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USE OF KASEGALUK LAGOON, CHUKCHI SEA, ALASKA, BY MARINE BIRDS AND MAMMALS, III: MARINE MAMMALS

by

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ABSTRACT

Aerial surveys were conducted in the northeastern Chukchi Sea during 1989-1991 to investigate the distribution, abundance, and habitat use of marine mammals in the Kasegaluk Lagoon region. Emphasis was on beluga whales and spotted seals that were known to regularly occur in the area during the open water season.

Beluga surveys were flown along coastal and offshore transects. Belugas were seen on every survey during 3-14 July 1990 and 4-16 July 1991, with numbers ranging from 7 to 1,212. The earliest and largest sightings were at the south end of the study area near Omalik Lagoon. Later sightings occurred near the passes north of Point Lay and in the pack ice off Icy Cape. Data from other years indicate that whales sometimes arrive as early as 22 June and always 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. It is unclear how much feeding occurs in the area. In recent years residents of Point Lay have harvested an average of 35 whales per year.

Spotted seal surveys covered the mainland coast and barrier islands. Seals were seen hauled out on particular spits and shoals near Utukok Pass, Akoliakatat Pass, and Avak Inlet. They were present in the area from mid-July through early November. Numbers counted were very variable but exceeded 1,000 on many days in July, August, and September. The maximum count of about 2,200 represents only a fraction of the total number of seals frequenting Kasegaluk Lagoon. Spotted seals probably feed on fishes and shrimps in or near the lagoon or in offshore waters of the Chukchi Sea. Seals were very responsive to disturbance by aircraft.

The Kasegaluk Lagoon region provides important habitat for marine mammals, with several thousand beluga whales and spotted seals using the area each year. Future studies should continue to monitor distribution and abundance by aerial surveys. In addition, satellite-linked telemetry should be used to learn more about movement patterns and behavior.

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INTRODUCTION

Beluga whales (*Delphinapterus leucas*) and spotted seals (*Phoca largha*) are seasonally the most abundant marine mammals in the Kasegaluk Lagoon region of the northeastern Chukchi Sea. They regularly use the coastal zone and lagoon waters during summer and autumn for a variety of purposes. Belugas feed, calve, and probably molt in nearshore waters. Spotted seals haul out to rest on sand bars and spits, and may feed in marine waters or on anadromous fishes in estuaries and rivers. Both belugas and spotted seals are important subsistence resources for local residents. The village of Point Lay regularly harvests belugas (Lowry et al. 1989), and in some years belugas may make up over 50% of the annual harvest of wild foods (Pedersen in press). However, despite the large numbers of beluga whales and spotted seals using Kasegaluk Lagoon and their importance to coastal residents, prior to 1989 there were no systematic studies of their distribution and abundance in this region.

In 1989 the Minerals Management Service (MMS) funded the Alaska Department of Fish and Game (ADF&G), under subcontract to LGL Alaska Research Associates, Inc., to investigate the use of Kasegaluk Lagoon by spotted seals and beluga whales. Field work serving as the basis for this study included two years of beluga surveys in July 1990 and 1991, and surveys of spotted seals at intervals during 1989-1991. This is a final report which presents the results of all field investigations and makes recommendations for future studies.

Background

Beluga Whales

Beluga whales are widely distributed in marine waters of western and northern Alaska, and show pronounced seasonal movements. During winter, belugas occur principally in the seasonal sea ice of the Bering Sea, although some may overwinter in the Chukchi Sea pack ice where open water in the form of leads and polynyas regularly occurs (Kleinenberg et al. 1964, Fay 1974, Seaman and Burns 1981, Ljungblad et al. 1986, Brueggeman

and Grotefendt 1988). The distribution of belugas changes greatly in March and April as the sea ice cover loosens. Many whales migrate northward then eastward through leads and shear zones of the Bering, Chukchi, and Beaufort seas. Most of these whales probably summer in the eastern Beaufort Sea, Amundsen Gulf, and the Mackenzie estuary (Fraker et al. 1978, Davis and Evans 1982). Due to ice conditions and seasonal movement patterns, this group spends little time in coastal waters of western Alaska. Other belugas migrate less extensively and appear in coastal waters of the Bering and Chukchi seas shortly after spring breakup. Concentration areas occur in Bristol Bay, Yukon Delta/Norton Sound, Kotzebue Sound, and near Kasegaluk Lagoon (Frost and Lowry 1990a).

Belugas begin appearing in Kotzebue Sound in early to mid-June, and are commonly seen in this region until July. In late June and July, belugas are seen along the Chukchi Sea coast northwest of Kotzebue and east of Cape Lisburne. In July large numbers appear near the barrier islands and passes off Kasegaluk Lagoon, both south and east of Icy Cape. Belugas are occasionally reported further to the northeast, especially near Wainwright, in late July through early September (Frost et al. 1983, Frost and Lowry 1990a).

Coastal residents have known about and relied upon the regular seasonal appearance of belugas along the Kasegaluk Lagoon coast for as long as they have lived and hunted there (Neakok et al. 1985). The first published reports of belugas in this region were summarized in Bee and Hall (1956). Those few reports were supplemented by Childs (1969) who reported seeing about 50 belugas near the Pitmegea River on June 24, 1958. ADF&G began studies in the vicinity of Kasegaluk Lagoon in 1978, when observations and conversations with residents indicated that large numbers of belugas occurred in the area each year. Based on this and subsequent work a compilation of beluga sightings was prepared (Frost et al. 1983) and the use of the area by belugas was described (Frost and Lowry 1990a).

The first estimates of the number of belugas in the Kasegaluk Lagoon region were made by Seaman et al. (1986). Aerial photographs taken in July showed a maximum of 703 whales in 1978 and 1,601 in 1979. Using various correction factors they estimated that approximately 2,300 belugas were present in 1979. Frost et al. (1983) reported a count of 670 belugas in the area in July 1981. In July 1987, Frost and Lowry (1990a, 1990b) counted 723 belugas west of Point Lay and estimated that this represented 1,400-2,100 whales.

Another aerial survey effort in 1987 reported a maximum sighting of 500-900 whales near Omalik Lagoon in early July (Hansen Environmental Research Services (HERS) 1988).

Spotted Seals

The general distribution of spotted seals, and their taxonomic status, have been discussed by Burns (1970), Fay (1974), and Shaughnessy and Fay (1977). Available information on their biology and natural history was reviewed and summarized by Quakenbush (1988). Spotted seals are closely related to Pacific harbor seals (*Phoca vitulina richardsi*), and may be mistaken for them in field observations. In Alaska most harbor seals use terrestrial haulouts for pupping in May-June and molting in August-September, although floating ice, particularly that from tidewater glaciers, is also used. In contrast, spotted seals are associated with sea ice from late autumn until early summer. They have their pups on the ice in late March-April and molt on the ice shortly thereafter. During spring the entire spotted seal population is found in the southern ice front of the Bering Sea, with the highest concentration within 25 km of the southern edge (Burns 1970, Burns et al. 1981). As the ice disintegrates and recedes, spotted seals move northward and towards the coast. During summer they are especially common in bays, estuaries, and the mouths of major rivers along the coasts of the Bering and Chukchi seas. Like harbor seals, they sometimes haul out on land at this time, particularly on sandy beaches, spits, and barrier islands. As the ocean begins to freeze in autumn and early winter, spotted seals move away from the coast and southward toward the ice front in the Bering Sea.

Systematic attempts to survey spotted seals have occurred in spring in the Bering Sea ice front (Burns and Harbo 1977, Braham et al. 1984, ADF&G unpublished data). While these surveys identified apparent concentration areas and gave an indication of overall abundance, they provided no information about distribution or abundance at other times of year. Frost et al. (1982, 1983) compiled all sightings available through 1982 of marine mammals in the coastal zone of the eastern Bering and Chukchi seas during summer and autumn, and identified areas of particular importance to the various species. Based on information from local informants and opportunistic sightings, they determined that major spotted seal haulouts

within Kasegaluk Lagoon were among the largest concentrations in Alaska. While seals were present throughout the Lagoon and hauled out at a variety of locations, the barrier island sandbars and spits adjacent to Utukok and Akoliakatat passes had by far the largest reported sightings, with up to 1,000 seals reported at each location. Apparently, there was no information collected on spotted seals in the Kasegaluk Lagoon region during the period from 1983 through 1988.

In areas of Alaska such as Bristol Bay, the behavior of spotted seals during summer and early autumn may be quite similar to that of harbor seals. Both species congregate near areas where there are predictable runs of anadromous fishes, and haul out on nearby beaches, sandbars, and spits. At Nanvak Bay where both spotted seals and harbor seals haul out, Johnson (1975) noted that the two species hauled out on separate parts of the beach, but there were no obvious differences in their behavior.

In Alaska harbor seals are generally found year round in areas with large tidal range, and their haulout behavior is known to correlate with tidal stage and time of day (Pitcher and Calkins 1979). In other parts of their range where adequate substrate for hauling out is available at all stages of the tide, a diurnal pattern may dominate (Stewart 1984). There is no information to indicate what factors may affect hauling out patterns of spotted seals. Tide should not have any influence on the behavior of spotted seals when they are associated with sea ice, and it is generally thought that peak numbers are hauled out at mid-day as is the case with ringed seals (*Phoca hispida*) (Frost et al. 1988). In most areas of northern Alaska where spotted seals are common in summer, the daily lunar tidal range is small and is frequently masked by wind and wave action. Also, there is little diurnal change in light or temperature during mid-summer months. Thus, there has been no information available with which to determine the best time of day or conditions in which to fly summer surveys of spotted seals, or to evaluate the possible sources of variability in counts.

Objectives

The general objective of this study was to conduct aerial surveys of belugas and spotted seals and use these data, along with historical data, to describe the distribution, relative abundance, and habitat use of beluga whales

and spotted seals in the Kasegaluk Lagoon area. Specific objectives were as follows:

Beluga whales

1. Determine distribution and relative abundance of beluga whales in Kasegaluk Lagoon and adjacent marine waters during two open water seasons by conducting replicate aerial surveys of the nearshore zone.

2. Obtain harvest data and opportunistic information on feeding of beluga whales in and near Kasegaluk Lagoon, based on samples collected by the North Slope Borough Department of Wildlife Management as part of a harvest monitoring study.

Spotted seals

1. Determine distribution, relative abundance, and habitat use of spotted seals in Kasegaluk Lagoon during two open water seasons.

2. Describe haulout behavior of spotted seals in Kasegaluk Lagoon relative to time of day, water level, and weather in order to determine the best conditions in which to conduct aerial surveys.

3. Obtain opportunistic information on feeding of spotted seals in and near Kasegaluk Lagoon, based on samples obtained from subsistence hunters.

STUDY AREA

Kasegaluk Lagoon is a long, shallow lagoon extending from approximately 69°16'N 163°17'W north and east to 70°28'N 160°30'W (Fig. 1). The lagoon is approximately 170 km in total length; 120 km from the southern end to Icy Cape, and 50 km from Icy Cape to the northeastern end. It is 6 km across at its widest point. Although there are few soundings, maximum depth is probably less than 4 m with much of the lagoon 1-2 m deep. The southern end of the lagoon, from Naokok Pass south, is extremely shallow and may be covered by only a few centimeters of water. The deepest water is found at the northern end of the lagoon, and east of Icy Cape. Seaward of the barrier islands the bottom slopes gently to a depth of 10 m approximately 2 km off shore. There are extensive gravel beds near shore between Point Lay and Point Hope and between Icy Cape and Wainwright (Lewbel 1984).

The lagoon is separated from the ocean by low, narrow, sandy barrier islands which are interrupted by a series of passes. Major passes from south to north, as indicated on most maps and charts are: Naokok (a double pass), Kukpowruk, unnamed pass across from the village of Point Lay (called Point Lay Pass in this report), Akunik, Utukok, unnamed double pass (called Twin Pass in this report), Icy Cape, Akoliakatat, unnamed pass near Nokotlek Point, and Pingorarok (Table 1, Fig. 1). East of Icy Cape there is a a large inlet with a series of restrictions giving it the appearance of a lagoon within a lagoon; it is given the Inupiaq name of Avak which means "again". There are sandy spits at each of the constrictions.

Lunar tides in the Kasegaluk Lagoon region are minor, with a range generally less than 15 cm. During summer water level in the lagoon is greatly influenced by wind, with onshore, westerly winds creating high water and offshore, easterly winds creating low water. When the wind causes the lagoon to empty, muddy plumes of lagoon water can be seen extending north or south of the passes depending on wind direction, and the water remaining in the lagoon is warm with low salinity. In contrast, onshore winds cause plumes of clear, cold, high-salinity marine water to flow into the lagoon through the passes. Changing water level greatly affects the availability of spits and shoals where spotted seals haul out. In particular, the large shoal in the lagoon near Utukok Pass, spits east and west of Akoliakatat Pass, and

Table 1. Official and alternate names, with geographic coordinates, of locations referred to in this report.

Name Used in This Report	Latitude (North)	Longitude (West)	Comments and Other Names
Cape Sabine	68°55′	164°36′	Located at mouth of Pitmegea River and often referred to by river name; often confused with Cape Beaufort because World Aeronautical Charts (WAC) refer to Cape Beaufort as Cape Sabine; other maps and charts locate Cape Sabine near the mouth of the Pitmegea River; Pitmegea River shown on WAC sectional CC-8
Cape Beaufort	69°02′	163°50′	Referred to as Cape Sabine on WAC CC-8 and by most pilots; Beaufort DEW Line site located here; Point Lay residents refer to the DEW Line site rather than to a cape; called Cape Beaufort on NOAA charts and USGS maps
South Naokok Pass	69°25′	163°08′	Unnamed on all charts and maps; called "South Naokok" in this report because of its proximity to Naokok Pass immediately to the north; called "Mud Pass" by HERS (1991)
North Naokok Pass	69°27′	163°09′	Called Naokok Pass on charts and maps; unlabelled on WAC CC-8; the modifier "North" used in this report to distinguish it from the unnamed pass to the south which we call "South Naokok"
Kukpowruk Pass	69°40′	163°06′	Called "5-Mile Pass" by residents of Point Lay because of its location 5 miles (8 km) south of the village; unlabelled on WAC CC-8

Table 1. Continued.

Name Used in This Report	Latitude (North)	Longitude (West)	Comments and Other Names
Point Lay Pass	69°44′	163°04′	Sometimes called "Kali Pass" after the Eskimo name for Point Lay; this pass was created by dredging; unlabelled on maps and charts
Akunik Pass	69°54′	162°49′	Called Kokolik Pass on NOAA charts and Akunik Pass on USGS maps; unlabelled on WAC CC-8; Point Lay residents refer to this pass as "11-mile Pass" because it is 11 miles (17.6 km) north of the village
Utukok Pass	70°05′	162°31′	Same name used by USGS maps, NOAA charts, and local residents; unlabelled on WAC CC-8 but river name is shown
Twin Pass	70°16′	162°06′	A double pass south of Icy Cape Pass; unnamed on all maps and charts; local name unknown
Icy Cape Pass	70°18′	161°57′	Unlabelled on WAC CC-8 and NOAA charts
Akoliakatat Pass	70°18′	161°18′	Same name on USGS maps and NOAA charts; unlabelled on WAC CC-8
Nokotlek Pass	70°20′	161°02′	Near Nokotlek Point and River; unnamed on all maps and charts; pass often not shown
Pingorarok Pass	70°22′	160°49′	Same name used by USGS maps and NOAA charts; unlabelled on WAC CC-8

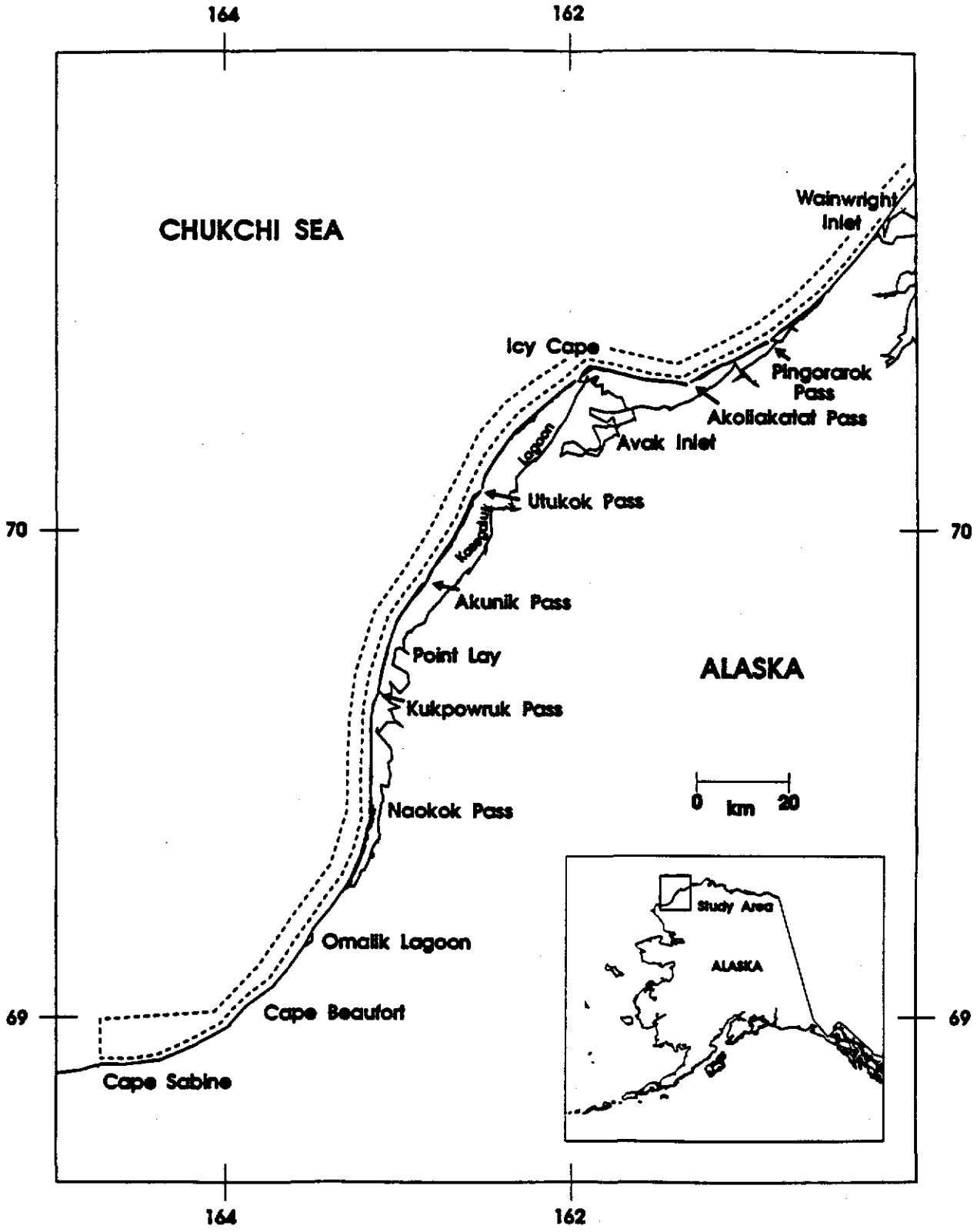

Figure 1. Map of the Kasegaluk Lagoon study area in the northeastern Chukchi Sea. Dashed lines indicate standard transects flown during beluga whale surveys.

several spits in Avak Inlet may be exposed and provide extensive substrate for hauling out, or they may be so covered by water that they are completely undetectable from the air. Water level may change considerably in just a few hours.

Kasegaluk Lagoon is ice covered for much of the year. The lagoon usually freezes in late October to early November, and the adjacent ocean freezes slightly later. Breakup occurs in late May or early June. Some ice may be present until July, particularly near and east of Icy Cape where it can become grounded on extensive, shallow shoals.

Relatively little is known about the invertebrate and fish fauna in and off shore from Kasegaluk Lagoon. Residents of Point Lay report catching pink (*Onchorhynchus gorbuscha*) and chum (*O. keta*) salmon, cisco (*Coregonus* spp.), arctic char (*Salvelinus alpinus*), smelt (*Osmerus mordax*), Pacific herring (*Clupea harengus*), and arctic flounder (*Liopsetta glacialis*). Studies conducted by LGL in 1982-83 indicated that marine fish species were more abundant than anadromous species in the Point Lay region (Craig and Schmidt 1985, Fechhelm et al. 1984). The most numerous marine species were herring, arctic cod (*Boreogadus saida*), fourhorn sculpin (*Myoxocephalus quadricornis*), and arctic flounder. Capelin (*Mallotus villosus*) and saffron cod (*Eleginus gracilis*) were less common. Smelt and pink salmon were the most numerous anadromous species, with chum salmon, arctic char, and arctic cisco (*Coregonus autumnalis*) also present.

METHODS

Aerial Surveys

Beluga Whales

Aerial surveys for belugas were conducted during 3-14 July 1990 and 4-16 July 1991 using a high-wing twin-engine Aero Commander Shrike, capable of seating the pilot and five others. 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. Lateral visibility was excellent.

Surveys were conducted at 305 m altitude and a ground speed of approximately 220 km/hr. Slower speeds and higher altitudes were sometimes used when counting and photographing concentrations of whales.

A combination of pre-selected transects (Fig. 1) and search surveys was used to provide the best possible coverage of the area between Barrow and Cape Sabine. During transit between Barrow and the north end of Kasegaluk Lagoon, flights were generally straight lines connecting points offshore from major coastal features. From the north end of the Lagoon to the mouth of the Pitmegea River the flight track followed the coastline, 0.9 km offshore. At the Pitmegea River, the aircraft turned and returned north and east flying along a series of transects that were about 5-9 km offshore. Additional transect lines were sometimes flown to expand the area of coverage or to make repeat counts.

Each observer looked for and counted belugas within a strip extending out 0.9 km from each side of the flight line. If conditions permitted (i.e., calm with no whitecaps) observers scanned a larger area. Whenever belugas were encountered, all animals, including 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. At the time belugas were counted, their direction of travel (if any) and position relative to lagoon passes, plumes of lagoon water, and sea ice were noted. Weather, sea state, and other marine mammals seen were recorded.

When animals were sufficiently concentrated they were photographed using a fully automatic 35 mm camera with an 80 to 210 mm zoom lens. Color slide film of ASA 64, 200, or 400 was used depending on light conditions. Photographs were developed and belugas were counted by projecting the slides on a white paper screen and marking each animal as it was counted. Overlap of slides was determined by examining coastal features or by the positioning of groups of whales. Black and white ASA 400 T-max film was tried and found unsatisfactory for counting large groups of belugas at high altitude.

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 aircraft was equipped with extended range LORAN that incorporated a microprocessor chip for the LORAN station at Port Clarence, Alaska. 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 along Kasegaluk Lagoon approximately 0.5 km offshore 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 7-power binoculars while the aircraft circled each haulout. An automatic 35 mm camera, equipped with a 70-210 mm telephoto lens, was used to photograph all large groups of seals. In 1989, ASA 100 or 400 color slide film was used. Seals were counted by projecting the slides onto a gridded white paper screen. To avoid duplication, each seal was marked as it was counted. Some photographs in 1990 and all in 1991 were taken using ASA 400 black and white T-max film. Negatives were enlarged to 20 X 25 cm, and counts were made from prints by

marking each seal on a mylar overlay placed over the photograph. Photographs taken with T-max film were found to be far superior to color slides for purposes of counting.

Several five to seven day survey periods were selected in order to give temporal coverage of most of the open water season when spotted seal were expected to be in the area. Surveys were flown on as many days as possible within each survey period. Due to weather conditions, the number of days flown within a period ranged from three to five. Multiple surveys were sometimes conducted on a single day.

During bird surveys conducted by LGL as part of this overall project, all observations of seals were also noted and estimates were made of the number of animals present. For bird surveys the aircraft flew at 45 m altitude along transects that were 200 m seaward and shoreward of the barrier islands and down the center of the lagoon. One observer was seated on each side of the aircraft. Known spotted seal haulouts were also checked during beluga whale surveys.

Harvest Studies

Each year since 1987 the North Slope Borough Department of Wildlife Management (NSB) has conducted a beluga whale harvest monitoring program at Point Lay. As part of this program, NSB biologists determine the number of belugas harvested and obtain samples of stomach contents, reproductive tracts, and teeth. Skin samples for use in DNA analysis have also been collected. Analysis of stomach contents has been done cooperatively by personnel from the NSB and ADF&G according to the methodology described in Seaman et al. (1982). The data obtained have been made available for inclusion in this report.

Spotted seal hunting occurs sporadically during the open water season. We attempted to collect stomachs from harvested spotted seals. Posters and other announcements were used to request that hunters provide us with stomachs and collection data (date and location where the seal was shot). This effort was largely unsuccessful.

Haulout Behavior

A field camp was established during 26-29 August 1990 at a location about 9 km southwest of the DEW Line tower at Icy Cape. Observers camped on the beach and hiked overland about 9 km to Avak Inlet. Visual counts and observations of the response of seals to aircraft were made at two locations in Avak Inlet. Personnel also conducted reconnaissance for possible future seal observations at Utukok Pass.

During 2-7 August 1991, a field camp was established on the barrier island at Utukok Pass. During this time, investigators caught and attached satellite-linked tags to four spotted seals. This was a cooperative undertaking involving ADF&G, the NSB, Texas A & M University, the National Marine Mammal Laboratory, and the people of Point Lay. Although this tagging project was not part of the MMS-funded Kasegaluk study, it was planned so that logistics needs could be incorporated into scheduled spotted seal surveys. Information from the four satellite-tagged seals will provide considerable insight into spotted seal behavior and be useful for interpreting results of aerial surveys conducted during 1989-91. More information about this study will be available from ADF&G.

During most aerial survey flights, observations were made of the response of seals to the survey aircraft. As the aircraft approached each haulout, the observer noted whether and at approximately what distance seals went into the water. For data analysis, seal behavior was classified as "response" when some or all seals went into the water, and as "no response" when no seals went into the water. Logistic regression was conducted using absence of a response as the outcome variable. The resulting logistic model predicts the probability of an outcome depending on the value of the explanatory variable and can be written as $\ln(p/1\text{-}p) = b_0 + b_1x$, where x is the airplane height and p is the probability of no response. This model can be solved for either p or x, thus allowing it to be used either to predict the probability of not disturbing seals at a particular altitude, or to predict the minimum altitude required to give a desired probability of not disturbing seals. The statistical software package SAS was used to estimate the parameters b_0 and b_1.

A regression-like model was used in an attempt to explain variability in spotted seal counts. Factors considered included:

Factors	Class or Continuous Variable	Levels or Ranges
water level	class	low, medium, high
location	class	Utukok, Akoliakatat, Avak
year	class	1989, 1990, 1991
time of day	continuous	10:00 h to 21:00 h
time of year	continuous	beginning 1 July

An ANOVA was not used to test treatment effects since surveys produced an observational data set, and because data were not randomly collected. Because the response variable was a count, a square-root transformation was conducted of the data. All factors were crossed when searching for an appropriate model, and a quadratic term was considered for each of the continuous factors. A process of backward elimination was used in model selection. The derived model was as follows:

$$Z_{ijkl} - u = L_i + Y_j + W_k + LYi_j + YW_{jk} + LYW_{ijk} + Tb + S_{ijkl}$$

where u is an overall mean effect, and
Z_{ijkl} is the square root of the count data,
L_i is the effect due to location i,
Y_j is the effect of year,
W_k is the effect due to water level k,
LY_{ij} is an interaction effect for location i and year j,
YW_{jk} is an interaction effect for year j and water level k,
LYW_{ijk} is an interaction effect for location, year, and water level,
T is the time since 1 July for any year,
b is a regression parameter,
S_{ijkl} is a residual random error term for the ith observation at each level of L, Y, and W.

The validity of the model was checked in several ways, including examination of a stem and leaf plot, a Shapiro-Wilks test for normality, comparisons of standard deviations on observations for each combination of L, Y, and W (n = 5), and examination of correlation of residuals.

RESULTS

Aerial Surveys

Beluga Whales

In 1990, surveys were flown on 12 consecutive days from 3 July through 14 July. Belugas were seen during every flight with numbers ranging from 31 to 1,200 (Table 2, Appendix A). Most of the numbers in Table 2 are based on multiple counts by observers. Several passes were usually made parallel to each group of whales, and counts were made by both left and right observers. Agreement between observers was very good; for example, on 3 July counts were 1,109 and 1,120, and on 4 July they were 1,102 and 1,100. Photographs were taken on some days for comparison with observer counts. The maximum number of belugas counted from photographs was 1,102 on 5 July. Counts from photographs were usually lower than those by observers. This is due in large part to the fact that photographs present an instantaneous view whereas observers may have an area in view for 5-10 seconds. An observer is therefore more likely to count whales that are diving and resurfacing. As an example, the visual count on 5 July was 1,200, which compares to counts from slides taken on three separate photographic passes of 683, 861, and 1,102.

The largest sightings during the survey were on 3-6 July, when a single large group of 800-1,200 was seen at the south end of the study area, off Omalik Lagoon (Fig. 2). During this period only one other small group of 12 belugas was seen about 23 km west of Point Lay. On 7 July the group of whales near shore 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 about 180. 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 (Table 2, Fig. 2). On 12-14 July, the only belugas seen were north of Point Lay; none were seen off the southern portion of Kasegaluk Lagoon, or in the region along the coast south to the Pitmegea River.

Table 2. Numbers of beluga whales seen on aerial surveys in the Kasegaluk Lagoon region, July 3-14, 1990. All locations were surveyed on each flight unless indicated by ns (not surveyed). Locations are shown in Figure 2 and Appendix A.

Location	July											
	3	4	5	6	7	8	9	10	11	12	13	14
Cape Sabine	0	0	0	0	0	0	0	44	0	ns	0	0
Cape Beaufort, N. of	0	0	0	0	0	0	31	0	180	0	0	0
Omalik Lagoon	1120	1140	1200	830	111	14	0	149	0	0	0	0
Naokok Pass	0	0	0	0	70	81	0	0	0	0	0	0
Kukpowruk Pass	0	0	0	0	0	77	0	0	0	0	0	0
Point Lay Pass	0	0	0	0	0	0	0	0	0	0	0	0
Akunik Pass	0	0	0	0	0	0	0	0	0	0	2	161
Akunik Pass, N. of	0	0	0	0	0	0	0	0	0	100	0	0
Utukok Pass	0	0	0	0	0	0	0	0	0	0	185	0
Twin Pass	0	0	0	0	0	0	0	0	0	0	0	0
Icy Cape Pass	0	0	0	0	0	0	0	0	0	0	0	0
Akoliakatat Pass	0	0	0	ns	0	0	0	0	0	0	0	0
Nokotlek Pass	0	0	0	ns	0	0	0	0	0	0	0	0
Pingororak Pass	0	0	0	ns	0	0	0	0	0	0	0	0
Offshore transects	ns	0	12	0	ns	13	0	19	62	0	23	ns
TOTAL	1120	1140	1212	830	181	185	31	212	242	100	210	161

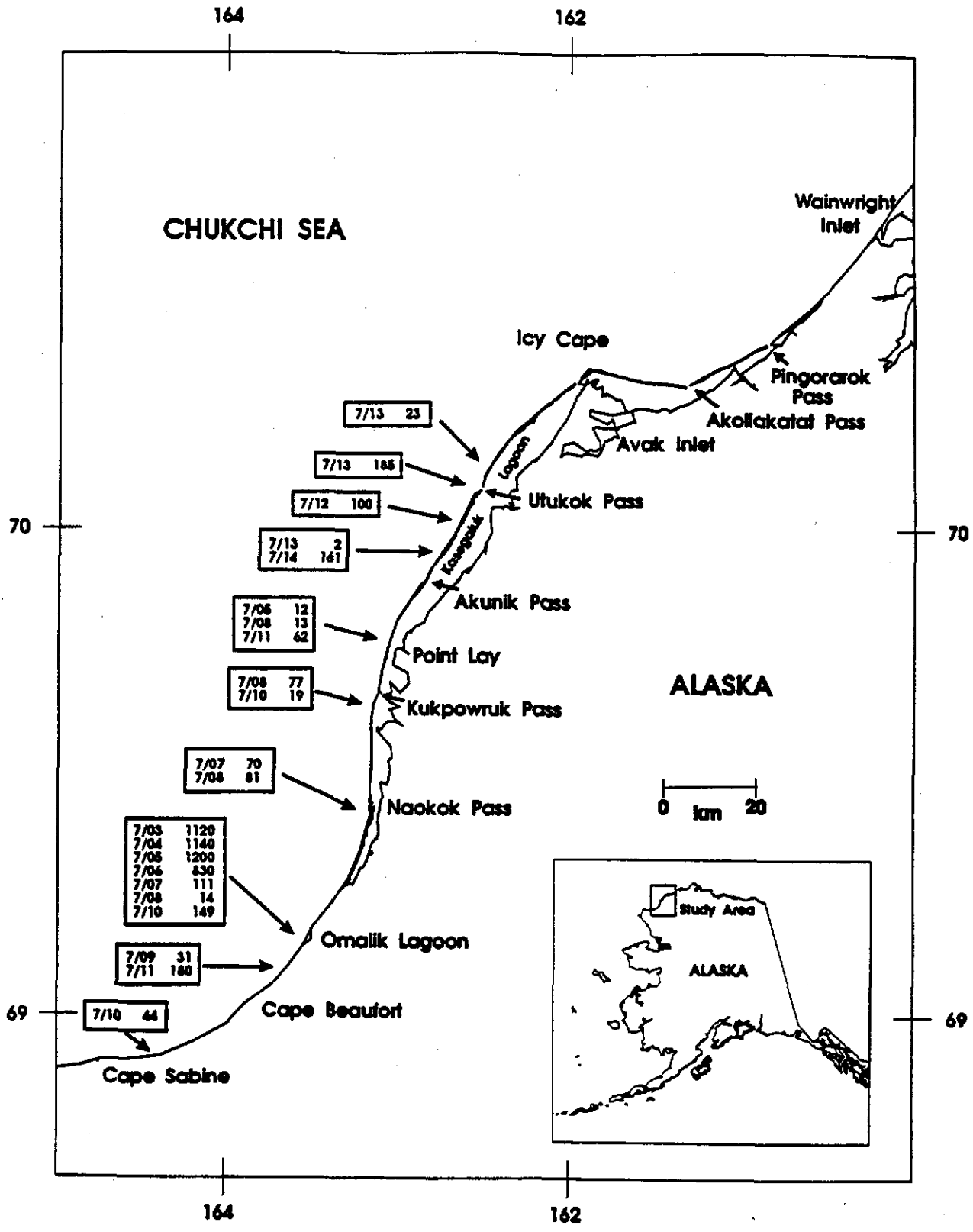

Figure 2. Dates and locations of beluga whale sightings made during aerial surveys of the Kasegaluk Lagoon region, July 3-14, 1990.

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 (Table 2). On 10 July we saw a group of 19 belugas on the transect off shore 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 off shore, but we did not locate any more belugas.

No surveys were flown from 15-25 July. Periodic spotted seal surveys commenced on July 26 and the lagoon and passes were searched for belugas, but none were seen on any of the flights.

In 1991, surveys were flown on 12 days during the period 4-16 July. Belugas were seen during every flight with numbers ranging from 7 to 938 (Table 3, Appendix B). As in 1990, most counts were based on multiple passes over the same groups of belugas and agreement between observers was good. Photographs were taken on four days for comparison with observer counts. The maximum number of belugas counted from photographs was 783, but field notes indicated that not all of the belugas counted visually were included in photographs. Counts from photographs were usually lower than those by observers, for reasons explained above.

When our surveys began on 4 July, belugas had already arrived along the coast. Over 400 were present near Omalik Lagoon and there were two other groups of 30-60 near passes to the north. From 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 (Fig. 3). 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 group of whales near Naokok Pass was gone and we sighted only 36 belugas along the entire coast and offshore survey route. A few belugas were seen south of Point Lay on 12 July; none were seen after that. 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 (Table 3).

On 13 and 15 July, when no belugas were seen near the coast, many were located along the ice edge northwest of Icy Cape. Over 200 were counted there on the 13th, and over 500 on the 15th. Belugas were also sighted in the ice there on the 16th, but were not surveyed by us. Prior to 13 July, belugas had been seen on offshore transects on only two days.

Table 3. Numbers of beluga whales seen on aerial surveys in the Kasegaluk Lagoon region, July 4-16, 1991. All locations were surveyed on each flight unless indicated by ns (not surveyed). Locations are shown in Figure 3 and Appendix B.

Location	July											
	4	5	6	7	8	9	11	12	13	14	15	16
Cape Sabine	0	0	0	0	0	0	0	0	0	0	0	0
Cape Beaufort	0	0	0	0	0	22	0	0	0	0	0	0
Omalik Lagoon	441	95	1	0	0	0	0	0	0	0	0	0
Naokok Pass	63	732	937	770	605	390	13	0	0	0	0	0
Kukpowruk Pass	0	0	0	0	0	0	10	6	0	0	0	0
Point Lay Pass	0	0	0	0	0	0	5	0	0	0	0	0
Akunik Pass	0	17	0	0	0	0	0	97	0	0	0	0
Utukok Pass	0	0	0	0	12	0	0	0	0	660	0	0
Twin Pass	31	0	0	0	0	0	0	0	0	1	0	0
Icy Cape Pass	0	0	0	0	0	0	0	0	0	0	0	7
Akoliakatat Pass	0	1	0	0	94	61	17	61	0	0	0	0
Nokotlek Pass	0	0	0	0	0	0	0	0	0	0	0	0
Pingororak Pass	0	0	0	0	0	0	0	0	0	0	0	0
Offshore transects	ns	51	0	0	0	0	0	1	237	21	516	ns
TOTAL	535	896	938	770	711	473	45	165	237	682	516	7

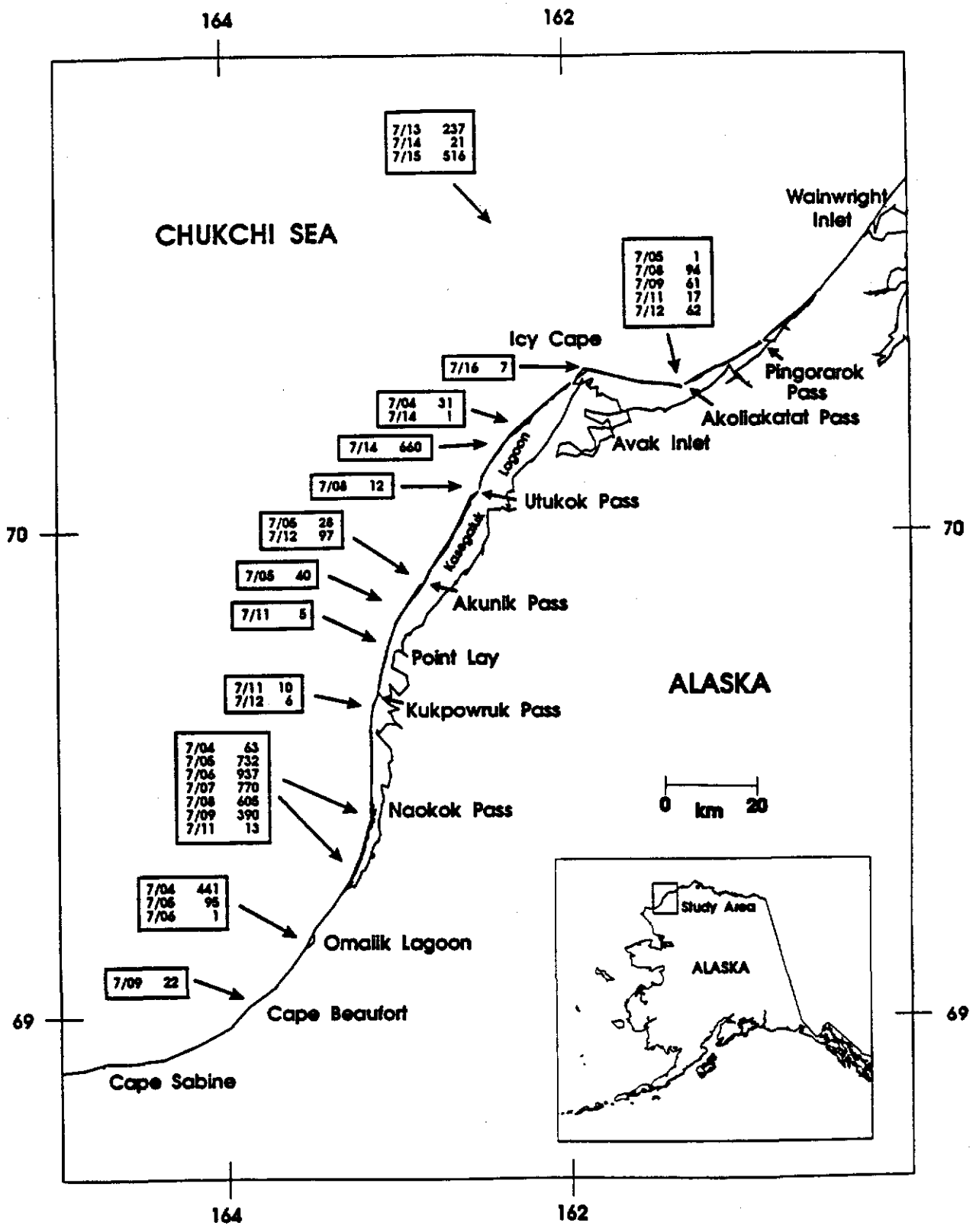

Figure 3. Dates and locations of beluga whales sightings made during aerial surveys of the Kasegaluk Lagoon region, July 4-16, 1991.

No surveys were flown from 17 to 28 July. Spotted seal surveys were conducted on 29 July 29 to 2 August, during which the lagoon and passes were searched for belugas. None were seen on any of the seal survey flights.

Spotted Seals

Surveys for spotted seals were flown between Naokok Pass at the south end of Kasegaluk Lagoon and Pingorarok Pass at the northeast end. In 1989 survey periods were 23 to 28 August and 11 to 14 September (Table 4). In 1990 surveys were conducted during 26 to 28 July, 11 to 13 August, 21 to 26 August, and 8 to 12 September (Table 5). In 1991, surveys were spaced farther apart and extended later into the fall; they were conducted during 29 July to 2 August, 18 to 22 August, 25 to 29 September, 21 to 25 October, and 6 November (Table 6). Additional information was collected during beluga whale and bird surveys (see Part II of this volume).

Hauled out spotted seals were very responsive 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 that were 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 cloud conditions allowed flying at a 914 m altitude, the seals usually remained on the haulout and it was possible to circle them for counting and photographing.

In 1989 surveys began part way 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 during 13 and 14 July, especially north and east of Icy Cape. There were no spotted seals hauled out at any of the lagoon passes, but groups of up to 20 seals were commonly seen in the water, especially on offshore transects. When spotted seal surveys were flown during 26 July, there were seals hauled out in the lagoon. In 1991, the ice broke up and moved off shore earlier than it did in 1990. No spotted seals were seen during 4- to 11 July. On 12 July the first seals were seen hauled out at Utukok and Akoliakatat passes. No seals were seen hauled out at Utukok on 13 to 16 July. However, they were seen at Akoliakatat on 15 and 16 July.

Table 4. Numbers of spotted seals at haulouts in the Kasegaluk Lagoon study area during August-September 1989. All locations were surveyed on each flight unless indicated by ns (not surveyed). Repeat counts made on the same date are indicated by letters. Locations are shown in Figures 4-6. Relative level of water in the lagoon is indicated as: H = high, M = medium, L = low.

Date	Water level	Utukok	Akoliakatat			Avak Inlet				Total
			West	Pass	East	#1	#2	#3	#4	
Aug 23	H	50-100	0	0	0	150	70	8	0	278-328
Aug 24	H	80	75	38	1	ns	ns	ns	ns	--
Aug 26a	M	±175	90	6	>250	0	30	500	0	>1051
Aug 26b	M	75	40	0	700	ns	ns	ns	ns	--
Aug 27a	H	120	0	25	10	0	0	1	0	156
Aug 27b	H	145	75	50	10	0	5	0	0	285
Aug 28	M	290	10	0	1	0	2	20	0	323
Sep 1	L	845-895	>350	0	550	0	15	20	0	>1780-1830
Sep 3	L	305	0	0	117	ns	ns	ns	ns	--
Sep 8	H	300	0	0	0	0	0	55	100	455
Sep 11	H	600-700	25	2	18	6	28	190	35	904-1004
Sep 13	H	500-600	0	0	2	0	75	85	30	692-792
Sep 14	H	700-750	35	0	3	0	120	>250	0	>1108-1158

Table 5. Numbers of spotted seals at haulouts in the Kasegaluk Lagoon study area during July-September 1990. All locations were surveyed on each flight unless indicated by ns (not surveyed). Repeat counts made on the same date are indicated by letters. Locations are shown in Figures 4-6. Water levels are indicate as in Table 4.

Date	Water level	Utukok	Akoliakatat			Avak Inlet				Total
			West	Pass	East	#1	#2	#3	#4	
Jul 26	L	330-430	20	0	0	0	>140	±30	0	>520-620
Jul 27	L	380-600	45	0	0	0	60	50	0	535-755
Jul 28	L	±1800	45	0	0	0	230-250[1]	15	0	2090-2110
Aug 11a	H	±100	0	0	0	0	15-25	0	0	115-125
Aug 11b		>8	>215	33	0	0	ns	ns	ns	--
Aug 12	H	10	150	0	26	0	ns	ns	ns	--
Aug 13	H	0	85-90	0	0	0	40-45	60-80	8-10	193-225
Aug 21	H	280-350	450-600	35-45	23-28	0	90-120	65-80	0	943-1223
Aug 22a	H	0	300-350	30-35	0	0	ns	ns	ns	--
Aug 22b		0	325	125	0	0	ns	ns	ns	--
Aug 23a	M	>110	343	±550	68	0	15	420	0	>1506
Aug 23b		15	250	550	0	0	ns	ns	ns	--
Aug 23c		60	>130	400	6	0	ns	ns	ns	--
Aug 24	H	20-30	>15	>560	0	0	0	±340	2	>937-947
Aug 25		5	±315	±740	0	0	0	532	0	1592
Aug 26	H	20-30	>80	>200	0	>20	15-20	>200	0	550
Sep 7	H	±6	0	850-900	0	0	100	>50	0	>1006-1056
Sep 8a	H	>10	>5	900-1000	0	0	±50	100-150	0	>1065-1215
Sep 8b		0	0	850-900	0	0	ns	ns	ns	--
Sep 8c		15-20	0	750-850	0	0	ns	ns	ns	--
Sep 9		6	190	±1301	0	0	0	>285	0	1782
Sep 10a	H	150-275	250-325	450-600	0	0	ns	ns	ns	--
Sep 10b		550-675	300-350	300-400	0	ns	ns	ns	ns	--
Sep 10c		175-200	650-700	0	0	ns	ns	ns	ns	--
Sep 10d		0	>170	>100	0	0	1	>175	0	>446
Sep 11a	H	0	>20	700-800	0	0	10	150-200	0	>880-1030
Sep 11b		25	5	550-600	0	0	12	75	0	667-717

[1] 150 of these were hauled out on a shoal near Avak #2 that was usually submerged.

Table 6. Numbers of spotted seals at haulouts in the Kasegaluk Lagoon study area during July-November 1991. All locations were surveyed on each flight unless indicated by ns (not surveyed). Repeat counts made on the same date are indicated by letters. Locations are shown in Figures 4-6. Water levels are indicated as in Table 4.

Date	Water level	Utukok	Akoliakatat			Avak Inlet				Total
			West	Pass	East	#1	#2	#3	#4	
July 11	L	0	0	0	0	0	0	0	0	0
July 12	L	25	±30	0	0	0	0	0	0	55
July 15	H	0	40	0	0	0	0	0	0	40
July 16	H	0	104	0	0	ns	ns	ns	ns	--
July 29	H	300-350	400	550	0	0	0	>200	0	>1450-1500
July 30a	H	50	850	255	0	0	0	10	0	1165
July 30b		>35	500	0	0	0	0	0	0	>535
July 31		0	800-925	0	0	0	1	20-30	0	821-956
Aug 1a	L	600-700	850-900	85	55	0	0	5	0	1595-1745
Aug 1b		0	0	0	0	0	0	0	0	0
Aug 2	M	>150	60-70	5	0	ns	0	0	0	>215-225
Aug 18	M	225	0	200	0	0	0	0	0	425
Aug 19	H	500-550	0	350-400	0	0	3	0	0	853-953
Aug 20a	H	0	370	0	550	0	0	100-125	0	1020-1045
Aug 20b		50	525	0	600	0	10	50	0	1235
Aug 21a	H	0	50	0	75	0	2	30	0	157
Aug 21b		0	70	0	40	ns	ns	ns	ns	--
Aug 22	H	0	25	0	0	0	0	175	0	200
Sep 25	M	>750	80-100	0	600-700	0	3	0	0	>1433-1553
Sep 27	L	>400	>50	0	>70	0	>150[1]	0	0	>670
Sep 29	L	±1185	±200	0	700-800	0	52	0	0	2137-2237
Oct 23	Frozen	0	0	0	0	0[2]	0[2]	0[2]	0[2]	0
Oct 24	Frozen	65	0	100	0	ns[2]	ns[2]	ns[2]	ns[2]	165
Nov 6	Frozen	2	0	0	0	ns[2]	ns[2]	ns[2]	ns[2]	2

[1] All except 6 of these were hauled out on a shoal near Avak #2 that was usually submerged.

[2] Avak Inlet was frozen during these surveys.

No seals were observed hauled out at the passes south of Point Lay during July-September 1989-1991, although single seals were occasionally seen in the water. No seals were seen hauled out at three of the four passes between Point Lay and Icy Cape: Akunik, Twin, and Icy Cape passes. The fourth, Utukok Pass, was used by a large number of seals in all three years. The seals used several haulout locations (Fig. 4). When the water level was low, a large shoal was exposed off the east end of the north side of the Pass. The largest number of seals was always on that shoal when it was exposed. Smaller groups of seals sometimes hauled out near the end of the barrier island forming the north side of the Pass.

In August 1989, the number of seals seen at Utukok Pass ranged from 50-100 to 290. From 1 to 14 September, the number ranged from 300 to 845-895. A report from a local resident indicated that over 400 seals were hauled out at Utukok Pass in early October (A. Agnasagga, personal communication).

In 1990, the maximum number of seals seen at Utukok Pass was approximately 1,800 on 28 July. In August numbers were usually less than 100; the maximum count was 280-350 on 21 August. In September the highest count was 550-675 on 10 September. Counts on the other four early September surveys were 0-25.

In July 1991, the highest count at Utukok Pass was 300-350 on 29 July; most counts were less than 50. In August 1991, a maximum of 600-700 was counted. On some days no seals were present and on others 50-550 were counted. On 29 September approximately 1,185 seals were hauled out on the bars and spit at Utukok.

Of the three passes northeast of Icy Cape, seals hauled out only at Akoliakatat Pass. Long, narrow spits extend into the lagoon to the east and west of Akoliakatat Pass (Fig. 5). These spits, and the spit extending off the west end of the Pass itself, were all used in 1989-1991. In 1989, the largest sightings were on the spit east of Akoliakatat Pass: 700 on 26 August and 550 on 1 September. The highest combined totals for all three Akoliakatat sites in 1989 were 740 on 26 August and 900 on 1 September.

During the earliest surveys in July 1990, very few (less than 50) seals were counted at Akoliakatat. Numbers increased in August and by the week of 21 to 26 August there were usually more than 500 seals on the three sites combined. Numbers remained high in September with counts ranging from 600-1,490. In 1990 the largest number of seals was almost always hauled out at

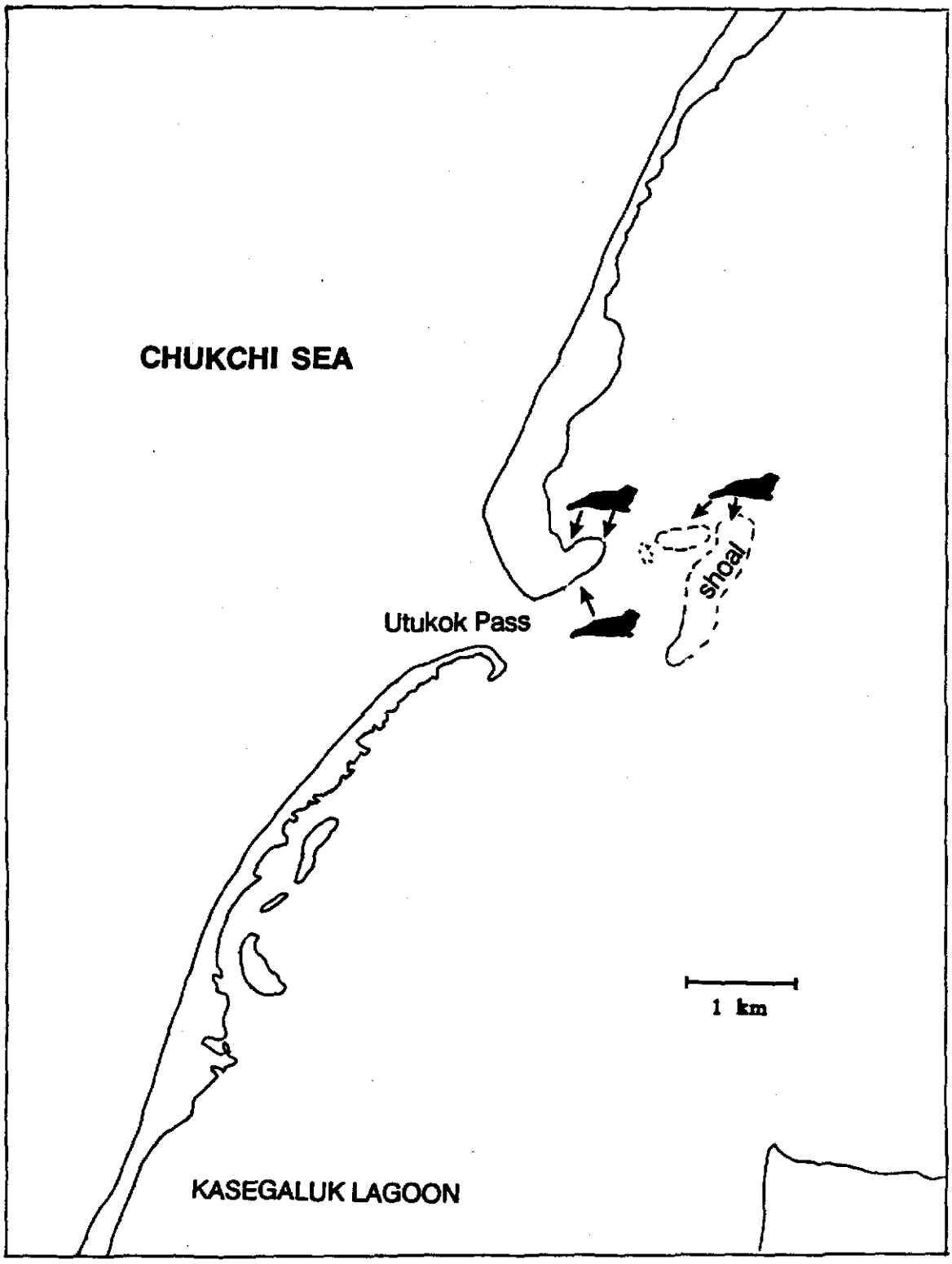

Figure 4. Map showing specific locations used as haulouts by spotted seals at Utukok Pass in Kasegaluk Lagoon.

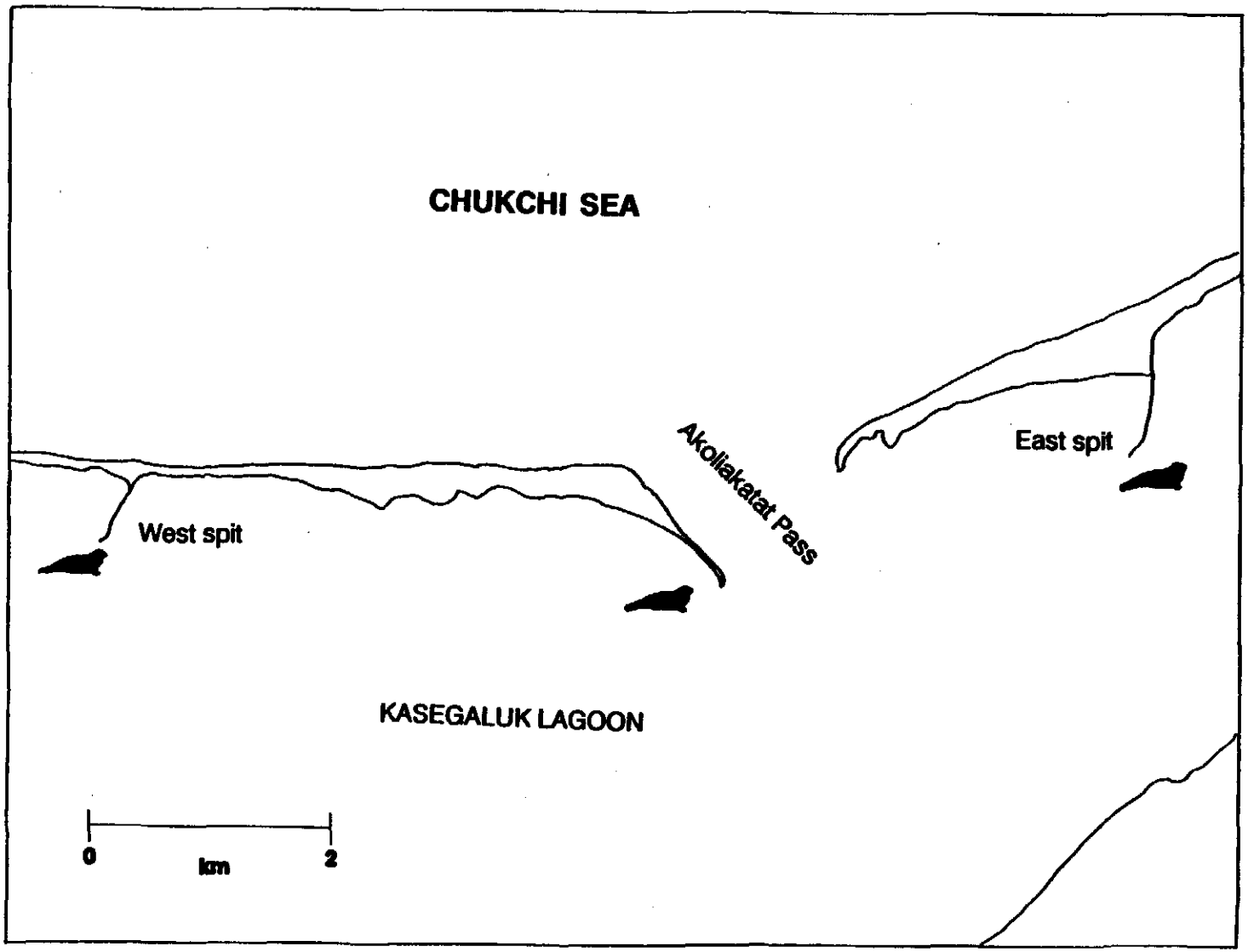

Figure 5. Map showing specific locations used as haulouts by spotted seals at Akoliakatat Pass in Kasegaluk Lagoon.

the spit west of Akoliakatat or at the pass itself. Seals were seen hauled out at the east spit on only three days in 1990.

During mid-July 1991 surveys, when seals had just arrived, 100 or less were counted and all were on the western spit. In late July, there were usually 800-1,100 seals on the three locations combined. During August surveys, counts ranged from 25-1,125 with wide variation from day to day. The maximum count in late September was 900-1,000. By late October, only 100 seals were counted at Akoliakatat. As in 1990, the west spit was the most consistently used haulout. In July and early to mid-August, the pass was also used quite regularly. After 19 August, most seals were counted on the eastern spit.

Seals hauled out at five locations in Avak Inlet (Fig. 6). These locations were referred to as Avak #1-#4 and Avak shoal. Avak #1 and Avak #4 were seldom used. The primary haulout sites were Avak #2 and Avak #3. In 1989 up to 120 seals were seen at Avak #2, in 1990 up to 250 were counted, and in 1991 up to 45; usually there were less than 100 seals there. Avak #3 was the major haulout, with a maximum of 500 seals counted in 1989, 532 in 1990, and 200 in 1991. In 1990 more seals hauled out at Avak Inlet sites in late August (155-532) than in July (110-265) or September (150-210). In 1991, numbers were never as high as in 1989 or 1990, but were highest in late July (200) and again in late August (175). Seals were seen hauled out on an offshore shoal near Avak #2 on two days during the three summers of surveys. This shoal is exposed only at very low water, and seals used it on the only two days that it was visible.

In 1991, surveys were extended into early November 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. However, the lagoon and Avak Inlet were completely frozen and covered with recently formed 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. The entrances to all passes were ice-free, and there were small pools of open water immediately inside each entrance. New ice or slush ice was rafted up along the seaward shore of the barrier islands, and also along both sides of most passes. On 23 October, no seals were observed near any pass or in Avak Inlet. On 24 October, approximately 100 seals were hauled out on broken, snow-covered ice floes at

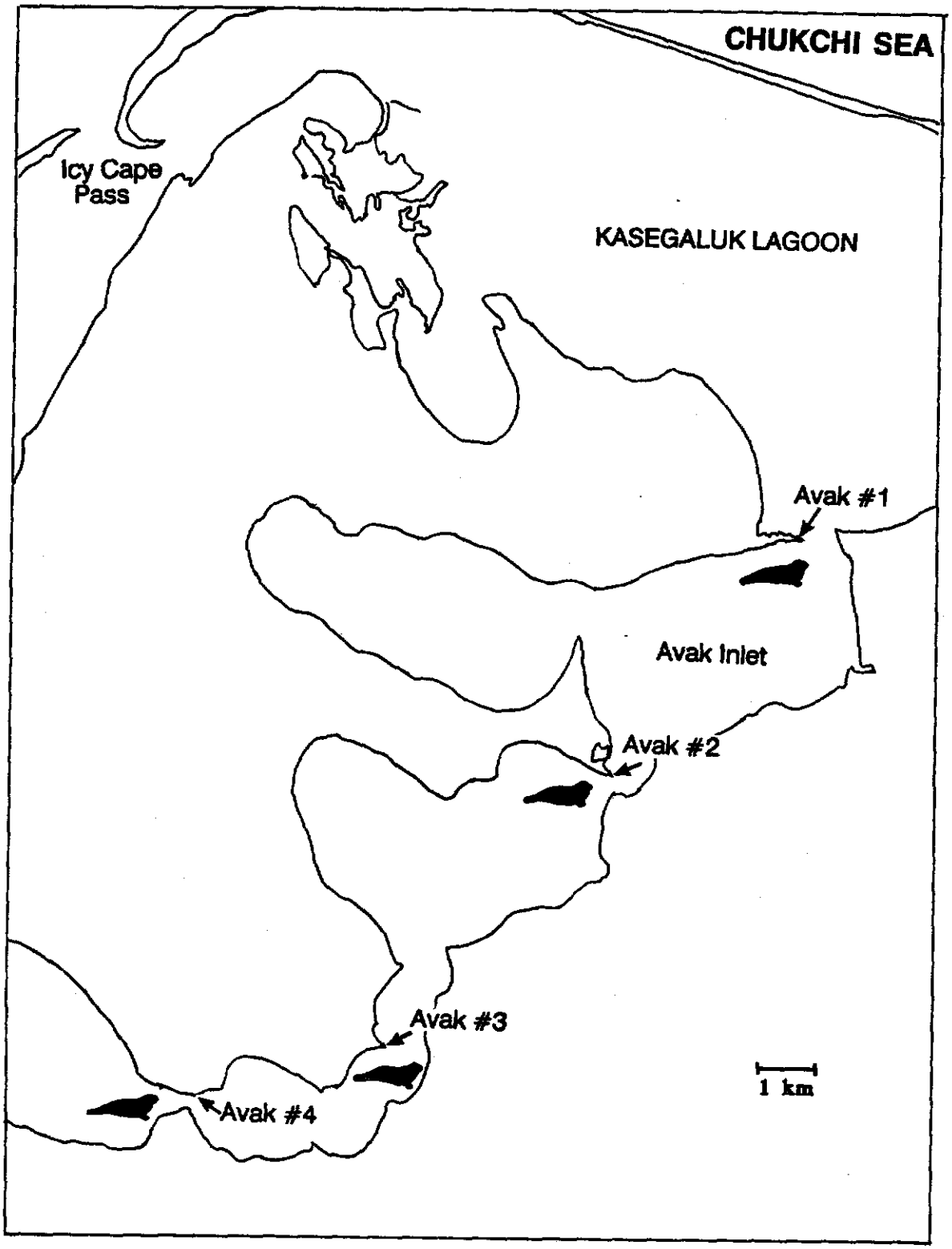

Figure 6. Map showing specific locations used as haulouts by spotted seals at Avak Inlet in Kasegaluk Lagoon.

the edge of the open water pool inside Akoliakatat Pass. Seals were in groups of 5-40 per floe. At Utukok Pass, about 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 November 6. Two 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.

Sightings of spotted seals were also recorded during low-altitude bird surveys by LGL. These data indicated that most seals in the water were seen near the major haulouts at Utukok and Akoliakatat passes and in the mid-lagoon areas either side of the passes (Figs. 7-9). Bird surveys did not include Avak Inlet where the other major seal haulouts were located. Several spotted seals were seen in the water near Akunik Pass each year, and in 1990 there were several sightings near Point Lay. Few seals were sighted near shore on the ocean side of the barrier islands and almost none along the mainland coast of the lagoon.

Harvest Studies

Harvest Levels and Characteristics

The beluga harvest in Point Lay usually occurs during early July. The hunt is a communal event, in which most of the local boats are used to drive (herd) belugas to a shallow water site near the village where they are killed. The animals are processed by members of the community working together, and then stored in family ice cellars or shared with friends and relatives in other communities.

Since 1977 the average annual harvest of belugas by Point Lay hunters has been 23-25, with a range of 0-64 (Table 7). The harvest has tended to increase as the village, which was reestablished in 1972, has grown. Average harvests were 10 for the period 1977-1980, 19-27 for 1981-1985, and 35 for 1986-1991. The largest harvest in the 14-year period for which we have data occurred in 1990.

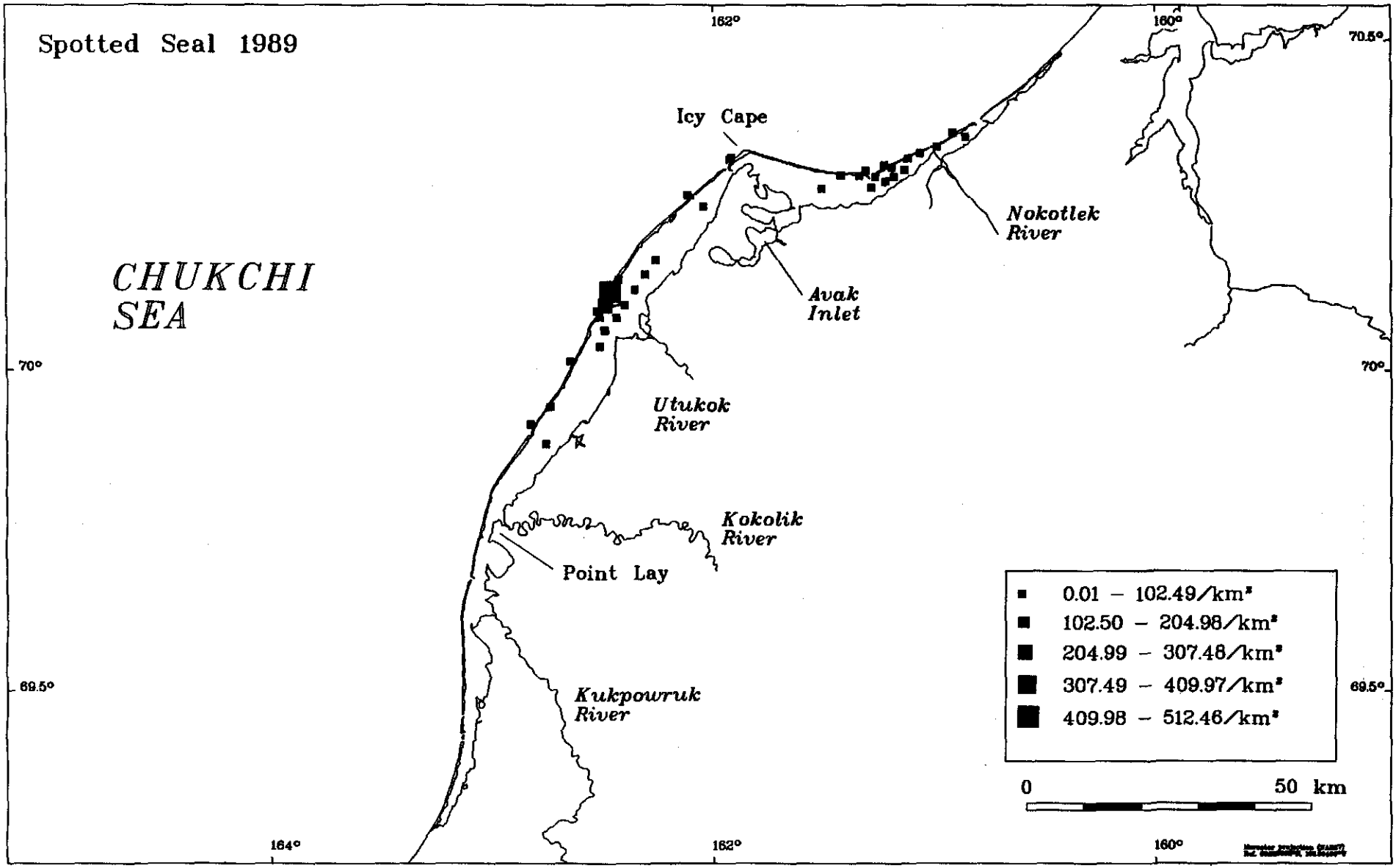

Figure 7. Summary of densities of spotted seals on 1-minute transect segments in the Kasegaluk Lagoon study area in 1989. Data are from marine bird surveys conducted by LGL.

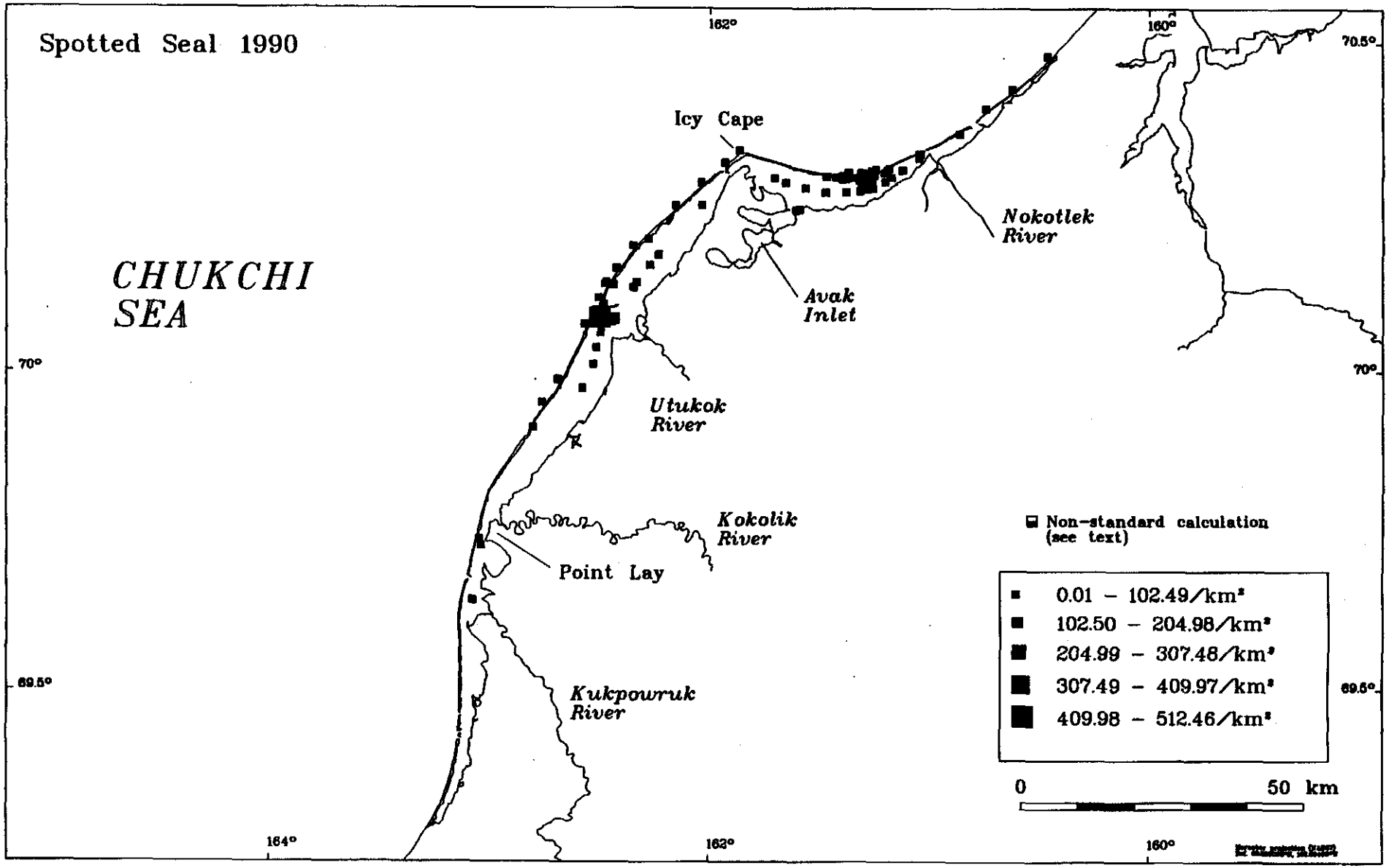

Figure 8. Summary of densities of spotted seals on 1-minute transect segments in the Kasegaluk Lagoon study area in 1990. Data are from marine bird surveys conducted by LGL.

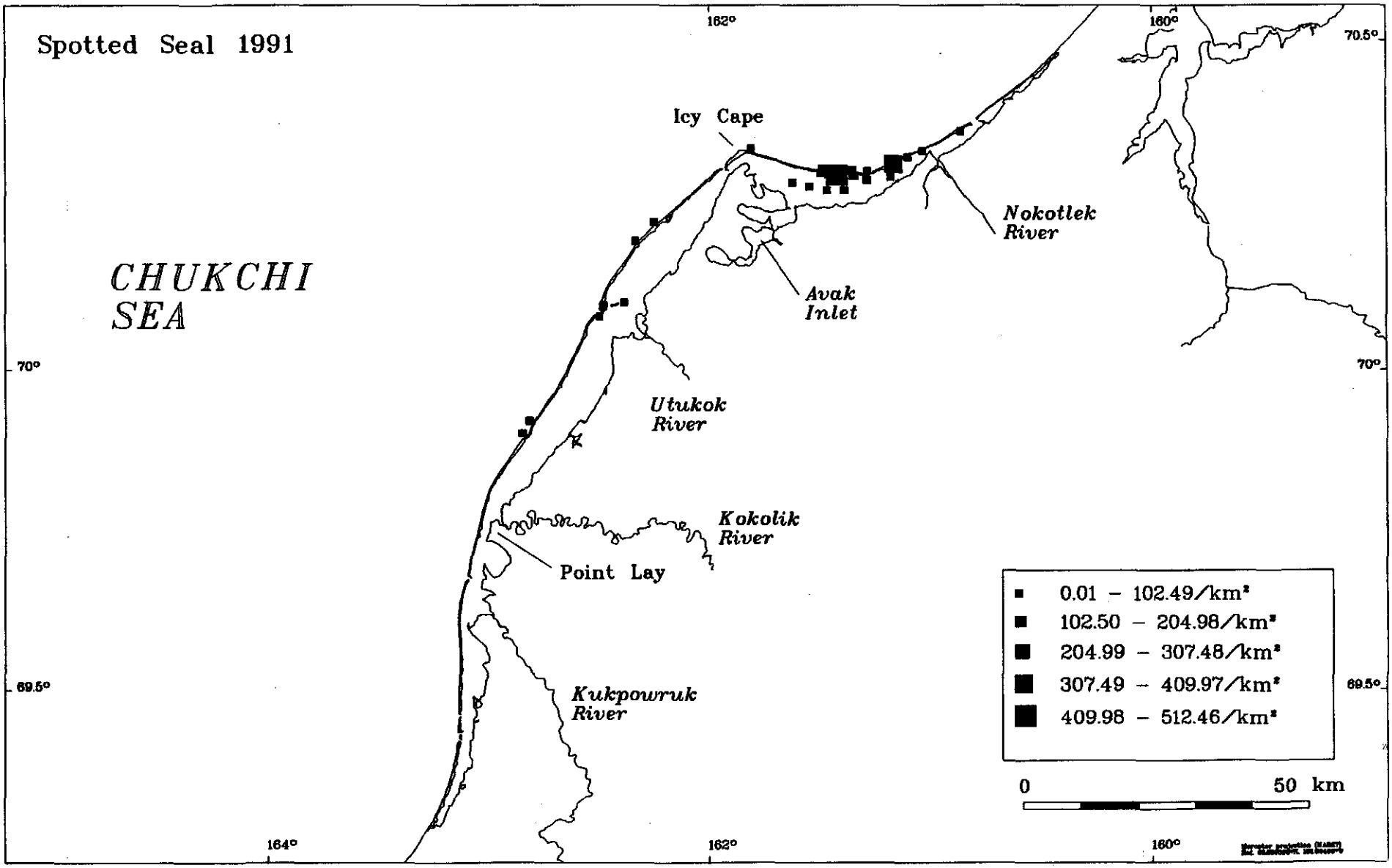

Figure 9. Summary of densities of spotted seals on 1-minute transect segments in the Kasegaluk Lagoon study area in 1991. Data are from marine bird surveys conducted by LGL.

Table 7. Harvest of beluga whales at Point Lay, Alaska, 1977-1991. Total number is the recorded harvest. Numbers in parentheses are estimated total harvest, not including animals that may have been struck and lost. Data are from Seaman and Burns (1981), Burns and Seaman (1986), Lowry et al. (1989), ADF&G (unpublished), and North Slope Borough Department of Wildlife Management (unpublished).

	Sex			
Year	Males	Females	Unknown	Total
1977	--	--	8	8
1978	8	4	1	13
1979	--	--	3	3
1980	--	--	15	15(15-18)
1981	--	--	29	29(29-38)
1982	--	--	28	28(28-33)
1983	8	10	0	18
1984	--	--	0	0(30)
1985	--	--	18	18
1986	--	--	33	33(34-37)
1987	13	6	3	22
1988	24	13	3	40
1989	3	13	0	16
1990	34	28	2	64
1991	11	24	0	35

Foods Eaten by Marine Mammals

During 1989 and 1990 we were able to examine the stomachs of three spotted seal that was shot by Point Lay hunters near Utukok Pass in early September. All three stomachs were empty. No other spotted seal stomachs were examined by us in the course of this study.

Since 1987, stomachs from belugas have been collected and examined by personnel from the North Slope Borough Department of Wildlife Management. Because the belugas are usually driven for several hours before they are killed and/or because they have not been feeding, the stomachs are often empty. This was true in 1987, and 1989-1991. In 1988 the drive was short, and 11 of 21 stomachs had measurable amounts of contents (Table 8). Ten stomachs contained remains of crangonid shrimps. Two genera were represented (*Argis* and *Sclerocrangon*) with volumes ranging from less than 1 ml to 750 ml. Echiuroid worms (*Echiurus echiurus*) were present in seven stomachs. In five stomachs only spines were present, while the other two had 185 ml and 300 ml of fecal castings. One stomach had a jaw from a polychaete worm, and another had remains of a sipunculid worm. All of these prey indicate that the belugas were feeding on the bottom.

Behavior of Spotted Seals

A field camp was established during 26 to 29 August 1990 to observe the hauling out behavior of spotted seals. We wanted to situate the camp at Utukok Pass, where large numbers of seals are usually hauled out and available for observation. However, although hundreds of seals were present in the water, none were hauled out on our arrival, and few had been seen hauled out during the preceding four days (Table 5). The water was rising and the weather poor, and there was no suitable place to camp near the Utukok Pass haulout. Instead, camp was established on the mainland about 9 km south of Icy Cape. Observers had to hike about 9 km over land to Avak Inlet to get to a location where seals hauled out. Observations were made on 26 August. That evening and the following day, 70-90 km/hr winds precluded further observations. On 28 August the weather improved enough to allow another trip over land to Avak Inlet. On 29 August we returned to Point Lay,

Table 8. Stomach contents of beluga whales harvested near Point Lay, Alaska, July 1988. Values given are volumes in milliliters; P indicates that the item was present but no volume could be determined. Samples were collected by the North Slope Borough Department of Wildlife Management with the cooperation of Point Lay hunters, and analyzed by ADF&G.

Prey Species	Specimen Number										
	6	7	9	14	15	18	20	23	25	28	29
Family Crangonidae	750	--	--	--	--	--	--	--	P	70	26
Argis sp.	--	--	5	12	P	P	200	10	--	--	P
Sclerocrangon sp.	--	--	--	25	--	P	--	--	--	--	P
Echiurus echiurus	P	--	--	185	P	P	P	300	--	--	P
Family Sipunculidae	--	--	--	--	--	--	--	--	--	5	--
Family Polychaeta	--	P	--	--	--	--	--	--	--	--	--
Total Volume	750	<1	5	232	120	215	200	310	<1	75	26

on the advice of our local guide and boat operator. Our return was followed by another extended period of stormy weather.

On 26 August no seals were hauled out on the Avak Inlet spits, and only a few were seen in the water. On 28 August seals were observed at Avak #3 and Avak #4. Those at Avak #4 were all in the water, oriented into the current which was headed out the inlet, and possibly feeding. At Avak #3, 430 seals were hauled out in three groups on the sand spit when investigators first arrived at noon. At least 100 more were seen in the water. There was considerable exchange between the water and land, with some seals going into the water as others hauled out. Approximately one hour after observations began, a local air carrier flew overhead in a Cessna 206 at about 150 m altitude. When the aircraft was about 1.6 km away, seals began going into the water and continued to do so until none remained hauled out. They milled in the area for several minutes and then dispersed. For the remainder of the day (until 2000 hours) observers were never able to count more than 100-150 seals in the area and no more than 30-40 hauled out. At 1420 hours, about one hour after the aircraft disturbance, seals began to haul out again. At 1445 hours a plane flew over in the clouds, audible but not visible, and seven of the eight seals that had hauled out returned to the water. From then until 1800 hours, 12-31 seals were hauled out on the spit. At 1850 hours a Twin Otter flew by 2-3 km to the east at about 1,500 m altitude, and 14 of 31 hauled out seals went into the water. One hour later, when observations were terminated, there were 37 seals hauled out.

On the return trip to Point Lay, Utukok Pass was again investigated as a possible site for a future seal observation camp. It was apparent that there was no safe place to camp that had a suitable view of the seal haulout. Avak Inlet provided a much better place to observe seals: the vantage point was higher and afforded a better view; observers could approach closer to the haulout; and the area is more protected from storms. However, access to Avak Inlet by boat is not practical due to unpredictable weather, shallow water, and distance from Point Lay.

Observations were made of the response of seals to the survey aircraft during most aerial survey flights (Table 9). Seals were extremely wary, often moving off the haulout into the water when the plane was 2 km away. During 1989 we began flying at 150-305 m, which is the usual range of altitudes used for seal surveys. It was immediately apparent that spotted seals

Table 9. Responses of spotted seals to aircraft flying at various altitudes near Kasegaluk Lagoon. Unless noted otherwise, the aircraft was a Cessna 206 on floats.

Date	Location	Altitude (m)	Number of Seals	Comments
8/23/89	Avak #1	60	100-150	All went into water when plane >1 km away
	Avak #2	90	75	Went into water as plane approached
	Utukok	150	50-100	Into water when 1 km away
8/26/89	Akol. W	305	90	About 50% went into water when circled
	Utukok	305	100+	Some into water when circled
	Avak #3	365	500+	About 50% went into water when 1 km away
8/27/89	Utukok	365	120+	Into water at >1 km away
8/28/89	Utukok	610	150+	Into water at >1 km away; by 1 hour later all had hauled out again; into water again at 1 km away
7/26/90	Utukok	305	300+	Into water at about 2 km away; all hauled out again 1 hour later
	Avak #2	762	140+	Little response
	Avak #3	762	30+	Some went into water when circled
7/27/90	Utukok	914	380	Stayed hauled out as plane circled down; all went into water at 210 m
	Avak #2	427	60	No reaction; clouds below plane
	Avak #3	305	50	All went into water
8/23/90	Utukok	610	100+	Some went into water
	Akol. W	914	300+	No response; plane circled down to 457 m and all went into water
	Akol. Pass	914	550	Some went into water when circled
	Akol. E	914	68	No response
	Avak #3	914	420	Some went into water at >1 km
8/24/90	Avak #3	914	340+	Stayed hauled out until plane descended to 457 m
8/25/90	Akol. W	914	300+	Most went into water at >1 km; almost all hauled out again within 15 min.
	Akol. Pass	914	700+	No response

Table 9. Continued.

Date	Location	Altitude (m)	Number of seals	Comments
8/26/90	Avak #3	914	>100	All into water at 2 km
8/28/90	Avak #3	150	430+	Cessna 206 on wheels; seals began going into the water at 1.6 km away
	Avak #3	unknown	8	Plane above clouds, not visible; 7 seals went into water
	Avak #3	1500	30	Twin Otter passed 2-3 km away; 50% of seals went into water
9/8/90	Akol. Pass	914	900-1000	Some into water as plane approached
	Avak #3	762	35+	Some into water at 1 km
9/9/90	Akol. Pass	762	1300	Some into water as plane approached; after that little response until circled at 457 m
	Avak #3	457	285	Some into water at 1 km
9/10/90	Akol. Pass	365	100+	Into water as approached
	Avak #3	305	75+	Into water; low clouds
9/11/90	Akol. Pass	457	600-700	Into water as approached
	Avak #3	488	150-200	Plane approached over land; seals stayed on bar long enough to count
	Akol. Pass	396	500+	No response
	Avak #3	610	25	Some into water even though plane in clouds; after first group went in, others stayed out until plane at <183 m
7/12/91	Akol. Pass	305	30+	Aero Commander; all went into water at >1 km
7/29/91	Utukok	914	350-400	Aero Commander; about 50% went into water when circled
	Akol. W	914	400	50% into water when circled
	Akol. Pass	610	500+	No response
7/30/91	Akol. Pass	914	325	Aero Commander; no response
	Akol. W	914	500-700	About 30% went in water
	Utukok	914	50	75% went into water >1 km away on 1st survey; all into water at >2 km on 2nd survey

Table 9. Continued.

Date	Location	Altitude (m)	Number of seals	Comments
8/1/91	Akol. W	914	850-900	Aero Commander; 50% into water when circled
8/18/91	Utukok	914	200-250	Aero Commander; no response
	Akol. Pass	914	200-225	No response
8/19/91	Akol. Pass	122	350	Aero Commander; many into water on first pass
8/20/91	Akol. E	1219	550	Aero Commander; no response at 1200 m; seals started to go in at 1067 m; 50% in water at 914 m
	Akol. W	914	350	No response
	Avak #3	1067	100-125	60% into water at >1 km
8/21/91	Akol. E	914	75	Aero Commander; no response at 914; seals into water at 381 m on 2nd survey
	Akol. W.	914	50	No response; 2nd survey at 381 m also no response; windy
	Avak #3	518	30	No response; windy
8/22/91	Avak #3	122	175	Aero Commander; most went into water
9/25/91	Akol. E	229	600-700	Cessna 207 on wheels; 50% into water at >1 km
	Akol. W	229	80-100	>60% into water at 1 km
9/27/91	Utukok	122	400+	Cessna 207; all into water at 1 km
9/29/91	Akol. E	229	700-800	Cessna 207; Many into water as approached
	Utukok	914	1250-1400	No response; circled down to 488m; windy
10/23/91	Akol. Pass	213	100	Aero Commander; seals on ice; very few into water;
	Utukok	213	65	Seals on ice; about 30% into water w/ multiple circles

went into the water much more readily than other species of seals that we have surveyed. Survey altitude was gradually increased to 610 m with no abatement of response; seals still went into the water when the aircraft was 1-2 km away. In 1990 and 1991 we used a survey altitude of 914 m, and occasionally higher, whenever weather permitted. On some days haulouts could be approached at 914 m and then circled by the aircraft down to about 457 m without any apparent response by the seals. On other days seals went into the water when the aircraft was at 914 m and 2 km away. The same response occurred on several instances when the plane circled at 1,067 m. At approach altitudes below 500 m, we observed a response on all but three occasions. On one of those days there was a patchy cloud layer between the plane at 427 m and the seals and on another it was very windy. Responses were similar will all types of aircraft used.

The logistic regression model developed to predict the response of spotted seals to aircraft at different altitudes ($\ln(p/1-p) = b_0+b_1x$, see Methods) was plotted using parameters derived from response data presented in Table 9:

Parameter	Estimate	Std. error	Prob. $b_i=0$
B_0	-3.0658	-0.8864	0.0005
B_1	0.0031	0.0011	0.0049

The probability of no response (p) was plotted against aircraft altitude (x) to produce a nonlinear, sigmoidal curve (Fig. 10). Figure 10 shows a histogram of the empirical data, with each box indicating the proportion in each category with no response to the aircraft. It is clear from Figure 10, and by solving the logistic model for $p > 0.5$, that it is necessary to fly at altitudes greater than 986 m to have a greater than 50% chance of not disturbing a group of seals.

Seals were noticeably less responsive to aircraft noise when they were hauled out on ice than when they were hauled out on land. During October, survey altitude was 152-213 m. Most seals remained hauled out while the aircraft circled several times to count.

The model developed to examine the influences of water level, location, year, time of day, and time of year on the number of spotted seals hauled out (Fig. 11) was very complicated (see Methods), and probably of little

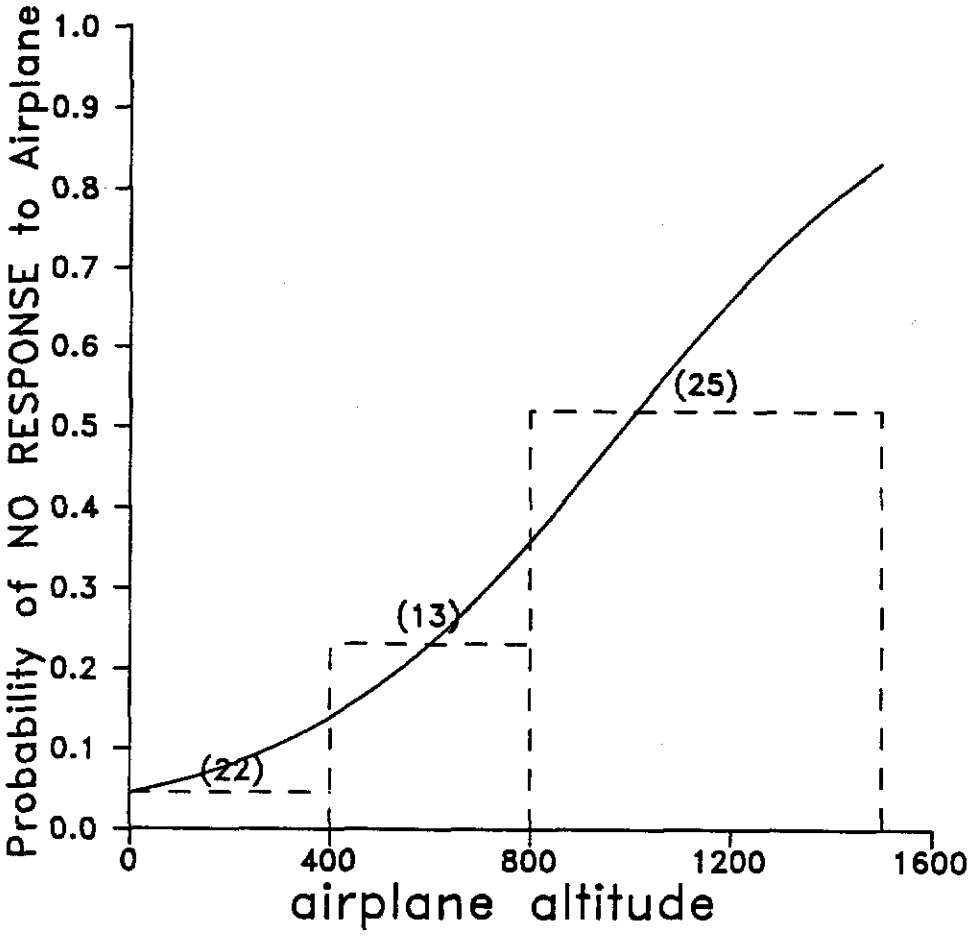

Figure 10. Probability of no response by spotted seals to aircraft overflight at different altitudes.

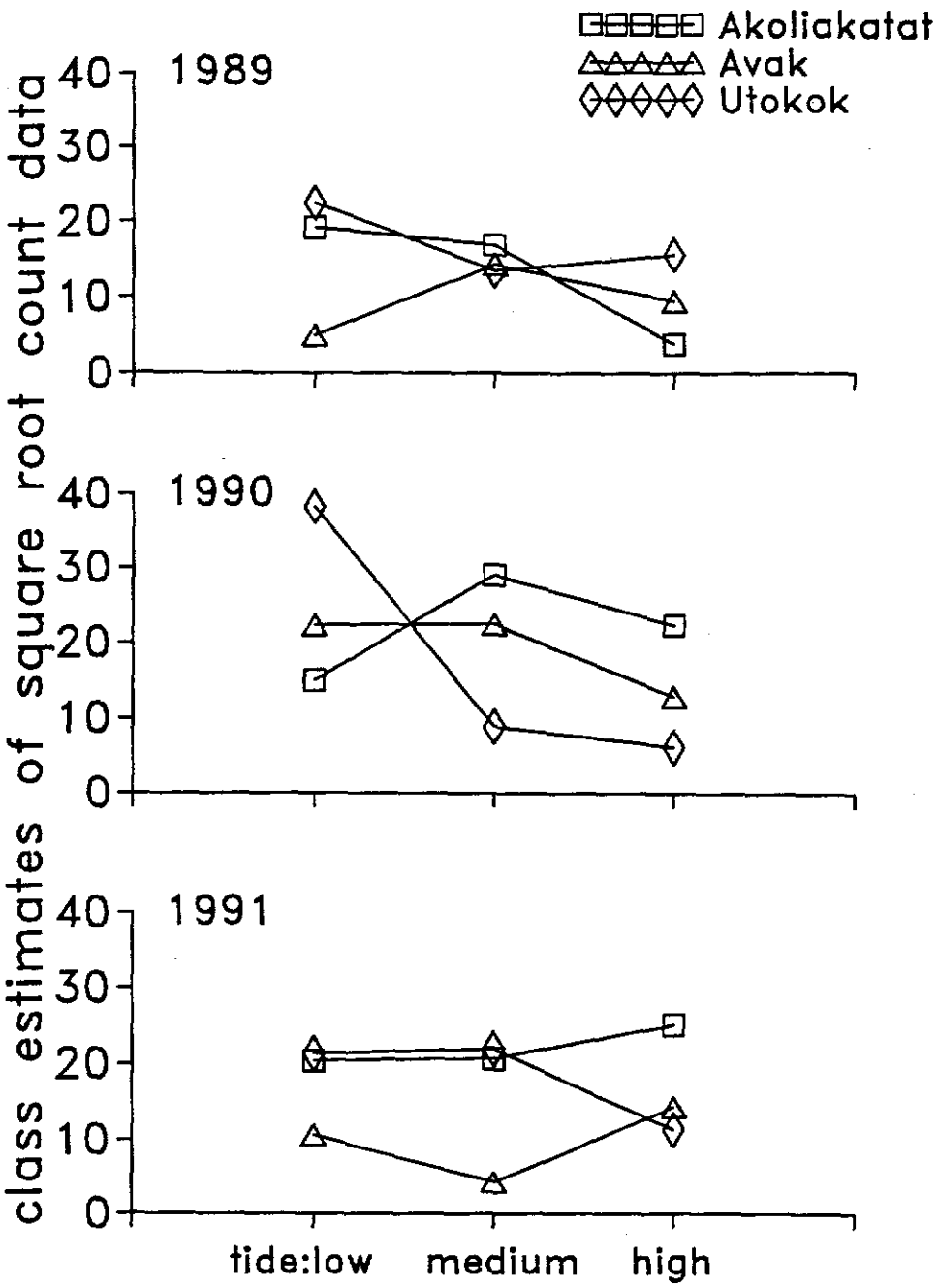

Figure 11. Variability in spotted seal count data according to water level, year, and location.

biological significance. There was some indication that residuals were not independent (particularly locations), and that assumptions of equal variances across classes were violated. The relationship of seal counts to variables, as measured by aerial surveys, was highly variable and not consistent (Fig. 11). This was not surprising since one of the key variables (water level) could not be adequately assessed from the air.

DISCUSSION

Beluga Whales

Period of Use

There is annual variability in the dates during which belugas use the Kasegaluk Lagoon area (Table 10). Since data from many years are based on observations by hunters rather than systematic surveys and are thus constrained by weather and hunting effort, it is likely that belugas arrive a few days earlier and remain longer than indicated by available reports. This is particularly true at the southern and northeastern extremes of the lagoon. Hunters do not often travel the 50-100 km to Cape Sabine or Omalik Lagoon to search for belugas, and these are areas where belugas usually arrive first. Similarly, after the beluga hunt is over most sightings are made during other activities or when belugas happen to swim by the village. Since Point Lay hunters seldom travel north and east of Icy Cape, there are few sightings from hunters that indicate how long belugas may remain at the northeastern end of the lagoon.

The earliest sighting we know of in the Kasegaluk Lagoon region was on June 22, 1979, when 100+ belugas were seen at Kukpowruk Pass. Late June sightings were also reported for 1958, 1987, 1988, and 1991 (Table 10). In eight other years, the earliest sightings were in the first week of July. Thus, there is about a two week window during which belugas make their first appearance in the Kasegaluk Lagoon region. The earliest sightings are always at or south of Point Lay, usually between Cape Sabine and Omalik Lagoon, although in 1979 the first sighting was at Kukpowruk Pass and in 1991 it was at Point Lay.

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. Belugas are sometimes sighted along the coast north of Kasegaluk Lagoon, near Wainwright, in mid- to late July. Reported sighting dates there range from 15 to 25 July. Belugas may be present somewhat later, but are not observed or reported. However, surveys in 1990 and 1991 suggest that few belugas remain near shore by late July. In 1990, 160 belugas were present at Utukok Pass on 14 July. Surveys were not flown from then until 26 July, when no belugas were seen anywhere along Kasegaluk Lagoon on

repeated daily surveys. In 1991, several hundred belugas were present in the ice north of Icy Cape on 16 July. None were seen there or along the lagoon on July 18 (HERS 1991), or during spotted seal surveys beginning on 29 July.

Our systematic surveys and compilation of sightings together indicate that belugas are usually present near Kasegaluk Lagoon (including the coast south to Cape Sabine) for approximately 2-4 weeks from late June until mid- or late July. The longest documented period was in 1979, when belugas were seen from 22 June through 19 July. Belugas usually appear first at the southern end of the lagoon; dates of first sightings are later at the passes north of Point Lay than to the south (Table 10).

There are references in the literature to August and September sightings of belugas near Wainwright (Nelson 1969; Fiscus et al. 1976). Belugas are most likely to be sighted near the northeastern Chukchi Sea coast in August and September in years when the pack ice does not move far off shore. Some sightings may represent belugas returning from summering areas farther to the east. There has been no systematic effort to determine where belugas go after they leave the Kasegaluk Lagoon region. In mid-summer 1991, belugas were observed in the pack ice 100-200 km northwest of Icy Cape (J. Burns, personal communication).

Abundance

Aerial surveys of this eastern Chukchi Sea beluga concentration have been conducted by ADF&G during six years: 1978, 1979, 1981, 1987, 1990, and 1991 (Table 11). Not all of these surveys covered the entire study area from Cape Sabine to the eastern end of Kasegaluk Lagoon, but they did include major passes and areas where belugas had been reported by local residents or pilots. Surveys were conducted on 1-12 days in each year. The maximum number of belugas counted during any one of the most recent surveys was 1,212 in 1990 and 938 in 1991. This compares to 879 in 1978 (703 counted on photographs plus an estimated 25% not photographed), 1,761 in 1979 (1,601 on photographs plus an estimated 10% not photographed), 670 in 1981, and 723 in 1987 (Table 11). HERS also conducted surveys of the southern lagoon in 1987 and 1991 and obtained similar maximum counts (Table 11).

Table 10. Sightings of beluga whales in the Kasegaluk Lagoon region, based on published and unpublished literature and surveys conducted during this project.

Location	Date	Number	Comments (Source)
Cape Lisburne, N of	10 Jun 81	15	moving NE, near ice (a)
Cape Sabine	24 Jun 58	50	Pitmegea R mouth (b)
	1 Jul 91	101	headed SW towards shore, no belugas seen on 6/25 & 6/28 surveys (d)
C. Sabine and N	3 Jul 82	2000-2500	spread along 20 miles of coast (a)
C. Sabine, 5 mi S	5 Jul 84	3	(e)
C. Sabine to Naokok P.	6 Jul 82	500-1000	close to shore (a)
C. Sabine	8 Jul 85	200	close to beach (e)
	8 Jul 81	1	(a)
	10 Jul 90	44	(a)
	11 Jul 90	100's	harvested (e)
Cape Beaufort	early 1800s	present	(f)
	3 Jul 79	500	close to shore (a)
	9 Jul 91	22	(g)
Omalik Lagoon area	27 Jun 87	300	moving north (c)
	30 Jun 87	250	near shore (c)
	1 Jul 87	300	(c)
	2 Jul 87	510	(c)
	3 Jul 90	1120	(g)
	4 Jul 90	1140	(g)
Omalik Lagoon, N of	4 Jul 91	303	milling, one big group and several smaller (d)
Omalik Lagoon area	4 Jul 91	441	(g)
	5 Jul 90	1200	(g)
	5 Jul 91	95	(g)
Omalik Creek, 12 mi S	6 Jul 87	400	(c)
Omalik to Amatusuk Cr.	6 Jul 87	530	(c)
Omalik Lagoon	6 Jul 90	830	(g)
	6 Jul 91	1	(g)
	7 Jul 90	111	(g)
	8 Jul 90	14	(g)
	9 Jul 90	31	(g)
	10 Jul 87	55	(h)
	10 Jul 87	10	(h)
	10 Jul 90	149	(g)
	10 Jul 91	90	milling (d)
Omalik Lagoon, N of	10 Jul 91	26	milling (d)
	11 Jul 90	180	(g)

Table 10. Continued.

Location	Date	Number	Comments (Source)
Omalik Lagoon, N of	13 Jul 87	300	(c)
	22 Jul 85	320	(c)
Naokok Pass	1 Jul 83	present	(e)
	2 Jul 78	100	moving north (a)
	4 Jul 91	220	milling (d)
Naokok Pass, S of	4 Jul 91	63	(g)
	5 Jul 91	732	(g)
	6 Jul 91	937	(g)
Naokok Pass	7 Jul 90	70	(g)
	7 Jul 91	890+	milling (d)
	7 Jul 91	770	(g)
	8 Jul 90	81	(g)
Naokok Pass, S of	8 Jul 91	605	(g)
Naokok Pass, 2 mi S	9 Jul 79	400-500	headed north (a)
Naokok Pass	9 Jul 91	390	(g)
Naokok Pass, S of	10 Jul 91	75	moving south (d)
Naokok Pass	10 Jul 91	86	north & south passes 1-4 km off (d)
	11 Jul 91	14	(g)
	13 Jul 91	4	milling (d)
Naokok Pass area	19 Jul 83	30	inside lagoon (e)
Kukpowruk Pass	22 Jun 79	100+	ocean side, first of year (a)
	30 Jun 79	400-500	in pass (a)
	2 Jul 79	many	nearshore and in lagoon (a)
	2 Jul 87	50	(c)
	3 Jul 78	40-50	(a)
	8 Jul 90	77	(g)
	10 Jul 78	700-1000	moving S; in pass and to S (a)
	10 Jul 87	1	(h)
	10 Jul 91	21	two groups, N and S of pass, moving north (c)
	12 Jul 79	250-300	(a)
	12 Jul 91	6	(g)
	16 Jul 83	118	(e)
Point Lay	24 Jun 79	many	moving south (a)
Point Lay, S of	25 Jun 88	present	hunted (j)
	27 Jun 88	present	hunted (i)
Point Lay	28 Jun 91	many	35 harvested (d)
	29 Jun 79	200	many groups, moving north (a)

Table 10. Continued.

Location	Date	Number	Comments (Source)
Point Lay	?? Jul 86	many	inside lagoon (e)
	4 Jul 78	100's	moving north and south 4-7 Jul, inside and outside lagoon (a)
	5 Jul 81	100+	moving south, chased by killer whales (a)
	5 Jul 90	12	(g)
	5 Jul 91	11	(g)
	8 Jul 78	50-75	moving north inside lagoon, calf born (a)
	8 Jul 87	723+	actual count (h)
	8 Jul 87	100	hunted 3, 8, 9 Jul (c, h)
	9 Jul 78	100-150	moving south, ocean side (a)
	10 Jul 79	350	moving by for 5 hours (a)
Point Lay, SW	10 Jul 90	19	(g)
Point Lay, N of	11 Jul 90	62	(g)
Point Lay	11 Jul 91	5	(g)
	13 Jul 79	100+	moving N, nearshore (a)
	15 Jul 79	3-5	pursued by killer whale (a)
Akunik Pass	1 Jul 91	30-40	(d)
	5 Jul 91	57	(g)
	8 Jul 81	60-70	moving N, within 200 m of shore (a)
	8 Jul 90	13	(g)
	9 Jul 79	300-500	moving S and off shore (a)
	10 Jul 78	2	cow w/ neonate in lagoon (a)
	12 Jul 91	61	(g)
Akunik Pass, N of	12 Jul 91	36	(g)
Utukok Pass, N of	3 Jul 79	25+	many w/ calves (a)
Utukok Pass	8 Jul 79	500+	N side, in area 2-3 days (a)
	8 Jul 91	12	(g)
Utukok Pass, S of	12 Jul 90	100	(g)
Utukok Pass	13 Jul 90	208	23 of these NW and off shore (g)
Utukok Pass, S of	14 Jul 90	161	between Utukok Pass and Akunik

Table 10. Continued.

Location	Date	Number	Comments (Source)
Utukok Pass, N of	14 Jul 91	660	(g)
Icy Cape Pass	4 Jul 79	200+	(a)
Icy Cape Pass, S of	4 Jul 91	31	Twin Pass (g)
Icy Cape, S of	6 Jul 81	5+	Twin Pass, nearshore (a)
Icy Cape, N	6 Jul 81	10+	nearshore (a)
Icy Cape Pass	8 Jul 81	400-600+	more than half w/ calves (a)
Icy Cape	11 Jul 80	50	moving N near shore (j)
Icy Cape Pass, S of	11 Jul 81	40-50	nearshore, midway to Utukok (a)
Icy Cape, N of	13 Jul 91	237	(g)
Icy Cape	13 Jul 91	8	moving ENE (d)
Icy Cape, N of	14 Jul 91	21	(g)
	15 Jul 91	516	near ice (g)
	16 Jul 91	100's	near ice (c,f)
Icy Cape	16 Jul 91	7	near shore (g)
Akoliakatat Pass	5 Jul 91	1	(g)
	8 Jul 91	94	(g)
	9 Jul 91	61	(g)
	11 Jul 91	17	(g)
	12 Jul 91	62	(g)
	13 Jul 79	1600-1700	present 13-18 Jul, photographs (a)
	15 Jul 79	2300-2400	photographs (a)
	15 Jul 81	75-100	(a)
Pingorarok Pass	19 Jul 79	1000+	moving N, one large group (a)
Wainwright	15 Jul 78	100	heading NE (a)
	17 Jul 79	100's	headed NE (a)
	18 Jul 79	100's	Headed NE (a)
	19 Jul 79	200+	moving N (a)
Wainwright, near Kuk R	19 Jul 79	500+	moving N (a)
Wainwright	20 Jul 79	400-500	moving N, passed by for hours (a)
Wainwright, NW	20 Jul 80	2	(k)
Wainwright	21 Jul 91	present	harvested (d)
	25 Jul 87	present	(i)
	?? Aug 75	many	(a)

a) Frost et al. 1983; b) Childs 1969; c) W. Hanson, personal communication; d) HERS 1991; e) ADF&G, unpublished data; f) Beechey 1831 cited in Bee and Hall 1956; g) This report; h) Frost and Lowry 1990b; i) North Slope Borough, unpublished data; j) Lenhausen and Quinlan 1981; k) Ljungblad 1981

Table 11. Maximum counts of beluga whales seen on aerial surveys in the Kasegaluk Lagoon region, 1978-1991.

Year	# of Surveys	Maximum Count		
		Location(s)	Number	Date
1978[1]	1	Kukpowruk Pass	879	10 Jul
1979[1]	3	Akoliakatat	1,761	15 Jul
1981[2]	5	Akunik (70), Icy Cape (600)	670	8 Jul
1987[3]	2	Point Lay	723	8 Jul
1987[4]	9	Omalik	930	6 Jul
1990[5]	12	Omalik	1,212	5 Jul
1991[5]	12	Naokok Pass	938	6 Jul
1991[6]	9	Naokok Pass	916	7 Jul

[1] Seaman et. al 1986
[2] Frost et. al 1983
[3] Frost and Lowry 1990b
[4] HERS 1988
[5] Frost and Lowry, this study
[6] HERS 1991

All of these counts under-represent the number of belugas that were actually present. One source of under-estimation results from the fact that not all animals that are at or near the surface are counted. At a survey altitude of 305 m, few neonates and small yearling calves are visible. This is partly because of their dark coloration and partly because they swim so close to their mothers that they are difficult to differentiate. This problem is especially acute in conditions of muddy water or waves and whitecaps. In those circumstances even larger gray animals are also almost certainly undercounted.

Perhaps the most important factor affecting counts is that an unknown, but significant, proportion of the belugas are underwater when counts are made. If the whales are resting at the surface or are in clear, shallow water relatively few may be missed. However, if they are in deep or muddy water and diving to travel or feed, the proportion missed is much higher. Frost et. al (1985) calculated a correction factor of 2.75 based on surface and dive interval data from two radio-tagged belugas in Bristol Bay. Similar correction factors of 2-3 have been proposed by others (Sergeant 1973, Fraker 1980). If such correction factors are applicable to our recent Kasegaluk Lagoon data, this would suggest that there were about 2,000-3,500 belugas in the area we surveyed.

Even within a relatively small area such as the Kasegaluk Lagoon region it is very difficult to fly enough transects to ensure that all groups of whales are detected and counted. The ease with which whales can be missed probably explains the fact that within years, and sometimes even from day-to-day, ten-fold differences in counts were not uncommon. While it is possible to make some generalizations about the pattern of beluga distribution, relatively rapid and long-distance movements make it very difficult to cover all areas where whales might be on a particular day. During 1990 and 1991 when our surveys were geographically and temporally the most extensive, on some days all of the belugas appeared to be together in the same large group, while on other days they were split into smaller groups. On some surveys, animals would be concentrated at a single pass early in the flight and by later the same day the group would be split and at adjacent passes. HERS (1988) conducted ground as well as aerial observations near Omalik Lagoon in 1987, and on several occasions noted that one group of several hundred belugas would move into the area as another group departed. In both 1990 and 1991,

the largest groups occurred nearshore at the southern end of the study area early in the survey period. Later they were found in smaller groups at a variety of passes.

The maximum counts of belugas near Kasegaluk Lagoon have differed substantially over the 14 year period from 1978-1991. However, there was no apparent trend in these counts; the highest counts were in 1979 and 1990 and the lowest in 1978, 1981, and 1987 (Table 11). It is not clear whether these differences reflect actual inter-annual differences in abundance or simply differences in the proportion counted since, as discussed above, counts may be affected by water turbidity, wave action, behavior, and distribution of the animals, as well as the actual number present.

For many species of cetaceans, population estimates are derived from surveys using strip or line-transect methodology, which allows statistical calculation of variance. Transect surveys have at times been used for belugas when animals are spread over a wide area, but when whales are tightly clumped in concentration areas it is common practice to count and/or photograph the entire group (Smith and Hammill 1986, Richard 1991). In the Kasegaluk Lagoon area, belugas occur in concentration areas and are usually counted as one or at most a few groups. This extreme clumping, in which all of the animals are within an area not much greater than the normal width of a standard aerial transect strip, is much more suited to total counts.

The ability of surveys to detect and measure trends in abundance depends in large part on the variance of the abundance estimates (Gerrodette 1988). Some of the daily variability of beluga counts can be eliminated by confining surveys to the period when abundance is expected to be greatest. However, this will not eliminate the effects of weather or changing onshore/offshore distribution of whales within or between days. Since it is unlikely that the same proportion of the population will be in the study area each day, multiple counts cannot be considered replicates. It is therefore essential that enough surveys be flown to obtain a reasonable estimate of the seasonal maximum number within the concentration area. The seasonal maximum can then be treated as a count for that year, and trends can be examined using methods developed for colonial breeding pinnipeds (e.g., Boveng et al. 1988). The number of years required to detect a trend will depend on the rate of population change to be detected and the desired degree of certainty (Forney et al. 1991).

We recommend that monitoring surveys be conducted during two consecutive years, followed by an inter-survey interval of two years before the next pair of monitoring surveys is conducted (i.e., the next set of surveys should be conducted in 1994-1995). This will allow evaluation of inter-annual variability and reduce the likelihood that one unusual year will misrepresent the overall pattern of abundance. It will be necessary to evaluate trends with a long-term perspective because of the considerable interannual variability in counts. Unless the interval between surveys is relatively short, it will not be possible to accumulate enough surveys for trend analysis within a reasonable time frame. Behavioral and movements data from belugas tagged with satellite-linked transmitters would also be very useful in interpreting survey results.

Reasons for Concentration

We think it is likely that belugas concentrate near Kasegaluk Lagoon for reasons associated with their annual skin molt. Observations that belugas rub on gravel substrate and in doing so shed (or molt) their yellowed epidermis were first described by Finley (1982) and Finley et al. (1987) in eastern Canada. In most cetaceans, growth and replacement of the epidermis is thought to be continuous. In belugas, however, this replacement is seasonal and is marked by pronounced differences in the thickness of the external epidermal layer (St. Aubin et al. 1990). The outer layer, or stratum externum, is thickest (and yellow) during spring, when the sloughing rate is slow, intermediate during the summer molt, and thinnest (and very white) in fall after the molt is completed. 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.

Belugas seen in coastal waters of the Chukchi Sea during June-July appear to be in pre-molt condition; the skin is yellowish with many pockmarks and irregularities. Local hunters recognize "spring belugas" and "fall belugas" based on whether the skin is yellow and old or white and new.

Areas in Alaska that are particularly used for molting have not been identified. This is at least in part because environmental conditions are poorly suited for behavioral observations; the water is usually muddy at locations where belugas congregate and the low coastal terrain does not provide a good view of the animals. At molting sites in Canada, the water is clear, high bluffs allow a good downward view of the whales' activities, and the belugas can be clearly seen rubbing on coarse gravel substrates.

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 the beach (sometimes just a few meters from 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 (K. Frost pers. obs.).

Previous investigators have suggested a variety of other factors to explain concentrations of belugas in nearshore waters throughout their range. One suggestion has been that warm, coastal waters could confer a thermal advantage to neonates (e.g., Sergeant and Brodie 1969, Fraker et al. 1979). Seaman et al. (1986) found that belugas occurred most commonly in the plumes of water flowing out of Kasegaluk Lagoon where the July water temperature was as much as 2° C higher than in adjacent marine waters. Calves were sighted among groups of whales using these areas, and some calves were born in the lagoon (G. Seaman pers. comm.). However, small calves presumed to be neonates have also been seen within groups of whales off shore and in pack ice.

The 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 fishes and some invertebrates (Seaman et al. 1982, Lowry et al. 1986). According to hunters from Point Lay, some nearshore feeding does occur on sculpins, smelt, char, and probably capelin. The stomachs examined by us contained shrimp and echiuroid worms. 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 over 1,000 belugas for a period of several weeks.

Fisheries studies conducted near Point Lay indicate that herring, smelt, arctic cod, and fourhorn sculpins are the most numerous species (Craig and Schmidt 1985). Pink salmon, arctic flounder, capelin, arctic char, and cisco also occur in this area (Fechhelm et al. 1984). Peak spawning runs of smelt occur in late June, about the time belugas are first seen near Kasegaluk Lagoon. Other species such as herring, arctic cod, and capelin are not common near shore until mid- to late July or early August, after the belugas are gone.

There is little information available on epibenthic invertebrate fauna in this area. Feder et al. (1989) conducted studies of the benthos in the eastern Chukchi Sea, but did not sample the epifauna. They reported that Echiurus echiurus, one of the main items found in beluga stomachs at Point Lay, was present at a density of 83 individuals/m^2 at 11 sampling locations 50-150 km west of the coast from Cape Lisburne to Icy Cape. Frost and Lowry (unpublished) conducted five otter trawls near Kasegaluk Lagoon in September 1981. Crangonid shrimps, which were also common in beluga stomachs, were among the most abundant species in trawls near Cape Sabine and Akoliakatat Pass.

We think it is likely that belugas feed mostly off shore, where species such as shrimps, echiuroid worms, and arctic cod are relatively abundant. Hunters in Point Lay believe that belugas go out to the ice to feed. They suggest that the belugas may remain near the lagoon passes for a few days, move off shore to the ice to feed, and then return to the passes. This is consistent with our observations that, particularly later in the concentration period, groups are seen irregularly at passes north of Point Lay. In 1991, we observed many belugas milling at the surface near the ice edge off Icy Cape in mid-July. We observed belugas that were almost certainly feeding in mid-July near Akunik Pass. They were several kilometers off shore and were making many steep dives in which they dove straight down and surfaced by coming straight up. This was in marked contrast to the milling or shallow traveling rolls seen earlier in the month at the lagoon passes.

Movements in and out of coastal concentration areas have been observed for belugas in other areas. Four belugas radio-tagged in Cunningham Inlet on Somerset Island, NWT in 1988 milled near the river mouth for one to several days following tagging, left the area, and subsequently returned (K. Frost unpub. data). One animal was absent for six

days, returned for two, moved offshore into the ice for a day, went back to inlet for one day, and then left and was later found in the pack ice to the west. Another left the inlet and was relocated several days later with a group of belugas that appeared to be feeding in the pack ice. These tagged animals appeared to move independently of each other, but as part of groups of several hundred animals. Daily counts at Cunningham Inlet varied substantially as groups came and went. Satellite-linked time/depth recorders deployed on belugas near Somerset Island in 1989-1991 obtained dive profiles indicating that belugas in the pack ice were making steep, repetitive feeding dives to the ocean bottom (T. Martin pers. comm.).

Spotted Seals

Distribution and Abundance

Most of the available information pertaining to spotted seals refers to their distribution and biology during the late winter and spring when they are associated with seasonal pack ice. In the Bering Sea at this time they are concentrated in three areas: the southeastern Bering Sea, the Gulf of Anadyr, and Karaginskii Bay (Tikhomirov 1966, Shaughnessy and Fay 1977, Braham et al. 1984). There is little published information on their distribution and abundance during summer and autumn when spotted seals are found near shore. 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. ADF&G unpub.), 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 1,000 or more spotted seals have been seen: the mouth of the Kuskokwim River on offshore sandbars near Quinhagak (5,600-6,000 in May 1978); on sandbars in Scammon Bay (1,000+ in June 1978); at Cape Espenberg (1,000+ in late August, year unknown); and at the passes of Kasegaluk Lagoon. Kasegaluk Lagoon is the only one of these areas where, as part of this project, systematic counts have been conducted and numbers documented with photographs.

The period when spotted seals use Kasegaluk Lagoon for hauling out extends from approximately mid-July until freeze-up in late October or early November (Table 12). During aerial surveys conducted in 1990-1991, no spotted seals were seen at any Kasegaluk Lagoon passes during early July. In 1990, seals were present in the water off shore, but not hauled out, through the end of the beluga surveys on July 14. However, when seal surveys began on July 26, there were over 500 seals hauled out. In 1991, no seals were seen hauled out on 4 to 11 July; about 50 were hauled out on 12 July and over 1,300 by the end of July. Frost et al. (1983) reported sightings of 1,000 or more hauled out seals on 10 July 1978 and 15 July 1981.

Survey data for 1991 clearly indicated that spotted seals were still very abundant in Kasegaluk Lagoon in late September; over 2,000 seals were hauled out on 29 September. 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, W. and D. Neakok pers. comm.). In October 1989, at least 400 spotted seals were seen hauled out at Utukok Pass (A. Agnasagga pers. comm.) and in early October 1990, over 200 were present at Akunik Pass (D. Ljungblad pers. comm.). In late October 1991, several hundred spotted seals were hauled out on the ice near the two main haulouts at Utukok and Akoliakatat passes. There was no sea ice present but the lagoon was completely frozen except for small pools at the entrances to passes.

Table 12. Sightings of spotted seals in the Kasegaluk Lagoon region, based on published and unpublished literature and surveys conducted during this project.

Location	Date	Number	Comments (Source)
Cape Lisburne	14 Aug 80	4-10	in water (a)
	19 Aug 80	numerous	(a)
Naokok Pass	late autumn	present	seals hauled out on ice (b)
Kukpowruk Pass	summer	many	hauled out on sand spit (c)
Point Lay	Jul 78	present	moving N outside of islands (a)
	Jul 79	present	moving N outside of islands (a)
	8 Jul 78	50+	in lagoon (a)
	18 Sep 74	2300-3000	aerial survey; gps of 500-700; ubiquitous from N to S end of lagoon; haulouts on insides of islands near entrances (a)
Kokolik River	summer-autumn	present	feed in river mouth (a)
Akunik Pass	9 Jul 78	400-500	(a)
	3 Oct 90	360	hauled out (d)
Utukok Pass	Jul-Oct	abundant	haul out on sandbars, enter lower part of Utukok River to eat fish (e)
	10 Jul 78	700-900	main haulout (a)
	19 Jul 79	400-500	(a)
	20 Jul 79	400-500	(a)
	11-16 Jul 91	0-25	Table 6 (f)
	26-28 Jul 90	330-1800	Table 5 (f)
	29 Jul-2 Aug 91	0-700	Table 6 (f)
	11-13 Aug 90	0-100	Table 5 (f)
	15 Aug 81	1000	hauled out plus many in water (a)
	18-22 Aug 91	0-550	Table 6 (f)
	21-26 Aug 90	0-350	Table 5 (f)
	23-28 Aug 89	50-290	Table 4 (f)
	1-14 Sep 89	300-895	Table 4 (f)
	17 Sep 81	300	(a)
	7-11 Sep 90	0-675	Table 5 (f)
	25-29 Sep 91	400-1185	Table 6 (f)
	Oct 89	400	(g)

Table 12. Continued.

Location	Date	Number	Comments (Source)
Utukok Pass	23,24 Oct 91	0-65	Table 6 (f)
	6 Nov 91	2	Table 6 (f)
Icy Cape Pass	15 Aug 81	10	in water (a)
Icy Cape	summers	present	in extensive lagoons near Icy Cape (h)
	summer 80	present	21 sightings of individuals and loose groups of ± 10 seals; none hauled out (i)
Avak Inlet	Jul-Sep	many	haul out on sandbars, go into Avak and Tunalik rivers to eat fish; a few stay all winter (e)
	Jul Sep	many	haul out on spits and go up Avak River to feed; sometimes they eat seaweed (b)
	Jul 78	50-75	W side and middle inlet (a)
	Jul 79	50-75	W side and middle inlet (a)
	26-28 Jul 90	110-265	Table 5 (f)
	29 Jul-2 Aug 91	0-200	Table 6 (f)
	11-13 Aug 90	25-532	Table 5 (f)
	18-22 Aug 91	0-175	Table 6 (f)
	23-28 Aug 89	1-530	Table 4 (f)
	1-14 Sep 89	35-370	Table 4 (f)
	7-11 Sep 90	87-285	Table 5 (f)
	25-29 Sep 91	3-150	Table 6 (f)
Akoliakatat, W spit	Jul-Oct	present	(b)
	10 Jul 78	100+	major haulout (a)
	11-16 Jul 91	30-104	Table 6 (f)
	19 Jul 79	40-50	(a)
	26-28 Jul 90	20-45	Table 5 (f)
	29 Jul-2 Aug	0-925	Table 6 (f)
	11-13 Aug 90	0-215	Table 5 (f)
	18-22 Aug 91	0-525	Table 6 (f)
	23-28 Aug 89	0-90	Table 4 (f)
	21-26 Aug 90	15-600	Table 5 (f)
	1-14 Sep 89	0-350	Table 4 (f)
	7-11 Sep 90	0-700	Table 5 (f)
	25-29 Sep 91	50-200	Table 6 (f)

Table 12. Continued.

Location	Date	Number	Comments (Source)
Akoliakatat Pass	Jul-Oct	present	sometimes eat seaweed on bottom (b)
	Jul-Oct	abundant	haulout out on sand bars at and near the pass until lagoons freeze (e)
	23 Jul 84	10+	(j)
	29 Jul-2 Aug	0-550	Table 6 (f)
	11-13 Aug 90	0-33	Table 5 (f)
	18-22 Aug 91	0-400	Table 6 (f)
	21-26 Aug 90	30-740	Table 5 (f)
	23-28 Aug 89	0-50	Table 4 (f)
	1-14 Sep 89	0-2	Table 4 (f)
	7-11 Sep	0-1301	Table 5 (f)
	16 Sep 81	200	hauled out and in water (a)
	23-24 Oct 91	0-100	Table 6 (f)
Akoliakatat, E spit	29 Jul-2 Aug 91	0-55	Table 6 (f)
	11-13 Aug 90	0-26	Table 5 (f)
	15 Aug 81	1000	± 100 hauled out, rest in water (a)
	18-22 Aug 91	0-600	Table 6 (f)
	21-26 Aug 90	0-68	Table 5 (f)
	23-28 Aug 89	1-700	Table 4 (f)
	1-14 Sep 89	0-550	Table 4 (f)
	25-29 Sep 91	70-800	Table 6 (f)
Nokotlek River	summer	present	enter river to eat fish (e)

a) Frost et al. 1983; b) Neakok et al. 1985 and personal communication c) C. D. Brower, cited in Neakok et al. 1985 d) Brueggeman et al. 1991; e) Nelson 1982; f) This report; g) A. Agnasagga, personal communication; h) Bailey and Hendee 1926; i) Lehnhausen and Quinlan 1981; j) L. Lowry, unpublished data

During July-October surveys in 1989-1991, we saw spotted seals hauled out at Utukok and Akoliakatat passes and Avak Inlet. Local residents also report that these are the only major haulouts. Occasionally, we saw a few seals in the water near other passes. Seals in the water were also observed during bird surveys conducted by LGL (Figs. 7-9). Most of these were seen near the major haulouts at Utukok and Akoliakatat. A few were also seen near Kukpowruk, Point Lay, Akunik, and Nokotlek passes. As noted above, several hundred seals were reported hauled out in early October 1990 at Akunik Pass. According to long-time residents of Point Lay, Akunik Pass was once often used by spotted seals, but circulation patterns and the location of bars has changed and this area is no longer regularly used (W. Neakok pers. comm.. We know of only one other recent sighting there, in July 1978 (Table 12). Spotted seals also were once abundant near Naokok Pass just before freeze-up, sometimes hauling out on the newly formed lagoon ice (W. and D. Neakok pers. comm.). There is a site near there called Kasigialik which means "place where spotted seals remain." As at Akunik Pass, coastal morphology has changed in the last 30-40 years and Naokok Pass is now seldom used. During late October surveys in 1991, no spotted seals were seen near Naokok Pass.

Sightings reported by Frost et al. (1983) and others for passes at Kasegaluk Lagoon are of similar magnitude to those made in this study (Table 12). In September 1974, 2,500-3,000 seals were estimated to be present at Lagoon passes. Maximum counts for July-September 1990 and 1991 were 2,100 and 2,400. Previous large sightings at Utukok Pass were of 700-900 seals in July 1978, 400-500 in July 1979, 1,000 in August 1981, and 300 in September 1981. The highest counts at Utukok Pass in this study were 845-895 on 1 September 1989; approximately 1,800 on 28 July 1990; and approximately 1,185 on 29 September 1991. Previous sightings at Akoliakatat Pass were of 40-100 seals in July 1978 and 1979, 1,000 in mid August 1981, and 200 in mid-September 1981. During this study the highest counts at the three Akoliakatat haulout sites combined were 1,105 on 30 July 1991; 1,055 on 25 August 1990; 1,125 on 20 August 1991; 1,490 on 9 September 1990; and 1,000 on 29 September 1991. Previous reports indicated that about 100 seals were hauled out at Avak Inlet in July 1978 and 1979. Substantially higher numbers were counted in this study, with over 500 animals at the four haulout sites combined on 26 August 1989 and 25 August 1990 and at least 200 on 29 July 1991.

Data collected in 1989-1991 do not indicate a clear pattern in the timing of use of the three general haulout areas (Tables 4-6). 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 others, seals were present in substantial numbers at all haulouts. Based on the observations made during bird surveys, there was no indication that the number of seals seen in the water in the lagoon increased when the number on haulouts decreased. This suggests that seals did not leave the haulouts to feed in the lagoon. In fact, sightings of seals in the water tended to be highest when many seals were present at the haulouts (LGL unpub. data).

Data from four seals radio-tagged in August 1991 confirm that some seals use several haulouts (K. Frost and L. Lowry unpub. data). Three of the four tagged seals used both Utukok and Akoliakatat passes during August; the fourth used only Utukok. During September only one continued to use both passes; two others used Utukok. In October, none used Akoliakatat Pass and only one of four hauled out at Utukok. One of the tagged seals hauled out near Naokok Pass at the south end of the lagoon in late October as the lagoon was freezing.

There was no obvious pattern in the total number of spotted seals hauled out in Kasegaluk Lagoon during late July through late September (Fig. 7). In 1989-1991 maximum daily counts at all haulouts combined were over 1,000 on dates throughout this period, and similar large counts have been reported as early as 10 July in other years (Table 12). Maximum yearly combined counts occurred on 1 September 1989, 28 July 1990, and 29 September 1991.

It is not clear how many spotted seals are actually using Kasegaluk Lagoon as a place to haul out during the ice-free season. Many additional data on seal behavior will be needed to develop correction factors that can be applied to aerial survey counts. Nonetheless, it is clear that hauling out is not entirely synchronous and that some seals were away from the haulouts even when high counts were made. For example, when about 2,200 seals were counted on 29 September 1991, only 1 of 4 satellite-tagged seals was hauled out in Kasegaluk Lagoon (K. Frost and L. Lowry unpub. data).

It was difficult, based on surveys flown once or twice a day and often spaced days or weeks apart, to determine what factors affected the number of seals hauled out. We had assumed that it was more likely for large numbers

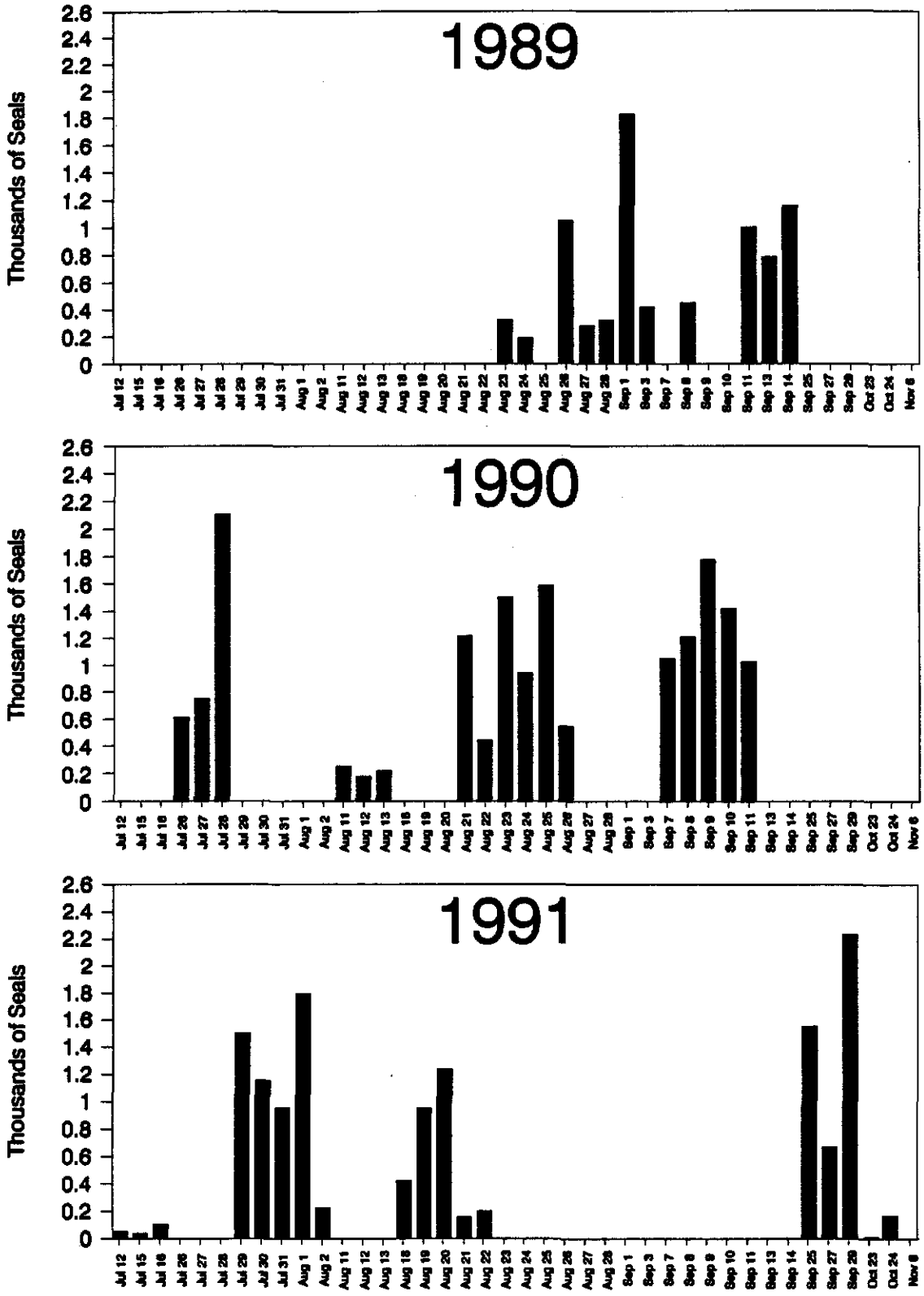

Figure 12. Maximum combined daily counts of spotted seals made at haulouts in Kasegaluk Lagoon in 1989, 1990, and 1991.

of seals to be hauled out when the water was low and that spotted seals might prefer a particular time of day for hauling out. However, these were difficult relationships to quantify and test using data obtained from aerial surveys. Surveys could not be conducted at all hours, but were restricted to periods of daylight and to suitable weather. Replicate surveys conducted at different times on the same day were difficult to compare due to frequent disturbance of haulouts by aircraft. There was not an equal distribution of high and low water during survey periods. Water level was difficult to classify and small differences in water level made large differences in the amount of shoal or bar that was exposed. Furthermore, water level sometimes varied substantially over short periods of time and in different parts of the lagoon. Not surprisingly, statistical analyses of 1989-1991 survey data did not confirm that there are relationships between time of day or water level and the number of seals hauled out.

In contrast, ground-based observations by project personnel (Frost and Lowry unpub. obs.), and observations of Point Lay residents (W. and D. Neakok pers. comm.), clearly indicate a strong relationship between water level and the number of seals hauled out. When the water is high and much of the available hauling out substrate is submerged, few seals are present. The greatest number of seals is always present at low water when bars and shoals are exposed. However, seals are not always present in large numbers at low water. Much remains to be learned about what factors, in addition to water level, influence their hauling out behavior.

It is apparent that aerial surveys are not a suitable method for studying haulout patterns and diurnal activity of spotted seals, particularly in remote areas where logistics are difficult and the weather is unpredictable and often unsuitable for flying. In contrast, satellite telemetry may prove to be a reliable and highly satisfactory method for obtaining such data. Satellite-linked transmitters attached to four spotted seals during August 1991 have transmitted data for 3-5 months and yielded considerable information on movements between passes, periodicity of hauling out, onshore-offshore movements, and the southward migration (Frost and Lowry unpub. data).

Foods and Feeding

Following the period of reduced food intake and lower metabolic rate which occurs during the April-June molt (Ashwell-Erickson et al. 1986), spotted seals feed intensively (Tikhomirov 1966). Throughout their range, they generally congregate after the molt at haulouts near an abundant food supply, especially near large runs of spawning fishes such as salmon, herring, capelin, or smelt or other locally abundant fishes such as arctic cod or sand lance (*Ammodytes hexapterus*) (Ognev 1935, Tikhomirov 1966, Goltsev 1971, Frost et al. 1983, Bukhtiyarov et al. 1984).

Very little direct information is available on spotted seal feeding in the Kasegaluk Lagoon region. Ten seals were collected near Utukok and Akoliakatat passes in September 1981 (L. Lowry and K. Frost unpub. data). Nine of them had empty stomachs; one had eaten arctic cod. Point Lay hunters report that the seals eat fish, but not which kinds (W. Neakok, pers. comm.). Wainwright hunters report that they eat Bering ciscos (*Coregonus laurettae*), as well as other fishes, when they are in the freshwater rivers of Avak Inlet, and that they sometimes have seaweed in their stomachs (Nelson 1982).

It is possible to speculate on which species spotted seals might be eating based on results of fish studies that have been done near Kasegaluk Lagoon, and what we know about spotted seal foods in other areas of Alaska. We have previously examined the contents of stomachs from 62 spotted seals collected in the Bering and Chukchi seas during July-September (Table 13). In all except a few, fish made up almost all of the contents. The species most often consumed were herring, saffron cod and sculpins. Also present were arctic cod, sand lance, smelt, capelin, flatfish, and salmon. All of these species except sand lance have been caught in and near Kasegaluk Lagoon. Shrimp, especially crangonids, were major foods of some seals collected at Shishmaref and Wainwright.

Both local residents (Pedersen in press) and fisheries studies (Craig and Schmidt 1985) report that smelt are present during June-September. Near Point Lay, peak abundance of smelt, which run up the rivers to spawn, occurs in about the third week of June. Following spawning the smelt return to the ocean, probably at about the time spotted seals arrive, and they may be present along the coast during the rest of the year.

Table 13. Stomach contents of spotted seals from the northern Bering and Chukchi seas, July-December, 1966-1987. Data are from Lowry et al. (1981), Frost and Lowry (1990b), and ADF&G unpublished. Values for invertebrates and total fish are percent of total volume. Values for individual fish species are percent of the total number of identifiable fishes. P indicates that the item was present, but the number could not be determined.

	July				August	
Prey	Gol 1981 n=1	Shi 1976 n=3	Shi 1977 n=10	Wai 1975 n=1	Wool 1972 n=1	Wai 1975 n=1
Amphipods	--	<1	--	--	<1	<1
Mysids	--	--	--	--	--	<1
Shrimp	--	--	1	26	--	--
Fam. Crangonidae	--	87	<1	--	<1	--
Other Invertebrates	--	--	--	--	--	1
TOTAL INVERTEBRATES	0	87	1	26	4	2
TOTAL FISHES	100	13	99	74	96	98
Sculpins	--	--	--	--	--	100
Saffron cod	--	38	4	P	92	--
Arctic cod	--	--	--	P	--	--
Herring	--	--	96	--	--	8
Flatfish	--	62	--	--	--	--
Salmon	100	--	--	--	--	--
MEAN VOLUME (ml)	1670	403	632	7	76	17

Abbreviations for locations are as follows: Gol=Golovin; Shi=Shishmaref; Wai=Wainwright; Wool=Cape Wooley; Tel=Teller; Esp=Espenberg; Akol=Akoliakatat; Utuk=Utukok; Gam=Gambell; Kotz=Kotzebue Sound.

Table 13. Continued.

Prey	September					October					
	Wool 1971 n=1	Tel 1970 n=1	Esp 1981 n=1	Akol 1981 n=2	Utuk 1981 n=1	Gol 1981 n=5	Gam 1966 n=1	Tel 1970 n=2	Tel 1972 n=3	Shi 1977 n=14	Kotz 1987 n=3
Amphipods	--	--	--	--	--	--	--	--	--	<1	--
Crabs	--	--	--	--	--	--	7	--	--	--	--
Shrimp	--	--	--	--	--	<1	--	--	--	<1	<1
Other Invertebrates	--	--	--	--	--	--	7	--	--	--	--
TOTAL INVERTEBRATES	0	0	0	0	0	<1	14	0	0	1	6
TOTAL FISHES	100	100	100	100	100	100	86	100	100	99	94
Sculpins	--	--	--	7	100	--	100	--	--	--	--
Saffron cod	98	--	100	--	--	100	--	--	--	17	64
Arctic cod	--	--	--	93	--	--	--	--	--	--	31
Herring	--	33	--	--	--	--	--	100	95	83	5
Sand lance	2	--	--	--	--	--	--	--	--	--	--
Rainbow smelt	--	--	--	--	--	--	--	--	5	--	--
Capelin	--	67	--	--	--	--	--	--	--	--	--
MEAN VOLUME	24	530	<1	13	<1	513	112	1470	1793	433	8

Abbreviations for locations are as follows: Gol=Golovin; Wai=Wainwright; Shi=Shishmaref; Wool=Cape Wooley; Tel=Teller; Esp=Espenberg; Akol=Akoliakatat; Utuk=Utukok; Gam=Gambell; Kotz=Kotzebue Sound.

Table 13. Continued.

	November							December	
	Tel 1966 n=1	Tel 1972 n=2	Nome 1966 n=2	Nome 1976 n=1	Nome 1980 n=1	Shi 1977 n=1	Esp 1984 n=1	Nome 1966 n=1	Nome 1980 n=1
Shrimp									
Fam. Crangonidae	--	--	--	--	--	--	9	--	--
TOTAL INVERTEBRATES	0	0	0	0	0	0	9	0	0
TOTAL FISHES	100	100	100	100	100	100	91	100	100
Sculpins	--	--	P	<1	--	--	37	50	--
Saffron cod	12	24	P	<1	22	--	8	--	--
Arctic cod	--	--	--	--	22	100	--	--	100
Herring	--	--	--	--	--	--	--	50	--
Sand lance	--	--	--	99	51	--	--	--	--
Flatfish	--	--	--	--	--	--	55	--	--
Rainbow smelt	88	76	--	--	--	--	--	--	--
Other Fishes	--	--	--	--	5	--	--	--	--
MEAN VOLUME	200	965	400	867	915	751	88	175	<1

Abbreviations for locations are as follows: Gol=Golovin; Wai=Wainwright; Shi=Shishmaref; Wool=Cape Wooley; Tel=Teller; Esp=Espenberg; Akol=Akoliakatat; Utuk=Utukok; Gam=Gambell; Kotz=Kotzebue Sound.

Herring occur in the Kasegaluk Lagoon area from late July until at least mid-September, with greatest numbers present after mid-August. They occur inside the Lagoon and in nearshore and offshore marine waters (Craig and Schmidt 1985). In the southern Chukchi Sea herring was the major food of spotted seals near Shishmaref in July and October, and was eaten by seals in Kotzebue Sound in October (Lowry et al. 1981). It is likely that herring are also eaten by the seals in and near Kasegaluk Lagoon.

Arctic cod are widespread in northern Alaska and are a major forage species for seals and birds. They have been reported as food of spotted seals in the northern Bering Sea in spring, and in Kotzebue Sound and off Wainwright in summer (Lowry et al. 1981, Bukhtiyarov et al. 1984). Near Kasegaluk Lagoon arctic cod occur in marine and lagoon waters, and are sporadically abundant from late July until early September (Craig and Schmidt 1985). Lowry and Frost (unpub. data) caught arctic cod in an otter trawl near Utukok Pass in September 1981, and arctic cod were present in the stomach of a seal collected there.

Considering the above information, we think it is likely that spotted seals in the Kasegaluk Lagoon area are feeding primarily on herring, capelin, smelt, arctic cod, and sculpins and probably to a lesser degree on arctic flounder and saffron cod. Invertebrates, particularly shrimp, may also be important prey. Crangonid shrimp are very abundant in sandy nearshore areas of the southern Chukchi Sea and may be abundant in the vicinity of Kasegaluk Lagoon. When the seals are in Avak Inlet, they may be eating ciscos.

There are no estimates of the size of fish stocks in the Kasegaluk Lagoon region or the eastern Chukchi Sea. However, the large number of seals hauling out there from July until at least October suggests that there must be a substantial biomass of fish somewhere within range of the seals. Ashwell-Erickson and Elsner (1981) calculated that a spotted seal would eat about 1.7 kg/day of a diet of primarily fish. Applying this estimate to the maximum count of seals hauled out at Kasegaluk Lagoon (2,237) would result in a consumption of about 3,800 kg of food/day, 114,000 kg/month, or over 342,000 kg in a three month period. This is only a minimum estimate since the total number of seals in the area, as opposed to the number hauled out, is unknown and by all indications is substantially higher than the maximum count. The actual degree to which seals are feeding in this area is also

unknown. Ashwell-Erickson and Elsner (1981) found that metabolism and fat levels in captive spotted seals were lowest in May-July, somewhat higher in August and September, and highest in October-April. Tikhomirov (1966) indicated that intense feeding occurred in July, following the molt, and that seals remained in areas of high fish abundance despite predation by bears and disturbance by humans. It is common knowledge among hunters that seals sink when they first arrive in July and early August, but that by late August or early September they have put on fat and float when shot.

Responses to Disturbance

Based on our observations at Kasegaluk Lagoon during 1989-1991, the spotted seals there are the most wary of any seals on which we have worked. Principal investigators of this project have surveyed harbor seals on coastal haulouts, and spotted, ringed, ribbon (*Phoca fasciata*), and bearded (*Erignathus barbatus*) seals, and walruses (*Odobenus rosmarus*) on the ice. Of those, harbor seals on coastal haulouts have been the most easily disturbed. Nonetheless, it has usually been possible to fly over groups of hauled out harbor seals at 150-300 m with little visible response. In our Kasegaluk Lagoon surveys, spotted seals sometimes went into the water when the aircraft was more than 1 km away even at 914 m altitude. At altitudes below 500 m it was almost impossible to fly over large groups of seals without causing some or all of them to go into the water. Often, however, after an initial "wave" of seals closest to the waterline went in, the rest would remain hauled out.

During summer and autumn surveys, the notable exception to spotted seals' extreme responsiveness to aircraft noise was during October 1991 when the seals were hauled out on ice at the passes. Most seals remained on the ice when the aircraft circled at 150-400 m, although some looked up at the aircraft, or moved around on the ice. This behavior was similar to what we have observed during ice-front surveys of spotted seals conducted in March-May in the southern Bering Sea. We suggest that this difference in behavior is due to the density of seals rather than the substrate on which they are hauled out. On ice, seals usually haul out some distance apart. If an animal becomes uneasy and moves around it does not physically impact other seals. In contrast, on shoals and bars seals are usually tightly packed together and

one seal may be in physical contact with several others. Any small movement is immediately transmitted to adjacent animals, and the response may travel as a wave through an entire group. We sometimes observed that after an initial wave of seals went into the water the remaining seals spread apart and remained hauled out even though the plane continued to circle.

Although seals in Kasegaluk Lagoon were more likely to flee into the water in response to aircraft noise than harbor seals, they also hauled back out more readily. It has been our experience with harbor seals that once seals are disturbed and leave a haulout they may not return until the next tidal cycle. In contrast, on several occasions at Utukok and Akoliakatat passes counts of seals on surveys flown only a few hours apart were similar, even though almost all of the seals had gone into the water during the first flight. This behavior was confirmed by the field camp observations made at Avak Inlet.

We do not know why spotted seals at Kasegaluk Lagoon respond so readily to aircraft. To our knowledge, aircraft do not regularly land on or near seal haulouts, nor do they intentionally fly over or otherwise harass the seals. The low lying coastal topography should not amplify sounds, neither does it provide any relief that would reduce or block aircraft noise. The area does experience frequent low altitude aircraft traffic. Commuter airlines flying among Barrow, Wainwright, and Point Lay pass over Kasegaluk Lagoon several times a day when weather permits. On days when flying resumes after a period of stormy weather, six or more planes may land at Point Lay. This may represent 12 flights over some of the seal haulouts. The most commonly used flight path passes almost directly over haulouts at Akoliakatat Pass and Avak Inlet; fewer aircraft pass over Utukok Pass. The rapid re-hauling behavior of spotted seals at Kasegaluk Lagoon may be an accommodation to the frequent aircraft disturbances that occurs.

Residents of Point Lay confirm that spotted seals are very responsive to disturbance, noting that "they won't stay anyplace where there are people around, they'll go someplace else" (Neakok et al. 1985). Spotted seals in other regions are similarly responsive. In the Sea of Okhotsk, Tikhomirov (1966) described their response to danger as "similar to an avalanche." He considered spotted seals to be the most cautious of all pinnipeds.

In the Kasegaluk Lagoon region, spotted seals may sometimes be disturbed on their haulouts by grizzly bears (*Ursus arctos*). On many of the days when we flew surveys, we saw one or more bears on the barrier islands

near Akoliakatat and Utukok passes. Disturbance by humans in boats or on land may also be common. Although Point Lay hunters seldom travel beyond Icy Cape (W. Neakok pers. comm.), Akoliakatat Pass and Avak Inlet are commonly used by hunters from Wainwright. Waterfowl and caribou (*Rangifer tarandus*) hunting occurs there as well as near Utukok Pass. Spotted seals are hunted by residents of both Wainwright (near Akoliakatat and Avak) and point Lay (near Utukok) during late August and September. Although hunting for spotted seals is less intensive than it once was when seals were fed to sled dogs, it still occurs with some regularity (W. Neakok pers. comm.). In addition to hunting *per se*, there is considerable small boat activity in Kasegaluk Lagoon as people move to and from hunting camps. During ground-based field work, we noticed that the noise from distant aircraft and distant outboard motors was hard to distinguish, and that seals responded similarly to both. It is possible that the extreme responsiveness to noise is due to a combination of frequent small boat activity, sometimes combined with hunting, and to the high density of seals on haulouts with correspondingly small inter-animal distances. In our experience, no other seals haul out in such close proximity, providing for the instantaneous physical transmission of any small reaction to a disturbance.

CONCLUSIONS

1. Aerial surveys conducted in 1989-1991 provided systematic information on the distribution, abundance, and habitat use of beluga whales and spotted seals in the Kasegaluk Lagoon area during the open water season.

2. Beluga whales were seen during every survey flown during the 3-14 July 1990 and 4-16 July 1991 periods. Most whales seen were within 2 km of the coast. Early in the survey period most sightings were of large groups south of Point Lay. Later, belugas dispersed and were seen at passes north of Point Lay and near pack ice off Icy Cape. A review of past sightings indicates that whales may appear in the region as early as June 22 and are always gone by late July.

3. The maximum counts of beluga whales in 1990 (1,200) and 1991 (938) were comparable to counts made in previous years. These counts may represent 2,000-3,500 whales actually using the area.

4. The most likely reason for beluga whales appearing in this region is the presence of warm, low salinity water and submerged gravel beds that facilitate the annual molt. It is unclear how much feeding occurs in the Kasegaluk Lagoon region.

5. Beluga whales are harvested by Point Lay residents in drive hunts that are a communal effort of the village. The average annual harvest from 1986 to 1991 was 35 animals.

6. Spotted seals occur in the region from shortly after the ice moves offshore (early to mid-July) until freeze-up in November. The principal areas used for hauling out are sandy spits and shoals near Utukok Pass, Akoliakatat Pass, and Avak Inlet. There was no obvious seasonal pattern of usage of any particular haulout area.

7. Counts of 1,000-2,000 seals occurred regularly throughout the period from late July through late September. Counts were similar to those that had previously been reported. Factors that affect the number of animals hauled

out at a particular place and time are not known. Nonetheless, it is clear, based on data from satellite-tagged seals, that even at times of peak counts the numbers greatly underestimate the total number of seals using the Kasegaluk Lagoon region.

8. Spotted seals hauled out on spits and bars are very responsive to disturbance by aircraft flying at altitudes below 914 m. Although some or all seals often moved into the water as aircraft approached they commonly hauled out again shortly afterward. This response is different from what occurs when spotted seals are hauled out on the ice, and may be due to frequent small boat activity in combination with the close physical proximity of animals on terrestrial haulouts.

9. It is not known where spotted seals using the Kasegaluk Lagoon region go to feed. Likely prey include several species of fishes and shrimps. The total food requirement of several thousand seals is substantial, suggesting that an abundant food supply must be available within feeding range.

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APPENDIX A

DAILY FLIGHT LINES AND SIGHTINGS FROM AERIAL SURVEYS FOR BELUGA WHALES IN THE KASEGALUK LAGOON REGION, JULY 3-14, 1990

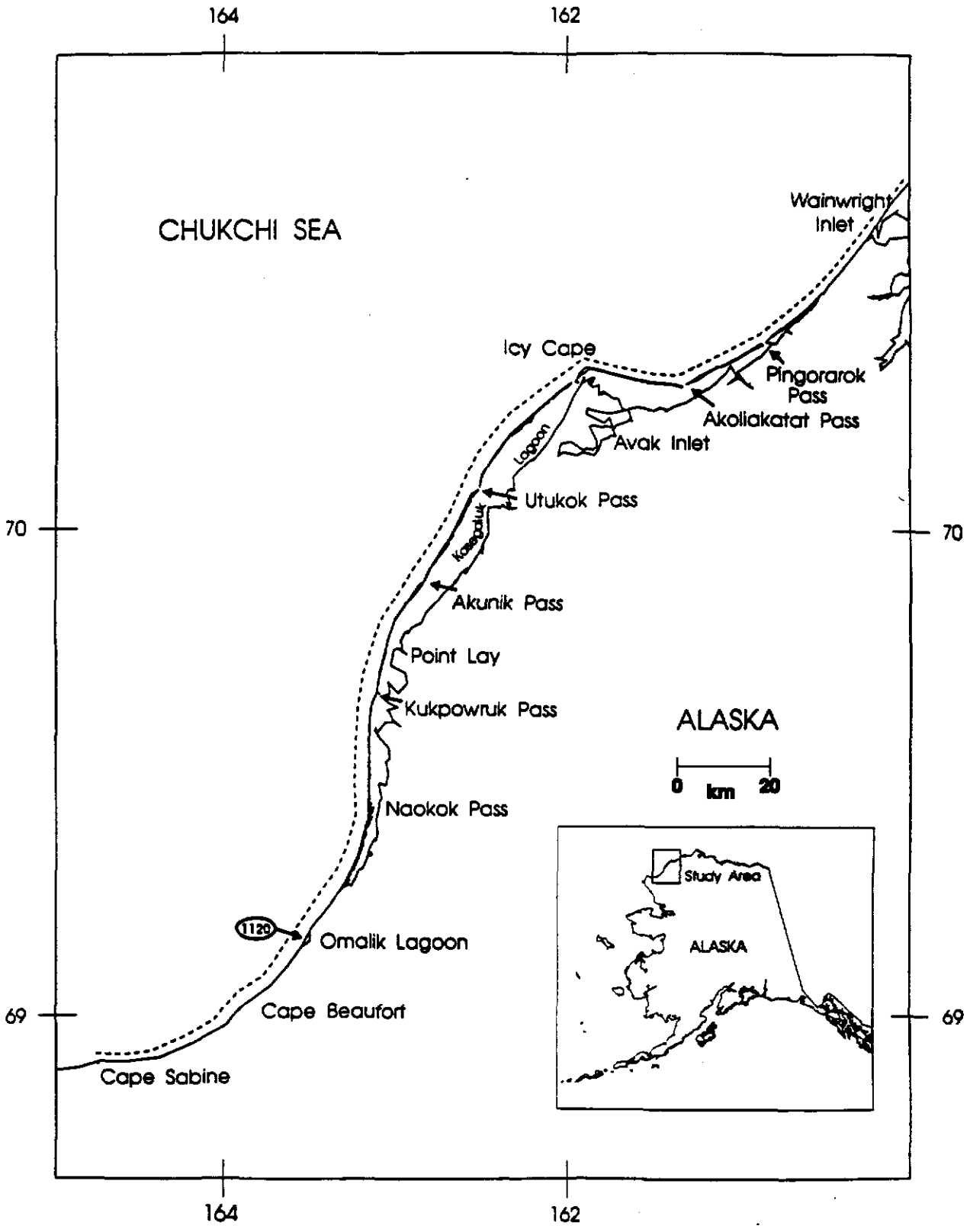

Figure A-1. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 3, 1990.

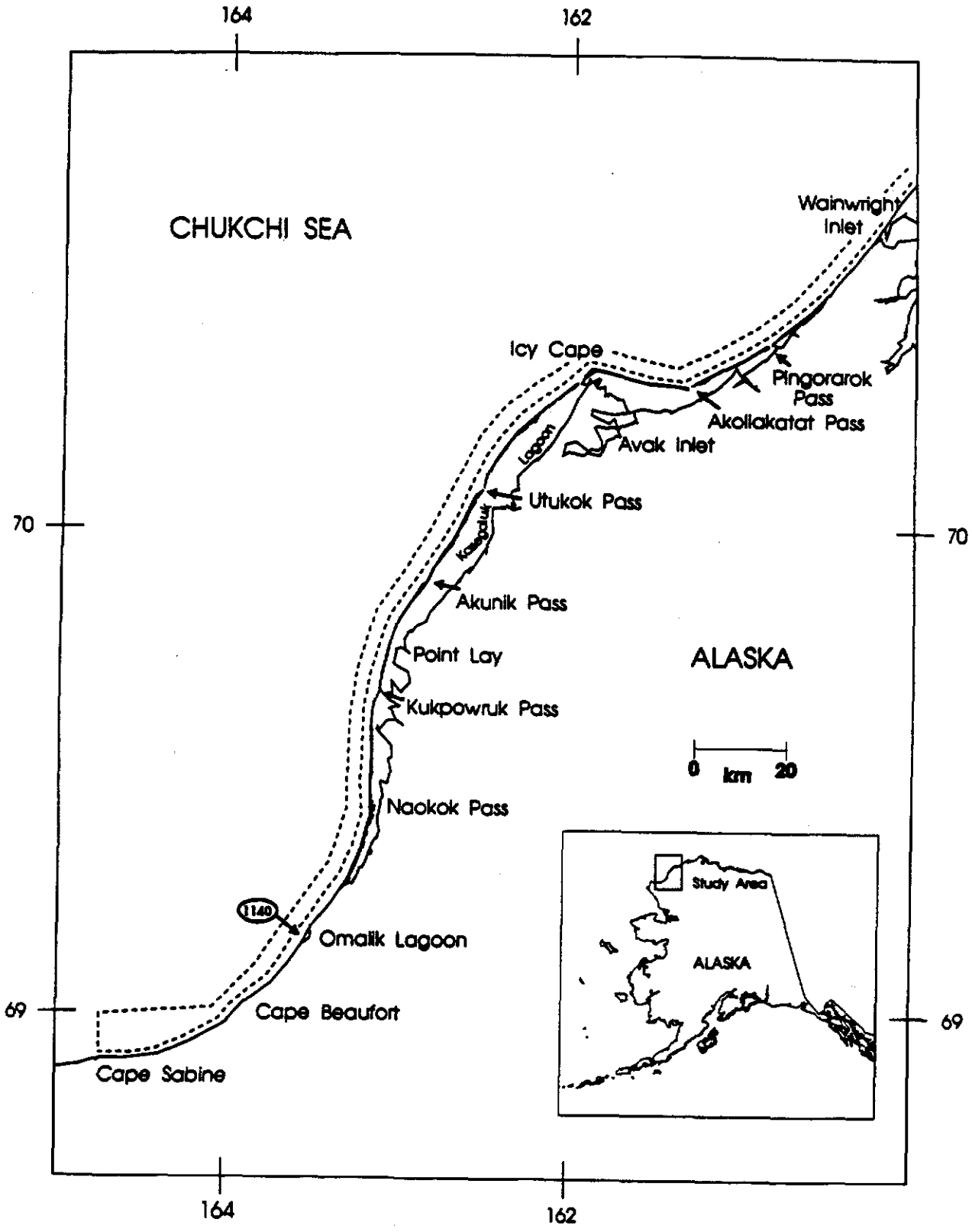

Figure A-2. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 4, 1990.

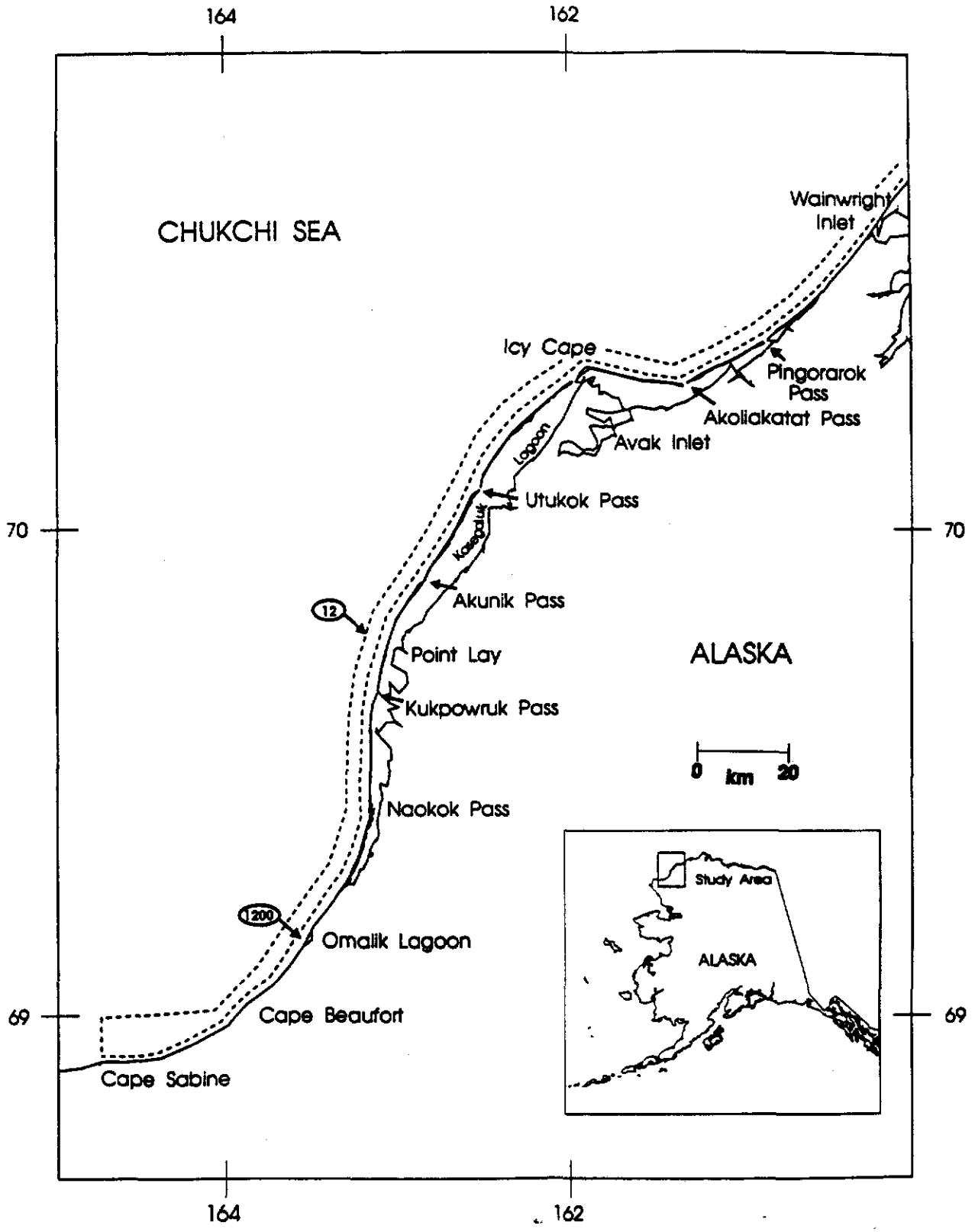

Figure A-3. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 5, 1990.

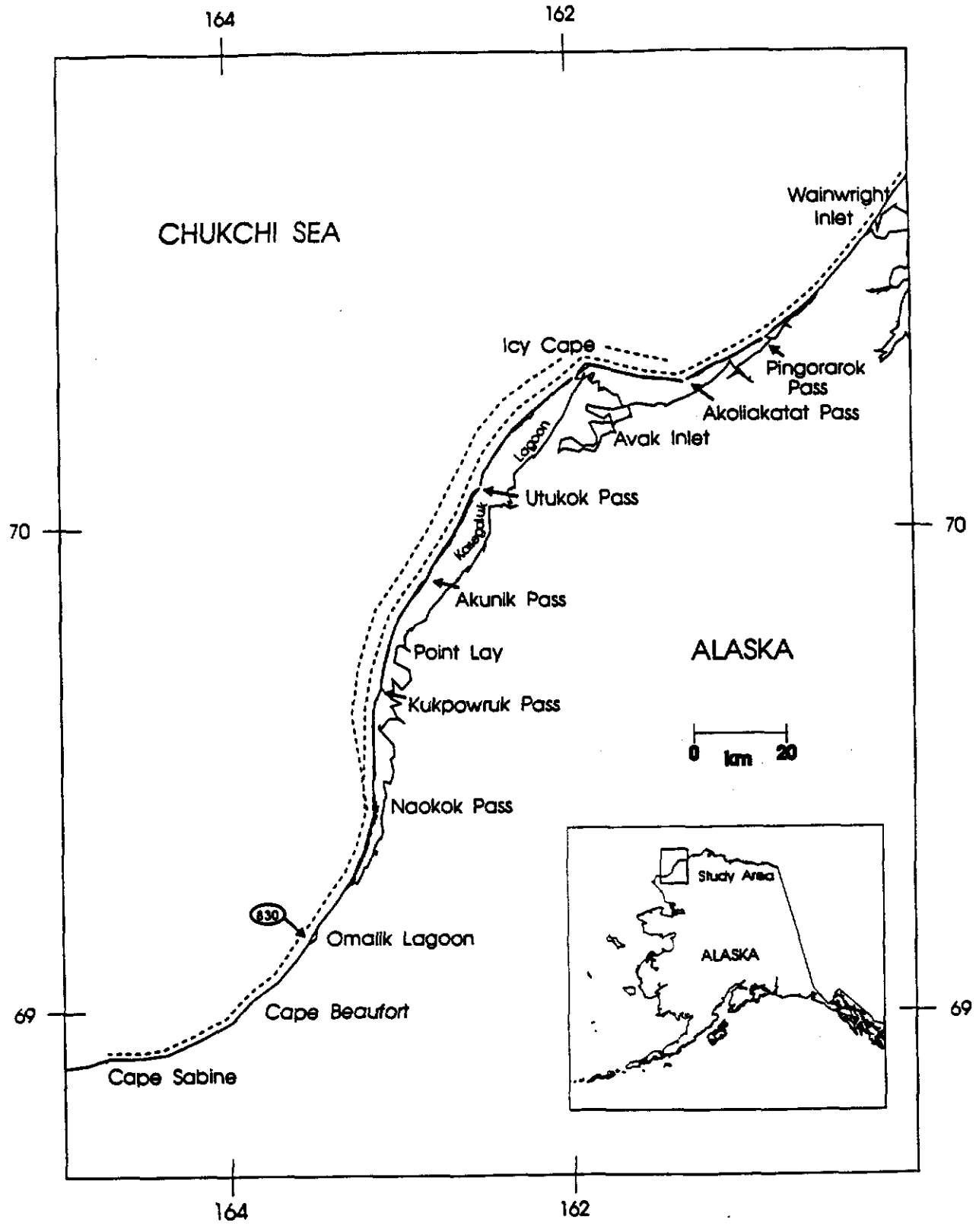

Figure A-4. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 6, 1990.

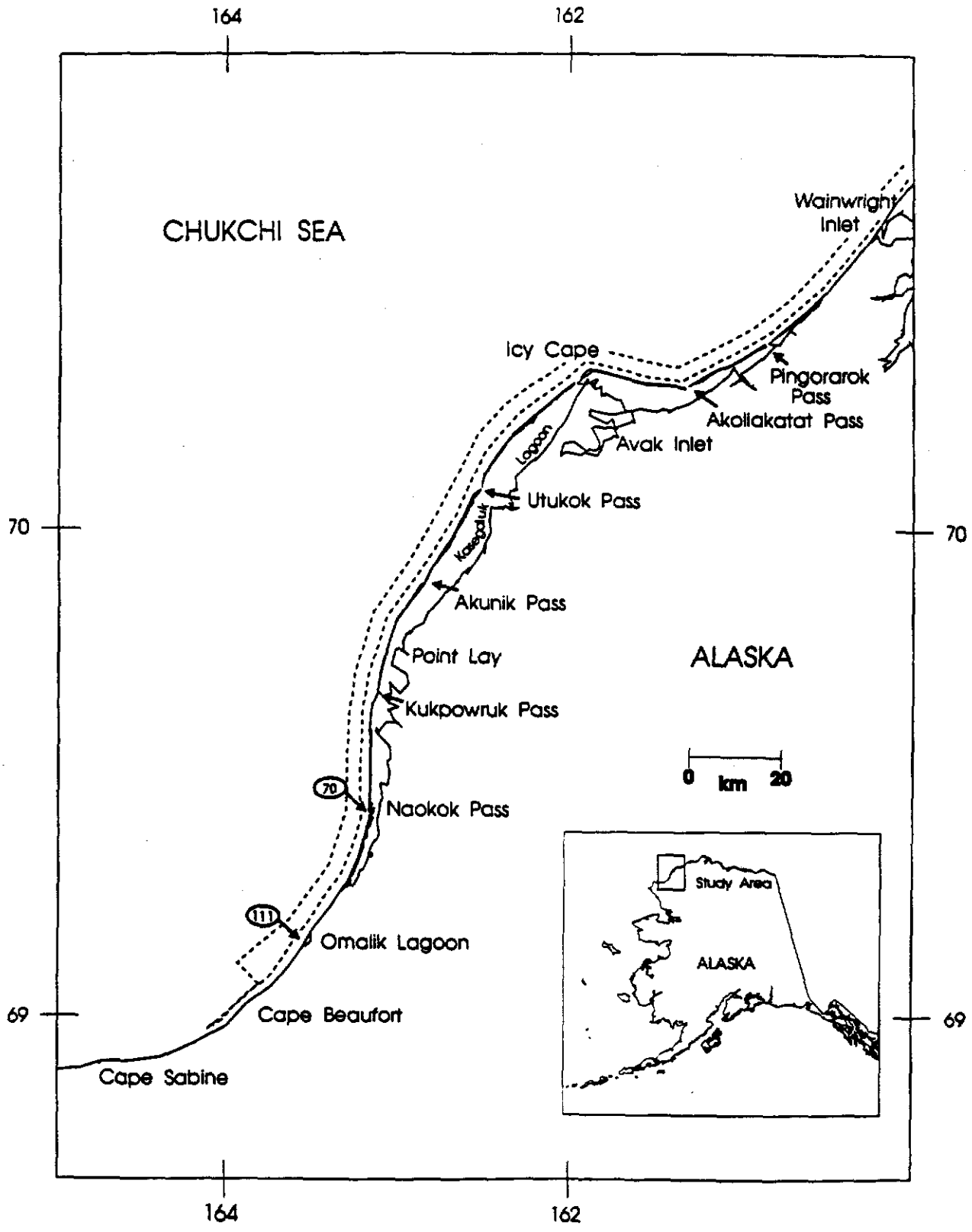

Figure A-5. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 7, 1990.

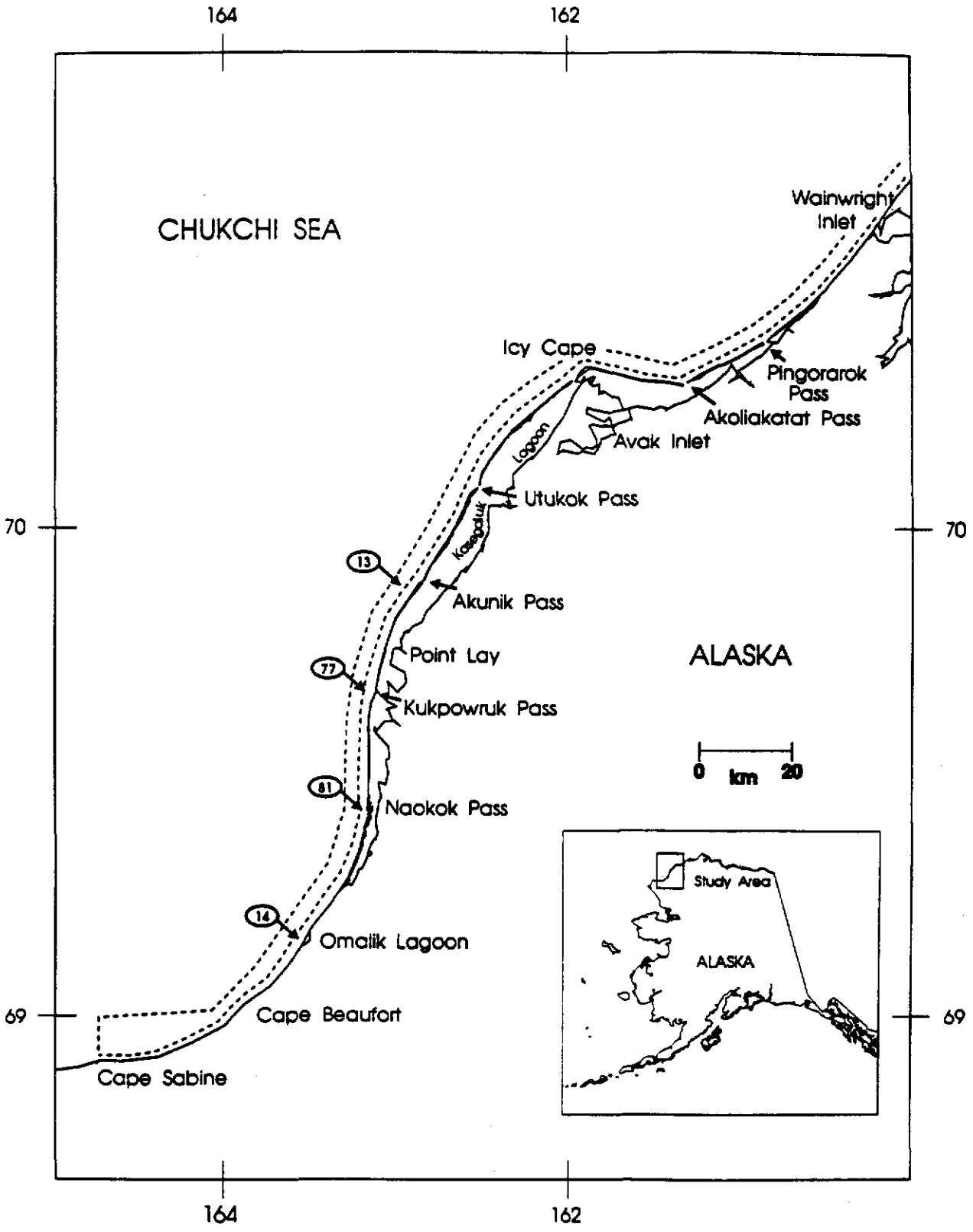

Figure A-6. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 8, 1990.

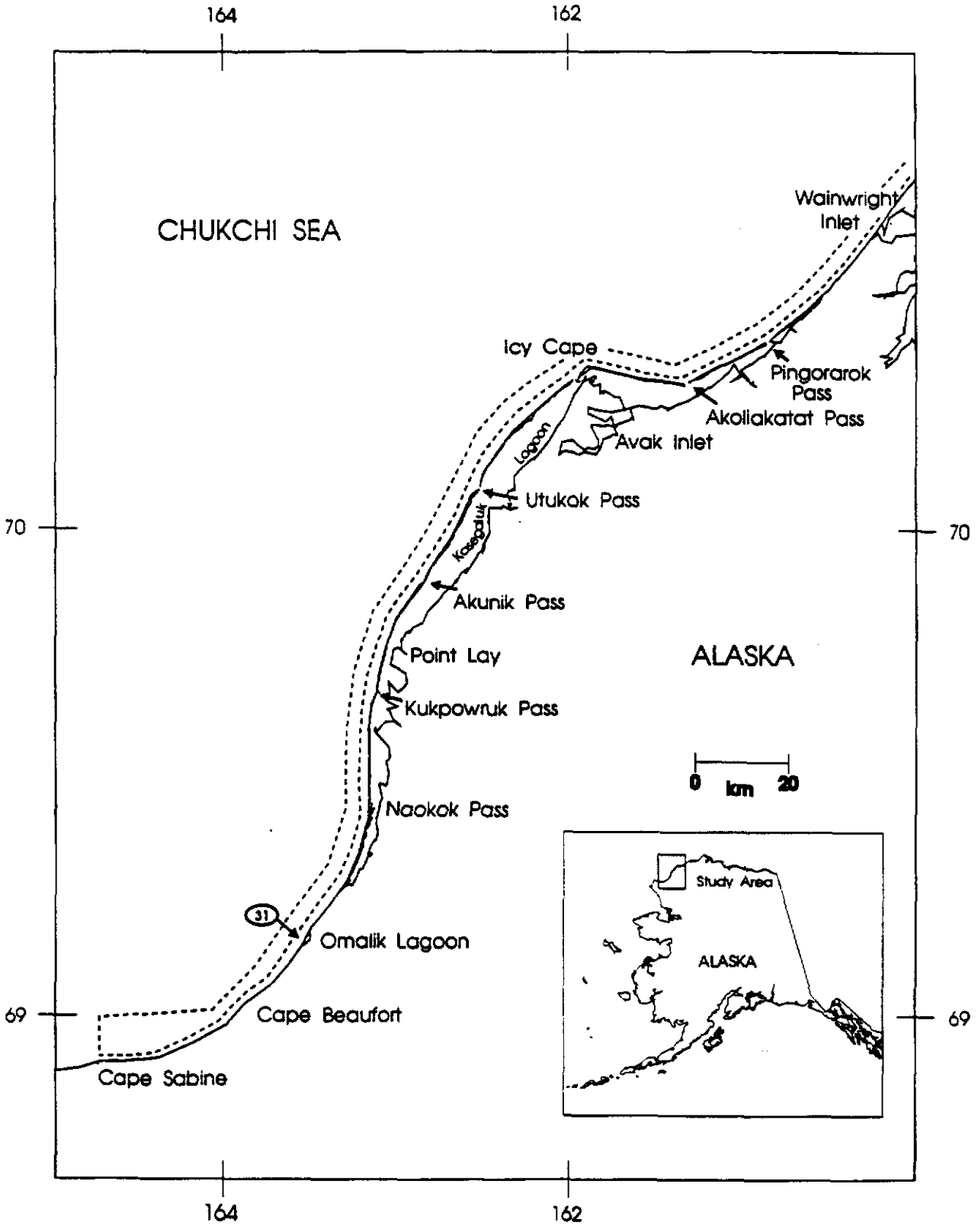

Figure A-7. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 9, 1990.

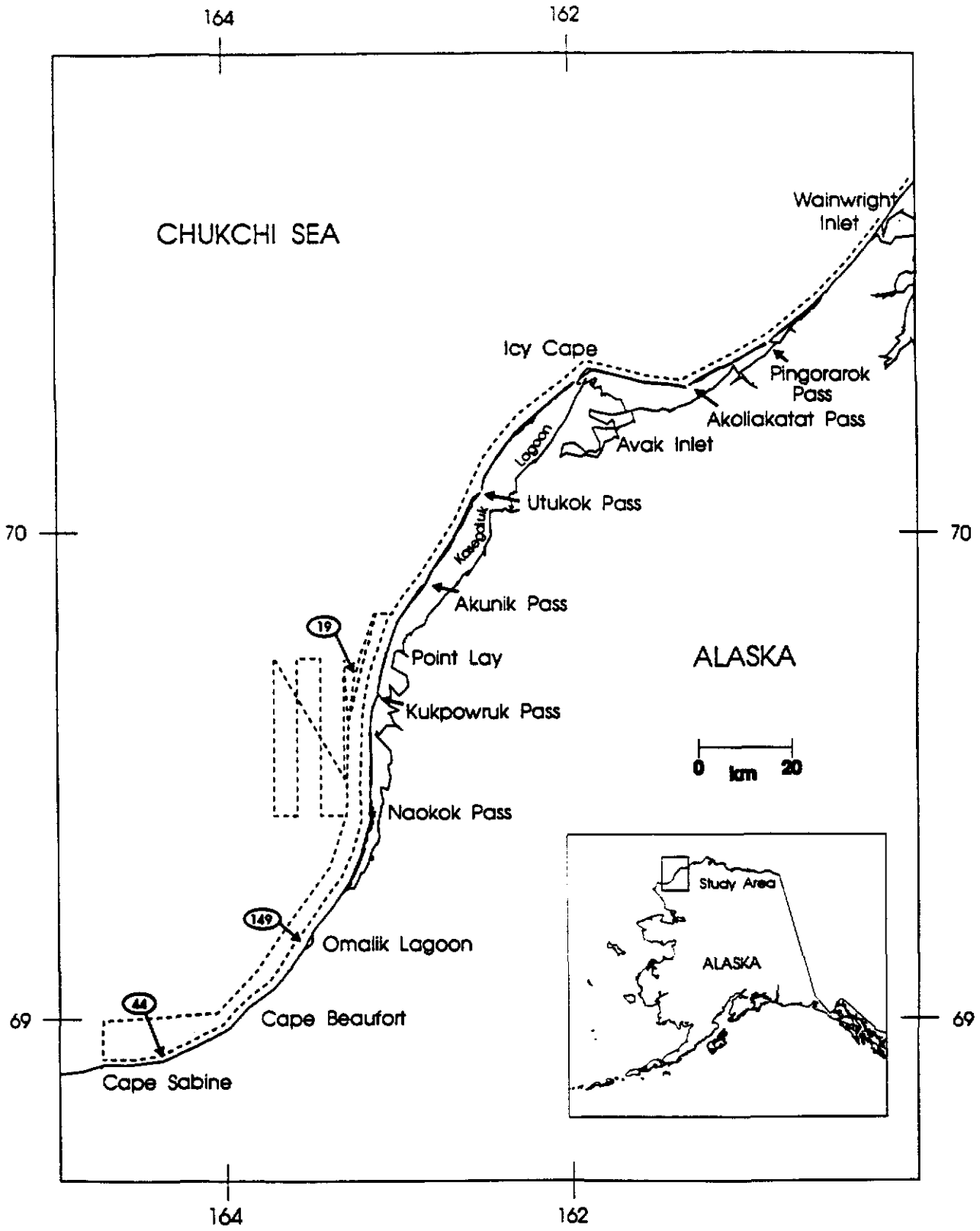

Figure A-8. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 10, 1990.

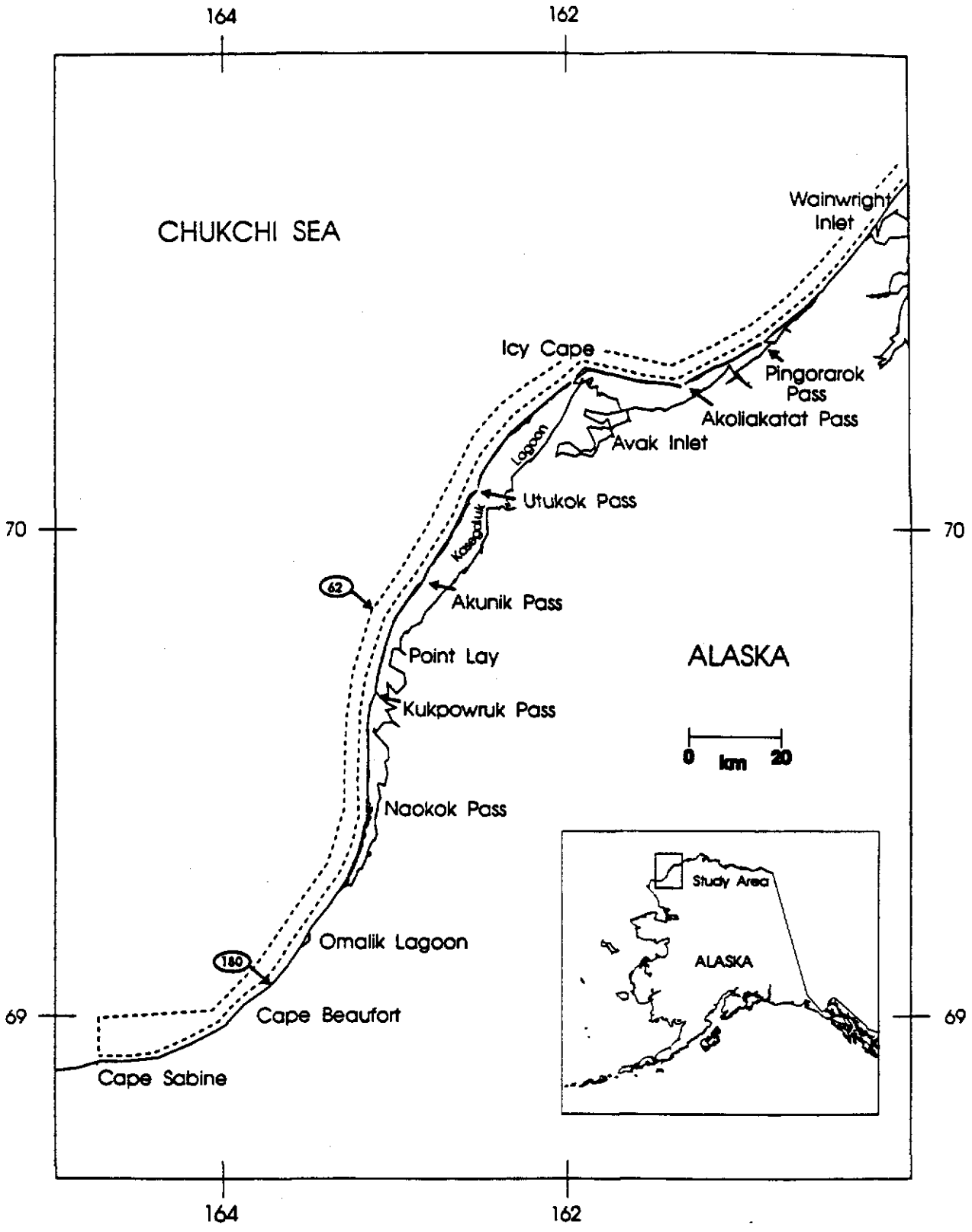

Figure A-9. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 11, 1990.

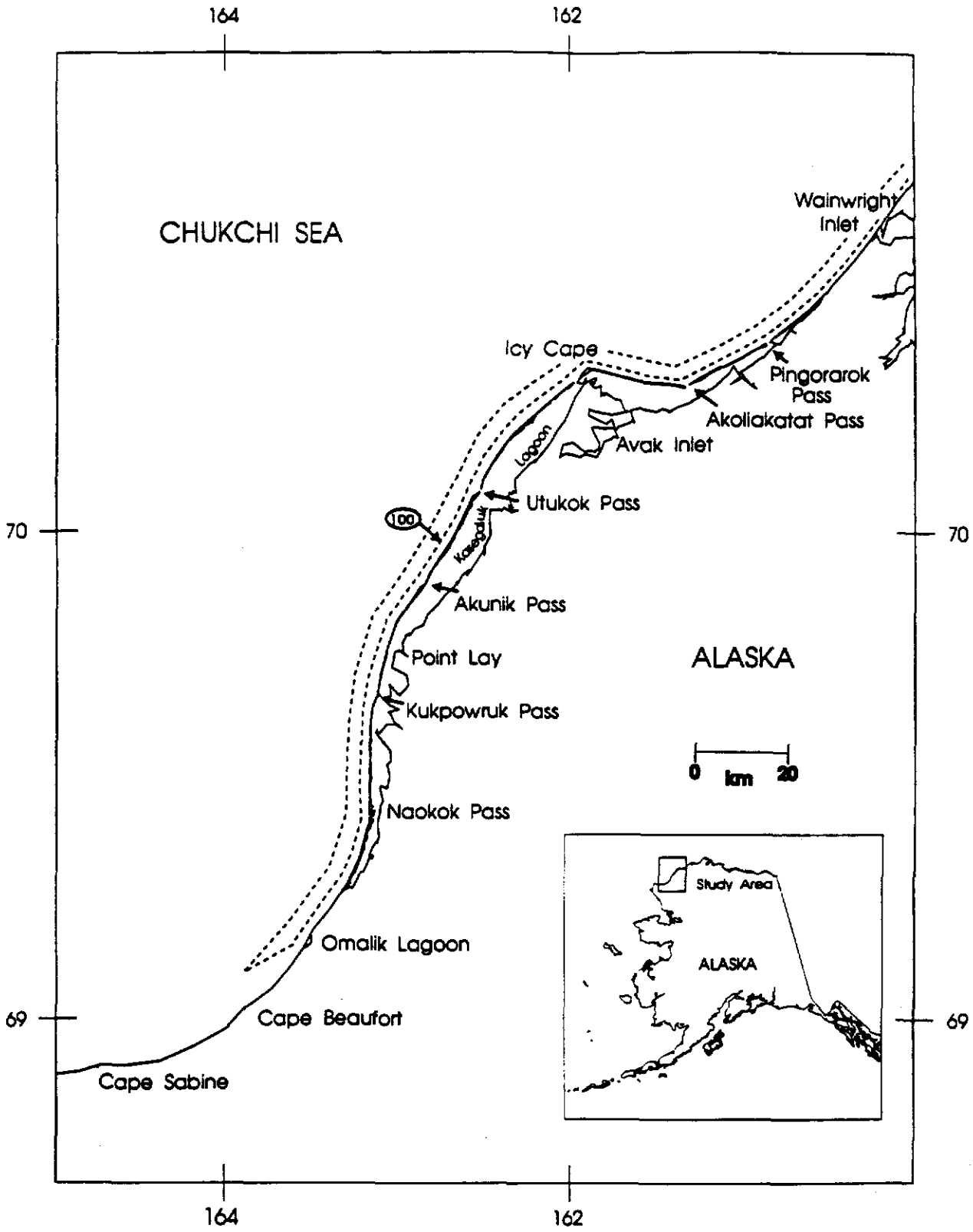

Figure A-10. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 12, 1990.

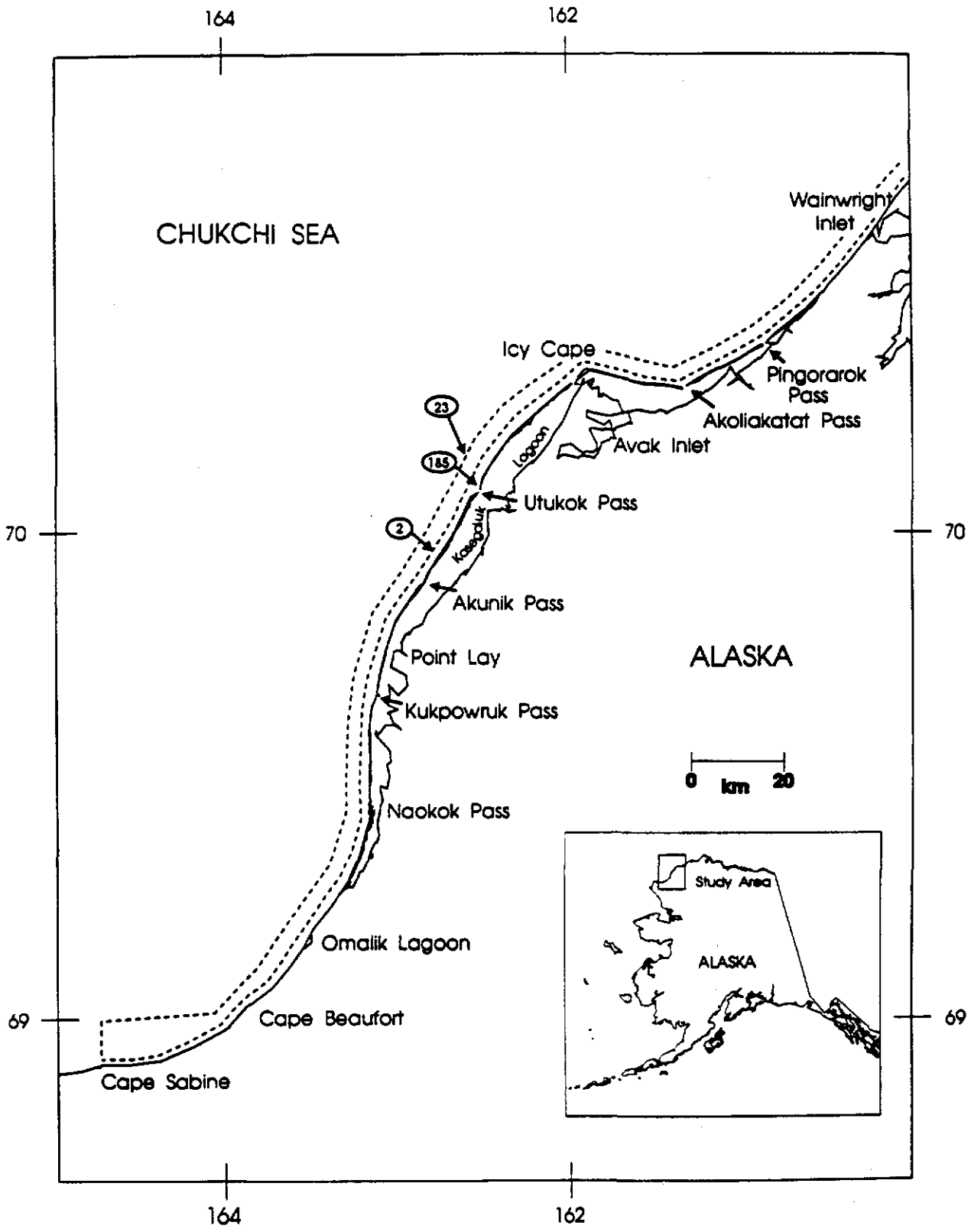

Figure A-11. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 13, 1990.

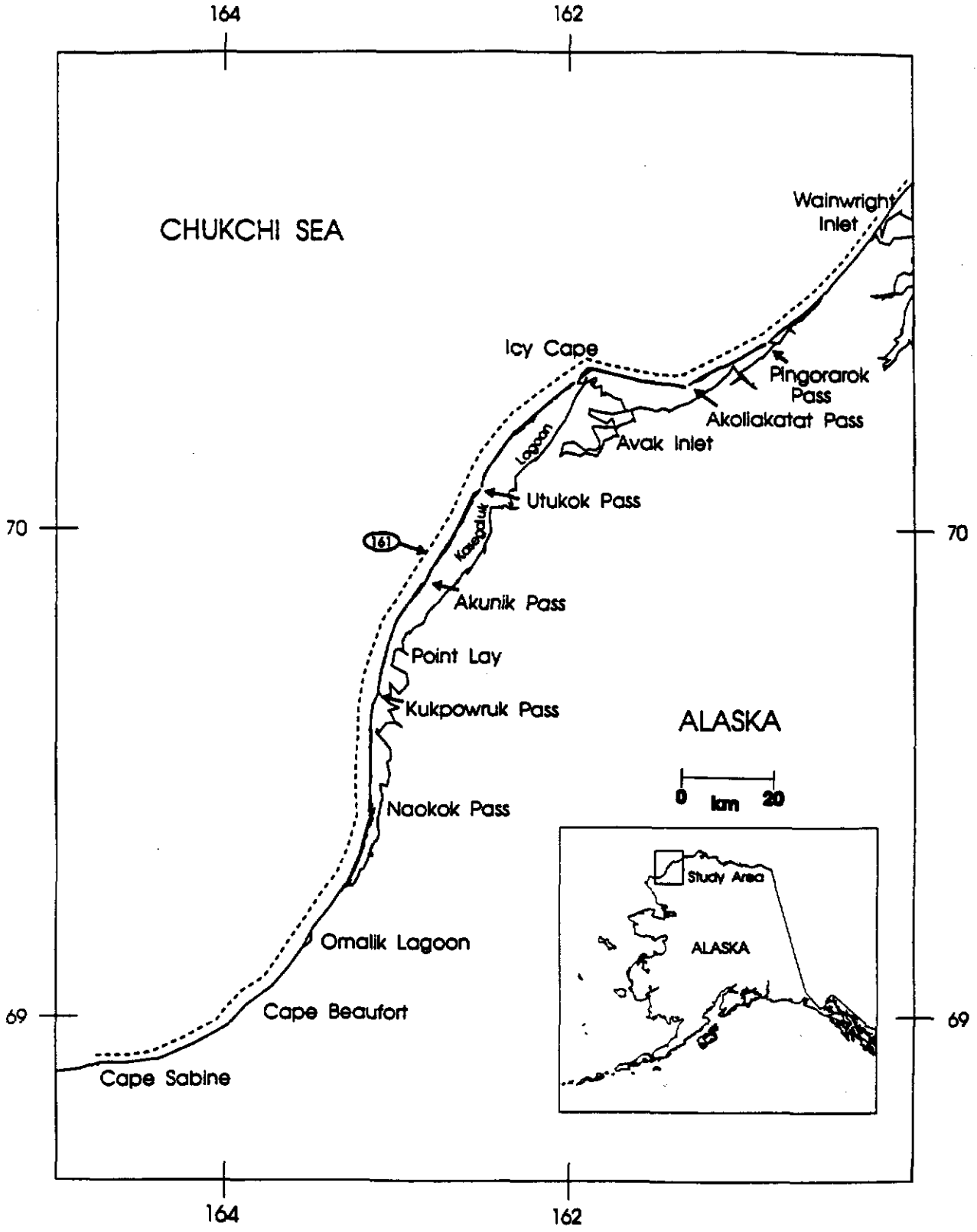

Figure A-12. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 14, 1990.

APPENDIX B

DAILY FLIGHT LINES AND SIGHTINGS FROM AERIAL SURVEYS FOR BELUGA WHALES IN THE KASEGALUK LAGOON REGION, JULY 4-16, 1991

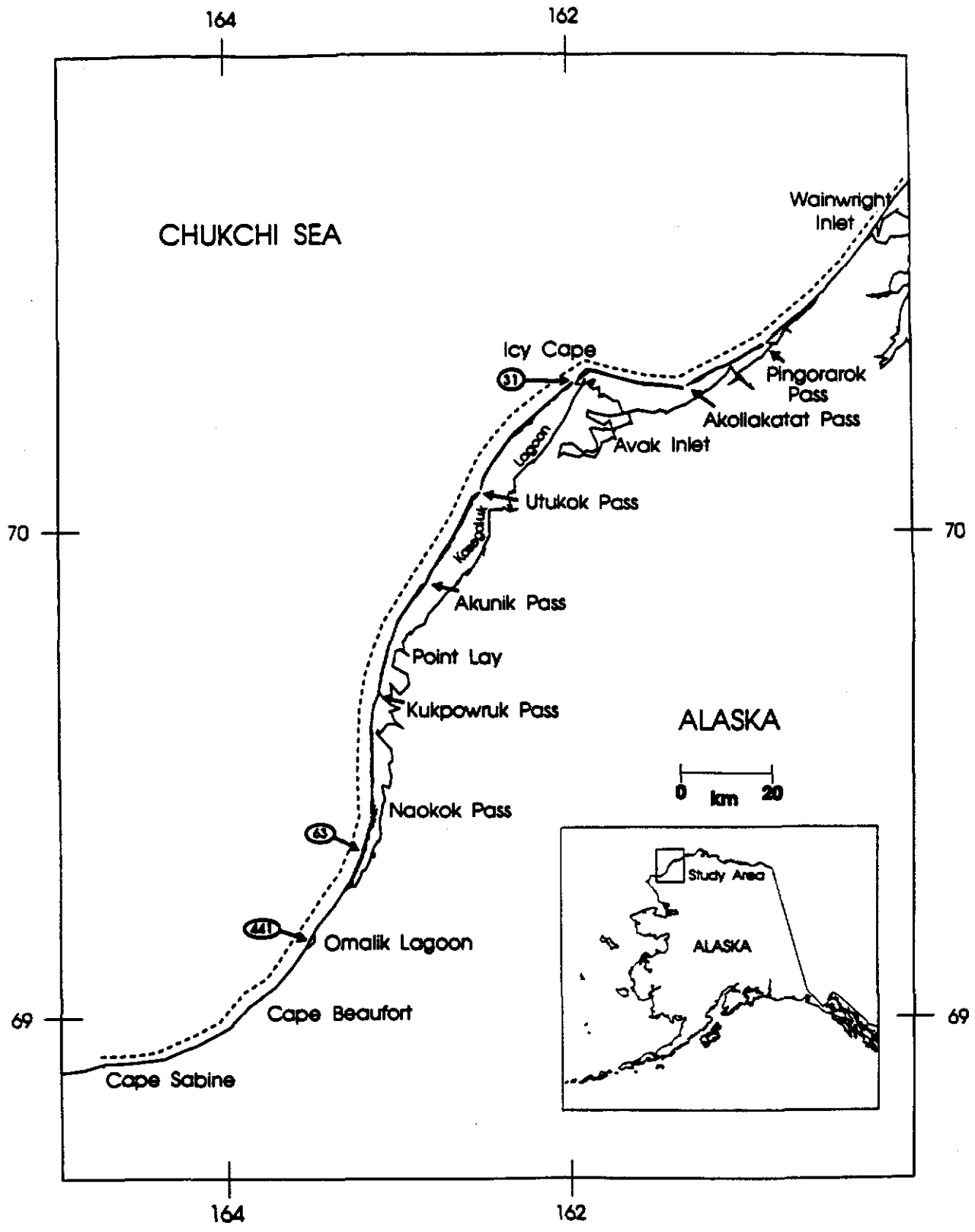

Figure B-1. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 4, 1991.

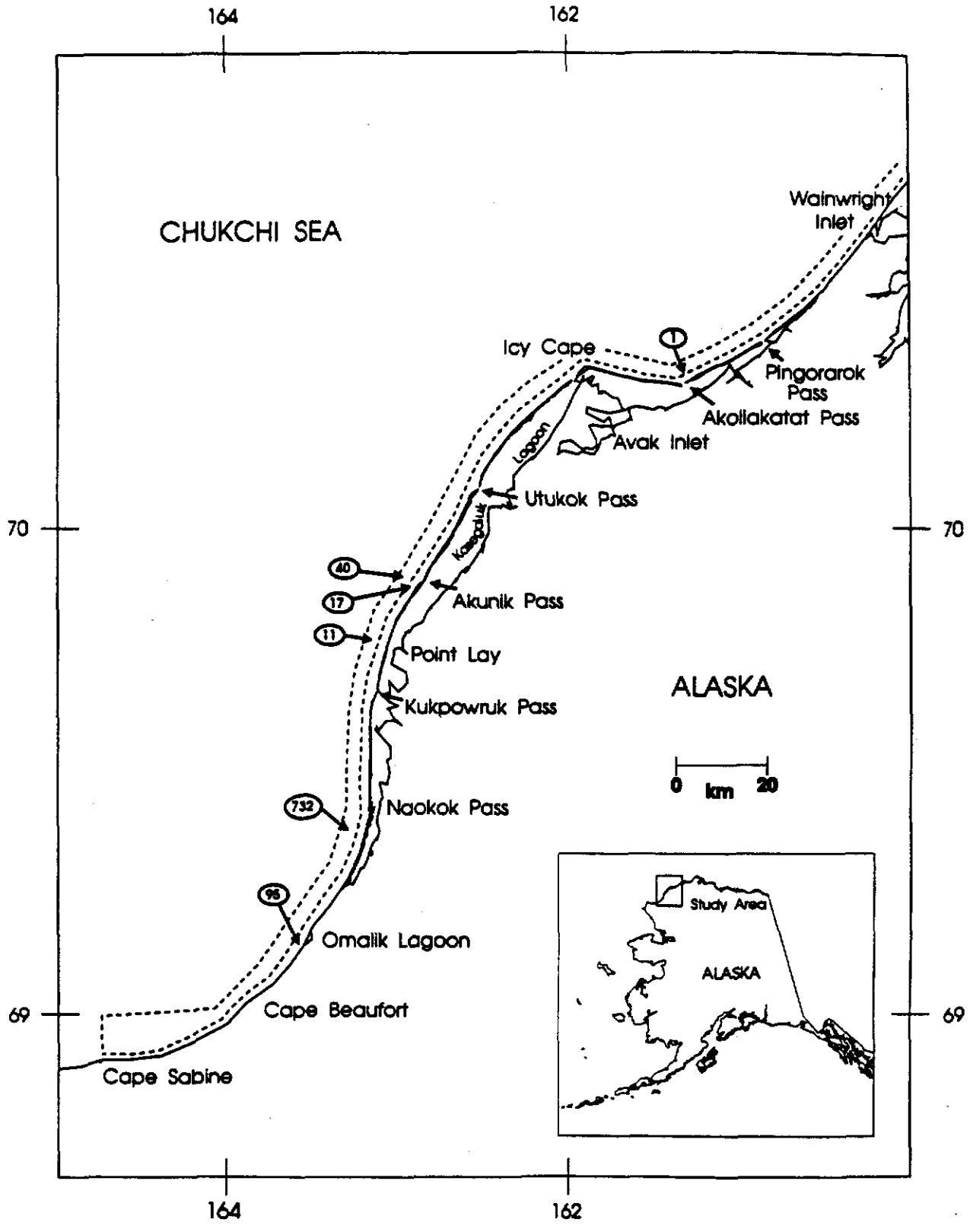

Figure B-2. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 5, 1991.

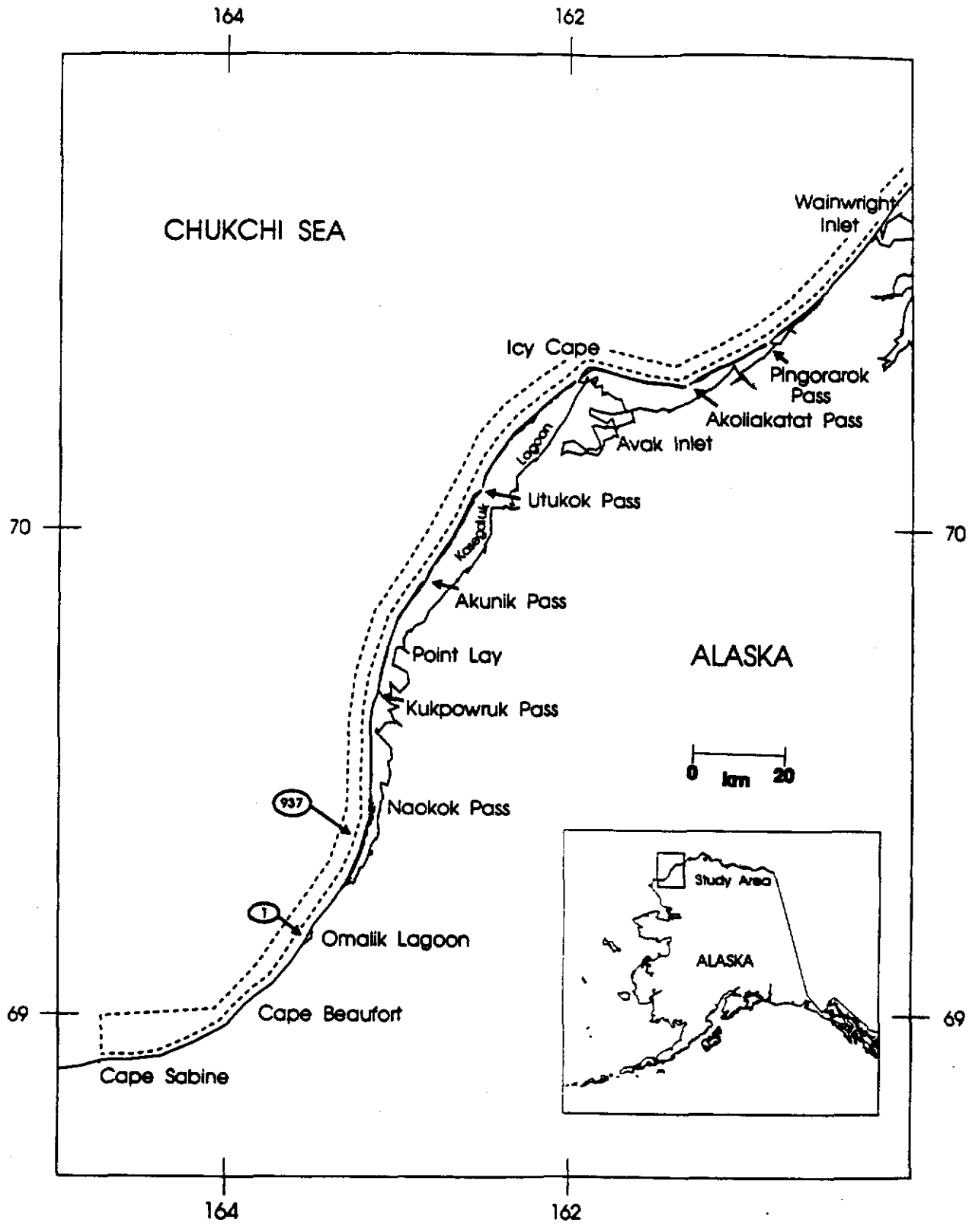

Figure B-3. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 6, 1991.

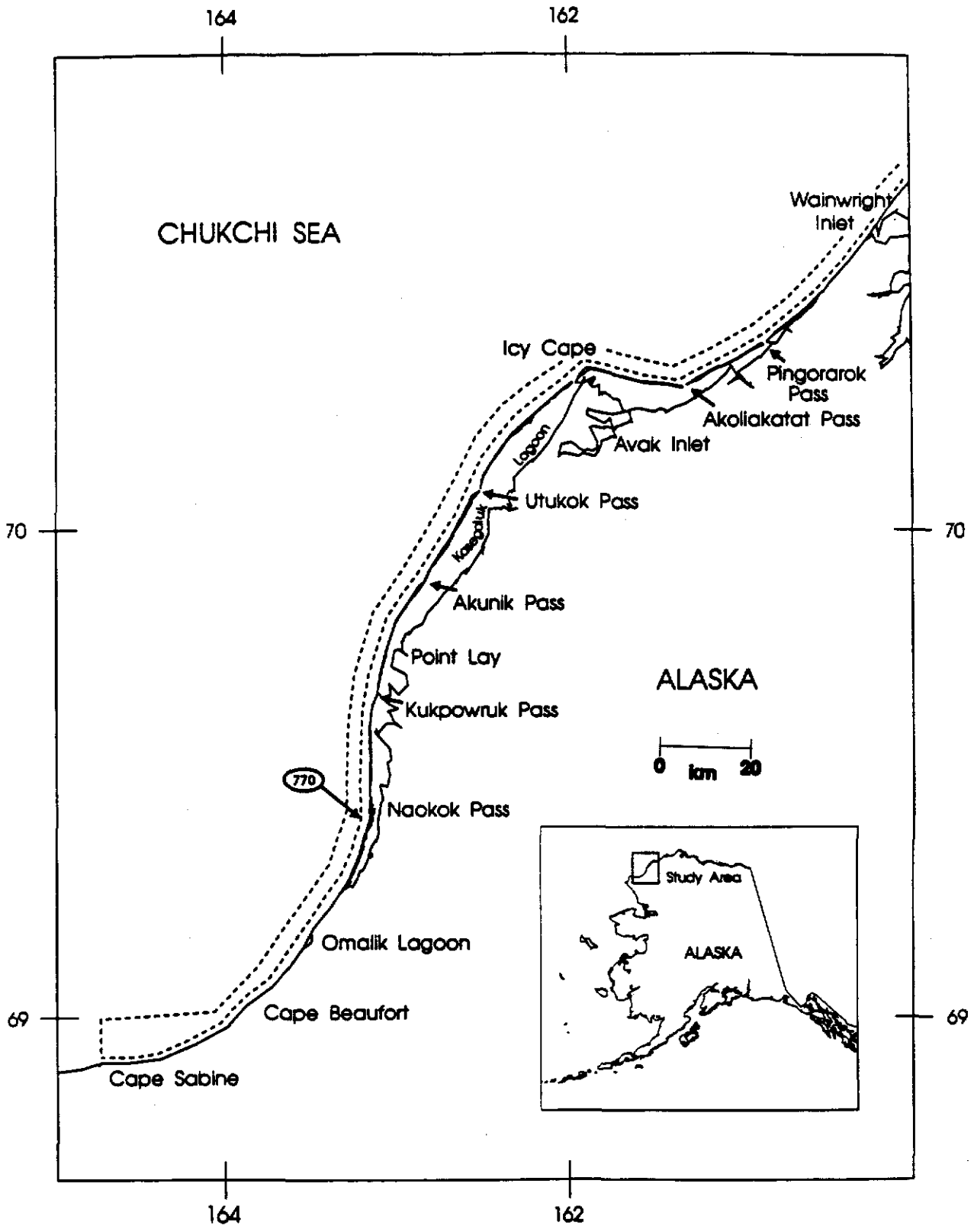

Figure B-4. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 7, 1991.

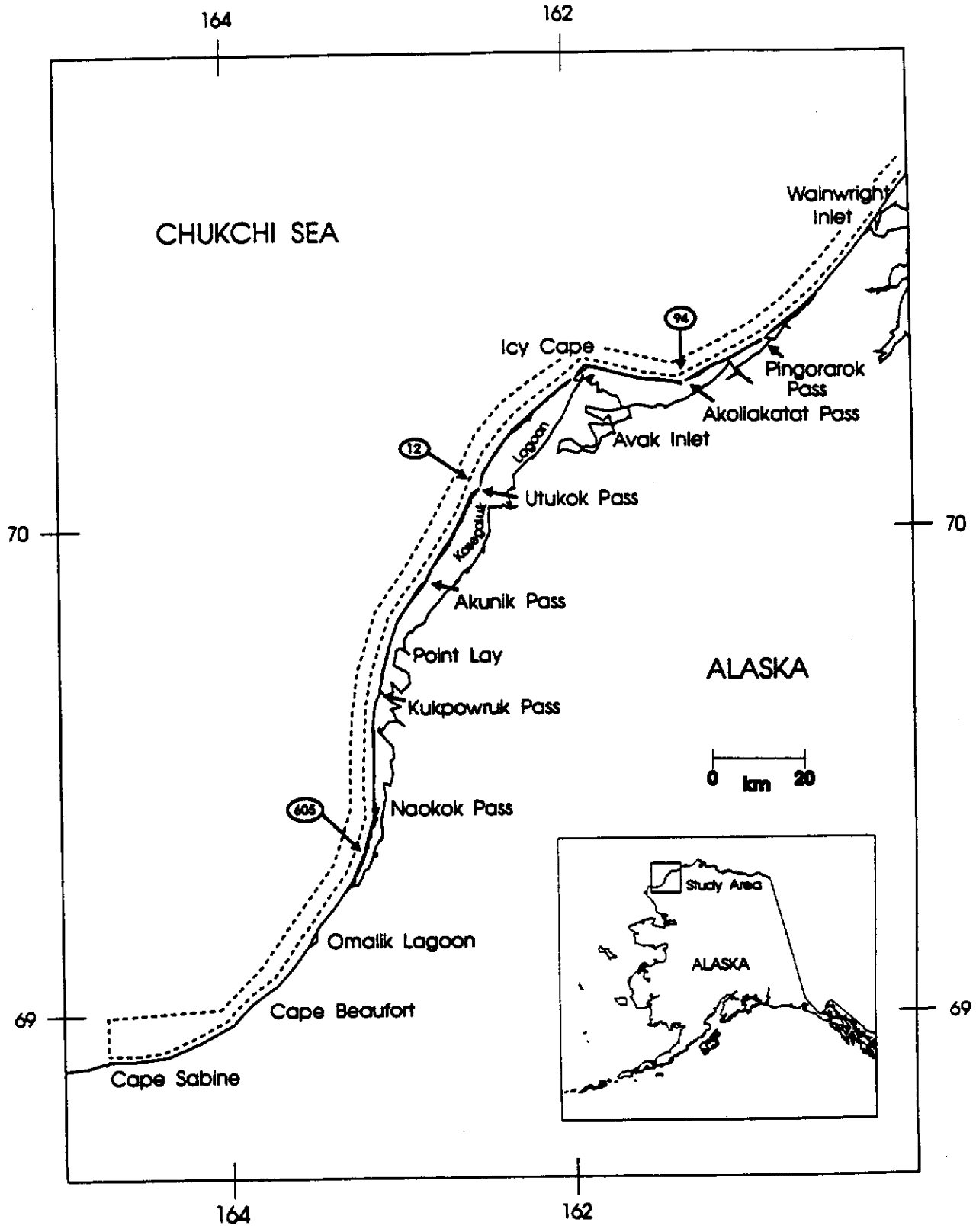

Figure B-5. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 8, 1991.

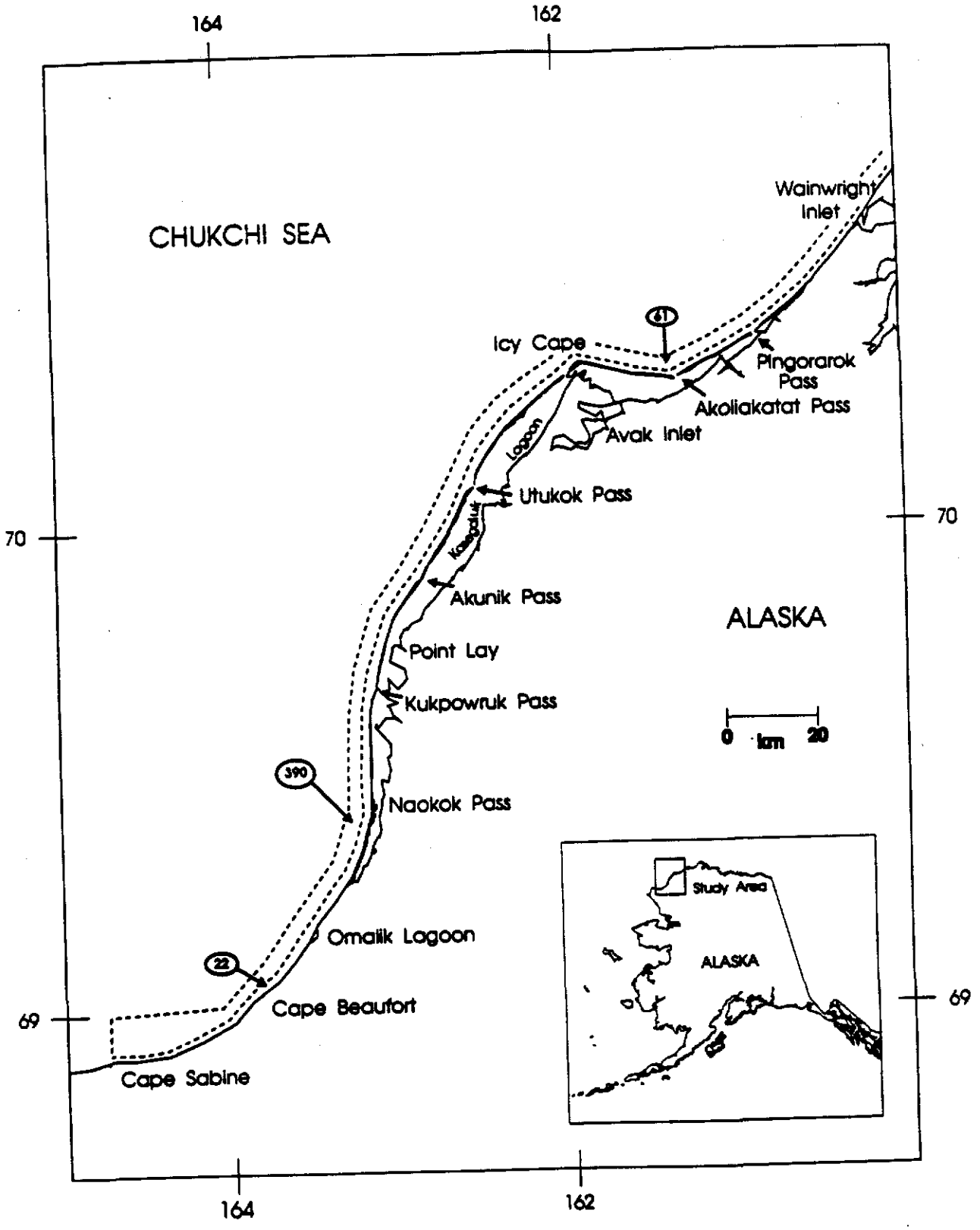

Figure B-6. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 9, 1991.

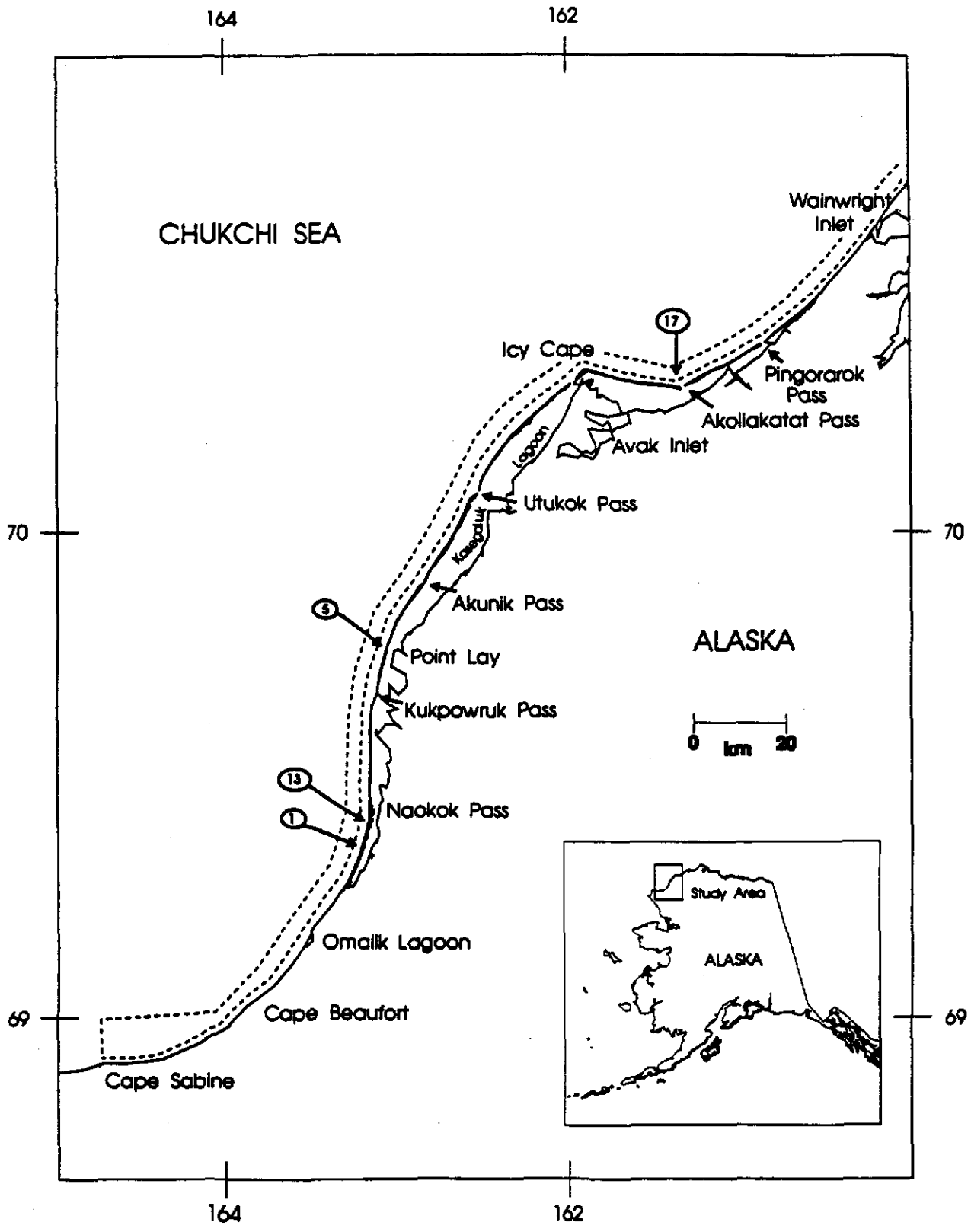

Figure B-7. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 11, 1991.

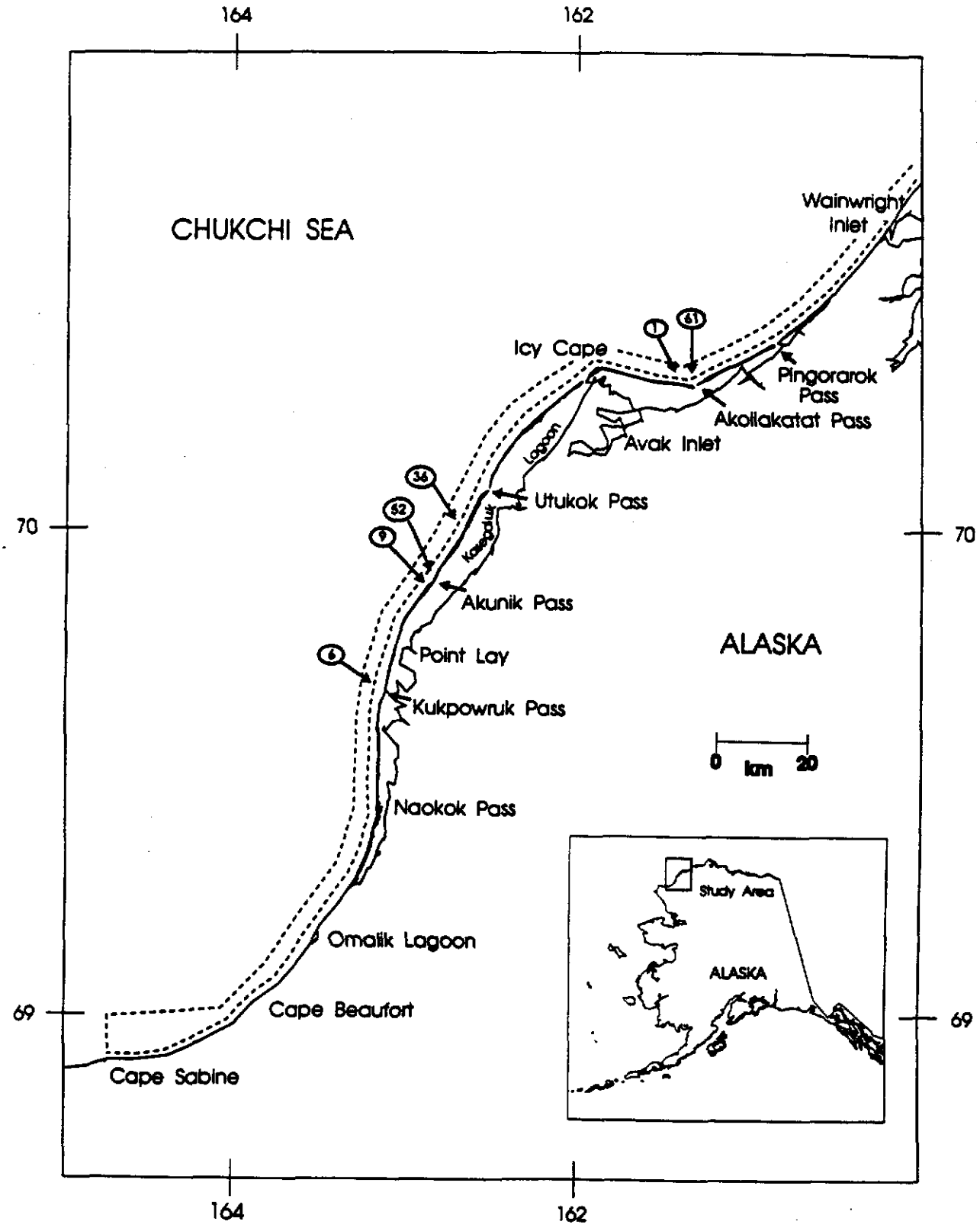

Figure B-8. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 12, 1991.

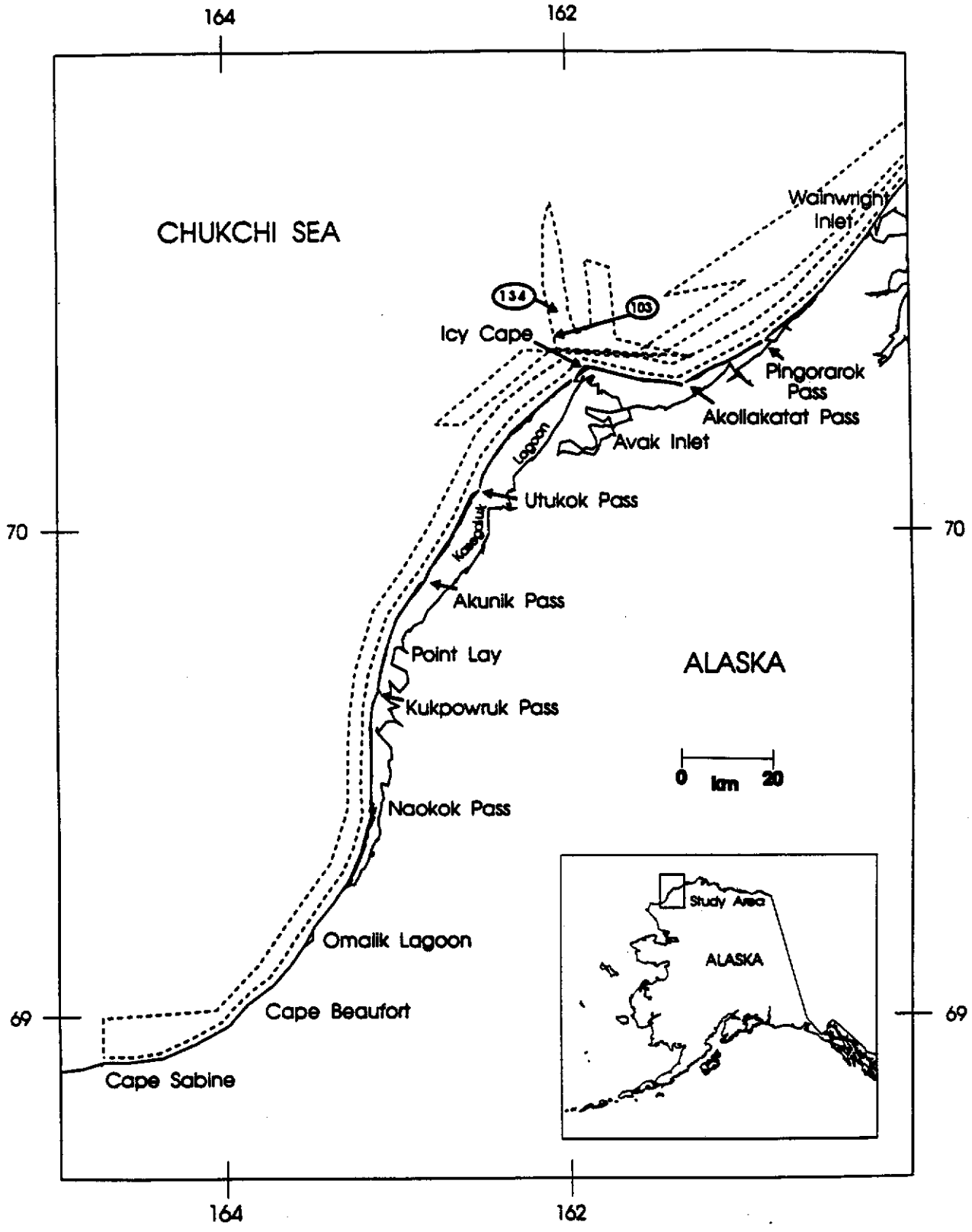

Figure B-9. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 13, 1991.

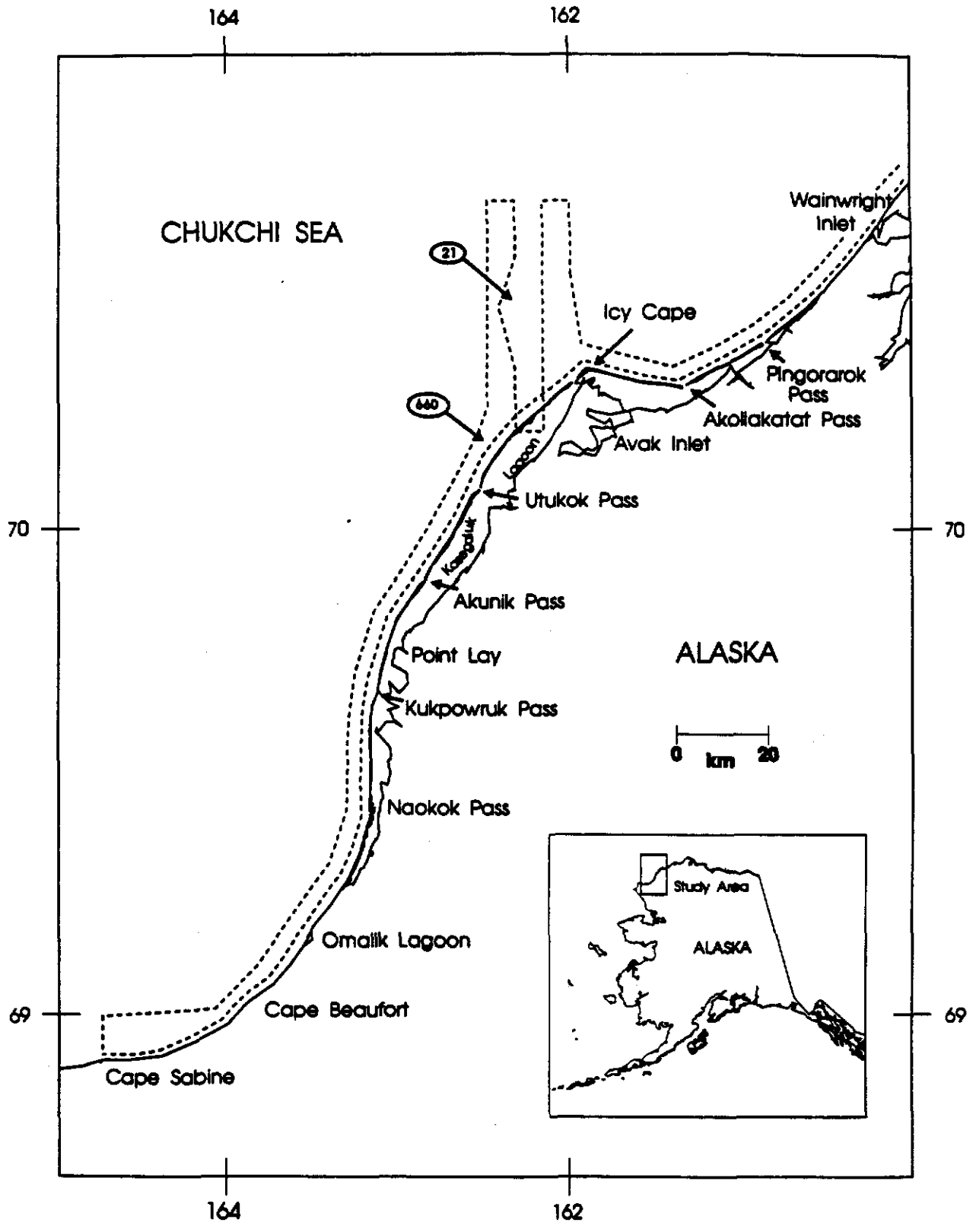

Figure B-10. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 14, 1991.

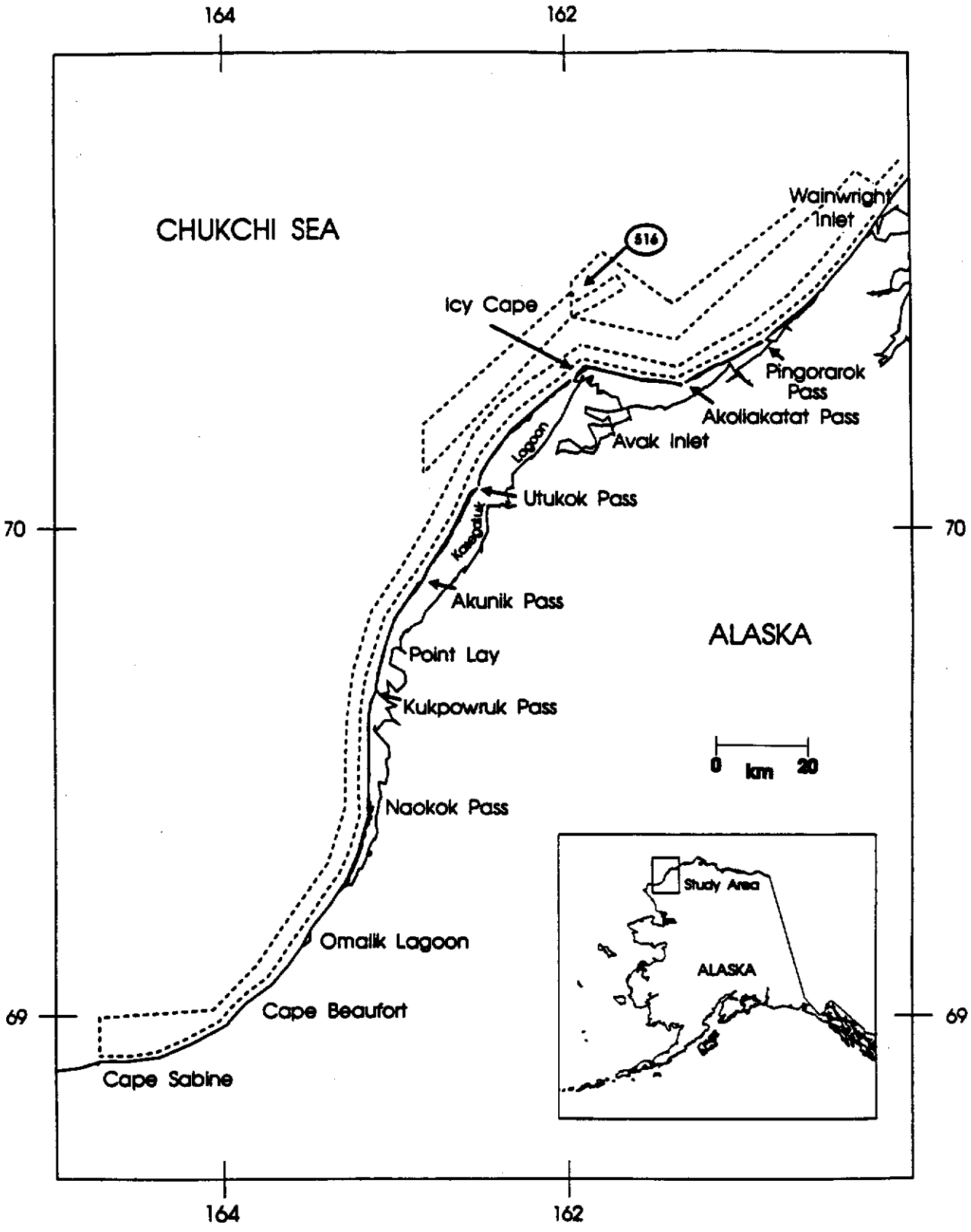

Figure B-11. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 15, 1991.

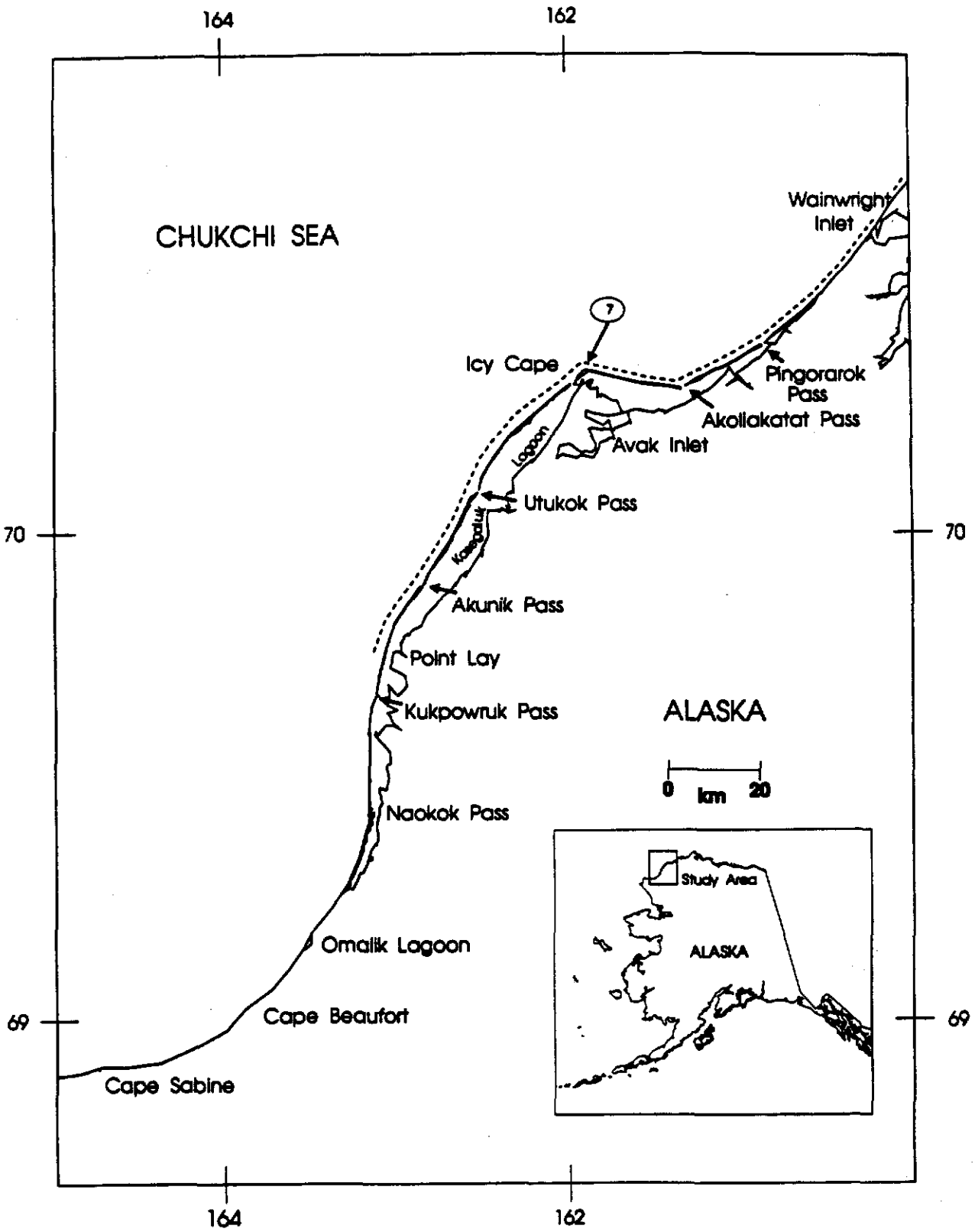

Figure B-12. Flight lines and beluga whale sightings in the Kasegaluk Lagoon study area on July 16, 1991.