

**AERIAL SURVEYS OF BELUGAS IN COOK INLET, ALASKA,  
JUNE 2003**

David J. Rugh<sup>1</sup>, Barbara A. Mahoney<sup>2</sup>, Christy L. Sims<sup>1</sup>,  
Brad K. Smith<sup>2</sup>, and Roderick C. Hobbs<sup>1</sup>

<sup>1</sup>National Marine Mammal Laboratory  
Alaska Fisheries Science Center  
National Marine Fisheries Service, NOAA  
7600 Sand Point Way NE  
Seattle, Washington 98115, U.S.A.

and

<sup>2</sup>Alaska Regional Office  
National Marine Fisheries Service, NOAA  
222 W 7th Ave., Box 43  
Anchorage, Alaska 99513, U.S.A.

**Abstract**

The National Marine Fisheries Service (NMFS) conducted an aerial survey of the beluga population in Cook Inlet, Alaska, during 31 May -12 June 2003. The 61 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 2003 included one or more surveys of coastal areas (flown 1.4 km offshore) around the entire Inlet and 1,145 km of transects across the Inlet, effectively searching 25% 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 0-41 belugas in the Susitna delta (between the Beluga and Little Susitna Rivers), 30-94 in Knik Arm (there appeared to be exchanges of whales between the Susitna area and Knik Arm), and 21-65 in Chickaloon Bay (including the western end of Turnagain Arm). 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 2003 is 174 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 counts made during the past four years (193 in 1998, 217 in 1999, 184 in 2000, 211 in 2001, and 192 in 2002).

## 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). This project has been 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 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 (Rugh *et al.* 2000b; Laidre *et al.* 2000; O’Corry-Crowe *et al.* 1997), which, until 1999, was subjected to an unregulated harvest (Mahoney and Sheldon 2000). On 31 May 2000, this stock was listed as depleted under the Marine Mammal Protection Act (65 FR 34590) and is now managed with a small, regulated harvest.

## Methods

### Aircraft and data

The survey aircraft, an Aero Commander 680 FLP (*N98UP*), 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, but 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 (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

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 this area 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 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 around Elmendorf Air Base, Merrill Field, and the Anchorage International Airport where whales could not be circled for the standard counting protocol. As the surveys were completed in Knik Arm (usually taking more than an hour if there were several groups of whales), low tide was in Turnagain Arm. Because the change of tides in Turnagain Arm can be so rapid that tide rips compromise visibility, it proved best to take a break and refuel in Anchorage 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 the Anchorage Station. When the tide is very low in Chickaloon Bay, belugas sometimes disperse away from shore and can be hard to count. At high tide, belugas in Chickaloon are sometimes found close to shore or in Chickaloon River where they are relatively easy to count. 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. The flight pattern for each day's survey 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  $10^\circ$  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 addition to the coastal surveys, systematic transects were flown across the inlet. Offshore tracklines were designed to run the length of Cook Inlet or cross it with a minimum of overlapping (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). 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 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.

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 on each flight, not including counts made later on video tapes. These aerial 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.

### **Video cameras**

Two digital video cameras were operated on each counting pass by having the pair mounted together on a common board. Magnification on the "standard" camera (a Sony DVCAM, DSR-PDX10 Model L10A) 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 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 counts that will be used in 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.

Cameras were tested during three days of dedicated flights (31 May - 2 June) prior to the beluga surveys conducted in 2003. One of the tests was to compare standard video images on a camera used in the past (Sony Digital 8 DCR-TRV103) to a new camera with higher resolution (Sony DVCAM DSR-PDX10 Model L10A). Both of these cameras were operated together on a common mount for 17.5 minutes on two days, and video images will be examined to maintain the comparability of whale counts between years.

In addition, during some 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 operated during dedicated passes over whale groups, and it was fired only when there may have been whales in view, unlike the video camera which kept running well before and after a whale group passed through the field of view. The digital still images will provide greater detail in the images to help detect calves, which are darker than the adults and do not rise above the surface as much as adults do.

## Results

### Survey effort

A total of 61 hrs were flown around Cook Inlet from 31 May to 12 June 2003. All of these flights (17 take-offs and landings ranging from 2.0 to 6.5 hrs) were based out of Anchorage, sometimes with refueling stops in Homer. Of the 61 flight hours, 53.5 were spent in the standard search and counting efforts (not including flights to test the camera systems). Systematic search effort was conducted for 27.4 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 1.3 hrs (4.4% 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) have flown with this project in the past, and two of the observers have participated in this project almost every season since it began in 1993.

### Coverage

The composite of the surveys in June 2003 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 1,146 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 5,100 km<sup>2</sup>, which is 25% of the 19,863 km<sup>2</sup> 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 six times, especially areas where groups of belugas have consistently been found in the past – such as the Susitna delta, Knik Arm, and Chickaloon Bay.

### Day by day reports

On the first three days of the project, 31 May to 2 June, camera systems were tested to compare videos used during previous surveys to a new higher resolution digital camera (see Methods) and to test a digital still camera for documenting small, dark calves, which are difficult to detect in most video systems.

Upper Cook Inlet was surveyed on 3 June in excellent conditions. Winds were mild and skies clear. A high tide in Turnagain Arm meant the waters were flat and visibility excellent. No whales were found within Turnagain Arm, but a large group (median count of 64) was found in Chickaloon Bay. The survey then continued around Point Possession and south to the Forelands, then north around the Susitna delta, including surveys up Beluga, Susitna, and Little Susitna Rivers. A small group of belugas (median count of 16) was found near the mouth of the Little Susitna River, and a large group (median count of 94) was in Eagle Bay of Knik Arm. The sum of these counts (174) was the highest made this season. Locations where belugas were found on this day – Chickaloon Bay, at the mouth of the Little Susitna River, and in Knik Arm – are very typical of the sighting distribution at this time of year. After making this thorough survey of upper Cook Inlet, it was decided that the remaining surveys did not need to go more than a few kilometers south of Point Possession or Beluga River, focusing instead on areas where belugas are known to occur (Rugh et al. 2000b).

On 4 June, another survey was made of upper Cook Inlet, but winds compromised the search in Turnagain Arm. Two groups of belugas were found in Chickaloon Bay, but counts here (median count of 40) were lower than on the previous day, because high winds caused deteriorated viewing conditions. The survey then continued south to Moose Point and across the inlet to Three-Mile Creek and north around the Susitna delta. Although survey conditions were good, no belugas were found in the Susitna area. Knik Arm had good to excellent viewing conditions. Whales were again found in Eagle Bay. The median count here was 77, which is less than the count made on 3 June.

On 5 June, winds picked up, making it too difficult to survey all of Turnagain Arm, although a group of belugas (median count of 25) was seen southeast of Anchorage (near Potter's Marsh). Poor sighting conditions in Chickaloon Bay meant that the only group found there (median count of 1) was in the protected waters of Chickaloon River. In spite of excellent conditions in the Susitna delta, no whales were found there, and in Knik Arm viewing conditions were good, but only one small group (median count of 7) was found, perhaps because the tide was high. It appears that when the tide is high, the whales disperse over a large area in the middle of Knik Arm, which means they are hard to find and count.

Another survey of upper Cook Inlet was made on 6 June. Wind and rain prevented an effective survey of Turnagain Arm, but conditions were good in Chickaloon Bay. Belugas (median count of 21) were found in Chickaloon River. In the search around the Susitna delta, belugas were found at Beluga River (2 maximum count), at the mouth of the Susitna River (10 maximum count), and the Little Susitna River (2 maximum count), but in all of these cases, the median count was zero because these small groups were hard to find during the multiple passes made near the sighting area. In Knik Arm, two groups were found (median counts 86 and 6), resulting in counts similar to that found on 3 June (median count of 94).

The east side of lower Cook Inlet was surveyed on 7 June. Thorough coverage was made along all coastal areas between Point Possession and Elizabeth Island. Transects were then flown across the inlet and back to Homer then continuing north up the western third of the inlet, including a survey around Kalgin Island. No belugas were found, but five humpbacks and three fin whales were seen along the southern limits of the inlet. In addition, 203 sea otters were seen in or near Kachemak Bay, and 140 harbor seals were hauled out at the eastern end of Kachemak Bay.

Upper Cook Inlet was surveyed again on 8 June under excellent conditions, starting at Three-Mile Creek and covering the Susitna delta. Belugas were found near Beluga River (median count of 6) and the mouth of the Little Susitna River (median count of 28). Whales were found across Knik Arm from Goose Bay to Birchwood (median count of 30). They were spread out and difficult to count two hours after low tide.

No flight was made on 9 June due to the lack of good options with tidal conditions, and this break allowed the observers to catch up on data edits, including video reviews and backups of digital photos.

Upper Cook Inlet was surveyed on 10 June, starting from West Foreland and north across the Susitna delta. Belugas were again found at Beluga River (median count of 4), east of the Susitna River (median count of 15), and near the Little Susitna River (median count of 23). In Knik Arm, several groups of belugas (median count of 62) were found spread over a large area. Increasing rain prevented a search of Turnagain Arm and Chickaloon Bay.

A final survey of upper Cook Inlet was made on 11 June, again under excellent conditions. The search began at Fire Island and continued into Turnagain Arm to Bird Point where the tide was so low the survey was not continued any farther east. No whales were found in Turnagain Arm. In Chickaloon Bay, the waters were calm, and four groups of belugas were found (median count of 52 for the four groups). The Susitna delta was surveyed, and three groups were found in essentially the same locations as on 10 June, so no counts were made in order to get to Knik Arm on a low tide. One large group (median count of 53) was found in the middle of Knik Arm, and two small groups (median counts of 19 and 6) were in the southern part of Knik Arm. In this area of dense air traffic, counts were made on only one or two passes as allowed by air traffic control. The sum of median counts of belugas along the north side of Cook Inlet (Susitna delta to Knik Arm) was the same on 10 and 11 June (119) as it was on 3 June (110).

### **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 2003 was 174. 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.* 2000a). This median index (174) is essentially the same as counts from 1998-2002 (184-217; Table 2).

### Other marine mammals

Other than belugas, only harbor seals (*Phoca vitulina*) were encountered in upper Cook Inlet. In fact, no other marine mammals were seen north of 59°45'N (north of Kachemak Bay). Harbor seal concentrations were found at the Chickaloon River (up to 50), between Beluga and Susitna Rivers (up to 200), in Kachemak Bay (140 at Bradley River), Big River (130), and in or near Tuxedni Bay (100). There was a total of 36 sightings of 974 harbor seals.

Sea otters (*Enhydra lutris*) were common in the lower inlet south of 59°45'N, as in other years. There were 39 sightings of 291 sea otters in groups from 1 to 50.

Steller sea lions (*Eumetopias jubatus*) were seen near Elizabeth Island. There were 76 on one haulout on the south shore, and one other sea lion was seen in the water nearby.

Humpback whales (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*), were found in a concentrated area along the southern limits of Cook Inlet. On 7 June, 5 humpbacks and 3 fins were seen halfway between Augustine Island and the Barren Islands, and on 12 June, 12 humpbacks and 13 fins were seen within a few kilometers of each other just north of the Barren Islands. Also, on 7 June and 12 June, there were 1 and 2 humpbacks, respectively, seen west of Kachemak Bay.

### Discussion

The June 2003 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 (1993-2003; Rugh et al. 2000b), each of these annual surveys involved several replicate flights around upper Cook Inlet. The large number of flights and consistency of effort has helped us detect patterns of whale distribution. In 2003, as in most years, belugas were found in small groups near river mouths along the northwestern shores of upper Cook Inlet, in particular near Beluga River, Susitna River, Little Susitna River, and across the middle of Knik Arm, as well as 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 seen 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 consistently were in the upper inlet. Many other marine mammals were seen in the lower inlet, so the lack of beluga sightings there was not due to visibility.

The uncorrected sum of median estimates (174 belugas) made from the June 2003 aerial observations in Cook Inlet is lower than but essentially the same as similar index counts made each year since 1998, generally near 200 whales (Table 2, Fig. 4). 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, were 653, 491, 594, 440, 347, 367, 435, 386, and 313 for 1994-2002, respectively, with coefficient of variances (CV) that have ranged from 0.09 to 0.44 (Hobbs *et al.* 2000a; NMFS unpubl. data). The abundance estimates, with their associated CV, are the appropriate values to be used in interyear trend analyses.

### Acknowledgments

Funding for this project was provided through the Marine Mammal Assessment Program, NMFS, NOAA. Douglas DeMaster, Sue Moore, and Paul Wade have each in turn served as Program Leaders of NMML's Cetacean Assessment and Ecology Program during the conception, preparation, and conduct of this multi-year project. Rod Hobbs (NMML) has been task leader of the NMFS beluga research project in Cook Inlet, including directing studies on tagging and establishing correction factors for aerial counts of belugas. Dave Weintraub (Commander NW, Ltd., Wenatchee, WA) helped provide us with the aircraft and flew with us on most of the surveys. His investment in this project is greatly appreciated. Our primary pilot in 2003, Jay Sefferen, filled a critical role in keeping the aircraft at the preferred altitude and distance from shore while flying intricate patterns over whale groups as they moved in different directions and watching for aircraft in an exceptionally busy airspace. Earl Johnson piloted the aircraft on two days. Data entries were made on a program originally developed for harbor porpoise surveys in the northeast Atlantic (made available through Debi Palka, Woods Hole, MA; software designed by Lex Hiby of Conservation Research Ltd, UK and Phil Lovell of Sea Mammal Research Unit, Scotland.). The survey maps were done by Kim Shelden (NMML). This survey was conducted under MMPA Scientific Research Permit No. 782-1438.

### Citations

- Calkins, D.G. 1984. Belukha whale. Vol. IX in: Susitna hydroelectric project; final report; big game studies, Alaska Dept. Fish and Game. Doc. no. 2328.
- Calkins, D.G., K.W. Pitcher, and K., Schneider. 1975. Distribution and abundance of marine mammals in the Gulf of Alaska. Rep. for USDC/NOAA. Alaska Dept. Fish and Game, Anchorage, AK. 67 pp.
- Hobbs, R.C., D.J. Rugh, and D.P. DeMaster. 2000a. Abundance of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, 1994-2000. Marine Fisheries Review. 62(3):37-45.
- Hobbs, R.C., J.M. Waite, and D.J. Rugh. 2000b. Beluga, *Delphinapterus leucas*, group sizes in Cook Inlet, Alaska, based on observer counts and aerial video. Marine Fisheries Review. 62(3):46-59.
- Klinkhart, E.G. 1966. The beluga whale in Alaska. Alaska Dept. Fish and Game, Juneau, Fed. Aid Wildl. Restor. Proj. Rep. Vol. VII, Proj. W-6-R and W-14-R. 11pp.
- Laidre, K. L., K. E. W. Shelden, D. J. Rugh, and B. A. Mahoney. 2000. Beluga, *Delphinapterus leucas*, distribution and survey effort in the Gulf of Alaska. Mar. Fish. Rev. 62(3):27-36.

- Litzky, L.K. 2001. Monitoring recovery status and age structure of Cook Inlet, Alaska belugas by skin color determination. Thesis (M.S.) Univ. Wash. 76 p.
- Mahoney, B. A. and K. E. W. Shelden. 2000. Harvest history of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):124-133.
- Moore, S. E., D. J. Rugh, K. E. Shelden, L. K. Litzky, and B. A. Mahoney. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):60-80.
- Murray, N.K. and F.H. Fay. 1979. The white whales or belukhas, *Delphinapterus leucas*, of Cook Inlet, Alaska. Unpubl. doc. prepared for June 1979 meeting of the Subcommittee on Small Cetaceans of the Sci. Comm. of the Int. Whaling Comm. College of Env. Sci., Univ. Alaska, Fairbanks. 7pp.
- O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost, and A.E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.
- Rugh, D.J., R.P. Angliss, D.P. DeMaster, and B.A. Mahoney. 1995. Aerial surveys of belugas in Cook Inlet, Alaska, June 1994. Paper SC/47/SM10 presented to the IWC Scientific Committee, June 1995 (unpublished) 14pp.
- Rugh, D.J., K.E.W. Shelden, R.P. Angliss, D.P. DeMaster, and B.A. Mahoney. 1996. Aerial surveys of beluga whales in Cook Inlet, Alaska, July 1995. Paper SC/48/SM8 presented to the IWC Scientific Committee, May 1996 (unpublished) 21pp.
- Rugh, D.J., K.E.W. Shelden, J.M. Waite, R.C. Hobbs, and B.A. Mahoney. 1997a. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1996. Paper SC/49/SM19 presented to the IWC Scientific Committee, Sept. 1997 (unpublished) 22pp.
- Rugh, D.J., R.C. Hobbs, K.E.W. Shelden, and J.M. Waite. 1997b. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1997. Paper SC/49/SM20 presented to the IWC Scientific Committee, Sept. 1997 (unpublished) 17pp.
- Rugh, D.J., R.C. Hobbs, K.E.W. Shelden, B.A. Mahoney, and L.K. Litzky. 1999. Surveys of beluga whales in Cook Inlet, Alaska, June 1998. Paper SC/51/SM11 presented to the IWC Scientific Committee, May 1999 (unpublished) 11pp.
- Rugh, D.J., K.E.W. Shelden, B.A. Mahoney, L.K. Litzky, R.C. Hobbs, and K.L. Laidre. 2000a. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1999. pp. 1-10. In: Anita L. Lopez and Douglas P. DeMaster, editors, Marine Mammal Protection Act and Endangered Species Act implementation program 1999. U.S. Department of Commerce, Seattle, WA. AFSC Processed Report 2000-11. 195 p.
- Rugh, D.J., K.E.W. Shelden, and B.A. Mahoney. 2000b. Distribution of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska, during June/July 1993-2000. Mar. Fish. Rev. 63(3):6-21.
- Rugh, D., K.E.W. Shelden, B.A. Mahoney, and L.K. Litzky. 2001. Aerial surveys of belugas in Cook Inlet, Alaska, June 2000. pp 1-11 In: Anita L. Lopez and Robyn P. Angliss, editors, Marine Mammal Protection Act and Endangered Species Act implementation program 2000. U.S. Department of Commerce, Seattle, WA. AFSC Processed Report 2001-06. 115 p.

- Rugh, D., B.A. Mahoney, L.K. Litzky, and B. Smith. 2002. Aerial surveys of beluga in Cook Inlet, Alaska, June 2002. Unpublished document. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Pt Way, NE, Seattle, WA 98115. 12 p.
- Withrow, D.E., K.E.W. Shelden, D.J. Rugh, and R.C. Hobbs. 1994. Beluga whale, *Delphinapterus leucas*, distribution and abundance in Cook Inlet, 1993. Pages 128-153 In: H. Braham and D. DeMaster (eds.) Marine Mammal Assessment Program: Status of stocks and impacts of incidental take; 1993. Annual Rept. submitted to Office of Protected Resources, NMFS, 1335 East-West Highway, Silver Spring, MD 20910. 153 pp.

Table 1. Summary counts of belugas made during aerial surveys of Cook Inlet in June 2003. 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	3 Jun	4 Jun	5 Jun	6 Jun	7 Jun	8 Jun	10 Jun	11 Jun	12 Jun	Best count
Turnagain Arm (not including Chickaloon Bay)	0	0	24.5	---	---	0	---	0	---	64.5*
Chickaloon Bay/ Pt. Possession	<b>64.5</b>	39.5	0.5	21.3	---	38.0	---	51.5	---	
Pt. Possession to East Foreland	0	---	---	---	0	---	---	---	---	0
Mid-Inlet east of Trading Bay	---	---	---	---	0	---	---	---	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
Susitna delta (N Foreland to Pt. Mackenzie)	<b>15.5</b>	0	0	0	---	34.3	41.0	---	---	109.8**
Knik Arm	<b>94.3</b>	77.3	6.5	91.5	---	30.0	61.5	77.5	---	
Fire Island	---	0	0	---	---	---	---	---	---	0
<b><math>\Sigma =</math></b>										<b>174.3</b>

\* Include Turnagain counts in Chickaloon Bay counts.

\*\* Include Susitna delta counts in the Knik Arm counts because whales may cross easily between these areas.

Table 2. Summary of index counts of belugas made during aerial surveys of Cook Inlet in June or July 1993-2003.

Year	Dates	Index Counts	Lower Cook Inlet	Susitna delta	Elsewhere in Upper Cook Inlet
1993	June 2-5	<b>305</b>	0%	56%	44%
1994	June 1-5	<b>281</b>	4%	91%	5%
1995	July 18-24	<b>324</b>	4%	89%	7%
1996	June 11-17	<b>307</b>	0%	81%	19%
1997	June 8-10	<b>264</b>	0%	28%	72%
1998	June 9-15	<b>193</b>	0%	56%	44%
1999	June 8-14	<b>217</b>	0%	74%	26%
2000	June 6-13	<b>184</b>	0%	62%	38%
2001	June 5-12	<b>211</b>	1%	35%	64%
2002	June 4-11	<b>192</b>	0%	48%	52%
2003	June 3-12	<b>174</b>	0%	9%	91%

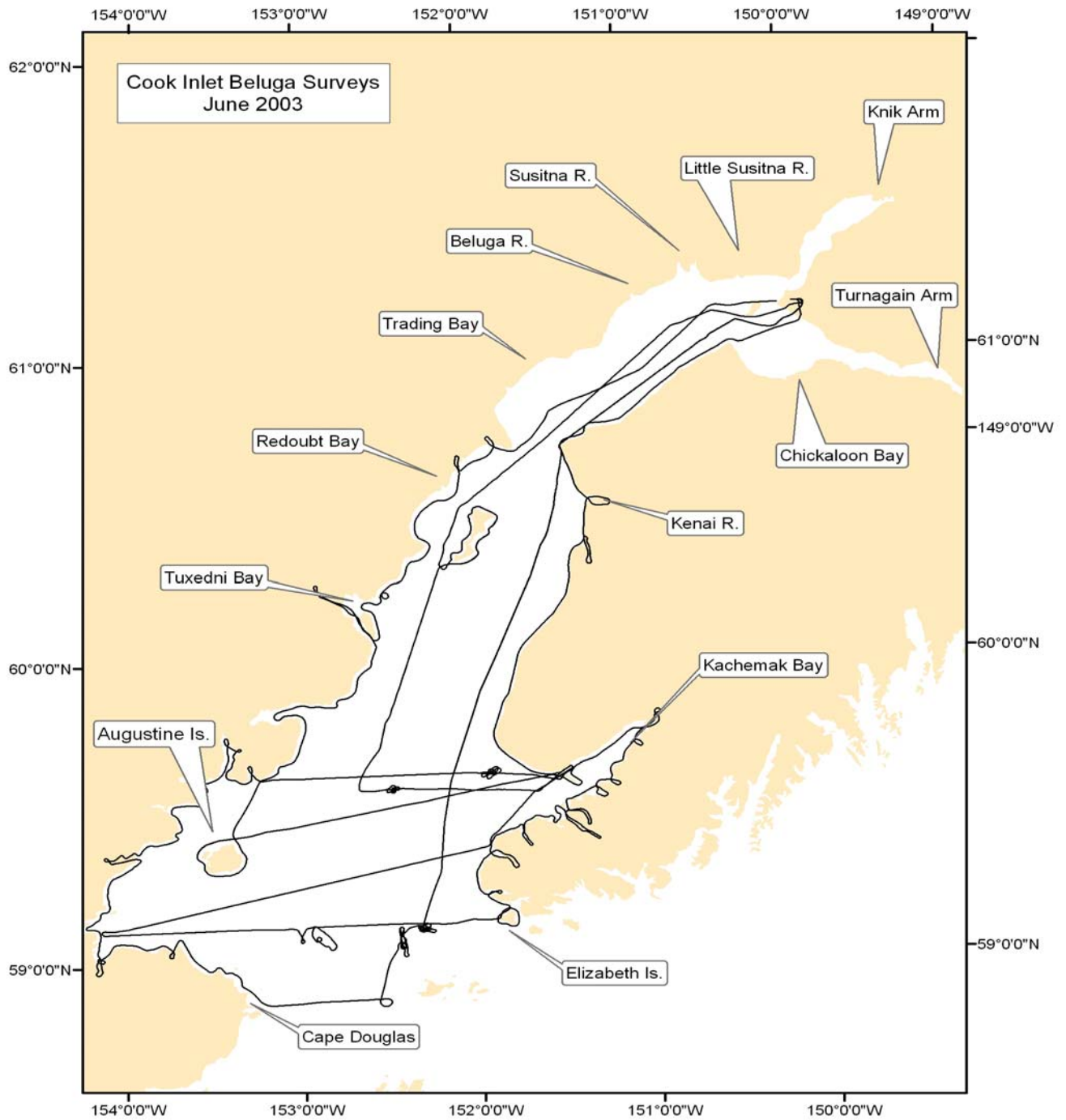


Figure 1. Aerial surveys of lower Cook Inlet conducted 7 and 12 June 2003, showing all flight lines including circling over whale groups (humpback and fin whales). The surveys of the lower and upper inlet (Fig. 2) covered all coastal areas in Cook Inlet and 1,145 km of offshore waters.

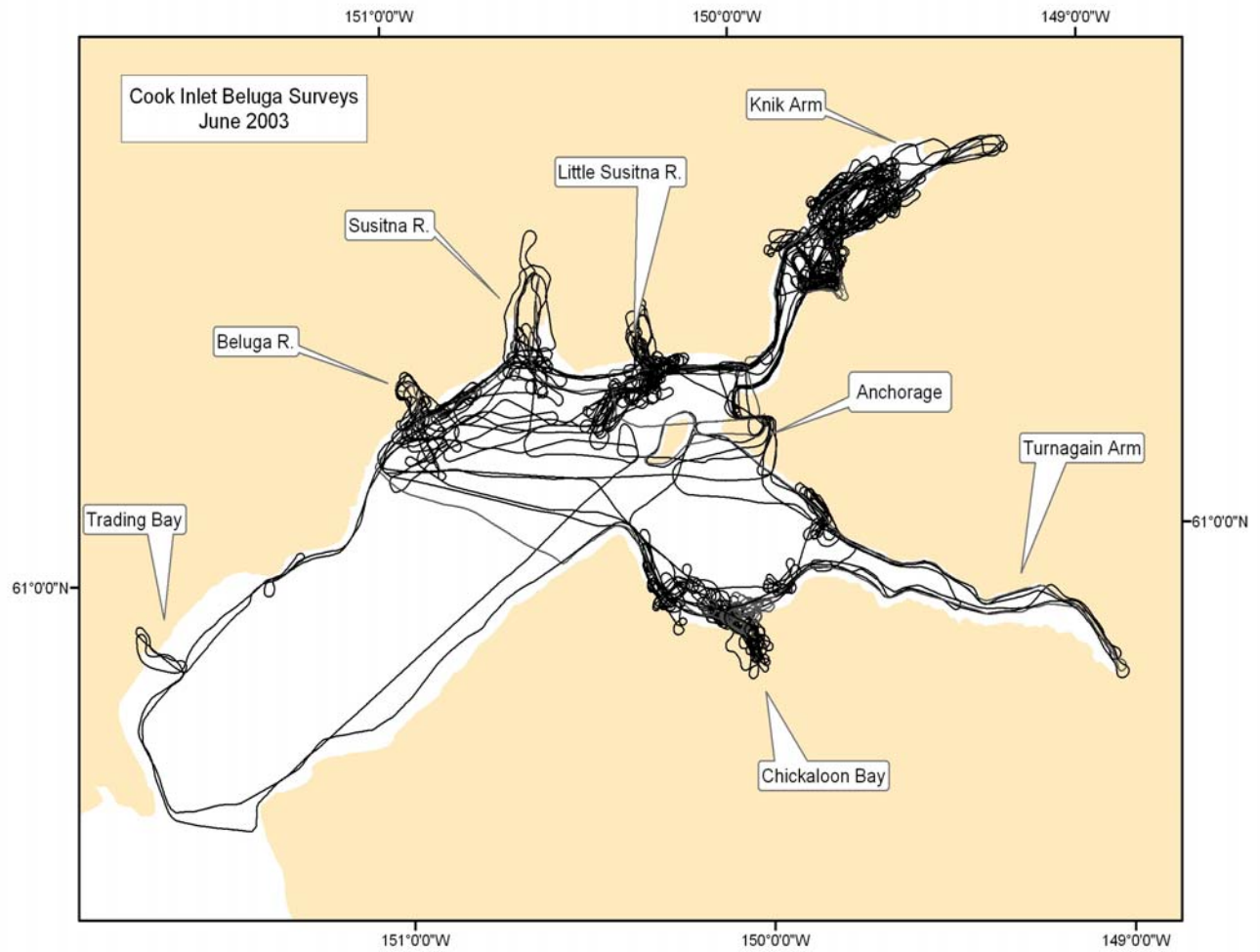


Figure 2. Aerial survey effort in upper Cook Inlet during flights conducted 3-12 June 2003, showing all flight lines including circling over beluga groups

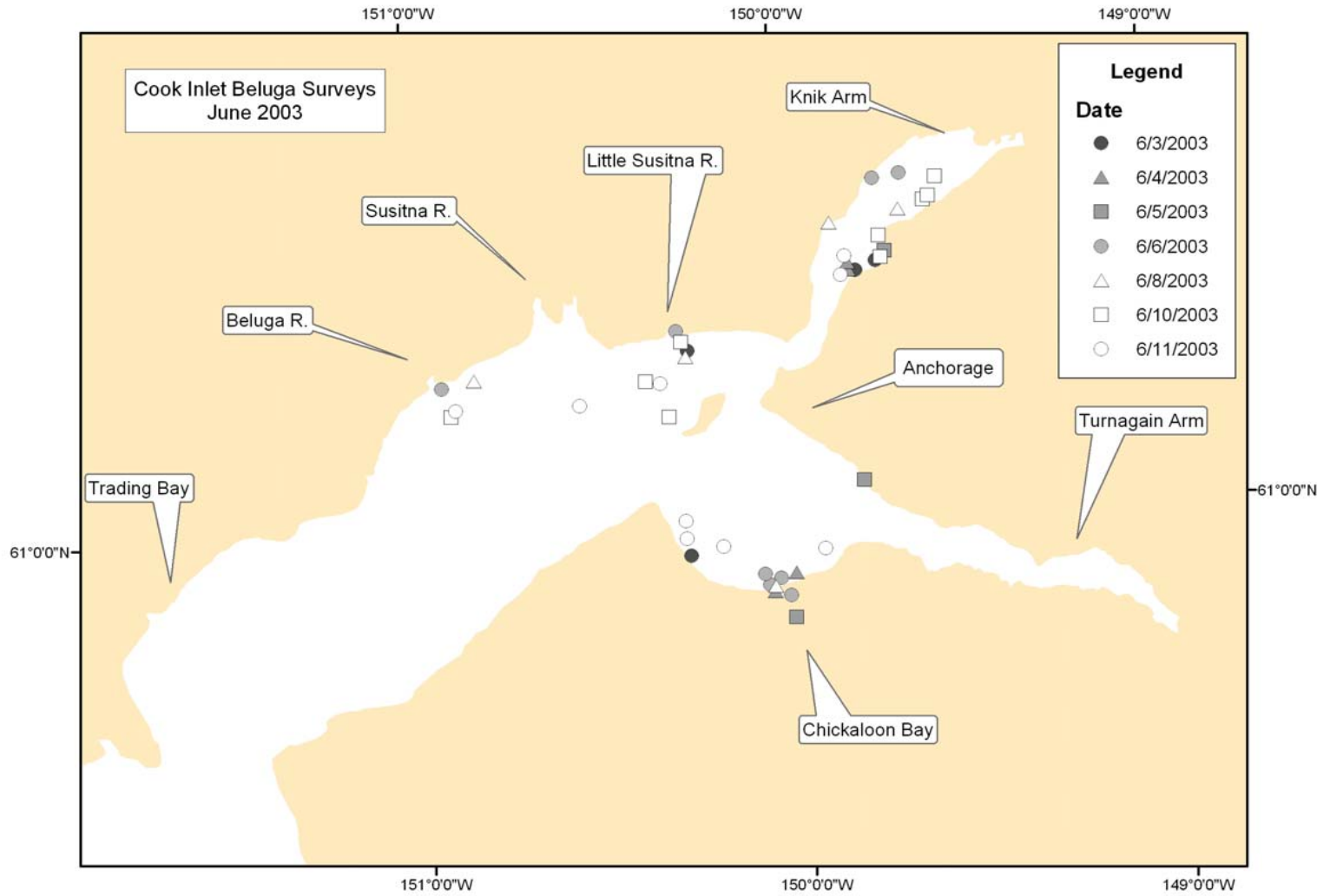


Figure 3. Beluga sightings made during surveys of Cook Inlet 3-12 June 2003. All whales were near river mouths or in shallow coastal waters of the northern part of the inlet.



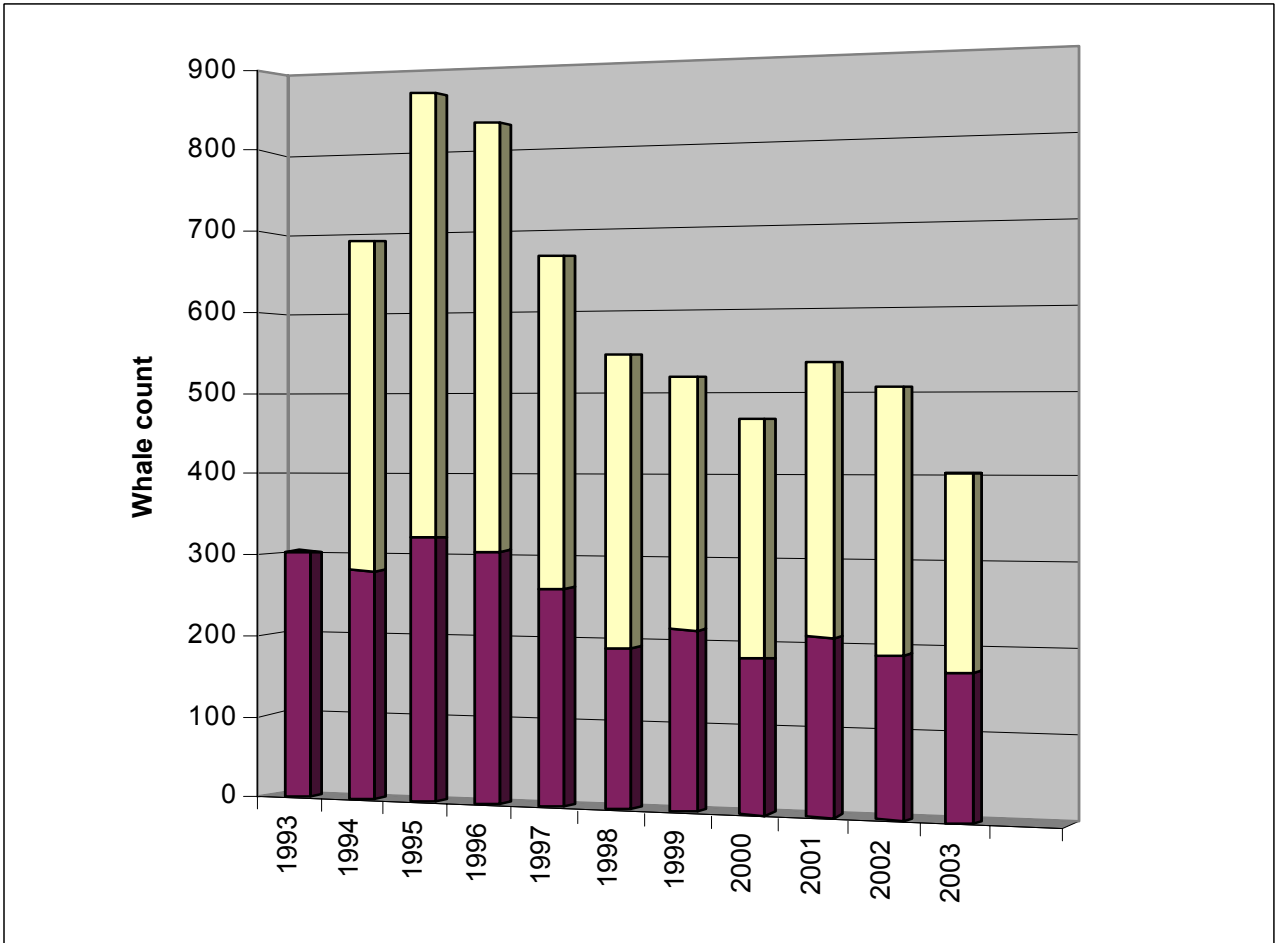


Figure 4. Maximum and median counts of belugas in Cook Inlet as recorded each June or July from 1993 to 2003.