

AERIAL SURVEYS OF BELUGA IN COOK INLET, ALASKA, JUNE 2001

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ABSTRACT

The National Marine Fisheries Service (NMFS) conducted an aerial survey of the beluga population in Cook Inlet, Alaska, during 5-12 June 2001. The 55 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 2001 included one or more surveys of coastal areas (flown 1.4 km offshore) around the entire Inlet and 1186 km of transects across the Inlet. 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 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 counts of each group. Median counts made in optimal viewing conditions on 5 different days were 44-114 beluga in the Susitna Delta (between the Beluga and Little Susitna Rivers), 60-127 in Knik Arm (there appeared to be exchanges of whales between the Susitna area and Knik Arm), 12-34 in Chickaloon Bay, and 0-10 in Turnagain Arm (the whales in Turnagain are thought to exchange with whales in Chickaloon). This sighting distribution has been consistent each June or July since 1996. In addition, two belugas were found in Kachemak Bay, an area where belugas have not been seen during our surveys since 1994. The sum of the median aerial estimates (not corrected for missed whales) for June 2001 is 211. 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 three years (193 in 1998, 217 in 1999, and 184 in 2000).

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 and bays during parts of the year (Rugh *et al.* In press^b). 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 press^a) in cooperation with the Alaska Beluga Whale Commission (ABWC) and the Cook Inlet Marine Mammal Council (CIMMC). 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 most recent studies have been some of the most thorough and intensive (Rugh *et al.* In press^b).

METHODS

Aircraft and data

The survey aircraft, an Aero Commander 680 FL (*N7UP*), has twin-engines, high-wings, and 10-hr flying capability. It 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.

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 highly variable 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 three hours prior to the predicted low tide at the Anchorage Station (near Ship Creek). The survey trackline went from Anchorage south to East Foreland, crossed the Inlet to West Foreland, and then proceeded north to the Susitna Delta, arriving just before low tide. Circling for an hour over a whale group there allowed the survey to arrive in Knik Arm just before low tide. When the survey was completed in Knik Arm (usually taking an hour if there were several groups of whales), low tide would be progressing up Turnagain Arm. However, the change of tides in Turnagain can be so rapid that tide rips compromise visibility. Accordingly, it proved best to refuel and take a rest break in Anchorage before continuing the survey into Turnagain Arm and Chickaloon Bay. When the tide was very low in Chickaloon Bay, the whales seemed to disperse away from shore and were harder to count. At higher tides, whales 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 nearshore, shallow waters where beluga are typically seen in summer (Rugh *et al.* In press^b). 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, 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 also 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 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 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 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.

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.* (In press ^a) for 1994-2000 data.

RESULTS

Survey effort

A total of 55 hrs of aerial surveys were flown around Cook Inlet from 5-12 June 2001. All of these surveys (16 flights ranging from 0.8 to 6.5 hrs) were based out of Anchorage, sometimes with refueling stops in Homer. Systematic search effort was conducted for 29.4 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 only 1.5 hrs (5% of the effective search time) when the left-front observer considered the visibility poor or worse. All of the primary observers (the authors of this report) also flew with this project in 1998-2000, and three of the four observers have participated in this project almost every season since it began in 1993.

Upper Inlet surveys

On the first three days of this survey (5-7 June) and the last three days (10-12 June), standard coastal tracklines were flown around upper Cook Inlet for a total of six times. The route proceeded from Anchorage, around Fire Island, south to Pt Possession, then to East Foreland and across the Inlet to West Foreland (5-7 June only; 10-12 June the route went from Pt Possession west to North Foreland), north to the Susitna Delta (including flights up the MacArthur, Beluga, Susitna, and Little Susitna rivers), Knik Arm (up Knik River as far as Eklutna), Turnagain Arm, and Chickaloon Bay (including Chickaloon River). There were two flights on each of these six days, with 5.9 to 7.3 flight hrs per day. Ideal counting conditions and thorough coverage of the upper Inlet occurred on most of five surveys on 5-7 and 10-11 June. On the sixth survey, 12 June, winds in Turnagain Arm, a dispersal of whales in Chickaloon Bay, and difficulties with dense aerial traffic in Knik Arm made for poor survey conditions. Therefore, the upper Inlet is considered to have been sampled 5 times.

Beluga groups were found in the Susitna Delta (particularly from the west mouth of the Susitna River to the mouth of the Little Susitna), Knik Arm (mostly along coastal areas south of Goose Bay and Eagle Bay at low tide), in Turnagain Arm (the first time our surveys have found beluga here since 1994), and in Chickaloon Bay (concentrated in Chickaloon River or on the south shore of the bay, but scattered when away from shore). Beluga in Turnagain and Chickaloon are assumed to mingle and separate easily between days. It is also assumed that beluga mingle easily between the Susitna Delta and Knik Arm, but we assume there is relatively little mingling between whales north and south of Anchorage, at least not during our 9-day survey period. Sighting locations were nearly identical to those made in most years except for a small group (~10 by count) in Turnagain Arm, seen one day in a whirlpool near Bird Pt, one day near Potter's Marsh, and later that day seen midway across the mouth of Turnagain Arm. On other days, no beluga were seen in Turnagain, but counts in Chickaloon Bay were sometimes higher by an equal amount, indicating that whales seen in Turnagain sometimes joined the group in Chickaloon.

Harbor seals (*Phoca vitulina*) were the only other marine mammals seen in upper Cook Inlet. They were seen on almost every flight, with concentrations on the west side of the Susitna River (70, 210, or 253 on different days) and in the Chickaloon River (37 or 120 on different days).

Lower Inlet surveys

On 8 and 9 June, the lower Inlet was surveyed by following the east coast from Pt Possession south to Elizabeth Island (including a flight up the Kenai River and around Kachemak Bay). Then an offshore trackline was flown north to Anchorage along the east third of the Inlet. On the following day, an offshore trackline was flown south from Anchorage along the west third of the Inlet. After reaching Cape Douglas, the survey continued north up the west side of Cook Inlet as far as West Foreland, then an offshore transect was followed back to Anchorage (Fig.1). Refueling and rest stops were made in Homer on each of these two days.

For the first time since June 1994, beluga whales were seen by our observers in Kachemak Bay. An adult and young whale (not a calf) were near the north central shore of the bay in shallow, clear water. They appeared to be eating or nosing the sea floor. No other

beluga were seen on this day except at the end of the flight in Chickaloon Bay. Other marine mammals seen on 8-9 June in lower Cook Inlet were 33 sightings of 795 harbor seals (of which 448 were at Fox River, 217 in Iniskin Bay, and 79 in Redoubt Bay), 25 sightings of 66 sea otters (*Enhydra lutris*, all coastal and south of 59°41'N), 5 sightings of 35 Steller sea lions (*Eumetopias jubatus*, ~10 on Elizabeth Island and 20 on Shaw Island), 22 sightings of 25 harbor porpoise (*Phocoena phocoena*, all seen south of Kalgin Island), 2 gray whales (*Eschrichtius robustus*, at Elizabeth Island), 2 fin whales (*Balaenoptera physalus*, midway across the southern boundary of Cook Inlet), 26 humpback whales (*Megaptera novaeangliae*, along the southern boundary of Cook Inlet), and 15 killer whales (*Orcinus orca*, in one pod west of Seldovia, swimming into Kachemak Bay). All of these species were seen in the relatively clear water south of Kalgin Island. During our 9-day survey period, the only marine mammals seen north of Kalgin were beluga and harbor seals.

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 1,186 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 5,200 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 observer for each group; therefore, 16 counts were made on each flight, but because whale groups were fairly constant from day to day through the survey period, there could be over 320 counts of a single group, not including counts made on the 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. Observers' summary counts ranged from 209 to 241, depending on observer. The median index count for all observers was 211. 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.* In press^b). The median index of counts in June 2001 (211) is higher than the previous year (184 in 2000), 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 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.* In press^b), 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 1996-2000 only single or dead whales were seen south of North Foreland, until the pair of beluga was seen in Kachemak Bay in June 2001. 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, and humpback whales were seen in the lower Inlet, so the lack of beluga sightings there was not due to poor visibility.

Sighting data in the 1970's and 1980's indicate a proportional shift from the upper Inlet in June to the lower Inlet in July, a shift which was no longer apparent in the 1990's (Rugh *et al.* In press^b). However, in 2001 this shift might have occurred again: the whales found 5-12 June were mostly where they have been found throughout the 1990's in the upper Inlet, but a survey on 2 July resulted in a median count of only 37 belugas (NMFS, unpubl. data). It seems possible, that whales may had moved offshore or into parts of the lower Inlet in July, as they have done in the past.

The uncorrected sum of median estimates made from the June 2001 aerial observations in Cook Inlet was 211 beluga. Using the same procedure of summarizing median estimates from the highest seasonal counts at each site for each year 1993-2000, there were, respectively, 305, 281, 324, 307, 264, 193, 217, and 184 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.* In press^b). There was an apparent decline in whale distribution, counts, and abundance estimates until 1998. After this, whaling ceased, and the declines seem to have stopped.

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distances flown were provided by Kristin Laidre (NMML). This survey was conducted under MMPA Scientific Research Permit No. 782-1438.

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Table 1. Summary counts of beluga made during aerial surveys of Cook Inlet in June 2001. Medians counts are from the four observers doing multiple counts of each group of whales. Highest counts are shown in parentheses. 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	5 June	6 June	7 June	8-9 June	10 June	11 June	2001
	med	med	med	med	med	med	best
Turnagain Arm (north and east of Chickaloon Bay)	8 (10)	0	0	--	0	10 (20)	34
Chickaloon Bay/ Pt. Possession	22 (30)	14 (28)	12 (14)	--	34 (52)	21 (33)	
Pt. Possession to East Foreland	0	0	0	0	--	--	0
Mid-Inlet east of Trading Bay	--	--	--	0	--	--	0
East Foreland to Homer	--	--	--	0	--	--	0
Kachemak Bay	--	--	--	2	--	--	2
West side of lower Cook Inlet	--	--	--	0	--	--	0
Redoubt Bay	--	--	--	0	--	--	0
Trading Bay	0	0	0	--	--	--	0
Susitna Delta (N Foreland to Pt. Mackenzie)	48 (67)	44 (82)	97 (118)	--	114 (138)	71 (111)	175
Knik Arm	127 (171)	107 (162)	72 (98)	--	60 (120)	61 (107)	
Fire Island	0	0	0	--	--	0	0
						$\Sigma =$	211

Table 2. Summary of beluga sightings made during aerial surveys of Cook Inlet in June or July 1993-2001. Medians were used when multiple counts occurred within a day, and the high counts among days were entered here.

Year	Dates	Counts	Percent Sightings		
			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

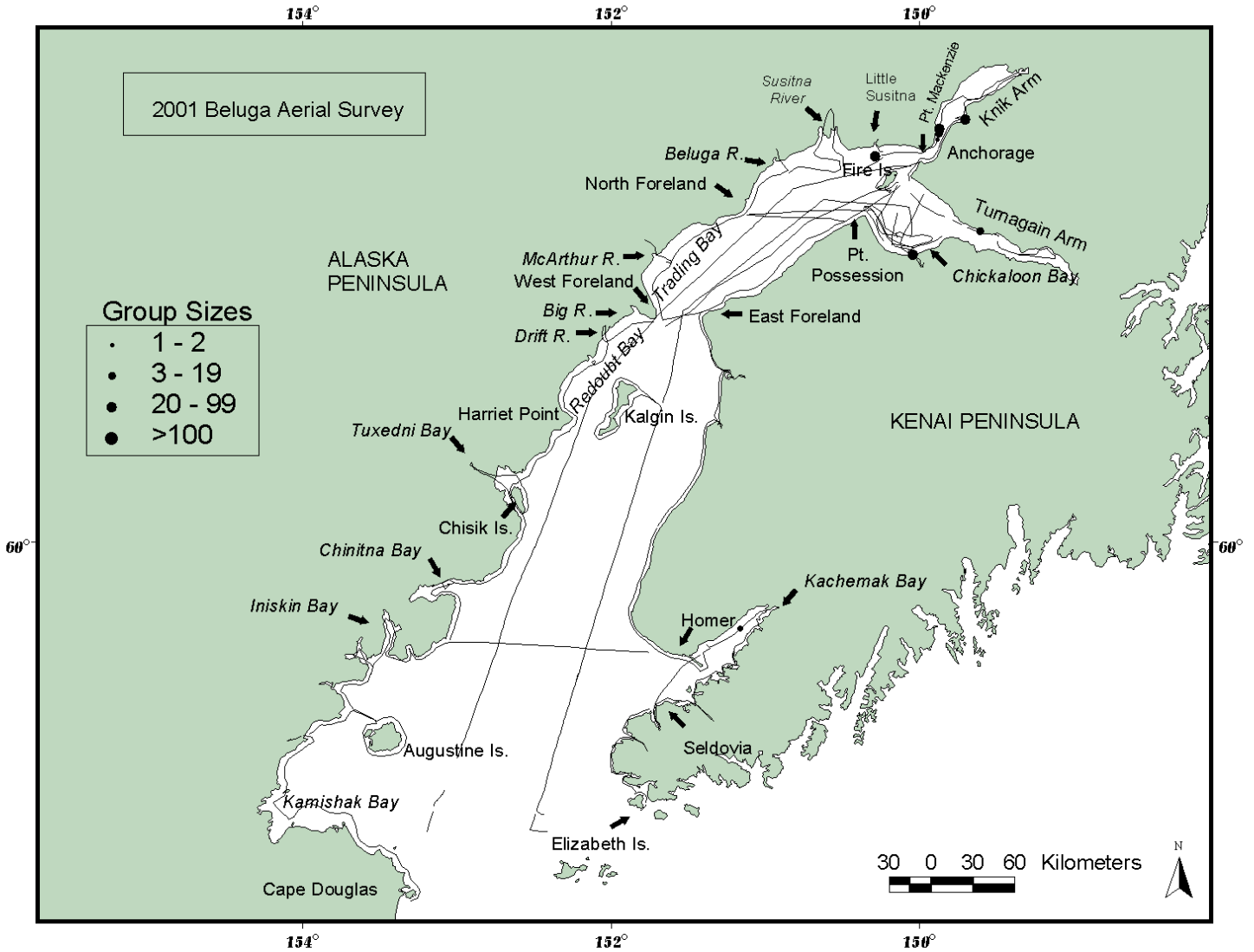


Figure 1. Aerial survey effort and beluga groups seen in Cook Inlet during flights conducted 5-12 June 2001. All but two whales (found near Homer) were near river mouths or in shallow coastal waters of the northern part of the inlet. The survey covered all coastal areas and 1186 km of offshore waters. The northern part of the inlet was surveyed six times, but only one representative trackline is shown here.