AERIAL SURVEYS OF BELUGAS IN COOK INLET, ALASKA, JUNE 2004

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Abstract

The National Marine Fisheries Service (NMFS) conducted an aerial survey of the beluga population in Cook Inlet, Alaska, during 2-9 June 2004. 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 2004 included one or more surveys of coastal areas (flown 1.4 km offshore) around the entire inlet and 1,653 km of transects across the inlet, effectively searching 31% 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 four or more independent counts of each group. Median counts made in optimal viewing conditions on six different days were 11-99 belugas in the Susitna delta (between the Beluga and Little Susitna Rivers) and 11-176 in Chickaloon Bay/ Turnagain Arm. No belugas were seen elsewhere, including Knik Arm (the first time significant numbers have not been seen in Knik Arm since 1995). On these annual surveys, belugas have often been seen in the Susitna area and Chickaloon Bay, but never before have such large numbers been seen in Chickaloon Bay and in Turnagain Arm. It is evident that many whales were passing from the Susitna area to Chickaloon Bay and back within the time period of this survey. 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 2004 is 187 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 similar to other counts made during the past seven years (193 in 1998, 217 in 1999, 184 in 2000, 211 in 2001, 192 in 2002, and 174 in 2003).

Introduction

The National Marine Fisheries Service (NMFS) has conducted annual aerial surveys to study the distribution and abundance of belugas (*Delphinapterus leucas*) in Cook Inlet each June/July since 1993 (Withrow *et al*. 1994; Rugh *et al*. 1995, 1996, 1997a, 1997b, 1999, 2000a, 2001, 2002, 2003). This project has been in cooperation with the Cook Inlet Marine Mammal Council (CIMMC) and the Alaska Beluga Whale Commission (ABWC). Aerial surveys are proven to be the most efficient method for collecting distribution and abundance data for belugas in Cook Inlet and have been used for many years prior to the NMFS surveys (e.g., Klinkhart 1966; Calkins *et al*. 1975; Murray and Fay 1979; Calkins 1984). The NMFS studies have been the most thorough and intensive (Rugh *et al.* 2000b). The primary objectives for the current study are to document the location of sightings and count belugas in Cook Inlet while maintaining a continuity with preceding studies to allow for inter-year trend analyses.

Much of the motivation for this research has been driven by the small size (approximately 400 whales; Hobbs et al. 2000a) and isolation of the beluga stock in Cook Inlet (O'Corry-Crowe *et al*. 1997; Laidre et al. 2000; Rugh et al. 2000b), which, until 1999, was subjected to an unregulated harvest (Mahoney and Shelden 2000). On 31 May 2000, this stock was designated as depleted under the Marine Mammal Protection Act (65 FR 34590) and is now managed with a small, regulated subsistence harvest.

Methods

Aircraft and data

The survey aircraft, an Aero Commander 680 FLP (*N7UP*), has twin-engines, high-wings, and 10-hr flying capability. There are bubble windows at each of three primary observer positions, maximizing the search area. An intercom system provided communication among the observers, data recorder, and pilots, but a selective listening device was used to aurally isolate each observer position. 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 (every two seconds), 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 recorded. Observer seating positions were noted each time they were changed, generally every 1-2 hrs to minimize fatigue.

Tides

The broad geographical range of these surveys in conjunction with rapidly changing tide heights made it impractical to survey at specific tidal conditions throughout Cook Inlet. There was an attempt to synchronize flight timings with low tides in the Susitna delta and Knik Arm. 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. In the past it has proved best to survey Knik Arm during a rising tide because whale groups were relatively more concentrated as they moved up flooding channels. Also, when the whales followed the current north, they moved away from the intense air traffic experienced near Anchorage with Elmendorf Air Base, Merrill Field, Hood Lake, and the Anchorage International Airport where observed whales could not be circled for the standard counting protocol. Because the change of tides in Turnagain Arm can be so rapid that tide rips compromise visibility, it proved best to survey there on a high tide while it was slack. Also, at high tide, belugas in Chickaloon Bay are sometimes grouped close to shore or in Chickaloon River where they are relatively easy to count. The timing of aerial surveys of areas south of Point Possession and North Foreland were a function of weather, not tides.

Although there are many hours of daylight in this area during early June (just prior to the summer solstice), light levels were low enough at night to limit our survey to hours between 07:30 and 20:30, local time. The flight schedule for every survey day was designed to take advantage of tidal patterns, as described above, relative to workable daylight hours.

Tracklines

Coastal surveys were conducted approximately 1.4 km offshore. The objective was to search all nearshore, shallow waters where belugas are typically seen in summer (Rugh *et al.* 2000b). 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 or as recommended by Native hunters who have flown with us in the past.

In addition to the coastal surveys, systematic transects were flown across the inlet (Fig. 1). Offshore tracklines were designed to run the length of Cook Inlet or cross it, minimizing overlap (Fig. 2). 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). Visual barriers were 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 directly 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 the 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 a counting pass were included; whale tracks in the muddy water or ripples were not counted. Count records were not shared on the aerial team until after all surveys were completed. This was done to maximize the independence of each observer's counts.

Because most whale groups were counted on eight different aerial passes, and because two observers were counting on each pass, there were usually 16 counts made per group per day, not including counts made later on video tapes. The daily aerial counts are represented by medians of each of the four observers' median counts on multiple passes over a group (Table 1). 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.

Video cameras

Two digital video cameras were operated together on most counting passes by having the pair mounted together on a common board. The “standard” camera (a Sony DVCAM, DSR-PDX10 Model L10A) was kept at its widest angle to keep the entire group of belugas in view. The second camera (a Sony DSR PD100a) was kept at maximal optical zoom (12x). Images from the “standard” camera will be studied in the laboratory for whale counts relative to the precise length of time that images were available to be counted. These are the beluga counts that will be used to determine the abundance estimates (Hobbs *et al*. 2000a). Images from the camera kept at maximal zoom will be examined for subtle surfacings that did not show up in the standard video and for color ratios (white adults vs dark juveniles) within the respective groups (as described in Litzky 2001). Analysis of both the aerial counts and counts from the video tapes are detailed in Hobbs *et al*. (2000b) for 1994-2000 data.

In addition, on half of the aerial passes, a digital still camera (Nikon D1X with a 300 mm Nikkor AF lens) was mounted alongside the video camera used for standard images. The still camera was fired when there were whales in view, unlike the video camera which videotaped well before and after a whale group passed through the field of view. The digital still images provide greater detail to help detect calves, which are darker than the adults and do not rise above the surface as much as the white adults do.

Results

Survey effort

A total of 45 hrs were flown around Cook Inlet from 2 to 9 June 2004. All of these flights (14 take-offs and landings ranging from 1.8 to 5.0 hrs) were based out of Anchorage, sometimes with refueling stops in Homer or Kenai. Of the 45 flight hours, 29 hrs were spent in the standard search, not including time spent taxiing on the runway, deadheading without a search effort, circling whale groups to conduct counts, or periods with poor visibility. Visibility conditions interfered with the survey effort during 0.8 hrs (3% of the effective search time) when the left-front observer considered the visibility poor or useless. All of the primary observers (the authors of this report) have flown with this project in the past, and three of the observers have participated in this project almost every season since it began in 1993.

Coverage

The composite of the aerial surveys in June 2004 provided a thorough coverage of the coast of Cook Inlet (1,388 km) for most of the area within approximately 3 km of shore (Figs. 1 and 2). In addition, there were 1,653 km of systematic transects flown across the inlet (853 km in the upper inlet and 800 km in the lower inlet). Assuming a 2.0 km transect swath (1.4 km on the left side plus 1.4 km on the right side, less the 0.8 km blind zone beneath the aircraft), the cumulative survey tracklines covered roughly 6,000 km^2, which is 31% of the 19,863 km^2 surface area of Cook Inlet; however, these surveys covered virtually 100% of the coastal areas. This coverage was typical of these beluga surveys during the past decade (Rugh et al. 2000b). Most of upper Cook Inlet was surveyed five times, especially areas where groups of belugas have consistently been found in the past – such as the Susitna delta, Knik Arm, and Chickaloon Bay.

Daily reports

A survey was flown on 2 June with the intention of doing a complete coverage of upper Cook Inlet; however, Turnagain Arm and Chickaloon Bay were too windy, so the survey started at Fire Island and flew south to East Foreland and across the inlet to Big River (Redoubt Bay) then north to the Susitna Delta. A large group of belugas was found near the Little Susitna River (Table 1). It was to be counted after taking a break in Anchorage; however, radio communication problems meant that the survey was terminated for this day.

The survey on 3 June had a mix of excellent to poor visibility in Turnagain Arm and Chickaloon Bay at high tide. No belugas were found, probably because the search was compromised by visibility. Conditions were good as far south as Kenai Airport, where the plane was refueled and enough time passed for the tides to lower in the Susitna area. From Kenai, the survey flew west to Drift River and north along the coastline and rivers until two groups of whales (median counts = 5 + 94; Table 1) were found near the Little Susitna River (in the same area as a group was seen on the previous day, 2 June). The survey of Knik Arm resulted in no beluga sightings in spite of excellent conditions. This is the first time no

significant whale groups have been seen in Knik Arm by these annual surveys since July 1995.

Upper Cook Inlet was surveyed again on 4 June. Conditions were excellent in Turnagain Arm and Chickaloon Bay (at high tide), and as has been typical for almost every survey since 1993, a small group of belugas (n = 11; Table 1) was found in Chickaloon Bay. The search continued south to Kenai, and after refueling it went directly to North Foreland and along the coast in excellent viewing conditions (heavy overcast, no wind) around the Susitna delta and Knik Arm. A large group of belugas (n = 65; Table 1) was found west of the Little Susitna River, in the same location as on the previous two days. No whales were found in Knik Arm.

On 5-6 June the lower half of Cook Inlet was surveyed to take advantage of favorable weather conditions. On 5 June the survey searched coastal areas on the east side and returned north on a series of straight-line transects up the west third of the inlet, including coastal surveys around Augustine and Kalgin Islands. On the second day, straight-line transects were flown south on the east third of the inlet as far as Cape Douglas then up the west coast (plus a refueling stop in Homer) to West Foreland and then straight to Anchorage. Conditions for the coastal surveys on these two days were generally excellent and many marine mammals were seen (see "Other marine mammals" below), but no belugas were seen.

Upper Cook Inlet was resurveyed on 7 June, starting with Chickaloon Bay to better synchronize the timing with high tide in Turnagain Arm. Two groups of belugas (n = 129 and 47; Table 1) were found in Chickaloon Bay, the largest numbers ever seen there. The survey also covered Turnagain Arm, the Susitna Delta, and Knik Arm. No belugas were found outside of Chickaloon Bay other than a small group (n = 11; Table 1) at Theodore River, southwest of the mouth of Susitna River.

Upper Cook Inlet was surveyed again on 8 June. Rain and fog limited the search initially to the Susitna area. A small group of belugas (n = 15; Table 1) was found near the Little Susitna River, similar to the small group found near the Theodore River on the previous day. The survey then went to Point Possession and down the east coast to Kenai Airport. When weather improved, surveys were resumed and many belugas were again found in Chickaloon Bay (n = 44 + 9 + 20 + 39; Table 1) and near the entrance to Turnagain Arm (n = 37; Table 1), and again none were in Knik Arm, in spite of good survey conditions.

The final survey, on 9 June, covered most coastal areas in upper Cook Inlet north of Moose Point and North Foreland. Two groups of belugas (n = 9 and 32; Table 1) were found in and near the Little Susitna River (a location consistent with almost all surveys this season), well up in Turnagain Arm near Six Mile Creek (n = 50; the largest group seen in Turnagain since these surveys began in 1993), and in Chickaloon Bay (n = 65 in a wide scatter across most of the nearshore area). It seems some of the whales that had been in Chickaloon over the past few days had returned to the Susitna delta.

Summary counts of belugas

Medians of counts of belugas are shown in Table 1, and sighting locations are shown in Figure 3. The median index count for all observers in June 2004 was 187. This summary count does not reflect any correction for missed whales. Calculations for whales missed during these aerial counts and estimates of abundance were described in Hobbs *et al*. (2000a, 2000b). This median index (187) is essentially the same as counts from 1998-2003 (184-217; Table 2).

Other marine mammals

Besides belugas, the only other marine mammals seen in upper Cook Inlet were harbor seals (*Phoca vitulina*). In 2004, harbor seals were seen from the Theodore River to Ivan River (over 200 each day), on the Susitna mudflats (75), and near the Chickaloon River (20-100 each day). Although belugas were not seen in lower Cook Inlet, many other marine mammals were observed (Fig. 4): harbor seals occurred in Kachemak Bay (300+), near Elizabeth Island (1), from Cape Douglas to Iniskin Bay (225), Tuxedni Bay (20), and near Big River (35); sea otters (*Enhydra lutris*) were observed in Kachemak Bay (221), Port Graham (6), from Cape Douglas to McNeil Cove (87), Augustine Island (54), Iliamna to Iniskin Bay (12), and Oil Bay to Chinitna Bay (7). Only one Steller sea lion (*Eumetopias jubatus*); it was near Akumwarvik Bay. Cetacean sightings included 2 fin whales (*Balaenoptera physalus*) near the Barren Islands, 16 humpback whales (*Megaptera novaeangliae*) in groups of 1 to 3 individuals in the central inlet between Anchor Pt. and the Barren Islands, and at least 100 harbor porpoise (*Phocoena phocoena*) from Cape Douglas to Kalgin Island.

Discussion

The June 2004 survey of Cook Inlet was very similar to previous surveys in terms of research protocol and coverage. The type of aircraft, window configuration, altitude, air speed, and coastal search patterns were kept as constant as possible between years, and at least two of the observers have returned for almost every survey, maintaining continuity in effort. This consistency has the benefit of minimizing variables. In addition to the many years this project has been underway (1993-2004), each of these annual surveys has involved several replicate flights around upper Cook Inlet in June or July. The large number of flights and consistency of effort has helped us detect patterns of whale distribution. In 2004, as in most years, belugas were found in small groups in June near river mouths along the northwestern shores of upper Cook Inlet, in particular near the Susitna River, Little Susitna River, and along the shores of Chickaloon Bay; however, no belugas were found south of the Forelands in lower Cook Inlet (Fig. 3; Table 1). Prior to 1996 it was not uncommon to see groups of belugas south of North Foreland (Rugh *et al.* 2000b), but since then only one or two belugas have been found there, if any. Sighting conditions have generally been ideal during the searches of coastal and offshore waters, but the only places where belugas were seen regularly have been in the upper inlet. Because many other marine mammals were seen in the lower inlet, the lack of beluga sightings was not due to visibility.

The uncorrected sum of median estimates (187 belugas) made from the June 2004 aerial observations in Cook Inlet is essentially the same as similar index counts made each year since 1998, generally near 200 whales (Table 2). Index counts made prior to 1998 were higher, generally near 300. These medians must be treated as merely a rough index that provides a quick assessment of the raw counts made from the air. Calculated abundances – including corrections for whales missed within the viewing range of observers and whales missed because they were beneath the surface – are shown in Table 2 with estimates from 1994-2000 reported in Hobbs *et al*. (2000a) and 2001-03 from NMFS unpublished data. The abundance estimates, with their associated CV, are the appropriate values to be used in interyear trend analyses.

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Table 1. Summary counts of belugas made during aerial surveys of Cook Inlet in June 2004. Counts are medians 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	2 June	3 June	4 June	5 June	6 June	7 June	8 June	9 June
Turnagain Arm (not including Chickaloon Bay)	---	0	0	---	---	0	37	50
Chickaloon Bay/ Pt. Possession	---	---	11	---	---	176	112	65
Pt. Possession to East Foreland	0	0	0	0	---	---	0	---
Mid-inlet east of Trading Bay	---	---	0	0	0	---	---	---
East Foreland to Homer	---	---	---	0	---	---	---	---
Kachemak Bay	---	---	---	0	---	---	---	---
West side of lower Cook Inlet	---	---	---	---	0	---	---	---
Redoubt Bay	0	0	---	---	0	---	---	---
Trading Bay	0	0	---	---	---	---	---	---
Susitna delta (N Foreland to Pt. Mackenzie)	**	99	65	---	---	11	15	41
Knik Arm	---	0	0	---	---	0	0	0
Fire Island	0	0	0	---	---	0	0	0

** Large beluga group seen but not counted.

Table 2. Summary of index counts of belugas made during aerial surveys of Cook Inlet in June or July 1993-2004 with abundance estimates and the respective CV where available (Hobbs et al. 2000a; NMFS unpubl. data). Percentages of sightings made in three generalized zones are indicated.

Year	Dates	Index Counts	Abundance estimates	CV	Lower Cook Inlet	Susitna delta	Elsewhere in Upper Cook Inlet
1993	June 2-5	**305**	---	---	0%	56%	44%
1994	June 1-5	**281**	653	0.43	4%	91%	5%
1995	July 18-24	**324**	491	0.44	4%	89%	7%
1996	June 11-17	**307**	594	0.28	0%	81%	19%
1997	June 8-10	**264**	440	0.14	0%	28%	72%
1998	June 9-15	**193**	347	0.29	0%	56%	44%
1999	June 8-14	**217**	367	0.14	0%	74%	26%
2000	June 6-13	**184**	435	0.23	0%	62%	38%
2001	June 5-12	**211**	386	0.09	1%	35%	64%
2002	June 4-11	**192**	313	0.12	0%	48%	52%
2003	June 3-12	**174**	357	0.11	0%	9%	91%
2004	June 2-9	**187**	---	---	0%	6%	94%

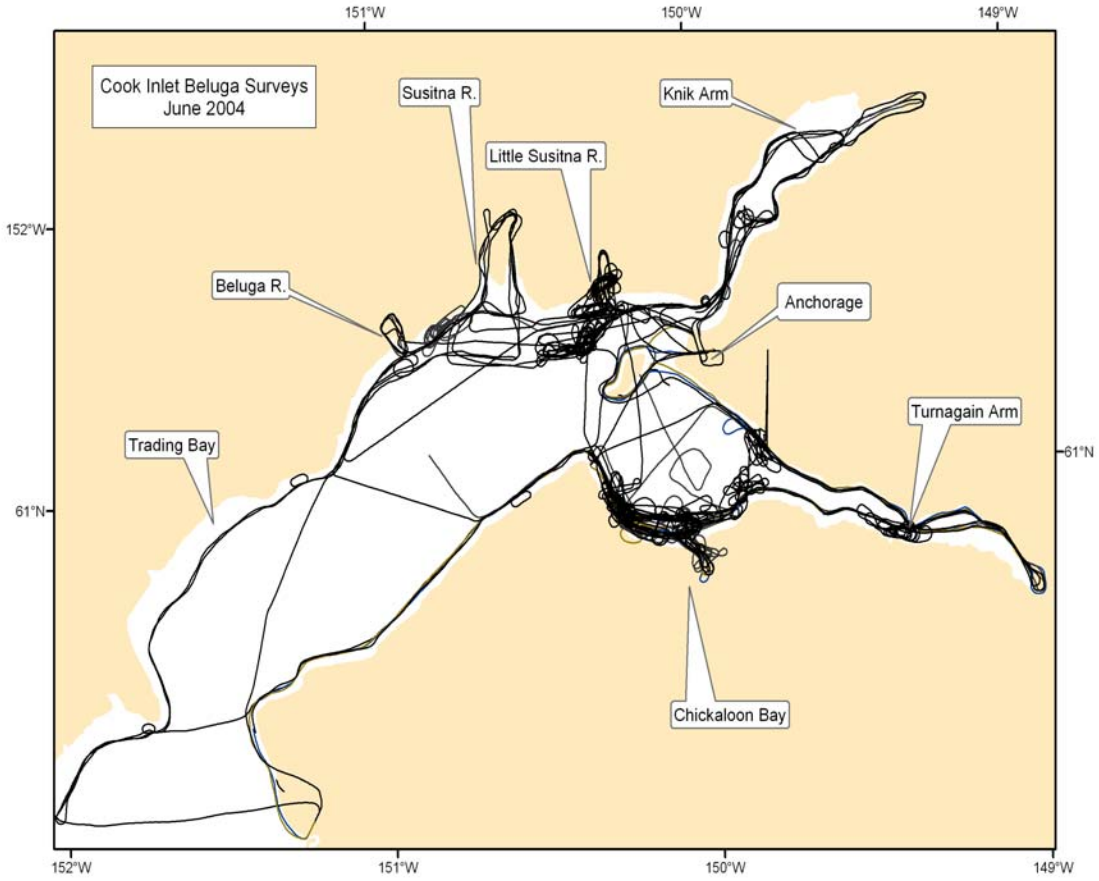

Figure 1. Tracklines in upper Cook Inlet in June 2004.

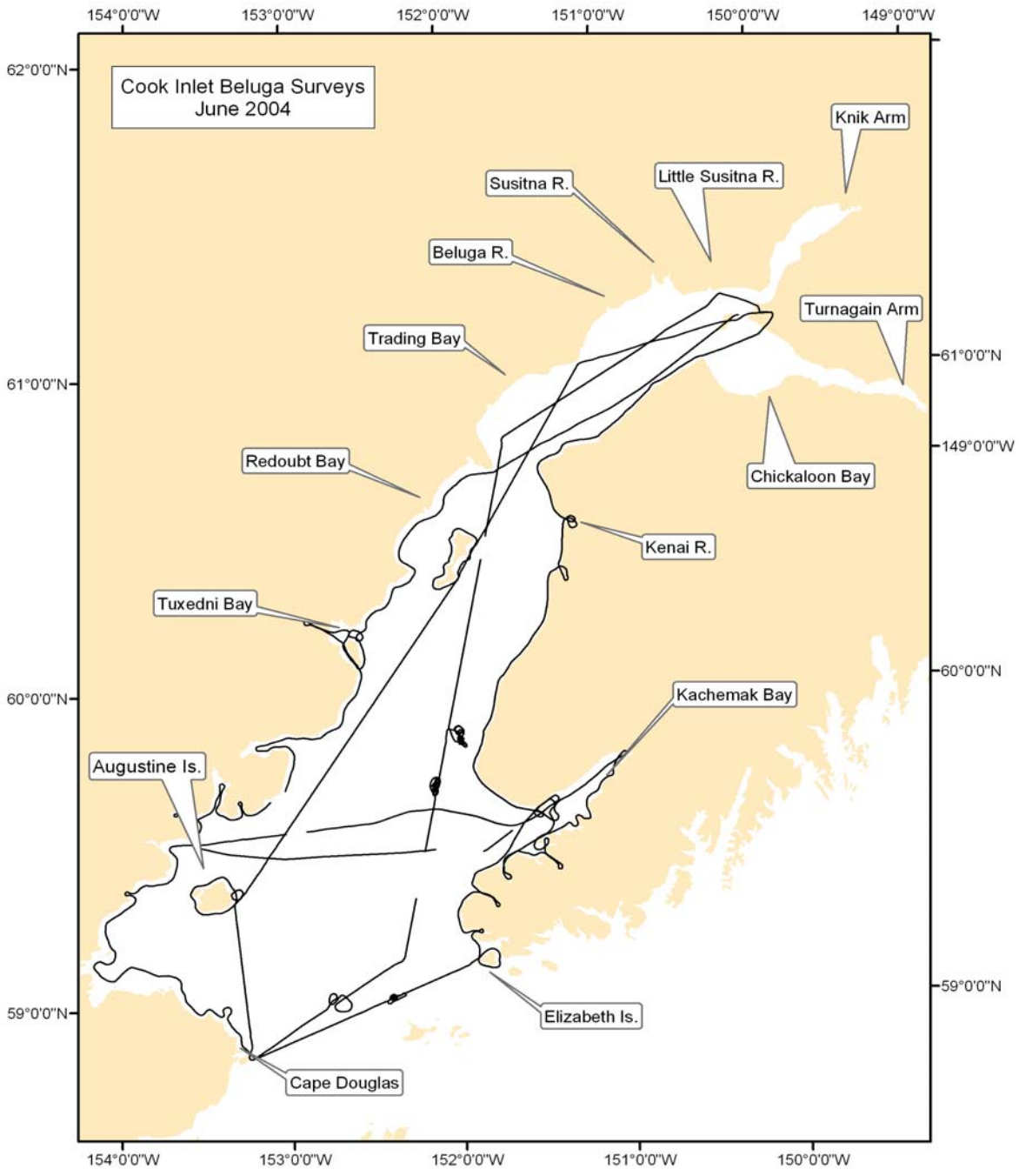

Figure 2. Tracklines used to survey lower Cook Inlet, 5-6 June 2004.

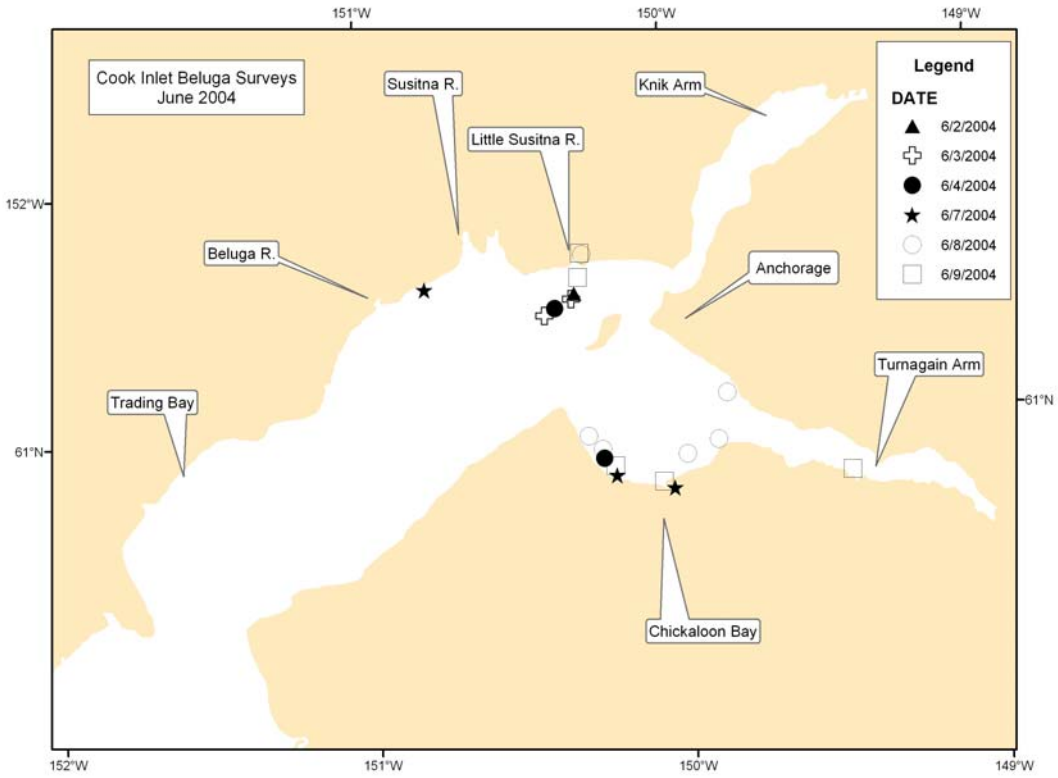

Figure 3. Beluga sightings in upper Cook Inlet in June 2004.

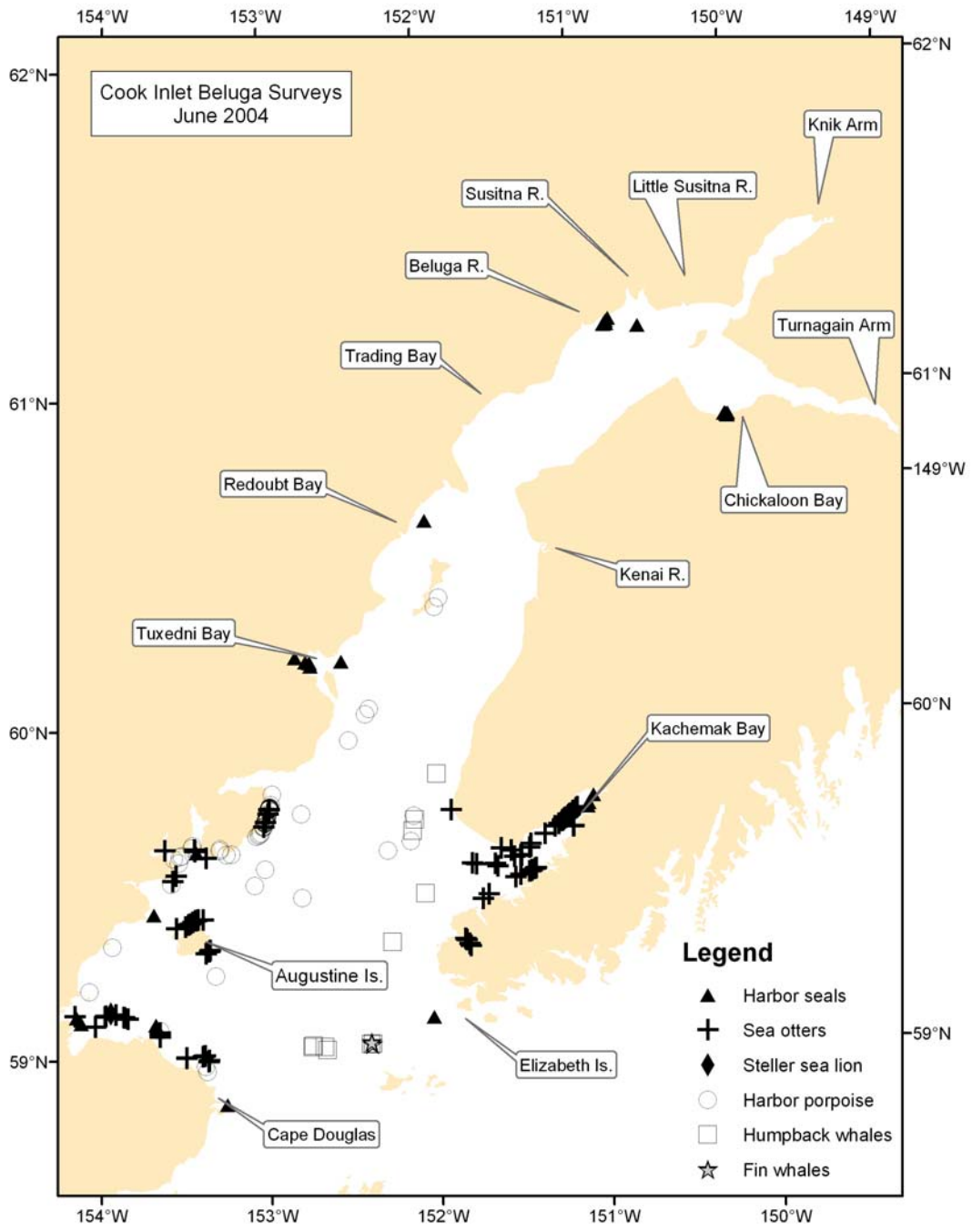

Figure 4. Sightings of marine mammals other than belugas in Cook Inlet in June 2004.