AERIAL SURVEYS OF BELUGA IN COOK INLET, ALASKA, JUNE 2002

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ABSTRACT

The National Marine Fisheries Service (NMFS) conducted an aerial survey of the beluga population in Cook Inlet, Alaska, during 4-11 June 2002. The 45 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' surveys conducted each year since 1993. The flights in June 2002 included one or more surveys of coastal areas (flown 1.4 km offshore) around the entire Inlet and 1,234 km of transects across the Inlet, effectively searching more than 26% of Cook Inlet but nearly 100% of the coastal areas. Paired, independent observers searched on the coastal (left) side of the plane, where virtually all beluga sightings occur, while a single observer was on the right. A computer operator/data recorder was also on the left side. After finding beluga groups, a series of aerial passes were made with two pairs of primary observers each making 4 or more independent counts of each group. Median counts made in optimal viewing conditions on 2 to 6 different days were 0-93 beluga in the Susitna Delta (between the Beluga and Little Susitna Rivers), 54-97 in Knik Arm (there appeared to be exchanges of whales between the Susitna area and Knik Arm), and 10-11 in Chickaloon Bay. No belugas were seen elsewhere. This sighting distribution has been consistent in June or July most years since 1996. The sum of the median aerial estimates (a very rough but quick index of relative abundance, not corrected for estimates of whales missed) for June 2002 is 192 belugas. This is below index counts for years prior to 1998 (305 in 1993, 281 in 1994, 324 in 1995, 307 in 1996, and 264 in 1997), but it is essentially the same as counts made during the past four years (193 in 1998, 217 in 1999, 184 in 2000, and 211 in 2001).

INTRODUCTION

Five stocks of beluga whales (*Delphinapterus leucas*) are recognized around Alaska: Cook Inlet, Bristol Bay, Eastern Bering Sea, Eastern Chukchi Sea, and the Beaufort Sea (Angliss *et al.* 2001; 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.* 2000).

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, 2001) in cooperation with the Alaska Beluga Whale Commission and the Cook Inlet Marine Mammal Council. Aerial surveys are proven to be the most efficient method for collecting distribution and abundance data for beluga in Cook Inlet and have been used for many years (e.g., Klinkhart 1966; Calkins *et al*. 1975; Murray and Fay 1979; Calkins 1984). The NMFS studies have provided some of the most thorough and intensive surveys of belugas in Cook Inlet (Rugh *et al.* 2000). The objective of the current study is to maintain this series of surveys with minimal changes in protocol. This provides the best option for interyear comparisons of whale distribution and abundance, minimizing variables.

METHODS

Aircraft and data

The survey aircraft, an Aero Commander 680 FL (*N7UP*), has twin-engines, high-wings, and 10-hr flying capability. There are bubble windows at each of four observer positions, maximizing the search area. An intercom system provided communication among the observers, data recorder, and pilots. 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 time, 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.

Tides

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 rapidly changing tide heights made it impractical to survey at specific tidal conditions throughout the Inlet. Synchronizing with the tide at locations where most whales have been seen in the past (the Susitna Delta and Knik Arm) was accomplished by departing from Anchorage less than three hours prior to the predicted low tide at the Anchorage Station near Ship Creek. The routine survey trackline went from

Anchorage south to East Foreland, crossed the inlet to West Foreland, and then proceeded north to the Susitna Delta, arriving at approximately low tide. Circling for an hour over a whale group in the Delta allowed the survey to arrive in Knik Arm shortly after low tide. It proved best to survey in Knik Arm during the rising tide because whale groups would be in long lines as they moved up flooding channels, which made them easy to count. Also, when the whales followed the current north, they moved away from the intense air traffic experienced near Anchorage where groups could not be circled for the standard counting protocol. When the survey was completed in Knik Arm (usually taking more than an hour if there were several groups of whales), low tide would be well up in Turnagain Arm. However, the change of tides in Turnagain can be so rapid that tide rips compromise visibility. Accordingly, it proved best to take a break and refuel in Anchorage or Birchwood after surveying Knik Arm before continuing the survey into Turnagain Arm and Chickaloon Bay. An alternative was to survey Turnagain Arm prior to surveying other areas, which meant leaving Anchorage nearly four hours before low tide at Ship Creek. When the tide was very low in Chickaloon Bay, the belugas disperse away from shore and were hard to count. At higher tides, belugas in Chickaloon were sometimes found close to shore or in Chickaloon River where they were relatively easy to count.

Tracklines

Coastal surveys were conducted on a trackline approximately 1.4 km offshore. The objective was to search all nearshore, shallow waters where beluga are typically seen in summer (Rugh *et al.* 2000). The trackline distance from shore was monitored with an inclinometer such that the waterline was generally 10° 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 or riffles.

In addition to the coastal surveys, systematic transects were flown across the Inlet. Two tracklines were designed to run the length of Cook Inlet without overlapping the transects flown in June 2001, and many incidental crossings of the Inlet provided additional offshore sampling effort (Fig. 1). Each year there has been an attempt to alter the offshore sampling effort to conduct as broad an array of searches as is practical.

Counting protocol

Immediately upon seeing a beluga group, each observer independently 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 (left front, left center, etc.) was recorded. An important component of the survey protocol was the independence of the paired observers (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. After a group of whales was reported, the trackline was maintained until the group was well behind the aircraft; then the aircraft returned to the group and began the circling routine. This allowed each observer full opportunity to independently sight and report whale groups. The pilot and

data recorder did not 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 (four passes for each of two pairs of observers on the right side of the aircraft), there were typically eight or more separate counting opportunities per whale group. Counts began and ended on a cue from the front observer, starting when the leading edge of the group was close enough to be counted and ending when the trailing edge 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 the location of a group, not how many whales were at the surface on the respective pass. Ratings were 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 counted. 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.

Video cameras

Two digital video cameras were operated on each counting pass. The pair of cameras were mounted together on a common board: magnification on the "standard" camera (Sony Digital 8 DCR-TRV103) was adjusted to keep the entire group of belugas in view, but magnification was kept constant throughout a pass; the other camera (a Sony DSR PD100a) was kept at maximum zoom (12x). Images from the "standard" camera will be studied in the laboratory for whale counts relative to the infield counts, and images from the camera kept at maximal zoom will be examined for color ratios (white adults vs dark juveniles) within the respective groups. Analysis of both the aerial counts and counts from the video tapes are detailed in Hobbs *et al*. (2000 [a]) for 1994-2000 data.

RESULTS

Survey effort

A total of 45 hrs of aerial surveys were flown around Cook Inlet from 4-11 June 2002. All of these surveys (13 flights ranging from 1.2 to 4.7 hrs) were based out of Anchorage, sometimes with refueling stops in Homer, Birchwood, or Palmer. Systematic search effort was conducted for 25 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 1.5 hrs (5.8% of the effective search time) when the left-front observer considered the visibility poor or useless. All but one of the primary

observers (the authors of this report) also flew with this project in 1998-2001, and two of the four observers have participated in this project almost every season since it began in 1993.

Lower Inlet surveys

Because the weather forecast for 4-5 June indicated unusually calm conditions throughout Cook Inlet, the aerial survey effort started by focusing on coastal and offshore areas south of the Forelands, an area susceptible to storms in the Gulf of Alaska. Conditions remained nearly ideal throughout this period with generally low sea states and heavy overcast (reducing glare) but very little rain. On 4 June, the survey followed an offshore trackline down the western third of the inlet and returned on a coastal survey of the western side. On 5 June, the survey went south along the east shore and returned to Anchorage along a trackline bordering the eastern third of the inlet (Fig. 1). Although one beluga group was seen near Pt Possession while en route to the lower inlet, no belugas were encountered south of the Forelands (lower Cook Inlet) even though many other marine mammals were seen: 1,481 harbor seals (*Phoca vitulina*, in 57 sightings, of which 270 seals were at Fox River and 492 in Iniskin Bay); 151 sea otters (*Enhydra lutris*, in 27 sightings, all coastal and south of 59°47'N); 54 Steller sea lions (*Eumetopias jubatus*, in 6 sightings all in Kamishak Bay except for 2 sea lions near Elizabeth Island); and 20 humpback whales (*Megaptera novaeangliae*, in groups of 1-3 each scattered along the southern boundary of Cook Inlet). All of these species were seen in the relatively clear water south of Chisik Island. During our 8-day survey period, the only marine mammals seen in the upper inlet were belugas and harbor seals.

Upper Inlet Surveys

On each day 6-11 June, attempts were made to survey the coastal areas of upper Cook Inlet. After a particularly thorough survey of the area on 7 June (as represented in Fig. 1), it was decided that the remaining surveys did not need to go south of Pt Possession or North Foreland, focusing instead on areas where belugas have been found in the past. A frontal system elevated the sea state on 8-9 June, reducing survey options to Knik Arm, where waters were relatively protected. On 10-11 June, conditions were again favorable except that Turnagain Arm and the offshore areas of Chickaloon Bay remained difficult to survey because of high winds.

Belugas were found in Chickaloon Bay, sometimes as far west as Pt Possession or east near Chickaloon River, but none were seen in Turnagain Arm in spite of several good to excellent surveys of that area. Median counts in Chickaloon Bay were 11 on 6 June and 10 on 7 June. Belugas were seen here on other days as well, but winds were too high to make good counts.

The Susitna Delta was surveyed well on 6 and 7 June. Visibility was excellent on these days, and the survey effort included tracklines nearly half way across the inlet. However, no belugas were seen here even though this is the area where belugas have been the most consistently found during the past decade. High winds lowered visibility in this area on 8 and 9 June, but on 10 and 11 June, conditions were again good. On 10 June, 32 belugas were counted in two groups between Beluga River and the Susitna River, and on 11 June the count rose to 93 in one long group in a north-south line south of the Susitna River. The group was moving east in an echelon formation. It appears there were exchanges of whales between

the Susitna area and Knik Arm during the survey period. Some of this distribution may be a function of tides.

Most of the beluga sightings occurred in Knik Arm this year. Because Knik Arm is relatively protected from winds, counts were made on each of the six days that surveys were made of upper Cook Inlet. Median daily counts in Knik Arm ranged from 54 to 97 (Table 1). There were from 1 to 7 groups seen here on different days with group sizes ranging from 1 to 87 whales. Although the whales seemed to consolidate into fewer groups when the tide was low, on an incoming tide they moved north, following channels in long lines making them easier to count. Also, when the whales retreated to the south with an ebbing tide, they concentrated in an area where it is not practical to fly our race track pattern for counts because of the intense air traffic around Elmendorf Air Base, Merrill Field, and the Anchorage International Airport. At high tide, belugas would spread out across the shallow mud flats, making it difficult to recognize perimeters of groups and impractical to circle them for counts and videotaping. Therefore, it appears that the ideal time to survey Knik Arm is approximately an hour after the tide has started to rise.

Harbor seals were the only other marine mammals seen in upper Cook Inlet. There were 125 seals in 11 sightings: 6 seals were at the McArthur River (on two different days); 10-56 seals were seen on different days in the western Susitna Delta; and 4-40 seals were in the Chickaloon River.

Coverage

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 1,234 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 5,244 sq km, which is 26% of the 19,863 sq km surface area of Cook Inlet; however, these surveys covered virtually 100% of the coastal areas. Most of upper Cook Inlet was surveyed six times, especially areas where large groups of beluga have consistently been found in the past–such as the Susitna Delta, Knik Arm, and Chickaloon Bay.

Summary counts

Medians of counts of belugas are shown in Table 1, and sighting locations are shown in Figure 1. Typically, there were 4 good counts made by each of the four observers for each group; therefore, 16 counts were made on each flight, but because whale groups were fairly constant from day to day throughout the survey period, there could be over 320 redundant aerial counts, not including counts made on video tapes. These counts are represented by medians of each of the four observers' median counts on multiple passes over a group. The process of using medians instead of maximums or means reduces the effect of outliers (extremes in high or low counts) and makes the results more comparable to others' surveys which lack multiple passes over whale groups. Medians are also more appropriate than maximums when counts are corrected for missed whales. The median index count for all observers was 192. This summary count does not reflect any correction 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*. 2000 [b]). The median index of counts in June 2002 (192) is essentially the same as counts from 1998-2001 (193-217; Table 2).

DISCUSSION

In Cook Inlet, beluga concentrate near river mouths during spring and early summer across the northernmost reaches of the 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 both upper and lower Cook Inlet in June and July (Rugh *et al.* 2000), but since 1993, when the NMFS surveys began, only 0-4% of the annual sightings have occurred in the lower Inlet (Table 2). Furthermore, from 1996-2002 whales were very rarely seen south of North Foreland. Sighting conditions have generally been ideal during the searches of coastal and offshore waters, but the only places where beluga were seen consistently were in the upper Inlet (Table 1, Fig.1). Many sea otters, harbor seals, harbor porpoise, gray whales, humpback whales, and other marine mammals were seen in the lower Inlet, so the lack of beluga sightings there was not due to poor visibility.

The uncorrected sum of median estimates made from the June 2002 aerial observations in Cook Inlet was 192 beluga. Using the same procedure of summarizing median estimates from the highest seasonal counts at each site for each year 1993-2002, there were, respectively, 305, 281, 324, 307, 264, 193, 217, 184, 211, and 192 beluga (Table 2). Calculated abundances, including corrections for whales missed within the viewing range of observers and whales missed because they were beneath the surface, were 653, 491, 594, 440, 347, 367, and 435 for 1994-2000, respectively (Hobbs *et al*. 2000 [b]). There was an apparent decline in whale distribution, counts, and abundance estimates until 1998. After this the subsistence harvest was regulated, and the declines seemed to have stopped.

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Table 1. Summary counts of beluga made during aerial surveys of Cook Inlet in June 2002. Medians counts are from the four observers doing multiple counts of each group of whales. 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	4-5 June median	6 June median	7 June median	8 June median	9 June median	10 June median	11 June median	2002 best
Turnagain Arm (north and east of Chickaloon Bay)	--	0	0	--	--	0	**0**	**0**
Chickaloon Bay/ Pt. Possession	--	11	10	--	--	--	**--**	**11**
Pt. Possession to East Foreland	--	--	0	--	--	--	**--**	**0**
Mid-Inlet east of Trading Bay	0	--	--	--	--	--	**--**	**0**
East Foreland to Homer	0	--	--	--	--	--	**--**	**0**
Kachemak Bay	0	--	--	--	--	--	**--**	**0**
West side of lower Cook Inlet	0	--	--	--	--	--	**--**	**0**
Redoubt Bay	0	--	--	--	--	--	**--**	**0**
Trading Bay	--	0	0	--	--	--	**--**	**0**
Susitna Delta (N Foreland to Pt. Mackenzie)	--	0	0	--	--	32	**93**	**93**
Knik Arm	--	67	97	81	72	54	**88**	**88**
Fire Island	--	0	0	--	0	--	**0**	**0**
							∑ =	**192**

Table 2. Summary of index counts of beluga made during aerial surveys of Cook Inlet in June or July 1993-2002.

Year	Dates	Index 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%
2001	June 5-12	**211**	1%	35%	64%
2002	June 4-11	**192**	0%	48%	52%

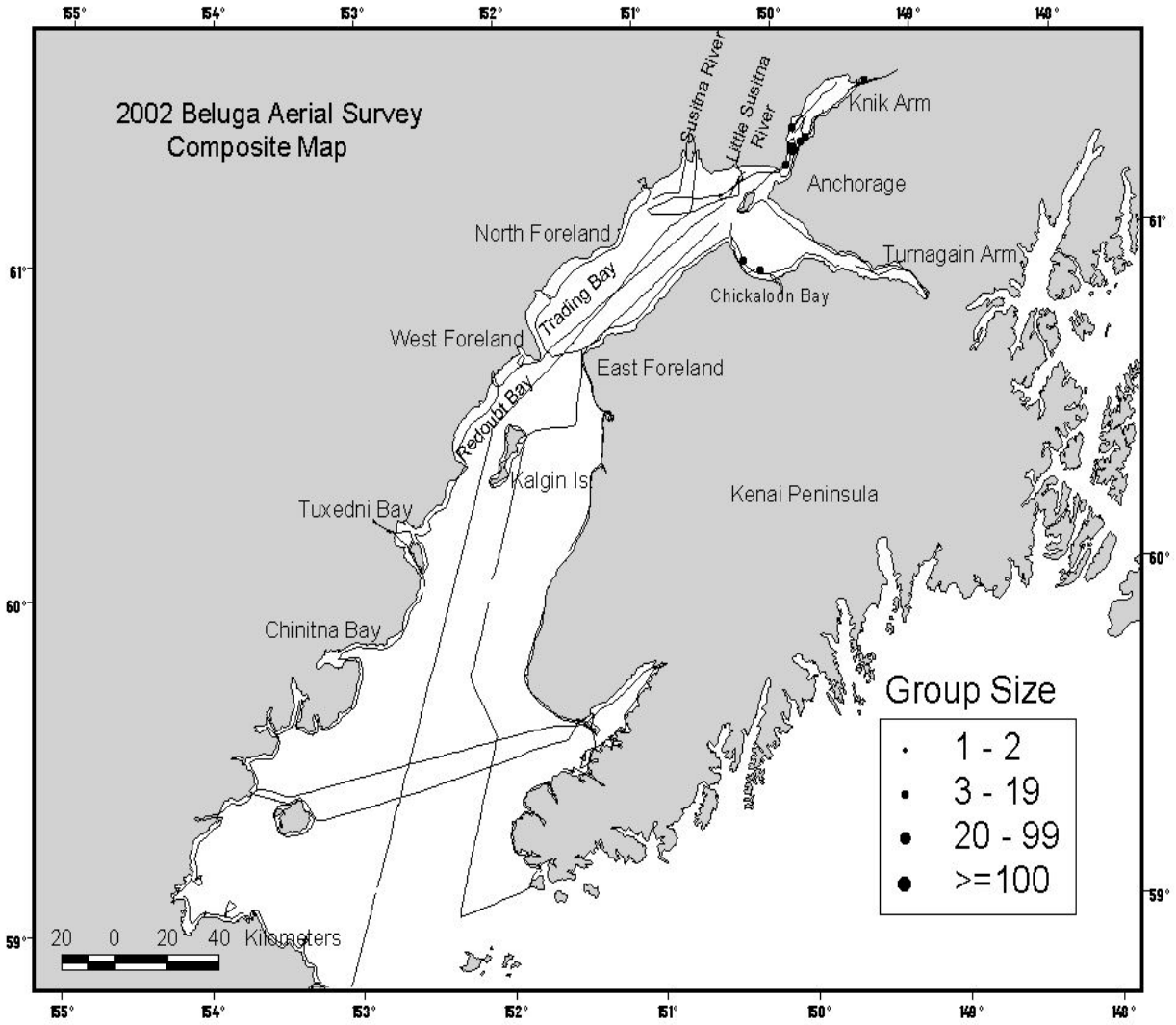

Figure 1. Aerial survey effort and beluga groups seen in Cook Inlet during flights conducted 4-11 June 2002. All whales were near river mouths or in shallow coastal waters of the northern part of the inlet. The survey covered all coastal areas and 1,234 km of offshore waters. Most of the northern part of the inlet was surveyed six times, but only one representative trackline is shown here.