Photo-Identification of Beluga Whales in Cook Inlet, Alaska

Summary of Field Activities and Whales Identified in 2020

Prepared by:

The Cook Inlet Beluga Whale Photo-ID Project

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TABLE OF CONTENTS

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
FR	Federal Register
GPS	Global Positioning System
IPM	Integrated Population Model
ISO	International Standards Organization
JBER	Joint Base Elmendorf Richardson
JPEG	Joint Photographic Experts Group
MMPA	Marine Mammal Protection Act
MML	Marine Mammal Laboratory (NMFS)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PCoD	Population Consequence of Disturbance model
PVA	Population Viability Analysis
R/V	Research Vessel
SD	Secure digital
SLR	Single lens reflex
TEK	Traditional Ecological Knowledge

LIST OF TABLES

LIST OF FIGURES

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 sixteen field seasons (2005–2020) provide information on the distribution, movement patterns, and life-history characteristics of individually identified CIBWs. This report summarizes field effort and whales identified in 2020. Vessel- and land-based photo-ID surveys were conducted of the Susitna River Delta, Knik Arm, the Kenai River Delta, and Turnagain Arm on 38 days in 2020, bringing the total number of surveys conducted 2005–2020 to 542. Sixty-seven groups were encountered in 2020, with the largest group containing 200 whales. Most groups contained white belugas, gray belugas, and calves. The first neonate of the 2020 field season was seen July 16 (in the Susitna River Delta), and neonates were seen as late as September 18 (in Turnagain Arm). Suspected feeding behavior was observed April–October, and in all areas where beluga groups were encountered.

The CIBW Photo-ID Project catalog contains photographs collected between 2005 and 2020. Sighting histories have been compiled for 487 whales identified by right-side photographs, 519 whales identified by left-side photographs, and 185 whales identified as "dual" whales (i.e., individual whales whose right- and left-side catalog records are linked). Forty-six percent of catalog whales are presumed to be mothers, based on photographs of calves in close proximity. Thirty-one percent of individuals in the dual-side catalog had scars consistent with anthropogenic trauma from entanglement, vessel strikes, and/or non-research punctures. The CIBW Photo-ID Project received three reports of live-stranding events and 10 reports of dead-strandings in 2020. Two stranded whales (one live, one dead) were matched to individuals in the catalog. Eight of the 20 CIBWs originally captured and/or tagged between 1999 and 2002 were photographed alive in 2020. Biopsy samples were obtained from 51 individuals 2016–2019 and photographs of these individuals were matched to the catalog for long-term sighting and reproductive histories. There were 250 incidental reports of sightings of CIBWs received by the CIBW Photo-ID Project in 2020, including sightings in the Upper, Middle, and Lower Inlet. Outreach activities, which included formal and informal presentations about CIBWs and the CIBW Photo-ID Project, were given to community groups and at scientific conferences. There were over 8,131 views by the public of the beluga sighting map for 2020.

We are cautious in reporting life-history parameters such as reproductive or survival rates 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 have been developed using the photo-ID data to quantify the effects of environmental factors and sampling bias on estimating population and life-history parameters and will be updated with the 2020 data. The CIBW Project shares 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 on Upper Cook Inlet and some effort in and near the Kenai River. 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 (McGuire et al. 2020a), movement patterns, and life-history characteristics of individually identified beluga whales, including mothers with calves (McGuire et al. 2020b), and stranded individuals (McGuire et al. 2020c) and individuals showing signs of anthropogenic trauma (McGuire et al. 2021). The CIBW Photo-ID Project has been supported by research grants and contracts from a variety of sources (Table 1) between 2005 and 2020.

This report presents results of vessel-based photo-ID surveys of the Susitna River Delta and Knik Arm, and land-based surveys of the Kenai River Delta, the Kenai River Delta, and Turnagain Arm in 2020. 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 April through October 2020 in Cook Inlet, Alaska (Figure 1). Survey effort was focused on Upper Cook Inlet, primarily in the Susitna River Delta (generally defined here as the area between Tyonek, Point Possession, and Point MacKenzie), Knik Arm, Chickaloon Bay, Fire Island, the Kenai River Delta (defined as the area between the Kasilof River and just south of 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, 2015b), 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. 2020d). 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 2020, 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. Vessel-based surveys in 2020 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 on low tide. Vessel-based surveys were not conducted in the Kenai River Delta in 2020 due to local boat launch conditions that did not allow us to comply with pandemic safety precautions such as social distancing. All vessel surveys were conducted under NMFS MMPA/ESA Scientific Research Permit # 2222.

Shore-based surveys

Shore-based surveys were conducted from observation stations along Turnagain Arm and the Kenai River. Unlike previous years, shore-based observations were not conducted at the mouth of Eagle River in Knik Arm because pandemic restrictions at JBER prevented travel through the restricted area used to access the field site. Photo-ID surveys along Turnagain Arm generally began around four 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 there milling or if several groups of whales traveled 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 in the Kenai River Delta were conducted from sites overlooking the mouth of the Kenai River, the Port of Kenai dock, and at observation sites along the road between Nikiski and Kenai, and Kenai and Kasilof.

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 where 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 3.16 (http://www.qgis.org/) and figures were prepared that showed 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 to 2002. The CIBW Photo-ID Project depends on existing marks and does not apply marks to whales. Mark-type categories were created 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). When the relationship between an individual calf and individual adult was ambiguous, either because of multiple adults being near the calf, little difference in color or size, or a distance of more than several meters between the adult and the calf, the individuals were classified as either *possible mother* or *possible calf*. For more details of methods of classifying mothers and calves in photographs, see McGuire et al. (2020b).

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; 2017; 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 sources are presented in McGuire et al. (2021).

Three experienced photo-analysts independently examined all photos of the dual-side whales in the 2005–2020 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 four types of anthropogenic scars (i.e., puncture, vessel strike, entanglement, and research, which was 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 and fourth field season in 2018 and 2019 (P. Wade, NMFS unpublished data). Photographs were taken of whales at the time of biopsy 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 identified individuals in the 2005–2020 photo-ID catalog and the information was shared with NMFS.

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 2005–2020 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 (2005–2020) have been 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 2005–2020 and are presented graphically for select individuals according to year and geographic area. Locations of cataloged beluga whale sightings were mapped in QGIS version 3.16 (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 NMFS AKR, NMFS's Marine Mammal Lab (MML), and any interested parties who requested a copy of the spreadsheet of annual sightings. Maps of annual sightings are publicly available on the project website.

RESULTS

Surveys

Survey effort, number of whales, and whale groups encountered in 2020

Photo-ID surveys of Cook Inlet were conducted on 38 days in 2020. The fieldwork completed in 2020 brought the project total to 542 photo-ID surveys conducted during sixteen consecutive field seasons (Table 2).

There were 67 groups encountered during photo-ID surveys in 2020 (Table 3; Figure 5). Maps of daily whale group sighting locations and survey routes in 2020 are presented in Appendix A. Figure 6 summarizes the locations of all groups encountered 2005–2020. Mean group size in 2020 was greatest in the Susitna River Delta (mean of 43.7 whales/group) and smallest in the Kenai River Delta (mean of 6.7 whales/group; Table 3). Group size in the Susitna River Delta ranged from 1 to 200 whales (Table 4); with the largest of these groups seen on July 23. Group size in Turnagain Arm in 2020 ranged between one and 41 whales, with the largest group seen on September 9 (Table 5). Group size in Knik Arm in 2020 ranged between 0 and 80 belugas, and 2020 group sizes in the Kenai River Delta ranged between 5 and 8 belugas (Table 6).

Color composition and age class of groups encountered during surveys in 2020

Group composition according to whale color and age-class varied somewhat by survey date and area (Tables 4, 5, 6, 7). All groups but one contained white belugas, while most also contained gray belugas and calves (Table 7). Groups with calves occurred in the same general locations as groups without calves, both in 2020 and for all 2005–2020 surveys combined (Figure 7; Figure 8).

More neonates (i.e., total count, and per group) were seen in the Susitna River Delta than in other areas (Tables 4, 5, 6), while more groups containing neonates (i.e., percent of groups with neonates) were encountered in Knik Arm than in other survey areas (Table 7). Neonates were not observed in groups in the Kenai River Delta in 2020. The greatest number of neonates noted on a single day was three (July 23, August 4, and August 17, all three times in Susitna River Delta).

The first neonate sighting during photo-ID surveys conducted in 2020 was in the Susitna River Delta on July 16 (Tables 4, 8). The first neonates of the season observed during photo-ID surveys in other locations, which were surveyed later in the season, were on August 20 in Knik Arm (Table 6) and on August 26 in Turnagain Arm (Table 5). The neonate on August 20 was extremely small and had patches of what appeared to be afterbirth on it. None of the groups encountered in the Kenai River Delta in 2020 contained neonates (Table 6; Figure 9). For all 2005–2020 surveys combined, groups with neonates occurred in the same general locations as groups without neonates (Table 8; Figure 10). Possible CIBW births in 2020 were observed on August 4 in the Susitna River Delta (Table 9) and August 21 in Knik Arm (Table 10).

Feeding behavior of whale groups encountered in 2020

Feeding behavior (suspected and confirmed) was observed in all months of the April–October 2020 field season, and in all the survey areas in which beluga groups were encountered (Figure 11; Tables 9, 10, 11) consistent with patterns from previous years of the study (Figure 12).

Stranded belugas photographed in 2020

The CIBW Photo-ID Project received three reports of live-stranding events in 2020 (Table 12) and was provided with photographs of two of these events. Ten belugas were reported dead-stranded in 2020 (Table 12) and photographs of nine of these were shared with the CIBW Photo-ID Project by NMFS and by other members of the Alaska Marine Mammal Stranding Network (Table 12). Two of the stranded whales (one live, one dead) were matched to individuals already in the 2005–2020 catalog; the others could not be matched either because the photos were taken at too great a distance, or the carcass was too decomposed for identification (Table 12).

Of the ten dead belugas, there were two males, four females, and four individuals of unknown sex. Two dead individuals were classified as adults, six individuals were classified as a calf or fetus, and one was classified as a subadult. One individual was of unknown age class. Eight of these 10 stranded animals were necropsied/sampled by the Alaska Marine Mammal Stranding Network.

Incidental sighting reports of belugas in 2020

The CIBW Photo-ID Project received 250 incidental reports of CIBW sightings in 2020 (Table 13). There were 8,131 views of the 2020 incidental sightings map on the CIBW Photo-ID Project website. Sightings were reported by fisherfolk, pilots, the media, law enforcement officers, vessel operators, tourists, biologists, educators, students, regulators, port operations staff, Protected Species Observers, 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 conducted by the Alaska Beluga Whale Monitoring Partnership, the Beluga Whale Alliance, and the Alaska Wildlife Alliance, as well as during CIBW Photo-ID Project participation in various outreach activities. In 2020, belugas were reported in every month of the year except December, as far north as Knik Arm and as far south as Kachemak Bay (Table 13; Figure

13). Compiled incidental sightings from 2005–2020 were made in all months of the year, and from Knik Arm to Kachemak Bay (Table 14).

Human Interactions during Photo-ID Surveys in 2020

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 seemed initially unaware that belugas were present.

Aircraft activity (e.g., small recreational planes and helicopters, large commercial aircraft for cargo and passengers, 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, setnetting, dipnetting, non-research drones, near-shore road construction, paddleboarders, surfers, and research activities (including the photo-ID survey vessel and vessels deploying/servicing acoustic gear).

Other Marine Mammals Encountered during CIBW Surveys or Reported to the Project, 2020

Harbor seals (*Phoca vitulina*) were commonly encountered in all areas surveyed in 2020. 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.

Reports were received from NMFS and the public of a live-stranded gray whale (*Eschrichtius robustus*) in Turnagain Arm in late May. There was a reported sighting of a live Steller sea lion (*Eumetopias jubatus*), also in Turnagain Arm in late May. A member of the public reported blows from a large whale of unknown, non-beluga, species by Point Woronzof in late August. Harbor porpoise (*Phocoena phocoena*) may have been observed as single animals on a few occasions during surveys near Fire Island but were not confirmed with photographs.

Other marine mammals that occasionally have been reported in Upper Cook Inlet in previous years of the study (McGuire and Stephens 2017) but were not encountered during surveys in 2020 are Dall's porpoises (*Phocoenoides dalli*), orcas (*Orcinus orca*) and fin whales (*Balaenoptera physalus*).

Catalog Development and Current Status 2005–2020

The CIBW Photo-ID Project took approximately 46,000 photographs in 2020. The public and colleagues provided photos of incidental sightings and stranded belugas, sharing approximately 2,000 photos in 2020. These include photos taken by biologists from Joint Base Elmendorf-Richardson (JBER) during land-based beluga observations, from MML during their vessel-based biopsy and aerial drone surveys, from the Alaska Department of Fish and Game (ADFG) along the Seward Highway, and from citizen scientists and the general public.

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 2019. In this current report, the right- and left-side catalogs have been updated simultaneously with results from the 2020 field season.

Sighting Histories of Identified Belugas 2005–2020

The following summary of sightings between 2005 and 2020 is for individuals in the right-side catalog, the left-side catalog, the dual catalog, and for subsets of particular interest.

Right-side catalog 2005–2020

The 2005–2020 right-side catalog contains records for 487 individuals (Figure 14a; Table 15), with 151 of these individuals photographed in 2020. There were 22 individuals added to the catalog who had been photographed in previous years but did not meet the criteria to become catalog individuals until the photos from 2020 were added to their sighting records. No new individuals were added to the catalog that were first photographed in 2020. Nine percent of the whales in the right-side catalog were seen over the 16-year period spanning 2005 to 2020 (i.e., they were photographed in both 2005 and in 2020; Table 15). Seven individuals in the 2005–2020 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 2009. There are 70 individuals in the right-side catalog suspected to have died by 2020 based on the lack of sightings after 2009, and another seven confirmed dead (from stranding records), leaving 410 individuals in the right-side catalog that may still be in the population in 2020.

Left-side catalog 2005–2020

The 2005–2020 left-side catalog contains records for 519 individuals (Figure 14b; Table 15), with 185 individuals photographed in 2020. No new individuals first photographed in 2020 were added to the catalog. There were 6 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 2020 were added to their sighting records. Nine percent of the whales in the left-side catalog were seen over the 16-year period spanning 2005 to 2020 (i.e., they were photographed in both 2005 and in 2020; Table 15). 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 2009. There are 58 individuals in the left-side catalog suspected to have died based on the lack of sightings after 2009, and another ten confirmed dead (from stranding records), leaving 451 individuals in the left-side catalog that may still be in the population in 2020.

Dual catalog 2005–2020

The 2005–2020 dual-side catalog contains records for 185 individuals (i.e., individuals whose right- and left-side catalog records are linked and who meet the criteria to be catalog individuals on at least one side (Figure 14c). In 2020, there were 70 new dual linkages made for individuals in the catalog. One dual-side individual who was photographed as recently as 2020 was identified in photographs taken by NMFS in 1998, giving it a 23-year sighting history (Table 15).

Classification of anthropogenic scars 2005–2020

Thirty-one percent (n=58 of 185) of 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 16. One of the 58 was a confirmed female, 47 were presumed or possible females, five were confirmed males, and five were presumed males. There were 29 individuals with scars from possible entanglements, as well as one dead beluga with confirmed entanglement scars, and one live beluga photographed with a heavy line encircling it. Twenty-eight individuals had scars that were possibly from vessel-strikes, and one individual had scars confirmed to be from a vessel-strike. Twenty-one individuals had scars that were possibly from puncture wounds. Several individuals had possible anthropogenic trauma scars from multiple possible sources, therefore numbers will not be additive across categories.

Identified individuals with satellite-tag scars 2005–2020

During a NMFS-led CIBW satellite tagging study between 1999 and 2002, a total of 20 CIBWs were captured and 18 of these were tagged; 12 of the 20 were female and eight were male (Table 17). 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 2005–2020 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 17); 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 to 2020 (Table 18). 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. Beluga D111, a female tagged in 2000, was photographed in 2019 with a neonate, and possibly with a larger calf in 2020. She had first been photographed with a calf in 2009 (calf estimated to be no more than 2 years old). She was again photographed with a calf in 2014 (calf estimated to be at least two years old) and in 2015 with a neonate, resulting in possible inter-calf intervals of 5, 3, and 4 years.

Thirteen individuals in the 2005–2020 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 18), and another individual was noted to have scars that may have been made by either satellite tag or by gunshot. Details on the photo-ID records of these individuals are presented in McGuire and Stephens (2016). Ten of these individuals were each photographed with an accompanying calf at least once during 2005 to 2020, and one was photographed with a possible calf. Photographic records of satellite-tag scars healing and/or deteriorating over time are presented in Figure 15.

Eight confirmed or possible satellite-tagged/captured whales were photographed in 2020; this represents 40% of the 20 CIBWs originally captured and/or tagged between 1999 and 2002. Three satellite-tagged whales have been confirmed dead (i.e., carcasses were documented) between 2001 and 2020. Two photo-identified whales with satellite tag scars have not been resighted since 2007 and are therefore presumed to be dead based on the number of years without sightings. Beluga D103, a female, had been photographed every year of the study 2005–2019, but was not photographed in 2020. Because of her strong previous sighting record, the abrupt cessation of sightings, and her very conspicuous scars, she is suspected to have died. At 401 cm at the time of her capture and tagging in 2001 (Table 17), she was the largest, and presumably the oldest, of the satellite-tagged females.

Identification of whales biopsied 2016–2020

In 2016, biopsy samples were obtained remotely from six whales; 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 19; 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 2020. Three of the individuals biopsied in 2016 were photographed in 2020; photographic records of resighted biopsy scars from 2016 are presented in Figure 16.

In 2017, biopsy samples were obtained remotely from twelve whales. Two additional whales were darted without yielding a sample (Table 19). Seven biopsied whales were female, five biopsied whales were male, and the two without samples 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 19). Five of the females have been photographed with an accompanying calf at least once between 2005 and 2020, and a sixth was photographed with a possible calf. Six of the individuals darted in 2017 were photographed in 2020; photographic records of resighted biopsy scars from 2017 are presented in Figure 16.

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 19). Six biopsy attempts were made in 2018 that did not result in samples, and 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 2020 (including during biopsy); photographic records of resighted biopsy scars from 2018 are presented in Figure 16.

In 2019, 14 biopsy samples were obtained; one of these individuals had been previously biopsied in 2017 (Table 20). With the exception of the male previously biopsied in 2017, the sexes of the whales biopsied in 2019 are unknown, pending results from NMFS (pandemic restrictions for laboratory access for NMFS in 2020/2021 has delayed processing of sex, hormone, and age results from the 2019 biopsy samples). Results, including calving histories of known females, will be updated once these results become available. Two of these individuals were photographed in 2020, but their biopsy scar healing cannot be photographically evaluated because one individual did not have photographs of the biopsy location during biopsy sampling in 2019, and the other did not have a clear view of the biopsy site in resighting photographs from 2020.

Identification of whales with concave backs 2005–2020

One of the whales biopsied in 2017 and 2019, D2379, had a pronounced concavity behind the dorsal crest (Figure 17). This male 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. When it was photographed in 2019, it also appeared to be more emaciated than in previous years. This whale was not photographed in 2020. There is no evidence the defect is related to biopsy or the biopsy vessel, as this deformity was documented years before biopsy was initiated.

Beluga D595 was also observed with a concavity behind its dorsal crest (Figure 18). The whale was photographed 2007–2010, then again 2014–2020. The sway was first noted in 2008 and appeared more pronounced each year, with skin sloughing and possible infection noted in 2019 and 2020. This individual was biopsied in 2018, and determined to be a male, born in approximately 1998 (Bors et al. 2020). There is no evidence the defect is related to biopsy or the biopsy vessel, as this deformity was documented years before biopsy was initiated.

Beluga D516 was photographed with pronounced concavity behind the dorsal crest, with signs of abrasions and or infection (Figure 19). This whale was only photographed in 2006 and is of unknown sex and age.

Identification of stranded belugas 2005–2020

To date, fifteen stranded CIBWs have been identified as individuals in the 2005–2020 photo-ID catalog. Fourteen of these identified whales were adults and one was a subadult; 13 were dead and two were alive.

Of the 13 dead whales, seven were males (six adults and one subadult) and six were females (all adults). Two of the males had scars from satellite tags. One of the dead females was pregnant at the time of stranding (McGuire et al. 2020c). Sighting histories of identified dead-stranded whales 2005–2017 are presented in McGuire and Stephens (2017) and McGuire et al. (2021). None of the whales found dead in 2018 or 2019 were matched to the catalog. The identified male found dead September 28, 2020 in Turnagain Arm was beluga D778, photographed alive in the Susitna River Delta in 2017 and again in 2019; he was classified as a subadult at the time of necropsy based on his total length immature testes, and tooth age (Dr. Kathleen Burek-Huntington, unpublished data).

Two belugas in the 2005–2020 catalog have been recognized during live-strandings. Both were adults and presumed to be females because they had stranded with live calves at their sides. One adult stranded in 2015 in Turnagain Arm. The Alaska Marine Mammal

Stranding Network photographed the stranding from a NMFS drone 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, previously photographed 2008–2014. 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 has been photographed subsequently with a calf alongside in 2017, 2018, 2019, and 2020 (this may have been the same calf that stranded in 2015 but a definitive match has not been made).

Beluga D3603 was photographed 2007–2019 in the Susitna River Delta and Knik Arm. In 2020, she was photographed in the Susitna River Delta during a photo-ID survey, then by the Alaska Marine Mammal Stranding Network and National Geographic when she live-stranded with a live calf at her side on Sept 11, 2020 in Turnagain Arm. She was later photographed alive and free-swimming in Turnagain Arm, on Sept 24, 2020, with a calf in the group, although it could not be determined if it was the same calf who had also live stranded on September 11.

Reproductive Histories

There are currently 246 presumed- and possible-mothers in the right-side catalog, which represents 50% of the individuals in the right-side catalog (Table 15). Similarly, there are currently 262 presumed- and possible-mothers in the left-side catalog, which also represents 50% of the individuals in the left-side catalog. If the ambiguous possible-mother classifications are removed, 46% of individuals in both the right-side catalog and the left-side catalog are presumed to be mothers (Table 15).

There were 12 different neonates photographed in 2020, based on evaluation of photographs of identified mothers and close proximity of neonate belugas to the adults. Eleven of the mothers were in the right-side catalog, 10 were in the left side catalog, and nine were in the dual catalog. One neonate was the calf of a mother who is classified as a potential catalog whale but is not yet in the catalog. Given 185 individuals were photo-identified from the left side in 2020, and 46% were presumed females, then 85 presumed females were identified on the left side in 2020, and 12% (10/85) of them were photographed with neonates in 2020. Likewise, given 151 individuals were photo-identified from the right side in 2020, and 46% were presumed female, then 69 presumed females were identified from the right side in 2020, and 16% (11/69) of them were photographed with neonates in 2020.

To date, there are 25 females and 26 males 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 the 2005–2020 catalog. There are 15 males and 15 females of confirmed sex in the dual-side catalog. Nineteen of the 25 (i.e., 76%) confirmed-sex females in the 2005–2020 catalog have evidence of having reproduced, either based on their photo-ID records with a calf 2005–2020, pregnancy status at biopsy, or signs of pregnancy, lactation, or recent birth during necropsy. Another confirmed-sex female has been classified as a possible mother based on ambiguous photos in which a calf may have been alongside the mother but could not be confirmed.

There were 19 females biopsied 2016–2018. The ages of these females were determined using epigenetics from the biopsy sample (Bors et al. 2020). Biopsied females were between the ages of 11 and 23 at the time of biopsy (Table 21). There were 13 females (i.e., 68% of females biopsied) with signs of having been pregnant at or before biopsy (i.e., either hormonally pregnant at the time of biopsy, or with photo-ID records of calf accompaniment before biopsy, or accompanying of calf post-biopsy that would have been born before biopsy) and these ranged between ages 12 and 23. Six biopsied females had no signs of having been pregnant at or before biopsy (i.e., 32% of females biopsied); these females ranged between ages 11 and 20. The average age of biopsied belugas with no signs of pregnancy at or before biopsy was 15.0 years, with a median of 15.0 years. The average age of biopsied female belugas with signs of pregnancy at or before biopsy was 16.0 years, with a median of 15.5 years.

DISCUSSION

Seasonal and Spatial Patterns of Beluga Group Encounters

Even after adjusting for variations in effort, the broad seasonal distribution patterns of CIBWs in Upper Cook Inlet and Kenai River Delta during the 2020 field season (Figure 20) repeated patterns found in previous years of this study (Figure 21) and in other studies (Moore et al. 2000; Hobbs et al. 2005; Nemeth et al. 2007; Shelden et al. 2015a, 2015b, 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 and early June, followed by salmon runs mid-July to through September; NMFS 2008b; McGuire and Stephens 2017; McGuire et al. 2020a). Details about these patterns, including discussion of sampling biases and ecological interpretations, can be found in McGuire et al. (2020a).

Patterns in Group Size

The occurrence of larger beluga groups in the Susitna River Delta in 2020 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). However, starting in 2012, there were noticeable increases in group size (both mean group size and annual maximum group size; Table 8).

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, and again in 2020, always occurred in the same area (Susitna River Delta) and during the same general time period (mid-July to early August), and there was 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 200 in 2020 is consistent with the pattern of larger groups seen in recent years and also consistent with the mid-late July occurrence. The underlying causes of variations in 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; 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 continues to be necessary to tease out any true inter-annual patterns in group size versus 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). 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 have shifted in recent years (McGuire et al. 2020a).

The 2020 field season marked the fourth consecutive year of a return to the Kenai River Delta to conduct photo-ID surveys. Surveys had been conducted here 2011–2013 thanks to 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 2020 were smaller than in other parts of the survey area. Not only were groups smaller than elsewhere, but photo-ID 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 2020 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 2020 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 indicate 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 2020 (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 have appeared to increase since 2011 when dedicated outreach efforts were undertaken in this area (McGuire et al. 2014; 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 several groups, including the CIBW Photo-ID Project, have not only provided an opportunity to share information about belugas and the CIBW Photo-ID Project with the public but have also enabled us to increase public awareness of the avenues for reporting beluga sightings (e.g., 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 2020, 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 2019, she was photographed in the Susitna River Delta, Knik Arm, and Chickaloon Bay, but not in Turnagain Arm. In 2020, she was photographed in the Susitna River Delta and in Turnagain Arm.

Likewise, beluga D403, also tagged by NMFS sometime between 1999 and 2002 and believed to be a female, had never been photographed in Turnagain Arm 2005–2019, despite being photographed almost every year. 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, likely due to the 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. In 2020, she was photographed in Turnagain Arm, as well as in the Susitna River Delta.

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). 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 become available and these data are able to be incorporated into the sighting records of cataloged whales.

Feeding Habitat and Behavior

Feeding behavior in 2020 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 2018–2020. 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 previously documented. 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, and again on August 4, 2020, provides additional support. Documentation of suspected births in Turnagain Arm (in 2016) and Knik Arm (in 2020), indicate that calving is not restricted to the Susitna River Delta.

The first neonates encountered during each field season 2005–2020 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). Evidence also suggests that the calving season extends into September and likely into October, as we documented a suspected birth in September of 2016 and have photographed neonates as late as October (McGuire et al. 2020b). 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 2005–2020 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 185 dual-side whales, we do not know which of the left-side catalog whales are the same individuals as the right-side catalog whales. If skin biopsies for genetic analysis continue to be collected concurrently with photographs of both sides of the whales (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 (95% confidence interval = 388–507 belugas; Jacobson et al. 2020). This was higher than the revised 2016 CIBW population estimate from NMFS aerial surveys of 293 belugas (95% probability interval = 271–318 belugas). The number of individuals in the 2020 photo-ID catalog, after subtracting known- and presumed-dead individuals (resulting in 410 in the right-side catalog, 451 in the left-side catalog), is roughly the midpoint of the 388–507 confidence interval of the population estimates from the IPM, but higher than the revised NMFS population estimate for 2016, and for 2018, which was 279 belugas (95% probability interval = 250–317 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 2009. 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 that allow 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 this segment 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 (Figure 14). In addition, as discussed previously, we have confirmed that both sexes are represented in the catalog. Identified whales of known sex in both the stranding dataset and the biopsy dataset indicate 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 125 dead CIBWs reported to NMFS 2005–2020, with photos of 69 (55%) of these shared with or taken by the CIBW Photo-ID Project (McGuire et al. 2020c). 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.com). 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. Photographs of 90% of the dead-stranded belugas in 2020 were shared, which was a marked increase from previous years.

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 (McGuire et al. 2020c). 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 whale, 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.

The value of linking sighting histories with necropsy data is also seen in the case of the dead stranded male beluga D778, whose sighting records initially indicated a possible match to a whale photographed in 2006, resulting in a minimum age of 18 years when he died. This was at odds with the total length at death and immature testes information, which indicated an immature male. Based on this possibly conflicting information (beluga males are reported to reach sexual maturity by age 15, summarized in NMFS 2016), requests were made to estimate age from teeth that were collected during necropsy. Tooth-age results indicated the whale was 7 or 8 years old at the time of death. Natalie Rouse and Dr. Kathleen Burek-Huntington of Alaska Veterinary Pathology Services are currently writing a case report of their examination of this whale for publication and will discuss tooth age results along with their findings of the generally poor condition of this individual. Photo-id matches for this whale were reviewed again, and the matches between the 2020 photos of the dead whale and the 2017 and 2019 live-whale photos were re-confirmed. The size and color of the whale in the 2017 and 2019 photos do not contradict it being around 7 or 8 years old at death in 2020, and therefore born in 2011 or 2012, and age 4 or 5 years old in 2017, and age 6 or 7 years old in 2019. The potential match between the 2006 and 2020 photos was rejected, in part because the 2006 photos were not in sharp focus, and in part because sections of the carcass that would have showed more marks used for identification were obscured (by rocks) or missing (scavenged) in the photos from 2020.

Unlike the compilation of 2005–2017 stranding data in McGuire et al. (2020c), CIBW strandings reported in 2020 were dominated by calves (60%), rather than by adults (20%) The previous years (2005-2019) had followed the general patterns of more adults than calves or subadults, with approximately equal representation of males and females and a high percentage of carcasses of unknown sex and age. Possible reasons for these previous patterns, as well as recommendations for increasing the information gained from stranded whales, is presented in McGuire et al (2020c). Possible reasons for the high number of calf strandings in 2020 is under investigation by the Alaska Marine Mammal Stranding Network.

Anthropogenic Scars

We have documented that injury from anthropogenic activities does occur at lethal and nonlethal levels. With roughly a third of the individuals examined bearing signs of confirmed or possible anthropogenic trauma, excluding scars 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 findings on prevalence and healing of anthropogenic scars, including those from satellite tagging and biopsy, in detail in McGuire et al. (2021) 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.

We do not know the cause, or causes, of the dorsal concavity of several whales in the catalog. Possibilities are injury (vessel strike, predation attempt, gunshot, and entanglement), disease, emaciation, scoliosis, genetic deformity, or some combination of the above. One possible source of infection that we hope to learn more about is the pathogen, *Erysipelothrix rhusiopathiae*, which can result in skin lesions and arthritis. Veterinarians with the Alaska Marine Mammal Stranding Network report that this pathogen has been found in CIBWs (Dr. Kathleen Burek-Huntington, pers comm), and we are curious to investigate if some of the skin lesions and spinal curvature we are photo-documenting might be associated with this pathogen. We will continue to follow these whales photographically, share their photographs with veterinarians with the Alaska Marine Mammal Stranding Network, and continue to screen all whales in the catalog for similar dorsal ridge concavity.

Number of Presumed Mothers in the 2005–2020 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 possible-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 of photographing the actual number of mothers in the population over the course of the study. Forty-six percent of individuals in the right-side catalog and in the left-side catalog have been classified as presumed mothers based on their cumulative 2005–2020 sighting histories.

Adding biological information obtained from invasive or semi-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).

Approximately three-fourths of the females of genetically confirmed sex had been classified as confirmed- or presumed-mothers based on their photo-ID histories. In other words, those 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-fourth 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 to 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. All existing evidence must be examined before any conclusions are reached; for example, several of the females determined not to be pregnant based on hormones in biopsy samples had photographic records indicating they gave birth in years immediately preceding, during, and after biopsy, and were therefore reproductively active.

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. (2020a) and a summary of survival information is presented in McGuire et al. (2020b).

We are cautious in reporting life-history parameters such as reproductive or survival rates from the annual photo-ID field and catalog data 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 being used to quantify the effect of these factors (and their interactions) on estimating these population and life-history parameters. For example, in 2020, the maximum number of neonates recorded in the field on a single day (July 23) was three, but once individuals that were photographed that day were cataloged, it was determined that there were in fact five neonates of identified mothers. While we have documented that there were at least 14 different neonates photographed in all of 2020, complex models are needed to translate these numbers into an annual reproductive rate for the population that can be compared to previous and future rates and used to examine the population’s trajectory.

We continue to collaborate with colleagues from Montana State University, NMFS MML, the University of Washington, the Knik Tribe, and ADF&G, to share and interpret our data (survey and photo-ID) from the CIBW Photo-ID database in the development and application of various models (e.g., Bayesian multievent mark-recapture models to estimate reproductive and survival rates for breeding females, survival rates for dependent calves and non-breeding individuals, and apparent survival for older calves; Bayesian integrated population models; a population viability analysis (PVA) to estimate quasi-extinction risk and the sensitivity of population dynamics to changes in demographic rates; population consequence of disturbance models (PCoD)) to examine population dynamics and trends, as well as to inform management actions and 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 500 whales over a 16-year period. The strength of the CIBW Photo-ID Project will continue to grow as the proportion of the CIBW population that is identified and resighted increases. The number of whales in the catalog continues to increase as more years of fieldwork are conducted, but also as more of the archived photos from previous years of fieldwork are cataloged. Keeping both sides of the catalog updated, and linking them into a dual-side catalog, allows 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 determine 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 2020. We described 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 being used 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). The continuation of a long-term, Inlet-wide, photo-ID dataset and its incorporation into 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. The foundation of such a model is currently being constructed by Amanda Warlick at the University of Washington, with some data and model components provided by the CIBW Photo-ID Project, NMFS (AKR and MML), and Gina Himes Boor at Montana State University.

RECOMMENDATIONS

In order to maximize the information by the CIBW Photo-ID Project provided to managers and decision makers for the recovery and conservation of the CIBW population, we recommend to future regulatory and funding entities that the following CIBW Photo-ID Project activities continue:

- 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 develop models to maximize the information collected by the CIBW Photo-ID Project,
- continue to collaborate with colleagues to combine multiple datasets into integrated models, and
- continue to communicate project results to managers, agencies (Federal, State, and Tribal), colleagues, and the public.

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TABLES

Table 1. Funding for the 2005–2020 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***	**Right-side Catalog***	**Fieldwork***
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
2019	NMFS AKR	NMFS AKR	NMFS AKR
2020	NMFS AKR	NMFS AKR	NMFS AKR

* 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 2020 according to survey sub-area and year.

	Year																
Sub-Area	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total Number of Surveys**
Susitna River Delta	16	17	5	8	13	14	11	13	8	9	10	11	9	11	12	9	176
Knik Arm	32	13	5	9	10	9	16	12	3	7	4	8	1	5	4	4	142
Turnagain Arm	0	4	5	12	12	15	16	158	12	8	8	7	3	9	12	24	162
Chickaloon Bay/ Fire Island	4	1	1	2	1	0	2	5	2	2	1	0	0	1	1	0	23
Kenai River Delta	0	0	0	0	0	0	4	14	6	0	0	0	3	6	3	3	39
Annual Number of Survey Days*	52	35	16	31	36	38	49	59	31	26	23	25	16	29	32	38	542 Surveys (536 survey days)

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

Table 3. Photo-identification survey effort and beluga whale groups encountered in Cook Inlet, Alaska in 2020.

	2020				
	Susitna River Delta	**Knik Arm**	**Turnagain Arm**	**Kenai River Delta**	**Chickaloon Bay/ Fire Island**
Range of survey dates	Jul 16–Aug 18	Jul 14–Aug 21	Apr 9–28 Aug 24–Nov 9	Oct 7–9	x
Number of surveys	9	4	24	3	0
Number of groups encountered	20	3	40	4	x
Number of beluga sightings	875	100	498	27	x
Mean number of groups per survey	2.2	0.8	1.7	1.3	x
Mean number of belugas per survey	97.2	25.0	20.7	9.0	x
Mean group size	43.7	33.3	12.4	6.7	x
Maximum group size	200	80	41	8	x

Table 4. Composition and size of the 20 groups sighted during vessel-based surveys of the Susitna River Delta in 2020. (Neonates are separate from calf total; CBD = could not be determined; Y = yes, color-class present, but could not be quantified.)

Date	# White	# Gray	# Calves	# Neonates	# Unknown	Group Size
2020-Jul-16	8	2	2	1	2	15
2020-Jul-20	2	0	1	0	0	3
2020-Jul-20	8	5	3	0	0	16
2020-Jul-21	Y	Y	Y	1	20	21
2020-Jul-21	3	2	0	0	0	5
2020-Jul-21	7	3	1	1	13	25
2020-Jul-21	10	CBD	CBD	CBD	0	10
2020-Jul-21	2	0	0	0	0	2
2020-Jul-21	CBD	CBD	CBD	CBD	1	1
2020-Jul-23	Y	Y	Y	3	197	200
2020-Jul-31	50	Y	Y	CBD	130	180
2020-Aug-02	5	3	2	1	0	11
2020-Aug-04	Y	Y	Y	3	180	183
2020-Aug-04	Y	Y	Y	CBD	25	25
2020-Aug-04	Y	Y	Y	CBD	30	30
2020-Aug-17	Y	Y	Y	3	97	100
2020-Aug-17	Y	CBD	CBD	CBD	5	5
2020-Aug-17	2	0	0	0	0	2
2020-Aug-18	Y	Y	Y	1	29	30
2020-Aug-18	6	3	1	1	0	11

Table 5. Composition and size of groups sighted during 24 land-based surveys of Turnagain Arm in 2020. (Neonates are separate from calf total; CBD = could not be determined.)

Date	# White	# Gray	# Calves	# Neonates	# Unknown	Group Size
2020-Apr-09	0	0	0	0	0	0
2020-Apr-12	0	0	0	0	0	0
2020-Apr-14	0	0	0	0	0	0
2020-Apr-23	4	0	2	0	0	6
2020-Apr-28	4	5	3	CBD	3	15
2020-Aug-24	1	0	0	0	0	1
2020-Aug-24	7	6	2	0	0	15
2020-Aug-24	3	2	0	0	0	5
2020-Aug-24	3	0	1	0	0	4
2020-Aug-24	6	0	1	0	0	7
2020-Aug-25	3	2	CBD	CBD	3	8
2020-Aug-25	6	4	3	CBD	3	16
2020-Aug-25	0	1	0	0	0	1
2020-Aug-25	3	4	1	0	0	8
2020-Aug-25	3	0	0	0	0	3
2020-Aug-26	2	0	1	0	0	3
2020-Aug-26	7	9	2	1	0	19
2020-Aug-27	15	11	4	CBD	4	34
2020-Aug-27	CBD	CBD	CBD	CBD	15	15
2020-Sep-08	3	CBD	CBD	CBD	5	8
2020-Sep-08	1	2	0	0	0	3
2020-Sep-08	3	2	1	0	0	6
2020-Sep-09	8	6	1	0	0	15
2020-Sep-09	13	21	6	1	0	41
2020-Sep-09	8	6	3	1	4	22
2020-Sep-10	5	1	1	0	0	7
2020-Sep-10	4	0	0	0	0	4
2020-Sep-10	5	0	0	0	0	5
2020-Sep-11	5	1	1	0	0	7
2020-Sep-11	4	4	1	CBD	11	20
2020-Sep-14	6	8	4	0	0	18
2020-Sep-16	5	9	2	CBD	2	18
2020-Sep-18	6	4	1	CBD	10	21
2020-Sep-18	6	4	4	1	0	15
2020-Sep-22	11	4	2	0	0	17
2020-Sep-24	5	7	3	0	0	15
2020-Sep-24	3	0	0	0	0	3
2020-Sep-24	3	2	1	0	0	6
2020-Sep-25	8	3	1	0	0	12
2020-Oct-07	4	2	1	0	0	7
2020-Oct-07	2	1	1	0	0	4
2020-0ct-15	18	12	4	0	0	34
2020-Oct-23	0	0	0	0	0	0
2020-0ct-28	10	8	4	CBD	8	30
2020-Nov-09	0	0	0	0	0	0

Table 6. Composition and size of groups sighted during surveys of Knik Arm and the Kenai River Delta in 2020. Knik Arm was surveyed from a vessel and the Kenai River Delta was surveyed from land. (Neonates are separate from calf total; Y = yes, color-class present but could not be quantified).

Date	Sub-Area	# White	# Gray	# Calves	# Neonates	# Unknown	Group Size
2020-Jul-14	Knik Arm	0	0	0	0	0	0
2020-Jul-31	Knik Arm	0	0	0	0	0	0
2020-Aug-20	Knik Arm	5	3	0	0	0	8
2020-Aug-20	Knik Arm	Y	Y	Y	2	78	80
2020-Aug-21	Knik Arm	Y	Y	Y	1	11	12
2020-Oct-07	Kenai River Delta	3	1	1	0	0	5
2020-Oct-08	Kenai River Delta	4	2	2	0	0	8
2020-Oct-08	Kenai River Delta	3	2	1	0	0	6
2020-Oct-09	Kenai River Delta	4	2	2	0	0	8

Table 7. Percent color/age-class composition of beluga whale groups sighted during surveys of Upper Cook Inlet, Alaska in 2020 (excluding those groups for which an age/color class could not be determined).

2020	% of groups per sub-area with:			
Sub-Area	White	Gray	Calves	Neonates
Susitna River Delta	100	82	82	64
Knik Arm	100	100	67	67
Kenai River Delta	100	100	100	0
Turnagain Arm	98	74	76	13

Table 8. Summary of date and location of the first and last neonate sightings, and maximum annual group size of each field season of beluga photo-ID surveys in Cook Inlet, Alaska during the 2005–2020 study period.

Year	Field Season	First Sighting	Last Sighting	# Weeks from First to Last Sighting	Location of First Sighting & Largest Group of Year	Date of Largest Group of Year	Maximum Group Size
2005[1]	Apr 14–Oct 21	Jul 6	n/a	n/a	Susitna River Delta	Jul 23	152
2006[1]	May 12–Oct 5	n/a	n/a	n/a	n/a	Jul 26	61
2007[1]	Jun 28–Oct 27	Jul 27	n/a	n/a	Susitna River Delta	Jul 27	74
2008	May 21–Oct 28	Jul 24	Sep 30	9	Susitna River Delta	Jul 29	121
2009	Jun 19–Oct 24	Aug 1	Oct 15	9	Susitna River Delta	Aug 3	152
2010	May 9–Oct 15	Jul 16	Oct 8	12	Susitna River Delta	Jul 16	173
2011	Apr 16–Oct 22	Jul 27	Sep 27	9	Susitna River Delta	Jul 27	136
2012	May 2–Oct 21	Jul 20	Oct 4	11	Susitna River Delta	Jul 20	200
2013	Apr 20–Sep 21	Jul 31	Sep 3	5	Susitna River Delta	Jul 22 & Jul 31	200
2014	Jul 8–Oct 3	Jul 21	Oct 3[2]	10.5	Susitna River Delta	Jul 27	250
2015	May 28–Oct 1	Jul 19	Oct 1[2]	10.5	Susitna River Delta	Jul 20	313
2016	May 24–Sep 30	Jul 15	Sep 30[2]	11	Susitna River Delta	Jul 19	148
2017	Jul 21–Sep 26	Jul 21	Sep 26[2]	9.5	Susitna River Delta	Jul 27 & Aug 5	300/302
2018	May 2–Sep 27	Jul 12	Sep 26[2]	10.5	Susitna River Delta	Jul 12	222
2019	May 18–Oct 7	Jul 16	Oct 7[2]	12	Susitna River Delta	Jun 3	200
2020	Apr 9–Nov 9	Jul 16	Sep 18	9	Susitna River Delta	Jul 23	200

[1] Neonates were not differentiated from calves during the 2005–2007 surveys, but neonates were noted if visible in photos from these years.

[2] Last day of field season.

Table 9. Summary of primary and secondary activities of beluga groups encountered in 2020 during vessel-based photo-identification surveys in the Susitna River Delta, Cook Inlet, Alaska. Human activities with the potential to affect belugas that were observed during surveys are also noted (CBD= could not be determined).

Date	Group Size	Primary Group Activities Noted	Secondary Group Activities Noted	Feeding Behavior (observed or suspected)	Human Activities Observed During Survey
2020-Jul-16	15	Diving	Milling Traveling	No	Aircraft Setnetters Very deep loud booms (reported to NMFS)
2020-Jul-20	3	Milling	None	No	Aircraft Setnetters
2020-Jul-20	16	Diving	Milling Traveling	No	Aircraft Vessels
2020-Jul-21	21	Milling	Traveling	No	Aircraft
2020-Jul-21	5	Diving	Traveling	No	Aircraft
2020-Jul-21	25	Feeding Suspected	None	Yes	Aircraft
2020-Jul-21	2	CBD	CBD	CBD	Aircraft
2020-Jul-21	10	CBD	CBD	CBD	Aircraft
2020-Jul-21	1	Diving	None	No	Aircraft
2020-Jul-23	200	Traveling	Feeding Suspected	Yes	Aircraft
2020-Jul-31	180	Traveling	Feeding Suspected	Yes	Aircraft
2020-Aug-02	11	Traveling	None	No	Aircraft
2020-Aug-04	183	Traveling	Socializing Possible Birth Milling	No	Aircraft Vessels
2020-Aug-04	25	Traveling	Milling	No	Aircraft
2020-Aug-04	30	Feeding Suspected	Milling	Yes	Aircraft
2020-Aug-17	100	Feeding Suspected	Diving	Yes	Aircraft Setnetters
2020-Aug-17	5	Milling	Traveling	No	Aircraft Setnetters
2020-Aug-17	2	Diving	None	No	Aircraft Setnetters
2020-Aug-18	30	Diving	Milling Feeding Suspected	Yes	Aircraft Vessels
2020-Aug-18	11	Traveling	Milling	No	Aircraft

Table 10. Summary of primary and secondary activities of beluga groups encountered in 2020 during vessel-based photo-identification surveys in Knik Arm and land-based photo-identification surveys in 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 Noted	Secondary Group Activities Noted	Feeding Behavior (observed or suspected)	Human Activities Observed During Survey
Knik Arm					
2020-Aug-20	8	Feeding Suspected	Milling	Yes	Aircraft Setnetters
2020-Aug-20	80	Milling Diving Socializing	Traveling Feeding Suspected	Yes	Aircraft
2020-Aug-21	12	Milling	Traveling Possible Birth	No	Aircraft Vessels
Kenai River Delta					
2020-Oct-07	5	Traveling	Feeding Suspected	Yes	None
2020-Oct-08	8	Traveling	None	No	Vessels
2020-Oct-08	6	Traveling	Feeding Suspected	Yes	Aircraft Vessels
2020-Oct-09	8	Traveling	None	No	Vessels

Table 11. Summary of primary and secondary activities of beluga groups encountered in 2020 during land-based photo-identification surveys in Turnagain Arm, 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 Noted	Secondary Group Activities Noted	Feeding Behavior (observed or suspected)	Human Activities Observed During Survey
2020-Apr-23	6	Traveling	Feeding Suspected	Yes	Vessel in Twentymile River Rifle casing along shore at MP 95.5
2020-Apr-28	15	Milling Traveling	Feeding Suspected	Yes	Road construction Dipnetters Big bundle of balloons in water
2020-Aug-24	1	Traveling	None	No	None
2020-Aug-24	15	Milling	Feeding Suspected	Yes	Group dispersed as train went by
2020-Aug-24	5	Milling	Feeding Suspected	Yes	None
2020-Aug-24	4	Traveling	Feeding Suspected	Yes	None
2020-Aug-24	7	Milling	Feeding Suspected	Yes	None
2020-Aug-25	8	Traveling	None	No	None
2020-Aug-25	16	Feeding Suspected	Milling	Yes	None
2020-Aug-25	1	Traveling	None	No	None
2020-Aug-25	8	Feeding Suspected	Traveling	Yes	None
2020-Aug-25	3	Milling	None	No	None
2020-Aug-26	3	Milling	None	No	None
2020-Aug-26	19	Feeding Suspected	Milling	Yes	None
2020-Aug-27	34	Feeding Suspected	Traveling	Yes	Float planes Helicopter
2020-Aug-27	15	Traveling	None	No	None
2020-Sep-08	8	Milling	Traveling	No	None
2020-Sep-08	3	Traveling	None	No	None
2020-Sep-08	6	Traveling	None	No	None
2020-Sep-09	15	Milling	Feeding Suspected	Yes	None
2020-Sep-09	41	Milling	Feeding Suspected	Yes	Drone and small plane (NMFS aware)
2020-Sep-09	22	Traveling	Milling	No	None
2020-Sep-10	7	Traveling	Feeding Suspected	Yes	None
2020-Sep-10	4	Traveling	None	No	None
2020-Sep-10	5	Traveling	None	No	Small aircraft

Date	Group Size	Primary Group Activities Noted	Secondary Group Activities Noted	Feeding Behavior (observed or suspected)	Human Activities Observed During Survey
2020-Sep-11	7	Traveling	None	No	None
2020-Sep-11	20	Milling	Feeding Suspected	Yes	Aircraft
2020-Sep-14	18	Milling Traveling	Socializing	No	Low-flying aircraft
2020-Sep-16	18	Milling	Feeding Suspected	Yes	None
2020-Sep-18	21	Milling	Feeding Suspected	Yes	Helicopter Train (whales dove when train blew whistle)
2020-Sep-18	15	Feeding Suspected	Socializing	Yes	None
2020-Sep-22	17	Milling	Traveling	No	Train
2020-Sep-24	15	Milling	Feeding Suspected	Yes	2 low-flying aircraft flew over; whales stayed underwater for ~10 minutes before resuming baseline behavior
2020-Sep-24	3	Traveling	None	No	None
2020-Sep-24	6	Traveling	Milling	No	None
2020-Sep-25	12	Traveling	None	No	Road construction
2020-Oct-07	7	Feeding Suspected	Milling	Yes	None
2020-Oct-07	4	Traveling	Milling	No	None
2020-Oct-15	34	Milling	Feeding Suspected	Yes	Paddle boarders and surfers (Total of 7 surfers between MP 95.5 and 93)
2020-Oct-28	30	Traveling Milling	Feeding Suspected	Yes	None

Table 12. Summary of 14 stranded Cook Inlet beluga whales reported by NMFS and the Alaska Marine Mammal Stranding Network (AMMSN) to the CIBW Photo-ID Project in 2020. Future genetic analysis of individuals may reduce the number of individuals of unknown sex (U). See Figure 1 for locations of place names where sightings were reported. (n/a=not applicable.)

NMFS AKR Stranding ID	Date Reported	Location of Stranded Beluga	Type of Stranding	Necropsy Performed by AMMSN	Age Class (as listed by examiners on necropsy form)	Sex	Length (cm)	Photo Received and Reviewed	Comment on Utility of Photo for Identification	Whale Matched to Known Catalog Whale	Initial Condition
2020016	2020-May-13	Knik Arm, Cairn Point	Beached/dead	Samples collected	Calf	U	158	Yes	Unusable, desiccated	No	Advanced decomposition
2020149	2020-Jul-23	Otter Creek	Beached/dead	Yes	Calf	F	145	Yes	Unusable, desiccated	No	Advanced decomposition
2020154	2020-Jul-28	Point Possession	Beached/dead	Yes	Calf	F	163	Yes	Unusable, desiccated	No	Moderate decomposition
2020174	2020-Aug-16	Anchorage, Capt. Cook State Park	Beached/dead	Yes	Calf	F	144	Yes	Unusable, desiccated	No	Advanced decomposition
2020179	2020-Aug-16	Fire Island	Beached/dead	Yes	Fetus	U	146.5	Yes	Unusable, desiccated	No	Advanced decomposition
2020188	2020-Aug-22	Anchorage, Kincaid Park	Beached/dead	Yes	Calf	F	162	Yes	Unusable, desiccated	No	Advanced decomposition
2020216	2020-Sep-12	Near Forelands	Floating/dead	No	Adult	U	Unknown	Yes	Unusable, taken from plane, too far away	No	Fresh dead
2020217	2020-Sep-11	Bird Point, Turnagain Arm	Beached/alive	No	Adult	F	366	Yes	Useable	L3603	Alive
2020219	2020-Sep-11	Bird Point, Turnagain Arm	Beached/alive	No	Calf	U	Unknown	Yes	Unusable, dim lighting, most of body submerged	No	Alive
2020230	2020-Sep-28	Turnagain Arm	Beached/dead	Yes	Subadult	M	318	Yes	Useable	D778	Moderate decomposition
2020232	2020-Sep-24	Point Possession	Beached/dead	No	Unknown	U	Unknown	No	n/a	No	Unknown
2020237	2020-Oct-19	Birchwood, Knik Arm	Beached/alive (mass stranding of 17 whales)	No	Unknown	U	Unknown	Yes	Unusable, taken from plane, too far away	No	Alive
2020238	2020-Oct-17	Hope, Turnagain Arm	Beached/alive	No	Adult	U	Unknown	No	N/a	No	Alive
2020240	2020-Oct-23	Point Possession	Beached/dead	Yes	Adult	M	401	Yes	Borderline, scavenger marks extensive	No	Fresh dead

Table 13. Summary of 250 incidental sighting reports of Cook Inlet belugas shared with the CIBW Photo-ID Project in 2020. Shaded cells indicate beluga sightings were reported. X indicates no sightings reported. See Figure 1 for a map showing locations of place names where sightings were reported.

2020	Susitna Delta (Beluga River to Little Susitna River)	Knik Arm	Turnagain Arm	Chickaloon Bay/ Fire Island	Kenai River/Delta (Nikiski to Kasilof)	Anchorage (Port of Anchorage to Potter Marsh)	Other
January	x	x	x	x		x	x
February	x	x	x	x		x	x
March	x	x	x	x		x	x
April	x	x		x		x	x
May		x	x	x	x		Kachemak Bay
June	x			x	x		x
July			x		x		x
August				x	x		x
September				x			x
October	x						x
November	x	x		x		x	x
December	x	x	x	x	x	x	x

Table 14. Summary of 1,304 incidental sighting reports of Cook Inlet belugas shared with the CIBW Photo-ID Project in 2005–2020. Shaded cells indicate beluga sightings were reported. X indicates no sightings reported. See Figure 1 for a map showing locations of place names where sightings were reported.

2005–2020	Susitna Delta (Beluga River to Little Susitna River)	Knik Arm	Turnagain Arm	Chickaloon Bay/ Fire Island	Kenai River/Delta (Nikiski to Kasilof)	Anchorage (Port of Anchorage to Potter Marsh)	Other
January	x	x		x		x	Big River and Kalgin Island; Tyonek Platform
February	x	x	x	x			x
March		x		x			x
April		x					x
May		x					Kachemak Bay
June							x
July			x				Kachemak Bay
August							
September							Mouth of Big River Lake (between West Forelands and Redoubt Bay)
October							x
November		x					x
December	x	x		x	x		x

Table 15. Summary of individual CIBWs and their sighting histories in the 2005–2020 photo-ID catalog.

Number of:	Left-Side Catalog	Right-Side Catalog
Individuals in 2005–2020 Catalog	519	487
Individuals photographed in 2020	185	151
Individuals in catalog first photographed in 2020	0	0
Individuals photographed prior to 2020 who achieved catalog criteria with inclusion of 2020 photos	6	22
Maximum years between sightings of an individual	10	10
Individuals presumed dead based on lack of resightings[1]	58	70
Confirmed-dead individuals matched to the catalog 2005–2020	10	7
Individuals presumed alive at end of 2020 field season[2]	451	410
Individuals who may be mothers (presumed and possible)	262 (50%)	246 (50%)
Individuals presumed to be mothers	241 (46%)	225 (46%)
Individuals seen in each year of the 16-year study	3	0
Individuals photographed in both 2005 and 2020 (16-year span)	48	44
Longest sighting record, in years[3]	23	23
Maximum number of days any single individual photographed	62	50

[1] i.e., not photographed since 2009 - using 10-year gap as most conservative.
[2] Individuals alive = (individuals in catalog - individuals presumed dead - confirmed identified dead).
[3] First photographed by NMFS in 1998.

Table 16. Summary of 58 belugas in the 2005–2020 dual-side CIBW Photo-ID catalog possessing scars consistent with anthropogenic trauma from entanglement, vessel strikes, and/or non-research punctures (i.e., excluding biopsy and tag scars).

	Scar Type										
ID #	Puncture	Vessel-strike	Entanglement	Scar Source (confirmed or presumed)	First Identified	Scar First Photographed (Status)	Sex[1]	Female Photographed with Calf after First Seen with Trauma Scar?	Last Photographed	Dead by 2020? (COD)[2]	Changes in Wound During Sighting History?
D100	No	Possible	Possible	Vessel strike or entanglement	2005	2005	Presumed female	Yes	2017	No	No
D102	No	Possible	Possible	Entanglement in line or rope, or vessel 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 from stranding	n/a	2013	Confirmed dead in 2013 at age 40 (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	2020	No	No
D108	No	Possible	Possible	Vessel strike or entanglement	2005	2005	Presumed female	Yes	2020	No	No
D109	No	No	Possible	Line entanglement	2005	1998 (during NMFS study)	Presumed female	Yes	2020	No	No
D112	No	No	Possible	Monofilament line or net	2005	2005	Presumed female	Yes	2020	No	No
D113	No	Possible	Possible	Vessel strike or entanglement	2005	2005	Presumed female	Yes	2017	No	No
D1102	No	Possible	Possible	Line entanglement scar around tailstock; prop marks around peduncle	2008	2015 for entanglement (body section with scar not photographed prior to 2015); possible prop marks in 2009 healed/faded in 2017	Presumed female	Yes	2020	No	Yes

ID #	Scar Type: Puncture	Scar Type: Vessel-strike	Scar Type: Entanglement	Scar Source (confirmed or presumed)	First Identified	Scar First Photographed (Status)	Sex[1]	Female Photographed with Calf after First Seen with Trauma Scar?	Last Photographed	Dead by 2020? (COD)[2]	Changes in Wound During Sighting History?
D11375	Possible	No	No	Gunshot or predation	2012	2019	Presumed male	Yes	2020	No	n/a (only photographed 1 day)
D118	Possible	Possible	No	Consistent with biopsy scar (shape and location; but not in list of photographed biopsied whales)	2005	2016	Presumed female	Yes	2020	No	Wounds smaller in 2018 than 2016
D1187	No	Possible	No	Propeller marks	2008	2020	Presumed female	Possibly	2020	No	No
D1220	Possible	Possible	Possible	Vessel strike or entanglement	2005	2005	Presumed female	Yes	2019	No	Infection in holes and folds intermittently throughout sighting history, including 2019
D1314	Possible	No	No	Projectile or predation	2006	2012	Presumed female	Yes	2019	No	No
D135	No	No	Possible	Mark from line around tailstock or could also be from predation	2005	2015 (body section with scar not photographed prior to 2015)	Presumed female	Yes	2020	No	No
D14	No	Possible	Possible	Vessel strike or predation attempt; line entanglement scar; dent in peduncle	2005	2005	Presumed female	Yes	2019	No	No
D1416	Possible	No	No	Consistent with biopsy scar (shape and location; but not in list of photographed biopsied whales)	2006 (right side only)	2007 (left side)	Presumed female	Yes	2020	No	No
D150	No	No	Possible	Line scar around base of peduncle	2005	2009	Presumed male	n/a	2011	No	n/a (area of scar not seen after 2009)

ID #	Scar Type: Puncture	Vessel-strike	Entanglement	Scar Source (confirmed or presumed)	First Identified	Scar First Photographed (Status)	Sex[1]	Female Photographed with Calf after First Seen with Trauma Scar?	Last Photographed	Dead by 2020? (COD)[2]	Changes in Wound During Sighting History?
D154	No	Possible	Possible	Line scar around base of peduncle	2005	2019	Presumed female	No	2019	No	n/a (not photographed in 2020)
D165	Possible	No	No	Puncture wound or lesion	2005	2018	Presumed female	Yes	2020	No	No
D16854	Possible	No	No	Unknown source of puncture wound; could also be infection scar	2014	2014	Presumed female	Yes	2019	No	No
D17	Possible	No	No	Hole with outer layer of skin missing around wound. Biopsy? Unknown puncture?	2005	2019	Presumed female	No	2020	No	Wound photographed May 2019; appeared to be healing by end of July 2019
D17790	Possible	No	No	Biopsy wound or lesion?	2008	2016	Presumed female	Yes	2020	No	Wound seems to be healing
D18846	Possible	No	No	Unknown puncture, biopsy, or infection	2015	2020	Presumed male	n/a	2020	No	n/a
D195	No	Possible	No	Vessel strike or predation attempt	2005	2008 (body section with scar not photographed before 2008)	Presumed female	Yes	2020	No	No
D19871	Possible	No	Possible	Line across back; biopsy or infection?	2006	2010	Presumed female	Yes	2020	No	No
D2052	No	No	Possible	Monofilament line	2005	2005	Presumed male	n/a	2020	No	No
D206	No	Yes	No	Propeller scars	2005	2005	Presumed female	Yes	2019	No	No
D219	No	No	Possible	Line across back	2005	2005	Presumed female	Yes	2020	No	No
D220	Possible	No	No	Gunshot? Infection? Predation attempt?	2005	2020	Confirmed female (biopsy)	Yes	2020	No	No

ID #	Scar Type: Puncture	Scar Type: Vessel-strike	Scar Type: Entanglement	Scar Source (confirmed or presumed)	First Identified	Scar First Photographed (Status)	Sex[1]	Female Photographed with Calf after First Seen with Trauma Scar?	Last Photographed	Dead by 2020? (COD)[2]	Changes in Wound During Sighting History?
D2241	No	No	Possible	Multiple lines	2005	2015	Presumed female	Yes	2020	No	No
D2303	No	No	Yes	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 from stranding	n/a	2015	Confirmed dead in 2015 at age 20 (COD severe lung infection, associated infection of tag scar)	n/a (entanglement scars not seen while alive)
D2379	No	Possible	No	Sway back-disease, birth defect, ship strike?	2005	2008	Confirmed male from biopsy in 2017 and 2019; biopsy indicates born in 1999	n/a	2019	No	Sway back/thinness detected in 2008 and seems to be getting worse every year; infection in dent in 2019 (diatoms?) Biopsied twice, what does the skin biome work say?
D276	No	Possible	No	Possible impact just above left pontoon	2005	2014	Possible female	No	2016	No	No
D2782	No	Possible	Possible	Rope and/or monofilament line; propeller	2006	2019	Presumed female	Yes	2020	No	Yes, appears to be healing in 2020
D3024	No	Possible	Possible	Dent in front of dorsal; could be entanglement, vessel strike, or sat tag	2009	2009	Presumed female	Yes	2020	No	No
D3813	Possible	No	No	Gun shot? Infection?	2010	2011	Presumed female	Yes	2020	No	No

ID #	Scar Type			Scar Source (confirmed or presumed)	First Identified	Scar First Photographed (Status)	Sex[1]	Female Photographed with Calf after First Seen with Trauma Scar?	Last Photographed	Dead by 2020? (COD)[2]	Changes in Wound During Sighting History?
	Puncture	Vessel-strike	Entanglement								
D3846	No	No	Yes	Heavy braided line visible on live whale	2010	2010	Presumed male	n/a	2013	Presumed dead[3]	Rope appears tighter and cutting into flesh more every fall compared to every spring, and with every year
D404	No	Possible	Possible	Vessel strike? Heavy line?	2005	2005	Presumed female	Yes	2018	No	No
D410	Possible	No	No	Round puncture wound. Gunshot? Harpoon?	2005	2005	Presumed female	Yes	2018	No	Infection in hole intermittently throughout sighting history, including 2018
D419	No	No	Possible	Rope and/or monofilament line	2005	2005	Presumed female	Yes	2020	No	No
D4153	No	Possible	Possible	Parallel marks on peduncle could be from propeller; or could be predation marks	2008	2014	Presumed female	Possibly	2020	No	No
D49	Possible	Possible	No	Possible sat tag	2005	2005	Presumed female	Yes	2020	No	No
D516	Possible	Possible	Possible	Possible gunshot, entrance wound on left, exit wound on right; could also be from vessel strike or entanglement	2006	2006	Presumed male	n/a	2006	Presumed dead[4]	n/a (only photographed 1 day)
D5319	No	Possible	No	Vessel strike	2007	2007	Presumed female	Yes	2020	No	No

	Scar Type										
ID #	**Puncture**	**Vessel-strike**	**Entanglement**	**Scar Source (confirmed or presumed)**	**First Identified**	**Scar First Photographed (Status)**	**Sex[1]**	**Female Photographed with Calf after First Seen with Trauma Scar?**	**Last Photographed**	**Dead by 2020? (COD)[2]**	**Changes in Wound During Sighting History?**
D595	No	Possible	Possible	Entanglement marks around neck. Swayed peduncle could be from vessel strike or entanglement, or disease. Becoming more swayed and emaciated every year	2007	2009	Presumed female	Possibly	2020	No	Becoming more swayed and emaciated every year
D60	No	No	Possible	Dorsal notch with possible line mark down body	2005	2005	Presumed female	Yes	2019	No	No
D68	No	Possible	Possible	Dent on neck, could be from vessel strike, or predation attempt	2005	2005	Presumed female	Yes	2020	No	No
D7244	No	Possible	No	Necropsy noted possible propeller injury left flank and probable blunt trauma, head, and neck	2007	2012 when dead (body section with scar not photographed before; scar fresh)	Confirmed male from stranding	n/a	2012	Confirmed dead in 2012 at age 15 (COD unknown; possible vessel strike)	n/a
D7459	Possible	No	No	Gunshot? Harpoon? Lesion?	2005	2005	Presumed female	Yes	2020	No	Edges more defined over time
D75	Possible	No	No	Gunshot: exit wound on right and entrance wound on left; possible satellite tag scar	2005	2005	Presumed female	Yes	2019	No	Infection in scars intermittently throughout sighting history, including 2019
D7590	No	Possible	No	Propeller marks	2009	2009	Presumed female	Yes	2017	No	No

ID #	Scar Type: Puncture	Vessel-strike	Entanglement	Scar Source (confirmed or presumed)	First Identified	Scar First Photographed (Status)	Sex[1]	Female Photographed with Calf after First Seen with Trauma Scar?	Last Photographed	Dead by 2020? (COD)[2]	Changes in Wound During Sighting History?
D7709	No	Possible	Possible	Vessel strike	2009	2009	Presumed female	Yes	2020	No	No
D84	No	Possible	No	Vessel strike on flank?	2005	2018	Presumed female	Yes	2020	No	n/a (area of scar not seen after 2018)
D85	No	No	Possible	Rope and/or monofilament line	2005	2005	Biopsy confirmed male born in 1990	n/a	2019	No	No
D8505	No	No	Possible	Net/line marks	2010	2020	Presumed female	Possibly	2020	No	No
D86	Possible	Possible	No	Possible shaft of arrow stuck in skin	2005	2006	Presumed female	Yes	2020	No	Projectile shaft not seen after 2006
D987	Possible	No	No	Bullet? Biopsy? Infection?	2007	2016	Presumed female	Possibly	2019	No	No change in 2018; area not visible in 2019

[1] Confirmed sex of whales from genetic samples collected at tagging (Shelden et al. 2018) or biopsy (Nick Kellar, NMFS SWFC unpublished data), or examination during necropsy. Identified belugas were classified as presumed females if they appeared in the same uncropped photo frame with a calf or neonate alongside them. When the relationship between an individual calf and individual adult was ambiguous, either because of multiple adults being near the calf, little difference in color or size, or a distance of more than several meters between the adult and calf, the adult was classified as a possible female.

[2] Cause of death (COD) assigned at necropsy from Burek et al. (2015), Rouse et al. (2017), and unpublished data from Drs. Kathy Burek-Huntington and Carrie Goertz.

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

[4] Presumed dead after >10 years without resighting; not photographed 2009–2020.

Table 17. Summary of CIBWs captured (n=20) and satellite-tagged (n=18) between 1999 and 2002 and matches to individuals in the 2005–2020 photo-ID catalog. An individual was classified as dead by 2020 if it had been confirmed dead as a carcass or presumed dead if it had not been photographed since 2009. 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[2]	Length during capture (cm)	Photo-ID Catalog Number	Dead as of 2020?	Last Photographed
No number (captured, not tagged)	Little Susitna	May 31, 1999	F	Gray	230	L2191	Presumed dead	2007
CI-99-01	Little Susitna	May 31, 1999	M	White	370	Possible match	?	?
No number (captured, not tagged)	Knik Arm	Sep 8, 2002	F	Light gray	274	No match (no tagging photos to examine)	?	?
CI-00-01	Knik Arm	Sep 13, 2000	M	White	413	Possible match	?	x
CI-00-02	Knik Arm	Sep 13, 2000	F	White/gray	272	D111	No	2020
CI-01-01	Little Susitna	Aug 10, 2001	F	Gray	257	D243	No	2020
CI-01-02	Knik Arm	Aug 11, 2001	M	White	323	Possible match	?	?
CI-01-03	Knik Arm	Aug 12, 2001	F	White	312	Possible match	?	?
CI-01-04	Knik Arm	Aug 13, 2001	F	White	340	No match (no tagging photos to examine)	May have died in 2001 post-tagging	?
CI-01-05	Knik Arm	Aug 13, 2001	F	White	357	Possible match	?	?
CI-01-06	Knik Arm	Aug 15, 2001	F	White	401	D103	No	2019
CI-01-07	Knik Arm	Aug 20, 2001	M	White	442	No matches (blurry tagging photos)	?	?
CI-02-01	Little Susitna	Jul 29, 2002	M	White	412	Possible match	?	?
CI-02-02	Little Susitna	Jul 30, 2002	F	White/gray	340	Possible match	May have died in 2002 post-tagging	?
CI-02-03	Knik Arm	Jul 31, 2002	F	White	366	Possible match	?	?

NMFS CIBW ID Tagging Number	Capture Location	Capture Date	Sex[1]	Color[2]	Length during capture (cm)	Photo-ID Catalog Number	Dead as of 2020?	Last Photographed
CI-02-04	Little Susitna	Aug 1, 2002	F	White	379	No post-2002 photos	Confirmed dead post-tagging Aug 9, 2002	?
CI-02-05	Knik Arm	Aug 2, 2002	M	White/gray	386	D2303	Confirmed dead Jun 12, 2015	2015
CI-02-06	Knik Arm	Aug 3, 2002	M	White/gray	353	D2204	Presumed dead	2007
CI-02-07	Knik Arm	Aug 3, 2002	F	White	374	Possible match	May have died in 2002 post-tagging	?
CI-02-08	Knik Arm	Aug 4, 2002	M	White/gray	376	D115	Confirmed dead May 26, 2014	2014

[1] Genetic sex from satellite tag samples analyzed by Greg O ’Corry-Crowe, Florida Atlantic University.
[2] Assigned during capture by NMFS.

Table 18. Sighting records of satellite-tagged individuals identified in the 2005–2020 CIBW Photo-ID catalog, including records of reproduction, survival, and satellite-tag scar status. Identified belugas were classified as presumed females if they appeared in the same uncropped photo frame with a calf or neonate alongside them.

Photo-ID # (NMFS tagging ID #)	Research Scar	Year Individual First Identified in Photo-ID Catalog	Year Trauma Scar First Photographed (* = scar fresh)	Sex[1]	Year Individual Last Photographed	Dead by 2020?[2]	Female Photographed with a Calf Born Post Tagging (2005-2020)?	Research Scar Sighting History (see Figure 15 for most-recent photos)
L2191	Captured, but not tagged	2007	n/a	Confirmed female	2007	Presumed dead	No	Not tagged or flipper banded
D103 (CI-01-06)	Confirmed satellite tag from 2001	2005	2001* during tagging	Confirmed female	2019	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* during tagging	Confirmed male	2015	Confirmed dead 2015 (COD 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	2000* during tagging	Confirmed female	2020	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* 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* during tagging	Confirmed male	2007	Presumed dead	n/a	scars conspicuous and appeared infected and deteriorating 2005–2007

Photo-ID # (NMFS tagging ID #)	Research Scar	Year Individual First Identified in Photo-ID Catalog	Year Trauma Scar First Photographed (* = scar fresh)	Sex[1]	Year Individual Last Photographed	Dead by 2020?[2]	Female Photographed with a Calf Born Post Tagging (2005-2020)?	Research Scar Sighting History (see Figure 15 for most-recent photos)
D243 (CI-01-01)	Confirmed satellite tag from 2001	2005	2001* during tagging	Confirmed female	2020	No	Yes	Conspicuous tag scars, 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	2020	No	Yes	Conspicuous tag scar; infection in tag scar intermittently throughout sighting history. Dark spot in scar indentation appears to be enlarging beginning in 2018
D549 (unable to match)	Confirmed satellite tag, tag year unknown	2005	2005	Presumed female	2020	No	Yes	Tag scars conspicuous but becoming smaller over time; no signs of infection
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	2020	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	2020	No	Yes	Tag scar conspicuous but no signs of infection
D5319 (unable to match)	Confirmed satellite tag, tag year unknown	2007	2007	Presumed female	2020	No	Yes	Tag scar conspicuous but no signs of infection

Photo-ID # (NMFS tagging ID #)	Research Scar	Year Individual First Identified in Photo-ID Catalog	Year Trauma Scar First Photographed (* = scar fresh)	Sex[1]	Year Individual Last Photographed	Dead by 2020?[2]	Female Photographed with a Calf Born Post Tagging (2005-2020)?	Research Scar Sighting History (see Figure 15 for most-recent photos)
R6 (unable to match)	Confirmed satellite tag, tag year unknown	2005	2005	Presumed female	2020	No	Yes	Tag scar conspicuous on right side but not left; one tag hole still open as of 2017 and seems to be widening and possibly infected in 2019; tag hole wider in 2020
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	2019	No	Yes	Conspicuous scars; possible infection in scars intermittently throughout sighting history

[1] Genetic sex from satellite tag samples analyzed by Greg O 'Corry-Crowe, Florida Atlantic University (Shelden et al. 2018).
[2] Confirmed as carcass or presumed if not photographed since 2009. COD=cause of death assigned during necropsy.

Table 19. Summary of photo-id matches made between the 2005–2020 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, as of April 1, 2022. This table represents 42 individuals (versus 47) because one individual was biopsied three times and three individuals were successfully biopsied but also struck with no sample. Individuals with more than one biopsy are noted by colored cells of matching colors. U=unknown, either because sample not collected, not analyzed, or results not available. X=not photographed following biopsy. n/a=not applicable. Matches between the CIBW Photo-ID Project catalog and biopsy photos are updated semi-annually; please contact Tamara McGuire (tamaracookinletbelugas@gmail.com) before using the data in this table as results may have changed as cataloging is ongoing.

Biopsy Date	Biopsy ID	Photo-ID Catalog ID	Year First Identified in Photo-ID Catalog	Genetic Sex[1]	Epigenetic Age at Biopsy in Years[2]	Side of Whale Biopsied	Year Whale last Photographed (cataloging complete through 2020)	Comments
2016								
August 13	DL-CIB16-31	R18703	2016	F	14	Right	2016	
August 15	DL-CIB16-32	D16873	2010	M	20	Right	2020	Also struck-no-sample in 2018
August 16	DL-CIB16-33	L18698	2011	F	Unavailable	Left	2016	
August 19	DL-CIB16-34	D16854	2014	F	16	Left	2019	
August 19	DL-CIB16-35	D154	2005	F	22	Left	2020	
August 20	DL-CIB16-36	D220	2005	F	22	Left	2020	
2017								
September 2	DL-CIB17-01	D18630	2015	F	18	Left	2020	
September 2	DL-CIB17-02	D19173	2016	F	13	Right	2020	
September 2	DL-CIB17-03	D2379	2005	M	18	Right	2019	Also biopsied 2019; DLCIB19-07
September 2	DL-CIB17-04	D3221	2005	M	17	Left	2018	
September 2	DL-CIB17-hitnosample-1	L10517	2011	U	U	Left	2017	

Biopsy Date	Biopsy ID	Photo-ID Catalog ID	Year First Identified in Photo-ID Catalog	Genetic Sex[1]	Epigenetic Age at Biopsy in Years[2]	Side of Whale Biopsied	Year Whale last Photographed (cataloging complete through 2020)	Comments
September 3	DL-CIB17-05	D1187	2008	M	23	Right	2020	Three shots taken at this whale same day: miss, biopsy, miss.
September 3	DL-CIB17-06	D28419	2017	F	17	Right	2018	
September 4	DL-CIB17-07	L2366	2005	M	28	Left	2020	
September 7	DL-CIB17-08	R28421	2017	F	11	Right	2020	
September 8	DL-CIB17-09	L28411	2017	M	23	Left	2017	
September 9	DL-CIB17-10	D326	2005	F	21	Right	2020	
September 9	DL-CIB17-11	D3813	2010	F	23	Left	2020	
September 9	DL-CIB17-12	D18993	2016	F	15	Right	2020	
September 9	DL-CIB17-hitnosample-2	L28412	2017	U	n/a	Left	2019	
2018								
September 6	DLCIB18-01	R34931	2018	F	15	Right	2018	
September 6	DLCIB18-02	R34164 possible match to L2014	2018; possibly 2006	M	16	Right	2018	
September 6	DLCIB18-03	R34933	2018	M	15	Right	2018	
September 9	DLCIB18-04	D85	2005	M	26	Right	2020	Biopsied three times in 2018; awaiting Kim Parson's genetic confirmation of multiple biopsies of same individual
September 9	DLCIB18-05	D18488	2012	M	21	Right	2019	
September 9	DLCIB18-06	D595	2007	M	20	Right	2020	Struck twice 2018; one biopsy and one no sample

Biopsy Date	Biopsy ID	Photo-ID Catalog ID	Year First Identified in Photo-ID Catalog	Genetic Sex[1]	Epigenetic Age at Biopsy in Years[2]	Side of Whale Biopsied	Year Whale last Photographed (cataloging complete through 2020)	Comments
September 10	DLCIB18-07	L34923	2018	F	20	Left	2018	Struck twice 2018; one biopsy and one no sample
September 10	DLCIB18-08	R34938	2018	F	20	Right	2019	
September 10	DLCIB18-09	R21930	2015	F	21	Right	2020	
September 10	DLCIB18-10	D85	2005	M	28	Left	2020	Biopsied three times in 2018; awaiting Kim Parson's genetic confirmation of multiple biopsies of same individual
September 10	DLCIB18-11	L33575	2011	M	19	Left	2020	
September 11	DLCIB18-12	D20266	2012	F	16	Left	2020	
September 11	DLCIB18-13	L34948	2018	M	8	Left	2020	
September 11	DLCIB18-14	D17286	2014	F	17	Left	2020	
September 11	DLCIB18-15	R21848	2016	M	15	Right	2020	
September 11	DLCIB18-16	R34941	2018	M	13	Right	2018	
September 12	DLCIB18-17	R17000	2014	M	23	Right	2019	
September 12	DLCIB18-18	D85	2005	M	26	Right	2020	Biopsied three times in 2018; awaiting Kim Parson's genetic confirmation of multiple biopsies of same individual
September 12	DLCIB18-19	D10860	2011	M	21	Right	2019	Also missed biopsy (no strike/no sample on left 2017-09-02
September 12	DLCIB18-20	D11374	2008	M	19	Right	2020	
September 12	DLCIB18-21	R34947	2018	F	15	Right	2018	

Biopsy Date	Biopsy ID	Photo-ID Catalog ID	Year First Identified in Photo-ID Catalog	Genetic Sex[1]	Epigenetic Age at Biopsy in Years[2]	Side of Whale Biopsied	Year Whale last Photographed (cataloging complete through 2020)	Comments
July 26	DLCIB18-hitnosample-1	D28362	2017	U	n/a	Left	2018	Strike, no sample
July 26	DLCIB18-hitnosample-2	D18101	2015	U	n/a	Right	2020	Strike, no sample
July 30	DLCIB18-hitnosample-3	L34922	2018	U	n/a	Left	2018	Strike, no sample
September 6	DLCIB18-hitnosample-4	D595	2007	M	20	Right	2020	Struck twice 2018; one biopsy and one no sample
September 10	DLCIB18-hitnosample-5	L34923	2018	F	20	Left	2018	Struck twice 2018; one biopsy and one no sample
September 11	DLCIB18-hitnosample-6	D16873	2010	M	20	Right	2020	Missed shot in 2018; successful biopsy in 2016

[1] Genetic sex from biopsy samples analyzed by Nick Kellar, NMFS Southwest Fisheries Science Center, and Kim Parsons, NMFS Northwest Fisheries Science Center.

[2] Epigenetic aging from biopsy samples (Bors et al. 2021).

Table 20. Summary of photo-id matches made between the 2005–2020 CIBW Photo-ID Project catalog and the 14 belugas sampled by biopsy in 2019 by Marine Mammal Lab (MML), as of April 1, 2022. Individuals with more than one biopsy are noted by colored cells of matching colors. U=unknown, either because sample not collected, not analyzed, or results not available. X=not photographed following biopsy. n/a=not applicable. Matches between the CIBW Photo-ID Project catalog and biopsy photos are updated semi-annually; please contact Tamara McGuire (tamaracookinletbelugas@gmail.com) before using the data in this table as results may have changed.

2019 Biopsy Date	MML Sample #	Biopsy Sample Label	Photo-ID Catalog #	Match to CIBW Photo-ID Catalog?	Year First Identified in Photo-ID Catalog	Genetic Sex[1]	Photographed with a calf between 2005 and 2019 biopsy?	Pregnant at biopsy?[2]	Female seen with calf after biopsy?	Epigenetic age at biopsy in years[3]	Side of whale biopsied	Year whale last photographed	Comments
28 Aug	MML-RA190828-B01	DLCIB19-01	U	Possible	2019	U	n/a	U	n/a	U	Left	2019	
28 Aug	MML-RA190828-B02	DLCIB19-02	U	Possible	2019	U	n/a	U	n/a	U	Right	2019	
28 Aug	MML-RA190828-B03	DLCIB19-03	U	Possible	2019	U	n/a	U	n/a	U	Right	2019	
29 Aug	MML-RA190829-B04	DLCIB19-04	R3235	Yes	2009	U	Yes	U	no	U	Right	2019	
30 Aug	MML-RA190830-B05	DLCIB19-05	U	Possible	2019	U	n/a	U	n/a	U	Left	2019	
30 Aug	MML-RA190830-B06	DLCIB19-06	L8151	Yes	2010	U	Possible	U	X	U	Left	2019	
31 Aug	MML-RA190831-B07	DLCIB19-07	D2379	Yes	2005	U (know from previous biopsy it is male)	n/a (male)	U (male)	n/a (male)	18 in 2017	Left	2019	Also biopsied in 2017; DL-CIB17-03
31 Aug	MML-RA190831-B08	DLCIB19-08	R16674	Yes	2012	U	Yes	U	X	U	Right	2019	
31 Aug	MML-RA190831-B09	DLCIB19-09	No photos	n/a	n/a	U	n/a no photo	U	n/a no photo	U	?	n/a no photo	
31 Aug	MML-RA190831-B10	DLCIB19-10	D3833	Yes	2009	U	Yes	U	No	U	Left	2020	
31 Aug	MML-RA190831-B11	DLCIB19-11	L27193	Yes	2017	U	Yes	U	No	U	Left	2019	

2019 Biopsy Date	MML Sample #	Biopsy Sample Label	Photo-ID Catalog #	Match to CIBW Photo-ID Catalog?	Year First Identified in Photo-ID Catalog	Genetic Sex[1]	Photographed with a calf between 2005 and 2019 biopsy?	Pregnant at biopsy?[2]	Female seen with calf after biopsy?	Epigenetic age at biopsy in years[3]	Side of whale biopsied	Year whale last photographed	Comments
31 Aug	MML-RA190831-B12	DLCIB19-12	U	Possible	2019	U	n/a	U	n/a	U	Left	2019	
31 Aug	MML-RA190831-B13	DLCIB19-13	U	Possible	2019	U	n/a	U	n/a	U	Left	2019	
13 Sep	MML-RA190913-B14	DLCIB19-14	D25L	Yes	2005	U	Yes	U	Yes	U	Left	2020	

[1]Genetic sex from biopsy samples analyzed by Nick Kellar, NMFS Southwest Fisheries Science Center, and Kim Parsons NMFS Northwest Fisheries Science Center; delayed due to pandemic.
[2] Pregnancy status from hormones in blubber samples analyzed by Nick Kellar, NMFS Southwest Fisheries Science Center; delayed due to pandemic.
[3] Epigenetic aging from biopsy samples (Bors et al. 2021).

Table 21. Summary of females in matches made between the 2005–2020 CIBW Photo-ID Project catalog and remote biopsy samples from the 2016, 2017, and 2018 Cook Inlet Beluga Biopsy Study, as of April 1, 2022. Information on age, sex, and reproductive hormonal status of CIBWs biopsied in 2019 not yet available at time of report. U=unknown, either because sample not collected, not analyzed, or results not available. X=not photographed following biopsy. n/a=not applicable. Matches between the CIBW Photo-ID Project catalog and biopsy photos are updated semi-annually; please contact Tamara McGuire (tamaracookinletbelugas@gmail.com) before using the data in this table as results may have changed.

Biopsy Date	Biopsy ID	Photo-ID Catalog #[1]	Year First Identified in Photo-ID Catalog	Genetic Sex[2]	Female photographed with a calf between 2005 and biopsy?	Pregnant at biopsy?[3]	Female seen with calf after biopsy?[4]	Epigenetic age at biopsy in years[5]	Year biopsied whale born[6]	Age of mom when first photographed with calf or biopsied pregnant[7]	Evidence suggesting pregnant at or before biopsy?	Year whale last photographed[8]
2016												
August 13	DL-CIB16-31	R18703	2016	F	No	No	X	14	2002	n/a	No	2016
August 16	DL-CIB16-33	L18698	2011	F	No	No	X	U	U	n/a	No	2016
August 19	DL-CIB16-34	D16854	2014	F	No	No	J3+ in 2017	16	2000	14 (assume calf born in 2014)	Yes	2019
August 19	DL-CIB16-35	D154	2005	F	First known calf 2009 or 2010 (J1- in 2010)	Yes	J1+ on day of biopsy; with calf 2017, 2018 and 2019	22	1994	15 or 16	Yes	2020
August 20	DL-CIB16-36	D220	2005	F	J1+ in 2007	Yes	Possibly with calf of unknown age in 2018; with calf in 2019 and 2020	22	1994	12 (assume gave birth in 2006)	Yes	2020
2017												
September 2	DL-CIB17-01	D18630	2015	F	J1- in 2015	No	YOY in 2020	18	1999	15 or 16	Yes	2020

Biopsy Date	**Biopsy ID**	**Photo-ID Catalog #**[1]	**Year First Identified in Photo-ID Catalog**	**Genetic Sex**[2]	**Female photographed with a calf between 2005 and biopsy?**	**Pregnant at biopsy?**[3]	**Female seen with calf after biopsy?**[4]	**Epigenetic age at biopsy in years**[5]	**Year biopsied whale born**[6]	**Age of mom when first photographed with calf or biopsied pregnant**[7]	**Evidence suggesting pregnant at or before biopsy?**	**Year whale last photographed**[8]
September 2	DL-CIB17-02	D19173	2016	F	No	No	Yes, with J1- on 2017-08-05; with older and YOY calves in 2019	13	2004	13 or 12	Yes	2020
September 3	DL-CIB17-06	D28419	2017	F	No	Yes	Possibly with calf of unknown age in 2018	17	2000	17	Yes	2018
September 7	DL-CIB17-08	R28421	2017	F	No	No	No	11	2006	n/a	No	2020
September 9	DL-CIB17-10	D326	2005	F	J1- in 2009; J1+ 2010, YOY in 2014; YOY in 2016	No	J2 in 2018; J3 2019; J1- in 2020)	21	1996	12 or 13	Yes	2020
September 9	DL-CIB17-11	D3813	2010	F	Possible J1+ calf in 2014; possible unknown age calf in 2016; confirmed J1+ calf in 2017	Yes	Possible J3+ in 2020	23 (whale looks much younger than this in photos, by maybe a decade)	1994	23 (possibly 20?)	Yes	2020
September 9	DL-CIB17-12	D18993	2016	F	No	U (skin only)	J2+ in 2019; J3+ in 2020	15	2002	15	Yes	2020
2018												
September 6	DLCIB18-01	R34931	2018	F	No	No	X	15	2003	n/a	No	2018
September 10	DLCIB18-07	L34923	2018	F	J2+ calf during biopsy event	No	J2+ week after biopsy	20	1998	18	Yes	2018

Biopsy Date	Biopsy ID	Photo-ID Catalog #[1]	Year First Identified in Photo-ID Catalog	Genetic Sex[2]	Female photographed with a calf between 2005 and biopsy?	Pregnant at biopsy?[3]	Female seen with calf after biopsy?[4]	Epigenetic age at biopsy in years[5]	Year biopsied whale born[6]	Age of mom when first photographed with calf or biopsied pregnant[7]	Evidence suggesting pregnant at or before biopsy?	Year whale last photographed[8]
September 10	DLCIB18-08	R34938	2018	F	No	No	No	20	1998	n/a	No	2019
September 10	DLCIB18-09	R21930	2015	F	J1- calf weeks before biopsy	U (skin only)	Possibly with calf during biopsy event; possibly with calf in 2019; with J1+ in 2020	21	1997	20 or 21	Yes	2020
September 11	DLCIB18-12	D20266	2012	F	No	No	J1- in 2020	16	2002	17 or 18	No	2020
September 11	DLCIB18-14	D17286	2014	F	J1+ in 2017	No	J3+ 2019 and YOY in 2020	17	2001	15 or 16	Yes	2020
September 12	DLCIB18-21	R34947	2018	F	No	No	X	15	2003	n/a	No	2018

[1] Individuals biopsied multiple times linked by same color cell.
[2] Genetic sex from biopsy samples analyzed by Nick Kellar, NMFS Southwest Fisheries Science Center, and Kim Parsons, NMFS Northwest Fisheries Science Center; delayed due to pandemic.
[3] Pregnancy status from hormones in blubber samples analyzed by Nick Kellar, NMFS Southwest Fisheries Science Center; delayed due to pandemic.
[4] Exact calf ages determined from year first seen as a neonate and estimated calf ages based on physical appearance. 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; J4+ calf is at least four years old; YOY = young of year.
[5] Epigenetic aging from biopsy samples (Bors et al. 2021).
[6] Birth year = Biopsy year - epigenetic age.
[7] Centered within -/+ 3 years for epigenetic aging range.
[8] Cataloging complete through 2020.

FIGURES

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

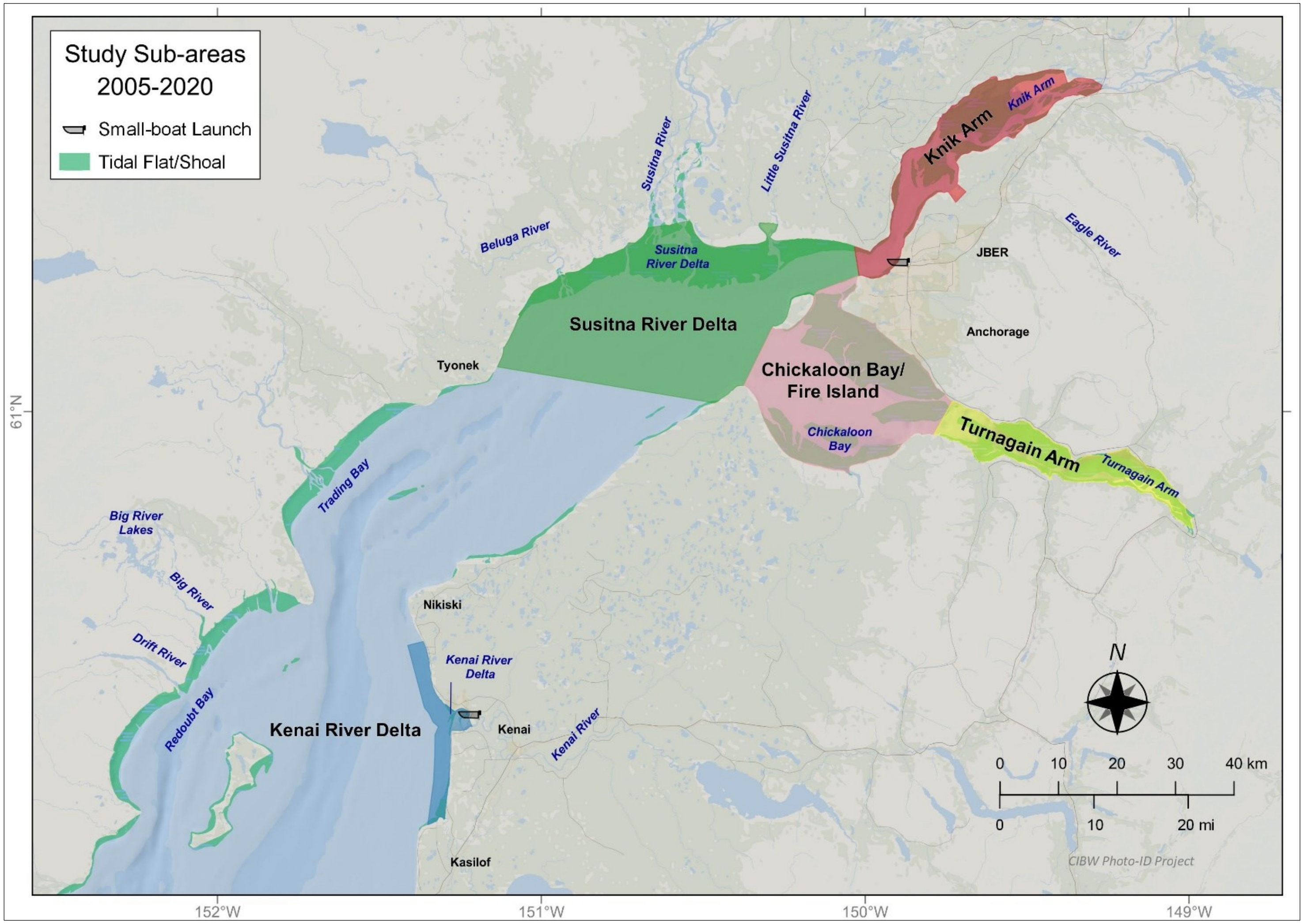


Figure 2. Map of Middle and Upper Cook Inlet, Alaska, showing boundaries of five survey sub-areas within the study area.

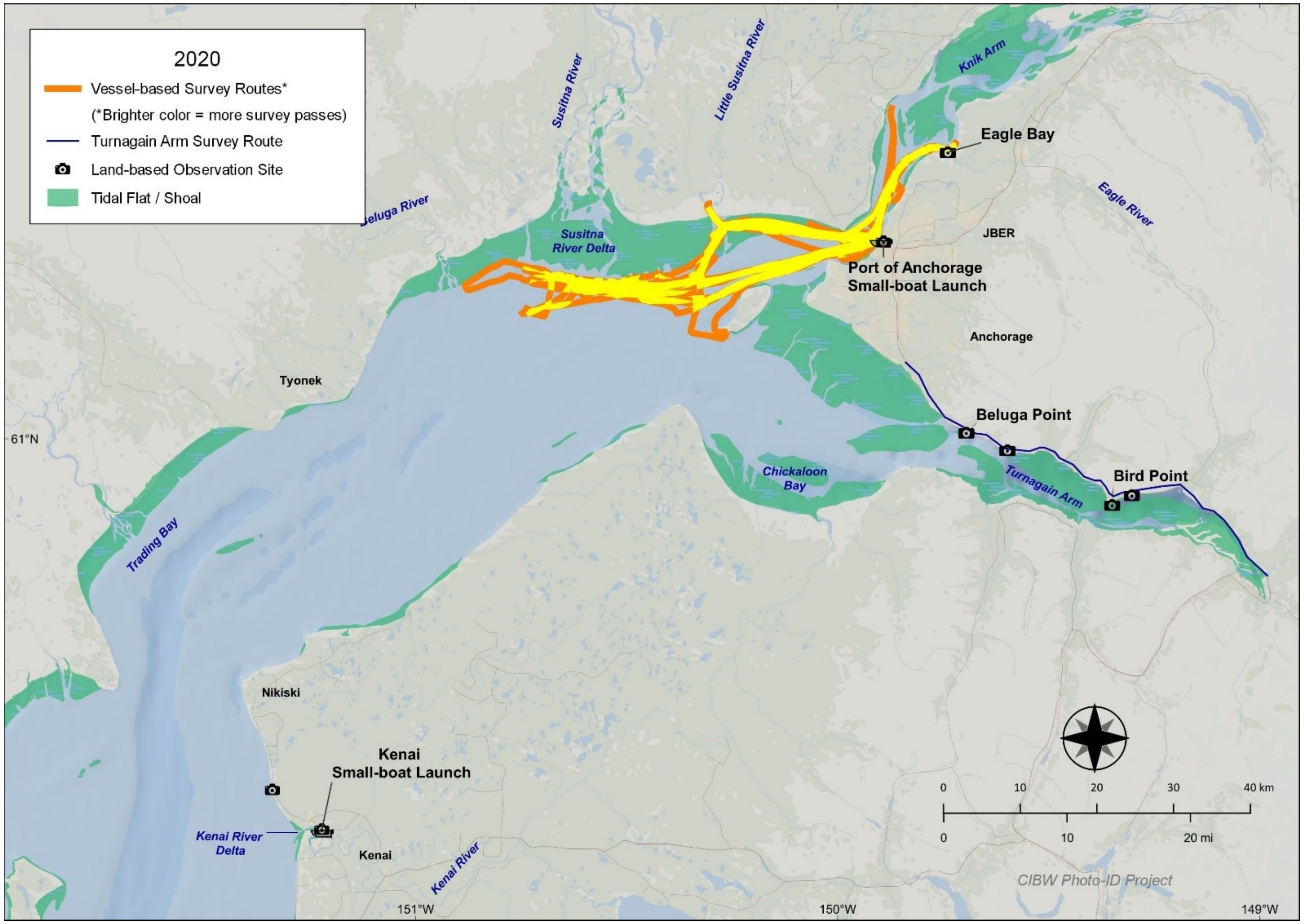


Figure 3. Vessel routes (from daily GPS track lines) with land-based stations and survey routes for all photo-ID surveys conducted in 2020. Level of effort of the vessel-based surveys is indicated by the intensity of the colors of the track lines. See Table 2 for exact number of surveys.

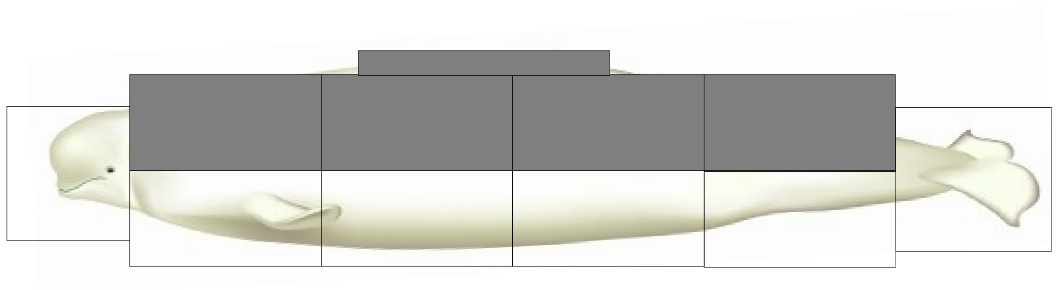


Figure 4. Body segments used when cataloging photographs of belugas for photo-ID. The five shaded areas were the critical sections used in matching marks. Beluga illustration courtesy of Uko Gorter.

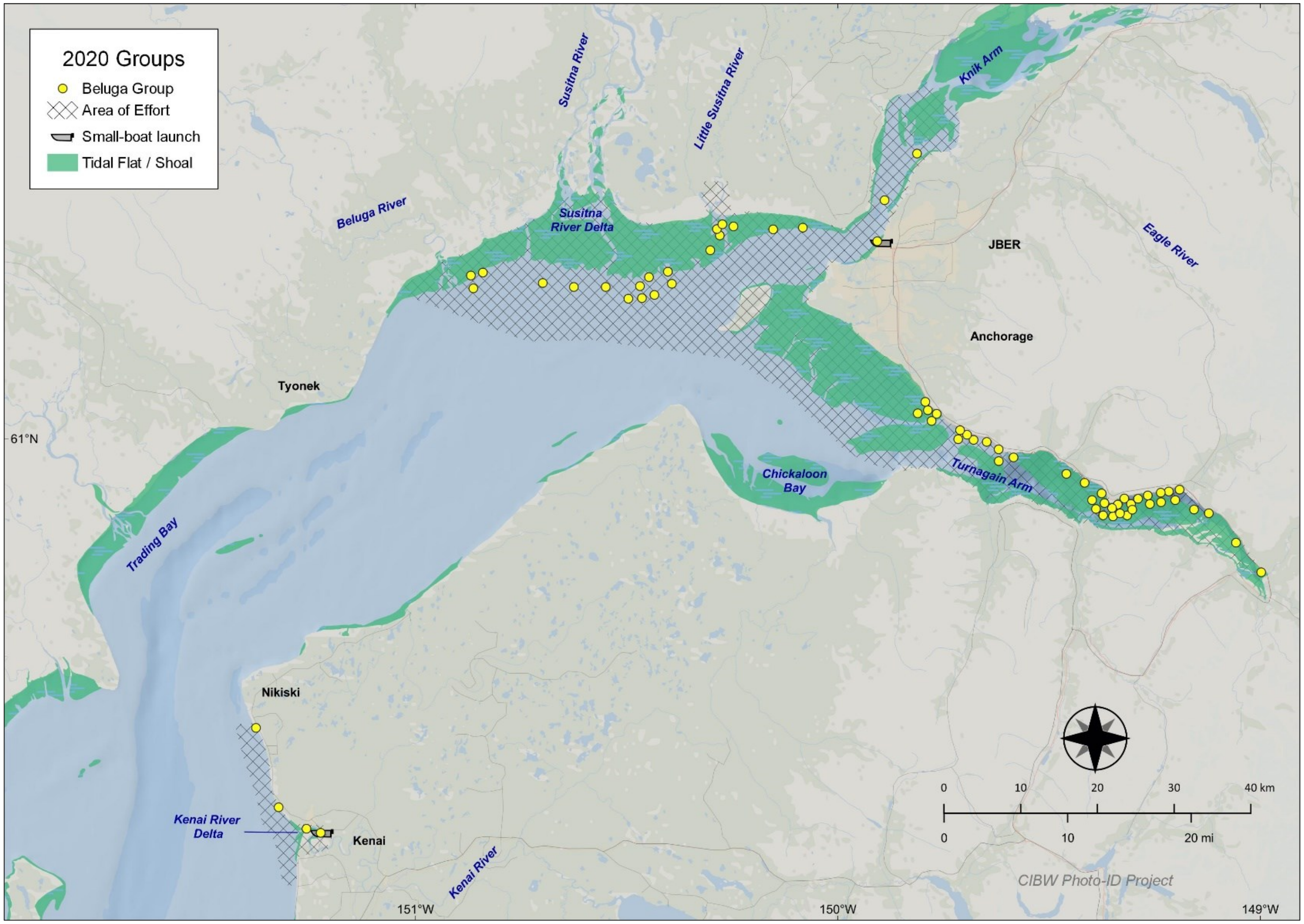


Figure 5. Beluga whale groups encountered during all photo-ID surveys conducted in 2020.

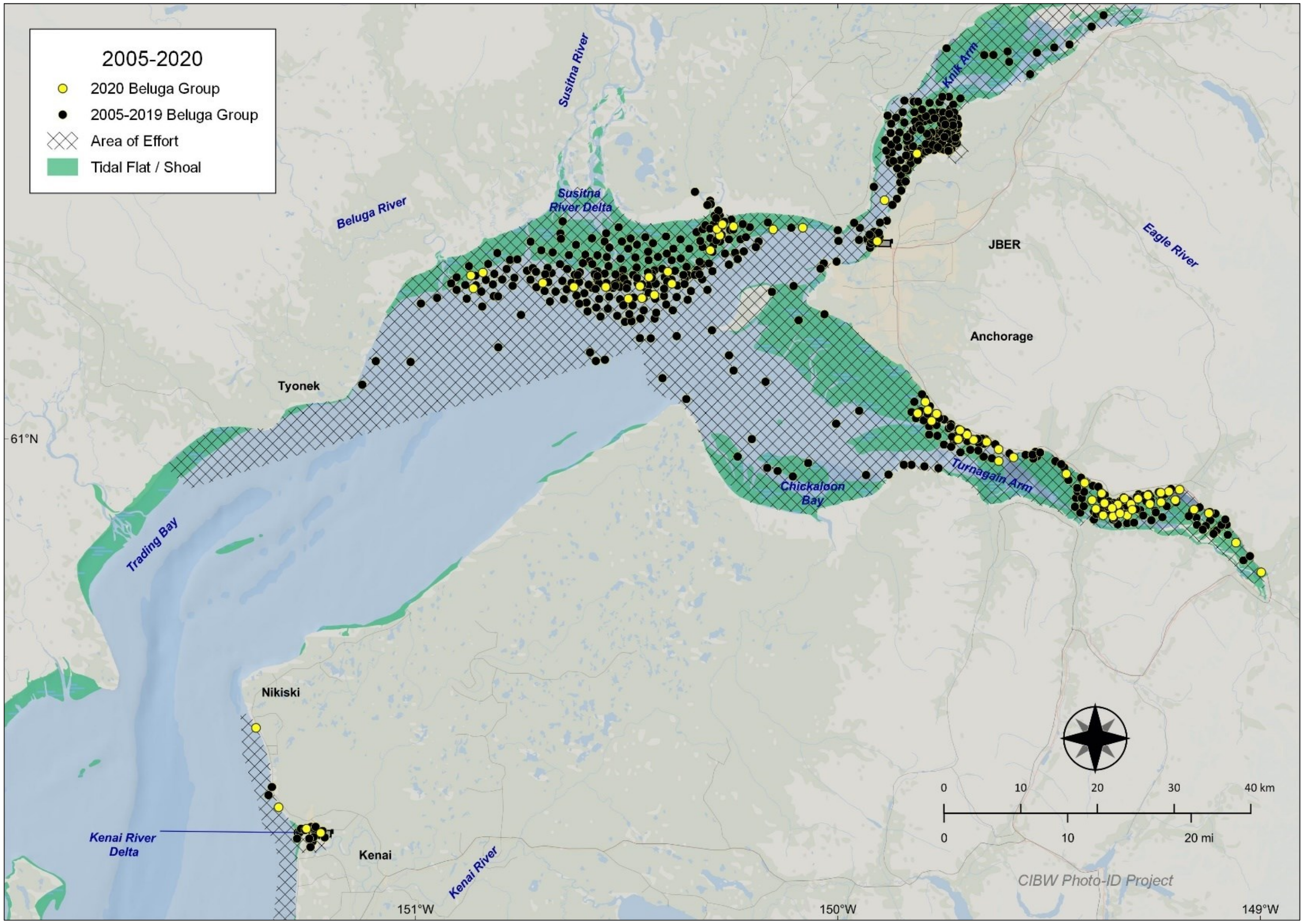


Figure 6. Beluga whale groups encountered during all photo-ID surveys conducted in 2005–2020.

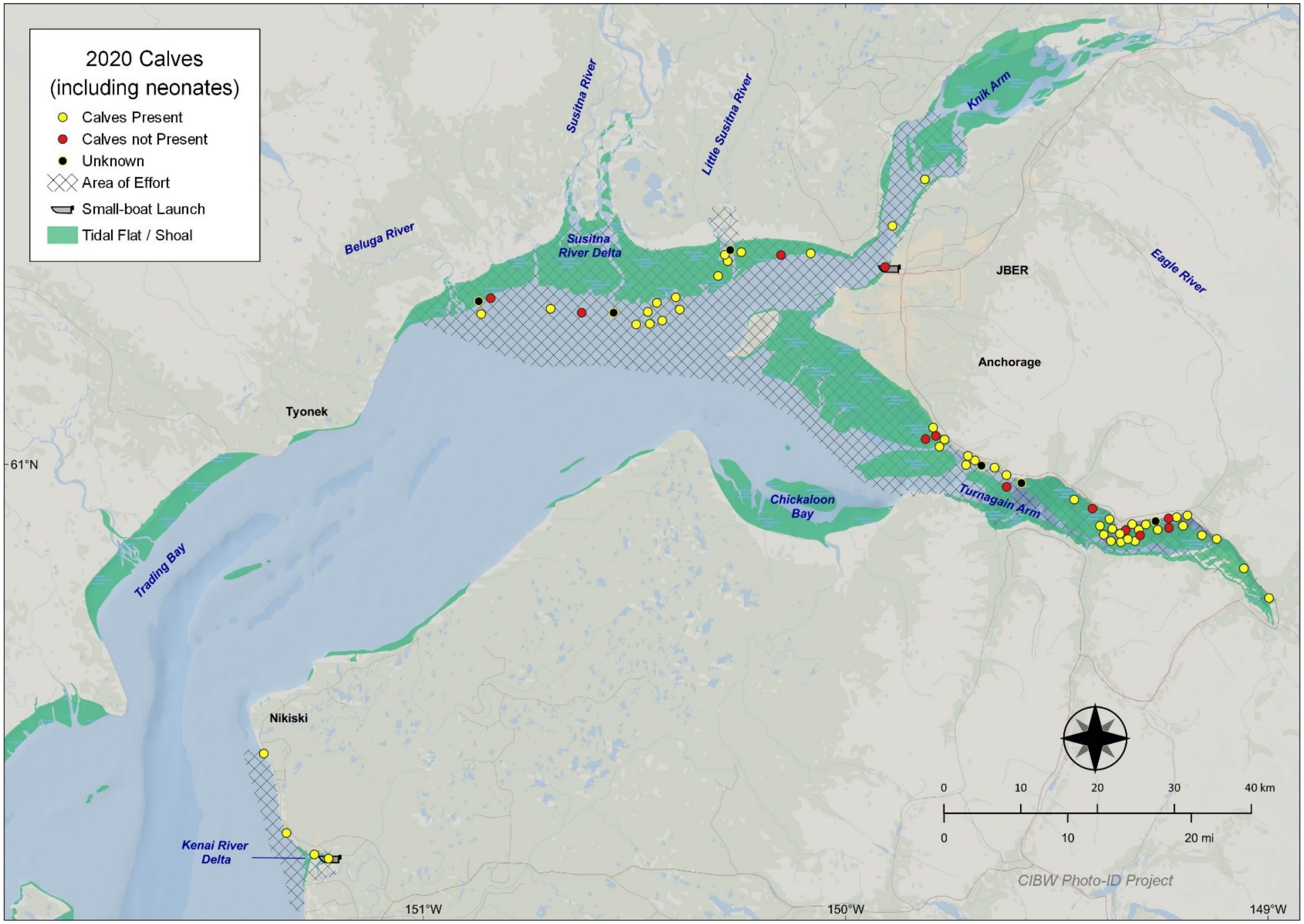


Figure 7. Location of groups with and without calves and or neonates encountered during photo-ID surveys conducted in 2020.

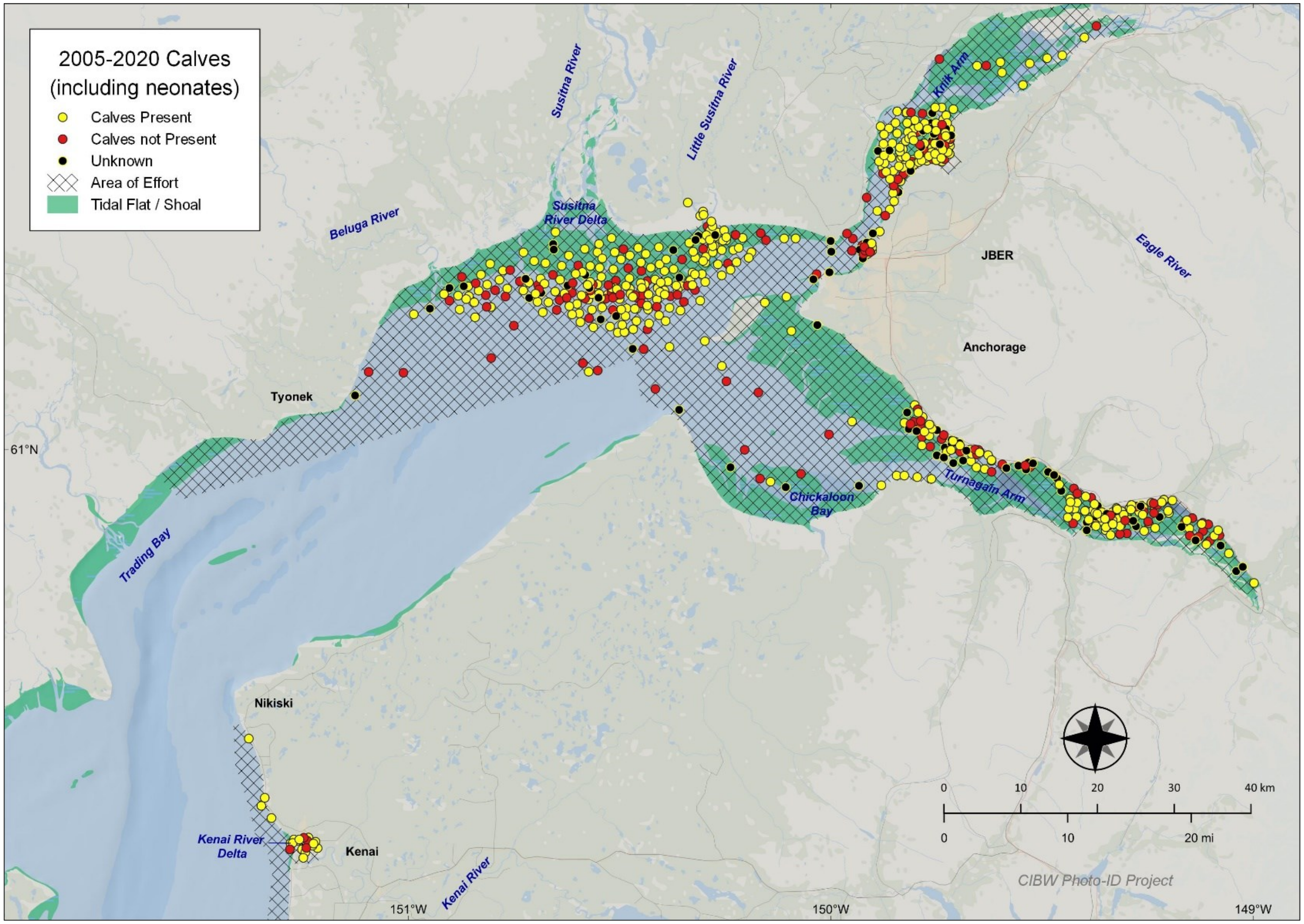


Figure 8. Location of groups with and without calves and/or neonates encountered during photo-ID surveys from 2005–2020.

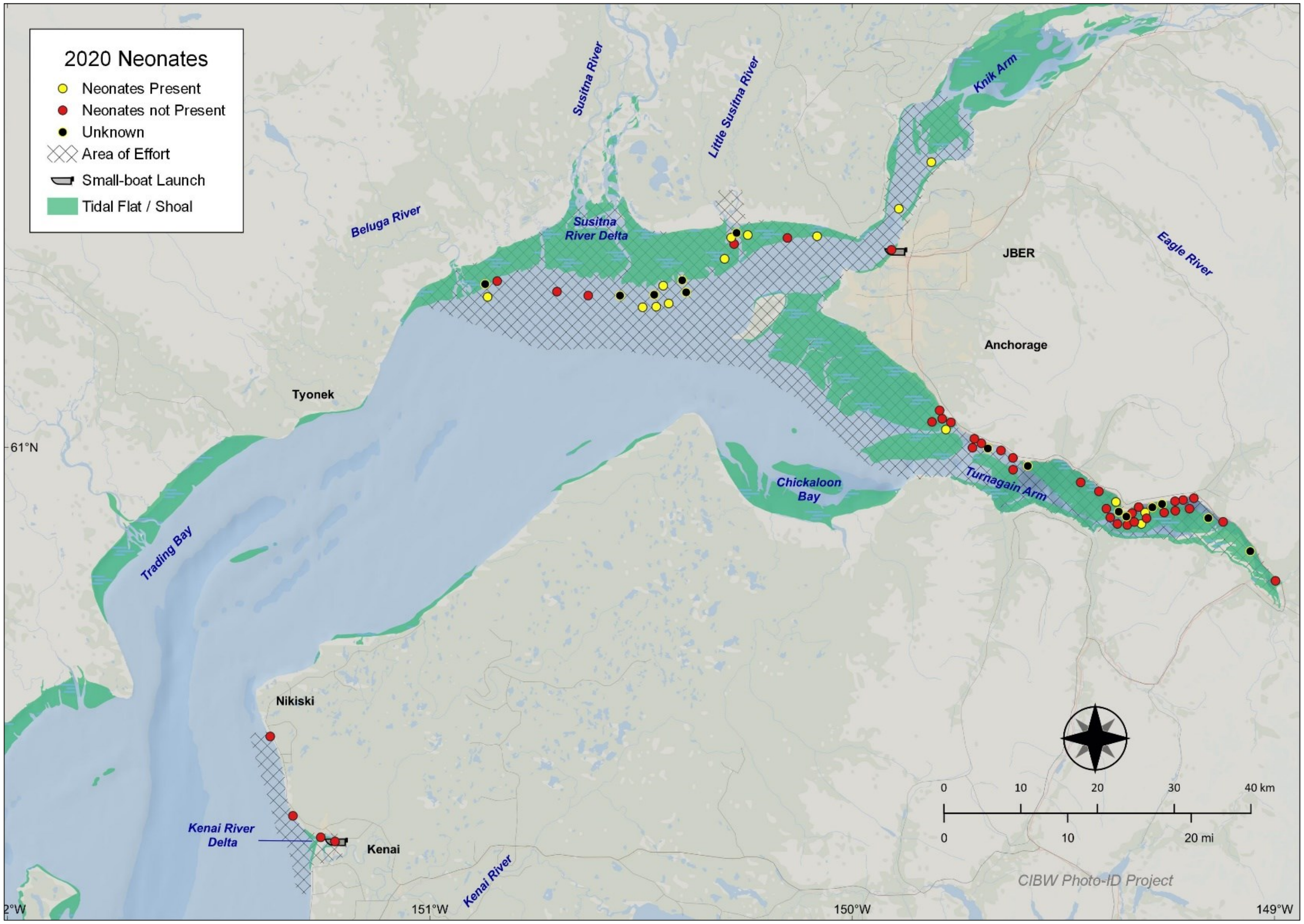


Figure 9. Location of groups with and without neonates encountered during photo-ID surveys in 2020.

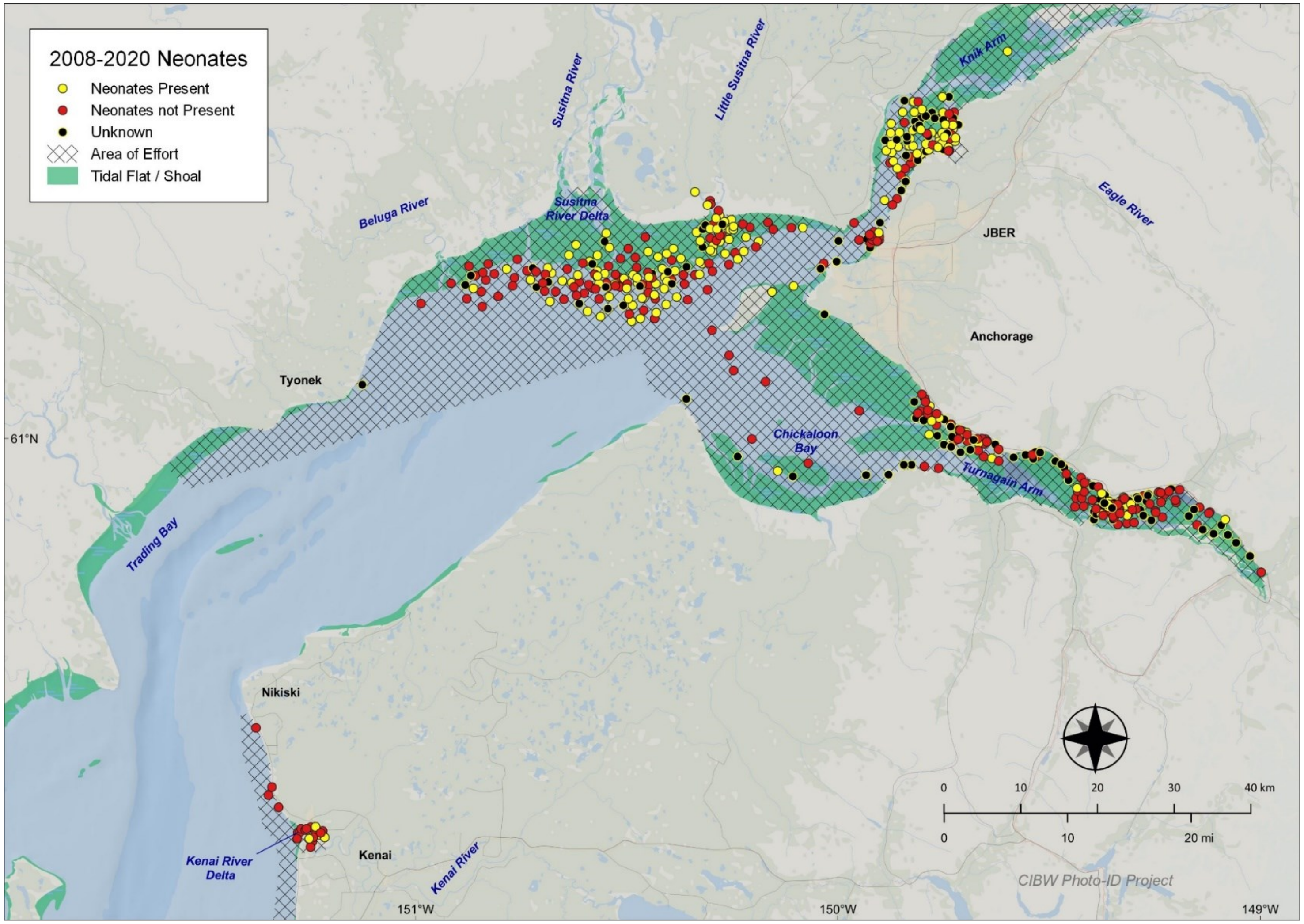


Figure 10. Location of groups with and without neonates encountered during photo-ID surveys conducted from 2008–2020.

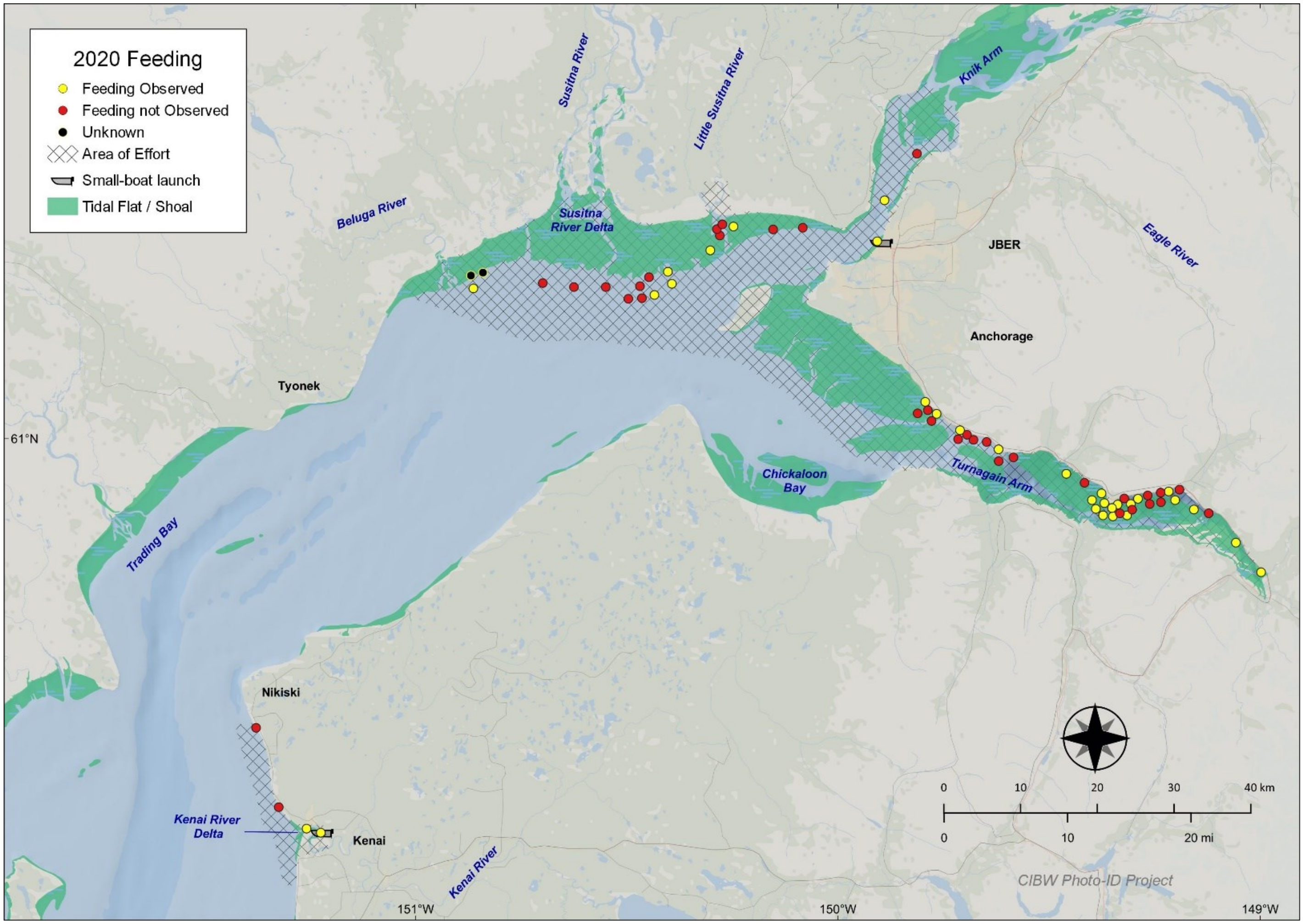


Figure 11. Location of groups with and without observations of feeding behavior (suspected or confirmed) during photo-ID surveys conducted in 2020.

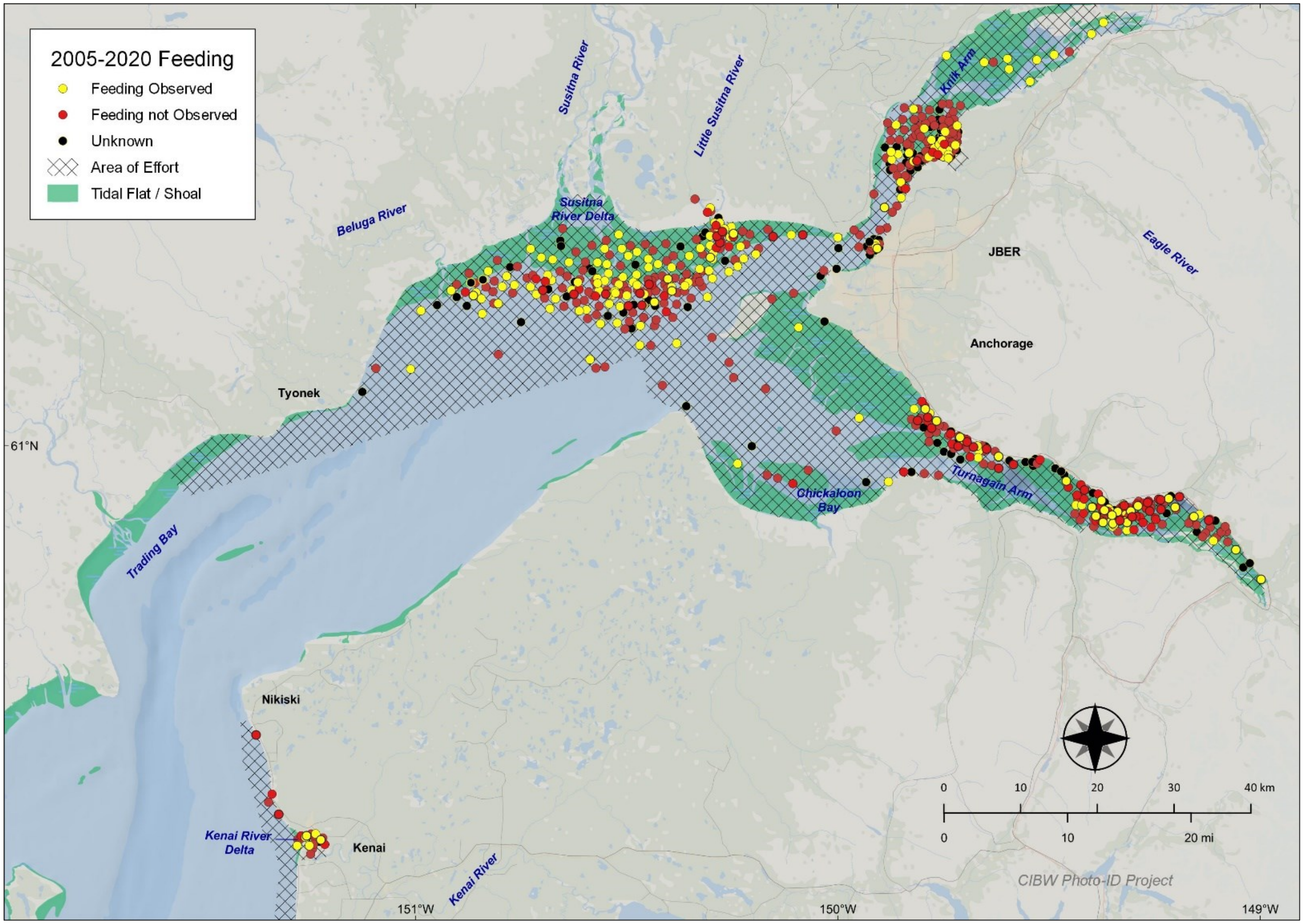


Figure 12. Location of groups with and without observations of feeding behavior (suspected or confirmed) during photo-ID surveys conducted 2005–2020.

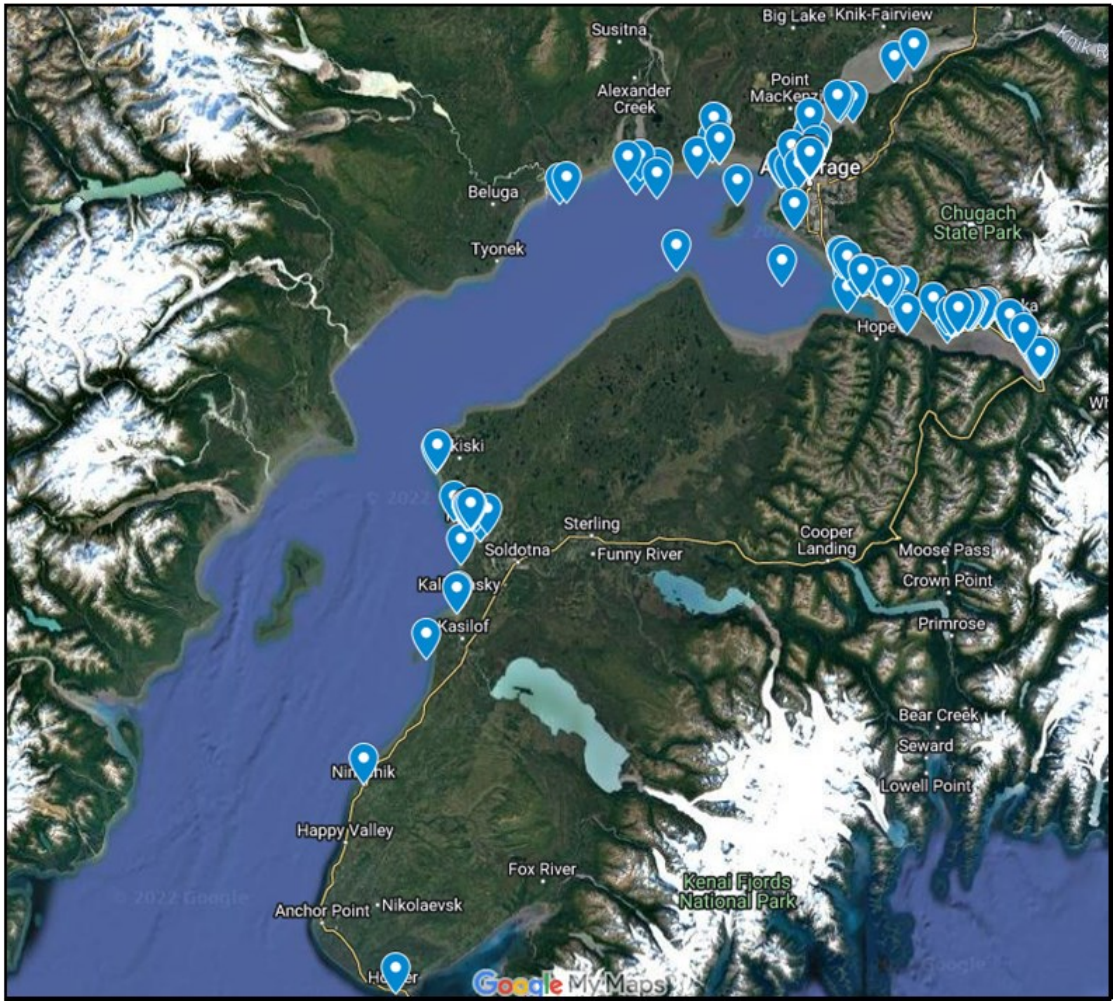
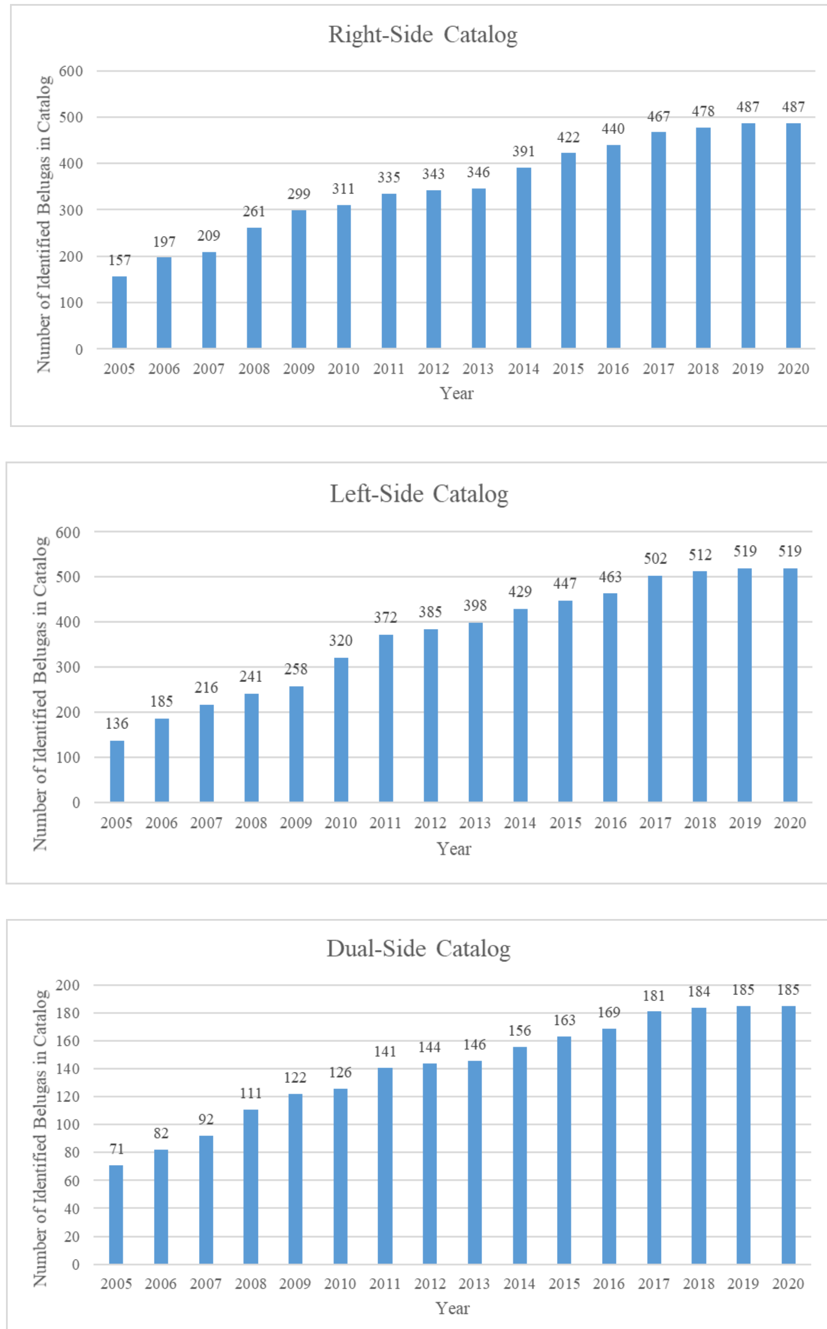


Figure 13. Map of incidental beluga sightings in 2020 (blue symbols) reported on the CIBW Photo-ID Project website (see www.cookinletbelugas.com for more details). Sightings were reported as far south as Homer.



a.

b.

c.

Figure 14. The cumulative number of identified individual belugas in the 2005–2020 (a) right-side, (b) left-side, and (c) dual-side catalogs, according to the year an individual was first photographed. This includes the right and left sides of dual-side individuals as well as those individuals that have died.

Photo-ID Catalog # Tagging ID #	Year Tagged	Recent Photo of Satellite-tag Scars and Year
D103 CI-01-06	Tagged 2001	 2019, left side
D2303 CI-02-05	Tagged & flipper-banded 2002	 died in 2015, left side (photo courtesy of Randy Standifer/Alaska Marine Mammal Stranding Network)
D111 CI-00-02	Tagged 2000	 2020, left side
D115 CI-02-08	Tagged & 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 2019)

Photo-ID Catalog # Tagging ID #	Year Tagged	Recent Photo of Satellite-tag Scars and Year
D243 CI-01-01	Tagged 2001	 2020, left side
D49	Tagging year unknown	 2020, left side
D549	Tagging year unknown	 2018, left side
D875	Tagging year unknown	 2017, left side
D403	Tagging year unknown	 2020, left side
D3024	Tagging year unknown	 2017, left side
D5319	Tagging year unknown	 2020, left side

Photo-ID Catalog # Tagging ID #	Year Tagged	Recent Photo of Satellite-tag Scars and Year
R6	Tagging year unknown	 2020, right side
L17368	Tagging year unknown	 2011, left side
D75	Possible satellite tag (year unknown) or possible bullet wound	 2019, right side

Figure 15. Recent photographs of satellite-tag scars of Cook Inlet beluga whales satellite-tagged 1999–2020.

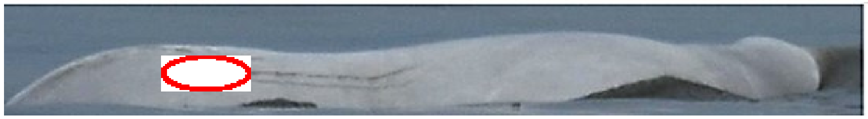
Photo-ID # Biopsy ID #	Year Side of Biopsy	Year Scar last Photographed Signs of Infection	Most Recent Photo of Biopsy Scar
D16873 DLCIB16-32	2016 right	2019 no	
D220 DL-CIB16-36	2016 left	2020 no	
D2379 DLCIB17-03	2017 right	2019 no	
D28419 DLCIB17-06	2017 right	2018 no	
D326R DLCIB17-10	2017 right	2020 no	

Photo-ID # **Biopsy ID #**	**Year** **Side of Biopsy**	**Year Scar last Photographed** **Signs of Infection**	**Most Recent Photo of Biopsy Scar**
D33575 DLCIB18-11	2018 left	2020 no	
R21848 DLCIB18-15	2018 right	2020 no	

Figure 16. 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; 2018) for the 2016 and 2017 biopsy photos. Records are only displayed for those individuals who were photographed at least a year 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.

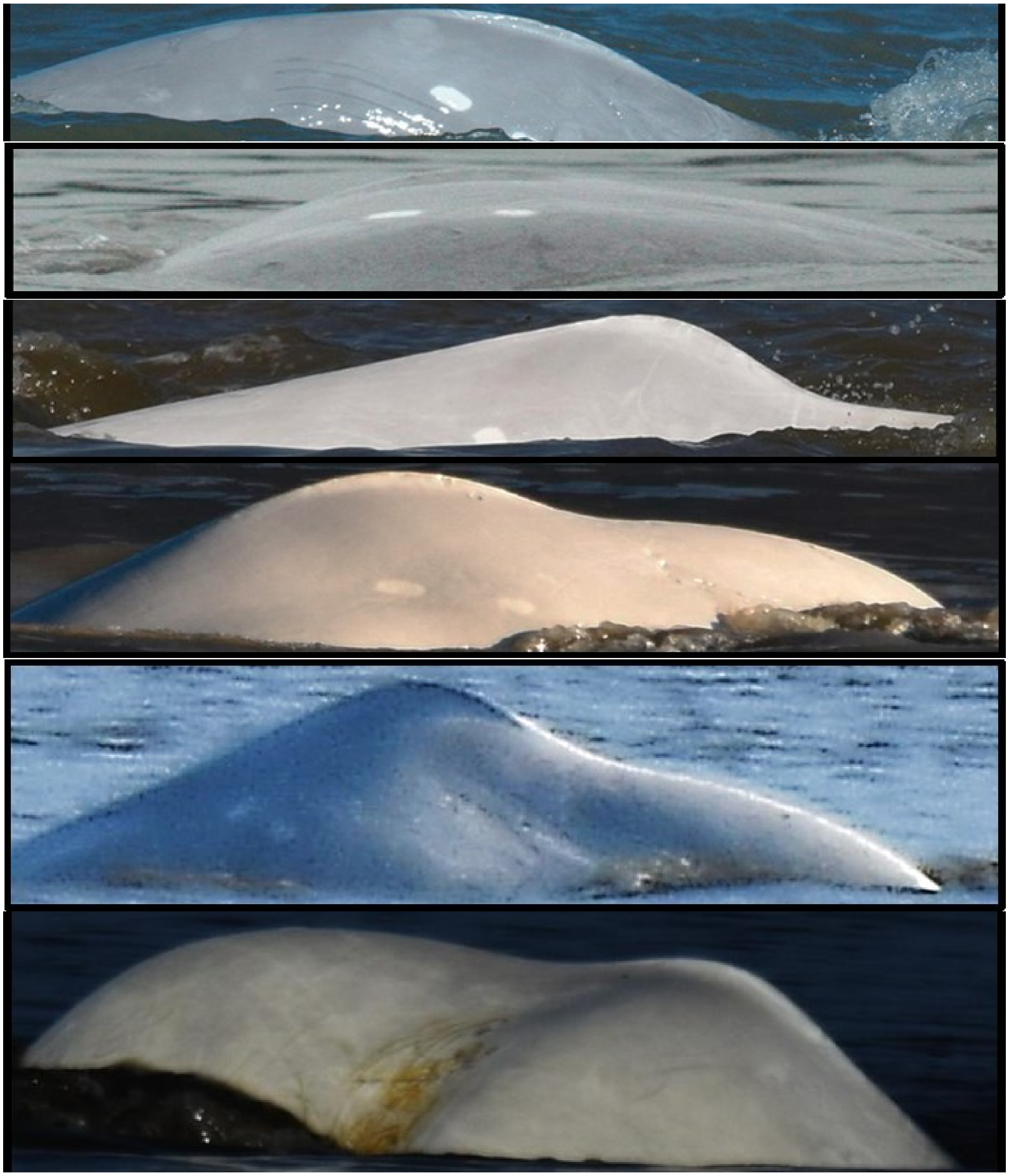


Figure 17. Photographs of beluga D2379 (DL CIB17-03). Biopsy determined this is a male (Nick Kellar, NMFS SWFSC, unpublished data) born in 1999 (Bors et al. 2021). Note the concavity behind the dorsal crest in 2017, 2018, and 2019 that was not present in 2005. The concavity was detected in 2008 and appeared to worsen with time. Signs of discoloration on the right side were photographed in 2019 and may be from infection of unknown origin or possibly diatoms (Photo order from top to bottom: 2005 left side, 2008 left side, 2017 left side, 2018 left side, 2019 left side, 2019 right side). This whale was not photographed in 2020.

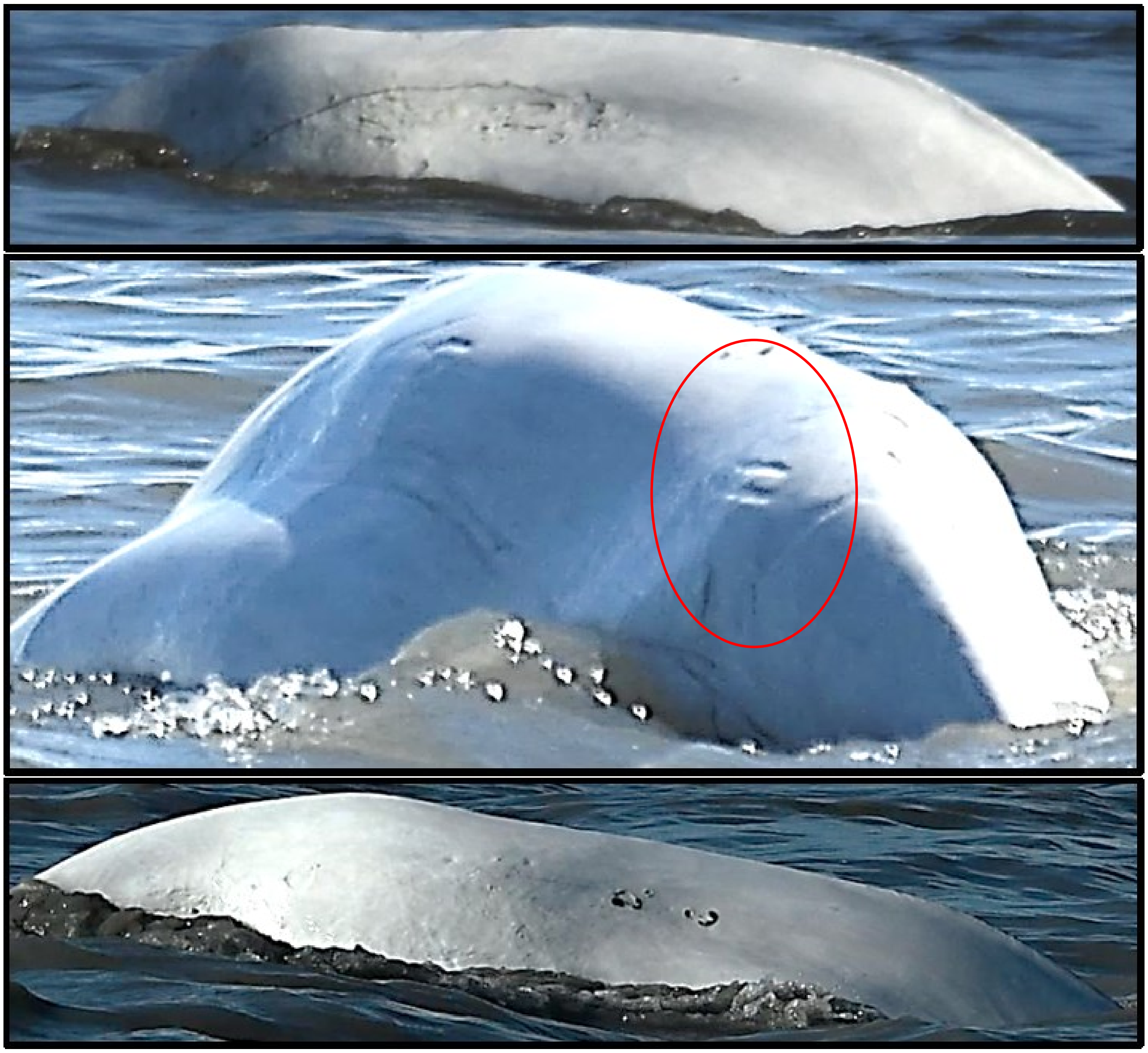


Figure 18. Photographs of beluga D595 with swayed area anterior to the peduncle that could be from vessel strike, entanglement, disease, and/or emaciation. The sway appeared more pronounced in 2019 and 2020 than in previous years. This beluga was biopsied in 2018 and biopsy samples indicate it is a male (Nick Kellar, NMFS SWFSC, unpublished data) and born in 1998 (Bors et al. 2021). The top photo is of the right side in 2019. The middle photo is of the left side and shows what may be an entanglement or vessel strike scar. The bottom photo is of the right side in 2020. Note skin sloughing and possible infection in right-side photos.

Figure 19. Right-side photographs of beluga D516 with pronounced concavity behind the dorsal crest, with signs of abrasions, punctures, and/or infection. This whale was only photographed in 2006 and is of unknown sex and age.

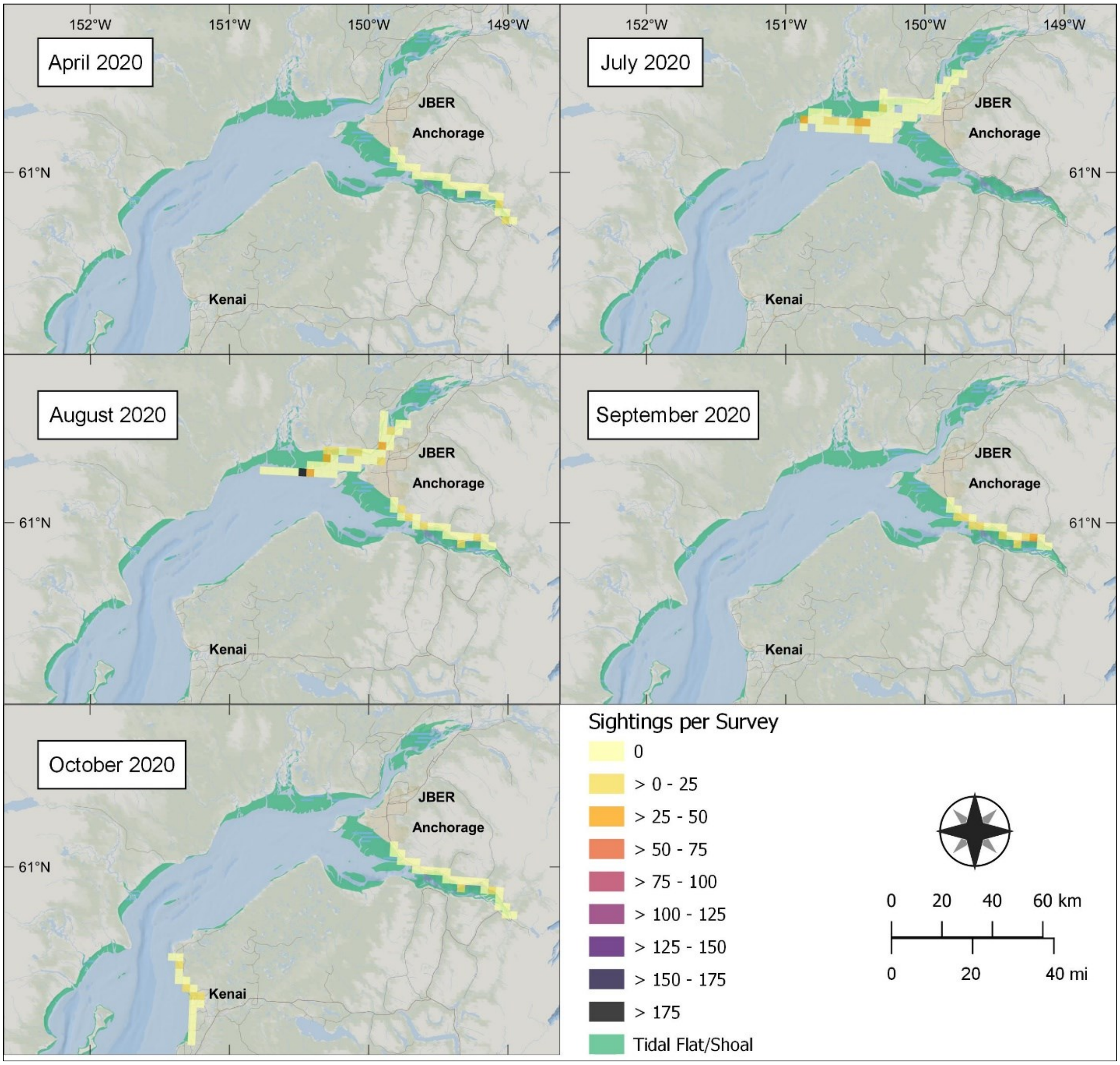


Figure 20. Average counts of belugas per survey by month for surveys conducted during 2020. Values were obtained by partitioning the study area into 3 km by 3 km grid cells and calculating the average number of belugas detected per survey for each cell.

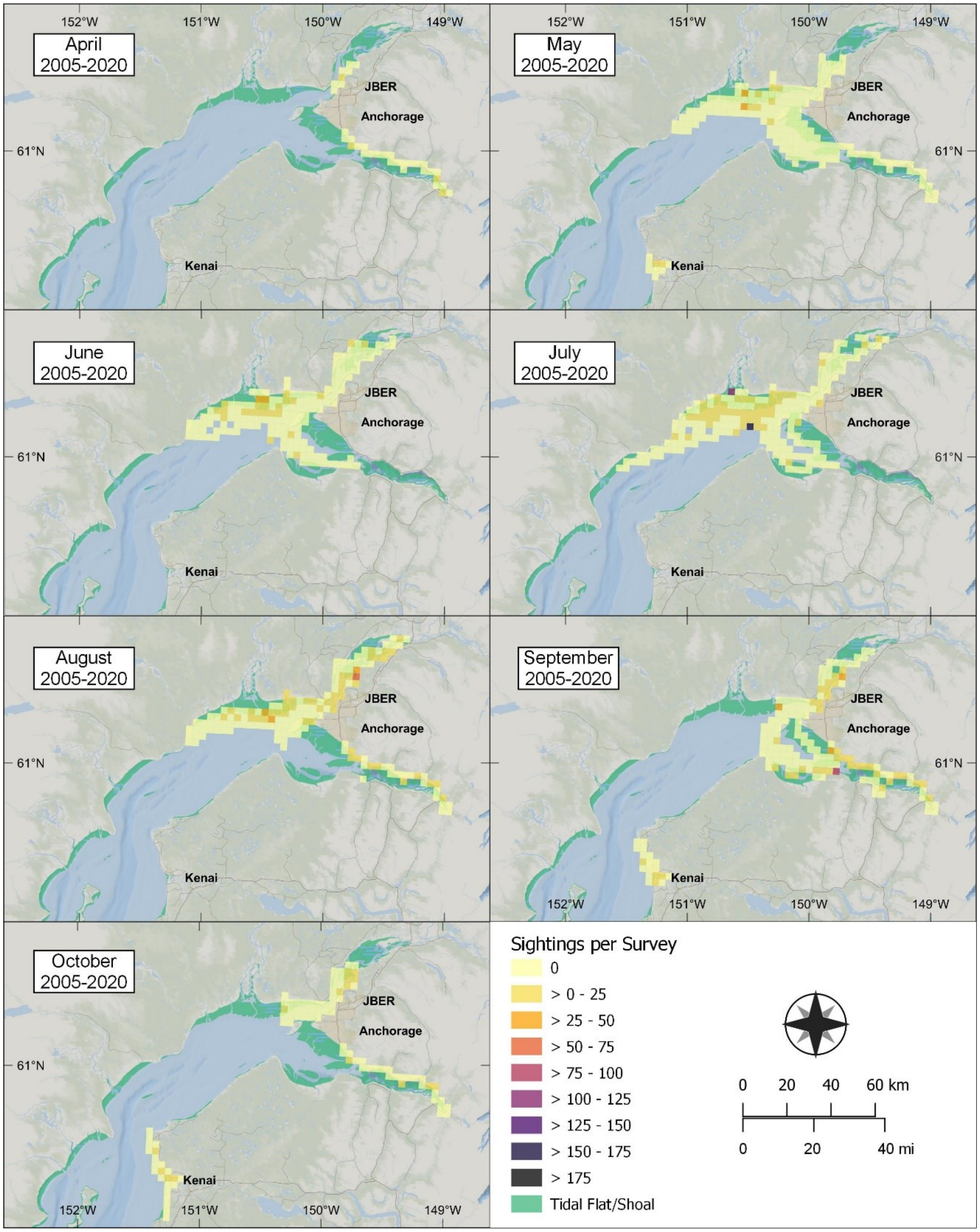


Figure 21. Average counts of belugas per survey by month for surveys conducted from 2005–2020. Values were obtained by partitioning the study area into 3 km by 3 km grid cells and calculating the average number of belugas detected per survey for each cell.

APPENDICES

Appendix A. Daily Survey Routes and Groups Encountered in 2020

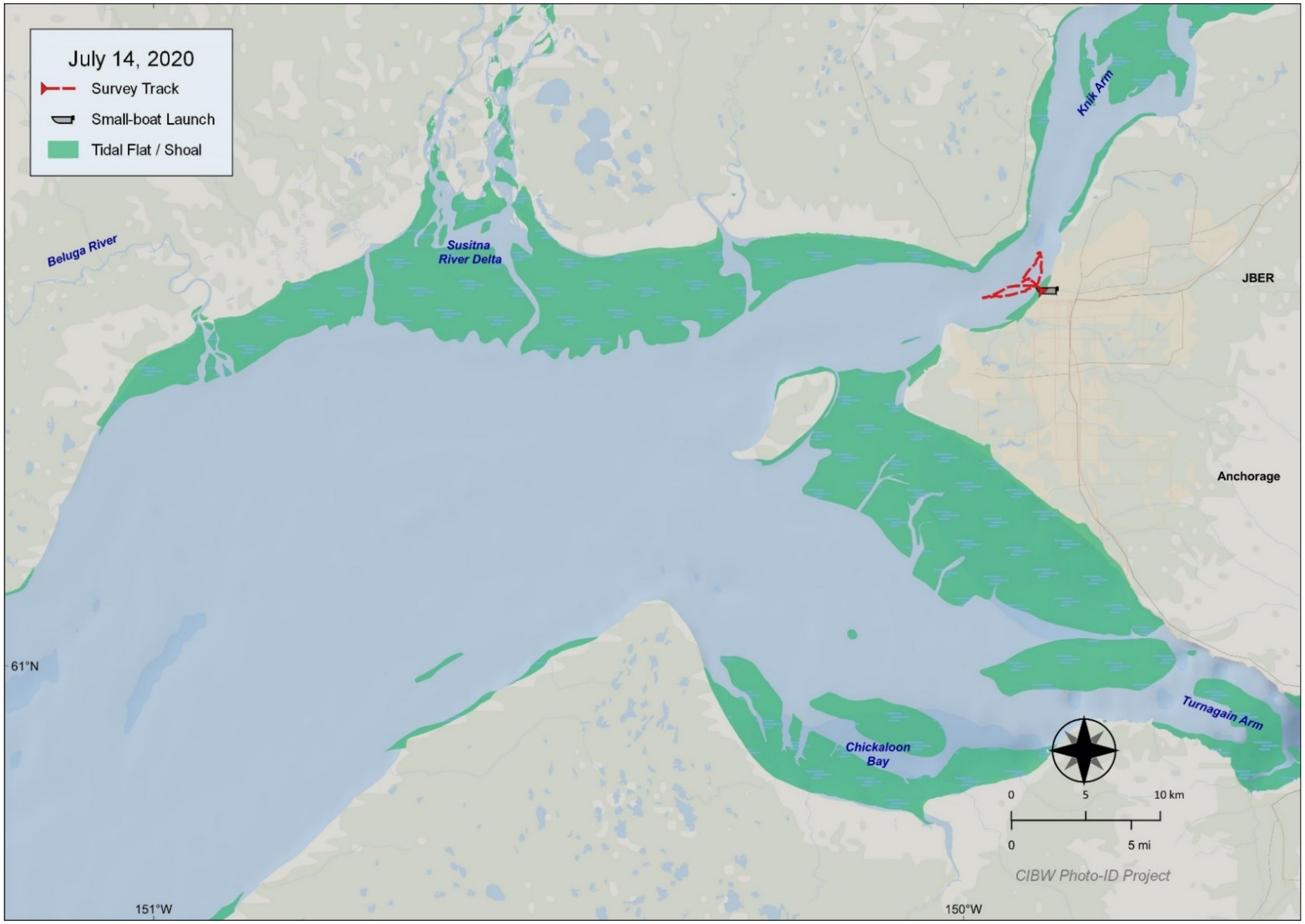


Figure A1. Route during the July 14, 2020, vessel-based survey in Knik Arm, Upper Cook Inlet, Alaska. No belugas were encountered this day.

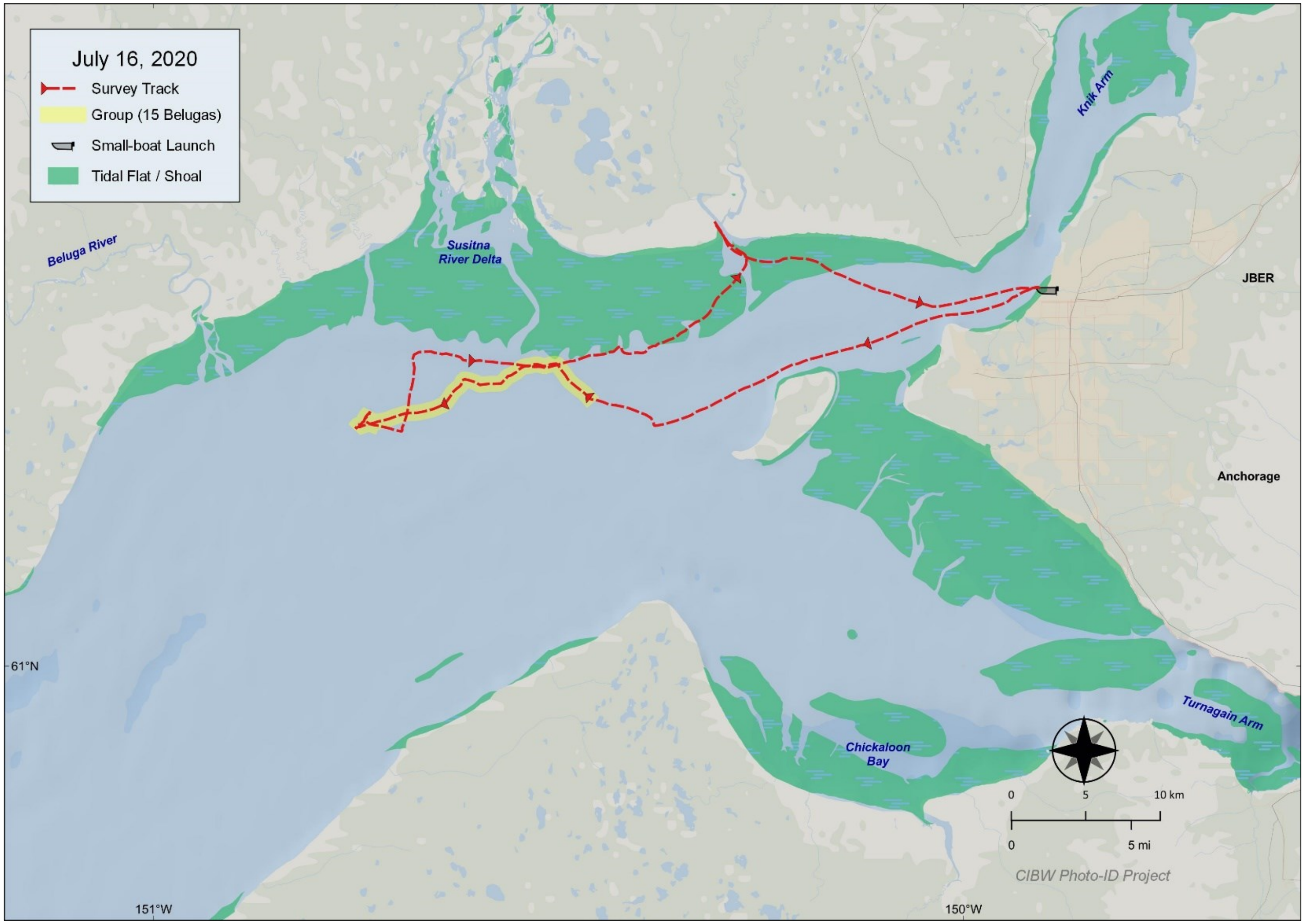


Figure A2. Route during the July 16, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

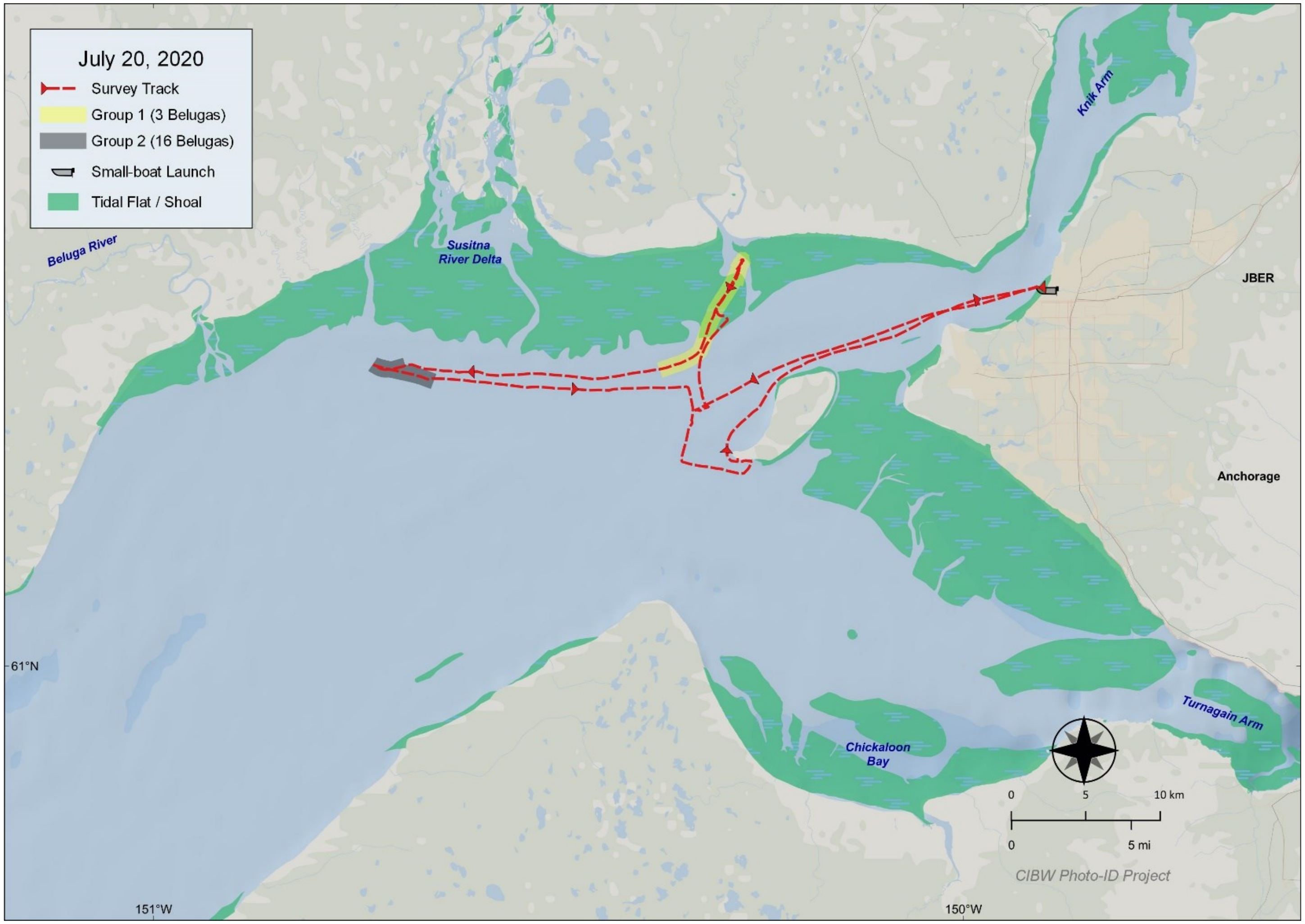


Figure A3. Route during the July 20, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

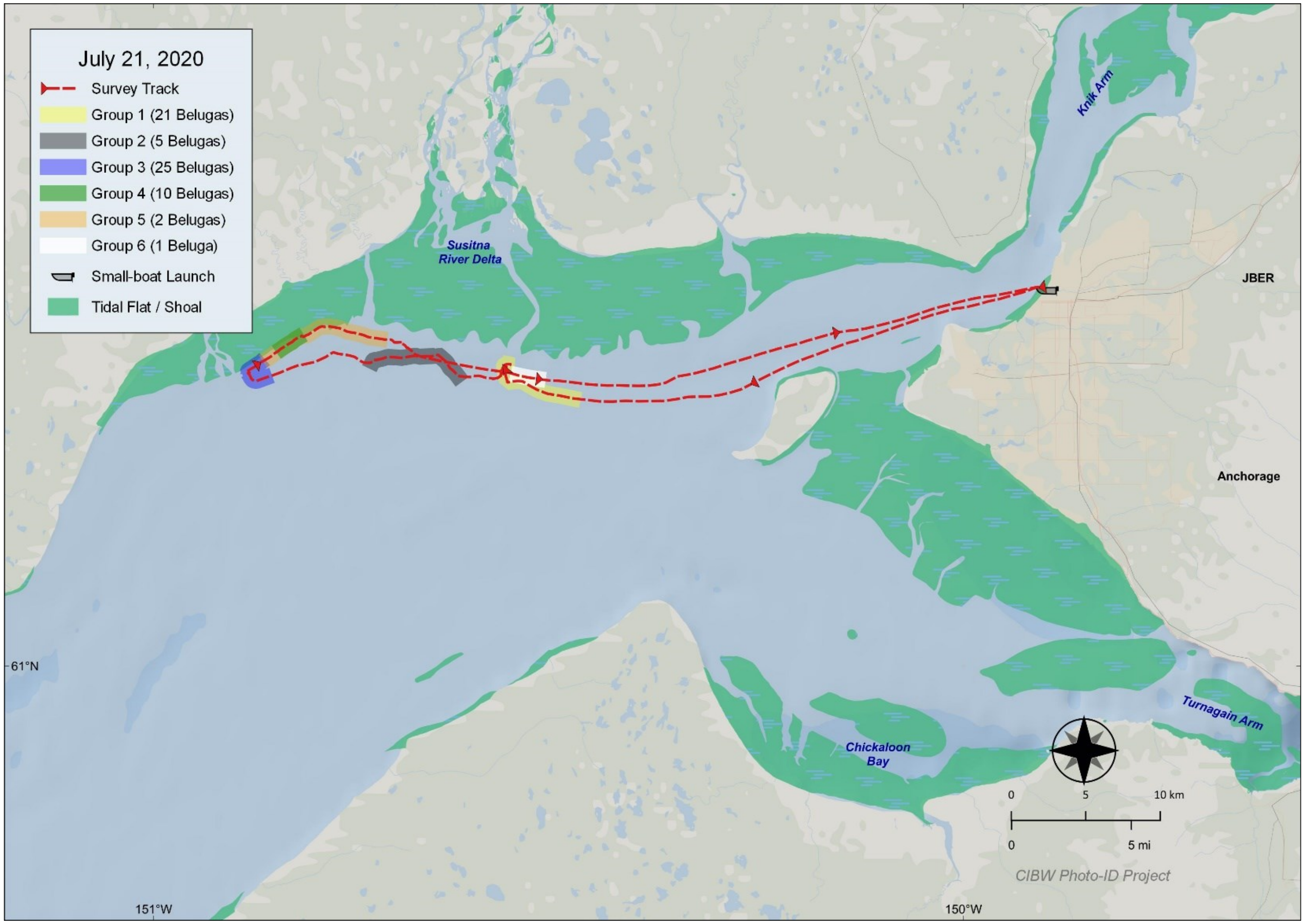


Figure A4. Route during the July 21, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

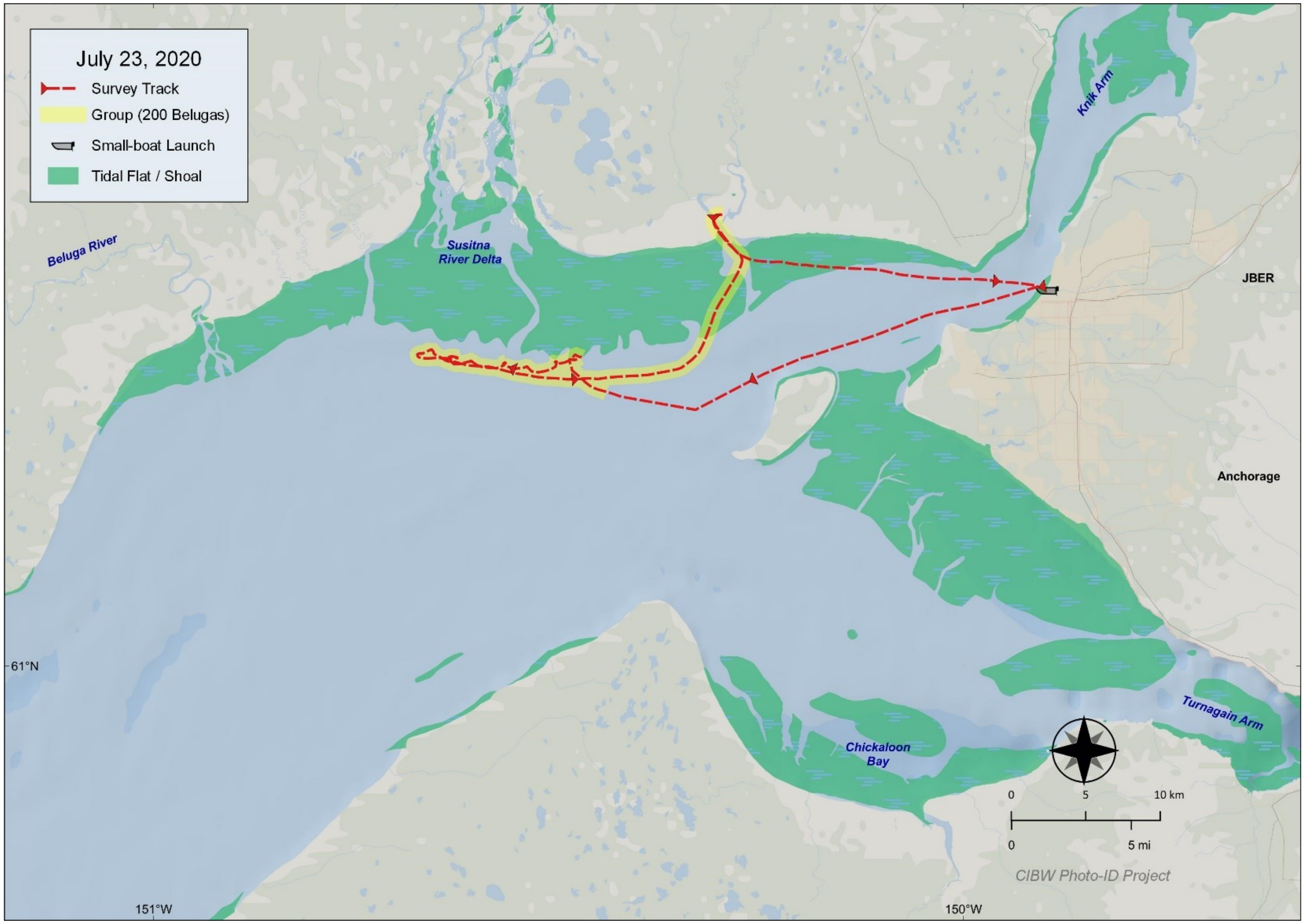


Figure A5. Route during the July 23, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

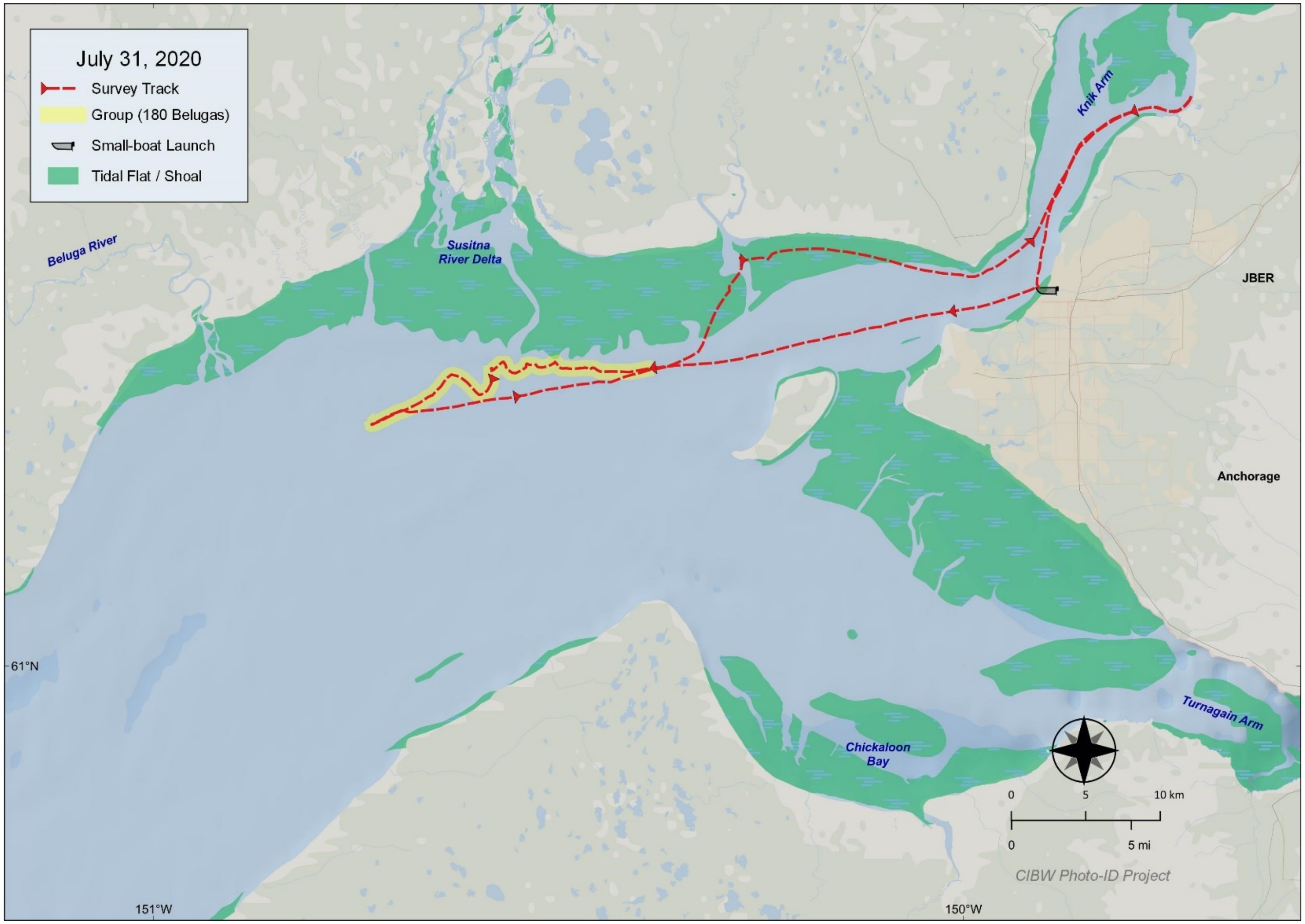


Figure A6. Route during the July 31, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

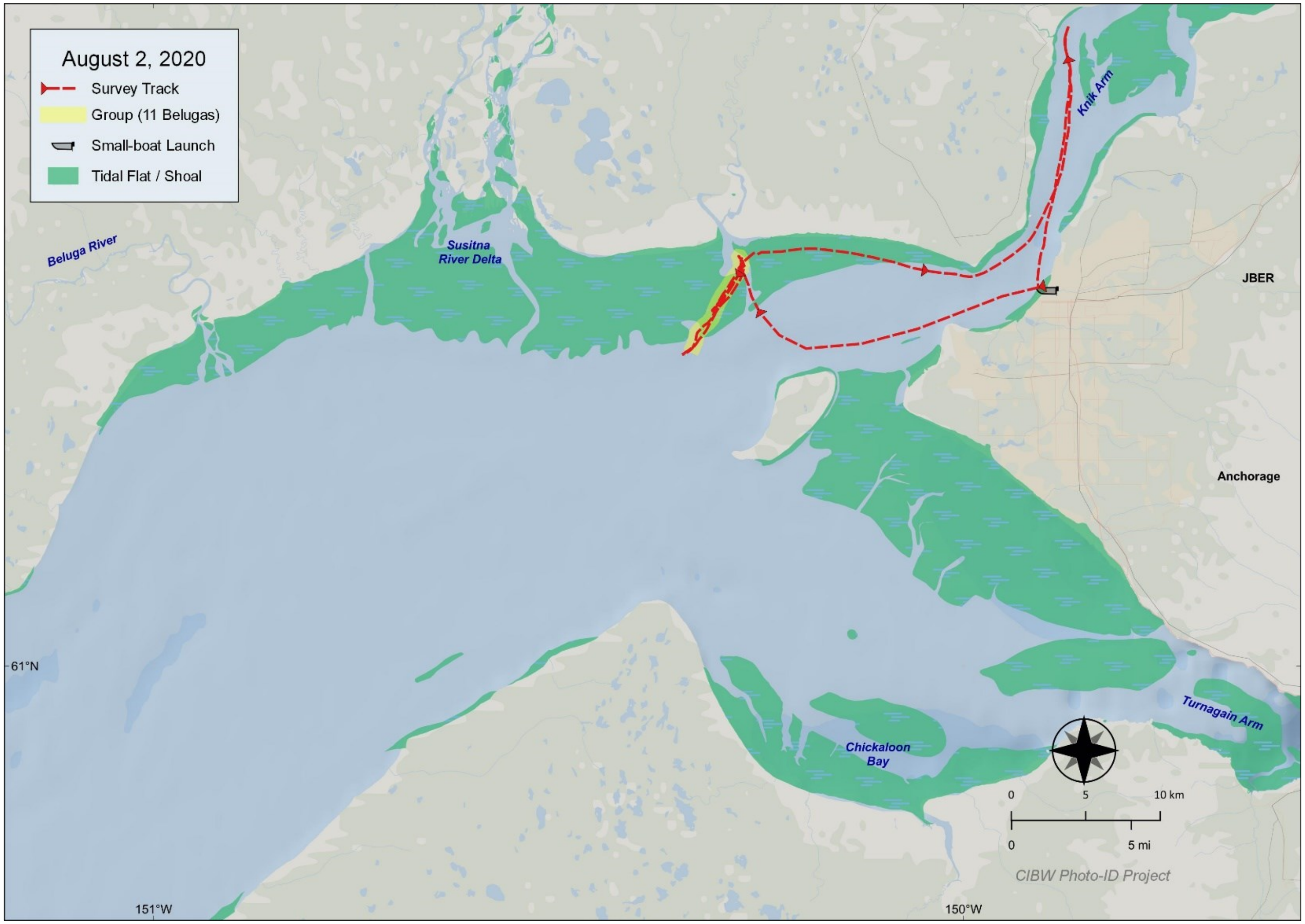


Figure A7. Route during the August 2, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

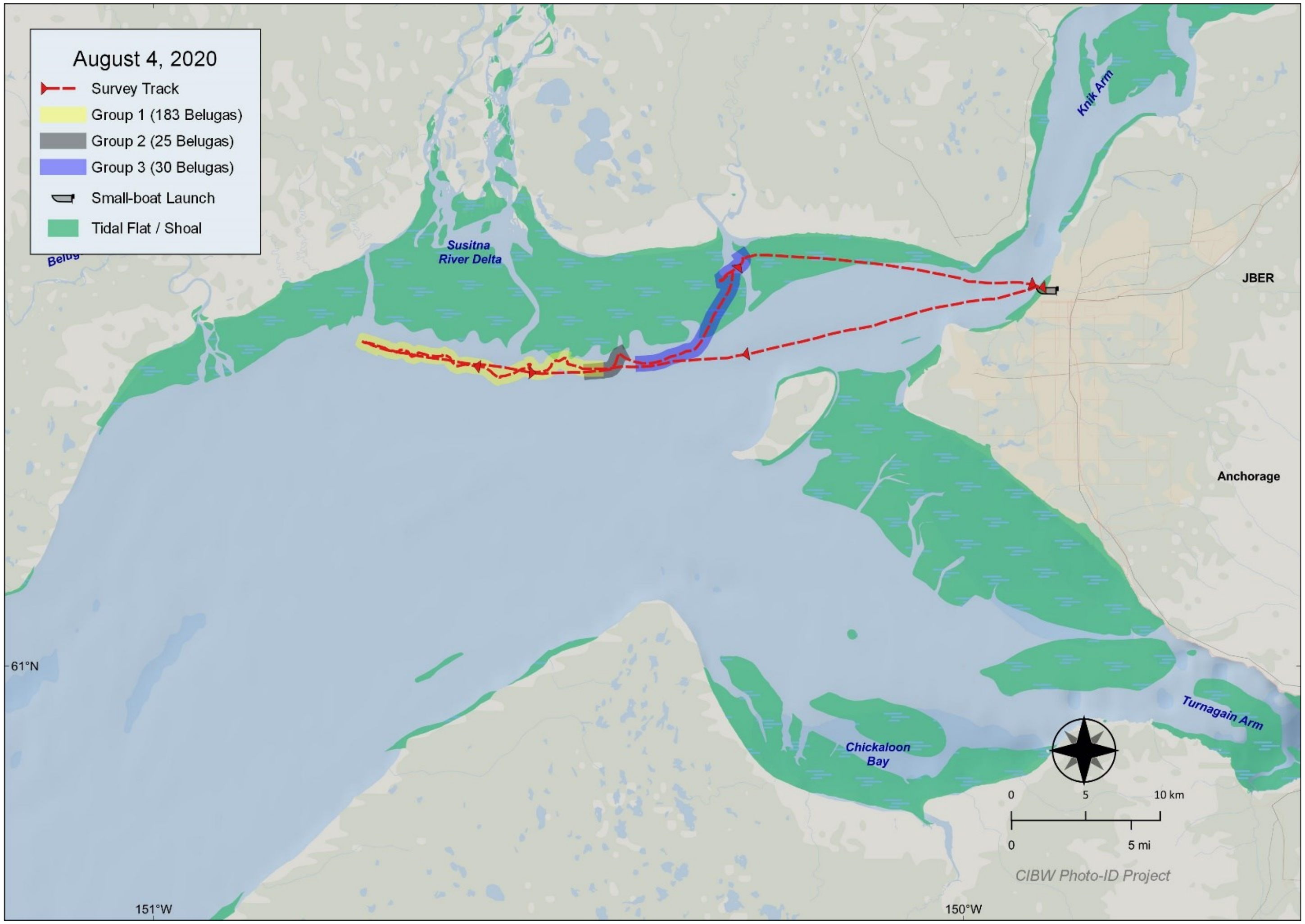


Figure A8. Route during the August 4, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

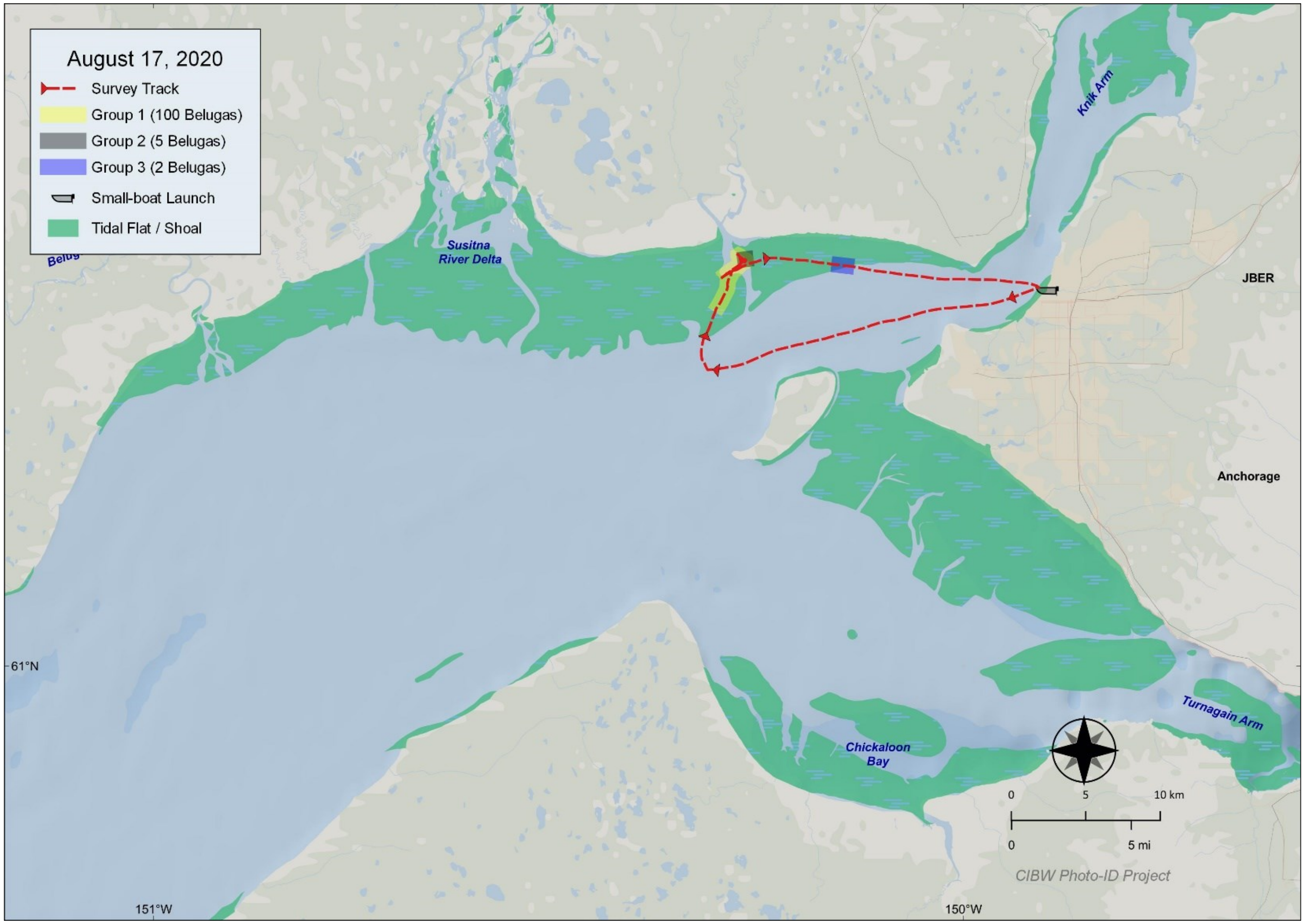


Figure A9. Route during the August 17, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

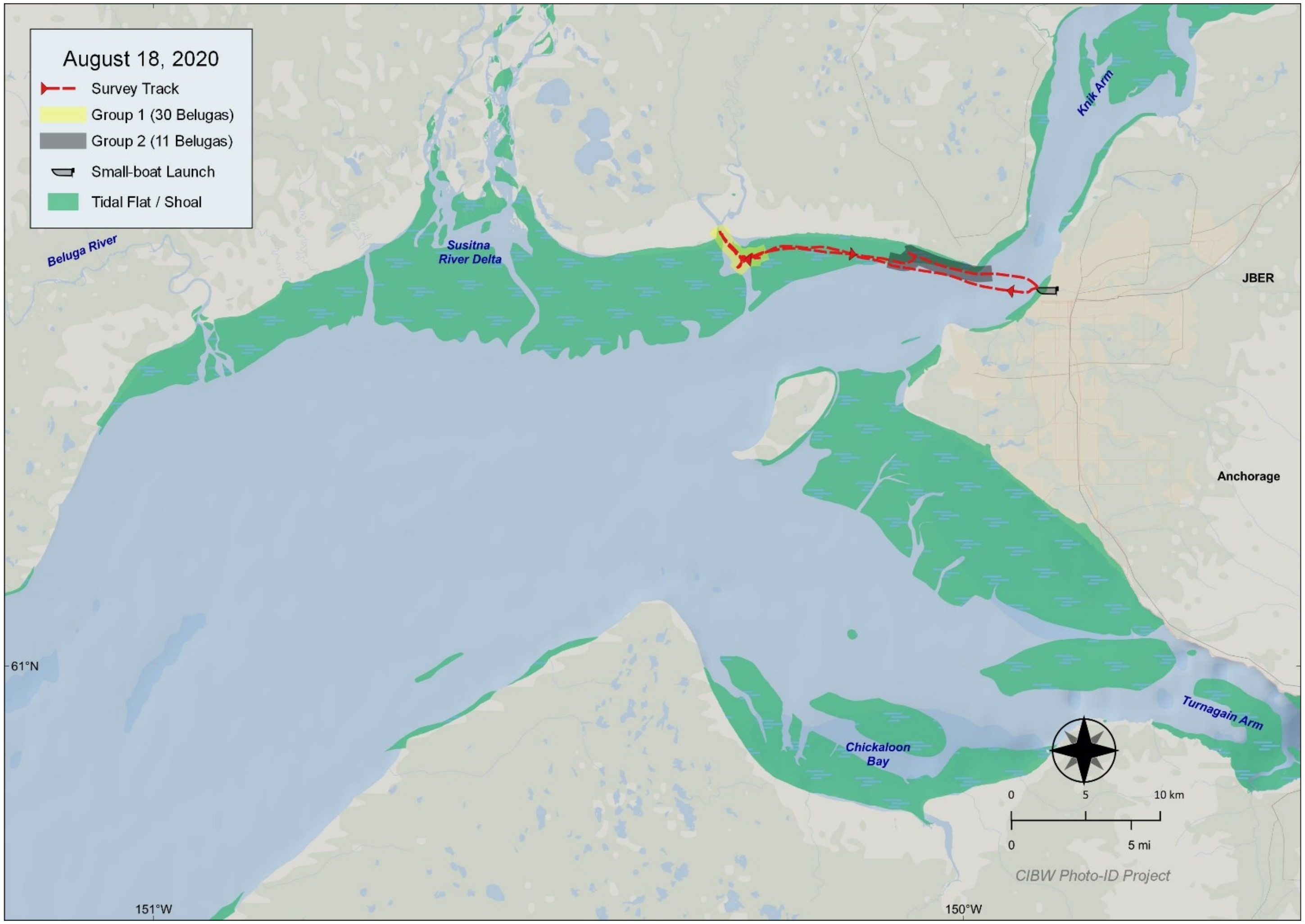


Figure A10. Route during the August 18, 2020, vessel-based survey in the Susitna River Delta, Upper Cook Inlet, Alaska.

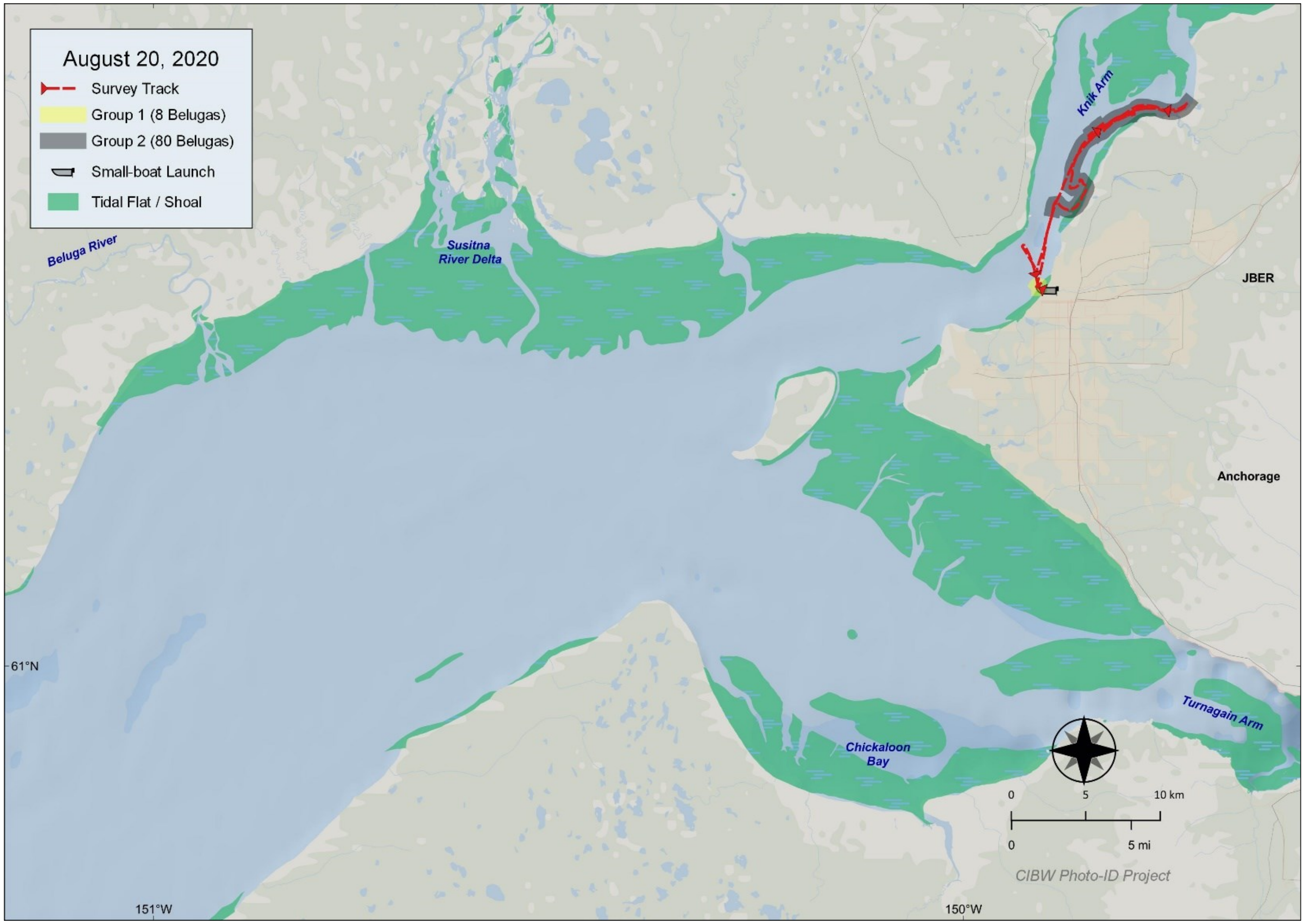


Figure A11. Route during the August 20, 2020, vessel-based survey in Knik Arm, Upper Cook Inlet, Alaska.

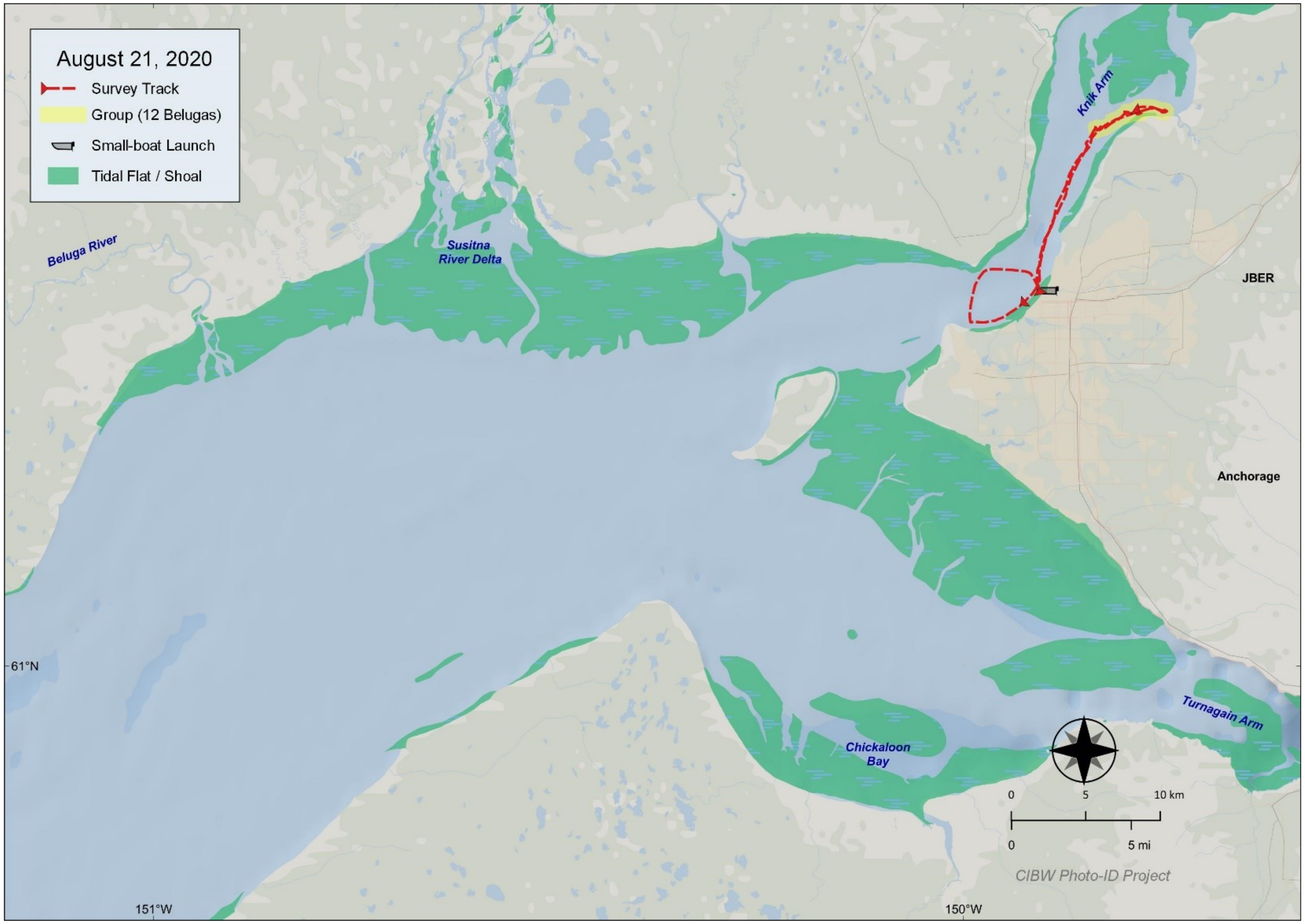


Figure A12. Route during the August 21, 2020, vessel-based survey in Knik Arm, Upper Cook Inlet, Alaska.

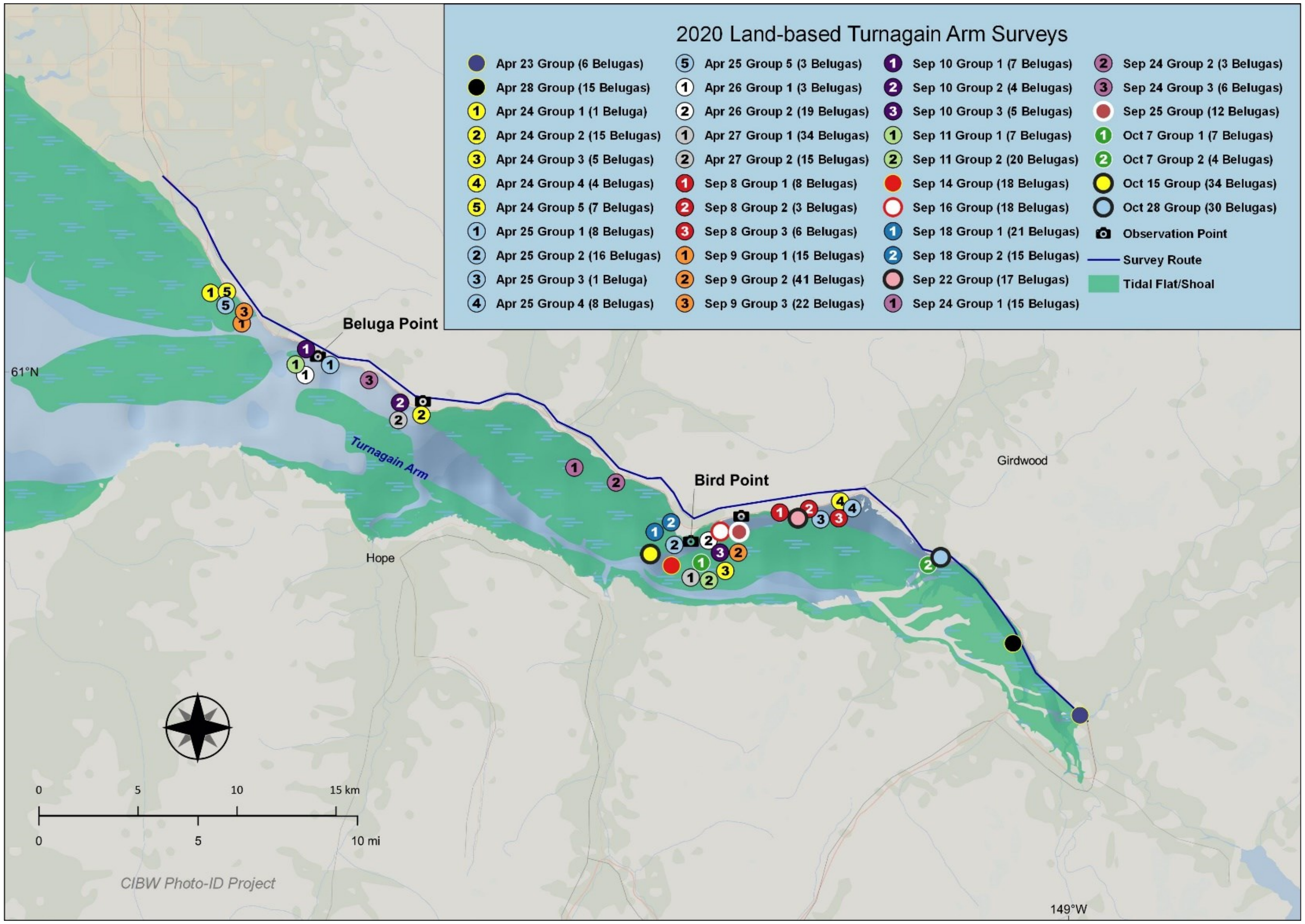


Figure A13. Beluga whale groups encountered in 2020 during land-based surveys in Turnagain Arm, Alaska.

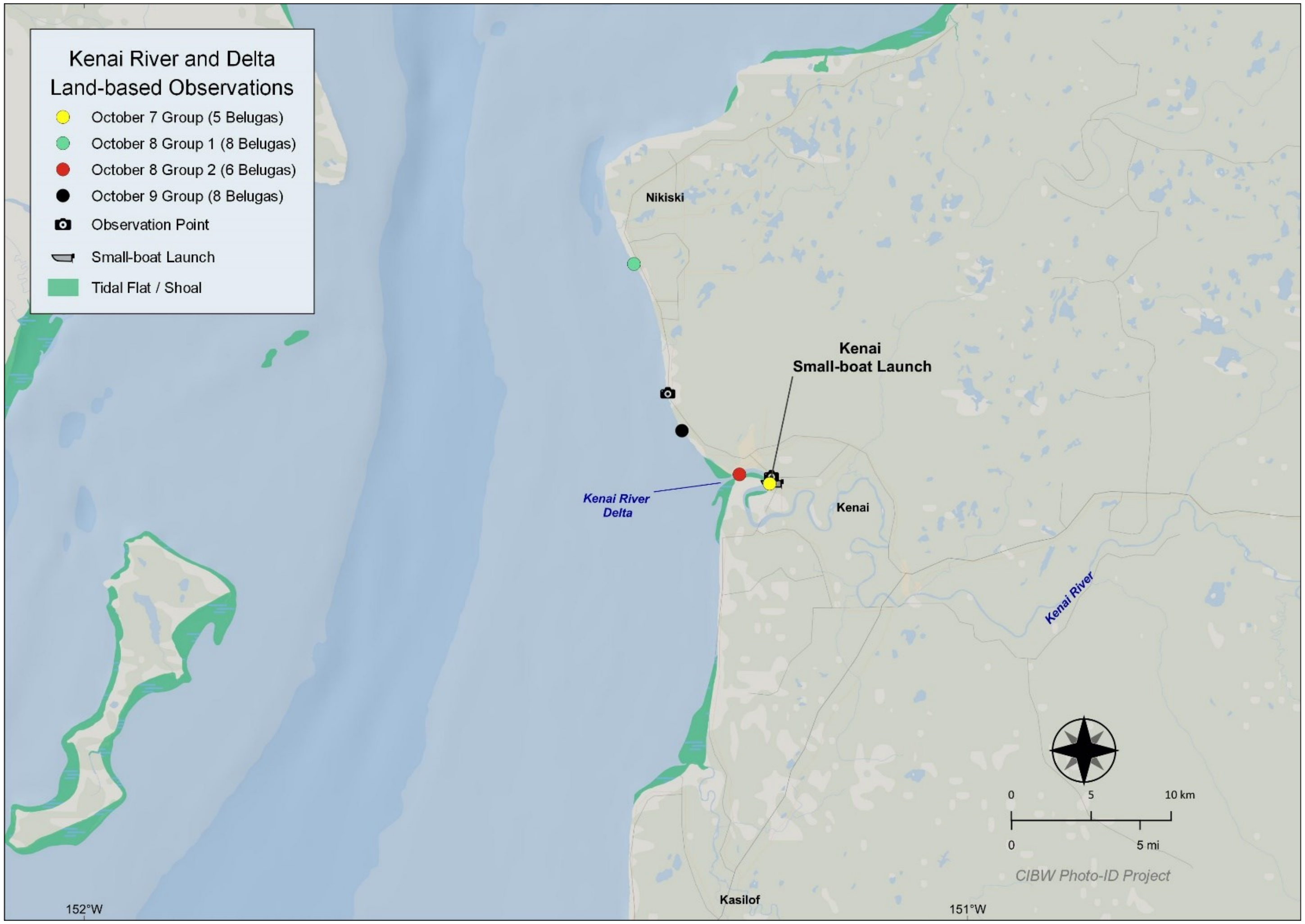


Figure A14. Beluga whale groups encountered during the October 7, 8, and 9, 2020, land-based surveys of the Kenai River and Delta.

Appendix B: Outreach Activities for the Cook Inlet Beluga Whale Photo-ID Project, 2020

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

- Alaska Marine Science Symposium, Anchorage, AK, January 2020
    - Three posters featuring work by the CIBW Photo-ID Project (Figure B1, B2, B3).
    - Three additional presentations using CIBW Photo-ID Data:
        - **Estimating Fecundity and Survival for the Endangered Cook Inlet Beluga Whales Using Multi-Event Capture-Resight Modeling of Photo-ID Data.** Gina K. Himes Boor, Tamara L. McGuire, Rebecca L. Taylor, John R. McClung, Amber D. Stephens
        - **Breeding and Calving Seasonality in the Endangered Cook Inlet Beluga Whale Population: application of captive field growth curves to fetuses and newborns in the wild.** K.E.W. Shelden, T.R. Robeck, C.E.C. Goertz, T.L. McGuire, K.A. Burek-Huntington, D.J. Vos, & B.A. Mahoney
        - **Framework for Examining Population Dynamics of Cook Inlet Beluga Whales: Bayesian Integrated Modeling and Population Viability Analyses.** Amanda J. Warlick, Charlotte Boyd, Tamara McGuire, Kim E.W. Shelden, Eiren K. Jacobson, Andre E. Punt, Sarah J. Converse

Participation in Cook Inlet Beluga Whale Recovery Task Force

- Volunteer members of Research (McGuire), Outreach (Stephens), and Habitats/Threats (McGuire) Committees

Virtual Presentations

- Kenai Peninsula College-Spring 2020
- Beluga Palooza- Fall 2020
- University of Alaska- Semester by the Sea- Fall 2020

Factsheets Produced and Distributed

Pamphlets and cards were not distributed during 2020 due to pandemic restrictions but were available to download from our website.

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 and beluga sighting networks 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 and ADFG.

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 2005-2020 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.

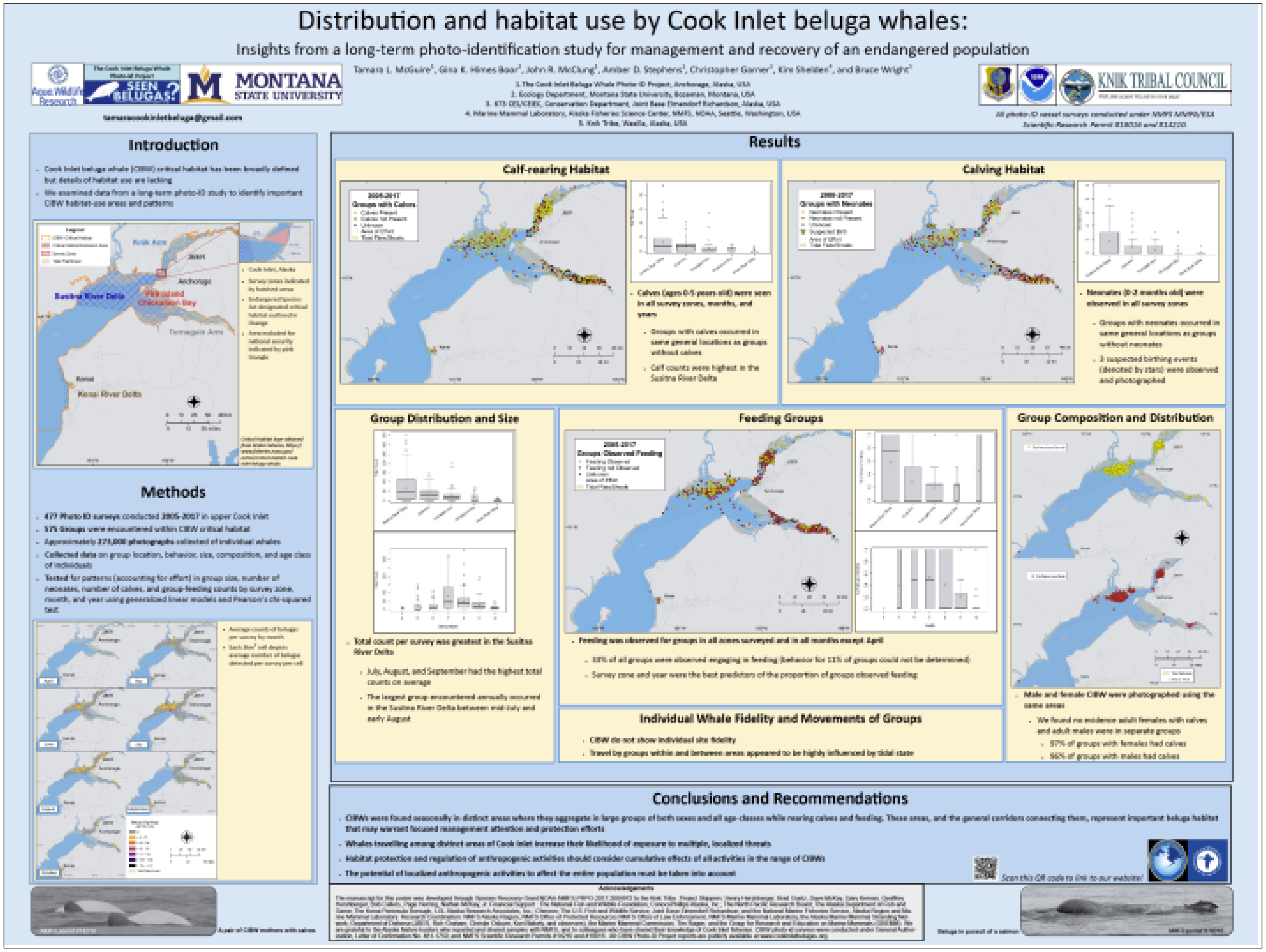


Figure B1. CIBW Photo-Id Project poster presented at the January 2020 Alaska Marine Science Symposium in Anchorage, Alaska.

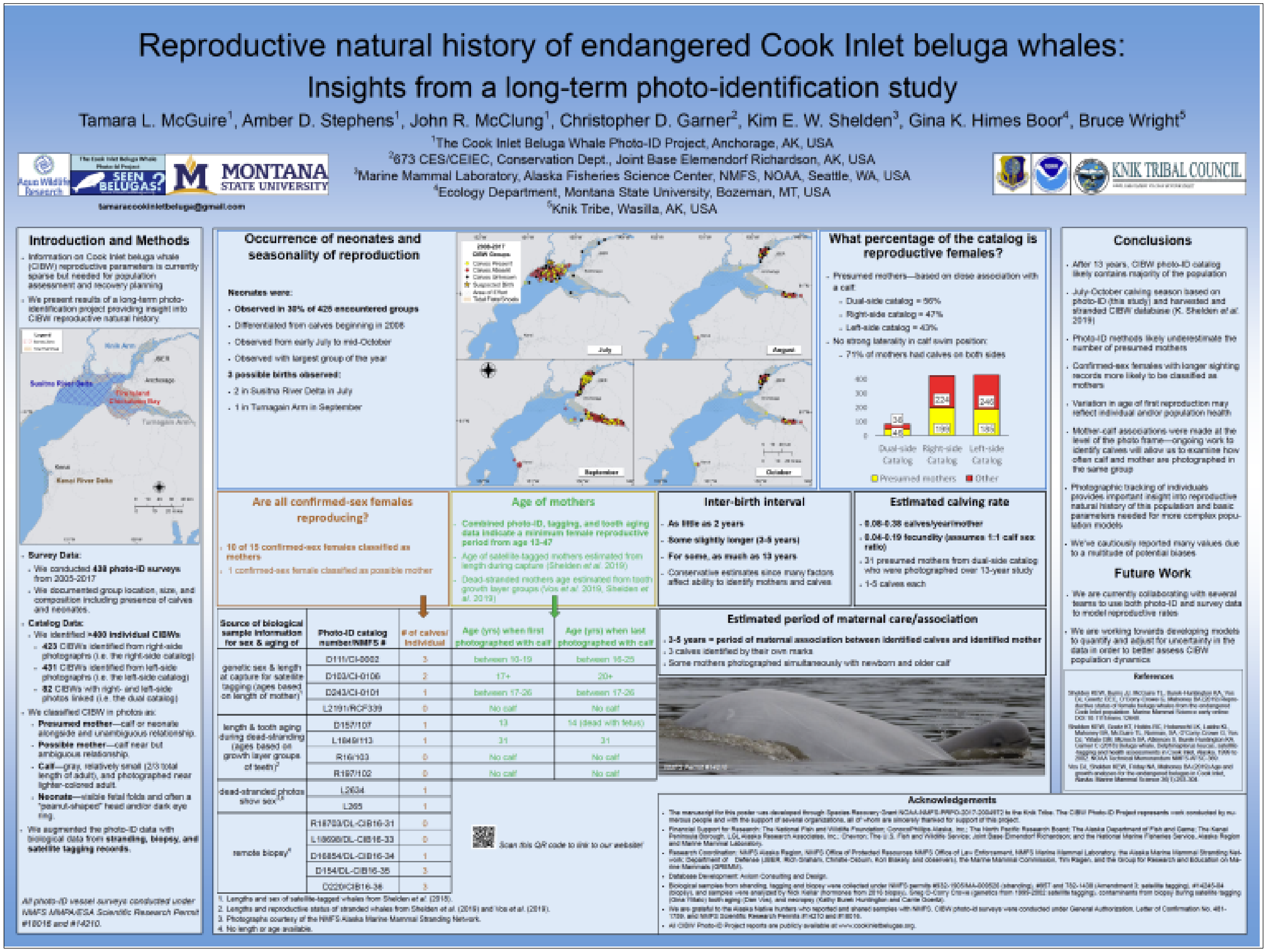


Figure B2. CIBW Photo-Id Project poster presented at the January 2020 Alaska Marine Science Symposium in Anchorage, Alaska.

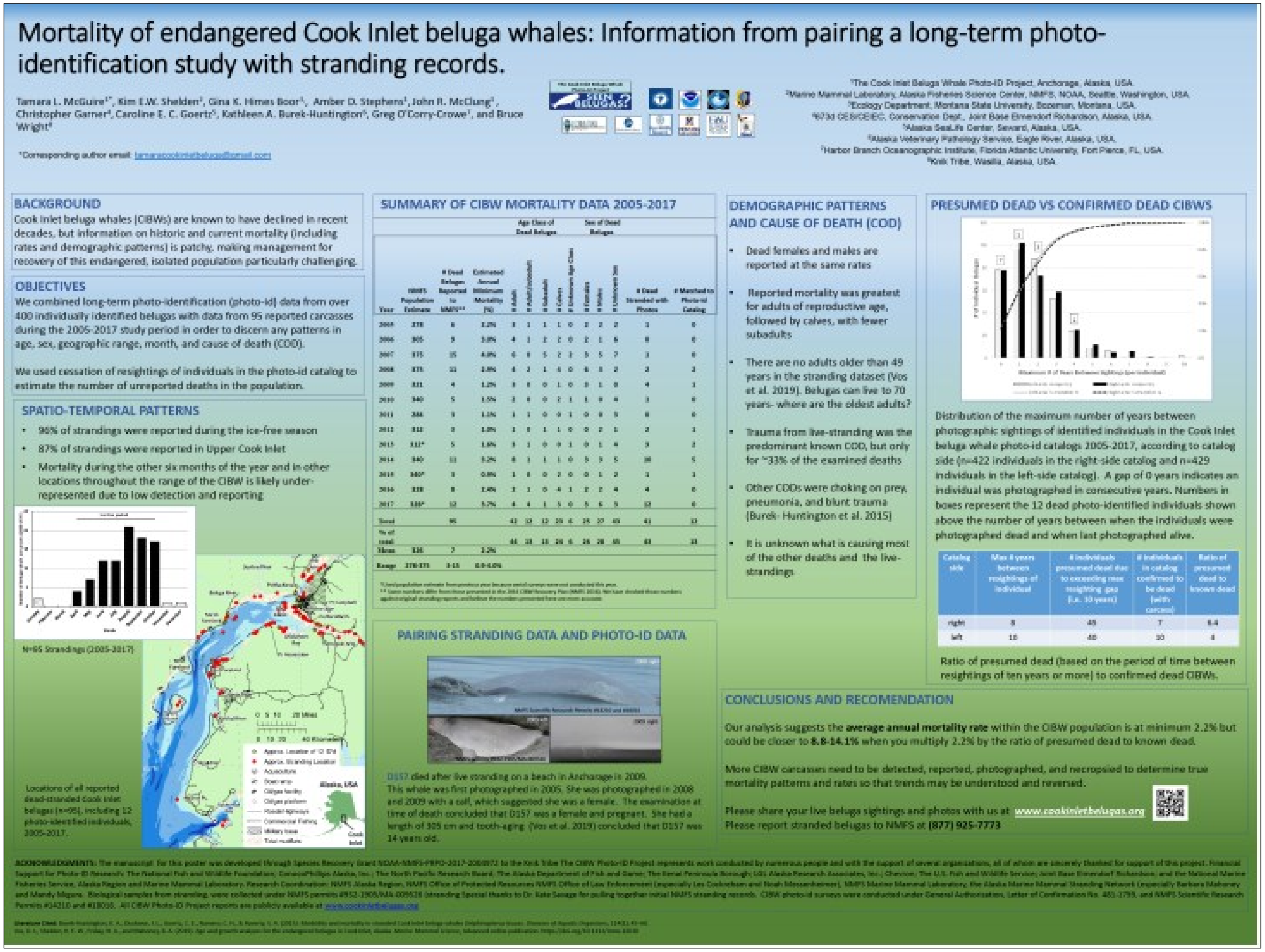


Figure B3. CIBW Photo-Id Project poster presented at the January 2020 Alaska Marine Science Symposium in Anchorage, Alaska.