

Spatio-temporal Changes in Beluga Whale, *Delphinapterus leucas*, Distribution: Results from Aerial Surveys (1977-2014), Opportunistic Sightings (1975-2014), and Satellite Tagging (1999-2003) in Cook Inlet, Alaska

KIM E.W. SHELDEN, KIMBERLY T. GOETZ, DAVID J. RUGH,
DONALD G. CALKINS, BARBARA A. MAHONEY, and RODERICK C. HOBBS

Introduction

The waters of Cook Inlet, Alaska, are occupied year-round by a small, distinct population of beluga whales, *Delphinapterus leucas* (Fig. 1). One of the earliest descriptions of this population's distribution within Cook Inlet is found in Cornelius Osgood's 1933 ac-

Kim Shelden (kim.shelden@noaa.gov) is with the National Marine Mammal Laboratory (NMML), Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115-6349. Kim Goetz was with the National Marine Mammal Laboratory (NMML), Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115-6349 (current address: National Institute of Water and Atmospheric Research, Ltd., 301 Evans Bay Parade, Wellington, 6021, New Zealand). Dave Rugh (retired NMML) is at 17416 95th Ave. NE, Bothell, WA 98011. Don Calkins is with North Pacific Wildlife Consulting, LLC, 12600 Elmore Road, Anchorage, AK 99516-2904. Barbara Mahoney is with the National Marine Fisheries Service, Alaska Regional Office, NOAA, 222 W. 7th Ave., Anchorage, AK 99513. Rod Hobbs is with the National Marine Mammal Laboratory (NMML), Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115-6349. The findings and conclusions in this paper are those of the author(s) and do not necessarily represent the views of the National Marine Fisheries Service.

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count from an ethnological expedition undertaken in 1931:

“Of the sea-mammals used for food, fur, or both (hair-seal, ground-seal, sea-otter, sea-lion, porpoise, beluga and whale) which were found in the Lower inlet, only two (hair-seal and beluga) were found elsewhere, that is, in the Middle inlet and seasonally in the Upper inlet” (p. 697).

Aerial surveys using fixed-wing aircraft were introduced in Alaska in the 1930's to assess wildlife populations (Eicher, 1953; Jones et al., 2007). The first aerial surveys to estimate beluga whale numbers were conducted in 1954 in Bristol Bay, Alaska (Brooks¹). Investigations by the Alaska Department of Fisheries were primarily in response to concerns expressed by commercial fishermen about beluga predation on Pacific salmon, *Oncorhynchus* spp. (Brooks¹). The Alaska Department of Fish and Game (ADFG) flew the first aerial surveys to enumerate the Cook Inlet be-

¹Brooks, J. W. 1954. Beluga. In Annual Rep. for 1954, Alaska Dep. Fish., Juneau, p. 51–57, and Brooks, J. W. 1955. Beluga. In Annual Rep. for 1955, Alaska Dep. Fish., Juneau, p. 98–106.

luga whale (CIBW) population in the 1960's (Klinkhart²). According to Edward Klinkhart²,

“Aerial surveys of Cook Inlet which I made in 1963 and 1964 indicated a summer population of 300 to 400 animals” (p. 3).

The information was limited, however, as Klinkhart² did not include a map or any descriptions of where or exactly when surveys took place during those summers.

In the 1970's, increasing interest in petroleum development throughout Alaska waters led to the National Oceanic and Atmospheric Administration (NOAA) funding large-scale, systematic surveys to determine seasonal distribution of seabirds and marine mammals. The Outer Continental Shelf Environmental Assessment Program (OCSEAP³) large-scale surveys of the Gulf of Alaska included aerial surveys of mid-inlet waters in lower and central Cook Inlet (primarily south

²Klinkhart, E. G. 1966. The beluga whale in Alaska. Alaska Dep. Fish Game, Juneau, Fed. Aid. Wildl. Restor. Proj. Rep. Vol. VII, Proj. W-6-R and W-14-R, 11 p.

³OCSEAP documents (avail. at <http://www.arlis.org/docs/vol1/OCSEAP2/>).

ABSTRACT—Cook Inlet is inhabited year-round by a small, distinct group of beluga whales, *Delphinapterus leucas*. This endangered and declining population lives near Anchorage, the largest city in Alaska, and waterways frequented by fishing fleets, container ships, oil-gas development, air traffic, and military operations. Their summer distribution has been well-studied but in winter and early spring the combination of poor sighting conditions (low light levels, white whales among ice floes) and whale behavior (close association with ice, longer, deeper diving patterns, smaller groups)

made detection difficult. Based on our review of beluga presence data from aerial surveys, satellite-tagging, and opportunistic sightings, their range has contracted remarkably since the 1990's. Almost the entire population is found in only northern waters from late spring through the summer and into the fall. This differs markedly from surveys in the 1970's when whales were found in or would disperse to the lower inlet by midsummer.

By early June, belugas now gather at river mouths in the Susitna Delta and Chickaloon Bay. Since the Endangered Species

Act listing decision in 2008, 83% of the total population now occupies the Susitna Delta in early June compared to roughly 50% in the past. In August, sightings increase in Knik Arm, with some dispersal to deeper upper inlet waters. In fall, belugas disperse south though few whales are found in the lower inlet. In winter, belugas now occur in the upper inlet and make occasional visits to the lower inlet, and there is no evidence of migration out of Cook Inlet. The population appears to now be consolidated into preferred habitat in the upper-most reaches of Cook Inlet.



Figure 1.—Place names in Cook Inlet, Alaska, mentioned in the text. Tidal mudflats (shaded areas) and the 10 m isobath are shown. The upper inlet is defined as waters north of East Foreland and West Foreland, the lower inlet includes all waters south of these Forelands, mid-inlet waters are defined as those deeper than the 10 m isobath (excluding bays).

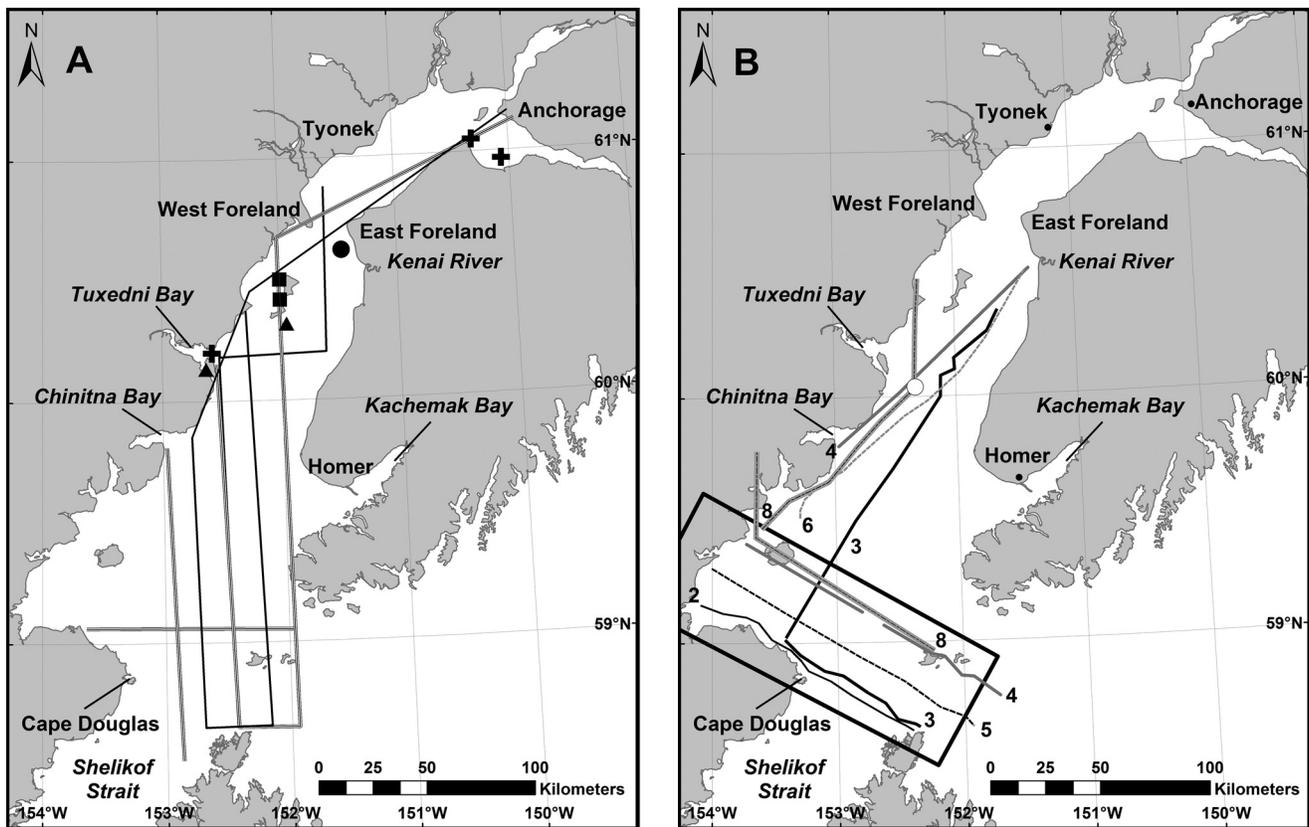


Figure 2.—Beluga whale sightings and survey effort in Cook Inlet, Alaska, from A) Harrison and Hall (1978) in 1975: October (squares, group sizes = 1 and 3); and 1977: March (triangles, group sizes = 1 and 3), April (pluses, group sizes = 1); and June (circle, group size = 20); and B) Leatherwood et al. (text footnote 4) showing Survey Block 7, Zone 1 as the box north of Shelikof Strait. Only surveys with effort collected north of Cape Douglas were plotted and are identified by number as: 2 (May–June 1982), 3 (July 1982), 4 (Aug. 1982), 5 (Sept. 1982), 6 (Oct.–Nov. 1982), and 8 (Feb.–Mar. 1983). The lone group of five belugas (circle shown mid-inlet east of Tuxedni Bay) was observed during a survey 8 on-effort training segment.

of East and West Foreland) during the mid- to late 1970's (Harrison and Hall, 1978) and early 1980's (Leatherwood et al.⁴). Only a few belugas were observed during these surveys (Fig. 2). The paucity of sightings was likely due to the survey design, which did not include coastal waters within the inlet. Leatherwood et al.⁴ noted:

“Belugas were also observed repeatedly in the Cook Inlet complex during our transit flights into and out of Anchorage, particularly

near the estuary of the Kenai River” (p. 312).

An OCSEAP study that originally focused on Steller sea lion, *Eumetopias jubatus*, investigations in the Gulf of Alaska (Calkins and Pitcher⁵) was “expanded to include an examination of the distribution and abundance of belukha whales (*Delphinapterus leucas*) in Cook Inlet” (p. 146). This first attempt to thoroughly document CIBW seasonal distribution using

aircraft occurred in the late 1970's (Murray⁶; Murray and Fay⁷). Under the direction of ADFG, aerial surveys were conducted in Cook Inlet from November 1977 through August 1979.

ADFG resumed aerial surveys in the early 1980's as part of the Susitna Hydroelectric Project funded by the

⁴Leatherwood, S., A. E. Bowles, and R. R. Reeves. 1983. Aerial surveys of marine mammals in the southeastern Bering Sea. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 42(1986):147–490 (avail. at <http://www.arlis.org/docs/vol1/OCSEAP2/authorindex.html> and accessed 16 June 2011).

⁵Calkins, D., and K. Pitcher (Principal Investigators). 1979. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska, U.S. Dep. Commer., NOAA, OCSEAP Annu. Rep. Princ. Invest. 1(1979):144–208 (avail. at <http://www.arlis.org/docs/vol1/OCSEAP2/Annual/5721406/A1979%20V01.pdf>, accessed 4 Mar. 2015).

⁶Murray, N. K. 1979. Belukha whales in lower Cook Inlet. U.S. Dep. Commer., NOAA, OCSEAP Annu. Rep. Princ. Invest. 1(1979):192–208. In Calkins, D., and K. Pitcher (Principal Investigators), Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska, Res. Unit 243, p. 144–208 (avail. at <http://www.arlis.org/docs/vol1/OCSEAP2/Annual/5721406/A1979%20V01.pdf> and accessed 4 Mar. 2015).

⁷Murray, N. K., and F. H. Fay. 1979. The white whales or belukhas, *Delphinapterus leucas*, of Cook Inlet, Alaska. Pap. SC/31/SM12 pres. to IWC Sci. Committee, June 1979, 7 p.

Alaska Power Authority (Calkins⁸). This study documented CIBW distribution in the upper inlet (north of East and West Foreland) during the ice-free season to assess potential impacts from proposed dam development on the Susitna River. Summary maps, and sometimes tables, showing seasonal sighting data from these ADFG studies were presented in contract reports (Murray⁶, Calkins^{8, 9, 10}) but never published in a peer-reviewed journal.

The Alaska Fisheries Science Center's National Marine Mammal Laboratory (NMML) received photocopies of some of the original field logs and maps from these ADFG studies in 1999.¹¹ Initially, beluga whale sightings from the June and July flight summaries were digitized and mapped, and subsequently compared to whale distributions from National Marine Fisheries Service (NMFS) aerial surveys conducted during the period 1993–2008 (Rugh et al., 2010). Rugh et al. (2010) documented a significant northward contraction in the early summer range of CIBWs since the 1970's. In 2012, all available tracklines and sightings from the 1977–79 and 1982–83 surveys were scanned and digitized to update the CIBW Opportunistic Database maintained by NMML (Vate Brattström et al.¹²). We

present the ADFG survey methods and effort in Appendix 1 (1977–79) and Appendix 2 (1982–83)¹³ transcribed from the original field notes and maps.

After the ADFG surveys, distribution studies did not resume until the 1990's. NMFS began dedicated CIBW distribution and abundance surveys in June 1991 (NMFS¹⁴; Shelden and Mahoney¹⁵). Subsequent aerial surveys during the period 1993–2014 focused on distribution and abundance primarily in June (Rugh et al., 2000, 2005; Shelden et al., 2013; Hobbs et al., 2015a; Shelden et al.¹⁶). NMFS also conducted aerial surveys in August from 2005 to 2012 specifically to look at the proportion of beluga calves in the northernmost waters of Cook Inlet (Hobbs et al., 2015b). Additional months were sampled from July 2001 to April 2002 to document CIBW numbers and distribution in other seasons (Rugh et al., 2004). The U.S. Department of Interior, Minerals Management Service (MMS, now the Bureau of Ocean Energy Management (BOEM)) also flew beluga whale distribution surveys during February and March of 1997 (Hansen and Hubbard¹⁷). Using these datasets, we

compared CIBW distribution across months and years from the late 1970's to 2014.

In 1999, NMFS began capturing CIBWs during the summer months and attaching satellite-linked time-depth recorders to their dorsal ridges (Ferrero et al., 2000; Hobbs et al., 2005; Goetz et al.¹⁸). In all, 18 belugas were captured and tagged during this project which continued until 2002. Some of these tagged whales transmitted locations during the fall, winter, and spring; therefore, we included these data to supplement the sighting data, particularly for months when aerial survey effort was limited. We also included sightings from the CIBW Opportunistic Database to provide additional, though anecdotal, insights into beluga distribution.

Attempts to estimate abundance for the Cook Inlet population in the past have often been based on observations of a single, large concentration of animals and applying a correction for surface intervals when animals are not visible beneath the turbid waters in the inlet (Hazard, 1988). The listing of CIBWs on the List of Candidate Vertebrate and Invertebrate Marine Species under the U.S. Endangered Species Act in 1988 (NOAA, 1988) was, in part, based on abundance estimates from these studies which suggested at minimum about 500 whales (Hazard, 1988). Calkins¹⁰, reporting on Murray's aerial survey findings (Appendix 1), noted:

“In subsequent aerial survey/sighting combinations, the highest minimum direct count I have obtained for a single day was 479 animals [*sic.* 473 in Appendix 1] on 21 August 1979. Some investigators have speculated that three times as many whales are pres-

⁸Calkins, D. G. 1984. Belukha whale. Vol. IX of Susitna hydroelectric project; final report; big game studies. Alaska Dep. Fish Game., Doc. 2328, 17 p. (avail. at <http://www.arlis.org/docs/vol11/Susitna/23/APA2328.pdf> and accessed 4 Mar. 2015).

⁹Calkins, D. 1983. Marine mammals of lower Cook Inlet and the potential for impact from outer continental shelf oil and gas exploration, development, and transport. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 20:171–263 (avail. at <http://www.arlis.org/docs/vol11/OCSEAP2/Final/6515301/F%20v20.pdf> and accessed 4 Mar. 2015).

¹⁰Calkins, D. G. 1989. Status of belukha whales in Cook Inlet. In L. E. Jarvela and L. K. Thorsteinson (Editors), Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting, Feb. 7–8, 1989, Anchorage, Alaska, p. 109–112. OCS Study MMS 89-0041, U.S. Dep. Inter., Bur. Land. Manage., Minerals Manage. Serv.

¹¹Courtesy of Kenneth W. Pitcher, Alaska Dep. Fish. Game, Anchorage, 15 June 1999.

¹²Vate Brattström, L., C. Sims, R. Hobbs, and B. Mahoney. 2010. The Cook Inlet beluga whale opportunistic database: A summary of opportu-

nistic sightings during the past 35 years. Poster pres. at Alaska Mar. Sci. Symp., Anchorage, AK, Jan. 2010 (avail. at http://access.afsc.noaa.gov/pubs/posters/pdfs/pVate-Brattstrom01_cook-inlet-beluga-db.pdf and accessed 22 Jan. 2014).

¹³Appendices are available in the online version of this article (doi: 10.7755/MFR.77.2.1).

¹⁴NMFS. 1992. Status report on Cook Inlet belugas (*Delphinapterus leucas*). Rep. prep. by Alaska Reg., Natl. Mar. Fish. Serv., 222 W. 7th Ave., #43, Anchorage, AK 99513-7577, 22 p.

¹⁵Shelden, K. E. W., and B. A. Mahoney. 2016. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1991. AFSC Proc. Rep. 2016-02, 22 p. Available at <http://www.afsc.noaa.gov/Publications/ProcRpt/PR2016-02.pdf>.

¹⁶Shelden, K. E. W., C. L. Sims, L. Vate Brattström, K. T. Goetz, and R. C. Hobbs. 2015. Aerial surveys of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2014. AFSC Proc. Rep. 2015-03, 55 p. Available at <http://www.afsc.noaa.gov/Publications/ProcRpt/PR2015-03.pdf> and accessed 8 Sept. 2015.

¹⁷Hansen, D. J., and J. D. Hubbard. 1999. Distribution of Cook Inlet beluga whales (*Delphinapterus leucas*) in winter. U.S. Dep. Inter., Bur. Land. Manage., Minerals Manage. Serv., Environ. Stud. Sec., Alaska OCS Reg., OCS Study MMS 99-0024, 30 p. (avail. at <http://alaskafisheries.noaa.gov/protectedresources/whales/be->

[luga/reports/distribution_hansen_hubbard99.pdf](http://alaskafisheries.noaa.gov/protectedresources/whales/beluga/reports/distribution_hansen_hubbard99.pdf) and accessed 16 Mar. 2015).

¹⁸Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Proc. Rep. 2012-03, 40 p. (avail. at <http://www.afsc.noaa.gov/Publications/ProcRpt/PR2012-03.pdf> and accessed 5 Dec. 2013).

ent as are counted in this type of survey. Using a correction factor of 2.7 to account for submerged whales (which was developed for estimating belukha whales in similar conditions in Bristol Bay) yields a minimum estimate of 1,293 whales in Cook Inlet in August 1979” (p. 110).

Applying this correction (2.75 per Frost et al. (1985)) to surveys undertaken by NMFS in June 1991 (Shelden and Mahoney¹⁵, correcting the estimate presented in NMFS¹⁴), where the highest count was 370 whales on a single day, resulted in an estimate of 1,018 belugas. Subsequent estimates produced from NMFS surveys (1994–2014) were based on correction factors developed for Cook Inlet (Hobbs et al., 2015a). These estimates show a steep decline in abundance prior to the moratorium on Alaska Native subsistence hunting (1994–98: -13.7% (SE = 4.5%) per year), and a 1.3% (SE = 0.8%) per year decline since harvest management regulations were put in place in 1999 (Shelden et al.¹⁶). The Cook Inlet stock was listed as depleted under the U.S. Marine Mammal Protection Act in 2000 (NOAA, 2000). In 2008, the Cook Inlet population was listed as endangered under the U.S. Endangered Species Act (NOAA, 2008).

This paper provides a review of CIBW spatio-temporal distribution based on results from aerial surveys, satellite-telemetry, and opportunistic sightings. With the continued decline in abundance of CIBWs (Hobbs et al., 2015a) and concomitant contraction in range observed during early summer (Rugh et al., 2010), identifying areas used by these whales during ice-covered and ice-free periods is critical to the recovery of this endangered population.

Methods

Study Area

Cook Inlet, Alaska, (lat. 59°–61.5°N, long. 149°–154°W) is a semi-enclosed tidal estuary covering an area of roughly 20,000 km² with 1,350 km

of shoreline (Fig. 1). The inlet extends about 370 km (200 n.mi.) southwest from Knik Arm to Cape Douglas and has marine connections with Shelikof Strait and the Gulf of Alaska, and freshwater input from many large rivers.

Osgood (1933) described the inlet as four regions: Lower, Middle, Upper, and Inland, based on the villages occupied by the Athapaskan-speaking Tanaina, a sea-hunting Alaska Native culture. The lower inlet region (which included the village of Seldovia) was described as having a mild climate and salt water. The middle inlet was less mild and salt-fresh water mixed and included the villages of Kenai and Tyonek. The upper inlet included Knik Arm (the village of Eklutna) and was described as a cold climate with waters that were a mixture of dirty, fresh, and salt. Inland villages were on the Susitna River and Iliamna River, regions described as fresh water only with cold climates. Osgood (1933) noted that belugas were found in lower, middle, and seasonally, in the upper inlet. For the purposes of this paper, we simplified the division of the inlet into upper and lower regions, separated at East Foreland and West Foreland (Fig. 1).

Tides in Cook Inlet are semi-diurnal, with two unequal high and low tides per tidal day (tidal day = 24 h 50 min). The mean diurnal tidal range varies from roughly 6 m (19 ft) at Homer to 9.5 m (30 ft) at Anchorage. These extremes in tide expose vast expanses of mudflats in the upper inlet, between the Beluga River and Little Susitna River (we refer to this region as the Susitna Delta), and in Knik Arm, Chickaloon Bay, and Turnagain Arm (Fig. 1). Beluga whales navigate these regions on the flooding and ebbing tides, following the deeper channels as the mud flats flood, allowing the whales to move closer to the shoreline and into the rivers. Whales move to the edges of the mudflats, to what appears to be mid-inlet waters, as the tide ebbs. We considered the mudflat edge to be an extension of the shoreline when describing whale distribu-

tion, and mid-inlet waters are defined as deeper than 10 m (Fig. 1).

Sea ice generally forms in October–November, reaches its maximum extent in February, then recedes and melts in March–April. By December, much of the upper inlet north of North Foreland and Point Possession is covered with ice ranging in thickness from 10 cm (new/pancake) to 30–70 cm (all as first year because there is no multi-year ice present in the inlet); and in concentrations ranging from 10% to 70–80% coverage (i.e., open (1/10) to close pack (7/10 to 8/10) (Mulherin et al.¹⁹). Hereafter, percent coverage is used in lieu of tenths when describing ice concentrations.

Thawing and refreezing create a dynamic ice environment. Tidal action and tidal currents often shatter sea ice in Cook Inlet to the extent that there is seldom uniform coverage. Waters are typically ice-free south of East and West Foreland until January, when ice extent and thickness increase, reaching maximums between mid-February and early March (Mulherin et al.¹⁹). In colder winters, ice extends south as far as Anchor Point and Augustine Island, filling Kamishak Bay to Cape Douglas on the lower west side of Cook Inlet. Despite the possibility of ice entrapment, beluga whales continued to inhabit upper inlet waters (Goetz et al.¹⁸). In general, beluga whales are pagophilic (i.e., “ice-loving”) and uniquely adapted to survive in Arctic and subarctic waters.

The endangered CIBW population lives in close proximity to Anchorage, the largest city in Alaska, and waterways frequented by fishing fleets, container ships, air traffic, oil and gas development, and military operations. The magnitude and the accumulated anthropogenic pressures within Cook Inlet beluga habitat are of particular concern for this small, isolated population (Norman et al., 2015).

¹⁹Mulherin, N. D., W. B. Tucker III, O. P. Smith, and W. J. Lee. 2001. Marine ice atlas for Cook Inlet, Alaska. ERDC/CRREL Tech. Rep. 01-10, 155 p. (avail. at <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA392126> and accessed 4 Dec. 2013).

Aerial Survey Datasets

Alaska Department of Fish and Game

From November 1977 through August 1979, aerial survey observers documented the seasonal distribution of CIBWs and also recorded the presence of other marine mammals including harbor seals, *Phoca vitulina*; minke whales, *Balaenoptera acutorostrata*; sea otters, *Enhydra lutris*; and harbor porpoises, *Phocoena phocoena*. Survey altitude ranged from 91 to 152 m (300–500 ft). This extensive effort included year-round surveys of coastal and mid-inlet waters in the upper and lower inlet. Survey platforms included floatplanes and helicopters with one pilot and one observer. Sightings (including group sizes) and tracklines were hand-drawn on a simple outline of the inlet or a NOAA chart of the particular area of Cook Inlet surveyed. Sometimes these data were later transcribed to another map template showing the outline of the entire inlet. Field notes were often, but not always, included with the maps that were received by NMML.

ADFG also conducted aerial surveys from May through August 1982 and April through July 1983 in upper Cook Inlet. Similar to the beluga whale surveys conducted in the 1970's, survey altitude ranged from 91 to 152 m (300–500 ft). Survey aircraft were primarily single engine floatplanes with one pilot and one or two observers onboard. Field notes or annotated maps displayed flight paths and sightings. Unlike the MMS and NMFS surveys described in the following sections, the ADFG efforts were not documented in annual field reports or publications; therefore, Appendices 1 (1977–79) and 2 (1982–83) include transcriptions of all available field notes, survey tracklines, and sighting locations.

Maps were created using ArcView²⁰ geographical information system software (ver. 10.1). Plots showing sighting locations were projected using the Alaska Albers Equal Area Conic coordi-

²⁰Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA

nate system which provided a more accurate depiction for area-use measurements. Each map was scanned and saved into a PDF, then the digital image was exported as a JPEG file. This file was imported into ArcMap as a raster dataset layer and saved as a georeferenced map. Beluga sighting locations and survey tracklines were redrawn as graphics then converted to shapefiles. The sighting shapefiles were edited to include group sizes for the maps in Appendices 1 and 2.

Minerals Management Service

In 1997, aerial surveys for beluga whales in ice-free areas of Cook Inlet occurred from 12 Feb. through 14 Mar. (Hansen and Hubbard¹⁷). Surveys were flown in a Twin Otter equipped with side bubble windows for the two observers. These windows allowed observers to view ahead of and beneath the aircraft. Similar to the NMFS surveys described in the following section, a computer operator collected survey data using an acquisition program designed for marine mammal surveys. The surveys covered 9,406 km of trackline and were flown at an altitude of 305 m (1,000 ft). Daily summaries and maps that included trackline effort and marine mammal species observations are provided in Appendix B in Hansen and Hubbard¹⁷. Beluga whale sighting locations (lat., long. from Table 4 in Hansen and Hubbard¹⁷) were imported and plotted in ArcMap. Group sizes and general locations of these sightings are provided in Table 1.

National Marine Fisheries Service

During the period 18–21 June 1991, aerial surveys²¹ were flown to document the distribution and group sizes of beluga whales in Cook Inlet (Shelden and Mahoney¹⁵). The survey aircraft was a NOAA Twin Otter that

²¹Until recently (February 2013), the original data from these surveys were thought lost. The only description of this survey, a short summary and single map, existed in an unpublished document titled "Status Report on Cook Inlet Belugas (*Delphinapterus leucas*)" (NMFS [text footnote 14], p. 7–9). Discovery of a floppy disk containing the original survey data led to the preparation of a field report in March 2013.

was equipped with side bubble windows for the two observers. The survey altitude range was 152 to 305 m (500–1,000 ft). A computer operator collected survey data using an acquisition program designed for marine mammal surveys. Effort included coastal and mid-inlet waters north of Chinitna Bay and Anchor Point. Daily summaries and maps are provided in Shelden and Mahoney¹⁵.

From 1993 to 2012, NMFS conducted annual surveys to determine abundance and distribution of belugas in Cook Inlet (hereafter referred to as "NMFS abundance surveys") (Rugh et al., 2000; 2005; Shelden et al., 2013) after which NMFS began a series of biennial surveys in 2014 (Hobbs, 2013; Shelden et al.¹⁶). Flights primarily took place in June, though in some years surveys began in late May (2005, 2011, and 2012), or were conducted in July (1993 and 1995). Surveys were flown in twin engine, high wing aircraft (Aero Commander or Twin Otter) equipped with side bubble windows. Surveys were flown at an altitude of 245 m (800 ft). Because most sightings occur near shore, two observers were positioned on the shoreward side of the aircraft, independently recording observations to help assess how often groups were missed. A third observer scanned mid-inlet waters and a computer operator recorded survey data. All marine mammals observed within the study area were included in the sighting database (Shelden et al., 2013:87–122).

Survey effort during the NMFS abundance surveys was fairly consistent across years with at least two survey flights covering lower inlet waters (south of East and West Foreland and north of Cape Douglas and Elizabeth Island) and multiple flights over the upper inlet. Daily summaries and maps showing sightings and trackline effort were published in Rugh et al. (2000, 2005) and Shelden et al. (2013). Surveys on a smaller scale were conducted in May (Rugh et al.²²), August (Hobbs

²²Rugh, D. J., K. T. Goetz, and C. L. Sims. 2006. Aerial surveys of belugas in Cook Inlet, Alaska, May 2006. Unpubl. field rep., 8 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/>)

Table 1.—Beluga whale group sizes and sighting locations during February–March 1997 aerial surveys conducted by U.S. Department of Interior, Minerals Management Service (Hansen and Hubbard, text footnote 17).

Date	Beluga whale group sizes					Total
	Lower inlet			Upper inlet		
	Kalgin Island			S of West Foreland	Near Boulder Pt.	
	SW tip	NW tip	NE tip			
12 Feb.	12					12
15 Feb.						0
28 Feb.		36	1		13	50
01 Mar.		12	22			34
03 Mar.						0
12 Mar.				24		24
13 Mar.		11				11
14 Mar.		9			10	19

et al., 2015b; Rugh et al.^{23, 24}, Shelden et al.^{25, 26, 27, 28, 29}, Sims et al.³⁰), Septem-

ber (Withrow et al.³¹; Shelden et al.³²), and October (Shelden et al.³²).

To document year-round beluga whale distribution, surveys were flown 1–2 days each month (with the exception of December and March) from July 2001 to April 2002 (Rugh et al., 2004). Aircraft and methods were the same as those used during the NMFS abundance surveys. Effort included coastal and mid-inlet waters in the upper inlet, and mid-inlet tracklines between East and West Foreland and the southern tip of Kalgin Island in the lower inlet. Daily summaries and maps showing sightings and effort were published in Rugh et al. (2004).

Beluga whale sighting locations from all of the NMFS surveys were imported and plotted in ArcMap. Group size estimates from the NMFS abundance surveys have been corrected for availability and perception biases (see Hobbs et al., 2015a) but counts

from all other studies (ADFG, NMFS, and MMS) are uncorrected.

Overview of Aerial Methods

It is important to note the differences and similarities among these aerial surveys. Surveys conducted by ADFG in the 1970's and 1980's were at lower altitudes (300–500 ft), in single engine airplanes or helicopters, and usually with only one observer on board. Although the pilot also searched for whales, detectability would be biased downward. MMS and NMFS surveys followed similar protocols with paired observers, side bubble windows, and survey altitudes at or above 800 ft. This improves detections though whale groups may still be missed (Hobbs et al., 2015a). Coverage of the inlet varied from project to project and season to season (e.g., Appendices 1 and 2, Rugh et al., 2004), largely driven by weather and day length, such that the summer period had the greatest amount of survey effort (Fig. 3). Therefore, we present the seasonal results by year (representing each project) and month, to account for any similarities or differences in subsequent analyses and discussions.

Satellite Tagging Dataset

Beluga whales in Cook Inlet were captured and tagged in late May 1999 ($n = 1$), September 2000 ($n = 2$), late July–August 2001 ($n = 7$), and late July–August 2002 ($n = 8$) (Table 2). The tagged whales included eight males and ten females ranging in size from 257 to 442 cm. Tags were placed on the dorsal ridge and held in place via plastic pins inserted through the blubber layer below the ridge (Fig. 4). Belugas were instrumented with either a satellite-linked time-depth recorder (Wildlife Computers Ltd., Redmond, WA) containing a Telonics ST-16 ARGOS transmitter (Telonics, Mesa, AZ) (ST-16), a smart position or temperature transmitting tag (SPOT2) (Wildlife Computers Ltd., Redmond, WA), or both (Table 2). Tags were programmed to transmit 24 hours a day (ST-16) or every 10 days for 24 hours

beluga/survey/report0506.pdf and accessed 19 July 2011).

²³Rugh, D. J., K. T. Goetz, and B. A. Mahoney. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, August 2005. Unpubl. field rep., 8 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/aerialsurvey05.pdf> and accessed 19 July 2011).

²⁴Rugh, D. J., K. T. Goetz, C. L. Sims, and B. K. Smith. 2006. Aerial surveys of belugas in Cook Inlet, Alaska, August 2006. Unpubl. field rep., 9 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/aug2006.pdf> and accessed 19 July 2011).

²⁵Shelden, K. E. W., K. T. Goetz, and J. A. Mocklin. 2007. Aerial surveys of belugas in Cook Inlet, Alaska, August 2007. Unpubl. field rep., 11 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/aug2007.pdf> and accessed 19 July 2011).

²⁶Shelden K. E. W., K. T. Goetz, L. Vate Brattström, B. A. Mahoney, M. Migura-Krajczynski, and B. S. Stewart. 2008. Aerial surveys of belugas in Cook Inlet, Alaska, August 2008. Unpubl. field rep., 11 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/aug2008.pdf> and accessed 19 July 2011).

²⁷Shelden K. E. W., K. T. Goetz, L. Vate Brattström, and B. A. Mahoney. 2009. Aerial surveys of belugas in Cook Inlet, Alaska, August 2009. Unpubl. field rep., 11 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/august09.pdf> and accessed 19 July 2011).

²⁸Shelden K. E. W., L. Vate Brattström, and C. L. Sims. 2010. Aerial surveys of belugas in Cook Inlet, Alaska, August 2010. Unpubl. field rep., 12 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/august2010.pdf> and accessed 19 July 2011).

²⁹Shelden K. E. W., K. T. Goetz, L. Vate Brattström, and B. A. Mahoney. 2009. Aerial surveys of belugas in Cook Inlet, Alaska, August 2009. Unpubl. field rep., 11 p. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/august09.pdf> and accessed 19 July 2011).

³⁰Sims, C.L., L. Vate Brattström, and K. T. Goetz. 2012. Aerial surveys of belugas in Cook Inlet, Alaska, August 2012. Unpubl. field rep., 11 p. (avail. at <http://alaskafisheries.noaa.gov/>

³¹Withrow, 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. In H. Braham and D. DeMaster (Editors), Marine Mammal Assessment Program: status of stocks and impacts of incidental take; 1993, p. 128–153. Annu. Rep. submitted to Off. Protected Resour., NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. (avail. at <http://www.fakr.noaa.gov/protectedresources/whales/beluga/reports/withrowetal1993.pdf> and accessed 19 July 2011).

³²Shelden K. E. W., K. T. Goetz, C. Sims, and B. A. Mahoney. 2008. Aerial surveys of belugas in Cook Inlet, Alaska, September and October 2008. Unpubl. field rep., 9 p. (avail. at http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/sept_oct08.pdf and accessed 19 July 2011).

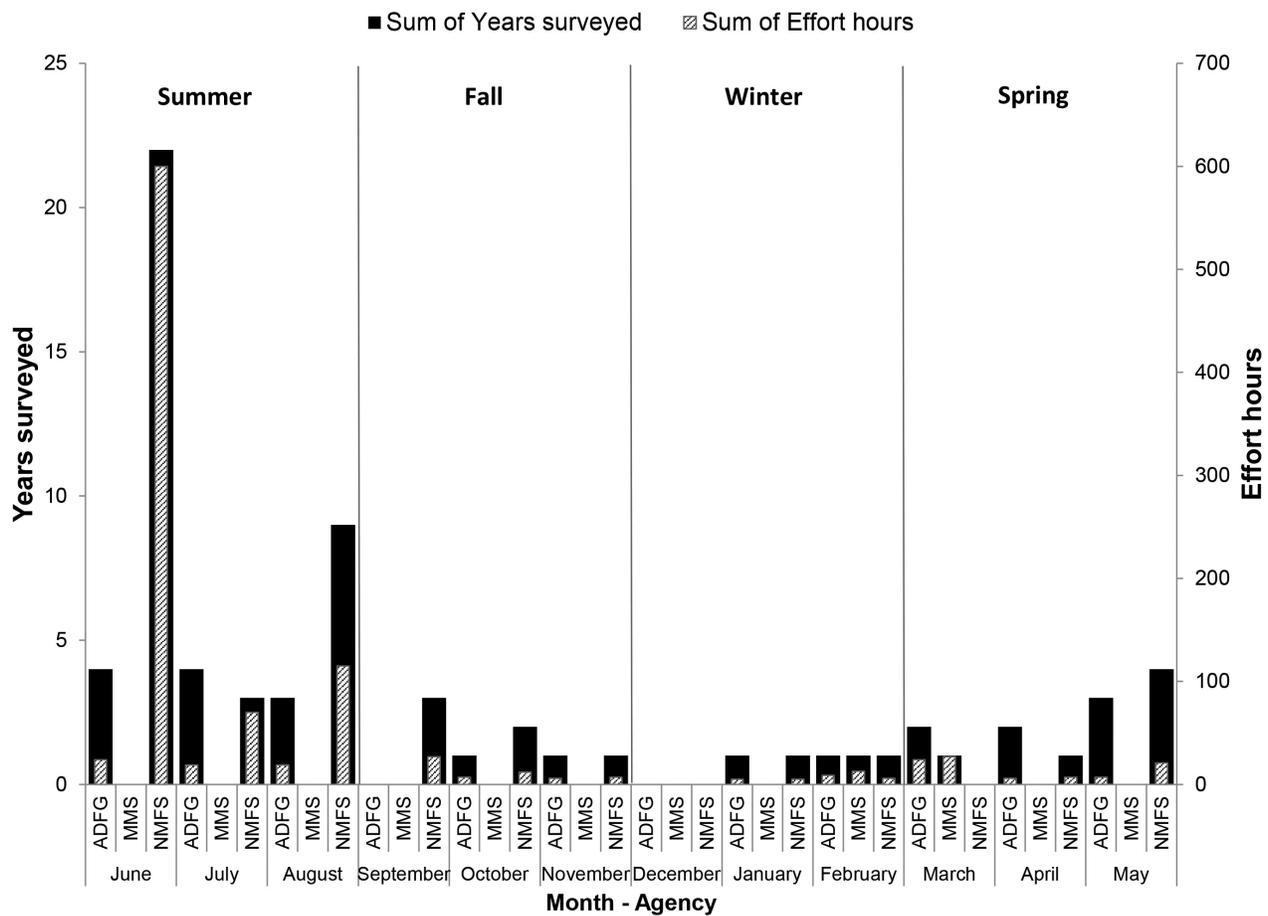


Figure 3.—Aerial surveys documenting beluga whales in Cook Inlet, Alaska, conducted by the Alaska Department of Fish and Game (ADFG:1977–79, 1982–83), Minerals Management Service (MMS: 1997), and National Marine Fisheries Service (NMFS: 1991, 1993–2012, 2014). Effort hours were compiled for all surveys, which ranged from 1 day to 11 days within each month during a particular year, and included 1–3 flights per day. ADFG effort hours were estimated for some surveys based on trackline coverage and similar surveys that included field notes when field notes were not available (Appendix 1 and 2).

(SPOT2). Tags transmitted locations from capture date to last uplink from 1 to 295 days (average = 116.4, SD = 84.5) (Table 2). Goetz et al.¹⁸ reanalyzed tag data presented in Ferrero et al. (2000) and Hobbs et al. (2005), applying a land avoidance algorithm and removing gaps in data of longer than 1 day from the interpolated track. We used this revised dataset for the seasonal distribution analysis. Maps displaying individual whale locations each month for the four study years are provided in Appendix 3, with the exception of the four whales whose tags transmitted for fewer than 2 analysis days (Table 2).

Opportunistic Sightings Dataset

NMFS maintains a Microsoft Access database of beluga whale sightings provided by the public opportunistically (i.e., no associated effort data), from aircraft patrols (e.g., Civil Air Patrol, NMFS Enforcement, and military recon), dedicated beluga whale surveys (vessel, shore-based, and aerial), other wildlife surveys, and industry monitoring studies. The CIBW Opportunistic Database was queried for all sightings from 1975 (the earliest reported sighting in the database) through 2014. Sightings from beluga whale aerial surveys that had associ-

ated effort (ADFG, NMFS-NMML, and MMS) were excluded as these are presented in the aerial survey datasets section. Although a number of monitoring studies have occurred in Cook Inlet, particularly in the last decade (e.g., Polasek et al., 2015; Carlson et al., 2015; Kendall and Cornick, 2015), we included these data here only if sightings were provided to NMFS for inclusion in the database.

We note that after the moratorium on the subsistence hunt in 1999, and subsequent listing of the CIBW population as endangered, the number of sightings in the database increased substantially due to public outreach,

Table 2. Tag type, date deployed and duration, tagging location, and physical characteristics of beluga whales tagged in Cook Inlet, Alaska, between 1999 and 2002. Animal ID was created for the mapping database to provide a unique identifier for PTT numbers that were used over multiple years. NA = not analyzed (< 1 day of uplinks). NT = no transmissions. L = 4 batteries. S = 2 batteries. "Days" = total days from capture date to last satellite uplink. For whales with two functioning tags (n = 3), transmission data were combined into one continuous time series for "days" and "analysis days" (shown in parentheses). "Analysis days" represent good quality uplinks only. Length was measured as straight length usually in feet and inches then converted to centimeters (note: some conversion errors occurred in Hobbs et al. (2005)). Photo-ID is currently in progress, therefore, only a 100% confirmed match to photographs taken during tagging are shown (T. McGuire, LGL Research Associates, Anchorage, AK). See Appendix 3¹ for maps of capture locations and monthly movements.

Beluga ID			Satellite-linked tags										Whale characteristics				Recaptured	
Field notes	Pectoral band (Left/ Right)		Animal ID	Type	PTT	Capture location	Capture date	First uplink	Final uplink	Days (analysis days)	Sex	Color	Length feet (cm)	Photo-ID (aft.2005)	Stranded/Died			
	Hobbs/Goetz ⁴	Hobbs/Goetz ⁴																
RCF 400 ²	DL00141(L)	DL00142(R)	25850111	ST-16	25850	Little Susitna	31 May 1999	Same day	17 Sept 1999	109 (103.0)	M	White	370					
CI-DL-03-00 ³	CI-0001		25850112	ST-16	25850	Knik Arm	13 Sept 2000	14 Sept 2000	06 Jan 2001	115 (111.5)	M	White	137"(413)					
CI-DL-02-00 ³	CI-0002		30719114	ST-16	30719	Knik Arm	13 Sept 2000	Same day	18 Jan 2001	127 (126.3)	F	White/gray	811"(272)	Yes				
CI-01-01	CI-0101		13934102	SPT02	13934	Little Susitna	10 Aug 2001	19 Sept 2001	10 Dec 2001	122 (5.6)	F	Gray	85"(257)	Yes				
CI-01-02	CI-0102		13937103	ST-16/	30720/	Knik Arm	11 Aug 2001	NT/	NT/	107 (5.6)	M	White	107"(323)					
	SPT02			SPT02	13937		16 Sept 2001											
CI-01-03	CI-0103		13933101	ST-16/	25847/	Knik Arm	12 Aug 2001/	13 Aug 2001/	2 Oct 2001/	130 (21.8)	F	White	103"(312)					
	SPT02			SPT02	13945		29 Sept 2001	NT/	20 Dec 2001									
CI-01-04	CI-0104 ⁵	NA	NA	ST-16/	25849/	Knik Arm	13 Aug 2001	NT/	31 Aug 2001	18 (< 1)	F	White	112"(340)					
	SPT02			SPT02	13945		30 Aug 2001		01 Jan 2002									
CI-01-05	CI-0105		13938104	SPT02	13938	Knik Arm	13 Aug 2001	16 Aug 2001	16 Aug 2001	141 (14.9)	F	White	118.5"(357)					
CI-01-06	CI-0106		13942105	ST-16/	13947/	Knik Arm	15 Aug 2001	16 Aug 2001/	28 Nov 2001/	105 (94.7)	F	White	132"(401)	Yes				
	SPT02			SPT02	13942		22 Aug 2001	27 Nov 2001										
CI-01-07	CI-0107		13943106	ST-16/	13948/	Knik Arm	20 Aug 2001	21 Aug 2001/	09 Mar 2002/	201 (200.3)	M	White	146"(442)					
	SPT02			SPT02	13943		21 Sept 2001	06 Jan 2002										
CI2002-01	CI-0201		25850113	ST-16 L	25850	Little Susitna	29 July 2002 ⁶	Same day	31 Oct 2002	94 (91.5)	M	White	136"(412)					
CI2002-02	CI-0202 ⁵	NA	NA	ST-16 L	30719	Little Susitna	30 July 2002	31 July 2002	31 Aug 2002	32 (< 1)	F	White/gray	112"(340)					
CI2002-03	CI-0203		13943107	ST-16 S	13943	Knik Arm	01 Aug 2002	01 Aug 2002	24 Aug 2002	24 (23.2)	F	White	120"(366)					
CI2002-04	CI-0204 ⁵	NA	NA	ST-16 L	25849	Little Susitna	01 Aug 2002	Same day	02 Aug 2002	1 (< 1)	F	White	125"(379)	No	9 Aug. 2002			
CI2002-05	CI-0205		13947108	ST-16 S	13947	Knik Arm	02 Aug 2002	03 Aug 2002	01 Apr 2003	242 (215.8)	M	White/gray	128"(386)	Yes	12 June 2015			
CI2002-06	CI-0206		13948109	ST-16 S	13948	Knik Arm	03 Aug 2002	04 Aug 2002	22 Mar 2003	231 (200.6)	M	White/gray	117"(353)	Yes				
CI2002-07	CI-0207		NA	ST-16 L	30720	Knik Arm	03 Aug 2002	04 Aug 2002	05 Aug 2002	2 (< 1)	F	White	123"(374)					
CI2002-08	CI-0208		25847110	ST-16 S	25847	Knik Arm	04 Aug 2002	05 Aug 2002	26 May 2003	295 (264.7)	M	White/gray	124"(376)	Yes	26 May 2014			

¹ Available in the online version of this article (doi: 10.7755/MFR.77.2.1).

² Ferrero et al. (2000)

³ Litzky, L. K., R. C. Hobbs, and B. A. Mahoney. 2001. Field report for tagging study of beluga whales in Cook Inlet, Alaska, September 2000, p. 13-19. In A. L. Lopez and R. P. Angliss (Editors), Marine Mammal Protection Act and Endangered Species Act implementation program 2000, p. 13-19. AFSC Proc. Report 2001-06, 115 p. <http://www.afsc.noaa.gov/Publications/ProcRptPR%202001-06.pdf>.

⁴ The original version of Goetz et al. (text footnote 18) contained ID numbers that did not match those presented in Hobbs et al. (2005). The report was revised in January 2016 to include corrected ID numbers.

⁵ Not included in Hobbs et al. (2005)

⁶ Year is incorrect (2001) in Table 1 in Hobbs et al. (2005).



Figure 4.—Cook Inlet belugas were instrumented with either a satellite-linked time-depth recorder (Wildlife Computers Ltd., Redmond, WA) containing a Telonics ST-16 ARGOS transmitter (Telonics, Mesa, AZ) (ST-16), or a smart position or temperature transmitting tag (SPOT2) (Wildlife Computers Ltd., Redmond, WA), or both during the 1999–2003 tagging project.

NMFS enforcement patrols, and monitoring studies (Table 3). Most sightings in the lower inlet were opportunistic (78%), while monitoring and patrols provided almost half of the sightings reported in the upper inlet.

Data Analysis

Beluga whale sightings were identified by year (representing each aerial survey project) as well as month when plotting the seasonal distributions for summer (June–Aug.), fall (Sept.–Nov.), winter (Dec.–Feb.), and spring (Mar.–May). Each sighting record on these plots represents a sighting location, not total number of belugas seen. For the summer, when much of the aerial survey effort took place (Fig. 3), each month includes separate maps for the 1970’s, 1980’s, 1990’s, and 2000’s, to alleviate the occurrence of overlapping sightings. Tagging data were also plotted by month within each season,

and identified by year. Additional data summaries include specific dates when tag transmissions coincided with aerial survey effort or opportunistic sightings (Table 4). This provided a means to “ground truth”³³ tagged whale locations as well as document when whales were missed during aerial survey efforts.

Results and Discussion

Summer

The greatest amount of survey effort was expended during the period of June–July–August (Fig. 3). In particular, aerial surveys designed to estimate abundance of CIBWs have occurred annually, primarily in June,

³³Observations or measurements made at or near the surface of the earth to verify an air or space-based remote sensing survey. In this case, verifying presence of tagged whale(s) through aerial observations/opportunistic sightings in the vicinity of satellite-transmitted locations.

from 1994 to 2012 (Rugh et al., 2000; 2005; Sheldon et al., 2013; Hobbs et al., 2015a) and biennially beginning in 2014 (Sheldon et al.¹⁶). Most whales were tagged in late July and early August, only one whale was tagged in late May and transmitted locations throughout the summer season (Table 2). The CIBW Opportunistic Database yielded 865 summer sightings from the period 1975–2014, with 65% reported in August (Table 3).

June

In the 1970’s and 1980’s, belugas were often observed near East and West Foreland or in Trading Bay (near the mouth of McArthur River) in June (Appendices 1 and 2, respectively), but from the early 1990’s until 2012, whales were not seen in these regions (Fig. 5). Beluga distribution within the inlet during June contracted into the northernmost regions of the upper

Table 3.—Opportunistic sightings of Cook Inlet beluga whales (CIBW) provided to the National Marine Fisheries Service, 1975–2014. Number of sightings and average group sizes are shown for each month and time period (1970's, 1980's, 1990's, and 2000's) within the lower and upper inlet (separated by East Foreland and West Foreland). The season total column includes total number of sightings within summer (June–July–Aug.), fall (Sept.–Oct.–Nov.), winter (Dec.–Jan.–Feb.), and spring (Mar.–Apr.–May). Information was collected by the general public, aircraft patrols, CIBW monitoring studies, and during surveys for other wildlife. Group sizes (when provided) represented a best estimate made by the observer. Although data lack associated effort and corrections for group sizes, these sightings provide additional, though anecdotal, information about beluga whale distribution. Number of sighting and average group sizes by month, year, and specific locations within each region are available upon request from the lead author.

Month	Lower Cook Inlet										Upper Cook Inlet										Season Total		
	Sightings					Group size (mean)					Total Sightings	Sightings					Group size (mean)					Total Sightings	
	1970-79	1980-89	1990-99	2000-08	2009-14	1970-79	1980-89	1990-99	2000-08	2009-14		1970-79	1980-89	1990-99	2000-08	2009-14	1970-79	1980-89	1990-99	2000-08			2009-14
June			1	2				1	2		3	3	1	6	163	32	39	8	24	23	24	205	
July		2	1	4		219	1	1		7	7	1	7	56	25	na	20	42	18	18	89	865	
Aug.	2		2	3	1	799	7	2	6	8	8	2	1	49	322	179	38	25	13	21	20	553	
Sept.	1		8	18	4	6	14	9	7	31	4	40	194	108		17	14	23	14	14	346		
Oct.	1		1	18	2	10	75	12	na	22	7	63	49		13	18	11	119	119	595			
Nov.		2	1	4	1		3	5	10	20	8		10	36	23		17	12	6	6	69		
Dec.				1					2	1		1	5	9		12	9	4	4	15			
Jan.		1		1	2	100	na	103	4	4	1	10	2		3	15	7	13	44	44			
Feb.					2			26	2	2		8	1		10	20	9			9			
Mar.		1		3	8	na	26	6	12	12			19	2		11	2	21	21				
Apr.		7	7	6	31	23	15	10	9	51	5	4	7	39	34	10	18	6	5	5	89	340	
May			2	1	7		27	3	13	10	3	1	16	88	49	45	na	40	28	10	157		

inlet temporally and spatially (Rugh et al., 2010). Though the range occupied by this population had contracted northward by the late 1990's, the percentage of whales in the population occupying the Susitna Delta remained fairly constant over time, at roughly half of the population during the periods 1978–79, 1993–97, and 1998–2008 (Rugh et al., 2010).

Knik Arm was another area occupied by large numbers of beluga whales in the 1990's (Fig. 5c) and up until 2007 (Fig. 5d), after which whales were not found in this area during the NMFS abundance surveys (Fig. 5e) (Shelden et al., 2013; Hobbs et al., 2015a; Shelden et al.¹⁶). Since the analyses in Rugh et al. (2010) ended with the 2008 survey, we revisited the dataset and compared the proportion of whales found in the upper inlet during the period 2009–14. The contraction in range, represented by directional distribution ellipses that captured 95% of CIBW sightings, continued northward while still centering within the Susitna Delta (Fig. 6). On average, 83% (SE = 5%; $n = 320$) of the population was observed in the Susitna Delta during 2009–14, compared to half of the population during the earlier time periods (Rugh et al., 2010).

The satellite-tagged whale remained near the Little Susitna River, among the largest number of whales (average group size = 248, range 178–314) seen in the Susitna Delta during the NMFS abundance survey in June 1999 (Table 4). Only on 17 June did this whale venture across the inlet to Point Possession before looping back to Fire Island and returning to the Susitna Delta that same day (Fig. 7a).

Opportunistic sightings in the lower inlet were rarely reported in June and group sizes were typically 1–2 animals (Table 3). Almost all sightings reported in the upper inlet were north of Trading Bay (North Foreland) and Moose Point (Fig. 1). Similar to the NMFS abundance surveys, the last reports of belugas in upper Knik Arm (i.e., Eagle Bay/Goose Bay area and north) during early June were in 2007, with more recent reports occurring only near the entrance of Knik Arm at the Port of Anchorage.

July

Mid-inlet waters and much of the lower inlet coastline were not surveyed by ADFG in 1978 and 1979, respectively (Appendix 1), and upper inlet surveys in the 1980's did not include

Turnagain Arm (Appendix 2) (Fig. 8a, b). NMFS surveys (Rugh et al. 2000, 2004; Withrow et al.³¹) included all coastal and some mid-inlet waters in the upper inlet and south to Kalgin Island (Fig. 8c). The only year NMFS calculated an abundance estimate in July was in 1995, which also included all coastal waters north of Elizabeth Island and Cape Douglas (Rugh et al. 2000). Rugh et al. (2000) noted:

“In the past, belugas were more concentrated in the upper inlet in June than in July; in the 1970's, the percent of sighting in the upper inlet relative to the lower inlet dropped from 86% in June to 52% in July...; and in the 1980's, percentages dropped from 100% in June to 32% in July...; but in the 1990's, this annual shift in distribution was no longer evident (from 99% to 98% for both June and July)” (p. 13).

We speculate that this change in behavior (i.e., whales remaining in the upper inlet in July) continued into the 2000's. Whales were not found south of East and West Foreland in July 2001 during NMFS surveys (Fig. 8c)

Table 4.—Beluga whale tag locations in Cook Inlet, Alaska, that coincided with aerial survey effort and/or opportunistic sightings, 1999–2003.

Date or period	Description
1999 May 31	An opportunistic sighting of 30 belugas in the Little Susitna River coincided with tag transmissions.
1999 June 6, 8–14	An opportunistic sighting of 36 belugas in the Little Susitna River coincided with tag transmissions on 6 June. The tagged whale remained near the Little Susitna River during the NMFS abundance survey (8–14 June), presumably among the 178 to 314 whales estimated at that location over the course of the survey.
1999 Aug.	Six of the 23 CIBW opportunistic sightings in 1999, all in Knik Arm, coincided with tag locations. Groups ranged in size from 5 to 18 whales and were described as mixed groups of adults and juveniles.
2001 Aug. 27	Three of four whales also transmitted locations on 27 Aug., the day of the NMFS aerial survey. Aerial observers identified a lone whale with a satellite tag (CI-0106) in mid-inlet waters, and counted groups near the Little Susitna River (16 whales) and in Knik Arm (71 whales) (areas visited by CI-0107), but they did not see beluga(s) (CI-0105) near the McArthur River (Appendix 3 ¹).
2001 Aug.	All CIBW opportunistic sightings during Aug. 2001 were in the upper inlet. Tag locations coincided with 11 of the 19 opportunistic sightings, all in Knik Arm. Ground truthing was difficult as multiple groups were seen some days. For example, one whale (CI-0103) transmitted locations in the vicinity of opportunistic sightings on 13 Aug. (one group of 10 whales), 24 Aug. (three groups with 10, 20, and 60 whales), and 25 Aug. (three groups with 6, 30, and 60 whales). One whale (CI-0106) was present when groups of 10 and 20 whales were observed on 20 Aug. This whale was also in the area with another tagged whale (CI-0107) when groups of 15 and 20 whales were reported on 21 Aug.
2002 Aug.	All CIBW opportunistic sightings in Aug. 2002 were in the upper inlet. Only one tagged whale's locations (CI-0203) did not coincide with any of these opportunistic sightings. Other whales' tag locations overlapped with sightings in Knik Arm (at least nine sightings) and included one to four of the remaining tagged whales among large groups of 40 to 200 whales. Near the end of the month, one whale (CI-0206) travelled from Knik Arm to Turnagain Arm where ~100 whales were reported, while another (CI-0205) went to the Little Susitna River and was presumably among the 40 whales seen that day.
1999 Sept.	Of the 29 CIBW opportunistic sightings in Sept. 1999, most in the upper inlet, tagged whale locations coincided with all sightings in Knik Arm ($n = 19$), but nowhere else. Group sizes during these observations ranged from 1 to 25 whales or were described as "two large groups."
2000 Sept.	Of the 27 CIBW opportunistic sightings reported during Sept. 2000, most occurred in Turnagain Arm ($n = 13$) and Knik Arm ($n = 10$). Tag locations coincided with six observations. The female beluga (CI-0002) was in Knik Arm in the vicinity of 4–5 belugas on 13 and 14 Sept., and 6–8 belugas on 17 and 18 Sept. The male beluga (CI-0001) was also near the 14 Sept. sighting. From 17 to 25 Sept., tag locations of the male beluga (CI-0001) overlapped with opportunistic reports in Turnagain Arm on 18 and 24 Sept., where group sizes, when provided, ranged from 4 to 22 whales.
2001 Sept. 15, 18	During the period when aerial surveys occurred (on 15 and 18 Sept.), four of the tags transmitted locations. Three of the tags overlapped with the aerial sightings in Knik Arm and Turnagain Arm, while the fourth whale was in Chinitna Bay.
2001 Sept.	Four CIBW opportunistic sightings were reported during Sept. 2001. Only one tag overlapped spatially and temporally with sightings, while the rest of the whales were either in others areas within the upper inlet ($n = 3$) or did not transmit locations on those days ($n = 2$, including the whale in Chinitna Bay). The adult female beluga (CI-0106) was near Point Possession on 8 Sept. (~50 whales seen) and in Turnagain Arm on 17 and 19 Sept. (~20 whales reported each day).
2002 Sept.	Tagged whales were in the vicinity of all but one of the 17 CIBW opportunistic sightings reported in the upper inlet during Sept. 2002. Half of the sightings included more than one tagged whale but never all four, though the sighting reports did not mention tagged whales. Group sizes averaged about 26 whales (range: 2–50) with the exception of one large group reported on 28 Sept. ("feeding...and stretched out covering $\frac{3}{4}$ of a mile at Beluga River" that included three tagged whales.
2000 Oct.	A CIBW opportunistic sighting in Turnagain Arm was the only one to coincide with tag locations from the male beluga (CI-0001) that had spent most of the month in Chickaloon Bay (Appendix 3). The tagged female beluga (CI-0002) was in the Susitna delta that day after having spent time in Redoubt Bay and Trading Bay earlier in the month (Appendix 3).
2001 Oct.	Five CIBW opportunistic sightings occurred during Oct. 2001, all in the upper inlet (Table 3). Sightings rarely coincided with tag locations, in part this was because some tags were duty cycled (i.e., did not transmit every day). For example, during the Trading Bay sighting on 1 Oct., when belugas were seen driving salmon toward the beach, half of the tagged whales ($n = 3$) were not transmitting while the rest were in Knik Arm (Appendix 3). Knik Arm CIBW opportunistic sightings on 12 and 15 Oct. included 120 whales and 15 whales, respectively. Three tagged whales, possibly as many as five (two tags transmitted in Knik Arm prior to and after this period), were in Knik Arm from 12 to 15 Oct. (Appendix 3).
2001 Oct. 12, 15	During the days when aerial surveys were flown (on 12 and 15 Oct.), three tagged whales, possibly as many as five (two tags transmitted in Knik Arm prior to and after this period), were in Knik Arm where most aerial observations occurred. NMFS aerial observers did not find whales in Chickaloon Bay though tag locations show one whale (CI-0106) occupied the area from 12 to 15 Oct.
2000 Nov.	In Nov. 2000, CIBW opportunistic sightings in the upper inlet occurred in Knik Arm, overlapping with tag locations from the female beluga (CI-0002) on every sighting, and the male whale (CI-0001) on four of the six sightings. Group sizes during these encounters ranged from 6 to 35 whales.
2001 Nov. 5	Only one CIBW opportunistic sighting was reported in the upper inlet: 65 whales in Turnagain Arm on 5 Nov. One tagged whale (CI-0106) was present but the remaining tags ($n = 4$) did not transmit locations that day.
2001 Nov. 9	In Nov. 2001, four tagged whales transmitted locations during the NMFS aerial survey, two from Turnagain Arm and two from Knik Arm, overlapping with the aerial observations.
2001 Dec. 17	Three whales, that appeared to be feeding as they rolled among ice floes mid-inlet off Trading Bay, were opportunistically observed by a pilot enroute to Nikiski in the vicinity of two tagged whales (Appendix 3: CI-0105 and CI-0107) that transmitted locations that day.
2002 Jan. 18–25	An opportunistic sighting in Turnagain Arm did not overlap temporally with locations from the last tag still transmitting that year, though the whale (CI-0107) had been in the vicinity the day before (Appendix 3). The opportunistic sighting report did note the absence of tags on the four whales that were milling in calm, ice-free waters. This tagged whale was likely among beluga whales observed during aerial surveys on 22 Jan. Though whales were not seen by the aerial team on 23 Jan., tag transmissions show this adult male beluga was still in the upper inlet near Trading Bay (Appendix 3), an area surveyed by NMFS that day. On 25 Jan., 30 beluga whales were seen by workers on the Grayling Oil platform in Trading Bay, an area where tag transmissions also occurred that day. The whales were in an open patch of water within the ice, swimming north on the incoming tide.
2002 Feb. 25–26	Aerial survey observers did not see whales during the two-day survey despite excellent to fair viewing conditions. Sea ice covered much of the survey area (Rugh et al., 2004). Tag transmissions from one whale (CI-0107) overlapped spatially with areas surveyed by the aerial team in the lower inlet, mid-inlet between East Foreland and Kasilof River, but we could not determine if the whale was in those locations at the same time as the aircraft.
2003 Feb. 12	An opportunistic sighting of ~15 whales swimming in circles near Fire Island occurred the same day two tagged whales were in the same area (CI-0205 and CI-0206).

¹Appendix 3 is available in the online version of this article (doi: 10.7755/MFR.77.2.1).

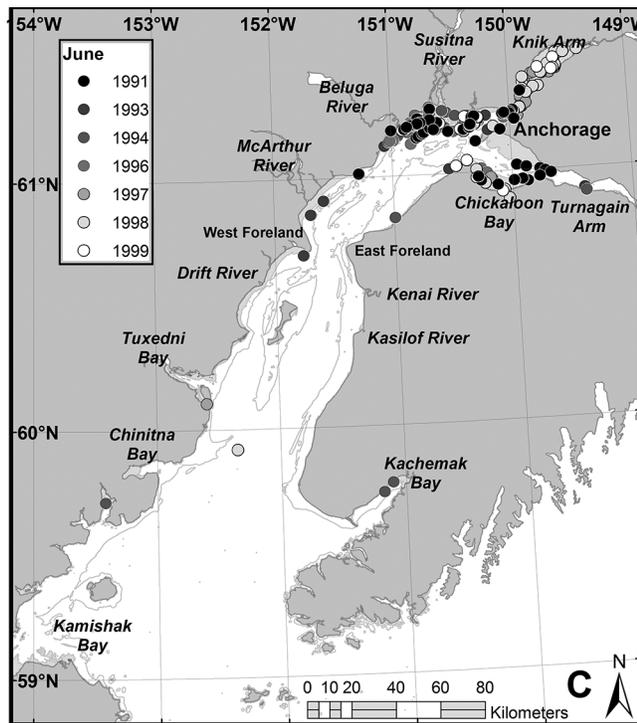
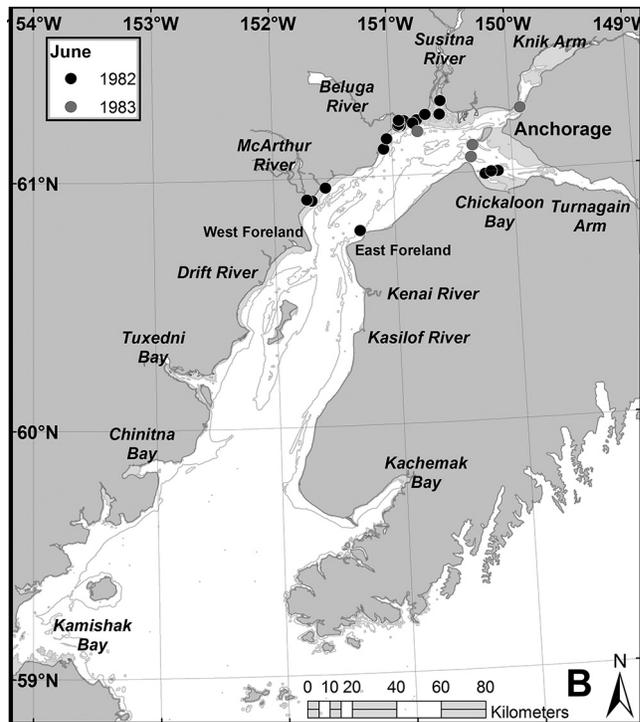
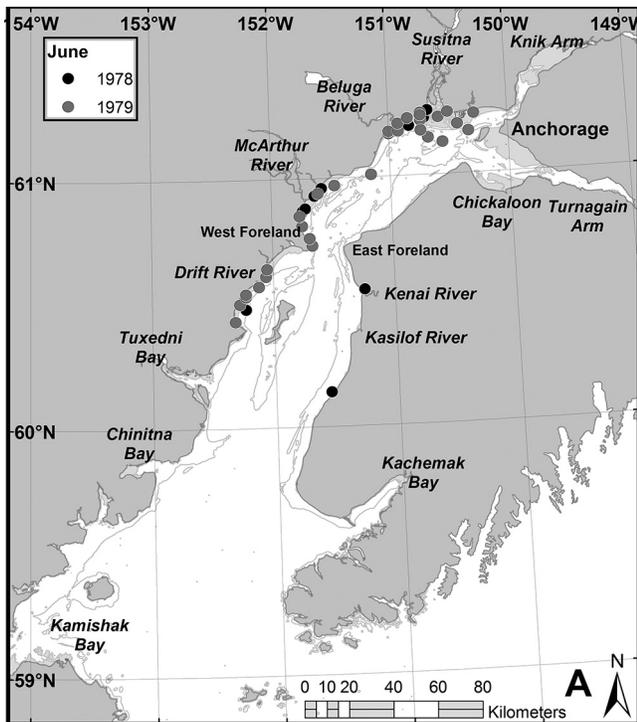


Figure 5.—Beluga whale group sighting locations during systematic aerial surveys of Cook Inlet, Alaska, in summer (June). Surveys were conducted by the Alaska Department of Fish and Game A. 1978–79, B. 1982–83, and National Marine Fisheries Service C. 1991–99, D. 2000–08, and E. 2009–14. Tidal mudflats (shaded areas) and the 10 m isobath are shown. Maps D and E are on next page.

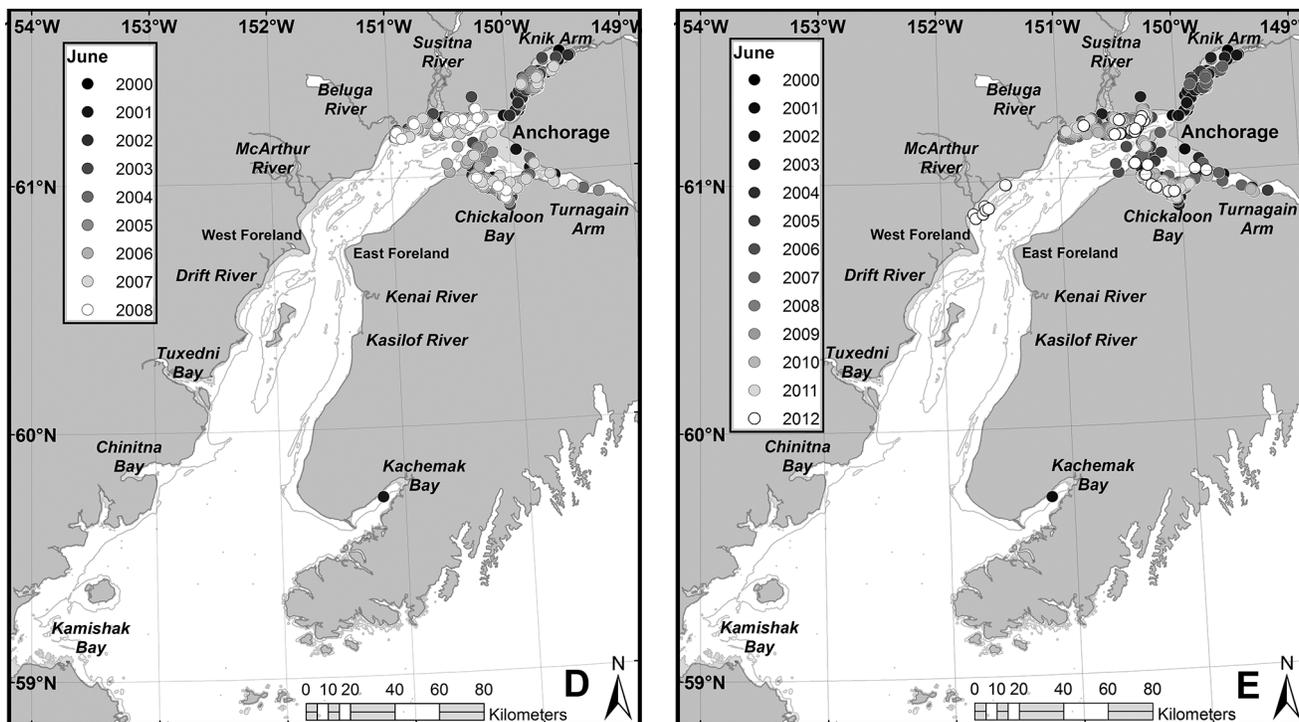


Figure 5.—Continued

but effort was hampered by low clouds and fog in Redoubt Bay (Rugh et al., 2004). The number of whales counted in July 2001 fell within the range of counts obtained that June (Rugh et al., 2004:6).

Whales tagged with satellite transmitters in 1999 and 2002 spent most of their time in the Susitna Delta in July (Fig. 7b). CIBW opportunistic sightings during these years did not overlap temporally or spatially with tag locations. Overall, survey efforts and sightings, both systematic and opportunistic, were less frequent in July (Fig. 3, Table 3) compared to the other summer months. Opportunistic sightings in the lower inlet included a few large groups during the 1980's. Since then, most sightings in the lower inlet have been of single whales (Table 3).

August

Aerial survey effort increased again in August with almost half of the 25 survey years sampled (Fig. 3). In the 1970's, ADFG observed large numbers

of beluga whales in the inlet south of East and West Foreland in August (Appendix 1). In 1978, all beluga sightings were in the lower inlet compared to over 70% in 1979 (Fig. 9a). A similar pattern of large numbers of whales moving from upper inlet waters to the lower inlet seems evident in the 1980's. Though survey effort did not include lower inlet waters (Fig. 8b, Appendix 2), the number of whales found in the upper inlet in August 1982 (176 whales) was similar to the August 1979 count (130 whales); and when compared to early June counts in 1982 (over 300 whales, Appendix 2), there were half as many whales in the upper inlet in August.

NMFS did not conduct surveys in August in the 1990's, though by early September 1993 the whales ranged from the Drift River and Kenai River in the lower inlet (the southern extent of the survey area) to Knik Arm (see Fall section). The August 2001 NMFS survey included coastal and mid-inlet tracklines in the upper and lower in-

let, south to Kalgin Island (Rugh et al., 2004). As mentioned previously, although this was not a NMFS abundance survey, the same methods were used. Whale numbers compared well with those observed in June (June, 211 belugas; August, 205 belugas) suggesting that most if not all of the population remained in the upper inlet (Fig. 9c), unlike the shifts in distribution to the lower inlet observed during the earlier time periods.

In 2005, NMFS began a series of surveys in the upper inlet to document beluga calving rates (Hobbs et al., 2015b). These surveys occurred annually until August 2012. Similar to ADFG surveys in the 1980's, all survey effort and sightings were north of East and West Foreland (Fig. 9c). Counts were similar to those obtained during the June abundance surveys for the period 2005–12 (Hobbs et al., 2015b), suggesting the contraction in range observed since the late 1970's and early 1980's occurred not only in June (as per Rugh et al., 2010) and

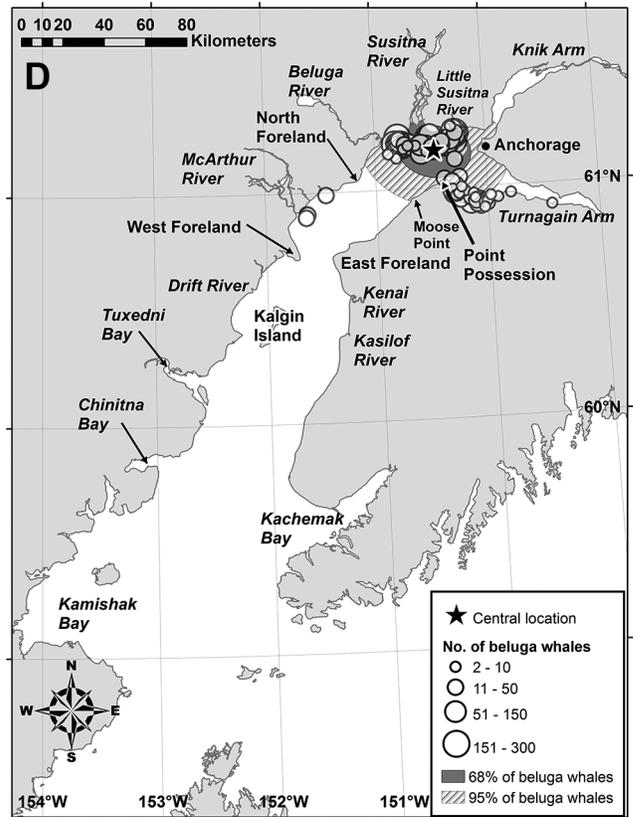
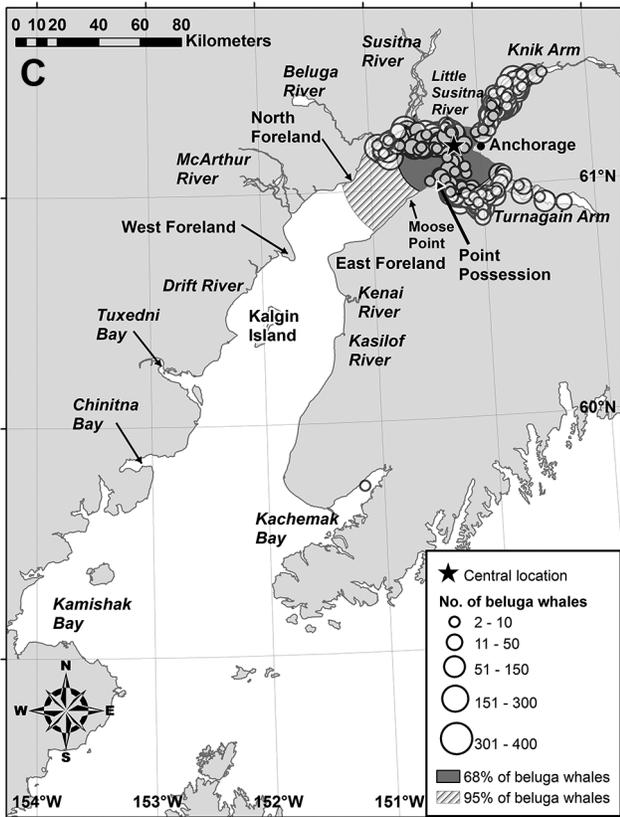
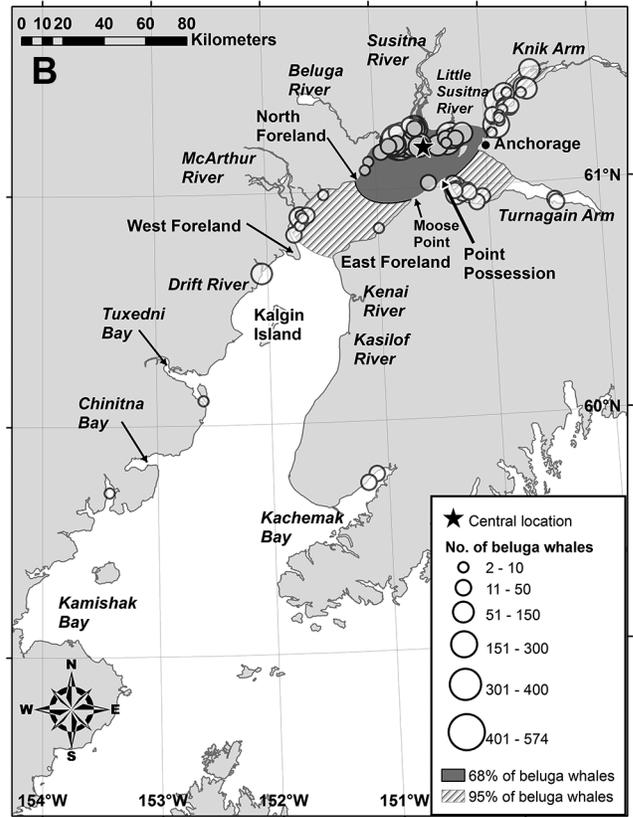
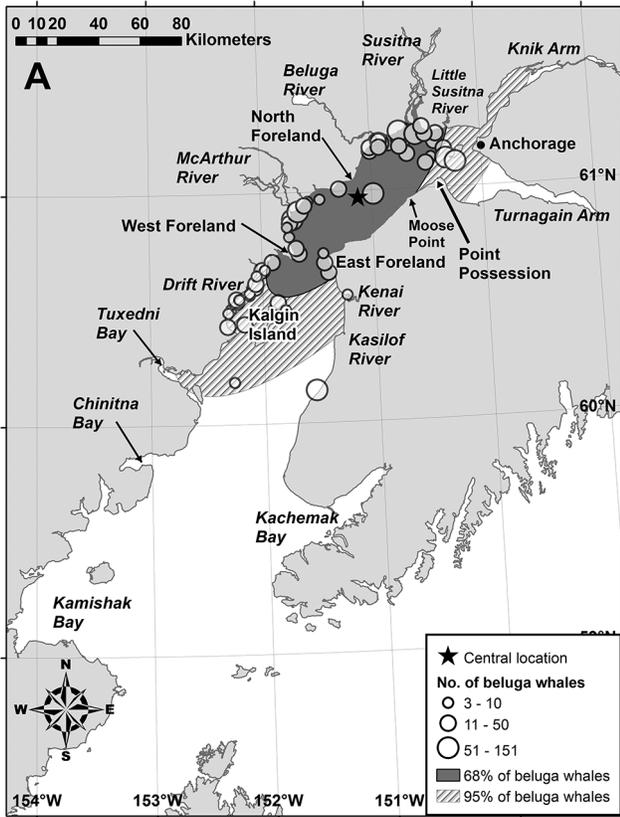


Figure 6.—Areas occupied by beluga whales in Cook Inlet, Alaska, during systematic aerial surveys in A. 1978–79, B. 1993–97, C. 1998–2008, and D. 2009–14. The distribution of beluga whales around each central location for each period was calculated at 1 and 2 SD (capturing ca. 68% and 95% of the whales; shaded regions). 95% core summer distribution contracted from 7,226 sq. km in 1978–79 to 1,787 sq. km in 2009–14 (25% of the 1978–79 range) (see Rugh et al., 2010 for methods).

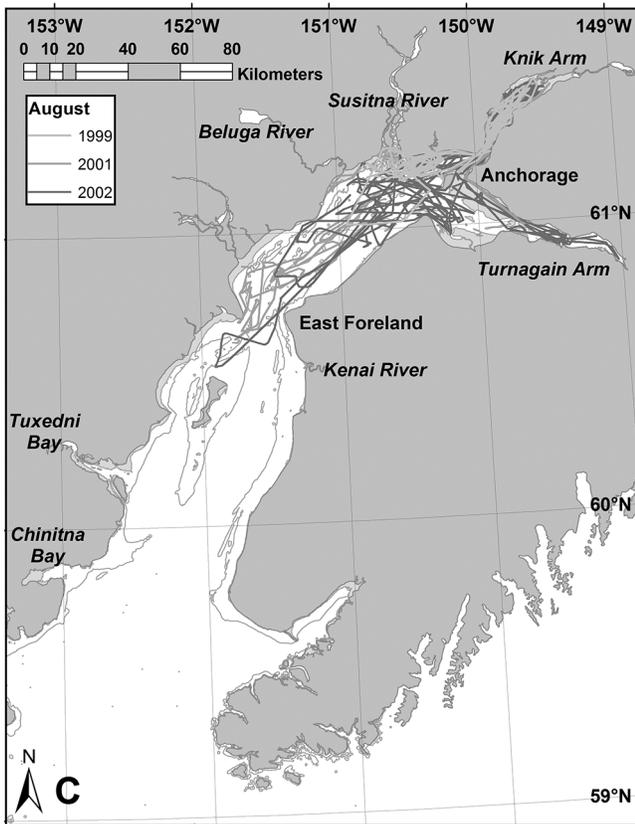
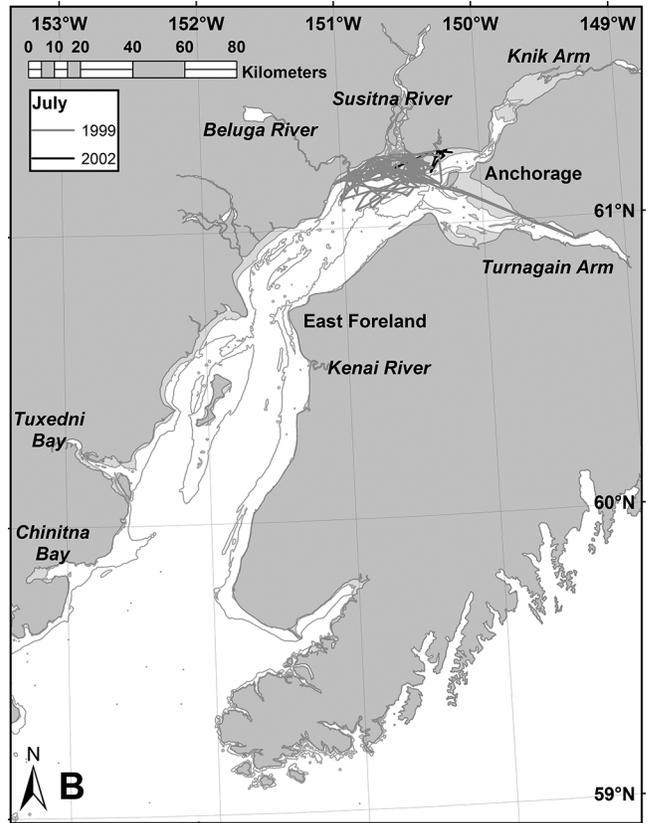
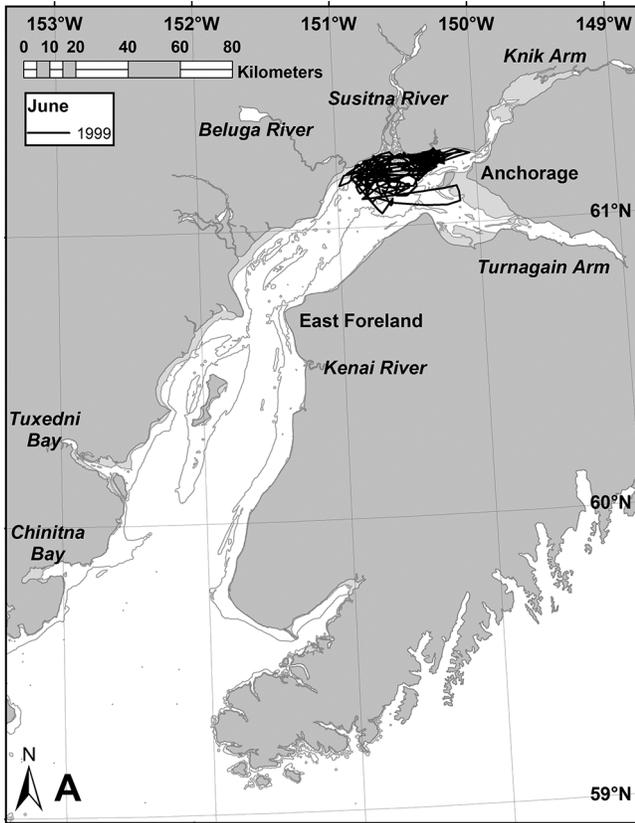


Figure 7.—Summer distribution of beluga whale satellite tag locations in Cook Inlet, Alaska, during: A. June 1999 ($n = 1$); B. July 1999 ($n = 1$) and 2002 ($n = 1$); and C. August 1999 ($n = 1$), 2001 ($n = 4$), and 2002 ($n = 5$). Tagged whales spent most of June and July in the Susitna Delta. See Appendix 3 for individual whale locations. Tidal mudflats (shaded areas) and the 10 m isobath are shown.

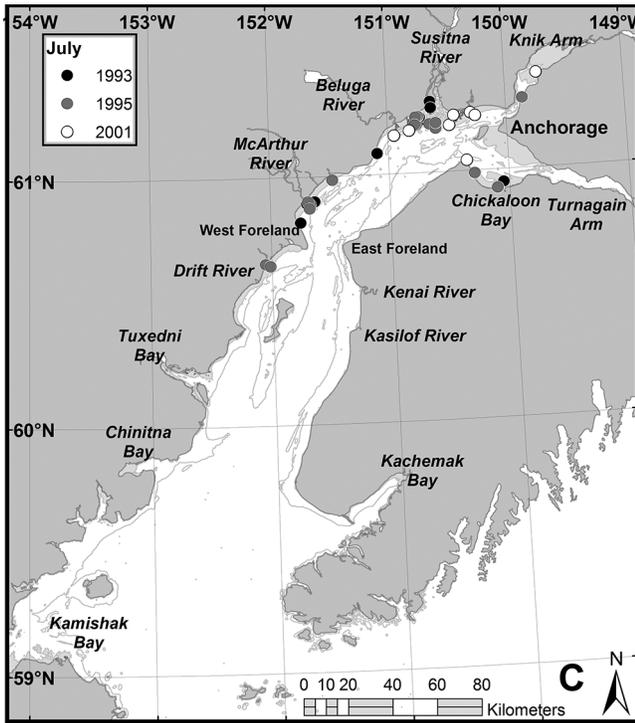
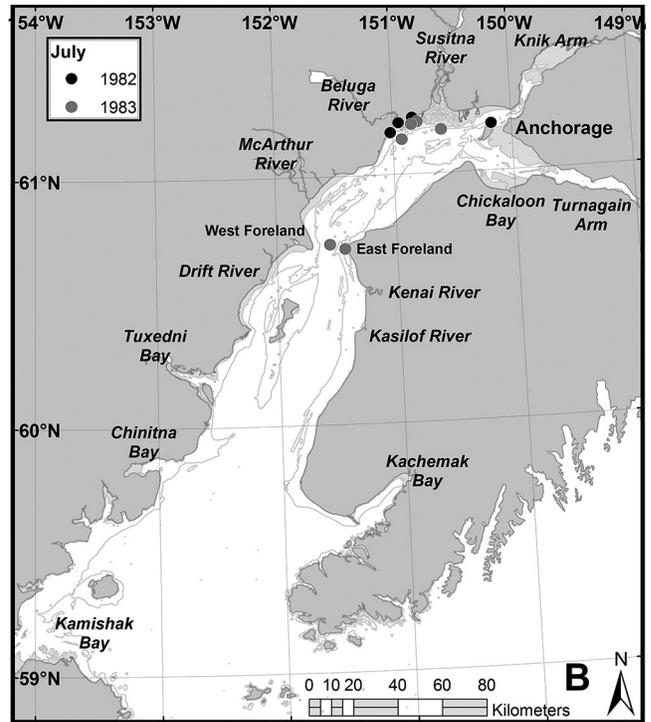
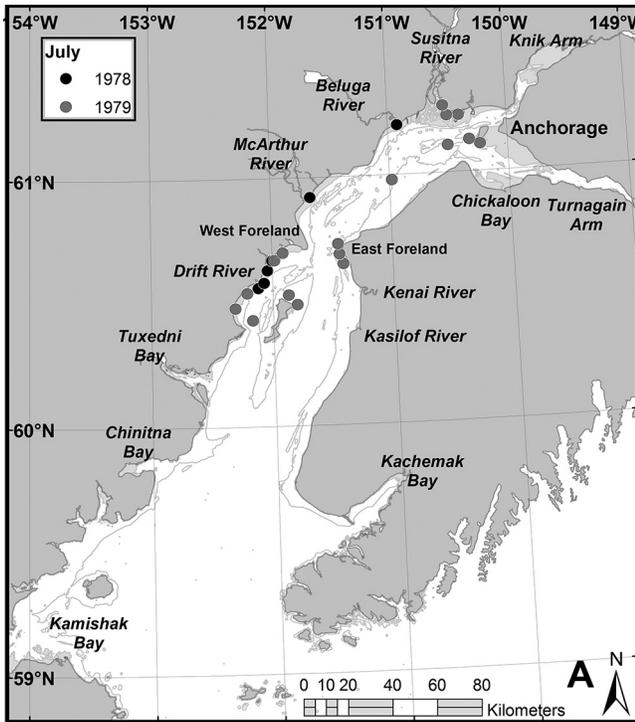


Figure 8.—Beluga whale group sighting locations during systematic aerial surveys of Cook Inlet, Alaska, in summer (July). Surveys were conducted by the Alaska Department of Fish and Game A. 1978–79, B. 1982–83, and C. National Marine Fisheries Service (1993, 1995, 2001). Tidal mudflats (shaded areas) and the 10 m isobath are shown.

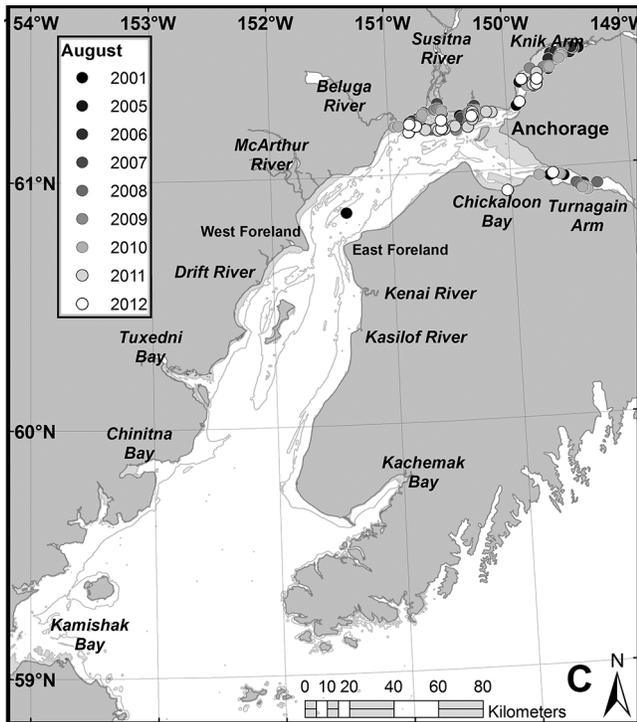
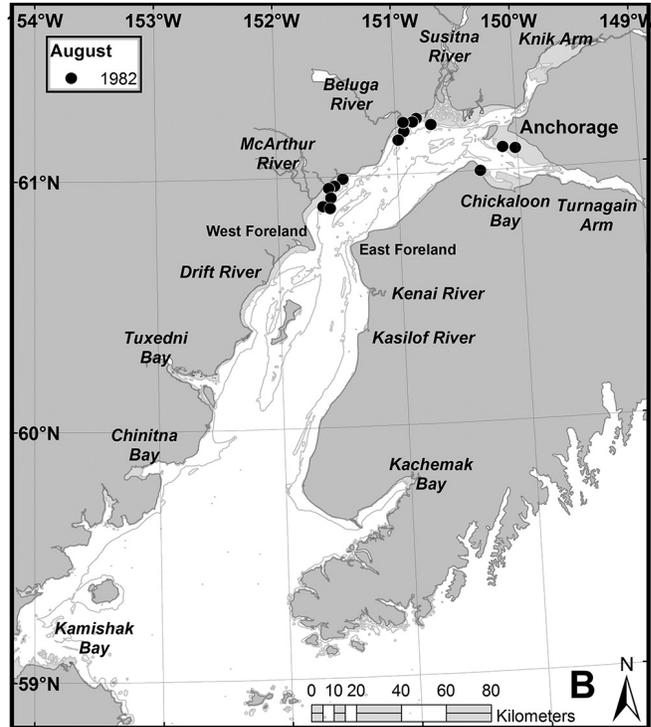
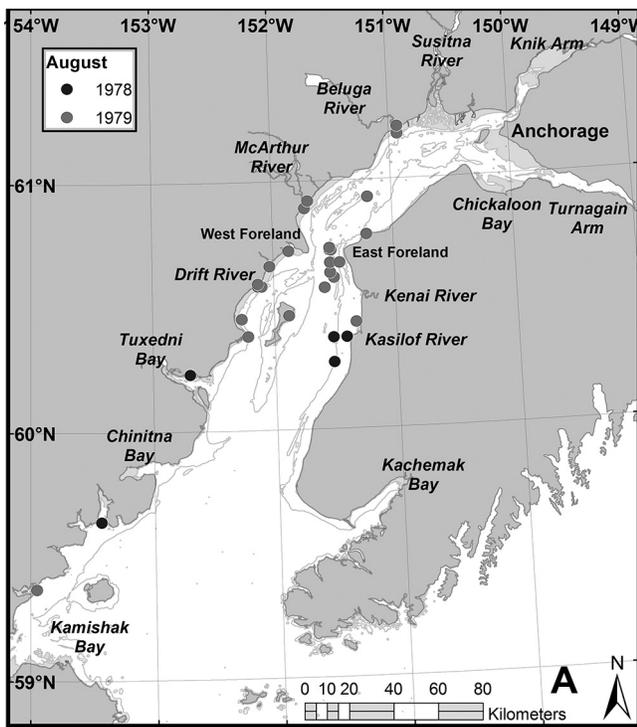


Figure 9.—Beluga whale groups observed during systematic aerial surveys of Cook Inlet, Alaska, in summer (August). Surveys were conducted by the Alaska Department of Fish and Game A. 1978–79, B. 1982, and C. National Marine Fisheries Service (2001, 2005–12). Tidal mudflats (shaded areas) and the 10 m isobath are shown.

July (Rugh et al., 2000) but also in August. Unlike the June surveys during the period 2008–12, whales were found in Knik Arm each August, often in large groups (average group size = 82, SD = 54) (Hobbs et al., 2015b).

Of the ten whales transmitting tag locations during August, only two ventured briefly south of East and West Foreland (Fig. 6c, Appendix 3). The whale tagged in 1999 remained in the upper inlet in August, primarily in Knik Arm and the Susitna Delta (Appendix 3). In 2001, most of the whales remained in the upper inlet, with the exception of one adult female who explored the waters south of West Foreland on 31 Aug. before returning to the upper inlet (Appendix 3).

In 2002, all whales transmitted locations during the month of August (Appendix 3). Similar to whales tagged in 2001, most remained in the upper inlet moving between the Susitna Delta, Knik Arm, and Turnagain Arm (Fig. 7c). One whale, the only adult female transmitting locations throughout the month, entered the lower inlet on 11 Aug. where she remained north of Kalgin Island for a day before returning to the upper inlet (Appendix 3). Tag transmissions overlapped with a number of opportunistic sightings in 1999, 2001, and 2002, and aerial survey effort in 2001 (Table 4).

Similar to July, opportunistic sightings in the lower inlet during August in the late 1970's included large groups of whales (Table 3). Since then reports of a single whale or small groups (3–13 whales) have been the norm.

Summer Discussion

Early summer had the greatest concentrations of whales in the upper inlet during all time periods. Shifts in distribution were evident in the 1970's and 1980's with large numbers of whales dispersing into lower inlet waters by mid- to late summer. This was not the case during the later survey periods when most of the Cook Inlet population continued to occupy the upper inlet well into late summer. The reduction of this population by half in the 1990's (Hobbs et al., 2015a) and the

northward contraction of range during this period (Rugh et al., 2010) suggest a consolidation of the population into a few preferred habitats.

Nearly half of the population occupied the Susitna Delta in early summer during all time periods (Rugh et al., 2010), and over 83% after 2007 when whales were no longer observed in Knik Arm. Whales returned to the Susitna Delta each year, and often remained in spite of extensive Native subsistence hunting in this region during the early 1990's (Mahoney and Sheldon, 2000). Goetz et al. (2012) modeled habitat preferences using the NMFS 1994–2008 abundance survey data. They found that in large areas, such as the Susitna Delta and Knik Arm, there was a high probability of beluga presence, and when present, group sizes were likely to be larger. Presence also increased closer to rivers with Chinook salmon, *Oncorhynchus tshawytscha*, runs (such as the Susitna River), and the Susitna Delta also supports two major spawning migrations of eulachon, *Thaleichthys pacificus*, a small, schooling smelt, in May and July. Stomachs from stranded belugas collected at the same time as the NMFS abundance surveys contained only Pacific salmon (Quakenbush et al., 2015).

It is not clear why belugas have not been seen in Knik Arm in June from 2008 to 2014. This change in distribution is not evident in the analyses presented by Rugh et al. (2010) or Goetz et al. (2012) because analyses ended with the June 2008 survey. Knik Arm was not abandoned for the entire summer, however, as large groups were observed here every August during the period 2008–12 (Hobbs et al., 2015b). Goetz et al. (2012) noted that anthropogenic disturbance, characterized as distance relative to coastal cities and oil development, was a significant predictor of beluga presence. Though presence increased with distance from these areas, the authors cautioned that many of the anthropogenic sources were south of the Susitna Delta, and that prey preferences rather than avoidance of development may

be a stronger driver for this predicted distribution.

Belugas appear to have stronger site fidelity during the early summer period, as evidenced by a single tagged whale and aerial survey records. The one whale tagged during the beginning of this season transmitted locations throughout the entire summer period, remaining in the Susitna Delta from late May to late July, before exploring Turnagain Arm in late July, and Knik Arm in August. While some of the whales tagged in late July and August moved throughout the upper inlet in August, others remained for long periods in a few locations such as Knik Arm, the Susitna Delta, and Turnagain Arm (Appendix 3).

Preliminary analyses of the dive data collected by the tags indicate whales made shorter, shallower dives during the period from June to November compared to the longer, deeper dives recorded during December to May (Goetz et al.¹⁸). Closer examination of the whale tagged in late May 1999 showed time at surface increased daily over a 2-week period from 31 May to 11 June (Hobbs et al., 2015a). This would be expected as belugas follow anadromous fish runs into shallow channels within the tidal flats of the Susitna Delta. Spending more time at the surface also increases the likelihood of aerial observers detecting these whales.

Near the end of August, two of the tagged whales spent brief periods in the lower inlet. In all three years, a few whales spent time in mid-inlet waters of the upper inlet in August (Fig. 7c). These behaviors may be representative of much larger groups of whales. Unfortunately, lower inlet and most mid-inlet tag locations did not coincide with aerial survey effort or opportunistic sightings. Nevertheless, by late summer some beluga whales begin to traverse into the lower inlet and mid-inlet waters of the upper inlet.

Fall

In the fall, day length shortens and anadromous fish runs come to an end. Survey effort was also much reduced

during the September–October–November period (Fig. 3, Fig. 10). The CIBW Opportunistic Database included 595 fall sightings during the period 1975–2014 (Table 3). Most opportunistic sightings were reported in September (63%) and decreased throughout the season. Thirteen tags transmitted locations of whales during the month of September, and eleven continued to transmit into November (Fig. 11).

September

ADFG did not survey Cook Inlet in September during the 1970's and 1980's (Fig. 3). NMFS surveys in 1993 (Withrow et al.³¹) included the coastline and mid-inlet waters of Cook Inlet north of the Drift and Kenai rivers. Belugas were encountered at the northern and southern limits of this survey—ranging from Turnagain Arm and Knik Arm to Kenai River and Drift River (Fig. 10a). The highest count, 197 whales on 3 Sept., included groups ranging in size from 5 to 59 whales (Withrow et al.³¹). Whale numbers dropped substantially during the 18–19 Sept. surveys (12 and 57 whales, respectively) when whales were found only in Knik Arm, Chickaloon Bay, and Turnagain Arm.

In 2001, NMFS conducted an aerial survey that included coastal and mid-inlet waters north of Harriet Point and Kasilof River (Rugh et al., 2004). On 15 Sept., a few belugas were seen near Beluga River (3 whales) and large groups were found in Knik Arm (113 whales) and Turnagain Arm (70 whales) (Fig. 10a). This count (186 whales) was in the middle of the range of daily counts (165–210 whales, average = 186) made in June that same year (Rugh et al., 2005).

A two day survey was conducted by NMFS in September 2008 with the objective of searching for beluga whales in lower Cook Inlet. Effort included 1) a coastal trackline down the western side of the inlet from the Little Susitna River to Cape Douglas, mid-inlet tracklines, and a coastal trackline along Kachemak Bay on 19 Sept.; and 2) a coastal trackline of the upper inlet

north of Point Possession and the Beluga River tidal flats on 20 Sept. (Shelden et al.³²). All whales observed (~66 total) were in the upper inlet in Knik Arm, Turnagain Arm, and Chickaloon Bay (Fig. 10a). This count also fell within the range of counts (58–126 whales) obtained in June 2008 (Shelden et al., 2013).

With the exception of one whale that spent time in the lower inlet in Chinitna Bay, tagged whales ($n = 12$) remained in the upper inlet during September (Fig. 11a, Appendix 3). Whales transmitting locations in 1999 and 2000 remained in the upper inlet north of North Foreland and Point Possession (Fig. 11a). One of the whales tagged in 2000 remained in Knik Arm during September. The other left Knik Arm on 15 Sept. and travelled to Turnagain Arm and Chickaloon Bay, similar to the whale tagged in 1999 (Appendix 3).

All of the whales tagged in 2001 transmitted locations in September (Appendix 3). Most (5 of 6) remained in the upper inlet while one female whale spent at least part of the month³⁴ in the lower inlet in Chinitna Bay (Fig. 11a). By September 2002, four of the six tagged whales, all males, were still transmitting locations (Fig. 11a). All remained in the upper inlet, but each would at times travel independent of the other tagged whales (to Turnagain Arm or Trading Bay) then rejoin one or more in the Susitna Delta or Knik Arm (Appendix 3). Tag transmissions overlapped with a number of opportunistic sightings in 1999, 2001, and 2002, and aerial survey effort in 2001 (Table 4).

CIBW opportunistic sightings began to increase in the lower inlet during September, though most reports were still occurring in the upper inlet (Table 3). With the exception of one sighting (6 whales) in 1975 in Kachemak Bay, all reports were from 1999 to 2011 and occurred in and near the Kasilof and Kenai rivers (32%), and Chinitna

(23%), Iliamna/ Iniskin/ Cottonwood (19%), Kamishak (7%), and Kachemak bays (16%).

October

In 1978, all beluga groups (75 whales total, Appendix 1) observed during aerial surveys were in the lower inlet (Fig. 10b). In 2001, NMFS flew mid-inlet transects on 12 Oct. in the upper inlet and in the lower inlet as far south as Harriet Point and Kasilof River; and on 15 Oct., a coastal survey of the upper inlet (Rugh et al., 2004). A small group of three whales was seen near the Little Susitna River during mid-inlet transects but most whales (162 total) were observed in Knik Arm during the coastline survey. Rugh et al. (2004) noted that similar to the September 2001 count, the October count of 162 whales was “well within the range of the daily counts in June...which meant that in October most of the whales were still in upper Cook Inlet” (p. 8).

On 22 Oct. 2008, NMFS flew an exploratory effort to look for belugas in Kamishak Bay similar to surveys in September of that same year (Shelden et al.³²). The shoreline survey from Cape Douglas to the Little Susitna River included effort in some parts of Kamishak Bay and from Chinitna Bay to Point MacKenzie. Unlike the ADFG surveys in the 1970's, no whales were found.

Only 2 of the 12 tagged whales travelled into the lower inlet during October (Fig. 11b). Both followed the western shoreline south to Redoubt Bay (in 2000 and 2002) but only the whale tagged in 2002 continued south to Chinitna Bay (Appendix 3). This whale travelled 6 days from West Foreland to Chinitna Bay, exploring Tuxedni Bay and Redoubt Bay twice before returning to the upper inlet 19 days later, and remained in Trading Bay until the end of the month (Appendix 3). Tag transmissions overlapped with opportunistic sightings in 2000 and 2001, and aerial survey effort in 2001 (Table 4). No CIBW opportunistic sightings were reported during October 2002.

³⁴The tag was duty cycled and transmitted locations from 1 to 16 September. When it resumed transmitting on 11 October, the whale had returned to Knik Arm.

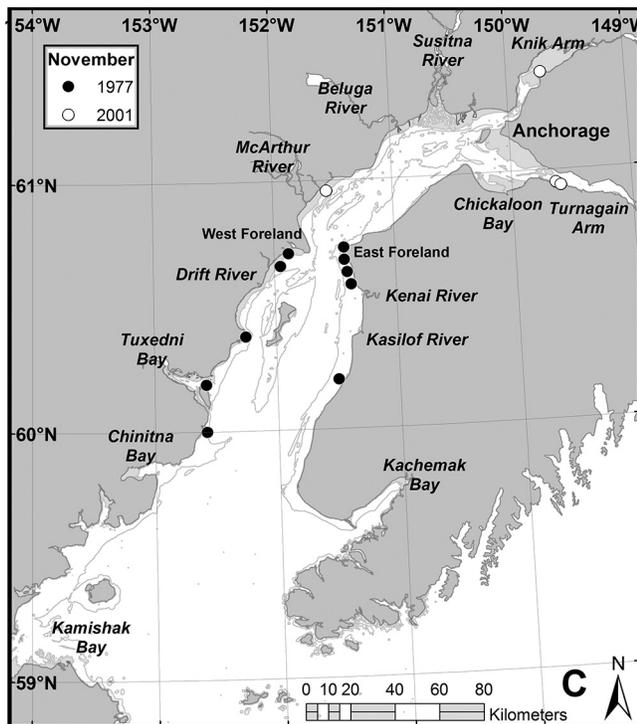
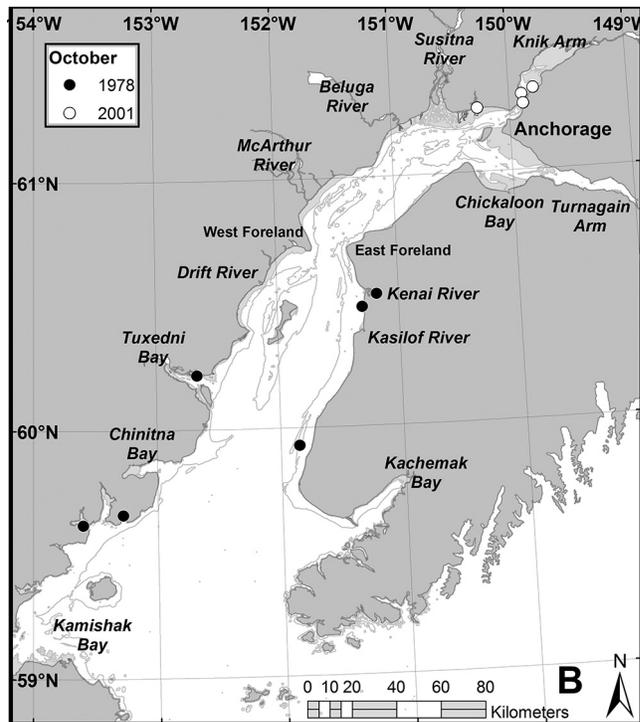
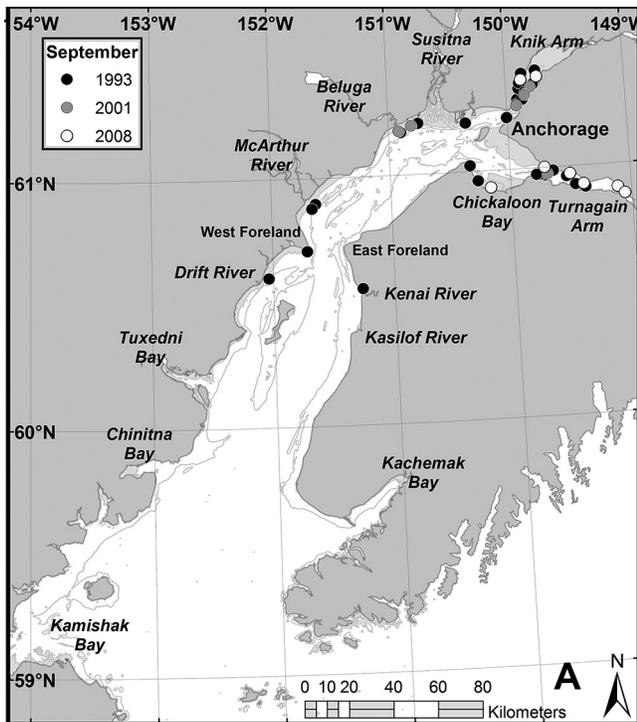


Figure 10.—Beluga whale group sighting locations during systematic aerial surveys of Cook Inlet, Alaska, in fall (A. September, B. October, and C. November). Surveys were conducted by the Alaska Department of Fish and Game (1977–78) and National Marine Fisheries Service (1993, 2001, 2008). Tidal mudflats (shaded areas) and the 10 m isobath are shown.

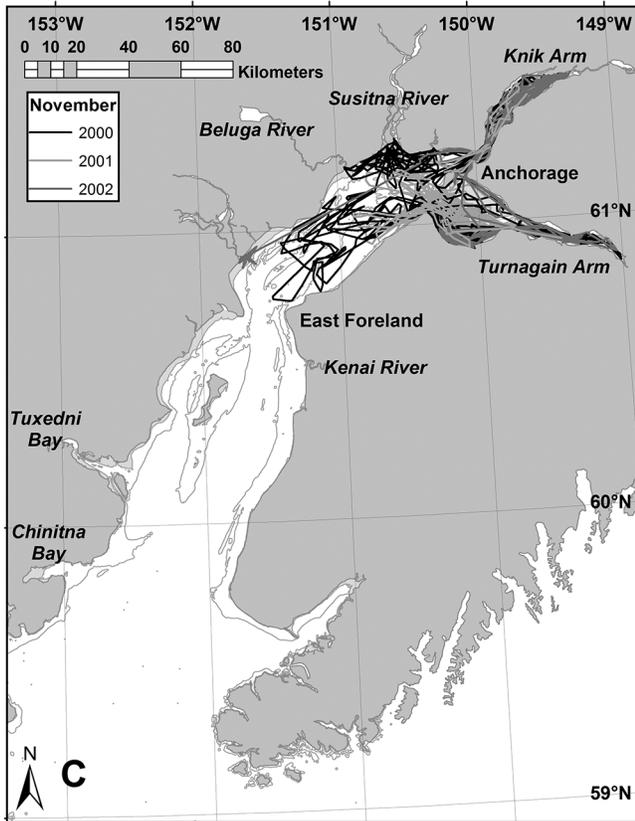
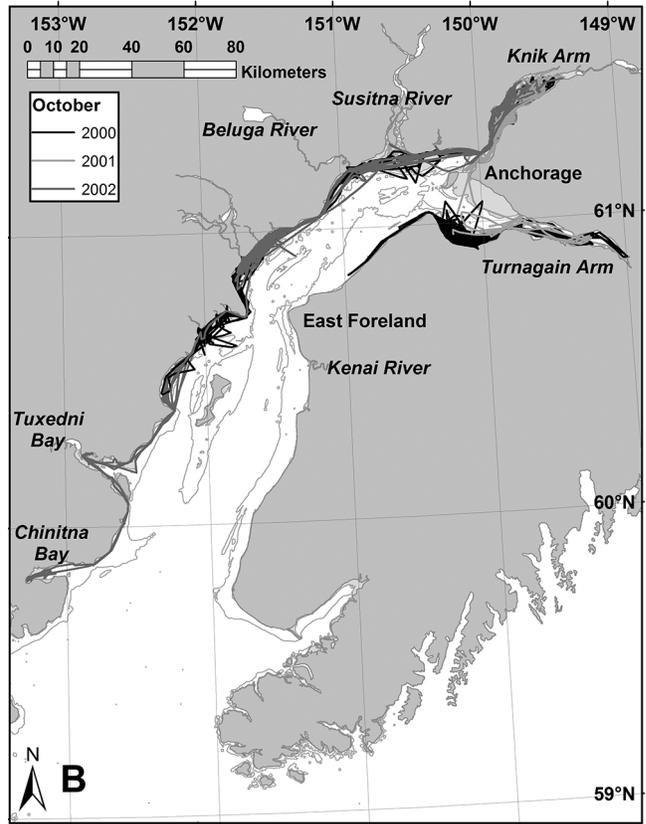
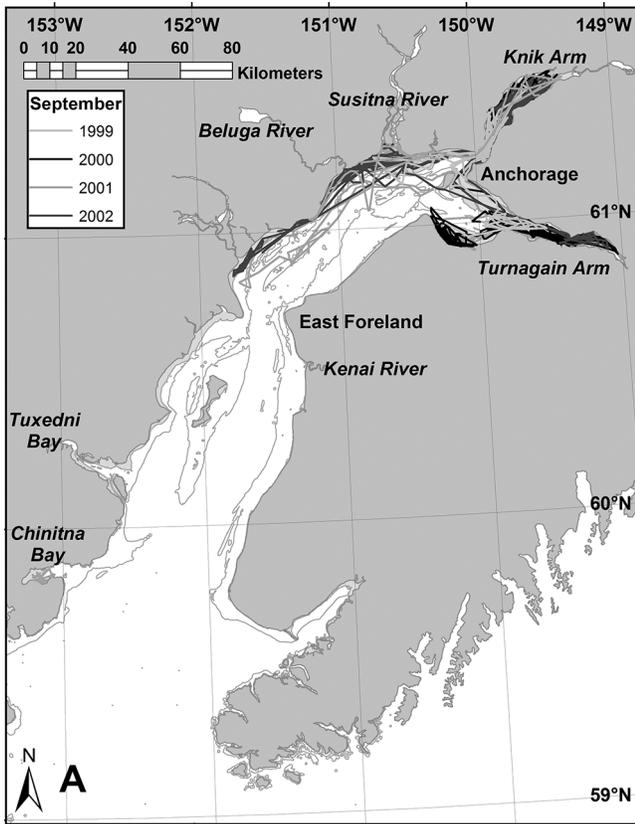


Figure 11.—Fall distribution of beluga whale satellite tag locations in Cook Inlet, Alaska, during: A. September 1999 ($n = 1$), 2000 ($n = 2$), 2001 ($n = 6$), and 2002 ($n = 4$); B. October 2000 ($n = 2$), 2001 ($n = 6$), and 2002 ($n = 4$); and C. November 2000 ($n = 2$), 2001 ($n = 6$), and 2002 ($n = 3$). See Appendix 3 for individual whale locations. Tidal mudflats (shaded areas) and the 10 m isobath are shown.

Overall, the number of CIBW opportunistic sightings began to decline from September to October in both upper and lower Cook Inlet (Table 3). With the exception of a single sighting in Kachemak Bay in 1976, all lower inlet sightings were during the period 1998 to 2010. Most were reported along the west side of the inlet (59%) in Redoubt, Tuxedni, Chinitna, Illiamna/Iniskin, and Kamishak bays. East side sightings were in or near Kenai River (36%). Upper inlet sightings were in areas occupied by whales during the summer months (Trading Bay (3%), Turnagain Arm (19%), Knik Arm (71%), Chickaloon Bay (4%), and the Susitna Delta (3%)) with almost all reported between 1999 and 2014 (two sightings occurred in Knik Arm in 1991).

November

Typically, ice begins to form in the upper inlet by November, and though there was no mention of ice during the one-day ADFG survey in 1977, and a note stated no whales were observed in upper Cook Inlet, all documented effort occurred in the lower inlet (Appendix 1). ADFG counted 41 whales³⁵ on 22 Nov. (Appendix 1) with 6 of the 10 sightings occurring south of East and West Foreland (Fig. 10c). By early November 2001, ice was present in Knik Arm, Turnagain Arm, Chickaloon Bay, and along the shore from Fire Island to Drift River during the NMFS survey (Rugh et al., 2004). Small numbers of whales were found in Turnagain Arm (3 and 6 whales), Knik Arm (14 whales), and Trading Bay (1 whale) on 9 Nov. (Fig. 10c).

All of the tagged whales transmitting locations in November ($n = 11$) remained in the upper inlet (Fig. 11c) and continued to travel within both Knik Arm and Turnagain Arm. One whale also explored deeper waters of the upper inlet, and another spent the first week of November in Trad-

³⁵Group sizes were not consistent between maps and table summaries: see Appendix 1 and Appendix 2, which are available in the online version of this article (doi: 10.7755/MFR.77.2.1).

ing Bay before returning to the Little Susitna River (Appendix 3). Tag transmissions overlapped with opportunistic sightings in 2000 and 2001, and aerial survey effort in 2001 (Table 4).

Similar to the systematic surveys, opportunistic sightings continued to decline from October to November (Table 3). Sightings occurred between 1999 and 2014, with the exception of one sighting at Kenai River in 1982 and one in Knik Arm in 1991. All CIBW opportunistic sightings in the lower inlet were in the Kenai River (63%), Kachemak Bay (25%), or Redoubt Bay (12%). Upper inlet sightings were in Knik Arm (93%), Turnagain Arm–Chickaloon Bay (3%), the Susitna Delta (2%), and Trading Bay (2%).

Fall Discussion

Some belugas move between the upper and lower inlet during the fall, as evidenced by one tagged whale during each year of the tagging study (Fig. 11a, b). NMFS surveys in 2001 continued to detect large numbers of whales in the upper inlet until November, when ice extent and concentration may have affected the ability of aerial observers to detect belugas. Dispersal of large numbers of whales into lower inlet waters in the fall was not evident in the later years of the NMFS surveys. Tagged whales still transmitting locations by the end of the fall had remained in or returned to the upper inlet (Fig. 11).

This differs markedly from surveys in the 1970's, when whales began to disperse into the lower inlet by mid-summer. Although sightings occurred in the lower inlet during fall surveys in the 1970's, counts were low (41–75 whales) compared to the summer. It is possible that smaller, dispersed groups were harder to detect. In the early 1990's, whale groups appeared to disperse by late September (Withrow et al.³¹), though we have only one survey in the fall during this time period and no opportunistic sightings. By 2001, the contraction of this population's range into the upper reaches of Cook

Inlet appeared to continue not only through the summer months but into the fall (Rugh et al., 2004; Shelden et al.³²).

Winter

The winter period covers the months from December through February. Winter survey efforts and sightings, both systematic (Fig. 3, Fig. 12) and opportunistic (Table 3), were few compared to other seasons, in part because of weather and short day length. Nine of the satellite tags continued to transmit location data at the beginning of the season (Table 2), though only four were still functioning in February (Fig. 13; Appendix 3).

December

December was the only month with no aerial survey effort (Fig. 3). Data from nine satellite tags showed whales in the upper inlet and areas just south of East and West Foreland (Fig. 13a, Appendix 3). Belugas inhabited shallow, nearshore areas as well as deeper, mid-inlet waters, primarily in the region north of East and West Foreland and south of Point Possession. Only whales transmitting locations in 2000 and 2002 entered Knik Arm and Turnagain Arm during December (Appendix 3).

The CIBW Opportunistic Database included 16 sightings for the month of December (Table 3), all during the period 1999–2014. With the exception of one sighting of two whales at Kenai River in 2002, all sightings were in the upper inlet. Group sizes, when provided, ranged from 1 to 30 whales. Only one opportunistic sighting, on 17 Dec. 2001, coincided with locations transmitted from tagged whales (Table 4).

January

In 1978, during a survey flight that followed the ice edge (Appendix 1), belugas were found in three groups (12, 50, and 30 whales) in ice-free water south of Kasilof River (Fig. 12). On a series of mid-inlet tracklines on 22 Jan. 2002, belugas were in five small groups (15 whales total, Fig. 12) in sea ice ranging from 10% to 30% cover-

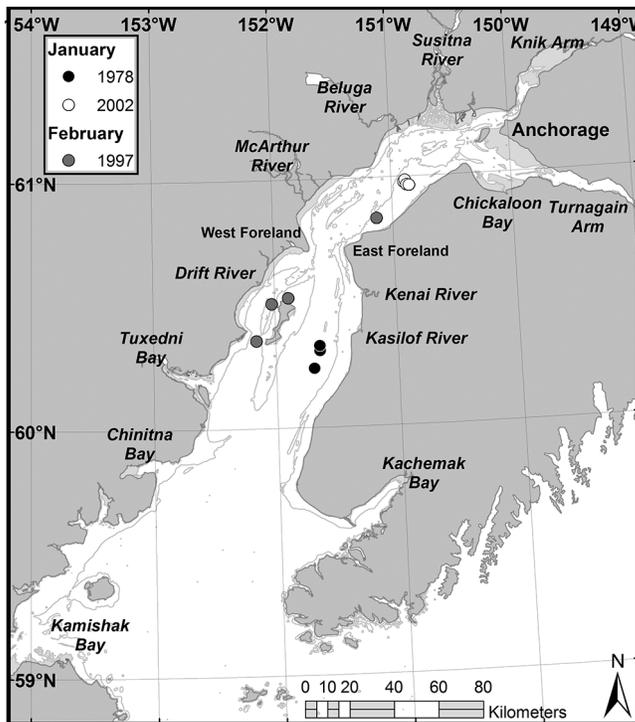


Figure 12.—Beluga whale group sighting locations during systematic aerial surveys of Cook Inlet, Alaska, in winter (January–February; surveys were not conducted in December). Surveys were conducted by the Alaska Department of Fish and Game (1978), Minerals Management Service (1997), and National Marine Fisheries Service (2002). Tidal mudflats (shaded areas) and the 10 m isobath are shown.

age (Rugh et al., 2004). None were found during the shoreline survey on 25 Jan. when “much of the area was ice-covered, making it difficult to find whales” (Rugh et al., 2004:9).

In January 2001, tagged whales remained south of the Susitna Delta (Fig. 13b, Appendix 3), never entering Knik Arm or Turnagain Arm where all CIBW opportunistic observations occurred. Tagged whales behaved similarly in January 2003. The three tagged whales travelled extensively between the Susitna Delta and East and West Foreland, often but not always together, crossing mid-inlet waters, and entering the lower inlet and returning to the upper inlet multiple times (Appendix 3). Only during January 2002 did a tagged whale spend any time in Knik Arm and Turnagain Arm (Appendix 3). Tag transmissions from

this whale overlapped spatially and temporally with aerial survey effort and opportunistic sightings during the period 18–25 Jan. (Table 4).

The CIBW Opportunistic Database included 17 sightings for the month of January, of which 13 occurred in the upper inlet (Table 3). Just over half of the upper inlet sightings were reported in Turnagain Arm, an area easily accessible by car. Average group size was 100–200 whales in the lower inlet during the 1980’s and 2000’s, and 3 to 15 whales, respectively, in the upper inlet during those same time periods (Table 3).

February

February surveys were flown by ADFG, MMS, and NMFS (Fig. 3). Belugas were not seen during ADFG surveys in 1979 (Appendix 1). Ice was

present throughout much of the inlet and snow storms prevented exploration south of Kachemak Bay on 25 Feb. In 1997, MMS observers saw belugas on 12 and 28 Feb. (Fig. 12, Table 1), but not on 15 Feb. despite thorough coastal coverage south to Chinitna Bay and Niniichik (Hansen and Hubbard¹⁷). Hansen and Hubbard¹⁷ reported that ice conditions near Kalgin Island ranged from 40% to 60% coverage in mid-February to open water by late February. The authors noted “the presence of extensive shorefast ice at the mouth of the Susitna River and other major streams made it difficult to see if whales were in these areas” (p. 13). Belugas were not seen during NMFS aerial surveys on 25–26 Feb. 2002 (Rugh et al., 2004). Ice covered much of the survey area, in the range of 70% to 100% coverage mid-inlet and in Knik Arm and Turnagain Arm, with areas of open water (50% coverage) just south of the Susitna River.

During February 2002, the last whale transmitting locations moved from Knik Arm into mid-inlet waters before entering the lower inlet (Fig. 13c, Appendix 3). Transmissions overlapped with areas surveyed by the aerial team (Table 4). Three whales tagged in 2002, all males, continued to transmit positions in February 2003 (Fig. 13c). One young male beluga frequented Turnagain Arm and joined another young male in Knik Arm (Appendix 3). The three whales moved throughout upper inlet waters before travelling south of East and West Foreland in mid-February (Appendix 3). Tag transmissions from two of these three whales were in the vicinity of an opportunistic sighting (Table 4).

No CIBW opportunistic sightings were reported in February during the 1970’s, 1980’s, or 1990’s (Table 3). Nine of the eleven CIBW opportunistic sightings reported in February between 2001 and 2014 were in the upper inlet in Trading Bay (56%), Turnagain Arm (22%), and Knik Arm near the Port of Anchorage (22%). Lower inlet sighting included 50 whales near Drift River in Redoubt Bay and a lone whale in the Kenai River (Table 3).

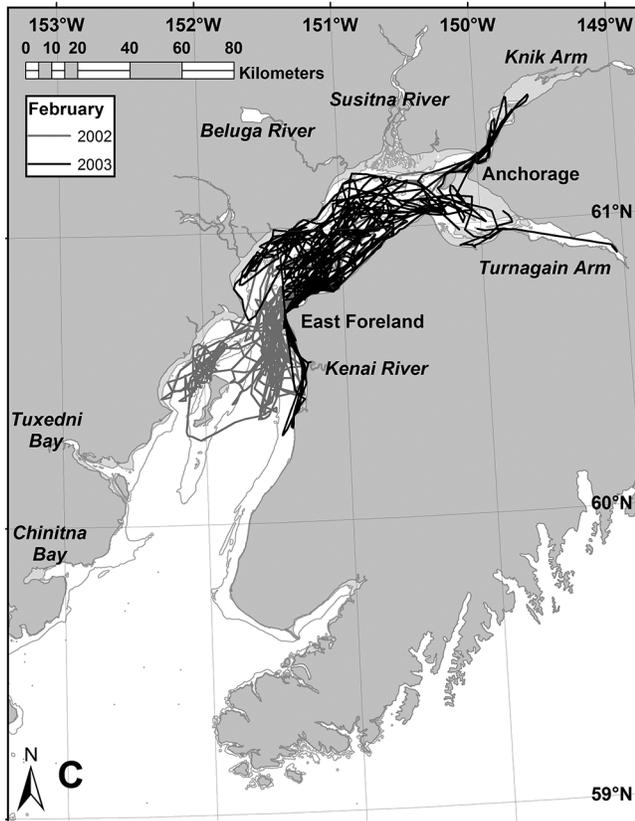
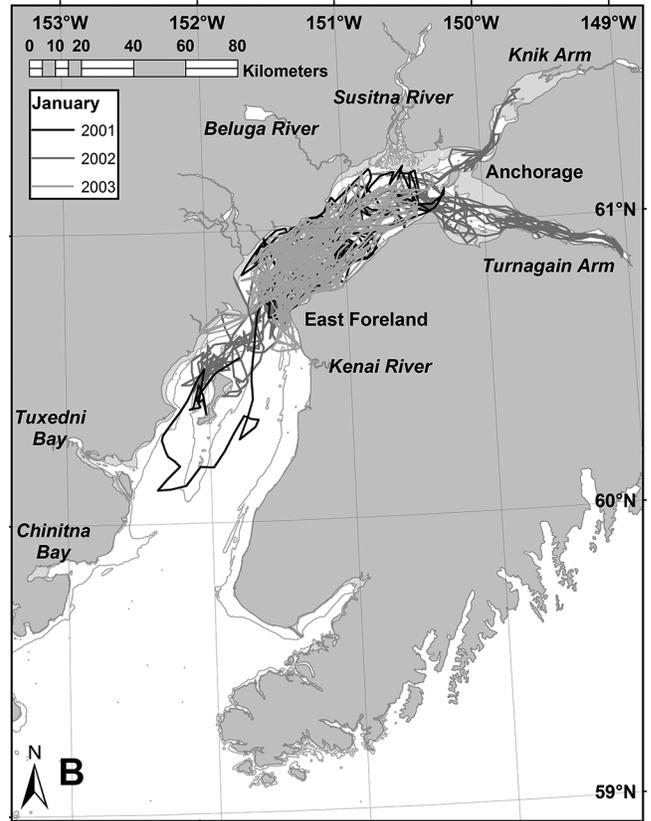
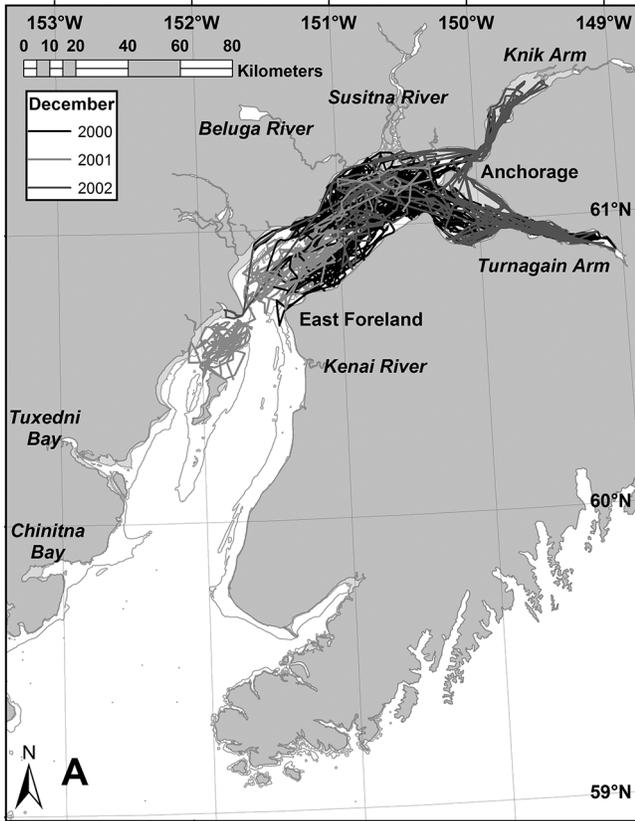


Figure 13.—Winter distribution of beluga whale satellite tag locations in Cook Inlet, Alaska, during: A. December 2000 ($n = 2$), 2001 ($n = 4$), and 2002 ($n = 3$); B. January 2001 ($n = 2$), 2002 ($n = 2$), and 2003 ($n = 3$); and C. February 2002 ($n = 1$) and 2003 ($n = 3$). See Appendix 3 for individual whale locations. Tidal mudflats (shaded areas) and the 10 m isobath are shown.

Winter Discussion

Winters in Cook Inlet are characterized by short day lengths and ice-covered waters. Despite the possibility of ice entrapment, CIBWs remained in upper inlet waters particularly during the later time period (Rugh et al., 2004; Hobbs et al., 2005; Goetz et al.¹⁸). Large tidal fluctuations create a dynamic ice environment such that whales were able to access the upper reaches of Knik Arm and Turnagain Arm during the winter period. Although whales transmitting locations in 2001 never entered these areas, opportunistic sightings confirmed whales were present.

Goetz et al.¹⁸ found that movements of tagged belugas were influenced by the presence of ice in Cook Inlet during the winter. After examining the biweekly proportion of ice type (ranging from very open pack to compact ice) throughout the inlet, from Dec. 2001–Mar. 2002 and Dec. 2002–Apr. 2003, total ice cover was always less than 50% for every 2-week period. When ice was present, belugas were most commonly found in open pack ice (winter of 2001–02) and very open pack ice (winter of 2002–03). During the winter of 2001–02, belugas ($n = 2$) preferred open water only 2% of the time when ice was present compared to 30% during the winter of 2002–03 ($n = 3$). On most occasions when belugas preferred open water, ice covered less than 10% of Cook Inlet.

In addition to this close association with ice, diving was another behavior that may have confounded detection during winter aerial surveys. Preliminary analyses of the tag data indicate whales were diving deeper and longer during the period December–May compared to the period June–November (Goetz et al.¹⁸). Average depth (m) and duration (minutes) increased almost three times, from 3.0 m (SD = 4.7) to 8.2 m (SD = 12.3) and 1.6 minutes (SD = 1.9) to 5.2 minutes (SD = 5.5) for the 11 whales equipped with ST-16 tags (Goetz et al.¹⁸:19).

The combination of poor sighting conditions (low light levels in win-

ter and white whales among ice floes) and whale behavior (close association with ice, longer, deeper diving patterns, and smaller groups) made it difficult to ground truth or even detect groups during this season. This was most evident during the NMFS survey that overlapped with tagged whale locations and detected whales in January but not in February. Combining satellite-tagging with real-time acoustic monitoring and aerial ground truthing may be the best option for quantifying habitat use patterns and visual detectability during winter.

Spring

During spring (Mar.–Apr.–May), ice is still present in Cook Inlet. By March, ice cover has reached its maximum extent and begins to recede and melt through March and April. Spring survey efforts and sighting reports, both systematic (Fig. 3, Fig. 14) and opportunistic (Table 3), increased throughout the season. Four tags continued to transmit whale locations at the beginning of the season (Fig. 15), though by May, as aerial survey effort increased, only one tag continued to function (in 2003). Tagging of an adult male beluga in 1999 occurred on the last day of May (Table 2, Appendix 3).

March

Belugas were found on both aerial survey days in 1978 and one of the two survey days in 1979 (Appendix 1). The number of whales counted in 1978 ranged from 43 (5 sightings) on 1 Mar. to 146 (17 sightings) on 2 Mar., compared to the lone group of 11 whales seen mid-inlet in 1979 (Fig. 14a). Ice appeared to be more prevalent in the inlet in 1979; maps showed ice along the shore in the lower inlet and near Kalgin Island in mid-March, vs. 1978 when the northernmost areas of the upper inlet had large expanses of open water by early March.

The survey area was ice free during the 1997 aerial surveys (Hansen and Hubbard¹⁷). Sighting locations, number of sightings, and group sizes were similar to those observed during the MMS February surveys (Fig. 14a,

Table 1). NMFS did not fly surveys in March 2002, however, it was noted during the April survey that ice still covered much of the upper inlet (Rugh et al., 2004).

The last tag transmitting in 2002 stopped on 9 Mar.; at the time, the male beluga was in the lower inlet in waters north and west of Kalgin Island (Fig. 15a, Appendix 3). Similar to behaviors observed during the winter months, the three male whales transmitting locations in 2003 continued to travel extensively in mid-inlet waters north of East and West Foreland (Fig. 15a, Appendix 3).

All CIBW opportunistic sightings in the lower inlet (Table 3) were between Ninilchik and the Kenai River. None of the opportunistic sightings in the upper or lower inlet overlapped with tagged whale locations. Most upper inlet sightings were reported in Turnagain Arm (29%) and Knik Arm (62%), with lone sightings in Trading Bay (1 whale) and near Tyonek (22 whales).

April

The 1978 aerial surveys occurred in the lower inlet (Appendix 1), while the 1983 surveys were restricted to the upper inlet north of North Foreland and Moose Point (Appendix 2). In 1978, beluga whales were found in roughly five groups (about 56 whales total³⁵) in bays along the west side of the lower inlet (Fig. 14b). Four groups were observed on each survey day in 1983 (6 Apr.: $n = 10$ whales; 28 Apr.: $n = 38$ whales³⁵) (Fig. 14b). In contrast to the ADFG surveys, ice covered much of the upper inlet during NMFS surveys conducted 2–3 Apr. 2002 (Rugh et al., 2004). Two groups (8 and 10 whales) were found on mid-inlet transects on 2 Apr., while none were found during the coastal surveys on 3 Apr., despite fair to excellent viewing conditions.

By April 2003, only two whales were transmitting locations. One tag stopped transmitting near the Susitna River on 1 Apr. (Appendix 3). Hobbs et al. (2005) did not analyze tag data collected after March, as only one whale continued to transmit locations

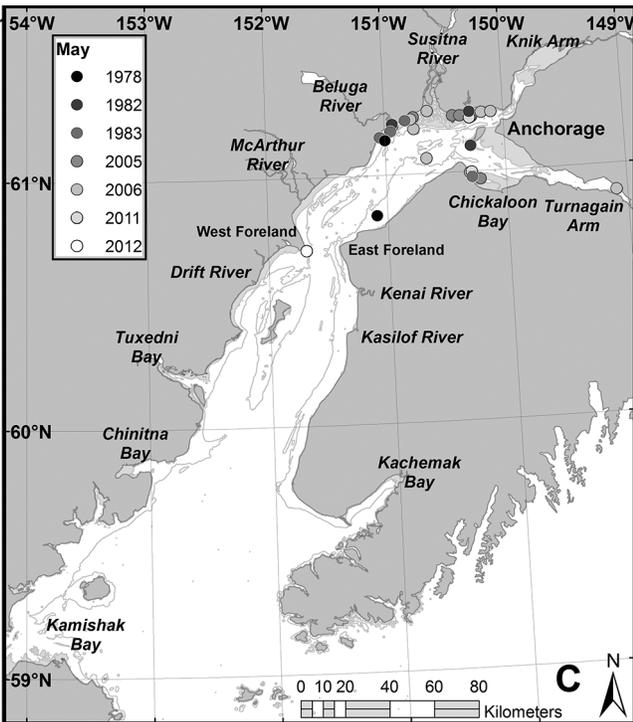
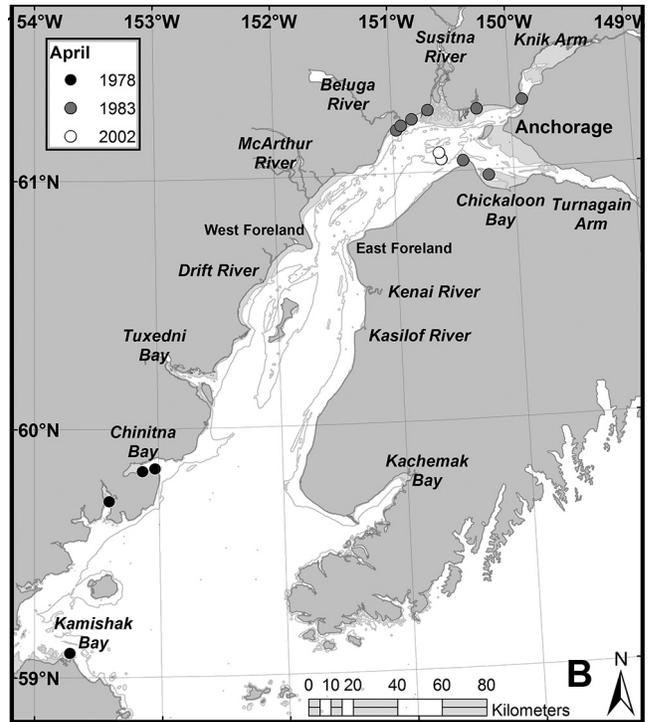
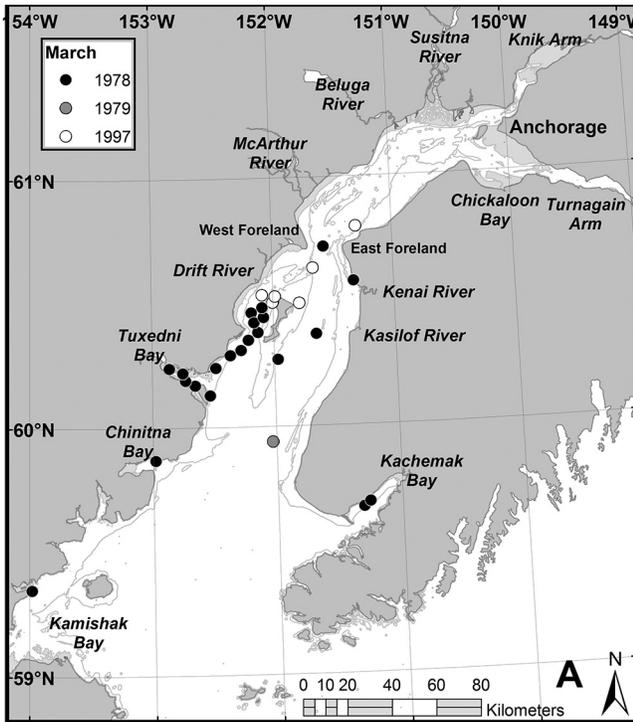


Figure 14.—Beluga whale group sighting locations during systematic aerial surveys of Cook Inlet, Alaska, in spring (A. March, B. April, and C. May). Surveys were conducted by the Alaska Department of Fish and Game (1978–79, 1982–83), Minerals Management Service (1997), and National Marine Fisheries Service (2002–12).

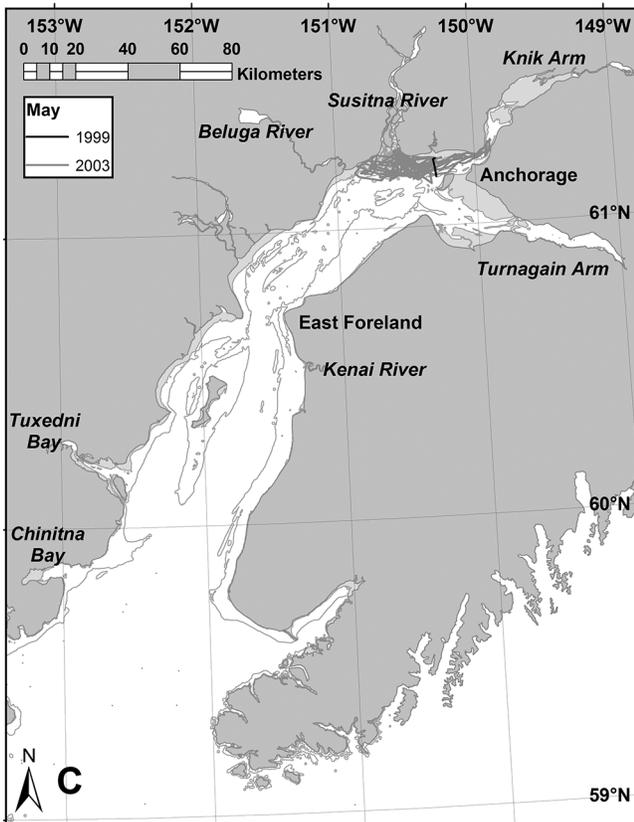
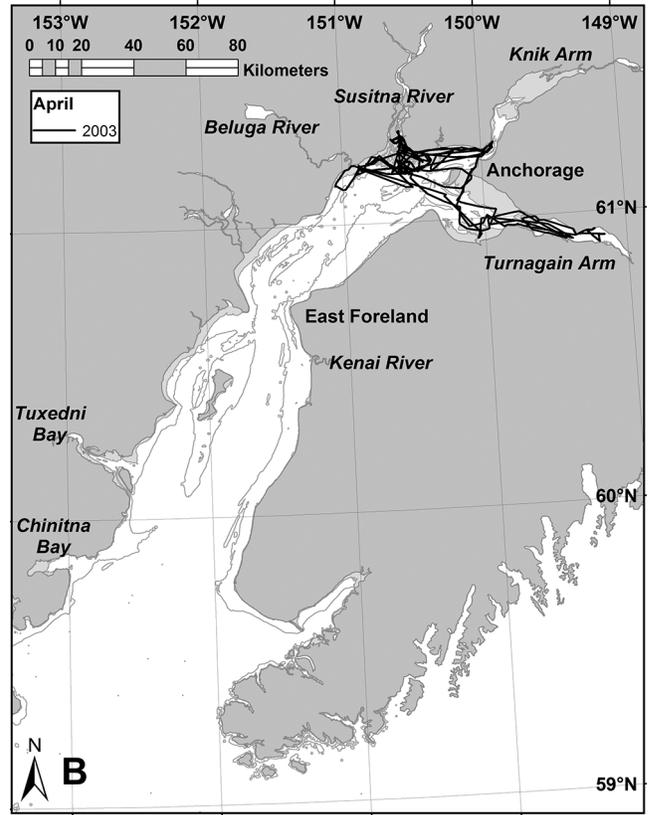
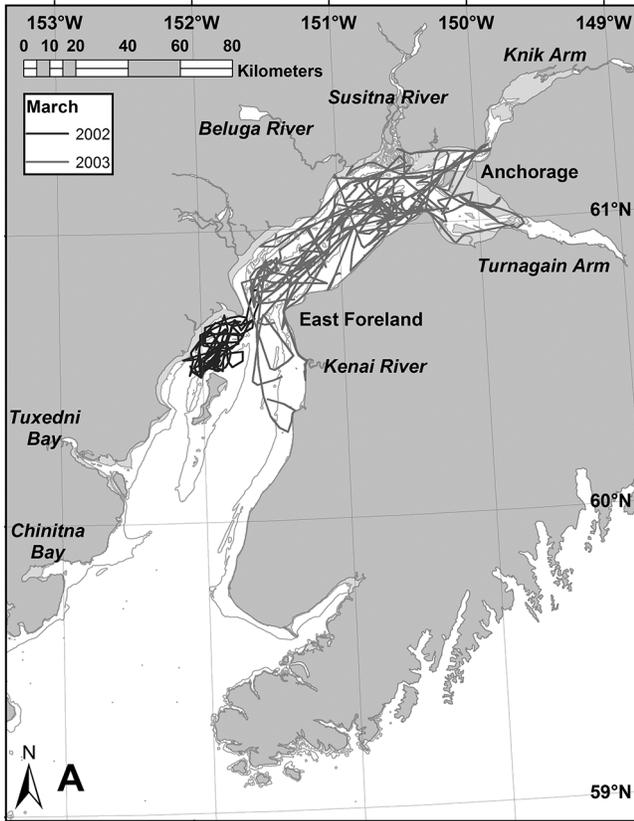


Figure 15.—Spring distribution of beluga whale satellite tag locations in Cook Inlet, Alaska, during: A. March 2002 ($n = 1$) and 2003 ($n = 3$); B. April 2003 ($n = 2$); and C. May 1999 ($n = 1$) and 2003 ($n = 1$). See Appendix 3 for individual whale locations. Tidal mudflats (shaded areas) and the 10 m isobath are shown.

through April and most of May. That whale remained in the upper inlet for the entire month, travelling between Knik Arm, Turnagain Arm, and the Susitna Delta (Fig. 15b, Appendix 3).

CIBW opportunistic sightings increased substantially from March to April (Table 3), though none coincided with aerial survey effort or tag transmissions. Lower inlet sightings prior to 2000 (Table 3, $n = 14$), with the exception of one sighting in the Kenai River, were on the west side of the inlet in or near Illiamna/Iniskin (57%) or Kamishak (36%) bays. Since then, all opportunistic sightings have been reported in or just north of the Kasilof ($n = 4$) and Kenai rivers ($n = 32$), or in Redoubt Bay ($n = 1$). In the upper inlet, sightings were reported during all time periods with groups ranging from 1 to 25 whales. Most sightings occurred in the Susitna Delta (27%), Turnagain Arm/Chickaloon Bay (37%), and Knik Arm (30%), with a few in Trading Bay (5%) and near East Foreland (1%).

May

Aerial surveys occurred in May during 7 of the 25 aerial survey years (Fig. 3, Fig. 14c), in part, because NMFS abundance surveys began near the end of May before continuing into June (which is also reflected in the low number of effort hours during May: Fig. 3). In 1978, ADFG found only two groups (20 and 7 whales) in the upper inlet on 22 May (Appendix 1), while upper inlet surveys in the early 1980's documented large numbers of belugas north of Threemile Creek and Moose Point (Appendix 2). Three groups were seen each year with counts ranging from 45 (17 May 1982) to 262 whales (27 May 1983).

In 2005, the NMFS abundance survey began on the last day of May (Shelden et al., 2013). Belugas were found in Chickaloon Bay (37 whales) and in the Susitna Delta near the Ivan River (229 whales) and the Little Susitna River (7 whales) during a survey that included coastal waters north of the Kenai River and West Foreland (Shelden et al., 2013). In contrast, a

NMFS survey of the upper inlet conducted in early May 2006 (Rugh et al.²²) found only small numbers of whales: four sightings (18 whales total) on 2 May and six sightings (25 whales total) on 3 May (Fig. 14c). Broken ice was present in the Susitna River in early May 2006 (Rugh et al.²²), but had melted away by the time the NMFS abundance survey began on 6 June (Shelden et al., 2013), and 296 whales (11 groups) were found in the upper inlet that day.

Similar to 2005, the abundance surveys in 2011 and 2012 included days at the end of May (Shelden et al., 2013). Two groups of belugas were found during the upper inlet survey on 31 May 2011: in Chickaloon Bay (57 whales) and the mouth of the Little Susitna River (200 whales) (Fig. 14c). Three days of lower inlet surveys occurred in May during the 2012 survey (Shelden et al., 2013). About seven belugas were found near West Foreland headed toward Trading Bay on 31 May (Fig. 14c). Whales were seen in Trading Bay on subsequent survey days (see Summer section and Fig. 5e).

On the last day of May in 1999, NMFS tagged a beluga whale near the Little Susitna River (Fig. 15c). This whale remained in the Susitna Delta until the end of July (see Summer section). In 2003, locations from the last remaining tag show the whale travelled back and forth between the Beluga River and Knik Arm before transmissions ended on 25 May (Fig. 15c, Appendix 3). Tag transmissions coincided with one CIBW opportunistic sighting on 31 May 1999 (Table 4).

CIBW opportunistic sightings increased in the upper inlet and declined in the lower inlet from April to May (Table 3). Lower inlet sightings prior to 2000 ($n = 2$) were in Kachemak or Iniskin bays, while the remaining opportunistic reports occurred in the Kenai River almost annually since 2007.

Spring Discussion

Similar to winter, the year-to-year variability in ice extent and concentration appeared to affect the ability of aerial observers to detect beluga

whales during the spring. In spring, when the ice breakup begins, whales gather together as they regain access to river mouths. In early spring, whales continued to move throughout mid-inlet waters. Not until late spring and early summer, when anadromous fish return to natal streams, did whale behaviors shift to longer surfacing periods and shallower diving patterns (Hobbs et al., 2015a; Goetz et al.¹⁸). Group sizes tended to be smaller in spring, until the end of May when whales began to coalesce into larger groups at the river mouths. Most aerial survey and opportunistic sightings, and all tag locations, were in the upper inlet by May.

Conclusions

Cook Inlet is a complex and dynamic environment, covered in ice part of the year and opaque waters year-round that confound detection of beluga whales. This review of the tremendous amount of survey effort undertaken thus far shows how little we still know outside of the open water season and early summer period. Based on available information from aerial surveys, tagged whales, and opportunistic sightings, these whales show a preference for waters in the upper portion of Cook Inlet, and when the population declined (Hobbs et al., 2015a), the distribution of animals became more concentrated in the northern region (Rugh et al., 2010). Although belugas do inhabit mid-inlet waters and bays in the lower inlet, sightings south of East and West Foreland have been relatively rare in the past two decades. This contraction in range was observed not only during the summer months (Rugh et al., 2000; 2010) but also into the fall during the later period of this seasonal study (Rugh et al., 2004; Shelden et al.³²). There has also been a shift away from Knik Arm in early June, observed since 2008, but this area was not abandoned entirely as whales were observed there in August. It is unknown if this contracted distribution is a result of changing habitat (Moore et al., 2000; Norman et al., 2015), prey concentration, or predator avoidance

(Shelden et al., 2003), or if it could be explained as the contraction of a reduced population into a small number of preferred habitat areas (Rugh et al., 2010; Goetz et al., 2007, 2012).

Remaining in the upper inlet exposes beluga whales to potential natural and anthropogenic threats such as ice entrapment, stranding, vessel traffic, coastal development projects, dredging, and increased proximity to urban runoff and waste from the largest city in Alaska, Anchorage (Norman et al., 2015). Contraction of the population into the upper inlet, not only during early summer (Rugh et al. 2010) but also throughout the year, may increase vulnerability to catastrophic events and localized group mortality events (Hobbs et al., 2015c). Live strandings are not uncommon for this population, when they become trapped on the upper inlet mudflats on the ebbing tide. And although the whales refloat and swim off on the incoming tide, prolonged stranding could compromise survival (Vos and Shelden, 2005; Burek-Huntington et al., 2015).

Habitat associations during the early summer period have been studied, and note “beluga presence was negatively associated with sources of anthropogenic disturbance and positively associated with fish availability and access to tidal flats and sandy substrate” (Goetz et al., 2012). These predicted habitats varied depending on whale group size, where larger groups were more closely tied to tidal flats and high flow rivers (a proxy for suitable habitat for anadromous fish). Distributions predicted in Goetz et al. (2012) were similar to those observed during the late 1970’s, possibly indicating that as this population recovers it may reoccupy these areas.

Based on our review, additional studies are needed to better quantify habitat use patterns during seasons other than early summer. Acoustic monitoring studies are underway in Cook Inlet, attempting to detect whales year-round (Castellote et al., 2011). However, these studies depend on animals vocalizing to determine presence. Combining satellite-tagging

with real-time acoustic monitoring and aerial ground truthing may be the best option for quantifying habitat use patterns and visual detectability particularly during ice-covered seasons.

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- _____, _____, K. T. Goetz, C. L. Sims, L. Vate Brattström, J. A. Mocklin, B. A. Mahoney, B. K. Smith, and R. C. Hobbs. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-263, 122 p.
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Appendix 1.—Field Note Summaries from Beluga Whale Aerial Surveys conducted by the Alaska Department of Fish and Game, November 1977–August 1979 (Map descriptions and field reports (when available) were transcribed by K.E.W. Sheldon, notes about these data are italicized, original texts are shown in quotes). Results of some of these surveys were reported in Murray (text footnote 6), Murray and Fay (text footnote 7), and Calkins (text footnotes 8, 9, and 10).

November 22, 1977:

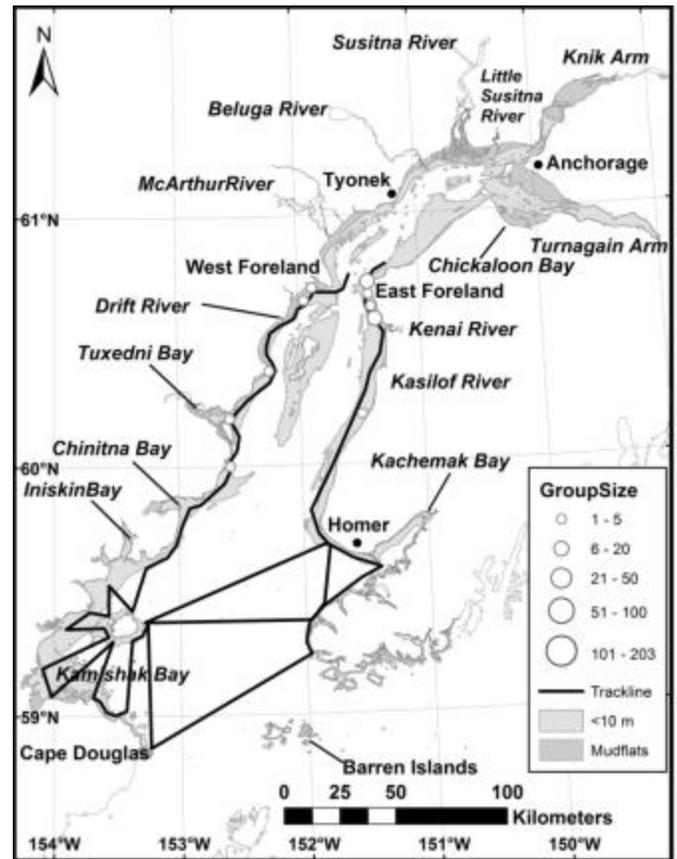
Transcriber’s note: *This survey included two maps with different handwriting and no field notes. The observer was not identified on the first map but the handwriting appeared to be Don Calkins based on other maps/field notes. The first map, which only shows the lower inlet south of East and West Foreland, was labeled:*

“Nov 22, 1977 Locations of observations of 42 Belukha whales in Lower Cook Inlet 8:30-1500 AST [none obs. in U.C.I.]”

This map shows 10 sightings (41 belugas total – not 42 as written in the map label). Locations are summarized in the table below. Although there is mention of no sightings in upper Cook Inlet in the map label, the map did not show this part of the inlet.

Location	Group size
Redoubt Bay, between West Foreland and Drift River	1, 2
Harriet Point	1
Chisik Island, NE tip	1
Between Tuxedni and Oil bays	2
Between Kasilof River and Anchor Point	1
Between Kenai River and East Foreland	18 (2 calves), 4 (1 calf), 1, 10

A composite map (the second map mentioned above) shows the entire inlet, the trackline and sightings, with handwriting that appears to be Nancy Murray (based on other maps/field notes). This map identifies Don Calkins as the observer: “11/22/77: Cook Inlet Aerial Survey: Don Calkins”



November 22, 1977

January 11, 1978:

Transcriber's note: *This survey included two maps and field notes. The original survey map and field notes do not identify the observer but the handwriting appeared to be Don Calkins. The map is labeled:*

"Belukha Survey Jan. 11, 1978, ice edge ---, outbound, inbound, number of belukhas sighted 92, total sighted 92."

This map shows three sightings (92 belugas total = 12+50+30) in open water south of Kasilof River (recreated here). Ice edge is also hand drawn on the map. The field notes stated:

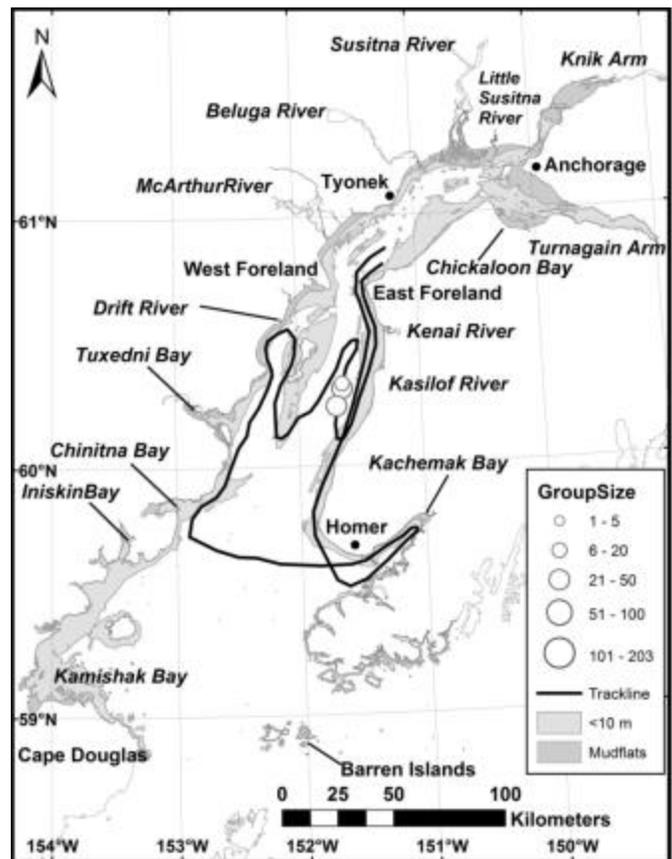
"Belukha survey Jan. 11, 1978

All belukhas sighted were probably within one large pod. They were within 1 to 2 Km of each other although the three different numbers shown are actually 3 different locations. Many gray animals were sighted in all three groups. All animals sighted were headed in a northerly direction. No belukhas were sighted in any other location survey of the inlet."

A composite map showing the entire inlet, recreating the trackline, ice edge, and sightings, was also included with handwriting that appeared to be Nancy Murray.

This map identifies Don Calkins as the observer:

"1/11/78: Cook Inlet Belukha Aerial Survey: Don Calkins"



January 11, 1978

March 1, 1978:

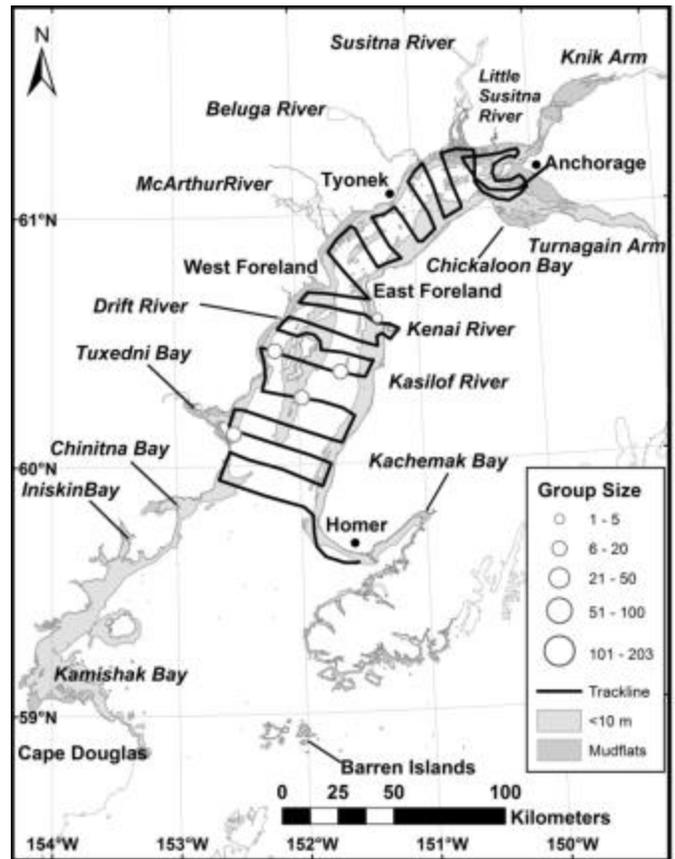
Transcriber's note: *This survey included three maps and field notes. The original survey maps and field notes do not identify the observer but the handwriting appeared to be Don Calkins. Maps are labeled:*

"Belukha Survey Cook Inlet 3/1/78 Upper Inlet No Belukhas sighted north of east and west foreland" and "Belukha Survey 3/1/78 continued from upper inlet (no Belukhas sighted north of east and west foreland)"

The lower inlet map shows 5 sightings (43 belugas total = 1 (adult) + 6 (adults/juveniles) + 20 + 9 (adults/juveniles) + 7 (adults)). The field notes stated:

"Belukha survey 3/1/78 – departed Anch. 1:20 P. Some ice in upper inlet. Lots of open water – appeared to be sufficient open water for belukhas none sighted north of East and West forelands. 36 total sighted in Kalgin Island, Kenai area, 7 sighted just off Chisik Island. All belukhas sighted were in or near water <10 fm weather clear some breeze from N to NE at probably 10-15 kts by late afternoon – breeze, incoming tide plus sun glare made conditions fair. Survey completed at 5 mi intervals from Anchorage to Anchor Point and Slope Mt."

A composite map showing the entire inlet, recreating the trackline and sightings (ice is not shown on any of the maps though it was described in the field notes), was also included with handwriting that appeared to be Nancy Murray. This map identifies Don Calkins as the observer: "3/1/78: Cook Inlet Belukha Aerial Survey: Don Calkins"



March 1, 1978

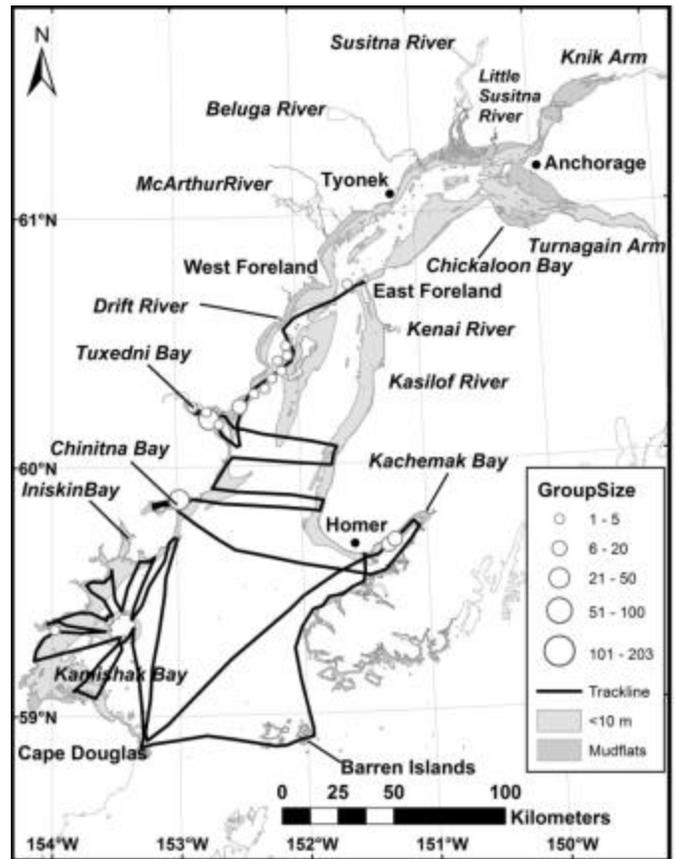
March 2, 1978:

Transcriber's note: *This survey included two maps and field notes. The original survey map and field notes do not identify the observer but the handwriting appeared to be Don Calkins. Map is labeled: "Belukha Survey 3/2/78"*

Field notes stated:

"Survey started at 8:50am from Homer. Weather clear and calm. Winds 15-20 kts between Kenai Pen. and Barren I. Seas to 3 ft. Calm in Kamishak Bay and calmed down to small chop in rest of inlet for rest of day. Total belukhas sighted 146. Many subadults (gray) as well as white adults. Most singles sighted were white adults. Most animals appeared to be in or very near shallow <10 m water. Group of 20 in Kachemak Bay was composed of 14 white, 6 grays. Group of eight (7+1) near Chisik I. outside Tuxedni Bay was 5 white 3 gray."

A composite map showing the entire inlet, recreating the trackline and sightings, was also included with handwriting that appears to be Nancy Murray. This map identifies Don Calkins as the observer: "3/2/78: Cook Inlet Belukha Aerial Survey: Don Calkins".



March 2, 1978

The following was on a separate sheet of paper:

"Karl, I had planned a pattern about the same as this. Transects approx. 5 mi. apart – flown at about 300-400 ft. alt. Nancy Murray will arr. in Homer at 9:35 am Apr. 8th on AAI. If you complete the survey before then she can go along on the beach surveys. Don Calkins"

Additional maps show a series of offshore transects with latitudes and longitudes noted at endpoints, crossing the mid-Inlet from the Forelands to Ninilchik then circling Kalgin Island and resuming coastal survey at West Foreland headed south with a spoke pattern of tracklines off Augustine Island. These appeared to be proposed tracklines.

April 7, 1978:

Transcriber's note: *On 7, 9, and 10 April 1978, ADFG conducted three surveys in lower Cook Inlet. The 7 April survey did not include field notes and the handwriting on the two maps did not match Don Calkins or Nancy Murray – possibly the "Karl" referred to in the March 2, 1978 note. Part of the text is cut off on the photocopy. One map shows the trackline flown in Kachemak Bay, the second shows where sea otters were seen. The maps are labeled:*

"4/7/78 1400-1540 Belukha survey – helicopter, visibility very good east of Homer spit, fair west of spit, tide – high, stating to ebb. Belukhas sighted = 0.", and "Sea otter sightings 4/7/78. Entire south shore of Kachemak Bay covered from Fox R. to Hesketh I. except Sadie Cove by skiff & much of it by helicopter."

This second map shows four sightings of sea otters (8 + 3 + 4 + 1 = 16 otters).

April 9, 1978:

Transcriber's note: *Field notes were not provided for this survey which included five maps showing enlargements of portions of the western shoreline from Tuxedni Bay to Cape Douglas. The observer was not identified but the handwriting appeared to be Don Calkins. The first map shows trackline from Tuxedni Bay to Ursus Cove with sea otters in Tuxedni Bay (n = 1) and Chinitna Bay (n = 1) labeled: "Sea otters sighted on Belukha survey 4/9/78. Vis – fair. Cloudy and choppy in AM, sunny and light breeze in PM." The second map shows trackline from Ursus Cove to Augustine Island with an otter in Ursus Cove: "Sea otters sighted on Belukha survey 4/9/78." The third map shows beluga sightings in Chinitna Bay and Iniskin Bay with trackline from Tuxedni Bay to Ursus Cove, simply identified as: "Survey 4/9/78." Only this map shows the composition of the beluga groups: Chinitna Bay (21 including 4 gray moving into the bay + an additional 4 gray juveniles in the bay), and Iniskin Bay (23-30 (total given as 27 + 2 gray)). The fourth map has no label and shows the spoke pattern surveyed in Kamishak Bay with 2 belugas seen near Akumwaruk Bay, and harbor seals (2 near Ruby Cove) and sea otter*

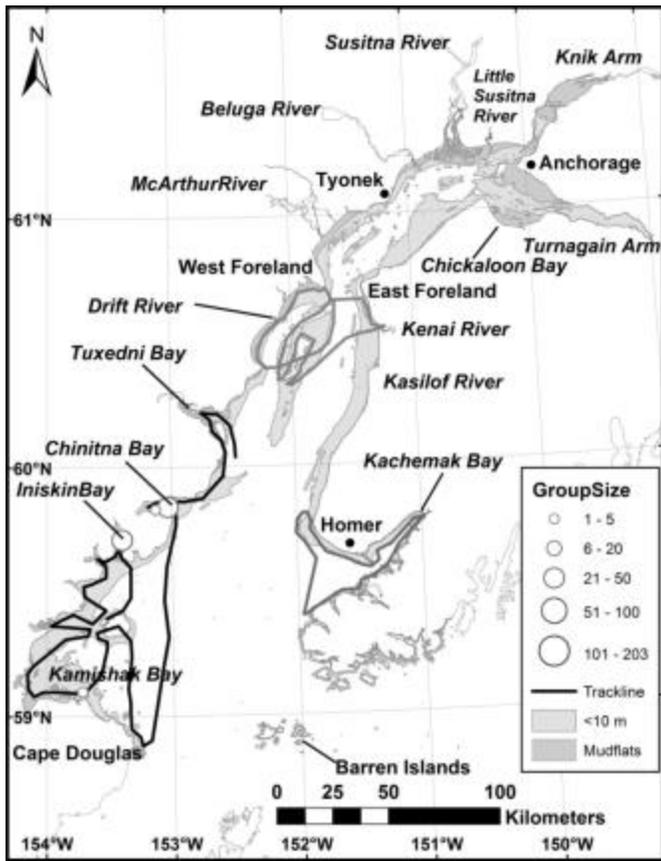
sightings along line headed from Augustine Island to Cape Douglas (4 sightings, 5 animals). The fifth map with Calkins handwriting shows the entire lower inlet and all beluga sightings (though the Akumwaruk Bay sighting is now where the offshore track heads to Augustine Island), labeled: "Belukha Survey 4/9/78."

A composite map showing both the April 7 and April 9 surveys included tracklines and the beluga group totals (with the Akumwaruk Bay sighting closer to the spot where the aircraft turned offshore to fly back to Augustine Island). Handwriting on this map appeared to be Nancy Murray and identifies Don Calkins as the observer:

*"4/7/78: Cook Inlet Belukha Aerial Survey: Surveyor Helo: Kachemak Bay Don Calkins
4/9/78: Kamishak to Tuxedni Bay: (name is cut off on the photocopy but appears to be Don Calkins) & N. Murray"*

April 10, 1978:

Transcriber's note: *Field notes were not provided for this survey which included a map of the middle inlet showing Kalgin Island. The map is labeled: "Belukha Survey 4/10/78" with handwriting that appeared to be Don Calkins. No composite map by Nancy Murray. The survey track headed north from Kenai to Nikiski, crossing the inlet to an exposed sandbar then crossing Kalgin Island to Harriet Point. The survey route followed Redoubt Bay shoreline to East Foreland going offshore to exposed mudflat then following the mud south to the southern tip of Kalgin Island. The route continued clockwise around Kalgin Island before crossing inlet and landing back in Kenai. No sightings reported.*



April 7 (Kachemak Bay survey), April 9 (western shoreline survey), and April 10 (Kenai survey), 1978

May 22, 1978:

Transcriber's note: *Field notes were not provided for this survey which included a map labeled: "5/22/78: Cook Inlet Belukha Survey: D. Calkins, ADF&G & N. Murray." Handwriting appeared to be Nancy Murray. Map shows beluga groups off Beluga River (20 with 2-3 grey) and between Moose Point and East Foreland (7), and two large circles labeled "porpoise" one south of Tuxedni Bay, and the other south of Chinitna Bay.*



May 22, 1978

June 18, 1978:

Transcriber's note: *This survey included comprehensive field notes and a map labeled:*

"6/18/78: Cook Inlet Belukha Survey: N. Murray & K. Bunch (pilot)", which included a legend showing beluga, harbor seal and harbor porpoise sightings. The field notes stated:

"6/18/78

Cook Inlet Aerial Survey: Anchorage. Nancy Murray.

Ken Bunch met me in his Widgeon at the Air Taxi Terminal at Anchorage International Airport at 0915. We took off from Anchorage at 0930 under rainy, windy weather conditions. (Tide was low in the upper Inlet).

The survey route and marine mammal sightings are on the following page. At 1045 we encountered a "mother" with large grey subadult just west of the Susitna. At 1050 we encountered a group of ~20 white adults heading toward the mouth of the Susitna. At 1055 we sighted an adult and grey subadult and then another 9 adults. Then very near shore we saw 2 more adults. All of these whales were heading south.

At 1105 in Trading Bay we began sightings whales again. First there were 2 adults, then a group of 12 adults, then a large group of ~25 adults (this could have been considerably more), and then 5 adults. Again all of these whales were heading south.

At 1130 I sighted 2 adults just around the first turn up the Kenai River. (They appeared to be just milling around (feeding?)).

At 1155 about mid way between Clam Gulch and Niniichik we saw a group of ~25 white adults heading south in the midst of the crab pot buoys.

On landing at Homer at 1225 for fuel, we discovered that the rear tire of the Widgeon had gone flat. While waiting for Ken to fix the tire and take on fuel, I talked with Jack at Homer Air who says that he's seen groups of ~15 belukhas around September and October at the head of Kachemak Bay.

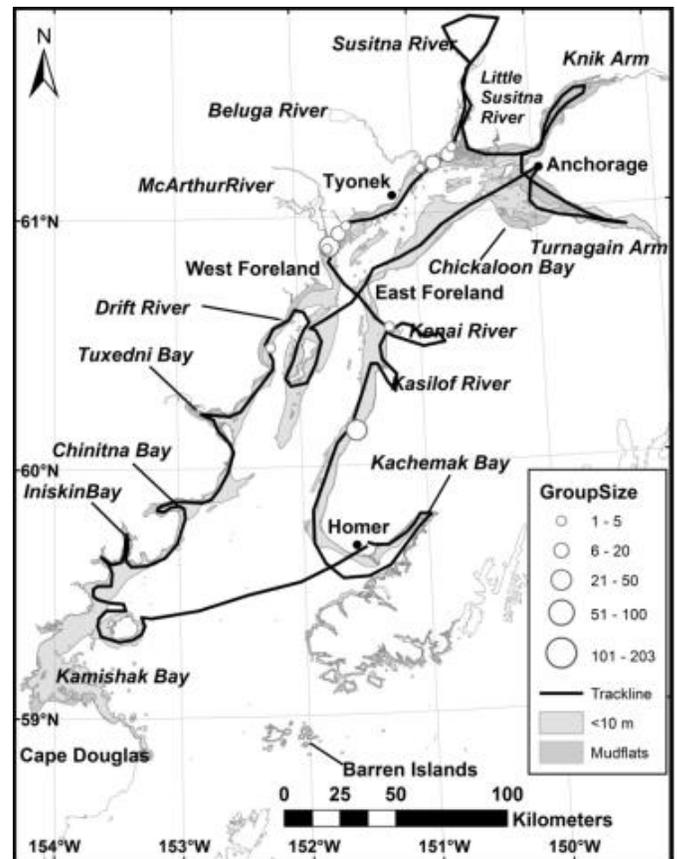
We took off from Homer at 1400. At 1435 I sighted a harbor seal off Augustine and another one at 1445. At about 1540 I saw 1 harbor porpoise swimming in a southerly direction just south of Chisik Island.

In future surveys when we fly south of Tuxedni in the bays, every effort should be made to get food aerial photos of any belukhas encountered. The water there seems ideal for this.

At 1605 I sighted a tightly packed group of 3 white adult belukhas just around the point into Redoubt Bay. These whales were heading south west toward shore.

We landed at Anchorage Airport at 1710 after seeing a minimum total of 109 belukhas.

After our initial poor weather conditions, from the Susitna River on we had good to excellent sighting conditions. Since we encountered few (only 2) grey subadults and have seen many more on previous occasions, I am puzzled by their absence. I almost fell out of Ken's plane trying to look for small calves – but I couldn't see a one. Are they not yet born or, if born, where in these waters are they hiding? The mystery remains."



June 18, 1978

July 19, 1978:

Transcriber's note: *Two surveys were conducted by ADFG in July 1978. The 19 July survey included comprehensive field notes and a map labeled: "7/19/78: Cook Inlet Belukha Survey: N. Murray & K. Bunch (pilot)". The field notes stated:*

"7/19/78

Cook Inlet Aerial Survey: Nancy Murray, Ken Bunch, Merrill Field, Anchorage.

Ken and I took off in the widgeon at 0920 from Merrill Field in rainy, windy weather. Sighting conditions were not good in Turnagain Arm or the open waters of mid Cook Inlet. All other locations including bays and shorelines provided good to excellent sighting conditions. The flight path and locations and numbers of belukha groups seen are illustrated on the following page. Heavy rain and low clouds forced us to head toward Homer from just north of Tuxedni Bay. We were able to pick up this area in the afternoon.

The first group of belukhas was encountered off the Beluga River just south of two fishing boats. The whales were difficult to count since they were in scattered small groups heading in various directions. The group consisted of about 50-60 whales. There were several (8-10) very large white animals, and about 12 small grey animals about ¼ - ⅓ the length of the larger white "females" they swam alongside. These small animals were very dark slate grey, darker than any juveniles I've seen so far. I can't help but think that these are recently born calves which have been born since the June 18th flight. This large group was probably feeding.

The next group of 42 whales seen in Trading Bay were definitely feeding. This group contained 10-15 small dark grey animals. All but 7 of these whales in this group were very close to shore. Being in very shallow water, several of the whales could be seen lying at the surface dipping forward as if to pick a fish off the bottom. Other whales made quick sprints, dove, and then slowed after returning to the surface. Either a portion of the whale or its "footprint" could be continually observed.

Four more groups of whales were observed in Redoubt Bay off the Big and Drift Rivers. From north to

south these groups consisted of 6, 1, 18, and 1 animal respectively. All whales were white adults except for 4 small grey animals in the group of 18. Again the whales were close in to the shoreline with random directional headings and appeared to be feeding.

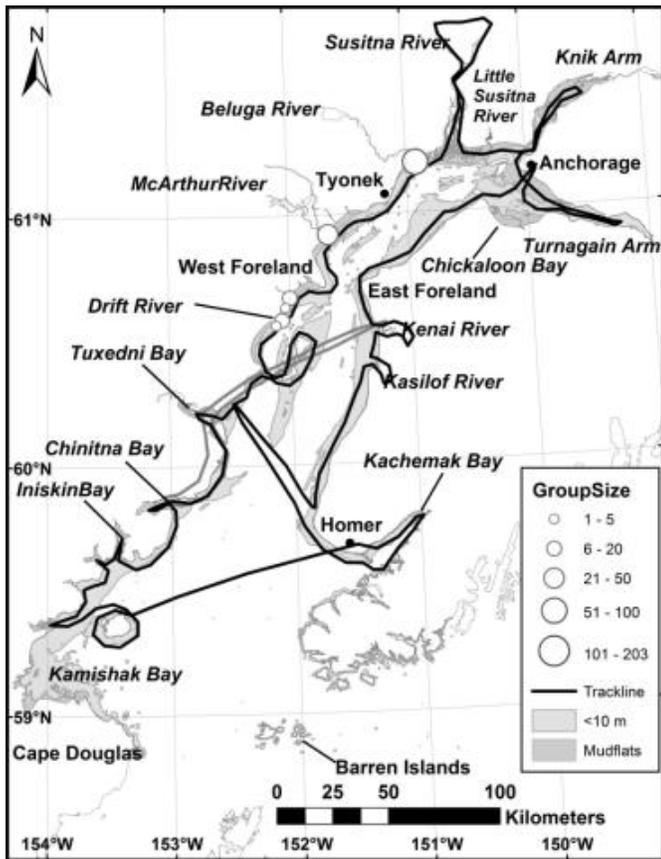
We landed at Homer at 1230 hours and took off from there after refueling at 1315 hours. I saw 3 harbor seals in the cove off the southwest corner of Augustine Island. We saw 3 bears along the shoreline of Iniskin Bay. No further belukhas were sighted.

The whales we sighted on this survey were in very similar areas to last month. I was surprised that we saw no whales off Kalgin Island or on the eastern shoreline where the red salmon are running now.

We saw a total of 118-128 belukhas on this survey."

July 24, 1978:

Transcriber's note: *The 24 July survey did not include field notes and the handwriting on the map was difficult to read: "7/24/78 Belukha Skull & Information Flight: N. Murray & Bud L*geted** [last name illegible] (pilot) Note: No belukhas were sighted." The trackline ran from Kenai across the inlet to Tuxedni Bay then down the coast to Chinitna Bay before crossing land back to Tuxedni Bay then crossing the inlet back to Kenai – unable to decipher notes along the trackline.*



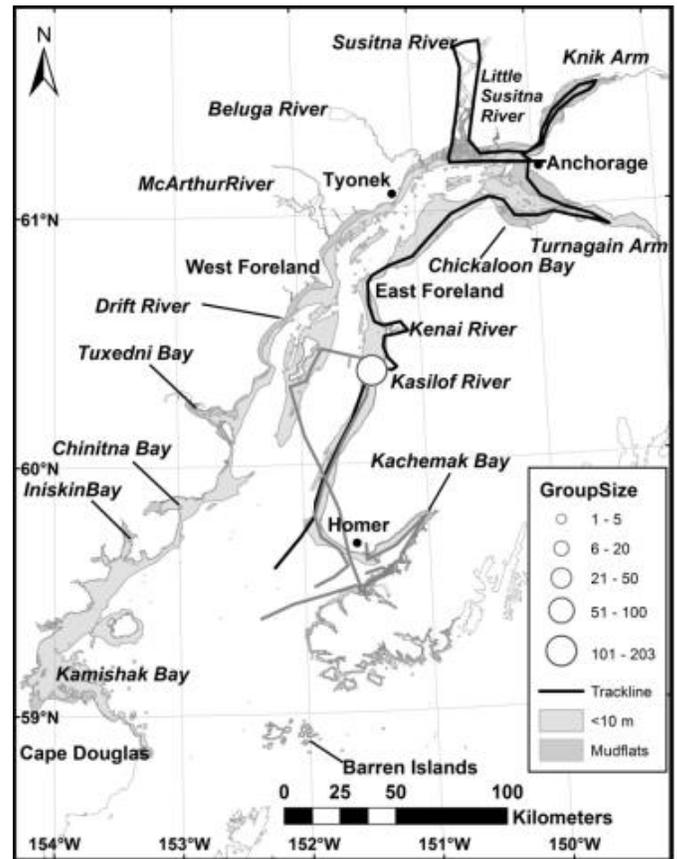
July 19 (black trackline) and July 24 (gray trackline), 1978

August 14-18, 1978:

Transcriber's note: ADFG conducted multiple surveys in August, however, field notes were not included with the five maps. Each map was labeled with the date of the survey and the following: "Cook Inlet Belukha Aerial Survey: Surveyor: Helo, N. Murray & R. Dietrickson." Some results were reported in Murray (1979) [text footnote 6] and Murray and Fay (1979) [text footnote 7] and are summarized after the map descriptions below.

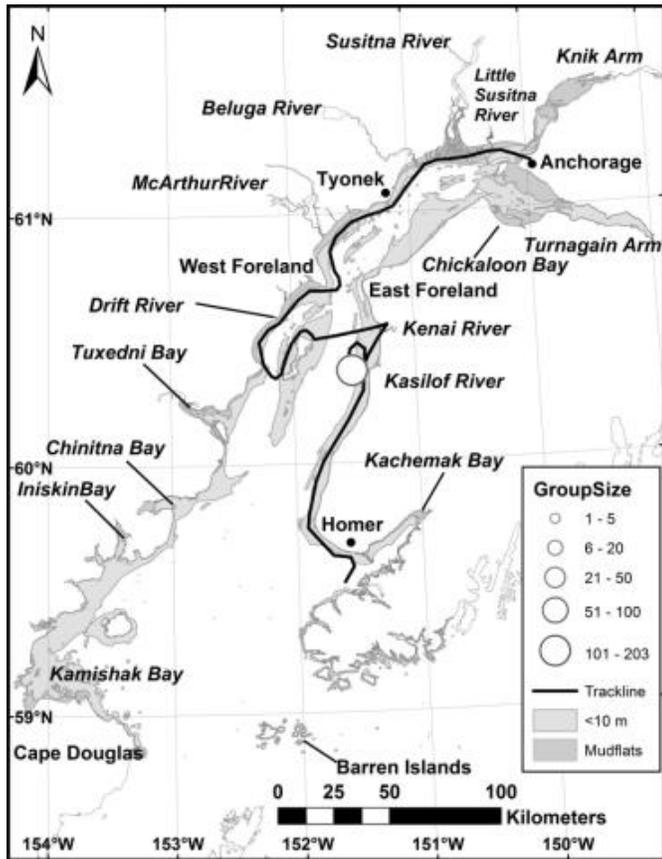
The map on 14 August shows the aircraft departing Homer and surveying the north shore of Kachemak Bay ("20 HS" and "50 HS" 20 + 50 harbor seals near Fox River) then the south shore before heading offshore where the line ends. A second line, possibly a second flight after landing somewhere offshore (labeled "II") heads back toward Kachemak Bay turning north to follow the shore to Kasilof River (there is a note near Anchor Pt. that is hard to decipher – possibly "carcass"?). At Kasilof River, the aircraft crossed the inlet to Kalgin Island, following the shoreline south to the southern tip then crossing the inlet back to the eastern shoreline between Ninilchik and Anchor Pt. The aircraft continued across land to Kachemak Bay, crossing the bay to Sadie Cove finally ending the survey off Homer Spit.

The map on 15 August shows the trackline beginning offshore of Kachemak Bay (labeled "I") headed north to Anchor Pt. following the shoreline to Kasilof River where a circle indicated "Large # 130+" (see Table below). The aircraft continued north, circling the Kenai River, passing East Foreland, Pt. Possession, Chickaloon River ("10 HS" 10 harbor seals), surveying Turnagain Arm to Bird Pt., then following the north shoreline before landing in Anchorage. The second flight (labeled "II") covered Knik Arm to the bridge, then followed the west shoreline to the Susitna River, surveying up the river to the power lines ("75 HS" 75 harbor seals in the river) before returning along the west shoreline to Anchorage.



August 14-15, 1978

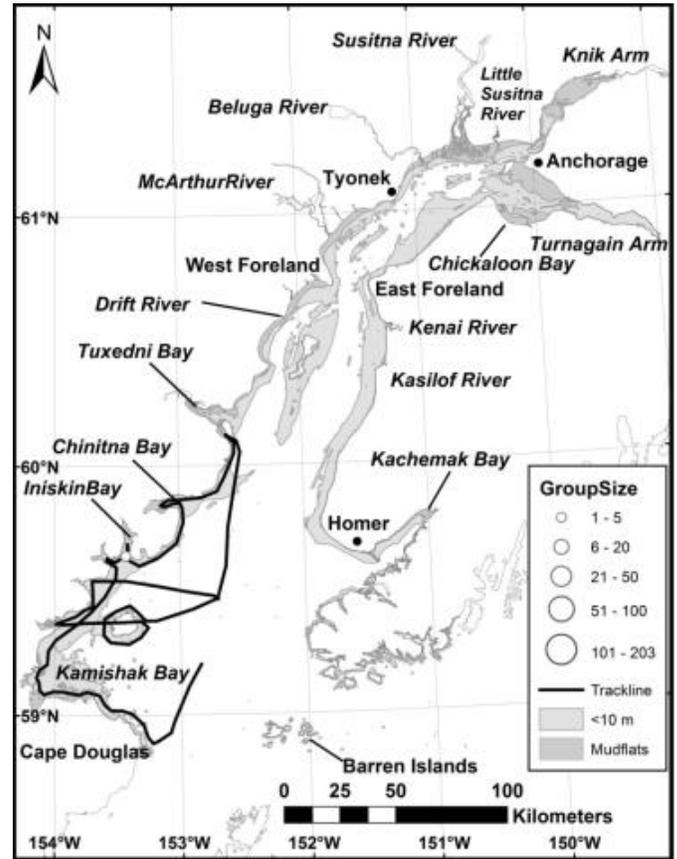
The map on 16 August shows the aircraft departing Anchorage (labeled "I") following the west shoreline south to Harriet Pt. The track crossed the inlet to the south tip of Kalgin Island, followed the shoreline to the north tip then crossed the inlet to land in Kenai. The second flight (labeled "II") headed south along the eastern shoreline, encountering a large number of belugas off the Kasilof River (see Table below). The track continued south into Kachemak Bay, turning offshore (6 harbor seals noted just before the track went offshore) near Homer. The track ends in the middle of the Bay.



August 16, 1978

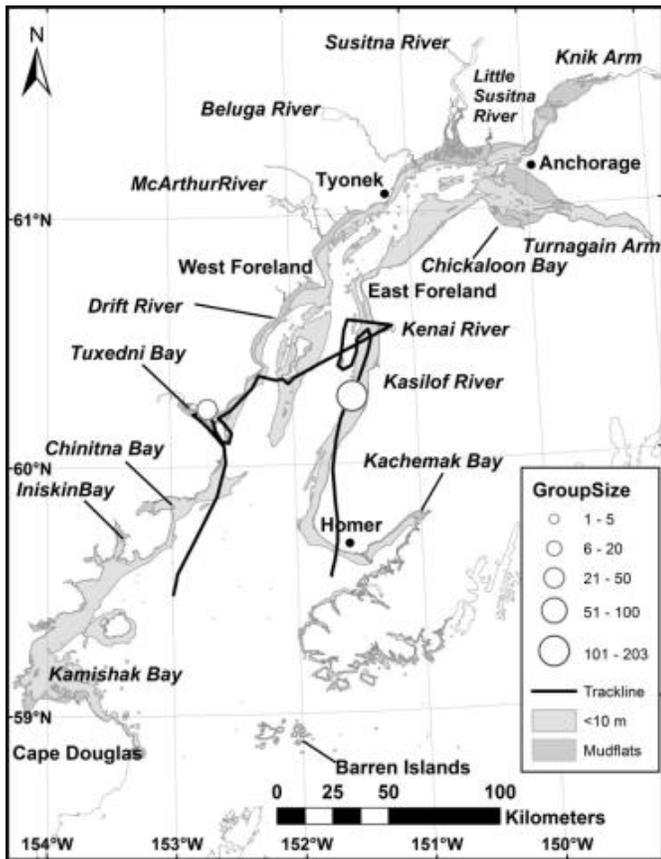
The map on 17 August shows the track beginning in the middle of the inlet heading toward Cape Douglas. At the cape, the aircraft began surveying the shoreline heading into Kamishak Bay. The track continued north to Tuxedni Bay. Belugas were seen in Iniskin Bay (3 whales). The aircraft headed offshore to begin a spoke pattern off Augustine Island, circling the island ("100s HS" 100s of harbor seals on south shore +

"2 HS" on north shore) then heading to shore at Bruin Bay then surveying the shoreline north to Ursus Cove ("25 HS" 25 harbor seals south of Ursus Cove) before heading back offshore where the trackline ends.



August 17, 1978

The map on 18 August shows the trackline beginning offshore (labeled "I"), northeast of Augustine Island. The aircraft entered Tuxedni Bay, encountering 30 belugas. The shoreline survey continued north to Harriet Pt. crossed the inlet to the south tip of Kalgin Island then crossed the inlet landing in Kenai. The second flight departed Kenai heading offshore for a series of north-south tracks returning to the Kenai River before heading south along the eastern shoreline. Belugas ("130+" were encountered south of Kasilof River. The aircraft cut across land near Ninilchik before terminating the flight mid Kachemak Bay (illegible writing at the termination point).



August 18, 1978

In the first section of a letter dated 18 December 1979, Nancy Murray stated:

“Don and Dennis –

Here are the remaining data you need to complete the OCS forms. If you have any further questions just give me a call or send the forms up here.

Date	Total # of belukhas	Location
14 Aug 78	0	
15 Aug 78	142	Kasilof River → offshore
16 Aug 78	203	Offshore from Kalifonsky Beach
17 Aug 78	3	Mouth of Iniskin Bay
18 Aug 78	30	Tuxedni Bay
“	130	South of Cape Kasilof (offshore)

Note: you should have write-ups that accompany the maps.”

In Murray (1979) [text footnote 6], Nancy Murray noted:

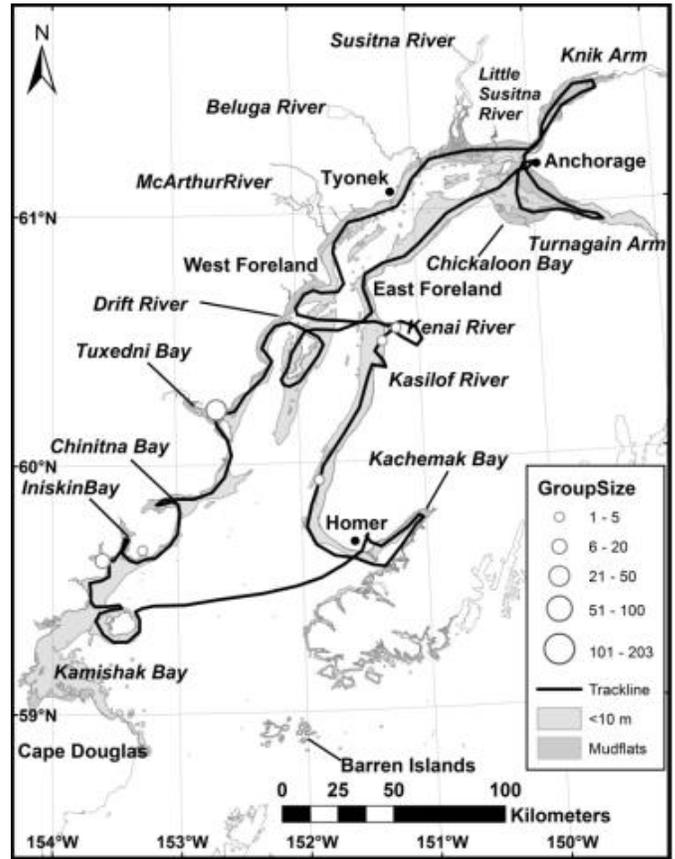
“In mid-August a group of at least 150 whales was observed on three different days in the waters between Kalgin Island and the Kasilof River. The whales remained in this general area over at least a 4 day period. The whales were all aligned on the same directional heading with lead animals observed to break off from the front of the group. This behavior did not result in the remainder of the group changing its heading. Consequently, this type of large group formation most likely represents a feeding aggregation, although no feeding behavior (such as darting after a fish, etc.) or food source was directly observed” (p. 195).

In Murray and Fay (1979) [text footnote 7]:

“Visual counts on three consecutive days of the main concentration of animals in the central part of the Inlet in August 1978 yielded approximately 150 individuals at each count. Since these were made from a moving aircraft, and since the animals were in turbid water where they could be seen only when surfacing, we consider that there is a high probability that the actual number present was at least three times the number counted on each occasion” (p. 2).

October 15, 1978:

Transcriber’s note: *Field notes were not included with the map for this survey. The map was labeled: “10/15/78 Cook Inlet Belukha Survey. N. Murray & K. Bunch (pilot).” The trackline for the first flight (labeled “I”) departed Anchorage crossing Chickaloon Bay to the river turning into Turnagain Arm. After surveying to Bird Pt. the aircraft flew the northern shoreline past Anchorage and entered Knik Arm. Surveying to the bridge, the aircraft left Knik Arm following the shoreline south to Big River before crossing the inlet and resuming the coastal survey north to Pt. Possession. The track continued from Pt. Possession to the south tip of Fire Island, following the east coast of the island before landing in Anchorage (illegible notes are written at the end point – possibly suggesting departing for Homer?). The second flight (labeled “II”) begins in Homer, crossing the inlet to Augustine Island, circling the island then heading to the western shoreline at Ursus Cove. The coastal survey continued north to Drift River, crossed the inlet to circle Kalgin Island then continued across the inlet entering the Kenai River. The survey continued south along the shoreline then entered Kachemak Bay, surveying the south and north shoreline to Fox River before landing in Homer. Belugas were encountered in Iliamna Bay (12), Dry Bay (5), Tuxedni Bay (50), Kenai River (4), north of Kasilof River (2), and near Ninilchik (2).*



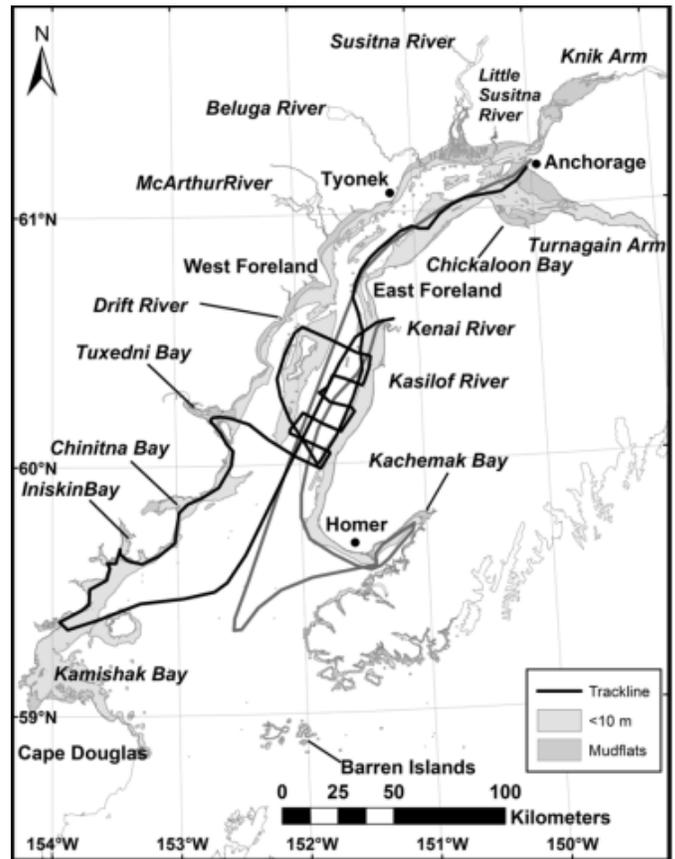
October 15, 1978

February 24, 1979:

Transcriber's note: ADFG conducted two surveys in February 1979. Field notes were not included with the map for the 24 February survey. The map was labeled: "2/24/79 Cook Inlet Belukha Survey. N. Murray, K. Bunch, S. Starr, C. Hamilton." The flight departed Anchorage headed toward Pt. Possession surveying what appears to be open water between iced areas south to Ninilchik before turning and flying to Kalgin Island. The track followed the western shoreline of the island to the north tip, crossing the inlet to Kasilof River where a series of east-west tracks were flown south over open areas in the ice until reaching Ninilchik. At Ninilchik, the aircraft crossed the inlet and entered Tuxedni Bay, following the coastline south to Bruin Bay before heading offshore to the ice edge and following open water north before landing in Kenai (see recreated figure for trackline (black line)); no beluga sightings and ice noted throughout much of the inlet).

February 25, 1979:

Transcriber's note: Similar to the 24 February survey, field notes were not included with the map for the 25 February survey. The map was labeled: "2/25/79 Cook Inlet Belukha Survey. N. Murray, K. Bunch, S. Starr, C. Hamilton." The aircraft departed Kenai headed south along the ice edge entering Kachemak Bay and surveying the bay to Fox River. After exiting the bay, the aircraft headed across the inlet but encountered a snow storm. Turning north, the aircraft continued along an offshore track before landing in Anchorage (see recreated figure for trackline (gray line)); no beluga sightings and ice and snow storms noted with a reference saying "see conditions on 2/24/79").



February 24 (black trackline)-25 (gray trackline), 1979

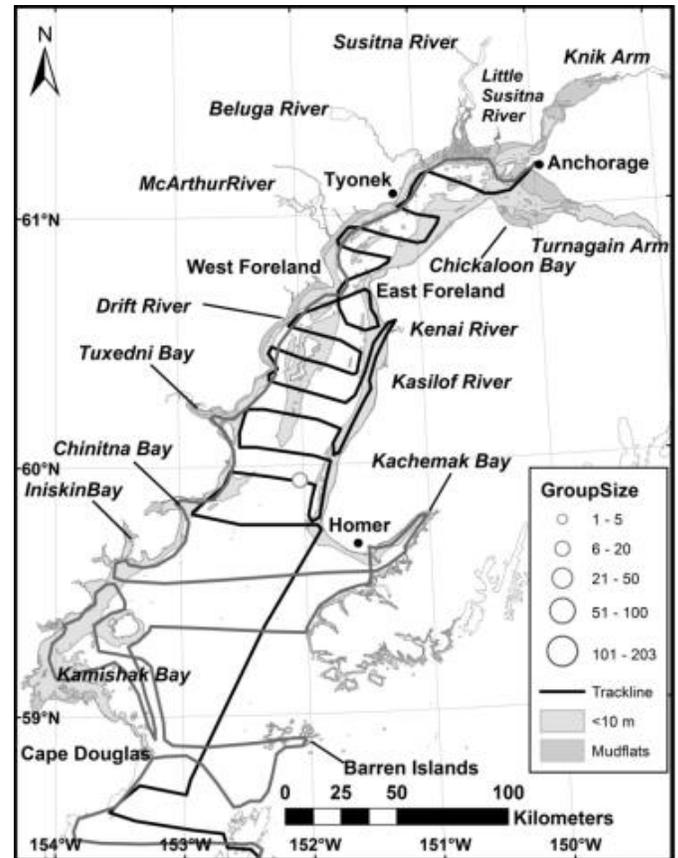
March 15, 1979:

Transcriber's note: ADFG conducted a two-day survey on 15-16 March 1979. Field notes were not included with the map for the 15 March survey. The map was labeled: "3/15/79 Cook Inlet Belukha Survey. N. Murray, K. Bunch, L. Banner?" (last name illegible on photocopy). On the first flight, the aircraft departed Anchorage heading south around Fire Island then crossed to the Little Susitna River. The track continued south along the shoreline to Iliamna Bay then crossed the inlet to Kachemak Bay, surveying the south and north shores to Fox Island before landing in Homer. The second flight departed Homer crossing the bay to Sadie Cove following the shoreline south to English Bay then crossed the inlet to Augustine Island. From Augustine Island the track followed the ice edge to Cape Douglas then turned north to survey along the ice edge into Kamishak Bay to Ursus Cove. The flight path again turned offshore to Augustine Island, circling the west shore before heading south to Cape Douglas. At Cape Douglas, the aircraft flew offshore to the Barren Islands (encountering an "SL" (sea lion?)) before turning south toward Shuyak Island. The aircraft again turned north heading to Cape Douglas, then resumed the shoreline survey south into Shelikof Strait (encountering "S.Otters" (sea otters) north of Kiukpalik Island and "SO+HS" (sea otter + harbor seal or maybe 50+ harbor seals?) in Hallo Bay. The aircraft crossed the strait and landed in Kodiak (see recreated figure for trackline (gray line); no beluga sightings and ice noted in areas, no key provided for sightings).

March 16, 1979:

Transcriber's note: Similar to the 15 March survey, field notes were not included with the map for the 16 March survey. The map was labeled: "3/16/79 Cook Inlet Belukha Survey. N. Murray, K. Bunch, L. Banner?" (last name illegible on photocopy). On the first flight, the aircraft departed Kodiak crossing Shelikof Strait to Kiukpalik Island following the shoreline a short distance north before heading offshore then heading north to Anchor Point. At Anchor Point, the aircraft began a series of east-west tracks across the inlet, ending near Ninilchik then heading to Kenai to land. Belugas (11) were encountered on the trackline south of

Tuxedni Bay. The second flight departed Kenai and resumed the east-west tracks just south of Kalgin Island. East-west tracks ended at Pt. Possession and the aircraft landed in Anchorage (see recreated figure for trackline (black line) and beluga sighting, ice noted in area).



March 15 (gray trackline) – 16 (black trackline), 1979

March 27-29, 1979:

Transcriber's note: *ADFG conducted a three-day survey 27-29 March that included areas outside of Cook Inlet. The only record of this survey was provided in the third section of a letter dated 18 December 1979 and addressed to "Don and Dennis" (see August 14-18, 1978 section above), in this letter Nancy Murray stated:*

"The survey from 27 March 79 to 29 March 79, where no belukhas were seen, covered the following areas:

27 March: Anchorage → Cape Elizabeth (eastern mouth of Cook Inlet)
Cape Elizabeth → Port Dick
Port Dick → Kodiak

28 March: Kodiak → Shelikof Strait
Shelikof Strait → Kujulik Bay
Kujulik Bay → Port Heiden
Port Heiden → Chignik Bay
Chignik Bay → Cape Douglas (all shoreline)
Cape Douglas → Homer
Homer → Port Dick
Port Dick → Seward (all shoreline)

29 March : Seward → Cape Cleare
Cape Cleare → Cordova
Cordova → Valdez
Valdez → Knight Island
Knight Island → Port Nellie Juan
Port Nellie Juan → Whittier Pass
Whittier Pass → Turnagain Arm
Turnagain Arm → Anchorage"

We were unable to map this comprehensive survey as this was the only information provided.

June 18, 1979:

Transcriber’s note: *This survey included comprehensive field notes and a map labeled:*

“6/18/79: Cook Inlet Belukha Aerial Survey: N. Murray, K. Bunch (pilot), W. Keefer”. *The field notes stated:*

“6/18/79 Cook Inlet Aerial Survey: Nancy Murray, Ken Bunch (pilot), W. Keefer: Wigeon
Weather conditions: clear, sunny, 60°F, <10 knot winds, seas calm.

EXCELLENT SIGHTING CONDITIONS.

0745 Take off from Anchorage.

0800 5 white adult belukhas are west of Fire Island heading northeast.
Groups of 3, 1, and 1 are near mud flats west of Fire Island.

38 belukhas (including 2 grey juveniles) are heading south near mud flats about 2 miles off the Susitna (Wendy: WK#1, 3 photos).

35+ belukhas (including 5 grey juveniles) off the mouth of the Ivan River.

12 white adults off the mouth of the Theodore River.

6 “ “ “ “ “ “ “ “ “

“

5 “ “ “ “ “ “ “ “ “

“

A group of 5 white adults + 3 grey juveniles plus several gulls are just north of Beluga River.

Group of 10 adults, then a group of 7 adults & 1 juvenile, and a group of 6 white adults are off the Beluga River and just south of it.

Note: All belukhas from the Ivan River to the Beluga River appeared to be feeding in the shallows. They were stirring up a lot of mud and were heading in “random” directions.

0835 Took black & white photos (NM Roll #1) of the Beluga River area.

No belugas were up river due to low tide.

0845 7 belukhas are just north of Tyonek heading south.

0850 3 belukhas are near an oil rig (the fourth one down from the north).

6 belukhas are off the mouth of the McArthur River.

Groups of 1, 1, 5, and 5 belukhas are in southern Trading Bay.

0905 In Redoubt Bay off the Drift River the following groups of belukhas were observed:

2 (adult & dark grey juvenile ~ ½ length of adult)
6 belukhas

1 “

4 “

1 “

4 “

8 (includes a few grey juv.: large)

1005 Landed at Kenai

1035 Take off from Kenai

1105 2 brown bears (an adult with a juvenile) are on shoe in eastern Tuxedni Bay.

1115 One harbor seal swimming in the water just off Chisik Island in Tuxedni Bay.

1145 There are about 40 harbor seals on a rock outside the mouth of Iniskin Bay.

1215 Land on a lake just south of Ursus Cove for a lunch break.

1245 Take off from lake. One sea otter is swimming in the water at the entrance to Bruin Bay.

Two harbor seals are hauled out in Bruin Bay.

1300 200-250 harbor seals are hauled out on a beach (same place as Aug. 1978 Surveyor cruise) on NE side of Augustine Island.

1355 Landed at Homer.

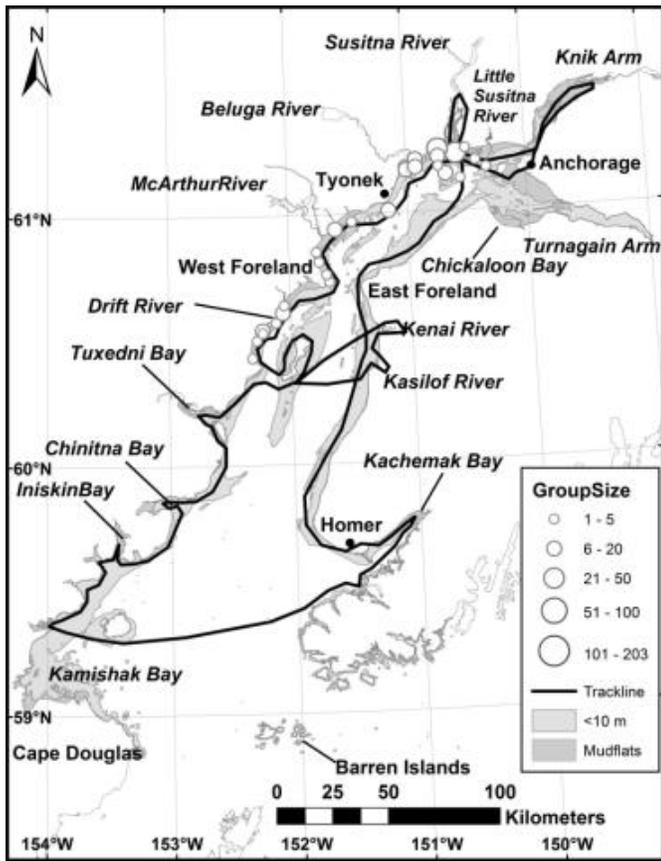
1430 Take off from Homer.

1525 One white adult belukha is heading north about 4-5 miles southeast of the mouth of the Susitna River.

1600 Landed at Anchorage.

Note: No calves were observed during this survey.

Total of 193 belukhas (includes 12+ juveniles).”



June 18, 1979

June 22, 1979:

Transcriber’s note: *This survey included comprehensive field notes and a map labeled: “6/22/79: Flight to Beluga River Field Camp from Lake Hood, Anchorage: N. Murray, W. Keefer, M.H. Cunningham, Dwaine (pilot): Ketchum Cessna 205”. The field notes stated:*

“6/22/79 Field Camp Flight: Anchorage to Beluga River: Ketchum Air Service 205: Nancy Murray, W. Keefer, M.J. Cunningham, pilot (Dwaine).

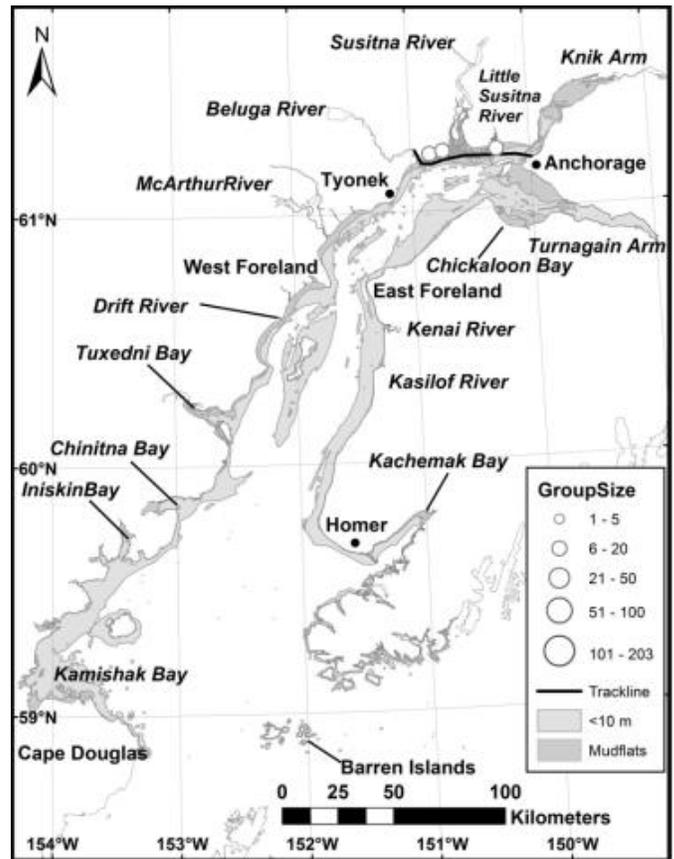
Weather conditions: clear, sunny, ~55°F, <1 knot winds, seas calm.

EXCELLENT SIGHTING CONDITIONS.

0600-0630 After takeoff from Lake Hood, we flew along the shoreline from Anchorage to the Beluga River. We sighted the following belukhas at the following locations:

- Little Susitna: 10 belukhas
- Ivan River: 6 “
- Theodore River: 12 “

Most of these whales were white adults. It was difficult to get an accurate count or age class info. ON ONLY ONE PASS.”



June 22, 1979

In the second section of a letter dated 18 December 1979 and addressed to “Don and Dennis” (see August 14-18, 1978 section above), Nancy Murray stated:

“For the Beluga river data on the next page, counts are given for each of the two high tides. I don’t think the whales from each high tide should be totalled to give a single number for each date, since whales which entered on a particular high tide could conceivably contain some or all of the numbers from the other high tide. The same problem, of course, exists throughout the study. Please feel free to handle this any way you see fit.

The pluses after the count indicate that a definite determination was not possible and the minimum number of whales is given. There could have been more” (at this point the photocopy cuts off on page 1 of the letter, the following table was on page 2).

Belukhas observed in the Beluga River from 22 June 79 to 12 July 79:

Date	Time Period	Total # whales
22 June	1504	1
26 June	1904	1
27 June	0718-0951	22
"	1715-2145	35
28 June	0510-0810	18
"	1815-2006	13
29 June	1930-2245	12+
30 June	0629-0850	28+
1 July	0717-0847	9
"	2034-2345	14
2 July	1040	1
"	2200-0015	5
3 July	0955-1250	15
"	2150	1
4 July	1145	1
5 July	1220-1223	2
7 July	0037-0115	2
"	0400	1
"	1410-1543	8
8 July	0115-0330	8
"	1502	2
9 July	0430	1+
"	1744	8 (offshore)
10 July	0300	1
"	0520-0740	5+
"	0710-1900	7
11 July	0350-0731	10 + 5 offshore
"	1709-1927	5+
12 July	0453-0626	3

July 17, 1979:

Transcriber's note: *This survey included comprehensive field notes and a map labeled: "7/17/79: Cook Inlet Belukha Aerial Survey: N. Murray, W. Keefer, K. Bunch (pilot)". The field notes stated:*

"7/17/79 Cook Inlet Aerial Survey: N. Murray, W. Keefer, K. Bunch (pilot): Wigeon.

Weather conditions: overcast → sunny. Temperature ~70°F. Wind <5 knots. Sea state is calm.

EXCELLENT SIGHTING CONDITIONS.

0745 Take off from Anchorage International.

0840 East of the Susitna, we sighted the following groups of belukhas near mud flats:
7 white adults
2 medium grey juveniles
4 adults + 3 juveniles
stirring up mud.

0847 Off the mouth of the Susitna near the mud flats are 13 adult belukhas, 3 light-medium grey juveniles and 1 dark grey juvenile.

0852 11 harbor seals are hauled out on the exposed mud flats about ½ mile up the Big Susitna River.

0900 Beluga River. Our tower still stands on its original position, but the Hilton is gone – Completely gone except for a "hitching" post. Apparently the whole shoreline under the cabin was swept away as well. Earl's cabin was moved about a mile inland near the pond and Mile's cabin was moved about ½ mile down river. Took lots of photos (NM #7).

0930 Off the mouth of the Big River there were 4 white adults and 2 medium grey juveniles.

0932 One adult belukha was sighted just south of the Big River.

0941 Off the mouth of the Drift River, I sighted a trio of 2 white adults and 1 medium grey juvenile (~1 or 2 years old) heading east in the following formation: (*drawing of whales in echelon formation lead by 1 white adult*)

0945 To the northwest of *bell(?)* to west of Kalgin Island is a scattered group of 5 white adults, 3 white adults + 1 grey juvenile. These whales appear to be feeding along the shoal. There is

another groups of 2 white adults over near the shoreline.

1000 Off the north end of Kalgin Island was a group of 15 white adult belukhas + 2 grey juveniles. They were doing a lot of splashing and making vertical dives.

1009 Two white adults were sighted northeast of Kalgin Island.

Note: Between Kalgin Island and Kenai, numerous salmon were seen jumping out of the water, primarily along shoal lines.

1020 Landed at Kenai.

John at Arctic Aviation said that there have been very few fish so far this summer. The red salmon are about 3 weeks late coming in. He has seen belukhas coming in to the Kenai River over the past 2 months. He has seen belukhas north and southwest of Kalgin Island.

1105 Take off from Kenai.

1130 Two harbor seals diving in the water just south of Harriet Point.

1135 One harbor seal in water just north of Tuxedni Bay.

1147 One harbor seal swimming just west of Chisik Island in Tuxedni Bay.

1156 One harbor seal out from Snug Harbor Cannery on Chisik Island.

1220 A marine mammal carcass (*sic.*) (seal or porpoise?) is floating just under the surface. It is surrounded by a dense flock of gulls. It was located about a mile east of Chinitna Bay.

1225 To the north east of the carcass (*sic.*), we sighted a dense black ball of unknown composition (fish?) just below the surface surrounded by a flock of gulls.

1250 About 2 miles offshore west of Ninilchik, we sighted 4 minke whales. There was one lone whale, 2 diving side by side in unison, and 1 more lone whale. I took a few photos with my 55 mm lens (NM#7) of the pair. All four minkes were heading northwest.

1345 Landed at Kenai to remove the mosquitos from the windshield. Were hardly able to see out.

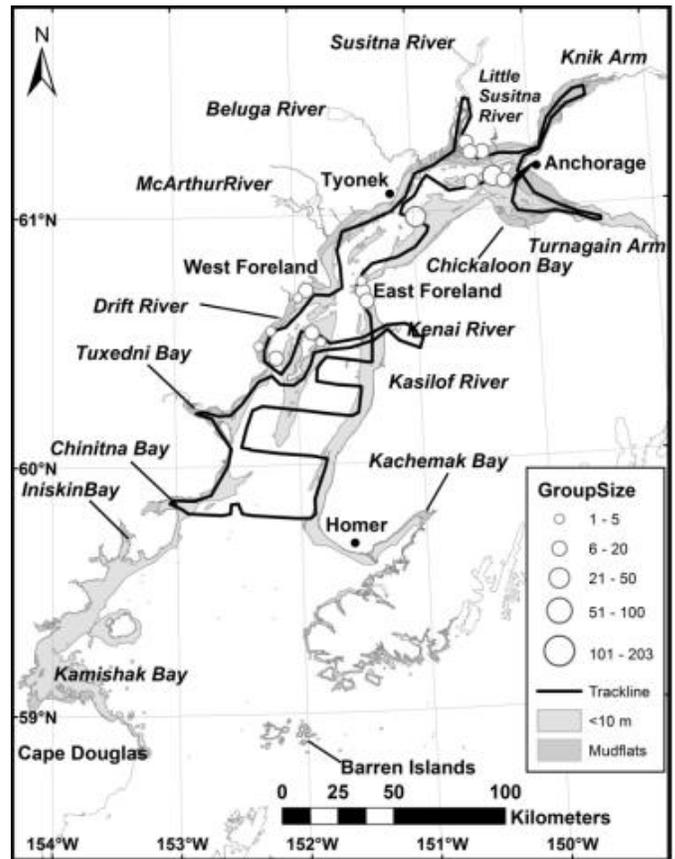
1420 Take off from Kenai.

- 1435 6+ white adult belukhas are between the oil dock off North Kenai and south of the East Forelands. They all had a long down time, indicating the possibility that they were feeding.
- 1439 There are 10 white adult belukhas and one grey juvenile just south of the East Forelands. All whales were heading south. One white adult is directly off the East Forelands heading south.
- 1455 About midway up the upper inlet out in open water, we sighted a group of 20 adult belukhas + 6 grey juveniles + 4 small calves. All whales were heading southwest. Two of the calves were very small dark animals swimming on the left side of the mother near the caudal peduncle. The other two calves were a bit larger and lighter in color and were swimming next to the midsection of the adult – one of these was on the left side, the position of the other is uncertain. I took several photos on NM#7 and all 20 frames of NM#8 (TRI-X). Wendy also took photos (WK#11, frames ~ 18-36).
- 1505 Two large scattered groups of belukhas, all heading north – northwest were sighted in the upper inlet about 3 to 10 miles south of Fire Island. The first group consisted of 16 white adults and 2 calves. The second group (further north) was composed of 26 white adults, 9 juveniles, and 2 calves. (37 total) I took a few photos of this last group (NM#9).
- 1530 Off the southern tip of Fire Island very close to shore were a group of feeding whales consisting of 19 white adults and 1 grey juvenile.
- 1540 Landed at Anchorage.

Total of 194 belukhas consisting of:

155 adults	
31 juveniles	20% J:A ratio
8 calves	25% J+C:A ratio

Note: This is the best age class data that has been acquired to date.”



July 17, 1979

August 21, 1979:

Transcriber's note: *This survey included comprehensive field notes and a map (with key and beluga totals from 8/21/79 and 8/22/79) labeled: "8/21/79: Cook Inlet Belukha Aerial Survey: N. Murray & K. Bunch (pilot)". The field notes stated:*

"8/21/79 Cook Inlet Belukha Aerial Survey: N. Murray & K. Bunch (pilot: wigeon).

Weather conditions: sunny, clear, 55-60°F, calm seas (<2 ft.); afternoon: 70°F, hazy in central inlet and low cloud cover in lower inlet.

0830 Take off from Anchorage International.

Note: Hydraulic system warning buzzer and light came on and stayed on.

0850 Landed at Merrill Field.

Note: Hydraulic system repaired by bleeding off excess nitrogen.

1120 Take off from Merrill Field to begin survey.

1145 32 white adult belukhas were sighted just south of the mouth of the Beluga River. The tide was very low. It was difficult to tell whether the animals were feeding. The majority were on a northerly heading. A second (but poorer) count of this group yielded 33 belukhas.

1202 8 white adults and 1 light grey juvenile belukha were sighted just north of the mouth of the McArthur River. These whales were making long duration dives and were oriented in a variety of directions. Most likely this group was feeding. 12 white adults and 3 grey juveniles were swimming in the shallow muddy areas just south of the mouth of the McArthur River. The whales moved back and forth between clear water where the animals could be seen a couple of feet below the surface to muddy water where sediment plumes were created by their movements. I took several photos, since I had not previously seen belukhas in a similar water situation before.

1224 3 white adult belukhas were sighted off the mouth of the Kustatan River. These whales dived and were not sighted again during the approximately 2 minutes of circling with the aircraft.

1226 30 adults (+? Lt. grey juveniles) and 1 calf were sighted off the Big River. Took photos #28-36 of this group.

1240 At the Drift River, 7 belukhas were sighted about ¼ mile out from the mouth, 6 belukhas in the mouth of the river, and 1 belukha about ¼ mile up the river.

1250 4 white adults and 1 calf were sighted in southern Redoubt Bay.

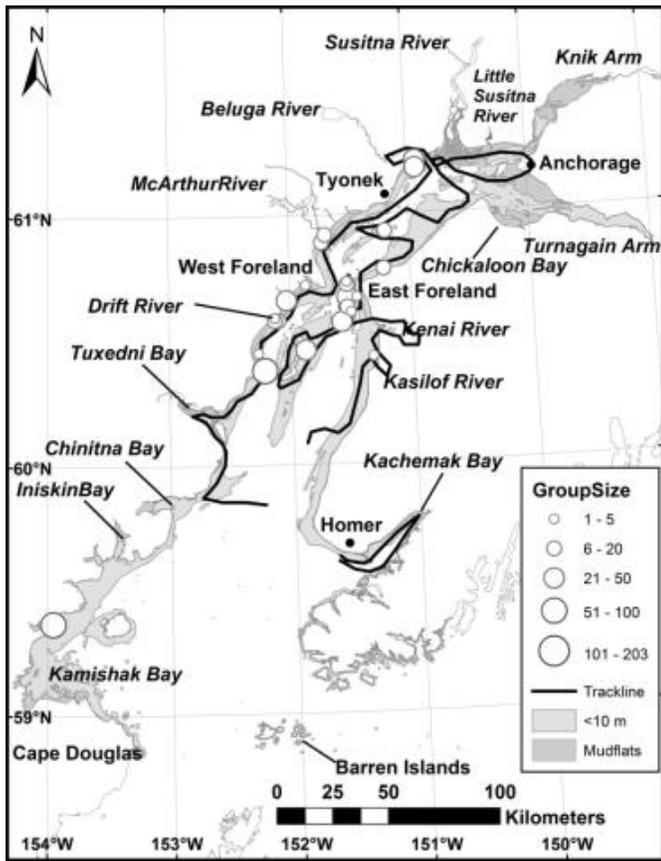
1303 Directly off Harriet Point, 45 white adults, 6 grey juveniles, and 5 calves were seen. The whales had a variety of headings and were diving deeply (or long duration) in a single spot - indicative of feeding behavior. Within the larger group was a group of ~25 whales which included all the calves. While the adults and larger juveniles dived, the calves surfaced repeatedly together, surfacing very frequently. Three of the calves swam very close together and "wobbled" as they dived. These youngsters don't appear to be very coordinated yet. When I've seen calves moving in concert with a white adult, I have never noticed this "wobbling" movement. I took photos #1-12 on the next roll.

1325 When we arrived at the northern point of Chinitna Bay, there was a very heavy layer of low clouds. When we gained altitude, we could see that the layer completely covered Kamishak Bay. Therefore, we decided to cross over to the eastern shoreline of Cook Inlet to determine whether we could survey Kachemak Bay. Upon arrival there, we discovered that it was free of clouds (the only part of the lower Inlet that could be surveyed).

1345 At the northern part of the entrance to Kachemak Bay, Ken saw a whale dive. The flukes were dark colored and larger than those of a belukha. The flukes were curved, but he didn't think they were "scallop" like that of a humpback. The whale dived and did not return to the surface while we circled.

1445 5 white adult belukhas were in a widely scattered group southwest of the mouth of the

- Kasilof River. Since the tide was high, we flew the river (~1 mile up), but sighted no whales.
- 1505 Landed at Kenai to refuel. John at Arctic Aviation said that recently he has seen lots of belukhas (he estimates about 300-400) off the southern tip of Kalgin Island in the rip currents.
- 1540 Take off from Kenai.
- 1550 About 2 miles northeast of Kalgin Island we sighted a group of whales containing 36 white adults, 5 juveniles, and 6 calves. Two of these calves were swimming as a pair, surfacing very close to one another.
- 1605 In the bay just south of the northeast tip of Kalgin Island, we sighted a group of 9 adults, 9 juveniles, and 8 calves. I've never seen group composition so heavily skewed to immature animals. The general heading of the group was northerly. However, it appeared that some whales were making long duration dives, indicative of feeding. Since most whale groups observed today seem to be composed of adult whales diving for a long duration with young whales swimming at the surface, perhaps this group had a larger proportion of white adults than we observed. I took photos #14-27 on the second roll of this group.
- 1625 In the waters just south of the Forelands, we sighted 7 widely scattered groups of belukhas. These whales were north-northeast of the group sighted at 1550 which had been sighted again a few minutes ago. The count resulted in groups of 5, 2, 6, 2, 9, 26, and 9 belukhas. No breakdown of these groups into age classes was possible, since such wide scattering made even total counts very difficult. When the whales are scattered in a manner such as this, I begin to wonder if all of these whales are really one large group broken down into several "sub-groups".
- 1630 The carcus (*sic.*) of a white adult belukha was floating belly up in the rafted debris of the rips, about midway between Kalgin Island and the Forelands.
- 1645 Just north of the East Forelands, a group of belukhas consisting of 7 adults, 1 juvenile, and 2 calves, was sighted.
- 1700 In the central part of the upper Inlet, east of Trading Bay, we sighted a group of belukhas composed of the following: 12 white adults, 3 juveniles, and 3 calves. One of the calves was swimming very close to the mother near her caudal peduncle. This calf was very small and dark, apparently recently born (maybe 1-2 weeks old). Most of the calves I've seen so far today are larger than this one, a bit lighter in color and were either swimming next to the "mother's" mid-section or in little groups together at the surface while the adults were making feeding dives.
- 1730 Flew by the Beluga River again, and this time the tide is high. No whales were in the river. However, a larger group of whales, than the one I saw this morning, was a little further out from the shoreline and heading in a southerly direction. Although some of these whales may be ones I counted this morning, since I have no way of knowing, I'm including this group as part of the census. The group was composed of 40 white whales, 4 juveniles, and 2 calves. I took photos #28-32 on the second roll of the river and the tower.
- 1800 Landed at Anchorage International Airport. Observation and survey ended.
- 8/22/79
- Tom Shrader of the Homer Office, ADF&G, sighted a group of 97 belukhas in Bruin Bay. (Info. via Don Calkins, 8/28/79 phone call)." *This sighting was included on the map and in the following table.*



August 21-22, 1979

8/21/79 : Age Class and Census Data from Cook Inlet Belukha Aerial Survey

Time	Location	Number of Belukhas				Total
		Unid. (Ad & Ju)	Adults	Juv.	Calves	
1145	Beluga River: low tide		32			32
1202	McArthur R.: north		8	1		9
"	McArthur R.: south		12	3		15
1224	Kustatan River		3			3
1226	Big River	30			1	31
1240	Drift R.: offshore	7				7
"	" : mouth	6				6
"	" : up river	1				1
1250	Lower Redoubt Bay		4		1	5
1303	Harriet Pt.		45	6	5	56
1445	Kasilof River		5			5
1550	N. of Kalgin Is.		36	5	6	47
1605	Kalgin Is.: NE Bay		9	9	8	26
1625	N. Central Inlet	59+				59+
1645	E. Forelands		7	1	2	10
1700	Central Upper Inlet		12	3	3	18
1730	Beluga River: high tide		40	4	2	46
Total		103	213	32	28	376
8/22/79						
sighting	Bruin Bay	97				97
					Grand Total	473

Appendix 2. —Field Note Summaries from Beluga Whale Aerial Surveys conducted by the Alaska Department of Fish and Game, May-August 1982 and April-July 1983 (Map descriptions and field reports (when available) were transcribed by K.E.W. Sheldon, notes about these data are italicized, original texts are shown in quotes). Results of some of these surveys were reported in Calkins (text footnote 8)

May 17, 1982:

Transcriber's note: *This survey included field notes on which the observer is not identified but handwriting appears to be Don Calkins. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

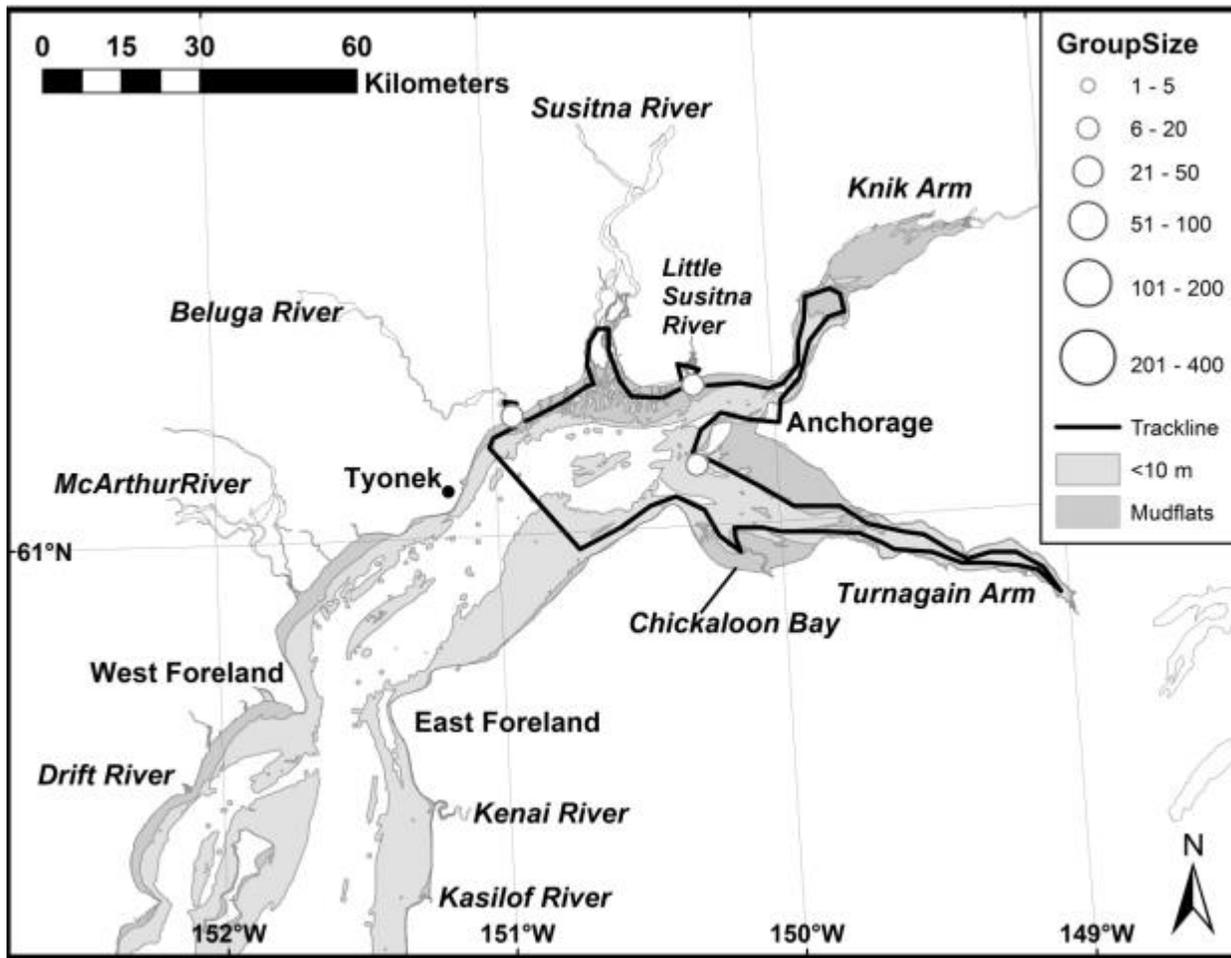
"May 17, 1982 Belukha Survey

Rust's Flying Service Cessna 206

Pilot – Dale Railey

Air Service reports lots of belukhas across inlet in area of Big Su River.

- 1025 Off Lake Hood
- 1033 Eagle River
- 1037 Across Knik Arm
- 1040 Goose Bay
- 1046 Point MacKenzie
- 1052 Little Su – 15 whales just south of Little Su
- 1057 Big Su heading up river
- 1103 Chugach lines turn back [*power lines that cross the Susitna River*]
- 1110 Ivan River
- 1118 Beluga River, N. side – 6 grey, 4 white [*belugas*]
- 1120 Threemile Creek – cross inlet north of the platform [*offshore oil platform*]
- 1130 Moose Point
- 1134 Point Possession
- 1140 Chickaloon River
- 1148 Hope
- 1152 Sunrise
- 1156 Girdwood
- 1200 Twentymile – turn back [*at end of Turnagain Arm*]
- 1204 Girdwood
- 1207 Bird Point
- 1210 Indian
- 1214 McHugh Creek
- 1218 Anchorage (Potter)
- 1225 Fire Island west point – 15 whales 1 gray.
- 1231 Point Woronzof
- 1233 Survey complete
- 1235 Land Hood Lake."



May 17, 1982

June 4, 1982:

Transcriber's note: *This survey included field notes on which the observer is not identified but handwriting appears to be Don Calkins. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

"June 4 Belukha Survey

Off Anch [*Anchorage*] 2:13

2:19 Eagle Bay

2:22 Across to Goose Bay

2:25 Goose Bay

2:30 Point MacKenzie

2:35 Little Su

2:39 Big Su

2:44 Power lines turn around on river

2:50 Mouth of Big Su

2:51 Circle offshore of mouth

2:59 Lewis River – 150-200 whales off mouth of Lewis River appear to be feeding. Many gray but no newborn. About 100 move to mouth of Beluga River. Circled several times saw small very dark animals – couldn't tell calves.

3:37 Chuitna River

3:38 North Foreland – cross inlet

3:50 Boulder Point

4:01 Moose Point

4:07 Point Possession

4:14 SW side Chickaloon Bay – 15 whales

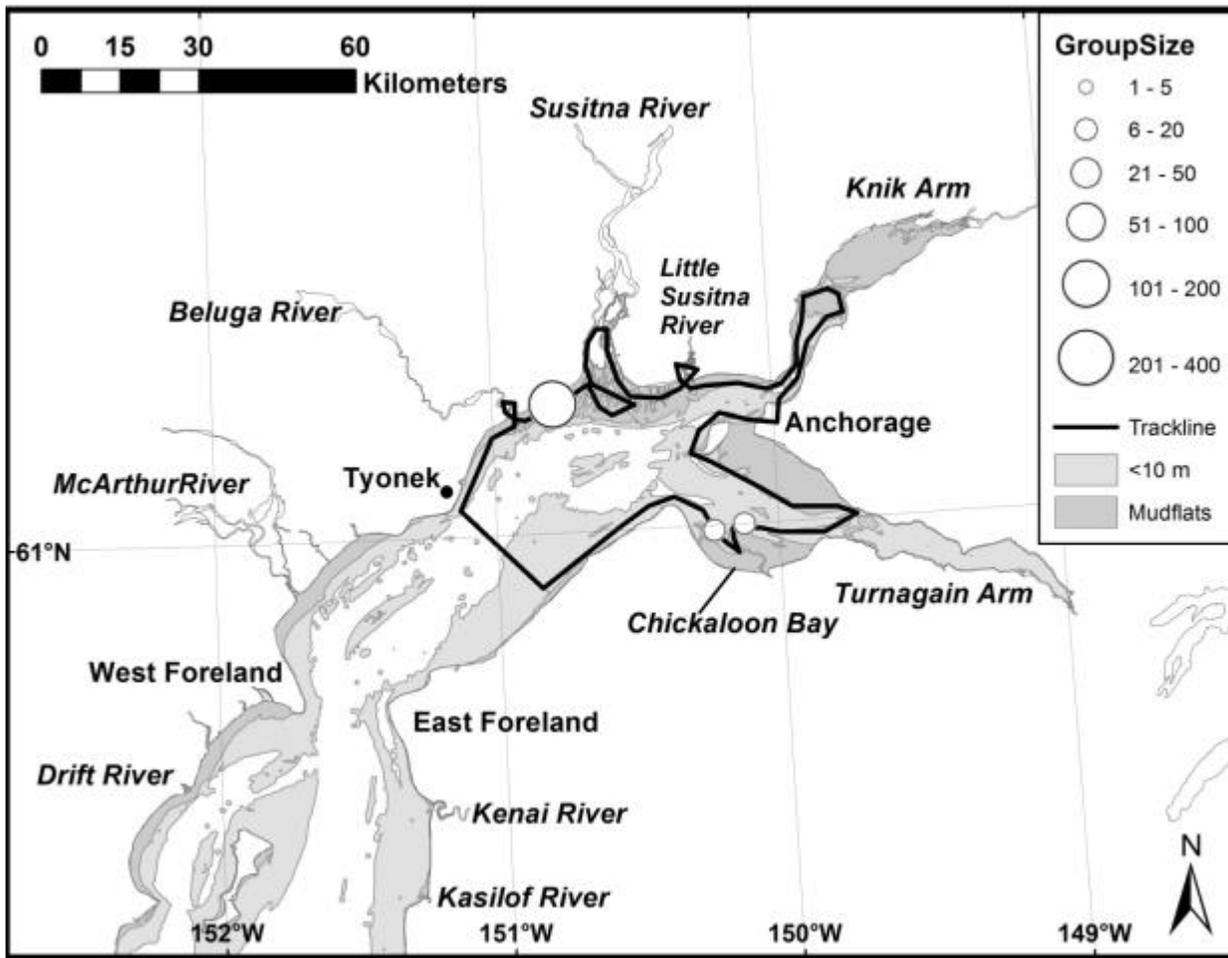
4:16 Chickaloon River mouth – 20 whales ½ mi to 1 mi offshore

4:26 Across Turnagain – stiff breeze across Turnagain Arm

4:33 Point Campbell

4:41 Around Fire Island

4:43 Point MacKenzie finish."



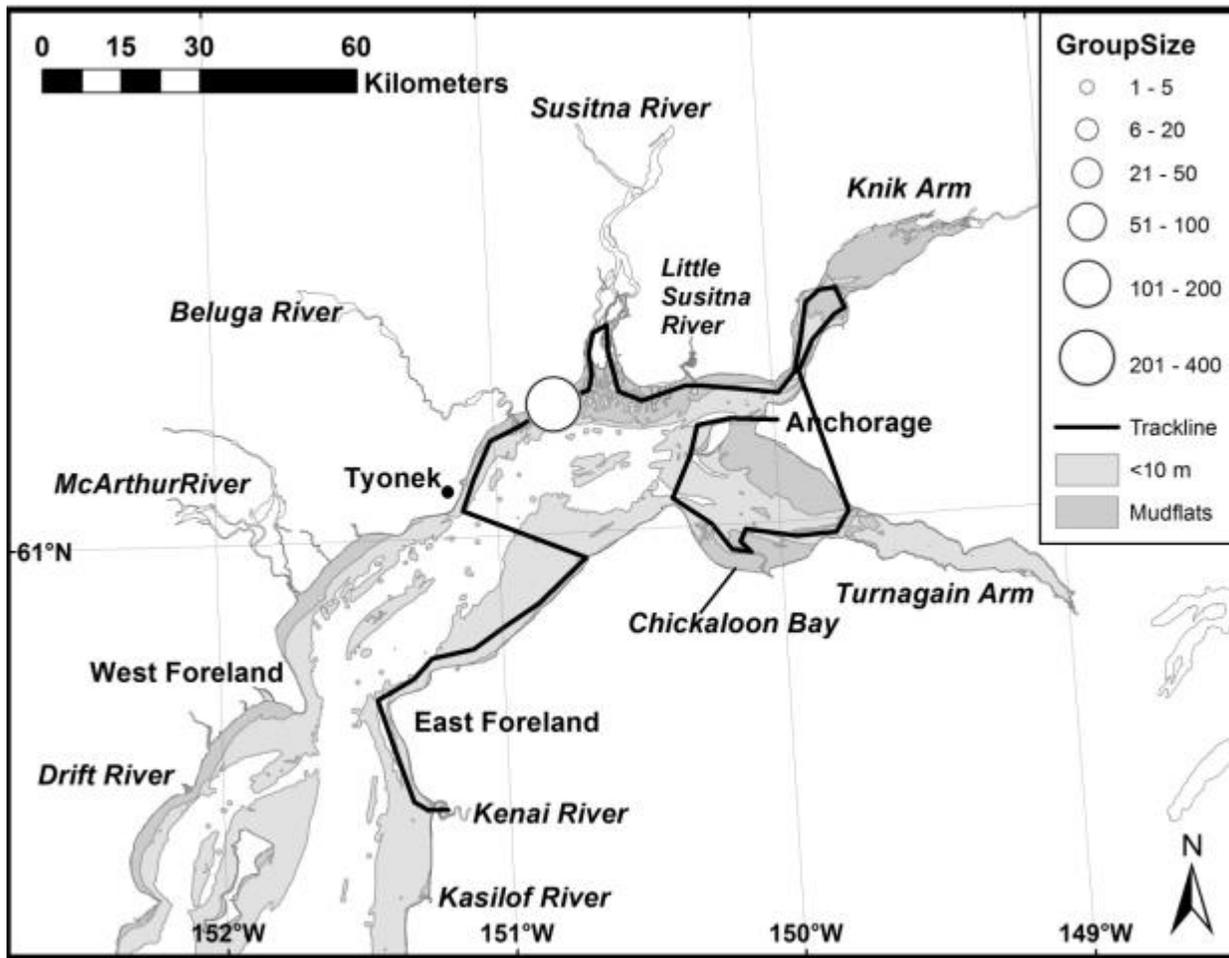
June 4, 1982

June 11, 1982:

Transcriber's note: *This survey included field notes on which the observer is not identified but handwriting appears to be Don Calkins. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

"Belukha Survey June 11

- 2:10 Take off Lake Hood
- 2:13 Fire Island N point
- 2:16 Fire Island W point
- 2:20 Point Possession – lots of white caps – conditions poor
- 2:25 Chickaloon Bay
- 2:28 Chickaloon River
- 2:35 Across Turnagain Arm
- 2:40 Point Campbell
- 2:45 Cairn Point
- 2:48 Eagle Bay
- 2:50 Across Knik Arm
- 2:52 Goose Bay
- 2:59 Point MacKenzie
- 3:04 Little Su
- 3:09 Big Su
- 3:12 Up mouth of river
- 3:16 Back down river turn at power lines
- 3:23 Ivan River
- 3:25 Large group Belukhas 200-300 from mouth of Lewis River to Beluga River.
- 3:42 Moved on S. – couldn't tell if any were new calves – many – belukhas appear to be in much the same area as last week. Bruce Campbell reports both hooligan [*eulachon*] and king salmon in Theodore River.
- 3:48 N. Foreland
- 3:50 Across to Moose Point
- 3:56 Moose Point turn S
- 4:17 Kenai River
- 4:20 finish up Kenai River."



June 11, 1982

June 18, 1982:

Transcriber's note: *This survey included field notes on which the pilot and observers were identified and handwriting appears to be Don Calkins. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

"Belukha Survey June 18 upper Cook Inlet

Rust's Flying Service Cessna 206

Pilot – Dale Railey

Observers Don Calkins, Mark Chihuley

8:44 Take off Lake Hood

8:46 Start survey

8:50 Cairn Point

8:51 Eagle River

8:53 Across [*Knik*] Arm

8:56 Goose Bay

9:01 Point MacKenzie

9:03 Susitna flats

9:07 Little Susitna River

9:14 Mouth of Susitna

N side – 6 w 4 g + 17 [6 white, 4 gray + 17 additional belugas = 27] (2nd pass 4 w 3 g)

S – 14 w 7 g +17 [38 belugas]

6 w 4 g [10 belugas]

9:22 27

6 [total of 108 reported in Table 1 in Calkins (text footnote 8)]

9:23 Turn back to go up river

9:30 Back down

9:34 Out at mouth – sand bars

Belukhas were scattered around mouth of Susitna River on outside of sand bars. No belukhas in river inside sand bars – viewing conditions good.

9:38 Ivan River – 5 belukhas

9:40 6 belukhas

28 w 6 g [total of 39 between Ivan River and Beluga River reported in Table 1 in Calkins (text footnote 8)]

9:41 Beluga River 50-75 belukhas at mouth

9:44 6 belukhas

34 w 10 g

13 4

9:45 3 w

9:49 8 belukhas [6+34+10+13+4+3+8=78]

Tyonek Village [total of 78 between Beluga River and Tyonek reported in Table 1 in Calkins (text footnote 8)]

9:50 North Foreland

9:51 Across Inlet

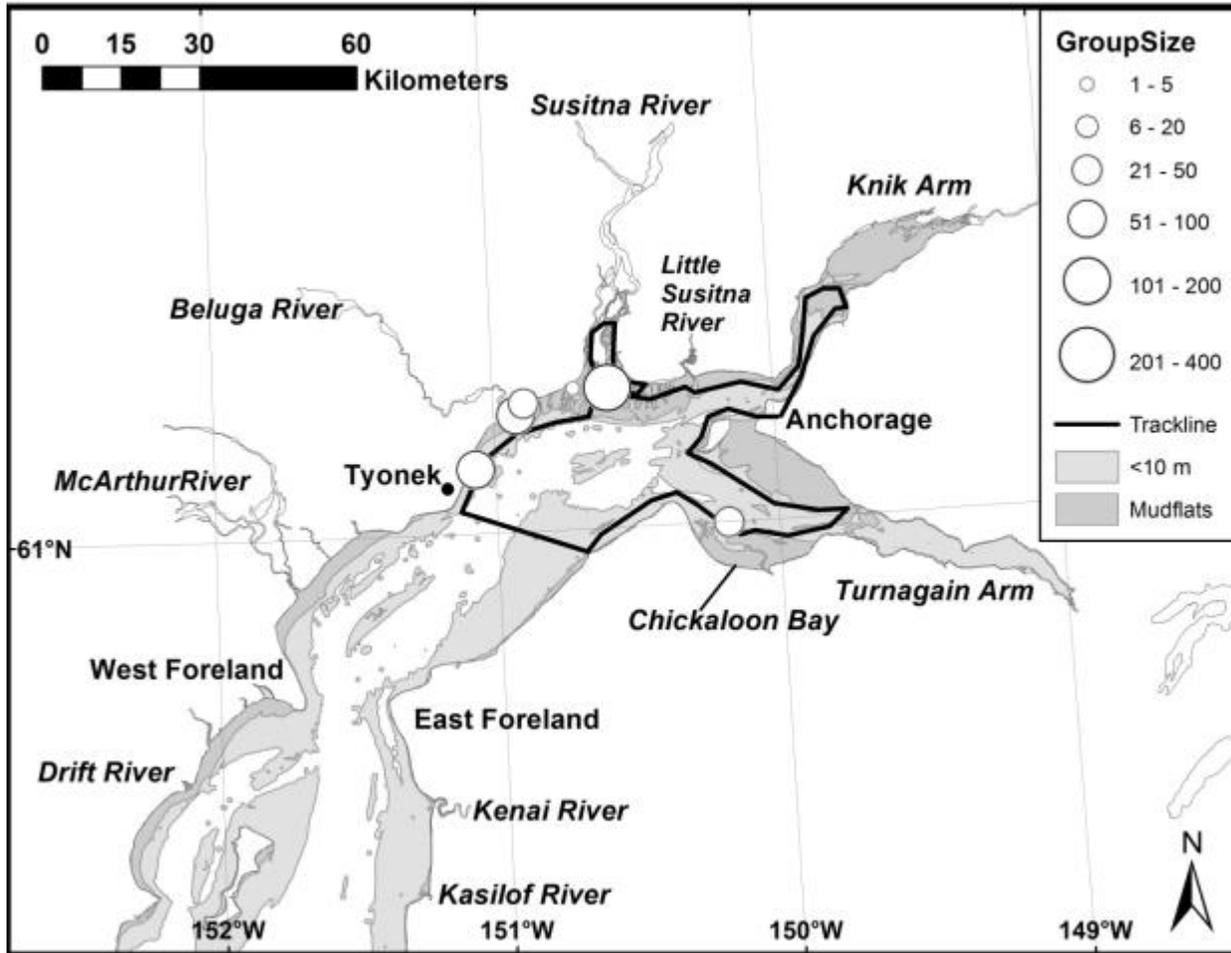
9:58 East side

10:01 Moose Point

10:07 Point Possession

10:13 25 w 5 g [30 belugas] Chickaloon Bay low tide – sand bars exposed

- 10:17 Little Indian Creek
- 10:18 Across Turnagain Arm
- 10:20 W to Fire Island (from Potter)
- 10:26 W point of Fire Island
- 10:29 Race Point
- 10:34 Finish survey
- 10:37 on Lake Hood."



June 18, 1982

June 22, 1982:

Transcriber's note: *This survey included field notes on which the pilot and observer were identified and handwriting appears to be Don Calkins. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

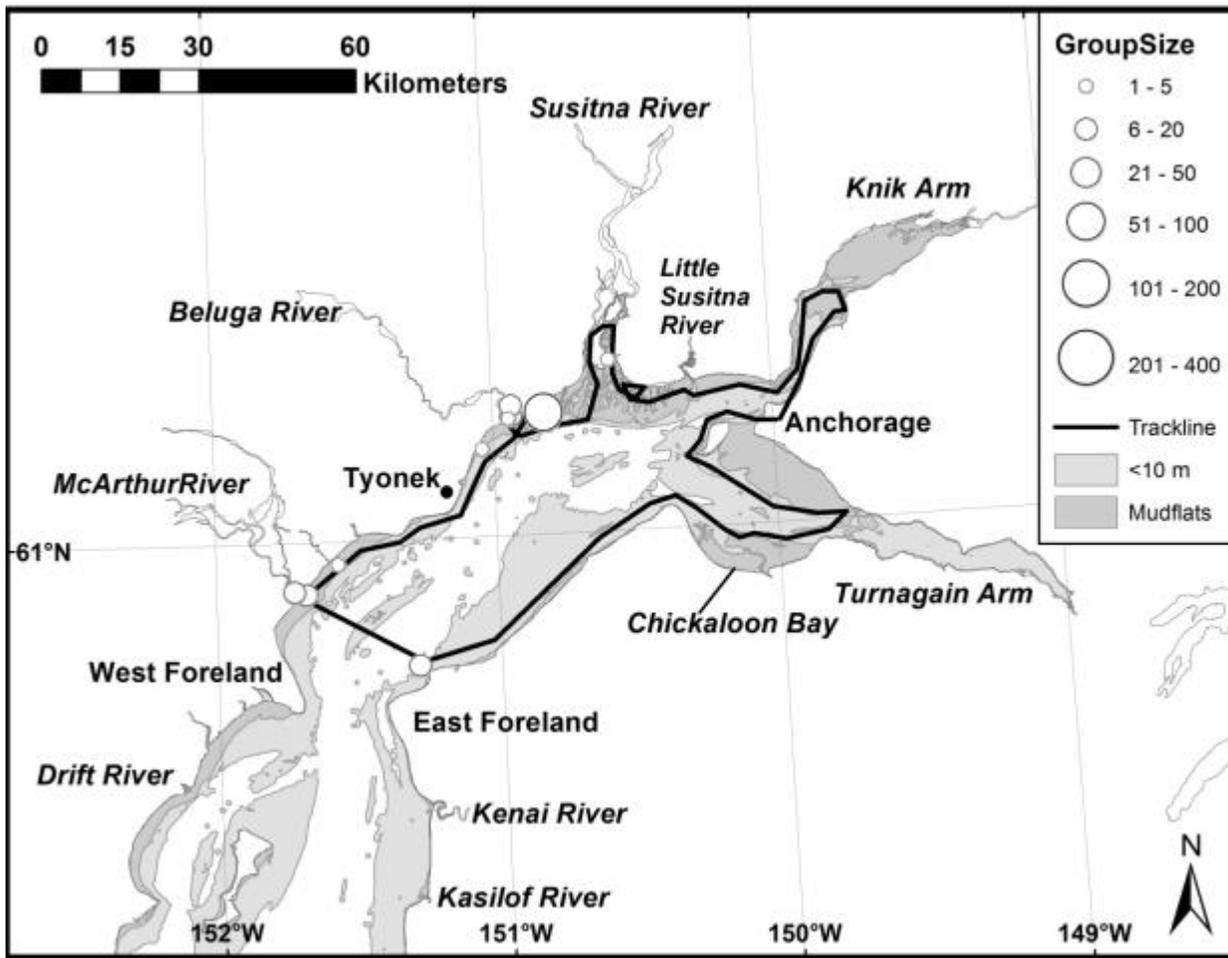
"Belukha Survey June 22

Kenai Air 185

Pilot – V. Lofst [*Lofstead? See notes from August 27 flight*]

Observer - Calkins

2:37 off lower Salamatof Lake
2:41 Start Boulder Point
2:47 15 belukhas just north of Boulder Point
2:55 Moose Point
3:03 Point Possession
3:08 Chickaloon Bay poor conditions 2-3 ft. seas – many white caps
3:15 Across Turnagain [*Arm*]
3:17 Potter [*Marsh*]
3:22 West point Fire Island
3:30 Point MacKenzie
3:36 Eagle Bay
3:37 Across Knik [*Arm*]
3:40 Goose Bay
3:46 Point MacKenzie
3:48 Little Su flats
3:51 Little Susitna River
3:55 Big Susitna [*Susitna River*]
3:57 4 belukhas, turn up river
4:03 Turn at power lines
4:11 Ivan River
4:12 Lewis River
4:12-4:17 50-75 belukhas between Lewis and Theodore rivers
4:19 1 belukha
4:19 Beluga River
4:20 15-20 belukhas ¼ mi. off mouth
4:25 10-15 belukhas in river
4:28 1 belukha, 1 belukha
4:29 Threemile Creek
4:31 Tyonek
4:32 North Foreland
4:34 Granite Point
4:37 Shirleyville
4:40 1 belukha
4:42 McArthur River – 10-15 belukhas north of river mouth, 9 belukhas in river
4:57 Across inlet
4:59 Finish."

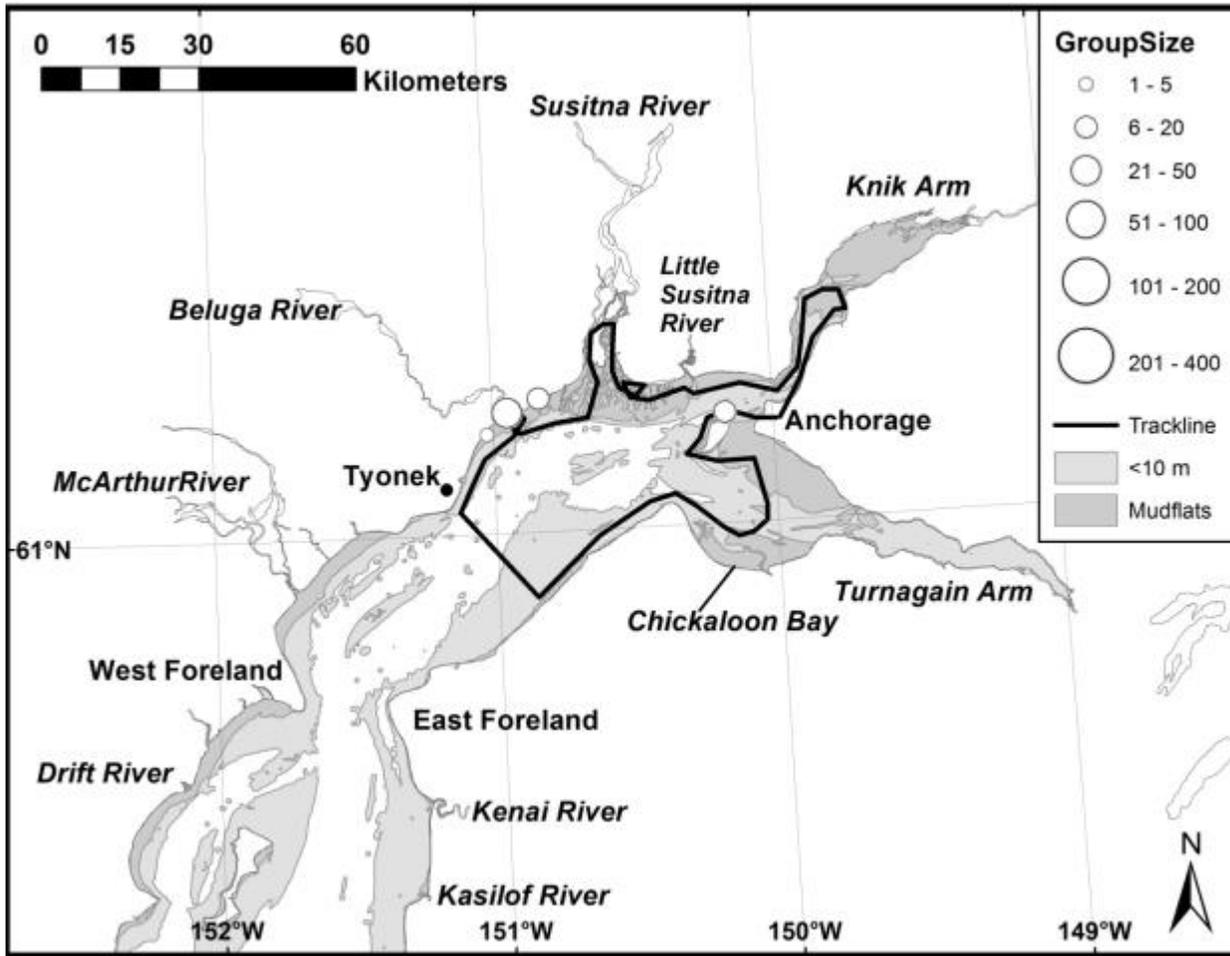


June 22, 1982

July 2, 1982:

Transcriber's note: *This survey included field notes on which the flight service was identified but not the pilot or observer(s) were identified. Handwriting appears to be Mark Chihuly based on notes from July 8 flight. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

"Belukha Survey 7/2/82
Partly Cloudy Skies Rust's Flying Service
Wind Calm Cessna 185
Depart 8:30
Begin Pt MacKenzie 8:33
Cairn Pt 8:37
Eagle Bay 8:39
Goose Bay 8:43
Pt MacKenzie 8:47
Mouth Little Su 8:52
Mouth Big Su 8:58 – So. wind white caps
Big Su Delta 45-50 seals hauled out
Powerline Big Su River 9:06
Lewis River 9:11
Stop survey landed at Lewis River to pick up two bags left by Bruce Campbell
Start survey Lewis R 9:25
Theodore River 9:33 9 adults, 1 juvenile
Beluga River 9:37 31 adults, 2 juveniles
City of Beluga 9:40 2 adults, 1 juvenile (near Pulp dock)
Old Tyonek 9:44 cut across Cook Inlet
Boulder Pt 9:50
Moose Pt 10:00
Pt Possession 10:06
Strong wind blowing out of Turnagain Arm wind 35-40 mph
Middle of Chickaloon Bay cut across to Pt Campbell 10:15 too rough to survey further
West point Fire Island 10:18
North Pt Fire Island 10:20 5 adults, 2 juveniles
Pt MacKenzie 10:25
Lake Hood 10:30
Total 47 adults 6 juveniles
Over."



July 2, 1982

July 8, 1982:

Transcriber's note: *This survey included field notes on which the flight service and observer were identified and handwriting is presumably Mark Chihuly. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

"Kenai Air 185 Overcast Skies Wind Calm

7/8/82 Chihuly

Belukha Survey

Off Lake Hood 2:12

North point Fire Is. 2:16

West point Fire Is. 2:20

Chickaloon Bay 2:30 cut across

Pt. Campbell 2:35

Cairn Pt. 2:45

Eagle Bay 2:53

Goose Bay 2:55

Pt MacKenzie 3:02

Little Su 3:10

Big Su 3:15 turn up river west fork

Powerline 3:20

45 seals Big Su Delta

Lewis River 3:30

Beluga River 3:35 7 adult belukhas

North Foreland 3:40 cut across

Moose Pt shoal 3:47

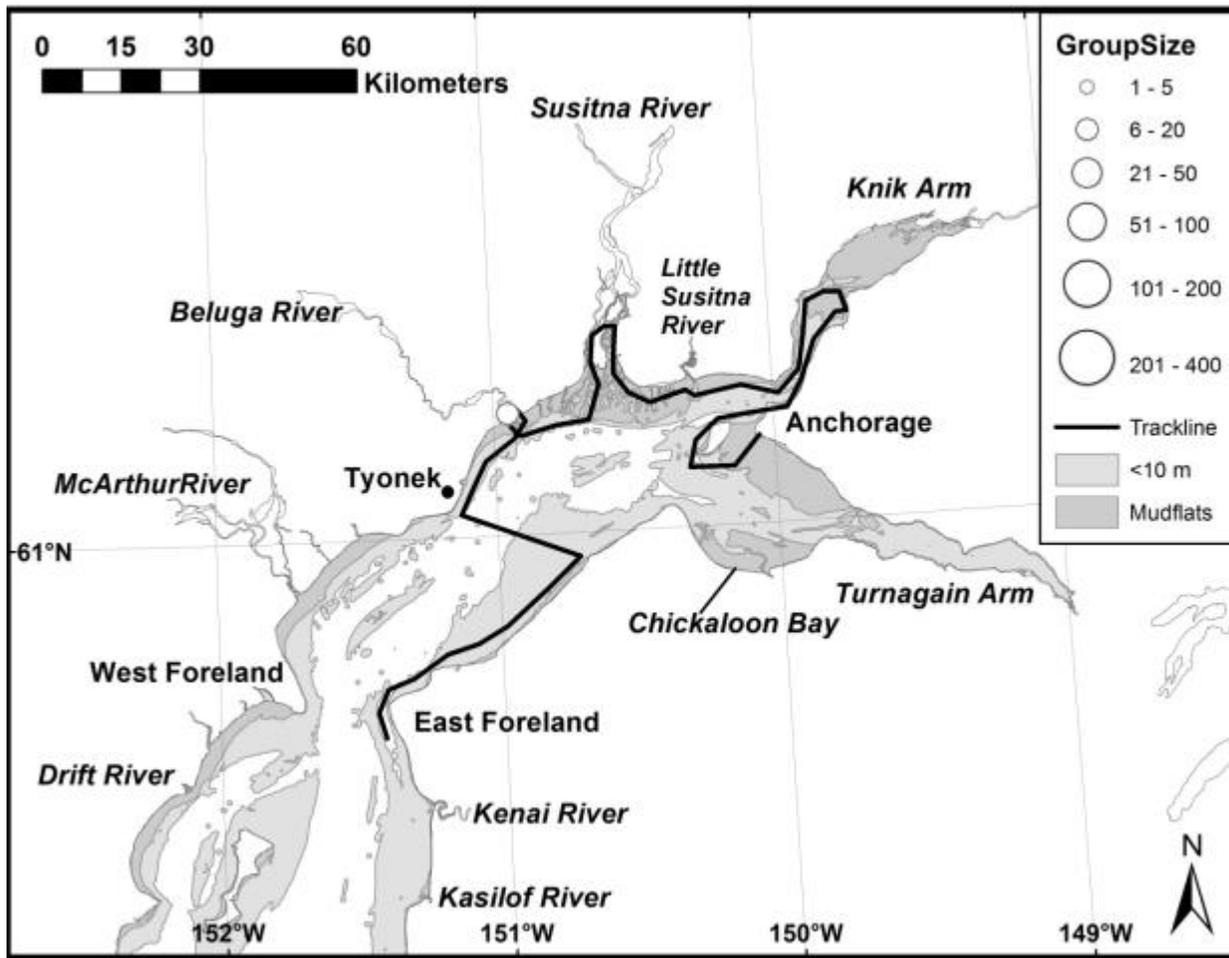
Number 3 Bay 3:55

Boulder Point 4:02

East Foreland 4:04

Oil Refinery 4:06

End Survey 4:10."



July 8, 1982

August 5, 1982:

Transcriber's note: *During this survey, field notes were written on a series of four maps showing time, trackline direction, and sighting locations. Maps were numbered 1 to 4 with notations at the end of each trackline segment indicating which map provided the next segment flown (e.g., "2*1" indicates the next part of the trackline on map #1 appears on map #2). Map #1 shows upper Cook Inlet north of Point Possession and the Little Susitna River, Map #2 shows the area surveyed north of Threemile Creek and Moose Pt., and south of Pt Possession and the Susitna River, Map #3 shows the area between Boulder Pt. and Moose Pt., and Threemile Creek and Granite Pt., and Map #4 shows the area surveyed south of Boulder Pt. and Granite Pt. to the Forelands. Handwriting appears to be Dennis McAllister (see also 6 April 1983 flight). The survey timeline from map to map is described below as the flight path moved counter-clockwise around the upper inlet:*

MAP #1

"Belukha Whale Survey

5 August 1982

D.C. McAllister & S. Albert

Cessna 185 M. Hauth

Off L. Hood 11:00 a.m.

On L. Hood 2:20 p.m.

Beluga R. area ~ 63

McArthur R. area ~ 62

Chickaloon Bay area ~ 30

Potter Marsh area ~ 21

176 total"

11:00 Lake Hood

11:10 Cairn Pt.

11:14 Eagle Bay

11:22 Goose Bay

11:27 Pt. MacKenzie

11:34 Little Susitna River, first bend

MAP #2

11:48 Susitna River, powerlines

11:52 Ivan River (noted "seals" on mudflats)

Off Theodore River noted "8 w/no@c" presumably 8 adult belugas with no calves

12:06 Beluga River "7 w/no@c" in the river mouth and "40 w/some@c" just offshore

Offshore of Threemile Creek "2 w/no@c"

MAP #3

12:20 Threemile Creek

12:24 North Foreland

12:29 Granite Pt.

MAP #4

Off Nikolai Creek "8 W/no@c", south of this group "4 w/1@c" and "15 w/2@c", then "11 w/0c", Off McArthur River "16 w/3@c+immatures" and "8 w/unk@c"

Last sighting was at 12:54

12:57 West Foreland

1:01 East Foreland

1:04 Boulder Pt.

MAP #3

1:14 Moose Pt.

MAP #2

1:20 Pt. Possession

MAP #1

At Pt. Possession bluffs "30 w/few@c"

1:30 Chickaloon River

1:35 Burnt Island

1:38 Crossing Turnagain Arm to Potter Marsh

Along mudflats south of Pt. Campbell "10 w/immature" and "11 w/immature"

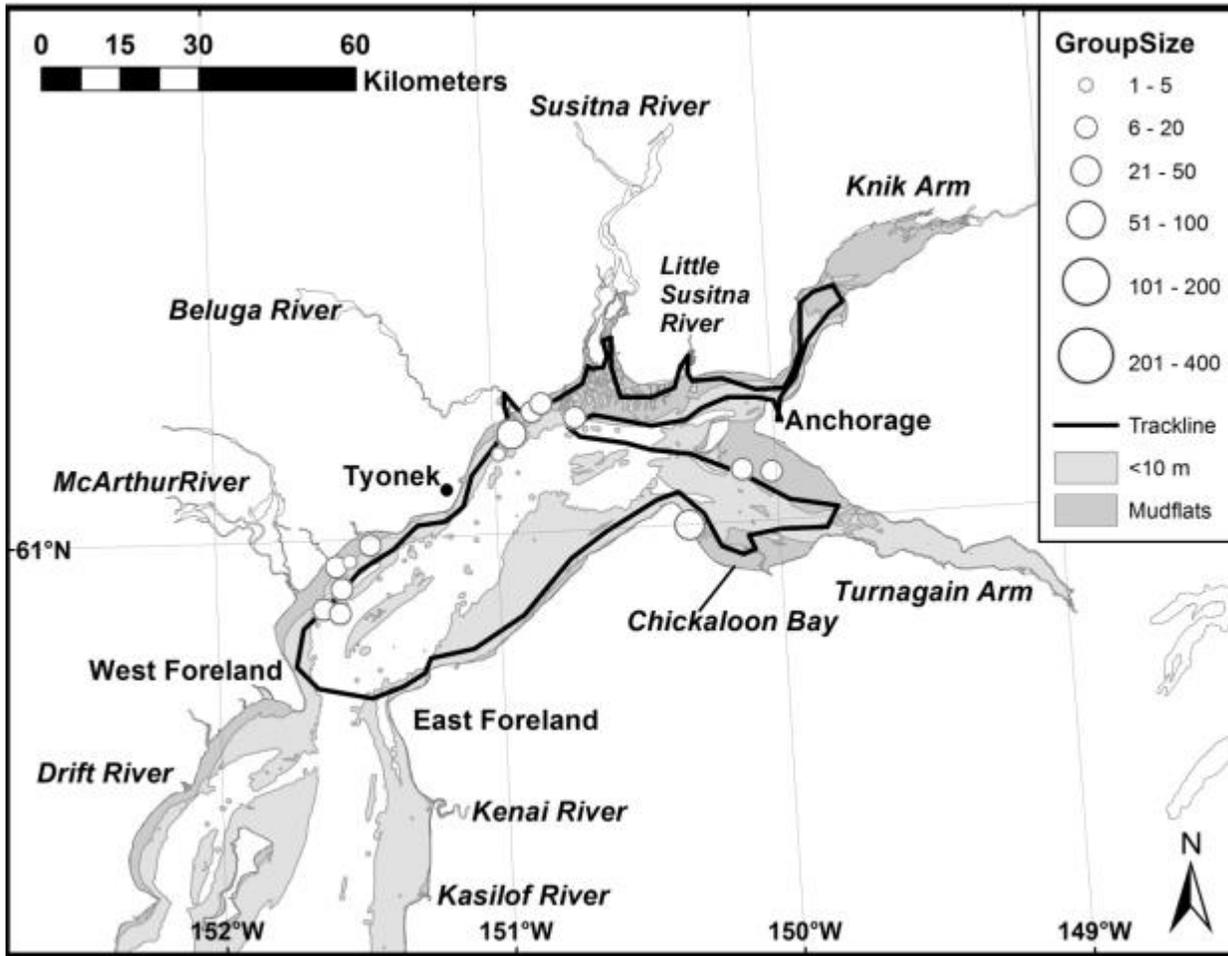
1:55 West Pt. on Fire Island

MAP #2

Crossed inlet along Susitna mudflats before turning offshore of Ivan River to follow mudflats back toward Anchorage at 2:07 – noted "6 w/10@c"

MAP #1

Offshore transect back to Lake Hood, landing at 2:20 p.m.



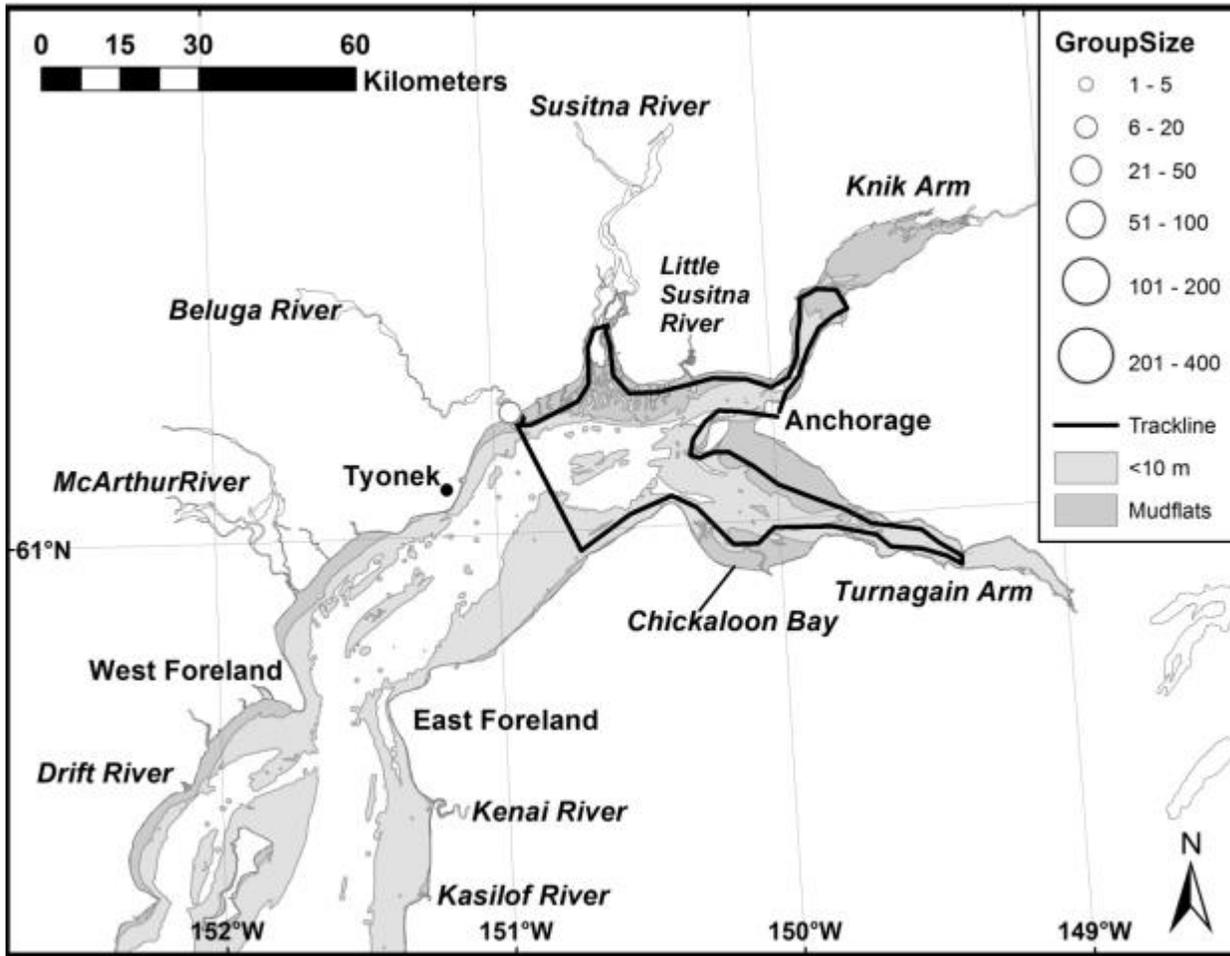
August 5, 1982

August 27, 1982:

Transcriber's note: *This survey included field notes on which the flight service, pilot, and observers were identified and handwriting appears to be Don Calkins. A map was not provided, therefore, trackline and sighting locations were recreated based on the following field notes:*

"Aug. 27, 1982

Belukha Survey Lorfstead
Kenai Air 185
McAllister Calkins
Off at 11:13
11:16 Fort Rich [*Richardson*]
11:20 Eagle Bay
11:25 Across [*Knik Arm*]
11:29 Goose Bay
11:36 Pt. MacKenzie
11:42 Little Su
11:46 Big Su
11:47 Up Big Su
11:53 Down (power line)
11:55 Out mouth, down Inlet
11:57 Ivan River
11:59 Theodore River
12:01 Beluga River – 15 belukhas in mouth
12:11 Across Inlet straight to Moose Pt.
12:18 Moose Pt.
12:24 Pt. Possession
12:29 Chickaloon
12:46 Bird Pt. back up Turnagain [*Arm*]
12:48 Indian [*Creek*]
12:53 Potter flats
12:55 Rabbit Creek
12:59 Pt. Campbell
1:00 Fire Island
1:03 West Pt. [*of Fire Island*]
1:10 end survey"



August 27, 1982

Table 1. Belukha survey of upper Cook Inlet 17 May 1982 through 27 August 1982 (from Calkins (text footnote 8)).

Date	Number sighted	Location sighted
May 17	15	South of Little Susitna R.
	10	North of Beluga R.
	15	W. pt. Fire Island
June 4	150-200	Between Susitna R. and Lewis R.
	100	Lewis R. to Beluga R.
	15	SW side Chickaloon Bay
	20	Chickaloon R. mouth
June 11	200-300	Lewis R. to Beluga R.
June 18	108	Susitna R. mouth
	39	Ivan R. to Beluga R.
	50-75	Beluga R. and mouth
	78	Beluga R. to Tyonek Village
	30	Chickaloon Bay
June 22	15	Boulder Pt. (N. of Kenai)
	4	Mouth of Susitna R.
	50-75	Lewis to Theodore R.
	40	Beluga R. and mouth
	25	McArthur R. and mouth
July 2	46	Susitna R. to Beluga R.
	7	
July 8	7	Beluga R. area
Aug. 5	63	Susitna R. mouth to Beluga R.
	62	McArthur R. area
	30	Chickaloon Bay
	21	Potter Marsh
Aug. 27	15	Mouth of Beluga R.

April 6, 1983:

Transcriber's note: *This survey included field notes that were written on a NOAA chart and show time, trackline direction, and sighting locations. Handwriting appears to be Dennis McAllister. The survey map is described below:*

"Belukha Whale Survey

6 April 1983

Craig Lofstedt – Pilot Kenai Air Alaska, Inc.

Roger Sleeper – Obs. [observer]

Dennis McAllister – Obs. [observer]

Cessna 185 \$160.00/Hr.

Total 10 Adult Whales

0 Subadult

0 Calf"

8:20 *Takeoff [Anchorage] heading into Knik Arm*

"1A" [1 adult beluga near Cairn Pt.]

8:38 *Plane turned to head out of Knik Arm before reaching Eagle Bay and continued to follow shoreline toward Susitna River.*

8:54 *At mouth of Susitna River (winds south at 5 mph, tide coming in), continued to follow shoreline to Theodore River, "1A" [1 adult beluga off Theodore River], circled mouth of the Beluga River.*

9:13 *"4A" [4 adult belugas offshore of the Beluga airstrip]*

9:20 *At North Foreland, turned offshore and crossed the inlet to just south of Gray Cliff*

9:24 *Gray Cliff (sunny, winds south at 5 mph, incoming tide).*

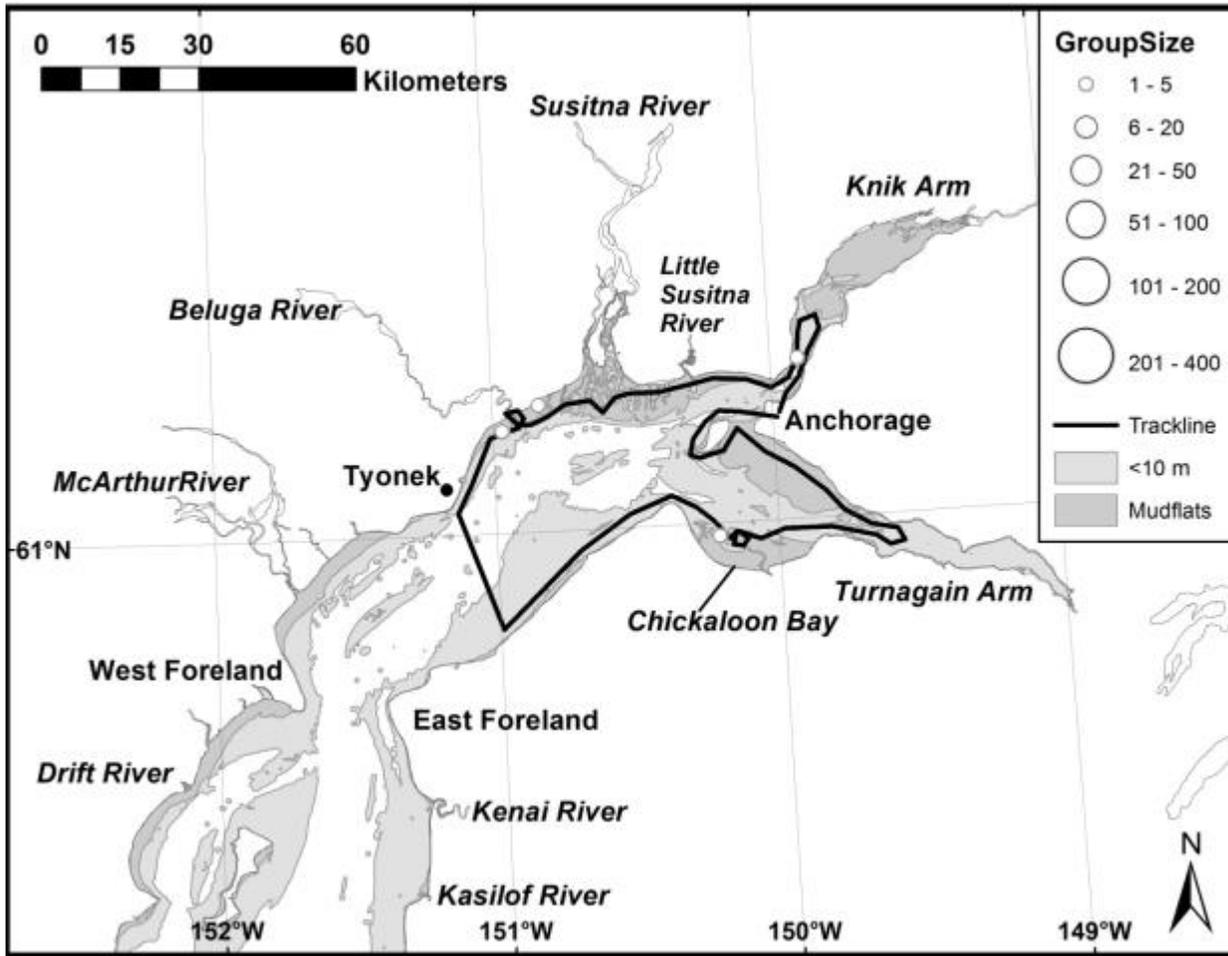
9:39 *Pt. Possession*

9:50 *Circled Chickaloon River, "4A" [4 adult belugas near bluffs] (sunny, winds west at 15 mph, incoming tide), continued in to Turnagain Arm.*

10:01 *Turned to exit Turnagain Arm at Windy Pt., followed shore line to Pt. Campbell.*

10:13 *Turned offshore to circle Fire Island, following east coast then west coast, crossing back toward Anchorage at North Pt.*

10:30 *Landed.*



April 6, 1983

April 28, 1983:

Transcriber's note: *This survey included field notes that were written on a NOAA chart and show time, trackline direction, and sighting locations. Handwriting appears to be Dennis McAllister. The survey map is described below:*

"Cook Inlet Belukha Whale Survey

28 April 1983

Kenai Air Alaska, Inc. Cessna 185

Monte Hauke – Pilot

Dennis McAllister – Obs. [observer]

Tina Cunning – Obs.

rain 28 Adult Whales [note: should be 34 Adult Whales based on total count from map]

calm 3 Juveniles

1 Calf?"

9:10 *Takeoff [Anchorage] heading into Knik Arm*

9:15 *Cairn Pt.*

Surveyed Eagle Bay (outgoing tide, calm, dry), then crossed inlet to Goose Bay.

9:20 *Completed Goose Bay, then continued along shore line to Little Susitna River.*

9:30 *Surveyed to first bend of Little Susitna River, "5A" [5 adult beluga at mouth of Little Susitna River]*

9:41 *Entered Susitna River, up to power lines, then back to coastline.*

9:45 *"1A" [1 adult beluga off Ivan River]*

9:55 *Approaching Beluga River, circled mouth "6A" [6 adult belugas off mouth of river]*

10:00 *Threemile Cr. (light rain, calm, outgoing tide)*

10:05 *North Foreland, turned offshore and crossed the inlet to Number Three Bay*

10:13 *Number Three Bay*

10:19 *Moose Pt.*

"1C 3J 22A" [1 calf, 3 juveniles, and 22 adult belugas south of Pt Possession]

10:25 *Pt. Possession*

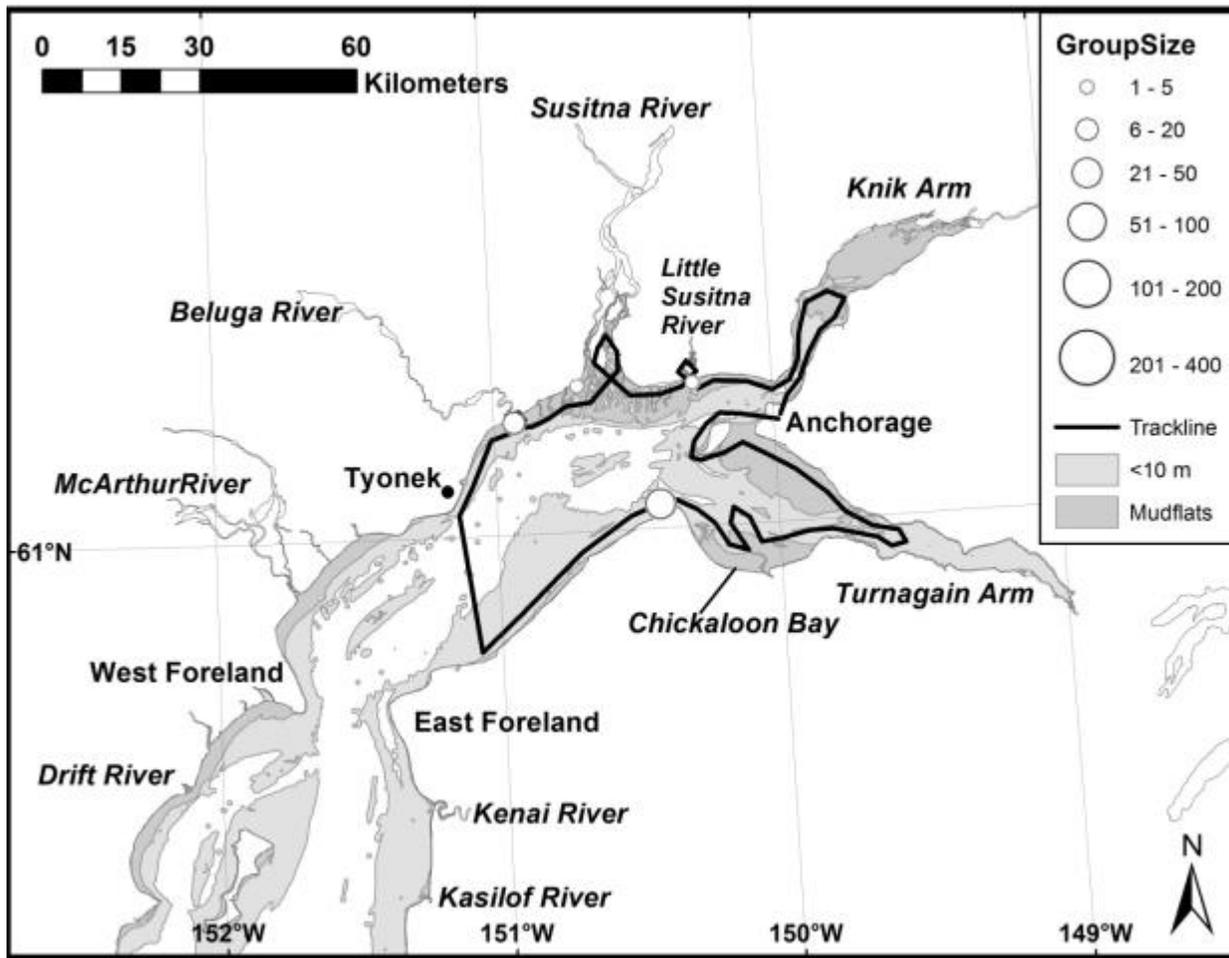
10:35 *Chickaloon River (calm, dry, outgoing tide)*

10:45 *Entering Turnagain Arm*

10:50 *Turned to exit Turnagain Arm at Windy Pt. (calm, rain, outgoing tide), followed shore line to Pt. Campbell, turned offshore to circle Fire Island, following east coast then west coast*

11:05 *At North Pt., crossing back toward Anchorage*

11:10 *Landed.*



April 28, 1983

May 27, 1983:

Transcriber's note: *This survey included comprehensive field notes and a NOAA chart showing trackline, time, and composition of beluga groups. Handwriting on map appears to be Jon Lewis and handwriting on the field notes appears to be Mark Chihuly. The field notes stated:*

"Beluga Survey 5-27-83

Pilot – Chris Branham

Observers – Jon Lewis & Mark Chihuly

Aircraft – Helio Courier

Survey time 9:12 to 11:16

Total Cost - \$300.00 = 2 hrs. x 150.00 per hour.

Weather – high overcast. Light wind from the south (2 mph)

Tide – High and receding, the water was calm.

Total number of belugas counted – 262 – no. of juveniles 47, no. of adults 215

173 whales were sighted near the mouth of the Beluga River in Cook Inlet. 29 of those whales spotted were juveniles.

83 whales were sighted near the mouth of the Theodore River in Cook Inlet. 18 of those were considered Juveniles.

6 whales were sighted just south of Point Possession. All of those were Adults.

2 passes were made on the whales near the Beluga River and Theodore River. The first pass was at approx. 300 ft. altitude. The second pass was at 500 ft. altitude. The counts were 154 and 256, respectively.

The whales in both of these areas were heavily concentrated and very hard to count accurately. My estimation is that our count is low.

No calfs (sic.) were spotted that were smaller than half of the size of the adult belugas.

4 harbor seals were also sighted."

The survey map is described below:

*"Beluga Survey – 5-27-83, Cris Branham – pilot, Chihuly/Lewis – ob
High tide – going out, Good/exc. conditions, Aircraft – helio courier"*

9:02 Departed Anchorage

9:12 Takeoff and crossed Knik Arm to survey western shoreline to Goose Bay

9:22 At Goose Bay, crossing arm to Eagle Bay where shoreline survey continued south

9:29 Cairn Pt. (note on map "FISHING?"), crossed arm to Pt. MacKenzie and resumed coastal survey to Little Susitna River

9:37 Little Susitna River, continued along shore entering Susitna River

9:48 Power lines on Susitna River, turning to exit river

9:54 Ivan River, at Theodore River, 8 harbor seals and beluga groups near the Theodore and Beluga rivers

Pass 1: Theodore count – 4J, 61A, 9J, 17A

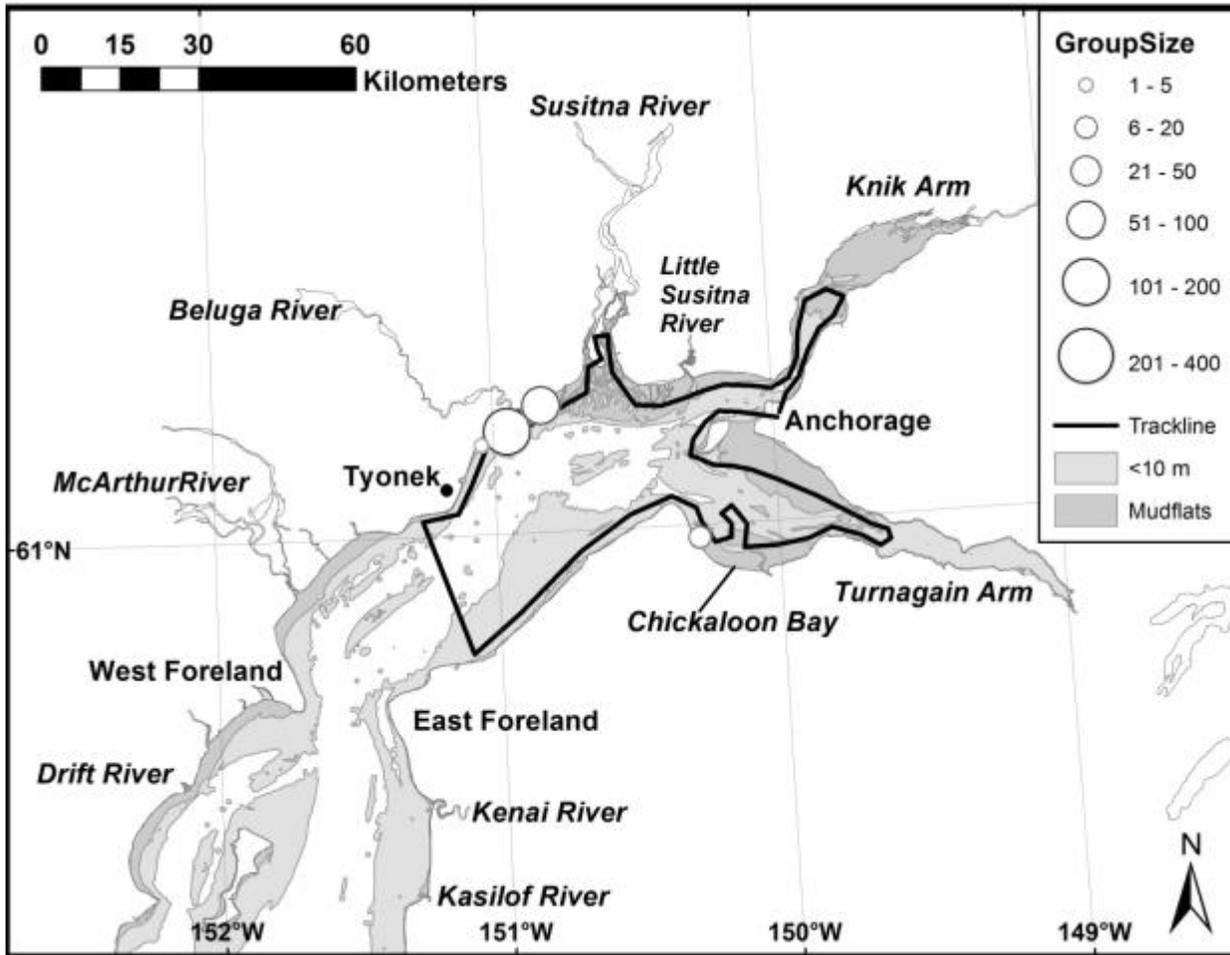
Beluga River count – 11A, 3J, 38A, 11J

Pass 2 (500 ft fly by): Theodore count – 59A, 18J, 6A

Beluga River count – 95A, 11J, 99A, 18J

10:10 "5A" (five adult belugas) off Beluga airstrip, survey continued south to Beshta Bay then crossed the inlet.

- 10:25 (shoreline cut off on photocopy but appears to have crossed to Number Three Bay/Gray Cliff)
- 10:39 Pt. Possession
- 10:44 Bluffs between Chickaloon River and Pt. Possession, "6A" (six adult belugas), track continued into Turnagain Arm
- 10:55 Aircraft crossed arm to Rainbow Creek, resuming survey out of Turnagain Arm along north shoreline following mud flats to West Pt. of Fire Island
- 11:09 Shelter Bay on Fire Island, followed mudflats from North Pt. to Pt Woronzof
- 11:16 Landed Anchorage.



May 27, 1983

June 24, 1983:

Transcriber's note: *This survey included field notes and a NOAA chart showing trackline, time, and composition of beluga groups. Handwriting on field notes appears to be Mark Chihuly, handwriting on the NOAA chart does not match any previous observers yet other observers were not noted. Field notes stated:*

"Beluga Survey – 6-24-83

Pilot – Dale from Rust's Flying Service

Observer – Chihuly

Time off 7:20 AM

Land – end survey 9:20

2 hrs at 190 hr = 380.00 Cessna 206

Tide was high and receding

Skies were high overcast & wind was calm

13 total belugas were observed.

1 seal on bar in Su. River.

Note* Dale the pilot commented that because we were between runs of salmon he believed most of the whales had moved out to below Kenai somewhere and would follow the next run up."

The survey map is described below:

"[Date is cut off on photocopy]

Beluga Survey

off 7:20

Rust Flying Service

206

High tide going out

High overcast

Wind calm

In 9:20"

7:20 *Takeoff, surveyed east shore of Knik Arm, "1 Adult" [adult beluga] south of Cairn Pt.*

7:*3 *[fold in paper obscuring time], at Windy Pt. in Eagle Bay, crossed arm to Goose Bay and continued coastal survey to Little Susitna River*

7:45 *Little Susitna River, continued following shoreline then entered eastern tributary of the Susitna River, "1 seal" [harbor seal] near Delta Island. At power lines began survey of western tributary back to the inlet. Resumed coastal survey, encountering "4 Adults" [belugas] off the Theodore River*

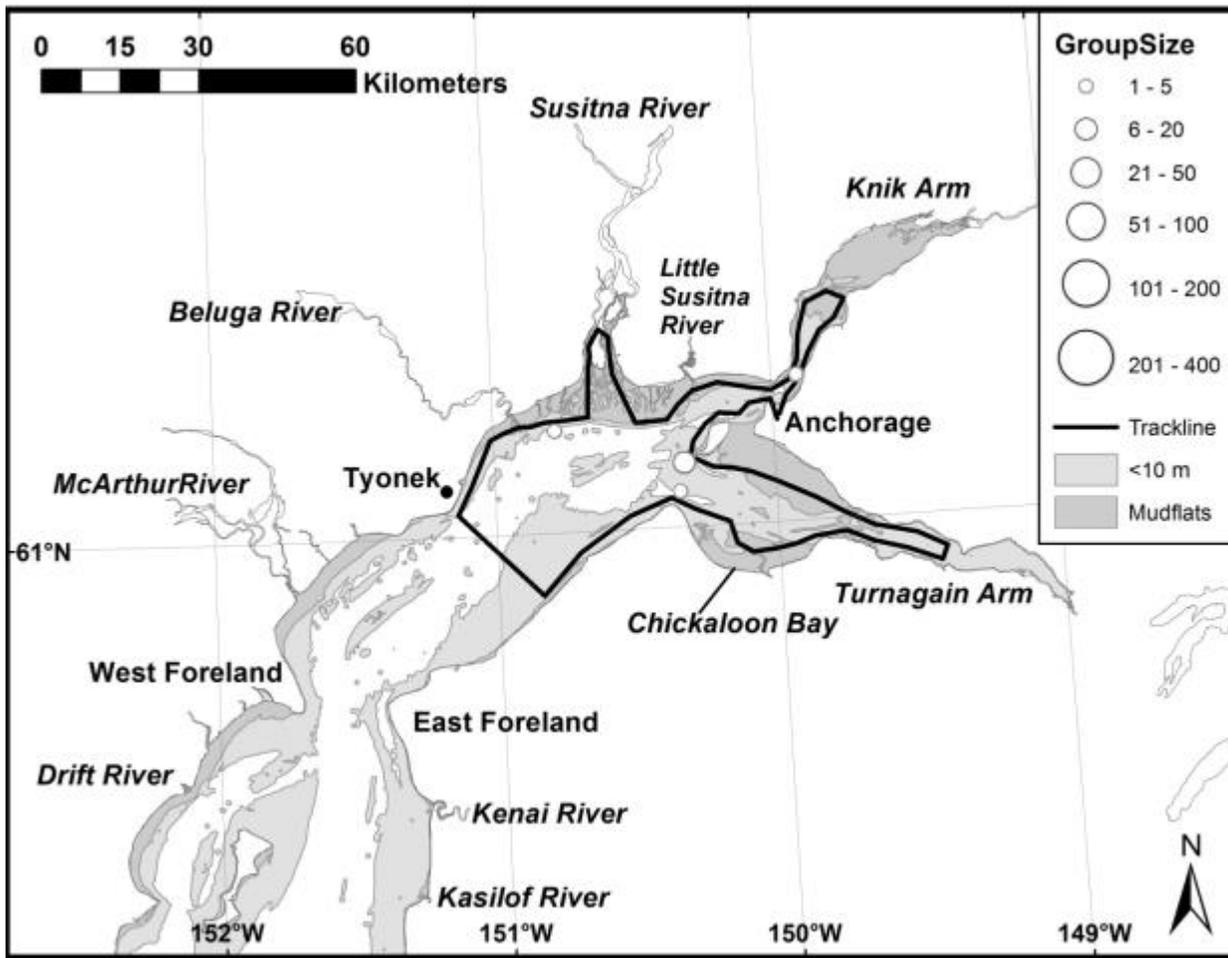
8:05 *Beluga River*

8:10 *North Foreland, crossed inlet to eastern shore just north of Gray Cliff and continued north*

8:30 *Pt. Possession, "1 Adult" [beluga], continued to Chickaloon River and surveyed part way up the river then continued into Turnagain Arm*

8:45 *At Hope in Turnagain Arm, continued to Sunrise then turned to follow north shoreline back to Fire Island, off West Pt. of Fire Island encountered "7 Adults" [belugas], surveyed west shoreline of Fire Island before heading in to land*

9:20 *Landed*



June 24, 1983

July 19*, 1983:

Transcriber's note: *This survey included a short summary of the flight and a NOAA chart showing time, trackline direction, and sighting locations. Handwriting appears to be Don Calkins. *In Table 2 of Calkins (see text footnote 8 and Table 2 below) the date for this flight was July 20 not 19). Field notes stated:*

“Belukha Survey

7/19/83

Pilot: Monty Houck C185 Kenai Air

Obs.: Don Calkins

Departed Anchorage International Airport at 1240

Weather – scattered clouds warm sunny day winds light and variable, seas calm

Land at Kenai at 1430 – total air time less ferry time from Kenai – 1 hr 50 min

Sighted total of 176 whales comp count not possible. Whales scattered across inlet between West and East Forelands. Large group near East Foreland just off N. Kenai. No whales at mouth of Kenai R.”

The survey map is described below:

“Belukha Survey

7/19/83

Pilot Monty H.

Kenai Air 180

Observer Calkins”

Photocopies of NOAA charts labeled 1-5.

1240 Start

1248 Transect “A” headed into Turnagain Arm along north shoreline, did not enter arm instead cut across at McHugh Creek to Gull Rock headed toward Chickaloon Bay

1255 East of Burnt Island, crossed Chickaloon Bay to Pt. Possession

1300 Pt. Possession, crossed to West Pt. of Fire Island

1309 Transect “B” Fire Island, crossed to Pt. Woronzof and entered Knik Arm following east shoreline

1318 Eagle Bay

1322 Goose Bay

1328 Pt. MacKenzie

1333 Little Susitna River, continued along shore to Susitna River, at eastern tributary “20 whales no composition” [belugas], at western tributary surveyed up river to power lines

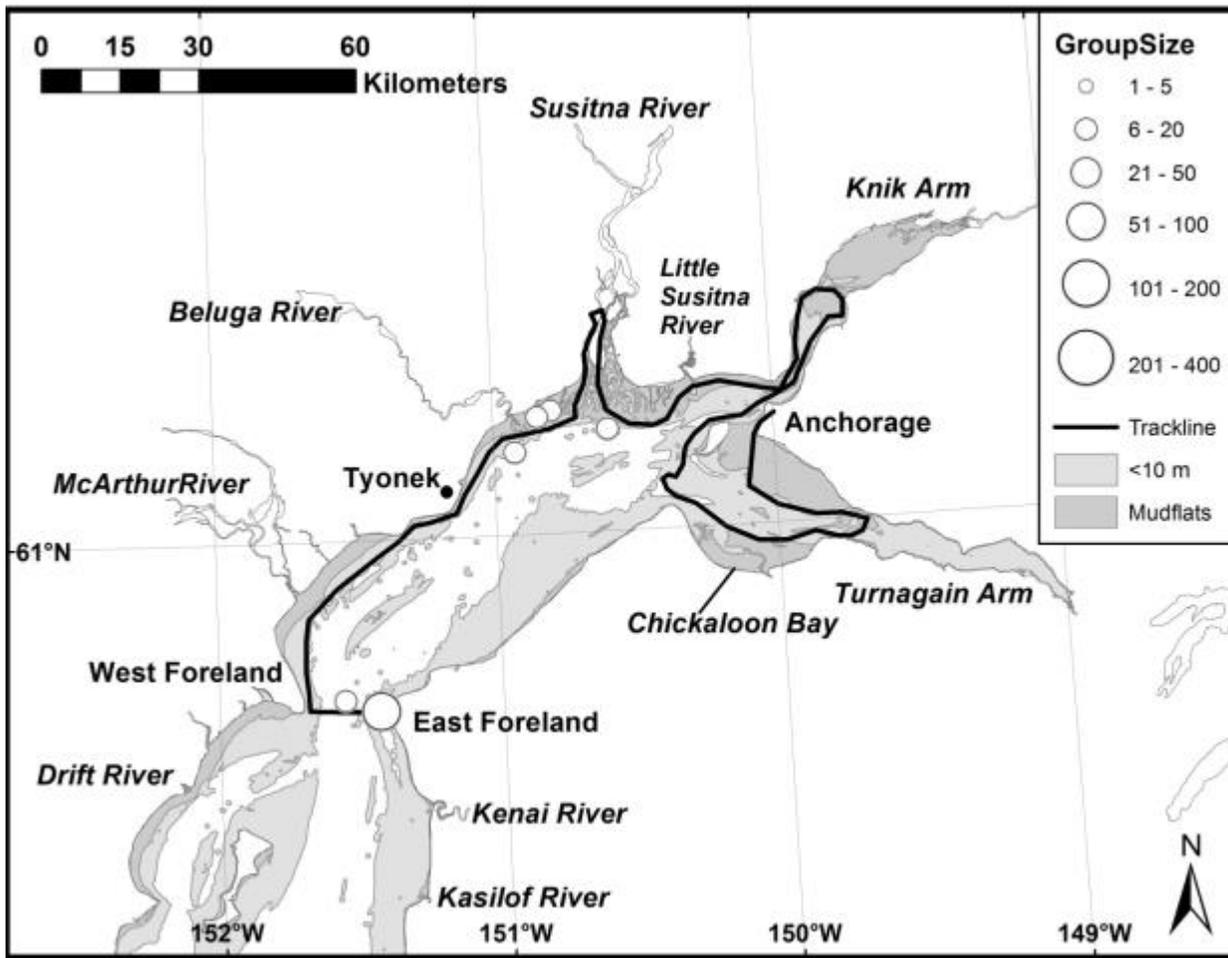
1344 Transect “C” at Lewis River “16w” [16 adult belugas], then “10w” at Theodore River, and “10w” at Beluga River

1400 North Foreland

1406 Transect “D” Shirleyville

1412 West Foreland, crossed inlet to East Foreland encountering “several - 15-20” mid-inlet, then “about 100 whales” along the shore at East Foreland

1430 Land at Kenai



July 19 or 20 (see table and notes), 1983

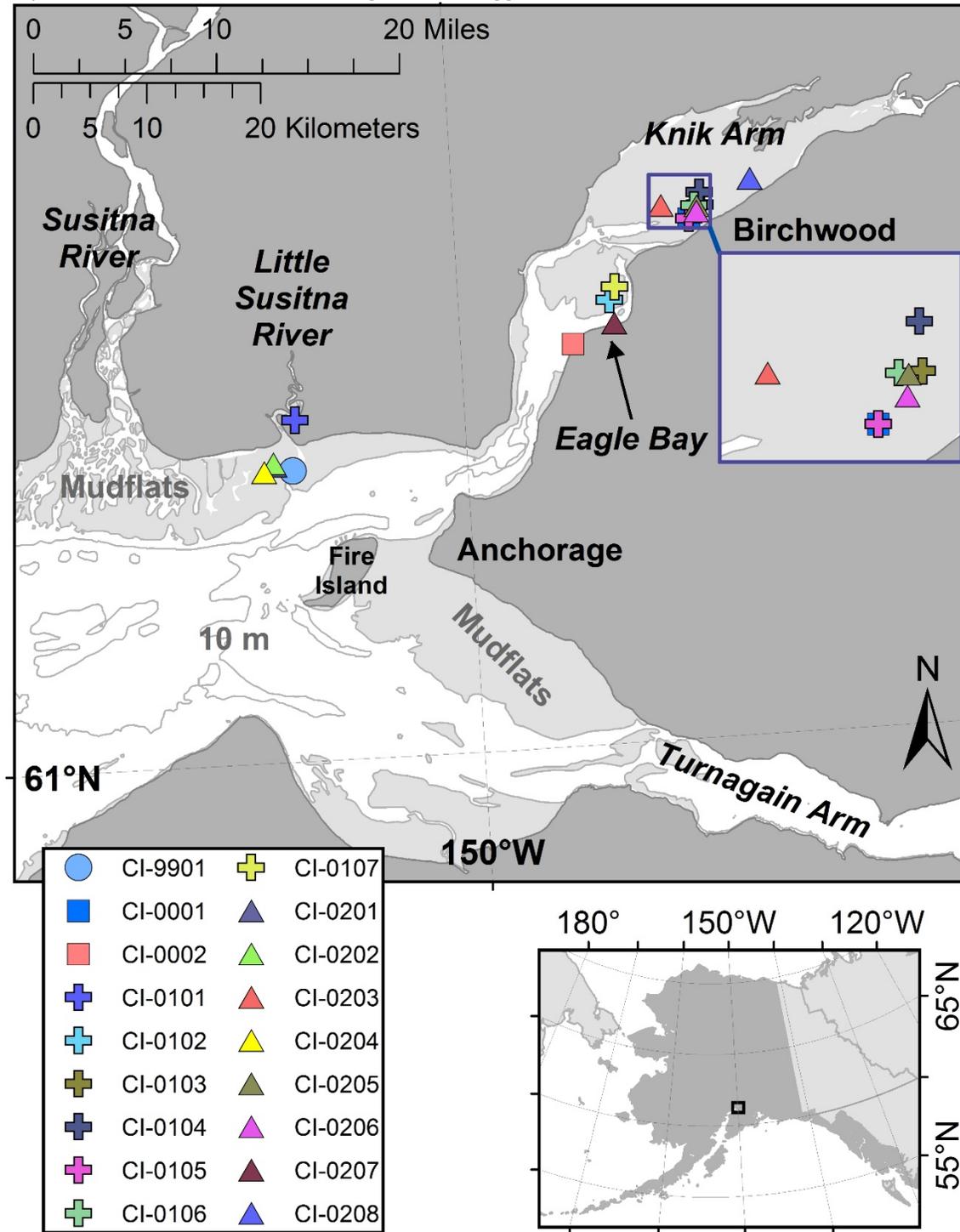
Table 2. Belukha survey of upper Cook Inlet 6 April 1983 through 20 July 1983 (from Calkins (text footnote 8)).

Date	Number sighted	Location sighted
April 6	1	Knik Arm
	1	Mouth of Theodore R.
	4	Mouth of Beluga R.
	4	Chickaloon Bay
April 28	5	Little Susitna R.
	1	W. side Susitna R.
	6	Mouth of Beluga R.
	25*	Off Pt. Possession
May 27	173	Mouth of Beluga R.
	83	Mouth of Theodore R.
	6	Chickaloon Bay
June 24	1	Knik Arm N. of Anch.
	4	Off mouth of Theodore R.
	1	Off Pt. Possession
	7	S.W. of Fire Island
July 20	20	S.E. Susitna R. mouth
	16	Lewis R. mouth
	10	Theodore R. mouth
	10	Beluga R. mouth
	20	3 mi. E. of West Foreland
	100	Off E. Foreland

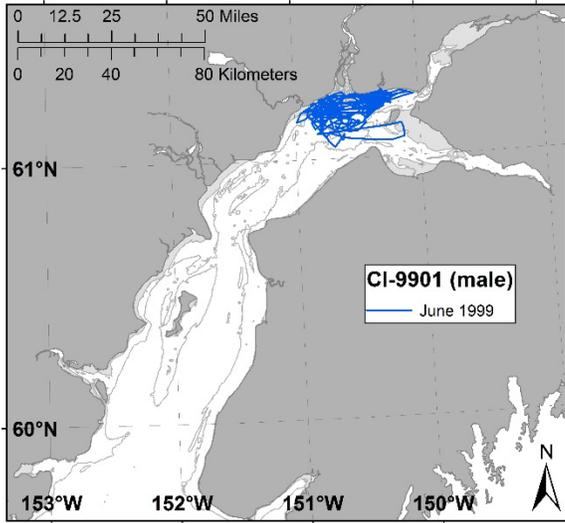
**note: group size is 26 on the 28 April map.*

Appendix 3.—Beluga whales tagged with satellite-linked transmitters during the period 1999-2003 in Cook Inlet, Alaska. Maps show movements of each individual whale identified by CI number (see text Table 2) within a particular month.

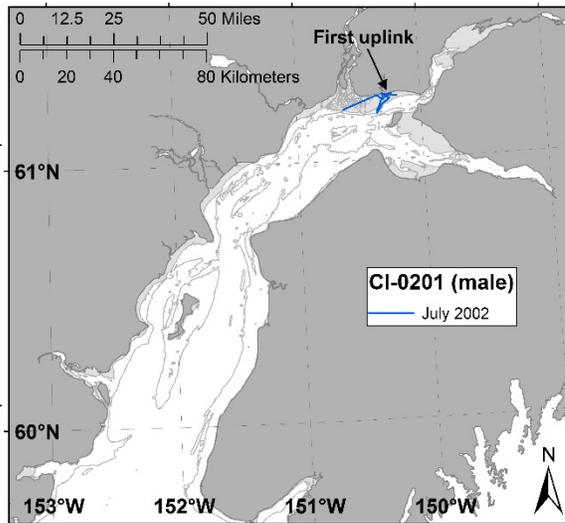
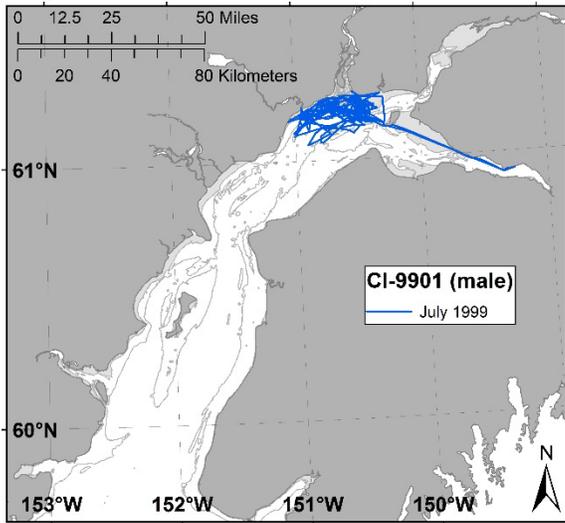
Capture locations of Cook Inlet beluga whales tagged with satellite-linked transmitters



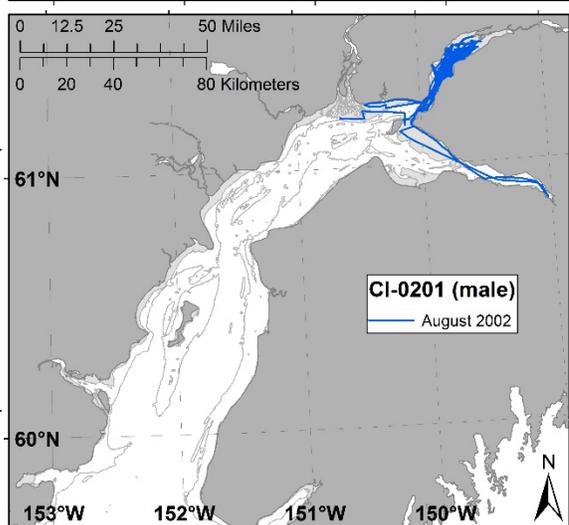
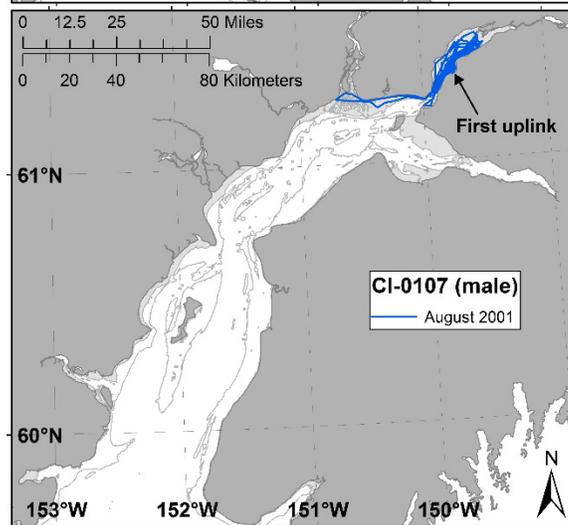
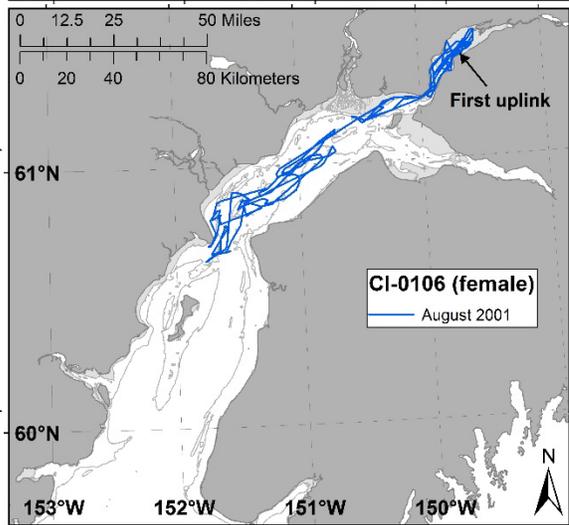
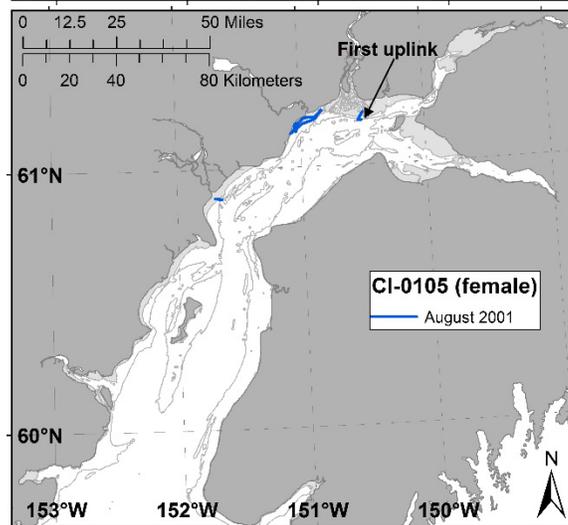
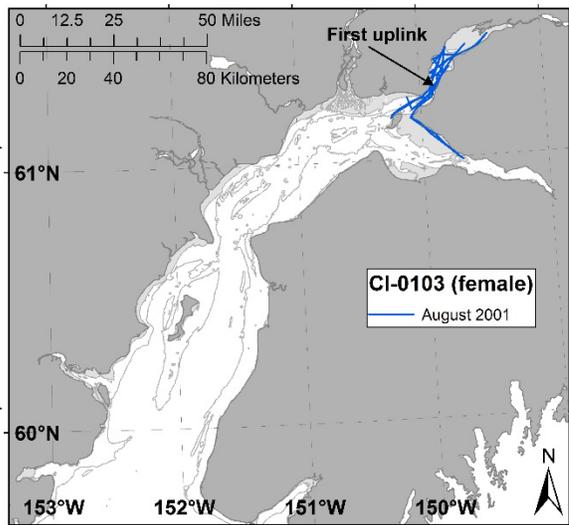
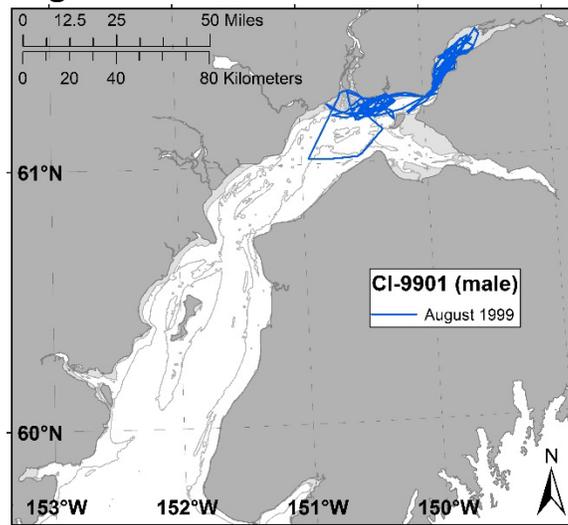
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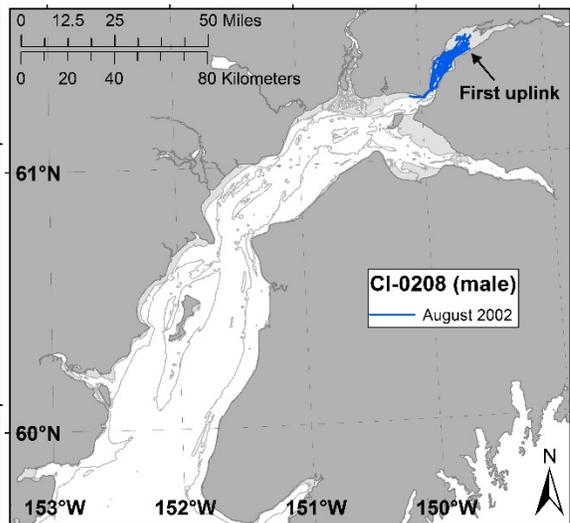
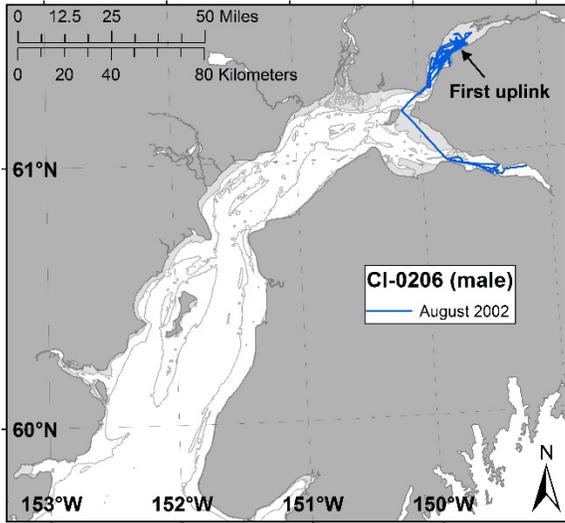
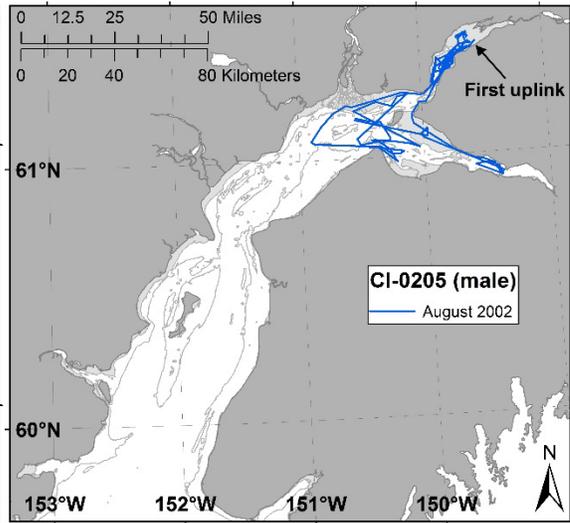
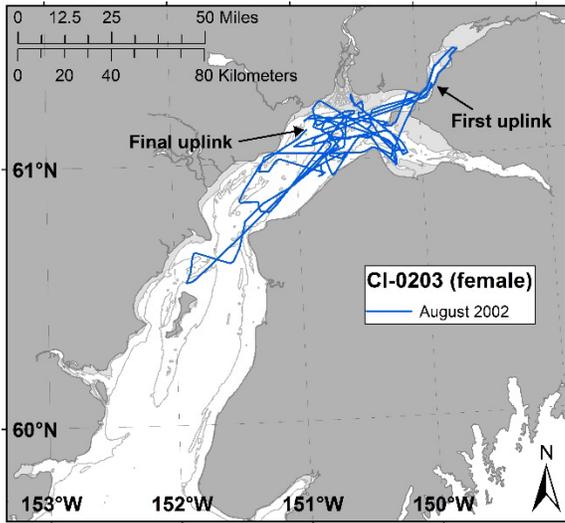


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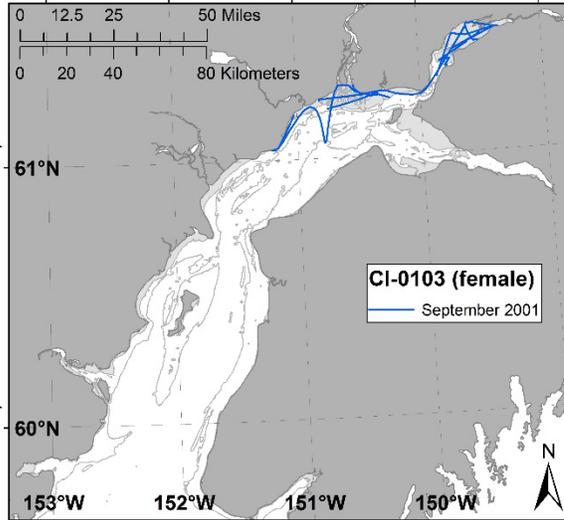
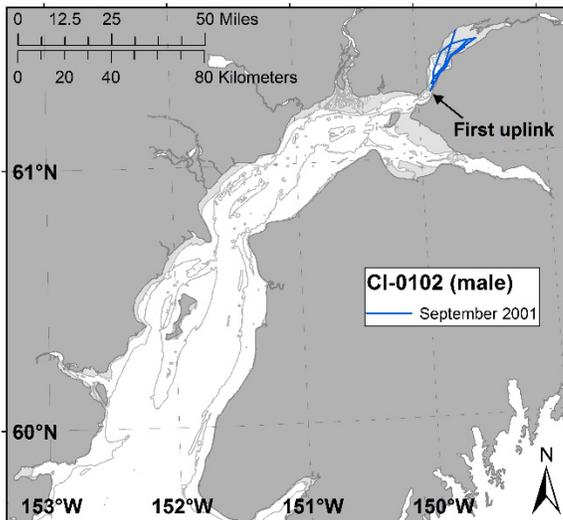
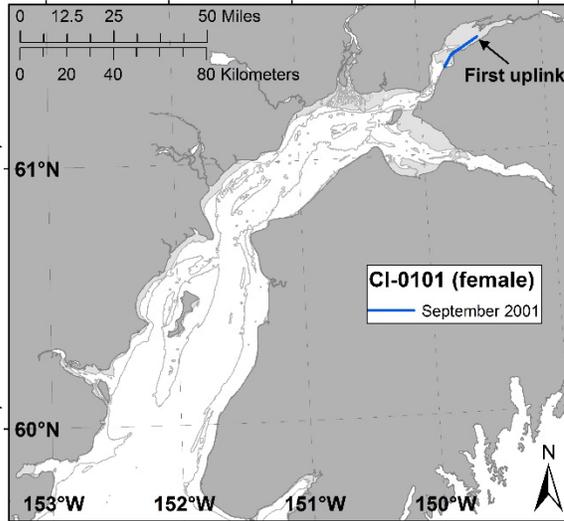
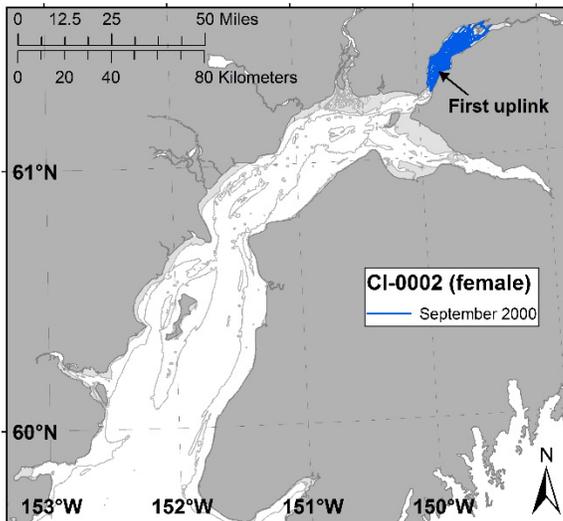
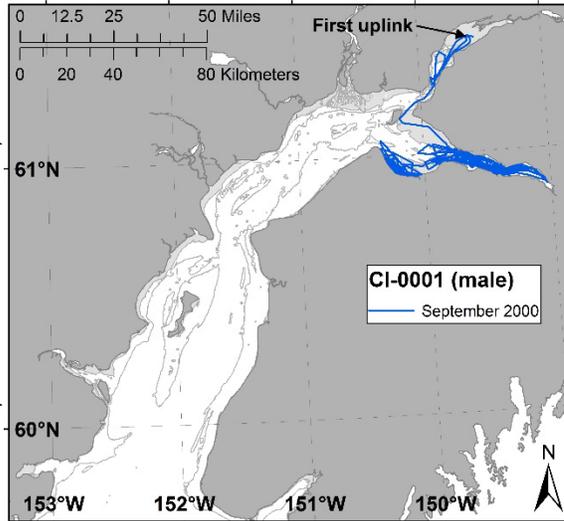
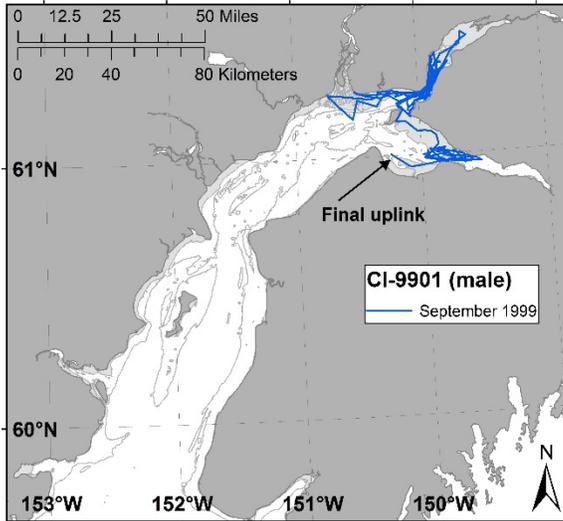


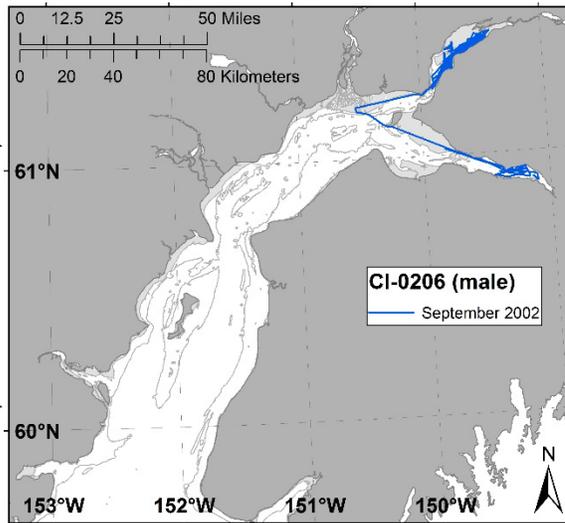
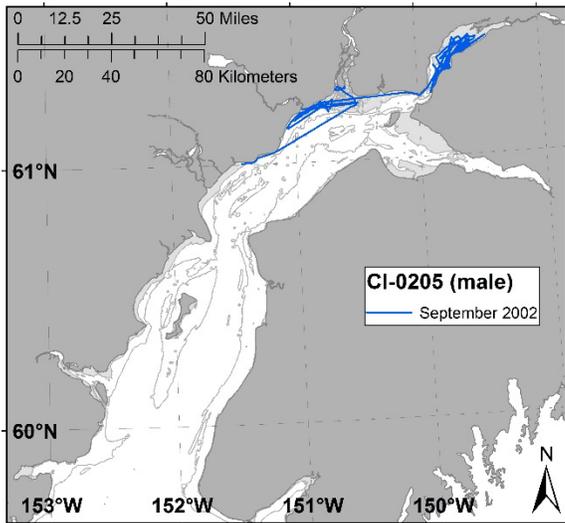
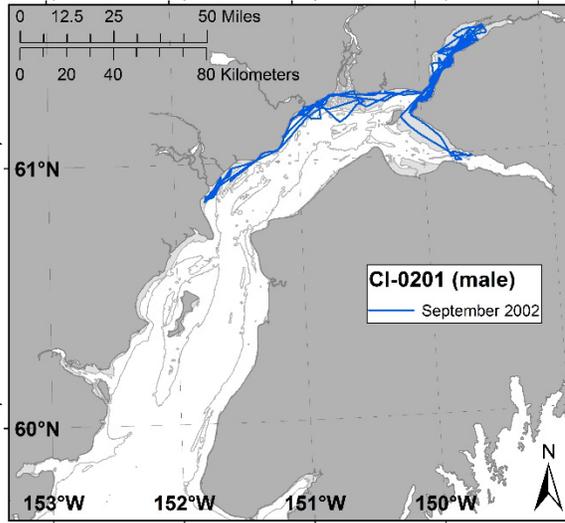
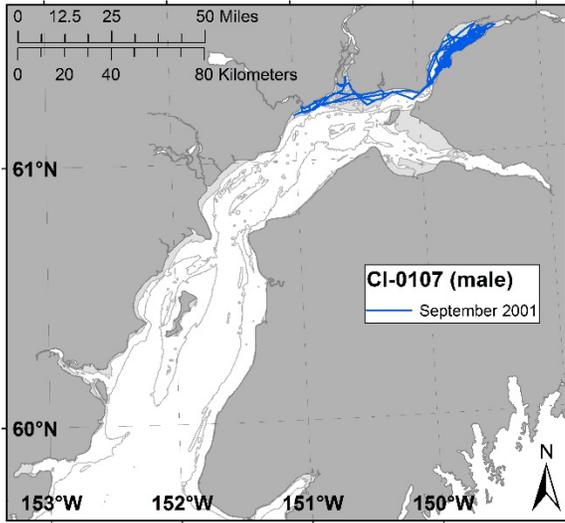
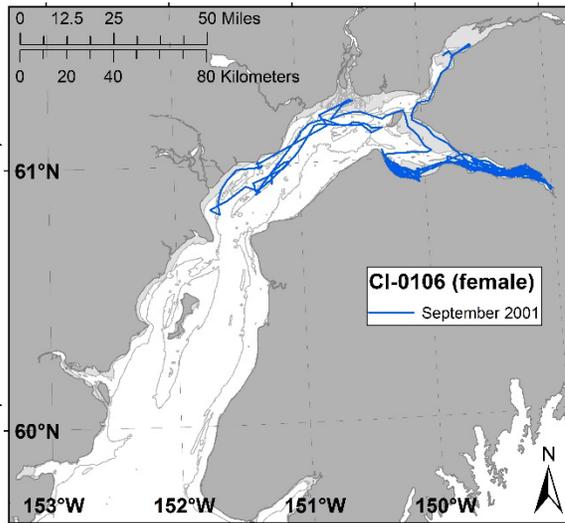
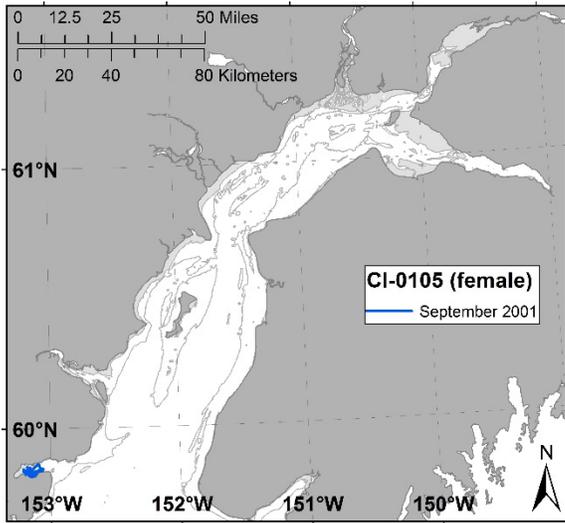
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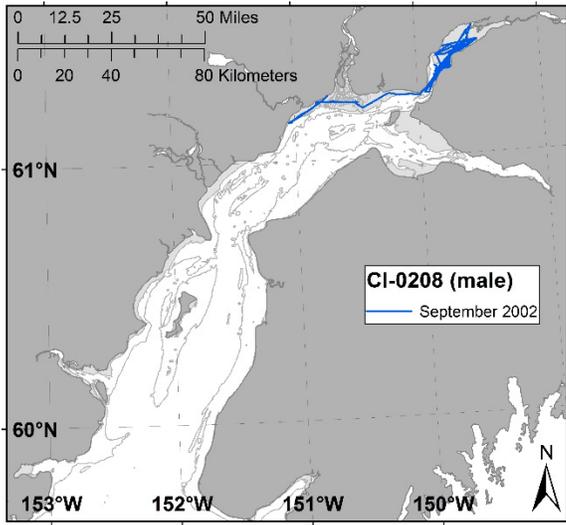




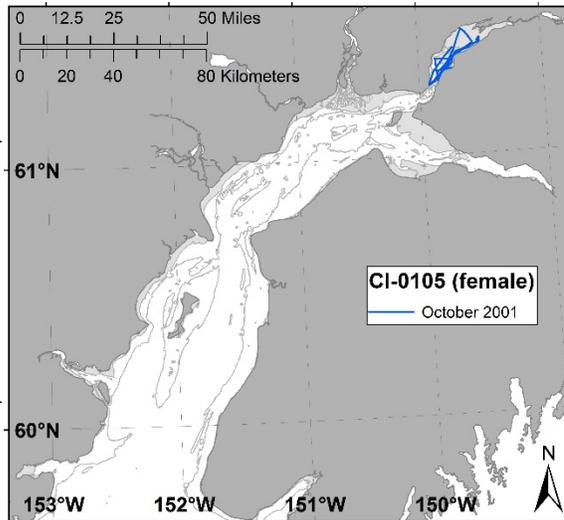
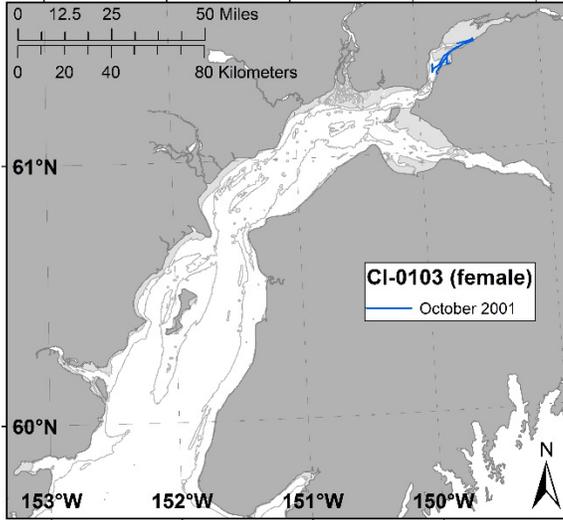
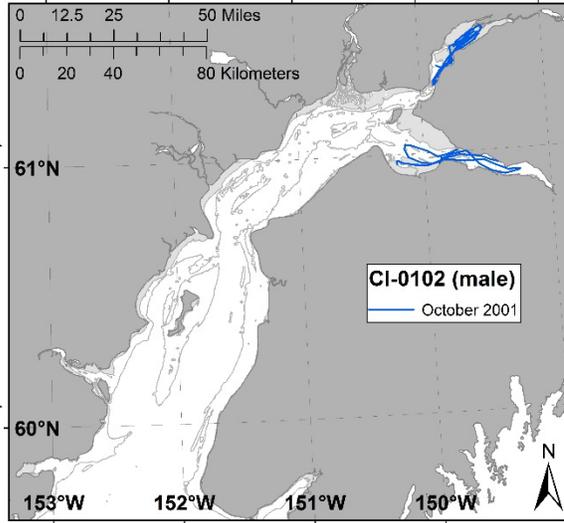
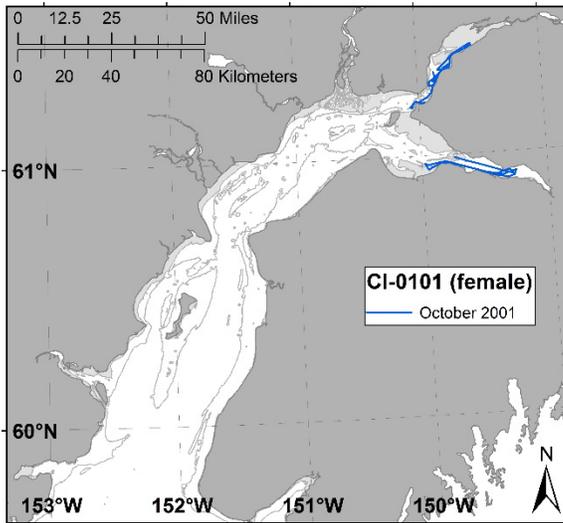
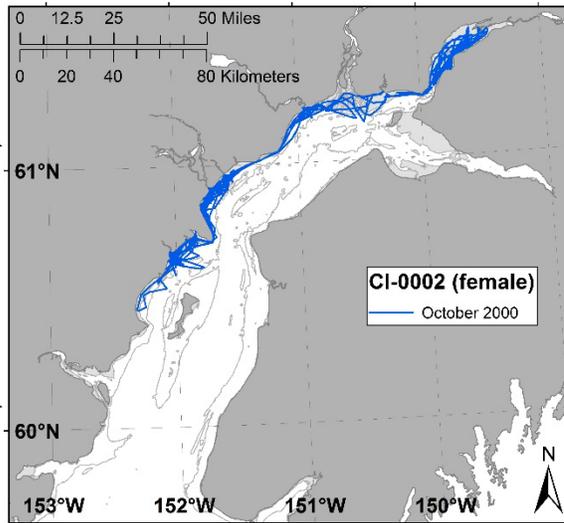
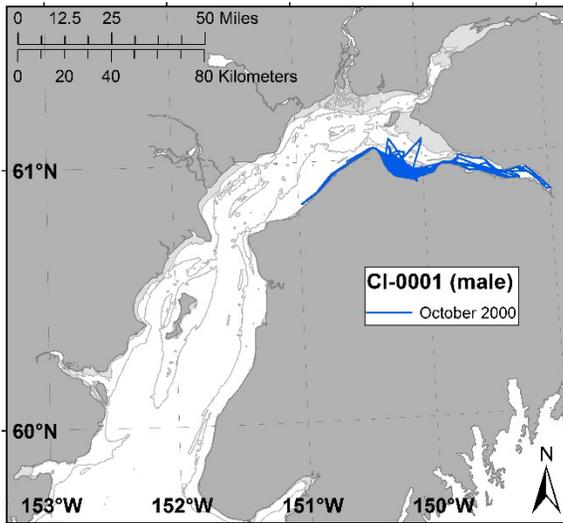
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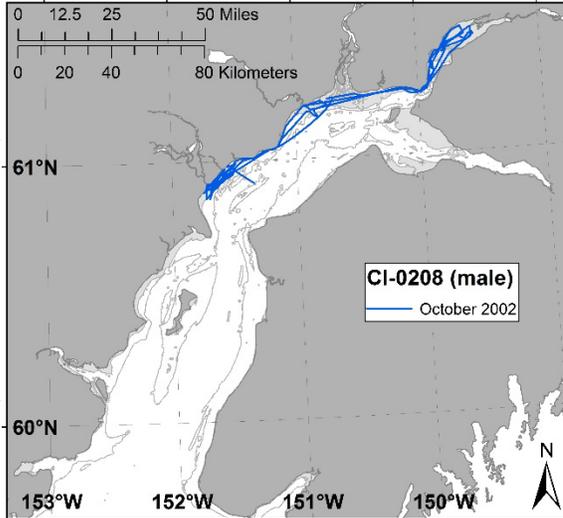
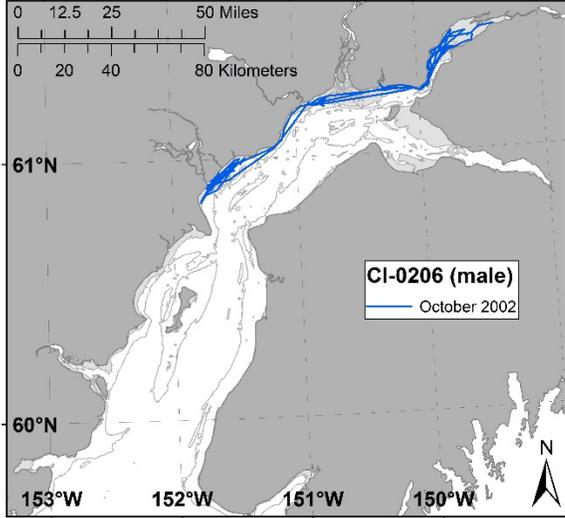
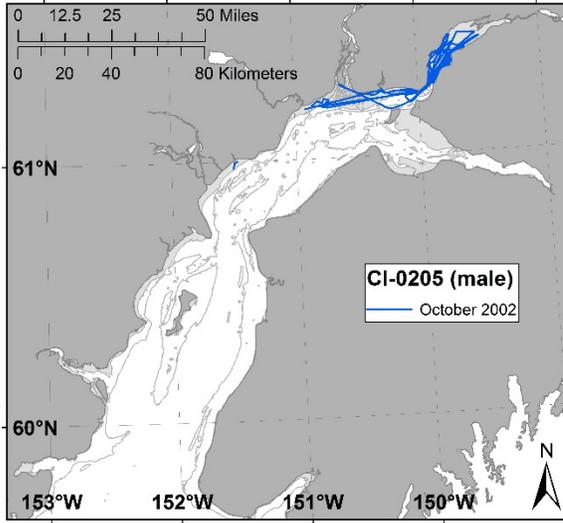
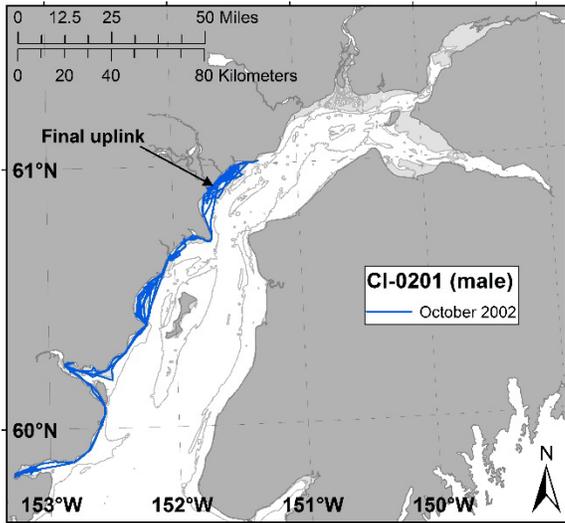
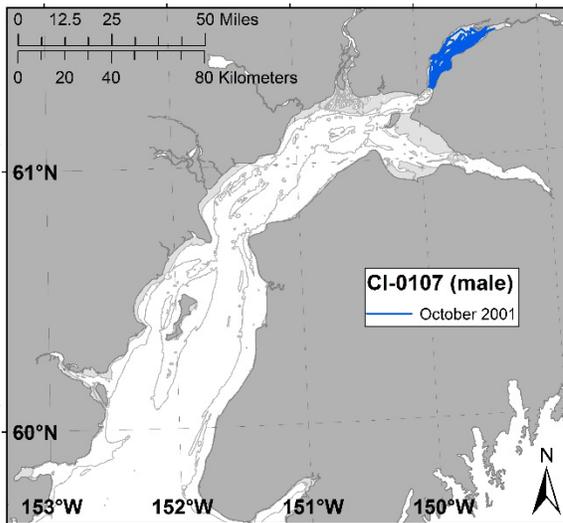
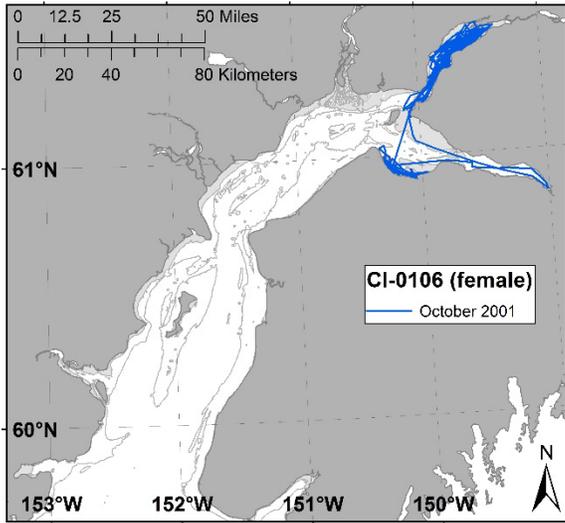




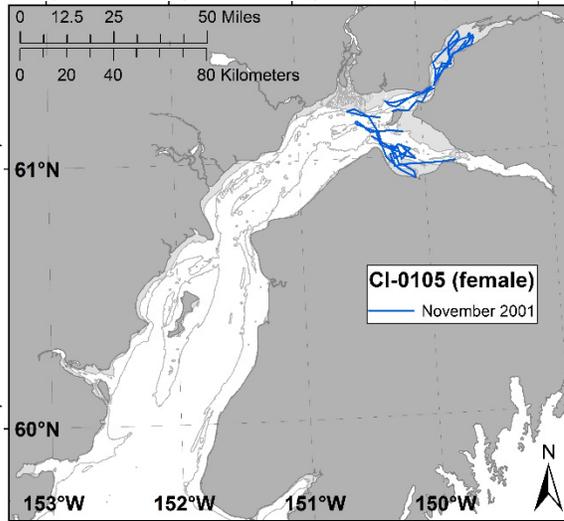
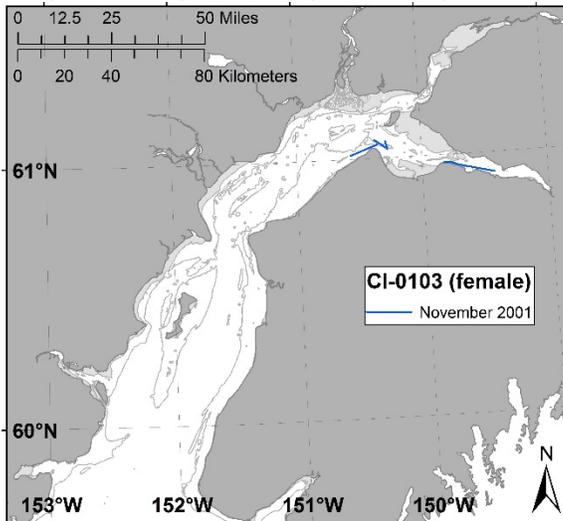
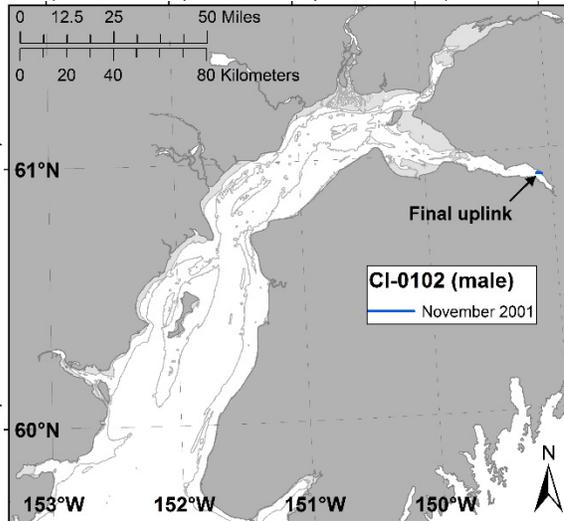
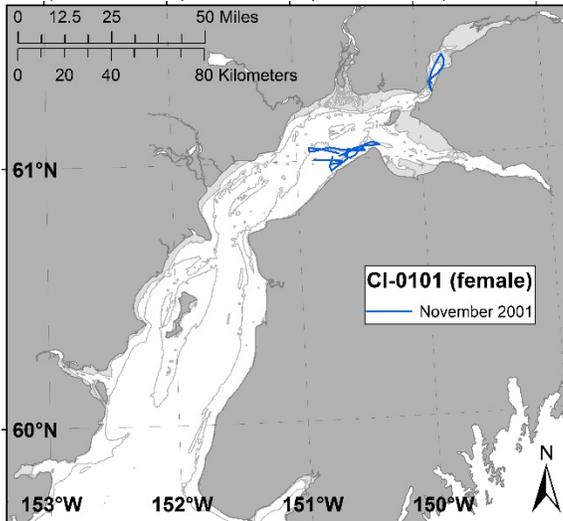
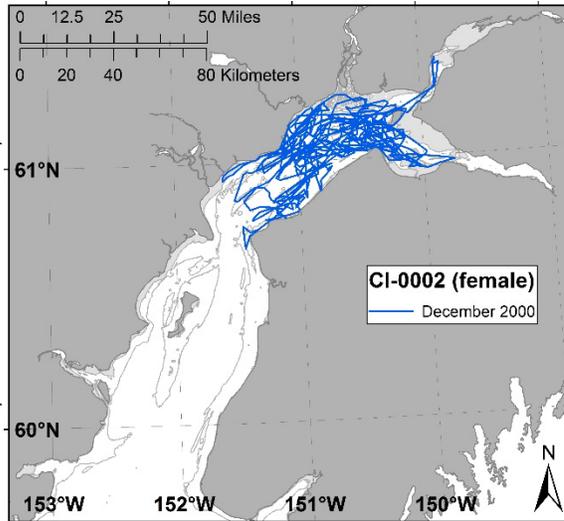
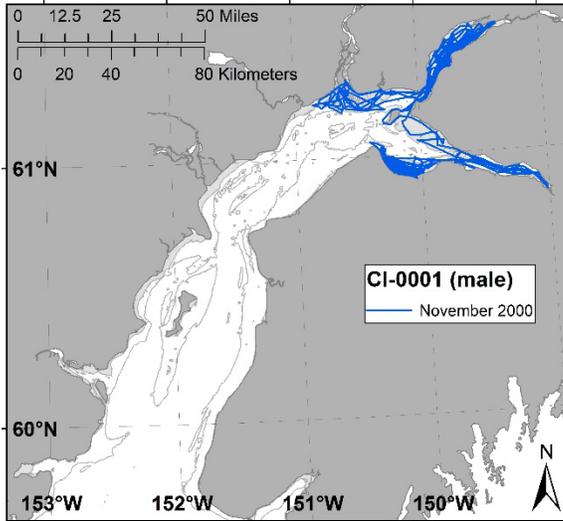


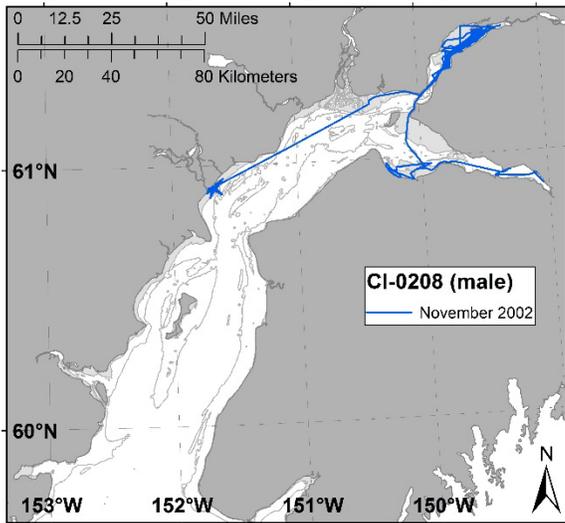
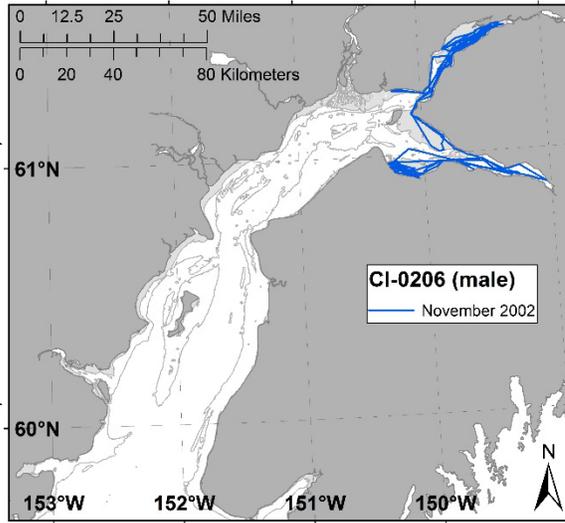
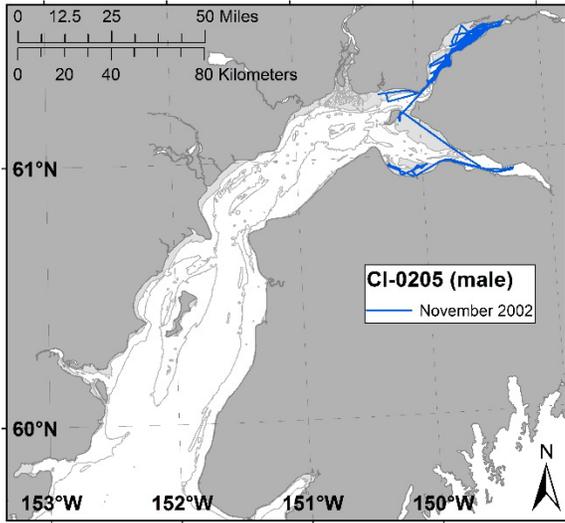
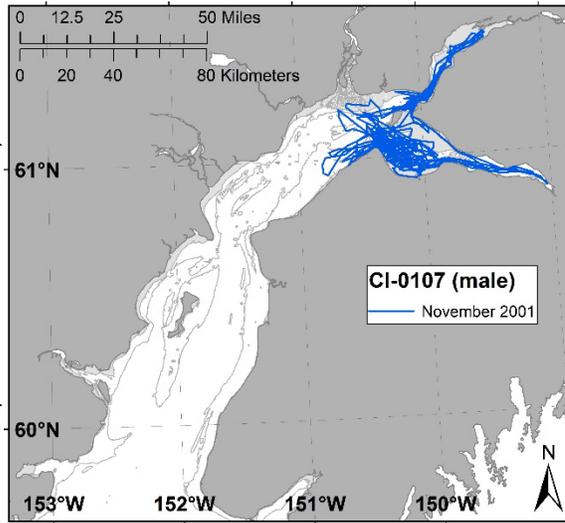
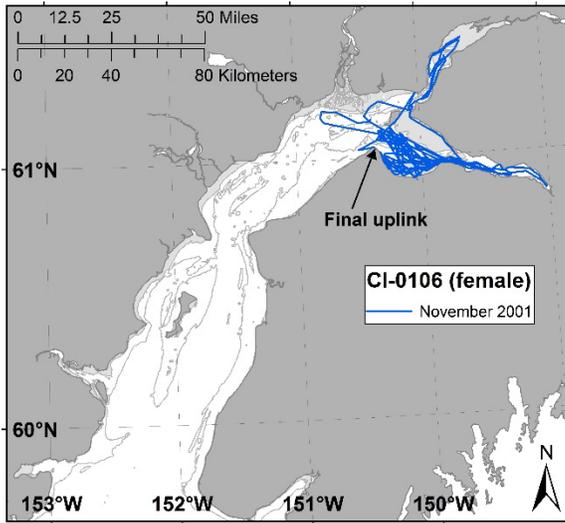
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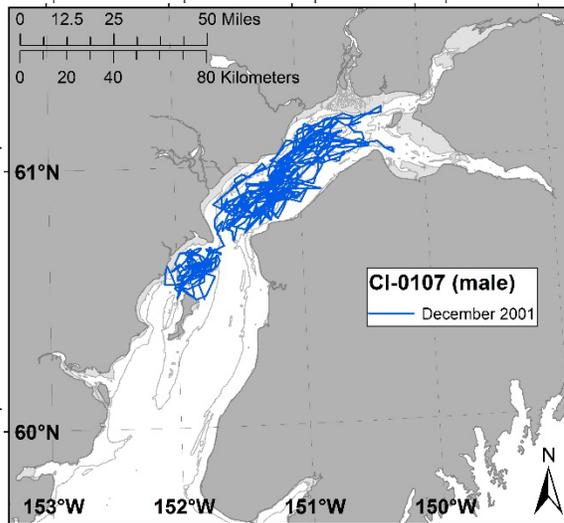
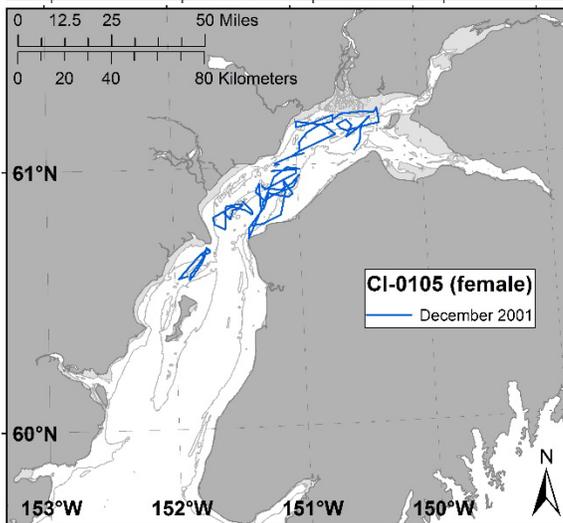
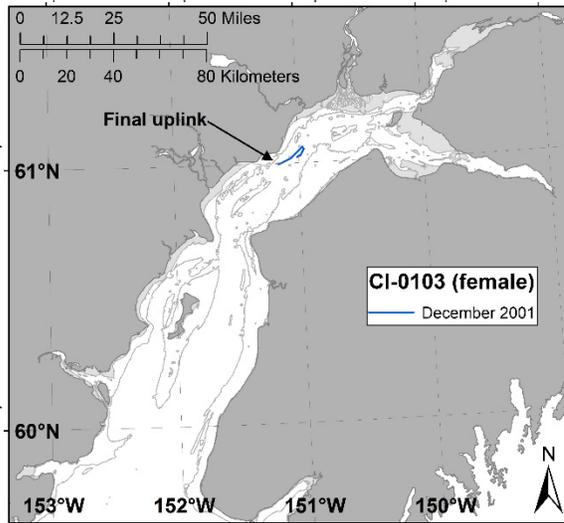
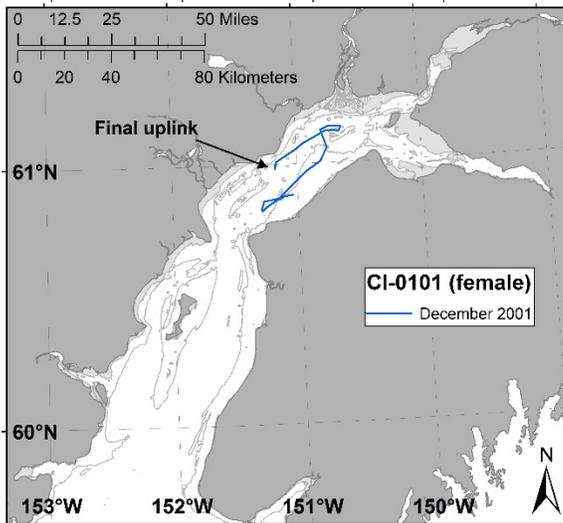
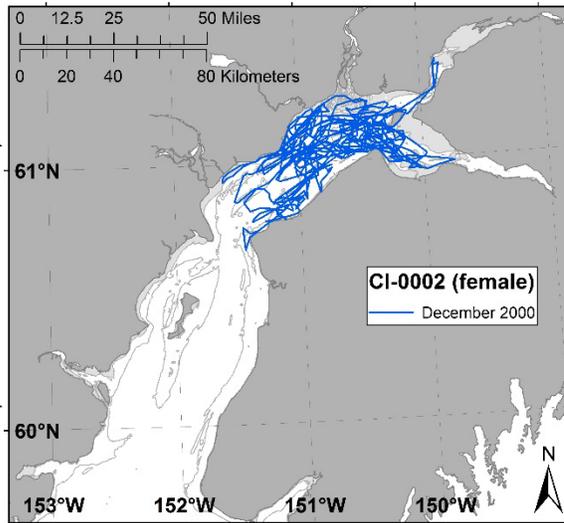
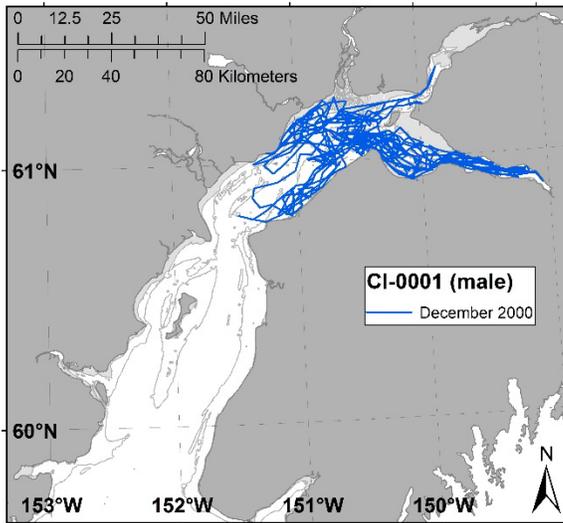


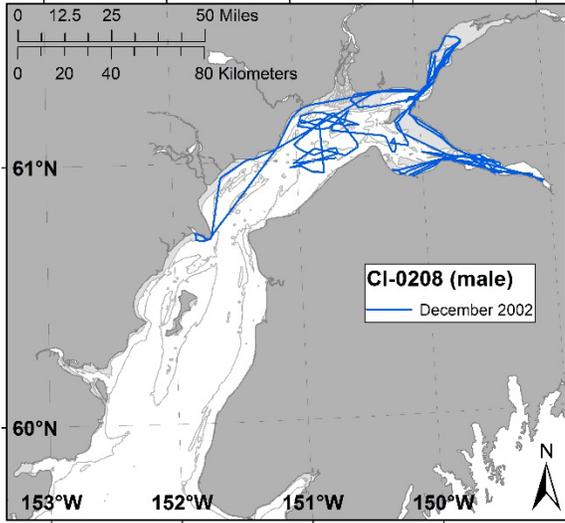
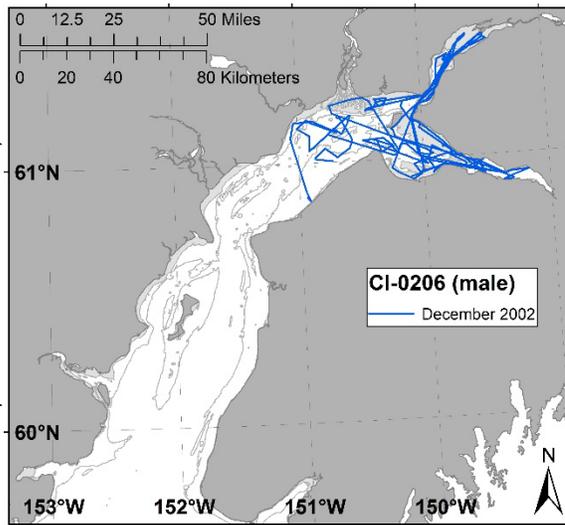
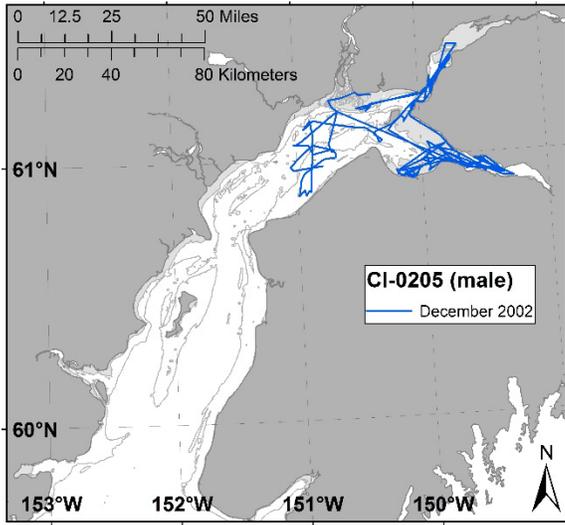
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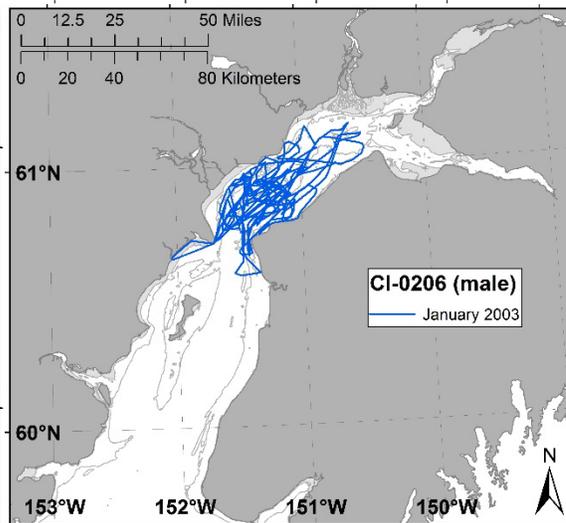
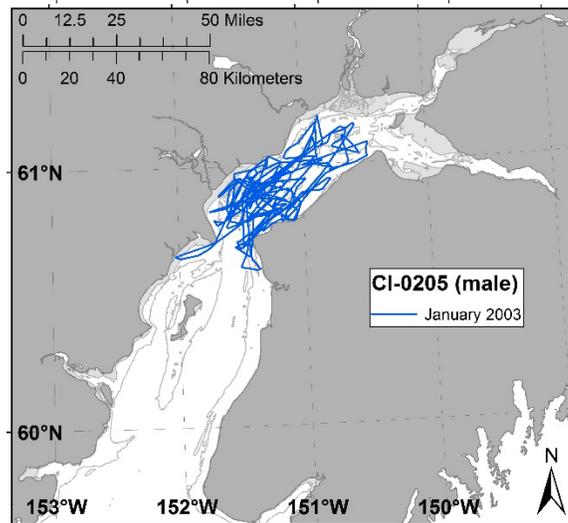
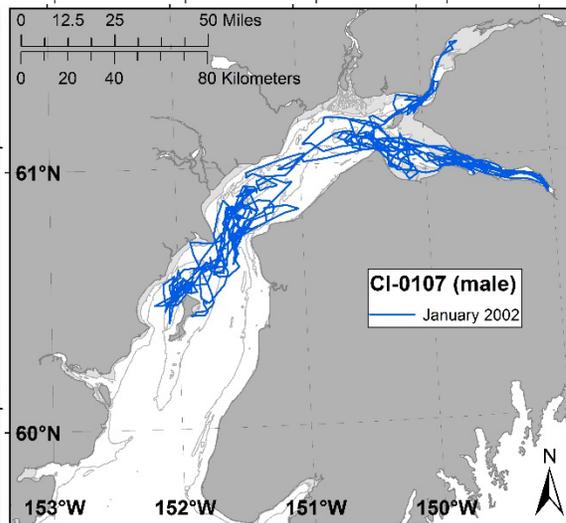
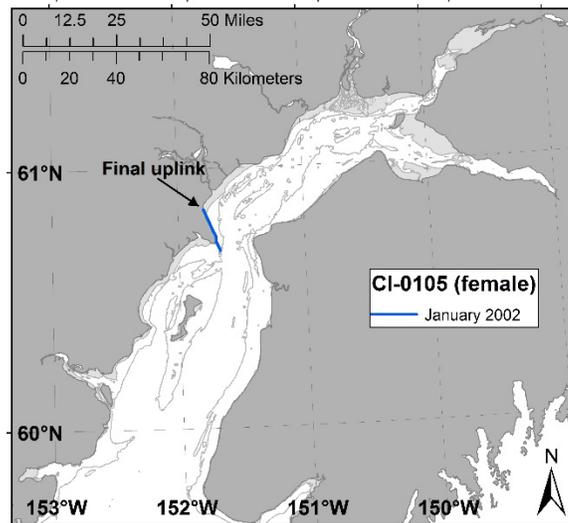
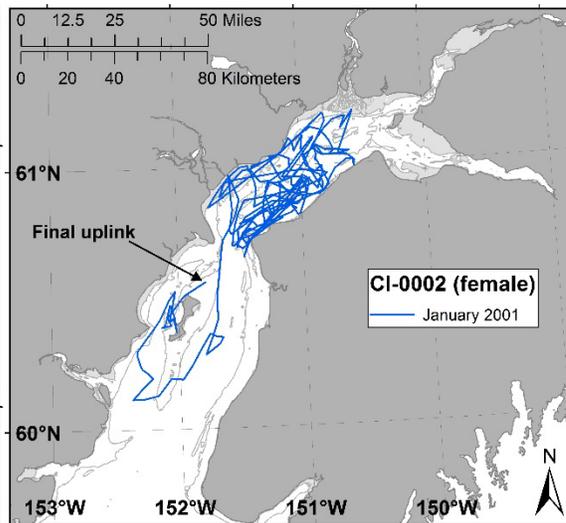
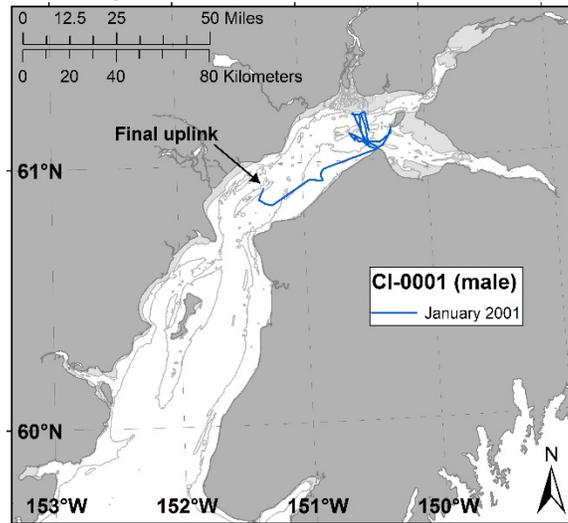


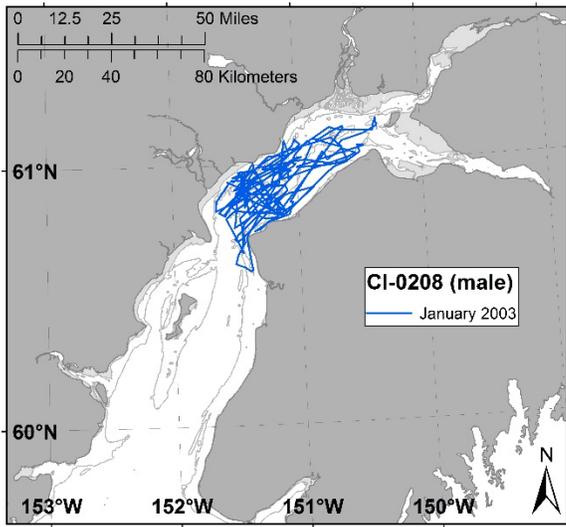
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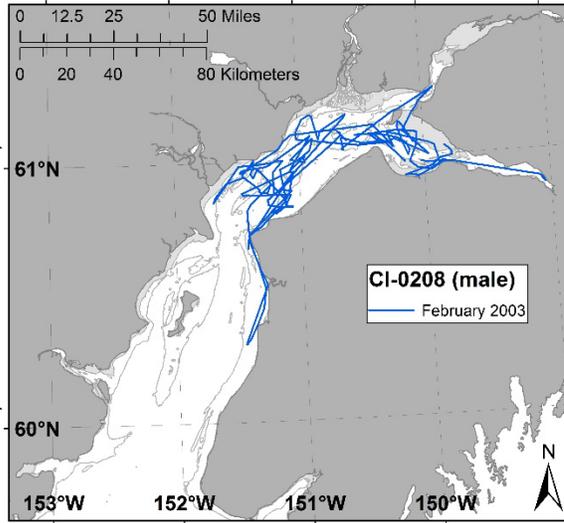
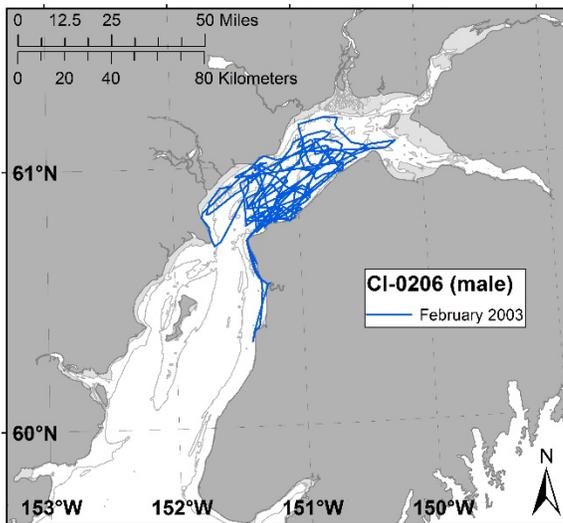
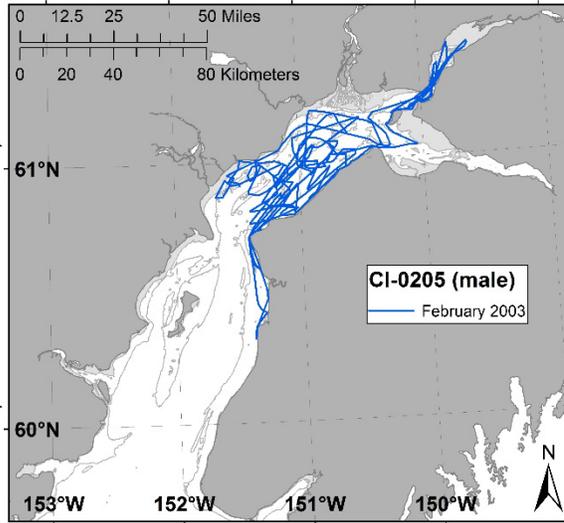
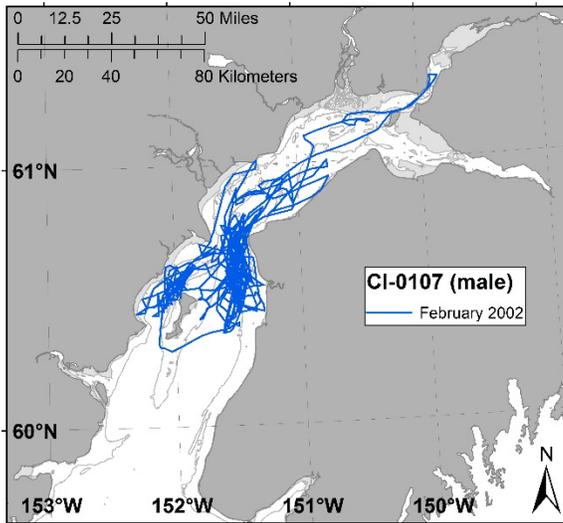


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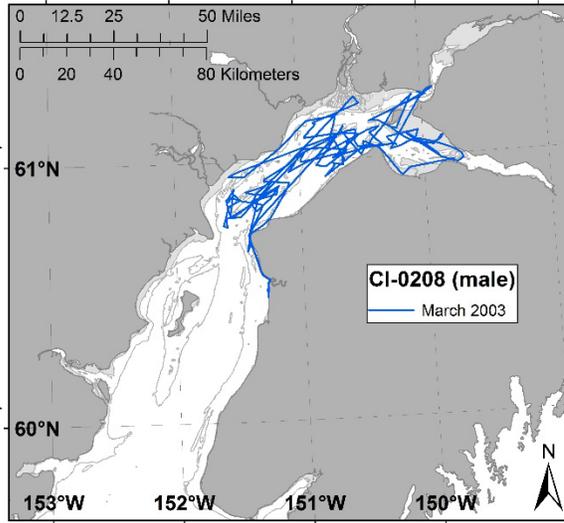
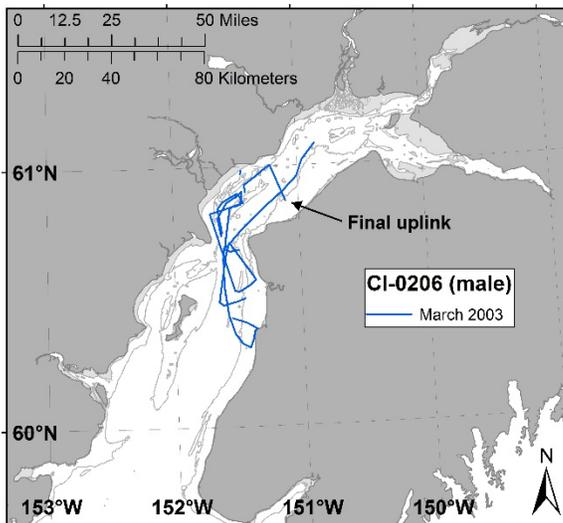
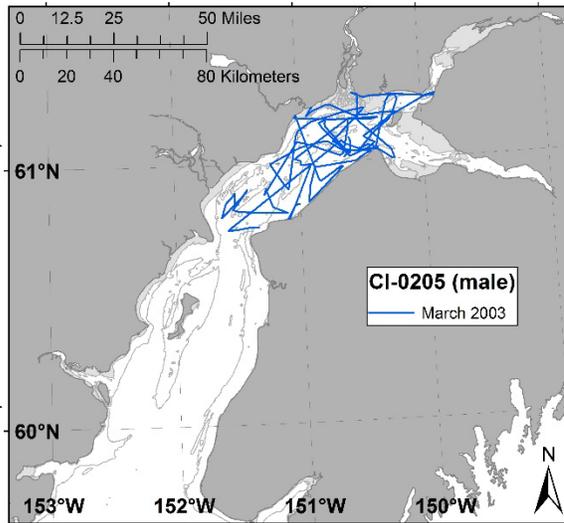
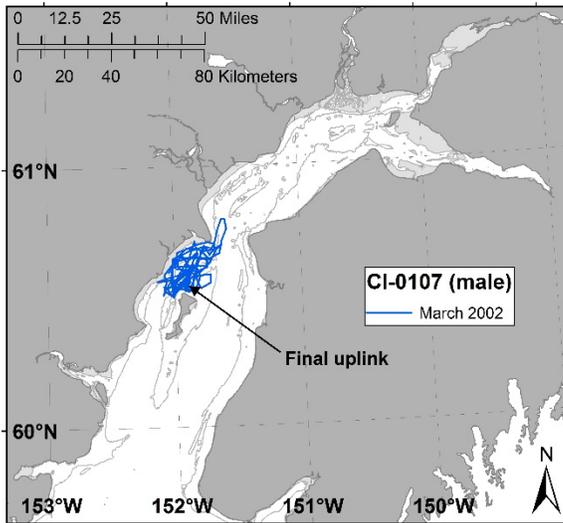




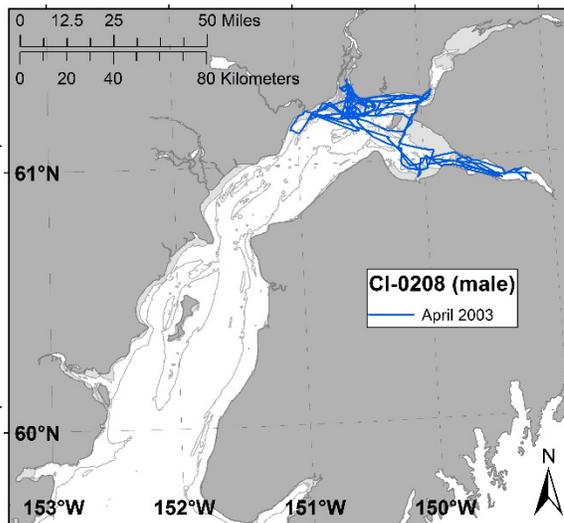
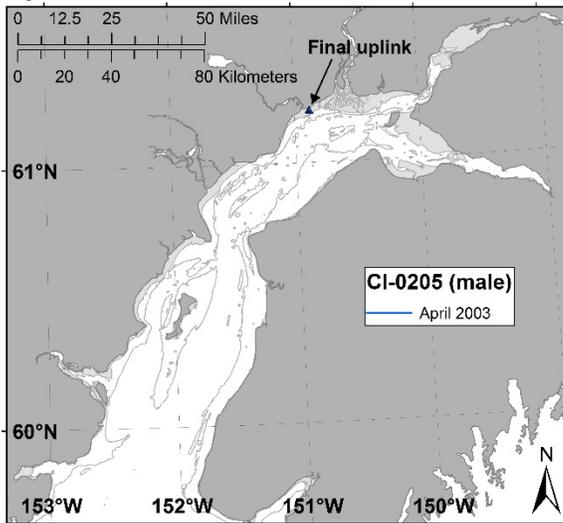
February



March



April



May

