Photo-identification of Beluga Whales in Cook Inlet, Alaska

Summary of Field Activities and Whales Identified in 2018

Prepared by:
The Cook Inlet Beluga Whale Photo-ID Project

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Prepared by:

Tamara McGuire, John McClung, and Amber Stephens
The Cook Inlet Beluga Whale Photo-ID Project
Anchorage, Alaska, USA
tamaracookinletbeluga@gmail.com

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LIST OF ACRONYMS

AKR	Alaska Region
ADF&G	Alaska Department of Fish and Game
CIBW	Cook Inlet Beluga Whale
DNA	Deoxyribonucleic Acid
ESA	Endangered Species Act
GPS	Global Positioning System
IPM	Integrated Population Model
ISO	International Standards Organization
JBER	Joint Base Elmendorf Richardson
JPEG	Joint Photographic Experts Group
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 (for NOAA)
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 develop strategies to promote its recovery. The CIBW Photo-identification (Photo-id) Project catalog and associated surveys from fourteen field seasons (2005-2018) provide information about the distribution, movement patterns, and life-history characteristics of individually identified CIBWs. This report summarizes field effort and whales identified in 2018.

In 2018, vessel and land-based photo-id surveys were conducted of the Susitna River Delta, Knik Arm, the Kenai River Delta, and Turnagain Arm on 29 days, bringing the total number of surveys conducted from 2005-2018 to 466. Forty-eight groups were encountered in 2018, with the largest group containing 222 whales. Most groups contained white belugas, gray belugas, and calves. The first neonate of the 2018 field season was seen July 12 (in the Susitna River Delta), and neonates were seen as late as September 26. Suspected feeding behavior was observed July-September in all of the areas in which beluga groups were encountered.

The CIBW Photo-ID Project catalog contains photographs collected between 2005 and 2018. Sighting histories have been compiled for 446 whales identified by right-side photographs, 476 whales identified by left-side photographs, and 84 whales identified as "dual" whales (i.e., individual whales whose right- and left-side catalog records are linked). Of these, 209 of the "right-side" whales and 200 of the "left-side" whales are presumed to be mothers, based on accompaniment by calves in photos.

Photographs of seven belugas who stranded in 2018 were examined for possible matches to the catalog, but no matches were made. There is only one live-stranded adult to date in the 2005-2018 catalog. Although she and her calf swam away with the rising tide after the live-stranding event in 2015, she was not photographed again later that year or during the 2016 field season, which raised concerns that she may have suffered post-stranding complications and died. However, she, along with a calf, was photographed on several occasions in 2017 and again in 2018.

Eight of the 20 CIBWs originally captured and/or tagged between 1999 and 2002 were photographed alive in 2018. Biopsy samples were obtained from 37 individuals 2016-2018, and 26 of these individuals were identified as individuals already in the CIBW Photo-ID catalog. By the end of the 2018 field season, nine of the biopsied whales had been resighted one or two years after they were first biopsied.

There were 213 incidental reports of sightings of CIBWs received by the CIBW Photo-ID Project in 2018, including sightings in the Upper, Middle, and Lower Inlet. Outreach activities included formal and informal presentations about CIBWs and the CIBW Photo-ID Project given to community groups and at scientific conferences. There were over 13,000 views by the public of the beluga sighting map for 2018.

We are cautious in reporting life-history parameters such as reproductive or survival rates of the population based on resighting records of individuals because there are many factors that affect our ability to detect, photograph, and identify individuals, particularly mothers and calves. Multivariate models are being developed with the data to quantify the effects of environmental factors and sampling bias on estimating population and life-history parameters. The CIBW Project is sharing survey and resighting data with colleagues to quantify and explicitly incorporate uncertainty into models in order to better assess beluga population dynamics and trends. In the meantime, these descriptive results will be useful to managers seeking to minimize effects of human activities on belugas, and to help inform future research efforts.

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). Because 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, the most-recent population assessment from NMFS indicates the population in 2018 was following a downward trend (Wade et al. 2019). 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 remain and limit 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 direct efforts 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 (Table 1) between 2005 and 2018.

This report presents results of vessel-based photo-id surveys of the Susitna River Delta and the Kenai River Delta, and land-based surveys of Knik Arm and Turnagain Arm in 2018. 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 outreach.

Field Surveys

Survey effort

Dedicated photo-id surveys were conducted from small vessels and from shore May through September 2018 in Cook Inlet, Alaska (Figure 1). Boat-based surveys planned for late May/early June were cancelled due to vandalism of the research vessel and theft of an engine the day before surveys were scheduled to begin in May and the subsequent time needed to make repairs and replace equipment. 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, the Kenai River Delta (defined as the area between the Kasilof River and Nikiski) and Turnagain Arm (Figure 2; Figure 3). 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 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, although deviations were made depending on where beluga groups were encountered. Surveys lasted approximately six hours, although the exact 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 2018, vessel-based surveys were conducted from the R/V *Lucinda Lee*, a 6 m (20 ft) Silver Marine Phoenix® 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.

Boat-based surveys in 2018 were scheduled to encounter the largest groups of belugas. Surveys were not appropriate for line-transect methods designed to estimate abundance. A whale group generally 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.

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 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 or remained in one area if whales stayed here milling or if several groups of whales travelled by the turnout. Most photographs were taken from sites where whales approached closest to shore and that afforded relatively easy vehicle access.

Shore-based surveys of the Eagle River Flats of Knik Arm (Figure 1; Figure 2) were conducted from the north shore of the mouth of the river by a team of observers led by Joint Base Elmendorf Richardson (JBER), with invited participation by a CIBW Photo-ID team member. The survey was 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.

Land-based surveys in the Kenai River Delta were conducted from sites overlooking the mouth of the Kenai River or the Port of Kenai dock during times when the survey vessel could not be safely operated (e.g., small-craft advisories, extreme low tide, duck hunters firing over the water).

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 of the group relative to the observer, 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 for groups greater than about 35 individuals, 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 specific 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., <3/4 the total length of adult belugas), and usually swimming within one body length of an adult-sized beluga. 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. 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 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 track line 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 3.2 (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 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 re-examined 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 marks from conspecifics, pigmentation patterns, scars from injury or disease, and marks left from satellite tags attached by NMFS from 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 4); 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 classified as 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., <3/4 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 were classified as dual-side whales if they met the criteria to be classified as individuals in 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 prefix 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 L220 would have the dual name of D100.

Classification of anthropogenic scarring

Categories of scars were developed by comparing scars and deformities seen on individuals in the CIBW photo-id catalog and stranding photos, to descriptive classifications and photographs of injuries to other marine mammal species (e.g., Rommel et al., 2007; Byard et al., 2012; Moore and Barco 2013; George et al., 1994; 2000; Azevedo et al., 2008; Bradford et al., 2009; Read and Murray, 2000). Marks that likely came from non-anthropogenic sources such as competition, predation, disease, and the physical environment are not included in this report. Scars appearing to be consistent with anthropogenic sources were classified as four types: puncture, vessel strike, entanglement, or research. Scars from permitted research came from satellite tags, flipper bands, biopsy of restrained belugas during tagging, and remote biopsy of free-swimming belugas. Details of how we classified scars according to possible source are presented in McGuire et al. (2020d [Submitted]).

Three experienced photo-analysts independently examined all photos of the dual-side whales in the 2005-2018 catalog for signs of anthropogenic scars and assignment of scar type. The review for anthropogenic scars focused on the dual-side catalog because individuals photo-identified on both sides of their bodies have the most-complete sighting records in the catalog and, are therefore, the most useful for obtaining information about survival and reproduction. Combining sighting records and associated reproductive histories from both sides of an individual provides a more complete sighting record, and reduces the risk that a sighting of an individual was missed because only one side was photographed in a year, or that a sighting of an individual with a calf was missed because the calf was only observed on one side of the mother. Scar types were incorporated into the photo-id database via scar-type labels that were applied to individual photos and later queried to generate summaries of individual whales with particular scar types. A matrix was created of the five types of anthropogenic scars (i.e., puncture, vessel strike, entanglement, satellite-tagging, or biopsy) and each dual-side whale's identification number. Each identified whale was scored as "confirmed" (unambiguous evidence, such as an attached rope), "possible" (ambiguous, the mark also could have been from another source), or "no" (without any evidence of anthropogenic trauma) in each of the scar type categories. The location of each scar that had been assigned a "confirmed" or "possible" was then noted, using the sections illustrated in Figure 4, as well as the year in which a scar was first photographed.

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 (biopsy samples were collected during capture for tagging). 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.

Classification of biopsied whales

A feasibility study for remote biopsy of CIBWs was conducted in 2016 (McGuire et al. 2017a), followed by a second field season in 2017 (McGuire et al. 2018) and a third field season in 2018 (P. Wade, NMFS unpublished data). 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 skin samples and levels of reproductive hormones (for females) were obtained from blubber samples. Photographs were taken of whales at the time of biopsy in order to match them to previously identified individuals in the 2005-2018 photo-id 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 only 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 and on the CIBW Photo-ID Project website www.cookinletbelugas.org. Photographs of stranded belugas were examined for marks that could be used to compare to records from the 2005-2018 catalog, and for signs of anthropogenic trauma. 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 (2005–2018) 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 2005-2018 and are presented graphically for select individuals according to year and geographic area. Locations of cataloged beluga whale sightings were mapped in QGIS version 3.2 (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.

RESULTS

Surveys

Survey effort, number of whales, and whale groups encountered in 2018

Photo-id surveys of Cook Inlet were conducted on 29 days in 2018. The fieldwork completed in 2018 brought the project total to 466 photo-id surveys conducted over fourteen consecutive field seasons (Table 2).

There were 48 groups encountered in 2018 (Table 3; Figure 5). Maps of daily whale group sighting locations and survey routes in 2018 are presented in Appendix A. Figure 6 summarizes the locations of all groups encountered 2005-2018. Mean group size in 2018 was greatest in the Susitna River Delta and smallest in the Kenai River Delta (Table 3). Group size in the Susitna River Delta ranged from 1 to 222 whales (Table 4). The largest of these groups was seen on July 12. Group size in Turnagain Arm in 2018 ranged between one and 75 whales, with the largest group seen on Sept 8 (Table 5). Group size in the Kenai River Delta in 2018 ranged between 6-15 belugas; and between 17-36 in Knik Arm (Table 6).

Color composition and age class of groups encountered during surveys in 2018

Color and age-class composition of groups varied somewhat by survey date and area (Tables 4, 5, 6, 7). More neonates were seen in the Susitna River Delta than in other areas (Table 4). Groups with calves and neonates occurred in the same general locations as groups without calves or neonates, both in 2018 and for all 2005-2018 surveys combined. (Figure 7; Figure 8).

The first neonate sighting during photo-id surveys conducted in 2018 was in the Susitna River Delta on July 12 (Table 8). The first neonates of the season during field surveys that were conducted later in the season in other locations were: Knik Arm on August 22 (Table 6); Turnagain Arm on August 15 (Table 5); and the Kenai River Delta on September 25 (Table 6). Groups with neonates occurred in the same general locations as groups without neonates, both in 2018 and for all 2005-2018 surveys combined (Figure 9; Figure 10).

Feeding and reproductive behavior of whale groups encountered in 2018

Suspected feeding behavior was seen in most of the areas in which beluga groups were encountered in 2018 (Figure 11; Tables 9, 10, 11) consistent with patterns from previous years of the study (Figure 12). Suspected feeding behavior was first noted July 22, concurrent with the largest group of the year and first neonate sighting. Feeding behavior was observed through the rest of the July through September field season.

CIBW births (suspected or confirmed) were not observed during photo-id surveys in 2018.

Stranded belugas photographed in 2018

Photographs of seven belugas that dead-stranded in 2018 were shared with the CIBW Photo-Id Project by NMFS and by other members of the Alaska Marine Mammal Stranding Network (Table 12). There were three males and four individuals of unknown sex. Four stranded individuals were adults. Three stranded belugas were classified as calves and were small enough to have been born in 2018, based on growth curves in Vos et al. 2019. None of these seven whales were matched to individuals already in the 2005-2018 catalog, either because the photos were of poor quality, or the carcass was unsuitable for identification (Table 12).

Incidental sighting reports of belugas in 2018

The CIBW Photo-ID Project received 213 incidental reports of CIBW sightings in 2018 (Table 13). Sightings were reported by fisher folk, pilots, the media, law enforcement officers, vessel operators, tourists, biologists, educators, students, regulators, port operations staff, environmentalists, energy-sector employees (oil and gas, coal, tidal power), citizen scientists, and the general public. Many reports were solicited and received during outreach activities (Appendix B). In 2018, belugas were reported March through November, as far north as Knik Arm and as far south as Kachemak Bay (Figure 13). There were 13,332 views of the 2018 sightings map on CIBW Photo-ID Project website.

Human Interactions during Photo-id Surveys in 2018

Human activities with the potential to affect belugas in the vicinity were noted during photo-id surveys (Tables 9, 10, 11). In the majority of instances, these activities were incidental in the sense that the people conducting them were likely unaware belugas were even present, as in the case of a small vessel travelling at high speed over a pod of belugas in the Kenai River (Figure 14). In a few cases, activities appeared to be intentionally directed at belugas and potentially harmful, such as the small plane flying at low altitude and circling belugas at low altitude (Figure 15). In such instances, the National Oceanic and Atmospheric Administration (NOAA) Office of Law Enforcement (OLE) was alerted.

Aircraft activity (e.g., small recreational aircraft, large commercial aircraft, military jets, and military transport) was the human activity most-commonly noted during photo-id surveys. Other human activities that were observed near belugas included shipping/transport, vessel-based duck hunting, the train whistle along Turnagain Arm (at which belugas appeared to startle and dive) and research activities (including the photo-id survey vessel, aerial drones, and remote biopsies of belugas from vessels.

Other Marine Mammals Encountered during CIBW Surveys or Reported to the Project, 2015-2018

Harbor seals (*Phoca vitulina*) were commonly encountered in all areas surveyed in 2018. The largest (often over 200 seals) and most persistent haul out occurred at the mouth of the Susitna River. Harbor seals and belugas were often observed in the same areas, such as the mouths of the Big and Little Susitna rivers, Eagle River, the Kenai River, and at Bird Point in Turnagain Arm.

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 2018: Steller sea lions (*Eumetopias jubatus*), humpback whales (*Megaptera novaeangliae*), harbor porpoises (*Phocoena phocoena*), Dall’s porpoises (*Phocoenoides dalli*), fin whales (*Balaenoptera physalus*), orcas (*Orcinus orca*), or gray whales (*Eschrichtius robustus*).

Catalog Development and Current Status 2005-2017

The CIBW Photo-Id Project took approximately 74,000 photographs in 2018. The public and colleagues provided photos of incidental sightings and stranded belugas, sharing approximately 8,000 photos in 2018. These include photos taken by biologists at JBER during land-based beluga observations, and by colleagues from MML during their vessel-based biopsy and aerial drone surveys.

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. Funding was later obtained that allowed for the cataloging of all left-side photos taken between 2005 and 2011, and later those from 2012 to 2017. In this current report, the right- and left-side catalogs have been updated simultaneously with results from the 2018 field season.

Sighting Histories of Identified Belugas 2005-2018

The following summary of sightings between 2005 and 2018 is for individuals in the right-side catalog, the left-side catalog, the dual catalog, and for subsets of particular interest.

Right-side catalog 2005-2018

The 2005-2018 right-side catalog contains records for 446 individuals (Figure 16a; Table 14), with 128 individuals photographed in 2018. One new individual was added to the catalog that was first photographed in 2018. There were 23 individuals added to the catalog that had been photographed in previous years but did not meet the criteria to become catalog individuals until the photos from 2018 were added to their sighting records. Ten percent of the whales in the right-side catalog were seen over the 14-year period spanning 2005 to 2018 (i.e., they were photographed in both 2005 and in 2018; Table 14). Seven individuals in the right-side catalog have been matched to photos of dead individuals. Because 10 years is the maximum gap between resightings of any individual in the catalog, an individual was suspected to have died if it had not been photographed after 2007 (although eight years was the maximum gap between resightings of individuals in the right-side catalog, ten years was the maximum gap in the left-side catalog; 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 left-side whales). There are 26 individuals in the right-side catalog suspected to have died by 2018 based on the lack of sightings after 2007, and another seven confirmed dead (from stranding records), leaving 413 individuals in the right-side catalog that may still be in the population in 2018.

Left-side catalog 2005-2018

The 2005-2018 left-side catalog contains records for 476 individuals (Figure 16b; Table 14), with 171 individuals photographed in 2018. Three new individuals were added to the catalog that were first photographed in 2018. There were 44 individuals added to the catalog that had been photographed in previous years but did not meet the criteria to become catalog individuals until the photos from 2018 were added to their sighting records. Eleven percent of the whales in the left-side catalog were seen over the 14-year period spanning 2005 to 2018 (i.e., they were photographed in both 2005 and in 2018; Table 14). Ten individuals in the left-side catalog have been matched to photos of dead individuals. Because 10 years was the maximum gap between resightings of individuals, an individual was suspected to have died if it had not been photographed after 2007. There are 50 individuals in the left-side catalog suspected to have died based on the lack of sightings after 2007, and another ten confirmed dead (from stranding records), leaving 416 individuals in the left-side catalog that may still be in the population in 2018.

Dual catalog 2005-2018

The 2005-2018 dual-side catalog contains records for 84 individuals (i.e., individuals whose right- and left-side catalog records are linked and who meet the criteria to be catalog individuals on each side (Figure 16c). In 2018, there were 14 new dual-side linkages made for individuals in the catalog. One dual-side individual who was photographed as recently as 2018 was identified in photographs taken by NMFS in 1998, giving it a 21-year sighting history (Table 14).

Classification of anthropogenic scars 2005-2018

Twenty three of 84 individuals in the dual-side catalog had scars consistent with anthropogenic trauma from entanglement, vessel strikes, and/or non-research punctures (i.e., excluding biopsy and tag scars). Survival, reproduction, and wound healing histories of these individuals are summarized in Table 15. Sixteen of the 23 were female (confirmed or presumed), six were male (confirmed or presumed), and one was of unknown sex. Four individuals had scars that were possibly from puncture wounds. Eleven individuals had scars that were possibly from vessel-strikes, and one individual had scars confirmed to be from a vessel-strike. There were 13 individuals with scars from possible entanglements, as well as one with confirmed entanglement scars, and one with a heavy line encircling it.

Identified individuals with satellite-tag scars 2005-2018

A total of 20 CIBWs were captured and 18 of these were tagged by NMFS between 1999 and 2002); 12 of the 20 were female and eight were male (Table 16). Details about the capture and tagging, as well as whale movements during the life of the tags, are presented in Shelden et al. 2018. Six individuals in the 2005-2018 photo-id catalog have been identified as individuals in the photos taken at the time they were captured and tagged between 1999 and 2002 (Table 16); three of these were females and three were males (confirmed via DNA collected during capture). The three photo-identified tagged females were each photographed with an accompanying calf at least once during 2005-2018 (Table 17). 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, has not been photographed with a calf, and is presumed dead.

Thirteen individuals in the 2005-2018 photo-id catalog were confirmed as whales bearing scars from satellite tags, although not all could be matched to known individuals at the time of tagging. Additionally, one individual in the catalog was identified as a whale that had been captured but not tagged (Table 17), and another individual was noted to have scars that may have been made by a satellite tag or by gunshot. Details on the photo-id records of these individuals are presented in McGuire and Stephens (2016). Ten of these 15 individuals were each photographed with an accompanying calf at least once during 2005-2017, and one was photographed with a possible calf. Photographic records of satellite-tag scars are presented in Figure 17.

Eight confirmed- or possibly- satellite-tagged/captured whales were photographed in 2018; this represents 40% of the 20 CIBWs originally captured and/or tagged between 1999 and 2002. Three satellite-tagged whales were confirmed dead (i.e., carcasses were documented) between 2001 and 2018. Two photo-identified whales with satellite tag scars have not been resighted since 2007 and are therefore presumed to be dead.

Identification of biopsied whales 2016-2018

Biopsy samples were obtained remotely from six whales in 2016; five of these whales were photographically matched to individuals who were already in the CIBW Photo-ID Project catalog, and the sixth was entered as a new individual in the catalog (Table 18; McGuire et al. 2017b). Genetic sex determined from biopsy skin samples indicates that five of the whales biopsied in 2016 were female and one was male. Three of the females have been photographed with an accompanying calf at least once between 2005 and 2018. Three of the individuals biopsied in 2016 were photographed in 2018; photographic records of resighted biopsy scars from 2016 are presented in Figure 18.

In 2017, biopsy samples were obtained remotely from twelve whales. Two additional whales were darted without yielding a sample (Table 18). Seven were female, five were male, and two were of unknown sex. Ten darted whales were photographically matched to individuals who were already in the CIBW photo-id catalog from previous years (Table 18; McGuire et al. 2018). Two of the females have been photographed with an accompanying calf at least once between 2005 and 2018, and a third was photographed with a possible calf. Five of the individuals darted in 2017 were photographed in 2018; photographic records of resighted biopsy scars from 2017 are presented in Figure 19. One of the whales biopsied in 2017, D2379, had a pronounced concavity behind the dorsal crest (Figure 19). This individual was first photographed as a large calf in 2005, was not photographed in 2006 or 2007, but was seen to have a slight sway in the back in photos from 2008 that appeared to become more pronounced with each year, including when it was photographed in 2018. It is unknown if this is a result of injury, disease, or genetic deformity. There is some photographic evidence it could be from a failed predation attempt. There is no evidence the defect is related to biopsy or the biopsy vessel, as it was seen years before biopsy was initiated.

In 2018, 21 biopsy samples were obtained; however, because one whale appears to have been biopsied three times in 2018, these represent 19 newly sampled individuals (Table 18). Six shots were fired in 2018 that did not result in samples - three of these were of whales previously biopsied in either 2018 or in previous years. Of the 19 individuals biopsied in 2018, seven were females and 12 were males. Four of the females have been photographed with an accompanying calf at least once between 2005 and 2018 (including during biopsy). Photographic records of resighted biopsy scars from 2018 are presented in Figure 18.

Identification of stranded belugas 2005-2018

Thirteen stranded CIBWs have been identified as individuals in the 2005-2018 photo-id catalog. 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. Sighting histories of identified stranded whales are presented in McGuire and Stephens (2017).

The only live-stranded adult to date in the 2005-2018 catalog stranded in 2015 in Turnagain Arm. The Alaska Marine Mammal Stranding Network photographed the stranding from a NMFS hexacopter and from a NMFS observer on the mudflats and shared the photos with the CIBW Photo-ID Project. The adult was identified as beluga D1032, first seen in 2008, and presumed to be a female because she stranded with a live calf at her side. Although she and her calf were seen to swim away with the rising tide after the live-stranding event in 2015, she was not photographed again later that year or during the 2016 field season, which raised concerns that she may have suffered post-stranding complications and died. However, she was photographed on several occasions in 2017 along with a calf, and again in 2018 (Figure 20).

Reproductive Histories

There are currently 209 presumed mothers in the right-side catalog, which represents 47% of the individuals in the right-side catalog. There are currently 200 presumed mothers in the left-side catalog, which represents 42% of the individuals in the left-side catalog.

To date, there are 29 females of confirmed sex (i.e., confirmed from genetics taken during satellite tagging, biopsy, or necropsy, or from physical examination during necropsy; McGuire et al. 2020c [In revision]) in the 2005-2018 catalog. Fifteen of the confirmed-sex females have evidence of having reproduced, either based on their photo-id records with a calf 2005-2018, pregnancy status at biopsy, or signs of pregnancy, lactation, or recent birth during necropsy. Another four confirmed-sex female has been classified as possible mothers based on ambiguous photos in which a calf may have been alongside the mother but could not be confirmed.

DISCUSSION

Seasonal and Spatial Patterns of Beluga Group Encounters

The broad seasonal distribution patterns of CIBWs in Upper Cook Inlet during the 2018 field season (Figure 21) repeated patterns found in previous years of this study (Figure 22) and in other studies (Moore et al. 2000; Hobbs et al. 2005; Nemeth et al. 2007; Shelden et al. 2015 a, b, 2018), as well as in reports of incidental observations. In general, the seasonal distribution patterns of belugas during the ice-free months mirror the patterns of seasonal migrations of their prey (e.g., eulachon and salmon runs in May, followed by salmon runs late July to through September; NMFS 2008b; McGuire and Stephens 2017, McGuire et al. 2020a [Accepted]). Details about these patterns, including discussion of sampling biases and ecological interpretations, can be found in McGuire et al. 2020a (Accepted).

Patterns in Group Size

The occurrence of larger beluga groups in the Susitna River Delta in 2018 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. 2015b; 2018), and with those observed in previous years of the CIBW photo-id study (McGuire and Stephens 2017; McGuire et al. 2017c).

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, McGuire et al. 2020a [Accepted]). However, starting in 2012, there were noticeable increases in group size (both mean group size and annual maximum group size).

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 2005-2018 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, with a record high to date of a group of 313 whales in 2015. (McGuire and Stephens 2017). The maximum group size of 222 in 2018 is consistent with the pattern of larger groups seen in recent years.

Results from the 2016 field season had 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 River Delta 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.

Group sizes in Turnagain Arm in 2017 returned to pre-2016 levels and remained low in 2018. The underlying causes of these interannual 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.

The revised estimated total CIBW population size based on NMFS aerial surveys shows an upward trend 2005-2010, but then a decreasing trend 2012-2018 (Wade et al. 2019), with the inflection period being the same time period we noted changes in maximum group size (McGuire et al. 2020a [Accepted]). Whether the NMFS abundance trends reflect true changes in abundance or instead demonstrate how sensitive the methods used to estimate abundance are to changes in spatial distribution and methodology is unclear. It may be that the CIBW population has become spatially more concentrated as the population decreases. An integrated population model, derived from the aerial survey data, hunt data, and our photo-id data, had noted a change in group sizes detected during aerial surveys 2010-2016, but concluded that it was uncertain if the apparent decrease in group sizes was real or instead reflected a decrease in the proportion of groups counted by the survey (Jacobson et al. 2020). Regardless of which method and estimate most accurately reflects true CIBW population size and trends, the contrast between our higher group counts after 2010 and NMFS lower population estimates and smaller group sizes after that year are noteworthy, and suggest that temporal and spatial aggregation patterns may have shifted in recent years (McGuire et al. 2020a [Accepted]).

The 2018 field season marked the second consecutive year of a return to the Kenai River Delta to conduct photo-id surveys. Surveys had been conducted here 2011-2013 as a result of dedicated funding from the Kenai Peninsula Borough for these years but had not been conducted in other years of the 2005-2016 CIBW Photo-ID Project. As in previous years, group sizes in the Kenai River in 2018 were smaller than in other parts of the survey area. Not only were groups smaller than elsewhere, but photo-identification of individuals indicates that groups here are often smaller than they appear. For example, shore-based observers once counted a group of five belugas in the Kenai River, but photographs of the individuals taken at closer range from the survey vessel revealed there were in fact only three individuals that were dispersed and erratic in their movement and surfacing patterns. Larger groups have been incidentally observed outside of the mouth of the Kenai River than have been seen entering it, and the same pattern has been observed at the mouths of Eagle River and the Little Susitna River.

Color and Age Composition of Groups

There is no 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 2018 contained roughly equal proportions of white and gray whales, and most of the group also contained calves and/or neonates. Although the majority of groups were mixed with respect to color and age-class, within mixed groups there was occasional stratification by subgroups where there were small subgroups of only white belugas (1-6) that then joined the larger mixed groups. 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 and counted, gray belugas may have been more likely to be photographed and identified 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 2018 were rarely observed traveling among survey areas but were instead encountered in distinct "hot spots", i.e., in and near river mouths in predictable seasonal patterns that had been observed in previous years. Similar patterns of localized aggregations coupled with 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 and salmon runs in May, followed by salmon runs late July to early August; NMFS 2008b), and access to foraging habitat, 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 move among hotspots. Because sightings of belugas transiting between known hot spots (i.e., the Susitna River Delta, Knik Arm, the Kenai River Delta, and Turnagain Arm) are relatively infrequent, it remains unknown if there are distinct movement corridors (e.g., deeper channels or shorelines) among areas or if movement patterns are more diffuse and variable. For example, although whales in the Kenai River Delta have been identified as the same individuals seen in the Susitna River Delta, Knik Arm, and Turnagain Arm, we do not know their travel route between upper and middle Cook Inlet. 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 around the Forelands in 2006 and 2012 (Shelden et al. 2015a). Satellite-tagged whales were last tracked around the Forelands in 2003 (Shelden et al. 2018). 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 has 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 just south of the Forelands. Reports from the Kenai River were first received in 2007, then yearly between 2008 and 2018 (with the exception of 2016, when reports of belugas south of the Upper Inlet were not received). 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; regardless of what prompted the reports, this indicates that belugas are not restricted to the Upper Inlet.

Ongoing outreach efforts by the CIBW Photo-ID Project and others 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 and displayed publicly on the project website. 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. The State of Alaska has also referred to incidental sighting reports while preparing comments on proposed development projects in Cook Inlet.

Habitat Use by Individuals

As indicated in the maps of the individual sighting histories in McGuire and Stephens (2017) and reinforced by the sighting histories of belugas identified in 2018, individually identified belugas do not display fidelity to any single area of Cook Inlet during the ice-free season, but instead move often within the study area. The same was true of the individuals tracked with satellite tags (Shelden et al. 2018).

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, or avoidance of, any particular area. For example, up until 2018, we had thought that female D111 avoided Turnagain Arm. She had been captured and tagged by NMFS in 2000, and her 17-year span of records from both tagging (2000) and photo-id (2005-2017) showed her using Knik Arm and the Susitna River Delta, but never Turnagain Arm. However, in 2018 she was photographed in not only the Susitna River Delta, but also Chickaloon Bay and in Turnagain Arm.

In contrast, beluga D403, also tagged by NMFS sometime between 1999 and 2002 and believed to be a female, has never been photographed in Turnagain Arm, despite being photographed almost every year during 2005-2018. Based on photo-id records alone, we had assumed sampling bias may have been the reason we never detected her in Turnagain Arm during photo-id surveys, 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. However, this whale has conspicuous markings that should have been detectable even at sighting distances often experienced in Turnagain Arm. We will continue to monitor her sighting records to see if this pattern holds. She would nonetheless be the exception to the general rule of identified individuals being seen in all survey areas.

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 (McGuire et al. 2020a [Accepted]). We will be examining these data further to see if there are differences at a finer scale within the groups. This analysis will be greatly aided once the genetic sex and photographs from the whales biopsied in 2019 becomes available and is able to be incorporated into the sighting records of cataloged whales.

Feeding Habitat and Behavior

Feeding behavior in 2018 was observed in all of the areas surveyed. This was similar to previous years of the study, with the notable exception of 2017, when feeding behavior was not observed in Turnagain Arm or Knik Arm. It is unknown if the differences in 2017 were simply due to the smaller sample size, or if they were due to changes in timing of fish runs and/or changes in feeding behavior relative to when surveys were conducted. Feeding behavior was again seen in Turnagain Arm and Knik Arm in 2018. Possible correlations among beluga group size, timing and strength of fish runs, and feeding behavior (and inter-annual variations in all of these factors) will be investigated in future work, and compared to patterns detected during acoustic sampling of beluga presence and feeding behavior (Castellote et al. 2020).

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. We did not observe births in 2017 or 2018.

The first neonates encountered during each field season 2005-2018 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 have been 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 (McGuire et al. 2020b [In revision]). 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 as late as October (McGuire and Stephens 2017; McGuire et al., 2020b [In revision]). Information from dead-stranded adult females, calves, and fetuses also supports the July-October birth period for CIBWs (Shelden et al. 2019). It seems likely that we underestimate the number of neonates in groups, as well as are less likely to detect births later in the season (i.e., after mid-August) when beluga groups move to Turnagain Arm and Knik Arm, where distance between land-based observers and whales is greater.

Applicability of the 2005-2018 Photo-id Catalog to 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 84 dual-side whales, we do not know which of the 476 left-side whales are the same individuals as the 446 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. 2017a) and if photographs from subsequent biopsy studies and from aerial drones continue to be shared with the CIBW Photo-ID Project (McGuire et al. 2018) more of the left- and right-side sighting records of individuals in the catalog will be able to be linked.

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-analysts; 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.

An integrated population model (IPM) combined data from aerial surveys, 2005-2016 photo-id, and pre-2006 hunting, and estimated the CIBW population size in 2016 as 439 belugas, with a 95% confidence interval of 388–507 belugas (Jacobson et al. 2020). This was higher than the revised 2016 CIBW population estimate from NMFS aerial surveys of 293 belugas, with a 95% probability interval of 271 to 318 belugas. The number of individuals in the 2018 photo-id catalog, after subtracting known- and presumed-dead individuals (resulting in 413 in the rights-side catalog, 416 in the left-side catalog), approximates the maximum population estimates from the IPM, and is higher (by about 100 whales) than the revised NMFS population estimate for 2016, and for 2018, which was 279 belugas, with a 95% probability interval of 250 to 317 belugas (Wade et al. 2019). We do not believe our catalog numbers contradict either the Jacobsen or Wade estimates, but rather demonstrate the uncertainty involved in all methods of population estimation. We are very conservative in using a 10-year sighting gap to presume an identified individual has died (when it cannot be linked to a carcass) and it is likely that the catalog contains many whales who have died undetected since 2007.

Considering that during the duration of the CIBW Photo-ID Project several of the individuals in the catalog have died without photographs and with less than a 10-year gap in sighting records, and that many calves have been born that have not yet acquired permanent marks allowing for long-term identification, 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 adult and sub adult (>5 years old) individuals, and therefore data from individuals in the catalog should be representative of the CIBW population. 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. In addition, as discussed previously, we have confirmed that both sexes are represented in the catalog. Twelve dead-stranded whales have been matched to individuals in the 2005-2018 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. Life-history data derived from the catalog should therefore be generally characteristic of the CIBW population.

Mortality of Identified Individuals

There have been 102 dead CIBWs reported to NMFS 2005-2018, with photos of 48 of these shared with or taken by the CIBW Photo-ID Project (McGuire et al. 2020c [In revision]). Unfortunately, not all carcasses were photographed, not all photographs were of useful quality, and many carcasses were too decomposed to allow for mark recognition. 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.

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, others are not reported, and some are not investigated. Winter strandings, strandings in remote parts of Cook Inlet, and strandings of calves are likely to be underestimated because of detectability issues.

Linking the sighting history of a stranded 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. The tag scars had deteriorated on the carcass and were not recognizable as such to the examining veterinarian; review of the stranding photographs by the photo-id team flagged that it was a satellite-tagged whales, which was later confirmed by genetic comparisons of samples taken during capture for tagging and from the dead animal (McGuire and Stephens 2016). The potential exists for genetic samples taken from dead and live whales to provide information about kinship of identified individuals. We hope to be able to incorporate this type of information into the individual records in the CIBW Photo-ID Project catalog.

Anthropogenic Scars

We have documented that injury from anthropogenic activities does occur at lethal and nonlethal levels. With 27% of the individuals examined bearing signs of confirmed or possible anthropogenic trauma, not including from research, these levels are not inconsequential. Although our sample does not allow us to reliably infer the rate of anthropogenic trauma at the population level, it provides an important index of the types and level of trauma experienced by a subset of the population, with ship strike and entanglement being higher than puncture wounds. We present our finding on prevalence and healing of anthropogenic scars, including those from satellite tagging and biopsy, in detail in McGuire et al. (2020d [Submitted]) where we also examine reproductive and survival histories of individuals post-scar event. While we found no evidence that unauthorized take from the anthropogenic trauma sources we examined are the primary threat to beluga recovery, our data suggest it remains at least an important component of "cumulative effects", which were ranked as the threat of highest concern in the CIBW Recovery Plan.

Number of Presumed Mothers in the 2005-2018 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 individuals as "presumed mothers" if there was 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. Forty-seven percent of individuals in the right-side catalog and 42% in the left-side catalog have been classified as presumed mothers based on their 2005-2018 sighting histories.

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 individuals (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 et al. 2020b [In revision]).

Approximately two-thirds of the 29 photo-identified females of genetically confirmed sex had been classified as confirmed or presumed mothers based on their photo-id histories. In other words, 19 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 one-third of the genetically confirmed photo-identified females had not been classified as presumed mothers in the photo-id catalog. Photo-id records of genetically 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. For example, beluga D16854, first photographed in 2014 and confirmed genetically as a female from a biopsy in 2016, was not photographed with a calf until 2017. 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. None of these possibilities are mutually exclusive for the population. Photo-id sighting history data for many of these females of confirmed sex will need to continue be combined with data from NMFS on age, reproductive hormones, and contaminate burdens in order to better understand which of these processes may be occurring and to what extent.

Vital Rates of Individuals and the Population

A summary of reproduction information from the long-term CIBW Photo-ID project is presented in McGuire et al. 2020, and a summary of survival information is presented in McGuire et al. 2020. We continue to collaborate with colleagues from Montana State University, NMFS MML, the University of Washington, and ADF&G, to share and interpret data (survey and photo-id) from the CIBW Photo-ID database to develop various models to estimate reproductive and survival rates and to 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 over 450 whales over a 14-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 and updating both catalogs allowed us to obtain more information about life histories of individuals, including reproductive females and their calves.

The utility of the individual sighting records in the photo-id catalog is greatly increased with the addition of biological information obtained from other sources, such as satellite tagging, biopsy, aerial imagery, and 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 2018. We describe patterns and trends that are apparent within the data, while also pointing out sources of sampling bias and how these 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, which could 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. This 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, 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). An integrated population model using three datasets (aerial surveys, photo-id data, and hunting data) was recently developed to estimate population size and trends for CIBW (Jacobson et al. 2020). The continuation of a long-term, Inlet-wide, photo-id dataset and its incorporation into in an integrated model with additional datasets (e.g., acoustic surveys, biopsy sampling, stranding data, photogrammetry studies from aerial drones, prey data, water- temperature data), that appropriately accounts 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,
- continue to incorporate biological information (i.e., sex, age, reproductive status, contaminant load) 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,
- continue to 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. Funding for the 2005-2018 CIBW Photo-ID Project cataloging and fieldwork. 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.

	Funding for		
Year	Left-side Catalog[1]	Right-side Catalog[1]	Fieldwork[1]
2005	NPRB	NFWF	NFWF
2006	NPRB	NFWF	NFWF
2007	NPRB	NFWF	NFWF
2008	NPRB	NFWF	NFWF
2009	NPRB	NFWF	NFWF
2010	NPRB	NFWF	NFWF
2011	NPRB	NFWF; JBER/ADF&G; KPB	NFWF; KPB
2012	NMFS AKR	NMFS AKR; KPB	NFWF; KPB
2013	NMFS AKR	NFWF; KPB	NFWF; KPB
2014	NMFS AKR	NFWF; NMFS AKR	NFWF; NMFS AKR
2015	NPRB	NFWF/NMFS AKR (cooperative agreement)	NFWF/NMFS AKR (cooperative agreement)
2016	NFWF/NMFS AKR (cooperative agreement)	NFWF/NMFS AKR (cooperative agreement)	NFWF/NMFS AKR (cooperative agreement)
2017	NMFS AKR	NMFS AKR	NMFS AKR
2018	NMFS AKR	NMFS AKR	NMFS AKR

[1] The CIBW Photo-ID Project donated staff time for all years and components.

Table 2. Number of CIBW Photo-ID Project surveys conducted in Cook Inlet, Alaska between 2005 and 2018 according to survey sub-area and year.

	Year														
Sub-area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total Number of Surveys
Susitna River Delta	16	17	5	8	13	14	11	13	8	9	10	11	9	11	155
Knik Arm	32	13	5	9	10	9	16	12	3	7	4	8	1	5	134
Turnagain Arm	0	4	5	12	12	15	16	15	12	8	8	7	3	9	126
Chickaloon Bay/Fire Island	4	1	1	2	1	0	2	5	2	2	1	0	0	1	22
Kenai River Delta	0	0	0	0	0	0	4	14	6	0	0	0	3	6	33
Annual Number of Survey Days[1]	52	35	16	31	36	38	49	59	31	26	23	25	16	29	466

[1] Because multiple sub-areas may have been visited on a single survey day, the number of surveys according to sub-area will not always equal the total number of annual surveys.

Table 3. Photo-identification survey effort and beluga whale groups encountered in Cook Inlet, Alaska in 2018. In addition, one group of 60 was seen in Chickaloon Bay.

	2018			
	Susitna River Delta	Knik Arm	Turnagain Arm	Kenai River Delta
Range of survey dates	May 31 July 12-Aug 25	Aug 9-Sept 7	May 2 Aug 15-Sept 14	May 3-5 Sept 25-Sept 27
Number of Surveys	11	5	9	6
Number of Groups Encountered	18	4	20	5
Number of Beluga Sightings	1,064	99	358	50
Mean Number of Groups per Survey	1.6	0.8	2.2	0.8
Mean Number of Belugas per Survey	96.7	19.8	39.8	8.3
Mean Group Size	59.1	24.8	17.9	10.0
Maximum Group Size	222	36	75	15

Table 4. Composition and size of the 18 groups sighted during vessel-based surveys of the Susitna River Delta in 2018. (Neonates are separate from calf total. CBD = can't be determined; Unknown = beluga of unknown color and size; Y = yes, color-class present, but could not be quantified.)

Date	# White	# Gray	# Calves	# Neonates	# Unknown	Group Size	Comments
May 31	0	0	0	0	0	0	high winds, couldn't go west of Little Susitna River
July 12	60	40	20	2	100	222	
July 15	Y	CBD	CBD	CBD	25	25	
July 15	1	0	0	0	0	1	
July 15	Y	Y	Y	CBD	25	25	
July 15	1	0	0	0	0	1	
July 15	Y	Y	Y	1	30	31	
July 22	Y	Y	Y	Y	200	200	
July 23	0	0	0	0	0	0	
July 30	56	42	22	7	73	200	
July 31	1	0	0	0	0	1	
July 31	Y	Y	Y	Y	46	46	
July 31	3	1	1	0	0	5	
July 31	Y	Y	Y	Y	60	60	
July 31	Y	Y	Y	0	25	25	
Aug 08	Y	Y	Y	Y	75	75	
Aug 08	Y	Y	Y	Y	25	25	
Aug 09	Y	Y	Y	3	82	85	
Aug 22	12	6	6	1	0	25	high winds, couldn't go west of Little Susitna River
Aug 25	5	5	1	1	0	12	

Table 5. Composition and size of groups sighted during land-based surveys in Turnagain Arm and one vessel-based survey of Chickaloon Bay in 2018. (Neonates are separate from calf total. CBD = can't be determined; Unknown = beluga of unknown color and size; Y = yes, color-class present, but could not be quantified.)

Date	Sub-Area	# White	# Gray	# Calves	# Neonates	# Unknown	Group Size
May 02	Turnagain Arm	0	0	0	0	0	0
Aug 15	Turnagain Arm	3	0	0	0	0	3
Aug 15	Turnagain Arm	2	0	0	0	0	2
Aug 15	Turnagain Arm	11	10	3	1	0	25
Aug 15	Turnagain Arm	2	2	0	0	0	4
Aug 18	Turnagain Arm	8	5	2	0	10	25
Aug 31	Turnagain Arm	Y	Y	Y	CBD	15	15
Aug 31	Turnagain Arm	Y	Y	2	CBD	20	22
Sept 01	Turnagain Arm	2	2	0	0	0	4
Sept 01	Turnagain Arm	15	CBD	CBD	CBD	CBD	15
Sept 01	Turnagain Arm	2	2	1	0	0	5
Sept 01	Turnagain Arm	CBD	CBD	CBD	CBD	2	2
Sept 03	Turnagain Arm	Y	Y	CBD	CBD	10	10
Sept 03	Turnagain Arm	7	6	2	1	4	20
Sept 04	Turnagain Arm	CBD	CBD	CBD	CBD	35	35
Sept 08	Turnagain Arm	2	CBD	1	CBD	13	16
Sept 08	Turnagain Arm	2	0	0	0	0	2
Sept 08	Turnagain Arm	30	24	4	CBD	17	75
Sept 08	Turnagain Arm	CBD	CBD	CBD	CBD	8	8
Sept 10	Turnagain Arm	1	0	0	0	0	1
Sept 10	Turnagain Arm	26	21	7	CBD	15	69
Sept 14	Chickaloon Bay	Y	Y	Y	Y	60	60

Table 6. Composition and size of groups sighted during land- and vessel-based surveys in Knik Arm and the Kenai River Delta in 2018. (Neonates are separate from calf total. (Unknown = beluga of unknown color and size; Y = yes, color-class present but could not be quantified.)

Date	Sub-Area	Platform	# White	# Gray	# Calves	# Neonates	# Unknown	Group Size
Aug 09	Knik Arm	Vessel	0	0	0	0	0	0
Aug 22	Knik Arm	Vessel	9	5	4	1	9	28
Aug 24	Knik Arm	Land	9	5	3	0	0	17
Aug 25	Knik Arm	Vessel	Y	Y	3	1	14	18
Sept 07	Knik Arm	Land	15	18	3	0	0	36
May 03	Kenai River Delta	Land and Vessel	0	0	0	0	0	0
May 04	Kenai River Delta	Land and Vessel	0	0	0	0	0	0
May 05	Kenai River Delta	Vessel	0	0	0	0	0	0
Sept 25	Kenai River Delta	Vessel	5	2	2	1	0	10
Sept 25	Kenai River Delta	Vessel	Y	Y	3	1	11	15
Sept 26	Kenai River Delta	Vessel	Y	Y	1	0	6	7
Sept 26	Kenai River Delta	Vessel	8	1	2	1	0	12
Sept 27	Kenai River Delta	Land	4	1	1	0	0	6

Table 7. Percent color/age-class composition of beluga whale groups sighted during surveys of Upper Cook Inlet, Alaska in 2018 (excluding those groups for which an age/color class could not be determined).

	% of groups per sub-area with:				
Sub-Area	**White**	**Gray**	**Calves**	**Neonates**	**Unknown**
Susitna River Delta	100	78	78	65	63
Knik Arm	100	100	100	50	50
Kenai River Delta	100	100	100	60	40
Turnagain Arm	100	75	63	27	60
Chickaloon Bay	100	100	100	100	100

Table 8. Summary of date and location of the first and last neonate sightings and maximum annual group size for each field season of beluga photo-id surveys in Cook Inlet, Alaska during the 2005-2018 study period.

Year	Field Season	First Sighting	Last Sighting	# Weeks from First to Last Sighting	Location of First Sighting and Largest Group of Year	Date of Largest Group of Year	Maximum Group Size
2005*	Apr 14 – Oct 21	July 06	n/a	n/a	Susitna River Delta	July 23	152
2006*	May 12 – Oct 05	n/a	n/a	n/a	n/a	July 26	61
2007*	June 28 – Oct 27	July 27	n/a	n/a	Susitna River Delta	July 27	74
2008	May 21 – Oct 28	July 24	Sept 30	9	Susitna River Delta	July 29	121
2009	June 19 – Oct 24	Aug 01	Oct 15	9	Susitna River Delta	Aug 03	152
2010	May 09 – Oct 15	July 16	Oct 08	12	Susitna River Delta	July 16	173
2011	Apr 16 – Oct 22	July 27	Sept 27	9	Susitna River Delta	July 27	136
2012	May 02 – Oct 21	July 20	Oct 04	11	Susitna River Delta	July 20	200
2013	Apr 20 – Sept 21	July 31	Sept 03	5	Susitna River Delta	July 22 & July 31	200
2014	July 08 – Oct 03	July 21	Oct 03	10.5†	Susitna River Delta	July 27	250
2015	May 28 – Oct 01	July 19	Oct 01	10.5†	Susitna River Delta	July 20	313
2016	May 24 – Sept 30	July 15	Sept 30	11†	Susitna River Delta	July 19	148
2017	July 21 – Sept 26	July 21	Sept 26	9.5†	Susitna River Delta	July 27/Aug 05	300/302
2018	May 02 – Sept 27	July 12	Sept 26	10.5†	Susitna River Delta	July 12	222

* neonates were not differentiated from calves during the 2005-2007 surveys, but neonates were noted if visible in photos from these years.
† last day of the field season.

Table 9. Summary of primary and secondary activities of beluga groups encountered in 2018 during vessel-based photo-identification surveys in the Susitna River Delta, Cook Inlet, Alaska. x = no belugas observed. Human activities with the potential to affect belugas that were observed during surveys are also noted.

Date	Group Size	Primary Group Activities	Secondary Group Activities	Feeding Behavior (observed or suspected)	Human Activities Observed During Survey
May 31	0	x	x	x	None noted
July 12	222	Traveling	Milling, Patrolling, Vocalizing	No	Aircraft
July 15	25	Unknown	Unknown	Unknown	None noted
July 15	1	Traveling	Diving	No	Aircraft
July 15	25	Diving	Milling	No	Aircraft
July 15	1	Traveling	Milling	No	None noted
July 15	31	Traveling	Unknown	No	Aircraft
July 22	200	Traveling	Milling, Feeding Suspected, Vocalizing	Yes, belugas seen chasing salmon on surface	Aircraft
July 23	0	x	x	x	None noted
July 30	200	Milling	Traveling, Vocalizing	Unidentified fish	Aircraft; NMFS biopsy boat
July 31	1	Unknown	Unknown	Unknown	NMFS biopsy boat
July 31	46	Feeding Suspected	Traveling	Yes	NMFS biopsy boat
July 31	5	Traveling	Unknown	No	NMFS biopsy boat
July 31	60	Traveling	Feeding Suspected, Vocalizing, Milling, Diving	Yes	Tote Marine Cargo boat in shipping lane nearby
July 31	25	Traveling	Vocalizing, Socializing	Yes	None noted
Aug 08	75	Traveling	Feeding Suspected, Milling	Yes	Aircraft; ADFG boat/NMFS hexacopter
Aug 08	25	Milling	Traveling, Diving, Feeding Suspected	Yes	None noted
Aug 09	85	Milling	Feeding Suspected, Diving, Traveling, Patrolling, Vocalizing	Yes	Aircraft; ADFG boat/NMFS hexacopter
Aug 22	25	Milling	Patrolling	No	Aircraft, including helicopter; tug and barge
Aug 25	12	Milling	Traveling, Patrolling	No	None noted

Table 10. Summary of primary and secondary activities of beluga groups encountered in 2018 during land- and vessel-based photo-identification surveys in Knik Arm and the Kenai River Delta, Cook Inlet, Alaska. Human activities with the potential to affect belugas that were observed during surveys are also noted.

Date	Group Size	Primary Group Activities	Secondary Group Activities	Feeding Behavior (observed or suspected)	Human Activities Observed During Survey
Knik Arm					
Aug 22	28	Milling	Traveling, Feeding Suspected	Yes	None noted
Aug 24	17	Traveling	Milling, Diving	No	None noted
Aug 25	18	Traveling	Feeding Suspected	Yes	None noted
Sept 07	36	Traveling	Milling	No	NMFS vessel
Kenai River Delta					
Sept 25	10	Milling	Traveling	No	None noted
Sept 25	15	Feeding Suspected	Traveling, Milling, Feeding Suspected	Yes	Duck hunters in boat approached whales <1m and photographed on cell phones
Sept 26	7	Traveling	Unknown	No	None noted
Sept 26	12	Traveling	Milling, Patrolling, Diving, Feeding Suspected, Resting	Yes	Aircraft, duck hunter boat drives over whales (seemingly unaware of belugas)
Sept 27	6	Traveling	Milling, Patrolling	No	None noted

Table 11. Summary of primary and secondary activities of beluga groups encountered in 2018 during land-based photo-identification surveys in Turnagain Arm, Cook Inlet, Alaska. x = no belugas observed. Human activities with the potential to affect belugas that were observed during surveys are also noted. One survey of Chickaloon Bay on September 14 is also included.

Date	Group Size	Primary Group Activities	Secondary Group Activities	Feeding Behavior (observed and suspected)	Human Activities Observed During Survey
May 02	0	X	x	x	None noted
Aug 15	3	Traveling	Milling	No	None noted
Aug 15	2	Traveling	Milling	No	None noted
Aug 15	25	Milling	Traveling, Feeding Suspected	Yes	None noted
Aug 15	4	Traveling	Unknown	No	None noted
Aug 18	25	Milling	Feeding Observed, Traveling, Diving	Yes, unidentified fish in beluga mouth	Aircraft
Aug 31	15	Traveling	Milling	No	None noted
Aug 31	22	Traveling	Unknown	No	None noted
Sept 01	4	Traveling	Milling	No	None noted
Sept 01	15	Milling	Unknown	No	Aircraft circling whales
Sept 01	5	Traveling	Unknown	No	None noted
Sept 01	2	Traveling	Unknown	No	None noted
Sept 03	10	Traveling	Unknown	No	None noted
Sept 03	20	Traveling	Milling, Patrolling	No	None noted
Sept 04	35	Traveling	Feeding Suspected, Milling, Socializing	Yes	Train whistles passing by whales
Sept 08	16	Milling	Unknown	No	None noted
Sept 08	2	Traveling	Unknown	No	None noted
Sept 08	75	Milling	Socializing, Vocalizing	No	Aircraft
Sept 08	8	Milling	Feeding Suspected, Socializing	Yes	None noted
Sept 10	1	Milling	Unknown	No	None noted
Sept 10	69	Milling	Feeding Suspected, Vocalizing	Yes	Aircraft, train whistle
Sept 14 (Chickaloon Bay)	60	Milling	Feeding Suspected, Resting, Socializing, Vocalizing, Travel	Yes	None noted

Table 12. Summary of seven stranded Cook Inlet beluga whales reported by NMFS and the Alaska Marine Mammal Stranding Network (AMMSN) to the CIBW Photo-ID Project in 2018. n/a = not applicable. Future genetic analysis of individuals may reduce the number of individuals of unknown sex.

NMFS AKR Stranding ID	Date Reported	Location of Stranded Beluga	Type of Stranding	Necropsy performed by AMMSN	Number of Belugas	Age Class[1]	Sex	Length (cm)	Photo received & reviewed?	Comment on Utility of Photo for Identification	Whale Matched to Known Catalog Whale?
2018085	June 27	Floating by Julius Platform, about 15 mi NE of Nikiski	Floating	No (floating)	1	Adult	Unknown	Not measured	Yes	Too far away and blurry	No
2018123	July 02	Nikiski	Beached	No	1	Calf	Unknown	107	Yes	Too far away and blurry	No
2018093	July 02	Kasilof	Beached	Yes	1	Adult	Unknown [2]	359	Yes	Advanced decomposition	No
2018126	July 12	Pt. Possession	Beached	Yes	1	Neonate	Male	154	Yes	Too young for ID	No
2018268	Sept 28	Campbell Creek	Beached	Yes	1	Calf	Unknown	137	Yes	Desiccated	No
2018270	Oct 01	Nikiski/Trading Bay/ Middle Shoal	Floating	No (floating)	1	Adult	Male	Not measured	Yes	Floating belly up	No
2018278	Oct 13	Deep Creek, by Ninilchik	Floating	Yes	1	Adult	Male	376	Yes	Advanced decomposition	No

[1] As listed by examiners on necropsy form.

[2] Conflicting info on level A, NMFS will run genetics.

Table 13. Summary of 213 incidental sighting reports of Cook Inlet belugas shared with the CIBW Photo-ID Project in 2018. Shaded cells indicate beluga sightings were reported. x indicates no sightings reported. See Figure 1 for map showing locations of places where sightings were reported.

2018	Susitna Delta	Knik Arm	Turnagain Arm	Chickaloon Bay/ Fire Island	Kenai River & Delta	Port of Anchorage/ Ship Creek	Other
January	x	x	x	x	x	x	X
February	x	x	x	x	x	x	X
March	x	x	x	x		x	Nikiski; Kasilof
April	x	x		x		x	x
May		x		x	x	x	Point Campbell
June		x			x		Ladd Landing
July			x	x		x	Tyonek; Ladd Landing; Kachemak Bay
August				x	x		Ladd Landing; Carr Gottstein Park, Anchorage; Campbell Creek, Anchorage
September	x			x		x	Campbell Creek, Anchorage
October	x	x		x		x	x
November	x	x	x	x	x		x
December	x	x	x	x	x	x	x

Table 14. Summary of the number of individual CIBWs and their sighting histories in the 2005-2018 photo-id catalog.

Number of:	**Left-side catalog**	**Right-side catalog**
individuals in 2005-2018 catalog	476	446
individuals photographed in 2018	171	128
individuals in catalog first photographed in 2018	3	1
individuals photographed pre-2018 who achieved catalog criteria with inclusion of 2018 photos	44	23
maximum years between sightings of an individual	10	8
individuals presumed dead based on lack of resightings (i.e., not seen photographed since 2007, using 10-year gap as most conservative)	50	26
confirmed dead individuals matched to the catalog	10	7
individuals presumed alive end of 2018 field season (= individuals in catalog - individuals presumed dead -confirmed identified dead)	416	413
individuals presumed to be mothers	200	209
individuals seen in each year of the 14-year study	5	2
individuals photographed in both 2005 and 2018 (14-year span)	52	44
longest sighting record[1], in years	21	21
maximum number of days any single individual photographed	54	47

[1] First photographed by NMFS in 1998.

Table 15. Summary of 23 Cook Inlet beluga whales in the 2005-2018 stranding and dual-side photo-id datasets with scars indicative of anthropogenic trauma from entanglement, vessel strikes, and non-research punctures (i.e., excluding biopsy and tag scars).

Photo -ID #	Puncture scar	Vessel-strike scar	Entanglement scar	Scar source (confirmed or presumed)	Year first identified in photo-id catalog	Year trauma scar first photographed and status	Sex	Female photographed with calf born after first seen with trauma scar?	Year whale last seen	Dead by 2018? (COD)[2]	Changes in wound during sighting history?
D14	no	possible	possible	vessel strike or predation attempt; possible line entanglement scar	2005	2005	presumed female	yes	2018	no	no
D68	no	possible	no	vessel strike, or predation attempt	2005	2005	presumed female	yes	2018	no	no
D75	possible	no	no	possible gunshot: exit wound on right and entrance wound on right; possible satellite tag scar	2005	2005	presumed female	yes	2018	no	infection in scars intermittently throughout sighting history (but not in 2018)
D85	no	no	possible	rope and/or monofilament line	2005	2005	confirmed male	n/a	2018	no	no (also biopsied three times in 2018)
D86	possible	no	no	possible shaft of arrow stuck in skin	2005	2006[1]	presumed female	yes	2018	no	no
D100	no	possible	possible	vessel strike or entanglement	2005	1994 (during NMFS suction cup tagging study)	presumed female	yes	2016	no	no
D102	no	possible	possible	possible entanglement in line or rope, or ship strike; infection in fold	2005	2005	presumed female	yes	2016	no	infection in folds intermittently throughout sighting history
D106	possible	no	no	gunshot, possible entrance wound right, exit wound left; could also be from orca bite	2004	1994 (during NMFS suction cup tagging study)	confirmed male	n/a	2013	confirmed dead in 2013 (choked on flatfish)	infection in holes and folds intermittently throughout sighting history
D107	no	possible	possible	vessel strike or entanglement	2005	2005	presumed female	yes	2018	no	no
D108	no	possible	possible	vessel strike or entanglement	2005	2005	presumed female	yes	2018	no	no

Photo -ID #	Puncture scar	Vessel-strike scar	Entanglement scar	Scar source (confirmed or presumed)	Year first identified in photo-id catalog	Year trauma scar first photographed and status	Sex	Female photographed with calf born after first seen with trauma scar?	Year whale last seen	Dead by 2018? (COD)[2]	Changes in wound during sighting history?
D112	no	no	possible	monofilament line or net	2005	2005	presumed female	yes	2018	no	no
D113	no	possible	possible	vessel strike or entanglement	2005	2005	presumed female	yes	2017	no	no
D135	no	no	possible	line around tailstock, could also be predation attempt	2005	2015 (body section with scar not photographed before 2015)	presumed female	yes	2018	no	no
D195	no	possible	no	vessel strike or predation attempt	2005	2008 (body section with scar not photographed before 2008)	presumed female	yes	2018	no	no
D206	no	confirmed	no	propeller scars	2005	2005	presumed female	yes	2017	no	no
D419	no	no	possible	rope and/or monofilament line	2005	2005	presumed female	yes	2017	no	no
D516	possible	possible	no	possible gunshot, entrance wound on left, exit wound on right; could also be from vessel strike	2006	2006	sex unknown	no	2006	presumed dead[3]	n/a (only photographed 1 day)
D1102	no	no	possible	possible line entanglement scar around tailstock	2008	2015 (body section with scar not photographed before 2015)	presumed female	no	2018	no	no
D1220	no	possible	possible	vessel strike or entanglement	2005	2005	presumed female	yes	2018	no	infection in holes and folds intermittently throughout sighting history, including in 2018
D2052	no	no	possible	monofilament line	2005	2005	presumed male	n/a	2018	no	no

Photo -ID #	Puncture scar	Vessel-strike scar	Entanglement scar	Scar source (confirmed or presumed)	Year first identified in photo-id catalog	Year trauma scar first photographed and status	Sex	Female photographed with calf born after first seen with trauma scar?	Year whale last seen	Dead by 2018? (COD)[2]	Puncture scar
D2303	no	no	confirmed	necropsy noted acute and old net injury; also confirmed this whale satellite tagged in 2002	2006	2015 during necropsy (not from id photos)	confirmed male	n/a	2015	confirmed dead 2015 (Severe lung infection, associated infection of tag scar)	n/a (entanglement scars not seen while alive)
D3846	no	no	confirmed	heavy braided line visible	2010	2010	presumed male	n/a	2013	presumed dead[4]	rope appears tighter and cutting into flesh more every fall compared to every spring, and with every year
D7244	no	possible	no	necropsy noted possible propeller injury left flank & probable blunt trauma, head & neck	2007	2012[1] when dead (body section with scar not photographed before)	confirmed male	n/a	2012	confirmed dead in 2012 (COD undetermined ; possible vessel strike)	n/a

[1]Indicates fresh scar.

[2] Cause of death assigned during necropsy.

[3]Presumed dead after >10 years without resighting (McGuire et al. 2020c [In revision]).

[4]Presumed dead after abrupt end to robust sighting records and very conspicuous marks.

Table 16. Summary of CIBWs captured and satellite-tagged between 1999 and 2002 and matched to individuals in the 2005-2018 photo-id catalog. An individual was classified as dead by 2018 if it had been confirmed dead as carcass or presumed dead if it had not been photographed since 2007. Information on individuals who may have died within the same year as tagging is from Shelden et al. 2018.

NMFS CIBW ID tagging number	Capture location	Capture date	Sex[1]	Color (assigned during capture by NMFS)	Length during capture (cm)	Photo-ID catalog number	Dead as of 2018?	Last photographed
no number (captured, not tagged)	Little Susitna	May 31, 1999	F	gray	230	L2191	presumed dead	2007
CI-9901	Little Susitna	May 31, 1999	M	white	370	possible match	?	?
no number (captured, not tagged)	Knik Arm	Sept 8, 2002	F	light gray	274	no match (no tagging photos to examine)	?	?
CI-0001	Knik Arm	Sept 13, 2000	M	white	413	possible match	?	x
CI-0002	Knik Arm	Sept 13, 2000	F	white/gray	272	D111	no	2018
CI-0101	Little Susitna	Aug 10, 2001	F	gray	257	D243	no	2018
CI-0102	Knik Arm	Aug 11, 2001	M	white	323	possible match	?	?
CI-0103	Knik Arm	Aug 12, 2001	F	white	312	possible match	?	?
CI-0104	Knik Arm	Aug 13, 2001	F	white	340	no match (no tagging photos to examine)	may have died in 2001 post-tagging	?
CI-0105	Knik Arm	Aug 13, 2001	F	white	357	possible match	?	?
CI-0106	Knik Arm	Aug 15, 2001	F	white	401	D103	no	2018
CI-0107	Knik Arm	Aug 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	Aug 1, 2002	F	white	379	no post-2002 photos	confirmed dead post-tagging Aug 9, 2002	?
CI-0205	Knik Arm	Aug 2, 2002	M	white/gray	386	D2303	confirmed dead June 12, 2015	2015
CI-0206	Knik Arm	Aug 3, 2002	M	white/gray	353	D2204	presumed dead	2007
CI-0207	Knik Arm	Aug 3, 2002	F	white	374	possible match	may have died in 2002 post-tagging	?
CI-0208	Knik Arm	Aug 4, 2002	M	white/gray	376	D115	confirmed dead May 26, 2014	2014

[1] Genetic sex from satellite tag samples determined by Greg O'Corry-Crowe, Florida Atlantic University.

Table 17. Sighting records of satellite-tagged individuals identified in the 2005-2018 CIBW Photo-ID catalog, including records of reproduction, survival, and satellite-tag scar status.

Photo-ID # (NMFS tagging ID#)	Research scar (confirmed or presumed)	Year 1st identified in catalog	Year trauma scar first photographed	Sex (confirmed or presumed)[2]	Year last photographed	Dead by 2018?[3]	Female photographed with calf born post tagging (2005-2018)?	Research scar sighting history (see Figure 17 for most-recent photos)
L2191	captured, but not tagged	2007	n/a	confirmed female	2007	presumed dead	no (she looked very young at capture in 1999)	not tagged or flipper banded
D103 (CI-01-06)	confirmed satellite tag from 2001	2005	2001[1] during tagging	confirmed female	2018	no	yes	tag scars conspicuous but no signs of infection. Second hole from front getting bigger in 2018, 16 years after tagging.
D2303 (CI-02-05)	confirmed satellite tag and flipper band from 2002	2005	2002[1] during tagging	confirmed male	2015	severe lung infection (associated infection of tag scar)	n/a	scars conspicuous, worsening possible infection of tag holes, body around tag site becoming concave; signs of flipper damage from flipper band
D111 (CI-00-02)	confirmed satellite tag from 2000	2005	tagging	confirmed female	2018	no	yes	tag scars inconspicuous and no signs of infection; abrasions across dorsal ridge
D115 (CI-02-08)	confirmed satellite tag and flipper band from 2002	2005	2002[1] during tagging	confirmed male	2014	confirmed dead 2014 (COD live stranding)	n/a	tag scars conspicuous but no signs of infection; signs of flipper damage from flipper band
D2204 (CI-02-06)	confirmed satellite tag from 2002	2005	2002[1] during tagging	confirmed male	2007	presumed dead	n/a	scars conspicuous and appeared infected and deteriorating 2005-2007
D243 (CI-01-01)	confirmed satellite from 2001	2005	2001[1] during tagging	confirmed female	2018	no	yes	conspicuous tag scar, one scar appears healed, possible infection in two scars intermittently throughout sighting history
D49 (unable to match)	confirmed satellite tag, tag year unknown	2005	2005	presumed female	2018	no	yes	conspicuous tag scar; infection in tag scar intermittently throughout sighting history. Dark spot in scar indentation appears to be enlarging in 2018

Photo-ID # (NMFS tagging ID#)	Research scar (confirmed or presumed)	Year 1st identified in catalog	Year trauma scar first photographed	Sex (confirmed or presumed)[2]	Year last photographed	Dead by 2018?[3]	Female photographed with calf born post tagging (2005-2018)?	Research scar sighting history (see Figure 17 for most-recent photos)
D875 (unable to match)	confirmed satellite tag, tag year unknown	2005	2005	presumed male	2017	no	n/a	tag scar inconspicuous on right, conspicuous on left; no signs of infection
D403 (unable to match)	confirmed satellite tag, tag year unknown	2005	2005	presumed female	2018	no	yes	conspicuous tag scar; infection in tag scar intermittently throughout sighting history
D3024 (unable to match)	confirmed satellite tag, tag year unknown	2009	2009	presumed female	2017	no	yes	tag scar conspicuous but no signs of infection
D5319 (unable to match)	confirmed satellite tag, tag year unknown	2007	2007	presumed female	2018	no	yes	tag scar conspicuous but no signs of infection
R6 (unable to match)	confirmed satellite tag, tag year unknown	2005	2005	presumed female	2017	no	yes	tag scar conspicuous on right side but not left; no signs of infection but one tag hole still open as of 2017
L17368 (unable to match)	confirmed satellite tag, tag year unknown	2008	2008	presumed female	2011	no	possible (unconfirmed)	tag scar conspicuous, possible infection in all years photographed (2007, 2008, 2011)
D75 (unable to match)	possible satellite tag, tag year unknown; possible gunshot	2005	2005	presumed female	2018	no	yes	conspicuous scars; possible infection in scars intermittently throughout sighting history

[1]Scar was fresh in listed year.

[2]Genetic sex from satellite tag samples determined by Greg O'Corry-Crowe, Florida Atlantic University.

[3]Confirmed as carcass or presumed if not photographed since 2007. COD = cause of death assigned during necropsy.

Table 18. Summary of photo-id matches made between the 2005-2018 CIBW Photo-ID Project catalog and the 39 beluga biopsy samples and 8 belugas darted with no sample during the 2016, 2017, and 2018 Cook Inlet Beluga Biopsy Study. The table represents 42 individuals (not 47) because one individual was biopsied three times, and three individuals were successfully biopsied and also struck with no sample. U=unknown, either because sample was not collected, not analyzed, or results not available. x = not photographed following biopsy. n/a = not applicable.

Biopsy Date	Biopsy ID	Photo-ID Catalog ID[1]	Year First Identified in Photo-ID Catalog	Genetic Sex[2]	Female photographed with a calf between 2005 and biopsy?	Pregnant[3] at biopsy?	Female seen with calf after biopsy[4]?	Epigenetic age in years[5]?	Side of whale biopsied	Year whale last photographed	Comments
2016											
Aug 13	DL-CIB16-31	R18703	2016	F	no	no	x	U	right	2016	seen multiple times in 2016 pre-biopsy; appeared to be young whale without permanent marks; presume young and pre-reproductive
Aug 15	DL-CIB16-32	D16873	2010	M	n/a	n/a	n/a	U	right	2018	struck again in 2018, no sample
Aug 16	DL-CIB16-33	L18698	2011	F	no	no	x	U	left	2016	
Aug 19	DL-CIB16-34	D16854	2014	F	no	no	with j3+ in 2017	U	left	2017	
Aug 19	DL-CIB16-35	D154	2005	F	yes	yes	with j1+ on day of biopsy and was pregnant, with j4+ in 2017; with j2- in 2018	U	left	2018	
Aug 20	DL-CIB16-36	D220	2005	F	yes	yes	possibly with calf of unknown age in 2018	U	left	2018	
2017											
Sept 2	DL-CIB17-01	L18630	2015	F	yes	no	x	U	left	2017	
Sept 2	DL-CIB17-02	D19173	2016	F	no	no	no	U	right	2017	
Sept 2	DL-CIB17-03	D2379	2005	M	n/a	n/a	n/a	U	right	2018	
Sept 2	DL-CIB17-04	L381	2005	M	n/a	n/a	n/a	U	left	2017	
Sept 2	DL-CIB17-hitnosample-1	L10517	2011	U	no	U	n/a	U	left	2017	
Sept 3	DL-CIB17-05	R1187	2008	M	n/a	n/a	n/a	U	right	2018	three shots taken same day: miss, biopsy, miss.

Biopsy Date	Biopsy ID	Photo-ID Catalog ID[1]	Year First Identified in Photo-ID Catalog	Genetic Sex[2]	Female photographed with a calf between 2005 and biopsy?	Pregnant[3] at biopsy?	Female seen with calf after biopsy[4]?	Epigenetic age in years[5]?	Side of whale biopsied	Year whale last photographed	Comments
Sept 3	DL-CIB17-06	D28419	2017	F	no	yes	possibly with calf of unknown age in 2018	U	right	2018	
Sept 4	DL-CIB17-07	L2366	2005	M	n/a	n/a	n/a	U	left	2017	
Sept 7	DL-CIB17-08	R28421	2017	F	no	no	x	U	right	2017	
Sept 8	DL-CIB17-09	L28411	2017	M	n/a	n/a	n/a	n/a	left	2017	
Sept 9	DL-CIB17-10	R624	2005	F	yes	no	with 2-year-old calf in 2018	U	right	2018	
Sept 9	DL-CIB17-11	L10344	2011	F	no	yes	x	U	left	2017	
Sept 9	DL-CIB17-12	D18993	2016	F	no	U (skin only)	no	U	right	2018	
Sept 9	DL-CIB17-hitnosample-2	L28412	2017	U	no	n/a	n/a	n/a	left	2017	
2018											
July 26	DL-CIB18-hitnosample-1	L34921	2018	U	U	U	U	n/a	left	2018	strike, no sample
July 26	DL-CIB18-hitnosample-2	D30388	2018	U	U	U	U	n/a	right	2018	strike, no sample
July 30	DL-CIB18-hitnosample-3	L34922	2018	U	U	U	U	n/a	left	2018	strike, no sample
Sept 6	DL-CIB18-01	R34931	2018 (maybe 2011)	F	no	no	x	U	right	2018	
Sept 6	DL-CIB18-02	R34164 Possible match to L2014	2018; possibly 2006	M	n/a	n/a	n/a	U	right	2018	
Sept 6	DL-CIB18-03	R34933	2018	M	n/a	n/a	n/a	U	right	2018	
Sept 6	DL-CIB18-hitnosample-4	R34949	2018	M	n/a	n/a	n/a	U	right	2018	struck twice 2018: one biopsy and one no sample
Sep 9	DL-CIB18-06	R34949	2018	M	n/a	n/a	n/a	U	right	2018	struck twice 2018: one biopsy and one no sample
Sept 9	DL-CIB18-04	D85	2005	M	n/a	n/a	n/a	U	right	2018	biopsied three times in 2018
Sept 9	DL-CIB18-05	R18488	2012	M	n/a	n/a	n/a	U	right	2018	

Biopsy Date	Biopsy ID	Photo-ID Catalog ID[1]	Year First Identified in Photo-ID Catalog	Genetic Sex[2]	Female photographed with a calf between 2005 and biopsy?	Pregnant[3] at biopsy?	Female seen with calf after biopsy[4]?	Epigenetic age in years[5]?	Side of whale biopsied	Year whale last photographed	Comments
Sept 10	DLCIB18-07	L34923	2018	F	yes	no	with J2+ calf during biopsy event, Figure X	U	left	2018	struck twice 2018: one biopsy and one no sample
Sept 10	DLCIB18-hitnosample-5	L34923	2018	F	yes	no	with J2+ calf during biopsy event, Figure X	U	left	2018	struck twice 2018: one biopsy and one no sample
Sept 10	DLCIB18-08	R34938	2018	F	no	no	x	U	right	2018	
Sept 10	DLCIB18-09	R21930	2016	F	yes (with J1- calf weeks before biopsy)	U (skin only)	possibly with calf during biopsy event	U	right	2018	
Sept 10	DLCIB18-10	D85	2005	M	n/a	n/a	n/a	U	left	2018	biopsied three times in 2018
Sept 10	DLCIB18-11	L33575	2018	M	n/a	n/a	n/a	U	left	2018	
Sept 11	DLCIB18-12	L20266	2012	F	no	no	x	U	left	2018	
Sept 11	DLCIB18-13	L34948	2018	M	n/a	n/a	n/a	U	left	2018	
Sept 11	DLCIB18-14	D17286	2014	F	yes	no	x	U	left	2018	
Sept 11	DLCIB18-15	R21848	2016	M	n/a	n/a	n/a	U	right	2018	
Sept 11	DLCIB18-16	R34941	2018	M	n/a	n/a	n/a	U	right	2018	
Sept 12	DLCIB18-17	R17000	2014	M	n/a	n/a	n/a	U	right	2018	
Sept 12	DLCIB18-18	D85	2005	M	n/a	n/a	n/a	U	right	2018	biopsied three times in 2018
Sept 12	DLCIB18-19	D10860	2011	M	n/a	n/a	x	U	right	2018	also missed biopsy on left 2017-09-02
Sept 12	DLCIB18-20	D8151	2008	M	n/a	n/a	n/a	U	right	2018	
Sept 12	DLCIB18-21	R34947	2018	F	no	no	x	U	right	2018	
Sept 11	DLCIB18-hitnosample-6	D16873	2010	M	n/a	n/a	n/a	U	right	2018	missed shot

[1] Individuals biopsied multiple times linked by same color cell.
[2] Genetic sex from biopsy samples determined by Nick Kellar, NMFS Southwest Fisheries Science Center, and Kim Parsons, NMFS Northwest Fisheries Science Center.
[3] Pregnancy status from hormones in blubber samples determined by Nick Kellar, NMFS Southwest Fisheries Science Center.
[4] Exact calf ages determined from year first seen as a neonate and estimated calf ages based on physical appearance, with nomenclature developed by Gina Himes Boor, Montana State University: J1+ calf is at least one year old; J2 – calf is two years old or younger, J3+ calf is at least three years old.
[5] Epigenetic aging from blubber samples determined by Ellie Bors, Oregon State University/University of Washington/NMFS Marine Mammal Lab; will share results following publication of her results.

FIGURES

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

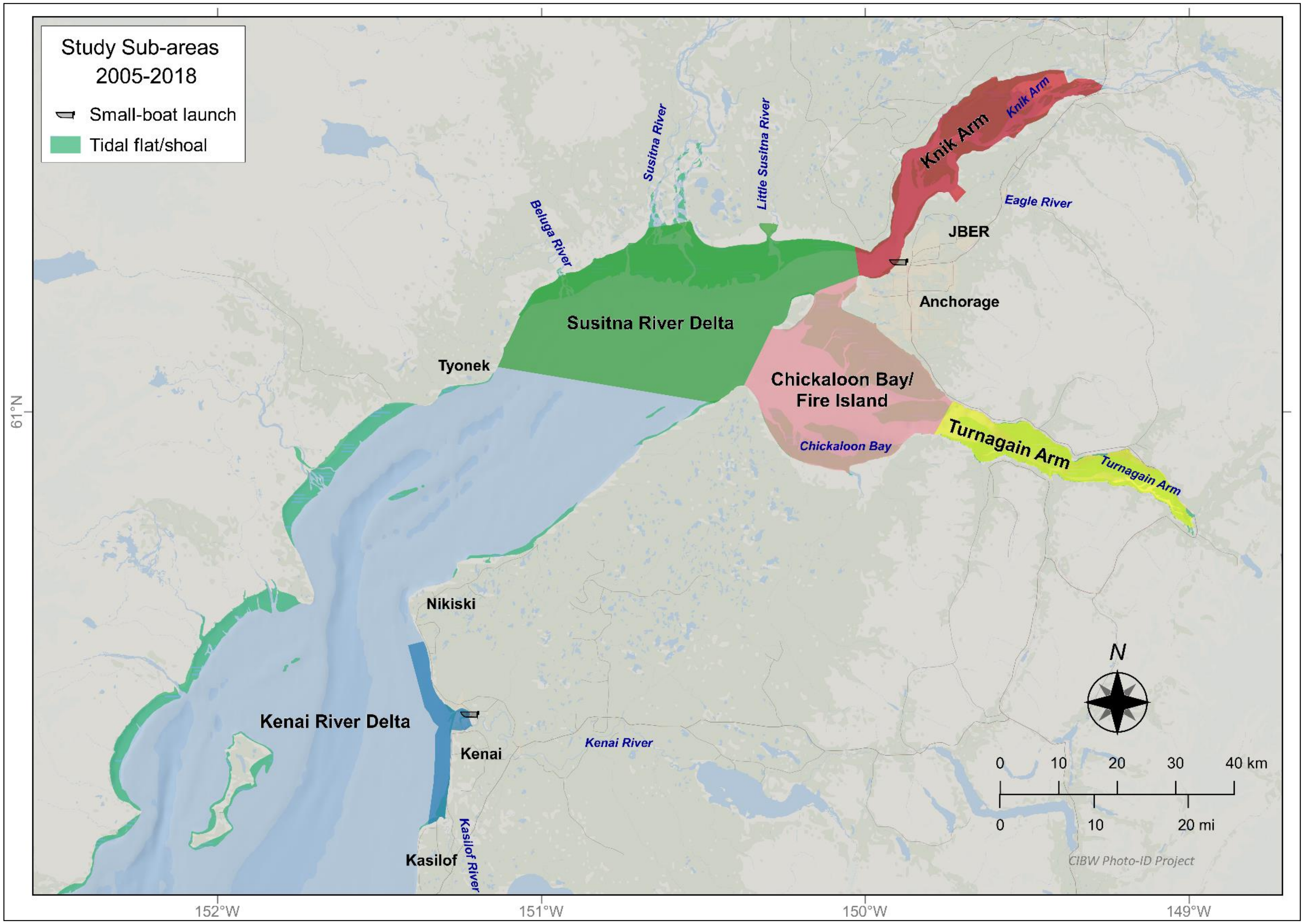


Figure 2. Map of Middle and Upper Cook Inlet, Alaska, showing boundaries of five survey sub-areas within the study area.

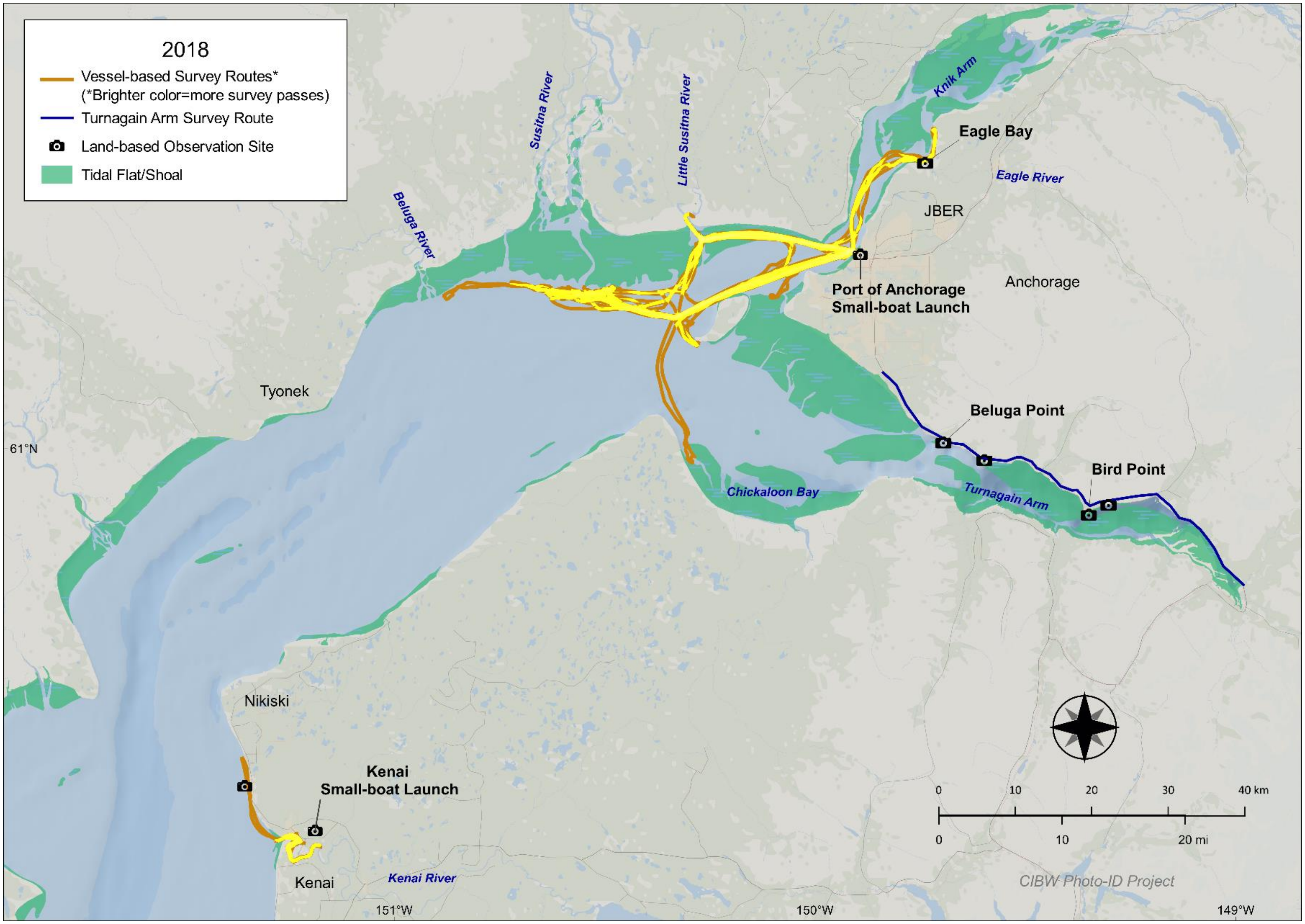


Figure 3. Vessel routes (from daily GPS track lines) with land-based stations and survey routes for all photo-id surveys conducted in 2018. Level of effort of the vessel-based surveys is indicated by the intensity of the colors of the track lines. See Table 2 for exact number of surveys. POA = Port of Anchorage.

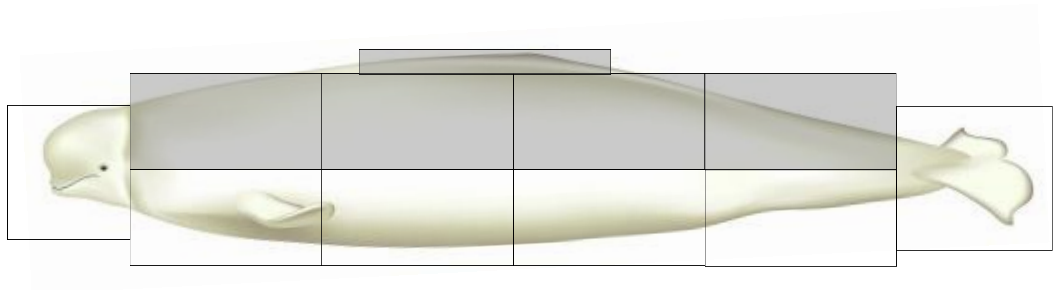


Figure 4. Body segments used when cataloging photographs of belugas for photo-id. The five shaded areas were the critical sections used in matching marks. Beluga illustration courtesy of Uko Gorter.

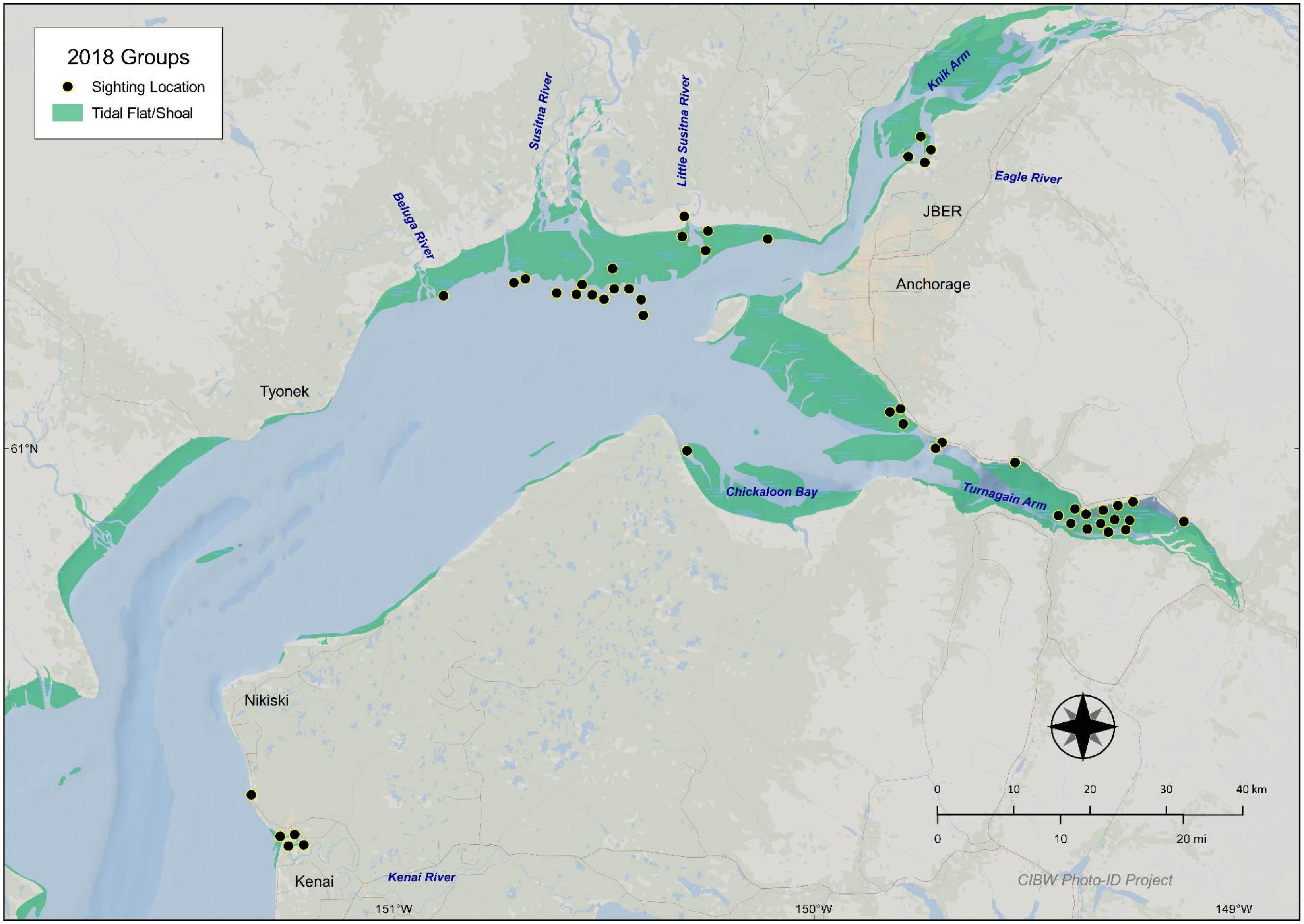


Figure 5. Beluga whale groups encountered during all photo-id surveys conducted in 2018.

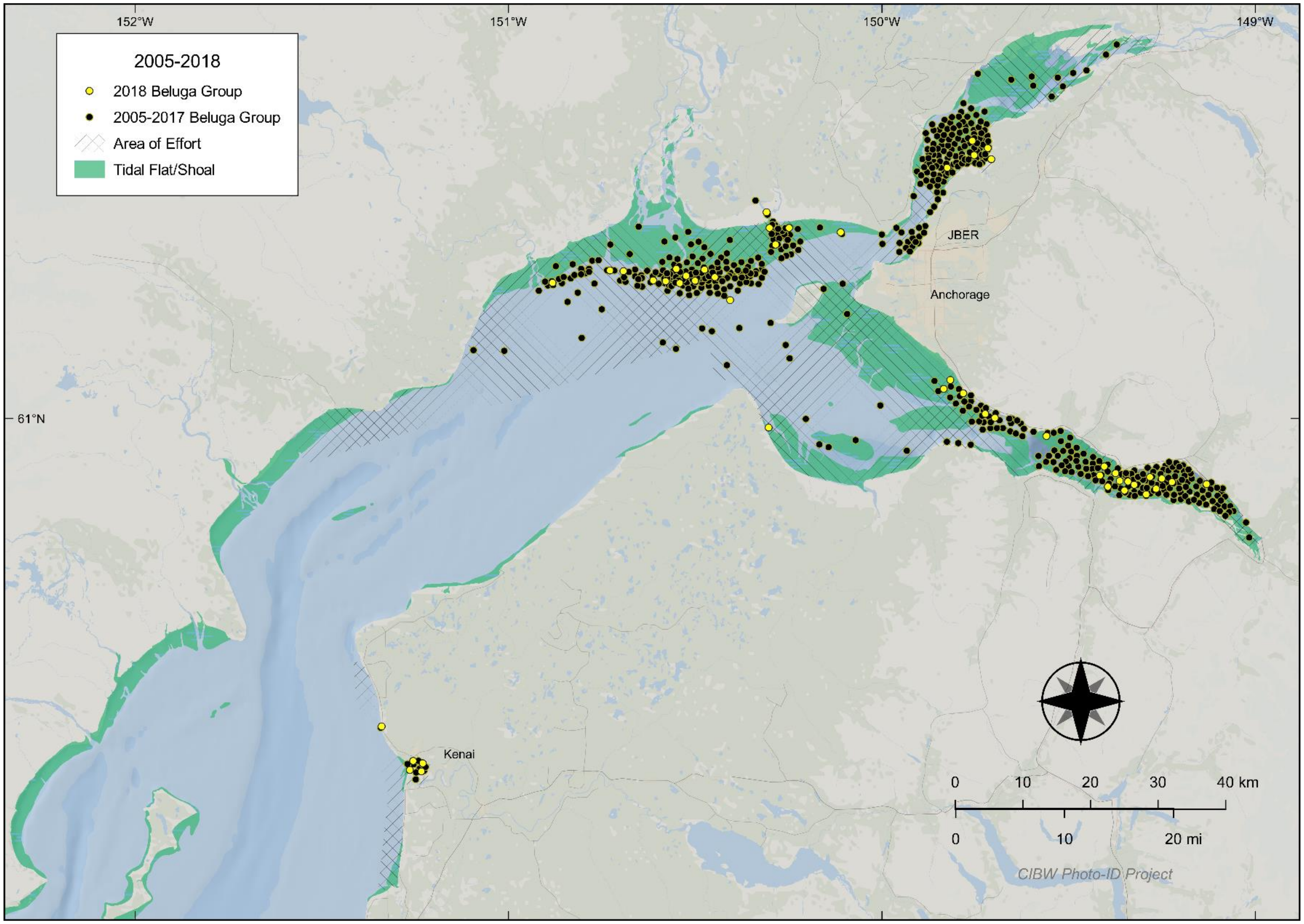


Figure 6. Beluga whale groups encountered during all photo-id surveys conducted from 2005-2018.

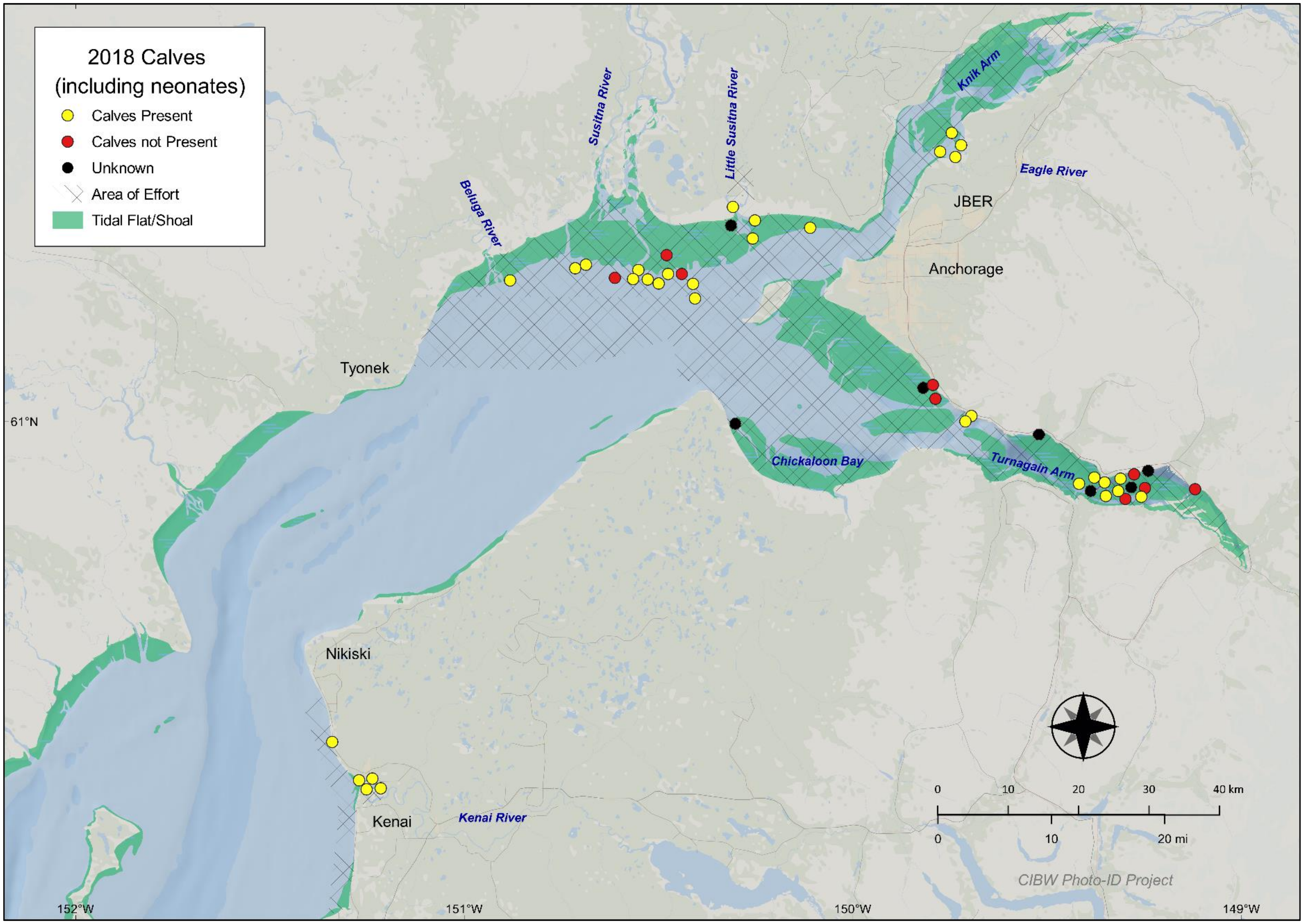


Figure 7. Location of groups with and without calves and/or neonates encountered during photo-id surveys conducted in 2018.

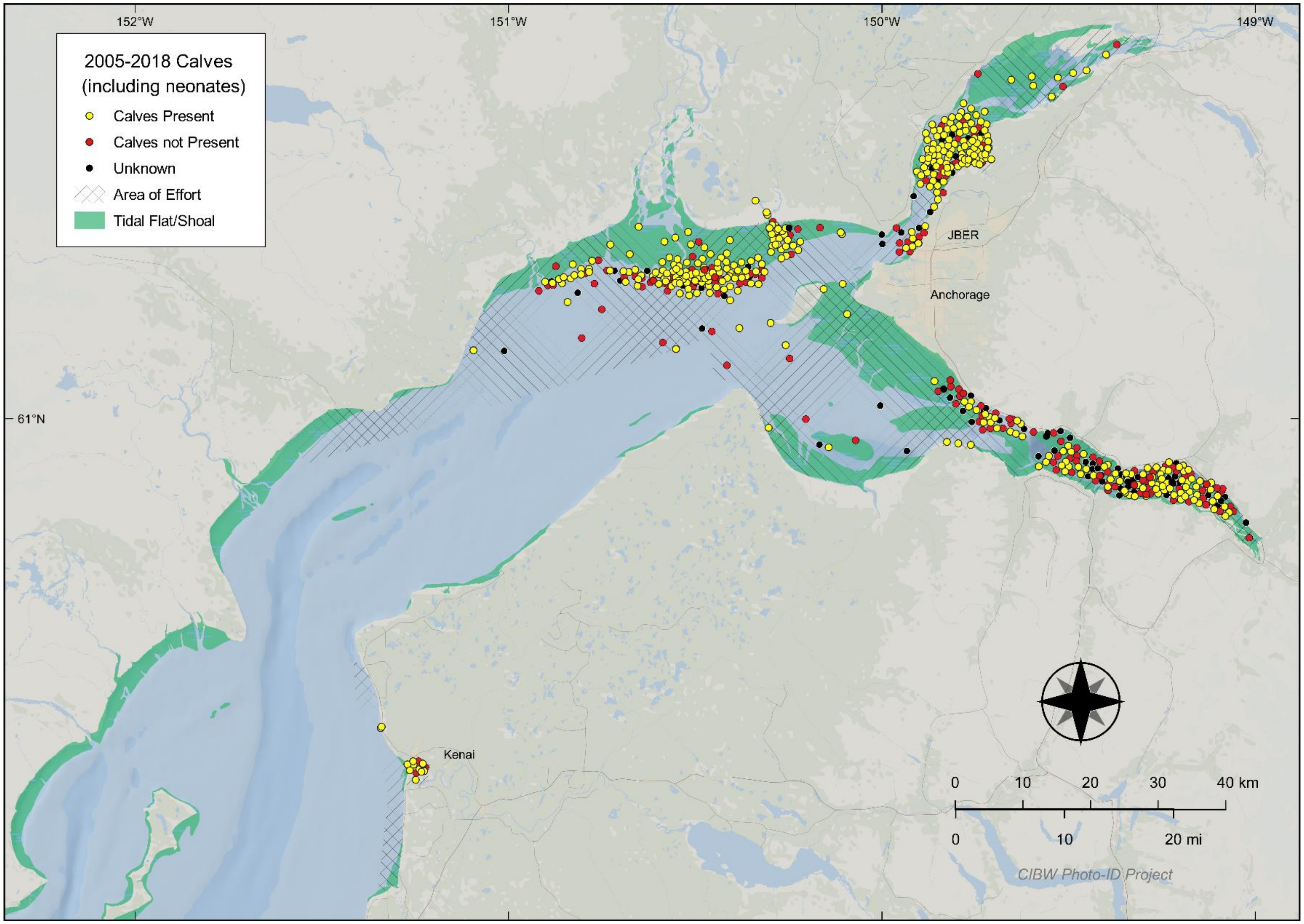


Figure 8. Location of groups with and without calves and/or neonates encountered during photo-id surveys conducted from 2005-2018.

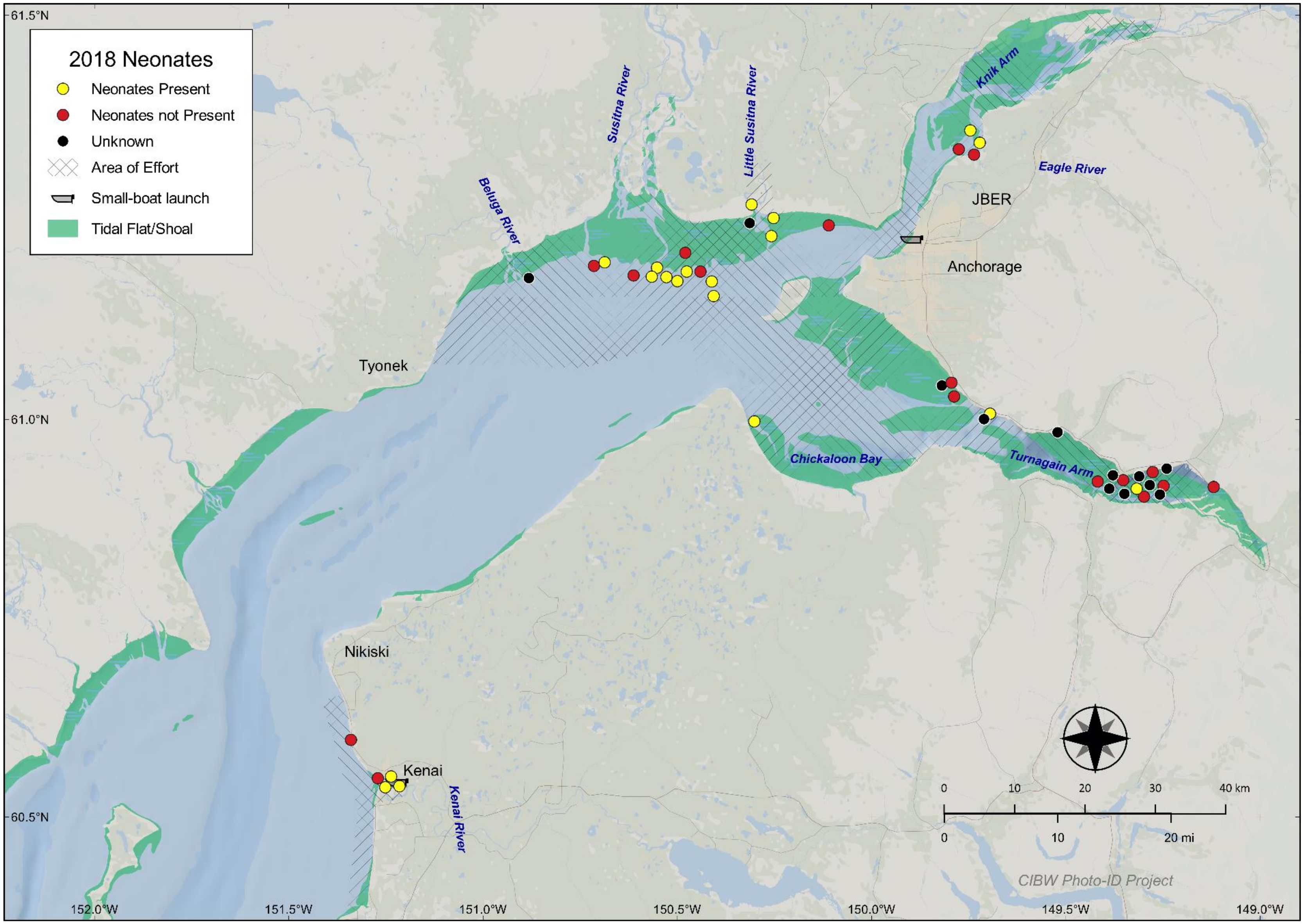


Figure 9. Location of groups with and without neonates encountered during photo-id surveys conducted in 2018.

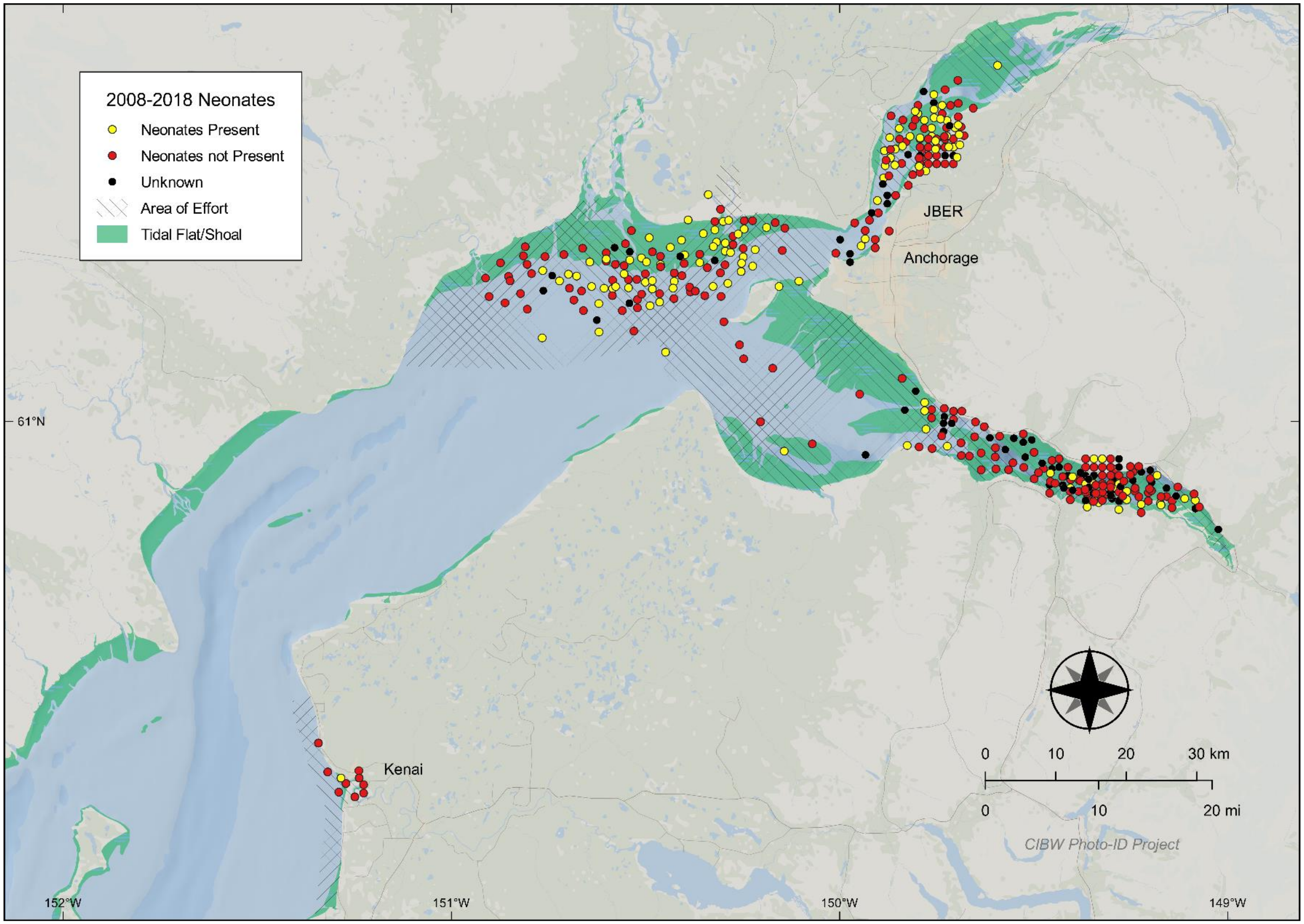


Figure 10. Location of groups with and without neonates encountered during photo-id surveys conducted from 2005-2018.

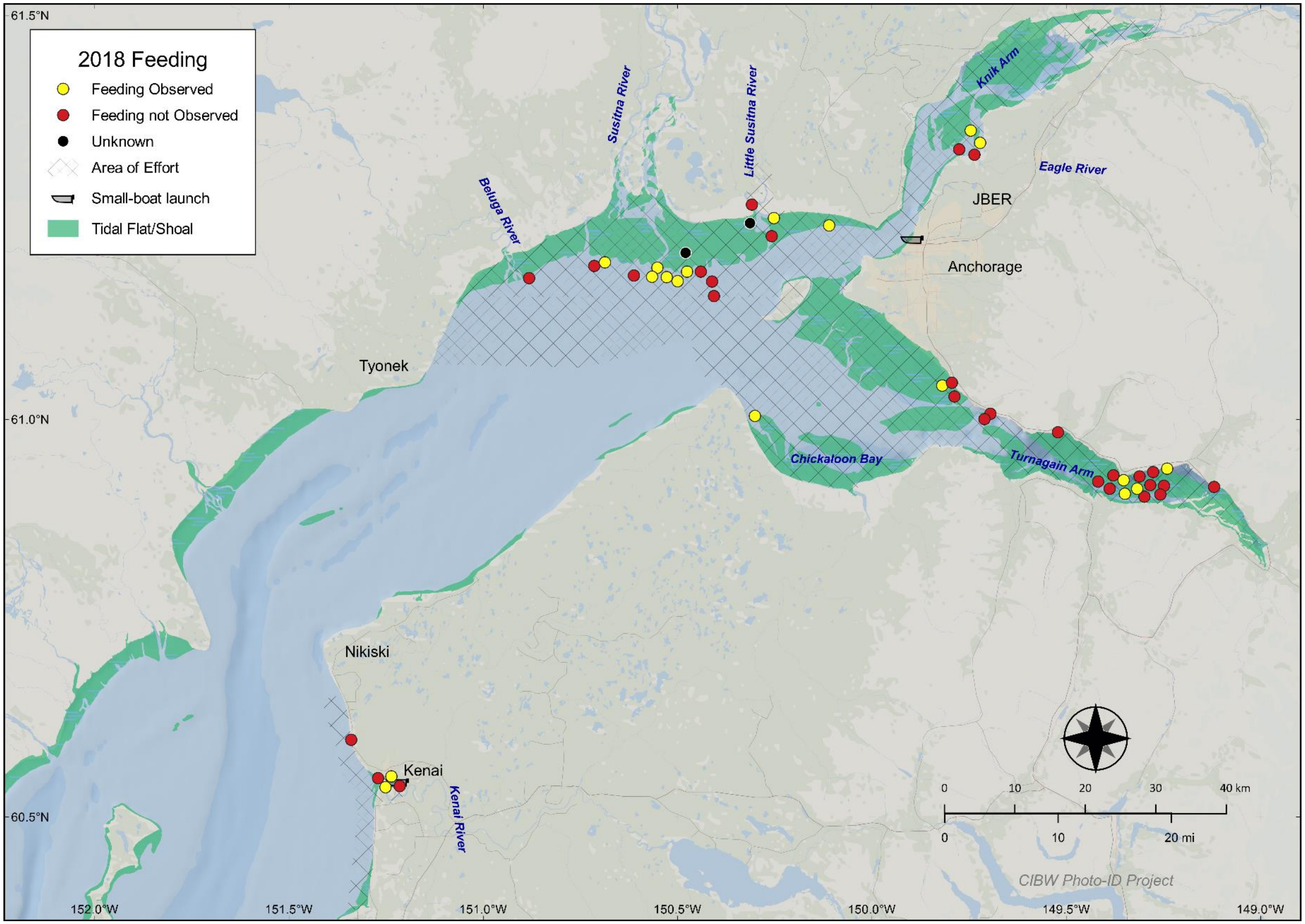


Figure 11. Location of groups with and without observations of feeding behavior (suspected or confirmed) during photo-id surveys conducted in 2018.

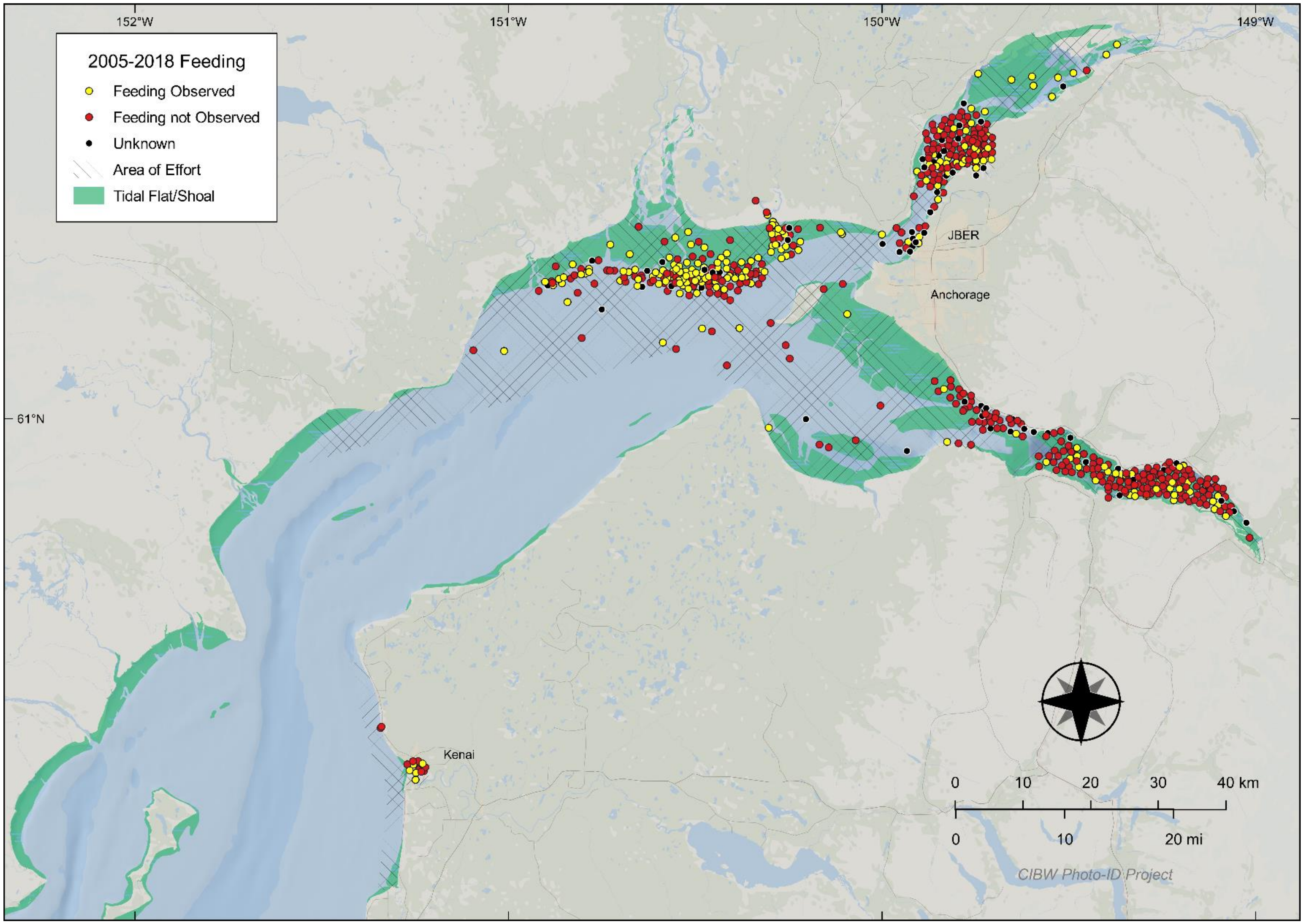


Figure 12. Location of groups with and without observations of feeding behavior (suspected or confirmed) during photo-id surveys conducted 2005-2018.

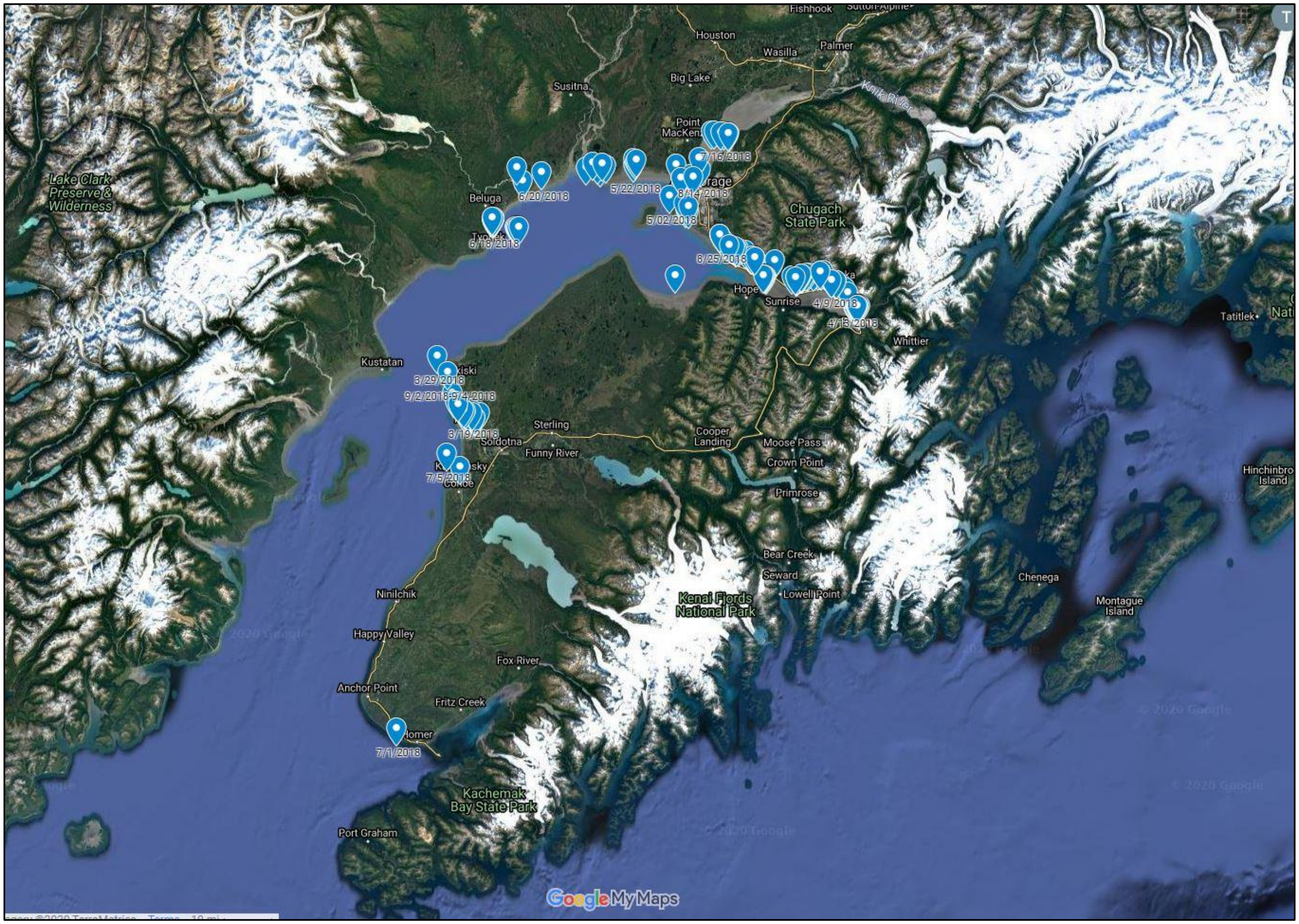
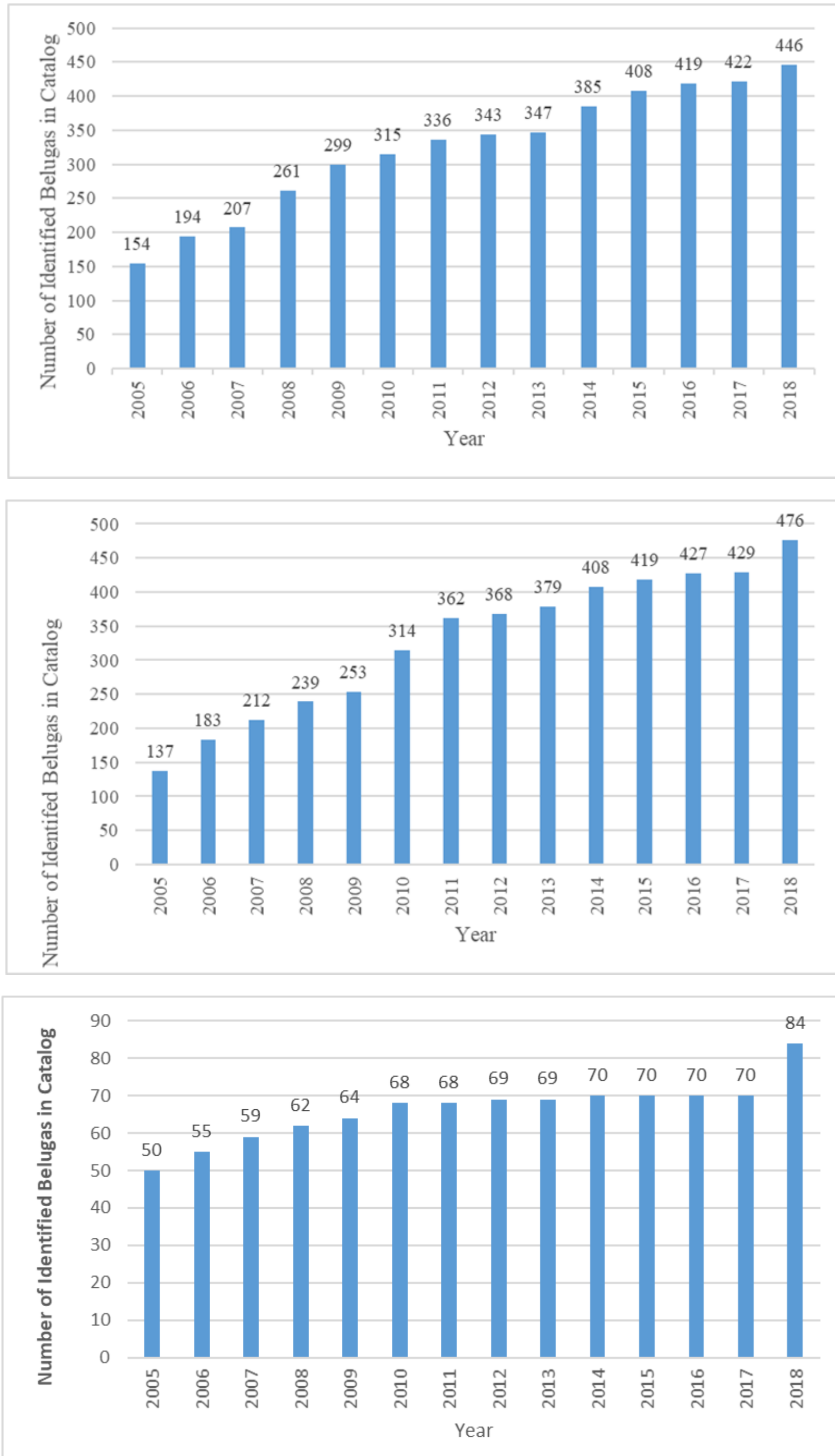


Figure 13. Map of 2018 incidental beluga sightings (in blue symbols) reported on the CIBW Photo-ID Project website (see www.cookinletbelugas.com for more details.

Figure 14. High-speed vessel passing over belugas (circled in red) in the Kenai River Delta in 2018. This incident occurred in a posted no-wake zone. Observers on the survey boat noted that the operator of the high-speed vessel did not appear to be aware of the belugas, despite attempts by the survey boat to warn the operator.

Figure 15. Low-flying aircraft over belugas (circled in red) in Turnagain Arm, 2018. Land-based observers noted that the aircraft intentionally decreased altitude and circled the whales.



A.

B.

C.

Figure 16. The number of identified individual whales in the right-side catalog (A), left side catalog (B), and the dual-side catalog (C) according to the year in which an individual was first photographed by study.

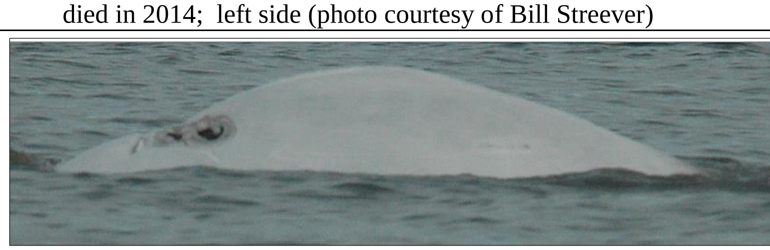
Photo-ID # /Tagging ID #	Year tagged	Most-recent photo of satellite-tag scars and year
D103 CI-01-06	Tagged 2001	 2018, left side
D2303 CI-02-05	Tagged and flipper banded 2002	 died in 2015; left side (photo courtesy of Randy Standifer/Alaska Marine Mammal Stranding Network)
D111 CI-00-02	Tagged 2000	 2018; left side
D115 CI-02-08	Tagged and flipper banded 2002	 died in 2014; left side (photo courtesy of Bill Streever)
D2204 (CI-02-06)	Tagged 2002	 2007, left side (presumed dead by 2018)

Photo-ID # /Tagging ID #	Year tagged	Most-recent photo of satellite-tag scars and year
D243 (CI-01-01)	Tagged 2001	 2018, right side
D49	Tagging year unknown	 2018, left side
D549	Tagging year unknown	 2018, left side
D875	Tagging year unknown	 2017, left side
D403	Tagging year unknown	 2018, both sides, head facing away
D3024	Tagging year unknown	 2017, left side

Photo-ID # /Tagging ID #	Year tagged	Most-recent photo of satellite-tag scars and year
D5319	Tagging year unknown	 2018, left side
R6	Tagging year unknown	 2017, right side
L17368	Tagging year unknown	 2011, left side
D75	Possible satellite tag (year unknown) or possible bullet wound	 2018, right side (photo courtesy of Robert Michaud)

Figure 17. Most-recent photographs of satellite-tag scars of Cook Inlet beluga whales tagged 1999-2002.

Photo-ID # /Biopsy ID #	Year and side of biopsy	Year scar site last photographed/ signs of infection?	Most-recent photo of biopsy scar
D16873 DLCIB16-32	2016 right	2018/no	 Photo courtesy R. Michaud
D16854 DLCIB16-34	2016 left	scar site only seen one day after biopsy 2016/no	
D220 DL-CIB16-36	2016 left	2018/no	
D2379 DLCIB17-03	2017 right	2018/no	
D28419 DLCIB17-06	2017 right	2018/no	
R624 DLCIB17-10	2017 right	2018/no	
D85 DLCIB18-04	2018 right	2018/scar seen 3 days after first biopsy when whale biopsied again 2018/no	 Photo courtesy Paul Wade

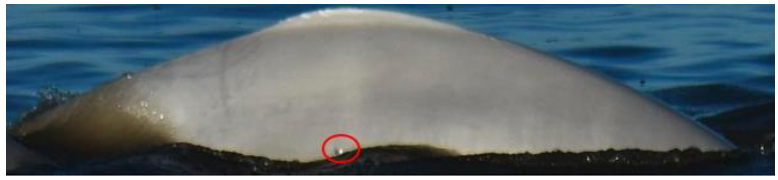
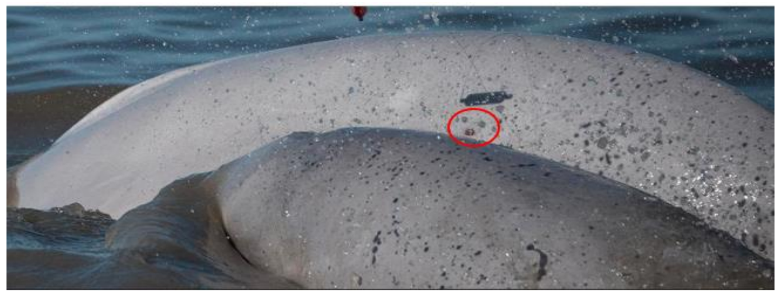
Photo-ID # /Biopsy ID #	**Year and side of biopsy**	**Year/ scar site last photographed/ signs of infection?**	**Most-recent photo of biopsy scar**
L33575 DLCIB18-11	2018 left	2018/seen 16 days after biopsy (in Kenai)/no	
R21848 DLCIB18-15	2018 right	2018/scar seen 3 days after biopsy /no	
L34923 DLCIB18-07	2018 left	2018/scar seen when biopsied again same day 2018	 Photo courtesy Paul Wade
L34923 DLCIB18-hitnosample-5	2018 left	Not photographed after second biopsy same day 2018	 Photo courtesy Paul Wade

Figure 18. Most-recent photographs of biopsy scars of Cook Inlet beluga whales biopsied 2016-2018. Photographs of the biopsy event are not included but can be found in McGuire et al. 2017 and 2018 for the 2016 and 2017 biopsy photos. Records are only displayed for those individuals who were photographed following the biopsy event and whose photographs included a view of the biopsy site. Individuals who did not have a photograph of the biopsy site at the time of biopsy are not included. Signs of possible infections (e.g., swelling, discharge, irregular wound margins) only evaluated for scars seen >1 day following biopsy).

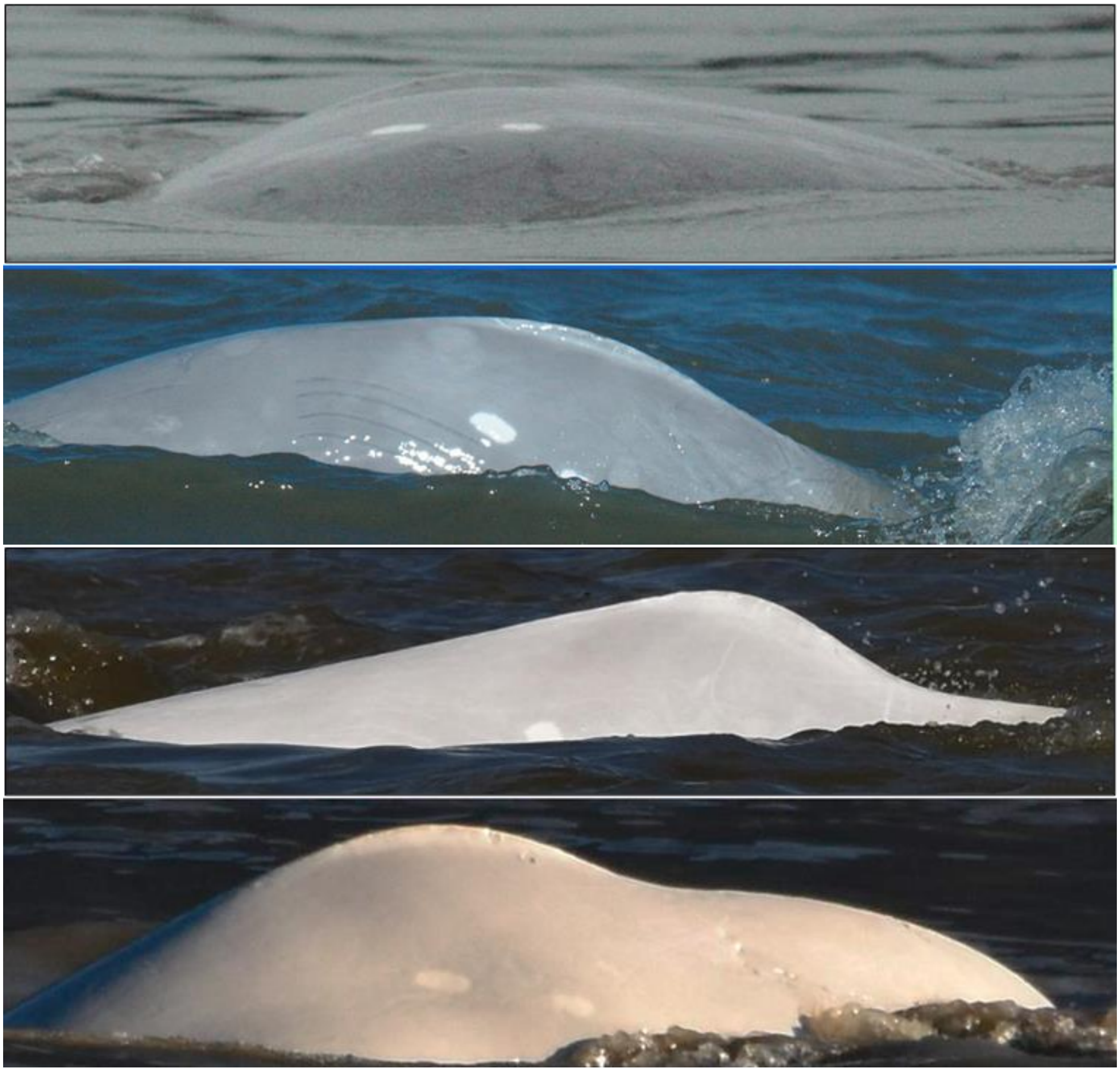


Figure 19. Photographs of the left side of male beluga D2379 (DL CIB17-03) whose sex was determined by biopsy in 2017. Note the concavity behind the dorsal crest in 2017 and 2018 that was not present in 2005. The concavity was detected in 2008 and appeared to worsen with time. (Photo order from top to bottom: 2005, 2008, 2017, 2018).

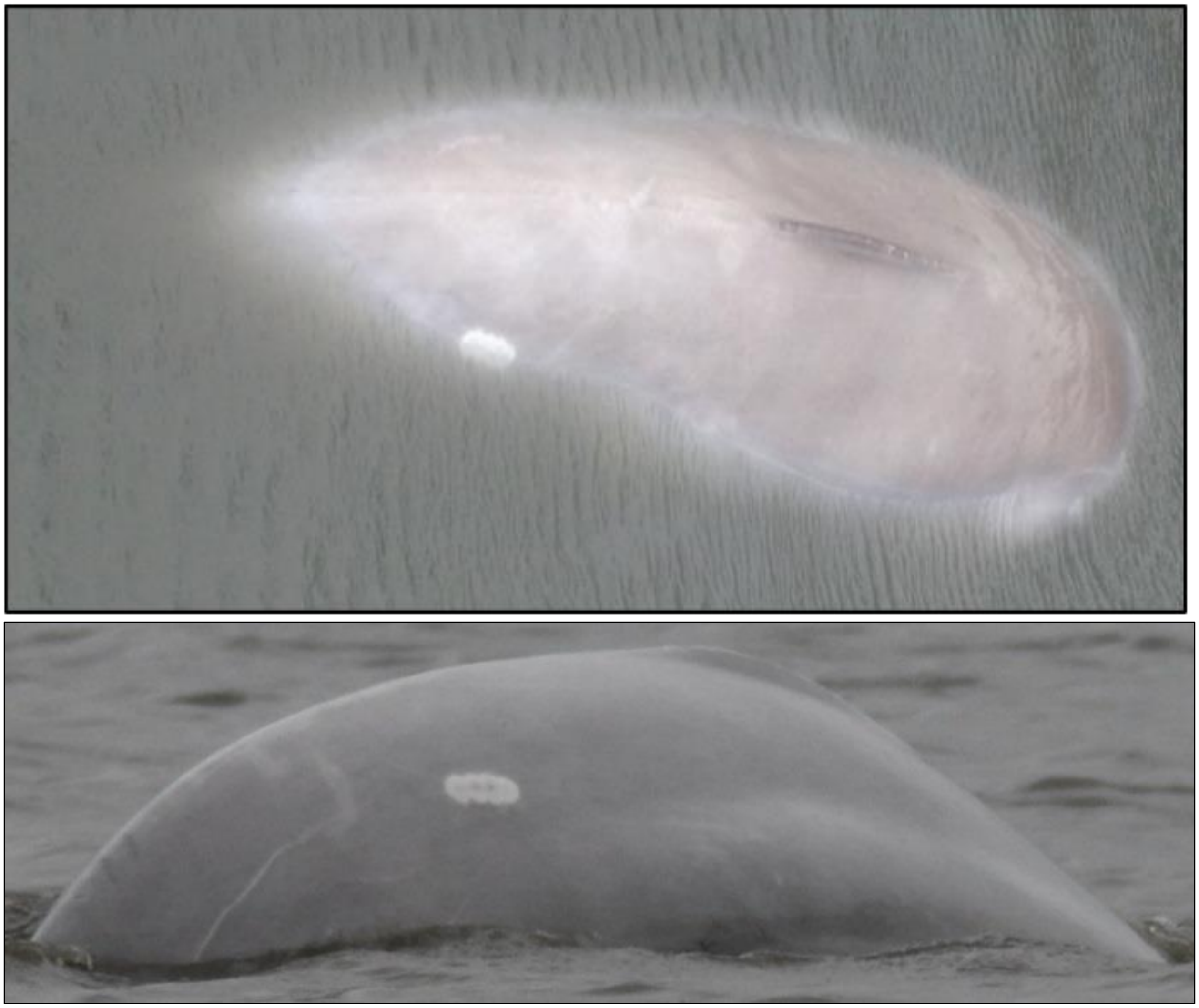


Figure 20. Beluga D1032 live-stranded on the mudflats in Turnagain Arm with a calf in 2015 and was later observed swimming away with the rising tide (top photo courtesy of Noah Messenheimer). The bottom photo is of the right side in 2018.

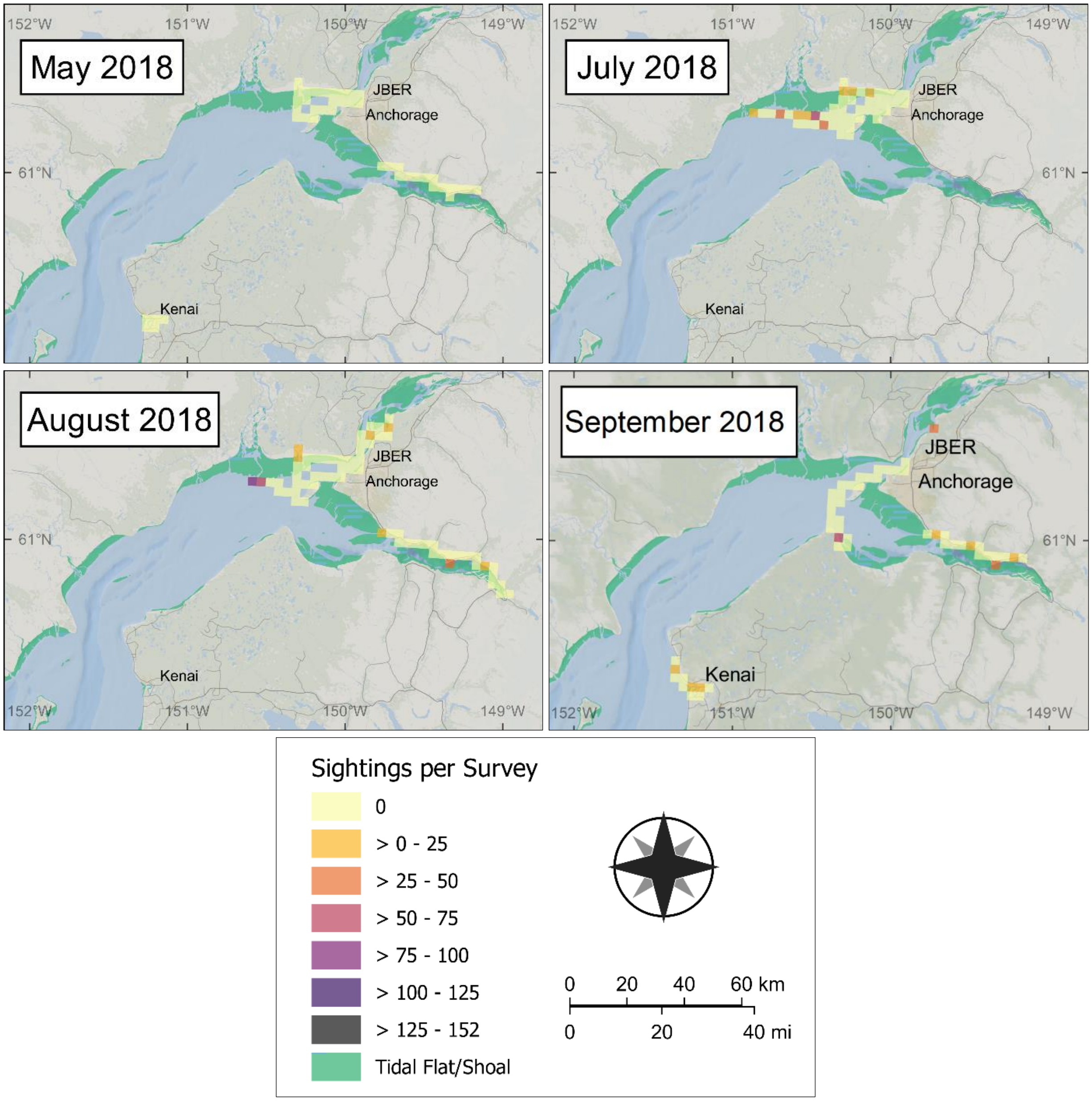


Figure 21. Average counts of belugas per survey by month for surveys conducted during 2018. Values were obtained by partitioning the study area into grid cells 3 km by 3 km and calculating the average number of belugas detected per survey for each cell.

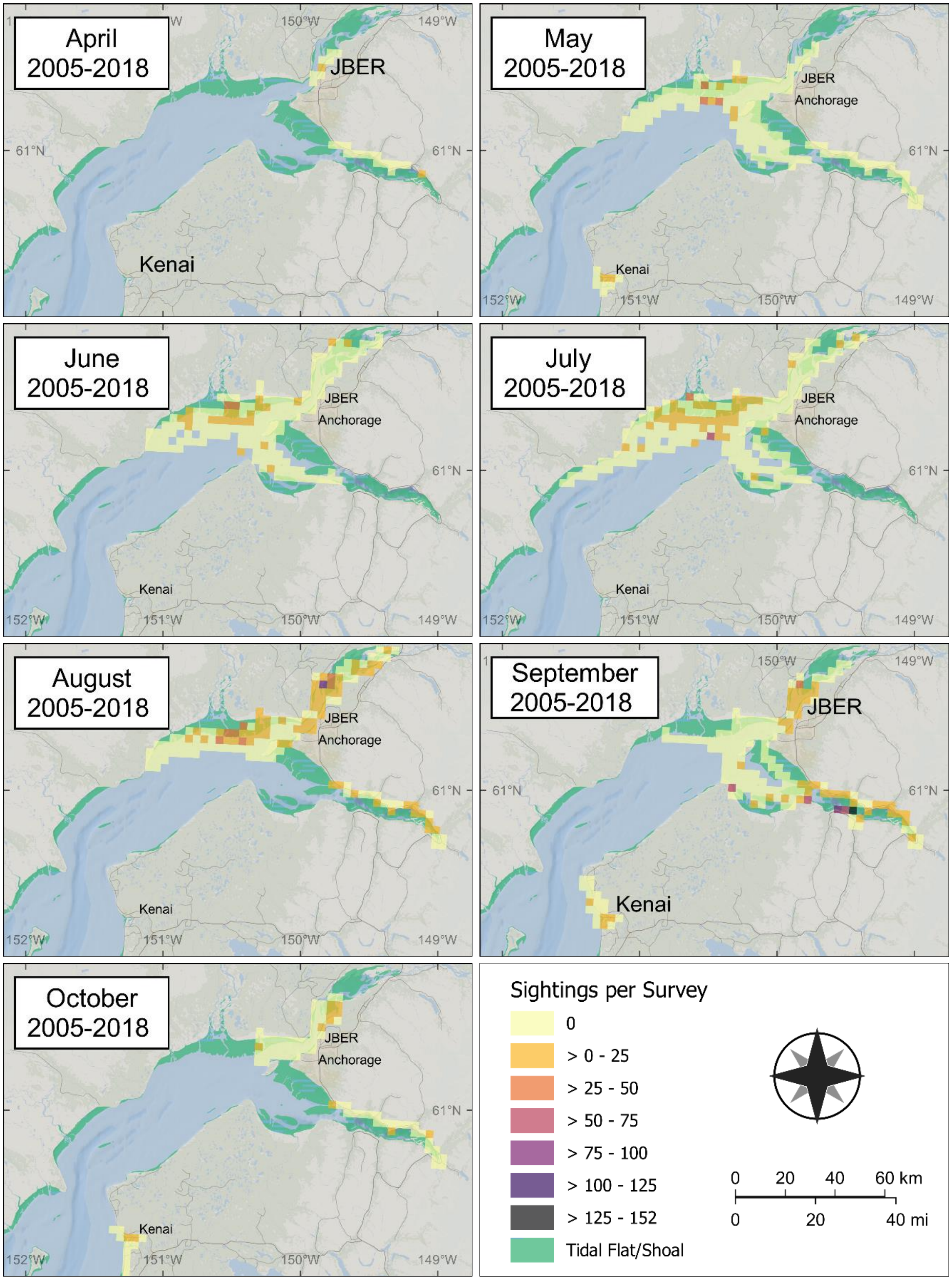


Figure 22. Average counts of belugas per survey by month for surveys conducted from 2005-2018. Values were obtained by partitioning the study area into grid cells 3 km by 3 km and calculating the average number of belugas detected per survey for each cell.

APPENDICES

Appendix A. Daily Survey Routes and Groups Encountered in 2018

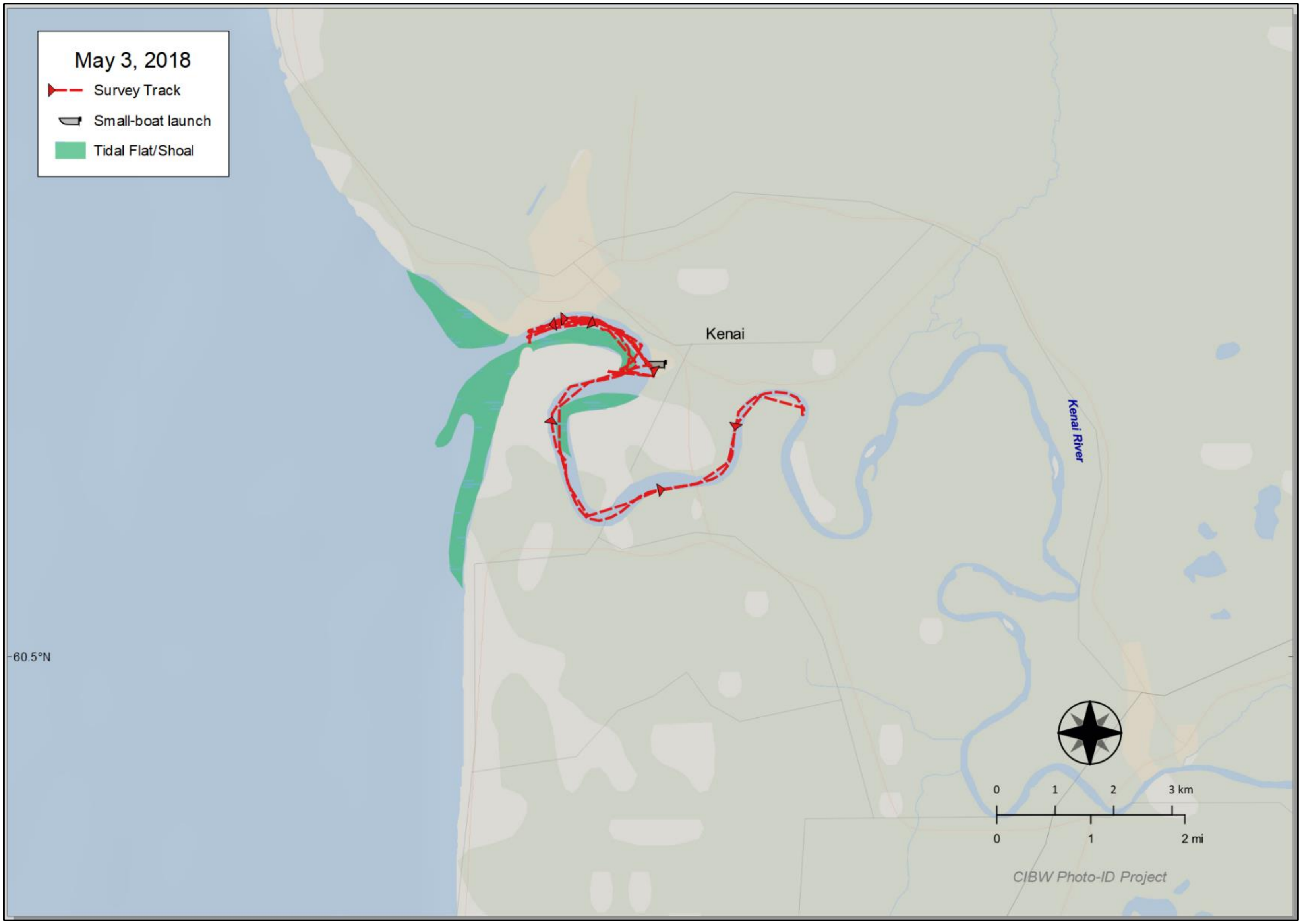


Figure A1. Route during the May 3, 2018 vessel-based survey in the Kenai River Delta, Upper Cook Inlet, Alaska. No beluga groups were encountered this day.

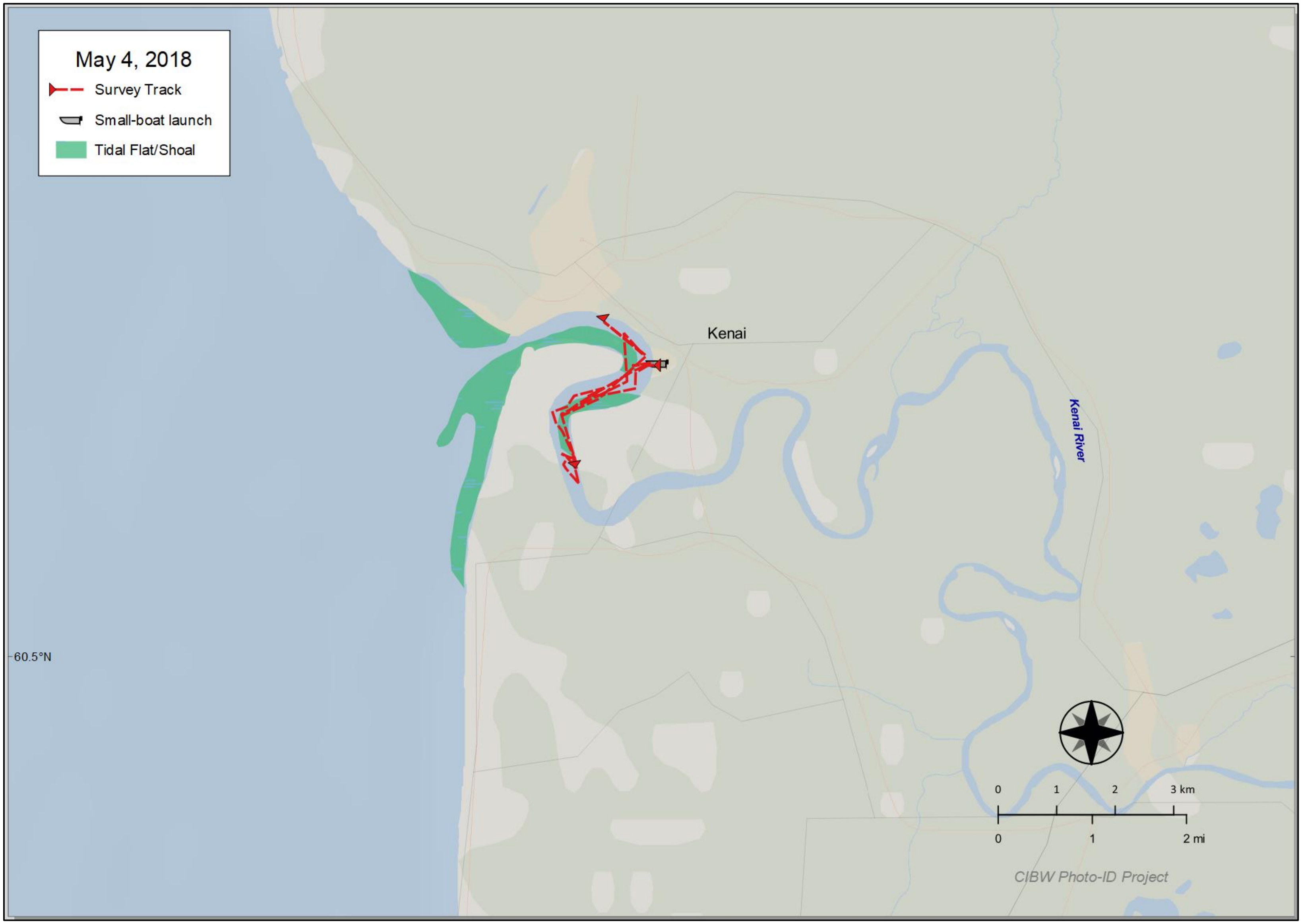


Figure A2. Route during the May 4, 2018 vessel-based survey in the Kenai River Delta, Upper Cook Inlet, Alaska. No beluga groups were encountered this day.

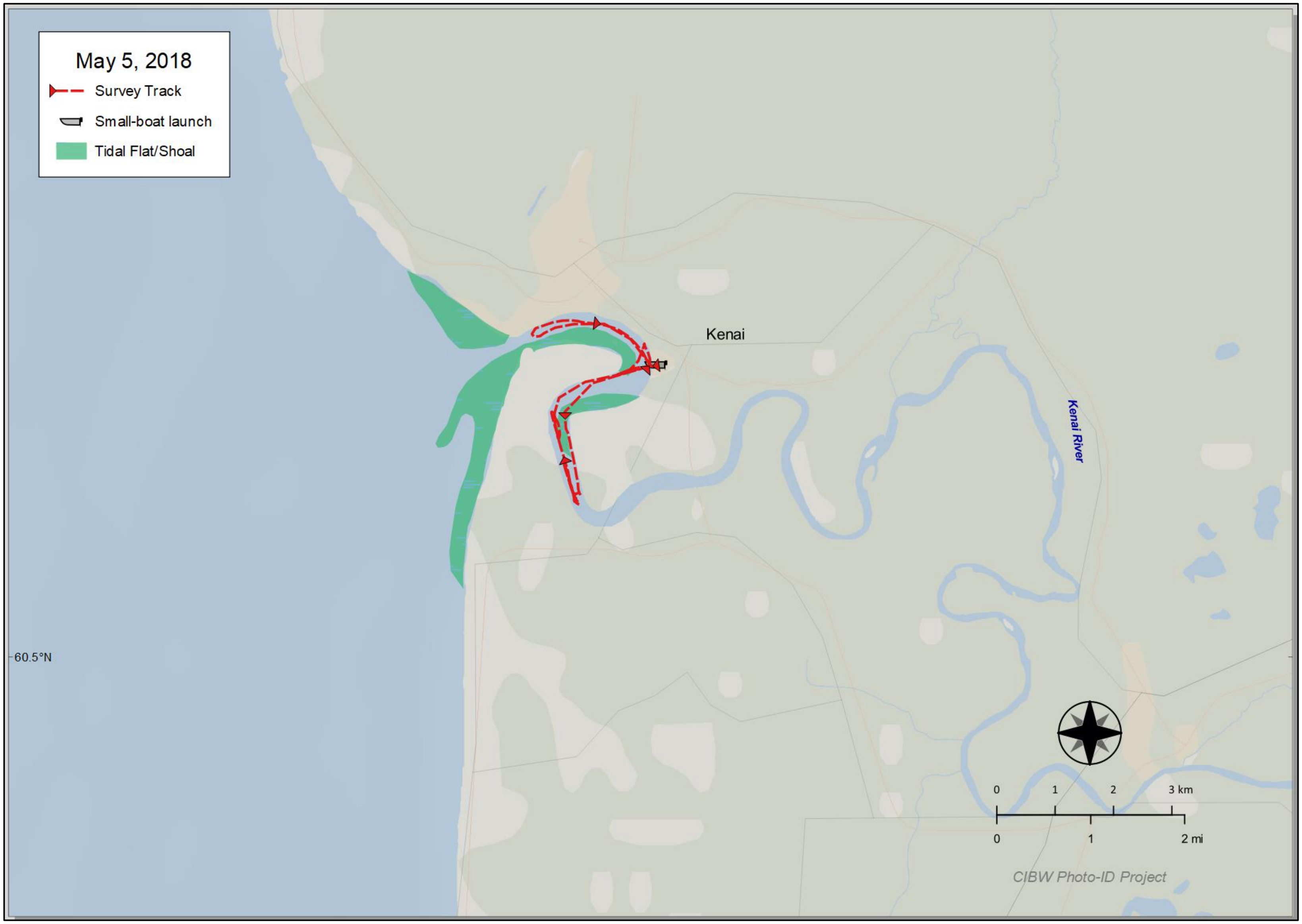


Figure A3. Route during the May 5, 2018 vessel-based survey in the Kenai River Delta, Upper Cook Inlet, Alaska. No beluga groups were encountered this day.

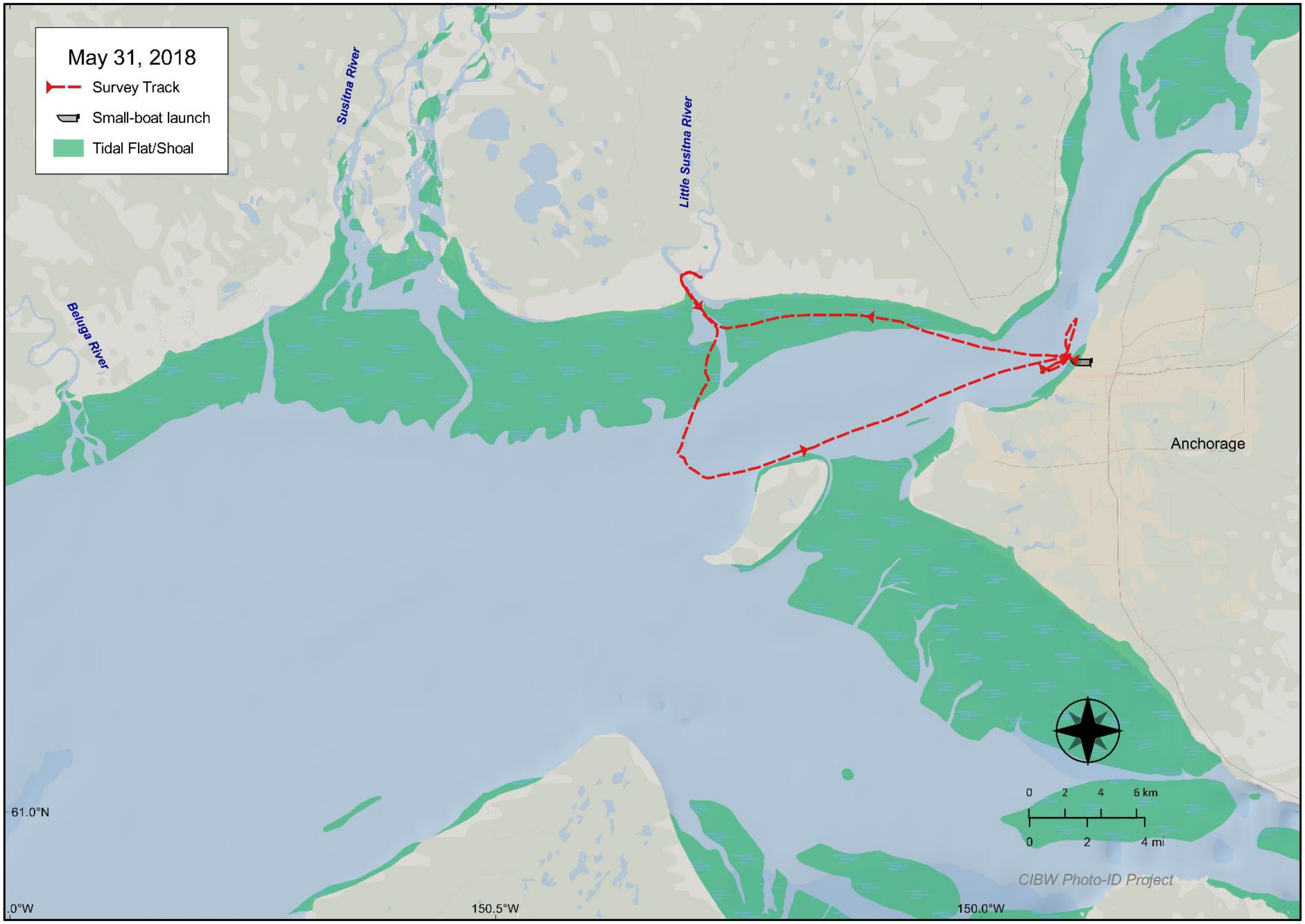


Figure A4. Route during the May 31, 2018 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska. No beluga groups were encountered this day.

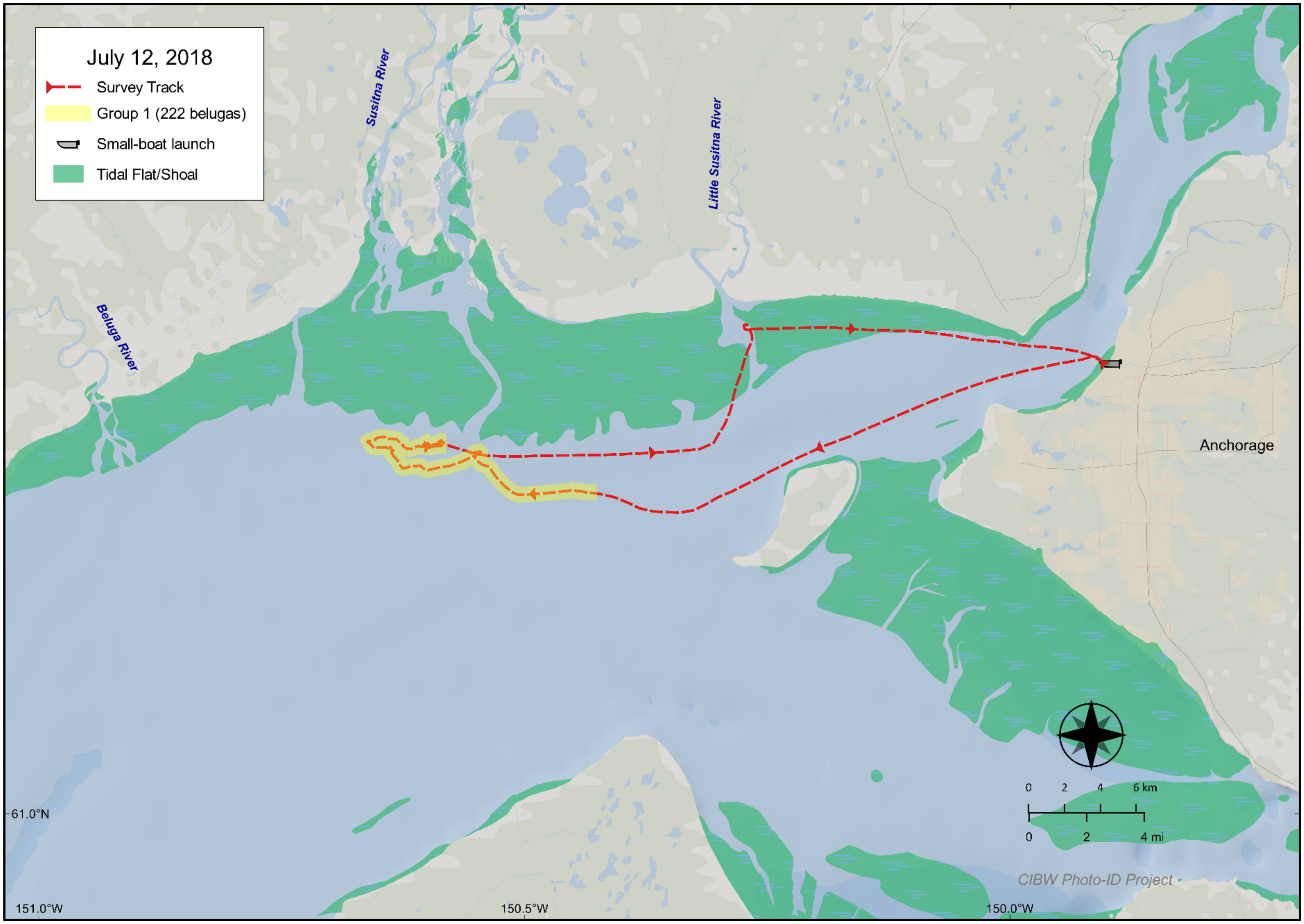


Figure A5. Route and beluga whale group encountered during the July 12, 2018 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

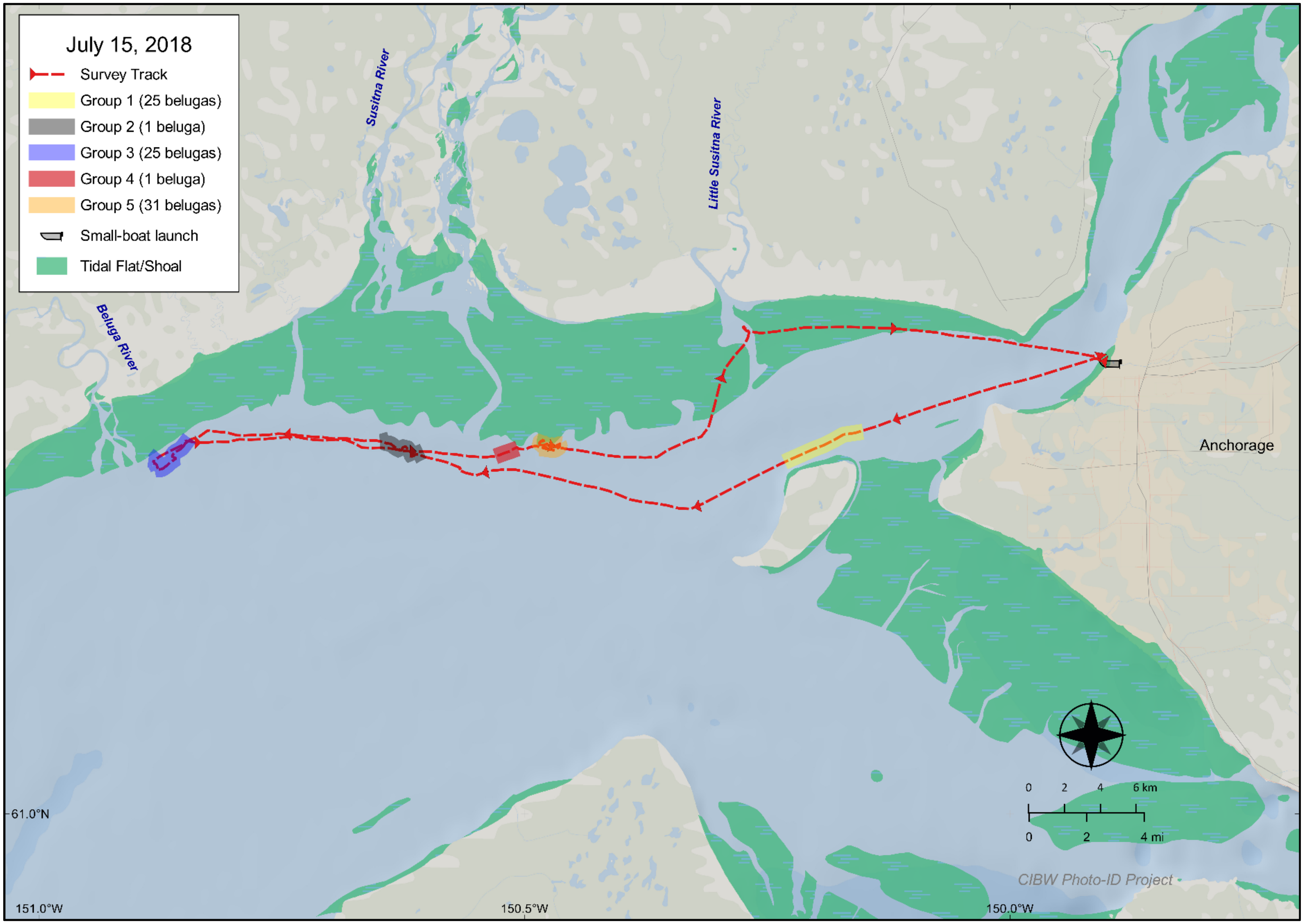


Figure A6. Route and beluga whale groups encountered during the July 15, 2018 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

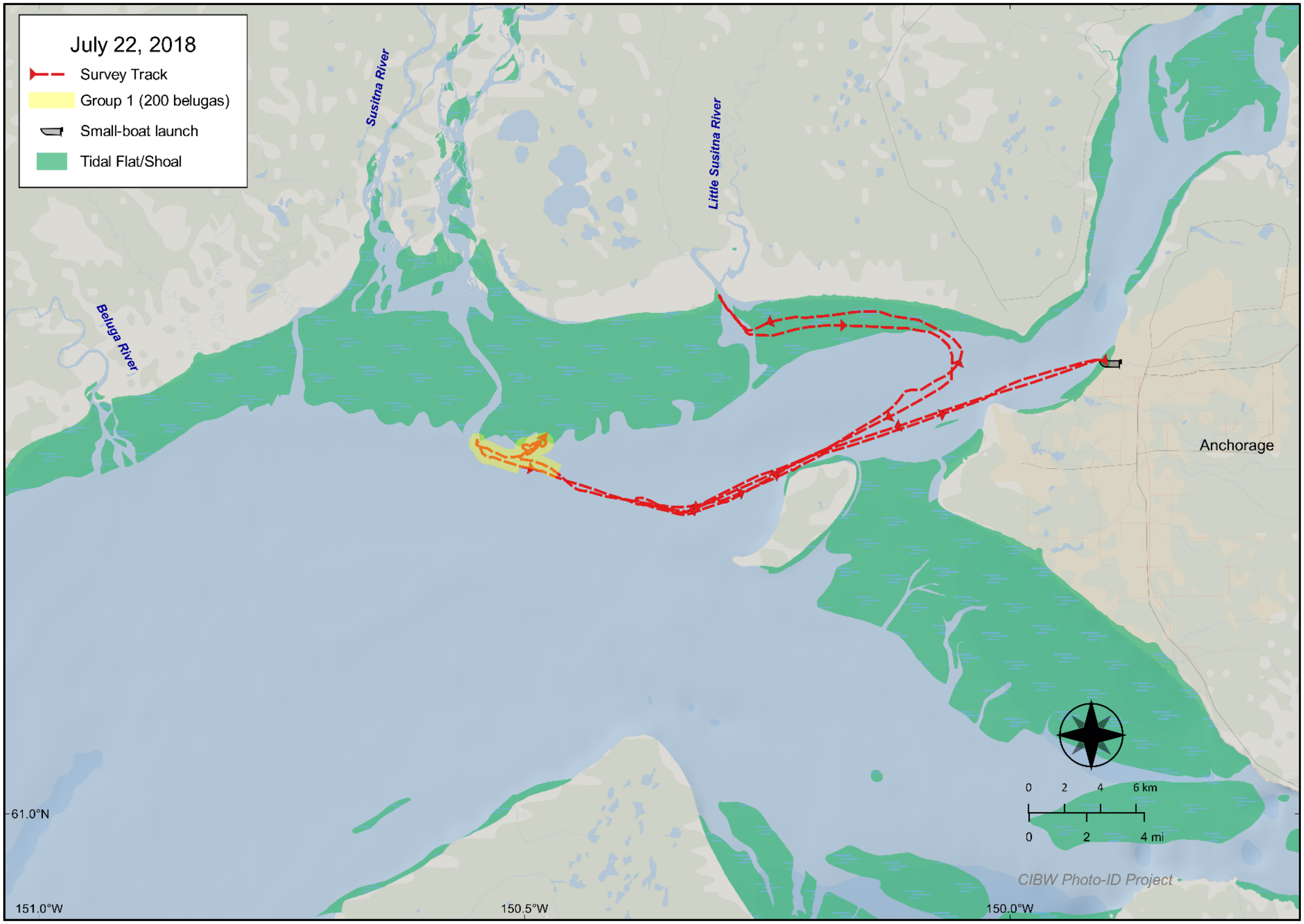


Figure A7. Route and beluga whale group encountered during the July 22, 2018 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

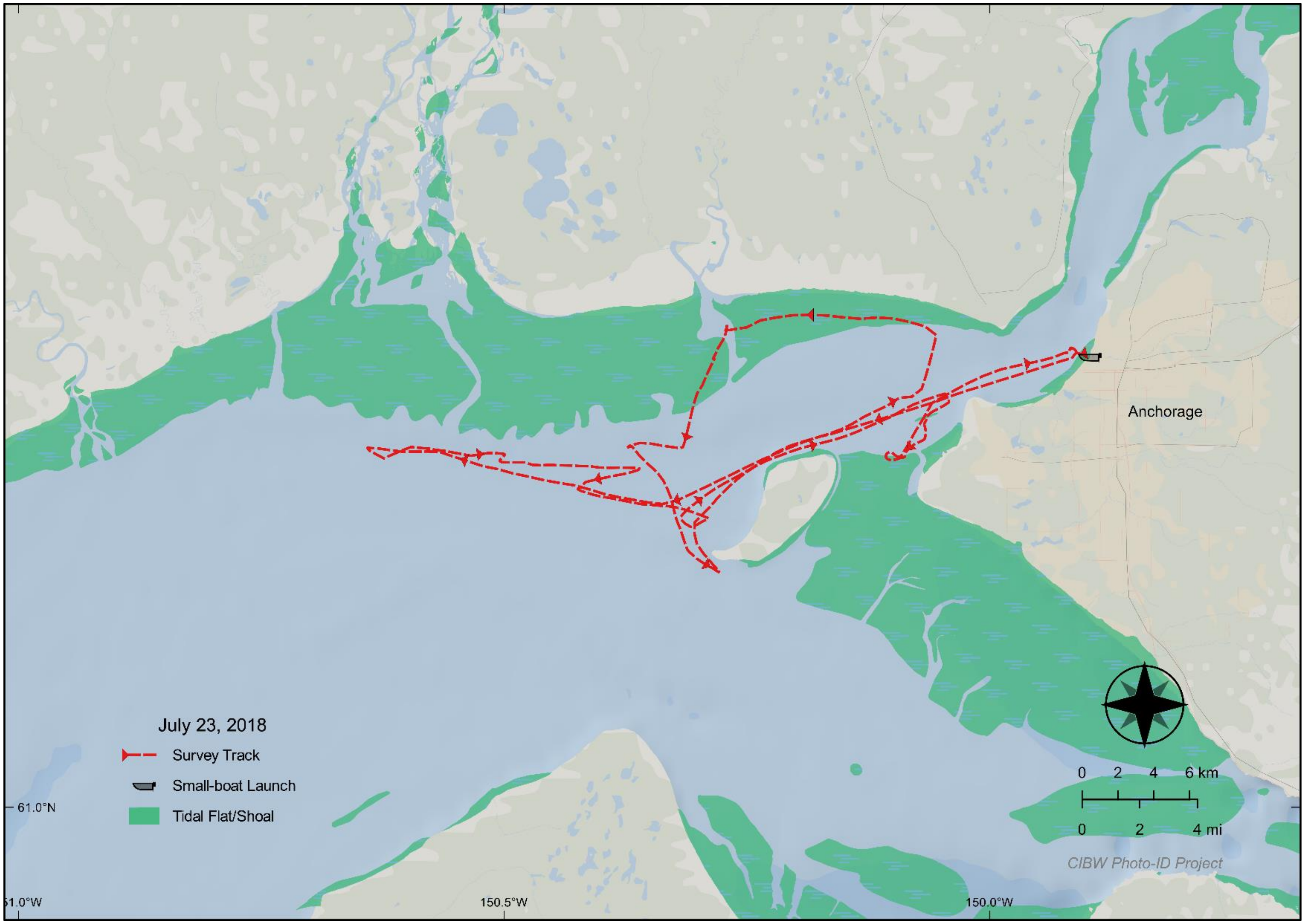


Figure A8. Route during the July 23, 2018 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska. No beluga groups were encountered this day.

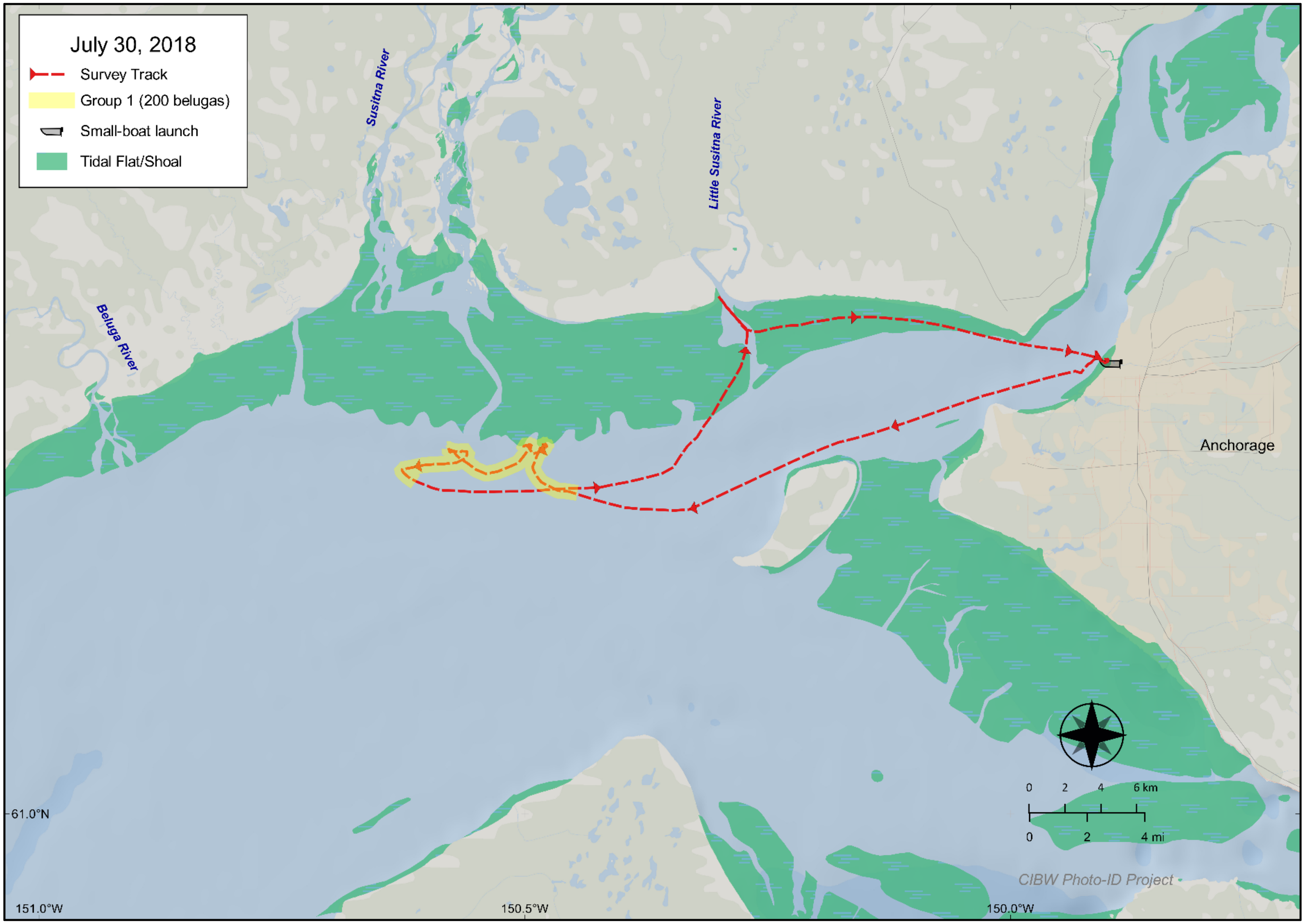


Figure A9. Route and beluga whale group encountered during the July 30, 2018 vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

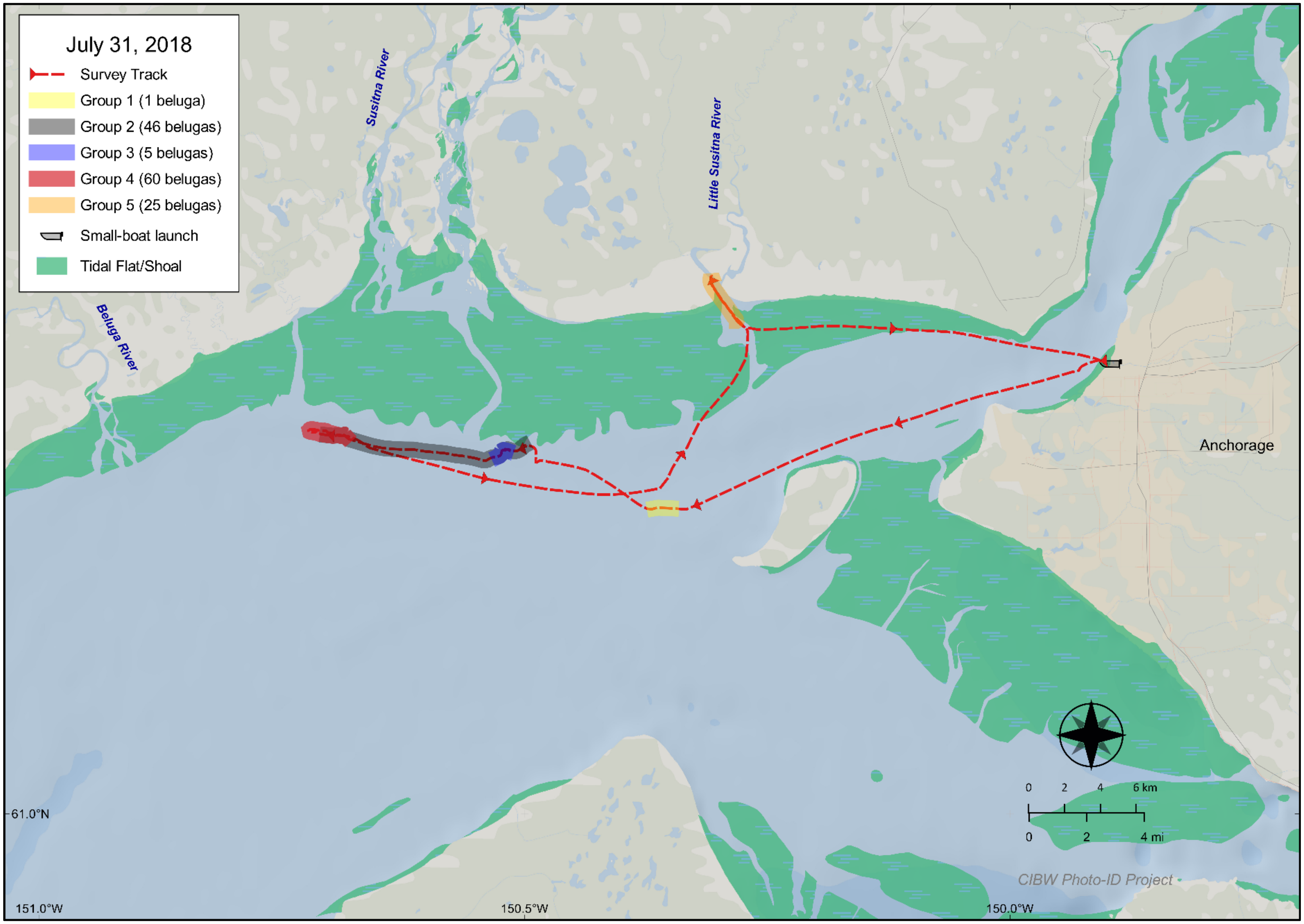


Figure A10. Route and beluga whale groups encountered during the July 31, 2018 vessel-based survey in the Susitna River Delta, Alaska.

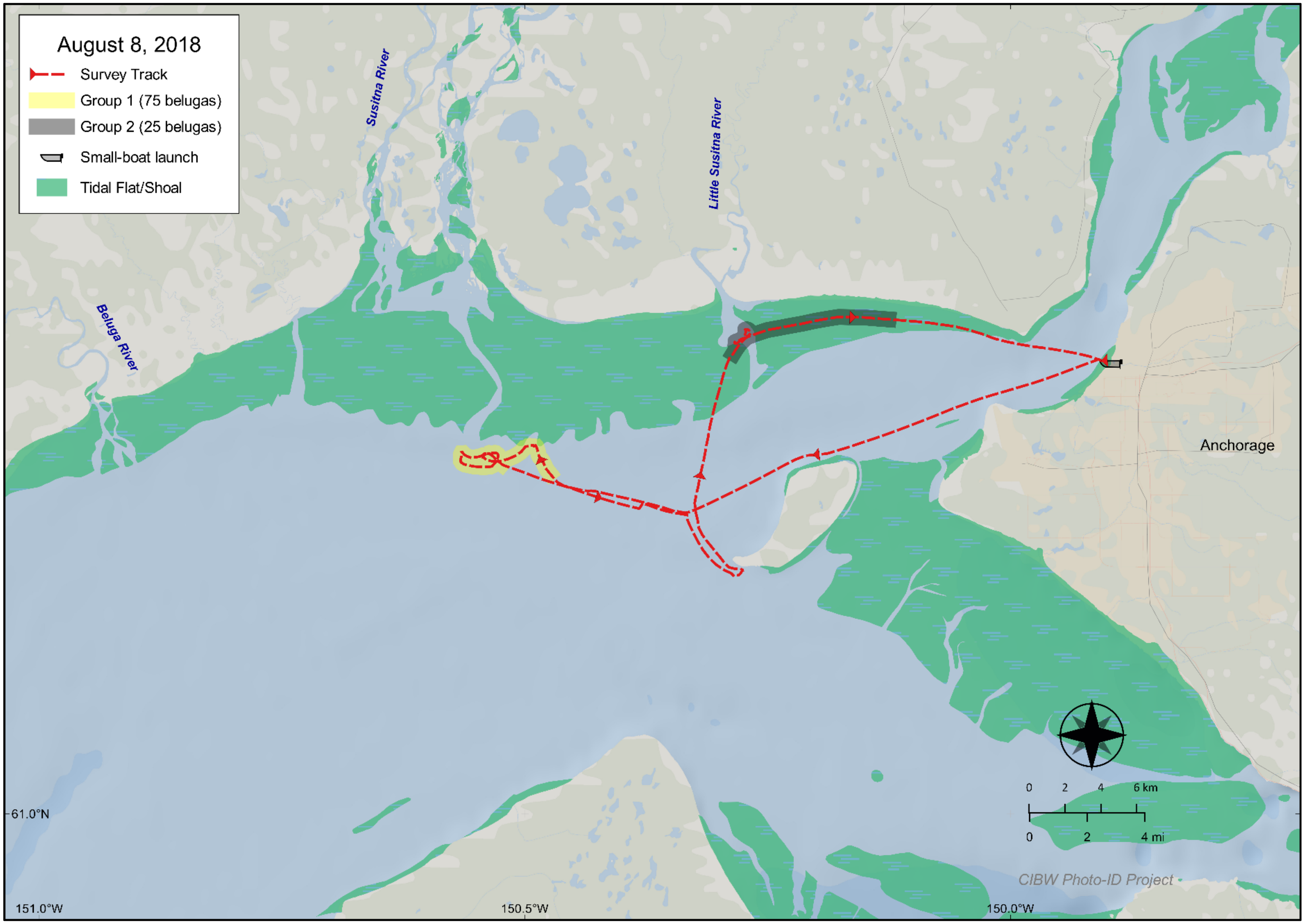


Figure A11. Route and beluga whale groups encountered during the August 8, 2018 vessel-based survey in the Susitna River Delta, Alaska.

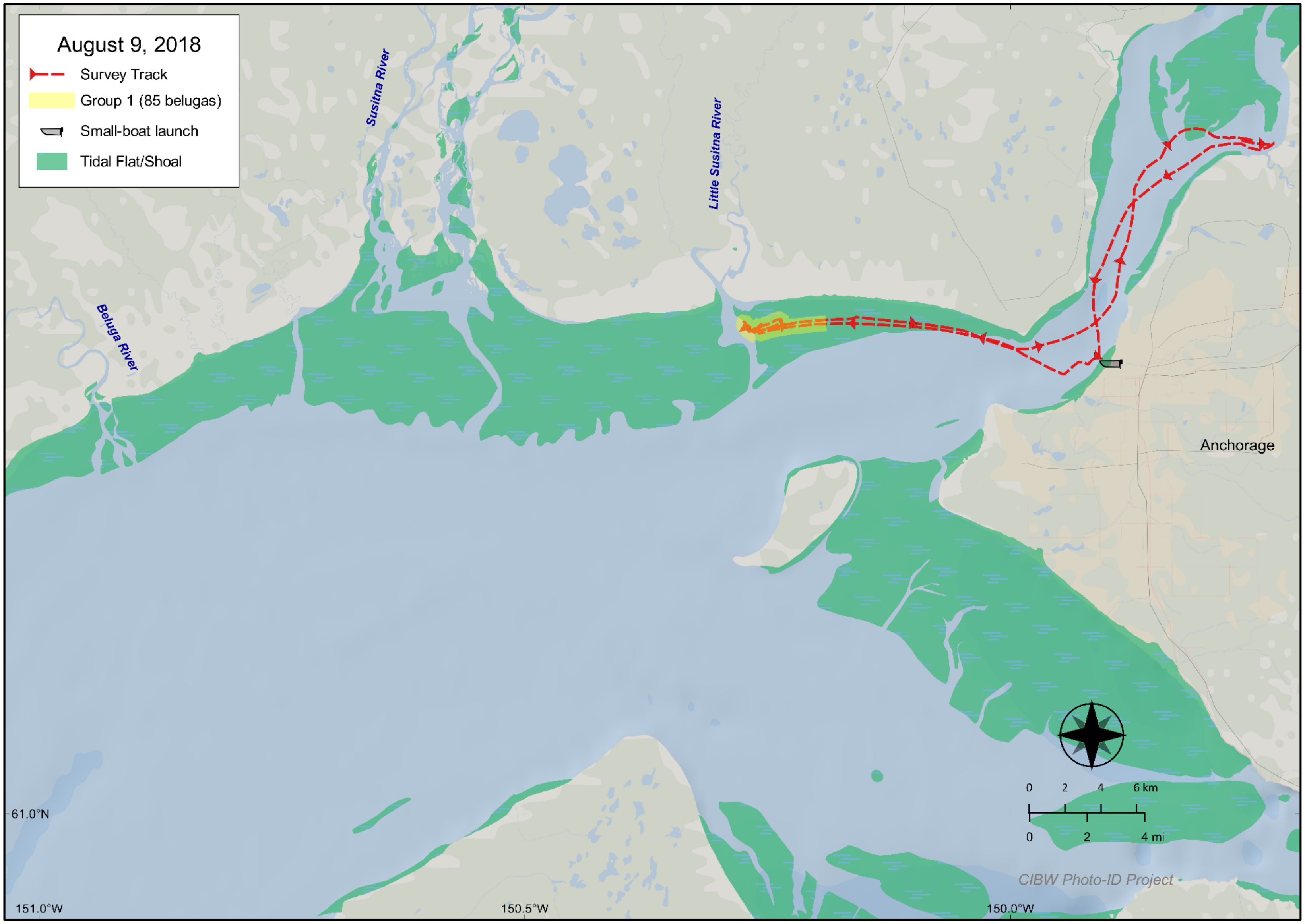


Figure A12. Route and beluga whale group encountered during the August 9, 2018 vessel-based survey in the Susitna River Delta, Alaska.

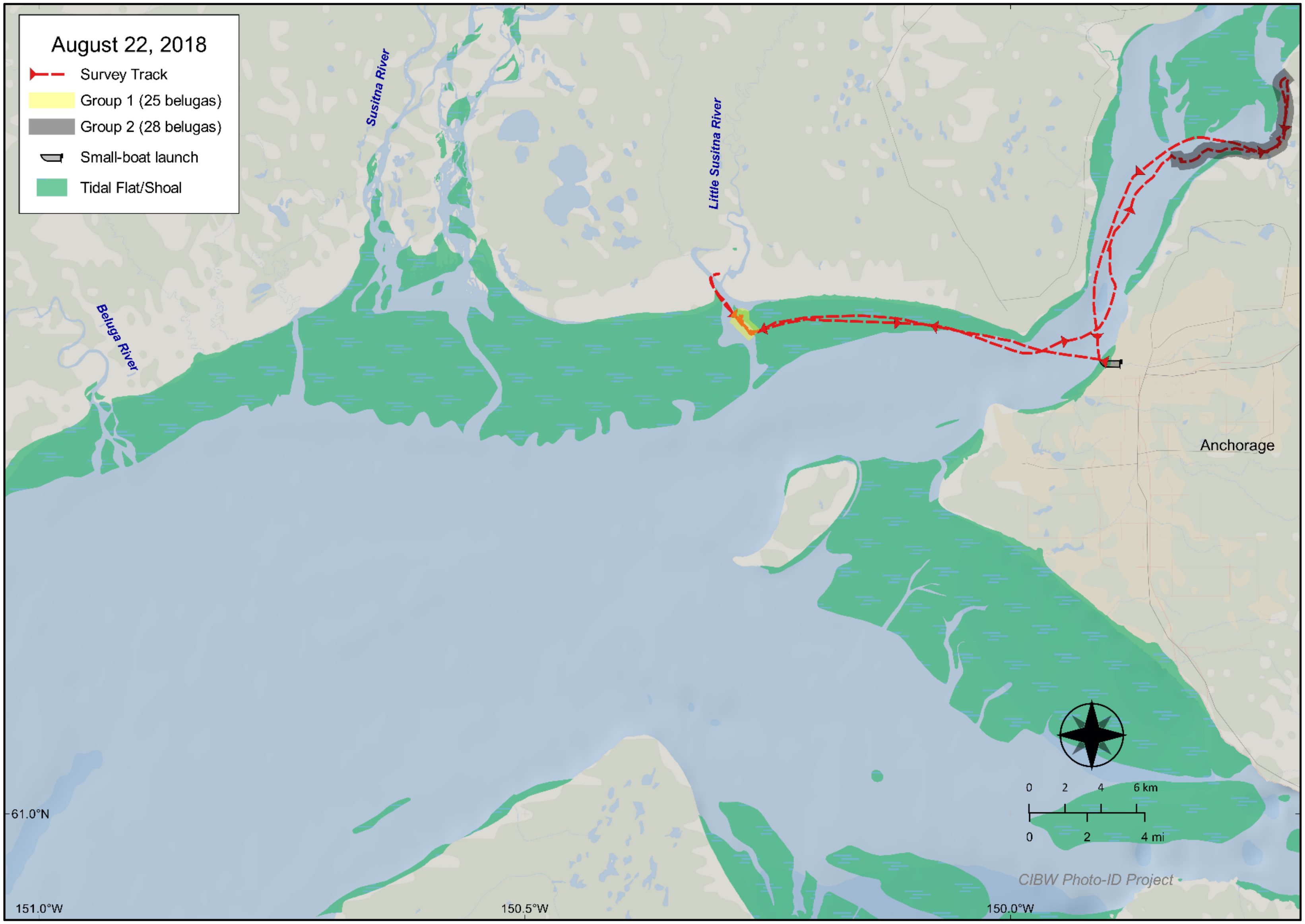


Figure A13. Route and beluga whale groups encountered during the August 22, 2018 vessel-based survey in the Susitna River Delta, Alaska.

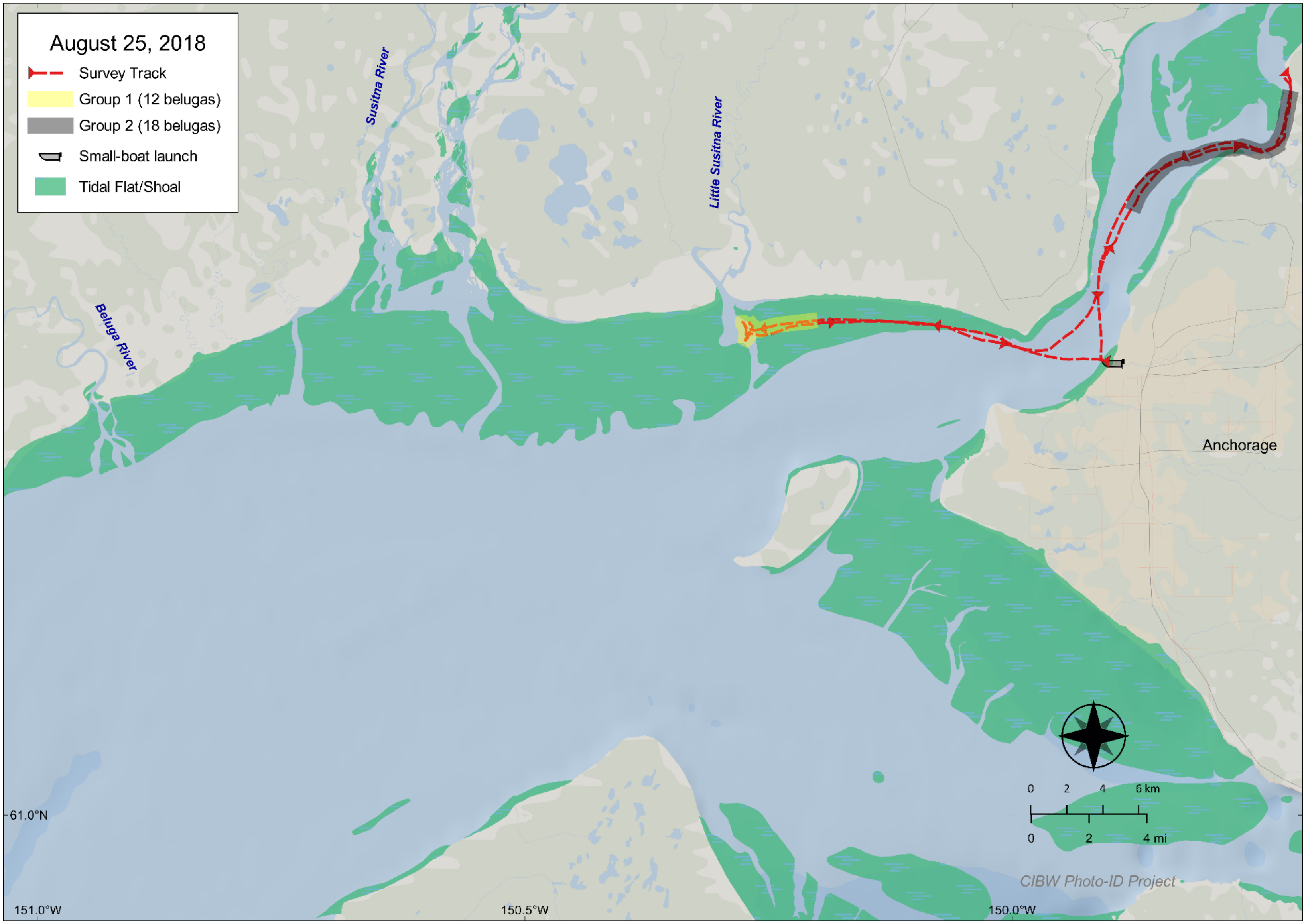


Figure A14. Route and beluga whale groups encountered during the August 25, 2018 vessel-based survey in the Susitna River Delta, Alaska.

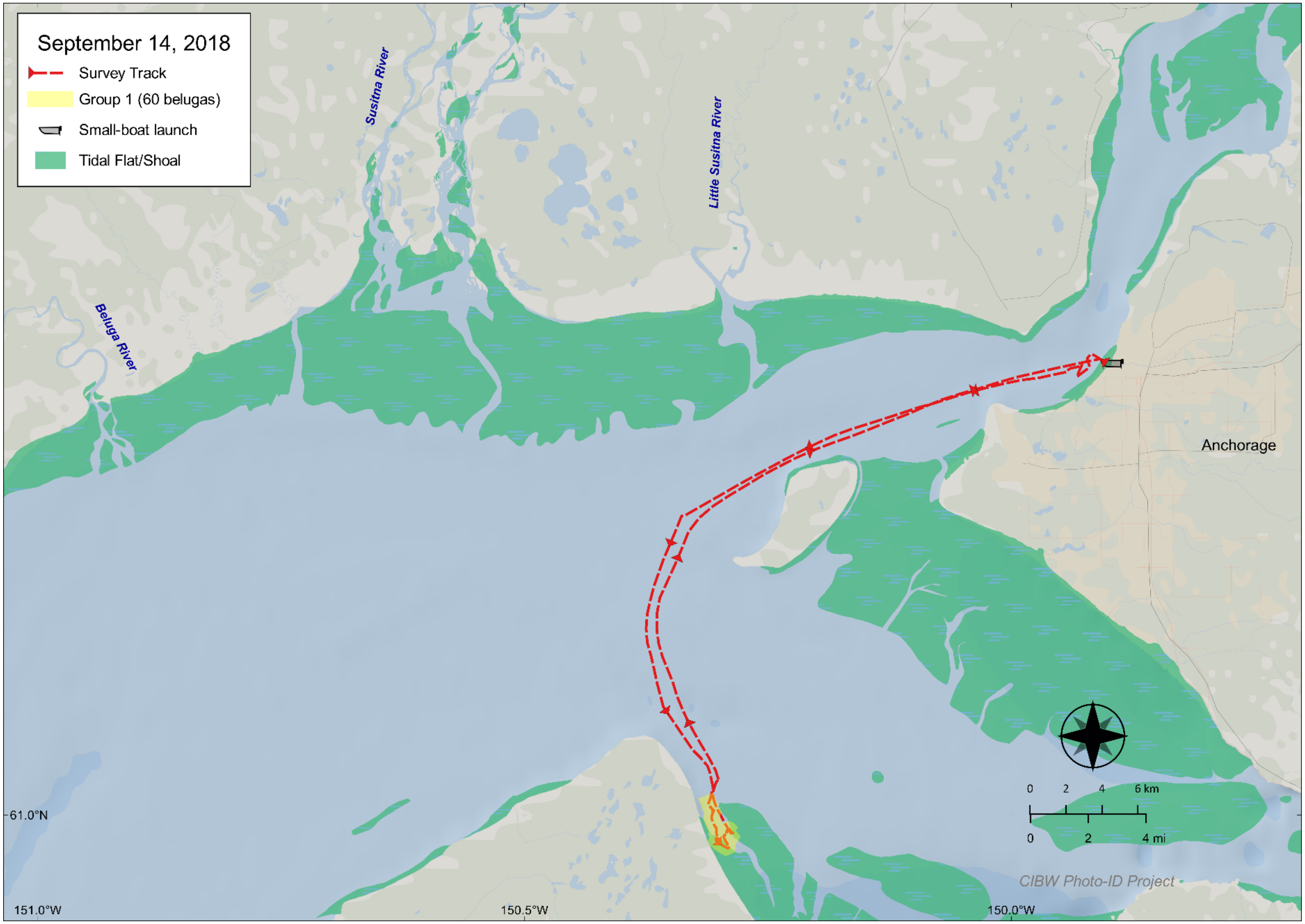


Figure A15. Route and beluga whale group encountered during the September 14, 2018 vessel-based survey in Chickaloon Bay, Alaska.

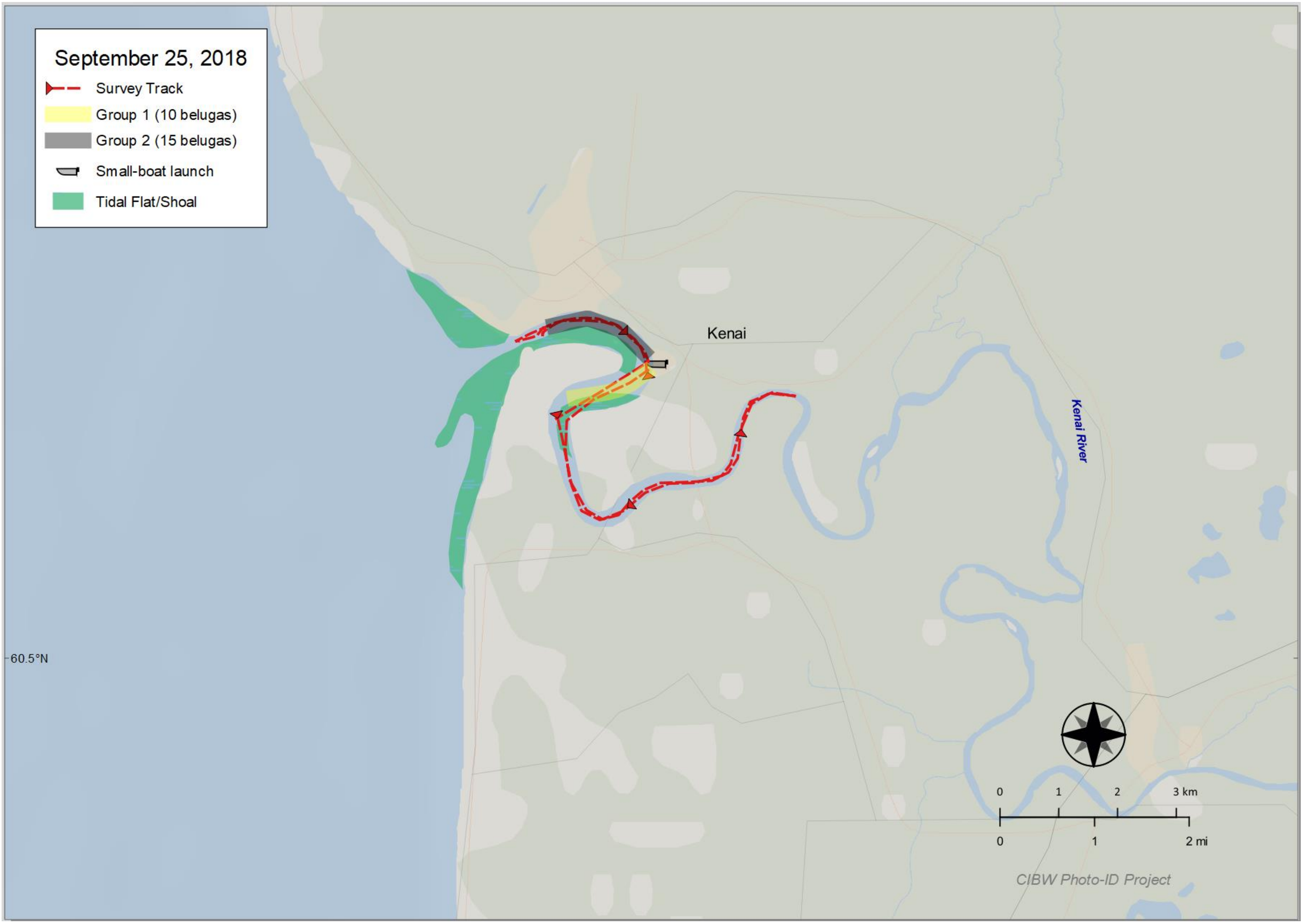


Figure A16. Route and beluga whale groups encountered during the September 25, 2018 vessel-based survey in the Kenai River Delta, Alaska.

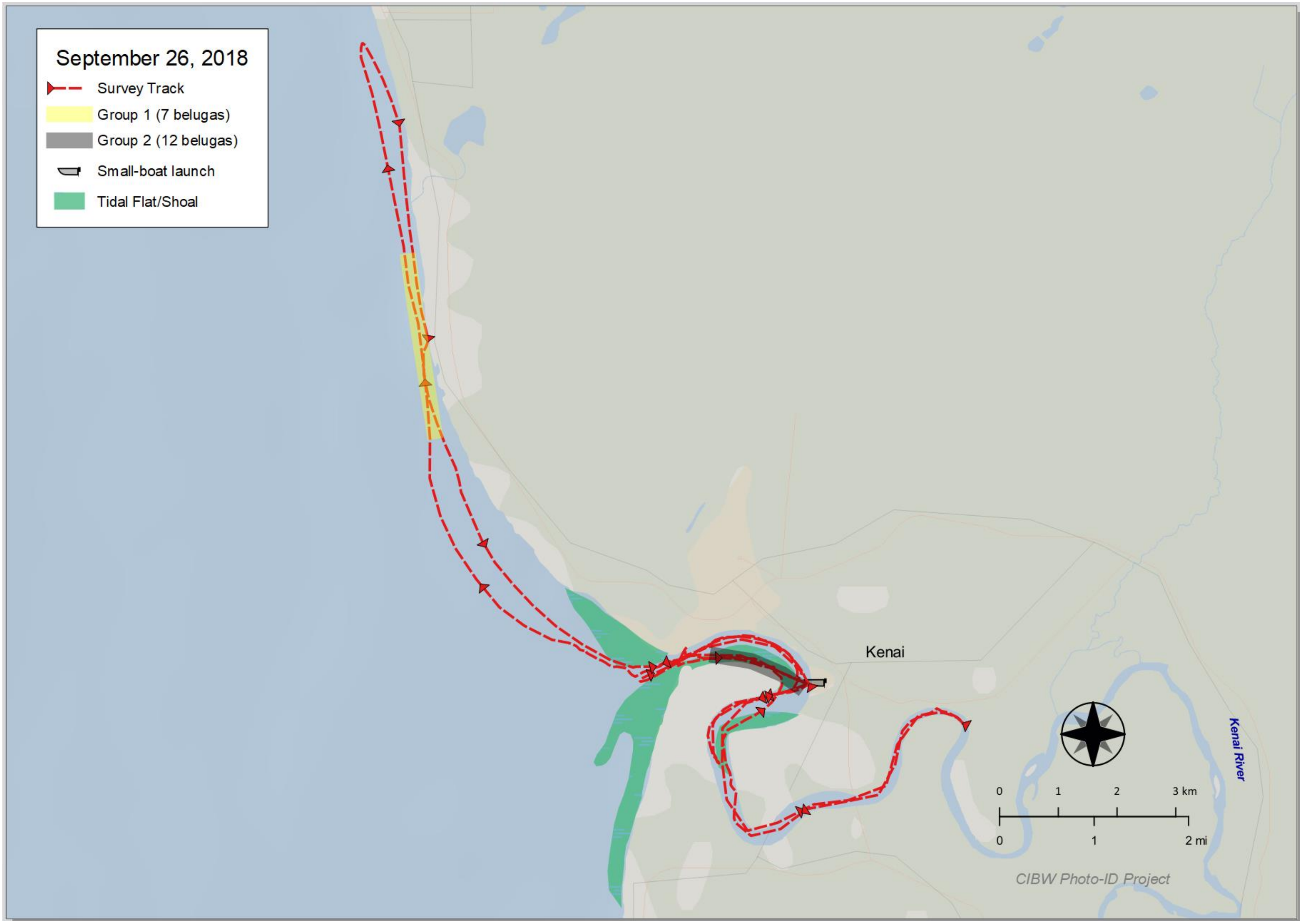


Figure A17. Route and beluga whale groups encountered during the September 26, 2018 vessel-based survey in the Kenai River Delta, Alaska.

Figure A18. Beluga whale group encountered during the September 27, 2018 land-based survey in the Kenai River Delta, Alaska.

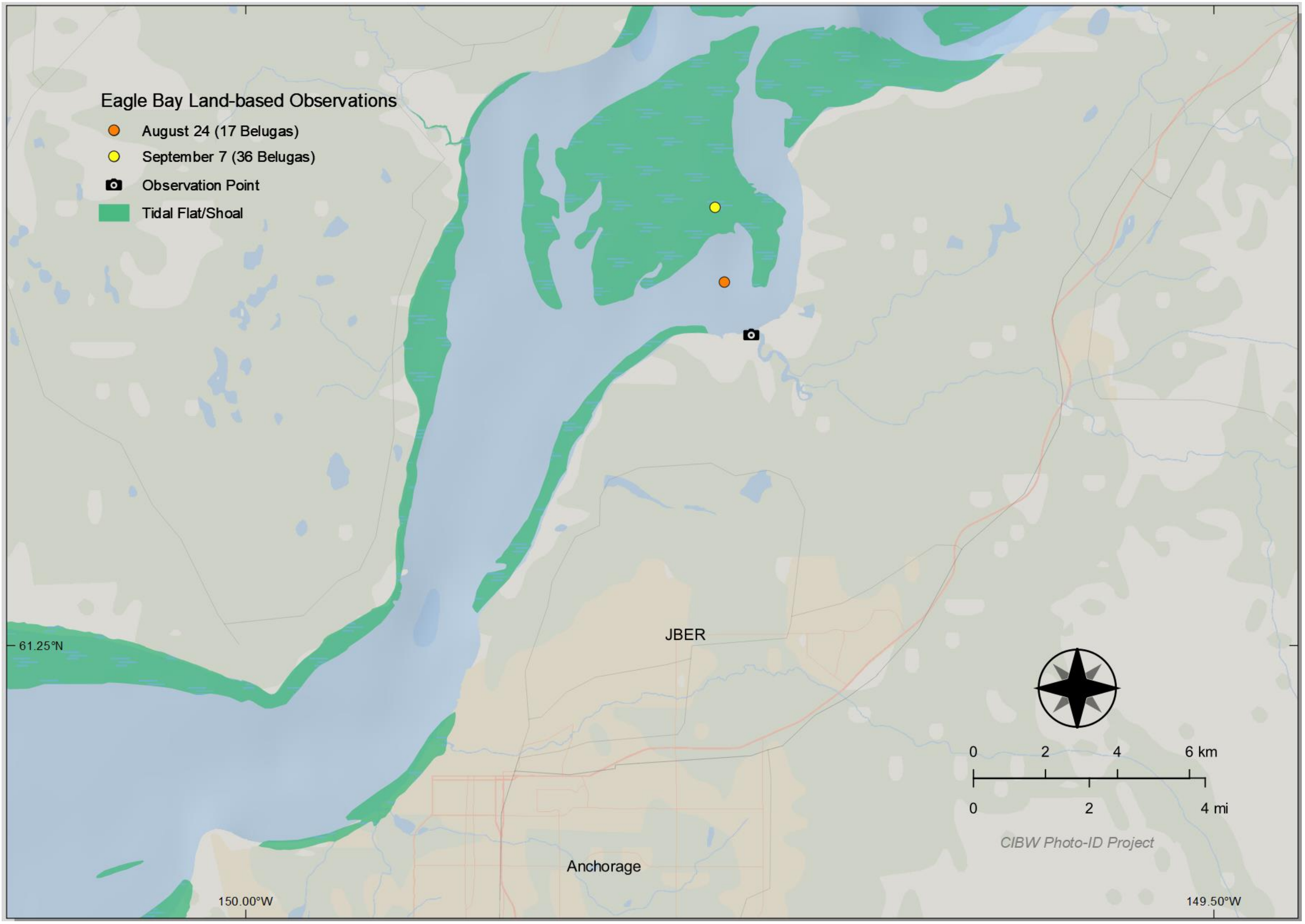


Figure A19. Beluga whale groups encountered during the August 24 and September 7, 2018 land-based surveys in Eagle Bay, Alaska.

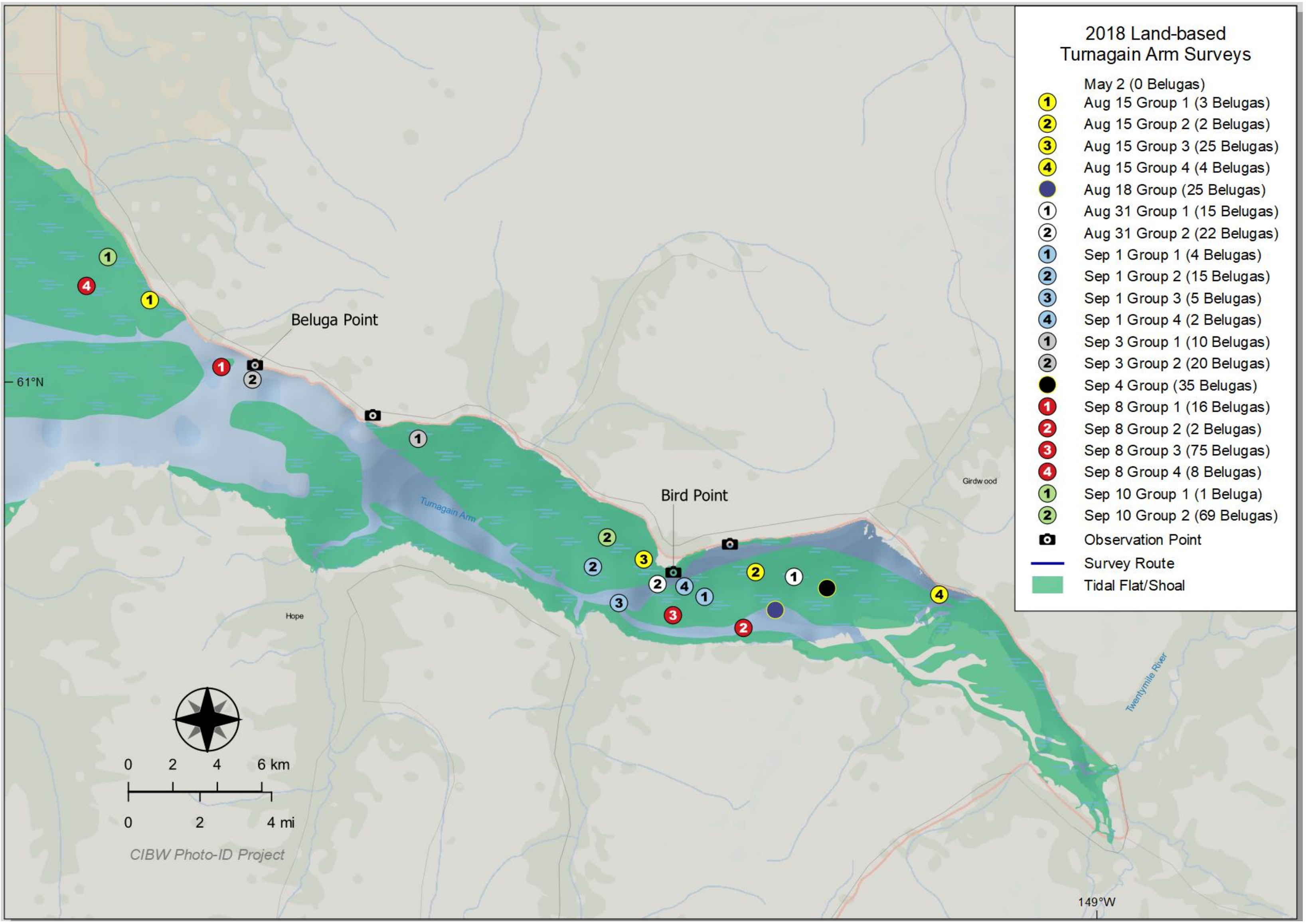


Figure A20. Beluga whale groups encountered in 2018 during land-based surveys in Turnagain Arm, Alaska.

Appendix B: Outreach Activities for the Cook Inlet Beluga Whale Photo-ID Project, 2018

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

- Alaska Marine Science Symposium, Anchorage, AK, January 2018
  - One poster featuring the CIBW Photo-ID Project (Figure B1).
  - Three additional presentations using CIBW Photo-ID Data:
    - Research strategy analysis for Cook Inlet beluga whales. Charlotte Boyd, Gina Himes Boor, Sarah J. Converse, Eiren Jacobson, Tamara McGuire, Mandy Migura, Andre Punt, Lori Quakenbush, Paul Wade
    - Preliminary findings about reproductive status of female belugas from Cook Inlet, Alaska. Kim E. W. Shelden, John Burns, Dan Voss, Kathleen Burek-Huntington, Tamara McGuire, and Barbara Mahoney.
    - Assessing cetacean populations using integrated population models: an example with Cook Inlet beluga whales. Eiren Jacobson, Charlotte Boyd, Gina Himes Boor, Tamara McGuire, André Punt, Kim Shelden, Paul Wade
- Beluga Whale Alliance Public Outreach event, Girdwood, AK, February 2018
- CIBW Research and Coordination Meeting, Anchorage, AK, April 2018

Presentations at Festivals/Events

- Belugas Count! 2018: Staffed a beluga counting station for the public at Bird Point; staffed an information booth at the festival at the Alaska Zoo. Anchorage, Alaska, September 2018.

Factsheets Produced and Distributed

- Informational pamphlet
- Guide for how to photograph free-swimming and 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 fisher folk, 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, as well as a sightings map to view reported sightings. 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, or were prior to a NOAA restructuring of the website, also available on https://alaskafisheries.noaa.gov/pr/beluga-research-cook-inlet. In addition, the CIBW Photo-ID Project has provided their 2005-2018 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.

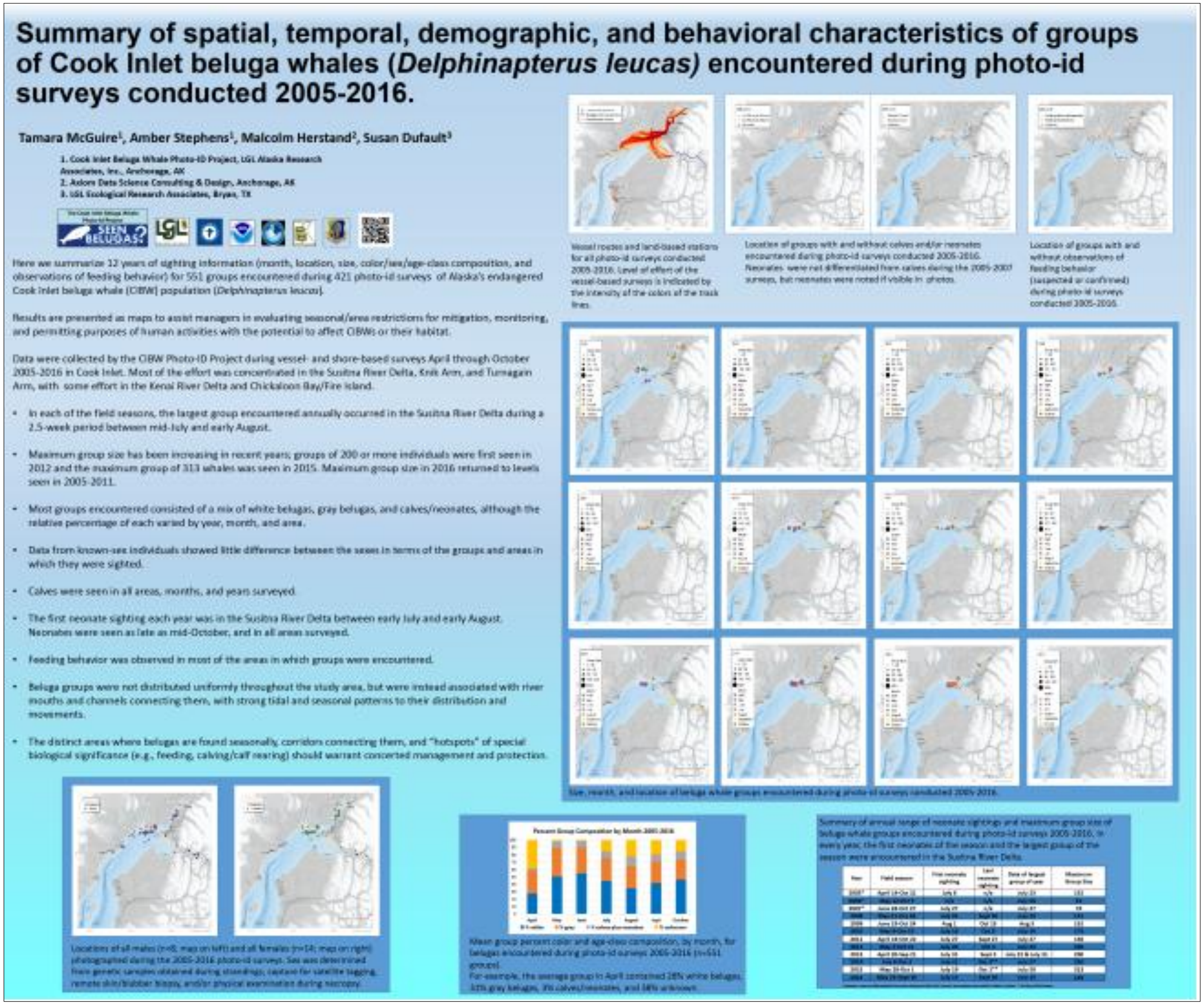


Figure B1. CIBW Photo-Id Project poster presented at the January 2018 Alaska Marine Science Symposium in Anchorage, Alaska.