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Alaska Beluga Whale Committee Surveys of Beluga Whales in Bristol Bay, Alaska, 1993-1994

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SUMMARY

Aerial surveys of beluga whales were flown in Bristol Bay in June-July 1993 and 1994. Thirteen surveys were flown, of which nine completely covered the survey area in good sighting conditions. Whales occurred principally in Kvichak and Nushagak bays. The number of whales counted on good surveys ranged from 269 to 443 in 1993 and 265-503 in 1994. The mean counts for the two survey years were virtually identical (359 versus 357). For the two years of surveys combined the overall mean count was 358 (s.d.=82.2, n=9). An estimate of the actual abundance of the Bristol Bay stock based on the overall mean count and partly corrected for animals that were likely to have been missed during the survey is 1,107. This estimate is likely to be somewhat conservative. A comparison with data collected from a similar survey in 1983 suggests that the number of whales in this area has been stable.

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.

The Bristol Bay region supports a great abundance of fish and wildlife. Beluga whales occur in this area throughout the year. They are most commonly seen in Kvichak and Nushagak bays, and are especially numerous in the months of April through August (Frost et. al. 1984, Frost and Lowry 1990). Kvichak and Nushagak bays also support large runs of anadromous fishes, especially red salmon (*Oncorhynchus nerka*) which are a major food for the belugas in this region (Brooks 1955, Frost et. al. 1984).

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 Bristol Bay during 1993 and 1994, and compares those results with previous beluga population estimates for this area.

REVIEW OF PREVIOUSLY AVAILABLE INFORMATION

Traditional knowledge of Bristol Bay residents indicates that belugas are common especially in nearshore waters of Kvichak and Nushagak bays during the summer (Chythlook and Coiley 1994). Whales concentrate at the mouths of large rivers and sometimes move long distances upstream. Subsistence use of belugas was documented in some of the earliest historical reports from this area,

and harvesting of belugas continues at at least 12 communities (Chythlook and Coiley 1994). Traditional knowledge also documents the historical occurrence of belugas in northwestern Bristol Bay in Togiak and Kulukak bays. Belugas were apparently common in those bays in the early 1900s, but have been seldom seen there since the 1930s (Chythlook and Coiley 1994).

The first scientific studies done in Bristol Bay involved observations of distribution and abundance, and collections of animals for biological investigations. Brooks (1955) estimated the number of belugas in Kvichak and Nushagak bays "based on surface observations, aerial observations, and fishermen and pilot reports" as 1,000 in 1954 and 525 in 1955. His studies confirmed the importance of red salmon in the diet of belugas in this area, and produced estimates of the number of smolts and adults being consumed. Concern for the level of predation on salmon stocks that were at the time depleted led to a program to displace belugas from certain river mouths (Fish and Vania 1971). Lensink (1961) continued the work of Brooks in the late 1950s. He concluded that "Accurate counts are impossible in the turbid waters of this area, but the population probably numbers between 1,000 and 1,500 animals."

Fried et al. (1979) flew a series of aerial surveys to count belugas mostly in the Nushagak Bay area. On June 28, 1979 they surveyed both Nushagak and Kvichak bays and reported a count of 84-144 belugas.

Research conducted in 1982-1983 with support provided by the NOAA Outer Continental Shelf Environmental Assessment Program provided additional information on belugas the Bristol Bay region. Those studies produced data on distribution and abundance, movements and diving patterns of radiotagged individuals, food habits, and entanglements in fishing nets (Frost et al. 1983, 1984, 1985). Aerial counts were made on 12 days in 1983, but most individual surveys did not provided complete coverage of all the areas used by belugas. A complete aerial survey conducted on 29 June 1983 resulted in a count of 334 belugas in Kvichak and Nushagak bays (Frost et al. 1984). Applying correction factors to account for whales beneath the surface and dark colored neonates and juveniles resulted in an estimate of 1,100 belugas in the area.

From 1984 through 1992 no efforts were made to assess the abundance of belugas in Bristol Bay. Frost et al. (1992) documented predation on belugas by killer whales (*Orcinus orca*), which appeared to be occurring at a higher rate than usual during 1989 and 1990.

ABWC SURVEYS

Methods

Aerial surveys were flown during 28 June-2 July 1993, 17-18 July 1993, and 5-8 July 1994. The survey aircraft was a high-wing, twin engine Aero Commander Shrike chartered from Commander Northwest.

The survey was designed to cover all coastal and offshore waters of Kvichak and Nushagak bays (Figures 1 and 2). The standard survey track followed the coast about 4,000 feet offshore from approximately Johnston Hill (southeast Kvichak Bay) to Nichols Spit (southwest Nushagak Bay).

Coastal surveys included the lower Kvichak River (upstream as far as the Branch (Alagnak) River), the lower Naknek River, the Nushagak River to above the Wood River, the Little Muklung River, the Snake River, and the Igushik River. Offshore surveys were flown along east-west transects at 2 nm intervals from 58°40'N to 58°58'N latitude in Nushagak Bay and 58°40'N to 58°52'N latitude in Kvichak Bay. Navigation was done by reference to landmarks and with a Global Positioning System (GPS) that was linked to a computer data entry program. Survey altitude was usually 1000 feet, and airspeed was 120 knots.

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. Observers were the same for all surveys (Lloyd Lowry and Kathy Frost). All belugas visible along the survey track were counted. When large groups were encountered, two or more counts were made. In those situations the aircraft circled after passing by the group and flew past again on a line oriented to provide one observer the best view of the entire group (i.e., minimum glare and no whales in the blind area under the plane). Multiple counts were recorded individually, and the highest count for that group was used in analysis of the data. A computerized data logging system recorded the time and position from the GPS at the beginning and end of every transect, at 60 second intervals along the transect, and at every beluga sighting. Weather, sighting conditions, and other relevant information were also recorded. Each observer also kept a written record of the time and number of whales sighted, which was used to check the computer database.

Results

Aerial surveys were conducted on eight days during June-July 1993 (Table 1). On three of those days (28 June, 1 and 2 July), weather was foggy or windy along part of the survey route and total counts were not obtained. For the other five days, survey conditions were judged to be good to excellent and all survey areas were counted. Counts on these five days ranged from 269-443, with a mean of 359 (s.d.=72.5) (Table 1). Most belugas (200-300) were found in Nushagak Bay, particularly the upper Nushagak near Grassy Island and the mouths of the Little Muklung and Wood rivers (Figure 3). A small group of belugas was always present in the Igushik River, and belugas were sometimes seen in the Snake River. In Kvichak Bay, belugas were most often sighted near the mouth of the Kvichak River, in Halfmoon Bay, and along the west side. Very few belugas were seen on offshore transects, and almost all of those were very near shore and would also have been counted during coastal transects.

During July 1994, surveys were flown on four days (Table 2). The first of those (5 July) was a reconnaissance flight in windy weather, with poor sighting conditions. Complete surveys were conducted on 6 and 8 July, and two complete coastal surveys were conducted on 7 July, one in the morning and one in the afternoon. The four surveys on 6-8 July were all flown under good to excellent conditions for sighting belugas. Total counts on good survey days ranged from 265-503, with a mean of 357 (s.d.=104.9) (Table 2). Belugas were seen in both Kvichak and Nushagak bays (Figure 4). The largest groups were seen in the upper Nushagak near Grassy Island and the mouths of the Little Muklung and Wood rivers, and along the west side of Kvichak Bay. Offshore transect lines were surveyed on only one day in 1994 and no belugas were seen.

There was no significant difference between the mean number of belugas counted in 1993 versus 1994 ($t=0.970$, $P>0.90$). The mean count for all of the complete surveys flown under good conditions in 1993 and 1994 combined was 358 (s.d.=82.2, n=9).

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 in Kvichak and Nushagak bays 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. 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 calculated correction factors for surveys flown at an altitude of 1000 feet and an airspeed of 120 kts were 2.62 for adult animals (n=3) and 3.24 for juveniles (n=2). We used the correction factor for adults only to adjust our 1993-1994 survey data. Because surveys were 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).

Corrected abundance estimates are shown in Table 3. Estimates based on maximum counts suggest a population of 1,370 whales in 1993 and 1,555 in 1994. If mean counts are used, abundance estimates for each year and for 1993-1994 combined range from 1,103-1,110.

COMPARISON WITH PREVIOUS ABUNDANCE ESTIMATES

Although earlier researchers estimated that there were about 1,000-1,500 beluga whales in Bristol Bay (Brooks 1955, Lensink 1961), abundance estimates based on aerial survey counts are not available prior to 1983. The 1983 research yielded a count of 334 whales, and a population estimate of 1,100 (Frost et al. 1984)

Frost et al. (1984) used a correction factor of 2.75 to account for animals missed because they were below the surface during the 1983 Bristol Bay beluga survey. With additional data and analysis, Frost and Lowry (1995) concluded that the appropriate factor would be 3.17 for a survey conducted as it was in 1983 (1,000 foot altitude and 150 knot speed). This change was due to the use of a

different value for the time a beluga would potentially be in view, incorporation of additional surface and dive time data from belugas tagged in Cunningham Inlet, and use of tagging data from only adult animals. The resulting abundance estimate, including the correction for missed neonates and yearlings, is 1,250 (Table 3).

If the actual count data are compared, the 1983 count (334) was slightly below the mean counts for 1993 (359) and 1994 (357). The calculated population estimate for 1983 (1,250) is somewhat higher than that derived from mean 1993-1994 counts (1,107) because the 1983 surveys were flown at a higher speed. The maximum count made in 1993-1994 (503) was about 50% higher than the 1983 count, and the corresponding population estimate (1,555) was 24% greater.

Overall, there has been considerable consistency in the counts and calculated population estimates for Bristol Bay. We conclude that it is very likely that the current population numbers at least 1,100-1,500 belugas. While the available data suggest that the Bristol Bay stock is probably stable at or near its historical size, additional surveys are needed to measure population trend.

ADEQUACY OF POPULATION ASSESSMENT

Studies of beluga whales in Bristol Bay have resulted in the identification of several summer concentration areas that have been used consistently since at least the mid-1950s (Brooks 1955, Frost et al. 1983, Frost and Lowry 1990). Whales occur mostly nearshore in the upper portions of Kvichak and Nushagak bays. In spite of a considerable amount of search effort, whales are virtually never seen far offshore during the summer (Frost et al. 1983, Frost and Lowry 1990, this study). This predictable distribution pattern makes it easy to locate and count beluga whales in Bristol Bay.

Complete counts made in good weather conditions in 1983 and 1993-1994 were reasonably consistent. Observers were the same in all the surveys, and similar technique were used. However, more whales were counted on some days than on others. Possible explanations for that include: 1) belugas may have behaved differently at different times (e.g., spent more or less time at the surface); 2) on some days some groups of belugas may not have been counted because they were not in the area surveyed; and 3) some whales at the surface within the survey area may have been missed because of sighting conditions or some other factor. We cannot at present evaluate how such factors may have affected our counts.

Although we cannot evaluate all the factors that cause variations in counts, we think that repetitive counts made of a standard survey area in good weather conditions provide data that can be used to estimate population size and monitor population trend of the Bristol Bay beluga stock. When the nine counts made in 1993-1994 are combined they produce a mean count with a coefficient of variation of 0.23. This suggests that a similar series of surveys, done once every year, could detect an annual change of 7% over a ten year period with reasonable assurance (i.e., 90% of the time, given a type 1 error of 0.05). If such surveys are only done once every five years, there is a 90% chance that an annual rate of change of approximately 5%, 9%, and 13% would be detected after 25, 15, and 10 years, respectively.

The abundance estimate produced in this paper depends not only on the quality of the count data, but also on the reliability of the correction factors used to expand the counts. Additional information on the fraction of time that whales spend at the surface where they can be counted would be very useful. Data on sightability of calves and yearlings, and the age structure of the population, could also be used to verify or refine correction factors.

We think that the population estimates for Bristol Bay belugas calculated in this report are likely to be conservative for several reasons. First, although aerial surveys and other sighting data for the Bristol Bay region show that most belugas are in Kvichak and Nushagak bays during June-July, occasional sightings have been recorded elsewhere (Frost and Lowry 1990). Of particular interest is Kuskokwim Bay. Kuskokwim Bay is in many ways similar to Bristol Bay, and until the late 1950s belugas were known to be common there during summer months. For unknown reasons belugas stopped using Kuskokwim Bay as a summering area and were not reported from there again until 1988 and 1989 (Frost et al. 1992). On July 11, 1994, three days after we finished our regular counts of belugas in Kvichak and Nushagak bays, we received a report from a biologist flying over Kuskokwim Bay of a large group of belugas estimated at 500-1,000 animals. In response, an aerial survey of Kuskokwim Bay and part of Nushagak Bay was conducted on July 13. On that survey, 8 belugas were seen in Kuskokwim Bay and 129 in upper Nushagak Bay (G. O'Corry-Crowe and R. Suydam, personal communication). Overall, while it seems likely that most of the Bristol Bay beluga stock is in Nushagak and Kvichak bays in June-July we cannot discount the possibility that some whales are elsewhere. Another reason why our Bristol Bay abundance estimates are 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. While we only used data from surveys made in good weather conditions to produce population estimates for Bristol Bay, some whales were undoubtedly missed by observers. A final factor that produces a conservative population estimate is the dive correction 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.

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Table 1. Counts of beluga whales in Bristol Bay, 28 June through 18 July 1993. Counts were done by Lloyd Lowry and Kathy Frost (ADF&G) for the Alaska Beluga Whale Committee. NS means not surveyed.

	Date							
Area	6/28/93	6/29/93	6/30/93	7/01/93	7/02/93	7/03/93	7/17/93	7/18/93
Nearshore Kvichak	12	113	82	46	107	80	82	99
Offshore Kvichak	NS	0	5[a]	NS	52[a]	31[a]	NS	88[a]
TOTAL KVICHAK	12	113	82	46	107	80	82	99
Etolin Point	8	6	8	0	NS	0	45	16
Upper Nushagak	13	135	274	29	NS	130	310	244
Snake River	9	16	30	22	NS	17	0	0
Igushik River	16	26	21	30	NS	42	6	4
Offshore Nushagak	NS	15[b]	18[a]	NS	NS	7[a]	0	0
TOTAL NUSHAGAK	38	188	325	81	--	189	316	248
TOTAL ALL AREAS	**58**	**307**	**415**	**127**	**--**	**269**	**443**	**363**

[a] all probably duplicates of coastal counts and not included in totals
[b] at least 4 were duplicates of coastal counts and are not included in total

Table 2. Counts of beluga whales in Bristol Bay, 5-8 July 1994. Counts were done by Lloyd Lowry and Kathy Frost (ADF&G) for the Alaska Beluga Whale Committee. NS means not surveyed.

	Date				
Area	7/05/94	7/06/94	7/07/94	7/07/94	7/08/94
Nearshore Kvichak	47	234	124	109	95
Offshore Kvichak	NS	1	NS	NS	NS
TOTAL KVICHAK	47	235	124	109	95
Etolin Point	0	0	31	36	7
Upper Nushagak	33	180	156	41	179
Snake River	9	68	74	46	7
Igushik River	16	20	6	33	12
Offshore Nushagak	NS	0	NS	NS	NS
TOTAL NUSHAGAK	58	268	236	120	198
TOTAL ALL AREAS	**105**	**503**	**360**	**265**	**300**

Table 3. Abundance estimates for beluga whales in Bristol Bay, based on the number of whales counted in 1993-1994, and 1983.

Survey Date	Belugas Counted	CF[a]	Corrected Number	Neo + Yrl CF[b]	Neo + Yrl Number	Total Belugas
1993 mean count	359	2.62	941	0.18	169	1,110
1993 maximum count	443	2.62	1,161	0.18	209	1,370
1994 mean count	357	2.62	935	0.18	168	1,103
1994 maximum count	503	2.62	1,318	0.18	237	1,555
1993-94 combined	358	2.62	938	0.18	169	1,107
1983 count	334	3.17	1,059	0.18	191	1,250

[a] correction factor for animals that were submerged and not counted
[b] correction factor for neonates and yearlings that were not counted

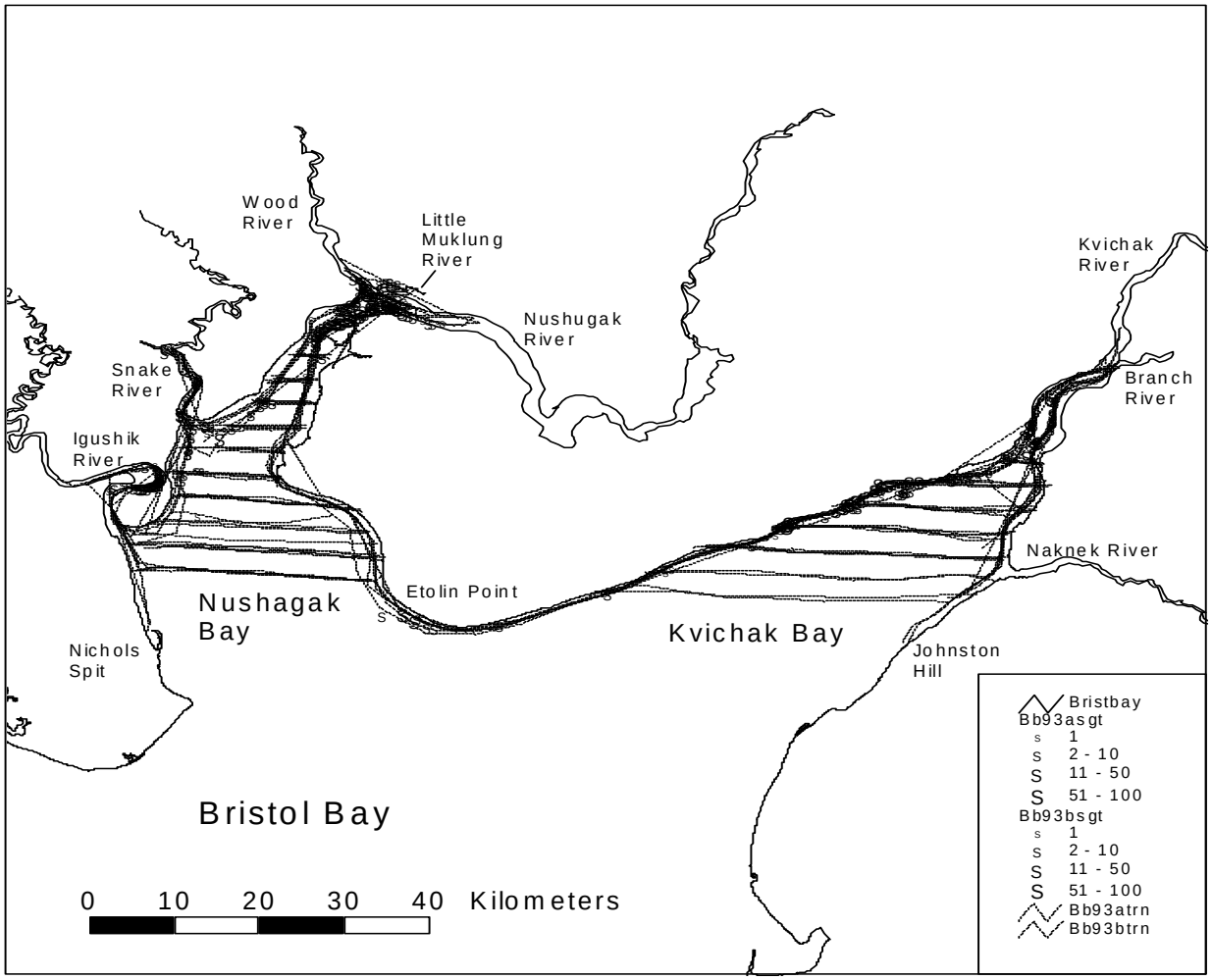

Figure 1. Transect lines and beluga whale sightings during aerial surveys in Bristol Bay, Alaska, 28 June-18 July 1993.

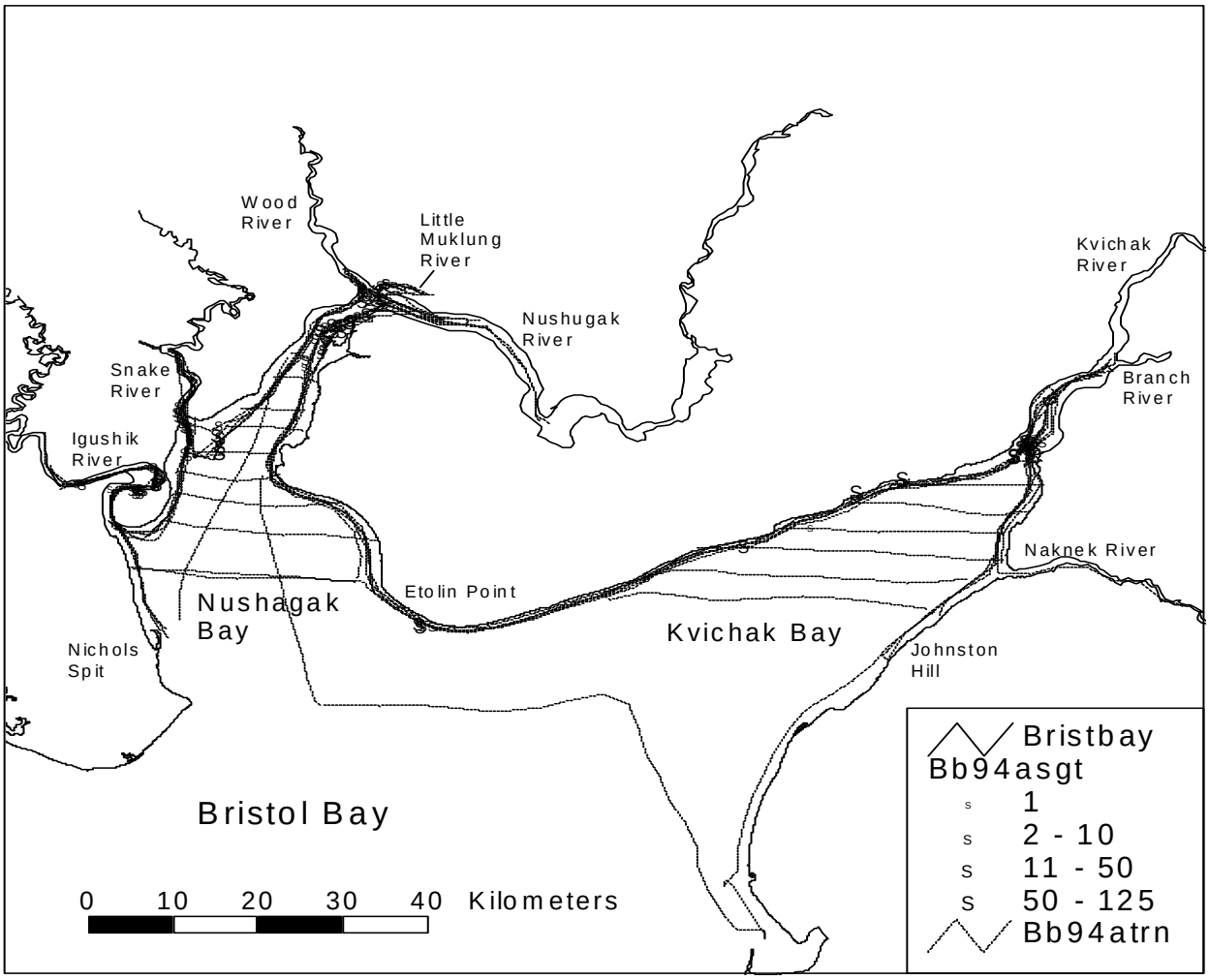

Figure 2. Transect lines and beluga whale sightings during aerial surveys in Bristol Bay, Alaska, 5-8 July 1994.