ALASKA BELUGA WHALE COMMITTEE
REPORT 99-2

Alaska Beluga Whale Committee Surveys of Beluga Whales in the eastern Bering Sea, 1992-1995

Prepared by

Lloyd F. Lowry[1], Douglas P. DeMaster[2], and Kathryn J. Frost[1]

[1]Department of Fish and Game, Fairbanks, AK 99701
[2]National Marine Mammal Laboratory, Seattle, WA 98115

Assisted by

Tom Blaesing, Debbie Blaesing, Rob DeLong,
Bob Nelson, and Dieter Betz

This project was funded by National Oceanic and Atmospheric Administration grants NA27FX0258-01, NA37FX0267, NA47FX0498, and NA57FX0368 to the Alaska Beluga Whale Committee.

23 March 1999

SUMMARY

The first systematic aerial surveys of beluga whales in the Norton Sound/Yukon Delta region were flown during May, June, and September 1992, and June 1993-1995. During May 1992 surveys, all of the survey area was covered with pack ice and only a few belugas were seen. In June 1992-1994, many whales were seen in the region of Pastol Bay and the Yukon River Delta, with a few animals seen in eastern Norton Sound. In June 1995 whales were seen off they Yukon River as well as throughout central Norton Sound. In September 1992 whales were more dispersed and occurred both off the Yukon Delta and in coastal waters of northern Norton Sound.

Beluga density estimates were calculated for June 1992 surveys using strip transect methods, and for June 1993-1995 using line transect methods. In 1995, fog precluded surveying the entire area during a single series of surveys so separate estimates were made for early and late June. Density estimates varied from 0.249 to 2.070 belugas/nm^2. Correction factors were applied to account for animals that were missed during the surveys. For the present, the best estimate of abundance for the eastern Bering Sea beluga stock is 17,675 based on counts made in early June 1995. This estimate is likely to be conservative. There are no previous abundance estimates that can be used to evaluate population trend.

INTRODUCTION

Beluga whales (*Delphinapterus leucas*) occur in coastal and offshore waters of western Alaska (Seaman et al. 1988). During summer months they predictably concentrate in certain coastal locations, and this distribution pattern was initially used to identify three provisional management stocks (Seaman et al. 1988, Frost and Lowry 1990). Studies of mitochondrial DNA have confirmed the existence of three beluga stocks that occur in western Alaska during summer months (O'Corry-Crowe et al., 1997), which are currently referred to as the Bristol Bay stock, the eastern Bering Sea stock, and the eastern Chukchi Sea stock.

During the ice-free season along the western coast of Alaska annual concentrations of belugas occur in Bristol Bay, the Norton Sound/Yukon Delta region, Kotzebue Sound, and at Kasegaluk Lagoon (Frost and Lowry 1990). There have been several studies of the distribution and seasonal abundance of belugas in Bristol Bay (Brooks 1955, Frost et al. 1984, 1985) and at Kasegaluk Lagoon (Seaman et al. 1988, Frost et al. 1993). However, prior to 1992 there had been no systematic surveys of beluga whales in the Norton Sound/Yukon Delta region, and information on whales in that area came only from opportunistic observations. In this report we will refer to this region as the eastern Bering Sea (EBS).

The National Oceanic and Atmospheric Administration (NOAA) has provided funds to the Alaska Beluga Whale Committee (ABWC) to conduct studies of beluga whales in Alaska. Part of the ABWC research program consists of aerial surveys to estimate the abundance and trends of western Alaska beluga stocks. This report describes the results of ABWC surveys flown in the EBS during 1992-1995, and compares those results with previous beluga population data for this area.

REVIEW OF PREVIOUS STUDIES

The occurrence of belugas in Norton Sound in the 1840s was described by Zagoskin (1967, cited in Lucier and VanStone 1995). He noted that beginning in July "the beluga appear in great numbers with their young as they follow the fish outside the mouths of the Yukon." He described large organized hunts that occurred in mid-July in Pastol Bay, where as many as 100 animals were taken in a single drive. According to Nelson (1887), belugas usually appeared at St. Michaels between the 5th and 10th of June, and schools of 20 to over 100 animals were frequently seen in the bay nearby. He documented the summer occurrence of belugas at the mouth of the Yukon River, and as much as 450 miles upstream. Lensink (1961) noted that movements into coastal estuaries occurred shortly after ice moved offshore and provided additional records of belugas in the Yukon River.

Limited observations from aerial surveys have provided some additional data on beluga distribution in the EBS. Harrison and Hall (1978) flew bird and mammal surveys in this region and made five sightings of belugas in Norton Sound in late August 1976. During 1981, Ljungblad et al. (1982) flew aerial surveys to look for whales in the northern Bering Sea, and saw belugas in Norton Sound on 22 June (12 animals), 6 July (10 animals), and 12 July (137 animals). Sightings made by Ljungblad et al. were all in southern Norton Sound in the region between Stuart Island and the north mouth of the Yukon River. They noted that on 12 July a sonobuoy recorded more than 100 belugas

"vigorously feeding in shallow, muddy water near the Yukon River delta." Alaska Department of Fish and Game biologists fly aerial surveys to assess herring (*Clupea harengus*) stocks in Norton Sound each year shortly after breakup (late May and early June). Those surveys have provided numerous sightings of beluga whales throughout Norton Sound and off the Yukon River Delta (Frost and Lowry 1990).

A further confirmation that belugas regularly occur in the EBS region comes from records of harvests by Alaska Native hunters. For example, Lowry et al. (1989) documented harvests of belugas at eight villages in southern, eastern, and northern Norton Sound during 1980-1986.

A compilation of all available observations showed that belugas occur throughout the coastal zone of the EBS from the mouth of the Yukon River to northern Norton Sound near Nome, with relatively few sightings made far offshore (Frost and Lowry 1990). Whales were seen from shortly after breakup (usually May) until freezeup (usually November).

Due to the lack of directed survey effort for belugas in the EBS, there are no reliable estimates of historical population size. Based on observations of local residents and biologists working in the area, Seaman et al. (1988) suggested a preliminary abundance estimate of 1,000-2,000 whales.

ABWC SURVEYS

Methods

Aerial surveys were flown during 27-29 May 1992, 17-21 June 1992, 18-22 September 1992, 14-18 June 1993, 11-16 June 1994, and 5-22 June 1995 (Table 1). The survey aircraft was a high-wing, twin engine Aero Commander.

The survey was designed to cover all coastal and nearshore waters of Norton Sound and the Yukon Delta (Figure 1). Some flights followed the coastline with the centerline of the aircraft kept approximately 0.5 nm offshore. Additional transects were flown east-west along lines of latitude and north-south along lines of longitude. When we began our surveys we had little idea where belugas would be located and how widely they might be distributed. An informal adaptive sampling design was therefore used to control the distribution of offshore transect lines. When whales were seen on an offshore transect, additional parallel transects were flown at a 2-5 nm spacing on both sides of the original line. We continued to fly parallel transects as long as whales were being seen, and stopped usually after two transects on which there were no sightings.

The flight crew included the pilot, a data recorder in the right front seat and two observers seated behind the pilot on the left and right sides of the aircraft. Survey altitude was usually 1,000 feet, and airspeed was 150 knots in 1992 and 120 knots in 1993-1995. Navigation was done by reference to landmarks and with a Global Positioning System (GPS). The survey was done in a passing mode, where whales were counted while staying on effort on the trackline. On coastal surveys, all belugas visible along the survey track were counted. For 1992 offshore transects, observers counted whales within 3,000 foot wide strips on each side of the aircraft. The strips were offset 1,000 feet from the centerline to eliminate the blind spot under the plane. In 1993-1995 the

primary transect was divided into seven zones and each whale sighting was recorded as in a particular zone. Inclinometers were used to delineate the inner and outer bounds of transects (15° to 53°) and zones (zone 0--less than 14°, zone 1--14° to 21°, zone 2--21° to 27°, zone 3--27° to 33°, zone 4--33° to 40°, zone 5--40° to 45°, and zone 6--45° to 51°).

In 1992 and 1993 sightings and other data were recorded by observers on datasheets in one-minute intervals. In 1994 and 1995 a computer data entry program was used that logged locations and times for the beginnings and ends of transects, position along transect every minute, and the exact time and position of each sighting. Weather, sighting conditions, seastate (using the Beaufort scale) and other relevant information were also recorded.

Beluga whale densities were calculated from the June 1992 strip transect survey data and from the 1993-1995 line transect survey data using the program DISTANCE (Laake et al. 1994). In line transect analyses, each sighting was considered to be a grouped cluster within a single sighting bin. Because belugas were almost never seen along coastal transects in northern and eastern Norton Sound those areas were not included in density calculations. The study area used for density calculations included the area in which transects were flown in central and southern Norton Sound and off the Yukon River delta, and the size of the study area varied based on the distribution of transects during a particular survey year.

Results

Surveys and Distribution

When aerial surveys were flown on May 27-29, 1992, Norton Sound was covered with pack ice. Only a few belugas were sighted in leads in the southern part of the Sound near Stuart Island (Figure 1).

During June 1992 surveys no whales were seen in coastal waters of northern or eastern Norton Sound, but many sightings were made in the area of Pastol Bay and off the Yukon River delta (Figure 2). Particularly high counts were made on June 19 (652 whales) and June 20 (792 whales; Table 1).

During September 1992, belugas were sighted north of the Yukon Delta, near Stuart Island, and at several locations in northern Norton Sound (Figure 3). The highest daily count of 214 whales was made on September 20.

In June 1993, survey effort concentrated in the Pastol Bay and Yukon Delta regions. Whales were commonly seen in this area (Figure 4), but counts were considerably lower than those made in 1992 (Table 1).

In June 1994, whales were seen off the Yukon Delta, in Pastol Bay, and also to the north and northeast of Stuart Island (Figure 5). Counts made in 1994 were generally similar to those in 1993, but considerably lower than in 1992 (Table 1).

In 1995 surveys began on 5 June. Belugas were seen on coastal transects off Cape Denbigh, and around Stuart Island (Figure 6). On offshore transects whales were seen throughout much of Norton Sound, southward into Pastol Bay. Daily counts on transects were 321, 294, and 114 (Table 1). Fog prevented adequate surveys in the area off the middle and south mouths of the Yukon. The only survey lines flown were either inshore or offshore of the usual concentration area or in poor survey conditions (Beaufort state 3).

Survey efforts resumed on 20 June 1995 in an effort to get coverage off the Yukon. On 20 June conditions were windy with dense fog in western Norton Sound and off the Yukon delta. Whales were seen on transects and coastal surveys in the southeastern Sound and around Stuart Island (Table 1; Figure 7). A group of more than 100 belugas was sighted about 35 nm east of Stuart Island. Fog prevented surveys on 21 June. On 22 June it was possible to fly surveys under the fog (800 ft altitude) off the Yukon, and 320 whales were counted on transects spaced 5 nm apart.

Density and Uncorrected Abundance Estimates

Density estimates were calculated for the June surveys in 1992, 1993, and 1994 by combining data from transects in the southern Norton Sound-Yukon River region on all days surveyed in a given year. Two separate density estimates were made for 1995. The first used data collected in the main part of Norton Sound during June 6-8, and the second used only data from June 22 off the mouth of the Yukon (Table 2). Density estimates were relatively low in 1993 (0.249/nm^2) and 1994 (0.278/nm^2), higher in 1992 (1.106/nm^2) and early June 1995 (0.957/nm^2), and highest in late June 1995 (2.070/nm^2). The distribution of belugas was clumped within the study area, and the density values obtained for a particular survey effort depend partly on the amount of survey effort that occurred in areas where there were no whales. The highest density estimate resulted from the late June 1995 survey which covered only the whale concentration area off the middle and south mouths of the Yukon River.

Uncorrected abundance estimates were calculated by multiplying the density estimate for each year times the area included in that year's survey (Table 2). The highest estimate was 5,717 whales for early June 1995, the year when surveys covered the largest area in Norton Sound.

CURRENT ABUNDANCE ESTIMATE

Belugas spend much of their time below the surface where they cannot be seen from the air (Frost et al. 1985, Martin and Smith 1992). Therefore, aerial survey counts must be corrected to estimate the actual number of animals that are present, not just the number that are at the surface. Some investigators have proposed correction factors for beluga surveys based on observations of breathing and diving cycles (Sergeant 1973), comparisons of simultaneous aerial and boat counts (Frost et al. 1983), and their impressions of sightability of different age classes (Brodie 1971). Data from radio-tagged belugas can be used to estimate the proportion of time spent at and below the surface (Frost et al. 1983, 1985), and that information can then be used to correct the actual survey counts for submerged belugas.

The water off the Yukon River delta and in southern Norton Sound where most of the belugas were counted was very muddy. Because animals were only visible when their backs were actually breaking the surface of the water, it is necessary to multiply actual counts by a correction factor to account for animals that were underwater and could not be seen to be counted.

There are no data on the surfacing and diving patterns of belugas in Norton Sound during the summer. Frost and Lowry (1995) analyzed surface and dive time data from two belugas tagged with VHF tags in Bristol Bay and three tagged in Cunningham Inlet (arctic Canada). The correction factors that they calculated varied with altitude and airspeed and differed for adult versus juvenile animals. We used the correction factor for adults only to adjust our 1992-1995 EBS survey data. Because surveys were usually flown at 1,000 ft altitude, it was not possible to see small, dark-colored neonates and young calves. For this reason, corrected counts were multiplied by an additional correction factor of 1.18 to account for these small, dark animals (Frost et al. 1984, Brodie 1971).

Population estimates obtained by correcting for the factors described above are shown in Table 3. Annual population estimates varied considerably from year to year principally because of differences in density estimates and area surveyed. At the current time we think the early June 1995 estimate of 17,675 whales is the best estimate of the size of the EBS beluga stock.

COMPARISON WITH PREVIOUS ABUNDANCE ESTIMATES

The ABWC surveys conducted in 1992-1995 have provided the first systematic information on the distribution of beluga whales in the Norton Sound/Yukon Delta region. Previously available information compiled by Frost and Lowry (1990) showed only scattered sightings of belugas in this region. There are no historical data available that can be used to compare with abundance estimates derived from 1992-1995 surveys. Results from this study indicate that the preliminary estimate of 1,000-2,000 whales for the EBS stock suggested by Seaman et al. (1988) was low by a very large amount.

While it is not possible to compare abundance estimates, the limited information available from previous aerial surveys in the EBS suggests a generally similar summer distribution of belugas has occurred for many years. Records from the 1800s indicate that belugas were very common off the mouths of the Yukon River and in Pastol Bay (Zagoskin 1967, cited in Lucier and VanStone 1995; Nelson 1887). Sightings reported by Harrison and Hall (1978) in August 1976 and Ljungblad et al. (1982) in June-July 1981 were in the southern half of Norton Sound and off the Yukon River delta, the region where we saw the highest densities of belugas during June 1992-1995.

ADEQUACY OF POPULATION ASSESSMENT

Based on the information available to us prior to these surveys (Frost and Lowry 1990) we expected to find belugas mostly near the coast during May-June. Contrary to our expectations, with the exception of around Stuart Island we sighted very few whales on transects that covered the strip

within 1 nm of the coast, or in areas such as Golovin Bay or Norton Bay. The most predictable region in which to find belugas was from the south mouth of the Yukon River to Stuart Island. West of the Yukon delta whales were seen every year in a narrow band 5-10 nm offshore. The location of this band of whales was virtually identical each year (Figure 8). North and east of the Yukon delta belugas were more broadly distributed in Pastol Bay. In 1995 the distribution of whales extended well into the northern half of Norton Sound (Figure 6). It is unclear whether whales were present in offshore waters of northern Norton Sound in other years also because there was little survey effort in that area (Figures 2, 4, and 5).

Our survey efforts were restricted to Norton Sound and nearshore waters off the Yukon River delta. Belugas are commonly seen in the Bering Sea to the west of Norton Sound during April-May when they are migrating northward through the ice (Moore et al. 1993). However, aerial surveys that were conducted during summer in the northern Bering Sea in 1975-1977 (Harrison and Hall 1978) and 1981-1983 (Ljungblad 1984, Moore et al. 1993) did not result in any beluga sightings west of our survey area.

Surveys conducted in 1992-1995 provided a good description of the general distribution of belugas in the Norton Sound/Yukon delta region in June. Whales in that region at that time are spread out over broad areas, and their distribution is conducive to counting using aerial surveys and line transect methods.

Because of the problems encountered with fog in 1995 it was not possible to survey the entire area normally occupied by belugas during a continuous time period. We chose not to combine the data from the two survey periods, and therefore each of the population estimates is based on only a portion of the total area. This undoubtedly resulted in conservative population estimates. While we were not able to fly the middle and south mouths of the Yukon in the earlier survey period, it is very likely that belugas were numerous in that region as they had been in June of 1992, 1993, and 1994. During the later survey period little effort was devoted to the main part of Norton Sound, but sightings made on June 20 indicated that belugas were in that region, as well as the area off the Yukon that was surveyed on June 22. If we could assume that the distribution of belugas within the overall survey area did not change significantly between June 5-8 and June 22 (i.e., the number of whales off the Yukon Delta during June 5-8 was similar to what we counted on June 22), our population estimate would be the sum of the early and later June estimates (i.e., approximately 24,000).

We think that the population estimate for EBS belugas calculated in this report is conservative for several reasons. Most importantly, as discussed above, we have used an estimate for 1995 that covered only a portion of the area known to be used by belugas and our estimate may not include a fairly large portion of this stock. Also, while we think the area we have focused on includes the main concentration of belugas in the EBS during June it is likely that some whales are elsewhere. For example, during summer months some belugas move into and up the Yukon River (Nelson 1887, Lensink, 1961, Frost and Lowry 1990), and our surveys have not included the river system itself. Another reason why our EBS abundance estimate is conservative is that no correction has been made for whales that were at the surface but missed by the observers. By comparing observer counts of belugas in Cook Inlet with videotapes, Hobbs et al. (1995)

concluded that observers missed a significant number of animals. DeMaster et al. (in press) have shown that on Norton Sound surveys more animals are missed in rougher sea states, and no adjustment for that undercounting has been made in this population estimate. A final factor that produces a conservative population estimate is the dive correction factor used. Frost and Lowry (1995) recommended that radiotag-based correction factors from adult animals only should be used to expand survey counts if separate corrections are made for missed calves and yearlings, and that recommendation was followed in this study. Belugas 1-2 years old have larger correction factors than adults because they generally are at the surface for shorter periods (Frost and Lowry 1995). It seems likely that 2-4 year old animals would also have shorter surfacings than adults, and applying the adult surface:dive correction factor to them therefore probably results in a negative bias in the population estimate.

DISCUSSION AND CONCLUSIONS

We have produced a preliminary estimate of abundance for the EBS beluga stock based on our 1995 surveys. However, there are clearly problems with that estimate because we were not able to survey the Yukon Delta and Norton Sound areas during the same dates. Heavy fog that develops off the Yukon Delta is a major problem and may complicate surveys in future years. Nonetheless we think an adequate population assessment of EBS belugas can be done using line-transect surveys flown in June provided that: 1) surveys of the Yukon Delta and Norton Sound areas can be done during the same range of dates; and 2) survey transects cover all of Norton Sound.

In order for survey counts to be useful for monitoring population trend they must be made in similar circumstances every year, or factors that affect the counts must be recorded and accounted for in the analysis (e.g., Frost et al. in press). DeMaster et al. (in press) have measured the effect that Beaufort state has on beluga counts in Norton Sound, and that information can be used to correct for sea state effects across years. Other factors such as the timing of environmental and biological events (e.g., sea ice breakup and the appearance of migratory fishes) may also be affecting beluga distribution and movements. Clearly, we do not yet fully understand the biology of belugas in this region, and more studies will be needed before we can develop a satisfactory population monitoring program.

ACKNOWLEDGMENTS

We thank Tom Blaesing and Dave Weintraub of Commander Northwest for their expert service as survey pilots, Bob Nelson for serving as an observer on many flights, Debbie Blaesing and Dieter Betz for recording data during surveys, and Rob DeLong for assistance with data analysis. Members of the Alaska Beluga Whale Committee and other residents of the Norton Sound region provided us helpful information on the distribution and biology of beluga whales. This project was funded by National Oceanic and Atmospheric Administration grants NA27FX0258-01, NA37FX0267, NA47FX0498, and NA57FX0368 to the Alaska Beluga Whale Committee. Personnel from the North Slope Borough, especially Marie Adams and Cindy Weber, provided

essential help with administration of this grant. Additional support for report preparation was provided by the Alaska Department of Fish and Game and the National Marine Fisheries Service.

LITERATURE CITED

Brodie, P. F. 1971. A reconsideration of aspects of growth, reproduction, and behavior of the white whale (Delphinapterus leucas) with reference to the Cumberland Sound, Baffin Island, population. J. Fish. Res. Board Can. 28:1309-1318.

Brooks, J. W. 1955. Beluga investigations. Annu. Rep. Alaska Dep. Fisheries, Juneau 7:98-106.

DeMaster, D., K. Frost, L. Lowry, and T. Pierce. 1995. Abundance estimate for beluga whales (*Delphinapterus leucas*) in Norton Sound: June 1992, 1993, and 1994. Appendix III *in*: R. Suydam, ed. Proceedings of the Alaska Beluga Whale Committee First Conference on the Biology of Beluga Whales.

DeMaster, D. P., L. F. Lowry, K. J. Frost, and R. A. Paulson. In press. The effect of sea state on estimates of abundance for beluga whales (*Delphinapterus leucas*) in Norton Sound, Alaska. Fish. Bull. U.S.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska. Pages 39-57 in: T. G. Smith, D. J. St. Aubin, and J. R. Geraci, eds. Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Frost, K. J., and L. F. Lowry. 1995. Radiotag based correction factors for use in beluga whale population estimation. Working paper for Alaska Beluga Whale Committee Scientific Workshop, Anchorage, AK., April 5-7, 1995. 12 p.

Frost, K. J., L. F. Lowry, and R. R. Nelson. 1983. Investigations of beluga whales in coastal waters of western and northern Alaska, 1982-83: marking and tracking of whales in Bristol Bay. U. S. Dep. Commerce, NOAA, OCSEAP Final Rep. 43(1986):461-585.

Frost, K. J., L. F. Lowry, and R. R. Nelson. 1984. Beluga whale studies in Bristol Bay, Alaska. Pages 187-200 *in*: Proc. of the workshop on biological interactions among marine mammals and commercial fisheries in the southeastern Bering Sea. Univ. Alaska Sea Grant Rep. 84-1.

Frost, K. J., L. F. Lowry, and R. R. Nelson. 1985. Radiotagging studies of beluga whales, *Delphinapterus leucas*, in Bristol Bay, Alaska. Mar. Mamm. Sci. 1:191-202.

Frost, K. J., L. F. Lowry, and G. Carroll. 1993. Beluga whale and spotted seal use of a coastal lagoon system in the northeastern Chukchi Sea. Arctic 46:8-16.

Frost, K. J., L. F. Lowry, and J. M. Ver Hoef. In press. Monitoring the trend of harbor seals in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. Marine Mammal Science.

Harrison, C. S., and J. D. Hall. 1978. Alaskan distribution of the beluga whale, *Delphinapterus leucas*. Can. Field-Nat. 92:235-241.

Hobbs, R., J. M. Waite., D. J. Rugh, and J. A. Lerczak. 1995. Preliminary estimate of the abundance of beluga whales in Cook Inlet based on NOAA's June 1994 aerial survey and tagging experiments. Appendix V *in*: R. Suydam, ed. Proceedings of the Alaska Beluga Whale Committee First Conference on the Biology of Beluga Whales.

Laake, J. L., S. T. Buckland, D. R. Anderson, and K. P. Burnham. 1994. Distance user's guide. Colorado Cooperative Fish & Wildlife Research Unit, Colorado State University, Fort Collins, CO. 84 p.

Lensink, C. J. 1961. Status report: beluga studies. Unpubl. Rep. Alaska Dept. Fish and Game, Juneau, AK. 20 p.

Ljungblad, D. K., S. E. Moore, D. R. Van Schoik, and C. S. Winchell. 1982. Aerial surveys of endangered whales in the Beaufort, Chukchi, and northern Bering seas. Naval Ocean Systems Center, San Diego, CA, Tech. Doc. 486. 215 p.

Ljungblad, D. K., S. E. Moore, and D. R. Van Schoik. 1984. Aerial surveys of endangered whales in the northern Bering, eastern Chukchi, and Alaskan Beaufort seas, with a five year review, 1979-1983. Naval Ocean Systems Center, San Diego, CA, Tech. Rep. 955. 119 pp.

Lowry, L. F., J. J. Burns, and K. J. Frost. 1989. Recent harvests of belukha whales, *Delphinapterus leucas*, in western and northern Alaska and their potential impact on provisional management stocks. Rep. Int. Whal. Commn. 39:335-339.

Lucier, C. V., and J. W. VanStone. 1995. Traditional beluga drives of the Inupiat of Kotzebue Sound, Alaska. Fieldiana, New Series No. 25. 91 p.

Martin, A. R., and T. G. Smith. 1992. Deep diving in wild, free-ranging beluga whales, *Delphinapterus leucas*. Can. J. Fish. Aquat. Sci. 49:462-466.

Moore, S. E., J. T. Clarke, and M. M. Johnson. 1993. Beluga distribution and movements offshore northern Alaska in spring and summer, 1980-84. Rep. Int. Whal. Comn. 43:375-386.

Nelson, E. W. 1887. Report upon natural history collections made in Alaska between the years 1877 and 1881. Arctic Series Publ. No. 3, Signal Service, U. S. Army, Washington, D.C.

O'Corry-Crowe, G. M., R. S. Suydam,, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.

Seaman, G. A., K. J. Frost, and L. F. Lowry. 1988. Investigations of beluga whales in coastal waters of western and northern Alaska. Part I. Distribution, abundance and movements. U. S. Dep. Commerce, NOAA, OCSEAP Final Rep. 56:153-220.

Sergeant, D. E. 1973. Biology of white whales (*Delphinapterus leucas*) in western Hudson Bay. J. Fish. Res. Board Can. 30:1065-1090.

Table 1. Aerial surveys for beluga whales in the eastern Bering Sea region, June 1992-1995.

Dates	Observers	Areas Covered	Whales Counted
5/27/92	Frost, Lowry	Norton Sound pack ice	8
5/28/92	Frost, Lowry	Norton Sound pack ice	0
5/29/92	Frost, Lowry	Norton Sound pack ice	0
6/17/92	Lowry, Nelson	coastal Norton Sound	0
6/18/92	Lowry, Nelson	coastal & nearshore Norton Sound	152
6/19/92	Lowry, Nelson	Yukon Delta & Pastol Bay	652
6/20/92	Lowry, Nelson	Yukon Delta & Pastol Bay	792
6/21/92	Lowry, Nelson	coastal & nearshore Norton Sound	36
9/18/92	Lowry	northern Norton Sound	0
9/19/92	Lowry, Nelson	coastal & nearshore Norton Sound	82
9/20/92	Lowry, Nelson	coastal & nearshore Norton Sound	214
9/21/92	Lowry, Nelson	coastal Norton Sound & Pastol Bay	58
9/22/92	Lowry, Nelson	coastal & offshore Norton Sound	63
6/14/93	Frost, Nelson	coastal northern Norton Sound	0
6/15/93	Frost, Nelson	offshore Norton Sound	0
6/16/93	Frost, Nelson	Yukon Delta & Pastol Bay	231
6/17/93	Frost, Nelson	Yukon Delta	65
6/18/93	Frost, Nelson	Yukon Delta & Pastol Bay	46
6/11/94	Lowry, Nelson	coastal Norton Sound	16
6/12/94	Lowry, Nelson	Yukon Delta & Pastol Bay	131
6/13/94	Lowry, Nelson	coastal & southern Norton Sound	83
6/14/94	Lowry, Nelson	Yukon Delta	21
6/15/94	Lowry, Nelson	Norton Bay and Yukon Delta	4
6/16/94	Lowry, Nelson	Yukon Delta	97
6/5/95	Lowry, Blaesing	Yukon Delta to Nome	0
6/6/95	Lowry, Blaesing	coastal & southern Norton Sound	334
6/7/95	Lowry, Blaesing	Norton Sound	312
6/8/95	Lowry, Blaesing	Norton Sound	114
6/20/95	Lowry, Blaesing	coastal & southern Norton Sound	129
6/22/95	Lowry, Blaesing	Yukon Delta	326

Table 2. Densities and uncorrected abundance estimates for beluga whales in the eastern Bering Sea region, based on aerial surveys conducted in June 1992-1995.

Year	Density per nm^2	C.V.	Area (nm^2)	Uncorrected Abundance Estimate
1992	1.106	0.20	1,837	2,032
1993	0.249	0.32	3,281	817
1994	0.278	0.33	4,175	1,161
1995 early	0.957	0.34	5,974	5,717
1995 late	2.070	0.26	1,002	2,074

Table 3. Population estimates for beluga whales in the eastern Bering Sea region, based on densities calculated from aerial surveys conducted in June 1992-1995.

Survey	Uncorrected Estimate	CF[1]	Corrected Number	CF[2]	Number	Total Belugas	Lower 95% C.I.[3]	Upper 95% C.I.[3]
1992	2,032	2.98	6,055	0.18	1,090	7,145	4,803	10,628
1993	817	2.62	2,140	0.18	385	2,525	1,395	4,565
1994	1,161	2.62	3,042	0.18	548	3,590	1,915	6,723
1995 early	5,717	2.62	14,979	0.18	2,696	17,675	9,056	34,515
1995 late	2,070	2.62	5,292	0.18	953	6,245	3,757	10,949

[1] correction factor for whales not counted because they were below the surface when the plane passed over
[2] correction factor for neonates and yearlings not counted because of their small size and dark coloration
[3] accounts only for variation in the initial density estimate

- Note – these figures are correct but the figure numbers are not. Should start with Figure 1. Figs were taken from IWC report.

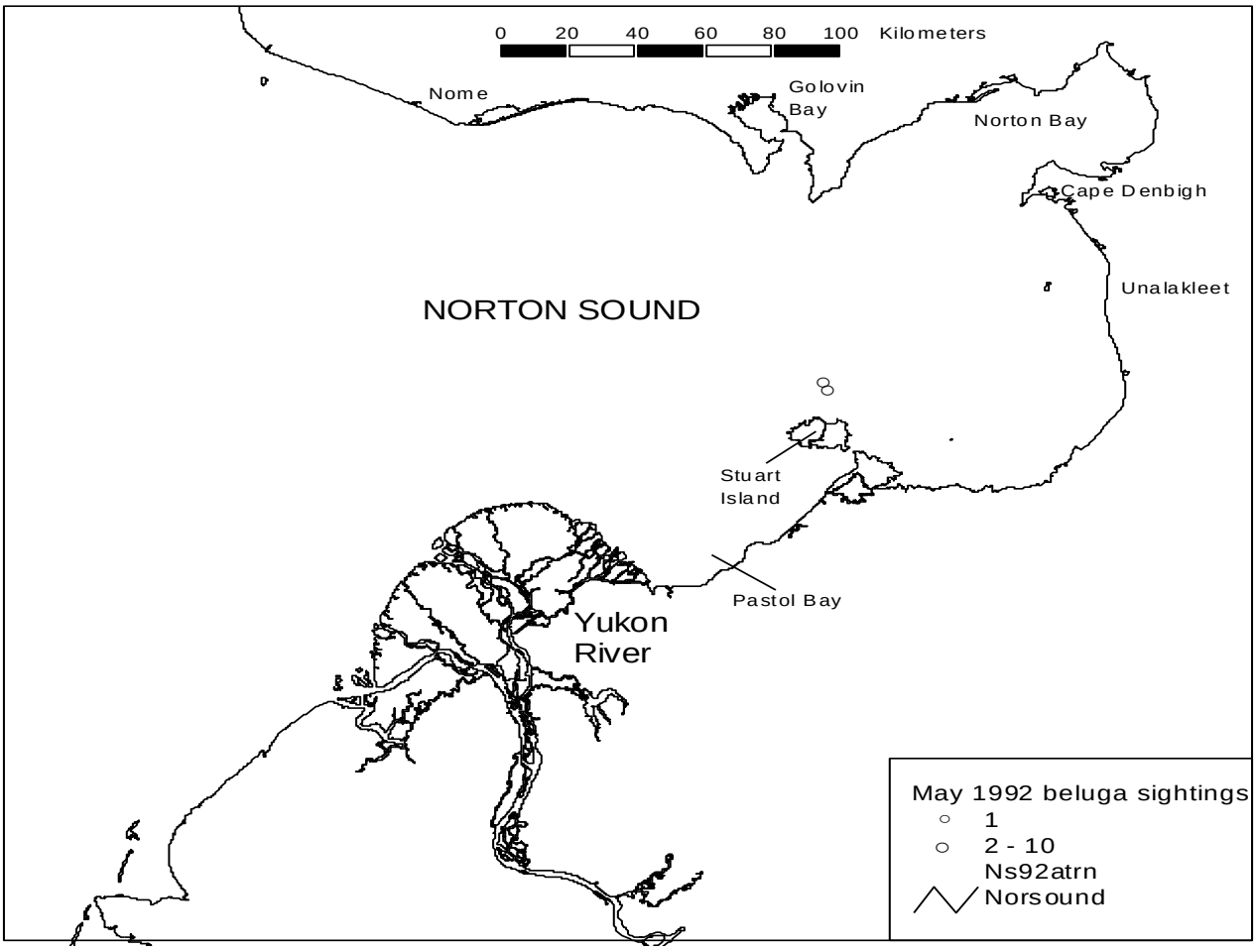

Figure 2. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 27-29 May 1992.

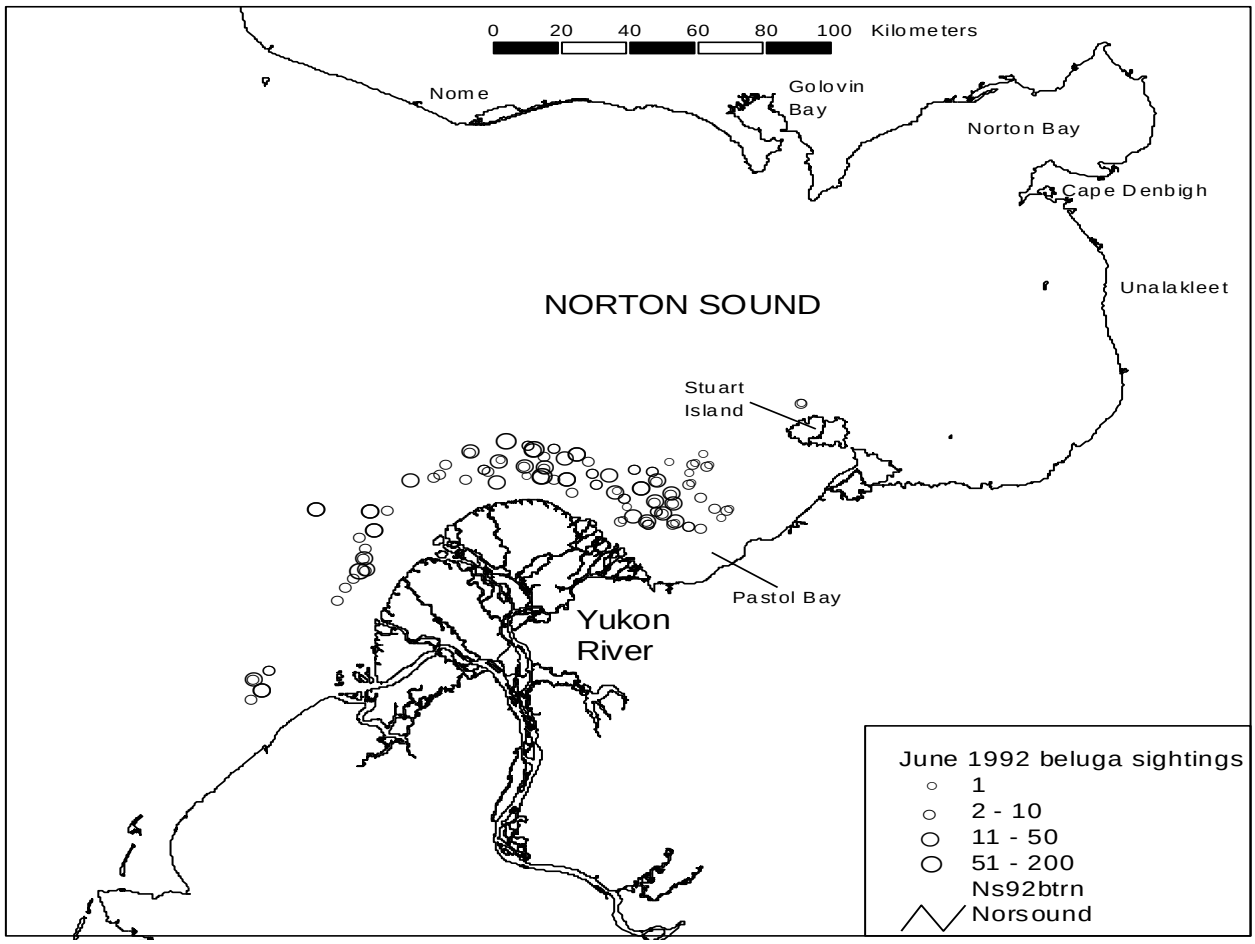

Figure 3. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 17-21 June 1992.

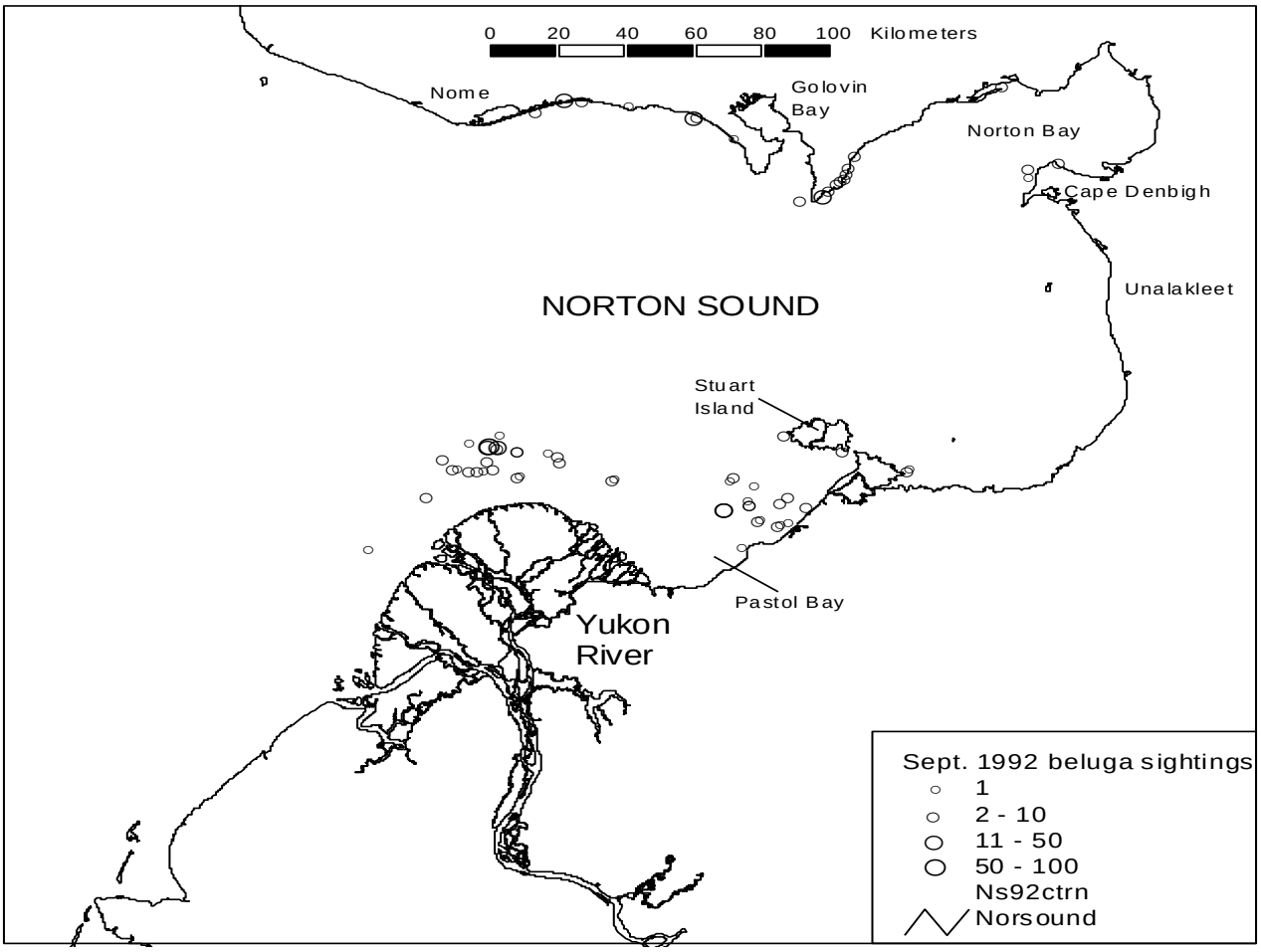

Figure 4. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 18-22 September 1992.

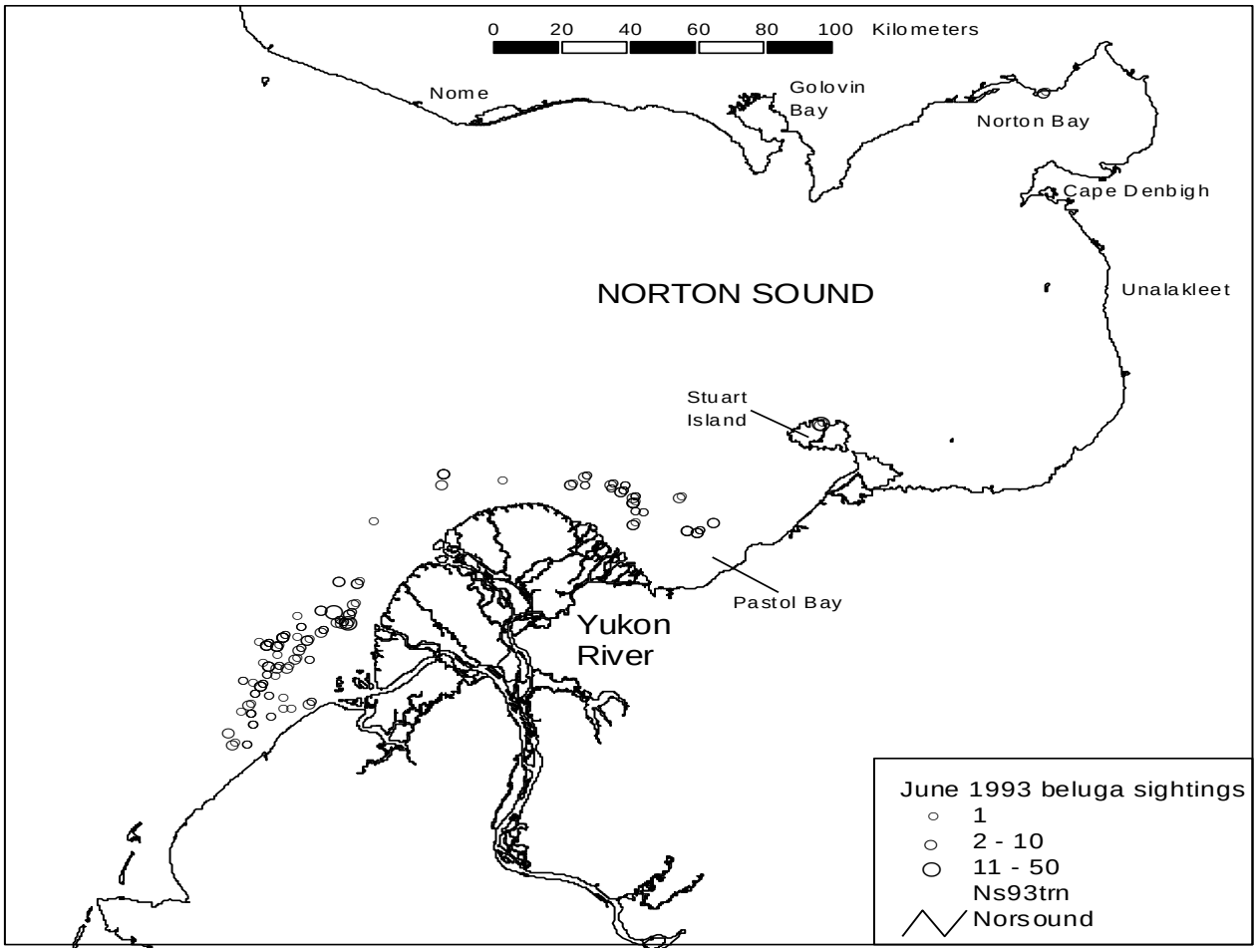

Figure 5. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 14-18 June 1993.

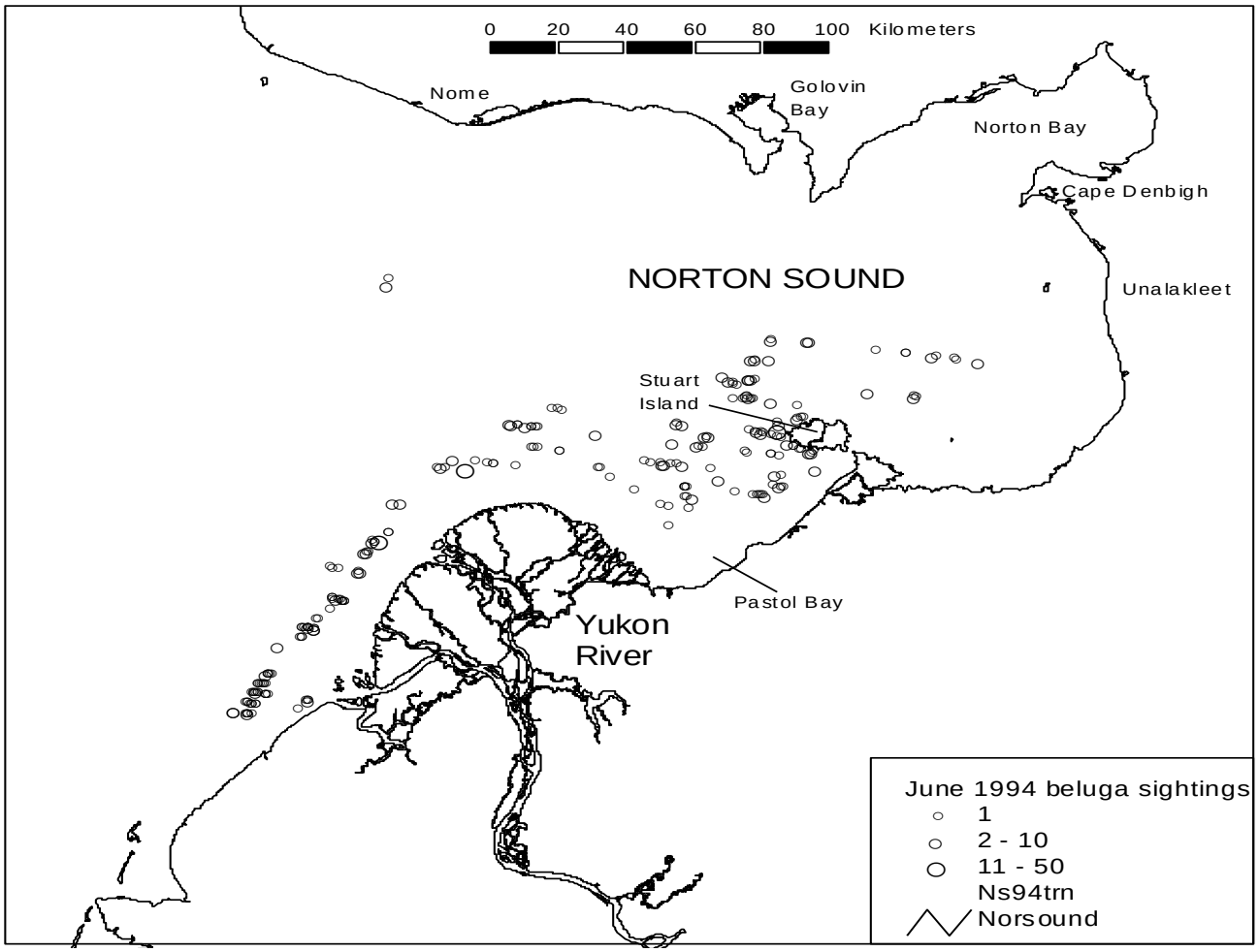

Figure 6. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 11-16 June 1994.

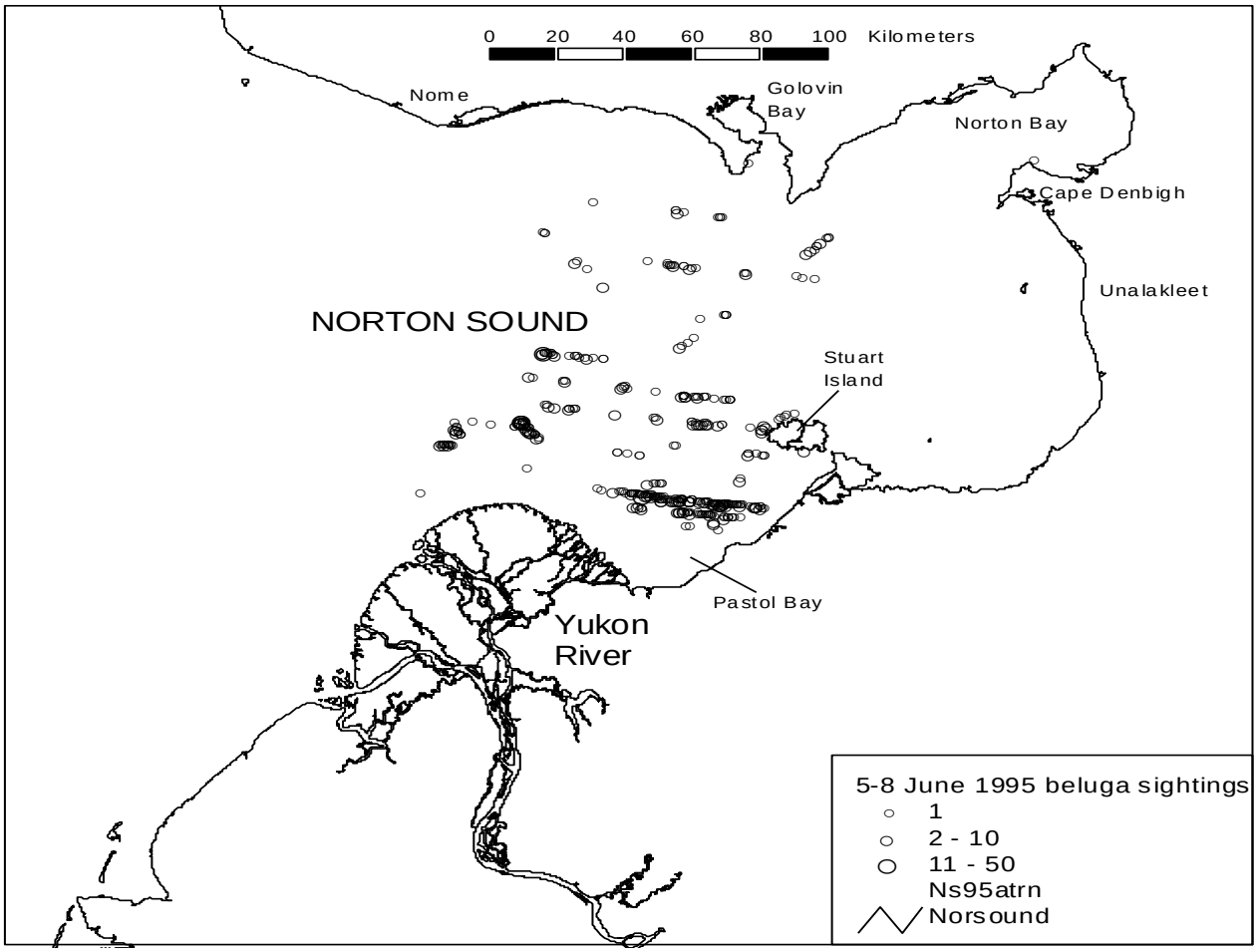

Figure 7. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 5-8 June 1995.

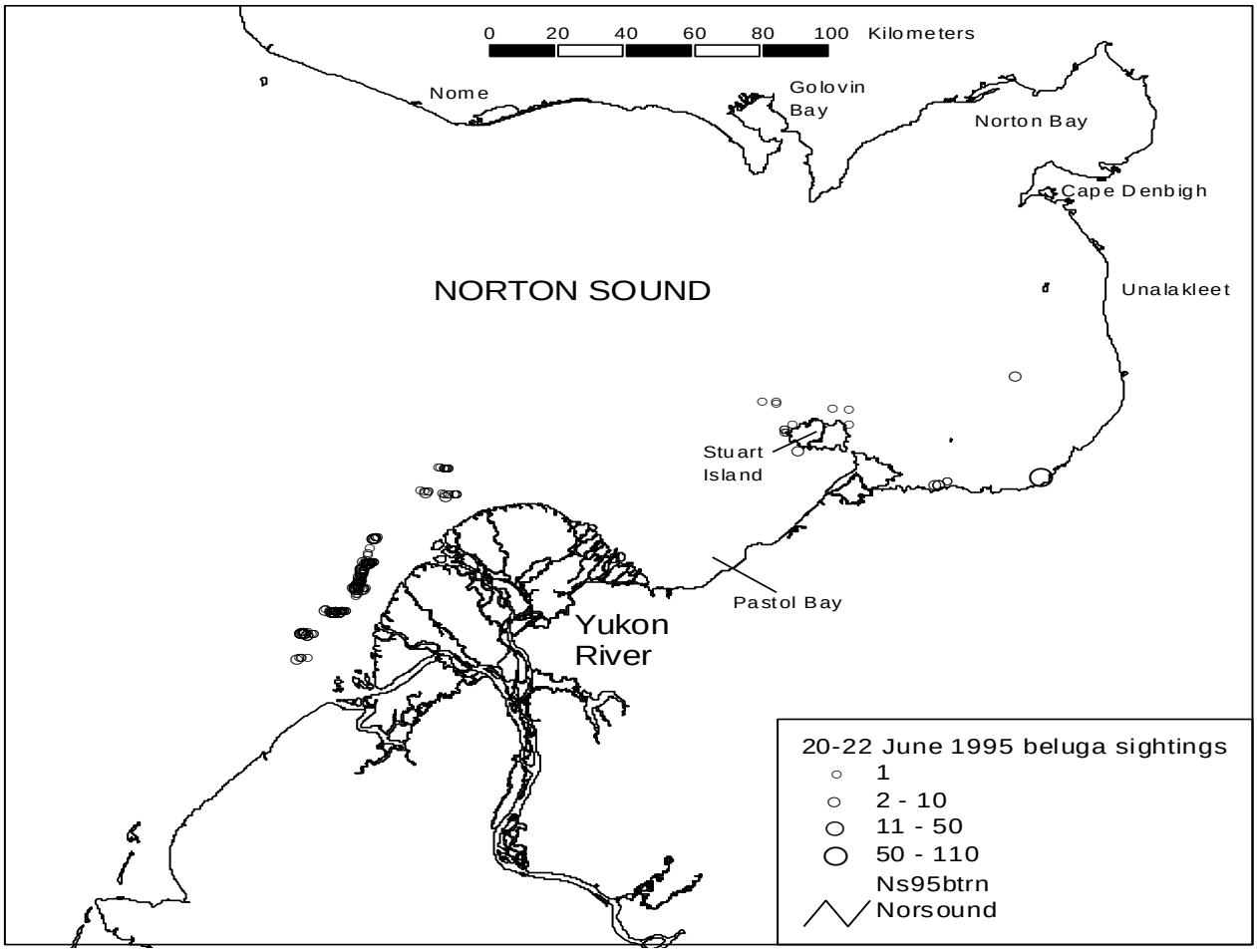

Figure 8. Map of the Norton Sound/Yukon Delta region showing beluga sightings and transects flown during 20-22 June 1995.

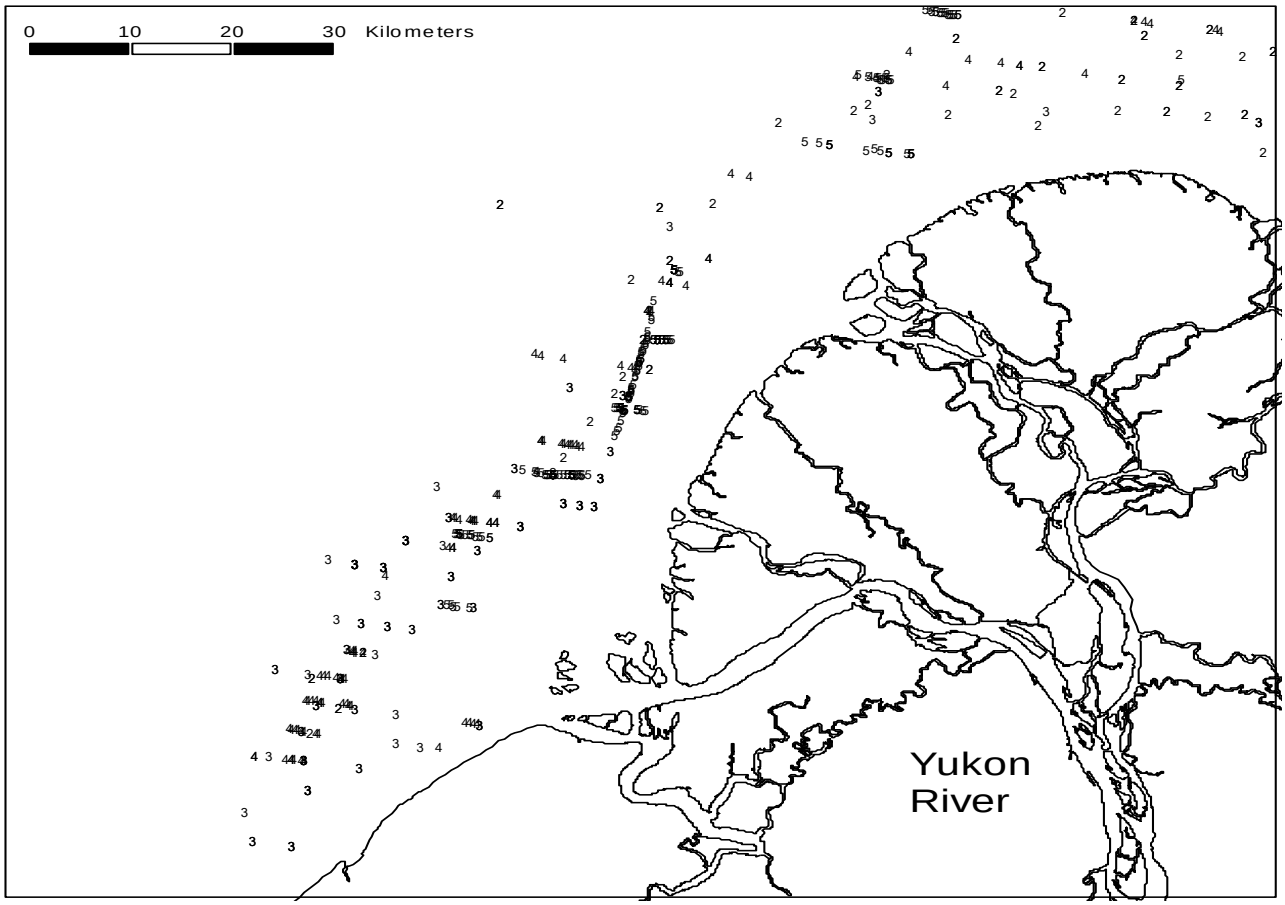

Figure 9. Transect lines and sightings of beluga whales off the Yukon River delta during June surveys. 2=1992, 3=1993, 4=1994, 5=1995