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Beluga Whale and Spotted Seal Use of a Coastal Lagoon System in the Northeastern Chukchi Sea

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ABSTRACT. Aerial surveys were conducted in the northeastern Chukchi Sea during 1989-91 to investigate the distribution and abundance of beluga whales and spotted seals. Emphasis was on the 170 km long Kasegaluk Lagoon, which was known to be regularly used by both species during the open-water season. Belugas were seen on every survey during 3-14 July 1990 and 4-16 July 1991, with numbers ranging from 7 to 1212. Data from other years indicate that whales sometimes arrive as early as 22 June and leave the area by late July. The presence of nearshore gravel beds and warm, low-salinity water probably combine to make this region important as a place for belugas to molt. Spotted seals occur in the area from mid-July through early November. They haul out on particular spits and shoals near Utukok Pass, Akoliakatat Pass, and Avak Inlet. Numbers counted were variable but exceeded 1000 on many days in July, August, and September. Telemetry data suggest that the maximum count of about 2200 represents only a small portion of the total number of seals frequenting Kasegaluk Lagoon. Comparisons with data from previous years suggest that the numbers of belugas and spotted seals using the area have been relatively stable since the late 1970s. Activities associated with oil, gas, coal, and mineral resource development should be regulated to minimize their potential impacts on important beluga and spotted seal habitats.

Key words: beluga whale, *Delphinapterus leucas*, spotted seal, *Phoca largha*, Chukchi Sea, Kasegaluk Lagoon, distribution, abundance

RÉSUMÉ. On a effectué des relevés aériens dans la partie nord-est de la mer des Tchouktches au cours de la période allant de 1989 à 1991 dans le but d'enquêter sur la distribution et le nombre de bélougas et de veaux marins en se concentrant sur la lagune Kasegaluk longue de 170 km, qui avait la réputation d'accueillir régulièrement les deux espèces durant la saison d'eau libre. On a aperçu des bélougas lors de chacun des relevés effectués du 3 au 14 juillet 1990 et du 4 au 16 juillet 1991, en nombres allant de 7 à 1212. Les données provenant d'autres années révèlent que les baleines arrivent parfois dans la région dès le 22 juin et la quittent fin juillet. La présence de bancs de galets à proximité du rivage combinée à une eau tempérée et une faible salinité explique l'importance de cette zone comme site pour la mue des bélougas. Les veaux marins sont dans la région de la mi-juillet jusqu'au début novembre. Ils vont à terre sur des flèches littorales et des bancs de sable à proximité d'Utukok Pass, d'Akoliakatat Pass et de l'inlet Avak. Leur nombre variait mais était très souvent supérieur à 1000 en juillet, août et septembre. Les données de télémesure suggèrent que le nombre maximal d'environ 2200 ne représente qu'une petite partie du total des veaux marins fréquentant la lagune Kasegaluk. Des comparaisons avec des données provenant d'années antérieures suggèrent que le nombre des bélougas et des veaux marins qui utilisent la région est resté assez stable depuis la fin des années 1970. Les activités reliées à l'exploitation du pétrole, du gaz, du charbon et des ressources minérales devraient faire l'objet d'une réglementation afin que soient minimisées les retombées potentielles sur l'habitat du bélouga et celui du veau marin.

Mots clés: bélouga, *Delphinapterus leucas*, veau marin, *Phoca largha*, mer des Tchouktches, lagune Kasegaluk, distribution, abondance

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INTRODUCTION

Beluga whales (*Delphinapterus leucas*) and spotted seals (*Phoca largha*) are seasonally abundant in nearshore waters of the northeastern Chukchi Sea (Frost *et al.*, 1983). Shorefast ice usually excludes them from the coastal zone from about mid-November through late June. However, during the open-water season many beluga whales and spotted seals appear in the area, especially in and near Kasegaluk Lagoon.

Kasegaluk Lagoon (Fig. 1) is approximately 170 km in total length and 6 km across at its widest point. The lagoon is separated from the ocean by low, narrow, sandy barrier islands, which are interrupted by a series of passes. East of Icy Cape there is a large inlet (Avak Inlet) with a series of restrictions, giving it the appearance of a lagoon within a lagoon. Maximum depths in Kasegaluk Lagoon are probably less than 4 m, with much of the area only 1-2 m deep. Lunar tides are weak in the northeastern Chukchi Sea, with daily tidal range generally less than 15 cm. During summer, water level in Kasegaluk Lagoon is influenced by wind, with onshore westerly winds creating high water and offshore easterly winds creating low water.

Coastal residents have known about and relied upon the regular seasonal appearance of belugas and spotted seals along the Kasegaluk Lagoon coast for as long as they have lived and hunted there (Neakok *et al.*, 1985). During 1980-86 villagers from Point Lay harvested an average of 21 belugas each year (Lowry *et al.*, 1989). Harvests of spotted seals have not been monitored.

The first published reports of belugas in this region were summarized in Bee and Hall (1956) and supplemented by Childs (1969). The Alaska Department of Fish and Game began studies in the vicinity of Kasegaluk Lagoon in 1978, when observations and conversations with residents indicated that at least several hundred belugas occurred in the area each year. Limited aerial surveys conducted in 1979, 1981, and 1987, combined with opportunistic observations and reports, resulted in a compilation of beluga sightings (Frost *et al.*, 1983) and a general description of the overall use of the area by belugas (Frost and Lowry, 1990).

Frost *et al.* (1983) also presented a compilation of all sightings of spotted seals in the coastal zone of the Chukchi Sea during June-November. Based on information from local informants and opportunistic sightings, they determined that spotted seal haulouts within Kasegaluk Lagoon were among the largest concentrations in Alaska. The barrier island sandbars and spits adjacent to Utukok and Akoliakatat passes had the largest reported sightings, with up to 1000 seals seen at each location. There are no other published reports on spotted seals in this region.

Despite their abundance and importance to coastal residents, prior to 1989 there were no systematic studies of the distribution and abundance of spotted seals and only limited work on beluga whales in the Kasegaluk Lagoon region. Available information provided only a general idea of the number of animals, areas used, and timing of use. The reasons why belugas and spotted seals come to this area and the significance of Kasegaluk Lagoon habitats to the animals have not been investigated.

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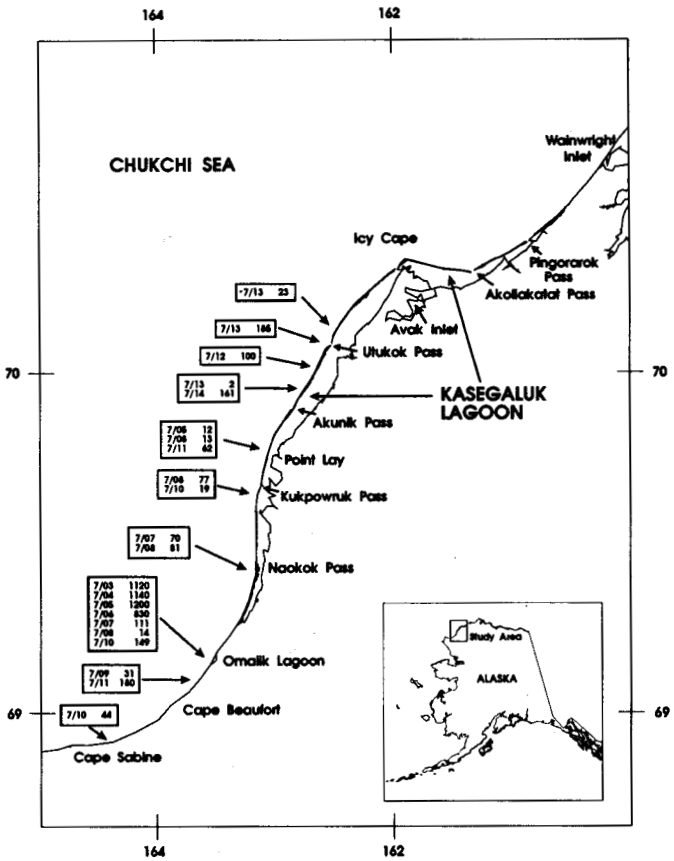

FIG. 1. Map of the Kasegaluk Lagoon study area in the northeastern Chukchi Sea showing locations and dates of beluga whale sightings made during aerial surveys 3-14 July 1990.

In May 1988 the U.S. Minerals Management Service (MMS) held an oil and gas lease sale in the northeastern Chukchi Sea. As a result, 339 leases were issued entitling operators to explore on 775 000 hectares, including areas as close as 20 km to Kasegaluk Lagoon (Gould *et al.*, 1991). Due to the potential for impacts of exploration and possible subsequent development of oil and gas reserves, the MMS sponsored a study of beluga whales and spotted seals in the Kasegaluk Lagoon region. Principal objectives were to gather data on the numbers and distribution of both species throughout the open-water season to be used for evaluating and mitigating potential impacts and to provide baseline information for subsequent monitoring programs.

METHODS

Beluga Whales

Aerial surveys for beluga whales were conducted from 3 to 14 July 1990 and 4 to 16 July 1991 using a high-wing twin-engine Aero Commander Shrike. During surveys one person sat in the right front seat and acted as an observer and navigator. The other observer sat directly behind the pilot on the left side. Surveys were conducted at 305 m altitude and a ground speed of approximately 220 km·h^{-1}. Slower speeds and higher altitudes were sometimes used when counting and photographing concentrations of whales. Belugas showed no obvious response to the survey aircraft at these altitudes and speeds.

Standard transects were flown each day parallel to the coast southward from Wainwright Inlet to Cape Sabine at a distance of 0.9 km offshore, with a return flight to the north approximately 6 km offshore. Additional transects were sometimes flown to provide more coverage of the study area — for example, locations where belugas were reported by local residents or other researchers. Surveys were conducted only when wind speeds were below 20 km·h^{-1} (Beaufort sea state scale 0-3). Each observer searched for belugas primarily in a strip extending out 0.9 km from each side of the flight line, but if conditions permitted (i.e., calm with no whitecaps) observers scanned a larger area. Whenever belugas were encountered, the entire group, including animals outside the primary strip and those partially submerged but visible, were counted. If the group exceeded approximately 50 animals the aircraft circled one or more times to allow additional counts. When animals were sufficiently concentrated they were photographed through the window of the aircraft using a fully automatic 35 mm camera with an 80-210 mm zoom lens. Color slide film of ASA 64, 200, or 400 was used, depending on light conditions. Photographs were developed and counted by projecting them on a white paper screen and marking each animal. Overlap of slides was determined by examining coastal features or by the positioning of groups of whales. Data presented are the largest count of a particular group, either visual or photographic, including all whales visible at or near the surface.

Transect widths were measured by inclinometer and indicated by marks on the aircraft windows. Locations of whales and transect waypoints were determined by LORAN and reference to known coastal features. The LORAN was initialized at takeoff in Barrow and as necessary at other known geographic locations during the flight. Accuracy was usually within 0.2-0.9 km at known landmarks.

Spotted Seals

Aerial surveys for spotted seals were conducted from a Cessna 206 on floats in 1989 and 1990 and from an Aero Commander Shrike or Cessna 207 on wheels in 1991. A single observer sat in the right front seat. The aircraft flew over Kasegaluk Lagoon approximately 0.5 km from the shoreline, with the observer facing the barrier islands and passes. Altitude varied depending on weather and sighting conditions but was usually 305 m in 1989 and 914 m in 1990 and 1991.

The observer recorded temperature, cloud cover, wind, and water level. Visual counts of seals were made with the aid of seven power binoculars while the aircraft circled each haulout. Oblique photographs were taken of any large groups using a fully automatic 35 mm camera equipped with an 80-210 mm telephoto lens. In 1989, ASA 100 or 400 color slide film was used. Slides of seals were counted by projecting them onto a gridded white paper screen. Each seal was marked as it was counted to avoid duplication. Some photographs in 1990 and all in 1991 were taken using ASA 400 black and white T-max film. Negatives were enlarged to 20 × 25 cm, and counts were made from prints by marking each seal on a mylar overlay placed over the photograph.

Survey periods of 5-7 days were selected to give temporal coverage during July, August, and September, when spotted seals were expected to be most numerous in the area. Due to weather conditions, the number of days flown within a period ranged from 3 to 5. Multiple surveys (2-4) were conducted on 12 days. In 1991, the survey was extended later into the season; surveys were flown on 2 days in October and 1 in November.

RESULTS

Beluga Whales

In 1990, belugas were seen on each of 12 flights, with total numbers ranging from 31 to 1212. During 3-6 July, 830-1200 whales were seen at the south end of the study area near Omalik Lagoon, and only one other small group of 12 belugas was seen offshore from Point Lay (Fig. 1). On 7 July, the group of whales nearshore to the south of Kasegaluk Lagoon decreased markedly in size, and from then until 11 July the number of whales seen in this area ranged from 14 to 183. At the same time belugas began to appear at Kasegaluk Lagoon passes. The first sighting was of 70 animals off Naokok Pass on 7 July, with subsequent sightings of up to 185 animals made at Kukpowruk, Akunik, and Utukok passes. During 12-14 July, 100-210 belugas were seen north of Point Lay; none was seen off the southern portion of Kasegaluk Lagoon or in the region along the coast south to Cape Sabine.

It appears that many of the belugas that left the Omalik Lagoon region on 6-7 July were not resighted in the study area. Small groups of belugas were occasionally sighted on the standard offshore transects, but no large concentrations were located. On 10 July, we saw a group of 19 belugas on the transect offshore from Kukpowruk Pass. Since it was a day with excellent weather and visibility, we flew about 180 km of additional transects extending as much as 36 km offshore but did not locate any more belugas. No surveys were flown from 15 to 25 July. No belugas were seen when spotted seal surveys commenced on 26 July.

In 1991, belugas were again seen during all 12 flights, with numbers ranging from 7 to 938. On 4 July, over 400 belugas were present near Omalik Lagoon and there were two other groups of 63 and 31 near passes to the north (Fig. 2). During 5-9 July, belugas were seen primarily near the south end of the study area. A large group of 390-937 was present near Naokok Pass on each of these five days. Other small groups (1-95) were seen during this period at Cape Beaufort, Omalik Lagoon, and Akunik, Utukok, and Akoliakatat passes. On 11 July, the large group of whales near Naokok Pass had left and we sighted only 36 belugas along the entire coastal and offshore survey route. On 12 July, only 6 belugas were seen south of Point Lay, and none was sighted in that region on subsequent surveys. A few sightings were made during this period along the coast north of Point Lay; the largest was of 660 belugas at Utukok Pass on 14 July.

On 13 and 15 July no belugas were seen near the coast, but there were many at the shoreward edge of loose pack ice northwest of Icy Cape. Over 200 were counted there on the 13th and over 500 on the 15th. Belugas were also sighted in that area on 16 July (W. Hanson, pers. comm. 1991). No surveys were flown from 17 to 28 July. No belugas were seen when spotted seal surveys commenced on 29 July.

Spotted Seals

The only places where seals were seen hauled out were near Utukok Pass, Akoliakatat Pass, and Avak Inlet. Single seals were occasionally seen in the water along the barrier islands and near other passes. At Utukok Pass the largest number hauled out on a large shoal that was sometimes exposed just inside the pass. Smaller groups of seals sometimes hauled out at several locations on the barrier island at the north side of the pass, inside the lagoon. At Akoliakatat Pass, seals used three long, narrow spits that extend

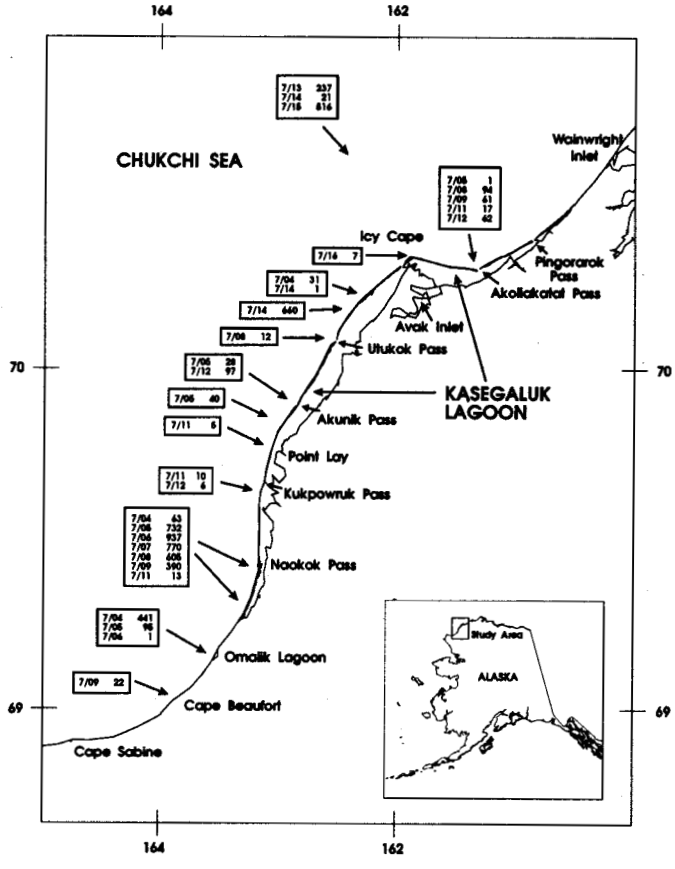

FIG. 2. Map showing locations and dates of beluga whale sightings made during aerial surveys 4-16 July 1991.

into the lagoon to the east and west of the pass. Seals hauled out at five locations in Avak Inlet, four small spits and a shoal.

Hauled-out spotted seals were very sensitive to disturbance. Frequently they responded to the approaching aircraft at a distance of 1 km or more, even when the plane was flying at an altitude of 760 m. As a result, in some instances the number of seals hauled out was estimated as the plane approached and that estimate was supplemented with subsequent counts of animals in the water near the haulout site. When conditions allowed flying at a 914 m altitude, the seals usually remained on the haulout and it was possible to circle and count them through binoculars and take photographs. Some of the daily counts are therefore precise, while others are presented as ranges or minimums.

In 1989, surveys began partway through the open-water season and there were seals hauling out in Kasegaluk Lagoon when the first survey was flown on 23 August. In 1990, there was still ice near shore during beluga surveys conducted 3-14 July. There were no spotted seals hauled out at any of the passes, but groups of up to 20 seals were commonly seen in the water, especially on offshore transects. When the first spotted seal survey was flown on 26 July, there were seals hauled out in the lagoon. In 1991, the ice broke up and moved offshore earlier than it did in 1990. No spotted seals were seen during 4-11 July. On 12 July, the first hauled-out seals were seen at Utukok and Akoliakatat passes.

During 1989, the total count of seals was over 1000 on 26 August and 1, 11, and 14 September (Table 1). The highest

TABLE 1. Numbers of spotted seals at haulouts in the Kasegaluk Lagoon study area during August-September 1989[1]

Date[2]	Utukok Pass	Akoliakatat Pass	Avak Inlet	All sites
Aug 23	50-100	0	228	278-328
Aug 24	80	114	ns	—
Aug 26a	175	>346	530	>1051
Aug 26b	75	740	ns	—
Aug 27a	120	35	1	156
Aug 27b	145	135	5	285
Aug 28	290	11	22	323
Sep 1	845-895	>900	35	>1780-1830
Sep 3	305	117	ns	—
Sep 8	300	0	155	455
Sep 11	600-700	45	259	904-1004
Sep 13	500-600	2	190	692-792
Sep 14	700-750	38	>370	>1108-1158

[1]All sites were surveyed on each flight unless indicated by ns.
[2]Repeat counts made on the same date are indicated by letters.

count of about 1800 was on 1 September; at that time the majority of seals were divided approximately equally at Utukok and Akoliakatat passes. High counts at Utukok Pass were mostly during 1-14 September, while at Akoliakatat Pass the highest counts were during 26 August–1 September. Numbers in Avak Inlet were variable.

In 1990, the highest total count of the season, about 2100, occurred on 28 July (Table 2). Other total counts of 1000 or more occurred on 23 and 25 August and 7-11 September. The number of seals seen at Utukok Pass was high on 28 July and much lower for the rest of the season. Occasional high counts were made at Akoliakatat Pass during 21 August–11 September. Numbers counted in Avak Inlet were again variable.

TABLE 2. Numbers of spotted seals at haulouts in the Kasegaluk Lagoon study area during July-September 1990[1]

Date[2]	Utukok Pass	Akoliakatat Pass	Avak Inlet	All sites
July 26	330-430	20	>170	>520-620
July 27	380-600	45	110	535-755
July 28	1800	45	245-265	2090-2110
Aug 11a	100	0	15-25	115-125
Aug 11b	>8	>248	ns	—
Aug 12	10	176	ns	—
Aug 13	0	85-90	108-135	193-225
Aug 21	280-350	508-673	155-200	943-1223
Aug 22a	0	330-385	ns	—
Aug 22b	0	450	ns	—
Aug 23a	>110	961	435	>1506
Aug 23b	15	800	ns	—
Aug 23c	60	>536	ns	—
Aug 24	20-30	>575	342	>937-947
Aug 25	5	1055	532	1592
Aug 26	20-30	>280	>235-240	>535-550
Sep 7	6	850-900	>150	>1006-1056
Sep 8a	>10	>905-1005	150-200	>1065-1215
Sep 8b	0	850-900	ns	—
Sep 8c	15-20	750-850	ns	—
Sep 9	6	1491	>285	>1782
Sep 10a	150-275	700-925	ns	—
Sep 10b	550-675	600-750	ns	—
Sep 10c	175-200	650-700	ns	—
Sep 10d	0	>270	>176	>446
Sep 11a	0	>720-820	160-210	>880-1030
Sep 11b	25	555-605	87	667-717

[1]All sites were surveyed on each flight unless indicated by ns.
[2]Repeat counts made on the same date are indicated by letters.

In 1991, the highest total count of about 2200 was made on 29 September, with large numbers of seals at both Utukok and Akoliakatat passes (Table 3). Other total counts of over 1000 were made on 29 and 30 July, 1 and 20 August, and 25 September. Highest counts at Utukok Pass were during 25-29 September, while at Akoliakatat high counts occurred at intervals during 29 July-29 September. Counts in Avak Inlet were generally lower than in 1989 and 1990.

TABLE 3. Numbers of spotted seals at haulouts in the Kasegaluk Lagoon study area during July-November 1991[1]

Date[2]	Utukok Pass	Akoliakatat Pass	Avak Inlet	All sites
July 11	0	0	0	0
July 12	25	30	0	55
July 15	0	40	0	40
July 16	0	104	ns	—
July 29	300-350	950	>200	>1450-1500
July 30a	50	1105	10	1165
July 30b	>35	500	0	>535
July 31	0	800-925	21-31	821-956
Aug 1a	600-700	990-1040	5	1595-1745
Aug 1b	0	0	0	0
Aug 2	>150	65-75	0	>215-225
Aug 18	225	200	0	425
Aug 19	500-550	350-400	3	853-953
Aug 20a	0	920	100-125	1020-1045
Aug 20b	50	1125	60	1235
Aug 21a	0	125	32	157
Aug 21b	0	110	ns	—
Aug 22	0	25	175	200
Sep 25	>750	680-800	3	>1433-1553
Sep 27	>400	>120	>150	>670
Sep 29	1185	900-1000	52	2137-2237
Oct 23	0	0	0[3]	0
Oct 24	65	100	ns[3]	165
Nov 6	2	0	ns[3]	2

[1]All sites were surveyed on each flight unless indicated by ns.
[2]Repeat counts made on the same date are indicated by letters.
[3]Avak Inlet was completely frozen during these surveys.

The survey period was extended in 1991 to determine how long spotted seals continued to use the Kasegaluk Lagoon haulouts. Surveys were flown of the entire lagoon on 23 and 24 October. The ocean was ice free at this time, but the lagoon and Avak Inlet were completely frozen and covered with thin gray-white ice. The spits and shoals where seals hauled out earlier in the season were covered with snow and ice and were almost undetectable from the air. There were small pools of open water immediately inside the entrance to each pass. On 23 October, no seals were observed near any pass or in Avak Inlet. On 24 October, 100 seals were hauled out on broken, snow-covered ice floes at the edge of the open-water pool inside Akoliakatat Pass. Seals were in groups of 5-40 per floe. At Utukok Pass, 65 seals were hauled out on a shelf of ice on the inside of the barrier island at the south side of the pass. Ice conditions were similar when the last survey was flown on 6 November. Two spotted seals were seen at Utukok Pass, one hauled out on the ice and one in the water. One seal was seen in the water near Naokok Pass. Seal breathing holes and probable haulout holes were seen in the thin ice near all the passes. While both ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) could be present in the area at this time of year and make holes in the ice, the location of these holes makes it more likely that they were made by spotted seals.

Survey data for 1989-91 were analyzed to determine if there was an effect of time of day or water level on the number of seals at haulouts. Linear and quadratic regressions of seal counts at each haulout versus time of day were not significant, and analysis of variance indicated no significant effect of water level on the number of seals at haulouts ($P > 0.05$).

DISCUSSION

Beluga Whales

Surveys conducted in 1990 and 1991 were of limited duration and designed to cover the period when belugas were most likely to be in the area and did not delineate the entire period of use. However, other sighting data show that there is annual variability in the dates during which belugas use the Kasegaluk Lagoon region. Since data from many years are based on observations by hunters and local residents rather than systematic surveys, it is likely that belugas arrive earlier and remain longer than indicated by reports we have received.

The earliest sighting we know of in the Kasegaluk Lagoon region was on 22 June 1979, when more than 100 belugas were seen at Kukpowruk Pass. Late June sightings were also reported in 1958, 1987, 1988, and 1991. In eight other years, the earliest reported sightings were in the first week of July (Frost *et al.*, 1983; Frost and Lowry, unpubl.). Thus, there is about a two-week window during which belugas make their first appearance in the vicinity of Kasegaluk Lagoon. The earliest sightings are usually at or south of Point Lay, usually between Cape Sabine and Omalik Lagoon.

The latest reported sightings of belugas near Kasegaluk Lagoon were 22 July 1985 near Omalik Lagoon, 19 July 1983 at Naokok Pass, and 19 July 1979 at Pingorarok Pass (Frost *et al.*, 1983; Frost and Lowry, unpubl.). Belugas are sometimes sighted along the coast north of Kasegaluk Lagoon, near Wainwright, in mid- to late July (Frost *et al.*, 1983). Results from surveys in 1990 and 1991 confirm that few belugas remain near shore by late July. There is no information on where these belugas go after they leave the northeastern Chukchi Sea coast.

The tendency of belugas to group together makes it particularly difficult to design rigorous surveys. Most studies (e.g., Richard *et al.*, 1990) combine reconnaissance flights with transects in an effort to ensure that all groups are detected and counted. The survey design we used at Kasegaluk Lagoon emphasized coverage of the nearshore area. It is evident from some of the low daily counts that not all whales were encountered during every survey. In both visual and photographic counts of belugas some portion of the animals present are below the surface, where they will be missed. Correction factors need to be developed and applied in order to derive population estimates from counts (e.g., Frost *et al.*, 1985). However, correction factors may vary greatly depending on whale behavior, water turbidity, etc., and lacking data on these parameters, we did not apply any correction factors to our counts at Kasegaluk Lagoon. In spite of these problems, the comparability of high counts within a year, such as during 3-5 July 1990, suggests that data from repetitive surveys during the first half of July provide a reasonable indicator of the number of whales using the area.

Seaman *et al.* (1986) estimated the abundance of belugas in the Kasegaluk Lagoon region based on photographs of whales taken on 13 and 15 July 1979. Counts of 1104 and 1601 were expanded using various correction factors to yield estimates of 1575 and 2282 total whales. Frost and Lowry (1990) reported that a count of 723 whales made off Point Lay on 8 July 1987 could represent 1400-2100 total animals. Although the methods used in the earlier surveys were different, a comparison with maximum counts of 1200 in 1990 and 938 in 1991 suggests that the number of belugas using this area has been relatively constant.

Several factors have been suggested to explain the tendency of belugas to concentrate in nearshore waters. One suggestion has been that warm, coastal waters could confer a thermal advantage to neonates, born without a thick blubber layer (Sergeant and Brodie, 1969; Fraker *et al.*, 1979). Seaman *et al.* (1986) found that the plumes of water flowing out of Kasegaluk Lagoon in July were as much as 2°C warmer than adjacent marine waters, and newborn calves were sighted among groups of whales in these areas. However, small calves presumed to be neonates are also seen within groups of whales offshore and in pack ice (Braham *et al.*, 1984). Doidge (1990) found that belugas and narwhals (*Monodon monceros*) are equally well insulated, and he therefore questioned the thermal importance of estuaries that are used only by belugas.

The possible importance of the Kasegaluk Lagoon region to belugas for feeding is unknown. Samples collected from various locations in Alaska have shown that beluga whales feed on a wide variety of fishes and some invertebrates (Seaman *et al.*, 1982). According to hunters from Point Lay, some feeding does occur on fishes such as sculpins (*Myoxocephalus* spp.), smelt (*Osmerus mordax*), arctic char (*Salvelinus alpinus*), and probably capelin (*Mallotus villosus*). Stomachs examined by us contained remains of crangonid shrimps and echiuroid worms (*Echiurus echiurus*). However, there is no indication that nearshore food resources are so abundant or suitable in this area in early July that they would attract and feed such a large number of belugas for a period of several weeks. Hunters from Point Lay suggest that the belugas may remain near the lagoon passes for a few days, move offshore to the ice to feed, and then return to the passes. Such a pattern was observed for belugas in Cunningham Inlet on Somerset Island, Northwest Territories, where radio-tagged individuals moved offshore for several days and subsequently returned to the inlet (Frost, unpubl.). In 1991, we observed many belugas near the pack ice off Icy Cape. However, those we saw were milling at the surface and showed no indication of feeding. We did observe belugas that were making vertical dives and appeared to be feeding several kilometres offshore from Akunik Pass on 12 July 1991.

We think that the main reason belugas concentrate near Kasegaluk Lagoon is associated with their annual skin molt. In belugas the outer layer of skin (*stratum externum*) is thick and yellow during spring, intermediate during the summer, and thin and very white in fall after the molt is completed (St. Aubin *et al.*, 1990). Observations that belugas in eastern Canada rub on gravel substrate and in doing so shed their yellowed epidermis were first reported in the scientific literature by Finley (1982). Warm lagoon and coastal water may accelerate the breakdown of old epidermal cells and may be important for rapid cell growth that occurs during the molt (Finley, 1982; St. Aubin *et al.*, 1990). Reduced salinity, and particularly the presence of fresh water, may also augment the molt process by hydrating cellular debris and accelerating the sloughing of old epidermis.

Hunters in northwestern Alaska recognize "spring belugas" and "fall belugas" based on whether the skin is yellow (old)

or white (new). There are extensive gravel beds near shore between Point Lay and Point Hope, especially in the Omalik Lagoon area (Lewbel, 1984; Feder *et al.*, 1989), and belugas probably go to these gravel areas to rub off loose epidermis. Belugas observed in these nearshore concentrations usually appear to be milling or diving in shallow water close to shore. They often stir up the bottom and create muddy plumes where they have been diving. This is similar to the behavior of belugas at molting sites in the Canadian Arctic.

Spotted Seals

There is little published information on the distribution and abundance of spotted seals during summer and autumn. In the western Chukchi Sea during open-water months, they occur at least as far north as Cape Schmidt and probably to Chaun Bay (Shaughnessy and Fay, 1977). In the east, they occur along the Alaska coast from Bristol Bay to the Beaufort Sea (Frost *et al.*, 1982, 1983; Alaska Department of Fish and Game, unpubl.) and in Canada east at least to Herschel Island (Porsild, 1945).

According to the data compilations by Frost *et al.* (1982, 1983), there are only four major haulout areas along the Alaska coast where 1000 or more spotted seals have been seen: the mouth of the Kuskokwim River on offshore sandbars near Quinhagak (5600-6000 in May 1978); on sandbars in Scammon Bay (1000+ in June 1978); at Cape Espenberg (1000+ in late August, year unknown); and at the passes of Kasegaluk Lagoon. Kasegaluk Lagoon is the only one of these areas where systematic counts have been conducted and numbers documented with photographs.

During our surveys in 1989-91, we saw spotted seals hauled out only at Utukok and Akoliakatat passes and Avak Inlet. Local residents also report that these are currently the only major haulouts. According to long-time residents of Point Lay, other locations near Akunik and Naokok passes were once used by spotted seals, but circulation patterns and coastal morphology have changed and those areas are no longer regularly used (W. Neakok, pers. comm. 1991). The specific characteristics that make certain areas suitable as spotted seal haulouts are difficult to quantify. All major haulouts in the Kasegaluk Lagoon area are protected from the ocean by the barrier islands. Most are on the ends of islands, on narrow spits extending from the islands into the lagoon, or on shoals, although three sites in Avak Inlet are on spits attached to the mainland tundra. Common features of areas used include low relief, sandy or fine gravel substrate, and ready access to relatively deep water channels. Presumably all sites provide some measure of protection and escape from potential predators, including humans and grizzly bears (*Ursus arctos*) that are common in the area. The two passes that have been abandoned as regular hauling-out locations have shallow entrances with no direct access to deep water.

Data collected in 1989-91 indicate considerable variability in daily use of the three general haulout areas (Tables 1-3). Sightings of large numbers of seals occurred at all three areas in all months. On some days almost all of the seals were hauled out in a single area. On other days seals were present in substantial numbers at all three areas. Factors that may affect the number of animals hauled out at a particular time include disturbance, water level, time of day, weather, and time of year. Disturbance from aircraft, including both the survey plane and local commercial operators, commonly caused all the seals to go into the water. When we flew back over some areas 2-3 hours after the seals had gone into the water, many animals were again on the haulouts. However, there is no way to know whether or not these were the same individuals. There was no clear relationship between survey counts and water level, time of day, or weather.

Spotted seals use Kasegaluk Lagoon for hauling out throughout the open-water season, from approximately mid-July until freeze-up in late October or early November. During aerial surveys conducted in 1990-91, no spotted seals were hauled out at any Kasegaluk Lagoon passes during early July; the earliest sighting was on 12 July 1991. Frost *et al.* (1983) reported sightings of 1000 or more hauled-out seals on 10 July 1978 and 15 July 1981. Residents of Point Lay and Wainwright report that spotted seals remain in Kasegaluk Lagoon until freeze-up, well into October (Nelson, 1982; Neakok *et al.*, 1985). In October 1989, at least 400 spotted seals were seen hauled out at Utukok Pass (A. Agnasagga, pers. comm. 1989). On 24 October 1991, many spotted seals were hauled out on the ice near the two main haulouts at Utukok and Akoliakatat passes, and a few seals were still in the area on 6 November 1991.

There was no obvious seasonal pattern in the total number of seals hauled out in Kasegaluk Lagoon during July-September (Fig. 3). During 1989-91, counts of over 1000 seals occurred any time from late July through late September, and similar large counts have been reported as early as 10 July (Frost *et al.*, 1983). Maximum yearly counts occurred on 1 September 1989, 28 July 1990, and 29 September 1991.

The variability in counts described above confounds efforts to develop methods to monitor spotted seal abundance using aerial surveys. Given the day-to-day variability in counts, the maximum count for a season at all haulouts combined is probably the best indicator to use. However, with the information currently available it is not possible to predict when during the open-water period the highest count is most likely to occur. If surveys must be flown throughout July-September in order to ensure that the maximum count is obtained, that will not provide a very efficient method for monitoring seal abundance.

Sightings reported by Frost *et al.* (1983) for passes at Kasegaluk Lagoon are of similar magnitude to those made in this study. In September 1974, 2500-3000 seals were estimated to be present at lagoon passes. Maximum counts for July-September 1990 and 1991 were approximately 2100 and 2200. It is unknown how many seals are actually using this region. Preliminary results of studies using satellite-linked tags to look at behavior of spotted seals in this area indicate that individual seals spend long periods at sea and a relatively small amount of time at haulout areas (Frost and Lowry, unpubl.). When about 2200 seals were counted on 29 September 1991, only one of four satellite-tagged seals was hauled out at Kasegaluk Lagoon.

Spotted seals give birth in the Bering Sea ice front mostly in late March and April, nurse their pups for about four weeks, then breed shortly thereafter (Burns *et al.*, 1972). They molt their pelage during April-June (Ashwell-Erickson *et al.*, 1986). Coastal haulouts in the Chukchi Sea are used during July-November and therefore are not important for pupping, breeding, or molting. It is generally thought that these haulouts are near abundant food supplies, such as where there are large runs of spawning fishes that are major prey items (Goltsev, 1971; Frost *et al.*, 1983). There is very little direct information available on spotted seal feeding in the Kasegaluk Lagoon

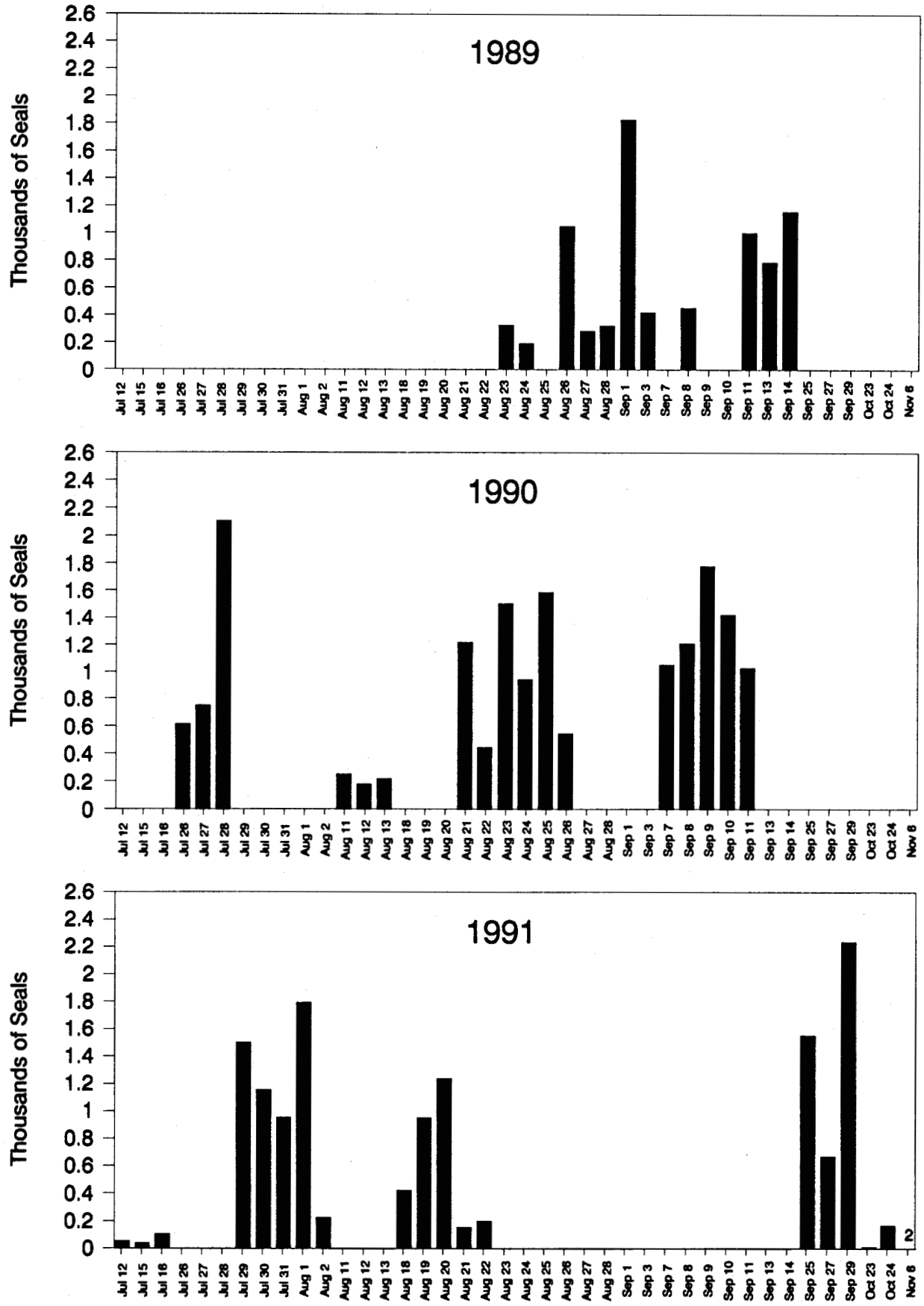

FIG. 3. Maximum combined daily counts of spotted seals made at haulouts in Kasegaluk Lagoon in 1989, 1990, and 1991. Within each year, surveys were flown only on the dates for which counts are shown.

region. Ten seals were collected near Utukok and Akoliakatat passes in September 1981; one had eaten arctic cod (*Boreogadus saida*) and the others had empty stomachs (Lowry and Frost, unpubl.). Spotted seals may feed in the Kasegaluk Lagoon area on a variety of fishes and invertebrates such as crangonid shrimps. Alternatively, they may feed some distance away in other parts of the Chukchi Sea. This latter possibility is suggested by preliminary results of satellite-tagging studies, which located seals 100-400 km at sea between haulout bouts at Utukok or Akoliakatat Pass (Frost and Lowry, unpubl.).

CONCLUSIONS

Results of this study, in combination with other available information, confirm that the Kasegaluk Lagoon region contains the most important summer habitats used by beluga whales and spotted seals in the northeastern Chukchi Sea. The regular occurrence of thousands of animals at specific locations suggests that they are of particular biological significance, although the activities that occur in these areas are currently poorly understood.

Until recently this region of the northeastern Chukchi Sea has been relatively remote. However, subsequent to an oil and gas lease sale in 1988, five exploratory wells have been drilled in the area 100-200 km offshore from Kasegaluk Lagoon. In addition a local landowner, the Arctic Slope Regional Corporation, is in the process of developing a large coal deposit located approximately 10 km inland. The coal will be transported overland, stored at Omalik Lagoon, and moved out by ship during the open-water season. It is therefore very likely that human activity in this area will increase markedly in the near future. Beluga whales in Alaska are known to respond to sounds produced by aircraft, ships, and small boats (Frost and Lowry, 1990). The extreme sensitivity of spotted seals to aircraft that we noted in this study is unlike that of any other Alaskan pinniped. While the long-term effects of such responses on patterns of beluga and spotted seal distribution and habitat use are unclear, restrictions on human activity in certain seasons and areas will be needed to provide prudent mitigation measures.

In addition to relative freedom from disturbance, geologic and oceanographic features appear to be important determinants of beluga and spotted seal habitats. Causeway construction and dredging, activities that commonly accompany development in arctic regions such as Prudhoe Bay, will need to be carefully evaluated to avoid altering areas of special biological significance in and near Kasegaluk Lagoon.

As development proceeds it will be necessary to monitor populations of key species to verify effectiveness of mitigating measures and to detect possible unforeseen impacts. Our current understanding of beluga whales is probably sufficient for monitoring through repetitive aerial surveys. However, further studies of spotted seal distribution and behavior are needed before an adequate monitoring protocol can be designed. Such studies, using satellite-linked telemetry, are currently under way.

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