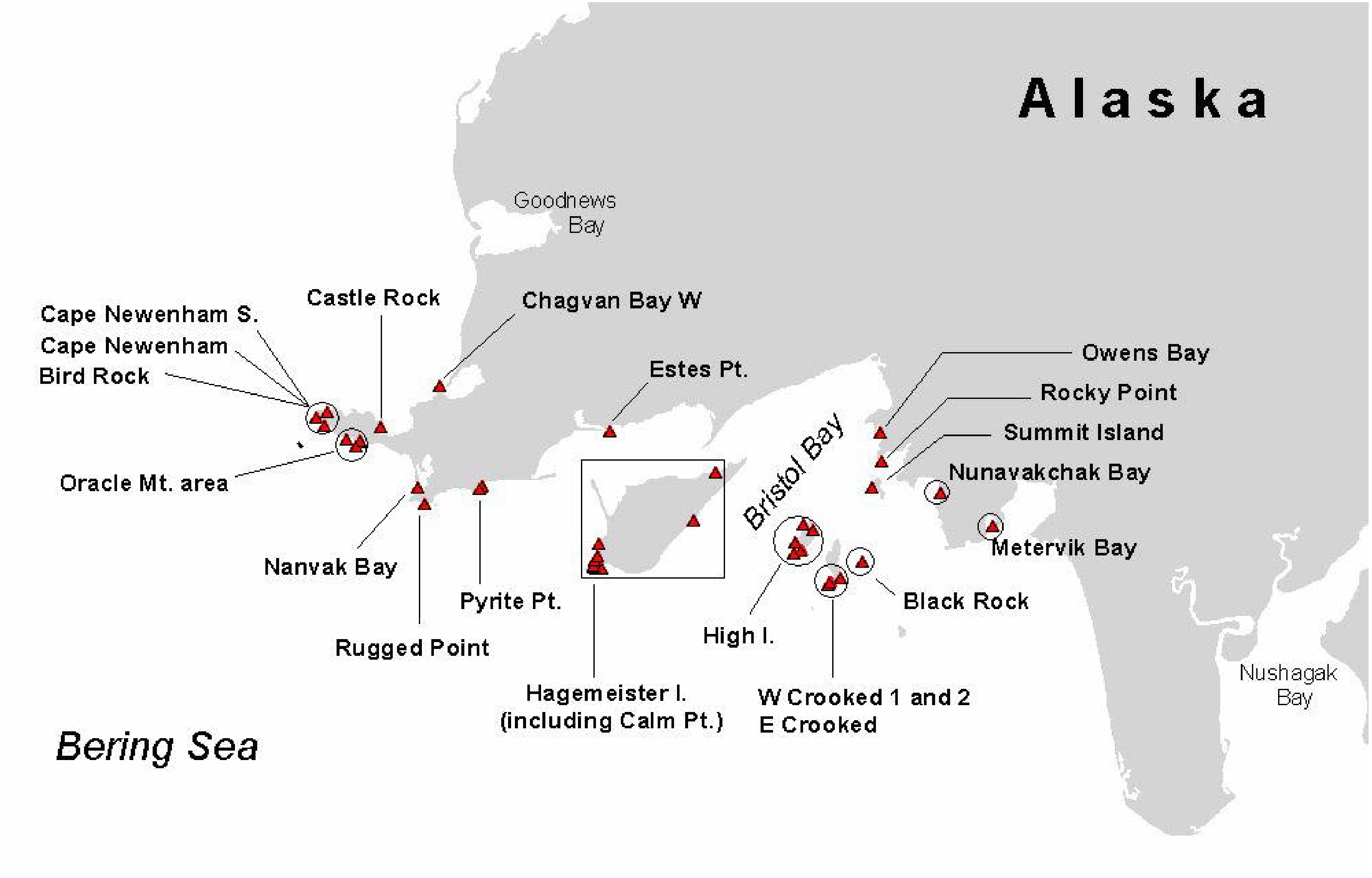

Figure 3. Zone 3 - Nushagak Bay (Dillingham) to north side of Goodnews Bay.

UPDATE ON THE NORTH PACIFIC HUMPBACK WHALE FLUKE PHOTOGRAPH COLLECTION, SEPTEMBER 2001

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Introduction

Starting in 1985, the National Marine Mammal Laboratory (NMML) has been developing and curating a collection of humpback whale fluke photographs taken in North Pacific waters using a computer-assisted matching system (Mizroch, Beard and Lynde, 1990). The collection of North Pacific humpback whale fluke photographs grew from about 750 photographs in 1986 to over 24,000 photographs by 2001, representing contributions from over 17 research groups, taken from all regions in the North Pacific (Table 1).

Matches in The Database

Unique ID numbers (NMMLID) are assigned when there are at least 2 photographs of a particular individual whale in the database. As of July 2001, there were 24,299 tail fluke photographs in the database: 13,441 photographs with a NMMLID (3,251 unique NMMLID numbers) and 10,858 photographs without a NMMLID (See Table 2. Note: 288 tail fluke photographs were submitted without the researcher noting a year and are not reflected on this table. Also, 47 tail flukes photographs were submitted with a year but no area specified. These photographs are not reflected in the total of 23,964 on the table). The exact number of individual whales in the database cannot be determined at this time because the database has not yet been thoroughly cross-matched between areas and different research collections. Some of the unmatched photos may be unique whales that have only one photograph in the database, and other photos may be unmatchable due to poor photo quality.

Life History Parameter Studies based on Data in the Database

Using data from the database, Chris Gabriele of Glacier Bay National Park and Preserve presented results from the paper on estimating calf mortality at the 13th Biennial Conference on the Biology of Marine Mammals in Hawaii in December, 1999. That paper was published this year in the Canadian Journal of Zoology (Gabriele et al. 2001).

Sally Mizroch distributed a first draft (August 2000) and second draft (June 2001) manuscript to co-authors on adult survival of North Pacific humpback whales (Mizroch et al. in review) using data in the database. She will present this paper as an oral presentation at the 14th Biennial Marine Mammal Conference in Vancouver, B.C., Canada.

Sally Mizroch presented an overview of humpback whale research entitled “Vital Rates of Humpback Whales Estimated from Ocean Basin-scale Collaborations in the North Pacific” at a conference on humpback whales in Nagoya, Japan in March 2001.

Using data from the database, Jan Straley of University of Alaska submitted an abstract on humpback whale birth intervals to the 14th Biennial Marine Mammal Conference, with a full manuscript on the topic to follow.

Other Studies

The database was used for other large-scale studies on movements, migration and population structure of humpback whales in the North Pacific (Calambokidis et al. 2001; Urban et al. 2001). Plans for continued use include development and matching of data from Isla Socorro, MX (J. Jacobsen).

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Table 1. Abbreviations and main contact people from the major contributing research groups.

Abbreviation	*Research group*	*Contact People*
CCS	Center for Coastal Studies	D. Mattila
CRC	Cascadia Research Collective	J. Calambokidis, G. Steiger
CWR	Center for Whale Research	K. Balcomb, D. Claridge
CWS	Center for Whale Studies	D. Glockner-Ferrari, M. Ferrari
GBNP	Glacier Bay National Park and Preserve	G. Gabriele
HWRF	Hawaii Whale Research Foundation	D. Salden
JSI	J. Straley Investigations	J. Straley
KBMML	Kewalo Basin Marine Mammal Laboratory	L. Herman, A. Craig
MLML	Moss Landing Marine Labs	S. Cerchio
NGOS	North Gulf Oceanic Society	O. von Ziegesar, C. Matkin
NMML	National Marine Mammal Laboratory	S. Mizroch
OEA	Okinawa Expo Aquarium	S. Uchida, N. Higashi
PBS-GE	Pacific Biological Station	G. Ellis
SeaSearch	SeaSearch	C, Jurasz
UABCS	Univ. Autonoma de Baja Calif. Sur	J. Urban
UNAM	Univ. Nacional Autonoma de Mexico	P. Lladron, J. Jacobsen
WCWRF	West Coast Whale Research Foundation	J. Darling, E. Mathews, D. McSweeney, K. Mori

Table 2. Number of humpback whale tail fluke photographs in the database, by area and year. Photos were submitted from 1997 through 2001, but most have not yet been entered into the database.

Year	Alaska	California	Canada	Colombia	Hawaii	Japan	Mexico	Oregon	Panama	Washington	**Total**
1966							1				1
1968	10										10
1969	4										4
1970	2										2
1972	29										29
1973	13										13
1974	50										50
1975	35				3						38
1976	65				89						154
1977	296		2		21						319
1978	267				64		84				415
1979	323				135		27				485
1980	620	2			511		68				1,201
1981	337				750		20			5	1,112
1982	190		1		246						437
1983	120	10	1		377		8				516
1984	375		1		261		10				647
1985	219	2	8		227		10				466
1986	502	95	4	1	421		103				1,126
1987	366	93	2		504	8	107				1,080
1988	252	111	16		941	18	163				1,501
1989	218	55	14	41	1,099	72	316				1,815
1990	131	115	13	2	958	122	247	23		1	1,612
1991	488	265	18		944	18	307				2,040
1992	851	398	28	8	890	15	180	5	1		2,376
1993	298	256	48		1,215	17	97				1,931
1994	545	242	88		413	37	82			13	1,420
1995	564	319			614	33	82			42	1,654
1996	25	41			946		252			34	1,298
1997	1				1		127			17	146
1998	1				41					9	51
1999	8									7	15
Total	7,205	2,004	244	52	11,671	340	2,291	28	1	128	23,964

HARVEST MONITORING OF ARCTIC ICE SEALS

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Introduction

Several species of ice-associated seals are taken by Alaska Native hunters for subsistence purposes: ringed (*Phoca hispida),* bearded *(Erignathus barbatus),* spotted (*Phoca largha),* and ribbon seals (*Phoca fasciata*). Although these seals are important resources for Native Alaskans, as well as key ecological components of Arctic marine ecosystems, relatively little is known of the seals' genetic discreteness, trends in abundance, life history status, or age structure. As apex predators, these seals are at or near the top of the food web, and consequently often concentrate a variety of contaminants (e.g., heavy metals, organochlorines) that are potentially harmful to the human populations that consume these seals. In addition, the distributions of these seals (and therefore their availability to subsistence hunters) are highly sensitive to suitable sea ice conditions, and as such, may be particularly vulnerable to climatic change.

Subsistence harvests offer an opportunity to obtain biological specimen materials from the seals, which can allow scientists to learn a considerable amount about the life history status, contaminant loads, and changes in trends of seal populations. Because of their wide distribution and extended seasonal movements, Arctic ice seals represent apex predators that integrate environmental conditions throughout the Bering and Chukchi Seas on broad spatial and temporal scales. Seasonal and inter-annual changes in the physical and biological environmental conditions encountered by seals throughout this zone are likely to influence the seals' diet, behavior, and physical condition. In particular, one would expect that if broad ecological shifts occurred, such changes would be reflected in these seal's life history parameters (e.g., diet, growth rates, reproductive condition). This project sought to use information obtained from the subsistence harvest of ice-associated seals to provide insight into various life history parameters of the harvested seals. In particular, biological specimen material was collected and analyzed to begin assessing the age structure and reproductive status of seals taken, as well as evaluating the stock structure of ice seals.

Methods

In the autumn of 2000, a biologist with the Alaska Department of Fish and Game (ADFG) traveled to Shishmaref and Diomede to coordinate the sampling effort in cooperation with Alaska Native hunters. Alaska Native hunters were requested to procure samples of ice seal teeth (for age estimation), blubber and liver (for contaminants analyses), reproductive organs (for reproductive status), and skin (for genetics) from the 2000 autumn subsistence hunt. The Eskimo Walrus Commission assisted in facilitating contacts with relevant Alaska Native hunters so that arrangements could be made to gather harvest information and to obtain specimen material. Biological specimen material was collected and prepared for shipment according to scientific protocols provided by the National Marine Mammal Laboratory (NMML). In addition, support was provided to a specimen collector to work out of Barrow in association with the North Slope Borough Department of Wildlife; this work was undertaken in collaboration with the U.S. Geological Survey. From these collections, teeth were provided to NMML staff; stomach contents will be analyzed by ADFG; and reproductive tracts were preserved and archived.

Results and Discussion

As this project began, it had been hoped that harvest monitoring information could have been obtained from a fairly broad group of hunting villages located in areas under the jurisdiction of the North Slope Borough (Kaktovik to Kivalina), the Maniilaq Association (Kotzebue area), and Kawerak Inc. (Shishmaref to Norton Sound, including St. Lawrence Island). Unfortunately, as steps were taken to implement these plans, it became apparent that the financial and personnel resources available were insufficient to cover as wide an area as had been desired for all of this project's original objectives (i.e., collecting specimen material and estimating the numbers of seals harvested). Therefore, the main results of this effort have been the acquisition of specimen materials from ringed and bearded seals.

During autumn 2000, a good sample of biological specimens was collected from seals taken by Alaska Natives in their subsistence harvest. Teeth, stomachs, reproductive tracts, and genetic material were collected from a total of 32 seals, and jaws were collected from an additional 40 animals in Shishmaref and Diomede, AK. Additional samples will become available from the Barrow collections. Analyses on specimen materials are presently underway by ADFG, NMML, and the U.S. Geological Survey.

DENSITY AND DISTRIBUTION OF RINGED SEALS ALONG THE EASTERN CHUKCHI SEA COAST, 1999-2000

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Abstract

The National Marine Mammal Laboratory (NMML) conducted aerial surveys focused on ringed seals (*Phoca hispida*) in coastal and offshore Chukchi Sea waters in 1999 and 2000. Survey lines were flown during mid-day (1000-1600 local time) at an altitude of 300 ft (91 m) and a speed of 100 knots (kt) (185 km/h) along 20 nautical miles (nm) (37 km) tracklines perpendicular to the shoreline. In addition, lines of 80-100 nm (148-185 km) were flown far offshore to assess how coastal densities of seals changed as a function of distance from shore. To evaluate the time that ringed seals spent basking on the ice surface, we attached satellite-linked time-depth recorders to ringed seals in both years. Haulout patterns indicated that ringed seals showed a transition to basking behavior in late May, and that seals were generally hauled out between 1000 and 1700 local solar time. Aerial surveys indicated that ringed seals were relatively common in coastal areas, and that densities dropped off as distance from shore increased. The highest densities of ringed seals were found in coastal waters south of Kivalina. Bearded seals were also surveyed during this work; they were generally more abundant farther from shore, with the exception of high bearded seal numbers observed south of Kivalina.

Introduction

Ringed seals (*Phoca hispida*) are small phocid seals that are circumpolar and widely distributed, usually associated with areas of seasonal sea ice (McLaren 1958, Smith 1987, Kelly 1988). These seals have historically been important to subsistence hunters in the Arctic and are also important prey species for polar bears (Stirling and McEwan 1975, Smith 1980); however, knowledge of ringed seal population dynamics is limited due to the difficulty of assessing populations in ice-covered environments. Bearded seals occur in the Bering, Chukchi, and Beaufort Seas and generally select pack ice habitats with well developed lead systems located farther offshore than the fast and pack ice habitats utilized by ringed seals along the coast.

Ringed and bearded seals overwinter in areas of pack or shorefast sea ice, where they maintain breathing holes through the ice or in lead systems (Smith and Stirling 1975, Burns et al. 1981). During the winter, ringed seals dig lairs in the snow surrounding their breathing holes, which they use for resting and for the birth and nursing of their young in March-May (McLaren 1958, Smith and Stirling 1975). Breathing holes and lairs are generally within 1 to 2 km of each other (Kelly and Quakenbush 1990) during the winter when seals' movements are constrained by the location of breathing holes in the fast ice. In late spring, the seals haul out for their annual molt on the surface of the ice near breathing holes or lairs (Smith 1973, Smith and Hammill 1981, Kelly et al. 1986). Increased temperature and day length at this time of year promote higher skin temperatures, which facilitates epidermal growth (Feltz and Fay 1966). Because both species of seals are abundant above the ice and readily visible at this time, conditions are good for conducting aerial surveys of the local distribution and abundance of ringed and bearded seal populations. Although ringed seals in the Beaufort Sea have been surveyed in 1996-1999 (Frost et al. 1997, 1998, 1999), seals in the eastern Chukchi Sea had not been assessed since 1985-87 (Frost and Lowry 1988). This paper presents results from ringed seal surveys conducted in 1999-2000 in the eastern Chukchi Sea. During these surveys, observations of bearded seals were also recorded.

Methods

Aerial Surveys

Aerial surveys were flown along the northwest coast of Alaska from 23 May-6 June 1999 and 21-31 May 2000. The survey aircraft was a twin-engine Aero Commander, equipped with "bubble" windows to accommodate visual observations out to the side and down from the aircraft's position. The survey area covered the eastern Chukchi Sea coast from just north of Bering Strait to Pt. Barrow (Fig. 1). In each of the survey zones from the northern coast of the Seward Peninsula to Barrow, lines of 20 nm (37 km) were flown at a speed of 90-100 kt (167-185 km/h) and an altitude of 300 feet (91 m) on a course generally perpendicular to the shoreline. In addition, lines of 80-100 nm (148-185 km) were flown far offshore to assess how coastal densities of seals changed as a function of distance from shore. Aerial surveys were conducted between 1000 and 1600 local time, to coincide with the time of day when maximal numbers of seals haul out (Burns and Harbo 1972, Smith and Hammill 1981). A minimum of two observers collected data during each flight: one each at windows on the right and left sides of the aircraft. Data were recorded by audio/video recorder. Weather and ice conditions were recorded by an observer during surveys. In addition, a belly-mounted video camera recorded the ice concentration and characteristics during all survey flights.

For all surveys, we utilized "line" transect surveys rather than "strip" transects. Strip transects are appropriate if all of the hauled out seals are seen and identified within the survey strip. However, if some of the hauled out seals are routinely not observed, abundance will be underestimated. Variation in the conditions that cause seals to be missed will be reflected as non-quantified variation in the estimates that may be incorrectly interpreted as changes in population abundance. Recording the perpendicular distance (closest distance abeam to the survey platform) to each observed seal allows testing whether distance within the strip affects visibility and to correct for visibility bias (Buckland et al. 1993). For these surveys, perpendicular distance between the aircraft and seals was measured by sighting along six fixed 10^{o} vertical angles (0^{o}-60^{o} from the horizon in 10^{o} increments) on a plexiglass strip attached to the aircraft's window. Correct eye position relative to the marks was maintained by aligning visually a pair of marks on a plexiglass sighting board like a gunsight. The sighting board allowed quick measurement of distance intervals in areas of high seal density and allowed the observer's view to remain focused on the ice to avoid missing nearby seals.

To accommodate concerns raised by Alaska Natives hunting bowhead whales, a 15 nm radius “no-fly” zone was maintained around the villages of Wales, Kivalina, Pt. Hope, Wainwright, and Barrow until whaling activities had been concluded. In 1999, whaling activities had concluded at Wainwright and Barrow by the time those areas were surveyed. In 2000, whaling activities were underway during the duration of the aerial surveys; permission was granted by Kivalina hunters to conduct aerial surveys within the Kivalina “no-fly” zone during the first round of surveys (21-24 May 2000). Permission to survey the “no-fly” zone was withheld during the follow-up surveys (31 May - 1 June 2000).

Ringed Seal Capture and Satellite Tag Deployment

In both 1999 and 2000, satellite-linked transmitters were deployed on three ringed seals to obtain detailed information on haulout behavior, which could be used to correct aerial survey counts for those seals not hauled out on ice. In 1999, we collaborated with Dr. Brendan Kelly (University of Alaska Fairbanks) at his field site at Reindeer Island (6 nm offshore from Prudhoe Bay). Ringed seals were captured using remotely-triggered nets set at breathing holes in subnivean seal lairs (Kelly 1996). In 2000, the capture net system was modified for use at breathing holes in the shorefast ice near Kotzebue, AK, during the time of year when ringed seals are basking on the ice surface. These traps were designed to allow seals to pass through their breathing holes and haul out (when the traps were open). The traps could then be triggered remotely by a radio signal, and block the seals’ access to the water. Using a helicopter, we located breathing holes that appeared to be used regularly in coastal fast ice, and set our net traps. On subsequent days, we flew over each trap site. If seals were hauled out, we triggered the net trap to close it, and landed the helicopter to capture the seal. After capture, satellite-linked time-depth recorders were attached to the seals’ fur with epoxy glue. Location and haulout data were collected from the recorders via the ARGOS satellite system.

Results and Discussion

Seal Densities

Ringed seals were relatively common in most coastal areas (Figs. 2-5, Table 1), ranging from about 0.37 - 5.7 seals per square kilometer. Unlike bearded seals, ringed seals were present on the shore-fast ice as well as the pack ice. Ringed seal densities declined as the distance offshore increased. Bearded seals were distributed throughout most of the study area, ranging in density from about 0.07 - 1.21 seals per square kilometer (Figs. 2-5). Bearded seals were only observed on the pack ice offshore, which was also reflected in the absence of bearded seals from the fast ice in Kotzebue Sound. As expected, relatively high densities of bearded seals were encountered within 20 nm (37 km) of the coast to the south of Kivalina, which is an area favored by Alaska Native subsistence hunters targeting bearded seals.

The density estimates for ringed seals presented here represent minimum estimates based on counts uncorrected for seals that were in the water during aerial surveys. Because seals do not all haul out onto the ice at the same time, and some may not haul out at all on a given day, estimates of seal density derived from aerial survey counts must be adjusted to account for the proportion of seals that were in the water and therefore not available to be counted. Such a haulout correction factor will be developed through subsequent analyses of the satellite-linked transmitter data, once a sample size of sufficient analytical power is obtained. Until then, the "unadjusted" estimates of abundance provided here should be considered minimum relative densities. The actual local abundance or densities of ringed seals are likely to be greater than the values presented in Table 1.

A comparison of two surveys repeated in 2000 near Kivalina (survey zone C2) revealed some differences in densities, but the same general pattern. The general distribution pattern for ringed seals was unchanged between the two surveys (see Figs. 4 and 6). Although the "uncorrected" estimated abundance of ringed seals was approximately 33% higher from the results of the second survey, these differences could also be explained by causes affecting seal haulout behavior as described above. The reasons for these differences are not immediately apparent, but could be caused by a combination factors such as the timing of molt (i.e., more seals hauling out as the weather gets warmer), weather conditions during the survey (i.e., fewer seals hauling out if the sun is obscured by clouds), or seal movements within the survey area (i.e., moving into the preferred feeding grounds south of Kivalina).

Haulout Behavior

The satellite-linked time-depth recorders that were deployed on the six ringed seals (Table 2) monitored the seals' dive and haulout behavior through June. The termination of transmissions occurred at about the time when we would have expected the transmitters to fall off of the seals due to the completion of their molt cycle. Haulout patterns from one ringed seal instrumented in early May 1999 indicated that the seal showed an abrupt transition in haulout behavior around 28 May (Fig. 7). Presumably, this shift was associated with a change from using subnivean lairs to basking on the ice surface. In early May, while the seal was using subnivean lairs, haulout periods tended to be scattered throughout the day. After the transition to basking behavior, the seal was generally hauled out between 1000 and 1700 local solar time, which corresponds well with the timing of aerial surveys that were conducted.

Acknowledgments

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Citations

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Table 1. Densities of ringed seals in coastal (within 20 nm of shore) and offshore (20-100 nm from shore) Chukchi Sea waters, May-June 1999 and 2000. "South" refers to the area north of Shishmaref, and "north" refers to the area north of Cape Lisburne. Note that "unadjusted" estimated abundances have not yet been adjusted for seals that had not hauled out during surveys. See Figure 1 for survey zone designations.

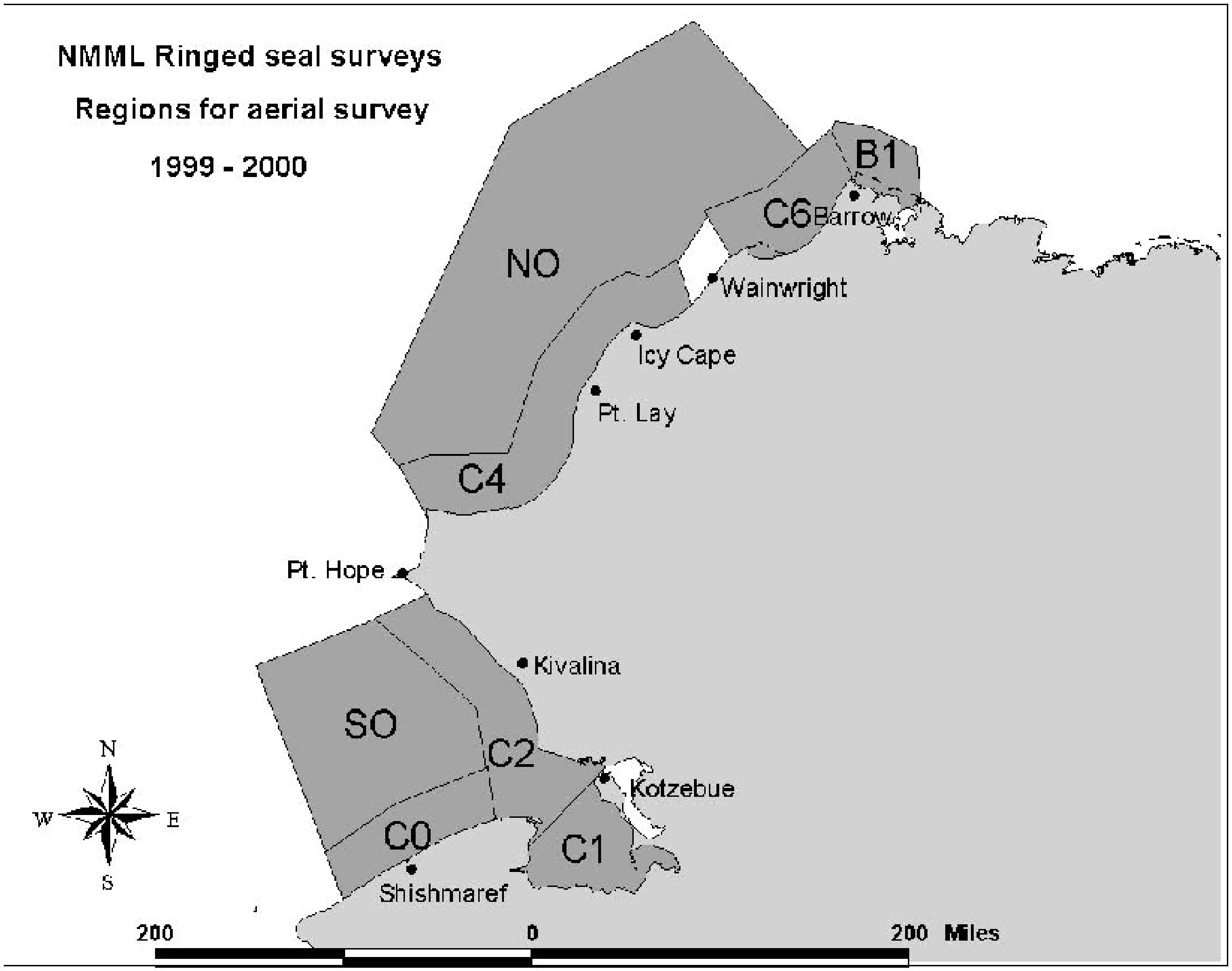
Survey Zone	Density (seals/km^2)		Density (seals/nm^2)		"Unadjusted" estimated coastal abundance	
	1999	2000	1999	2000	1999	2000
C0	1.8693	2.9248	6.4115	10.0318	12127	18974
C1	2.5992	2.2408	8.9150	7.6857	17143	14779
C2 & T1	3.6707	5.7151	12.5901	19.6022	127710	132555
C4 & C5	2.7747	1.4953	9.5170	5.1286	40246	21688
C6	0.3892	0.4756	1.3349	1.6312	2583	3155
Offshore area-south	0.4858	0.3724	1.6663	1.2775	21569	33071
Offshore area-north	0.4154	0.09837	1.4246	0.3374	23670	11212

Table 2. Ringed seals instrumented with satellite-linked time depth recorders at Reindeer Island, Beaufort Sea (1999), and Kotzebue Sound, Chukchi Sea (2000).

Location (latitude, longitude)	Instrument number	Sex	Weight (kg)	Length (cm)	Date of deployment	Date of last transmission
Reindeer I.	99-098	F	50.0		6 May 1999	28 June 1999
Reindeer I.	99-099	F	54.5		23 May 1999	27 June 1999
Reindeer I.	99-100	F	52.3		24 May 1999	15 June 1999
Kotzebue Sound	00-088	M		91	18 May 2000	25 June 2000
Kotzebue Sound	00-087	M		100	20 May 2000	21 June 2000
Kotzebue Sound	00-085	M		111	20 May 2000	23 June 2000

Figure 1. Zones for ringed seal aerial surveys in the eastern coastal Chukchi Sea, May-June 1999

and 2000.



NMML Ringed seal surveys
Regions for aerial survey
1999 - 2000
NO
B1
C6
Barrow
Wainwright
Icy Cape
Pt. Lay
C4
Pt. Hope
Kivalina
SO
C2
Kotzebue
C0
C1
Shishmaref
N
W
E
S
200
0
200 Miles

Figure 2. Ringed and bearded seal observations in the southern portion of the survey area, May 1999.

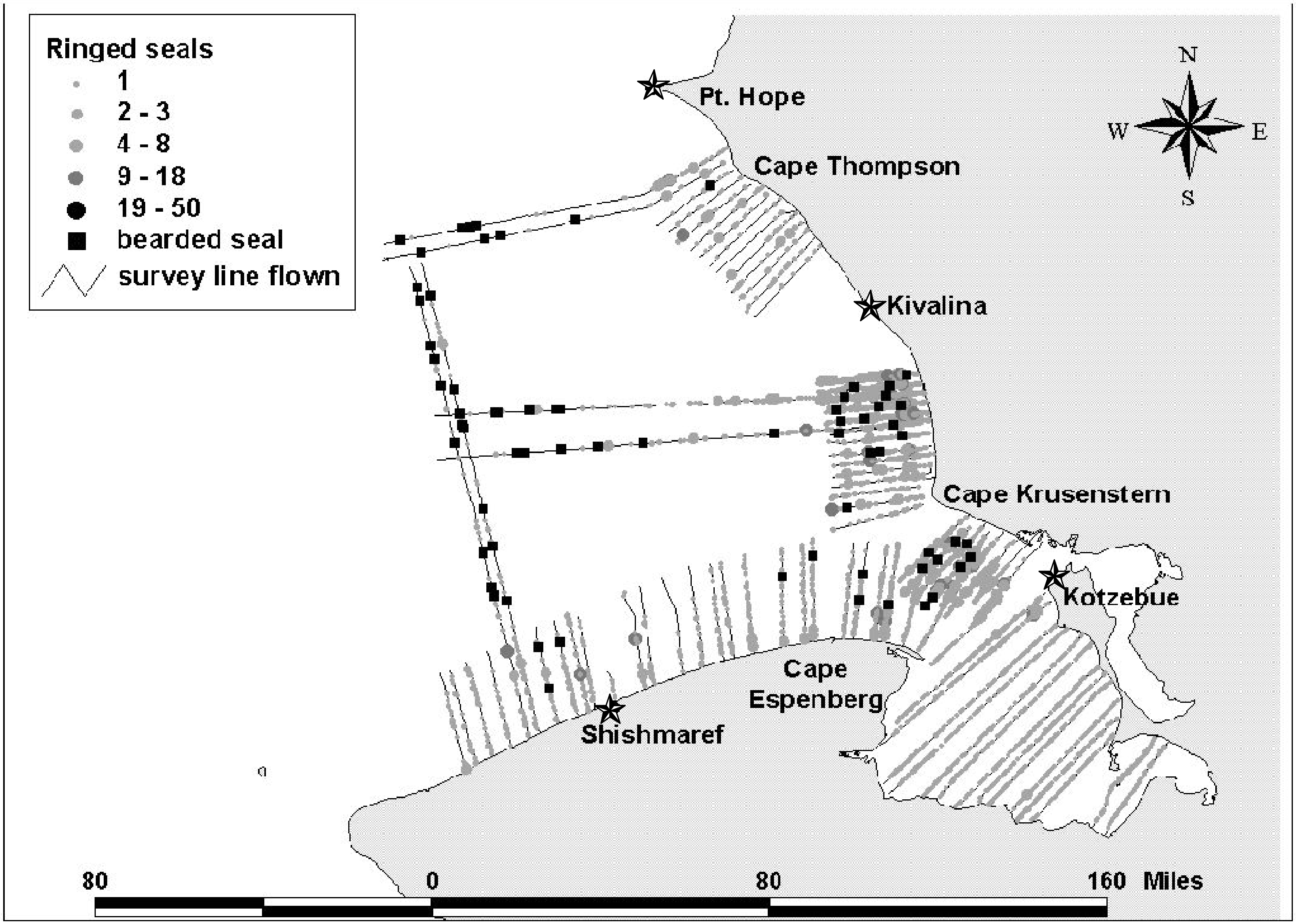


Figure 3. Ringed and bearded seal observations in the northern portion of the survey area, May-June 1999.

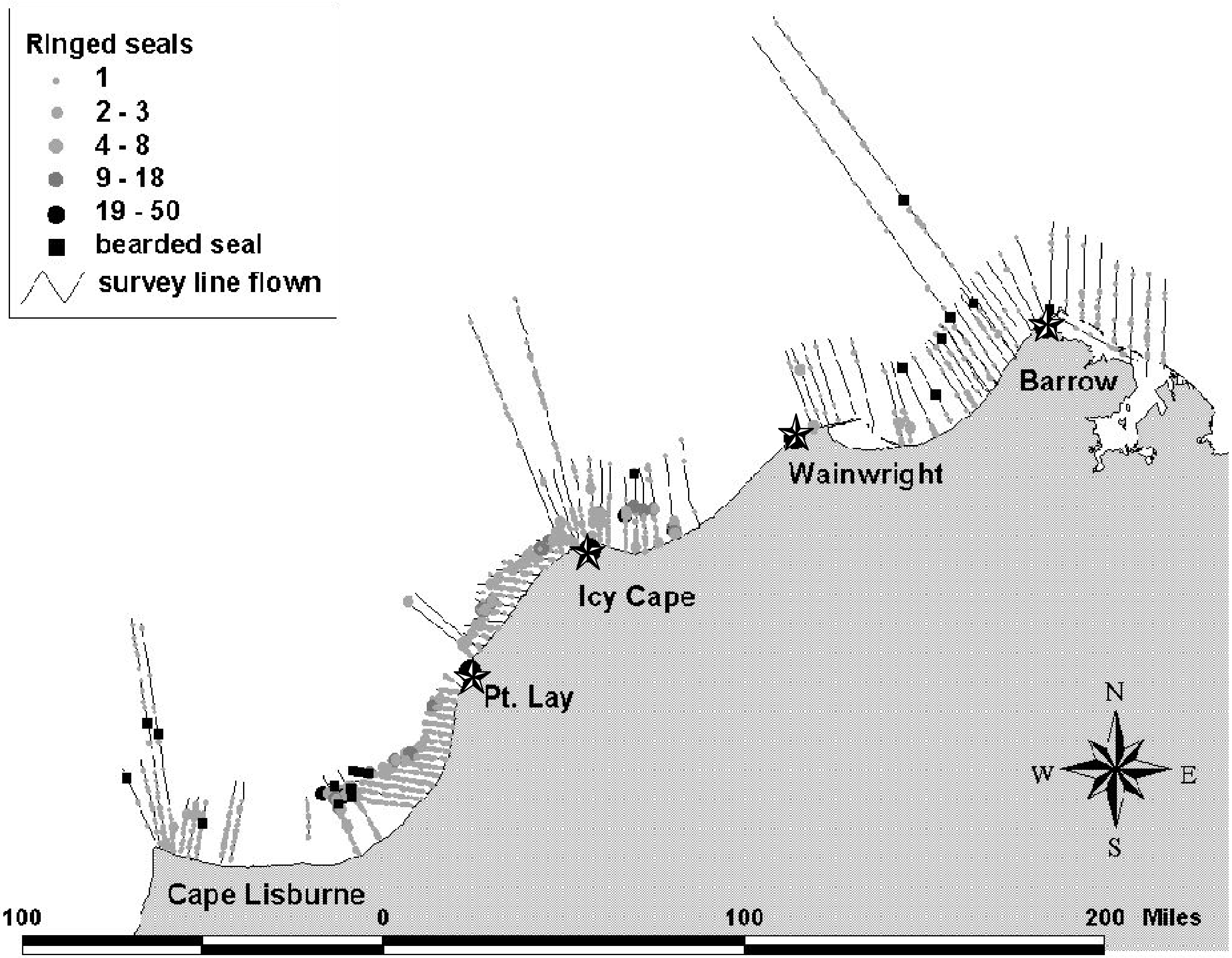


Figure 4. Ringed and bearded seal observations in the southern portion of the survey area, May 2000.

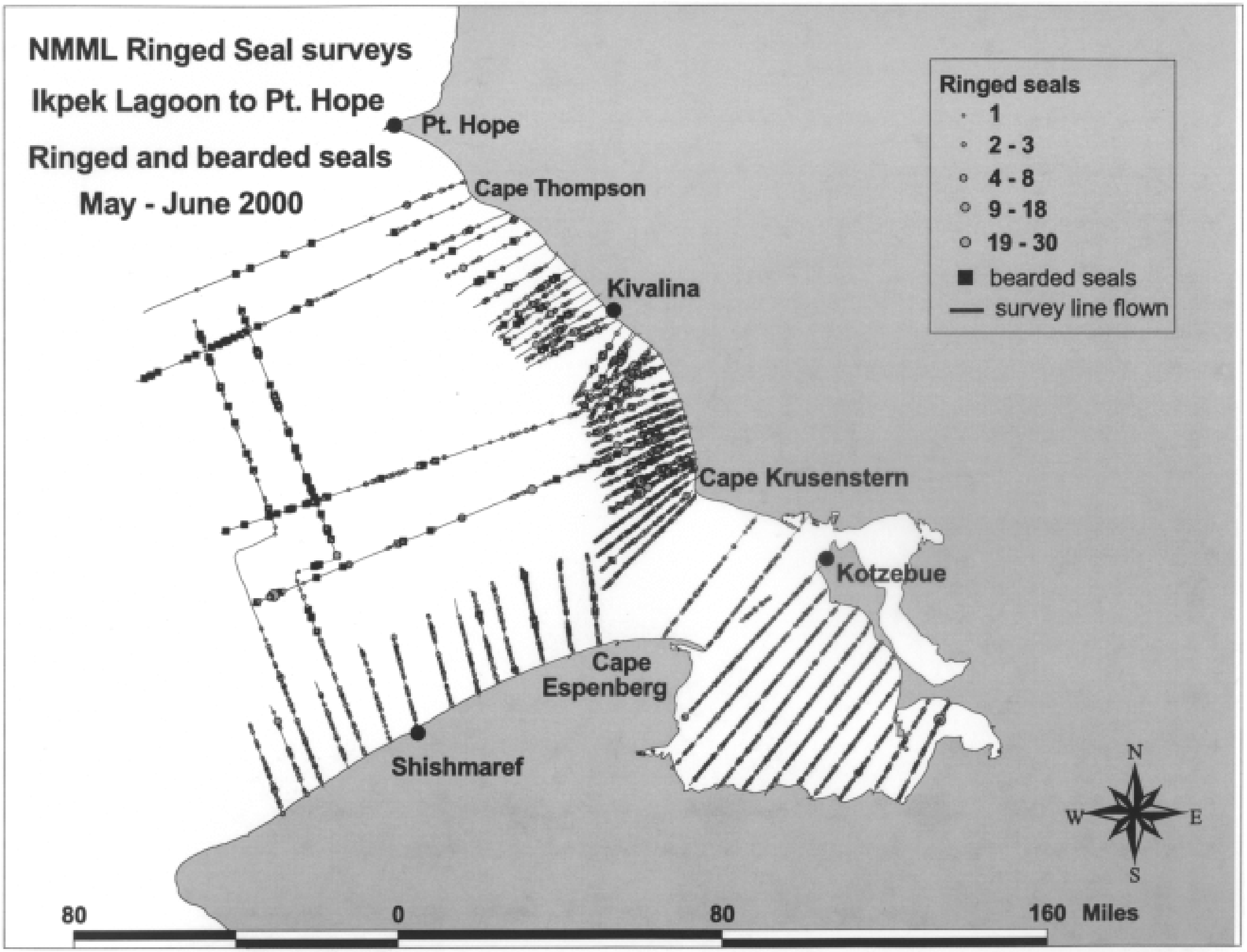


Figure 5. Ringed and bearded seal observations in the northern portion of the survey area, May-June 2000.

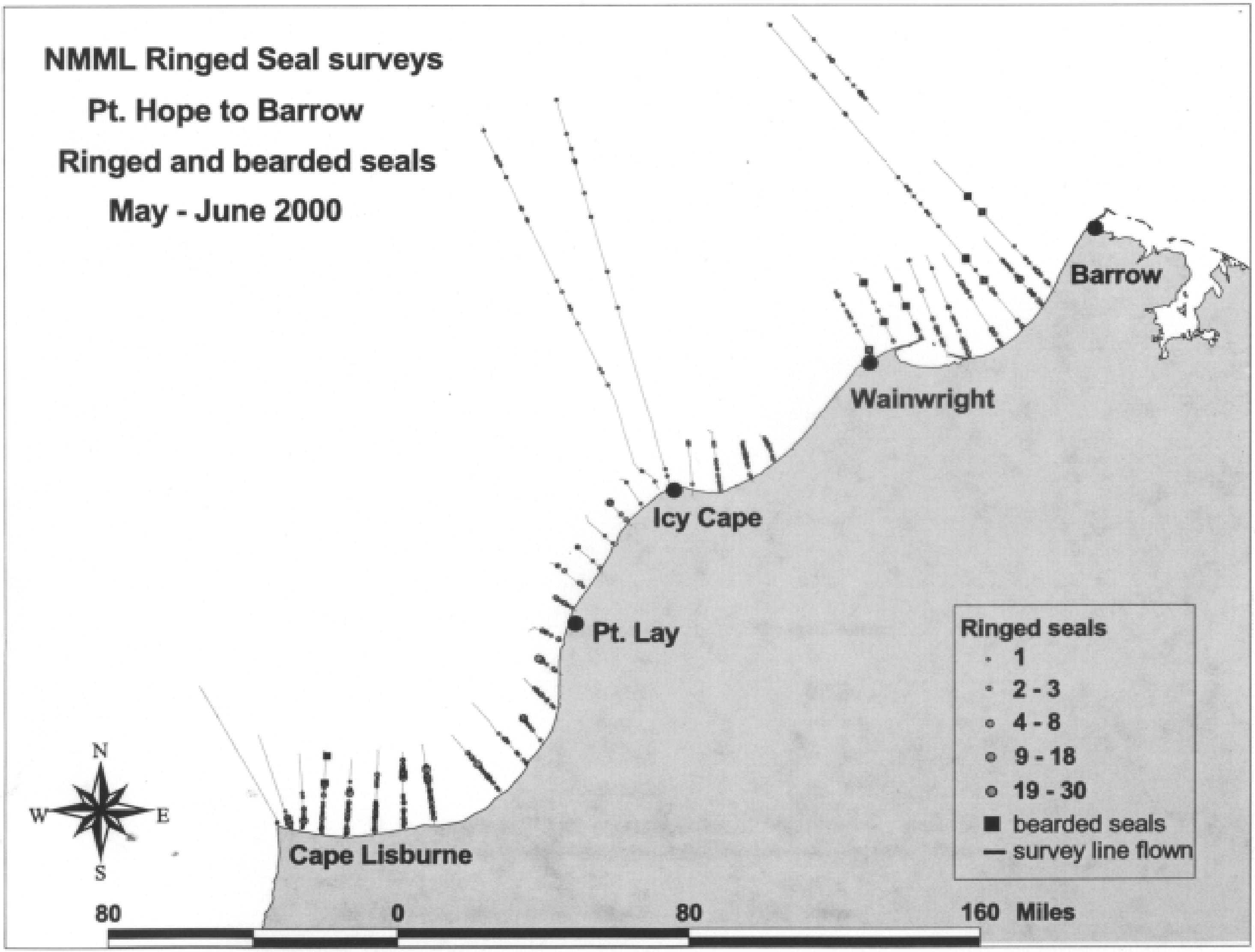


Figure 6. Observations of ringed and bearded seals in replicate surveys (31 May-1 June 2000). These surveys focused on the special area of interest around Kivalina, where high densities of both species of seals had been observed during previous surveys. The “no-fly” zone around Kivalina was not surveyed during these replicate surveys so that potential disturbance of bowhead whaling activities could be avoided.

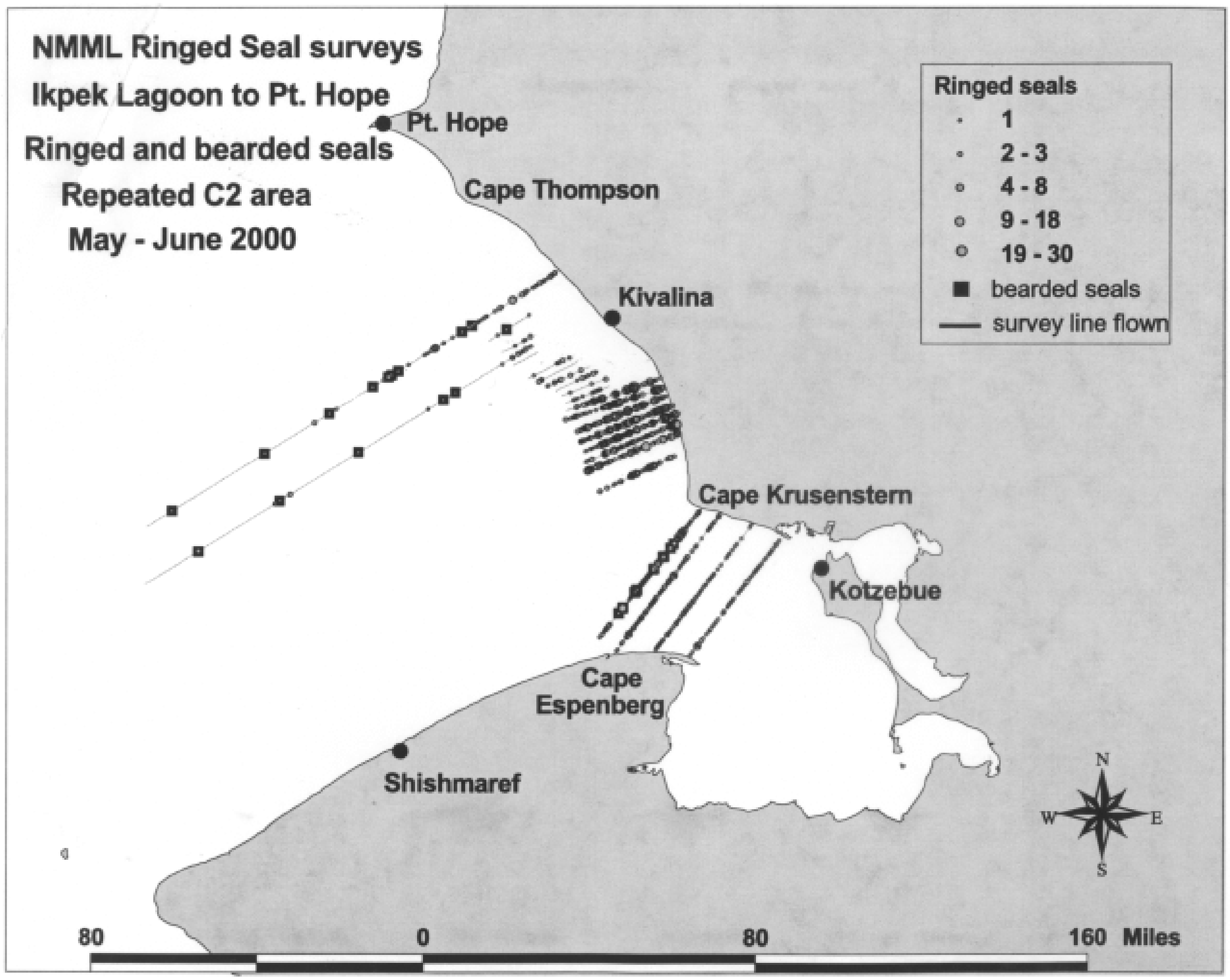
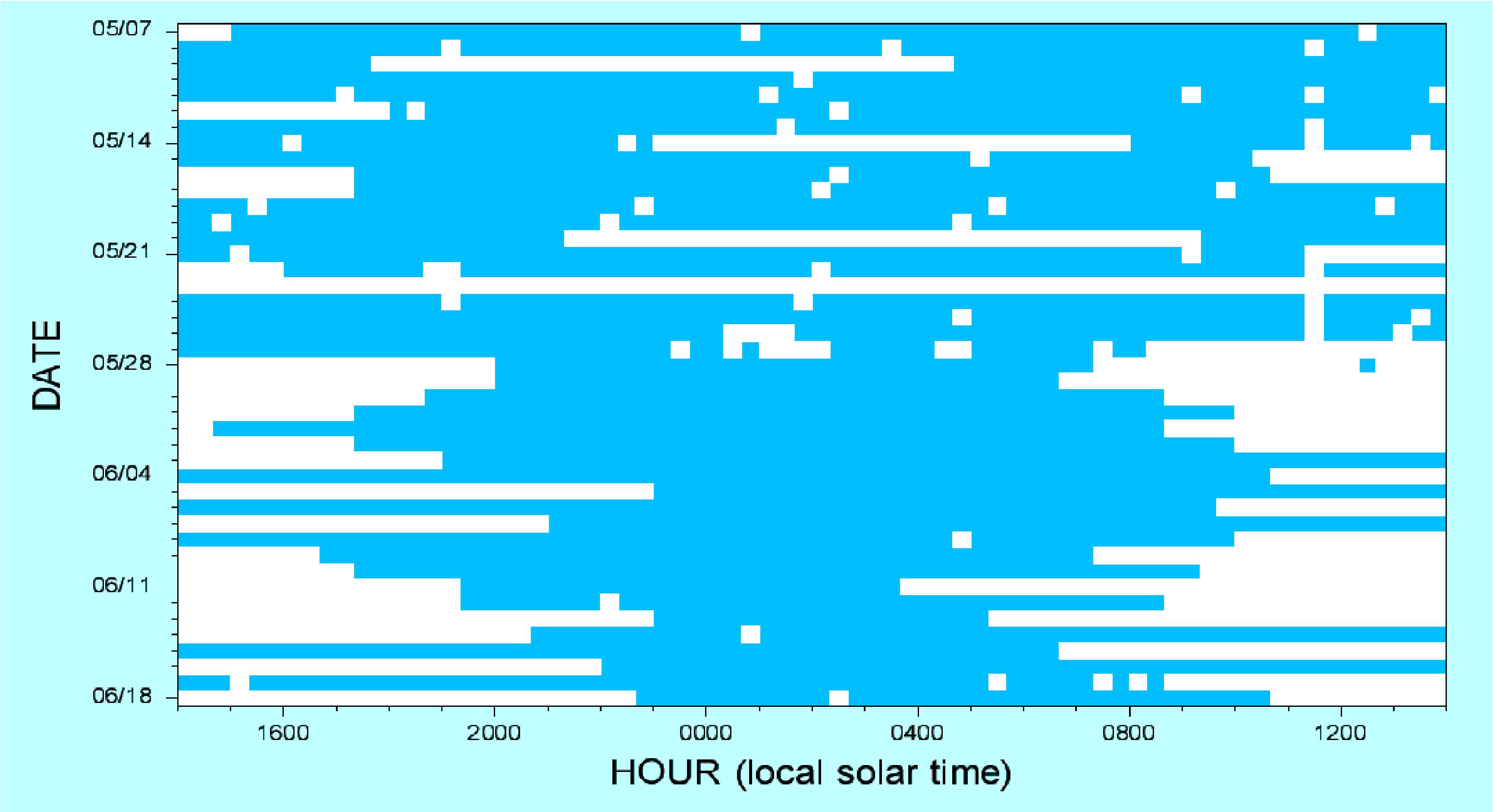


Figure 7. Ringed seal haulout patterns showing transition from using lairs under snow to basking on ice surface, around 28 May 1999. White indicates hauled out onto the ice, but does not differentiate between being above or under the snow surface.



STELLER SEA LION RESEARCH CRUISE IN THE ALEUTIAN ISLANDS AND GULF OF ALASKA, FEBRUARY-MARCH 2000

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Introduction

Scientists from the National Marine Fisheries Service's Alaska Fisheries Science Center, Colorado State University, and the University of Alaska Sea Grant Program conducted Steller sea lion research in the Aleutian Islands and Gulf of Alaska aboard the U.S. Fish and Wildlife Service vessel M/V *Tiglax* from 24 February through 15 March 2000. The primary goal of this cruise was to capture juvenile and pup sea lions for collection of blood and other biological samples and for deployment of satellite-linked time-depth recorders. A secondary goal was to go ashore at any accessible haul-out site to collect sea lion scats (fecal material) for food habits analyses. We concentrated our capture effort in three geographical regions: Seguam Island, the Krenitzen Islands and Unimak Pass, and eastern Kodiak.

Itinerary

The scientific party boarded the M/V *Tiglax* at Adak, Alaska, on 24 February and departed within a few hours. Most of the cruise was conducted under storm- or gale-warning flags, as a succession of low-pressure weather systems bringing high winds and heavy seas swept across the North Pacific and Bering Sea. Several of our intended research sites were fully exposed to weather (e.g., southwest winds and seas washing directly onto Lake Point, Adak). Other sites may have been on the leeward sides of islands, but the lack of protection from surging waves made them unworkable on most days (e.g., Seguam, Yunaska, and Jude Islands). In the relative protection of the Krenitzen Islands, we constantly changed anchorages and target haul-out sites in reaction to changes in wind direction. Consequently, we spent much of our time at anchor in shelter when conditions precluded safe landings at sea lion haul-out sites, striving to be in position to go ashore and work when the weather did let up. This strategy worked well at Turf Point, Seguam Island. Although we were able to land at haul-out sites in the Krenitzen Islands, the predominantly southerly winds were exactly wrong for stalking sea lions, making down-wind approaches difficult or impossible. On several occasions, all animals spooked and departed from the haulout before a capture could be attempted. We were unable to get ashore at haul-out sites along the eastern coastline of Kodiak Island (Twoheaded Island, Cape Barnabas, Gull Point, Cape Chiniak) because of easterly winds and seas, but we did have one workable day at Long Island near Kodiak City and one day in the northern Archipelago (Sea Otter Island and Latax Rocks). A severe storm warning caused us to curtail our work a day early. We concluded the cruise at

Homer, Alaska, on 15 March. A list of personnel and a detailed, day-by-day itinerary for the cruise are attached (Tables 1 and 2).

Results

During the *Tiglax* cruise we visited 29 Steller sea lion haul-out sites from Lake Point, Adak Island, in the central Aleutian Islands to Flat Island in lower Cook Inlet, including multiple visits to five sites. Latitude and longitude for all sites are listed in Table 3. We went ashore at nine different sites; the only multiple landings were three visits at Aiktak Island near Unimak Pass. On one occasion we went ashore but were unable to reach the haul-out site (Silak Island in Little Tanaga Strait), and three times we launched the skiff but were unable to get ashore (Adak Island/Lake Point, Jude Island, and the first visit to Basalt Rock). We collected a total of 219 scats from ten shore visits to nine different sites: 13 scats from Seguam, 174 scats from the Krenitzen Islands (5 sites), and 32 scats from the northern Kodiak Archipelago (3 sites). We sub-sampled 58 of the scats for hormonal analyses. A summary of counts and collected samples is included in Table 4.

We captured nine pup and yearling sea lions: five at Turf Point, Seguam Island (4 females, 1 male), two at Aiktak Island (1 female, 1 male), and two at Long Island (2 males). We administered valium (dose of 1.1!2.0 cc based on estimated weight) to each pup approximately 10 minutes prior to working with it. Mean mass was 82.2 kg (S.D. ' 14.3, range 61.8!100.2) for five females and 83.6 kg (S.D. ' 23.7, range 62.2!109.0) for 3 males. Mean mass for 8 animals of both sexes was 82.7 kg (S.D. ' 16.6). We were unable to weigh 1 male (white 586: estimated to be 95-100 kg) because of his struggling and the difficult position where he lay. This male may have been 21-22 months old, based on the length of his canine teeth. All others were pups of the year, approximately 9-10 months old. Complete measurements for all captured animals are listed in Table 5.

We successfully obtained blood from all captured animals. It was difficult to obtain a blood sample from the last animal (white 587, %) but we were able to get one large and one small (heparinized) tube of blood. We performed preliminary blood work-up onboard the ship (e.g., serum extraction, hematocrit, white cell counts). Samples retained for later analyses in the laboratory included frozen serum and plasma, hemoglobin preserved in reagent, and blood smears on slides. The white-cell counts were very low for the two smallest pups (red 939, &, 61.8 kg, Seguam Island; white 587, %, 62.2 kg, Long Island). Dr. Spraker thought this could be an indication of viral infection. This small male (white 587) also had ulcers on his foreflippers, possibly indicative of calicivirus infection. The largest female captured (red 942, 100.2 kg, Aiktak Island) had an ulcer on her vulva that also may have been caused by calici virus; however, her white cell count appeared within normal limits.

We collected a genetic sample (flipper punch) from each captured animal, and a blubber biopsy from all five Seguam animals and both from Long Island The two animals at Aiktak Island were marginally restrained in an awkward setting and we decided to forgo biopsy. We also biopsied one of the smaller flipper ulcers on the of the male pup at Long Island (white 587).

We deployed satellite-linked time-depth recorders and VHF transmitters on eight of the nine captured sea lions, not attaching instruments to the smallest of the female pups captured at Sequam Island Via e-mail, we were able to notify NMML immediately after PTT deployment, receiving confirmation by reply within a few hours that each instrument was working and that each animal had shown some movement. PTT identification numbers and VHF frequencies are listed in Table 5.

We collected a fresh-born fetus on Sea Otter Island, at the northern end of the Kodiak Archipelago. Judging from the overall condition of the fetus, Dr. Spraker estimated that it had been born a few hours prior to our arrival (but not during the disturbance caused by our capture attempt). Partial inflation of the lungs implied that the pup had been born alive but had not survived more than 15-30 minutes. Dr. Spraker performed a post mortem examination onboard the ship and collected full suites of formalin-preserved and frozen tissues for laboratory analyses. We also collected blood from the fetus, which we worked up according to the same protocols as for the live pups.

We had only two resightings of tagged animals: ***red 961*** at the Rocks Northeast of Tigalda on 4 March and ***red 995*** at Aiktak on 6 March. Both were tagged at Ugamak on 2 July 1998. We saw no branded sea lions during the cruise.

Other Observations

We had surprisingly few observations of other marine mammals. We saw killer whales on only three occasions: two whales in Amukta Pass on 3 March, four whales in Tigalda Bay on 7 March, and five whales cruising processor row in Kodiak harbor on 12 March. We were unable to obtain photographs of any killer whales. On 3 March a group of 6-10 Pacific white-sided dolphins rode our bow for several minutes north of Akutan Island, near Unimak Pass.

The most notable bird observation was of a male spectacled eider off the sea lion haulout on the Rocks Northeast of Tigalda, a site identified as “Kaligagan Rocks” by the Alaska Maritime Wildlife Refuge biologists. It is thought that most spectacled eiders winter in polynyas in the Bering Sea near St. Lawrence and St. Matthews Islands. The few sightings of these birds in the Aleutian Islands during winter likely is a function of low observer effort.

Concluding Remarks

The capture technique of using hand-held hoop nets on land worked very well. This technique does require adaptation to the physiography of each site, and improvisation to cope with local weather conditions (particularly wind direction), and haul-out distribution of the animals. Turf Point, Seguam Island, is the easiest and most productive site for capturing animals. In each of the last two years, the number of animals captured and handled was limited by the number of personnel to work them up. We probably could have caught animals at Jude Island, as we did in 1999, but we decided against going ashore in deteriorating weather conditions. Although we did successfully capture two animals at Long Island, this is not a very suitable site for future net captures. The sides of the haulout are very steep and rocky. If animals are pushed gently, they find their way carefully down the slope. When pushed suddenly, as during a hoop-net capture, they undoubtedly crashed into rocks in their haste to escape. On three occasions we experimented with using the skiff immediately in front of the haulout to herd and distract animals and drive them towards the capture team, who crept up from behind. This skiff-aided technique worked at Aiktak Island but resulted in near misses at Sea Otter Island and Latax Rocks.

We experimented with a variety of restraint methods and tools. We used a double-length automobile seat belt as a flipper restraint, essentially pinning the animal's foreflippers along its torso in a "full Nelson" wrestling hold. This belt first, when applied first to the animal, took away its greatest advantage over us and reduced its ability to struggle or escape. The weighing harness with 6 seat belts sewn in also worked very well. The seat belts were easily locked and tightened to restrain the animal's head, torso, and hindflippers. These belts went over the "full-Nelson" belt. Individual belts on the harness could be unbuckled and moved out of the way to facilitate drawing blood, attaching a PTT, or taking a blubber biopsy, then re-tightened. When all work on an animal was completed, the seat belts were easy to unfasten and clear out of the way, facilitating quick and easy release of the animal.

We used the capture nets both as a temporary holding device and as an aid for restraint during handling. On two occasions we captured two animals at the same time. While we worked up the first animal, we held the second animal in the net by twisting the hoop to tie off the bag. If the bagged animal was removed from the area of greatest activity it usually remained reasonably quiet for the 60-70 minutes required to finish the first animal. To transfer an animal to the weighing and restraining sling, we first positioned the animal approximately in position on the sling, then slowly untwisted the net and removed the hindflippers. Working the net up the torso, we first attached the "full-Nelson" strap, then the other seat belts along the animal's body. In most cases we kept the animal's head enclosed in the capture net, with the hoop positioned under its chest, weighing the animal with the sling and capture net. The net offered handlers some protection from bites and seemed to calm animals be restricting its vision and keeping its head in relative darkness. We also draped a folded piece of net (trawl net liner) over the animal's head, which offered additional protection to handlers and seemed to help calm the animals.

Dr. Spraker administered a dose of Valium (1.1!2.0cc depending on the animal's estimated weight) to each animal about 10 minutes before we started handling it. Each animal struggled while we attached the various restraints, but calmed down quickly thereafter, usually by the time we finished weighing and taking measurements. All animals lay still while we attached PTTs and took blubber biopsies; several appeared to sleep through much of the procedure. Valium greatly reduced the animals' struggles to escape, which in turn reduced the amount of wrestling and fighting required to restrain them, as well as the total handling time. Administration of Valium undoubtedly minimized the overall stress experienced by captured animals.

Table 1. Personnel for the research cruise aboard the M/V *Tiglax* in the Aleutian Islands and Gulf of Alaska, 24 February to 15 March 2000.

Scientific Personnel	
John Sease (Party Chief)	NMFS, NMML, Seattle, WA
Jim Thomason	NMFS, NMML, Seattle, WA
Jeremy Sterling	NMFS, NMML, Seattle, WA
Kate Call	NMFS, NMML, Seattle, WA
Dr. Terry Spraker	Colorado State University, Fort Collins, CO
Kate Wynne	University of Alaska Sea Grant Program, Kodiak, AK

M/V *Tiglax* crew	
Kevin Bell	Captain
Tom Cunningham	Mate
Eric Nelson	Chief Engineer
Dan Ericson	AB, skiff driver
Dan Peterbough	AB, skiff driver
Bob Ward	cook, AB

Table 2. Day-by-day itinerary of the research cruise aboard the M/V *Tiglax* in the Aleutian Islands and Gulf of Alaska, 24 February to 15 March 2000.

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24 February - NMML scientific party arrived in Adak, boarded the *Tiglax*, and departed for the Bay of Waterfalls, southwest Adak. En route, unable to land at Crone Island haulout. Anchored in the Bay of Waterfalls, Adak Island

25-27 February - Unable to land at Lake Point rookery because of prevailing SW wind and seas. Conditions not good for transit eastward. Anchored two days in the Bay of Islands, N of Lake Pt., and one more in the Bay of Waterfalls. Ca. 250-300 sea lions at Lake Point.

28 February - Again unable to land at Lake Point, weather okay to transit eastward. Unsuccessful landing at 2 haulouts in Little Tanaga Strait. Count sea lions at Chagul, Tagalak, Fenimore.

29 February - Turf Point, Seguam Island, captured five sea lions (4**&&**, 1**%**), attaching PTT and VHF transmitters to all except the smallest female.

1 March - Anchor at Korovin Bay, Atka, to hide from strong east winds, moving at night to Atka village when wind shifts west.

2 March - Forecast of wind and seas from west, highly unlikely that the relatively unprotected sites of Seguam Island through Yunaska were workable. Transit to eastern Aleutian Islands, looking at sites on the north side of Seguam Island

3 March - Pass by haulouts at Cape Aslik (Umnak), Bishop Point (Unalaska), and Billingshead (Akun). Only sea lions were on a haulout about 3 miles east of the Billingshead rookery beach. Anchor in Akun Bay.

4 March - Collect scats at Tanginak Island, look at Basalt Rock and decide to leave it undisturbed for future capture attempt. Collect scats at the Rocks NE of Tigalda after unsuccessful capture attempt. Anchor in Tigalda Bay.

5 March - Morning at anchor in 50kt SE winds. Mid-day depart for Akun Bay anticipating shift to W wind. Attempt but unable to land on Basalt Rock.

6 March - Transit to Aiktak. Near capture misses at 2 different locations on Aiktak. Collect scats and return to Tanaga Bay to hide from 50 kt SE wind.

7 March - Close but unsuccessful capture attempt at Basalt Rock. 260-300 sea lions at 6 different locations around Billingshead, but none on the rookery beach and none in potential capture sites. Collect scats at Basalt and 2 Billingshead sites. Return to Tigalda Bay.

8 March - Sea lions at first site on NE side of Aiktak spook. Capture team stay ashore hoping sea lions will return. At 1420 capture male pup on ledge of main haulout. Attach PTT and VHF, collect scats. Remain anchored off Aiktak cabin site.

9 March - A few young sea lions remained on haulout ledge when we tried grappling for lost net. Returned with 2 people on shore and 2 in skiff. Caught female pup that was more afraid of the skiff than of the people on shore. Attached PTT and VHF and collected fresh scats. Depart for Jude Island after working up blood.

10 March - About 200 on Jude Island but abort capture attempt. Could have landed, but building wind and seas forecast difficulty getting off the very exposed ans small island. Cruise by The Whaleback, Unga (Acheredin Point and Unga Cape).

11 March - Bucking into heavy and occasional strong winds out of NE. No chance to work sites between Shumagins and Kodiak as all are exposed to seas. Continue to Kodiak.

Table 2. Day-by-day itinerary (continued).

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12 March - Leave anchorage in Kalsin Bay, Kodiak, for Long Island Sea lions on Long inaccessible from water. Arrange helicopter airlift from nearby beach. Capture pup/yearling and pup, fitting each with PTT. Tie up at Kodiak city dock overnight.

13 March - Winds east 30 kts, run errands in Kodiak. Depart mid-day for north end of Afognak Island, passing inaccessible sea lions on Marmot Island and Sea Lion Rocks en route.

14 March - Attempt captures at Sea Otter Island and Latax Rocks. Position of sea lions on haul outs and wind direction not entirely suitable for captures. Fresh fetus (premature birth) found on Sea Otter Island; collected complete suite of samples and blood for analyses. Anchor overnight in Koyuktolik Bay, Kenai Peninsula.

15 March - Conditions unworkable in Barren Is. and Elizabeth Is., depart for Homer, arriving by mid-day to conclude cruise.

15-17 March - Scientific party returns home.

Table 3. Locations of Steller sea lion haul-out sites in the Aleutian Islands and Gulf of Alaska visited or observed during 24 February to 15 March 2000.

Site Name	**Latitude “from”**			**Longitude “from”**			**Latitude “to”**			**Longitude “to”**		
Adak/Crone Island	51	40.24	N	176	36.47	W						
Adak/Cape Yakak	51	35.5	N	176	57.1	W						
Adak/Lake Point	51	37.4	N	176	59.59	W						
Little Tanaga Strait	51	49.09	N	176	13.9	W						
Anagaksik	51	50.86	N	175	53	W						
Tagalak	51	57.6	N	175	37.2	W						
Fenimore	54	58.7	N	175	32.64	W						
Oglodak	51	59	N	175	26.5	W						
Seguam/Wharf Point	52	21.5	N	172	19.5	W						
Seguam/Turf Point	52	15.55	N	172	31.2	W						
Seguam/Saddleridge	52	21.05	N	172	34.4	W	52	21.02	N	172	33.6	W
Seguam/Finch Point	52	23.4	N	172	27.7	W						
Umnak/Cape Aslik	53	25	N	168	24.5	W						
Unalaska/Bishop Point	53	58.4	N	166	57.5	W						
Akun/Billings Head	54	17.61	N	165	32.06	W	54	17.57	N	165	31.71	W
Tanginak	54	12	N	165	19.39	W						
Basalt Rock	54	6.451	N	165	22.53	W						
Rocks NE of Tigalda	54	9.6	N	164	59	W	54	9.115	N	164	57.18	W
Aiktak	54	10.99	N	164	51.154	W						
Ugamak South	54	12.82	N	164	47.11	W						
Jude	55	15.75	N	161	6.273	W						
Unga/Acheredin pt	55	7.237	N	160	49.039	W						
Kupreanof Point	55	33.78	N	159	36.24	W						
Sitkinak/Cape Sitkinak	56	34.3	N	153	50.96	W	56	34.2	N	153	51.05	W
Long	57	46.82	N	152	12.9	W						
Marmot	58	13.65	N	151	47.75	W	58	9.9	N	151	52.06	W
Sea Lion Rocks (Marmot)	58	20.53	N	151	48.83	W						
Sea Otter	58	31.15	N	152	13.3	W						
Latax Rocks	58	40.1	N	152	31.3	W						
Flat	59	19.8	N	151	39.75	W						

Table 4. Summary of counts, captures, and scats collected in the Aleutian Islands and Gulf of Alaska, 24 February to 15 March 2000.

Site	Day	Mon.	Time	Estimated number of sea lions	Captures	Scats	Comments
Adak/Crone	24	Feb.	1910	30			could not land
Adak/Lake Point	25	Feb.	947	200-250			200 on rookery, 50 to S
Adak/Lake Point	27	Feb.	1150	250-300			250 on rookery, 50 to S
Adak/Cape Yakak	27	Feb.	1215	< 5			
Adak/Lake Point	28	Feb.	930	350			250 on rookery, 100 to S
Adak/Cape Yakak	28	Feb.	1030	10-12			
Little Tanaga Strait	28	Feb.	1345	75			
L.Tanaga Str./Silak	28	Feb.	1430	25-35			17 females & 8 pups plus others
Chagul/Cape Kagalus	28	Feb.	1750	15			
Tagalak	28	Feb.	1830	80			51 57.4N 175 36.8W
Fenimore	28	Feb.	1900	20			15+5
Seguam/Turf Point	29	Feb.	900		5	13	4 PTTs, 150-200 EJs ???
Seguam/Saddleridge	2	Mar.	1430	0			
Seguam/Finch Point	2	Mar.	1517	4			
Seguam/Wharf Point	2	Mar.	1550	75			
Umnak/Cape Aslik	3	Mar.	800	0			10ft seas W25-30, HO awash
Unalaska/Bishop Point	3	Mar.	1320	0			10ft seas W25-30, snow, HO awash
Akun/Billingshead rookery	3	Mar.	1850	0			no animals on rookery beach
Akun/Billingshead HO	3	Mar.	1855	10			on slab rock E of rookery bight
Tanginak	4	Mar.	845	155		11	115 on W side, 40 on E
Basalt Rock	4	Mar.	1024	70			did not go ashore
Rocks NE of Tigalda	4	Mar.	1215	40		33	unsuccessful capture attempt
Aiktak	4	Mar.	1445	100			in 4 spots, including boat landing
Ugamak Bay	4	Mar.	1500	10			on E side of bay
Akun Bay	5	Mar.	1700	7			54 12.8N, 165 24.3W
Aiktak	6	Mar.	920	125		17	25+60+40 EJs
Basalt Rock	7	Mar.	1200			25	unsuccessful capture attempt
Akun/Billingshead rookery	7	Mar.	1430	0			
Akun/Billingshead HO	7	Mar.	1430	300		38	
Aiktak	8	Mar.	1420		1	38	no estimate of numbers, 1 capture
Aiktak	9	Mar.	945		1	12	no estimate of numbers, 1 capture
Jude	10	Mar.	820	200			did not land
Unga/Acheredin Point	10	Mar.	1010	80			75 + 5
Unga/Unga Cape	10	Mar.	1115	0			
The Whaleback	10	Mar.	1315	150+			could not see S side, total ' 200 ??
Long	12	Mar.	1500		2	2	no estimate of numbers, 2 captures
Sea Otter	14	Mar.	840	40		23	unsucc. capture attempt, fresh fetus
Latax Rocks	14	Mar.	1245	100		7	unsuccessful capture attempt
Flat	15	Mar.	800	5			did not land
Total captures and scat samples					9	219	

Table 5. Details of sea lions captured in the Aleutian Islands and Gulf of Alaska during 24 February to 15 March 2000. We successfully collected blood and a genetic sample (flipper punch) from each animal. Biopsies were of blubber, taken at the base of the neck, just anterior to the PTT.

Tag	Location	Date	Sex	Age	Mass (kg)	Std.L. (cm)	Curv.L. (cm)	Axil.G. (cm)	Flipper (cm)	Valium (cc)	Blood	Genetic	Tetracy. (cc)	Biopsy	PTT #	VHF #
937 Red	Seguam/Turf Pt.	29 Feb.	F	P	87.0	151.0	160.0	108.5	46.0	1.5	Y	Y		Y	14111	164.903
		Comments: Suckling just prior to capture.														
938 Red	Seguam/Turf Pt.	29 Feb.	F	U	85.8	157.0	162.0	108.0	46.5	1.5	Y	Y		Y	14114	164.297
		Comments: Probably pup of the year.														
939 Red	Seguam/Turf Pt.	29 Feb.	F	P	61.8	138.0	149.0	90.5	45.0	1.5	Y	Y		Y	no	no
		Comments: Low white-cell count - virus infection (??). Did not attach PTT or VHF.														
940 Red	Seguam/Turf Pt.	29 Feb.	F		76.2	148.0	155.0	102.5	49.0	1.5	Y	Y		Y	14116	164.200
941 Red	Seguam/Turf Pt.	29 Feb.	M	P	109.0	156.0	163.0	113.0	56.0	2.0	Y	Y		Y	14163	164.780
		Comments: Canines not longer than incisors.														
946 Red	Aiktak	8 Mar.	M	P	79.6					1.1	Y	Y	4.0	N	14164	164.76
		Comments: Tags destroyed not applied. Unable to take measurements, animal too mobile.														
942 Red	Aiktak	9 Mar.	F	P	100.2	155	164			2.0	Y	Y	4.0	N	14167	164.102
		Comments: 1-mm ulcer on right lip of vulva - probably calici virus. Lengths not ideal because of animal's position and slope.														
586 White	Long	12 Mar.	M	P-1		150	165			2.0	Y	Y	4.0	Y	14170	166.24
		Comments: Mass estimated at 95-100 kg. Maybe yearling, canines extended past other teeth. Difficult to handle, not all measurements taken.														
587 White	Long	12 Mar.	M	P	62.2	145	150	90	47.5	1.5	Y	Y	4.0	Y	21094	164.83
		Comments: 2-cm ulcer on left fore flipper, 2 smaller ulcers on right fore flipper, probably calici virus. Biopsy of ulcer on right. Hard to get blood only, 1 large and 1 small tube. Suckling just prior to capture. Low white-cell count - virus infection (??).														

FATTY ACID PROFILES OF STELLER SEA LIONS AND NORTH PACIFIC OCEAN FORAGE FISHES, A PILOT STUDY USING NORTHERN FUR SEALS

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Introduction

Application of fatty acid techniques to diet analyses for Steller sea lions and other North Pacific Ocean (NPO) predators has been slowed by several factors. The most important may be that only one laboratory in North America performs fatty acid (FA) analyses on marine mammal tissues (Dr. S. Iverson, Dalhousie University), and its research has been focused on North Atlantic Ocean phocids. Similar information is unavailable for NPO prey and predator species. In addition to developing baseline values for prey FA profiles, potential spatial or age-based variability in prey FA profiles must be assessed because the potential for considerable variation exists.

This study was designed to address these factors through a 3-year collaborative effort between the National Marine Mammal Laboratory (NMML) and the Auke Bay Laboratory (ABL) of the National Marine Fisheries Service/Alaska Fisheries Service Center. Year-one was used for development of sampling techniques and collection of northern fur seal tissues for preliminary testing. Year two was used to develop FA profiles for blubber collected from St. Paul Island, Alaska, juvenile male and female northern fur seals from three body locations and two depths to assess the best body areas from which to collect tissue on an otariid. Year-three is being used to develop FA profiles for northern fur seal prey and for fur seals from St. George Island, Alaska. Laboratory analysis for year-three studies is still underway. A significant by-product of this research will be the development of a capability within the NMFS for marine mammal FA analyses and its application to Steller sea lions.

Methods

Fur seal blubber was collected in 1997 during the annual harvest on the Pribilof Islands. Blubber samples were collected from 16 juvenile males and 3 females on St. Paul Island and from 18 juvenile males on St. George Island. Each animal was sampled in three locations: neck, pelvis and shoulder. All samples were subsequently cut in half, and surface and deep layer blubber analysis was performed on all tissues. Utilizing the 164 blubber samples from animals from St. Paul Island, all lipids were initially extracted using a modification of Folch's method as outlined in Christie (1989). The non-polar lipid composition of the samples were then analyzed with high performance liquid chromatography (the HPLC method; see Christie, 1989), and the fatty acid composition was determined using a gas chromatograph equipped with a mass selective detector (GC/MS).

Statistical analysis was used to compare fatty acid and non-polar lipid contents between sexes and blubber layers, and among body locations and individuals. Differences in the non-polar lipid content of the entire blubber layer and between the three body locations were examined using analysis of variance (ANOVA). Statistical analysis to compare fatty acid compositions of blubber from St. Paul Island animals followed the procedures of Grahl-Nielsen (1999) using soft independent modeling by class analogy (SIMCA) (Wold and Sjöström 1977) with SIMCA-P version 8.0 from Umetrics AB. SIMCA is a multivariate technique based on principal components analysis (PCA). In addition, fatty acid compositions will be analyzed following the procedures of Smith et al. (1997; 1999) using classification and regression tree analysis (CART).

1998/99 Results

Data interpretation and statistical analysis of blubber from northern fur seals on St. Paul Island has begun, and will continue in the year 2000 - 2001 with the addition of the St. George Island animals and the prey items. Preliminary results indicate no difference between different areas or depths sampled. In addition, both juvenile male and female samples show a high level of wax esters and a high level of non-extractable dry weight in the blubber indicating that fur seal fat is high in protein.

Little in the way of results were available by the end of FY 1999. However, shortly into FY 2000, preliminary results were available. These results indicated that non-polar lipid content was highly variable among individuals and between sexes. The samples from females may have been overly influenced by the inclusion of a post-parturient female (female C) whose non-polar lipid content was especially low. Non-polar lipid content also varied with body location of sampled blubber in the juvenile males, with pelvic samples having the highest content and shoulder samples containing the lowest content. Pelvic samples were the best overall indicators of overall mean non-polar lipid content for individuals. There were no differences in non-polar lipids between inner and outer layers of blubber.

All juvenile males had unique fatty acid compositions, and the PCA models successfully discriminated between samples from different individuals 100% of the time. Female C had a distinct fatty acid composition from the two nulliparous females and all of the juvenile males. Juvenile males and the two nulliparous females overlapped in their fatty acid compositions, with only neck samples correctly classifying the sexes separately. The PCA models indicated that neck, shoulder and pelvic samples had fatty acid compositions that were not distinguishable from each other. However, when a model was built using the fatty acid compositions of the inner and outer layers of a particular set of samples (i.e., neck), and the corresponding set of entire blubber layers was applied to that model, the PCA model correctly identified the sample location 100% (neck) and 93.8% (shoulder and pelvis) of the time. Thus, a model for a particular tissue correctly described that particular tissue very well. Finally, the models indicated that there was no difference in fatty acid compositions between outer and inner blubber layers.

Non-polar lipid and fatty acid compositions of 95 prey items collected in 1997 in the Bering Sea and blubber from animals collected on St. George Island is underway with expected completion within the year 2001.

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