Photo-identification of Beluga Whales in Upper Cook Inlet, Alaska

Summary of Field Activities and Whales Identified in 2015 and 2016

Prepared by:

The Cook Inlet Beluga Whale Photo-Id Project

SEEN BELUGAS?

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LIST OF ACRONYMS

AKR	Alaska Region
ADF&G	Alaska Department of Fish and Game
CIBW	Cook Inlet Beluga Whale
ESA	Endangered Species Act
GPS	Global Positioning System
ISO	International Standards Organization
JBER	Joint Base Elmendorf Richardson
LGL	LGL Alaska Research Associates, Inc.
MMPA	Marine Mammal Protection Act
MML	Marine Mammal Laboratory
NFWF	National Fish and Wildlife Foundation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OLE	Office of Law Enforcement (OLE)
POA	Port of Anchorage
SD	Secure digital
SLR	Single lens reflex
TEK	Traditional Ecological Knowledge

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ABSTRACT

More information about Alaska's endangered Cook Inlet beluga whale (CIBW) population (*Delphinapterus leucas*) is needed to promote its recovery. The CIBW photo-identification catalog and associated surveys from twelve field seasons (2005-2016) provide information about the distribution, movement patterns, and life-history characteristics of individually identified CIBWs. This report summarizes field effort and whales identified in Upper Cook Inlet in 2015 and 2016.

Surveys of the Susitna River Delta, Knik Arm, and Turnagain Arm were conducted from vessels and from land. There were 48 photo-id surveys conducted in 2015 and 2016, bringing the 2005-2016 project total to 421 surveys. Thirty-nine groups were encountered and photographed in 2015, and 26 groups in 2016. The largest group in 2015 contained 313 whales and the largest group in 2016 contained 148 whales. Groups contained roughly equal ratios of white and gray belugas, and were composed of approximately 11% calves and 2 % neonates. Groups with calves and neonates occurred in the same general locations as groups without calves or neonates. The first neonates of each field season were seen in mid-July in the Susitna River Delta, and were seen as late as October. A birth was observed July 20, 2015 in the Susitna River Delta. Two other possible births were observed in 2016; the first on July 19 in the Susitna River Delta, and the second on September 13 in Turnagain Arm. Suspected feeding behavior was seen in most of the areas in which beluga groups were encountered. For groups in the Susitna River Delta in 2015, suspected feeding behavior early in the field season (May/June) was notably different from later in the season (July/August).

To date the CIBW Photo-ID Project right-side catalog contains sighting histories for 398 individual whales photographed on the right side between 2005 and 2016, and 187 of these are presumed to be mothers. The left-side catalog contains sighting histories for 304 individual whales photographed on the left side between 2005 and 2011, and in 2016 (cataloging of left-side photos from 2012-2015 is in progress and reproductive histories will be examined once the catalog gaps are filled). There are currently 63 "dual" whales in the catalog (i.e., individual whales whose right- and left-side catalog records are linked) and 29 of these are presumed to be mothers. Photographs of nine belugas who stranded in 2015 and 2016 were examined for possible matches to the catalog, and two matches were made.

We are cautious in reporting life-history parameters such as reproductive or survival rates because there are many factors that affect our ability to detect, photograph, and identify individuals, particularly mothers and calves, and they all may result in biased estimates. Multivariate models are needed to quantify the effect of environmental factors and sampling bias on estimating population and life-history parameters. The next phase of the CIBW Project, now underway, includes working with colleagues to build models to quantify these biases and confounding variables and explicitly build them into models that will allow scientists to better assess the significance of the patterns for understanding beluga population dynamics. In the meantime, however, these descriptive results will be useful to managers seeking to minimize effects of human activities on belugas, and to help inform future research efforts.

Approximately 165 incidental reports of sightings of Cook Inlet belugas were received by the CIBW Photo-Id Project in 2015 and 2016. Outreach activities included formal and informal presentations and interviews about CIBWs and the CIBW Photo-Id Project given to various schools and community groups and at scientific conferences.

INTRODUCTION

Alaska's Cook Inlet beluga whale (CIBW) population (*Delphinapterus leucas*) is considered a distinct population segment by the National Marine Fisheries Service (NMFS) due to geographic and genetic isolation from other beluga stocks (NMFS 2008a). A steep decline in the CIBW population was observed in the mid-1990s, and the population was designated as depleted in 2000 under the *Marine Mammal Protection Act* (MMPA). In 2008, NMFS listed the CIBW population as endangered under the *Endangered Species Act* (ESA, 73 FR 62919). As a consequence of the ESA listing, NMFS was required to designate critical habitat (i.e., habitat deemed necessary for the survival and recovery of the population) and to develop a Recovery Plan for CIBWs. In addition, the ESA mandates that all federal agencies consult with NMFS regarding any action that is federally authorized, funded, or implemented, to ensure that the action does not jeopardize the continued existence of the endangered species or result in the destruction or adverse modification of its designated critical habitat.

Despite the cessation of an unsustainable level of subsistence hunting that was thought to have contributed to the initial population decline (NMFS 2008b), and despite the protections of the ESA listing, there is no evidence that the CIBW population is recovering. Although monitoring of CIBW abundance and distribution has been conducted via aerial surveys, satellite tagging, photo-identification (photo-id) surveys, and passive acoustics, many information gaps and uncertainties are associated with the current understanding of the CIBW population's lack of recovery. More information on annual abundance estimates of age-specific cohorts, habitat preferences for feeding, calving, and rearing of young, life history characteristics associated with population growth (births, calving intervals, age at sexual maturity, etc.), and sources of stress and mortality (natural and human-induced) is needed to promote recovery and conservation of the CIBW population.

Studies of CIBWs using photo-id methods have been ongoing since 2005 as part of the Cook Inlet Beluga Whale Photo ID Project (CIBW Photo-ID Project), with primary geographic focus in Upper Cook Inlet. The CIBW Photo-ID Project has confirmed that most CIBWs possess distinct natural marks that persist across years, and these marks can be effectively identified and re-sighted with digital photography. The photo-id catalog and associated surveys provide information about the distribution, movement patterns, and life-history characteristics of individually identified beluga whales, including mothers with calves (McGuire and Stephens 2017). The CIBW Photo-ID Project has been supported by research grants and contracts from a variety of sources (Appendix E), including the National Fish and Wildlife Foundation between 2005 and 2017.

This report presents results of vessel-based photo-id surveys of the Susitna River Delta and land-based surveys of Knik Arm and Turnagain Arm in 2015 and 2016. It describes the groups encountered and the individual whales in those groups that were identified from photographs taken during the surveys.

METHODS

Project activities consisted of field surveys, photo processing, cataloging of photos, data entry, database management, data analysis, reporting, and educational outreach.

Field Surveys

Survey effort

Dedicated photo-id surveys were conducted from small vessels and from shore during the ice-free season (approximately May through October) 2015 and 2016 in Cook Inlet, Alaska (Figure 1). Survey effort was focused in Upper Cook Inlet, primarily in the Susitna River Delta (defined here as the area between the Beluga River and the Little Susitna River), Knik Arm, Chickaloon Bay, Fire Island, and Turnagain Arm (Figure 2). Survey schedules varied according to those combinations of season, location, and tide that provided the greatest likelihood of detecting whales. These combinations were derived from results of NMFS aerial surveys (Hobbs et al. 2015; Rugh et al. 2000, 2004, 2005, 2006, 2010; Shelden et al. 2013, 2015a&b), other studies of CIBWs (Funk et al. 2005, Markowitz and McGuire 2007, Markowitz et al. 2007, Nemeth et al. 2007, Prevel-Ramos et al. 2006), as well as from ongoing photo-id surveys in this area (McGuire and Kaplan 2009; McGuire et al. 2008, 2009, 2011a&b, 2013a&b, 2014a&b, McGuire and Stephens 2017). Survey schedules were also based on seasonal and tidal patterns from incidental reports of CIBW sightings in the area (reported to NMFS and to the CIBW Photo-ID Project via an existing observer network and the project website www.cookinletbelugas.org). Established general survey routes were followed (Figure 2), although deviations were made depending on where beluga groups were encountered. Surveys lasted approximately six hours, although the duration of surveys depended on hours of daylight, tidal conditions, if whale groups were encountered, and size and behavior of whale groups. Tidal information was obtained from the program JTides (www.arachnoid.com/JTides/), TIDES.net, and www.Tides.info.

Vessel-based surveys

In 2015, vessel-based photo-id surveys of the Susitna River Delta were conducted from the R/V *Leucas*, a 4.9 m (16 ft) inflatable Proman 9 Zodiac® powered by a 4-stroke 50 hp Yamaha motor. In 2016, the vessel-based surveys were conducted from the R/V *Yemaya*, a 6.4 m (21 ft) Proman 650 Zodiac® powered by a 4-stroke 150 hp Yamaha motor. The research vessel usually carried one skipper and one observer/photographer. Vessel position was recorded with a Garmin™ GPS (Global Positioning System) Map 76C.

Photographs for identification were also taken during a CIBW biopsy study conducted August 13-22, 2016. Biopsy surveys were conducted from vessels August 13-16 and August 22, and from shore August 17-21. See McGuire et al. (2017a,b) for detailed methods and results.

Boat-based surveys in 2015 and 2016 were scheduled to encounter the largest groups of belugas. Surveys were not appropriate for line-transect methods designed to estimate abundance. A whale group was only approached once per survey and usually followed in

the manner described by Würsig and Jefferson (1990): the research vessel approached slowly, parallel to the group, and matched group speed and heading in order to obtain images of lateral sides of individuals while minimizing disruption of the group. At times, the boat drifted with the engine off, or was at anchor with the engine off, and whales were photographed as they passed by. Researchers noted the position of whales relative to the vessel and GPS-logged tracks of the vessel were used to estimate approximate whale group positions. The majority of the vessel-based surveys were centered around low tide.

All vessel surveys were conducted under NMFS MMPA/ESA Scientific Research Permit # 18016. Vessel-based surveys of middle and upper Knik Arm were not conducted in 2015 in order to avoid disruption of beluga studies (visual and acoustic) being conducted in Eagle Bay by research teams with the Department of Defense and the Alaska Department of Fish and Game. At the request of NMFS, vessel-based photo-id surveys were not conducted during a two-week period at the end of May/beginning of June so as not to potentially interfere with aerial surveys of CIBWs by NMFS in 2016.

Shore-based surveys

Shore-based surveys were conducted from observation stations along Turnagain Arm and at the mouth of Eagle River in Knik Arm. Photo-id surveys along Turnagain Arm generally began three hours before high tide, based on results from previous research conducted by LGL that indicated that this was when belugas were most likely to be present (Markowitz and McGuire 2007). The observer(s) drove south and east from Anchorage along the Seward Highway adjacent to Turnagain Arm and stopped at turnouts along the highway, alternating searches for marine mammals with binoculars and the naked eye. When beluga whales were seen, the observer attempted to follow them along Turnagain Arm as they moved with the tide. Most photographs were taken from sites where whales approached closest to shore and that afforded relatively easy vehicle access.

Dedicated surveys of the Eagle River Flats of Knik Arm (Figures 1 and 2) were conducted from the north shore of the mouth of the river by a team of observers (2-4) led by Joint Base Elmendorf Richardson (JBER), with invited participation by an LGL photo-id team member. Surveys were scheduled around the low tide, as this provided the greatest likelihood of detecting whales at this location (Funk et al. 2005, McGuire et al. 2008, JBER 2010). Observers were stationed at the mouth of Eagle River, and had views of Eagle Bay and Eagle River.

Survey data

Standardized data forms were used to record beluga whale sightings and environmental conditions. For each beluga whale group sighting, observers recorded time of day, group size, GPS position of the vessel or location, magnetic compass bearing to the group, estimated distance of the observer from the group (distance at first detection and minimum distance to individual whales), water depth (under the vessel), group formation, direction of travel, movement patterns, behavioral data (see below for details), average

distance among individuals, and any other marine mammal sightings or human activities near the sighting.

For groups with multiple records on a single day, the best record was selected at the end of the survey, which was either the highest count (for groups that merged) or the count considered by all observers to be the most accurate. Group size was usually difficult to determine and counts provided are best estimates of the number of whales seen at the surface, rather than the actual number of whales in the group (i.e., correction factors were not applied). In cases when it was unclear if multiple groups encountered on the same day in similar locations were the same group, photo-id records were reviewed and if the same individuals were photographed in the same groups on the same day, the groups were re-classified as the same single group.

Behavioral data were collected using focal group sampling (Mann 2000). Behavior was recorded as activities (i.e., group behavior patterns of relatively long duration) or events (i.e., individual behavior patterns of relatively short duration, such as discrete body movements; Martin and Bateson 1993). Group activity was recorded at the beginning and end of each group encounter, and approximately every five minutes during the encounter. Events were noted as they were observed throughout the group encounters, although it should be clarified that the observers were focused on photographing whales, not observing all events. Activities were classified into primary and secondary activities. Primary activities appeared to be the dominant behavior of the group, and secondary activities occurred sporadically during primary activities. For example, a group might be recorded to have the primary activity of traveling (most of the group most of the time), with the secondary activity of diving (some of the group some of the time). A tail slap or spy hop would be an example of a discrete event by an individual, not a group activity.

Behavioral activities were defined as follows:

Traveling – directed movement in a linear or near-linear direction, transiting through an area, usually at a relatively high speed.

Diving – movement directed downward through the water column.

Feeding suspected – chasing prey, as evidenced by bursts of speed, lunges, and/or focused diving in a particular location, or by fish jumping out of the water near belugas.

Feeding confirmed – beluga was seen with a prey item in its mouth.

Resting – little or no movement, body of animal visible at or near the surface.

Milling – non-linear, weaving or circular movement within an area.

Patrolling – beluga(s) swimming back and forth along the same linear pathway, close to shore or an exposed tidal flat *Socializing* – interactions among whales indicated by physical contact observed at the surface, or by audible vocalizing of multiple whales.

Body color (white or gray) and relative size/age-class (calf, neonate) of whales in the group were recorded. Calves were usually dark gray, relatively small (i.e., <2/3 the total length of adult belugas), and usually swimming within one body length of an adult-sized beluga. Beginning in 2008, observers noted if any calves appeared to be neonates (i.e.,

newborns, estimated to be hours to days old) based on extremely small size (1.5 m [5 ft]), a wrinkled appearance because of the presence of fetal folds, and uncoordinated swimming and surfacing patterns. Between 2005 and 2007, neonates were not differentiated from calves in the photo-id survey data. Likewise, calves and neonates were not differentiated in the beluga group data shared by JBER biologists.

The method of recording group composition was altered slightly during the August 13-22, 2016 biopsy surveys; in order to maintain their focus on the biopsy effort, vessel-based survey crews estimated group size for groups >15 individuals, while recording actual counts for groups <15 Groups observed from land were recorded as counts (rather than estimates) because of the addition of dedicated observers focused solely on recording group size and behavior. Sub-groups during biopsy efforts were recorded, and were defined as the number of individuals within range for biopsy (<30 m from the biopsy rifle) and/or within five body lengths of targeted whales. For each beluga group encountered during a land-based survey, observers noted the presence of individuals of different body colors (white or gray) and of relative size/age classes (calf or neonate).

Environmental conditions were noted hourly or when conditions changed. Environmental variables recorded included Beaufort sea state, swell height, cloud cover, glare, visibility, wind speed and direction, air temperature, precipitation, water temperature at the surface, and water depth.

Digital photographs of beluga whales were collected using a digital SLR camera with a telephoto zoom lens (100-400 mm) with auto-focus. Typical settings included shutter speed priority, dynamic-area autofocus, 100-800 ISO, and shutter speed of 1/1,000 sec or faster. Photographs were taken in JPEG format. Photographs were stored on compact flash or SD memory cards. Photographs taken by the public and shared with the CIBW Photo-ID Project were taken on a variety of cameras and cell phones.

Archiving and Analysis of Data from Field Surveys

Photographs were downloaded from the memory card onto a computer hard drive and archived to external hard drives to preserve the original data before any further processing. All photo-id data, survey data, and photographs were integrated into the CIBW Photo-ID Project database. Data associated with each photograph included the metadata, such as the original camera settings, the time the original photograph was taken, and the dates and locations when photos were taken. Time was synchronized between the GPS and the cameras in the field, and the time and date stamps of the photos were linked to those of the trackline of the vessel when both were uploaded into the database, which allows for geo-referencing of the photos. Locations of beluga whale sightings and survey routes were mapped in QGIS version 2.14 (http://www.qgis.org/) and figures were prepared showing survey routes, group location, group size, and group color composition for each survey conducted.

Processing of Photographs

Photographs were sorted according to image quality using ACDSee photo software (http://www.acdsee.com). Photographs of unsuitable quality for identification (e.g., poor focus, whale obscured by splash, or too distant) were noted and archived, but not used for

subsequent analyses. If distinguishing marks were obvious even in poor quality photographs, the photo was considered for inclusion in the catalog.

All suitable quality images were cropped to show only the focal whale. When an original field photograph contained more than one whale, each whale was cropped individually and given a separate file name. Cropped images were separated into left and right sides of whales. Daily photo samples (i.e., all cropped photos taken on a single survey day) were sorted into temporary folders. Each temporary folder contained all of the cropped images taken of the same individual beluga on a single day (this could be one to many images). Images within a temporary folder may have been taken seconds or hours apart, and often showed different sections of the body as the beluga surfaced and submerged. Images within temporary folders were then examined to determine if there was a match to photographic records of individual belugas identified within that year or in previous years. If a match was made to a previous year in the catalog, the new photos were entered into the catalog. Temporary folders that were not matched to individuals within the photo-id catalog were archived and periodically reexamined for matches to the catalog as it developed and photos from new field seasons were added.

Cataloging of Photographs

Markings used for photo-id of individual beluga whales consist of natural marks from conspecifics, pigmentation patterns, scars from injury or disease, and marks left from satellite tags attached by NMFS during 1999-2002. The CIBW Photo-ID Project depends on existing marks and does not apply marks to whales. Mark-type categories were created in order to facilitate cataloging. Computer software specialized for this species was developed by the project to allow for computer-aided filtering of the database according to mark type and location.

As a beluga surfaces and submerges, different portions of its body are available to photograph. Side-profile photographs are most useful for matching marks used to identify individual whales. Profile images were divided into 11 sections along the right and left halves of the whale (Figure 3); sections containing the head, tail, and ventral half of the whale were less commonly captured in photographs and were therefore less likely to provide identifying marks than were the other five body sections. “Profile completeness” was determined by the number of sections with high quality images; a right or left side profile set was considered complete if it contained high quality images of all five sections of the dorsal half of the whale, beginning just behind the blowhole and extending to the base of the tail. In order to be included in the catalog and given a unique ID number, a whale had to have a complete profile set. Whales with complete profile sets were considered individuals in the catalog. Another criterion that allows for the acceptance of a whale into the catalog is if two temporary whale folders that spanned two or more years were matched, regardless of profile completeness. All matches in the existing catalog were reviewed and verified by at least two experienced photo-analysts.

Classification of mothers and calves in photographs

Identified belugas were classified as presumed mothers if they appeared in the same uncropped photo frame with a calf or neonate alongside them. Belugas were classified as

calves if they were gray, relatively small (i.e., <2/3 the total length of adult belugas), and photographed alongside a larger, lighter-colored beluga. Neonates were distinguished in photographs by visible fetal folds and often a "peanut-shaped" head. Sighting histories (i.e., dates and locations of sightings) were compiled for all identified presumed mothers and calves. Sighting records for presumed mothers included information on when the mother was photographed with and without a calf, as well as information on the relative size of the calf. If a presumed mother was seen with a calf in multiple years, and the calf appeared larger every year , it was assumed to be the same calf maturing (the majority of photographed calves cannot be identified as individuals because they are either not well marked with the long-lasting marks used for photo-id, or they are not photographed with enough of the body above water to allow marks to be seen).

Classification of dual-side whales

Whales where classified as dual-side whales if they met the criteria to be classified as individuals in both the right- and left-side catalogs and if marks that spanned both sides of the bodies could be used to link the two sides. Dual-side whales are given catalog names that begin with the pre-fix D, followed by the catalog number of the side that was first entered into the respective right-side or left-side catalog. For example, a whale identified on the right side as R100 and on the left as L 220 would have the dual name of D100.

Classification of previously satellite-tagged whales

Previous photo-id reports have documented CIBWs with scars from satellite tags attached by NMFS during 1999-2002 (McGuire and Stephens 2016). A whale was classified as a "confirmed satellite-tagged" individual if the following were visible in photographs: scars with a distinct shape (circular, crescent-shaped, or band-like); scars in an obvious pattern (depending on the tag type and attachment used, tags caused scars in pairs, trios, or up to five); and/or scars in known tagging locations on the body. In some cases, biopsy scars were seen in addition to the tag scars and were used as additional evidence of a tagging event. Individuals with photographs of scars that were similar to "confirmed tagging scars" but were less distinct in shape, pattern, or placement were classified as "suspected satellite-tagged" individuals. Individuals classified as satellite-tagged whales were differentiated from one another based on photographs showing a combination of natural marks and tag scars to avoid mistakenly matching similar scar patterns caused by the same tag type. Two experienced photo-analysts independently reviewed all photographs currently in the CIBW Photo-ID Project catalog to classify images of individuals bearing satellite-tag scars.

Classification of biopsied whales

A feasibility study for remote biopsy of CIBWs was conducted in 2016 (McGuire et al. 2017). Photographs were taken of whales at the time of biopsy in order to try to match them to individuals in the CIBW Photo-Id catalog. Genetic sex was determined from all biopsy samples, and used to confirm the sex of suspected mothers in the catalog.

Identification of Stranded Belugas

Stranding response to live and dead stranded marine mammals in general, and of endangered CIBWs in particular, is regulated by NMFS. Designated responders in the Alaska Marine Mammal Stranding Network may respond to CIBW strandings if activities are first authorized by NMFS on a per-case basis; these activities fall under the umbrella of the permit held by NMFS.

When stranded (dead or alive) belugas were encountered during surveys, or when informed of stranded belugas by the Alaska Marine Mammal Stranding Network, and as authorized by NMFS, CIBW Photo-ID Project biologists photographed stranded belugas or relied on other stranding responders to obtain photographs of stranded belugas. The project developed a protocol for photographing stranded belugas for identification marks that was distributed to members of the Alaska Marine Mammal Stranding Network and posted on the NMFS AKR website https://alaskafisheries.noaa.gov/sites/default/files/stranded-cibwphotoprotocols15.pdf. Photographs of stranded belugas were examined for marks that could be used to compare to records from the 2005-2016catalog. Sex and relative age (i.e., neonate, calf, juvenile, adult) of dead whales were determined from necropsy reports and/or photographs, and were entered into the records of individuals in the photo-id catalog.

Database Development

All photo-id data (2005–2016) are consolidated into a single integrated database. Data from surveys included the survey route, environmental conditions, photographs, and group size, color, and behavior. Data associated with each photograph included the "metadata", such as the original camera settings, the time the original photograph was taken, and the lighting conditions. Catalog data also included the number of photos in the catalog, the dates and locations when photos were taken, the number of individual whales represented in the catalog, and the number of temporary folders yet to be matched.

Sighting Histories

Sighting histories (i.e., dates and locations of sightings) were compiled for cataloged belugas in order to examine residency and movement patterns. These sighting histories include information from surveys conducted during 2005-2016, and are presented graphically according to year and geographic area in Appendix C. Locations of cataloged beluga whale sightings were mapped in QGIS version 2.14 (http://www.qgis.org/).

Incidental Beluga Sighting Reports and Photographs

Incidental beluga sighting reports were collected by the CIBW Photo-ID Project from the public and colleagues via email, phone calls, public presentations, and conversations in the field. The project website (www.cookinletbelugas.org) contains a page for the public to report CIBW sightings. The website address was distributed via the project bumper sticker, wallet-sized cards, project pamphlets, and public outreach. Incidental beluga sighting reports were entered into the project database and shared with the NMFS AKR and NMFS's Marine Mammal Lab (MML).

RESULTS

Surveys

Survey effort, number of whales, and whale groups encountered in 2015 and 2016

There were 23 photo-id surveys of Upper Cook Inlet conducted in 2015 and 25 in 2016 (Table 1, Figure 4). The fieldwork completed in 2016 brought the project total to 421 photo-id surveys conducted in Cook Inlet over twelve consecutive field seasons (Table 1).

In 2015, there were 17 groups encountered in the Susitna River Delta, five groups in Knik Arm, 17 groups in Turnagain Arm, and none at Fire Island (Table 2; Figure 5A). In 2016, there were 19 groups encountered in the Susitna River Delta, 12 groups in Knik Arm, and 22 groups in Turnagain Arm (Table 2, Figure 5B). Maps of daily whale group sighting locations and survey routes in 2016 are presented in Appendix A and B, respectively. Figure 6 summarizes the locations of all of the groups encountered 2005-2016.

In 2015, group size in the Susitna River Delta ranged from 1 to 313 whales (Tables 2 and 3). The largest of these groups was seen on July 20 (Table 3). Group size in Knik Arm in 2015 ranged between 1 and 129 whales (Tables 2 and 4), and the largest of these groups was seen on August 25 (Table 4). Group size in Turnagain Arm in 2015 ranged between 1 and 39 whales, with the largest group seen on October 1 (Table 5). Fewer groups per survey were encountered in Knik Arm than in either the Susitna River Delta or Turnagain Arm. Mean group size was greatest in the Susitna River Delta and smallest in Turnagain Arm (Table 2).

In 2016, group size in the Susitna River Delta ranged from 1 to 148 whales (Tables 2 and 3). The largest of these groups was seen on July 19 (Table 3). Group size in Knik Arm in 2016 ranged between 1 and 74 whales per group (Tables 2 and 4), and the largest group size was seen on August 17 and again on September 30 (Table 4). Group size in Turnagain Arm in 2016 ranged between 1 and 147 whales, with the largest group seen on September 13 (Table 5). Fewer groups per survey were encountered in Knik Arm than in either Turnagain Arm or the Susitna River Delta. Mean group size was greatest in Knik Arm and smallest in Turnagain Arm (Table 2).

Survey conditions in 2015 and 2016 provided good visibility (on a scale of good/fair/poor) on all survey days in the Susitna River Delta (Table 6), and on the majority of survey days in Knik Arm and Turnagain Arm (Table 7). The occasional fair to poor conditions were due to high winds and rough water. For example, on July 14, 2015, survey conditions quickly deteriorated due to increasing winds and building seas, and the survey vessel had to seek shelter along the north side of Fire Island after surveying the Little Susitna River, and was unable to proceed to the Susitna River. There were surveys in Knik Arm and Turnagain Arm when overall daily sighting conditions were good, but there were occasional periods of poor sighting conditions.

Color composition and age class of groups encountered during surveys in 2015 and 2016

Although color and age-class composition of groups varied by survey date (Tables 3, 4, and 5), in general, the average group contained white and gray belugas in roughly the same proportions, and was composed of approximately 11% calves and 2% neonates (Table 8). Groups with calves and neonates occurred in the same general locations as groups without calves or neonates (Figure 7).

The average group seen in 2015 in the Susitna River Delta contained 13% calves and 2% neonates, and was split roughly evenly between white and gray belugas, although 13% were of unknown age class/color (Table 8). These ratios were comparable with those for groups seen in Knik Arm. Groups in Turnagain Arm had a much higher percentage of animals of unknown age class/color, although the ratio of white to gray belugas and the percentages of calves and neonates were comparable to groups seen in the other areas surveyed.

The average group seen in 2016 in the Susitna River Delta contained 11% calves and 2% neonates, and was split roughly evenly between white and gray belugas, although 40% were of unknown age class/color (Table 8). Groups in Knik Arm had a slightly higher percentage of neonates than did groups in other areas, while the percentage of whales of unknown size class was very low.

In 2015, calves and/or neonates were seen in 12 of the 17 (70.6%) groups encountered in the Susitna River Delta (Table 3, Figure 8a) and in four of the five (80%) groups seen in Knik Arm (Table 4, Figure 8 a). Of the 17 groups seen in Turnagain Arm, poor sighting conditions (e.g., glare, groups seen at a distance, shadows) during surveys meant that age class/color composition could not be determined for 12 of these groups (Table 5). Calves and/or neonates were seen in all but one (80%) of the five groups for which age class/color composition could be determined in Turnagain Arm.

In 2016, calves and/or neonates were seen in 15 (83.3%) of the 18 groups for which calf and/or neonate presence could be determined in the Susitna River Delta (Table 3, Figure 8b), and in seven of ten (70%)of groups for which calf and/or neonate presence could be determined in Knik Arm (Table 4, Figure 8b). Of the 22 groups seen in Turnagain Arm, difficult sighting conditions (e.g., glare, groups seen at a distance, shadows) on some survey days meant that age class/color composition could not be determined for five of these groups (Table 5). Calves and/or neonates were seen in 10 of the 17 (58.8%) groups for which age class/color composition could be determined in Turnagain Arm.

The first neonate sightings of the year in the Susitna River Delta were on July 19 in 2015 and on July 15 in 2016. Neonates in Knik Arm were first seen on August 25 in 2015 and on August 17 in 2016. Neonates in Turnagain Arm were first seen on August 20 in 2015, coinciding with the first day that Turnagain Arm was surveyed that year, and on September 10 in 2016 (a week after surveys had begun in Turnagain Arm for that year). Groups with neonates occurred in the same general locations as groups without neonates (Figures 9 and 10).

Possible feeding and reproductive behavior of whale groups encountered in 2015 and 2016

Suspected feeding behavior was seen in most of the areas in which beluga groups were encountered in 2015 (Figure 11A) and 2016 (Figure 11B), consistent with patterns from previous years of the study (Figure 12).

Although suspected feeding behavior was not observed for all groups encountered in the Susitna River Delta in 2015, it was observed on each of the 10 days of surveys conducted there in 2015 (Table 9, Figure 11A). Feeding behavior was observed on five of the 11 survey days in the Susitna River Delta in 2016 (Table 10, Figure 11B).

In general, whales in mid/upper Knik Arm traveled down Knik Arm and entered Eagle Bay and Eagle River during the falling tide, milled around and possibly fed in Eagle Bay and the mouth of Eagle River during falling and low tide, and traveled back up Knik Arm during rising tide. One beluga group encountered in lower Knik Arm in 2015 as the survey boat was headed to the Susitna River Delta was observed traveling up Knik Arm with the falling tide. Suspected feeding behavior in Knik Arm was noted on August 25, 2015 and on August 17, 18, and 19 in 2016 (Table 11, Figure 11).

Belugas traveled up Turnagain Arm with the rising tide, then traveled rapidly back down the Arm with the falling tide. The outcropping at Bird Point appeared to be a frequently used area for belugas to congregate and wait until waters reached a sufficient depth with the incoming tide to allow for their continued travel up Turnagain Arm. On both the incoming and outgoing tides, belugas often used the coves and eddies created by natural and artificial outcroppings to mill, presumably search for food, and possibly reduce their exposure to strong currents. Unlike previous years of the study, in 2015 and 2016, belugas generally were not found traveling in the deeper channels along the north and south shores of Turnagain Arm. They were instead observed traveling in the visibly shallow areas in the middle of the Arm, and during the incoming tide, they sometimes appeared to be looking for and pursuing prey along the edges of these shallow areas. Suspected feeding behavior in Turnagain Arm was noted on August 23, August 28, and September 5 of 2015, and on September 10, 13, 26, and 27 of 2016 (Table 12, Figure 11).

A CIBW birth was observed and photographed on July 20, 2015 in the Susitna River Delta during a vessel-based survey. The birth took place during low tide, in shallow water (~1.3 m) along the exposed mudflats, 5-10 m from shore, in a cove-like area where the current was reduced relative to nearby areas. The birth occurred in a group of 313 whales, with at least three other neonates seen in the group. Little of the birth event was visible at the surface, and the turbid waters prevented viewing into the water. An adult beluga was observed a few meters away from the main group. The group was traveling along the exposed edge of the mudflats, but the lone beluga was floating log-like at the surface. It was eventually joined by other belugas (whites and grays), and soon after a neonate with deep fetal folds surfaced explosively from alongside the lone beluga. During the 37-minute observation period, the neonate was often seen listing to one side at the surface and appeared motionless, but then was pushed upright by other belugas. At times, it would disappear from view, but later was seen being pushed forcefully to the surface by the small group of attending belugas, with what appeared to be occasional blows to its

flanks. When last seen, the neonate appeared to be breathing and swimming on its own, but remained surrounded by a small group of belugas.

A second CIBW birth may have been observed and photographed July 19, 2016 at the Susitna River Delta, under circumstances very similar to the birth observed in the same location on July 20 of the previous year, with the exception that the neonate in 2016 was seen swimming and breathing on its own and was not observed to be supported, pushed, or struck by other belugas in the group. The neonate was observed in a subgroup of six whales that was part of a larger group of 148.

A third CIBW birth may have been observed, this time at Bird Point, Turnagain Arm on September 13, 2016 during a land-based survey. A group of 147 beluga whales was traveling south past Bird Point with a flood tide. At 17:10 a group of about six whales broke off from the larger group and turned around and headed north against the tide and returned to the observer's location at Bird Point. The group was moving at a fast pace and proceeded just out of view of the observer to the north. The group could be heard splashing and vocalizing. At first feeding was suspected. After the observer repositioned herself to get a better view of the group, she was able to see that a neonate was in the group. This neonate had deep fetal folds; it is possible that this calf was just born and the observer saw the end of the event. The whale group was observed milling in the same spot for about five minutes. The whales in the group were in a tight formation with each other, less than one body length from each other, and several flippers could be seen at the surface at any given moment. At first, it appeared that the other beluga whales were supporting the calf at the surface, but then the observer had the impression the mother was being heavily pursued by other whales and the neonate was struck by other whales several times in the process. After about five minutes, the group started moving/traveling with quick and sudden directional changes and splashing. Close formation continued and various flukes and flippers could be seen at the surface. Throughout this time, the neonate was swimming and surfacing on its own, although periodically the neonate would be forcibly thrust out of the water by other whales. This continued until 17:45 when the whales were no longer active at the surface and traveled out of the observer's view.

Stranded belugas photographed in 2015 and 2016

Photographs of nine belugas that stranded in 2015 and 2016 (eight stranding events) were shared with the CIBW Photo-Id Project by NMFS and by other members of the Alaska Marine Mammal Stranding Network (Table 13). Seven of the strandings were of dead belugas. The other stranding event involved an adult and a calf that live-stranded together and were assumed to be a mother and her calf. NMFS reviewed aerial drone video of the stranded mother and calf and reported that both belugas were seen to re-float with the rising water and swim away (Mandy Migura, NMFS, personal communication). Photographs of the live-stranded calf did not show enough of the body out of the water to allow for identification. The live-stranded mother and two dead individuals had photographs that were of sufficient quality for identification.

Incidental sighting reports of belugas in 2015 and 2016

The CIBW Photo-Id Project received 70 incidental reports of CIBW sightings in 2015 and 95 incidental reports in 2016 (Tables 14 and 15). Sightings were reported by fishers, pilots, the media, law enforcement officers, vessel operators, tourists, biologists, educators, students, regulators, port operations staff, environmentalists, and energy-sector employees (oil and gas, coal, tidal power). Many reports were solicited and received during outreach activities (Appendix D).

Belugas were reported in the following locations and months: the Susitna River Delta March through September; Knik Arm August through October; Turnagain Arm in January, March, April, May, June, and August through October; and the Port of Anchorage April through August. Large groups were reported near the Tyonek Oil and Gas Platform in January of both years (150 whales in 2015, and 200 in 2016). Reports were received in 2015 of belugas seen on the east side of lower Cook Inlet from Kasilof and south, including an unconfirmed report of belugas in or near Kachemak Bay (photos were provided, but were inconclusive with respect to species identification).

Human Interactions 2005-2016

Human activities with the potential to affect belugas were noted during photo-id surveys. In the majority of instances, these activities were incidental in the sense that the people conducting them were likely unaware belugas were even present. In a few cases when activities appeared to be intentionally directed at belugas and potentially harmful, the National Oceanic and Atmospheric Administration (NOAA) Office of Law Enforcement (OLE) was alerted.

In 2015 and 2016, aircraft (e.g., small recreational aircraft, large commercial aircraft, military jets, and military transport) were noted flying over belugas during almost all surveys of the Susitna River Delta and Knik Arm. Aircraft were only occasionally seen along Turnagain Arm, and these were limited to small recreational aircraft.

There were several instances in which small planes were observed circling beluga groups, seemingly intentionally. On two separate occasions on July 20, 2015 a large group of belugas was observed to suddenly quit vocalizing and exhibit low surfacing profiles when a small plane circled over them at the Susitna River Delta. In both instances, the belugas remained in the area and appeared to resume their previous behavior after the plane left.

Other human activities that were observed near belugas included bulldozers along the intertidal zone at the Port of Anchorage, set nets and set-net boats in the Susitna River Delta, noise from weapons firing at military and recreational shooting ranges, and research activities (including the photo-id survey vessel and remote biopsies of belugas from vessels and shore in 2016).

Other Marine Mammals Encountered During CIBW Surveys or Reported to the Project, 2015-2016

The following marine mammals were encountered during photo-id surveys for CIBWs, or were reported incidentally in 2015 and 2016:

Harbor seals (*Phoca vitulina*) were commonly encountered in both years in all areas surveyed. The largest (often over 200 seals) and most persistent haulout occurred at the mouth of the Susitna River. Harbor seals and belugas were often observed feeding in the same areas, such as the mouths of the Big and Little Susitna rivers, Eagle River, the Kenai River, and at Beluga Point at Turnagain Arm.

A dead humpback whale (*Megaptera novaeangliae*) was reported at the mouth of the Little Susitna River, and was necropsied by the Alaska Marine Mammal Stranding Network April 30, 2016. Another humpback whale was reported dead on the beach on June 28, 2016, at mile 13 of Hope Highway.

A dead fin whale (*Balaenoptera physalus*) was necropsied in Knik Arm by JBER biologists in September 2015. The whale had been brought into the area on the bow of a ship, and the captain reported that it had most likely been struck somewhere in Cook Inlet but not in Knik Arm (Chris Garner, JBER, personal communication). In June 2016, a very decomposed dead floating baleen whale was reported near the Port of Anchorage, and it was believed to be the same whale from September (tissue samples were taken to compare DNA; contact NMFS for results). A live-stranded fin whale in distress was reported near the Port of Anchorage on June 21, 2016 and biologists from JBER witnessed its death.

The following marine mammals, occasionally reported in Upper Cook Inlet in previous years of the study (McGuire and Stephens 2017), were not encountered during surveys in 2015 or 2016: steller sea lions (*Eumetopias jubatus*), gray whales (*Eschrichtius robustus*), harbor porpoises (*Phocoena phocoena*), Dall's porpoises (*Phocoenoides dalli*), and orcas (*Orcinus orca*). An incidental report was received of orcas in Turnagain Arm in August of 2015 (personal communication, Kathleen Leonard, formerly of LGL Alaska Research Associates).

Catalog Development and Current Status 2005-2016

The CIBW Photo-Id Project took 38,195 photographs in 2015 and 37,442 photographs in 2016. The public and colleagues also provided photos of incidental sightings and stranded belugas, sharing 773 photos in 2015 and 2,991 photos in 2016. The 2005-2016 CIBW Photo-ID catalog contains photos from 421 dedicated survey days in addition to photos from ca. 50 days of incidental effort by colleagues and the public.

The number of identified whales in the CIBW Photo-ID catalog has grown with each year of effort. The right-side catalog contains sighting histories for 398 individual whales photographed on the right side between 2005 and 2016, and the left-side catalog contains sighting histories for 304 individual whales photographed on the left side between 2005 and 2011, and in 2016 (Figure 13, Table 16). There are currently 63 "dual" whales in the catalog (i.e., individual whales whose right- and left-side catalog records are linked; Table 16).

In order to conserve project funds, beginning in 2006 only photographs of the right sides of the whales were cataloged and images of the left sides of the belugas were archived without cataloging. The choice of the right side over the left side was arbitrary at the time it was made. Funding was later obtained that allowed for the cataloging of left-side photos taken between 2005 and 2011 (McGuire et al. 2011a, 2014b; Appendix E).

Funding has more recently been obtained to allow for the cataloging of left-side photos from 2012-2015; this work is expected to be completed in spring of 2018.

Sighting Histories of Identified Belugas 2005-2016

The following summary of sightings between 2005 and 2016 is for individuals in the right-side catalog, the dual catalog, and for subsets of particular interest. Summaries of the left-side catalog are not presented because it is still in development; however, relevant left-side records are included in the dual catalog summary.

Because dual whales have the most complete sighting records of belugas in the catalog, they are one of two subsets of belugas in the catalog that are of highest value for obtaining information about survival and reproduction. The other subset contains those identified whales in the catalog that are of known sex because their photo-id records have been matched to whales whose sex was genetically determined during: 1) captures for satellite tagging, 2) examinations during strandings, or 3) biopsy studies.

Right-side catalog 2005-2016

The 2005-2016 right-side catalog contains records for 398 individuals. Fourteen percent of the whales in the right-side catalog were seen over the 12-year period spanning 2005 to 2016 (i.e., they were photographed in both 2005 and in 2016; Table 16). Seven individuals in the right-side catalog have been matched to photos of dead individuals. Because seven years was the maximum gap between resightings of individuals, an individual was suspected to have died if it had not been photographed after 2008. There are 47 individuals in the right-side catalog suspected to have died based on the lack of sightings after 2008, and another seven confirmed dead (from stranding records), leaving 344 individuals in the right-side catalog that are believed to have still been in the population in 2016.

Dual catalog 2005-2016

Thirty seven percent of the whales in the dual catalog were seen in both 2005 and 2016 (giving them each a 12-year sighting history). One individual who was photographed as recently as 2016 was identified in photographs taken by NMFS in 1998, giving it a 19-year sighting history (Figure C11). Five years was the maximum gap between resightings of individuals in the dual catalog; however, to be conservative and consistent in estimating the number of whales that had died, the same criterion from the right-side catalog was applied for dual whales, i.e., an individual was suspected to have died if it had not been photographed since 2008. There were four individuals in the dual catalog suspected to have died, based on the lack of sighting records after 2008 (one of these was later confirmed dead when its dead-stranded body was photo-identified). Another four whales were known to be dead (from stranding photos), leaving 55 individual belugas in the dual catalog that are believed to have still been in the population in 2016.

Identified individuals with satellite-tag scars

Fourteen individuals in the photo-id catalog were confirmed as whales bearing scars from satellite tags, and a 15th individual in the catalog was identified as a whale that had been captured but not tagged (20 CIBWs were captured and 18 were tagged by NMFS between 1999 and 2002). Details about the capture and tagging, as well as whale movements during the life of the tags, are presented in Shelden et al. (in press). Seven of the 15 satellite-tagged whales were photographed in 2016; this represents 47% of the 20 CIBWs originally captured and/or tagged between 1999 and 2002. Three satellite-tagged whales were confirmed dead between 2001 and 2015. Photo-id records suggest a fourth whale, tagged in 2002, may have died after its last sighting in 2007. Details on the photo-id records of these individuals are presented in McGuire and Stephens (2016). Twelve of these 15 individuals have photo-id records on both the right and left sides (i.e., they are dual-side whales). Sighting histories of satellite-tagged whales photographed in 2015 and/or 2016 are presented in Appendix C.

Six individuals in the photo-id catalog have been identified as individuals in the photos taken at the time they were captured and tagged (Table 17); three of these were females and three were males (confirmed via DNA collected during capture). The three females were each photographed with an accompanying calf at least once during 2005-2016. One of the whales that was captured but not tagged was also matched to the photo-id catalog; this whale was a female (confirmed via DNA collected during capture) who has not been photographed since 2007 and is therefore presumed dead.

Identification of stranded belugas 2005-2016

Thirteen stranded CIBWs have been identified as individuals in the 2005-2016 photo-id catalog (Table 18). All 13 of these identified whales were adults; 12 were dead and one was alive. Of the 12 dead whales, six were males and six were females. Two of the males had scars from satellite tags. One of the females was pregnant at the time of stranding. The live-stranded adult was presumed to be a female because she stranded with a live calf at her side. Sighting histories of identified stranded whales are presented in McGuire and Stephens (2017). In 2016, there was only a single stranded whale with photos that were of useable quality for photo-id, and her photos have not been matched to any individual in the catalog (Table 13).

Identification of biopsied whales

A feasibility study for biopsy of CIBWs was conducted in 2016 (McGuire et al. 2017). Biopsy samples were obtained from six whales; five of these whales were photographically matched to individuals who were already in the CIBW photo-id catalog, and the sixth has been entered as a new individual in the catalog (Table 19). Genetic sex determined from biopsy skin samples indicates that five of the biopsied whales were female and one was male. Two of these females have been photographed with an accompanying calf at least once between 2005 and 2016. Sighting histories of these six identified biopsied whales are presented in Appendix C.

Identification of individuals of known sex in the 2005-2016 catalog

There are 22 individuals of known sex in the 2005-2016 catalog; eight are males and 14 are females. Sighting histories of the individuals of known sex who were photographed in 2015 and/or 2016 are presented in Appendix C. There is little difference between sighting histories of the sexes with respect to mean number of years photographed, range of years photographed (Table 20), or survey areas in which they were photographed (Appendix C).

Reproductive Histories

Number of presumed mothers in the 2005-2016 catalog

There are 187 presumed mothers in the right-side catalog (158 right side only and 29 dual), which represents 47% of the individuals in the right-side catalog. There are 29 presumed mothers in the dual catalog, which represents 46% of the individuals in this catalog. There are 14 females of known sex (i.e., sex was confirmed from genetics or necropsy). Seven of the 14 known-sex females had been classified as presumed mothers based on their photo-id records. Another two known-sex females had been classified as possible mothers based on ambiguous photos in which a calf may have been alongside the mother but could not be confirmed. Five of the known-sex females were never photographed with a calf.

DISCUSSION

Seasonal and Spatial Patterns of Beluga Group Encounters

The seasonal patterns of CIBWs in Upper Cook Inlet during the 2015 and 2016 field seasons were consistent with patterns found in previous years of this study (McGuire and Stephens 2017) and in other studies (Moore et al. 2000; Hobbs et al. 2005; Nemeth et al. 2007; Shelden et al. in press). These studies found that belugas groups are large (>100 individuals) in the Susitna River Delta in late May/early June, smaller from mid-June through mid-July, then abruptly become large in mid-July, peaking mid- to late July through mid-August. Beluga groups appear in Knik Arm and Turnagain in early/mid-August, just as the large groups in the Susitna River Delta are breaking up, peak in mid- to late August through mid-September, then taper off for the rest of the ice-free season. The seasonal distribution patterns during the ice-free months are likely in response to patterns of seasonal migrations of prey (e.g., eulachon runs in May, followed by salmon runs late July to early August; NMFS 2008b). Large groups were also reported to the CIBW Photo-Id Project in January of both 2015 and 2016 near the Tyonek oil and gas platform in the western part of the Upper Inlet.

Annual Patterns in Group Size

The group of 313 whales seen at the Susitna River Delta in July 2015 was the largest group observed to date during the 12 years of the CIBW Photo-ID Project (McGuire and Stephens 2017). The occurrence of large beluga groups in the Susitna River Delta relative to groups found in other areas of Cook Inlet during the summer months is consistent with patterns reported by NMFS from aerial surveys conducted in June and August of multiple years (Shelden et al. in press).

Between 2005 and 2012, mean and maximum group sizes during photo-id surveys had varied somewhat from year to year, but stayed within the same general range (McGuire and Stephens 2017). However, starting in 2012 and 2013 and continuing into 2015, there were noticeable increases in group size (both mean group size and annual maximum group size) and beluga encounter rates during photo-id surveys.

One possible explanation for this is that over time the photo-id surveys became selectively more focused on targeting large groups in order to maximize the number of whales photographed per survey. Additionally, the survey team became more experienced in predicting when and where to find large groups of belugas. There is no doubt that fluctuations in beluga encounter rates were related to annual differences in photo-id survey effort (i.e., total hours spent on surveys, months surveyed, and areas searched). However, the change in survey effort alone does not explain the trend in increasing group size: the largest group of every year 2005-2015 always occurred in the same area (Susitna River Delta) and during the same general time period (mid-July to early August), and there was still a pattern of these groups becoming noticeably larger beginning in 2012 and continuing to increase in 2013 and 2014, with a record high in 2015.

Results from the 2016 field season provided a remarkable exception to this general pattern; maximum and mean group sizes in both the Susitna River Delta and Knik Arm

fell to approximately half of the sizes encountered the previous year. The largest group seen in the Susitna in 2016 fell to numbers not seen since 2011. Conversely, the largest group ever seen in Turnagain Arm during the history of the project was seen in 2016, and was almost four times the size of the largest group seen there the previous year. The underlying causes of these patterns will likely only be understood by examining them in the context of other annual changes in environmental conditions, especially the variations in the timing and strength of annual fish migrations (see Moore et al. 2000, NMFS 2016, and Bechtol et al. 2016 for discussions of distribution and seasonal movements of beluga prey and identification of data gaps). Modeling of the interactions of all contributory factors involved is needed to tease out any true inter-annual patterns from those influenced by sampling.

Color and Age Composition of Groups

There is little evidence to suggest that CIBW groups encountered during the ice-free field season are segregated according to age-class. As in previous years of the study, most of the groups encountered in 2015 and 2016 contained roughly equal proportions of white and gray whales, and most of the groups contained calves and/or neonates. Notable exceptions were six instances of groups that each consisted of a lone white beluga, but photographs of sufficient quality for identification could not be obtained and it is unknown if this was the same individual in all six instances. In four of the six cases, the lone beluga was assumed to have joined the larger group encountered later in each survey day because it was seen headed in the direction of the larger group.

Although the majority of groups were mixed with respect to color and age-class, within mixed groups there was occasionally stratification by subgroups (examples occurred on July 20 and July 27 in 2015, and on July 19 and July 27 in 2016) where there were clumps of mothers and calves, followed at intervals by clumps of white belugas, all traveling in a line within a much larger mixed group. A variation on this theme occurred August 1, 2015 when a clump of small gray belugas brought up the rear of a long line of belugas of mixed color and age class.

Although not quantified, observers had the impression that white beluga whales were more likely to be detected than gray beluga whales, as gray belugas tended to blend with the turbid gray waters of Cook Inlet. This suspected bias in detection towards white whales seemed greater with distance from the observer. Behavioral differences between white and gray belugas, however, may have resulted in an opposite bias. Observers also had the impression that gray animals were more likely to approach the survey boat and to remain near the boat. Therefore, although white belugas were more likely to be detected at a distance, gray belugas may have been more likely to be photographed from vessels. Environmental conditions, most notably ambient light, may also have resulted in some variability in color assigned to whales during surveys. Color composition was most difficult to determine in Turnagain Arm, where whales were often far from the land-based observers and harder to detect in the often-rough water resulting from the usually strong Turnagain winds.

General Patterns of Habitat Use by CIBWs

Beluga whales encountered during all photo-id surveys of Cook Inlet in 2015 and 2016 were rarely observed traveling among survey areas, but were instead encountered in distinct "hot spots" in predictable seasonal patterns that had been observed in previous years. Similar patterns of localized aggregations and rapid and directed travel among these areas of localized aggregations have been reported for satellite-tagged CIBWs (Hobbs et al. 2005) and beluga whales in Norway (Lydersen et al. 2001). The seasonal distribution and tidally driven movement patterns are likely in response to patterns of seasonal migrations of prey (e.g., eulachon runs in May, followed by salmon runs late July to early August; NMFS 2008b), as well as by variations in water temperature, ice coverage, and river discharge (Goetz et al. 2007, 2012; Ezer et al. 2013).

Photo-id and satellite tracking evidence shows that individually identified belugas occur in all three hotspots. But because sightings of belugas transiting between known hot spots (i.e., the Susitna River Delta, Knik Arm, Turnagain Arm) are relatively infrequent, it remains unknown if there are distinct movement corridors among areas or if movement patterns are more diffuse and variable. For example, the 2015 sighting of a group traveling along the far-western bank of lower Knik Arm between Port Woronzoff and headed up Knik Arm during a falling tide was unusual in terms of season, location, and tidal stage for CIBW groups seen during the history of the project.

For CIBW conservation and protection of critical habitat, the identification and protection of movement corridors that link hot spots would seem to be as essential as the identification and protection of the hot spots themselves.

Extent of Habitat Used and Incidental Sightings

Traditional Ecological Knowledge (TEK) reports that the historic range of CIBWs included the Lower Inlet, defined here as the area of Cook Inlet south of the East and West Forelands (Huntington 2000, Braund and Huntington 2011). Aerial surveys have indicated that the distribution of CIBWs has changed significantly since the 1970s, when surveys were initiated. There has been a northward contraction of the CIBW core range into Upper Cook Inlet, as well as a shift west toward Anchorage (Rugh et al. 2010). Aerial surveys often detected belugas south of the Forelands prior to 1996 (Rugh et al. 2000, 2010), but since then they were only seen in the Lower Inlet in 1997, 2001, and 2012 (Rugh et al. 2010, Shelden et al. 2015a), and were only seen in the Middle Inlet (area around the Forelands) in 2006 and 2012 (Shelden et al. 2015a). Satellite-tagged whales were last tracked in the Middle Inlet in 2003 (Shelden et al. in press). Incidental sightings of CIBWs south of the Upper Inlet have been reported to NMFS on occasion (Vate-Brattstrom et al. 2010), but not as often and not in the large numbers that were historically reported (Vate-Brattstrom et al. 2010, Dutton et al. 2012).

The CIBW Photo-ID Project received incidental sighting reports of belugas as far south as Kachemak Bay in the Lower Inlet, and around Kalgin Island, Redoubt Bay, and the Kenai River Delta in the Middle Inlet. Reports from the Kenai River were first received

in 2007, then yearly between 2008 and 2015. It is notable that reports of belugas south of the Upper Inlet were not received in 2016.

Incidental sightings of belugas outside of the Upper Inlet appeared to increase since 2011 when dedicated outreach efforts were undertaken in this area (McGuire et al. 2014a, McGuire and Stephens 2017). It is unknown if the observations of belugas during photo-id surveys and from incidental sightings in the Middle and Lower Inlet represent range expansion, or if they are simply the result of increased observer and reporting effort in the area. Likewise, it is unknown if the lack of reports outside of the Upper Inlet in 2016 represent fewer whales in these areas, or a decrease in observer effort and reporting effort, resulting from a decrease in outreach efforts to communities in these areas.

Outreach efforts by the CIBW Photo-ID Project have not only provided an opportunity to share information about belugas and the CIBW Photo-ID Project with the public, but have also enabled us to increase public awareness of the avenues for reporting beluga sightings (i.e., reporting free-swimming belugas to the CIBW Photo-ID website, and contacting the NMFS Stranding Hotline to report stranded belugas). Incidental sighting reports received from the public and colleagues are used by the CIBW Photo-ID Project to help plan surveys, to monitor general CIBW distribution and movement patterns annually, and to look at beluga presence information for specific areas and/or seasons where baseline studies are lacking. Incidental reports are consolidated annually and shared with NMFS and other CIBW researchers. NMFS uses incidental sighting reports in scientific publications and presentations on CIBW distribution patterns and trends, and in endangered species consultations for development projects in Cook Inlet.

For example, the incidental sighting reports of large groups of CIBWs in January of both 2015 and 2016 near the Tyonek oil and gas platform in the western part of the Upper Inlet provided important information about beluga aggregations during the winter months, when few studies of CIBWs have been conducted.

Habitat Use by Individuals

As indicated in the maps of the individual sighting histories in Appendix C, individually identified belugas did not display fidelity to any single area of Cook Inlet, but instead were found throughout the survey area. The same was true of the individuals tracked with satellite tags (Shelden et al. in press).

In general, the more robust the sighting record of an identified individual (i.e., the more times and years an individual is photographed), the more likely it is to have been photographed throughout the survey area in the Upper Inlet, without displaying obvious preference for any particular area. There are two interesting exceptions: the first is the female D111, who was captured and tagged by NMFS in 2000. Her sixteen-year span of records from both tagging and photo-id show her using Knik Arm and the Susitna River Delta, but never Turnagain Arm. Based on photo-id records alone, we had assumed sampling bias may have been the reason we never detected her in Turnagain Arm, because groups encountered in Turnagain Arm typically yield a much lower percentage of identified whales than groups encountered in other areas, which is likely a result of greater sighting distances in Turnagain Arm compared to other areas. After matching her photo-id records with her photos taken at the time of capture, we were able to see that her

satellite tagging records also indicated that she never entered Turnagain Arm while being tracked. A second whale, D403, has scars indicating it was captured and tagged by NMFS sometime between 1999 and 2002, and is presumed to be a female based on the close accompaniment of a calf in photos. Like D111, she has never been photographed in Turnagain Arm, despite being photographed almost every year during 2005-2016 and having conspicuous markings that would have still been detectable even at sighting distances often experienced in Turnagain Arm.

Photo-identified males and females were found in the same groups and areas at the same time and did not appear to be using habitats differently. We will be examining these data further to see if there are differences at a finer scale within the groups.

Feeding Habitat and Behavior

For groups observed in the Susitna River Delta, suspected/confirmed feeding behavior seen early in the field season in 2015 (late May and early June) was notably different than the suspected/confirmed feeding behavior seen later in the season (July and August). Early in the season, beluga groups would suddenly bunch up in a tight circular formation, then just as suddenly scatter, often with the group dividing in two and heading in opposite directions, then suddenly turning and bunching up again. Observers had the impression they were pursuing, or perhaps driving, fish that were schooling in circular clumps that would abruptly expand and contract, and frequently change direction. This fish behavior is consistent with schooling behavior of migrating eulachon (Moyle and Cech 2004). Later in the season, beluga groups that were suspected to be feeding were cohesive, faced the same direction (until a last minute high-speed lunge), and either traveled in a linear direction along the shoreline or displayed a circular path, following the current out of a river mouth, then traveling along the shoreline back upriver, then looping back downstream with the current. Observers had the impression that belugas were fishing along a steadily moving column of fish that were evenly spaced and traveling in a unidirectional linear formation. This fish behavior would be consistent with migrating salmon (Moyle and Cech 2004). We did not record the seasonal differences in behavior in previous years, but it may well have occurred and we failed to notice the difference, as behavioral observations were secondary to obtaining photographs. It may also be that the timing of the eulachon run in 2015 was different from in previous years of the study and we were observing it for the first time. We were unable to survey during this same period in 2016 to compare, because of a request from NMFS to suspend boat-based surveys during the 2-week window in late May/early June when aerial surveys for CIBWs were flown. One survey of the Susitna River Delta was conducted in May of 2016, prior to the aerial surveys that year, but feeding behavior was not observed. We frequently observed beluga groups heading towards the mouth of the Susitna River with the incoming tide, but we were unable to follow them due to hazardous boating conditions, and do not know how far up the river they continued or if they were in pursuit of prey (which we assumed was the reason they were headed upriver).

Belugas in Turnagain Arm typically entered the Arm about four hours before the high tide and moved up (i.e., south and east) the Arm with the rising tides. The strong seasonal pattern of belugas in Turnagain Arm coincided with fall salmon runs in this area, and the scattered incidental sightings in the spring may have been associated with the eulachon

runs up Turnagain Arm. Feeding behavior was more commonly seen in the middle and upper (i.e., eastern) ends of Turnagain Arm. The outcropping at Bird Point appeared to be frequently used for belugas to congregate and wait until waters reached a sufficient depth with the incoming tide to allow for their continued travel up Turnagain Arm. On both the incoming and outgoing tides, belugas often used the coves and eddies created by natural and artificial outcroppings to mill, presumably searching for food, and possibly reduce their exposure to strong currents. Unlike previous years of the study, in 2015 and 2016, belugas were not found traveling in the deeper channels along the north and south shores of Turnagain Arm. They were instead observed traveling in the visibly shallow areas in the middle of the Arm, and during the incoming tide, they sometimes appeared to be looking for and pursuing prey along the edges of these shallow areas.

Feeding behavior in Knik Arm was seen along the edges of mudflats during low tide and at the mouths of rivers during ebb and flood tides. In general, whales in mid-/upper Knik Arm traveled down Knik Arm and entered Eagle Bay and Eagle River during the falling tide, milled around and were suspected to feed in Eagle Bay and the mouth of Eagle River just before low tide, and traveled back up Knik Arm during rising tide. All photo-id vessel surveys, as well as the land-based surveys at Eagle River, were scheduled around the falling, low, and rising tides; therefore, we cannot describe feeding habitat during high tide.

Suspected and confirmed feeding behavior was observed in all months surveyed in 2015, and all months surveyed in 2016 except May. Feeding behavior was not observed as often in 2016 as it was in 2015. Possible correlations between group size and feeding behavior, and interannual variations in both, will be investigated in future work.

Calving Behavior/Calf-Rearing Habitat and Seasonality

Unlike other beluga populations, the scientific literature had not identified distinct calving grounds for CIBWs because births in the wild had not been documented previously. To our knowledge, our observation of a CIBW birth on July 20, 2015 in the Susitna River Delta is the first documentation of a CIBW birth, and provides evidence to support the designation of the Susitna River Delta as CIBW calving grounds. Our documentation of a second suspected birth in the same area almost a year to the day later further supports this. The documentation of a suspected birth in Turnagain Arm in 2016 suggests that calving is not restricted to the Susitna River Delta.

The first neonates encountered during each field season were always seen at the Susitna River Delta in July, and were later seen in the other areas where groups were encountered. Within the broad area defined as the Susitna River Delta, neonates were seen in the river mouths of the Susitna River and Little Susitna River, and along the mudflats between the two rivers. No particular location could be singled out as a calf-rearing habitat because calves and neonates were seen in all parts of the survey area where belugas were encountered.

Seasonality of beluga calving in the Canadian Arctic has been determined using seasonal differences in proportions of calves, juveniles, and adults (Smith et al. 1994). Based on the presence of calves sighted in summer aerial surveys, Calkins (1983) speculated that calving might occur between mid-June and mid-July in the larger estuaries of western

Upper Cook Inlet. Our observations of the confirmed and suspected births, as well as our documentation of the dates of the first neonate of each year, indicate that calving for CIBWs encountered in the survey areas begins in mid- to late July/early August, generally coinciding with our observed timing of annual maximum group size. Evidence also suggests that the calving season extends into September and likely into October, as we have seen a suspected birth in September of 2016 and have photographed neonates in October in 2015 and in previous years of the study (McGuire and Stephens 2017). It seems likely that we underestimate the number of neonates in groups, and perhaps fail to detect births later in the season (i.e., after July) when beluga groups move over to Turnagain Arm, where distance between land-based observers and whales is greater.

Is the 2005-2016 Photo-id Catalog Representative of the CIBW Population?

The number of identified individuals in the photo-id catalog is not a population estimate, although the number of individuals photographed each year does provide a minimum estimate of the number of CIBWs alive each year. We are unable to simply add the number of individuals in the right- and left-side catalogs to estimate population size for CIBWs for several reasons. With the exception of the 63 dual whales, we do not know which of the 304 left-side whales are the same individuals as the 398 right-side whales. If skin biopsies for genetic analysis continue to be collected concurrently with photographs of both sides of the whales, as they were during the 2016 CIBW biopsy feasibility study (McGuire et al 2017) and again during the second year of the biopsy study in 2017, more of the left- and right-side records will be able to be linked. In addition, many variables determine if an individual will be identified from photos. The photo-id sighting history of an animal depends on the availability and identifiably of the animal. Availability factors include the behavior of the animal (i.e., reaction to the research vessel or land-based photographer, surfacing behavior, other behavior), affinity of the individual for the study area, and survey effort. Factors contributing to identifiability include the experience and skill of the photographer, boat driver, and photo-analyst; the quality of the camera and lens; weather conditions; and the conspicuousness and distinctiveness of the identifying mark. The distance between the whale and photographer, which is constrained by the survey area, animal behavior, and research permit restrictions, also affects identifiability. Estimating population size from photo-id data first requires models that consider these variables and the role they play in the probability that a whale is identified.

The most-recent CIBW population estimate from aerial surveys in 2016 was 328 whales, with a range between 279 and 386 whales (https://alaskafisheries.noaa.gov/node/56813). The fact that the number of individuals in the photo-id catalog (398 individuals; 344 after subtracting known- and presumed-dead individuals) closely matches the population estimate from aerial surveys suggests that much of the population has been identified. Considering that during the duration of the CIBW Photo-ID Project several of the individuals in the catalog have died without photographs and many calves have been born that have not yet been identified, the numbers of individuals in the catalog should not be interpreted as a population count. Nevertheless, although the catalog does not represent every individual in the CIBW population, it does appear to contain records on the majority of individuals, and therefore data from individuals in the catalog should be representative of the CIBW population. As discussed previously, we have confirmed that

both sexes are represented in the catalog. The shape of the discovery curve, representing the number of new individuals added to the catalog every year, is leveling off, which further supports the idea that most of the population (or the portion of the population that is available to us with current survey methods) has been identified. Life-history data derived from the catalog should therefore be generally characteristic of the CIBW population.

Mortality of Identified Individuals

NMFS reports that there were 73 dead CIBWs recorded between 2005 and 2015, although the age and sex of these individuals are not stated (NMFS 2016). In 2016, six dead CIBWs were reported to the CIBW Photo-ID Project, resulting in a minimum of 79 dead CIBWs between 2005 and 2016. The CIBW Photo-ID Project was provided with or took photos of 22 of these individuals. There does not appear to be a clear pattern for mortality of the dead photographed whales in terms of age class or sex; 73% were adults, 14% were calves, one was of unknown age class, and two were fetuses. In addition, slightly over one third were female, one third were male, and sex was undetermined for the remainder; this suggests a near 50:50 sex ratio. Twelve dead-stranded whales have been matched to individuals in the 2005-2016 catalog, and six of these were males and six were females, again suggesting a 50:50 sex ratio in the population represented by the catalog.

Linking the sighting history of an identified whale with data obtained from its necropsy increases the value of both kinds of data. For example, being able to confirm the sex of a dead whale allows us to ground truth our assumption of mother/calf relationships based on photographs of live whales. Genetic identification of individuals also allows for the validation of photo-id of these same individuals. For example, a beluga that died in 2015 had been photo-identified as an individual that had been satellite-tagged in 2002 and later resighted between 2005 and 2015; genetic comparisons of samples taken during capture for tagging and from the dead animal confirmed it was the same individual (McGuire and Stephens 2016). The potential exists for genetic samples taken from dead and live whales to provide information about kinship of identified individuals and we hope to be able to incorporate this type of information into the individual records in the CIBW Photo-ID Project catalog.

Incorporating both the actual number of dead-stranded belugas and those predicted to have died based on a cessation of photo-id sighting records will be useful for population models. The number of stranded animals reported annually is surely an underestimate of the number of deaths, given that many carcasses are not encountered and others are likely not reported. Winter strandings and strandings of calves are likely to be particularly underestimated because of detectability issues.

In order to obtain the maximum amount of information possible from a photograph of a dead whale, we have updated and distributed a protocol for photographing beluga mortalities (available at www.cookinletbelugas.org). This protocol can be used as a guide for stranding responders who are willing to photo-document markings on beluga mortalities and share their photographs with the CIBW Photo-ID Project.

Photo-identification of live-stranded animals can also provide information about the survival of individuals post-stranding. For example, NMFS provided the CIBW Photo-ID Project with photos of a mother and calf who live-stranded in 2015 and were seen to swim away from the stranding on the rising tide. The mother was photographically identified as R1032, who was first photographed in 2008 and every year after for six years. Despite a very conspicuous mark and previously strong sighting record, she was not photographed again in 2015 after the stranding event, nor was she photographed in 2016. Thus, the photo-id evidence (i.e., no subsequent sightings) suggests that she may not have survived the live-stranding experience.

Number of Presumed Mothers in the 2005-2016 Catalog

It seems likely that photo-id methods underestimate the number of presumed mothers, and thus females, in the CIBW population within a field season. We only classified as "presumed mothers" those individuals who had clear evidence of a calf alongside them in the same photo frame. We classified whales as "potential mothers" when calf accompaniment was ambiguous, either because of uncertainty about which adult in the photo frame was the parent of the calf, uncertainty differentiating calves from juveniles (for larger light-gray whales), or because too little of the suspected calf was visible above the surface of the turbid water to confirm that it was a calf. Our current method of defining mother-calf pairs at the level of association within the photo frame limits our ability to detect mothers with older calves, because the distance between mothers and offspring increases with increasing age of the calf (Mann 1997, Krasnova et al. 2009). With each additional field season, however, we increase the chances that we photograph the actual number of mothers in the population over the course of the study. Approximately half of the individuals in both the right-side and dual catalogs have been classified as presumed mothers based on their 2005-2016 sighting histories.

We are also likely missing mothers because of the incomplete catalog status; we anticipate that the number of presumed mothers in the catalog will grow with the inclusion of the 2012-2015 left-side photographs to the catalog, particularly as we link right and left sides and increase the size of the dual catalog. For example, the addition of the left- and right-side photos from 2016 led to an increase from 48 individuals in the 2005-2015 dual catalog (McGuire and Stephens 2017) to 63 individuals in the 2005-2016 dual catalog.

Adding biological information obtained from invasive CIBW studies allowed for the validation of assumptions that had been made about individuals in the catalog based solely on their photo-id histories. We were able to use the information from the 22 individuals (eight males and fourteen females) for which sex had been genetically determined from samples collected during satellite tagging captures, strandings, and biopsy to test and refine our classification of mothers (McGuire and Stephens 2017).

Half of the 14 photo-identified females of genetically confirmed sex had been classified as presumed mothers based on their photo-id histories. In other words, seven individuals that had been presumed to be mothers based on their sighting histories with calves were later confirmed to be females from genetic samples. However, this means that 50% of the genetically confirmed females had not been classified as presumed mothers in the photo-

id catalog, although two were classified as potential mothers. Photo-id records of confirmed females that were not classified as presumed mothers may have been too sparse and/or the whales may simply have not been photographed when they had calves with them. Alternatively, it is possible they were relatively young females and had not yet reached reproductive maturity. Another possibility is that these females without calves were of reproductive age, but for some unknown reason were not reproducing, or had lost their calves. These photo-id sighting history data will need to be combined with data that NMFS is currently compiling about age, reproductive hormones, and contaminate burdens of many of these females of confirmed sex in order to better understand which of these processes may be occurring.

Reproductive Rate of Individuals and the Population

We are collaborating with colleagues from Montana State University, NMFS MML, and ADF&G to use both survey data and photo data from the 2005-2016 CIBW Photo-ID database to construct models to estimate reproductive rates and examine their implications for CIBW population viability and recovery.

CONCLUSIONS

The CIBW Photo-ID Project used non-invasive, observational methods to provide longitudinal data about CIBW population characteristics, habitat preferences, and individual life histories of 398 whales over a 12-year period. The strength of the CIBW Photo-ID Project will continue to grow with the proportion of the CIBW population that is identified and re-sighted. The number of whales in the catalog is always increasing as more years of fieldwork are conducted, but also as more of the archived photos from previous years of fieldwork are cataloged. Filling in the gaps in the catalog will allow us to obtain more information about life histories of individuals, including reproductive females and their calves (e.g., left-side photos from 2012-2015 are being analyzed and cataloged under a separate contract with NMFS, with a final report due spring 2018).

The utility of the individual sighting records in the photo-id catalog is greatly increased with the addition of biological information obtained from invasive studies and/or stranding response. Together these data help form a more comprehensive picture of an identified individual, framing the biological information from tissue samples within the context of historical data gained from photo-id, such as movement patterns, reproductive history, relative age, and social associations. To date, biological information obtained from skin samples has allowed us to know the sex of some individuals (from genetic samples collected during tagging, strandings, and biopsy). Additional information that can be provided from biological samples and incorporated into the catalog includes age, reproductive status, familial relationships, diet, and contaminant loads.

We obtained estimates of beluga encounter rates, group sizes, and relative color- and size-class composition from surveys, and the number of identified presumed mothers in 2015 and 2016. We describe patterns and trends that are apparent within the data, while also pointing out sources of sampling bias and how they may affect the data from photo-id surveys and identification of individuals. We are cautious in reporting life-history parameters such as reproductive or survival rates because there are many factors that affect our ability to detect, photograph, and identify individuals, particularly mothers and calves, and they all may result in biased estimates. Multivariate models are needed to quantify the effect of these factors (and their interactions) on estimating these population and life-history parameters. The next phase of the CIBW Project, now underway, includes working with colleagues to construct models to quantify these biases and confounding variables and explicitly build them into models that will allow scientists to better assess the significance of the patterns for understanding beluga population dynamics. In the meantime, however, these descriptive results will be useful to managers seeking to minimize effects of human activities on belugas, and to help inform future research efforts.

Insights were recently gained into the population decline of the endangered St. Lawrence Estuary belugas by constructing an integrated model from multiple datasets, which revealed patterns and population dynamics that any single dataset alone would not have been able to explain (Mosnier et al. 2015). The continuation of a long-term, Inlet-wide photo-id dataset combined in an integrated model with other datasets (e.g., aerial surveys, acoustic surveys, biopsy sampling, necropsies, photogrammetry studies from aerial drones) and appropriately modeled to account for sampling constraints and biases

inherent to each method will help with efforts to understand the continued lack of recovery of the CIBW population

RECOMMENDATIONS

In order to maximize the utility of the CIBW Photo-ID Project to provide information needed for decision making to recover and conserve the CIBW population, we recommend the following:

- continue photo-id surveys to add to the long-term dataset of a long-lived species,
- fill gaps in the existing catalog,
- incorporate biological information from other studies with information contained in the photo-id catalog,
- continue to team with colleagues to construct models to maximize the information collected by the CIBW Photo-ID Project,
- collaborate with colleagues to integrate multiple datasets into an integrated model, and
- continue to communicate project results to managers, colleagues, and the public.

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TABLES

Table 1. Number of CIBW Photo-ID Project surveys conducted in Cook Inlet, Alaska between 2005 and 2016 according to survey sub-area and year.

	Year												
Sub-Area	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***Total Number of Surveys***
Susitna River Delta	16	17	5	8	13	14	11	13	8	9	10	11	**135**
Knik Arm	32	13	5	9	10	9	16	12	3	7	4	8	**128**
Turnagain Arm	0	4	5	12	12	15	16	15	12	8	8	7	**114**
Chickaloon Bay/Fire Island	4	1	1	2	1	0	2	5	2	2	1	0	**21**
Kenai River Delta	0	0	0	0	0	0	4	14	6	0	0	0	**24**
Annual Number of Survey Days*	52	35	16	31	36	38	49	59	31	26	23	25	**421**

*Because multiple sub-areas may have been visited on a single survey day, the number of surveys according to sub-area will not add to the total number of annual survey days.

Table 2. Photo-identification survey effort and beluga whale groups encountered in Upper Cook Inlet, Alaska in 2015 and 2016.

	2015				2016			
	Susitna River Delta	**Knik Arm**	**Turnagain Arm**	**Fire Island**	**Susitna River Delta**	**Knik Arm**	**Turnagain Arm**	**Fire Island**
Range of Survey Dates	May 28 - Aug 12	Aug 1 - Sept 1	Aug 20 - Oct 1	Aug 12	May 24 - Aug 16	Aug 17 - Sept 30	Sept 3 - Sept 27	not surveyed
Number of Surveys	10	5	8	1	11	8	7	not surveyed
Number of Groups Encountered	17	5	17	0	19	12	22	not surveyed
Number of Belugas Encountered	1697	404	165	0	659	440	334	not surveyed
Mean Number of Groups per Survey	1.7	1.0	2.1	0	1.7	1.5	3.1	not surveyed
Mean Number of Belugas per Survey	169.7	80.8	20.6	0	59.9	55.0	47.7	not surveyed
Mean Group Size	99.8	80.8	9.7	0	34.7	36.7	15.2	not surveyed
Maximum Group Size	313*	129*	39	0	148	74	147*	not surveyed

*Largest group per survey area on record 2005-2016

Table 3. Number, composition, and size of groups sighted during vessel-based surveys of the Susitna River Delta in 2015 and 2016. (Neonates are separate from calf total. Unknown = beluga of unknown color and size. x = could not be determined. y = yes, color-class present, but could not be quantified.)

2015	# White	# Gray	# Calves	# Neonates	# Unknown	*Group Size*
May 28	5	3	1	0	0	9
May 28	5	3	0	0	0	8
June 1	5	5	2	0	0	12
June 1	41	52	10	0	0	103
July 14	0	0	0	0	0	0
July 19	1	0	0	0	0	1
July 19	1	0	0	0	0	1
July 19	85	70	18	3	0	176
July 20	1	0	0	0	0	1
July 20	118	144	47	4	0	313
July 27	50	40	15	3	160	268
July 31	40	20	15	5	70	150
July 31	90	60	20	3	0	173
August 1	30	24	6	2	0	62
August 1	80	80	40	5	0	205
August 3	70	54	23	5	0	152
August 12	20	20	20	3	0	63
2015 Total	**642**	**575**	**217**	**33**	**230**	**1697**

2016	# White	# Gray	# Calves	# Neonates	# Unknown	*Group Size*
May 24	10	5	2	0	0	17
July 13	1	0	0	0	0	1
July 13	1	0	0	0	0	1
July 13	x	x	x	x	5	5
July 13	10	3	2	x	10	25
July 15	35	25	12	2	25	99
July 16	3	5	2	0	0	10
July 17	4	2	1	0	0	7
July 17	3	2	0	0	0	5
July 19	55	65	25	3	0	148
July 20	15	10	5	x	20	50
August 3	20	18	5	2	0	45
August 13*	y	y	2	1	47	50
August 13	4	2	1	0	0	7
August 15*	y	y	4	1	20	25
August 15*	y	y	5	1	69	75
August 15*	y	y	4	1	20	25
August 16*	y	y	y	1	49	50
August 16	10	3	1	0	0	14
2016 Total	**171**	**140**	**71**	**12**	**265**	**659**

Table 4. Number, composition, and size of groups sighted during land- and vessel-based surveys in Knik Arm in 2015 and 2016. (Neonates are separate from calf total. Unknown = beluga of unknown color and size. x = could not be determined. y = yes, color-class present, but could not be quantified.)

2015	# White	# Gray	# Calves	# Neonates	# Unknown	*Group Size*
August 1	3	3	0	0	0	6
August 25	61	55	10	3	0	129
August 26	34	48	21	2	0	105
August 27	60	28	8	0	0	96
September 1	y	y	5	x	63	68
2015 Total	**158**	**134**	**44**	**5**	**63**	**404**
2016	**# White**	**# Gray**	**# Calves**	**# Neonates**	**# Unknown**	***Group Size***
August 13	3	2	0	0	0	5
August 17	34	34	4	2	0	74
August 18	27	11	6	3	0	47
August 19	1	0	0	0	0	1
August 19	39	17	8	2	0	66
August 20	24	7	6	1	0	38
August 21	22	37	9	4	0	72
August 21	1	0	0	0	0	1
August 22	x	x	x	x	3	3
August 22	x	x	x	x	6	6
August 22	17	24	7	5	0	53
September 30	24	29	18	3	0	74
2016 Total	**192**	**161**	**58**	**20**	**9**	**440**

Table 5. Number, composition, and size of groups sighted during land- and vessel-based surveys in Turnagain Arm in 2015 and 2016. (Neonates are separate from calf total. Unknown = beluga of unknown color and size. x = could not be determined. y = yes, color-class present, but could not be quantified.)

2015	# White	# Gray	# Calves	# Neonates	# Unknown	*Group Size*
August 20	5	3	3	1	0	12
August 23	4	5	1	0	0	10
August 23	x	x	x	x	1	1
August 23	x	x	x	x	1	1
August 28	5	1	3	x	6	15
September 5	x	x	x	x	3	3
September 5	x	x	x	x	3	3
September 5	x	x	x	x	10	10
September 5	x	x	x	x	5	5
September 6	3	1	1	0	0	5
September 6	x	x	x	x	10	10
September 19	x	x	x	x	3	3
September 19	4	2	2	x	2	10
September 20	2	1	0	0	0	3
September 20	x	x	x	x	20	20
September 20	x	x	x	x	15	15
October 1	9	21	8	1	0	39
2015 Total	**32**	**34**	**18**	**2**	**79**	**165**

2016	# White	# Gray	# Calves	# Neonates	# Unknown	*Group Size*
September 3	2	0	0	0	0	2
September 3	1	2	0	0	0	3
September 3	0	0	0	0	10	10
September 3	1	1	1	0	0	3
September 3	x	x	x	x	5	5
September 3	2	0	0	0	0	2
September 3	2	0	0	0	0	2
September 3	x	x	x	x	10	10
September 9	3	2	2	0	0	7
September 9	4	4	1	0	0	9
September 10	x	x	x	x	1	1
September 10	6	3	1	0	0	10
September 10	1	0	0	1	0	2
September 10	x	x	x	x	10	10
September 13	3	1	2	0	0	6
September 13	2	1	0	0	0	3
September 13	69	62	13	3	0	147
September 13	12	8	2	0	0	22
September 19	2	0	0	0	0	2
September 26	10	8	4	1	7	30
September 27	11	17	6	1	5	40
September 27	x	4	x	x	4	8
2016 Total	**131**	**113**	**32**	**6**	**52**	**334**

Table 6. Daily range of environmental conditions measured during vessel-based surveys conducted in 2015 and 2016 in the Susitna River Delta, Upper Cook Inlet, Alaska.

Date	Survey Start Time	Survey End Time	Sea Ice?	Surface Water Temp (°C)	Air Temp (°C)	Wind Speed (km/hr)	Wind Direction	% Cloud Cover	Precipitation	Visibility	Swell (m)	Beaufort Sea State*	Other Human Activities Noted
2015													
May 28	07:52	15:15	no	8.8-11.2	6.6-15.3	1.9-8.8	SW, then W	25-40	none	good	0-2	1	aircraft
June 1	10:19	17:22	no	7.9-13.0	12.9-14.0	0-13.9	SW, then W	50-90	none	good	0-0.5	0-2	aircraft
July 14	10:02	15:22	no	13.3-14.7	15.7-18.5	9-19.6	SE	70-90	none, then rain	good, then fair	0.25-0.5	2-3	aircraft, inter-tidal bulldozers at Port of Anchorage
July 19	12:30	19:25	no	13.3-14.6	18.3-20.8	6.5-7.2	W, then SW	15-20	none	good	0.25-0.5	1-3	aircraft, recreational boats
July 20	13:30	18:50	no	13.7-15.0	19.1-25.7	7.9-12.2	SW	5	none	good	0.25-0.5	1-3	set nets and boats, aircraft
July 27	07:34	13:48	no	13.7-15.1	13.2-19.3	0	n/a	0-75	none	good	0	0-1	set nets and boats, aircraft, tug and barge
July 31	10:49	15:15	no	12.4-15.3	18.6-24.1	2.7-8.9	E, then ESE	5-15	none	good	0-0.25	1	aircraft
August 1	11:35	17:00	no	14.5-15.4	21.7-28.5	0-4.5	E	01-05	none	good	0	0-1	aircraft
August 3	13:00	18:51	no	14.8-16.3	20.8-26.2	5.0-9.0	ESE, then E	2	none	good	0-0.25	0-2	set nets and boats, aircraft
August 12	09:38	13:57	no	14.0-15.5	16.0-18.9	0-6.5	n/a, then SE	0	none	good	0-0.5	1-2	aircraft
2016													
May 24	11:15	20:30	no	10.6-12.3	12-17.5	6-24	SW, then W	05-10	none	good	0-4	1-5	aircraft; bulldozers along intertidal at Port of Anchorage (took shelter in Little Susitna River when Beaufort >3)
July 13	06:10	12:48	no	14.7-16.8	17.5-19.4	0-10	NW, then SE	02-15	none	good	0-0.25	1-2	aircraft
July 15	07:35	13:30	no	14.0-16.4	15.4-18.1	8.4-8.6	W	40-50	none	good	0-0.5	2-3	
July 16	08:19	14:30	no	13.7-17.8	16.9-20.6	0-6.2	SE	15-90	none	good	0-0.25	0-2	set nets at Beluga River
July 17	09:21	15:23	no	14.8-16.8	17.1-19.7	0-6.5	SE	10-40	none	good	0-0.5	0-1	aircraft
July 19	10:05	17:00	no	15.7-16.9	18.3-27.7	0-16	SE then SW	0-30	none	good	0-0.25	0-2	aircraft
July 20	10:51	16:45	no	16.0-17.4	18.3-26.9	0-11.2	W	40-60	none	good	0-.25	1-2	aircraft
August 3	11:03	17:15	no	13.8-15.8	16.4-20.6	0-6.2	NW	25-60	none	good	0-0.5	1-2	aircraft
August 13	07:00	15:08	no	13.2-14.2	14.4-17.0	0-6.9	NE	80-99	light rain	good	0-0.5	0-2	aircraft, biopsy
August 15	07:05	17:12	no	12.5-13.6	14.5-15.3	0-3.3	N	50-70	none	good	0-0.5	0.5-1	aircraft, set nets, biopsy
August 16	07:10	17:00	no	13.1-14.4	14.8-15.3	2.6-13	NW	50-95	none	good	0	1-2	aircraft, biopsy

* Beaufort Sea State: 0 = sea like a mirror; 1 = ripples without foam crests; 2 = small wavelets, crests do not break; 3 = large wavelets, crests begin to break, scattered white caps

Table 7. Daily sighting conditions during land-based surveys conducted in 2015 and 2016 in Knik Arm and Turnagain Arm, Upper Cook Inlet, Alaska.

Date	Survey Area	Survey Start Time	Survey End Time	Sea Ice?	Visibility	Beaufort Sea State*	Other Human Activities Noted
2015							
August 25	Knik Arm	08:53	16:20	no	good	1	aircraft
August 26	Knik Arm	09:29	16:09	no	good	1	none
August 27	Knik Arm	08:50	16:00	no	good	2	aircraft
September 1	Knik Arm	11:40	18:39	no	good, then fair	1-2	aircraft, boat (JBER research)
August 20	Turnagain Arm	09:15	13:15	no	good	1-2	aircraft
August 23	Turnagain Arm	11:17	16:00	no	fair	3	none
August 28	Turnagain Arm	17:09	18:41	no	poor	3	none
September 5	Turnagain Arm	11:08	13:41	no	good	0	none
September 6	Turnagain Arm	12:43	15:40	no	fair	0-3	none
September 19	Turnagain Arm	09:04	12:36	no	fair	0-3	none
September 20	Turnagain Arm	09:45	12:30	no	good	0	none
October 1	Turnagain Arm	08:30	15:30	no	good	0-1	none
2016							
August 17	Knik Arm	08:20	16:36	no	good	0-1	aircraft, biopsy
August 18	Knik Arm	08:15	18:00	no	good	0-1	biopsy, detonations on land
August 19	Knik Arm	08:00	18:26	no	good	1-2	aircraft, biopsy
August 20	Knik Arm	09:30	19:15	no	good	0-1	aircraft, biopsy
August 21	Knik Arm	09:00	20:04	no	good	0-2	aircraft, biopsy
August 22	Knik Arm	09:30	18:00	no	fair	2-3	aircraft (including helicopter), biopsy
September 30	Knik Arm	10:50	16:32	no	poor-good	1-2	none
September 3	Turnagain Arm	06:44	12:54	no	good	2-3	none
September 9	Turnagain Arm	10:00	14:15	no	fair	5	none
September 10	Turnagain Arm	10:35	17:39	no	good	0	none
September 13	Turnagain Arm	14:31	20:20	no	good-fair	1	aircraft, including circling over belugas; weapon firing sounds from Hope and/or firing range at Potter Marsh
September 19	Turnagain Arm	14:15	16:35	no	good	1	aircraft
September 26	Turnagain Arm	13:09	18:55	no	good	1-2	none
September 27	Turnagain Arm	15:00	19:00	no	good	2-3	none

*Beaufort Sea State: 0 = sea like a mirror; 1 = ripples without foam crests; 2 = small wavelets, crests do not break; 3 = large wavelets, crests begin to break, scattered white caps

Table 8. Percent color/age-class composition of beluga whale groups sighted during surveys of Upper Cook Inlet, Alaska in 2015 and 2016. Numbers have been rounded up to the nearest whole number.

Area	Group Size Total	% White	% Gray	% Calves	% Neonates	% Unknown
2015						
Susitna River Delta	1,697	38	34	13	2	13
Knik Arm	404	39	33	11	1	16
Turnagain Arm	165	19	21	11	1	48
2016						
Susitna River Delta	659	26	21	11	2	40
Knik Arm	440	44	37	13	4	2
Turnagain Arm	334	39	34	9	2	16

Table 9. Summary of primary and secondary activities of beluga groups encountered in 2015 during vessel-based photo-identification surveys in the Susitna River Delta, Upper Cook Inlet, Alaska.

Date	Group Size	Primary Group Activities Noted	Secondary Group Activities Noted	Additional Group Activities Noted
May 28	9	diving, feeding suspected	milling, socializing	in Little Susitna River, rolling around in subgroups with flippers out of water. Lots of chasing, and splashing. Clumping up in cove along east bank then scattering in river and then patrolling along shore
May 28	8	traveling	diving	
June 1	12	milling	traveling	milling in deep cove at river bend
June 1	103	traveling, feeding suspected	milling	fishing in tidal rip created by water coming off of mudflats, whales seem to be driving prey along the shore and out to the Inlet. Very vocal, group fanning out, then bunching up again, diving , tails up, rapid turns, lots of splashing, group moves up the Susitna River with rising tide
July 19	1	traveling	diving	solitary white whale, patrolling along shore between tidal rips, and then following the rip into the Inlet
July 19	1	patrolling	diving	solitary white whale, patrolling along shore between two tidal rips, diving into rip
July 19	176	patrolling, traveling	socializing, diving, milling, feeding suspected	lots of vocalizing, group splits into two - one heads east and the other west. The western-most group turned and went up the Susitna River the rising tide, diving and tail waving as they went
July 20	1	traveling	none	
July 20	313	traveling, milling, patrolling	feeding suspected, socializing, diving	big group strung out along shore, traveling in clumps of mothers and calves, then clumps of all white big whales very close together. Lots of vocalizing. Birth observed. Whales head up Susitna River with rising tide. On two occasions, whales went quiet and low surfacing profiles when small plane approached low overhead, and for about 30 seconds afterward - didn't scatter, returned to previous activities in same locations
July 27	268	traveling, milling, feeding suspected	diving, head standing/tail waving	vocalizing, long line of whales heading west, clumps of whites together, then clumps of grays and mom/calves - whales only 2-3 m from shore. Long string broke up into smaller subgroups patrolling along shore. Entire group then traveled up Susitna River with rising tide
July 31	150	milling, traveling	diving, feeding suspected	in mouth of Little Susitna River - riding tidal rip out, then circling around, traveling up river close to shore, then riding tide out again, some belugas had muddy streaks on them after diving
July 31	173	traveling	feeding suspected, diving, resting	vocalizing. Group stopped traveling and appeared to rest/mill during lowest tide stage 5-10 m from shore, then belugas began to travel up Susitna River with rising tide, then turned back and went along shore towards Little Susitna River, then veered out into Inlet again following a tidal rip
August 1	62	traveling, feeding suspected	diving, socializing	belugas bunching up in mouth of the Little Susitna River, salmon (unidentified species) seen at surface swimming away from beluga
August 1	205	traveling	feeding suspected	group streaming by in line along shore, but in clumps of subgroups - more whites out front, then mother with calves and neonates, then group of small grays together. Group of white whales and large grays chase fish under anchored survey boat (seen on fish finder), then group of gray juveniles surround boat blowing bubbles, diving, and vocalizing for ~ 20 min
August 3	152	milling, traveling	diving, feeding suspected	group first seen in Little Susitna River on falling tide, then travel west along shore in a line of mixed age class and color, but with a subgroup of 3-5 small grays together at the end. The westbound group met an eastbound group, lots of vocalizing when joined, stopped and milled, then giant group headed east together, group heads up Susitna River on rising tide. A group of 100 hauled-out harbor seals entered the water as the belugas passed by in front of them
August 12	63	traveling, feeding suspected, diving	feeding suspected, diving, milling	riding current down the Little Susitna River, then looping back around and heading up river along shore, repeating. As tide turns and rises, groups tightens up and travels west towards Susitna River Delta

Table 10. Summary of primary and secondary activities of beluga groups encountered in 2016 during vessel-based photo-identification surveys in the Susitna River Delta, Upper Cook Inlet, Alaska.

Date	Group Size	Primary Group Activities Noted	Secondary Group Activities Noted	Additional Group Activities Noted
May 24	17	milling	traveling	whales were inside Little Susitna River, along west bank, then disappeared. Can't tell if went upriver or into Inlet. Glare and high winds, we can't leave the river. We motored up Little Susitna as far as water depths would allow but did not encounter whales again
July 13	1	diving	unknown	
July 13	1	diving	unknown	diving along rip line where brown (upper inlet) and greenish (mid-inlet) meet
July 13	5	diving		diving in shallows <4 ft; very high low tide today
July 13	25	diving	traveling	tight subgroup of 5 white whales in deeper water diving and traveling; others spread out and diving in shallower water near shore, subgroup of 5 turns to larger group of 9, including grays and a calf
July 15	99	travelling	diving, milling	belugas traveling back and forth between rips coming off of mudflats; seals follow group of belugas, then mix in with them; whales vocal; group of gray belugas dive, bubble, and squeal under and around survey boat (engine in neutral)
July 16	10	milling	traveling, feeding suspected	whales vocal, milling in and circling around mouth of Beluga River riding current and countercurrent; seals seen feeding at surface on pink-fleshed fish; belugas seen chasing fish (high speed waves, under water mud plumes in relatively clear green water); lots of fish seen on fish finder
July 17	7	milling	feeding suspected	seals mixed in with belugas; belugas chasing fish in 6 feet of water, fish seen flying out of water in front of beluga, smallish salmon, approx. 3 lbs., likely sockeye
July 17	5	diving	none	
July 19	148	travelling, milling	diving	whales vocal, large group spread over a mile, in several clumps of whales 1-3 body lengths apart; some clumps only gray whales, some mixed mothers and calves, others all white, some with very large white whales with gray animals and calves. Whales had been several hundred meters offshore, but then moved to within 20 m of shore while traveling; may have observed birth. Lots of head standing/tail waving during dives
July 20	50	feeding suspected	diving, milling	whales spread out over several miles along edge of mudflats, clumps of 5-8 whales form larger group; feeding suspected between tidal rips and along shore; salmon fin (unknown species) seen at surface of water near survey boat; belugas seen lunging after fish as fish jump out of water; whales vocal
August 3	45	traveling, milling	diving, feeding suspected	whales in mouth of Little Susitna River riding current and countercurrent in circles, then leave river with falling tide and are strung along edge of mudflats; feeding suspected when seen to lunge after fish just below surface of water, creating big waves; then diving with tails breaking the surface
August 13*	50	traveling, milling	diving	whales along edge of mudflats
August 13*	7	travel	none	whales difficult to approach and seemed to avoid boat, can't tell if this is in response to biopsy earlier in the day or becaue the tide has now turned and their movements are more erratic
August 15*	25	milling, traveling	diving	
August 15*	75	milling, then traveling	patrolling, diving	patrolling back and forth along shore; one whale in group very shallow water, rubbing against mudbank?
August 15*	25	milling, patrolling	diving	rising current and countercurrent around mouth of Little Susitna River
August 16*	50	milling	feeding suspected	belugas in mouth of Little Susitna River. Waves from submerged belugas lunging, believed to be prey pursuit; chum salmon (O. Keta) in spawning colors seen jumping at mouth of river; pink salmon (O. gorbuschca) photographed swimming along surface at mouth of river. Belugas leave with falling tide and head west to Susitna River Delta
August 16	14	traveling		belugas first seen by seal haulout site by east side of mouth of Susitna River Delta; belugas head up river with rising tide

*photo-id conducted during biopsy surveys

Table 11. Summary of primary and secondary activities of beluga groups encountered in 2015 and 2016 during land-based photo-identification surveys in Knik Arm, Upper Cook Inlet, Alaska.

Date	Group Size	Primary Group Activities Noted	Secondary Group Activities Noted	Additional Group Activities Noted
2015				
August 1	6	traveling	none	whales close to west bank, traveling in a line up Knik Arm
August 25	129	milling, traveling, diving	feeding suspected	
August 26	105	milling, traveling, diving	none	
August 27	96	travelling, milling	diving	
September 1	68	traveling	milling	
2016				
August 13*	5	traveling	diving	along shore at the Port of Anchorage and small boat launch
August 17*	74	traveling	milling, feeding suspected	whales seen lunging after jumping fish (unidentified species) in mouth of Eagle River
August 18*	47	traveling	milling, diving, feeding suspected	
August 19*	1	milling		milling in mouth of Ship Creek (same whale in same location same behavior, 10.5 hours apart, but same water depth/tidal stage)
August 19*	66	traveling	milling, diving, feeding suspected	prey pursuit observed
August 20*	38	traveling	milling, diving	salmon (species unknown) seen jumping out of water against bank of Eagle River
August 21*	72	traveling	milling	
August 21*	1	traveling	none	
August 22*	3	milling	none	mouth of Ship Creek
August 22*	6	milling	none	
August 22*	53	traveling		
September 30	74	traveling	socializing	whales vocal, seen spashing, bubbling, and rolling around with fins out of water along shallow mudflats in the middle of Eagle Bay

*photo-id conducted during biopsy surveys

Table 12. Summary of primary and secondary activities of beluga groups encountered in 2015 and 2016 during land-based photo-identification surveys in Turnagain Arm, Upper Cook Inlet, Alaska.

Date	Group Size	Primary Group Activities Noted	Secondary Group Activities Noted	Additional Group Activities Noted
2015				
August 20	12	traveling, milling	diving	also patrolling back and forth along riprap on north shore
August 23	10	feeding suspected, milling	traveling	seals and belugas seen driving fish against cove at Bird Point; seal seen with pink-colored fish flesh in mouth (unknown salmon species)
August 23	1	unknown	unknown	seen while driving
August 23	1	unknown	unknown	seen while driving
August 28	15	traveling, feeding suspected	milling	
September 5	3	unknown	unknown	seen while driving
September 5	3	unknown	unknown	seen while driving
September 5	10	travel	none	
September 5	5	milling	feeding suspected	
September 6	5	traveling, milling	none	
September 6	10	unknown	unknown	seen while driving
September 19	3	traveling	none	
September 19	10	milling	none	
September 20	3	traveling	none	
September 20	20	unknown	unknown	seen while driving
September 20	15	milling	none	
October 1	39	traveling	milling	
2016				
September 3	2	milling	none	
September 3	3	traveling	none	
September 3	10	traveling	milling	whales at entrance to cove at Bird Point
September 3	3	milling	diving	whales at entrance to cove at Bird Point
September 3	5	milling	none	whales mid-channel
September 3	2	traveling	none	
September 3	2	traveling	none	
September 3	10	traveling	none	
September 9	7	traveling	none	
September 9	9	milling	traveling	
September 10	1	unknown	unknown	seen while driving
September 10	10	feeding suspected	traveling, milling	seen chasing fish mid-channel along shallow mudlflat
September 10	2	traveling	milling	mom/neonate pair, swimming slowly in big loops, calf often 150-175 m away from mother. No wind, flat calm, easy to follow pair and also easy to see no other whales in view
September 10	10	traveling	none	
September 13	6	milling	traveling	whales seem to be spending more time underwater than usual
September 13	3	milling	feeding suspected	whales seem to be spending more time underwater than usual and lots of bubbling
September 13	147	traveling	socializing	possible breeding behavior? And/or possible birth? Aggressive behavior directed at neonate and mother.
September 13	22	traveling	milling	whales seem to be spending more time underwater than usual
September 19	2	milling	none	
September 26	30	milling	feeding suspected, traveling, socializing	very vocal, tailslaps, tailwaving, multple animals rolling around in close contact
September 27	40	traveling	milling	whales circling around Bird Point, riding current and countercurrent
September 27	8	milling	feeding suspected	

Table 13. Summary of stranded Cook Inlet beluga whales with photographs taken by or provided to the CIBW Photo-ID Project 2015 and 2016.

Year	Date	Location of Stranded Beluga	Type of Stranding	Necropsy performed by Alaska Marine Mammal Stranding Network?	Number of Belugas	Age Class	Sex	Photos taken?	Useable photos for identification?	Comment on Unusable Photos	Other Comments	Whale Matched to Known Catalog Whale?
2015	June 12	below Tyonek, western Upper Cook Inlet	dead on shore	yes	1	adult	male	yes	yes		had infected scars from previous satellite tag	yes, D2303 Sash
2015	August 27	Turnagain Arm: east of Bird Point, milepost 98.5	live on mudflats	not applicable	2	adult, calf	adult female*, calf of unknown sex	yes	yes for mother, no for calf	too little of calf visible in photo		yes for mother R1032 Bleacher, no for calf
2016	January 24	Turnagain Arm, near Hope	dead	no	1	fetus	unknown (skeleton)	yes	no	fetus, so not applicable	skeleton	not applicable
2016	April 3	south of Tyonek, western Upper Cook Inlet	dead	yes	1	adult	female	yes	right side yes, left side no		looked very skinny	no
2016	April 26	mouth of Little Susitna River	dead	yes	1	adult	female	yes	no	skin peeling and decomposed-unusable	with dead humpback	not applicable
2016	July 14	Carr Gottstein Park, Anchorage	dead	yes	1	aborted fetus	unknown (congenital defects)	yes	no	fetus, so not applicable		not applicable
2016	July 30	Tyonek/Shirley Ville, western Upper Cook Inlet	dead	yes	1	calf	unknown	yes	no	skin peeling and decomposed-unusable		not applicable
2016	August 12	Nikiski, Kenai River Delta	dead	yes	1	adult	female	yes	no	skin peeling and decomposed-unusable		not applicable

*assumed to be a female because of accompanying calf

Table 14. Summary of 70 incidental sighting reports of Cook Inlet belugas shared with the CIBW Photo-ID Project in 2015. Shaded cells indicate beluga sightings were reported. X indicates no sightings reported. See Figure 1 for a map showing locations of places where sightings were reported.

2015	Susitna Delta	Knik Arm	Turnagain Arm	Chickaloon Bay	Kenai River/ Delta	Port of Anchorage	Other
January	x	x		x	x	x	Tyonek Platform
February	x	x	x	x	x	x	x
March	x	x	x	x		x	x
April	x	x		x			Kasilof River, Point Possession
May		x		x	x		West of Homer/South of Anchor Point
June		x	x		x		Beluga River
July		x	x	x	x		Beluga, Theodore, and Lewis Rivers
August	x			x	x		x
September		x				x	
October	x			x	x	x	Kachemak Bay (unconfirmed)
November	x	x	x	x		x	
December	x	x	x	x	x	x	

Table 15. Summary of 95 incidental sighting reports of Cook Inlet belugas shared with the CIBW Photo-ID Project in 2016. Shaded cells indicate beluga sightings were reported. X indicates no sightings reported. See Figure 1 for a map showing locations of places where sightings were reported.

2016	Susitna Delta (Beluga River to Little Susitna River)	Knik Arm	Turnagain Arm	Chickaloon Bay/SE Fire Island	Kenai River Delta (Nikiski-Kasilof River)	Port of Anchorage	Other
January	x	x	x	x	x	x	by Tyonek (Community and Platform)
February	x	x	x	x		x	x
March		x		x			x
April		x		x		(Port MacKenzie)	x
May	x	x		x	x		x
June		x				x	Theodore, Ivan, Lewis, Beluga Rivers
July	x	x	x	x	x	x	
August		x		x	x	(Port MacKenzie)	Beluga River
September						x	
October	x	x		x		x	
November	x	x	x		x	x	
December	x	x	x	x	x	x	

Table 16. Summary of the number of individual CIBWs and their sighting histories in the 2005-2016 photo-id catalog.

Catalog	Years	Number of Individuals	Number of Individuals Photographed in Both 2005 and 2016 (12-year span)
right-side	2005-2016	398	54
left-side	2005-2011, 2016	304	56
dual	2005-2016 (right and left)	63	23

Table 17. Summary of CIBWs captured and satellite-tagged between 1999 and 2002, and matches to individuals in the 2005-2016 photo-id catalog.

NMFS CIBW ID Tagging Number	Capture Location	Capture Date	Sex	Color (assigned during capture)	Length (cm)	Photo-ID Catalog Number	Dead?	Photographed with a Calf 2005-2016?
no number (captured, not tagged)	Little Susitna	May 31, 1999	F	gray	230	L2191		yes
CI-9901	Little Susitna	May 31, 1999	M	white	370	possible match		
no number (captured, not tagged)	Knik Arm	September 8, 2002	F	light gray	274	no match (no tagging photos to examine)		
CI-0001	Knik Arm	September 13, 2000	M	white	413	possible match		
CI-0002	Knik Arm	September 13, 2000	F	white/gray	272	D111 Humperdink		yes
CI-0101	Little Susitna	August 10, 2001	F	gray	257	D243 Scrappy		
CI-0102	Knik Arm	August 11, 2001	M	white	323	possible match		
CI-0103	Knik Arm	August 12, 2001	F	white	312	possible match		
CI-0104	Knik Arm	August 13, 2001	F	white	340	no match (no tagging photos to examine)	may have died in 2001 post-tagging	
CI-0105	Knik Arm	August 13, 2001	F	white	357	possible match		
CI-0106	Knik Arm	August 15, 2001	F	white	401	D103 Strapped		yes
CI-0107	Knik Arm	August 20, 2001	M	white	442	no matches (blurry tagging photos)		
CI-0201	Little Susitna	July 29, 2002	M	white	412	possible match		
CI-0202	Little Susitna	July 30, 2002	F	white/gray	340	possible match	may have died in 2002 post-tagging	
CI-0203	Knik Arm	July 31, 2002	F	white	366	possible match		
CI-0204	Little Susitna	August 1, 2002	F	white	379	no post-2002 photos	confirmed dead post-tagging Aug 9, 2002	
CI-0205	Knik Arm	August 2, 2002	M	white/gray	386	D2303 Sash	confirmed dead June 12, 2015	no
CI-0206	Knik Arm	August 3, 2002	M	white/gray	353	D17367 Jabbathehut	lack of photo-id resightings since 2007 suggests this whale may have died	no
CI-0207	Knik Arm	August 3, 2002	F	white	374	possible match	may have died in 2002 post-tagging	
CI-0208	Knik Arm	August 4, 2002	M	white/gray	376	D115 Sashtoo	confirmed dead May 26, 2014	no

Table 18. Summary of stranded CIBWs that were identified as individuals in the 2005-2016 CIBW Photo-Id catalog.

Year	Date	Location of Stranded Beluga	Type of Stranding	Necropsy Performed by Alaska Marine Mammal Stranding Network?	# Belugas	Age Class	Sex	Comments	Photo-ID Catalog Number	Photographed with a Calf 2005-2016?
2008	Aug 8	Knik Arm	dead on shore	yes	1	adult	female		R16	no
2008	Aug 8	Knik Arm	dead floating	yes	1	adult	female		R197	no
2009	Oct 9	Knik Arm	dead on shore	yes	1	adult	female	pregnant	D157	yes
2012	Oct 5	Tyonek	dead floating	yes	1	adult	male		D7244	no
2013	Sep 4	Turnagain Arm	dead on shore	no	1	adult	female		L2634	yes
2013	Oct 7	Turnagain Arm	dead on shore	yes	1	adult	male	first photographed 1994 NMFS	D106	no
2014	May 26	Kincaid Park, Anchorage	dead on shore	yes	1	adult	male	satellite tag scars	D115	no
2014	Aug 1	Tyonek	dead on shore	yes	1	adult	male		L2294	no
2014	Sep 2	Chuitna River mouth	dead on shore	yes	1	adult	female		L1849	yes
2014	Sep 8	Turnagain Arm	dead on shore	yes	1	adult	male		L496	no
2014	Sep 27	Point Possession	dead on shore	no	1	adult	female		L265	no
2015	Jun 12	south of Tyonek	dead on shore	yes	1	adult	male	satellite tag scars	D2303	no
2015	Aug 27	Turnagain Arm	live on mudflats	not applicable	1	adult	female*	stranded with live calf	R1032	yes
Total				**10 necropsied**	**13**	**13 adults**	**7 female (6 confirmed, 1 presumed), 6 male**	**1 pregnant; 2 satellite-tagged**		

*presumed to be female because of accompanying calf

Table 19. Summary of photo-id matches made to the six individuals biopsied during the 2016 CIBW Biopsy Feasibility Study.

Biopsy Date 2016	General Location	Biopsy ID	Matched to Photo-ID Catalog?	Side Targeted for Biopsy	Linked Right and Left Side Photos?	Left-side Photo-ID	Right-side Photo-ID	Dual name Photo-ID	Year First Photographed	Genetic Sex*	Photographed with a Calf 2005-2016?
Aug 13	Little Susitna River	DL-CIB16-31	no	right	no	no photos	R18703	not dual	2016	female	no
Aug 15	Little Susitna River	DL-CIB16-32	yes	right	yes	L18813	R16873	D16873	2010	male	no
Aug 16	Little Susitna River	DL-CIB16-33	yes	left	no	L18698	no photos	not dual	2011	female	no
Aug 19	Eagle River	DL-CIB16-34	yes	left	yes	L18700	R16854	D16854	2014	female	no
Aug 19	Eagle River	DL-CIB16-35	yes	left	yes	L286	R154	D154	2005	female	yes
Aug 20	Eagle River	DL-CIB16-36	yes	left	yes	L2140	R220	D220	2005	female	yes

*genetic sex from biopsy samples determined by Nick Kellar, NMFS Southwest Fisheries Science Center

Table 20. Summary of 2005-2016 photo-id sighting histories of 22 individual CIBWs of known sex.

Known Sex	Source of Sex Information	Photo-ID Catalog Number	Number of Years Photographed 2005-2016
male	tagging	D17367	3
male	dead	D106	9
male	tagging and dead	D17366	10
male	tagging and dead	D115	9
male	dead	D7244	5
male	dead	L496	3
male	dead	L2294	5
male	2016 biopsy (DL-CIB16-32)	D16873	1
8 males		**mean # years photographed (male)**	**5.6**
		range of years photographed (males)	**1-10**
female	tagged	D111	9
female	tagged	D103	11
female	dead	D157	5
female	tagged	D243	10
female	dead	R16	4
female	captured for tagging (not tagged)	L2191	1
female	dead	L1849	3
female	dead	L2634	3
female	dead	L265	8
female	dead	R197	3
female	2016 biopsy (DL-CIB16-33)	L18698 V	1
female	2016 biopsy (DL-CIB16-34)	D16854	2
female	2016 biopsy (DL-CIB16-35)	D154	10
female	2016 biopsy (DL-CIB16-36)	D220	9
14 females		**mean # years photographed (females)**	**5.6**
		range of years photographed (females)	**1-11**

FIGURES

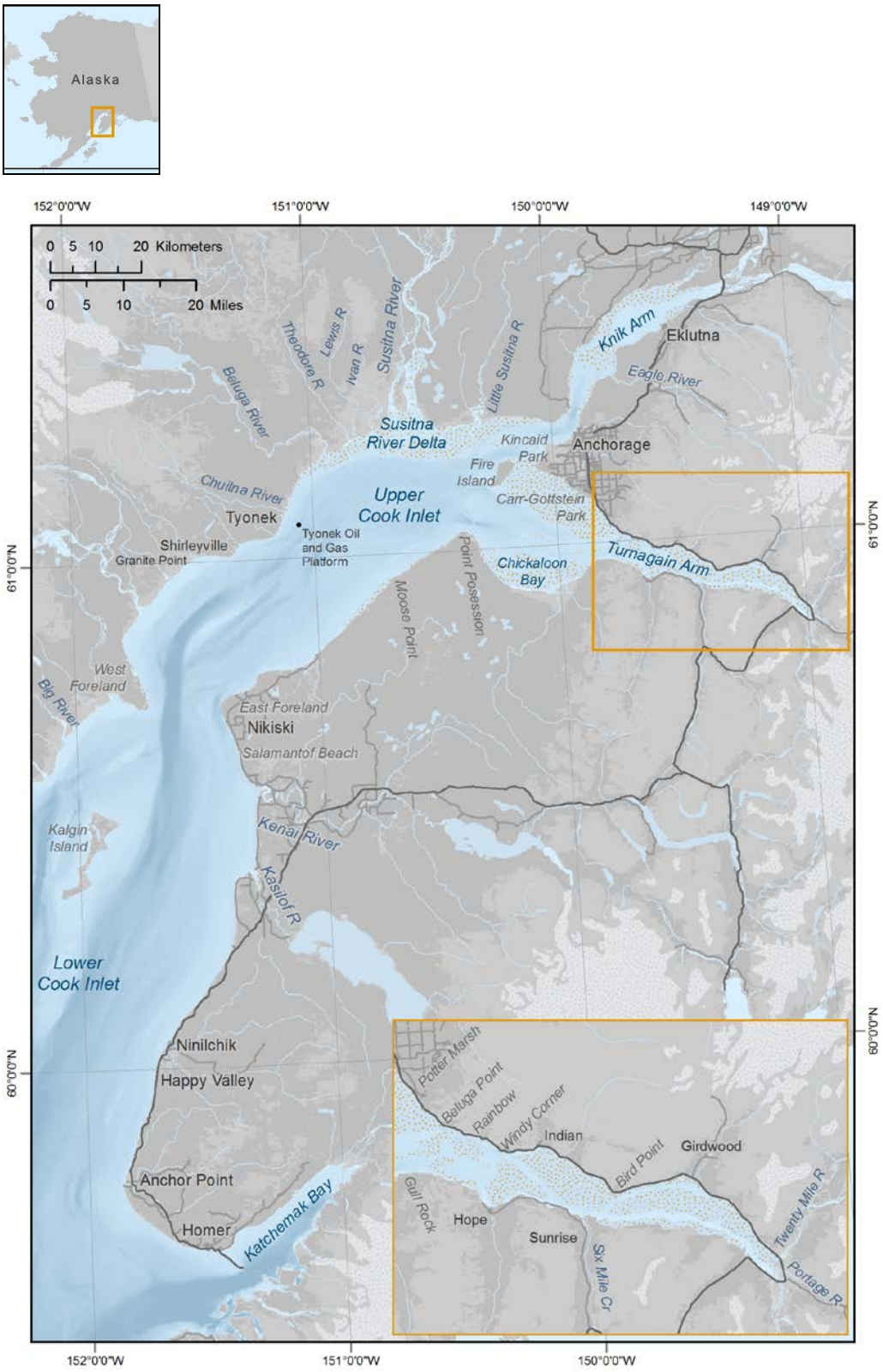


Figure 1. Map of Cook Inlet, Alaska, showing major features discussed in text.

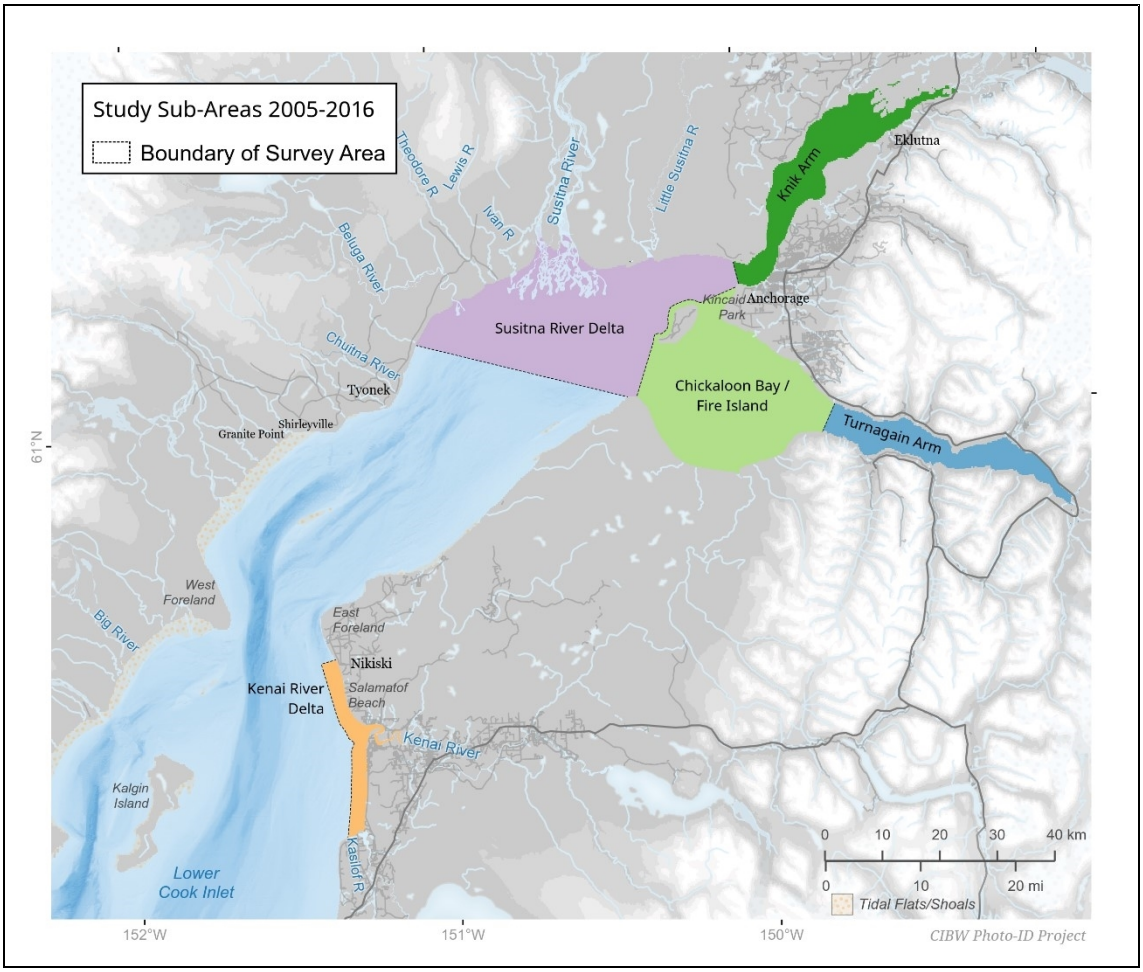


Figure 2. Map of Middle and Upper Cook Inlet, Alaska, showing boundaries of five survey areas within the study area. The Kenai River Delta study area was surveyed 2011-2013. This report is limited to surveys conducted in Upper Cook Inlet in 2015 and 2016.

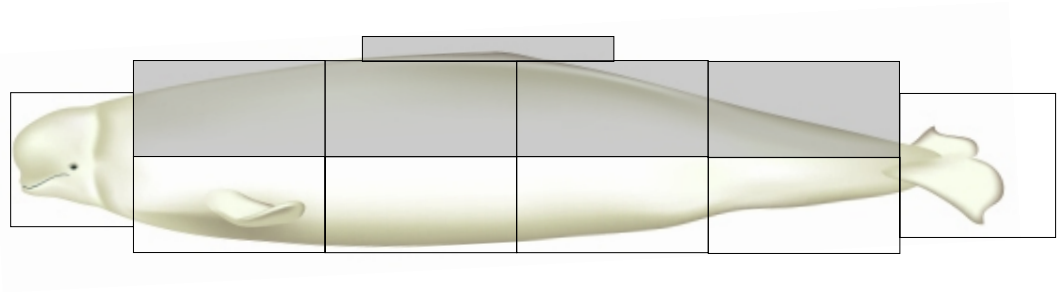
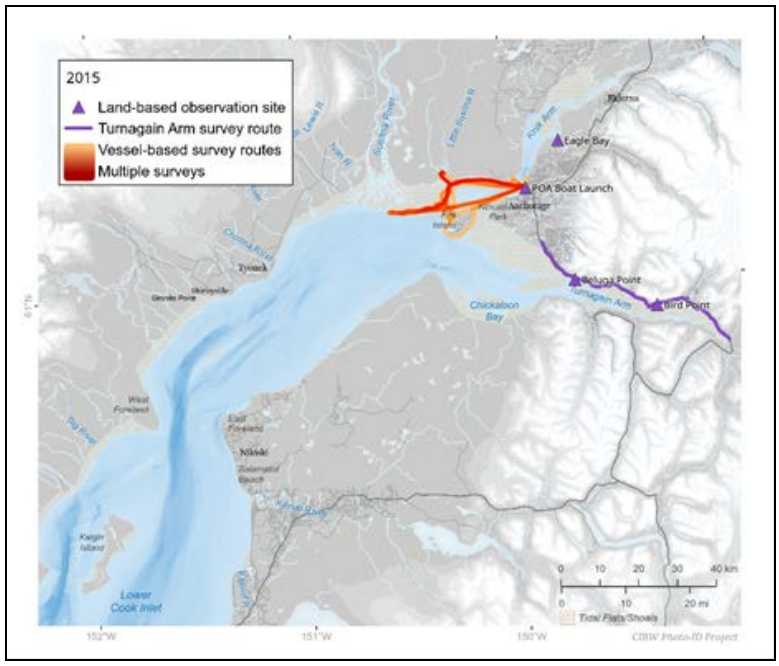


Figure 3. Body segments used when cataloging photographs of belugas for photo-id. The five shaded areas were the critical sections used in matching marks. Beluga illustration courtesy of Uko Gorter.



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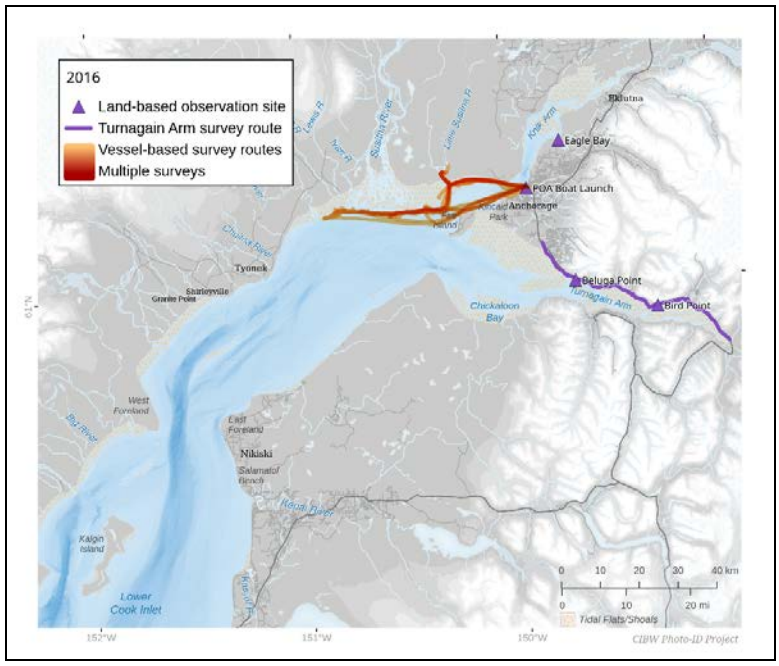
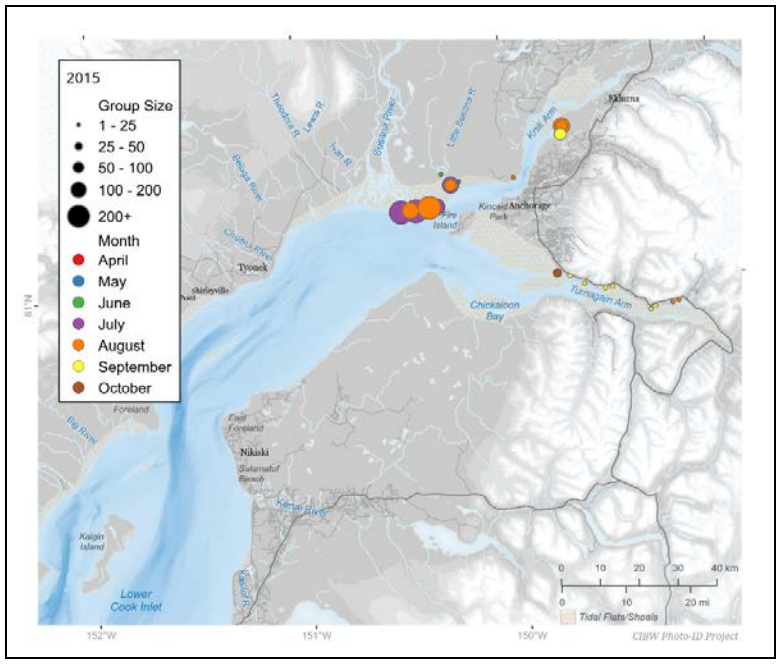


B.

Figure 4. Vessel routes (from daily GPS track lines) with land-based stations and survey routes for all photo-id surveys conducted in 2015 (A) and 2016 (B). Level of effort of the vessel-based surveys is indicated by the intensity of the colors of the track lines. See Table 1 for exact number of surveys. POA = Port of Anchorage.



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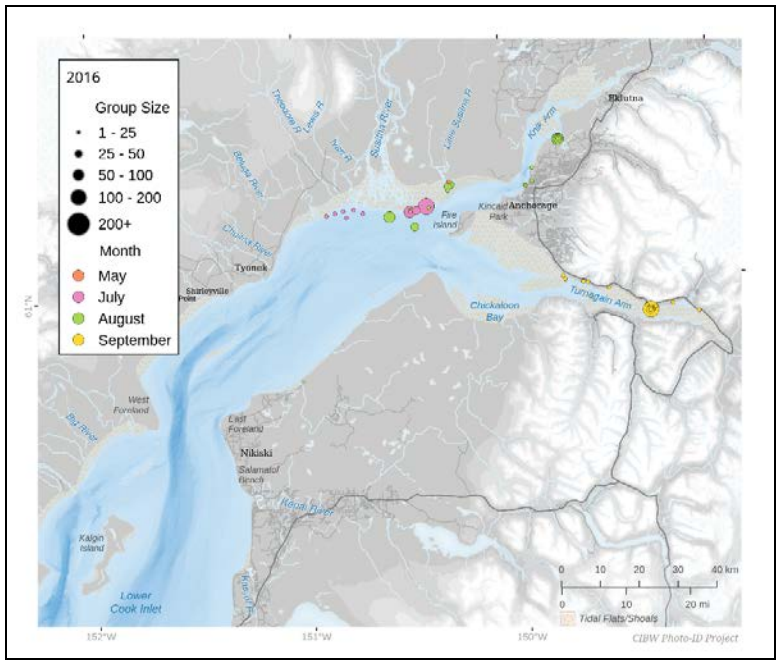

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Figure 5. Size, month, and location of beluga whale groups encountered during photo-id surveys conducted in 2015 (A) and 2016 (B).

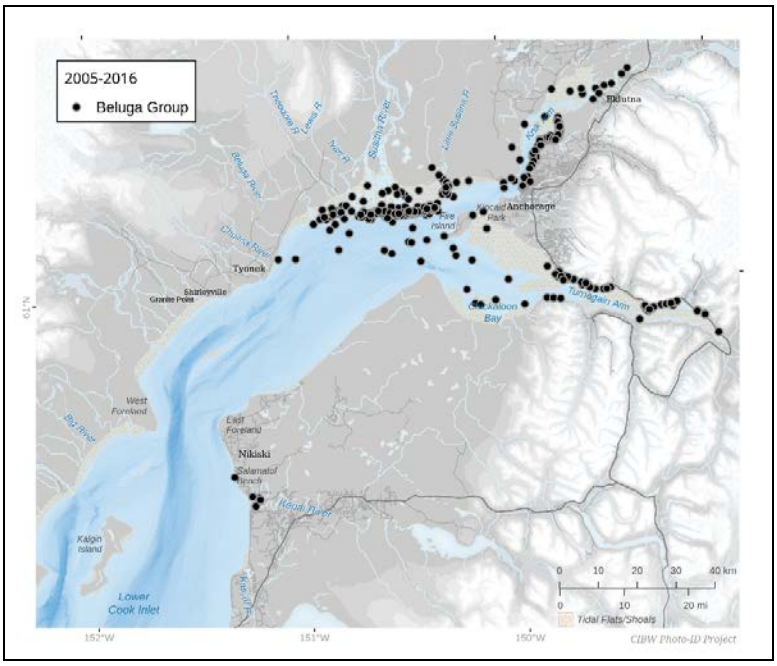


Figure 6. Beluga whale groups encountered during all photo-id surveys conducted 2005-2016.

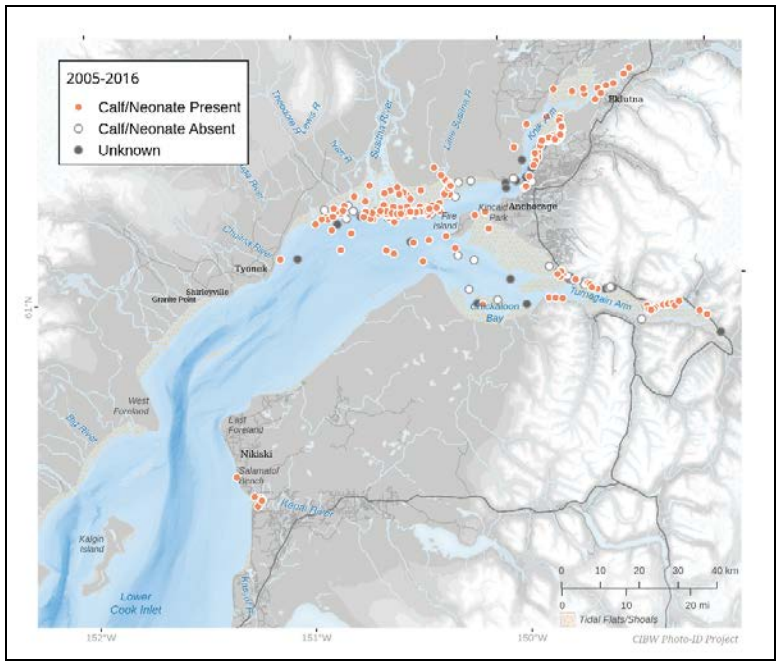
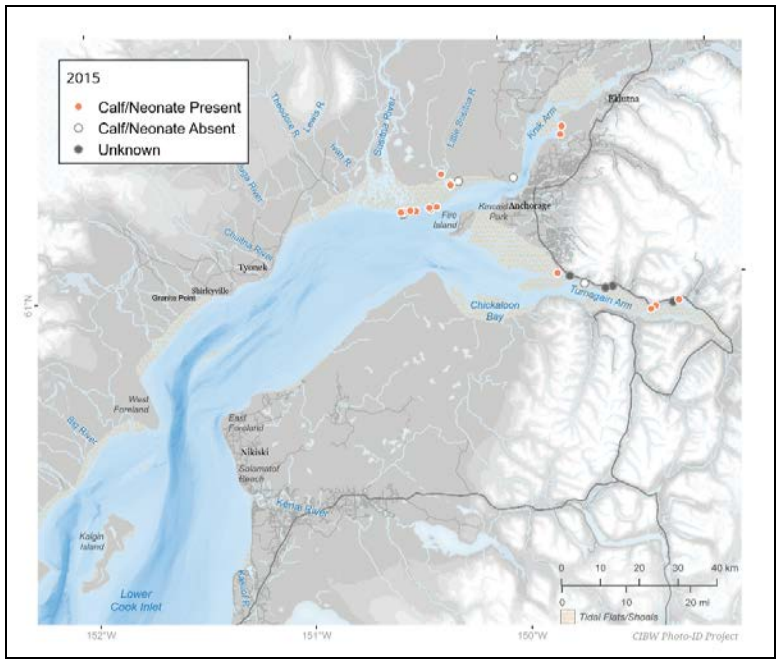


Figure 7. Location of groups with and without calves and/or neonates encountered during photo-id surveys conducted 2005-2016.



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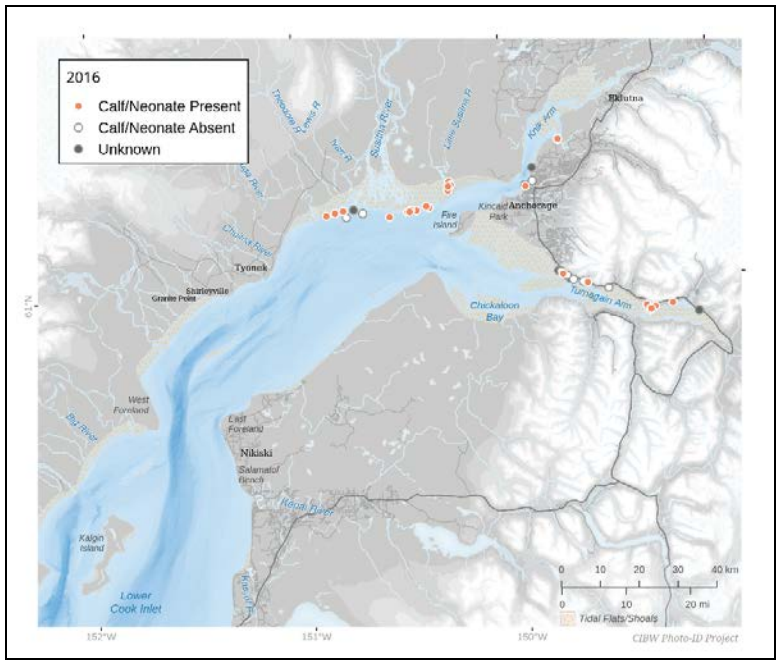

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Figure 8. Location of groups with and without calves and/or neonates encountered during photo-id surveys conducted in 2015 (A) and 2016 (B).

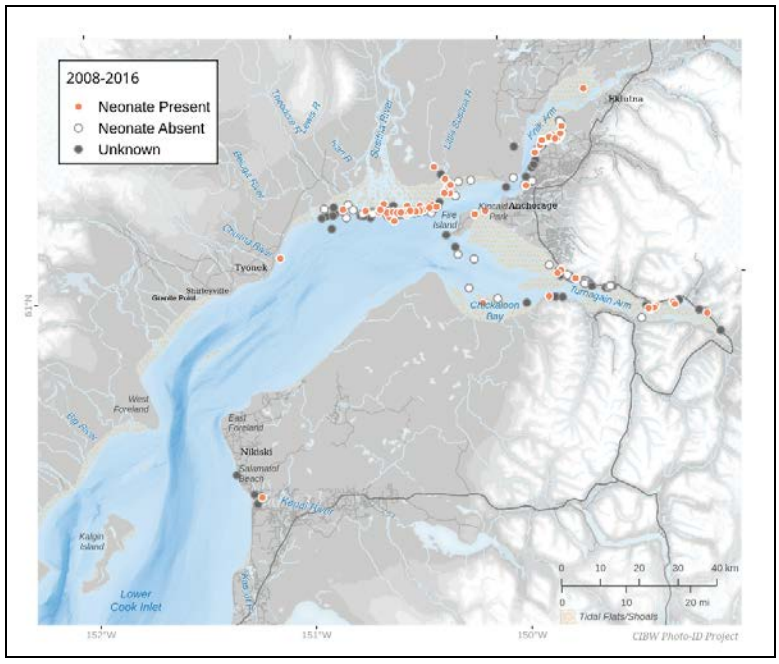
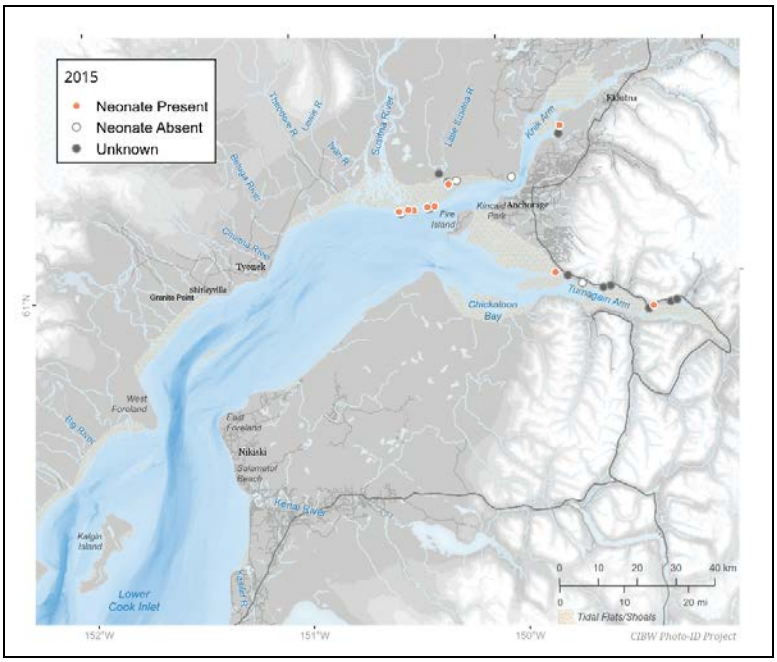


Figure 9. Location of groups with and without neonates encountered during photo-id surveys conducted 2008-2016. The group at the mouth of the Chuitna River was observed in 2005, before neonates were recorded separately from calves, but it is included here because a neonate is clearly visible in photographs taken of this group.



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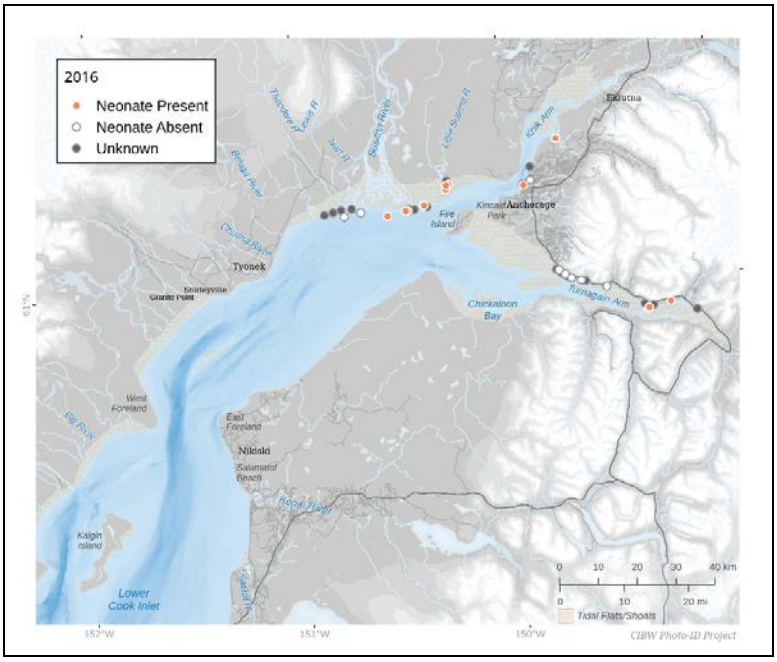

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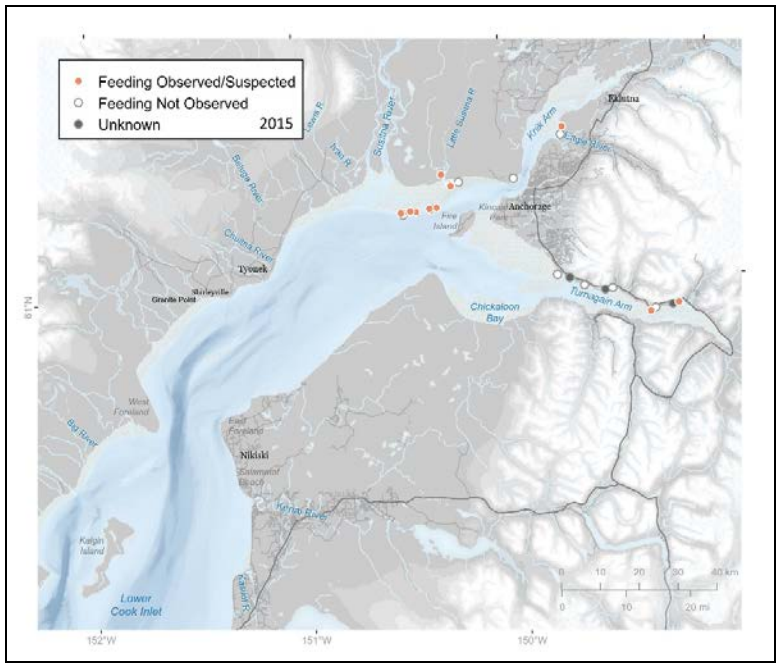
Figure 10. Location of groups with and without neonates encountered during photo-id surveys conducted in 2015 (A) and 2016 (B).



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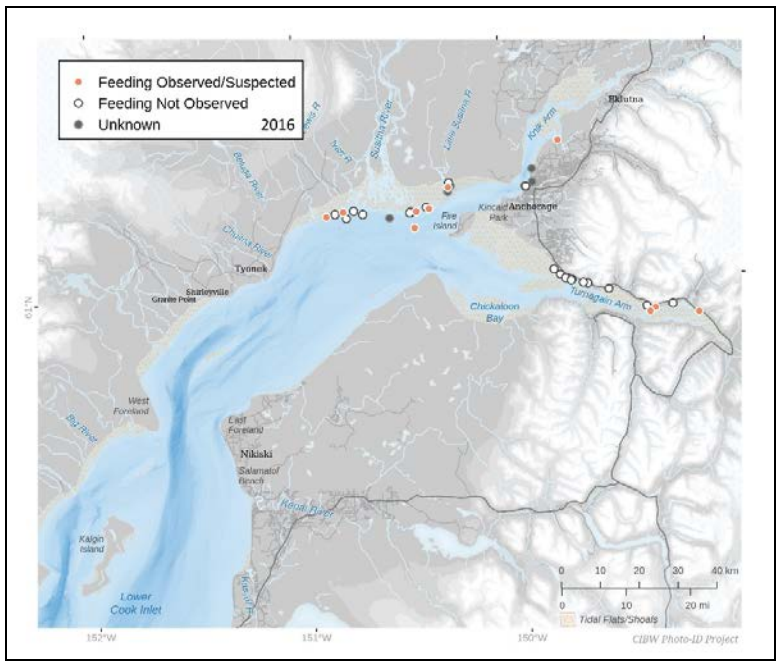


B.

Figure 11. Location of groups with and without observations of feeding behavior (suspected or confirmed) during photo-id surveys conducted in 2015 (A) and 2016 (B).

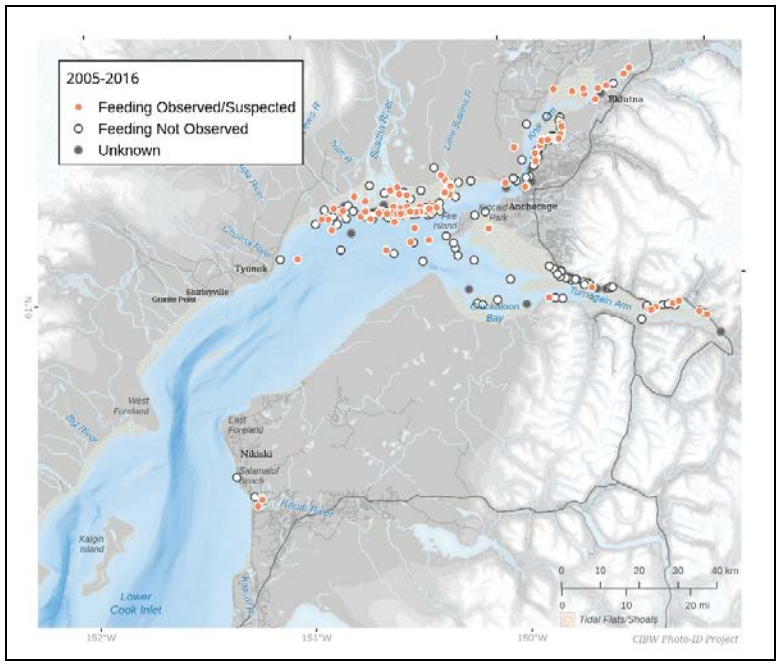
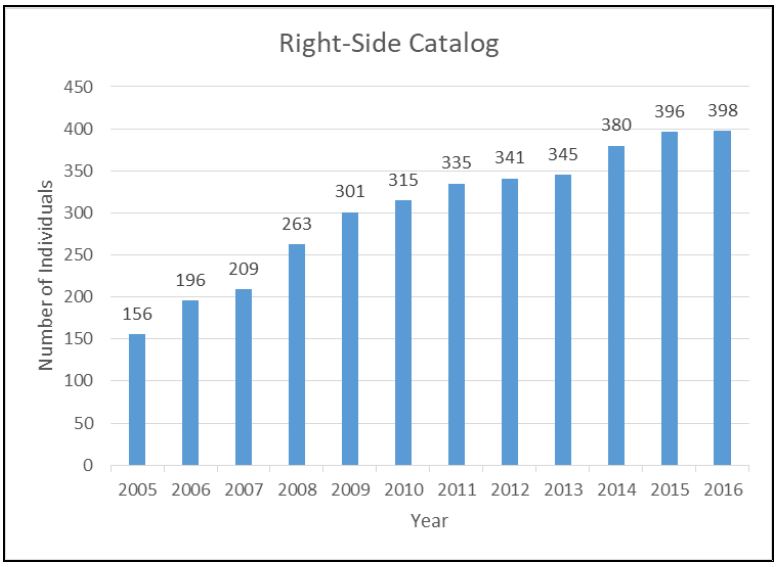


Figure 12. Location of groups with and without observations of feeding behavior (suspected or confirmed) during photo-id surveys conducted 2005-2016.



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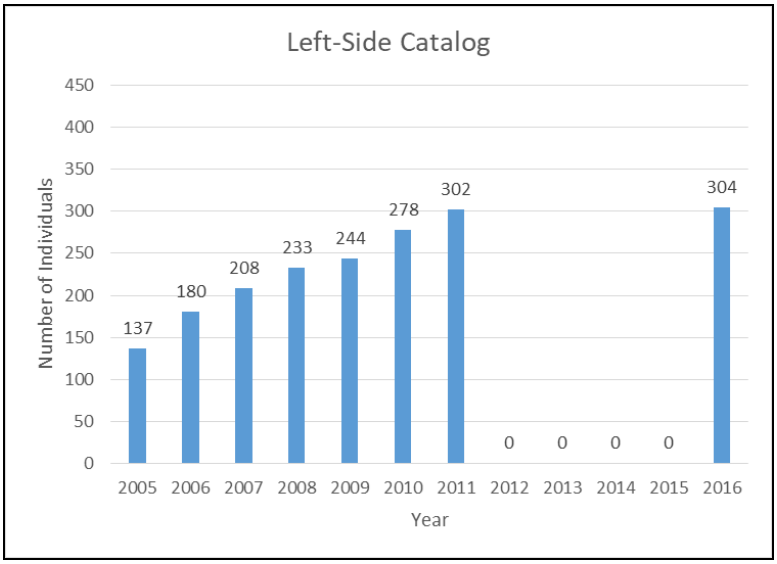


B.

Figure 13. The number of identified individual whales in the right-side catalog (A), and left side catalog (B), according to the year in which an individual was first photographed by study. (Cataloging of left-side photos from 2012-2015 is in progress).

APPENDICES

Appendix A. Daily Survey Routes and Groups Encountered in 2015

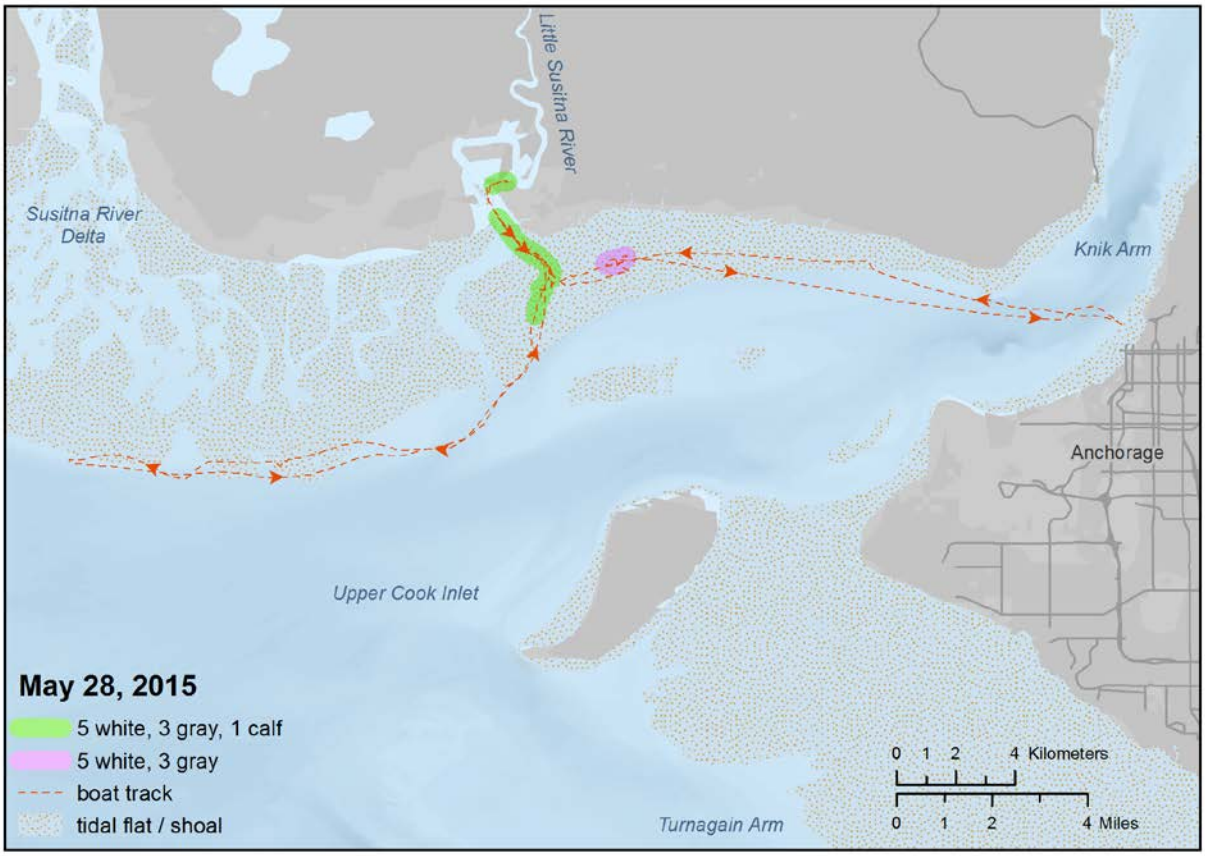


Figure A1. Route and beluga whale group(s) encountered during the May 28, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

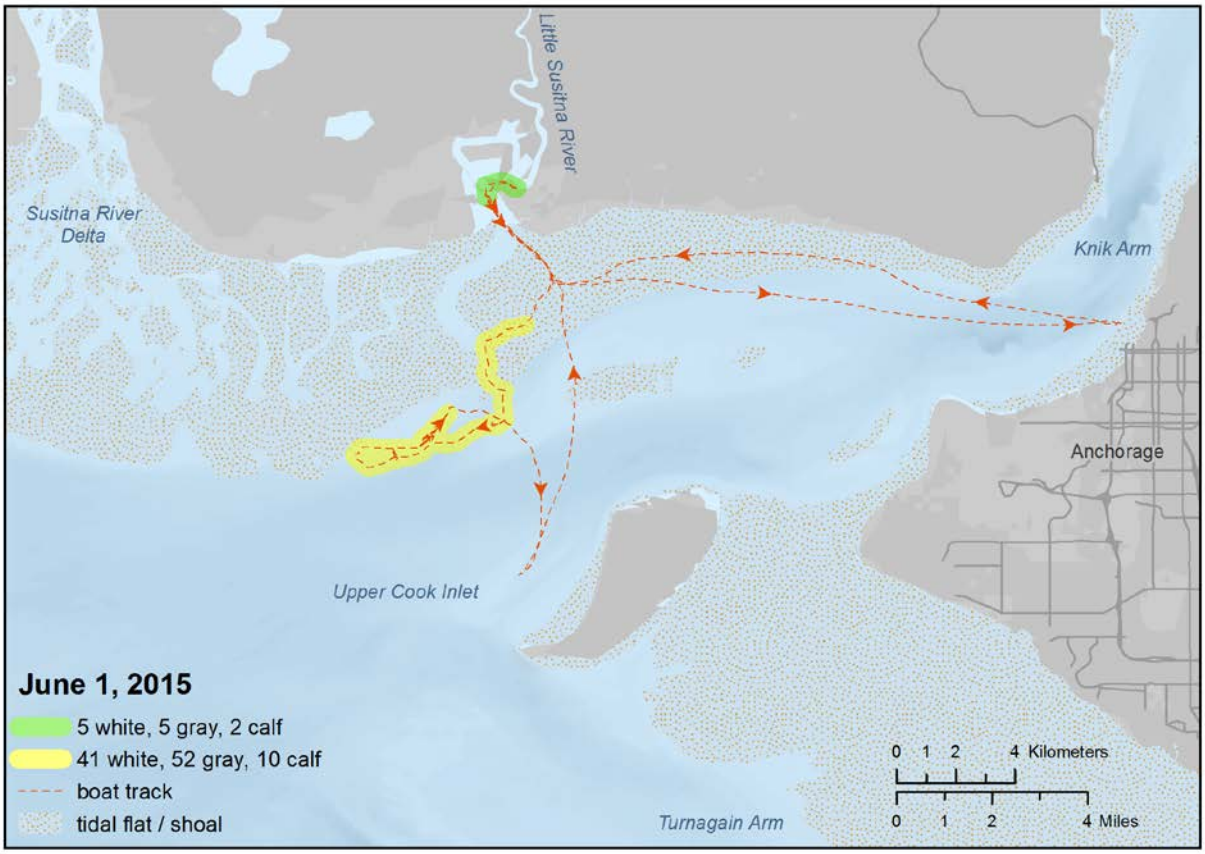


Figure A2. Route and beluga whale group(s) encountered during the June 1, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

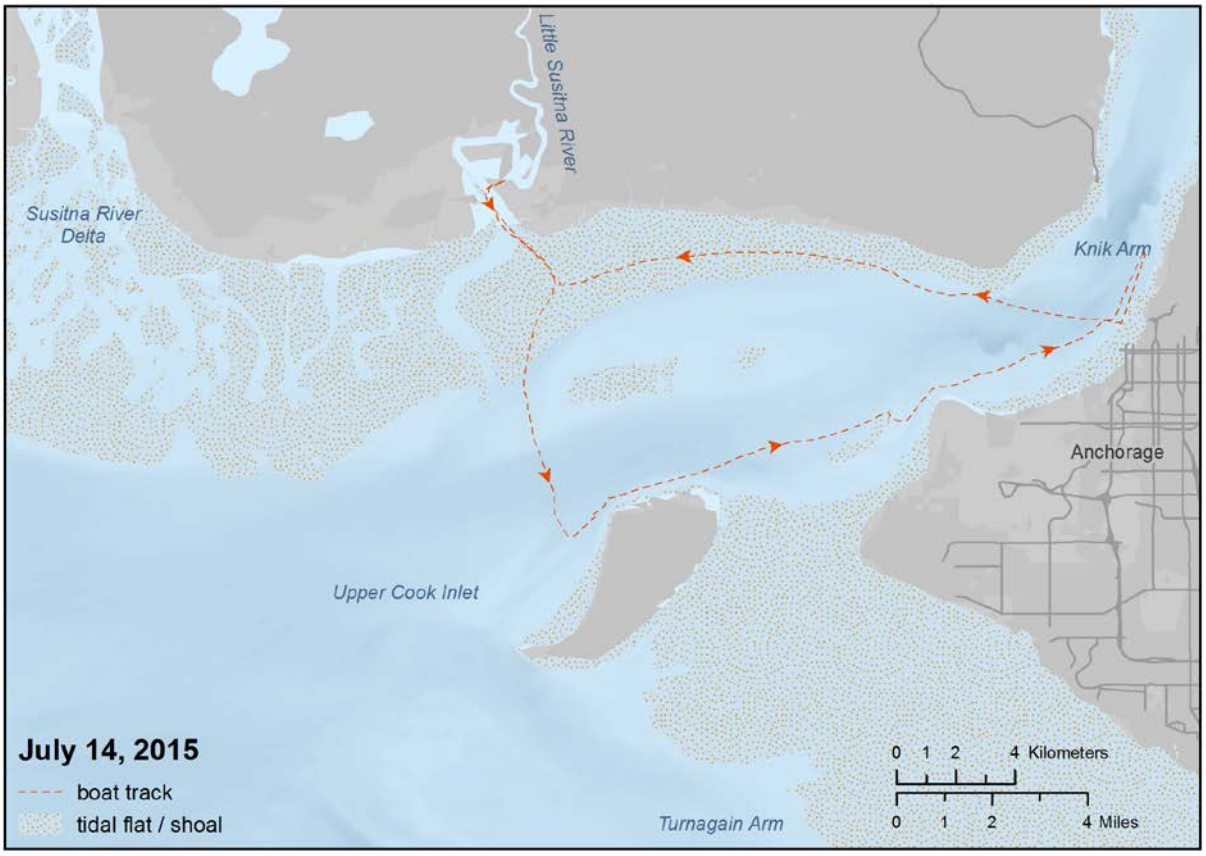


Figure A3. Route of the July 14, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska. No belugas were encountered this day, and building seas caused the survey-vessel to return to port early.

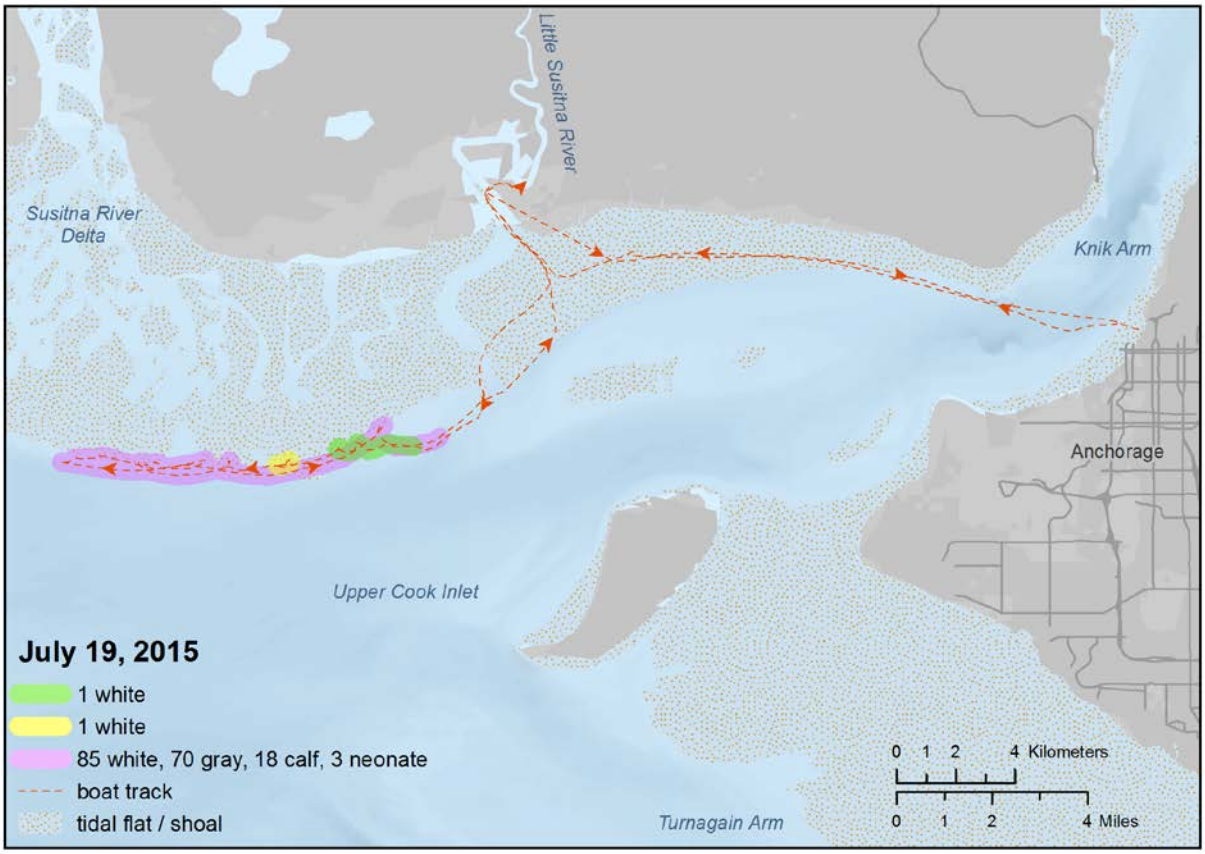


Figure A4. Route and beluga whale group(s) encountered during the July 19, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

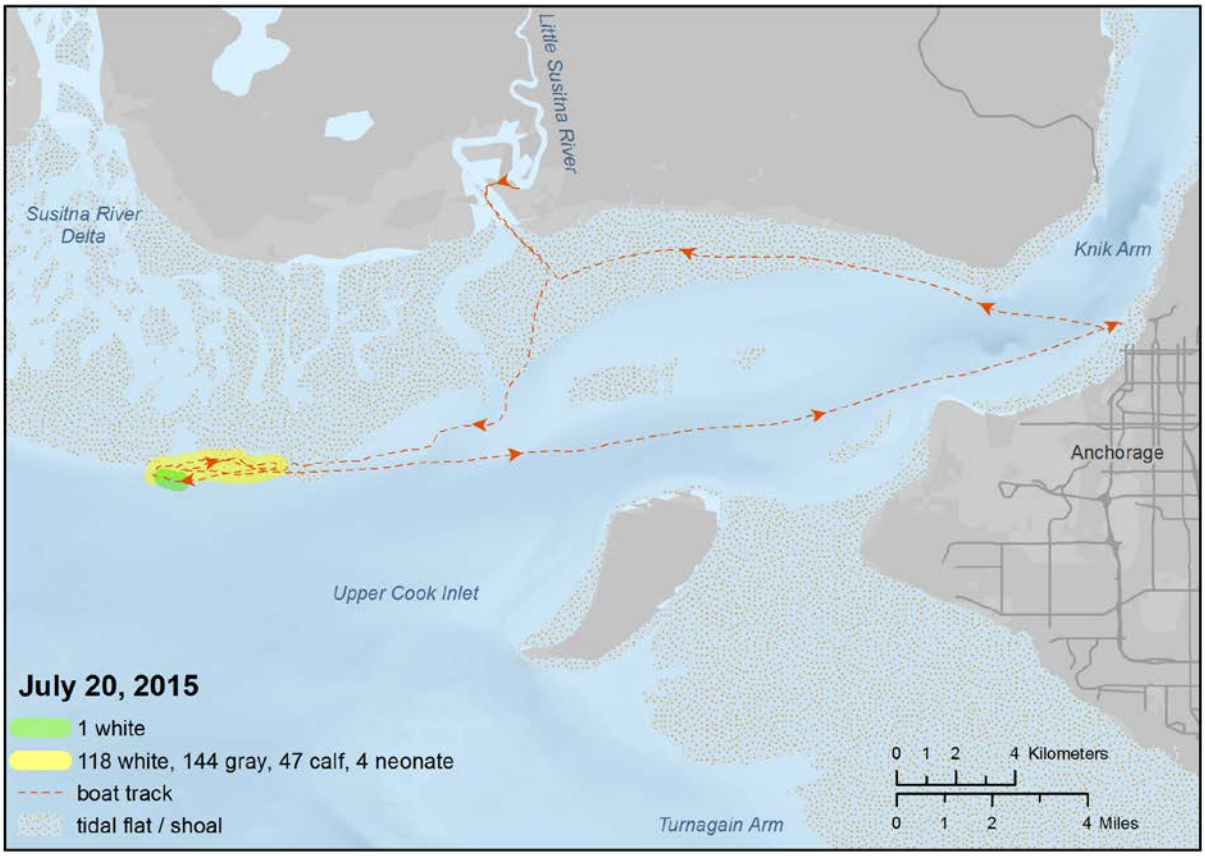


Figure A5. Route and beluga whale group(s) encountered during the July 20, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

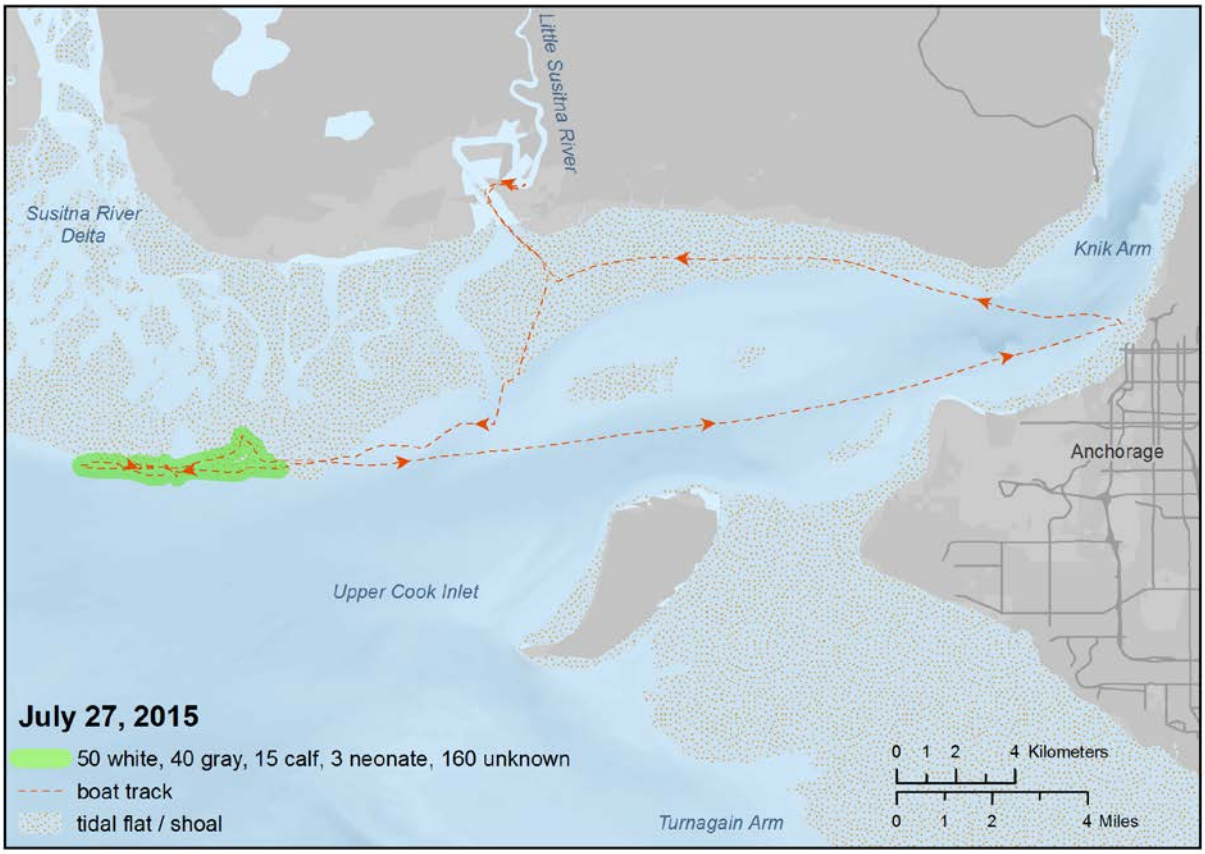


Figure A6. Route and beluga whale group(s) encountered during the July 27, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

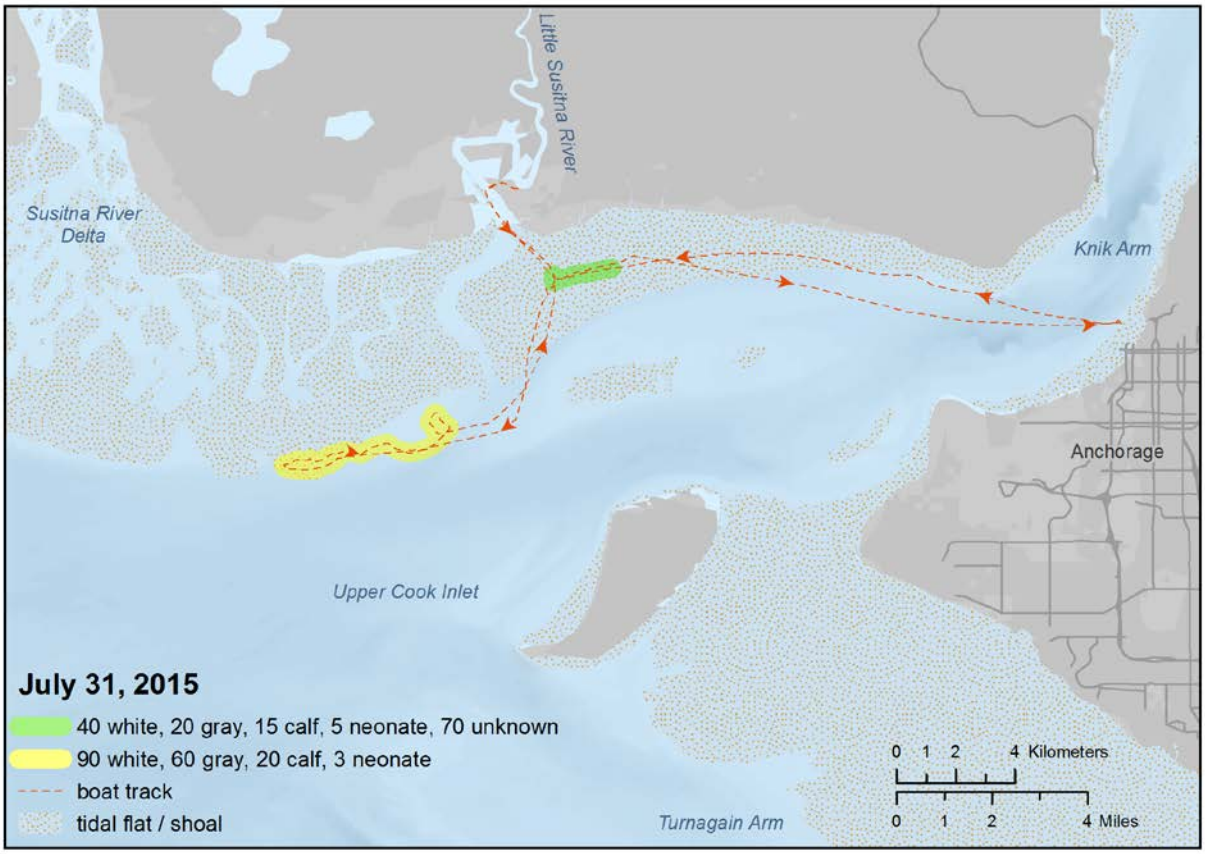


Figure A7. Route and beluga whale group(s) encountered during the July 31, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

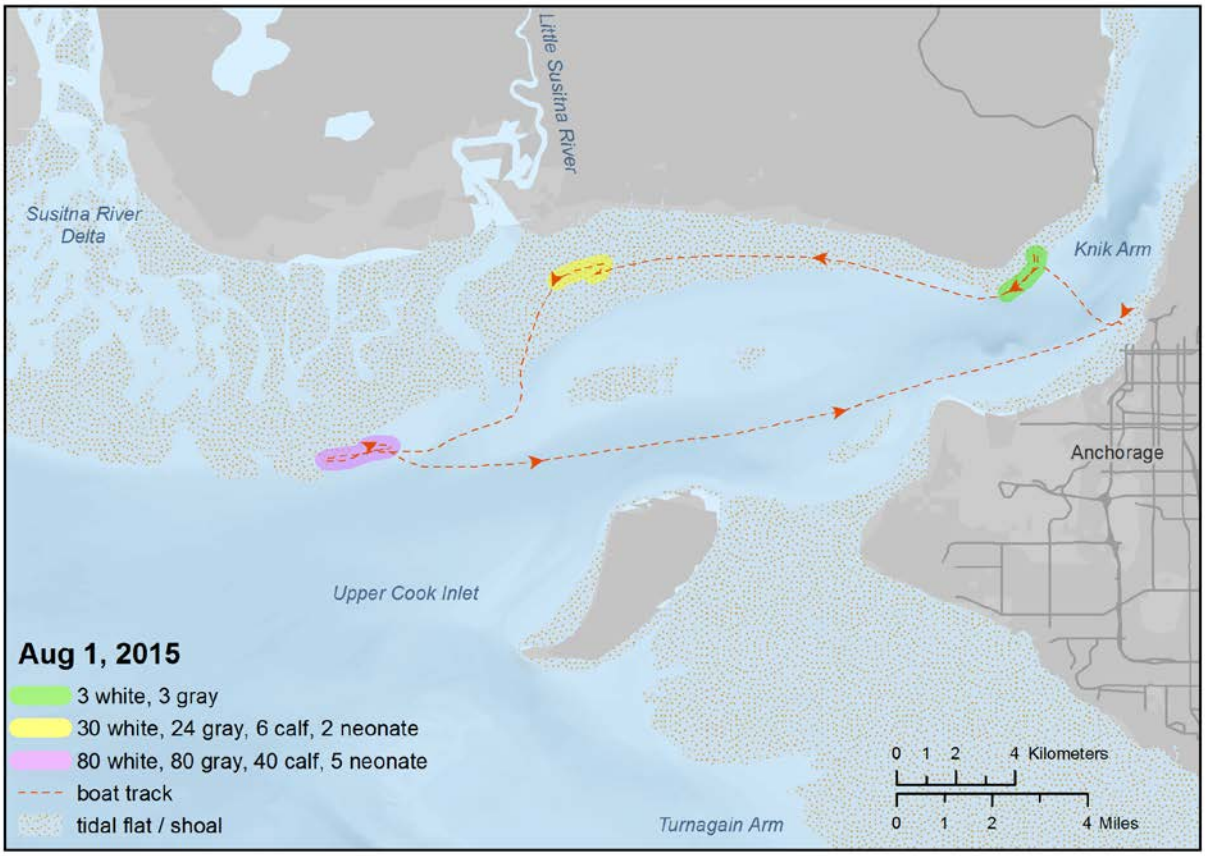


Figure A8. Route and beluga whale group(s) encountered during the August 1, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

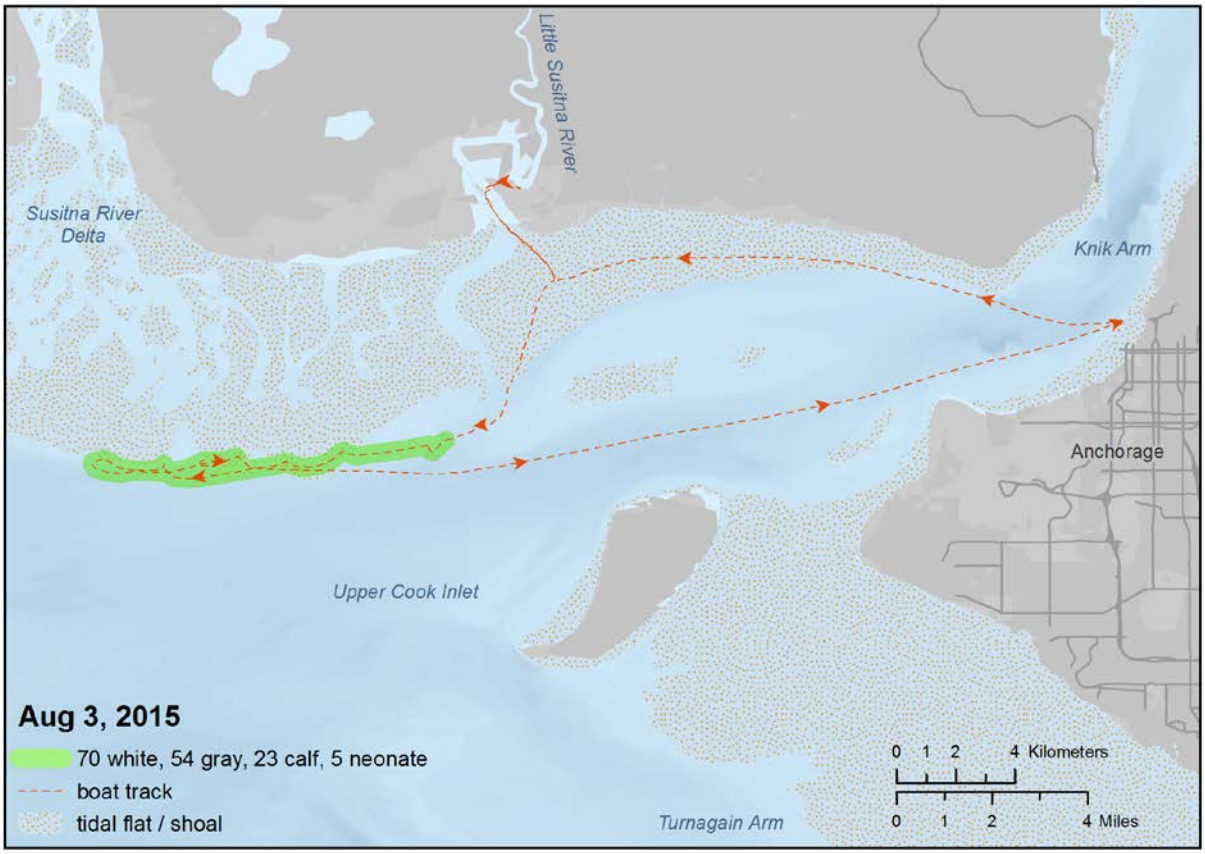


Figure A9. Route and beluga whale group(s) encountered during the August 3, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

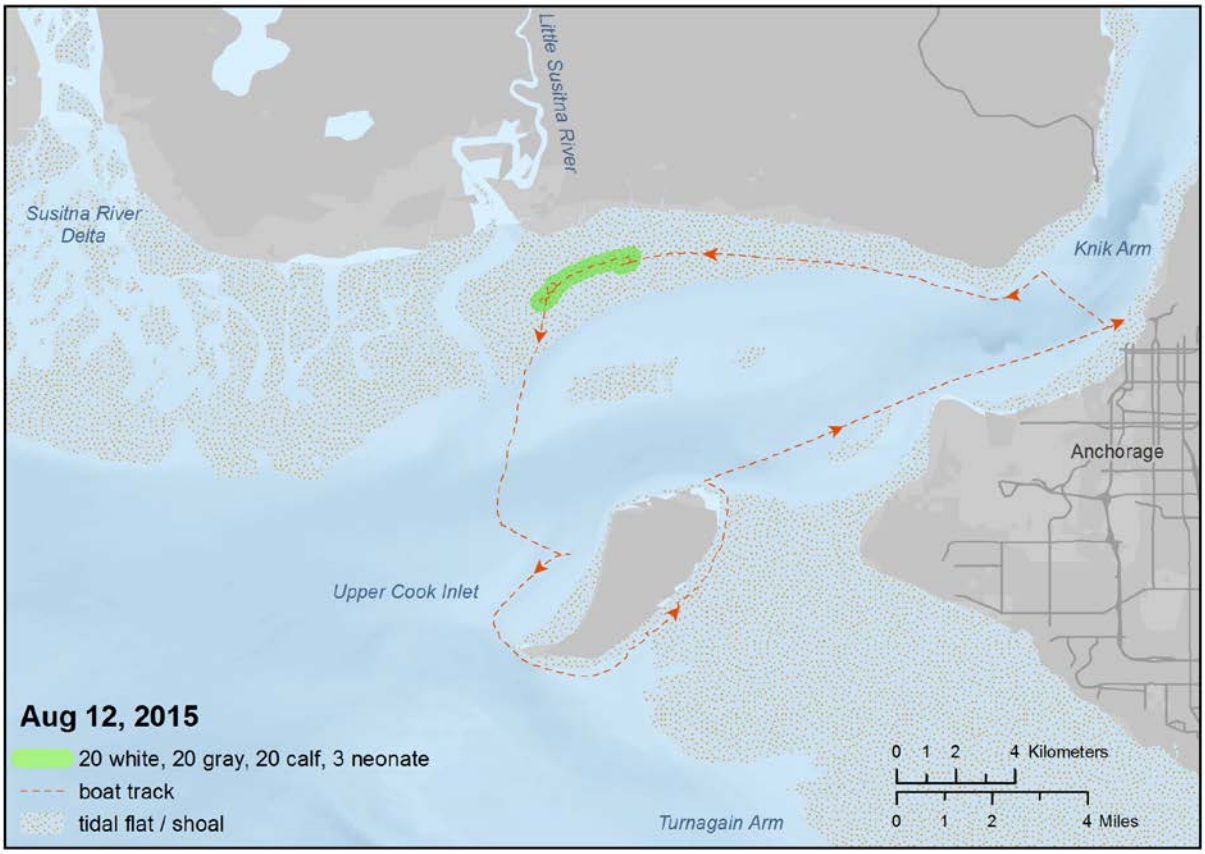


Figure A10. Route and beluga whale group(s) encountered during the August 12, 2015 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

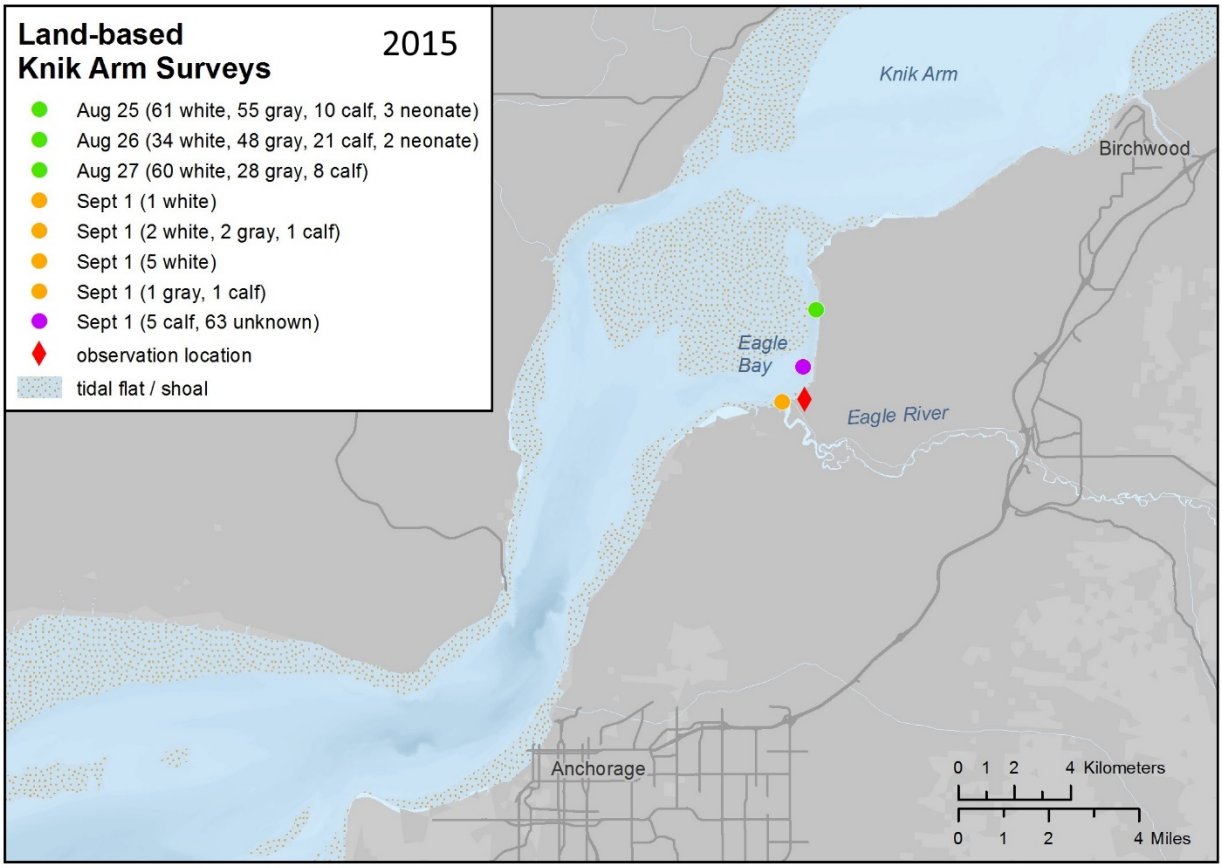


Figure A11. Beluga whale groups encountered during land-based photo-identification surveys of Knik Arm, Upper Cook Inlet, Alaska in 2015. The multiple groups recorded on September 1 (orange dots) were later combined into a single group of 68 individuals (5 calves and 63 unknowns; purple dot), after photo-id indicated the same individuals were found in multiple groups.

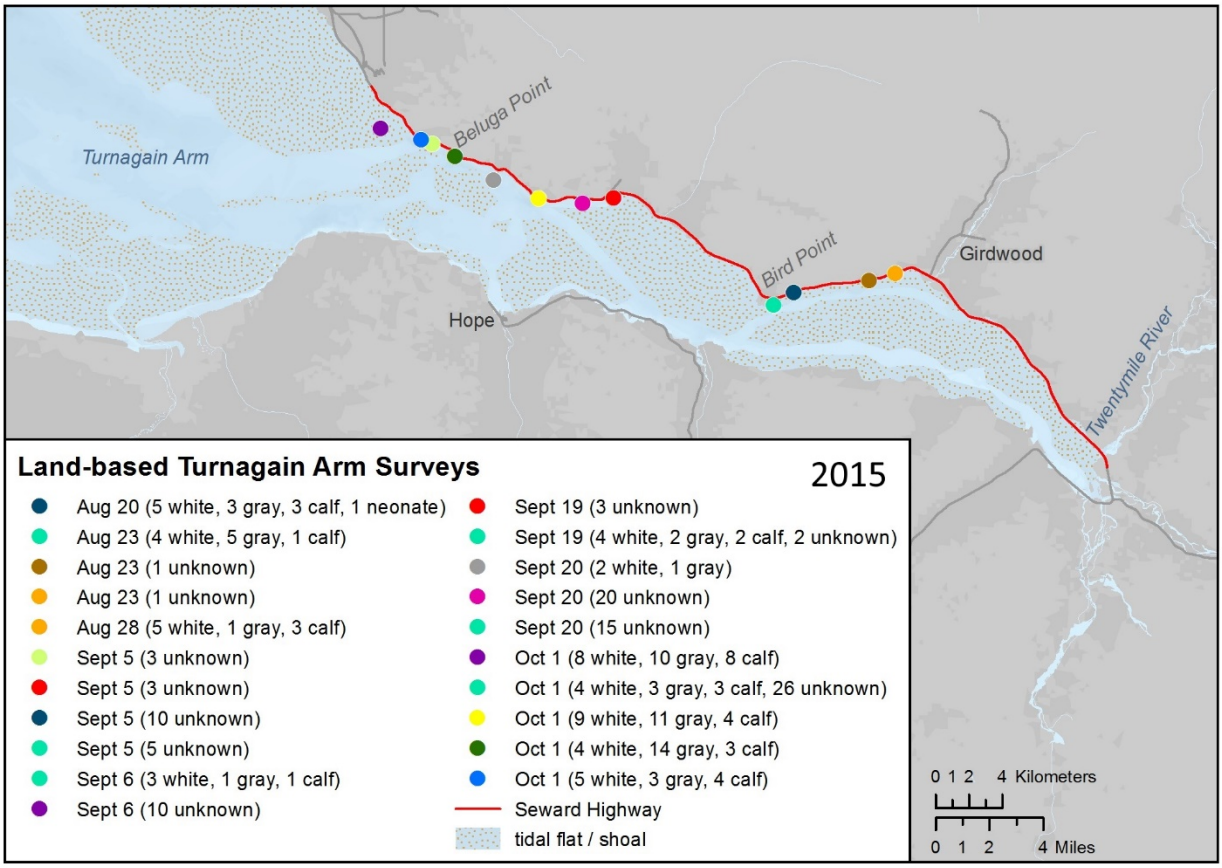


Figure A12. Beluga whale groups encountered during land-based photo-identification surveys of Turnagain Arm, Upper Cook Inlet, Alaska in 2015. The group on August 28 contained an additional 6 unknowns, for a total of 15 whales. The multiple groups recorded on October 1 were combined into a single group of 39 individuals (9 white, 21 gray, 8 calves, and 1 neonate), after photo-id indicated the same individuals were found in multiple groups.

Appendix B. Daily Survey Routes and Groups Encountered in 2016

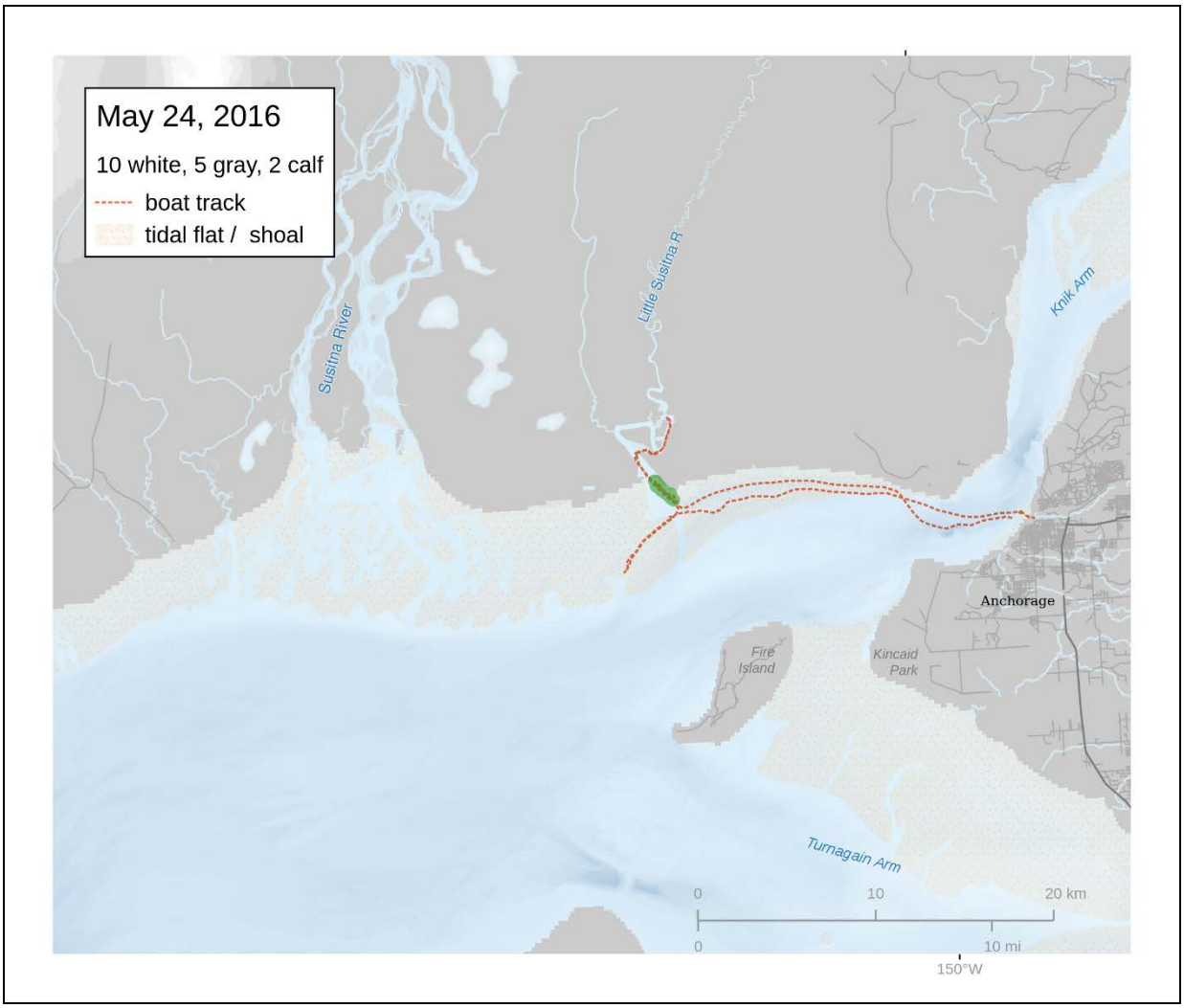


Figure B1. Route and beluga whale group(s) encountered during the May 24, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

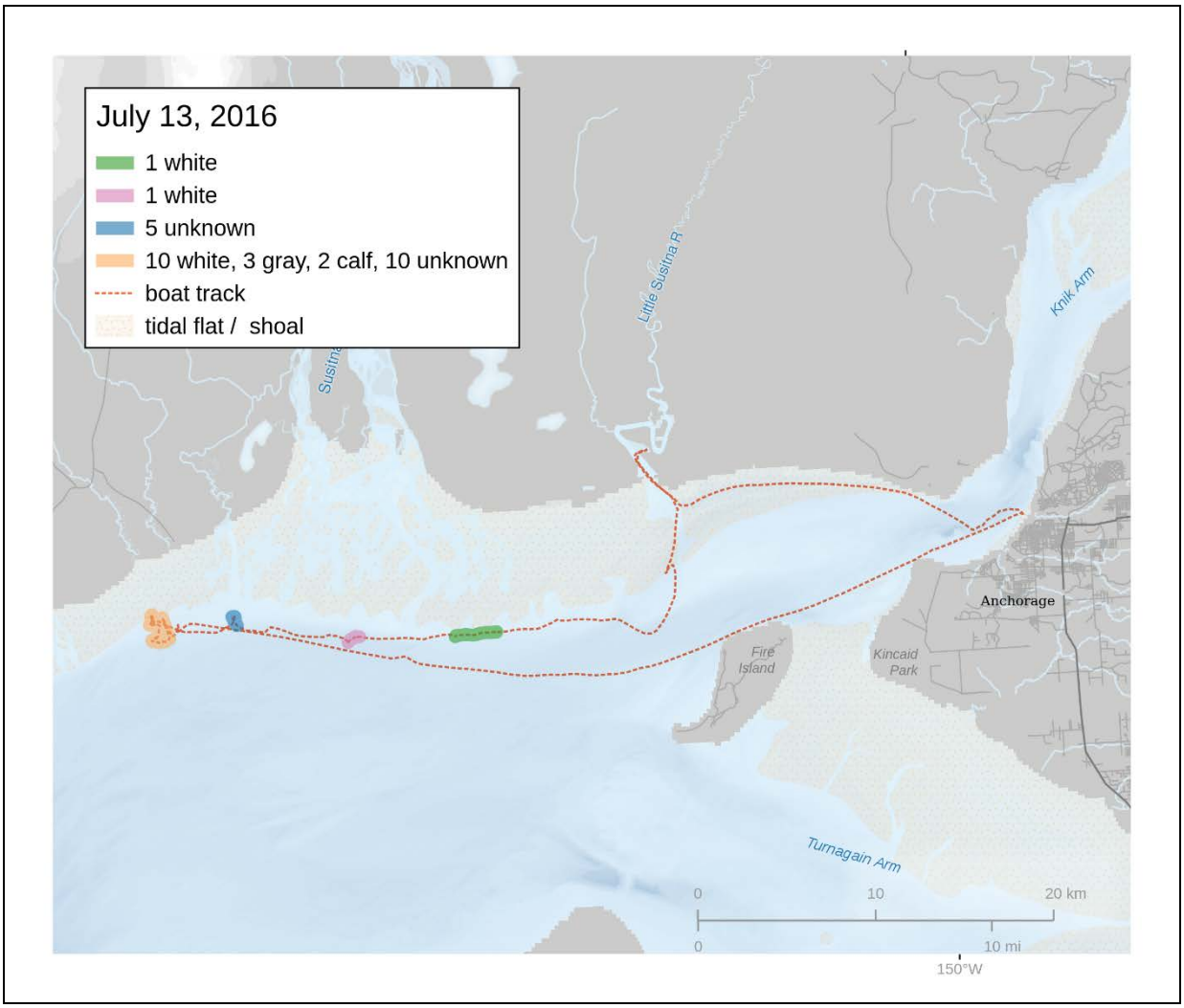


Figure. B2. Route and beluga whale group(s) encountered during the July 13, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

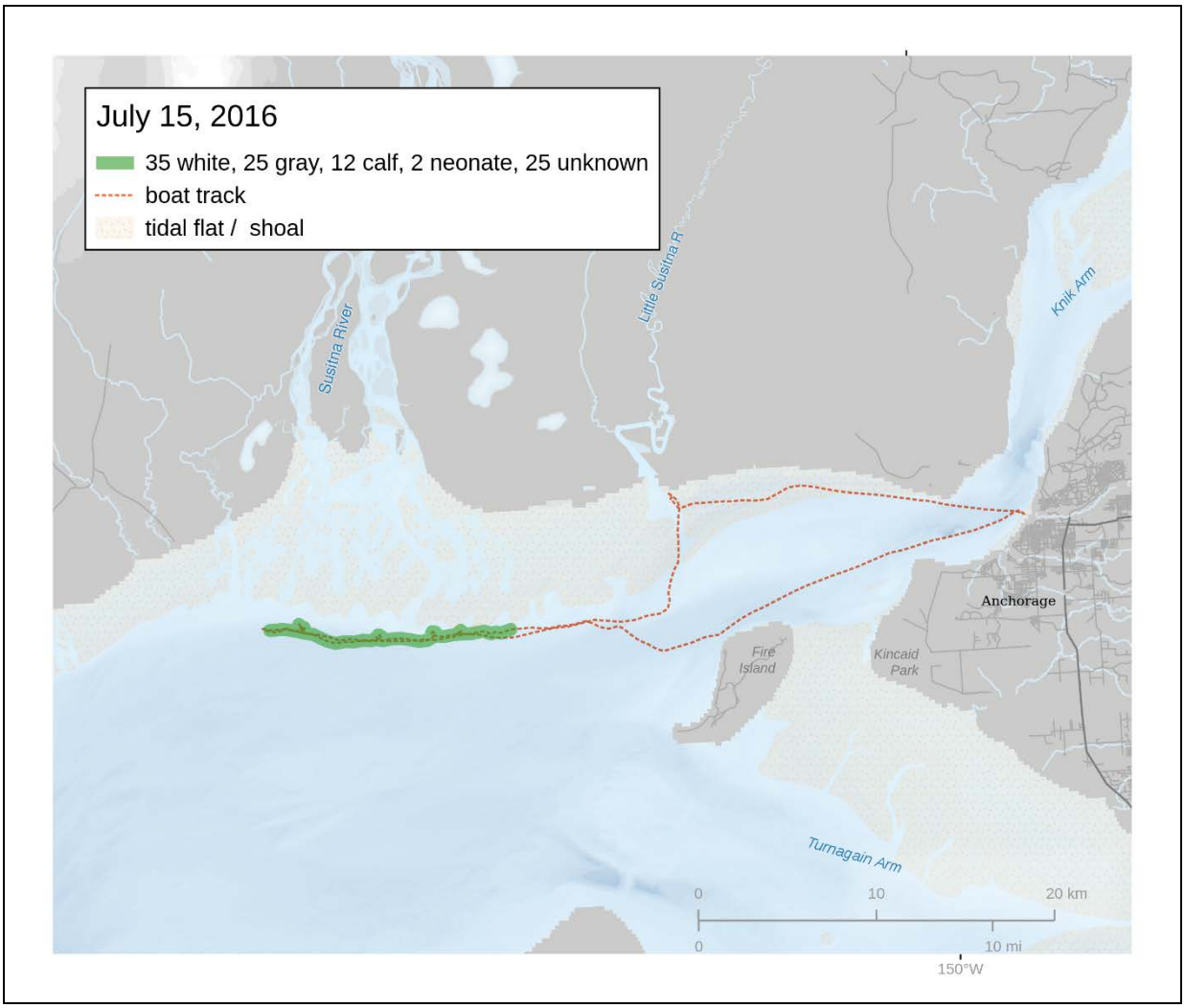


Figure B3. Route and beluga whale group(s) encountered during the July 15, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

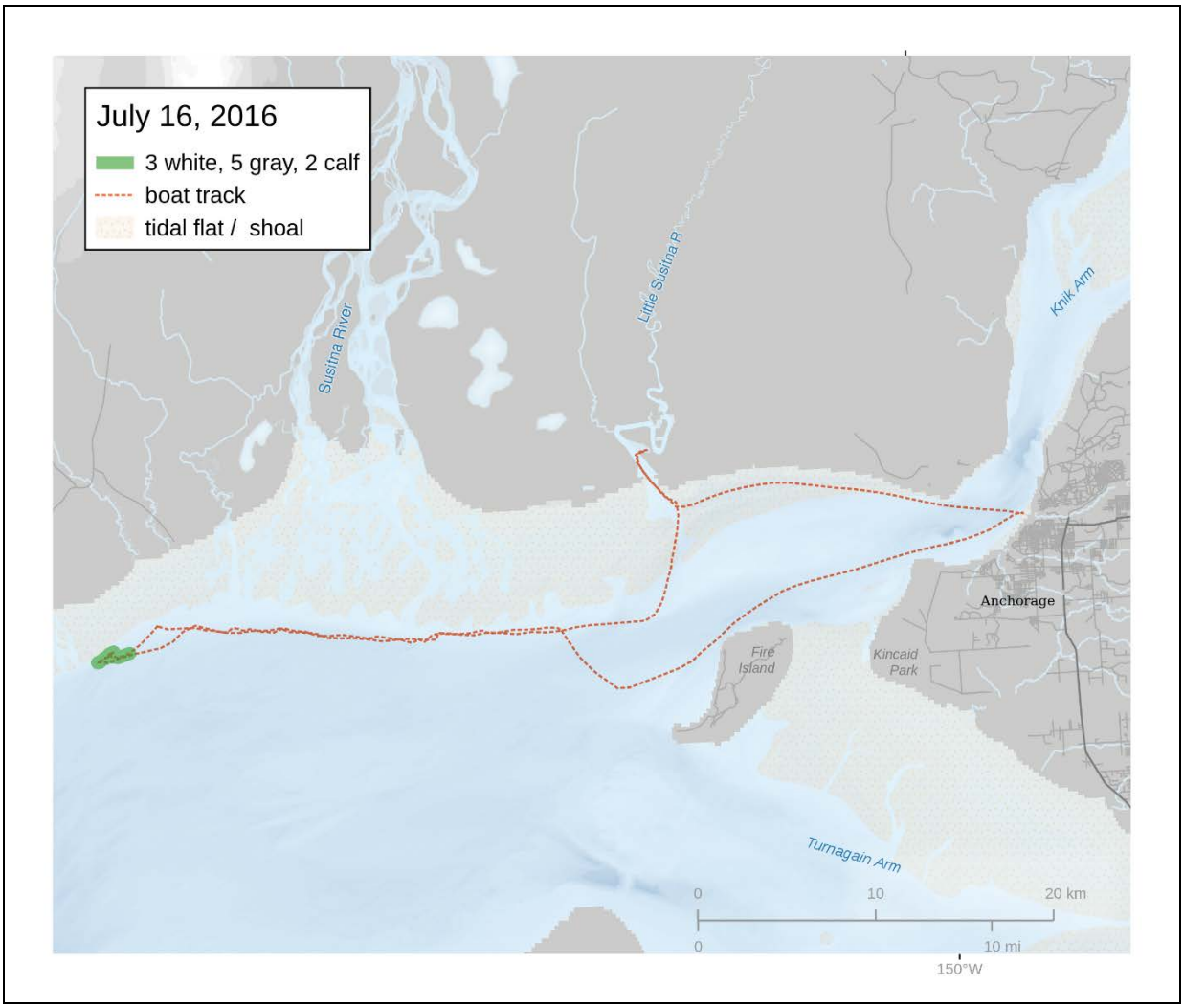


Figure B4. Route and beluga whale group(s) encountered during the July 16, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

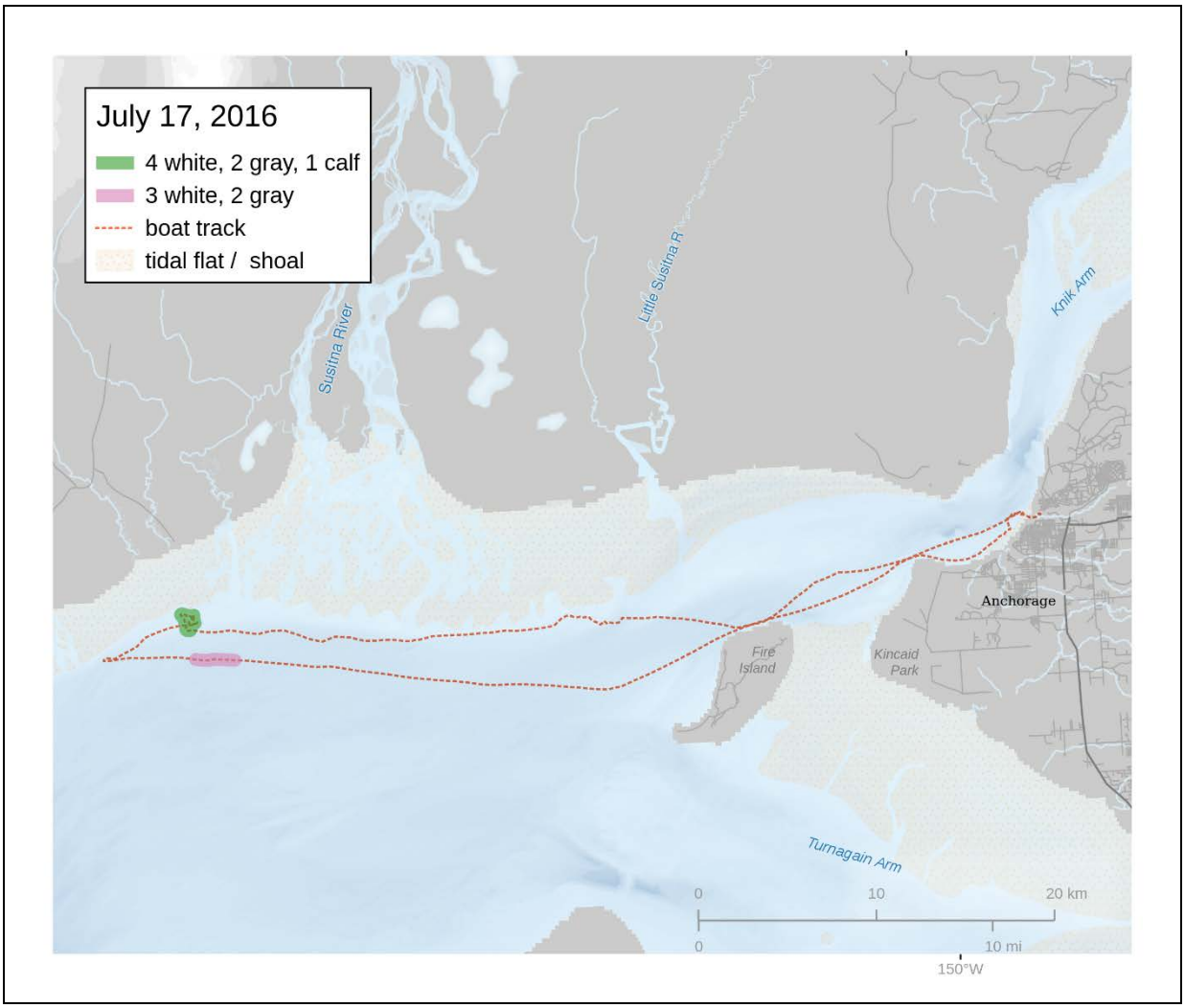


Figure B5. Route and beluga whale group(s) encountered during the July17, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

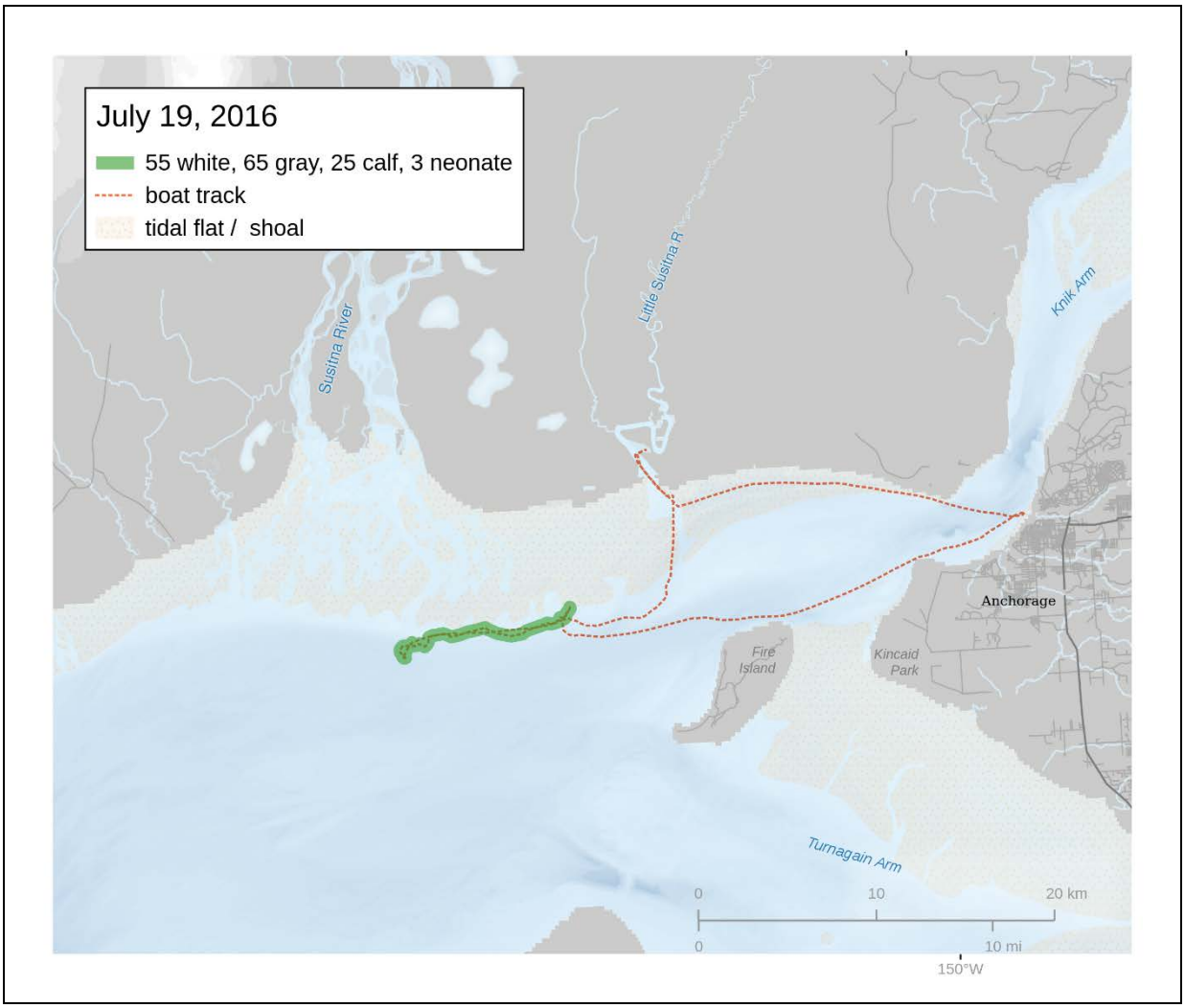


Figure B6. Route and beluga whale group(s) encountered during the July 19, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

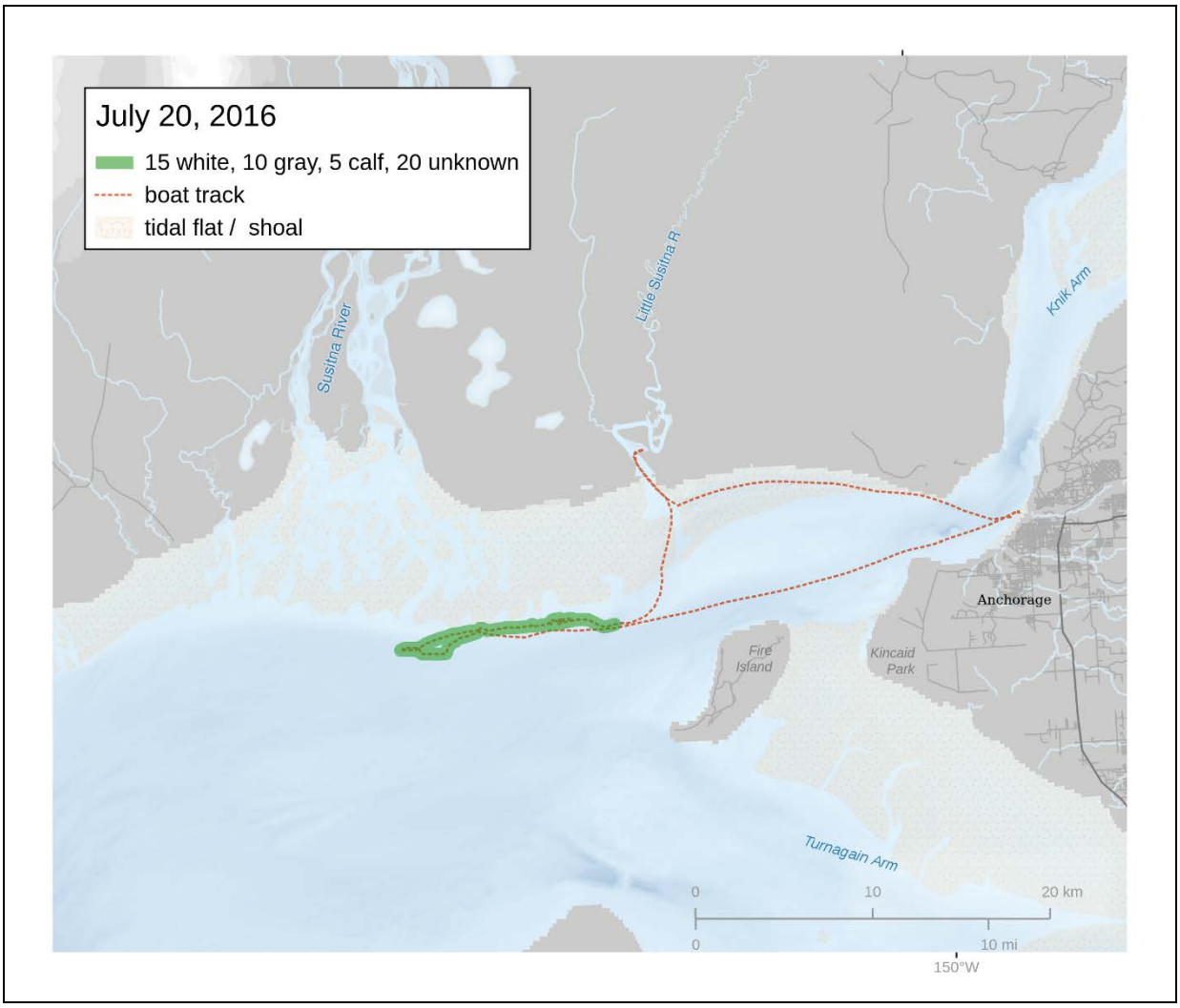


Figure B7. Route and beluga whale group(s) encountered during the July 20, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

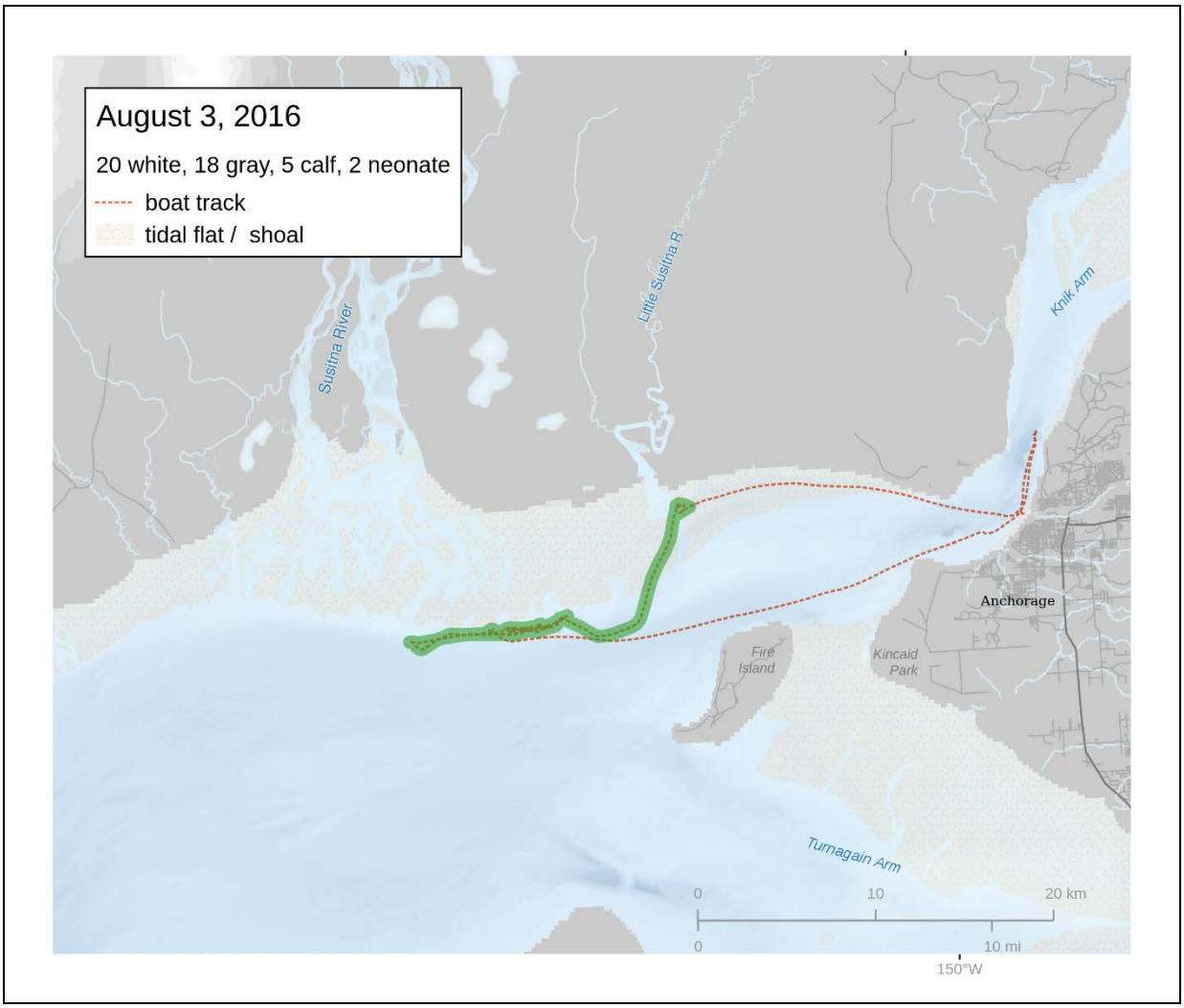


Figure B8. Route and beluga whale group(s) encountered during the August 3, 2016 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

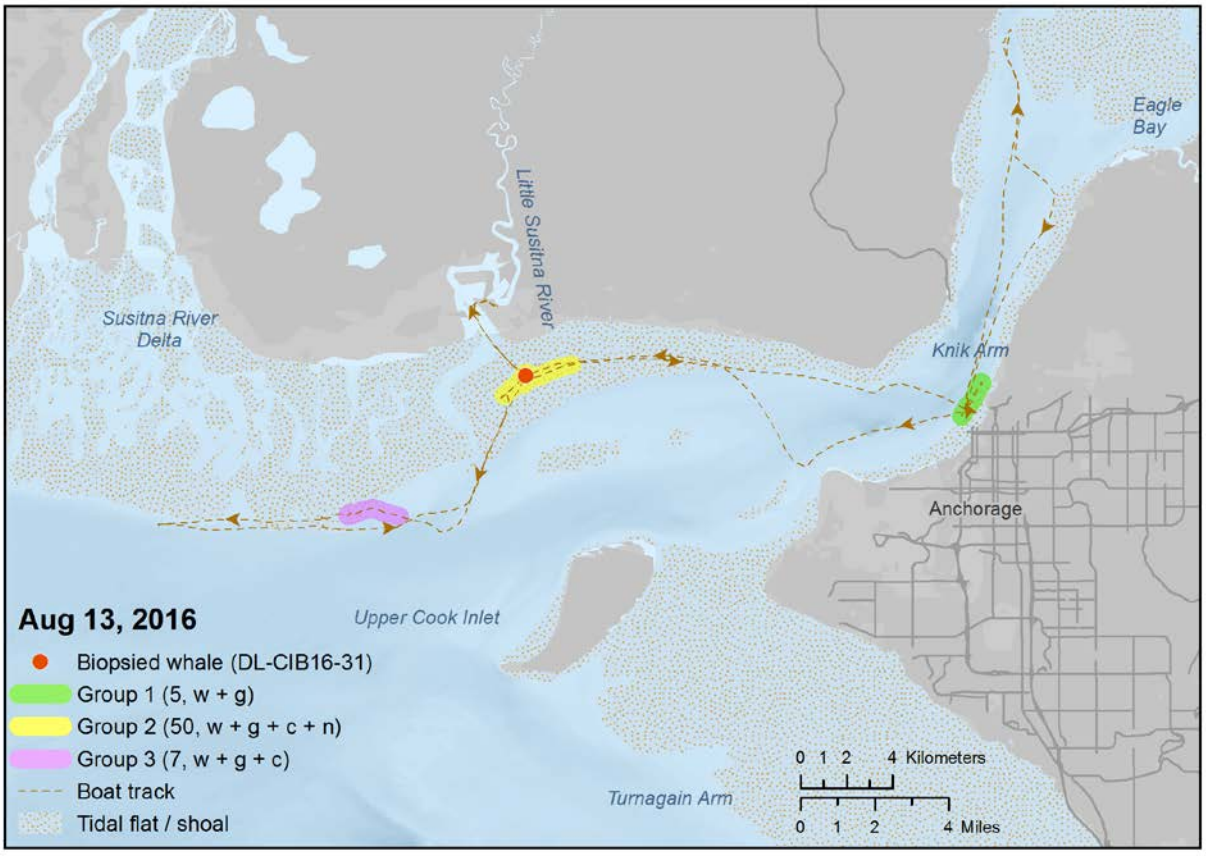


Figure B9. Location of survey route, beluga groups encountered, and biopsy sample on August 13, 2016. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

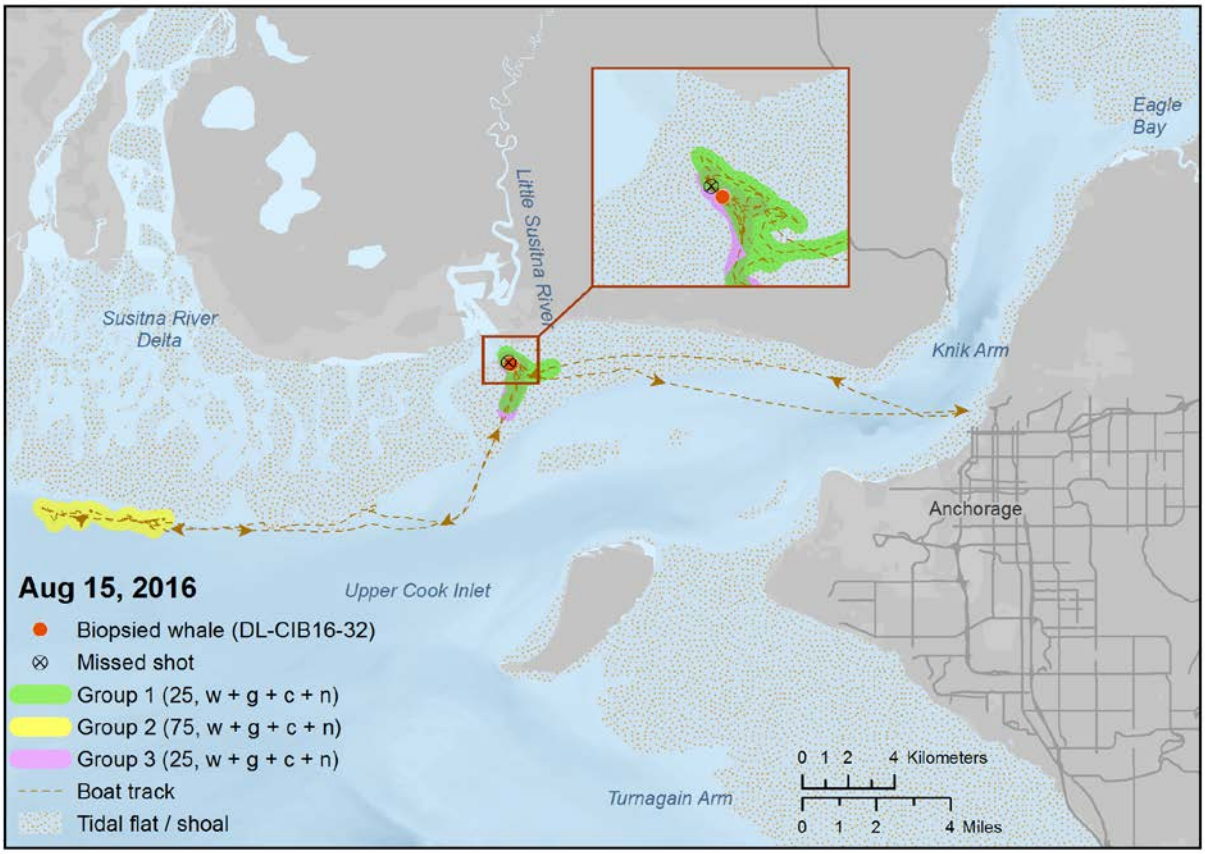


Figure B10. Location of survey route, beluga groups encountered, and biopsy sample on August 15, 2016. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

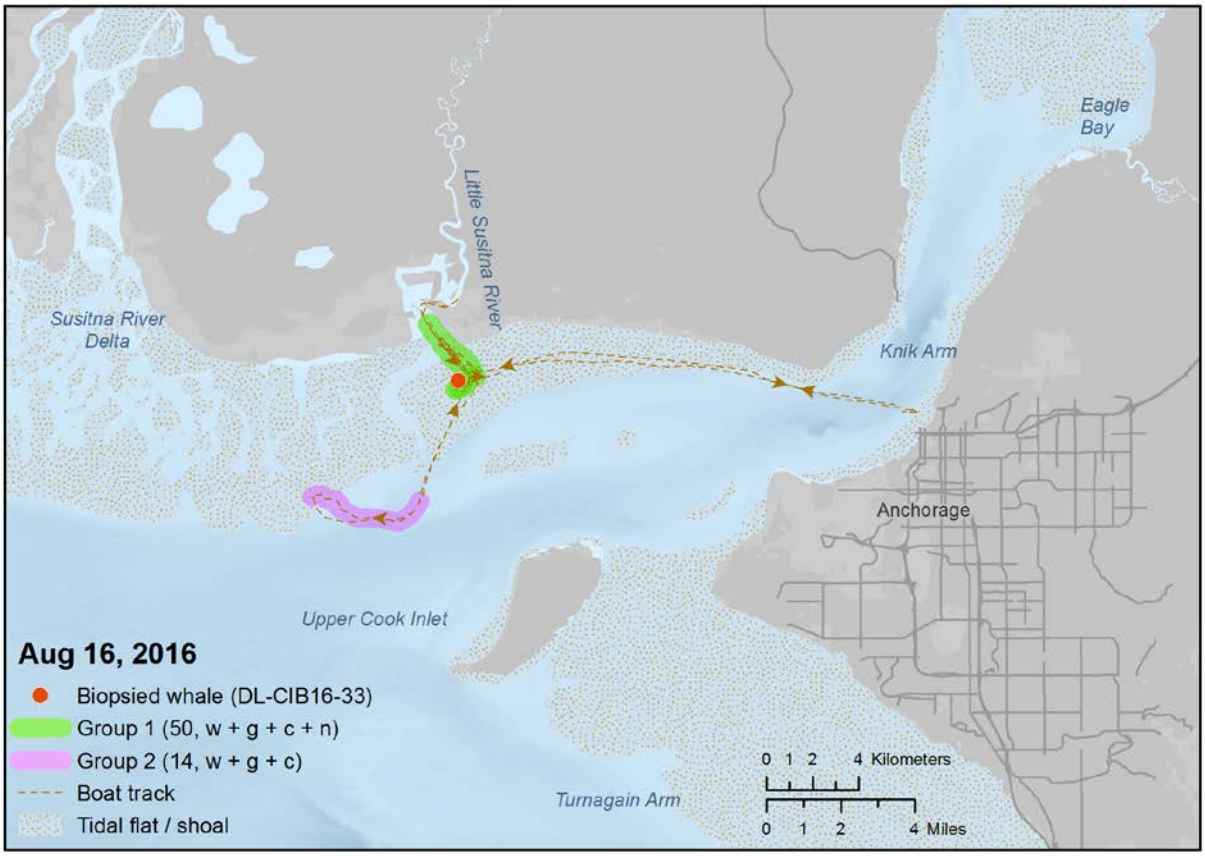


Figure B11. Location of survey route, beluga groups encountered, and biopsy sample on August 16, 2016. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

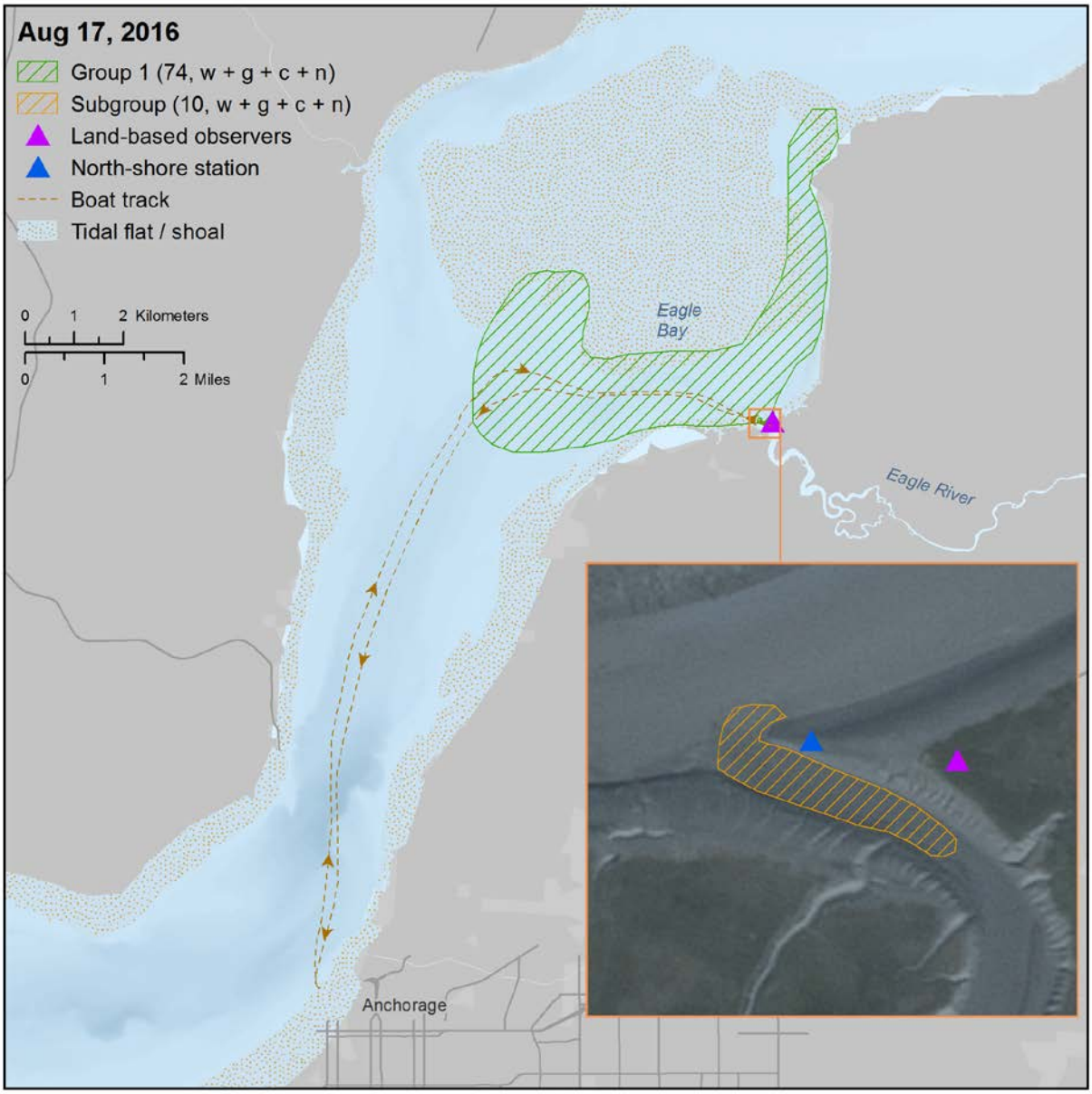


Figure B12. Location of sampling teams and beluga groups on August 17, 2016 in Knik Arm, Upper Cook Inlet, Alaska. The biopsy team was located at the north-shore station. A vessel was used to transport the team from the Anchorage small boat launch to the land-based site. No biopsy shots were attempted because unaccompanied whales did not approach within range of the land-based site. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

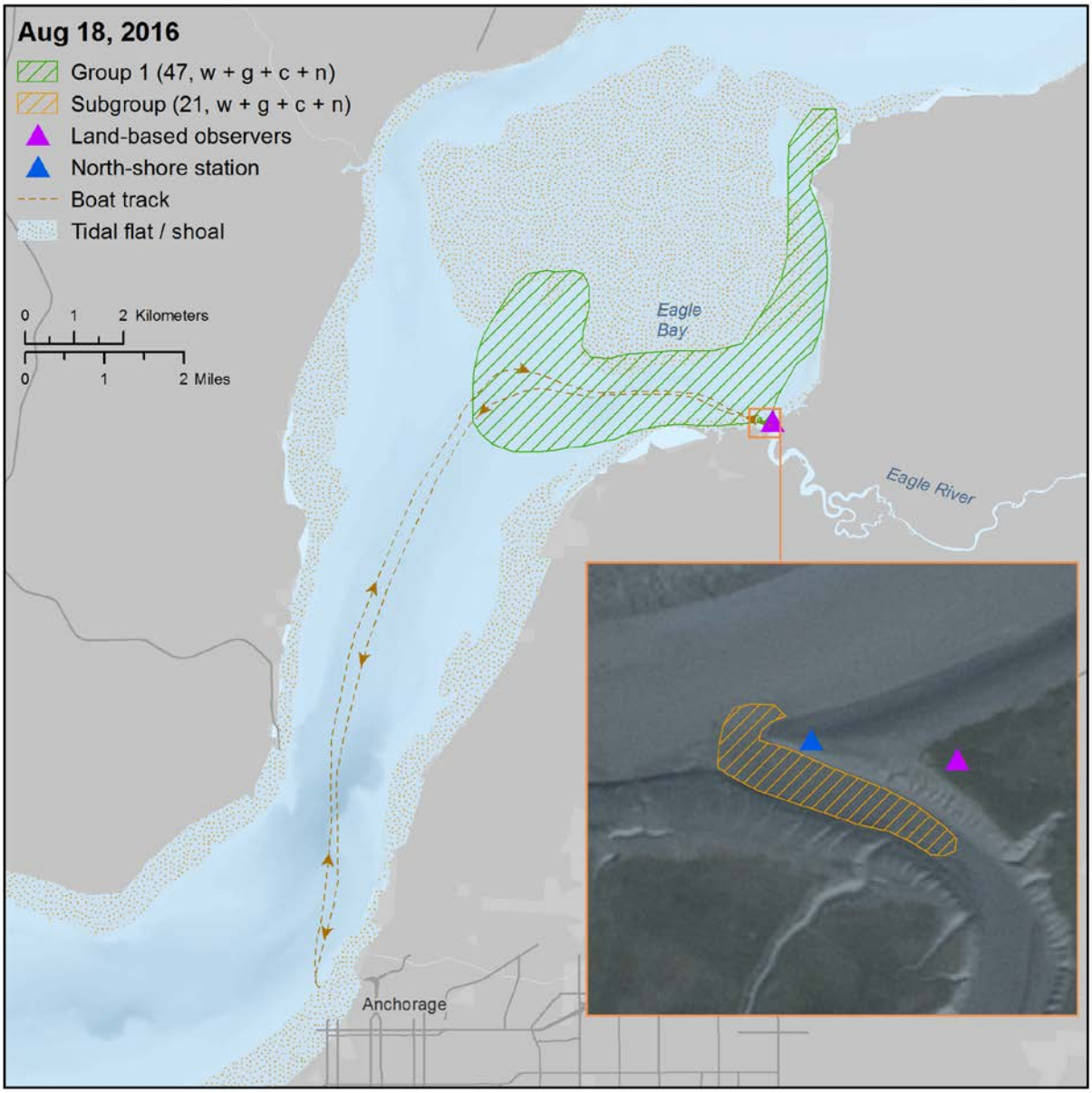


Figure B13. Location of sampling teams and beluga groups on August 18, 2016 in Knik Arm, Upper Cook Inlet, Alaska. The biopsy team was located at the north-shore station. A vessel was used to transport the team from the Anchorage small boat launch to the land-based site. No biopsy shots were attempted because unaccompanied whales did not approach within range of the land-based site. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present: the number in parenthesis is the group size total).

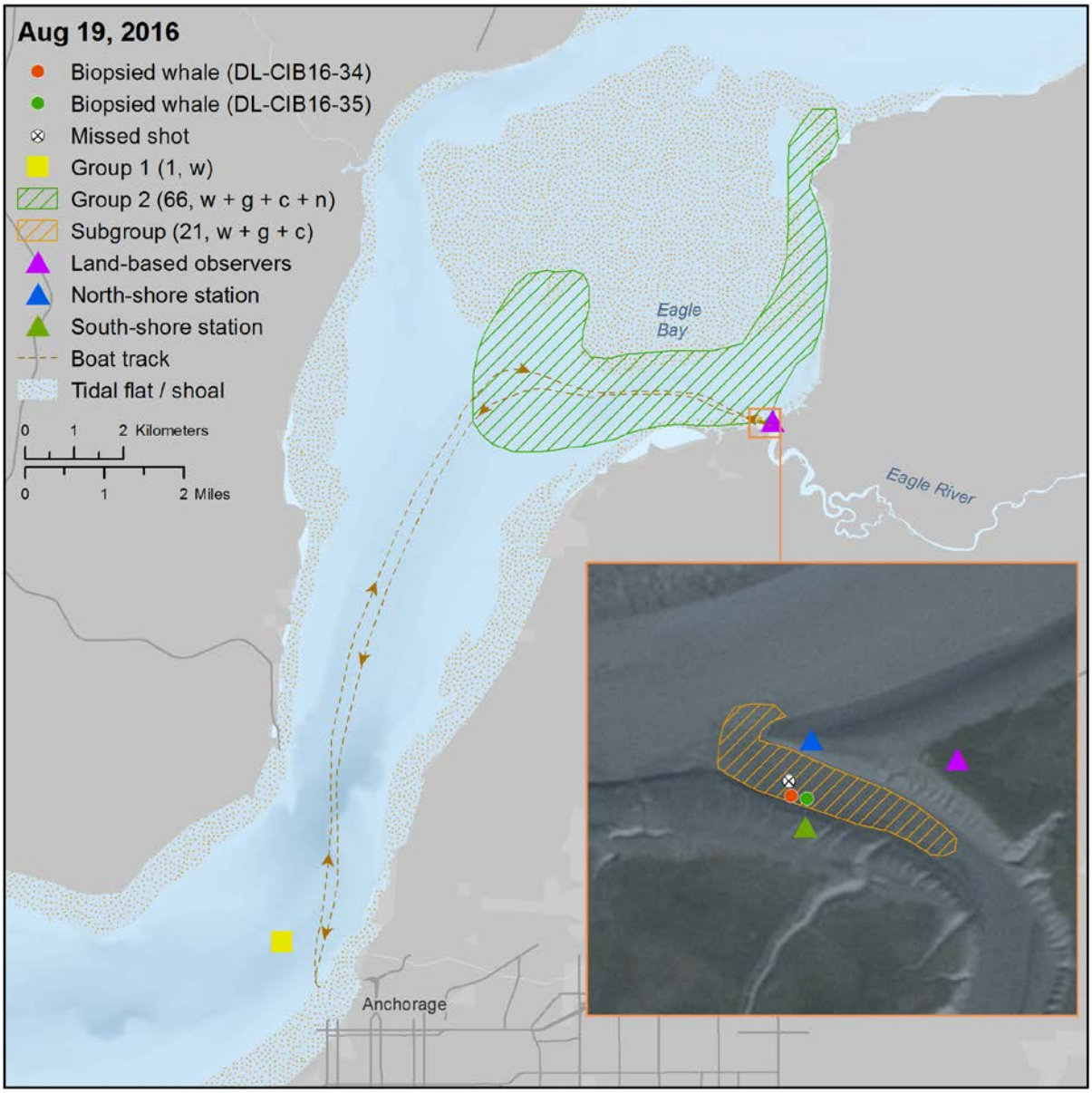


Figure B14. Location of sampling teams and beluga groups on August 19, 2016 in Knik Arm, Upper Cook Inlet, Alaska. The biopsy team was located at the south-shore station. A vessel was used to transport the team from the Anchorage small boat launch to the land-based site. Three biopsy shots were taken, resulting in two samples and one miss. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present: the number in parenthesis is the group size total).

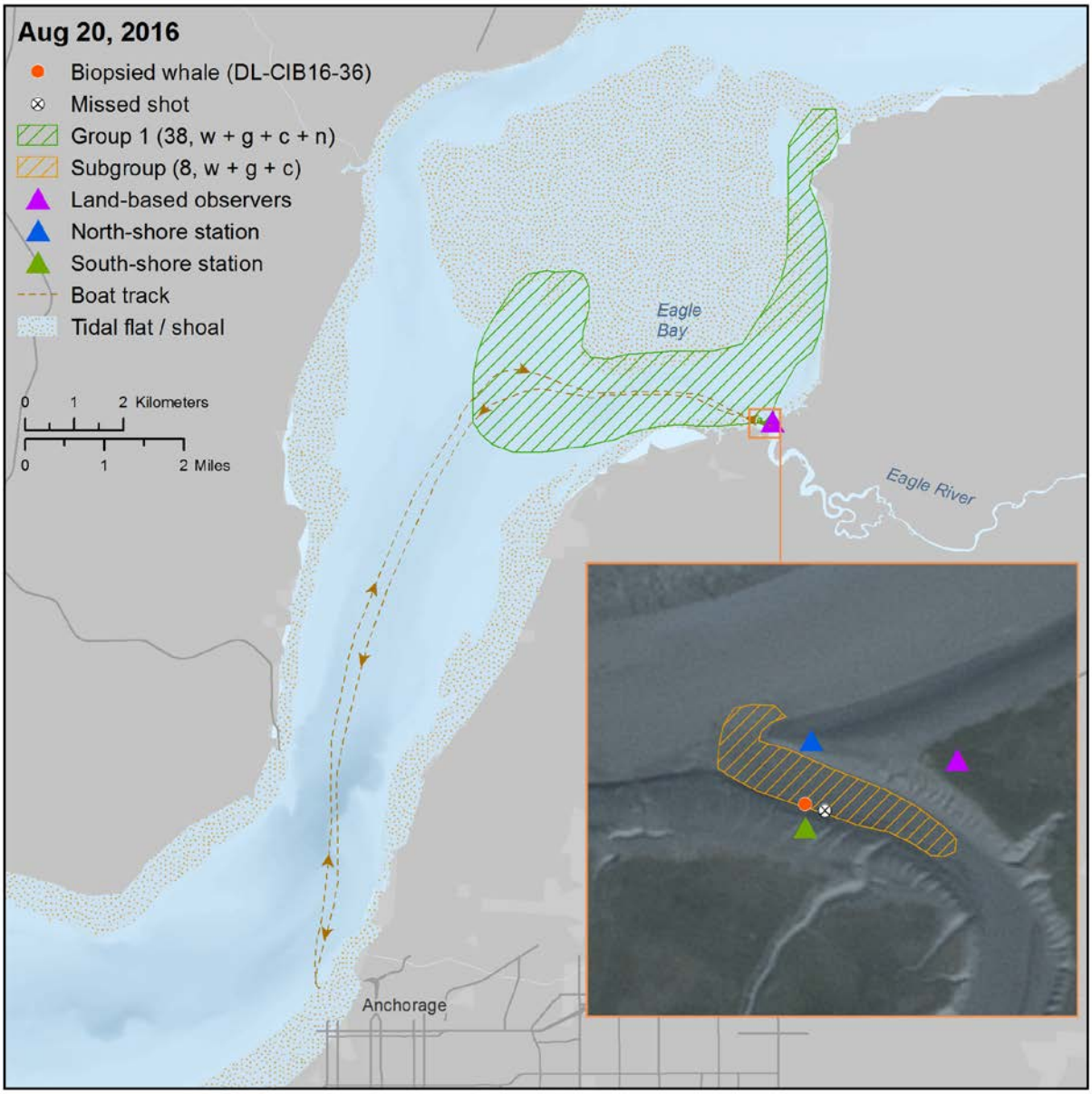


Figure B15. Location of sampling teams and beluga groups on August 20, 2016 in Knik Arm, Upper Cook Inlet, Alaska. The biopsy team was located at the south-shore station. A vessel was used to transport the team from the Anchorage small boat launch to the land-based site. Two biopsy shots were taken, resulting in one sample and one miss. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

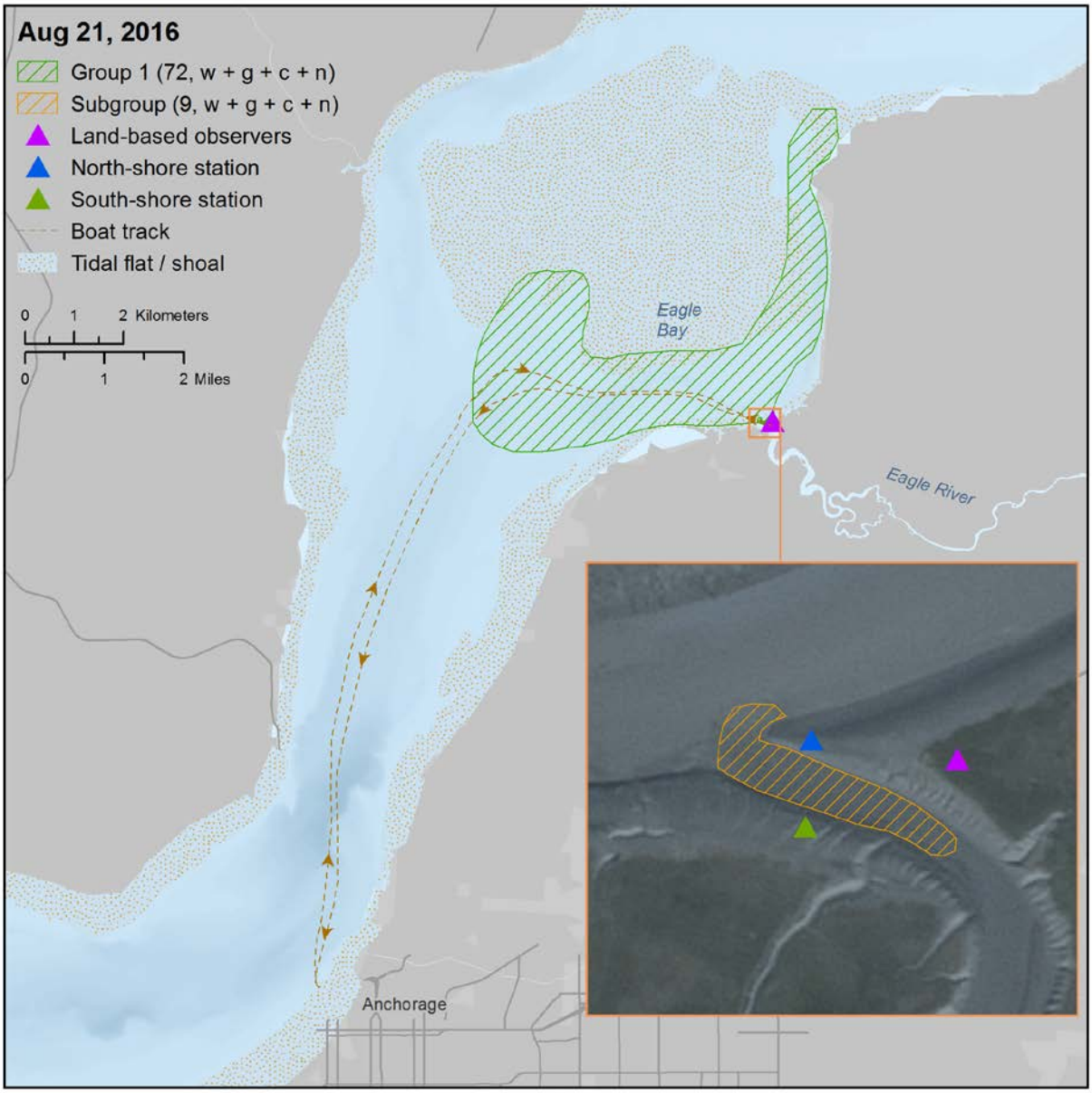


Figure B16. Location of sampling teams and beluga groups on August 21, 2016 in Knik Arm, Upper Cook Inlet, Alaska. The biopsy team was located at the south-shore station. A vessel was used to transport the team from the Anchorage small boat launch to the land-based site. No biopsy shots were attempted because unaccompanied whales did not approach within range of the land-based site. There was a lone white beluga at the Port of Anchorage small boat launch that is not shown on the map. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

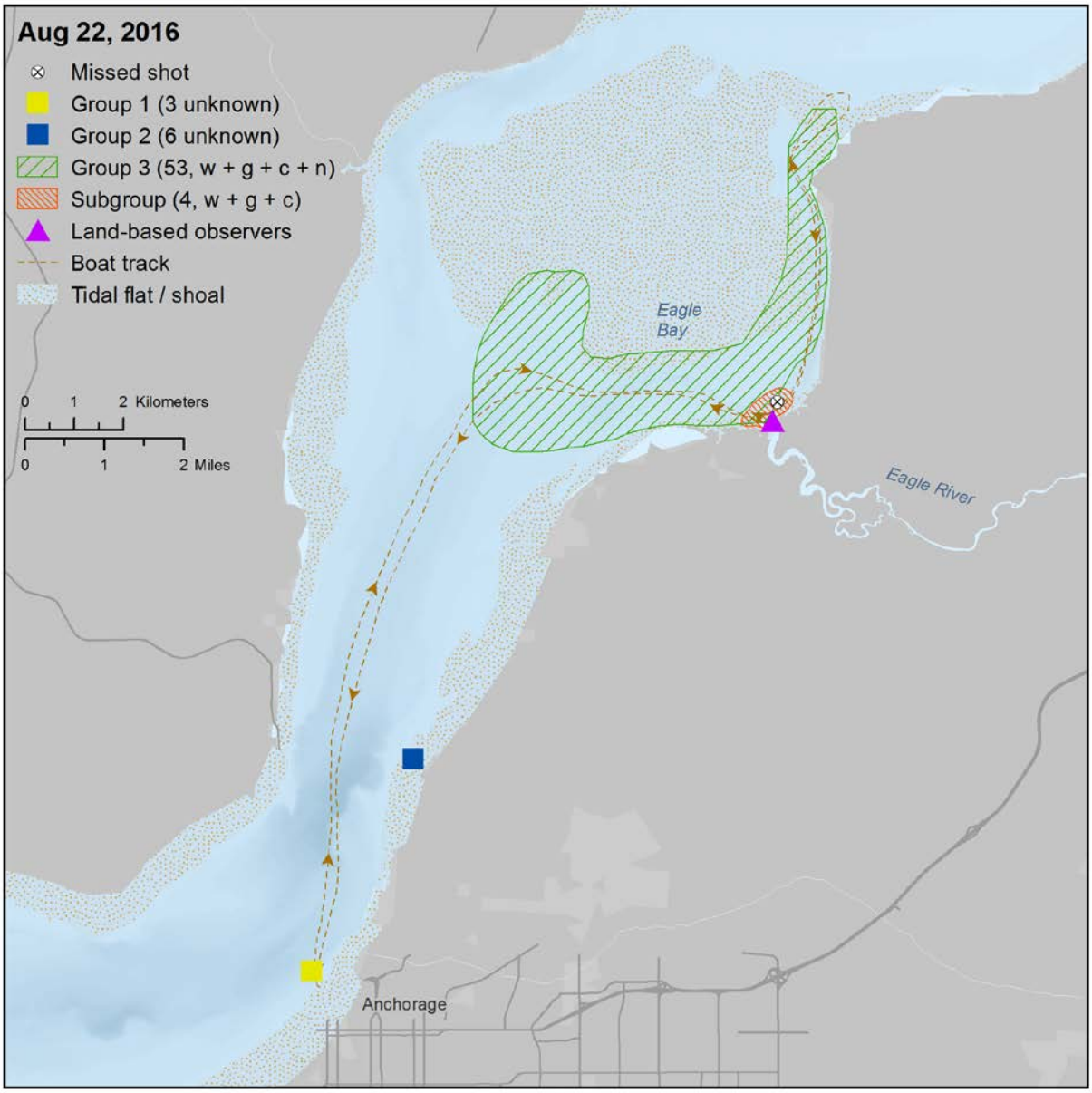


Figure B17. Location of survey route and beluga groups encountered on August 22, 2016 in Knik Arm, Upper Cook Inlet, Alaska. The biopsy team was located on the JBER survey vessel R/V *Valkyrie*. One biopsy shot was taken, resulting in a miss. (w = white belugas present; g = gray belugas present; c = calves present; n = neonates present; the number in parenthesis is the group size total).

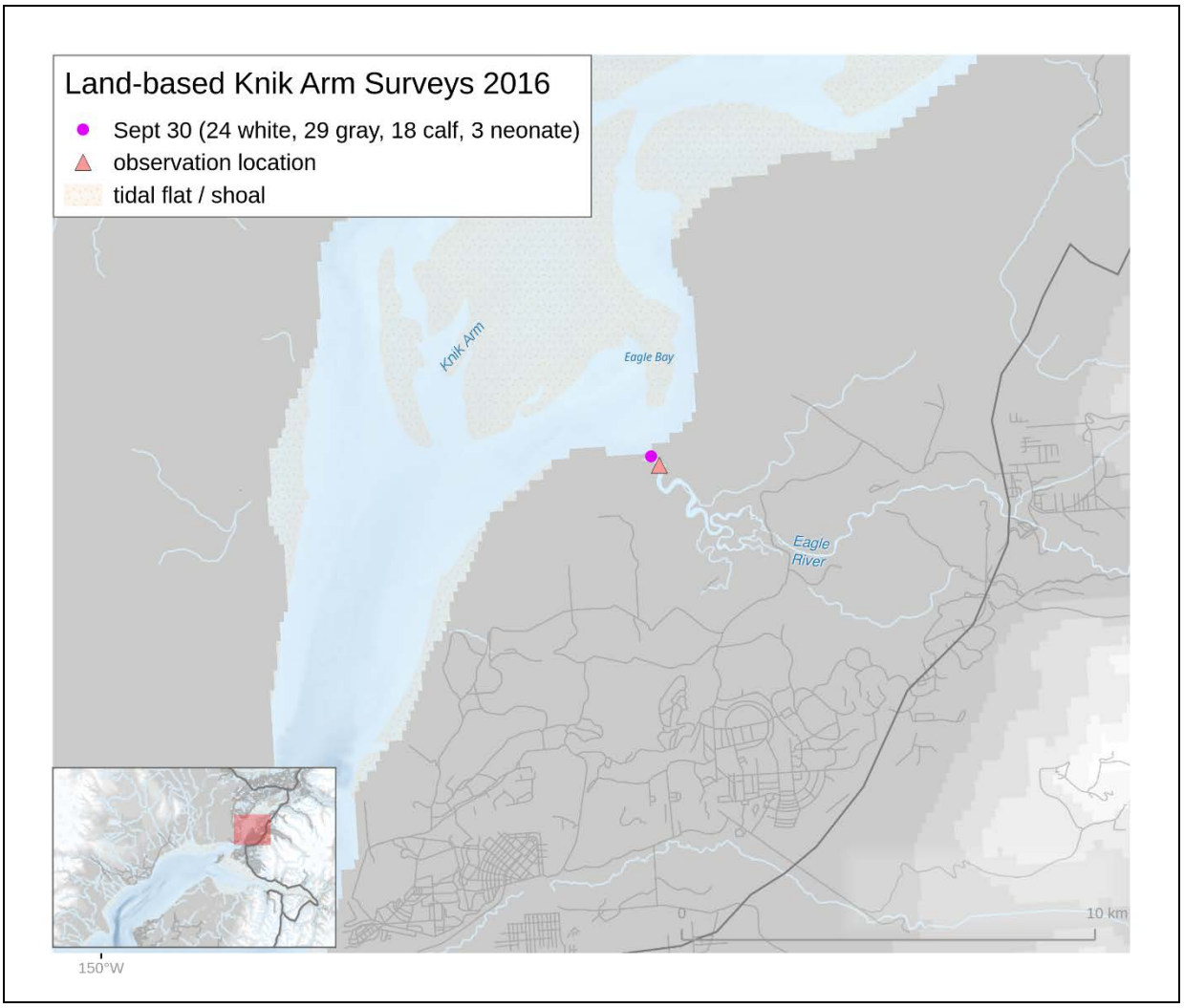


Figure B18. Beluga whale groups encountered during land-based photo-identification surveys of Knik Arm, Upper Cook Inlet, Alaska September 30, 2016.

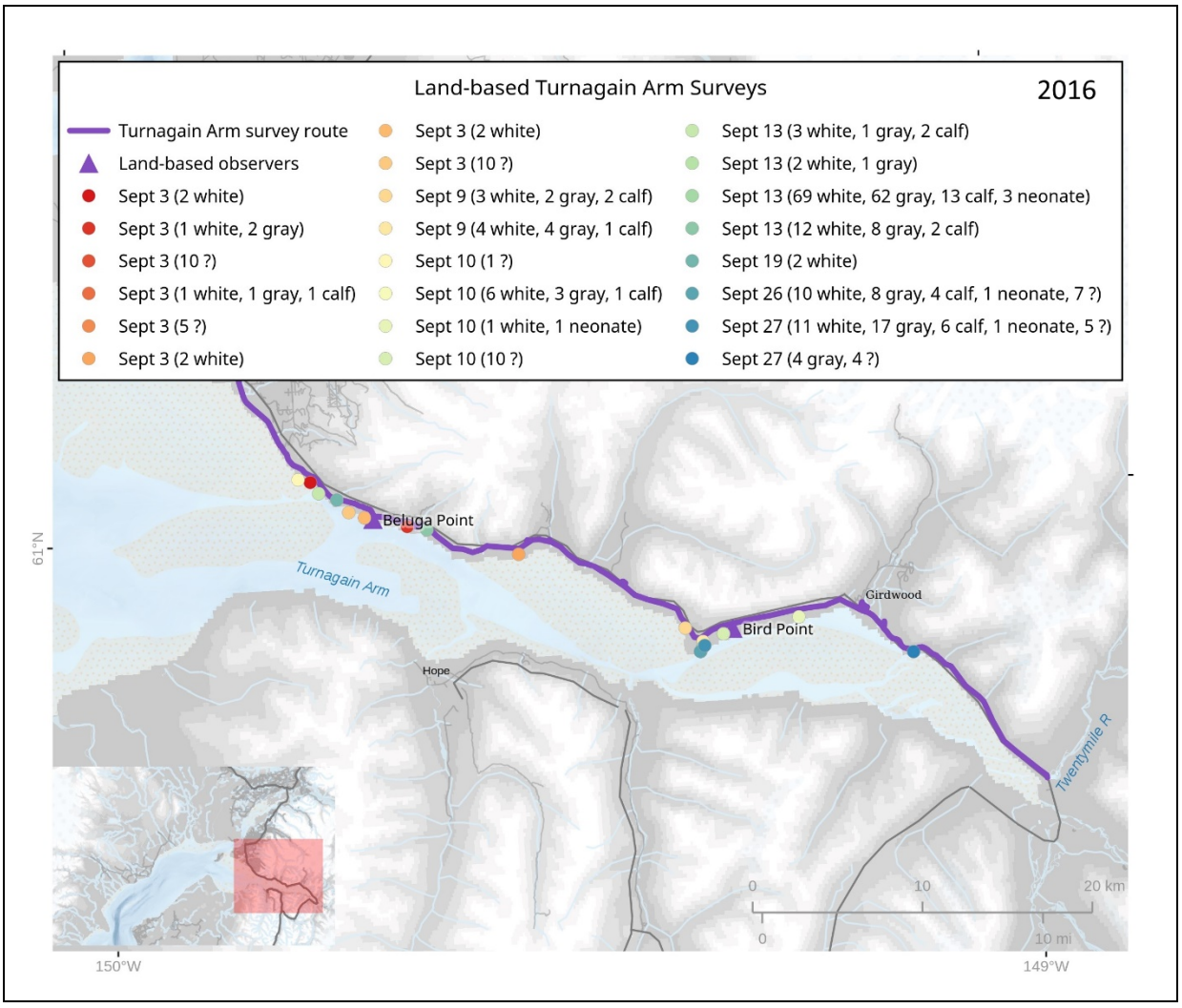


Figure B19. Beluga whale groups encountered during land-based photo-identification surveys of Turnagain Arm, Upper Cook Inlet, Alaska in 2016. ? indicates unknown color/size class.

Appendix C. Sighting Histories of Dual-side, Satellite-tagged, Biopsied, and Known-sex Individuals Photographed in 2015 and/or 2016.

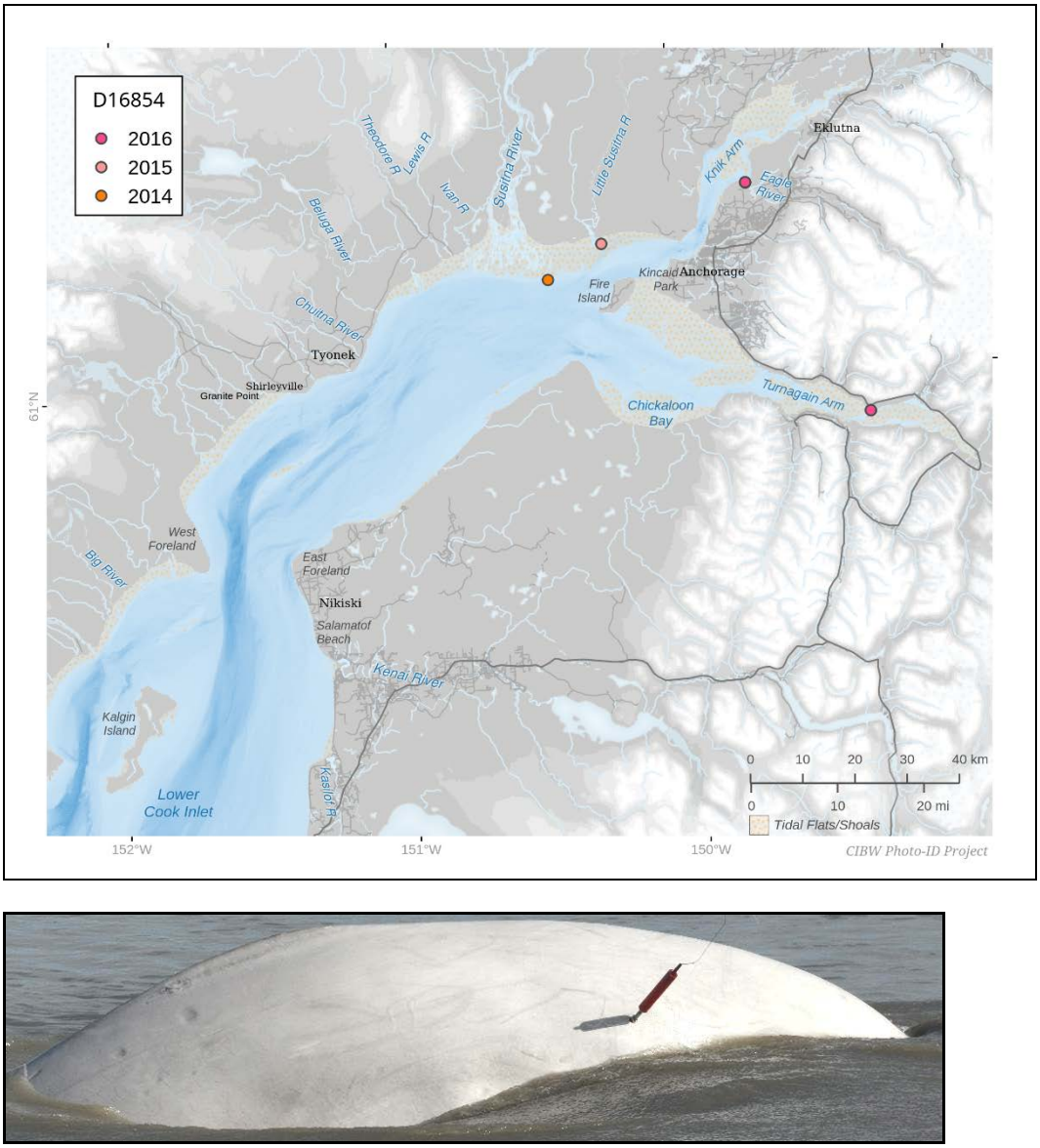
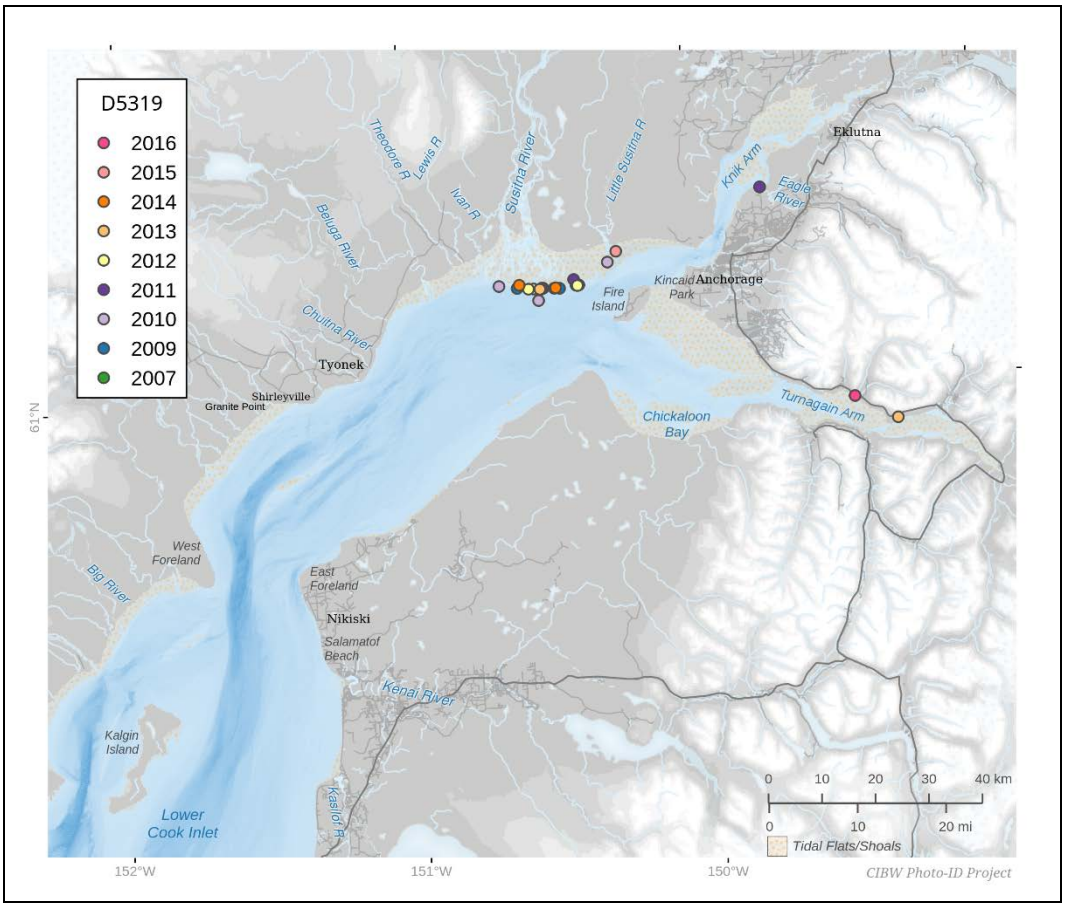


Figure C1. Sighting history and photographs of beluga D16854. This whale was biopsied from land on August 19, 2016. It was first identified in 2014. Although biopsy determined it is a female, it has not been photographed with a calf. (Photo is of the left side during biopsy.)



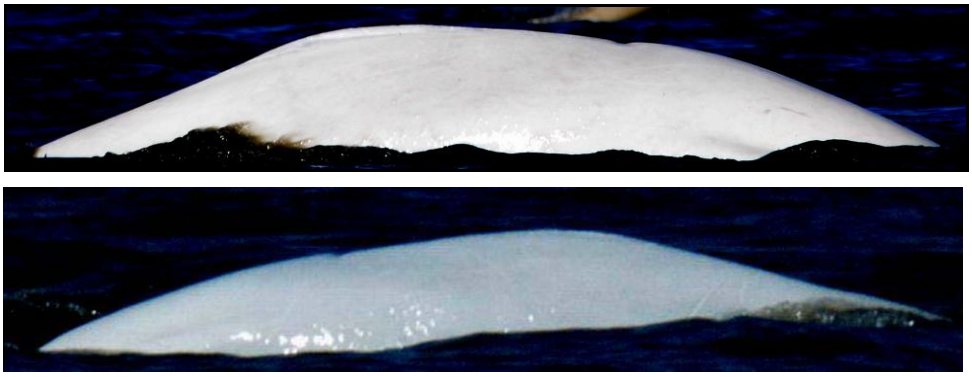
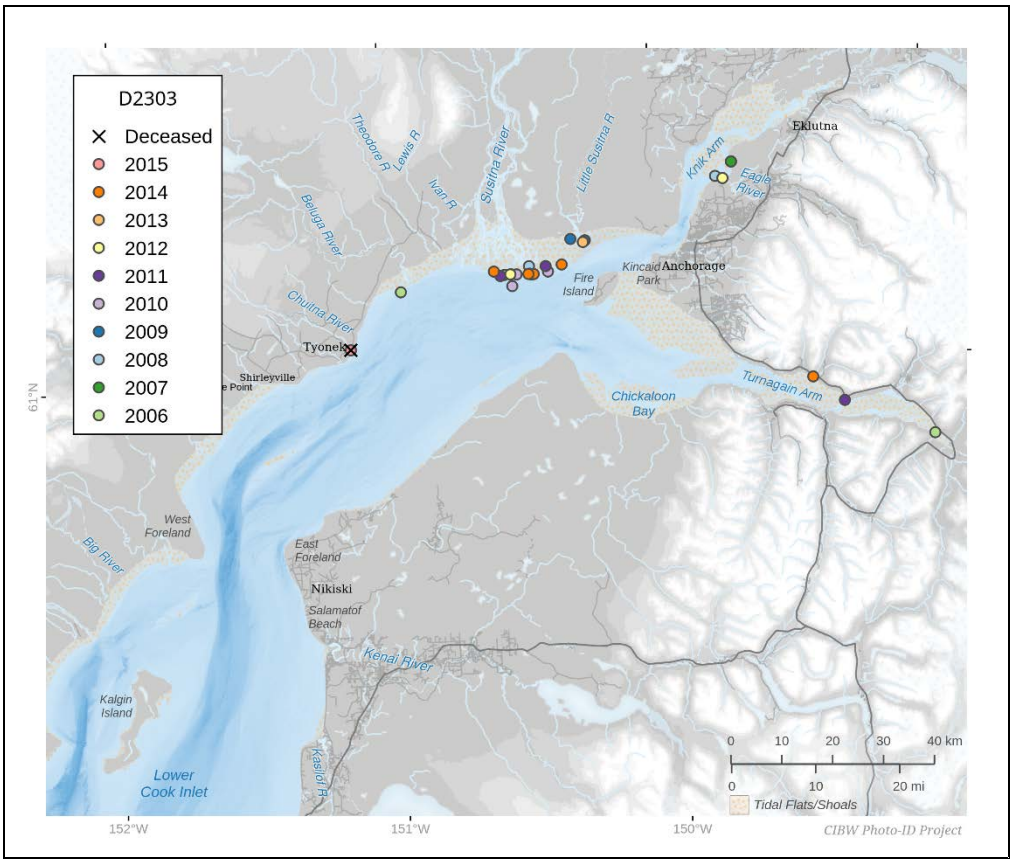


Figure C2. Sighting history and photographs of beluga D5319. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. This whale is a presumed mother based on photographs with an accompanying calf. (Top photo is of the right side; bottom photo is of the left side).



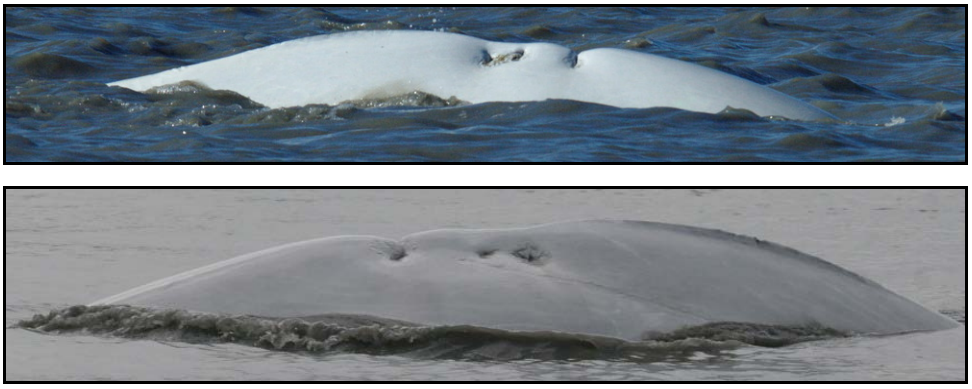


Figure C3. Sighting history and photographs of beluga D2303. This whale was tagged by NMFS on August 2, 2002 during their satellite tagging study. This whale is a male and was found dead in 2015. (Top photo is of the right side; bottom photo is of the left side).

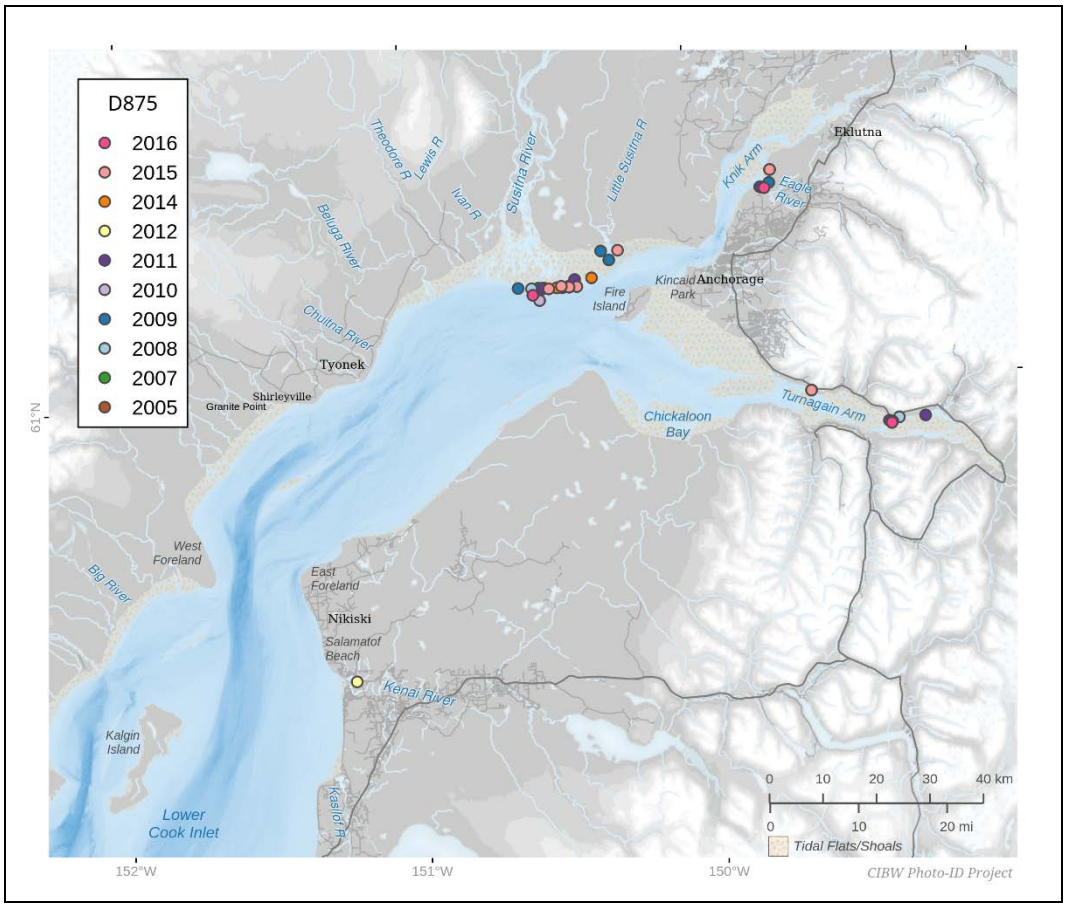


Figure C4. Sighting history and photographs of beluga D875. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. (Top photo is of the right side; bottom photo is of the left side).

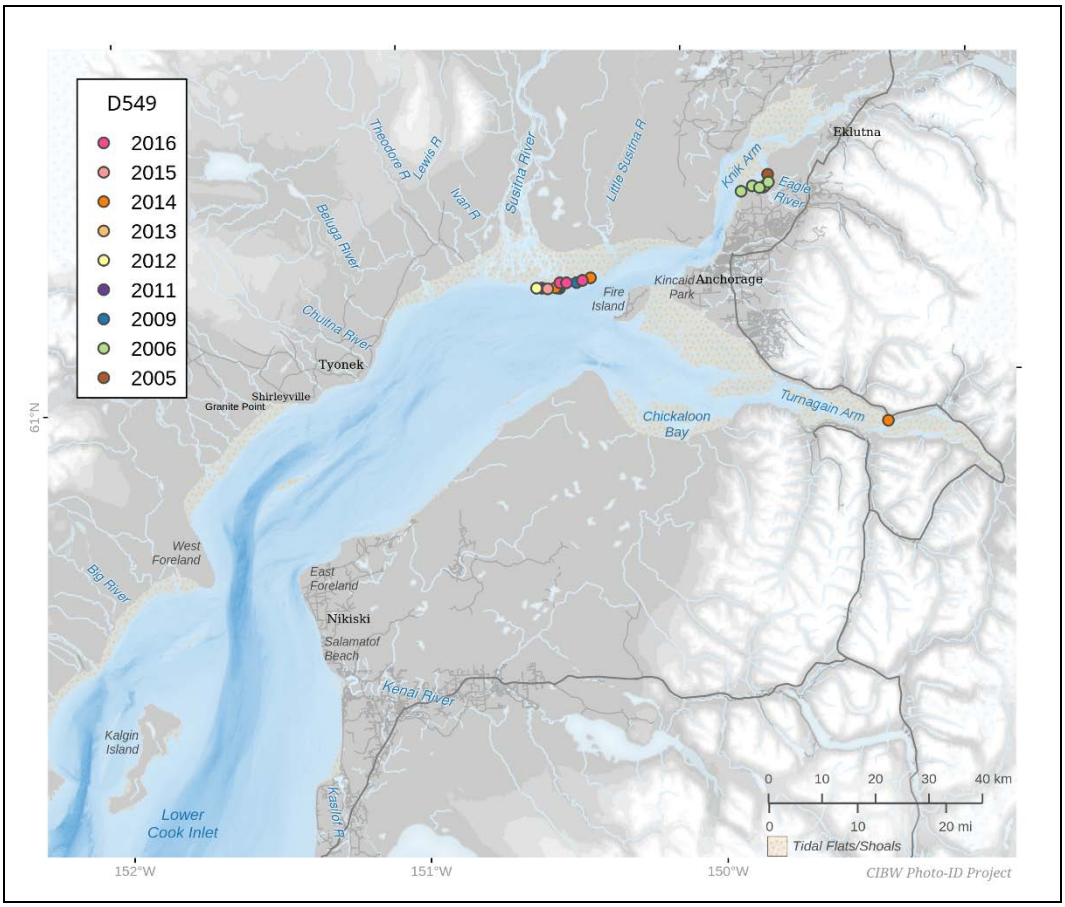
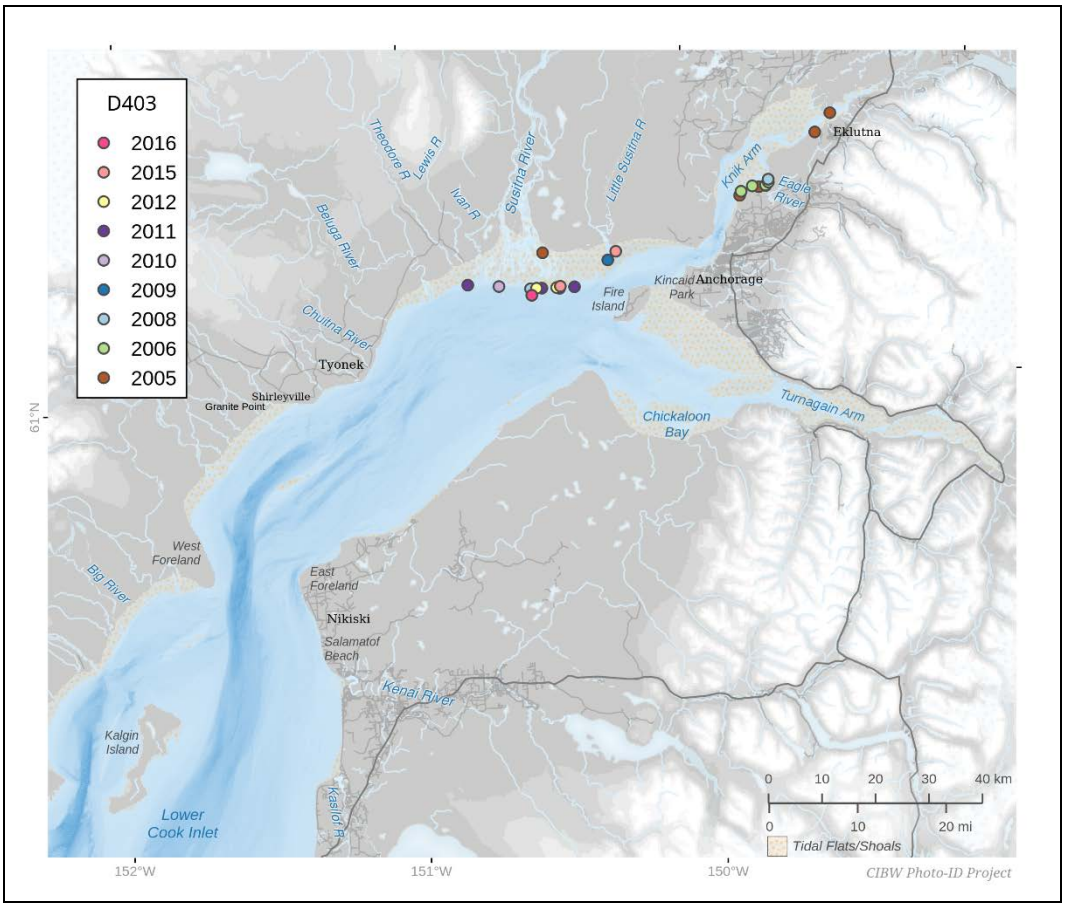


Figure C5. Sighting history and photographs of beluga D549. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. This whale is a presumed mother based on photographs with an accompanying calf. (Top photo is of the right side; bottom photo is of the left side).



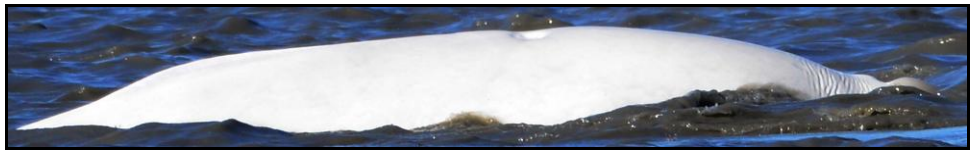
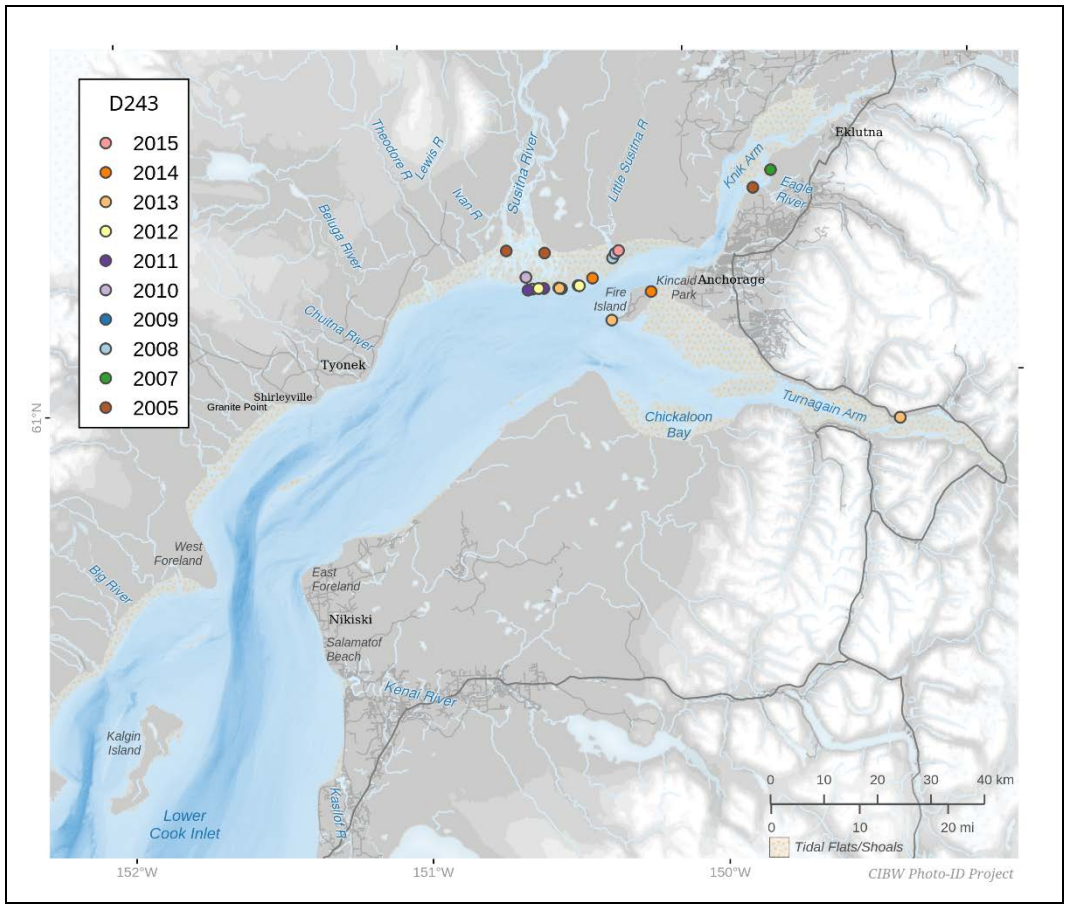


Figure C6. Sighting history and photographs of beluga D403. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. This whale is a presumed mother based on photographs with an accompanying calf. (Top photo is of the right side; bottom photo is of the left side).



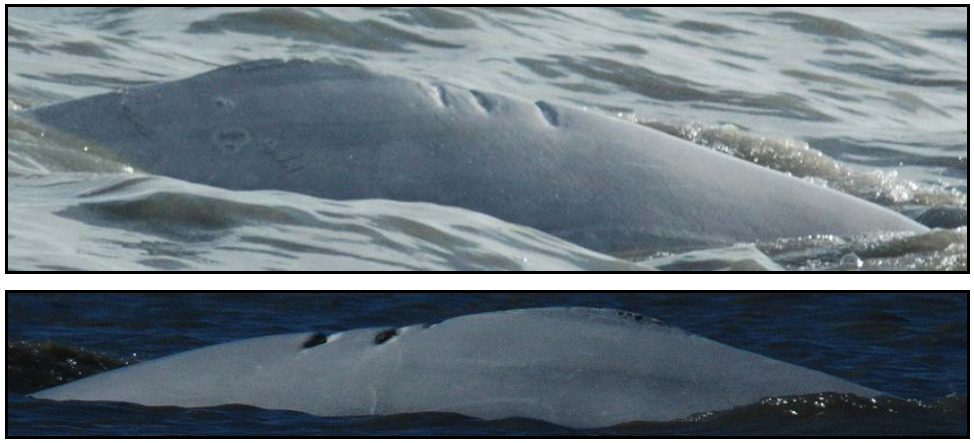


Figure C7. Sighting history and photographs of confirmed female beluga D243. This whale was tagged by NMFS on August 10, 2001 during their satellite tagging study. This whale is a female but has never been photographed with a calf. (Top photo is of the right side; bottom photo is of the left side).

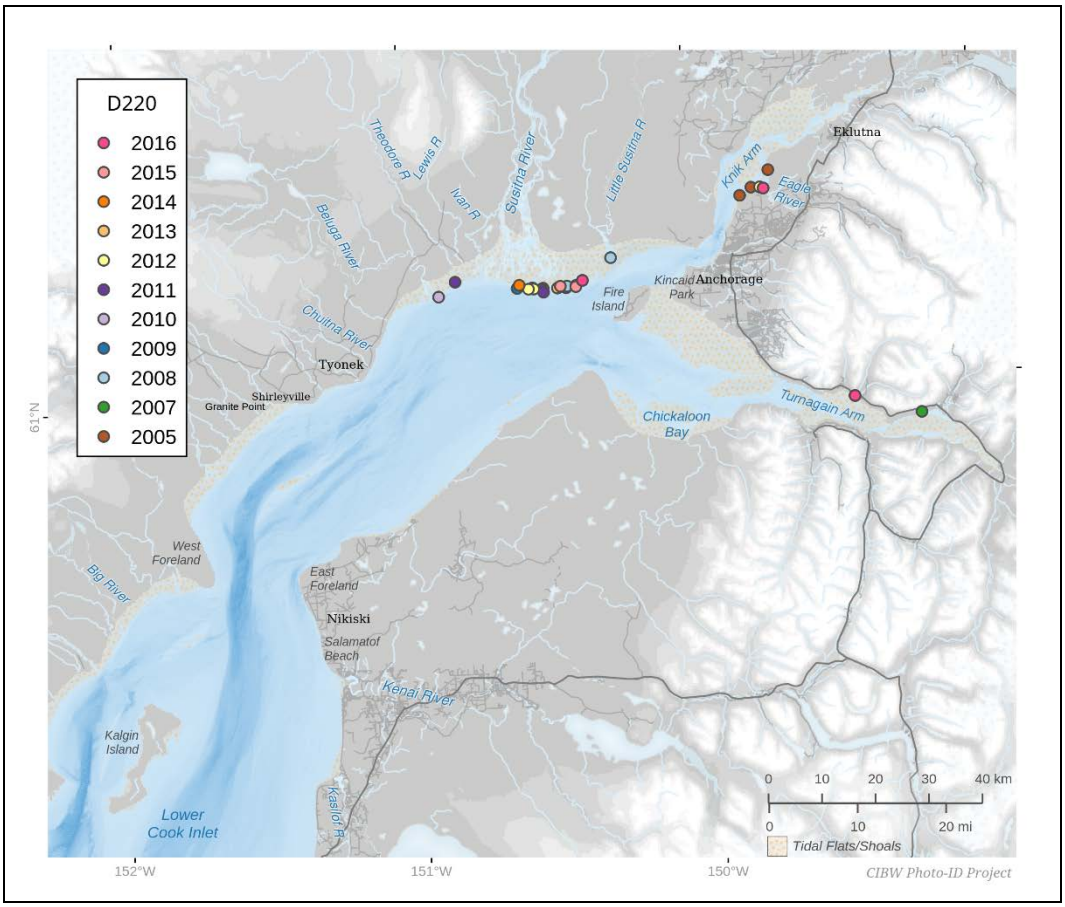


Figure C8. Sighting history and photographs of beluga D220. This whale was biopsied from land August 20, 2016. It was first photographed in 2005 and has a resighting history of being photographed with calves, and biopsy determined it is a female. (Top photo is of the right side; middle photo is of the right side with a calf; bottom photo is of the left side during biopsy).

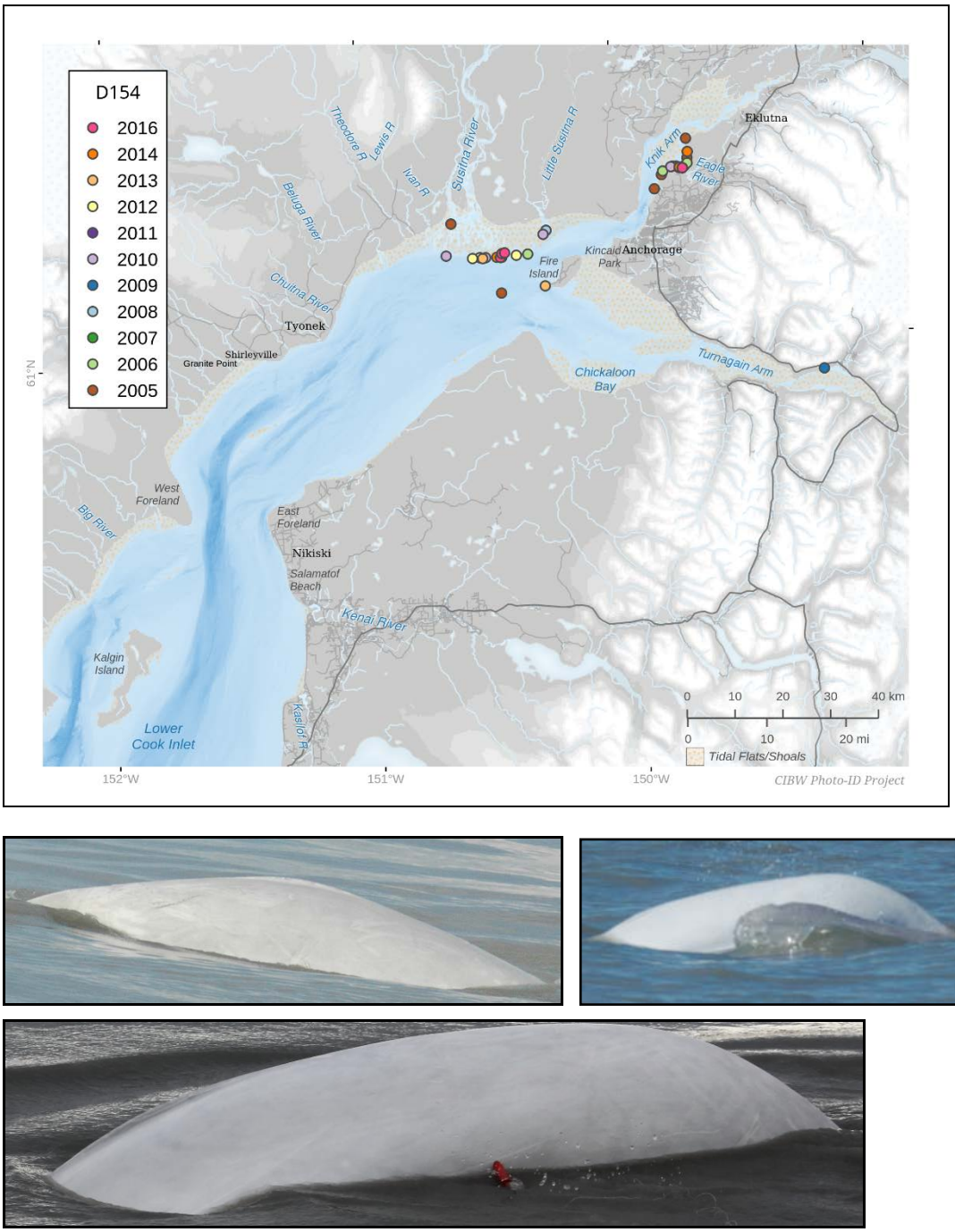


Figure C9. Sighting history and photographs of beluga D154. This whale was biopsied from land August 19, 2016. It has a resighting history of being photographed with calves, and biopsy determined it is a female. (Top left photo is of the right side; top right photo is of the left side with a calf; bottom photo is of the left side with biopsy dart).

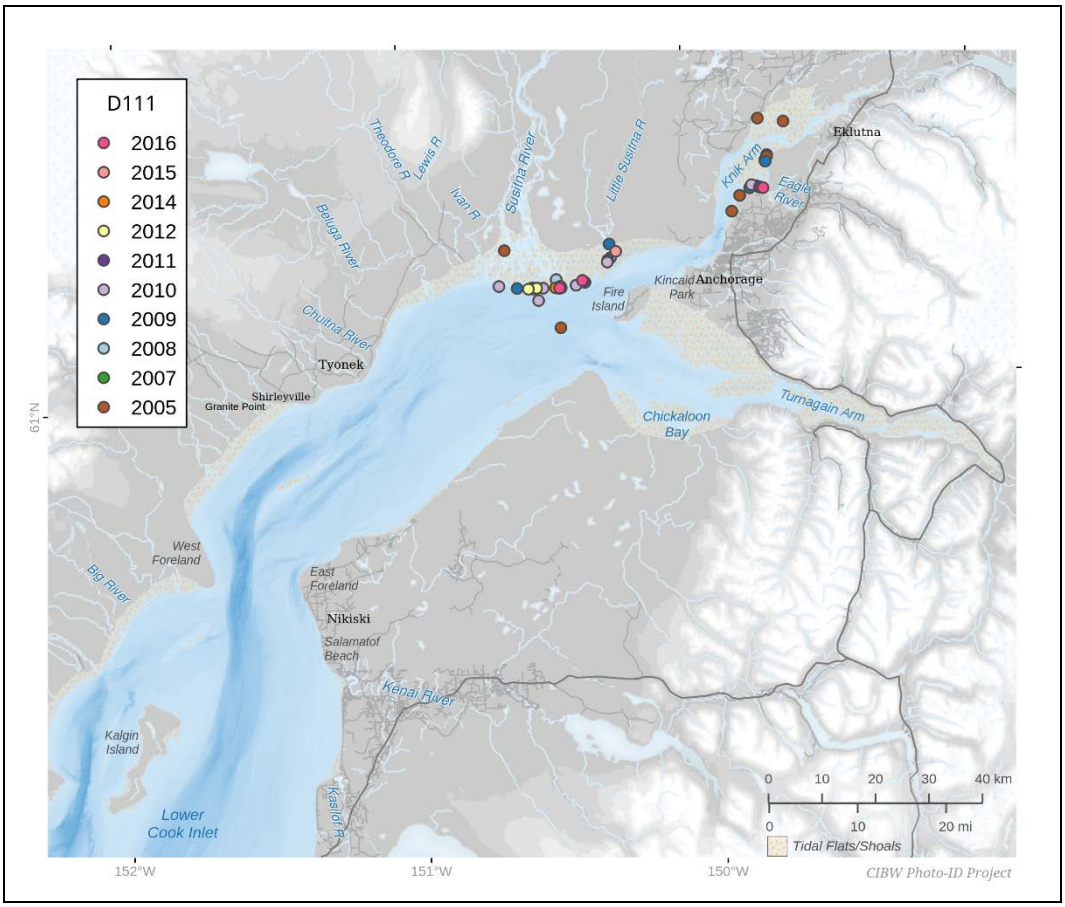


Figure C10. Sighting history and photographs of confirmed female beluga D111. This whale was tagged by NMFS on September 13, 2000 during their satellite tagging study. This whale is a female and a presumed mother based on photographs taken with an accompanying calf. (Top photo is of the right side; bottom photo is of the left side).

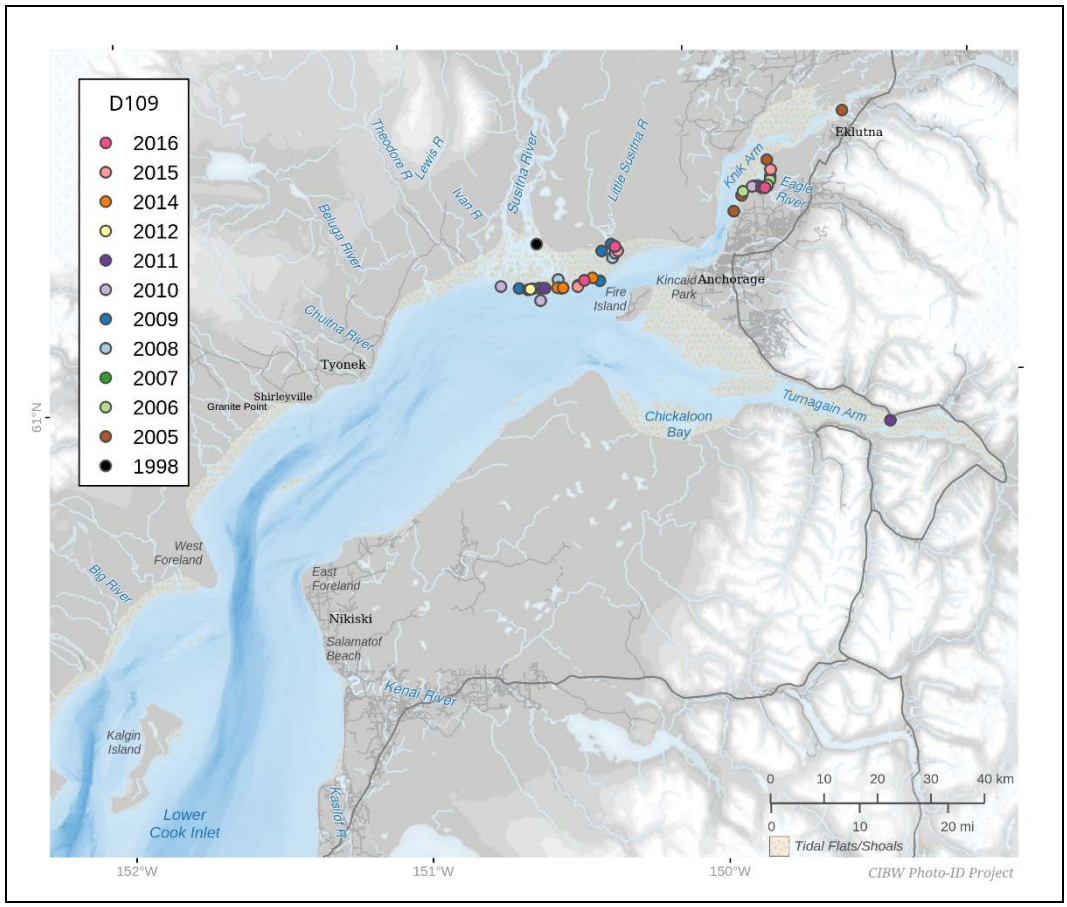


Figure C11. Sighting history of beluga D109. This whale was first photographed in 1998 by NMFS, indicating it was at least 18 years old when it was last photographed in 2016. This whale is a presumed mother based on photos with an accompanying calf. (Top photo is of the right side; bottom photo is of the left side).

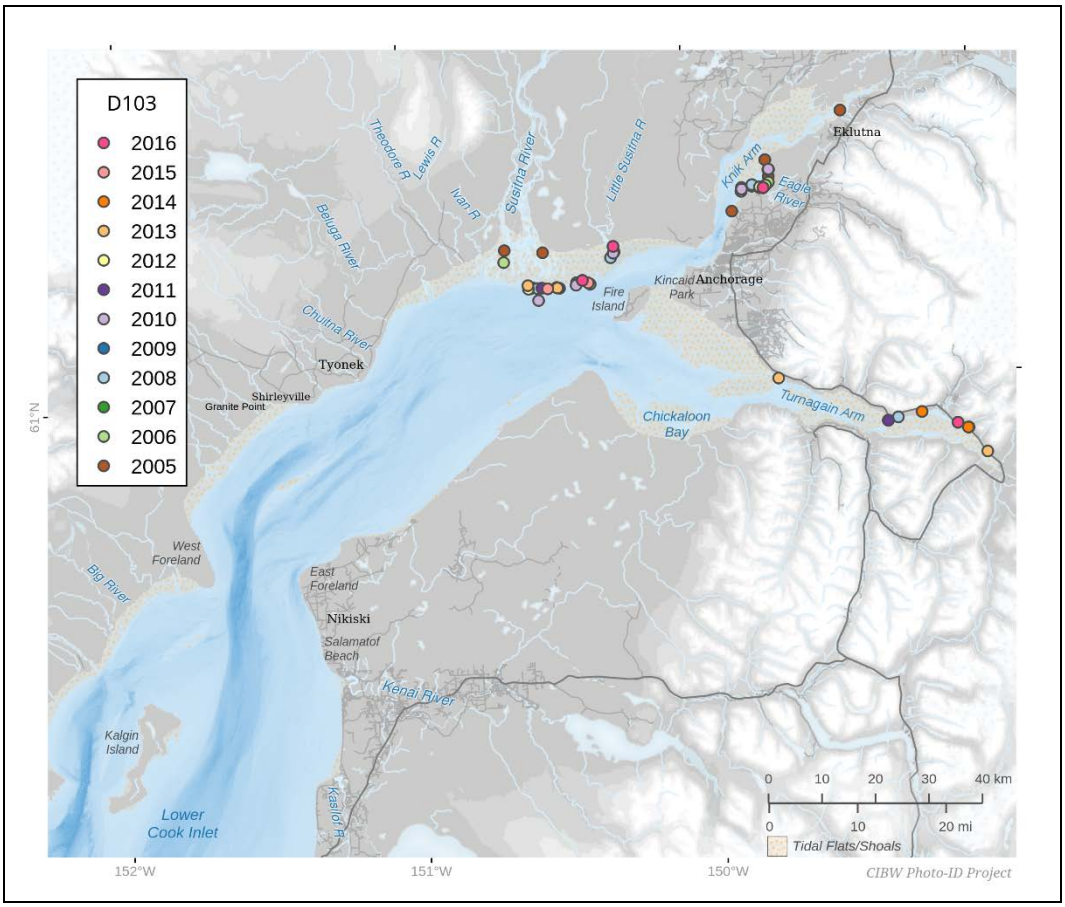


Figure C12. Sighting history and photographs of beluga D103. This whale was photographed in every year of the 2005-2015 study. This whale was tagged by NMFS on August 15, 2001 during their satellite tagging study, and was determined to be a female. D103 is a presumed mother based on photographs with an accompanying calf in 2008, 2010, and 2011. (Top photo is of the right side with a calf; bottom photo is of the left side).

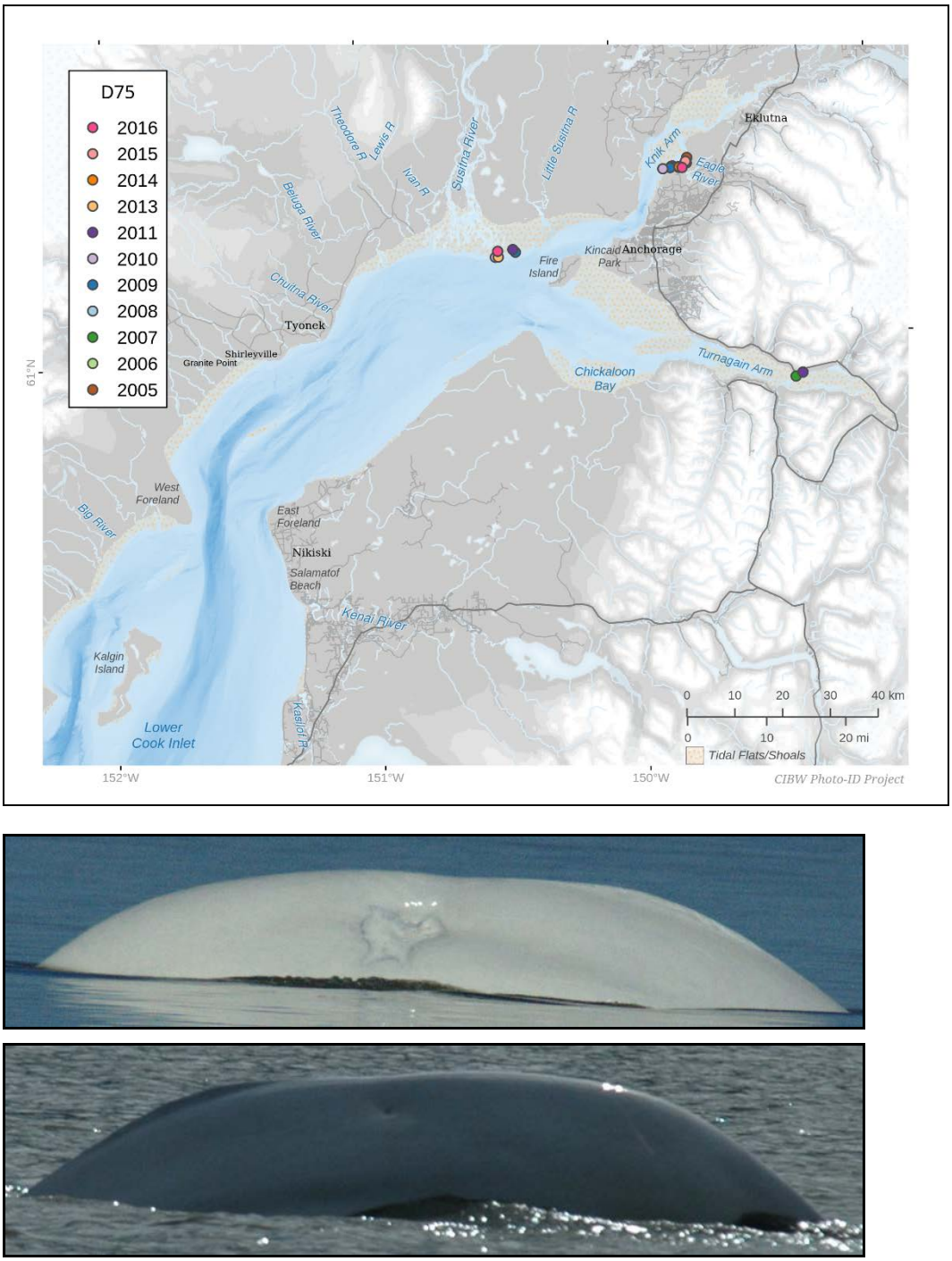
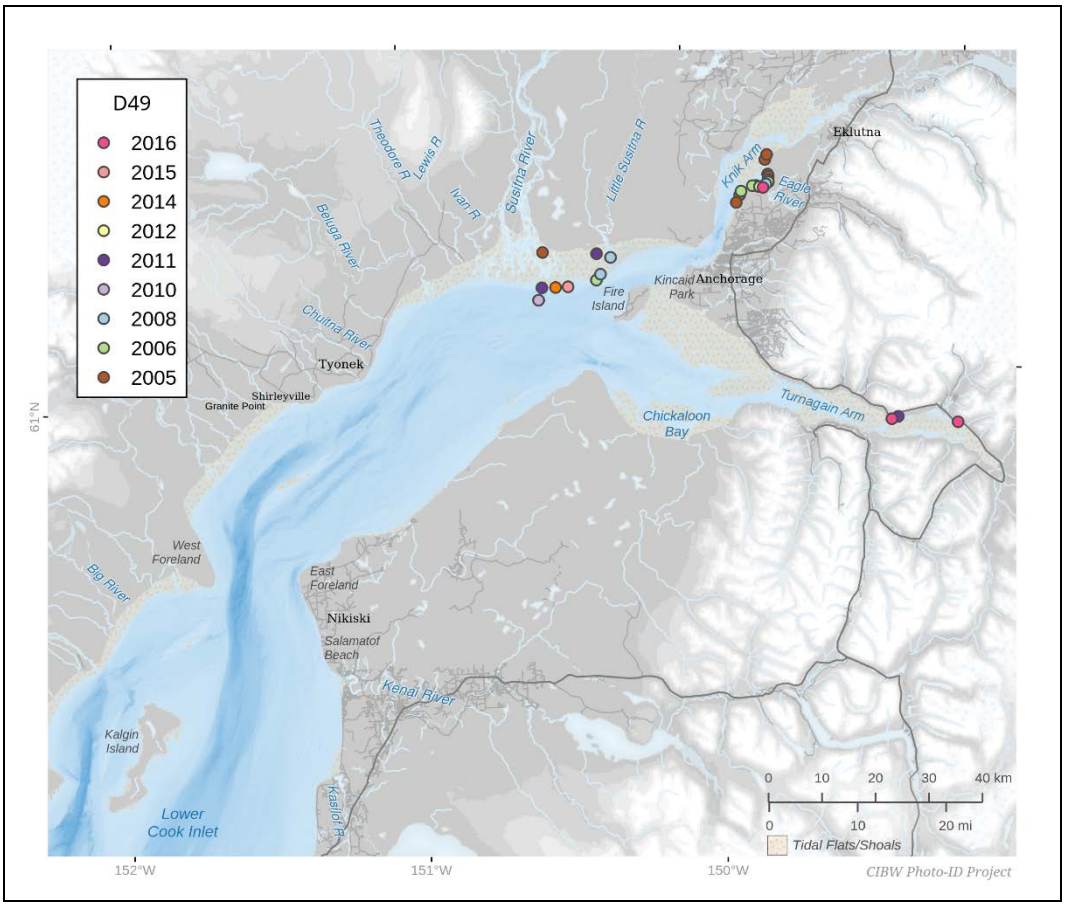


Figure C13. Sighting history and photographs of beluga D75. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. This whale is a presumed mother based on photographs with an accompanying calf (Top photo is of the right side; bottom photo is of the left side).



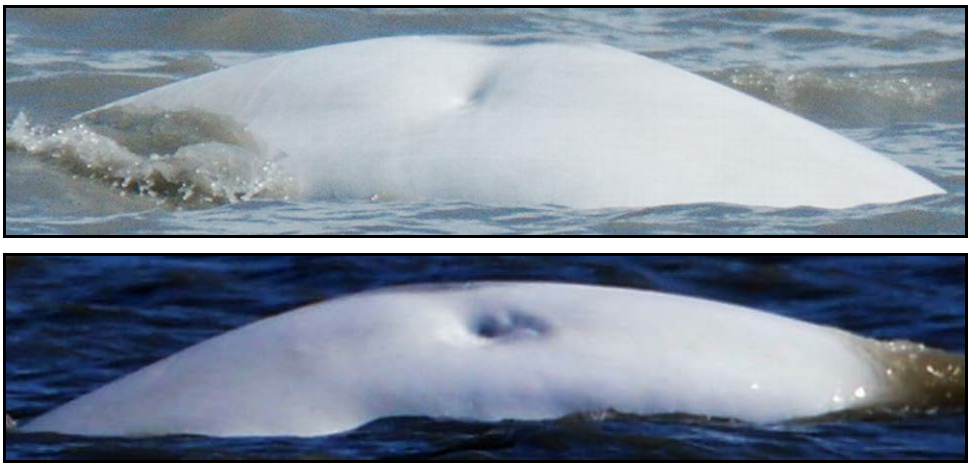


Figure C14. Sighting history and photographs of beluga D49. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. This whale is a presumed mother based on photographs with an accompanying calf. (Top photo is of the right side; bottom photo is of the left side).

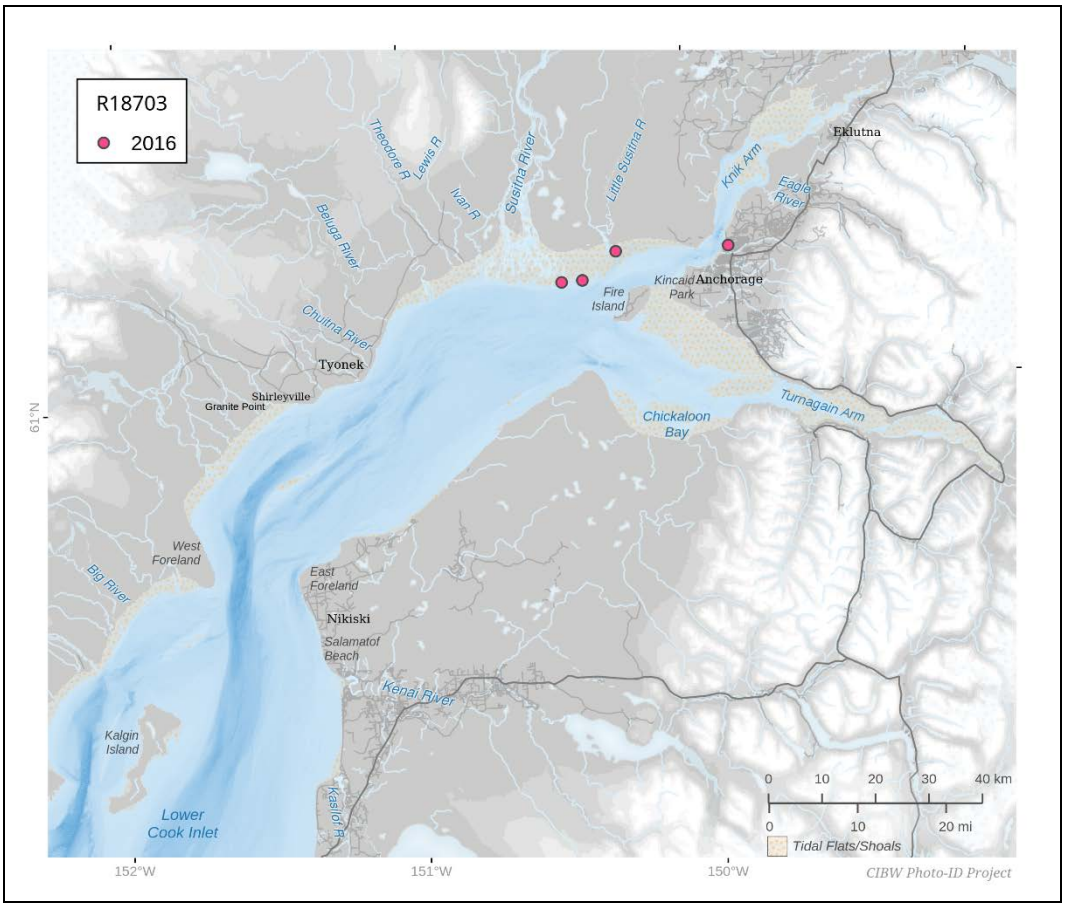


Figure C15. Sighting history and photograph of beluga R18703. This whale was first identified in 2016 and was biopsied August 13, 2016. Biopsy determined this whale is a female.

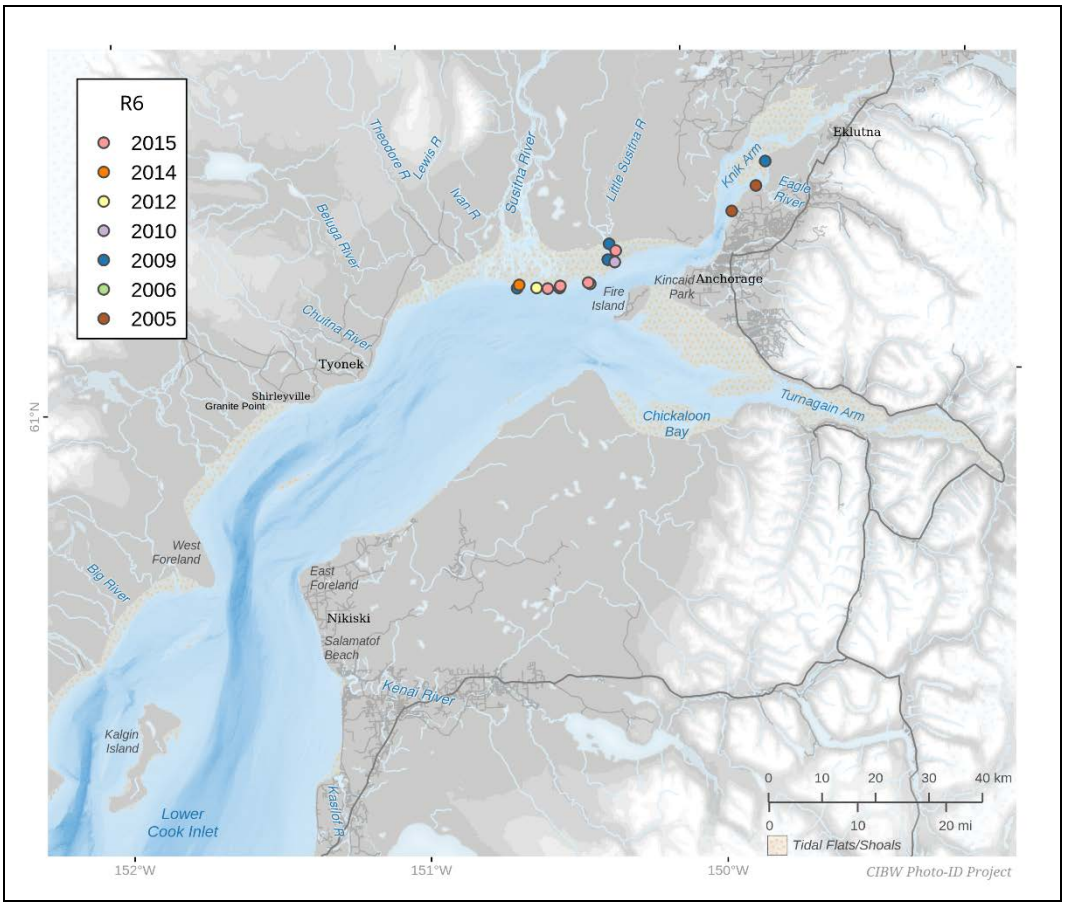


Figure C16. Sighting history and photograph of beluga R6. This whale has scars indicating it was tagged by NMFS during their 1999-2002 satellite tagging study. This whale is a presumed mother based on photographs with an accompanying calf. (Photograph is of the right side).

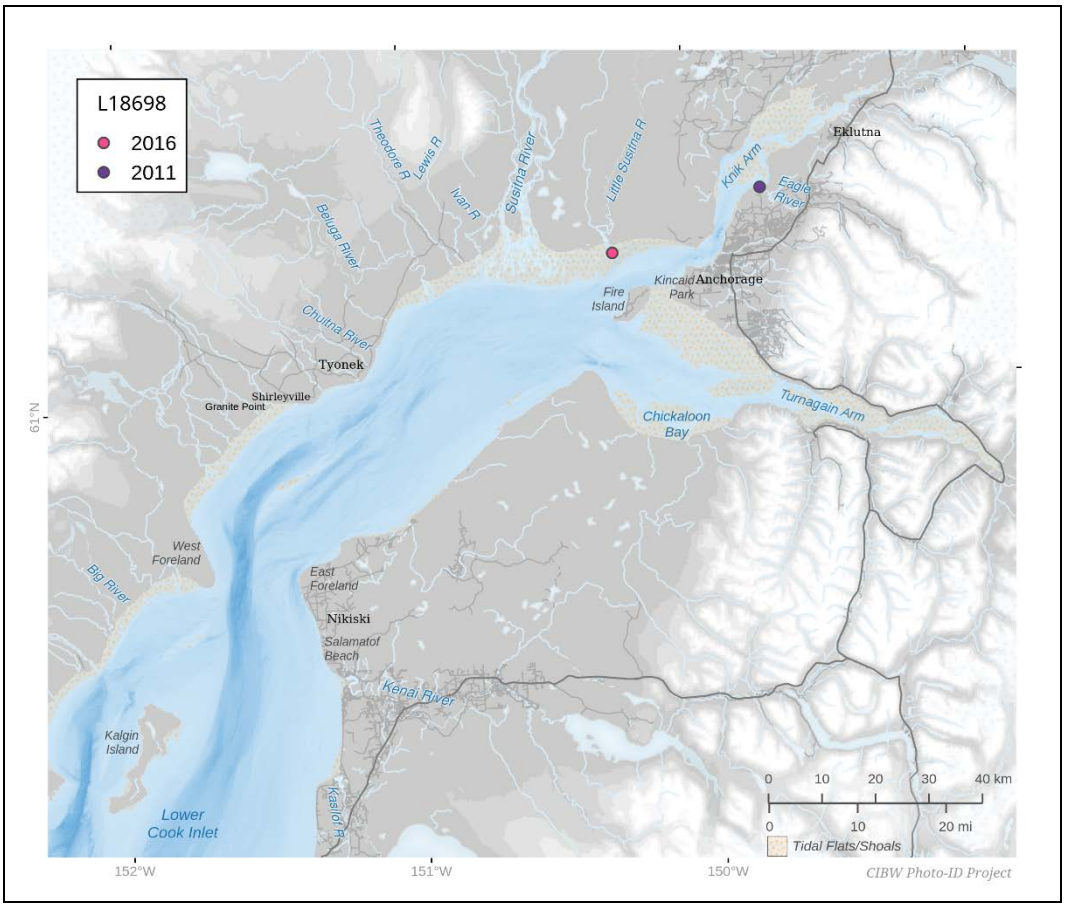


Figure C17. Sighting history and photographs of beluga L18698. This whale was biopsied on August 16, 2016 from a vessel. It was first identified in 2011 (top photo, left side). Although biopsy determined it is a female, it has not been photographed with a calf. (Bottom photo is of the left side during biopsy).

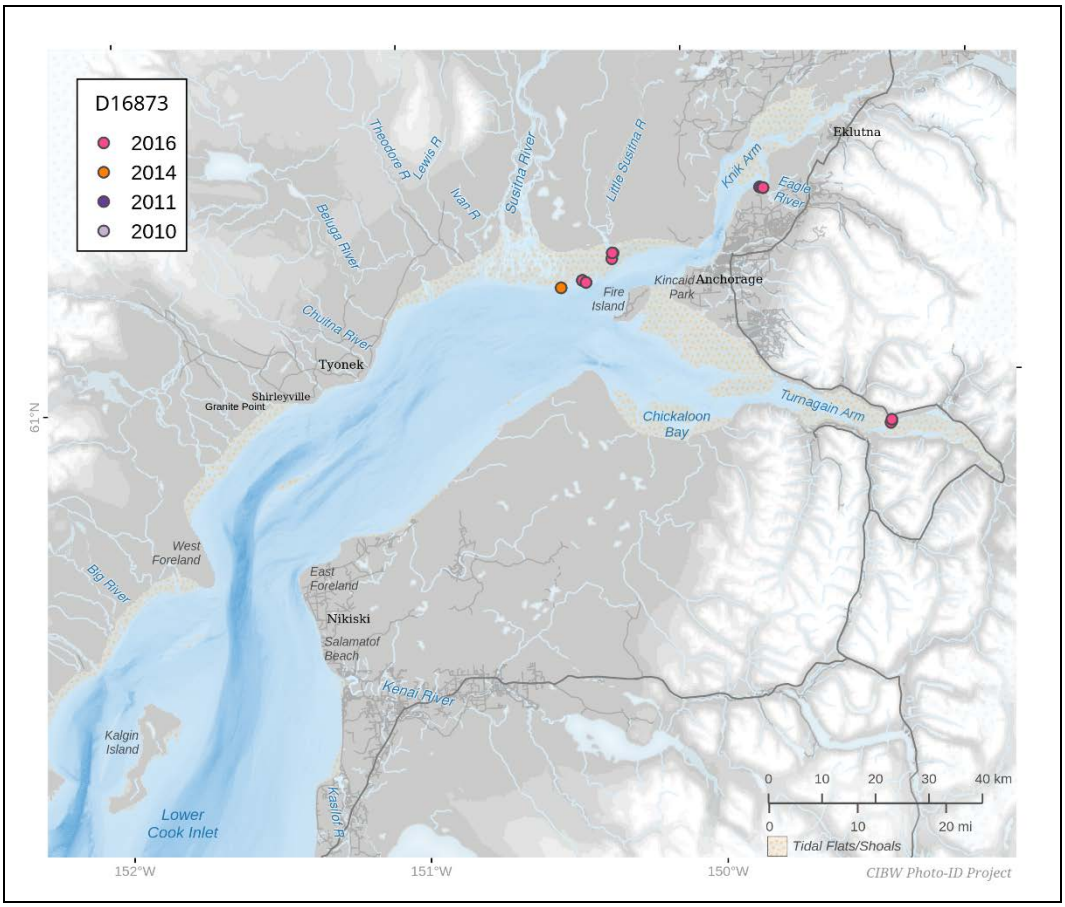


Figure C18. Sighting history and photograph of beluga D16873. This whale was biopsied on August 15, 2016. It was first identified in 2014. Biopsy determined it is a male. (Photo is of the left side).

Appendix D: Outreach Activities for the Cook Inlet Beluga Whale Photo-ID Project, 2015-2016

Presentations about Cook Inlet Beluga Whales and the Photo-ID Project

- the Alaska Marine Mammal Stranding Network Annual Meetings (2015)
- the Society for Marine Mammalogy Biennial Conference (2015; Figure D1.)
- the Alaska Marine Science Symposium (2015-2017; Figures D2, D3.)

Presentations at Festivals/Events

- Shared display booth with NOAA Office of Law Enforcement at "Great Alaska Gathering" Aviation Show, Ted Stevens International Airport, Anchorage. Made and distributed pocket-sized cards for pilots, with contact numbers to call and report live and dead beluga whale sightings to NMFS and the CIBW Photo-ID Project.
- Shared display booth with NOAA Office of Law Enforcement at "Great Alaskan Sportsman Show", Anchorage. Staffed table with display on belugas and the CIBW Photo-ID Project.

Presentations in Schools (K-12, Undergraduate)

- Presentation on CIBWs and the Photo-ID Project to University of Alaska Anchorage, (UAA) Homer Marine Mammal class (2015-2016).
- Mentored Alaska Native Science and Engineering Program (ANSEP) Intern (2016).
- Presentation on CIBW and the Photo-ID Project to Anchorage Central Middle School for Science (2015).

Factsheets Produced and Distributed

- Informational pamphlet
- Guide for how to photograph stranded CIBWs
- Business card-sized handout with information on how and where to report live and dead CIBWs.

Pamphlets and cards were distributed during fieldwork and at all public outreach events. Distribution during fieldwork included to fisherpeople, recreational boat users, and hunters at the Anchorage Small Boat Launch and Kenai City Dock; and to tourists and residents as they beluga-watched along the Seward Highway along Turnagain Arm.

Website

The CIBW Photo-ID project website (www.cookinletbelugas.org or www.cookinletbelugas.com) describes the project, gives background information about CIBWs and the project, and contains a page for members of the public to report beluga sightings and share photos with the project. The website address is distributed via the project bumper sticker (below), project pamphlets, and wallet-cards. All sighting reports are shared with NMFS.

Project Results

All CIBW Photo-ID Project reports are publicly available on the project website (www.cookinletbelulgas.org), and many are also available on https://alaskafisheries.noaa.gov/pr/beluga-research-cook-inlet. In addition, the CIBW Photo-ID Project has provided their survey dataset to the "NMFS Cook Inlet Beluga Whale Scientific Sightings Mapper"; these data are a layer in the publicly available and free-of-charge Alaska Ocean Observing System's (AOOS) Cook Inlet Beluga Whale Ecosystem Portal http://portal.aoos.org/cibw.php.

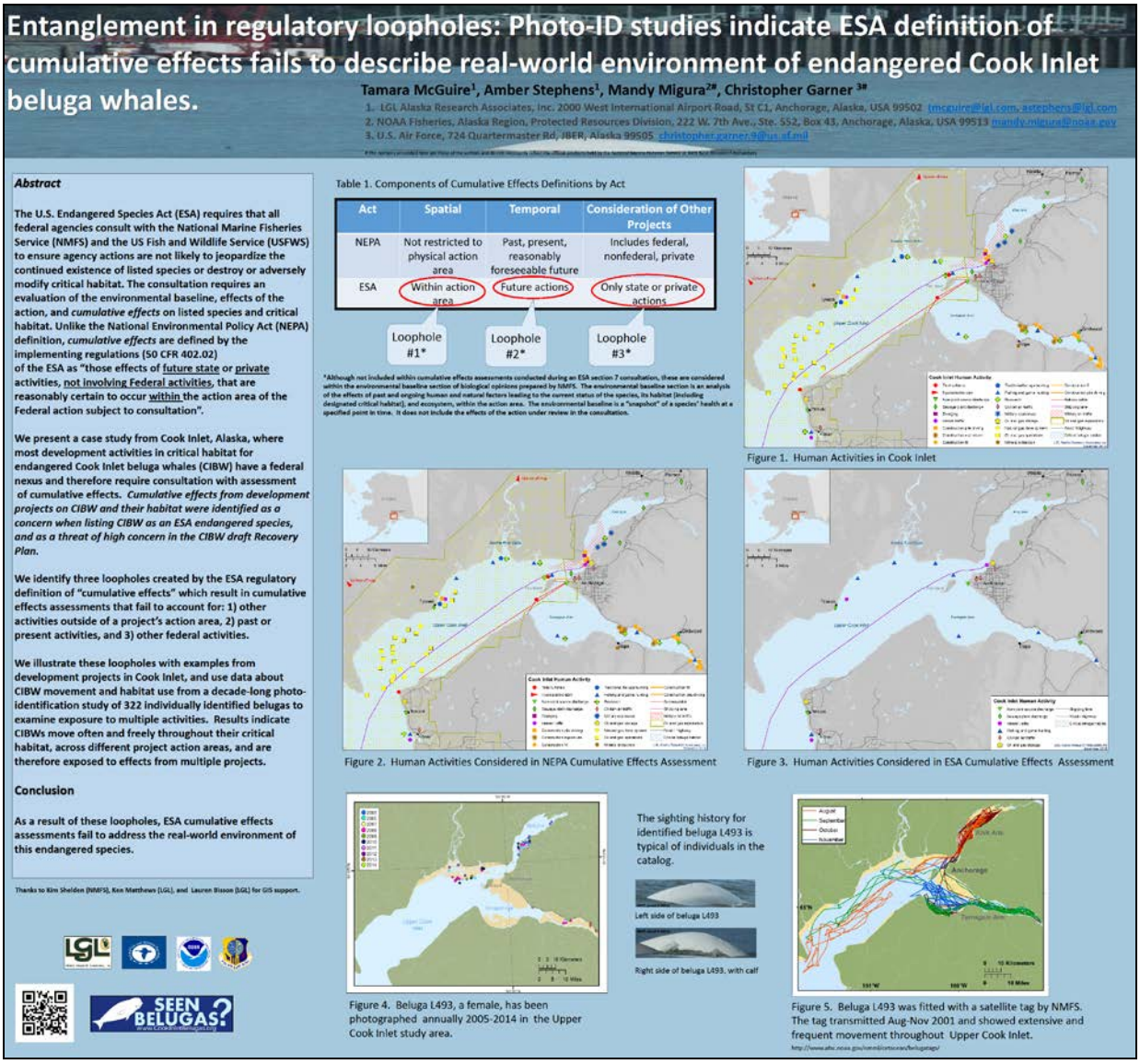


Figure D1. CIBW Photo-Id Project poster presented at the December 2015 Society for Marine Mammalogy Biennial Conference in San Francisco, California.

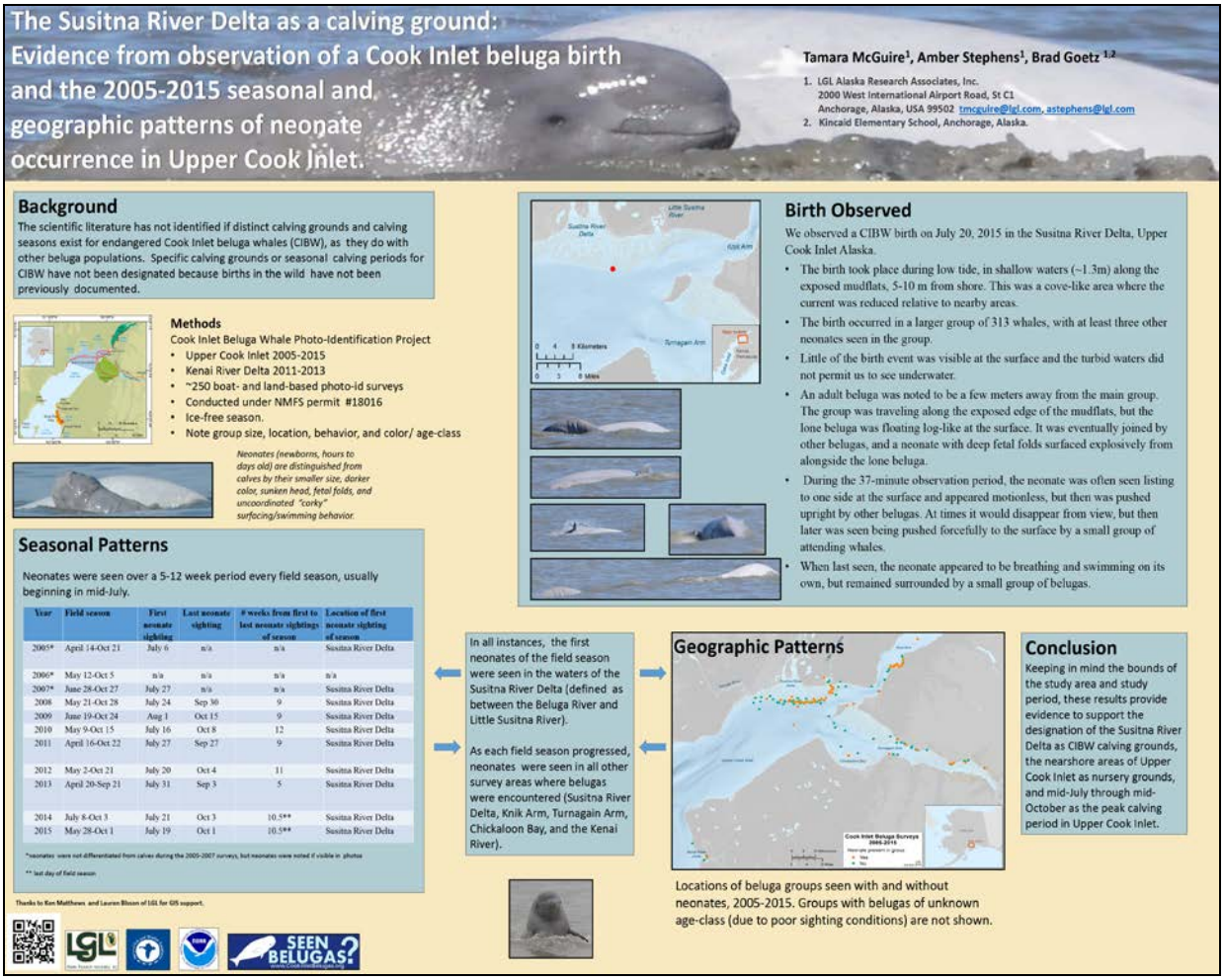


Figure D2. CIBW Photo-Id Project poster presented at the January 2016 Alaska Marine Science Symposium in Anchorage, Alaska.

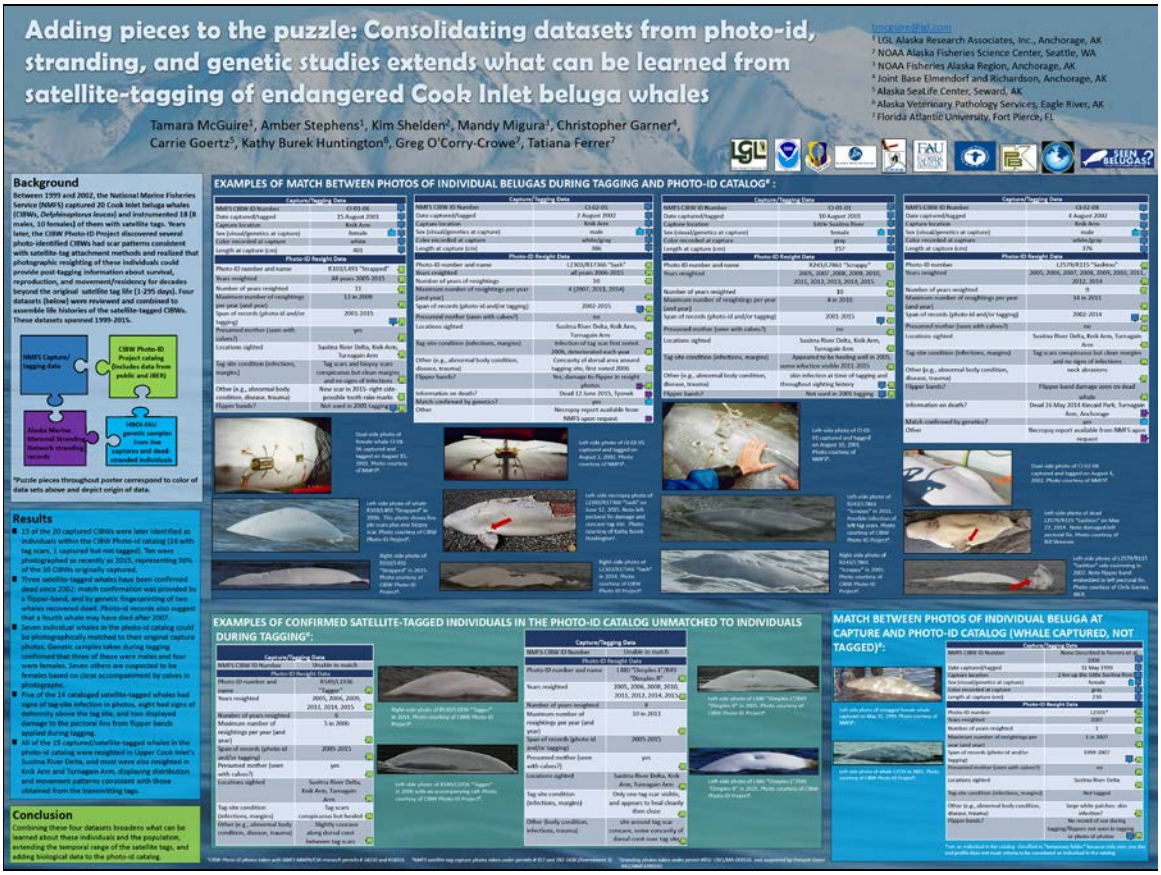


Figure D3. CIBW Photo-Id Project poster presented at the January 2017 Alaska Marine Science Symposium in Anchorage, Alaska.

Appendix E: Funding for the 2005-2016 Cook Inlet Beluga Whale Photo-ID Project

Table E1. Funding for the 2005-2016 Cook Inlet beluga whale photo-id catalog. NFWF = National Fish and Wildlife Foundation (with non-Federal match from Chevron, ConocoPhillips, Unocal, Donlin Gold, Royal Caribbean Cruise Lines, and Wells Fargo); NPRB = North Pacific Research Board; JBER = Joint Base Elmendorf Richardson, Department of Defense; ADF&G = Alaska Department of Fish and Game; KPB = Kenai Peninsula Borough; NMFS AKR = National Marine Fisheries Service, Alaska Region , * =LGL and the CIBW Photo-ID Project donated staff time for all years and components.

Year	Left-side Photos Cataloged and Analyzed?	Left-side Funding*	Right-side Photos Cataloged and Analyzed?	Right-side Funding*	Funding for Fieldwork*
2005	Yes	NPRB	Yes	NFWF	NFWF
2006	Yes	NPRB	Yes	NFWF	NFWF
2007	Yes	NPRB	Yes	NFWF	NFWF
2008	Yes	NPRB	Yes	NFWF	NFWF
2009	Yes	NPRB	Yes	NFWF	NFWF
2010	Yes	NPRB	Yes	NFWF	NFWF
2011	Yes	NPRB	Yes	NFWF, JBER/ADF&G, KPB	NFWF
2012	in progress	NMFS AKR	Yes	NMFS AKR, KPB	NFWF
2013	in progress	NMFS AKR	Yes	NFWF, KPB	NFWF; KPB
2014	in progress	NMFS AKR	Yes	NFWF , NMFS AKR	NFWF; NMFS AKR
2015	in progress	NPRB	Yes	NFWF/NMFS AKR (cooperative agreement)	NFWF/NMFS AKR
2016	Yes	NFWF/NMFS AKR	Yes	NFWF	NFWF/NMFS AKR