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ABSTRACT

In August 1991, satellite-linked platform transmitter terminals (PTTs) were attached to four spotted seals (Phoca largha) captured near a coastal haul out at Utukok Pass in the northeastern Chukchi Sea. The locations and diving behavior of the seals were monitored for periods of 64-259 days. Usable position information was obtained for about 50% of the days that the PTTs were operational. During August-October, seals made long feeding trips southwestward into the southern Chukchi Sea and returned to haul outs at Kasegaluk Lagoon. Durations of at-sea periods ranged from 8 to 902 hours, and the four seals on average spent 7% of their time hauled out. Three seals with still functional PTTs began their southward migration in October; two of them used haul outs in the Kotzebue Sound region and the northern Seward Peninsula. Seals migrated southward through Bering Strait in November and were near St. Lawrence Island in mid-December. The two seals whose PTTs worked into March-April spent the late winter and early spring in the sea ice south and southeast of St. Matthew Island. Haul outs on ice were infrequent, with seals hauled out only 6% of the time, on average. The number of dives to greater than 10 m depth averaged 160 and 284 per day for two of the seals. All dives were to depths less than 100 m, and most lasted for less than 10 minutes.

This study demonstrated the utility of satellite-linked telemetry for studying the biology of spotted seals. Modifications to PTT programming should allow future efforts to gather more detailed information on movements and diving behavior.

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INTRODUCTION

Spotted seals (Phoca largha) are medium-sized pinnipeds of the family Phocidae that occur principally in the Okhotsk, Bering, and Chukchi Seas. Because of morphological similarities with the North Pacific harbor seal (Phoca vitulina richardsi) and their adjacent and somewhat overlapping ranges, they have at times been considered a subspecies (Phoca vitulina largha) (Burns and Fay 1970, Bigg 1981). However, ecological differences in habitat use and reproductive activities (Burns 1970) and detailed morphological and craniometric analyses (Shaughnessy and Fay 1977, Burns et al. 1984) have confirmed that substantial differences exist between harbor and spotted seals.

Unlike the relatively well studied harbor seal, the biology of spotted seals is not well described (Quakenbush 1988). Most of the information available has come from studies conducted in the Bering Sea ice front in spring (e.g., Burns 1970, Fedoseev 1976, Braham et al. 1984). Pupping, breeding, and molting all occur in association with sea ice from March through May. As the sea ice cover diminishes and coastal areas become ice-free, spotted seals move to nearshore areas of Alaska and Siberia, some of them migrating northward into the Chukchi Sea. During the open water season, they are commonly seen hauled out on coastal barrier islands, sandbars, rocks, and reefs.

Frost et al. (1983) compiled information on the major summer haulout areas used by spotted seals along the coast of the eastern Chukchi Sea. The most important area identified was Kasegaluk Lagoon (named after the Inupiat word for spotted seal), where 1,000 or more seals were commonly seen hauled out inside the barrier islands. This led to a detailed study conducted during 1989-1991 to document spotted seal distribution, abundance, and habitat use in this region (Frost et al. 1993).

There have been no studies to describe the activities and behavior of spotted seals in Alaska at different times of the year other than during the spring. In August 1991 we conducted a study at Kasegaluk Lagoon to assess the feasibility of capturing and attaching satellite tags to spotted seals. The principal objective of this study was to evaluate the utility of satellite telemetry for identifying movements, habitat use, and diving behavior.

METHODS AND MATERIALS

Field Work

Field studies were conducted at Utukok Pass, a break in the barrier island system in the central portion of Kasegaluk Lagoon (Fig. 1). Personnel and equipment were transported by boat from Point Lay to Utukok Pass, where a field camp was set up during 4-7 August 1991.

Seals were caught using a net drifted in the lagoon near the pass. The net was constructed with large-diameter multifilament nylon twine with a stretched mesh size of 20 cm, and it was 3.7 m deep and 88 m long. The top of the net was supported by foam floats and the bottom weighted with a lead line. Seals that became entangled were immediately taken into a boat, removed from the net, and put into hoop nets constructed of soft nylon netting with a mesh size of about 2 cm. They were then taken to shore.

Once on shore, seals were either physically restrained or sedated with a mixture of ketamine and diazepam administered intramuscularly at standard doses of approximately 2-4 mg/kg ketamine and 0.05-0.10 mg/kg diazepam (Geraci et al. 1981). Each seal was weighed, measured (curvilinear length), and tagged on the hindflippers with individually numbered plastic tags. Approximately 50 cc of blood was drawn from the extradural intervertebral vein (Geraci and Smith 1975).

A satellite-linked platform transmitter terminal (PTT) was glued to the fur of the mid-dorsal surface of each seal using a fast-setting epoxy (Fedak et al. 1984; Stewart et al. 1989). With this type of attachment, it was assumed that the PTT would stay attached until the seal molted in May-June. After tagging was complete, animals were placed above the tide line near the capture site and left undisturbed until they chose to return to the sea.

Prior to being attached to the seals, PTTs were tested over a period of 1-4 days. They were placed in two locations on barrier islands off Kasegaluk Lagoon at a height of 2-3 m above sea level. Location data based on transmissions from the PTTs were compared to test site coordinates determined from National Oceanic and Atmospheric Administration (NOAA) nautical charts.

Equipment

Two types of PTTs were used. Units manufactured by Wildlife Computers (SLTDR 1.0W; Woodinville, Washington) measured 13.5 cm x 12.5 cm x 3.8 cm and weighed about 1,050 g. Units from Telonics (ST-3; Mesa, Arizona) measured 17.5 cm x 10.0 cm x 3.5 cm and weighed about 800 g. Both types were powered by four lithium C cells and had 1 watt of signal output through whip antennas. The PTTs transmitted on 401.65 MHz to receivers onboard NOAA polar orbiting satellites. PTTs were equipped with conductivity switches so that they transmitted only when they were out of the water. Telonics tags transmitted once every 60 seconds; Wildlife Computers tags transmitted once every 45 seconds when the animals were at sea, and switched to a rate of once every 90 seconds when animals were hauled out. Wildlife Computers tags operated continuously from the time they were attached, while Telonics tags were duty cycled and sent data for 7 day periods followed by 7 days of no transmissions. Data

transmitted included PTT identification code, temperature, and information on the number and duration of dives. Wildlife Computers tags also gave data on dive depths and battery status.

Wildlife Computers tags collected and reported dive data in bins. The minimum depth registered as a dive was 10 m. During a dive, the SLTDR sampled depth every 10 seconds to determine dive duration and maximum depth. At the end of each dive, it was incremented to one of six user-defined bins for maximum depth and for duration. A set of bins was referred to as either a depth or duration histogram. Depth bins were 10-50 m; 51-100 m; 101-150 m; 151-200 m; 201-250 m; and more than 250 m. Duration bins were: 0-120 seconds; 121-240 seconds; 241-360 seconds; 361-480 seconds; 481-600 seconds; and more than 600 seconds. Data for each bin were accumulated over 24-hour periods. Data were stored for the previous 4 days and were transmitted whenever contact was made with the satellite.

Telonics tags reported the duration of the previous dive (i.e., the length of time since the conductivity switch had last been dry), the number of dives in the previous 12-hour period (i.e., the number of separate times the conductivity switch had been dry), and the total amount of time spent diving in the previous 12 hours (i.e., the total length of time that the conductivity switch had been underwater).

Data Analysis

Data were obtained through the Argos system. Argos is a joint program of the French Space Agency, the U. S. National Aeronautics and Space Administration, and NOAA. Argos packages are flown on NOAA Tiros spacecraft, and data processing is done by Service Argos Inc., a subsidiary of the French Space Agency.

The Argos system recorded date and time of each signal received by the satellite (termed an "uplink") and calculated a location for the PTT based on Doppler shift whenever sufficient signals were received during a satellite pass. The accuracy of location calculations varies based in part on the number of uplinks that occur during a satellite pass. Service Argos assigns a quality ranking to location information. This rank is based on predicted accuracy which suggests that for the best data (assigned quality number 3), predicted locations are expected to be within 150 m of actual locations 68% of the time. Locations that are based on few uplinks or have other potential problems are assigned quality 0. Processing of data to calculate quality 0 locations is an extra cost option, and we requested the additional processing only for Wildlife Computers PTTs. Quality 0 locations were used principally to provide approximate positions of seals on days when no quality 1-3 fixes were obtained. When only one uplink occurred during a satellite pass, sensor data were recorded but no location was calculated.

Stewart et al. (1989) and Mate et al. (1992) provide additional description and analysis of the Argos system and its application to marine mammal tracking.

For analysis and presentation of data, dates and times reported by Service Argos were converted to true local time from Greenwich mean time by subtracting 11 hours.

The distance and speed between each sequential pair of fixes were calculated for all location records, and the results were used to screen out inaccurate locations. Apparent movement speeds of greater than 20 km/hr for periods greater than 5 minutes were considered suspect. Upon inspection of the data it was evident that these high speeds were due to one or more location fixes that clearly did not fit with the rest of the data. These records were deleted from the database and distances and speeds were recalculated.

A combination of location and sensor data was used to assess when seals were hauled out. Wildlife Computers PTTs reported the seals as hauled out or at sea based on the status of conductivity sensors. After the tenth transmission with no interruption of the conductivity switch, subsequent transmissions indicated that the seal was hauled out of the water. When the conductivity switch was interrupted, the status changed immediately back to at-sea. As a result this indicator underrepresented the actual duration of haul outs in two ways. First of all, since there was a delay of 10 transmissions before the beginning of a haul out was indicated, the haul out probably began about 450 seconds previously. To correct for this in data analysis, each haul out was assumed to have begun 7 minutes prior to the time indicated. Also, when seals are at coastal haul outs in the Chukchi Sea, they often lie in very shallow water where splashing or brief immersions of the conductivity switch could result in at-sea readings. Therefore, location records from around the times when sensors indicated haul outs were inspected, and the duration of the haul out bout was considered to include the entire period that the seal was in the vicinity of the haul out.

Telonics PTTs did not have a specific indicator of haul outs, but with every transmission they indicated the duration of the previous dive. Instances where the indicated duration of the previous dive remained constant for four or more transmissions were considered to represent seals hauled out. The time of the first identical transmission in the series was considered the start of the haul out bout, and the end was recorded as the time when the duration of the previous dive changed. When seals were in the Chukchi Sea there were some periods adjacent to the apparent haul out bouts in which there were a few dives indicated that were consistently short (less than 60 seconds), and for which locations plotted at or adjacent to the haulout site. Those periods were included in the determination of the total

duration of haul outs. Similar decision criteria were used by Born and Knutsen (1992) to determine haul outs of walrus (Odobenus rosmarus) from satellite telemetry data.

In most cases, it was possible to distinguish haul outs on land from those on ice simply by location. On some occasions in November, haul out locations plotted near shore and could have been either on land or on newly formed ice. In these instances, the series of location fixes received during the haul out bout was examined, and the substrate was considered to be ice if there was substantial variation among them (i.e., indicating that the seal was on ice that was drifting).

Dive data from Wildlife Computers tags were processed using software provided by the manufacturer. An error-checking algorithm was used to validate messages. Histogram messages were sorted by date, period, and type, and duplicate messages that provided data for the same day were removed.

A Kolmogorov-Smirnov test for goodness of fit (KS) was used to test for uniformity in the hauling patterns of spotted seals by time of day. Because hauling behavior is thought to change seasonally, diel patterns of haul outs were tested separately for the following periods: 4 August through 31 October 1991; 1 November through 31 December 1991; 1 January through 29 February 1992; and 1 March through 19 April 1992. In all tests the alpha was set at 0.05.

RESULTS

Capture and Tagging of Seals

Four spotted seals were captured during the period 4-7 August (Table 1). No capture attempts were made on 5 August due to stormy weather. Seals swimming toward the net at the surface appeared to see and avoid the floats. However, when underwater they did not seem to detect the webbing and readily became entangled. The water was quite muddy. None of the seals appeared injured or unduly stressed by the capture operations.

Three males and one female seal were captured. All animals appeared to be in excellent physical condition, ranging in weight from 45.5 to 106.8 kg. The three largest seals were sedated prior to tagging; the other was restrained physically. The total time required to measure an individual seal, collect blood, and attach the PTT and flipper tags was approximately 60 minutes. The seal that was not sedated went immediately into the water and swam away from the tagging site. Sedated seals remained on the beach an additional 20 to 40 minutes until they had recovered from the effects of the drugs. Individual seals will be referred

to in this paper by their PTT identification number (see Table 1).

PTT Performance

Satellite fixes were obtained from PTTs at two locations on land: one approximately 10 km north of Point Lay (69°49.8'N, 162°59.0'W), and the other at the tagging site at Utukok Pass (70°05.0'N, 162°31.0'W). The mean values of quality 3 locations derived from PTTs were virtually identical to the chart coordinates (69°49.6'N, 162°59.0'W and 70°05.0'N, 162°30.7'W). Since the positions derived from the satellite data are probably more accurate than those obtained from charts, variation among quality 3 locations and errors in quality 1 and 2 locations were determined by comparing each individual fix with the mean of the quality 3 locations (Table 2). On average, quality 3 fixes at the test location north of Point Lay varied by only 120 m; the errors in quality 2 and 1 locations were about twice as large. For all quality categories the mean error was about three times greater for fixes at Utukok Pass. No quality 0 locations were received from the transmitters on land.

After they were attached to seals, PTTs sent signals for 64-259 days. The first PTT to stop sending signals was last heard on 10 October 1991; one unit continued to transmit until 12 April 1992 (Table 1). The periods over which signals were received were as follows: PTT 14098-149 days; PTT 14099-64 days; PTT 10919-215 days; and PTT 10920-259 days. Because the Telonics tags were duty cycled, the actual number of days that the transmitters operated was about one-half of the total time (111 days for PTT 10919 and 133 days for PTT 10920). However, the Telonics tags were activated at mid-day so that during each on cycle there were two half days and six full days of transmission. Therefore, the total number of calendar days on which data could have been received was 126 for PTT 10919 and 152 for PTT 10920.

In total, 1,571 location records for all PTTs combined were received from Service Argos. When those records were screened based on the assumption that seals were unlikely to swim at speeds greater than 20 km/hour for more than 5 minutes, 126 records were deleted. Of those, 119 were location quality 0, 5 were quality 1, and 2 were quality 2. The remaining data set included 631 class 0 locations and 814 locations of classes 1, 2, or 3.

When only quality 1-3 locations are considered, the total number of fixes obtained for a single seal ranged from 51 to 289 (Table 3). Most were of location quality 1 (49%-60%) or quality 2 (35%-47%); relatively few were quality 3 (4%-6%). On average, each PTT gave 0.8 to 2.6 fixes of quality 1-3 per operational day. One or more fixes of quality 1-3 were obtained on 23%-59% of the days that each PTT was operational. Quality 0 locations

provided positions for seal 14098 on 52 additional days and for seal 14099 on 12 additional days.

Haulout Behavior

Interpretations of the daily behavior of each seal based on PTT data are given in Appendices A-D. In August and September all recorded haul outs were at either the tagging site, Utukok Pass (8 records), or to the north at Akoliakatat Pass (5 records) (Fig. 2). Three of the four seals hauled out at the southern end of Kasegaluk Lagoon in early to mid-October, and two later hauled out on land in Kotzebue Sound and on the north side of the Seward Peninsula. Undoubtedly some haulout bouts were not recorded since two of the transmitters were operational only 50% of the time. After mid-November all haul outs were on ice.

There was great variability in the lengths of haulout bouts and at-sea periods for seals in the Chukchi Sea during August-October (Table 4). Recorded haulout bouts ranged from 0.5 to 114.0 hours, with considerable variability within and among individual seals. Lengths of at-sea periods could be determined only for transmitters that were not duty cycled: they ranged from 8.1 to 902.2 hours. Based on the total time hauled out and the total time at sea, individual seals spent 1.2%-13.9% of their time on land and 86.1%-98.8% of their time at sea (Table 5). Combining data from all individuals, the four seals on average spent 6.8% of their time hauled out on land.

Data on the amount of time spent hauled out on ice were compiled for semi-monthly periods from November through mid-April (Table 6). Two of the three PTTs that functioned during this time were duty cycled, so the number of haulout bouts is underestimated. Nonetheless, the results show that seals hauled out infrequently with no obvious seasonal trend. Mean durations of individual haulout bouts (only complete haul outs included) for each seal were: PTT 10919-6.5 hours (s.d.=5.11, range 1.5-20.5 hours, n=20); PTT 10920-4.3 hours (s.d.=3.58, range 1.2-15.6 hours, n=22); and PTT 14098-7.9 hours (s.d.=4.0, range 0.2-14.2 hours, n=9). The overall mean duration of an on-ice haul out was 5.8 hours (s.d.=4.46). The proportion of the monitored time that individual seals spent hauled out within a semi-monthly period varied from 0% to 51.2%, with a combined average for the three seals of 6.2% (Table 7).

Because signals from the PTTs were not monitored constantly, it is not possible to determine the precise time of day that haulout bouts began and ended. In order to look for diurnal haulout patterns, we calculated the number of times that PTT data indicated a seal was hauled out at any time within each hour of the day. These data on frequency of haul out by hour were grouped by individual seal for four seasonal periods (Appendices E-H).

When data for all seals were combined, there were obvious seasonal changes in the time of day during which seals were recorded as hauled out (Table 8, Fig. 3). During August-October, seals hauled out with equal frequency during all hours of the day (KS score=0.016, n=312, P<0.59). In November-December, haul outs varied by hour (KS score=0.108, n=178, 0.01<P<0.05); the peak haul out occurred during 0200-0700 hours and 1700-2100 hours. The pattern was similar in January-February with a distinct minimum in haulout activity during 0800-1600 hours (KS score=0.155, n=129, P<0.01). In March-April, haulout behavior was not constant over time (KS score=0.206, n=57, 0.01<P<0.05). During this period, haulout frequency was highest between 1100 and 1600 hours.

Movements of Seals

During the time that the PTTs were functional, spotted seals moved over great distances. Based on the sum of distances between sequential locations, the total distances over which seals were tracked were: PTT 10919--6,036 km in 212 days; PTT 10920--4,426 km in 259 days; PTT 14098--9,642 km in 149 days; and PTT 14099--2,355 km in 64 days. Overall movements are shown in Figures 4-7, in which all location records that fit the time/speed criteria are plotted.

During August, September, and October, seals made trips to sea from coastal haul outs in the eastern Chukchi Sea (Fig. 8). Seals 14098 and 14099 spent most of their time between Kasegaluk Lagoon and Point Hope in a roughly triangular area extending offshore from Point Hope to a distance of about 200 km. Information on at-sea movements is much less detailed for seals 10919 and 10920 because their PTTs were duty cycled, and quality 0 location data were not obtained. It appears that their movements to sea were also mostly to the southwest from Kasegaluk Lagoon. Seal 10919 made two trips from Kasegaluk Lagoon to just north of Bering Strait and back.

The characteristics of trips to sea are listed in Table 9 for those instances where the complete trip is recorded in the data. Data from duty cycled PTTs were not included unless two haulout bouts occurred during a continuous 7-day period when the transmitter was on. Estimates of distances covered and speeds are minimums because they are based on straight-line distances between sequential locations.

The longest recorded trip was for seal 14099; it was at sea for 902 hours (37.6 days) and traveled a minimum distance of 1,685 km. It is quite possible that longer trips were made by seals with duty cycled PTTs. For example, seal 10919 was located at Utukok Pass on 15 September and on 30 September, it was off Inchoun on the Chukchi Peninsula, a straight-line distance of

530 km. On 14 October, it was again hauled out at Kasegaluk Lagoon near Naokok Pass.

Three PTTs were still operational when seals began their southward migration from Kasegaluk Lagoon (Fig. 9). Seal 10919 left Naokok Pass on 16 October and travelled to Kotzebue Sound, where it hauled out at Cape Espenberg on 10 November. Seal 10920 went to sea from Akunik Pass on 17 October and also moved to Kotzebue Sound, hauling out off Kotzebue on 30 October and in Shishmaref Inlet on 3 November. Because these two PTTs were duty cycled, it is possible that other haul outs were used, as well. Seal 14098 left Utukok Pass on 3 October, and its next recorded haul out was on ice north of the Seward Peninsula on 14 November. Since that PTT was not duty cycled, it appears that seal 14098 was at sea for approximately 990 hours (41.2 days) while on its southward migration.

Seal 10919 passed southward through Bering Strait between 17 and 23 November (while the duty cycle was off). It was subsequently located several times along the Chukchi Peninsula in Seniavin Strait and off Cape Chukotskiy (Fig. 9). On 14 December, it was located near the northwest tip of St. Lawrence Island.

After passing through Bering Strait sometime between 4 and 10 November (while the duty cycle was off), seal 10920 was located in Port Clarence, along the south side of the Seward Peninsula, and in Norton Sound (Fig. 9). During 9-13 December, it was in the vicinity of St. Lawrence Island.

Seal 14098 passed southward through Bering Strait during 16-17 November. It then spent time along the Chukchi Peninsula in the vicinity of St. Lawrence Bay, Mechigmen Bay, and Cape Chaplino (Fig. 9). From 19 to 22 December, seal 14098 was in the vicinity of St. Lawrence Island.

From St. Lawrence Island, all three seals moved generally southward, presumably with the advancing sea ice front (Fig. 10). Seal 14098 moved south in a virtually straight line. With the exception of one haul out on 29 December, it spent almost all of its time in the water until 1 January when it began a series of haulout bouts that lasted until the PTT stopped transmitting on 2 January. Seals 10919 and 10920 moved southward more slowly. Their positions on 6 January were 130 km and 205 km farther to the north than 14098 on 2 January. During January-March, seals 10919 and 10920 made considerable north-south and east-west movements, but they stayed in the general area south to southeast of St. Matthew Island.

Minimum distance moved and rate of movement of seals during their southward migration and while in the Bering Sea are summarized in Table 10. Because their PTTs provided fewer

locations, data for seals 10919 and 10920 are biased low. The rates of movement for seal 14098, which were at least twice as great, may be more realistic. The most rapid period of movement, with an average speed of 90 km/day, was for 14098 when the seal was moving southward from St. Lawrence Island in late December.

Diving Behavior

The Telonics PTTs did not have a pressure sensor, and they reported dive information based only on when conductivity sensors were wet or dry. The data that were reported included some dives that were of reasonable length, but in many instances the data suggested that dives lasted several hours or days. Since there was no way to determine which dive records were valid and which were not, no analysis was done on the dive data from the Telonics PTTs.

The Wildlife Computers PTTs used pressure sensors to measure the duration and maximum depth of dives, which was summarized in 24-hour histogram bins. Information on depth and duration of dive was collected for over 21,000 dives made by seal 14098 and over 12,000 dives by seal 14099. The minimum depth for which the pressure sensor recorded a dive was 10 m. Because all of Kasegaluk Lagoon and the nearshore waters along the Chukchi Sea coast are less than 10 m, dives in these shallow areas were not recorded and are not represented in the data. For both seals, the majority of dives were in the 10-50 m range and none were deeper than 100 m (Table 11, Fig. 11). Seventy-seven percent of all recorded dives for seal 14098 and 69% for seal 14099 were 10-50 m. For both seals, there was considerable monthly variability in depth of dive (Fig. 12). In August, 84% of the dives of each seal were 10-50 m. The proportion of shallow dives decreased to 62%-67% in September and 48%-56% in October. PTT 14099 stopped transmitting in October. During the southward migration in November-December, the dives of seal 14098 were again shallower, with 84%-95% of all recorded dives in the 10-50 m depth bin.

The number of dives recorded per day was substantially less for the large adult female than for the smaller male (Fig. 13). The adult female (14098) made an average of 160 dives per day while the smaller male (14099) made 284 dives per day. There was considerable variation in the average daily number of dives by each seal, but seal 14099 always made approximately 50% more dives. During August-October both seals had periods of intense diving followed by one or more days of few or no dives greater than 10 m. There was less variation in the number of dives per day for the adult female, but after 1 November her diving behavior became less regular.

The duration of dives differed considerably between the adult female (14098) and the young male (14099) (Table 12, Fig.

14). Only 14% of the total dives by the young male were longer than 4 minutes, and less than 1% were longer than 8 minutes. In contrast, 69% of dives made by the female were longer than 4 minutes and 12% were longer than 8 minutes. After migration began in November, the female made more short dives and fewer dives of intermediate length (Fig. 15). The percentage of long dives remained about the same. Forty-three percent of her dives in November and December were from 0-4 minutes, 44% were from 4-8 minutes, and 13% were longer than 8 minutes.

DISCUSSION

Utility of PTTs for Spotted Seal Studies

During our 1991 field work, spotted seals were relatively easy to catch. Weather was generally windy and water in the lagoon was relatively murky. Seals did not appear to detect the net, and four animals were caught in the 3 days that we were able to work. In contrast, when we attempted to catch seals in August 1992 the weather was good and the lagoon water was clear. Seals detected the net more readily and were much more difficult to catch. It appears that muddy conditions in the lagoon are necessary for effective netting of seals using the equipment and techniques that were available to us.

In general the PTTs that we attached to spotted seals worked well and provided a wealth of data. One unit (14099) failed prematurely, apparently due to faulty batteries. Prior to the failure of this PTT on 10 October 1991, there were several periods of 4-9 days when no signals were received (Appendix D). This was probably due to the automatic low battery power shutoff in the PTT being triggered when the unit was in cold water. The last signals were received about 1 hour after the seal had hauled out.

We obtained quality 0 location data for only two of the PTTs. While it was not possible to verify the accuracy of those locations, most of them (631/750) passed the criteria that we used to screen out unrealistic positions (apparent speeds greater than 20 km/hour for more than 5 minutes). Since no quality 3 locations and few quality 1 or 2 locations were deleted, we think the screening criteria that we used were appropriate. Using the quality 0 locations resulted in a near doubling of the number of days on which the seals' locations were known (from 57 to 109 days for 14098 and 15 to 27 days for 14099). We recommend that quality 0 location data be obtained for all PTTS put on spotted seals in the future.

Duty cycling two of the PTTs resulted in an approximate doubling of the period sampled, and extended the data series into March-April. However, there was a considerable loss of ability

to interpret the data, particularly with regard to the characteristics of feeding trips in the Chukchi Sea.

The Telonics PTTs did not provide useful information on diving behavior. Since they were mounted in the middle of the seals' backs, the conductivity switches did not break the surface after every dive. While the indicated duration of some dives appeared reasonable, many were unrealistically long. Telonics PTTs are available with an alternate programming mode in which they record the amount of time the conductivity switch is dry during a preset period of the day. This could provide useful information on haulout behavior, and we recommend collection of this type of data if additional Telonics PTTs are used on spotted seals.

The Wildlife Computers PTTs provided data on the maximum depths of dives and duration of dives. We had hoped to use these data, in combination with information on water depth and the seal's location, to indicate whether seals were feeding in the water column or near the bottom. However, the PTTs that we used had been designed for use on harbor seals that may feed in deep water, and the minimum depth to be considered a dive (10 m) and the depth bins were not ideal for spotted seals. The nearshore Chukchi Sea, particularly Kasegaluk Lagoon, is so shallow that the seals could have been diving regularly in this region and the PTTs would not have registered these dives. The shallowest depth bin (10-50 m) was too broad since much of the Chukchi Sea is less than 50 m deep and all of it is less than 75 m deep. Over two-thirds of the total dives by both seals were in the first bin, which provided little insight into the seals' behavior. In the future, we recommend that PTTs for spotted seals that are equipped with pressure sensors be programmed to record dives with minimum depths of 4 m, and that the dive depth bins be set to provide additional resolution in depths of less than 100 m.

Description of Spotted Seal Biology

Observations of locations and numbers of spotted seals hauled out in Kasegaluk Lagoon have been recorded for many years (Frost et al. 1983). Aerial surveys were conducted in 1989-1991 to document use of particular haul outs, and the seasonal variation in seal numbers (Frost et al. 1993). However, none of that information provided any insight into the movements, site fidelity, or diving behavior of seals. It was unknown how often they hauled out; whether individual seals used more than one haul out location; whether they fed in and near the lagoon, or travelled to other areas; and when the southward migration began.

Data from this study indicate that during the period from August through mid-April, spotted seals haul out infrequently. During August-October, the four seals that we tagged spent an average of only 7% of their time on land. During November to

early April, they spent 6% of their time hauled out on ice. There was no synchrony apparent in the days on which the four seals hauled out. Tagged seals were recorded as hauled out on land on 22 days during August-October: 11 August was the only day on which more than one seal hauled out. During November to early March, seals hauled out on 33 different days, but there were only eight instances when two seals were hauled out on the same day and none when three were hauled out.

The tagged seals showed significant seasonal changes in the diurnal pattern of hauling out. During August-October, seals hauled out with equal frequency during all hours, which confirms the results previously obtained from analysis of aerial survey counts (Frost et al. 1993). During November-February, seals showed a strong tendency to haul out less often during mid-day. Possible reasons for such a pattern are presently unknown. In March and April, seal behavior was different, and haul outs occurred predominantly during mid-afternoon. This may have been due to increasing daylight and temperatures and the onset of seasonal activities such as pupping and breeding.

Data from the tagged seals demonstrated that spotted seals using Kasegaluk Lagoon haul out at more than one location. Three of the four tagged seals used both Utukok and Akoliakatat Passes for hauling out in August and September. The fourth, seal 14099, hauled out only once after being tagged at Utukok and that was at the same location. No other haul outs were recorded as being used in August and September, although two of the seals were monitored only half of the time and they could have used other haul outs when the PTTs were not transmitting. During mid-October, when Kasegaluk Lagoon began to freeze, three of the seals hauled out near the southern end of the lagoon before beginning their southward migration. The large female (14098) did not, and her last haul out on land was at Utukok Pass on October 3. She did not haul out again until November 14, on ice. The use of the southern passes during October is in agreement with reports of Point Lay residents that spotted seals use the southernmost passes in Kasegaluk Lagoon after the lagoon to the north begins to freeze (Warren and Dorcas Neakok, Point Lay, Alaska, personal communication, 7 August 1991). In fact, the Inupiat name for the most southern part of Kasegaluk Lagoon (Kasigialik) means "place where spotted seals remain."

No new land haul outs were identified as a result of this study. The haul outs used by the four spotted seals tagged in 1991 had all been previously identified by coastal residents or in the course of biological studies (Frost et al. 1983, Frost et al. 1993). One or more of the tagged seals spent some time in most of the previously known haulout areas in northern Alaska, although according to the telemetry data, they did not always haul out. After leaving the Kasegaluk Lagoon region in mid-October, seals spent time near haul outs in Kotzebue Sound,

Port Clarence, northern Norton Sound, and the south side of St. Lawrence Island.

Perhaps the most surprising finding of this study was the great distances that spotted seals travelled during their summer foraging trips. The smallest male (10919) made two round-trips from Kasegaluk Lagoon to the area just north of Bering Strait, a one-way distance of over 500 km. On one of these trips the seal went to the coast of the Chukchi Peninsula just west of Inchoun, a major spotted seal haul out. Although the locations plotted at the coast, the PTT sensors did not record the seal as being hauled out. However, the PTT was duty cycled and was not transmitting during part of the time the seal was in this area. Two of the seals made trips of more than 300 km along the Alaskan coast to Cape Lisburne, Point Hope, and/or Kivalina. Only the adult female remained relatively close to Kasegaluk Lagoon. Until the middle of October, the farthest she travelled was about 100 km to the southern end of the lagoon.

The pattern of the fall migration was quite consistent among the three seals that still had functional transmitters. Movement southward began in mid-October. None of the tagged seals were located north of Point Hope after 6 November. All three passed through Bering Strait during the first 3 weeks of November, and all were near Saint Lawrence Island sometime during 13-22 December. After December, rates of movement differed, but the three seals all were generally south of Saint Matthew Island from January to April.

Although there were problems with the settings that we used to collect depth of dive data, some interesting information was obtained. Diving behavior appeared to change with time. In August, over 80% of the dives of both seals were less than 50 m deep. This correlates well with information on water depth at the locations where they were diving: both seals spent most of the month near shore in shallow water along Kasegaluk Lagoon or in Ledyard Bay. On some days when the seals were in Ledyard Bay the PTTs registered no dives, which is consistent with the fact that most of Ledyard Bay is shallower than 10 m. During late August, seal 14098 was located west of Cape Lisburne in water deeper than 50 m, yet most of her dives remained less than 50 m.

In September, both seals made more dives (33%-38%) in the 50-100 m range, and both began to feed in the area west and southwest of Cape Lisburne and Point Hope. Neither spent time in Ledyard Bay. As the number of shallow dives decreased, the number of dives shorter than 2 minutes in duration also decreased. In October, more of the dives of both seals were greater than 50 m, and there were fewer dives of short duration. Seal 14099 was located over 150 km west of Cape Lisburne where the water is deeper than 50 m. Seal 14098 spent a few days in

shallow water north of Cape Lisburne, but most of the time it was in deeper water west and southwest of Point Hope.

In early November, seal 14098 returned to Ledyard Bay and registered no dives while in this shallow area. This was followed by a few days spent diving in deeper water southwest of Point Hope. Most of her dives during late November and December were less than 50 m, and many were of short duration (less than 4 minutes).

These data suggest that feeding and diving behavior changed through summer and fall, and that the seals may have been moving to take advantage of variations in the availability of prey. Future tagging efforts using PTTs with different depth bin settings should provide more useful information about diving and feeding behavior.

Implications for Population Assessment

Spotted seal surveys are usually conducted when seals are hauled out on sea ice during the spring (e.g., Braham et al. 1984), or on land haul outs in the summer (e.g., Frost et al. 1993). Because only one PTT continued to function into April, we did not gather much information that could be used to interpret the results of spring surveys. Different types of PTTs or different programming could be used to extend battery life and gather information on haulout behavior during spring. We attached a 0.5 watt Wildlife Computers PTT to one spotted seal at Utukok Pass in late August 1992, and that tag provided continuous data through mid-April 1993.

The information that we obtained has major implications for surveying and estimating the abundance of spotted seals based on summer counts. Prior to this study, we knew that not all the spotted seals using an area hauled out at the same time on the same day. However, the alternation between very high counts and very low counts suggested some synchrony in haulout behavior, perhaps dependent on weather (Frost et al. 1993). We had assumed that maximum counts probably represented a substantial proportion of the seals using the area, and therefore could be used as a reasonable estimate of minimum abundance. Clearly, this is not the case. Seals are present at Kasegaluk Lagoon haul outs on almost every day of the summer and early autumn, yet tagged seals hauled out on only a few days each month.

Frost et al. (1993) flew aerial surveys of seal haul outs in Kasegaluk Lagoon during 18-22 August and 25-29 September 1991. Seal 14098 was hauled out on 18-19 August, but not during 20-22 August. None of the other three seals hauled out during this period. Relatively few seals were counted on 18, 21, and 22 August (157-425), but counts were quite high on 19 and 20 August (853-1235). Counts were relatively high on all three survey days

in late September, with the highest count of the season on the 29th (2,137-2,237). Seal 14098 was at haul outs on all the September survey days, seal 14099 did not haul out, and the other two PTTs were duty cycled off. Thus, although aerial survey counts were high on some days and low on others, telemetry data showed that not all seals were hauled out even on the days when the highest counts were made.

Use of satellite telemetry in conjunction with aerial surveys could provide better estimates of spotted seal abundance. However, a larger sample of tagged seals is needed to estimate the fraction of seals that are hauled out and counted during surveys. A preliminary analysis using data collected during this study suggests that a population estimate with a coefficient of variation of 30% could be obtained if data on haulout behavior were obtained from 10 to 20 tagged seals (J. Laake, NMML, Seattle, WA, pers. commun., 21 September 1993).

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Table 1.--Spotted seals captured and equipped with satellite-linked platform transmitter terminals (PTT) at Utukok Pass, Alaska, August 1991.

Tag date	PTT type* and ID no.	Sex	Curvilinear length (cm)	Weight (kg)	Date of last transmission
4 August	TEL. 10919	male	121	45.5	6 Mar. 1992
4 August	TEL. 10920	male	150	68.2	12 Apr. 1992
6 August	W.C. 14098	female	172	106.8	2 Jan. 1992
7 August	W.C. 14099	male	148	65.9	10 Oct. 1991

* TEL.=Telonics; W.C.=Wildlife Computers

Table 2.--Results of accuracy tests of satellite-linked platform transmitter terminals (PTT) at Kasegaluk Lagoon, Alaska, August 1991.

Location quality	Test location	
	North of Point Lay	Utukok Pass
Quality 3		
mean error (km)	0.12	0.37
error range (km)	0.00-0.25	0.00-1.26
No. locations	13	7
standard deviation	0.06	0.42
Quality 2		
mean error (km)	0.25	0.80
error range (km)	0.04-0.85	0.11-2.21
No. locations	14	10
standard deviation	0.20	0.66
Quality 1		
mean error (km)	0.27	0.89
error range (km)	0.00-0.60	0.19-1.68
No. locations	6	5
standard deviation	0.21	0.68

Table 3.--Number and quality of location fixes obtained for satellite-tagged spotted seals.

Tag No.	No. of fixes by location quality 1	2	3	Total	Total days operational	No. days with fixes
10919	173	100	16	289	111	65
10920	106	84	10	200	133	60
14098	135	124	15	274	149	57
14099	25	24	2	51	64	15

Table 4.--Durations of haulout bouts and trips to sea of spotted seals in the Chukchi Sea during August-October 1991. Times are given in hours.

Tag 10919		Tag 10920		Tag 14098		Tag 14099	
On land	At sea	On land	At sea	On land	At sea	On land	At sea
1.7	--	2.4	--	8.6	210.8	15.4	902.2
67.5	--	0.5	--	20.8	56.6	--	591.2
		5.2	--	17.2	424.8		
		3.5	--	8.7	8.1		
				7.2	11.7		
				10.1	416.0		
				7.8	26.8		
				114.0	45.7		

Table 5.--Characteristics of haulout bouts and trips to sea of spotted seals in the Chukchi Sea during August-October 1991. Times given are in hours. Ranges are shown in parentheses.

Tag No.	Haulout bouts N	Haulout bouts Mean length	Haulout bouts Total time	At sea N	At sea Mean length	At sea Total time	% time Hauled out
10919	2	34.6[a] (1.7-67.5)	76.6	--	--[b]	~~845.2~~ 837.5	8.~~5~~ 9
10920	4	2.9 (0.5-~~5.2~~ 26.4)	~~11~~ 35.6	--	--[b]	~~917.6~~ 886.2	~~1.2~~ 3.9
14098	8	24.3 (7.2-114.0)	194.4	8	150.1 (8.1-424.8)	1,200.5	13.9
14099	1	39.4a	40.4	2	746.7 (591.2-902.0)	1,493.4	2.6
Combined	15	19.9	323.0	10	271.8	4,456.7	6.8

[a] Incomplete haul outs are not included in mean length calculations.

[b] Lengths of individual at sea periods could not be determined due to duty cycling.

Table 6.--Amount of time (hours) hauled out on ice for spotted seals in the Chukchi and Bering Seas, November 1991-April 1992. Numbers in parentheses are the number of haulout bouts within the period.

Date range	Tag number 10919	10920	14098
1-15 November	20.5 (1)	19.3 (4)	27.2 (3)
16-30 November	10.2 (3)	35.4 (3)	7.0 (2)
1-15 December	0 (0)	5.3 (2)	6.9 (1)
16-31 December	4.4[a](1)	3.1 (2)	14.2 (1)
1-15 January	6.9 (2)	3.5 (2)	20.6 (3)[b]
16-31 January	21.3 (3)	4.9 (1)	---
1-15 February	49.6 (7)	3.5 (2)	---
16-29 February	0 (0)	1.8 (1)	---
1-15 March	22.2 (4)	1.8 (1)	---
16-31 March	---	12.8 (3)	---
1-15 April	---	3.6 (1)	---
Total	135.1 (21)	95.5 (22)	75.9 (10)
Total time operating	1,527.5	1,943.2	1,504.2

[a] Partial haul out.
[b] Transmitter failed on 2 January; one partial haul out included.

Table 7.--Percent of time hauled out on ice in the Chukchi and Bering Seas for individual spotted seals and all seals combined.

Date range	Tag number 10919	10920	14098	Combined
1-15 November	10.7	10.0	7.6	9.0
16-30 November	5.3	18.4	1.9	7.1
1-15 December	0	3.0	1.9	1.7
16-31 December	2.6	1.8	3.7	3.0
1-15 January	4.1	2.1	51.2*	8.2
16-31 January	12.7	2.9	---	7.8
1-15 February	30.0	2.1	---	15.8
16-29 February	0	1.1	---	0.5
1-15 March	17.9	1.0	---	7.9
16-31 March	---	5.9	---	5.9
1-15 April	---	2.5	---	2.5
Overall	8.8	4.9	5.0	6.2

* Transmitter failed on 2 January.

Table 8.--Frequency of hauling out of spotted seals in relation to time of day. Data from all individual platform transmitter terminals are combined.

Time	Date range			
	4 Aug.-31 Oct.	1 Nov.-31 Dec.	1 Jan.-29 Feb.	1 Mar.-19 Apr.
0000-0059	11	6	4	1
0100-0159	13	6	8	1
0200-0259	14	8	11	1
0300-0359	13	9	10	1
0400-0459	14	8	9	1
0500-0559	15	7	8	0
0600-0659	13	8	7	1
0700-0759	12	8	6	2
0800-0859	12	8	1	2
0900-0959	12	5	1	2
1000-1059	12	4	1	3
1100-1159	12	4	1	4
1200-1259	14	3	2	3
1300-1359	13	4	2	5
1400-1459	13	4	1	5
1500-1559	12	8	1	7
1600-1659	14	10	3	6
1700-1759	15	12	8	3
1800-1859	15	9	11	3
1900-1959	15	11	11	2
2000-2059	13	14	9	1
2100-2159	14	10	7	1
2200-2259	11	6	4	1
2300-2359	10	6	3	1

Table 9.--Characteristics of trips to sea by spotted seals during August-October 1991.

PTT No.	Dates	Distance (km)	Time at sea (hrs)	Speed (km/hr)	Description
10919	8/4-8/11	422	211	2.0	from Utukok Pass northeastward to Peard Bay then to Akoliakatat Pass.
14098	8/6-8/15	468	211	2.2	southwestward from Utukok Pass then to Akoliakatat Pass.
14098	8/15-8/18	98	57	1.7	from Akoliakatat Pass to Utukok Pass along the coast.
14098	8/19-9/5	942	425	2.2	from Utukok Pass southwestward off shore then back to Utukok Pass.
14098	9/6	75	8	9.2	from Utukok southwestward off shore and back to Utukok Pass.
14098	9/8-9/25	1,105	416	2.7	from Utukok Pass southwestward off shore then back to Utukok Pass.
14098	9/25-9/26	93	27	3.5	from Utukok Pass to Akoliakatat Pass along the coast.
14098	9/27-9/29	217	46	4.8	from Akoliakatat Pass off shore then to Utukok Pass.
14099	8/7-9/14	1,685	902	1.9	from Utukok Pass southwestward off shore then back to Utukok Pass.
14099	9/15-10/10	723	591	1.2	from Utukok Pass southwestward off shore then to south end of Kasegaluk Lagoon.

Table 10.--Movements of satellite-tagged spotted seals during the southward migration in the Chukchi and Bering Seas, October 1991-April 1992.

PTT No.	North of Bering Strait			Bering Str.- St. Lawrence I.			South of St. Lawrence I.		
	No. km	No. days	km/day	No. km	No. days	km/day	No. km	No. days	km/day
10919	814	29	28	586	29	20	1,953	80	24
10920	875	24	36	804	31	26	1,824	129	14
14098	3,482	45	77	1,888	35	54	993	11	90

Table 11.--Depths of dives of satellite-tagged spotted seals in the Chukchi and Bering Seas, August-December 1991.

	Tag 14098				Tag 14099			
	10-50 m		>50-100 m		10-50 m		>50-100 m	
Month	Number	(%)	Number	(%)	Number	(%)	Number	(%)
August	2,269	(84)	442	(16)	4,282	(84)	788	(16)
September	2,653	(67)	1,278	(33)	3,203	(62)	1,975	(38)
October	2,436	(56)	1,906	(44)	938	(48)	1,018	(52)
November	3,981	(95)	210	(5)				
December	5,046	(84)	965	(16)				
Total	16,385	(77)	4,801	(23)	8,423	(69)	3,781	(31)

Table 12.--Durations of dives (minutes) of two satellite-tagged spotted seals in the Chukchi and Bering Seas, August-December 1991. Percentages are given in parentheses.

	Tag 14098						Tag 14099					
	0-2	2-4	4-6	6-8	8-10	>10	0-2	2-4	4-6	6-8	8-10	>10
August	429	155	950	987	137	68	1,829	2,200	465	159	19	6
	(16)	(6)	(35)	(36)	(5)	(2)	(39)	(47)	(10)	(3)	(<1)	(<1)
September	432	338	1,484	1,190	402	62	1,504	3,425	585	116	14	21
	(11)	(9)	(38)	(30)	(10)	(2)	(27)	(60)	(10)	(2)	(<1)	(<1)
October	209	498	1,659	1,365	397	104	343	1,160	350	100	3	0
	(5)	(12)	(39)	(32)	(9)	(3)	(18)	(59)	(18)	(5)	(<1)	0
November	818	1,072	773	1,049	586	123						
	(19)	(24)	(17)	(24)	(13)	(3)						
December	1,502	1,083	1,428	1,349	522	128						
	(25)	(18)	(24)	(22)	(9)	(2)						
Total	3,390	3,146	6,294	5,940	2,044	485	3,676	6,785	1,400	375	36	27
	(16)	(15)	(29)	(28)	(10)	(2)	(30)	(55)	(11)	(3)	(<1)	(<1)

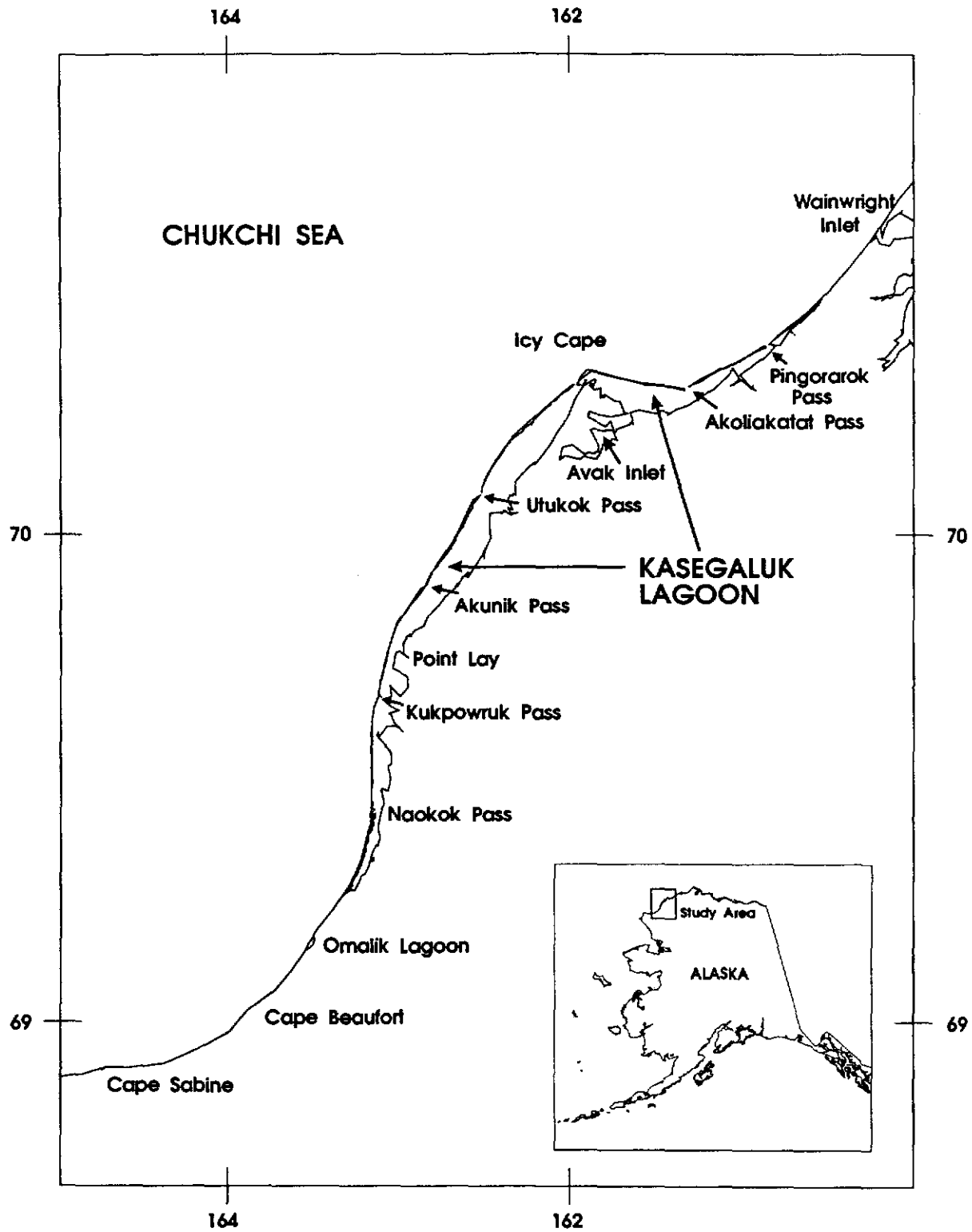


Figure 1. Map of the northeastern Chukchi Sea showing Kasegaluk Lagoon and Utukok Pass.

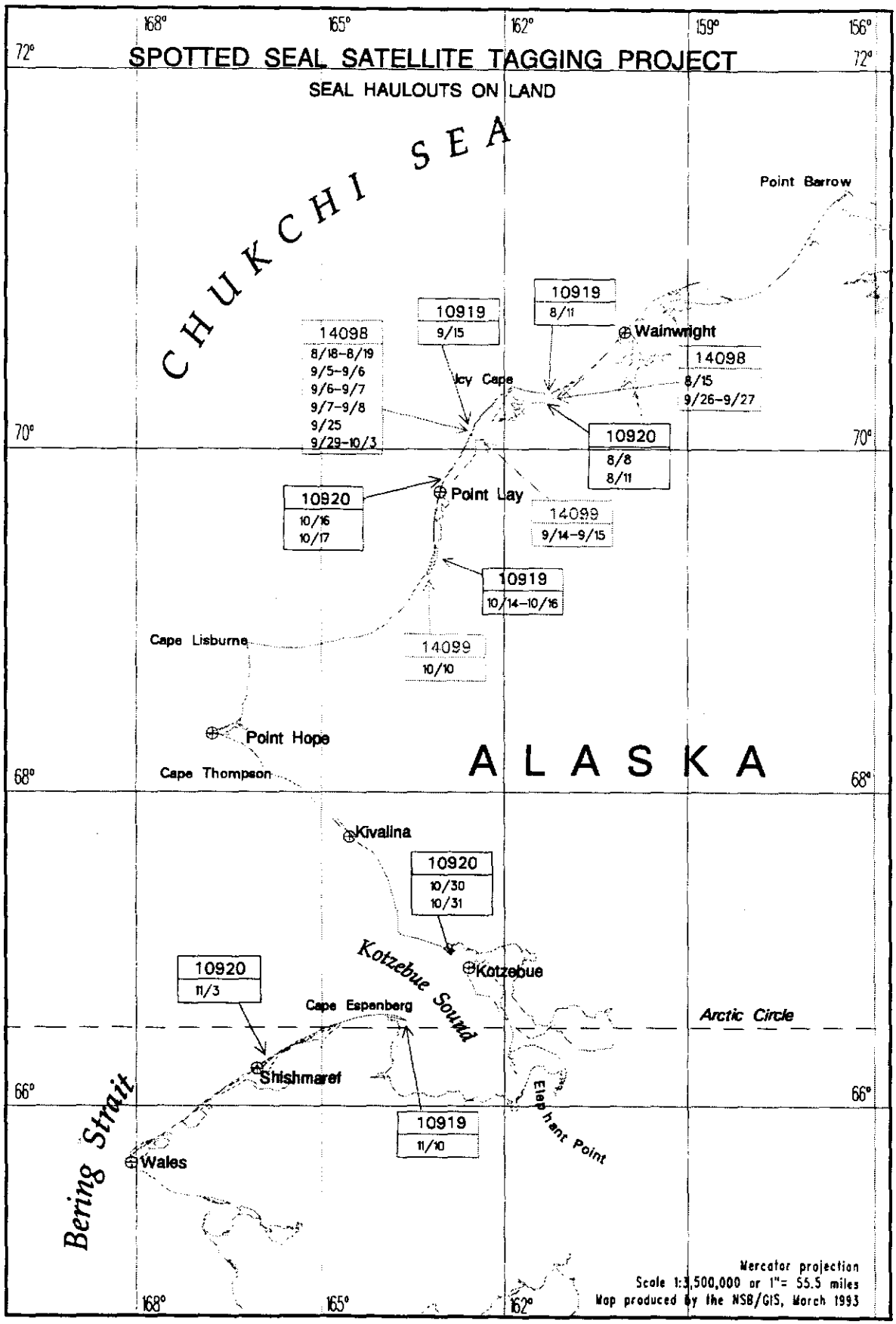


Figure 2. Map of the eastern Chukchi Sea and Bering Strait showing locations on land used for hauling out by satellite-tagged spotted seals, August-November 1991.

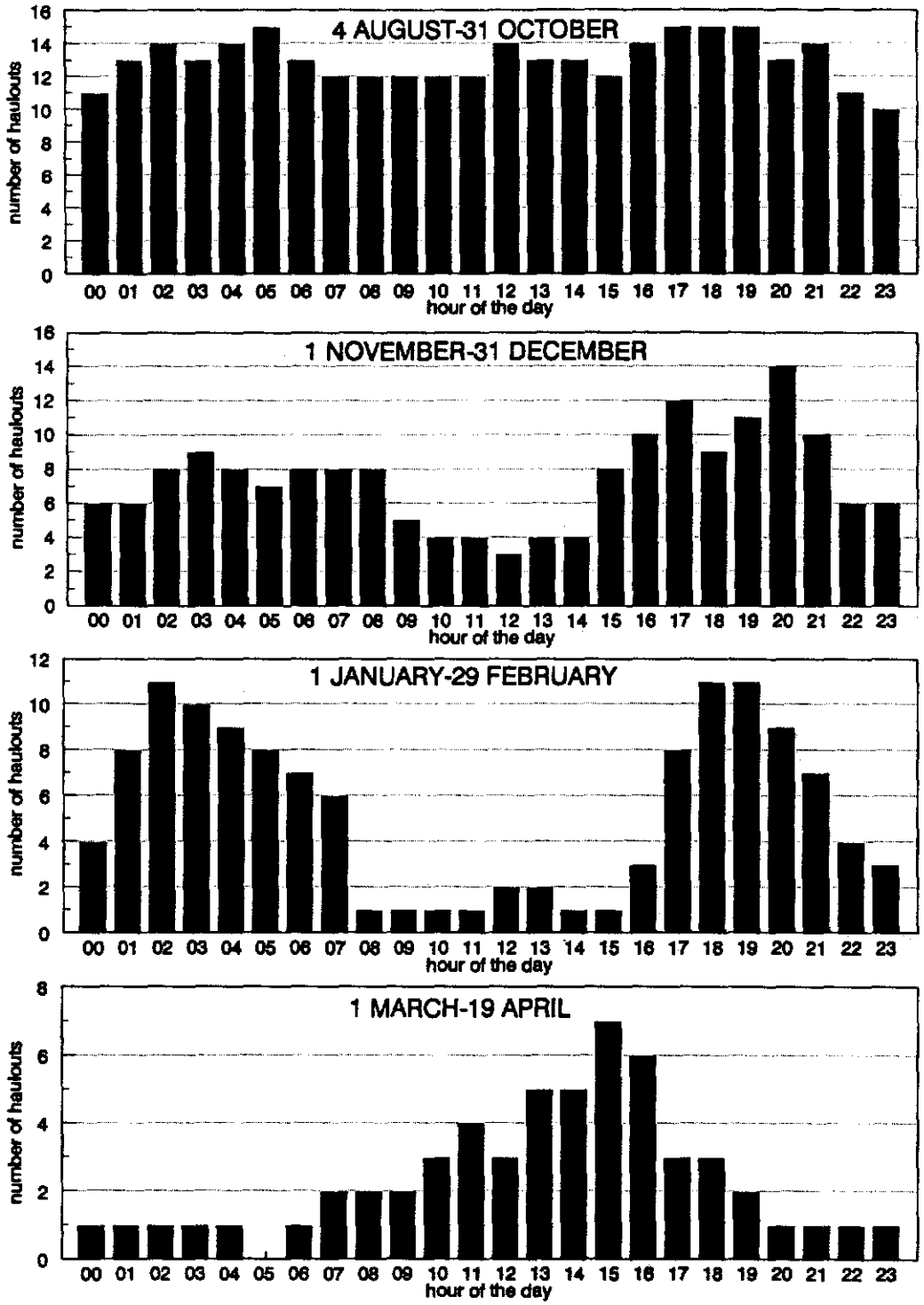


Figure 3. Seasonal changes in diurnal haulout patterns of satellite-tagged spotted seals in the Chukchi and Bering Seas, August 1991-April 1992.

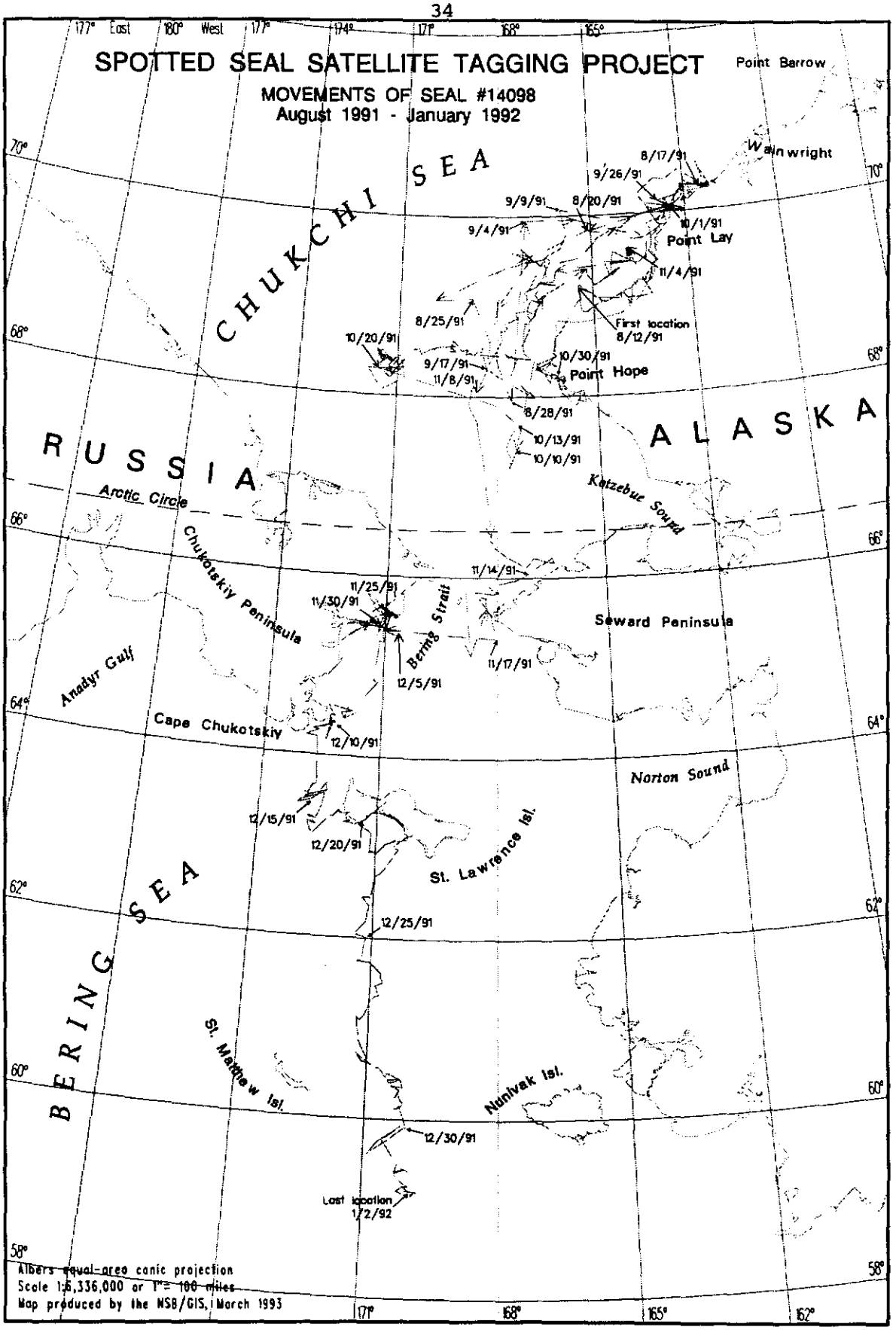


Figure 4. Map of the Chukchi and Bering Seas showing movements of seal 14098 during August 1991 to January 1992.

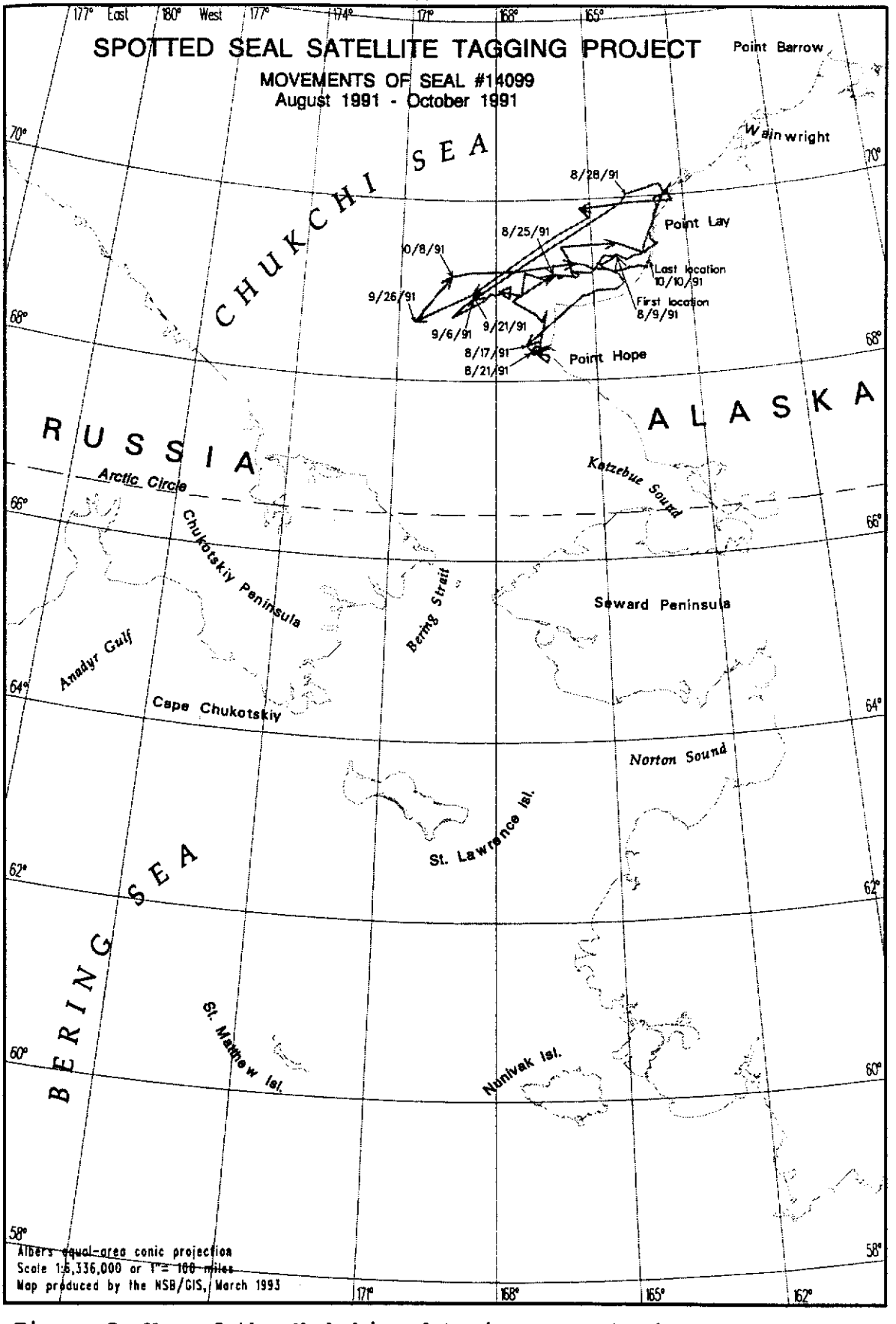


Figure 5. Map of the Chukchi and Bering Seas showing movements of seal 14099 during August 1991 to October 1991.

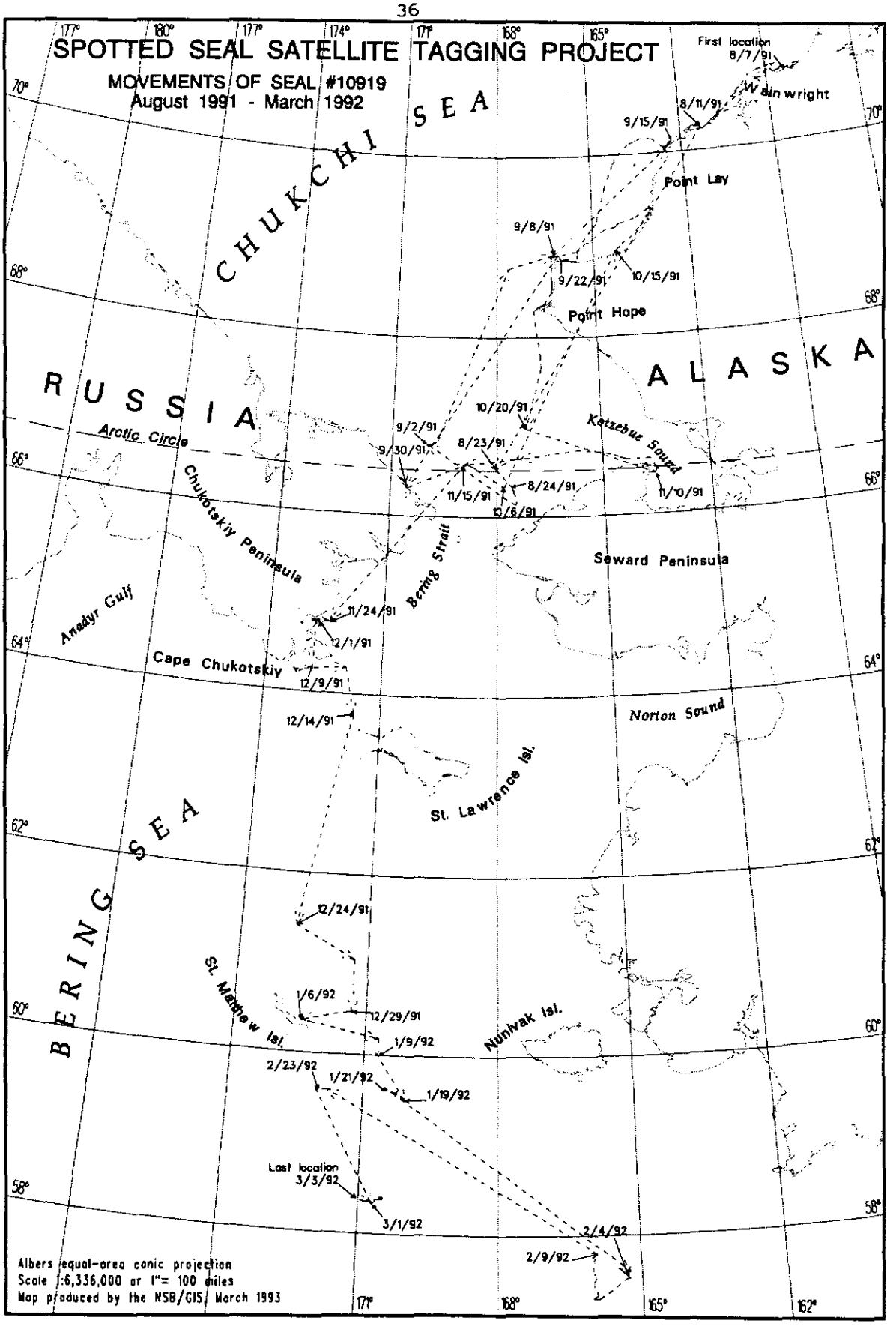


Figure 6. Map of the Chukchi and Bering Seas showing movements of seal 10919 during August 1991 to March 1992.

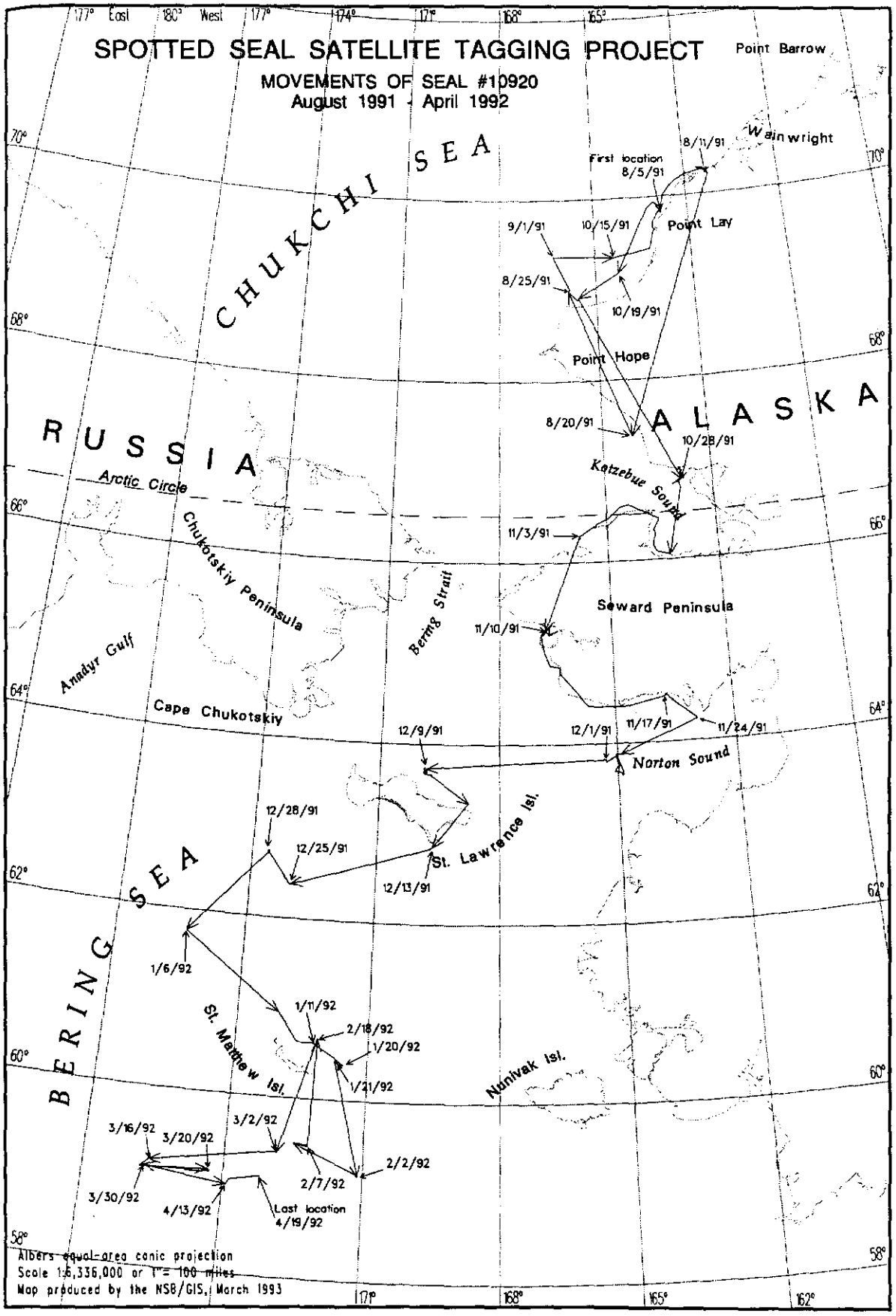


Figure 7. Map of the Chukchi and Bering Seas showing movements of seal 10920 during August 1991 to April 1992.

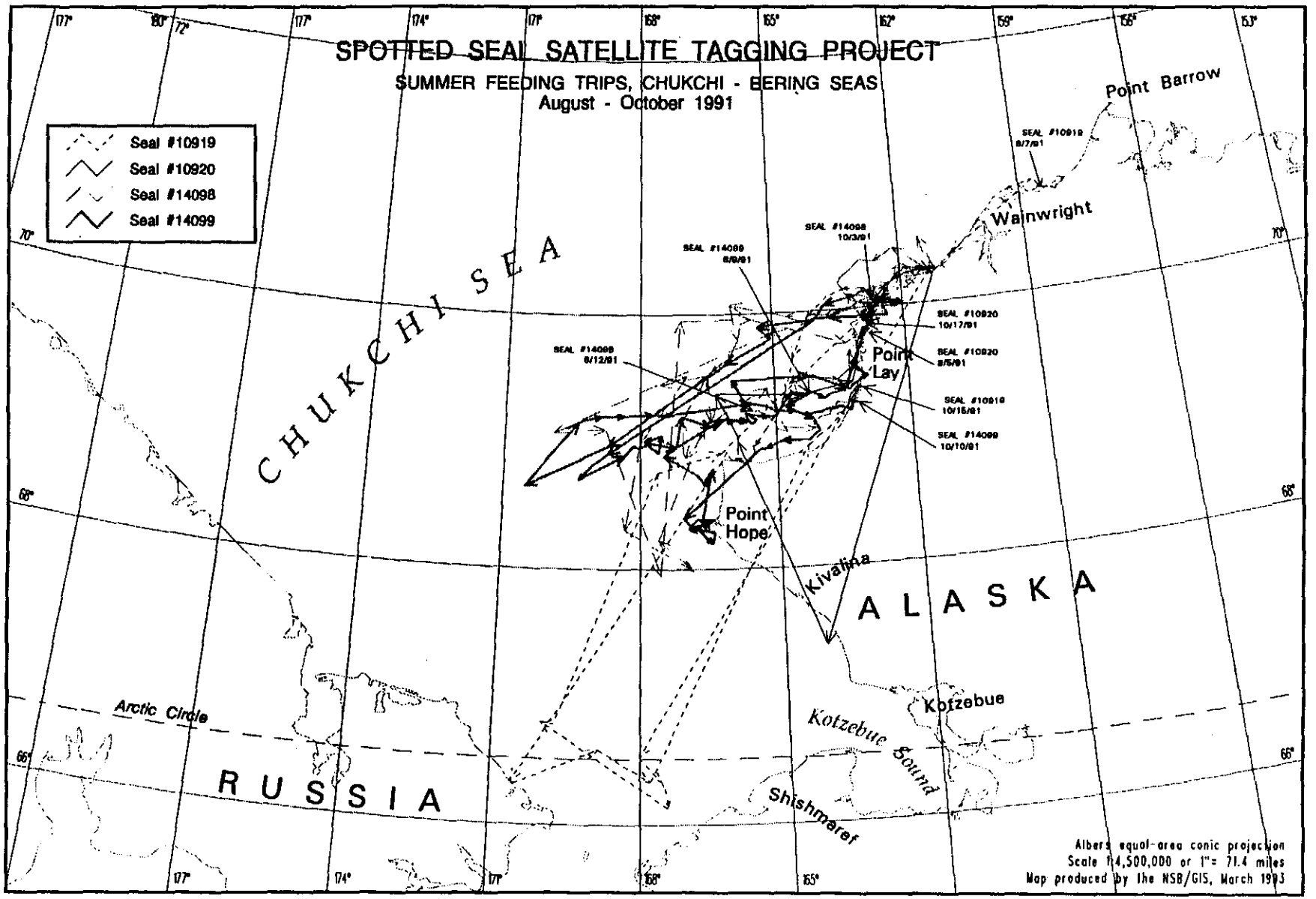


Figure 8. Map showing summer feeding trips of satellite-tagged spotted seals in the Chukchi Sea, August-October 1991.

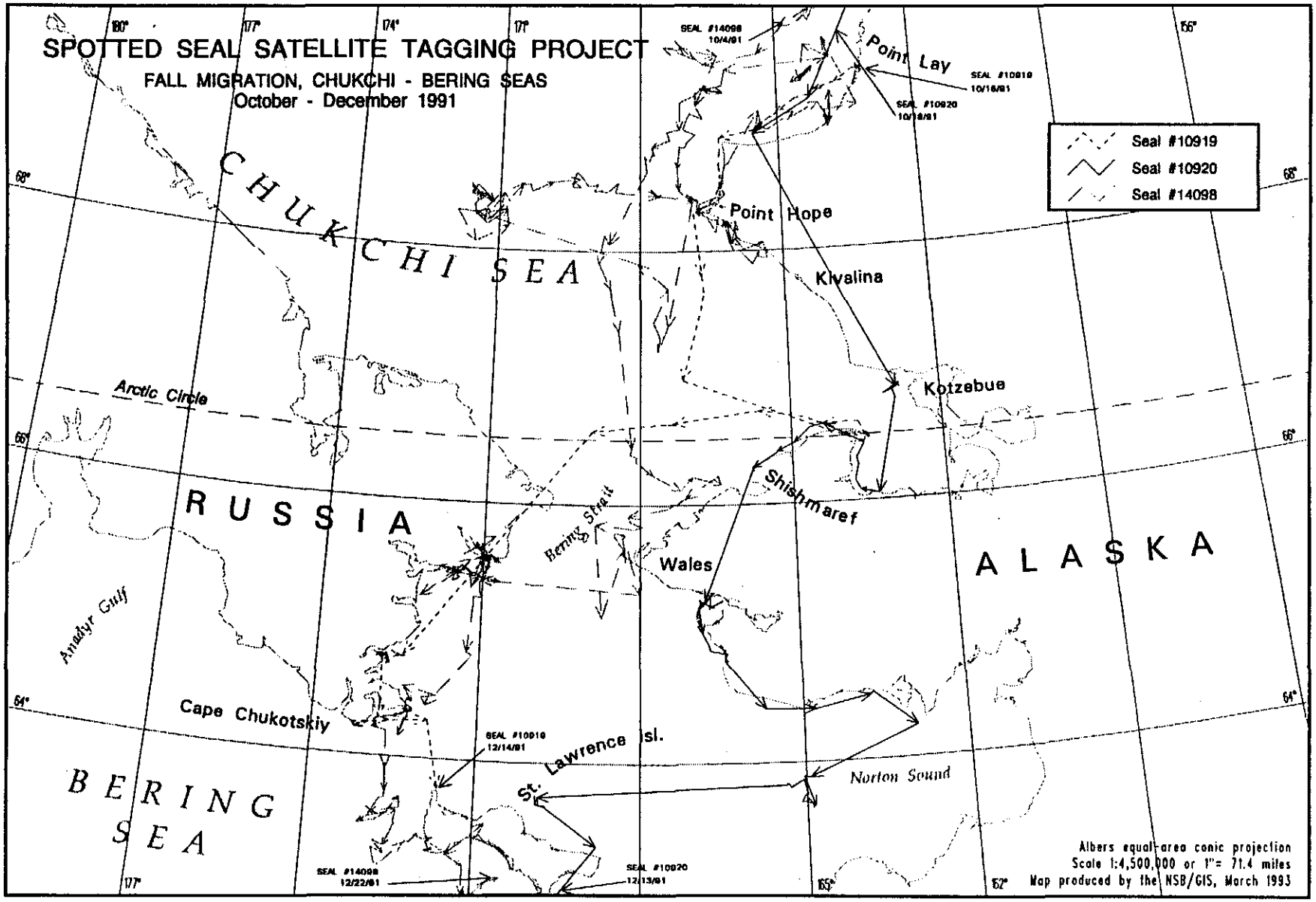


Figure 9. Map showing the fall migration of satellite-tagged spotted seals in the Chukchi and Bering Seas, October-December 1991.

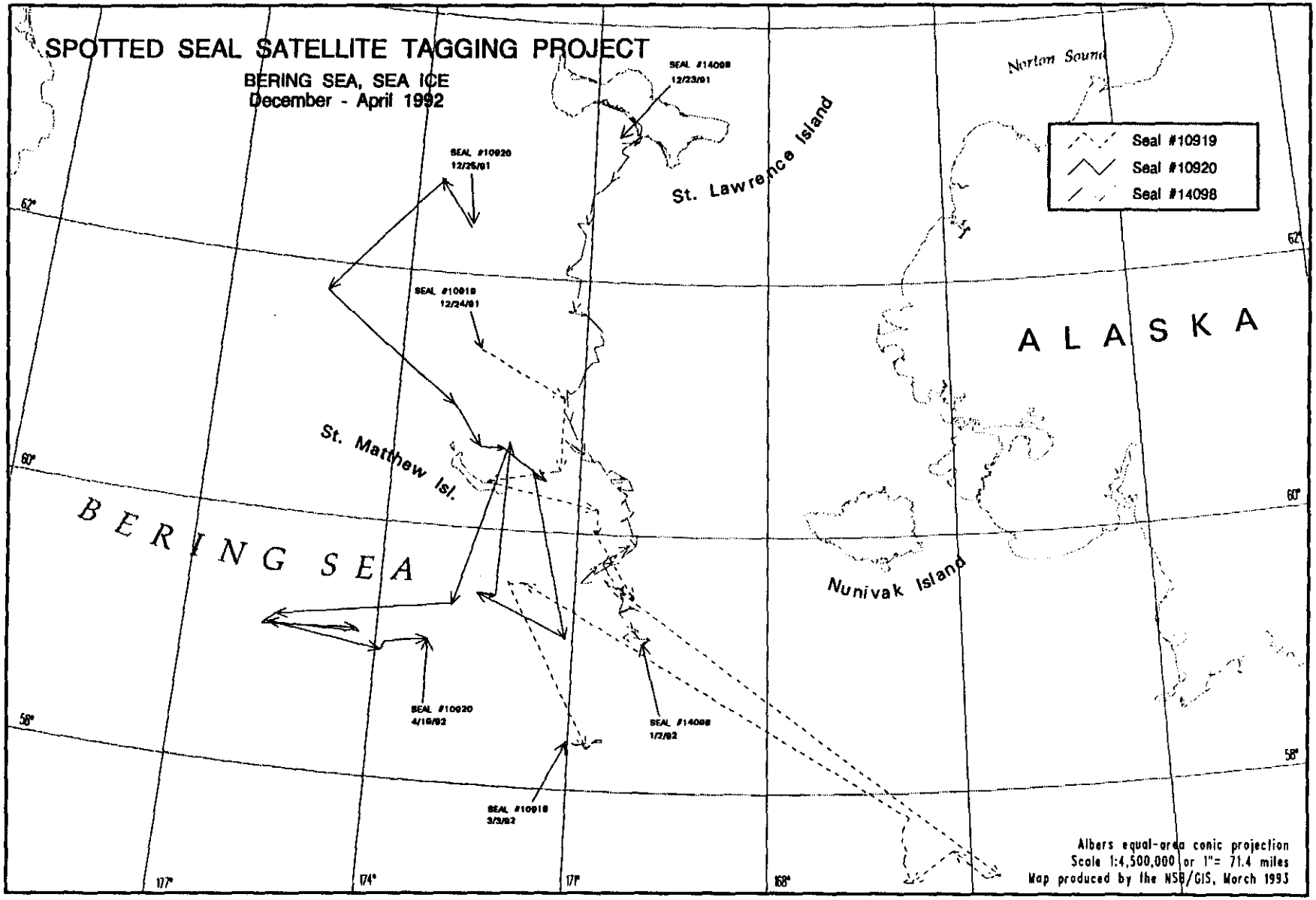
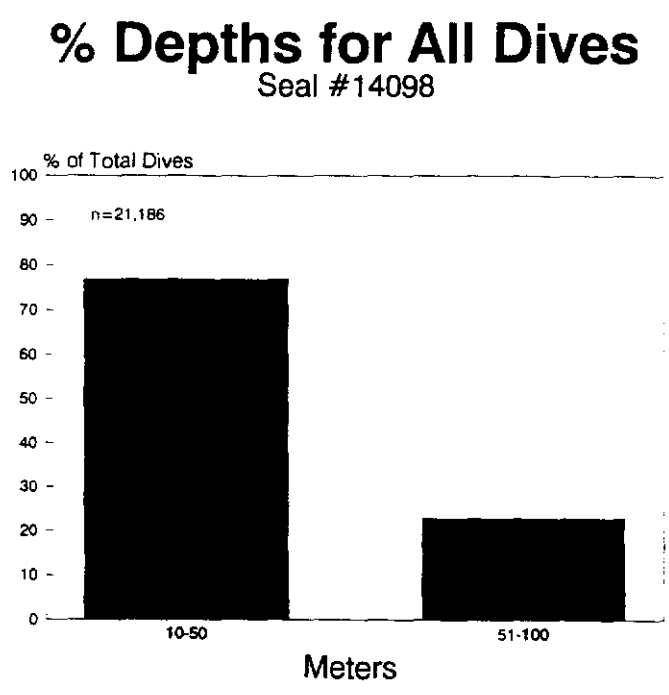


Figure 10. Map showing the winter movements of satellite-tagged spotted seals in the Bering Sea, December 1991-April 1992.



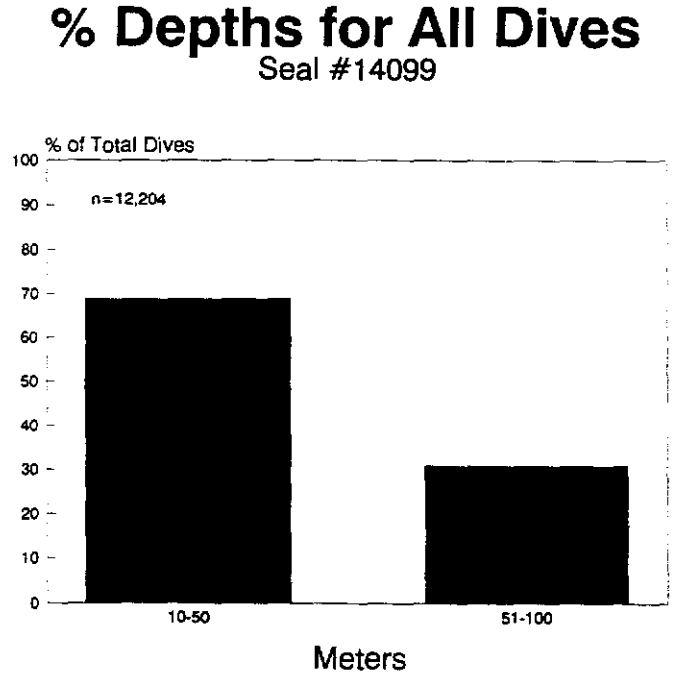


Figure 11. Depths of all dives recorded for two satellite-tagged spotted seals in the Chukchi and Bering Seas, 1991.

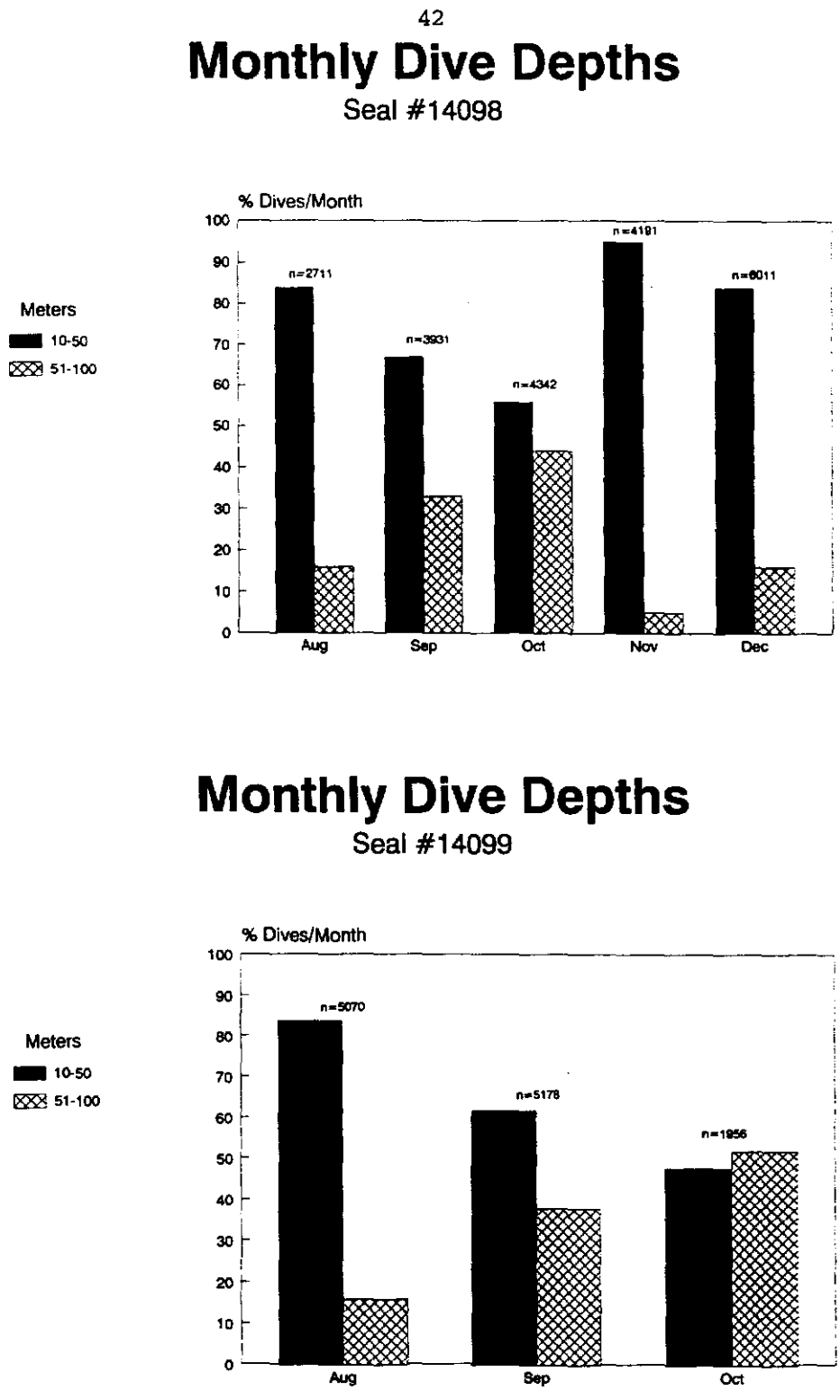
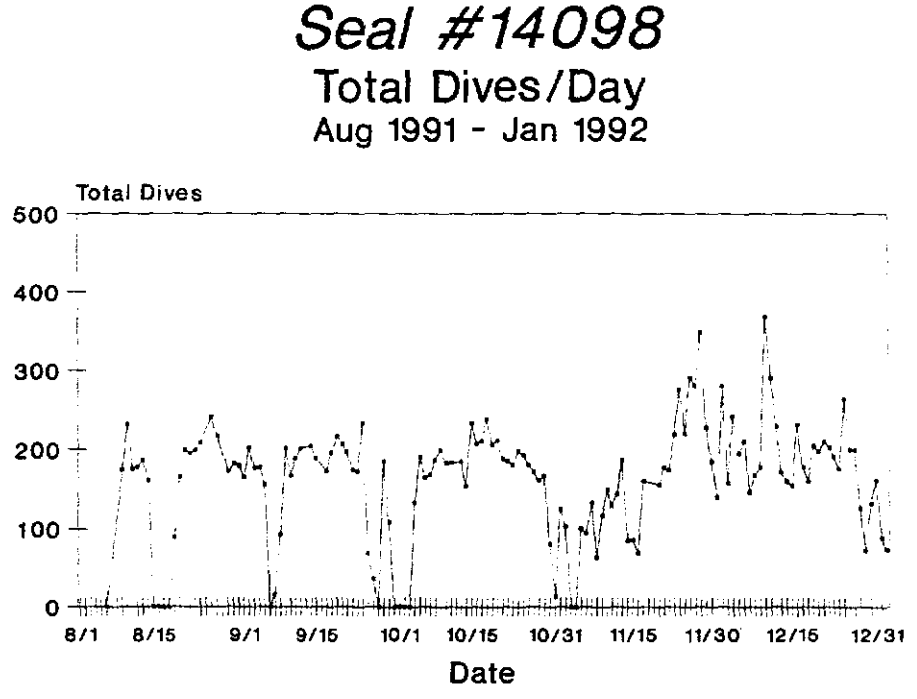


Figure 12. Monthly distribution of depths of dives recorded for two satellite-tagged spotted seals in the Chukchi and Bering Seas, 1991.



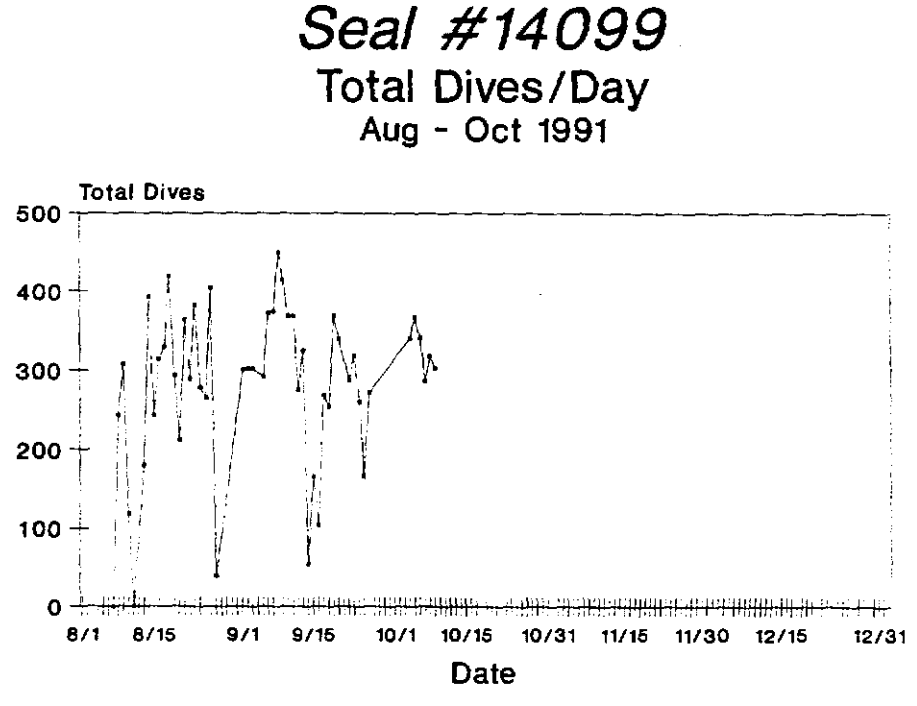
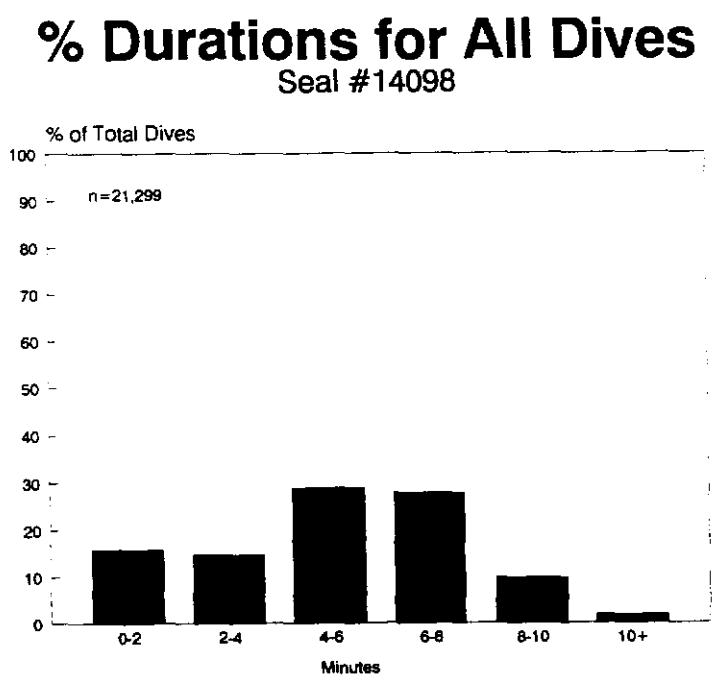


Figure 13. Number of dives recorded per day for two satellite-tagged spotted seals in the Chukchi and Bering Seas, 1991.



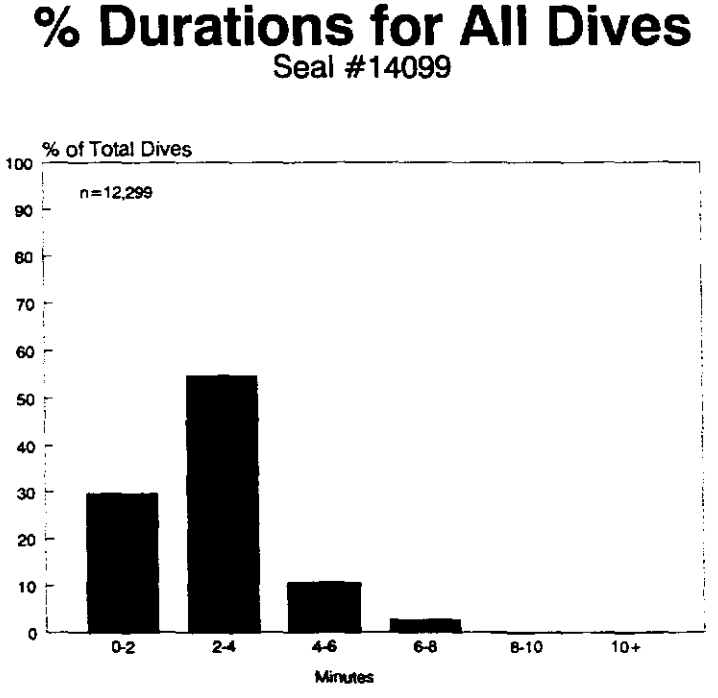
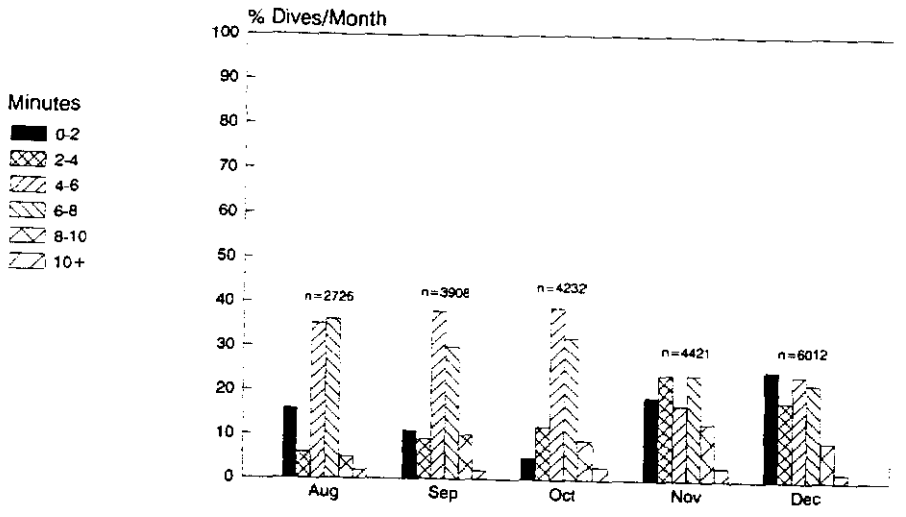


Figure 14. Duration of all dives by month for two satellite-tagged spotted seals in the Chukchi and Bering Seas, 1991.



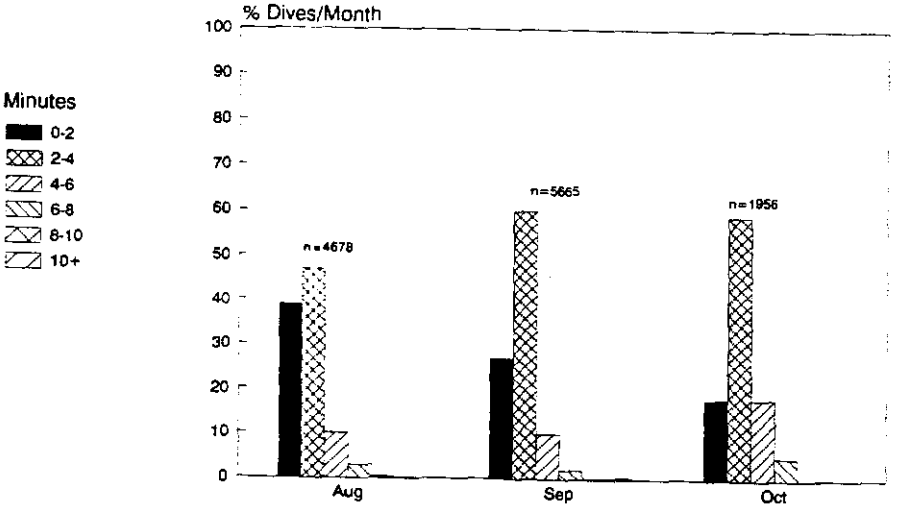


Figure 15. Monthly distribution of duration of dives recorded for two satellite-tagged spotted seals in the Chukchi and Bering Seas, 1991.

Appendix A.-- Daily activities of seal with PTT 10919. Positions of animals on land or ice are the average for all fixes obtained during that haulout bout. Positions at sea are the average of all fixes obtained during that day.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Aug. 4	tag/release-1920 h	70.083	162.516	Utukok Pass
5	at sea			
6	at sea			
7	at sea	70.827	158.400	
8	at sea	70.838	158.291	
9	at sea	70.896	158.784	
10	at sea	70.296	161.390	
11	land-0411 h	70.285	161.309	Akoliakatat Pass PTT off at 1137 h
12				PTT off
13				PTT off
14				PTT off
15				PTT off
16				PTT off
17				PTT off
18	no data			PTT on at 1137 h
19	no data			
20	at sea			
21	at sea			
22	at sea			
23	at sea	66.567	168.023	
24	at sea	66.264	167.496	
25	at sea			PTT off at 1137 h
26				PTT off
27				PTT off
28				PTT off
29				PTT off
30				PTT off
31				PTT off
Sept. 1	at sea			PTT on at 1137 h
2	at sea	66.846	169.861	
3	at sea			
4	at sea			
5	at sea			
6	at sea			
7	at sea	68.789	167.631	
8	at sea	68.939	166.212	PTT off at 1137 h
9				PTT off
10				PTT off
11				PTT off
12				PTT off
13				PTT off
14				PTT off

Appendix A.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Sept.15	land-1226 h	70.088	162.483	PTT on at 1137 h
	water-1406 h			Utukok Pass
16	at sea			near Utukok Pass
17	at sea	70.107	162.443	near Utukok Pass
18	at sea	70.030	163.851	
19	at sea	69.132	165.191	
20	at sea	68.873	165.732	
21	at sea	68.885	165.840	
22	at sea	68.909	166.053	PTT off at 1137 h
23				PTT off
24				PTT off
25				PTT off
26				PTT off
27				PTT off
28				PTT off
29	no data			PTT on at 1137 h
30	at sea	66.364	170.564	
Oct. 1	at sea			
2	at sea			
3	no data			
4	no data			
5	at sea	66.625	168.850	
6	at sea	66.376	167.795	PTT off at 1137 h
7				PTT off
8				PTT off
9				PTT off
10				PTT off
11				PTT off
12				PTT off
13	at sea	69.088	163.942	PTT on at 1137 h
14	land-0154 h	69.411	163.112	Naokok Pass
15	on land	69.413	163.125	Naokok Pass
16	water-2125 h	69.415	163.126	
17	at sea	69.195	164.495	
18	at sea	68.566	166.435	
19	at sea	67.764	166.701	
20	at sea	67.021	167.149	PTT off at 1137 h
21				PTT off
22				PTT off
23				PTT off
24				PTT off
25				PTT off
26				PTT off
27	no data			PTT on at 1137 h
28	no data			
29	at sea			
30	at sea			

Appendix A.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Oct. 31	at sea			
Nov. 1	at sea			
2	at sea			
3	at sea			PTT off at 1137 h
4				PTT off
5				PTT off
6				PTT off
7				PTT off
8				PTT off
9				PTT off
10	at sea	66.495	163.572	PTT on at 1137 h
	land-2056 h	66.555	163.531	Cape Espenberg
11	water-1721 h	66.550	163.522	
12	at sea	66.582	163.575	
13	at sea	66.698	164.741	
14	at sea	66.679	167.448	
15	at sea	66.616	168.943	
16	at sea			
17	no data			PTT off at 1137 h
18				PTT off
19				PTT off
20				PTT off
21				PTT off
22				PTT off
23				PTT off
24	at sea	64.824	172.417	PTT on at 1137 h
	ice-1926 h	64.820	172.450	Seniavin Strait
	water-2107 h			
25	in water			
26	in water	64.819	172.569	
27	in water	64.831	172.880	
28	ice-1756 h	64.826	172.780	Seniavin Strait
	water-2126 h			
29	in water	64.813	172.785	
30	ice-1534 h	64.785	172.701	
	water-2038 h			
Dec. 1	in water	64.812	172.746	PTT off at 1137 h
2				PTT off
3				PTT off
4				PTT off
5				PTT off
6				PTT off
7				PTT off
8	no data			PTT on at 1137 h
9	in water	64.325	172.787	
10	in water	64.256	173.235	
11	in water			

Appendix A.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Dec. 12	in water	64.331	171.913	
13	in water			
14	in water	63.804	171.658	
15	in water			PTT off at 1137 h
16				PTT off
17				PTT off
18				PTT off
19				PTT off
20				PTT off
21				PTT off
22	in water			PTT on at 1137 h
23	in water			
24	in water	61.446	172.723	
25	no data			
26	in water			
27	in water	61.093	171.307	
28	in water			
29	ice-0714 h	60.508	171.356	PTT off at 1137 h
30				PTT off
31				PTT off
Jan. 1				PTT off
2				PTT off
3				PTT off
4				PTT off
5	in water			PTT on at 1137 h
6	ice-0220 h	60.391	172.468	
	water-0408 h			
7	in water			
8	in water	60.218	170.694	
9	ice-1637 h	60.038	170.711	
	water-2144 h			
10	in water			
11	in water			
12	in water			PTT off at 1137 h
13				PTT off
14				PTT off
15				PTT off
16				PTT off
17				PTT off
18				PTT off
19	in water	59.519	170.069	PTT on at 1137 h
	ice-1622 h	59.540	170.080	
	water-2133 h			
20	ice-0437 h	59.613	170.268	
	water-0800 h			
	ice-1732 h	59.626	170.391	
21	water-0612			

Appendix A.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Jan. 22	in water			
23	in water			
24	in water			
25	in water			
26	in water			PTT off at 1137 h
27				PTT off
28				PTT off
29				PTT off
30				PTT off
31				PTT off
Feb. 1				PTT off
2	in water			PTT on at 1137 h
3	ice-0157 h	57.337	164.689	
	water-1334 h			
4	ice-1729 h	57.549	165.276	
5	water-0451 h			
6	ice-0117 h	57.305	165.910	
	water-0703 h			
	ice-1824 h	57.331	165.968	
	water-2014 h			
7	ice-1237 h	57.471	165.995	
8	water-0239 h			
	ice-1753 h	57.633	165.986	
	water-2106 h			
9	ice-0544 h	57.816	165.907	
	water-0740 h			PTT off at 1137 h
10				PTT off
11				PTT off
12				PTT off
13				PTT off
14				PTT off
15				PTT off
16	in water			PTT on at 1137 h
17	in water			
18	in water			
19	in water			
20	in water			
21	in water			
22	in water	59.615	171.802	
23	in water	59.612	172.022	PTT off at 1137 h
24				PTT off
25				PTT off
26				PTT off
27				PTT off
28				PTT off
29				PTT off

Appendix A.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Mar. 1	ice-1314 h	58.354	170.706	PTT on at 1137 h
	water-2000 h			sensors failing
2	ice-0629 h	58.420	170.482	
	water-1132 h			
	ice-1800 h	58.411	170.555	sensors failing
3	water-0252 h			
	ice-0747 h	58.391	170.859	sensors failing
	water-1614			
4	ice-1556 h			sensors failing
	water-1723 h			
5	in water			
6	in water			last signal-0356 h

Appendix B.-- Daily activities of seal with PTT 10920. Positions of animals on land or ice are the average for all fixes obtained during that haulout bout. Positions at sea are the average of all fixes obtained during that day.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Aug. 4	tag/release-1900 h	70.083	162.516	Utukok Pass
5	at sea	69.866	162.878	
6	at sea	70.145	162.445	
7	at sea	70.293	161.320	
8	land-0444 h	70.286	161.307	Akoliakatat Pass
9	water-0705 h			
10	at sea	70.301	161.407	
11	land-0547 h	70.286	161.310	Akoliakatat Pass
	water-0620 h			PTT off at 1138 h
12				PTT off
13				PTT off
14				PTT off
15				PTT off
16				PTT off
17				PTT off
18	no data			PTT on at 1138 h
19	at sea			
20	at sea	67.419	164.156	
21	no data			
22	no data			
23	at sea			
24	at sea			
25	at sea	69.038	165.852	PTT off at 1138 h
26				PTT off
27				PTT off
28				PTT off
29				PTT off
30				PTT off
31				PTT off
Sept. 1	at sea	69.404	166.316	PTT on at 1138 h
2	at sea			
3	at sea			
4	at sea			
5	at sea			
6	at sea			
7	at sea			
8	at sea			PTT off at 1138 h
9				PTT off
10				PTT off
11				PTT off
12				PTT off
13				PTT off
14				PTT off

Appendix B.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Sept.15	at sea			PTT on at 1138 h
16	at sea			
17	at sea			
18	at sea			
19	at sea			
20	at sea			
21	at sea			
22	at sea			PTT off at 1138 h
23				PTT off
24				PTT off
25				PTT off
26				PTT off
27				PTT off
28				PTT off
29	at sea			PTT on at 1138 h
30	at sea			
Oct. 1	at sea			
2	at sea			
3	at sea			
4	at sea			
5	at sea			
6	at sea			PTT off at 1138 h
7				PTT off
8				PTT off
9				PTT off
10				PTT off
11				PTT off
12				PTT off
13	at sea			PTT on at 1138 h
14	at sea			
15	at sea	69.375	164.397	
16	land-1614 h water-2125 h	69.903	162.844	Akunik Pass
17	land-0119 h water-0446 h	69.900	162.819	Akunik Pass
18	at sea	69.944	163.168	
19	at sea	69.071	164.924	
20	at sea			PTT off at 1138 h
21				PTT off
22				PTT off
23				PTT off
24				PTT off
25				PTT off
26				PTT off
27	at sea	66.915	162.902	PTT on at 1138 h
28	at sea	66.886	162.997	
29	at sea	66.924	162.826	

Appendix B.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Oct. 30	land-1624 h	66.909	162.911	off Kotzebue
	water-1811 h			
31	land-0154 h	66.908	162.910	off Kotzebue
	water-0344 h			
Nov. 1	at sea	66.882	162.905	
2	at sea	66.538	164.913	
3	land-0507 h	66.321	165.793	Shishmaref Inlet
	water-0833 h			PTT off at 1138 h
4				PTT off
5				PTT off
6				PTT off
7				PTT off
8				PTT off
9				PTT off
10	at sea			PTT on at 1138 h
	ice-1501 h	65.292	166.846	Port Clarence
	water-2101 h			
11	ice-0316 h	65.254	166.842	Port Clarence
	water-0906 h			
12	ice-1627 h	65.248	166.648	Port Clarence
	water-2019 h			
13	in water	65.268	166.861	
14	in water	64.922	166.617	
15	in water	64.452	165.691	
16	in water	64.439	164.769	
17	in water	64.544	163.736	PTT off at 1138 h
18				PTT off
19				PTT off
20				PTT off
21				PTT off
22				PTT off
23				PTT off
24	in water	64.266	162.992	PTT on at 1138 h
25	in water			
26	in water			
27	in water	63.916	164.977	
28	ice-1312 h	63.696	164.909	
29	water-0450 h			
	ice-1555 h	63.774	165.009	
30	water-0110 h			
	ice-2036 h	63.851	165.342	
Dec. 1	water-0707 h			PTT off at 1138 h
2				PTT off
3				PTT off
4				PTT off
5				PTT off
6				PTT off

Appendix B.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Dec. 7				PTT off
8	in water			PTT on at 1138 h
9	ice-1904 h water-2052 h	63.706	169.846	
10	in water	63.780	169.885	
11	ice-1640 h water-2013	63.698	169.718	
12	in water	63.379	168.776	
13	in water	62.874	169.679	
14	in water			
15	in water			PTT off at 1138 h
16				PTT off
17				PTT off
18				PTT off
19				PTT off
20				PTT off
21				PTT off
22	in water			PTT on at 1138 h
23	in water			
24	in water			
25	ice-0656 h water-0807	62.400	173.041	
26	in water			
27	in water			
28	ice-1541 h water-1738 h	62.760	173.602	
29	no data			PTT off at 1138 h
30				PTT off
31				PTT off
Jan. 1				PTT off
2				PTT off
3				PTT off
4				PTT off
5	in water			PTT on at 1138 h
6	in water	61.083	175.355	
7	in water			
8	no data			
9	ice-0146 h water-0331 h	60.992	173.078	
10	in water	60.667	172.627	
11	ice-0258 h water-0449 h	60.657	172.230	
12	in water			PTT off at 1138 h
13				PTT off
14				PTT off
15				PTT off
16				PTT off

Appendix B.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Jan. 17				PTT off
18				PTT off
19	no data			PTT on at 1138 h
20	in water			
21	ice-0243 h	60.478	171.717	
	water-0738 h			
22	in water			
23	in water			
24	no data			
25	in water			
26	in water			PTT off at 1138 h
27				PTT off
28				PTT off
29				PTT off
30				PTT off
31				PTT off
Feb. 1				PTT off
2	in water			PTT on at 1138 h
	ice-1815 h	59.192	171.102	
	water-1958 h			
3	in water			
4	in water			
5	ice-1846 h	59.519	172.525	
	water-2033 h			
6	in water			
7	in water	59.498	172.222	
8	in water			
9	in water			PTT off at 1138 h
10				PTT off
11				PTT off
12				PTT off
13				PTT off
14				PTT off
15				PTT off
16	in water			PTT on at 1138 h
17	in water			
18	ice-1738 h	60.713	172.153	
	water-1922 h			
19	in water			
20	in water			
21	in water			
22	in water			
23	no data			PTT off at 1138 h
24				PTT off
25				PTT off
26				PTT off
27				PTT off

Appendix B.--Continued.

Date	Activity	Lat. (°N)	Long. (°W)	Comments
Feb. 28				PTT off
29				PTT off
Mar. 1	in water			PTT on at 1138 h
2	ice-0304 h water-0452	59.412	172.891	
3	in water			
4	in water			
5	in water			
6	in water			
7	no data			
8	in water			PTT off at 1138 h
9				PTT off
10				PTT off
11				PTT off
12				PTT off
13				PTT off
14				PTT off
15	no data			PTT on at 1138 h
16	ice-1134 h water-1520 h	59.179	175.638	sensors failing
17	no data			
18	in water			
19	in water			
20	ice-1007 h water-1646 h	59.142	174.346	sensors failing
21	in water			
22	in water			PTT off at 1138 h
23				PTT off
24				PTT off
25				PTT off
26				PTT off
27				PTT off
28				PTT off
29	in water			PTT on at 1138 h
30	ice-1547 h water-1814 h	59.137	175.706	sensors failing
31	no data			
Apr. 1	in water			
2	no data			
3	no data			
4	in water			
5	no data			PTT off at 1138 h
6				PTT off
7				PTT off
8				PTT off
9				PTT off
10				PTT off

Appendix B.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Apr. 11				PTT off
12	no data			PTT on at 1138
13	ice-1300 h water-1633 h	59.046	173.879	sensors failing
14	no data			
15	no data			
16	no data			
17	no data			
18	no data			
19	ice or water?	59.129	173.199	
20				last signal-1321 h

Appendix C.-- Daily activities of seal with PTT 14098. Positions of animals on land or ice are the average for all fixes obtained during that haulout bout. Positions at sea are the average of all fixes obtained during that day.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Aug. 6	tag/release-1800 h	70.083	162.516	Utukok Pass
7	no data			
8	no data			
9	at sea			
10	no data			
11	no data			
12	at sea	69.220	165.233	
13	at sea	69.228	163.872	
14	at sea	69.847	162.856	
15	land-1246 h	70.283	161.305	Akoliakatat Pass
	water-2123 h			
16	at sea	70.288	161.513	
17	at sea	70.295	161.498	
18	land-0559 h	70.094	162.500	Utukok Pass
19	water-0246 h			
20	at sea	69.880	165.002	
21	no data			
22	no data			
23	no data			
24	at sea	69.092	169.930	
25	at sea	69.124	168.780	
26	no data			
27	no data			
28	at sea	67.989	167.566	
29	no data			
30	no data			
31	no data			
Sept. 1	no data			
2	at sea			
3	at sea			
4	at sea	69.989	166.287	
5	land-1934 h	70.095	162.497	Utukok Pass
6	water-1247 h			
	land-2053 h	70.091	162.369	Utukok Pass
7	water-0535 h			
	land-1719 h	70.102	162.480	Utukok Pass
8	water-0031 h			
9	at sea	69.662	166.570	
10	at sea	69.018	168.007	
11	at sea			
12	at sea			
13	at sea			
14	at sea			

Appendix C.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Sept.15	no data			
16	no data			
17	at sea	68.183	167.609	
18	no data			
19	at sea	68.264	167.608	
20	no data			
21	at sea			
22	at sea	69.155	166.527	
23	at sea	69.231	166.342	
24	at sea	69.505	163.937	
25	land-0830 h water-1838 h	70.083	162.477	Utukok Pass
26	land-2127 h	70.293	161.199	Akoliakatat Pass
27	water-0510 h			
28	at sea	70.269	162.994	
29	land-0256 h	70.089	162.477	Utukok Pass
30	on land			
Oct. 1	on land			
2	on land			
3	water-2055 h			
4	at sea	69.898	164.083	
5	at sea	69.581	166.725	
6	at sea	69.008	166.909	
7	at sea	68.616	167.105	
8	at sea			
9	no data			
10	at sea	67.453	167.439	
11	at sea	67.307	167.626	
12	at sea	67.484	167.733	
13	at sea	67.747	167.416	
14	at sea	67.941	168.043	
15	no data			
16	no data			
17	no data			
18	at sea			
19	at sea			
20	at sea	68.244	171.436	
21	at sea	68.324	171.163	
22	at sea	68.461	171.506	
23	at sea	68.453	171.419	
24	at sea	68.477	171.520	
25	at sea	68.354	171.191	
26	at sea	68.548	170.207	
27	at sea	68.553	169.020	
28	at sea	68.475	167.487	
29	at sea	68.248	166.362	
30	at sea	68.185	166.028	

Appendix C.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Oct. 31	at sea	68.021	165.581	
Nov. 1	at sea	68.407	166.475	
2	at sea	68.901	165.662	
3	at sea	69.104	164.008	
4	at sea	69.488	164.166	
5	at sea	69.294	166.572	
6	at sea	68.838	167.600	
7	no data			
8	at sea	67.927	168.691	
9	at sea	67.418	168.447	
10	at sea			
11	no data			
12	at sea	66.403	168.064	
13	at sea	66.218	166.777	
14	ice-0226 h	66.045	167.306	
	water-0803 h			
	ice-1740 h	65.859	168.043	
15	water-0414 h			
	ice-1720 h	65.789	168.329	
16	water-0400 h			
17	in water	65.351	167.985	
18	no data			
19	no data			
20	in water			
21	no data			
22	no data			
23	in water	65.450	171.012	
24	ice-1058 h	65.700	171.163	
	water-1750 h			
25	in water	65.640	171.020	
26	in water	65.620	171.004	
27	in water	65.644	170.983	
28	in water	65.589	170.731	
29	ice-2053 h	65.451	171.007	
	water-2104 h			
30	in water	65.478	171.202	
Dec. 1	ice-0232 h	65.504	171.551	
	water-0924 h			
2	in water	65.478	171.541	
3	in water	65.497	171.581	
4	in water	65.462	171.043	
5	in water	65.436	170.873	
6	in water	65.346	171.063	
7	in water	65.262	171.161	
8	in water	64.864	171.198	
9	in water	64.473	172.163	
10	in water	64.396	172.329	

Appendix C.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Dec. 11	in water	64.358	172.322	
12	in water	64.297	172.757	
13	in water	64.040	172.622	
14	in water	63.634	172.772	
15	in water	63.542	172.683	
16	in water	63.627	172.577	
17	in water	63.377	172.536	
18	in water	63.399	172.021	
19	in water	63.341	171.736	
20	in water	63.327	171.233	
21	in water	63.008	171.012	
22	in water	63.143	170.339	
23	in water	62.923	170.661	
24	in water	62.325	171.188	
25	in water	61.769	171.061	
26	in water	61.345	170.961	
27	in water	60.668	170.943	
28	in water	60.413	170.338	
29	ice-0204 h	60.168	170.233	
	water-1619			
30	in water	59.820	170.451	
31	in water	59.548	170.301	
Jan. 1	ice-0130 h	59.452	170.080	
	water-0753			
	ice-1734 h	59.261	170.011	
2	water-0312 h			
	ice-1610 h	59.181	169.892	last signal-2048 h

Appendix D.-- Daily activities of seal with PTT 14099. Positions of animals on land or ice are the average for all fixes obtained during that haulout bout. Positions at sea are the average of all fixes obtained during that day.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Aug. 7	no data			
8	no data			
9	at sea	69.385	164.227	
10	at sea	69.146	164.313	
11	at sea	68.985	165.139	
12	at sea			
13	no data			
14	no data			
15	no data			
16	no data			
17	at sea	68.368	166.889	
18	at sea	68.280	166.419	
19	at sea	68.345	166.877	
20	at sea	68.383	166.761	
21	at sea	68.347	166.949	
22	at sea	68.411	166.519	
23	no data			
24	at sea	68.796	166.813	
25	at sea	69.311	165.879	
26	at sea	69.557	163.432	
27	at sea	70.059	162.815	
28	at sea	70.025	163.913	
29	no data			
30	no data			
31	no data			
Sept. 1	no data			
2	at sea			
3	no data			
4	no data			
5	at sea			
6	at sea	68.840	169.038	
7	no data			
8	no data			
9	no data			
10	no data			
11	at sea	68.990	167.859	
12	at sea	69.188	165.856	
13	at sea	69.460	163.561	
14	land-0419 h	70.087	162.499	Utukok Pass
15	water-1942 h			
16	at sea	69.974	163.026	
17	at sea	69.799	165.497	
18	no data			
19	no data			

Appendix D.--Continued.

Date	Activity	Lat.(°N)	Long.(°W)	Comments
Sept.20	no data			
21	at sea	68.986	168.736	
22	no data			
23	no data			
24	at sea			
25	no data			
26	at sea	68.680	170.525	
27	at sea			
28	at sea			
29	no data			
30	no data			
Oct. 1	no data			
2	no data			
3	no data			
4	no data			
5	no data			
6	no data			
7	no data			
8	at sea	69.212	168.872	
9	at sea	69.274	166.153	
10	land-1053 h	69.299	163.218	S. end Kasegaluk L. last signal-1152 h

Appendix E.-- Frequency of hauling out of individual spotted seals in relation to time of day, 4 August-31 October 1991.

Time	PTT number			
	10919	10920	14098	14099
0000-0059	2	0	9	0
0100-0159	3	2	8	0
0200-0259	3	2	9	0
0300-0359	3	2	8	0
0400-0459	3	2	8	1
0500-0559	3	2	9	1
0600-0659	3	2	7	1
0700-0759	3	1	7	1
0800-0859	3	0	8	1
0900-0959	3	0	8	1
1000-1059	3	0	8	1
1100-1159	3	0	8	1
1200-1259	4	0	9	1
1300-1359	4	0	8	1
1400-1459	4	0	8	1
1500-1559	3	0	8	1
1600-1659	3	2	8	1
1700-1759	3	2	9	1
1800-1859	3	2	9	1
1900-1959	3	1	10	1
2000-2059	3	1	9	0
2100-2159	3	1	10	0
2200-2259	2	0	9	0
2300-2359	2	0	9	0

Appendix F.-- Frequency of hauling out of individual spotted seals in relation to time of day, 1 November-31 December 1991.

Time	PTT number		
	10919	10920	14098
0000-0059	1	3	2
0100-0159	1	3	2
0200-0259	1	2	5
0300-0359	1	3	5
0400-0459	1	3	4
0500-0559	1	3	3
0600-0659	1	4	3
0700-0759	2	3	3
0800-0859	2	3	3
0900-0959	2	1	2
1000-1059	2	0	2
1100-1159	2	0	2
1200-1259	1	1	2
1300-1359	1	1	2
1400-1459	1	1	2
1500-1559	2	4	2
1600-1659	2	6	2
1700-1759	3	6	3
1800-1859	2	5	2
1900-1959	3	6	2
2000-2059	4	7	3
2100-2159	3	4	3
2200-2259	1	3	2
2300-2359	1	3	2

Appendix G.-- Frequency of hauling out of individual spotted seals in relation to time of day, 1 January-29 February 1992.

Time	PTT number		
	10919	10920	14098
0000-0059	3	0	1
0100-0159	5	1	2
0200-0259	6	3	2
0300-0359	5	3	2
0400-0459	6	2	1
0500-0559	6	1	1
0600-0659	5	1	1
0700-0759	4	0	1
0800-0859	1	0	0
0900-0959	1	0	0
1000-1059	1	0	0
1100-1159	1	0	0
1200-1259	2	0	0
1300-1359	2	0	0
1400-1459	1	0	0
1500-1559	1	0	0
1600-1659	3	0	0
1700-1759	6	2	1
1800-1859	7	3	1
1900-1959	7	3	1
2000-2059	7	1	1
2100-2159	6	0	1
2200-2259	3	0	1
2300-2359	2	0	1

Appendix H.-- Frequency of hauling out of individual spotted seals in relation to time of day, 1 March-19 April 1992.

Time	PTT number 10919	10920
0000-0059	1	0
0100-0159	1	0
0200-0259	1	0
0300-0359	0	1
0400-0459	0	1
0500-0559	0	0
0600-0659	1	0
0700-0759	2	0
0800-0859	2	0
0900-0959	2	0
1000-1059	2	1
1100-1159	2	2
1200-1259	1	3
1300-1359	2	3
1400-1459	2	3
1500-1559	3	4
1600-1659	3	3
1700-1759	2	1
1800-1859	2	1
1900-1959	2	0
2000-2059	1	0
2100-2159	1	0
2200-2259	1	0
2300-2359	1	0

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