AERIAL SURVEYS OF BELUGA IN COOK INLET, ALASKA, JUNE 2000

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ABSTRACT

The National Marine Fisheries Service (NMFS) conducted an aerial survey of the beluga population in Cook Inlet, Alaska, during 6-13 June 2000. The 43 hr survey was flown in a twin-engine, high-wing aircraft at an altitude of 244 m (800 ft) and speed of 185 km/hr (100 kt), consistent with NMFS' annual surveys conducted each year since 1993. The flights in June 2000 included one or more surveys of coastal areas (flown 1.4 km offshore) around the entire Inlet and 1,841 km of transects across the Inlet. Paired, independent observers searched on the coastal (right) side of the plane, where virtually all beluga sightings occur, while a single observer and a computer operator/data recorder were on the left side. In addition, on each day a representative of the Cook Inlet Marine Mammal Council observed from the right side. After finding beluga groups, a series of aerial passes were made to allow at least two pairs of primary observers to make 4 or more counts of each group. Median counts made in optimal viewing conditions were 114 beluga in the Susitna Delta (between the Beluga and Little Susitna Rivers), 42 in Knik Arm, and 28 in Chickaloon Bay, but no beluga were found in lower Cook Inlet in spite of ideal sighting conditions. This is consistent with the sighting distributions observed each June or July since 1996. The sum of the aerial estimates (not corrected for missed whales) for June 2000 is 184, which is the lowest index count made by NMFS observers since these surveys began in 1993, but it is essentially the same as counts made in 1998 (193) and 1999 (217).

INTRODUCTION

Beluga whales (*Delphinapterus leucas*) are distributed around most of Alaska from Yakutat Bay to the Alaska/Yukon border (Hazard 1988). Five stocks are recognized in this region: Cook Inlet, Bristol Bay, Eastern Bering Sea, Eastern Chukchi Sea, and the Beaufort

Sea (Hill and DeMaster 1998; O'Corry-Crowe *et al*. 1997). The most isolated of these is the Cook Inlet stock, separated from the others by the Alaska Peninsula (Laidre *et al.* In press). Beluga in Cook Inlet are very concentrated in a few river mouths during parts of the year (Rugh *et al.* In press). The geographic and genetic isolation of the whales in Cook Inlet, in combination with their strong site fidelity, makes this stock vulnerable to impacts from large or persistent harvests.

NMFS's National Marine Mammal Laboratory (NMML) and the Alaska Regional Office have conducted annual aerial surveys to study the distribution and abundance of beluga in Cook Inlet each June/July since 1993 (Withrow *et al*. 1994; Rugh *et al*. 1995, 1996, 1997a, 1997b, 1999a, 1999b) in cooperation with the Alaska Beluga Whale Commission (ABWC) and the Cook Inlet Marine Mammal Council (CIMMC). A letter from the Alaska Regional Scientific Review Group (ASRG) to S. Pennoyer, NMFS, dated 13 May 1997, strongly urged NMFS to continue these surveys every year. Aerial surveys are proven to be the most efficient method for collecting distribution and abundance data for beluga in Cook Inlet (Klinkhart 1966; Calkins *et al*. 1975; Murray and Fay 1979; Calkins 1984). The most recent studies have been some of the most thorough and intensive (Rugh *et al.* In press).

METHODS

The survey aircraft, an Aero Commander 680 FL (*N7UP*), has twin-engines, high-wings, 10-hr flying capability, is equipped with seating for five passengers and one pilot. There are bubble windows at each of the four observer positions, maximizing the search area. An intercom system provided communication among the observers, data recorder, and pilot. A selective listening control device was used to aurally isolate the observer positions. Location data were collected from a portable Global Positioning System (GPS) interfaced with the laptop computer used to enter sighting data. Data entries included routine updates of locations, percent cloud cover, sea state (Beaufort scale), glare (on the left and right), and visibility (on the left and right). Visibility was documented in five subjective categories from excellent to useless; conditions rated poor or worse were considered unsurveyed. Each start and stop of a transect leg was reported to the recorder. Observer seating positions were recorded each time they were changed, generally every 1-2 hrs to minimize fatigue.

There was an attempt to synchronize flight timings with low tides in the upper Inlet. This was primarily to minimize the effective survey area (at low tide, large areas of mudflats are exposed that would otherwise have to be surveyed). However, the broad geographical range of these surveys in conjunction with highly variable tide heights made it impractical to survey at specific tidal conditions throughout the Inlet.

Coastal surveys were conducted on a trackline approximately 1.4 km offshore. The objective was to search nearshore, shallow waters where beluga are typically seen in summer (Rugh *et al.* In press). The trackline distance from shore was monitored with an inclinometer such that the waterline was generally 10^{o} below horizontal while the aircraft was at the standard altitude of 244 m (800 ft). Ground speed was approximately 185 km/hr (100 knots).

This coastal survey included searches up rivers until the water appeared to be less than 1 m deep, based on the appearance of rapids and riffles.

In addition to the coastal surveys, systematic transects were flown across the Inlet. A sawtooth pattern of tracklines was designed to cross over shore at points approximately 30 km apart starting from Anchorage and zigzagging to the southern limits of Cook Inlet, between Cape Douglas and Elizabeth Island (Fig. 1). This sawtooth pattern was offset from previous years to reduce resampling among years.

Immediately upon seeing a beluga group, each observer reported the sighting to the recorder. As the aircraft passed abeam of the whales, the observer informed the recorder of the inclinometer angle, whale travel direction, and notable behaviors but not group size. With each sighting, the observer's position (right front, right center, etc.) was also recorded. An important component of the survey protocol was the independence of the observers on the right (i.e., that they not cue each other to their sightings). They had visual barriers between them, and their headsets did not allow them to hear each other. When a group of whales was first seen, the aircraft continued on until the group was out of sight; then the aircraft returned to the group and began the circling routine. This allowed each observer full opportunity to independently sight the whale group. The pilot and data recorder did not call out whale sightings or in any way cue the observers to the presence of a whale group until it was out of sight. The whale group location was established at the onset of the aerial counting passes by flying a criss-cross pattern over the group, recording starts and stops of group perimeters.

The flight pattern used to count a whale group involved an extended oval around the longitudinal axis of the group with turns made well beyond the ends of the group. Whale counts were made on each pass down the long axis of the oval. Because groups were circled at least four times (4 passes for each of two pairs of observers on the right side of the aircraft), there were typically 8 or more separate counting opportunities per whale group. Counts began and ended on a cue from the right front observer, starting when the group was close enough to be counted and ending when it went behind the wing line. This provided a precise record of the duration of each counting effort. The paired observers made independent counts and wrote down their results along with date, time, pass number, and quality of the count. The quality of a count was a function of how well the observers saw a group, rated A (if no glare, whitecaps or distance compromised the counting effort) through F (if it was not practical to count whales on that pass). Only quality A and B estimates were used in the analysis. Only whales that were at the surface during the counting period were included; whale tracks in the muddy water or ripples were not included in the analysis. Count records were not exchanged with anyone else on the aerial team until after all of the aerial surveys were completed. This was done to maximize the independence of each observer's estimates.

Two digital video cameras were operated on each counting pass. The pair of cameras were mounted together on a common board: one camera was kept at maximum zoom; the other was adjusted to keep the entire group in view. Later, the images will be studied in the laboratory, and counts of whales will be compared to the infield counts. Analysis of both the aerial counts and counts from the video tapes are detailed in Hobbs *et al*. (In press [a]) for 1994-98 data.

RESULTS

A total of 43 hrs of aerial surveys were flown around Cook Inlet from 6-13 June 2000. All of these surveys (11 flights ranging from 2.5 to 5.1 hrs) were based out of Anchorage, sometimes with refueling stops in Homer. Systematic search effort was conducted for 26.5 hrs, not including time spent circling whale groups, deadheading without a search effort, or periods with poor visibility. Visibility and weather conditions interfered with the survey effort during 0.8 hrs (3% of the effective search time) when the right-front observer considered the visibility poor or worse. All of the primary observers (the authors of this report) who flew with this project in 1998 and 1999 returned in 2000. Three of the four observers have participated in this project almost every season since it began in 1993.

On 6 June, a test flight was conducted to be sure all onboard systems were operational, and calibration targets were circled and videoed in Goose Bay of Knik Arm. The targets–inflated inner tubes colored with various shades of white to gray–provided a test of sightability of beluga under different lighting conditions and on video tape. The methods were kept similar to those used to count beluga, so the abundance analysis can include a correction for whales missed because they are not white. During the aerial surveys of Cook Inlet, a pair of video cameras were operated over whale groups during counts. One camera had its lens magnification adjusted to include the full width of the group (but kept constant throughout a pass), and the other camera was held at maximum zoom to provide a sampling of color ratios within the respective groups. This is a part of a masters study being conducted by L. Litzky.

On 7 June, an aerial survey was conducted, but only the waters of Knik Arm were calm enough for a reasonable search effort. Two groups of beluga were found, and a full counting protocol was applied. The next day, 8 June, conditions were more favorable such that a survey could be conducted around much of upper Cook Inlet north of the Forelands; however, Chickaloon Bay and Turnagain Arm had marginal conditions due to high winds. In the Susitna area, a large group of beluga was found and counted. The only whales found in Chickaloon Bay were in the relatively calm waters of Chickaloon River. Other whales may have been offshore, but they were too hard to find among the whitecaps of the Inlet, so the effort there was abandoned. A flight was made into Knik Arm to confirm the location of the beluga groups counted there on the previous day (the sightings on these two days were only 1 km apart); therefore, the combination of survey results from 7 and 8 June provided partial or complete coverage of all primary areas where beluga have usually been found in the past.

With improved weather conditions after 8 June, surveys were conducted in the lower Inlet as far south as the Gulf of Alaska, where it is more challenging to find calm seas. On 9-11 June, coastal and offshore areas of Lower Cook Inlet (south of East Foreland and West Foreland) plus the Susitna area, were surveyed (Fig. 1). Survey conditions were generally good to excellent. No beluga were found except in the Susitna area (Table 2), although many other marine mammals were seen (2 gray whales, 11 humpback whales, 17 Dall's porpoise, 29 harbor porpoise, 10 sea lions, 236 sea otters, and over 1,800 harbor seals). This lack of beluga

sightings in the lower Inlet is in contrast to the fact that beluga groups were seen virtually every time the survey passed through the Susitna or Knik areas, even when making approaches to the airport or during the calibration test of the floating targets.

Optimal survey conditions were experienced in the upper Inlet on 12 June. The survey on this day included all coastal areas north of North Foreland and offshore transects north of East and West Forelands. Beluga groups were found in Chickaloon Bay, Knik Arm, and the Susitna Delta–consistent with previous sighting locations.

In an attempt to recount the whale groups of upper Cook Inlet, an additional survey was made on 13 June. However, the beluga in Chickaloon Bay were further offshore than usual, and white caps make it difficult to count them, so this effort was abandoned. At the mouth of the west side of the Susitna River, a group of whales was found again and counted, but the density of the group and reflective lighting conditions made the whales hard to count. Although Knik Arm had good conditions, a high volume of air traffic precluded the option to circle whale groups near Anchorage. Therefore, counts made on 12 June were considered the best for subsequent analysis.

The composite of these aerial surveys provided a thorough coverage of the coast of Cook Inlet (1,388 km) for most of the area within approximately 3 km of shore (Fig. 1). In addition, there were 1,841 km of systematic transects flown across the Inlet. Assuming a 2.0 km transect swath (1.4 km on the left plus 1.4 km on the right, less the 0.8 km blind zone beneath the aircraft), the cumulative survey tracklines covered roughly 6,500 sq km, which is approximately 33% of the 19,863 sq km surface area of Cook Inlet; however, these surveys covered virtually 100% of the coastal areas. All of upper Cook Inlet was surveyed at least once, and areas where large groups of beluga have consistently been found in the past–such as the Susitna Delta, Knik Arm, and Chickaloon Bay–were surveyed at least three times.

Counts of beluga are shown in Table 1, and sighting locations are shown in Figure 1. These counts are the medians of each primary observers' counts on multiple passes over a group. Ideal counting conditions and thorough coverage of the upper Inlet occurred on 12 June. Therefore, only the counts made on that date were used in summary calculations (which is consistent with methods used in the past). Observers' counts ranged from 173 to 191, depending on observer, and the median index count was 184. This sum was not corrected for missed whales. Calculations for whales missed during these aerial counts and an estimate of abundance will be developed in a separate document (e.g., Hobbs *et al*. In press [b]). The median index of counts in June 2000 (184) is lower than any previous year, but it is essentially the same as counts in 1998 (193) and 1999 (217) (Table 2).

DISCUSSION

In Cook Inlet, beluga concentrate near river mouths during spring and early summer across the northernmost portion of upper Cook Inlet, especially in the Susitna Delta, Knik Arm, and Chickaloon Bay (Fig. 1). Fish also concentrate along the northwest shoreline of Cook Inlet, mostly in June and July (Moulton 1994). These concentrations of beluga apparently last from mid-May to July or later and are very likely associated with the migration

of anadromous fish, particularly eulachon (*Thaleichthys pacificus*) (Calkins 1984; 1989) and several species of salmon.

Historically many beluga were seen in lower Cook Inlet (Rugh *et al.* In press), but since 1993, when the NMFS surveys began, only 0-4% of the annual sightings have occurred there (Table 2). Furthermore, since 1996 only single or dead whales have been seen south of North Foreland, and none were seen in the lower Inlet in 1999 and 2000. Sighting conditions were ideal during the searches of coastal and offshore waters in June 2000, but no beluga were seen except in the northern Inlet (Table 1, Fig.1) at locations where they have been found during June or July most years (Rugh *et al*. In press). Many sea otters, harbor seals, harbor porpoise, gray, and humpback whales were seen in the lower Inlet, so the lack of beluga sightings was not simply a function of visibility.

The uncorrected sum of median estimates made from the June 2000 aerial observations in Cook Inlet was 184 beluga. Using the same procedure of summarizing median estimates from the highest seasonal counts at each site for each year 1993-99, there were, respectively, 305, 281, 324, 307, 264, 193, and 217 beluga (Table 2). The process of using medians instead of maximum numbers reduces the effect of outliers (extremes in high or low counts) and makes the results more comparable to other surveys which lack multiple passes over whale groups. Medians are also more appropriate than maximums when counts will be corrected for missed whales. Not until the respective correction factors have been applied will absolute abundances or inter-year trends be calculated. The average abundance estimate for the period 1994-98 is 505 beluga (SE = 81, CV =0.16; Hobbs *et al*. In press [b]), including corrections for whales missed within the viewing range of observers and whales missed because they were beneath the surface.

Although the low abundance index that occurred in June 2000 might at first be interpreted as a decline in the true abundance, the precision of the index is not good enough to be a true reflection of such a small change (33 fewer whales than in 1999 and 9 fewer than in 1998). The abundance estimate for 1998 (347 beluga) had a CV of 0.29 (Hobbs *et al*. In press [b]); therefore, a large change in counts would be necessary to show a statistically significant difference.

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Table 1. Summary counts of beluga made during aerial surveys of Cook Inlet in June 2000. Medians from primary observers' counts were used from aerial passes where observers considered visibility good or excellent (conditions B or A). Dashes indicate no survey, and zeros indicate that the area was surveyed but no whales were seen. Sites are listed in a clockwise order around Cook Inlet.

Location	7-8 June		9-11 June		12 June		13 June		2000
	median	high	median	high	median	high	median	high	Highest medians
Turnagain Arm (East of Chickaloon)	---	---	---	---	0	0	---	---	0
Chickaloon Bay/ Pt. Possession	6	12	---	---	28	51	---	---	28
Pt. Possession to East Foreland	0	0	0	0	0	0	---	---	0
Mid-Inlet east of Trading Bay	---	---	0	0	0	0	---	---	0
East Foreland to Homer	---	---	0	0	---	---	---	---	0
Kachemak Bay	---	---	0	0	---	---	---	---	0
W side of lower Cook Inlet	---	---	0	0	---	---	---	---	0
Redoubt Bay	---	---	0	0	---	---	---	---	0
Trading Bay	---	---	0	0	---	---	---	---	0
Susitna Delta (N Foreland to Pt. Mackenzie)	100	179	104	145	114	167	67	96	114
Fire Island	0	0	---	---	0	0	0	0	0
Knik Arm	24	58	---	---	42	65	25	55	42
								$\sum$ =	**184**

Table 2. Summary of beluga sightings made during aerial surveys of Cook Inlet in June or July 1993-2000. Medians were used when multiple counts occurred within a day, and the high counts among days were entered here.

			Percent Sightings		
Year	Dates	Counts	Lower Cook Inlet	Susitna Delta	Elsewhere in Upper Cook Inlet
1993	June 2-5	**305**	0	56	44
1994	June 1-5	**281**	4	91	5
1995	July 18-24	**324**	4	89	7
1996	June 11-17	**307**	0	81	19
1997	June 8-10	**264**	0	28	72
1998	June 9-15	**193**	0	56	44
1999	June 8-14	**217**	0	74	26
2000	June 6-13	**184**	0	62	38

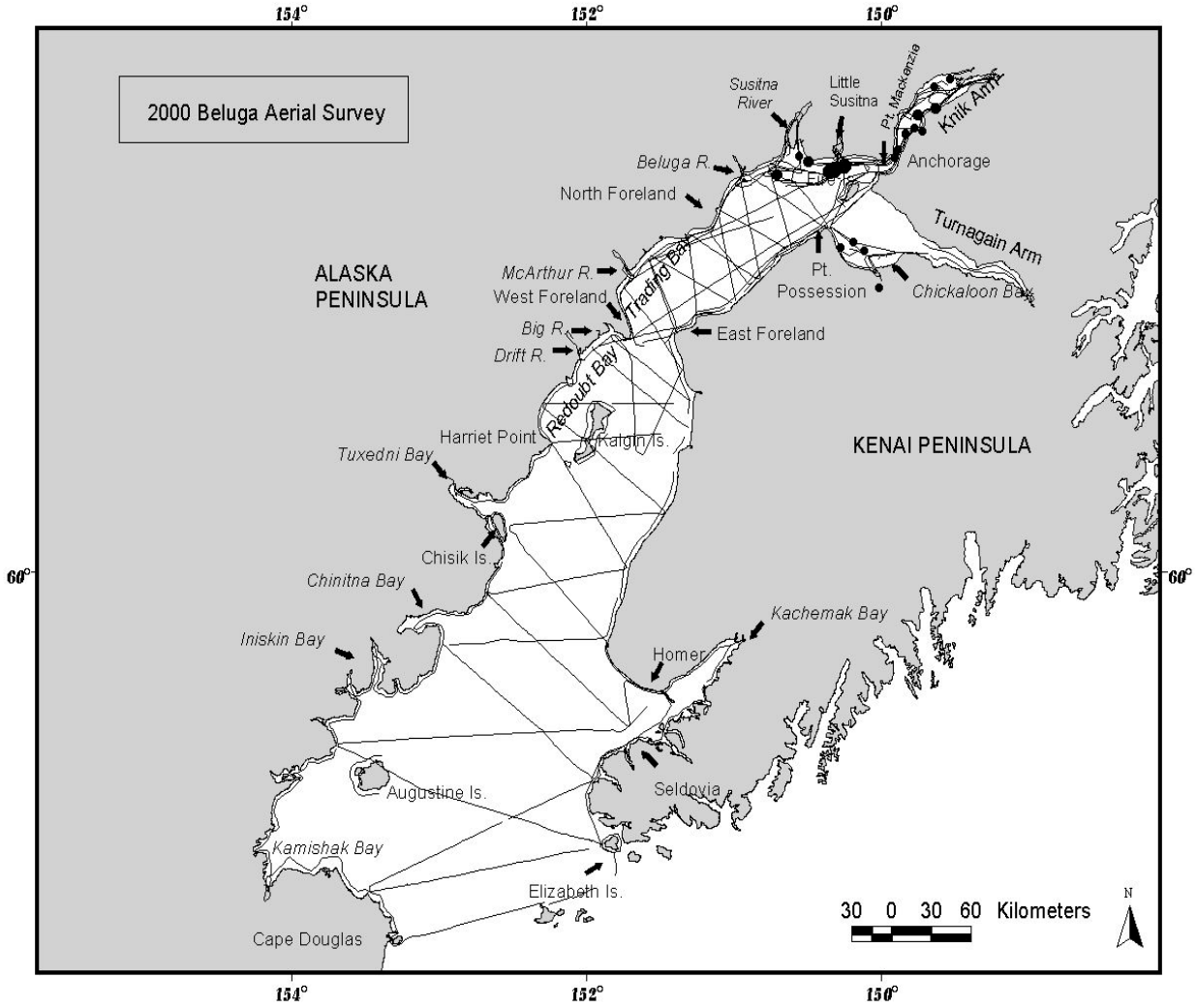

Fig. 1. Aerial survey tracklines and beluga groups seen 6-13 June 2000 during aerial surveys of Cook Inlet.