NORTH PACIFIC RESEARCH BOARD PROJECT FINAL REPORT

The development of a catalog of left-side digital images of individually-identified Cook Inlet beluga whales *Delphinapterus leucas*

NPRB Project 910 Final Report

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ABSTRACT

LGL's Photo-identification Study of endangered Cook Inlet beluga whales (CIBWs) *Delphinapterus leucas* has demonstrated that CIBWs in Upper Cook Inlet (UCI) possess persisting natural marks that can be identified and re-sighted photographically. Our catalog of images of the right sides of CIBWs photographed 2005-2010 has provided information about the distribution and movement patterns of individual CIBW and the population in general, including residency/movement patterns, habitat utilization, reproduction, injury, disease, mortality, and abundance. Due to budget constraints, we archived all photographs taken of the left-sides of CIBWs after 2005 and were unable to process and catalog these images. Funding from NPRB allowed us to catalog images of the left-sides of CIBWs photographed 2005-2008, and to develop the left-side catalog. The left-side catalog increased the existing information about identified CIBWs, without requiring additional field work, research permits, or potential disturbance to the whales. A total of 186 CIBWs were identified as individuals from left-side images, including 58 mothers, and 20 whales identified on both sides of the body. The creation of a left-side catalog allowed for increased representation of whales seen in Turnagain Arm, and added to the records of 255 CIBWs in the right-side catalog, increased the evidence that CIBWs do not display fidelity to any single area of UCI, that individuals move among Knik Arm and the Susitna River Delta, and Turnagain Arm, and that CIBWs are not divided into subgroups. All CIBWs are therefore likely exposed to multiple potential threats that may be endemic to certain areas of UCI.

KEY WORDS

Beluga whales, *Delphinapterus leucas*, Sub-arctic, Southcentral Alaska, Cook Inlet, photo-identification, movement, site fidelity, endangered species, marine mammal

CITATION

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STUDY CHRONOLOGY

A proposal for this project was submitted 05 December 2008. The project was recommended for approval by NPRB on 30 April 2009 and approved by the Secretary of Commerce on 13 May 2009. The project began in 01 October 2009. The original award period was 01 October 2009-31 October 2010. A no-cost extension was granted to the project that extended the final project period until 31 December 2010, with the final project report due 01 April 2011. Progress reports were submitted to NPRB on: 15 January 2010; 15 April 2010; 15 October 2010; 11 January 2011; and 11 February 2011.

INTRODUCTION

Context for this Work

Alaska's Cook Inlet beluga whale (CIBW) *Delphinapterus leucas* population is considered a distinct population segment (DPS) by the National Marine Fisheries Service (NMFS) due to geographic and genetic isolation. A dramatic decline in the CIBW population occurred in the late 1990s, and the population was designated as depleted in 2000 under the Marine Mammal Protection Act (MMPA). The CIBW population was listed as critically endangered by the International Union for the Conservation of Nature in 2006 (IUCN 2006). After finding little evidence to demonstrate the population was recovering, in October 2008 NMFS listed the CIBW population as endangered under the Endangered Species Act (ESA; NMFS 2008a). As a result of the ESA listing, NMFS is 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.

Many information gaps and uncertainties are associated with the current understanding of the CIBW population (NMFS 2008b). More information on annual abundance estimates of age-specific cohorts, habitat preferences, life history characteristics associated with population growth (births, calving intervals, age at sexual maturity, etc.), and sources of stress and mortality (natural and human-induced) is needed to promote recovery and conservation of the CIBW population. Data describing CIBW residency and movement patterns, habitat use by mothers and calves, and behavior will aid in the identification of movement corridors and locations of grounds for feeding, calving, and rearing of young.

Available sources of information used to identify and characterize critical habitat include the distribution of beluga whales sighted from annual aerial surveys, tidal flow models, and movement data from 15 satellite-tagged individuals from 1999 to 2002 (Rugh et al. 2000, 2004, 2005, 2006, Hobbs et al. 2005, 2008, Goetz et al. 2007, NMFS 2008a, Shelden et al. 2008). This information plays a key role in characterizing and understanding habitat needs, as does information on beluga movement and residency patterns obtained from land-based observational studies of CIBWs in Upper Cook Inlet (Funk et al. 2005, Prevel-Ramos et al. 2006, Markowitz and McGuire 2007, Markowitz et al. 2007, Nemeth et al. 2007). Land- and vessel-based photo-identification surveys (McGuire et al. 2008, McGuire and Kaplan 2009, McGuire et al. 2009, 2011) are also used to characterize distribution and movement patterns of individual beluga whales, and results of these surveys complement information from aerial surveys and tagging-tracking studies conducted by NMFS

Photo-identification has proven to be a reliable tool for characterizing abundance, residency, movements, social grouping, and life history of many marine mammal species in the wild (reviewed by

Mann 2000), and has been used to study the distribution, population dynamics, and social structure of beluga whales in Canada's St. Lawrence Estuary (Michaud 1996), and in the White Sea of Russia (Kryukova 2005). Photo-identification is less invasive than tagging and capture, and natural marks usually persist much longer than tags (McGuire et al. 2008). In the 2008 Conservation Plan for CIBWs, NMFS endorsed photo-identification as a method for establishing a long-term data set to monitor the CIBW population, and to provide information on habitat use and residency in Upper Cook Inlet (NMFS 2008b).

Reason for Work

LGL's CIBW Photo-identification Study has been ongoing since 2005, and has demonstrated that a large number of CIBWs possess distinct natural marks that persist across years, and that these marks can be effectively identified and re-sighted with digital photography. Our catalog of digital images of the right sides of individually-identified beluga whales photographed over six field seasons and the database of associated field surveys have provided information about the distribution and movement patterns of individually identified beluga whales and the Cook Inlet population in general, including residency/movement patterns, habitat utilization patterns, reproduction, injury, disease, mortality, and abundance (McGuire et al. 2008, McGuire and Kaplan 2009, McGuire et al. 2009, 2011). Due to budget constraints, we archived all photographs taken of the left-sides of beluga whales after 2005 and were unable to process and catalog these images. This NPRB-funded project allowed us to catalog images of left-sides of CIBWs photographed between 2006 and 2008, and to examine and match the left-side images to those of whales cataloged in 2005, or to determine that they represent previously unidentified whales that should be added to the catalog. Cataloging of left-side images added data to our existing information about identified CIBWs, without requiring additional field work, research permits, or potential disturbance to the whales.

The **hypothesis** being tested is that photo-identification methods can provide unique, useful biological information about individual and population characteristics of CIBWs.

OBJECTIVES

The **objectives** of the study were to:

1. Continue to build a photo-identification catalog of distinctively marked individual CIBWs, and to describe re-sight rates and discoveries of new individuals over time.
2. Develop abundance estimates of CIBWs using mark-recapture models.

3. Describe population characteristics of CIBWs, including age-class distribution, residency/movement patterns, habitat association, behavior, and social group structure, and
4. Determine life history characteristics of CIBWs, such as length of mother/calf bonds, frequency of reproduction, and survivorship.

Objective 1 has been achieved for the photographs taken 2005-2008. All left-side photographs of acceptable quality have been cataloged. The left-side catalog contains 186 individually-identified CIBWs (Table 1, page 23). Resighting histories for these whales span 2005-2008 and 14 whales were seen in each of these years (Table 5, page 39). There were 110 new whales identified in 2005, 42 in 2006, 22 in 2007, and 12 in 2008 (Table 3, page 24).

Objective 2 has not been achieved, although significant progress has been made that is required for us to achieve this objective in the future. The number of individuals in the left-side catalog (n=186) may be viewed as a rough minimum abundance estimate, although the number of individuals in the right side catalog (n=255) is a more accurate estimate because the sample size represents more years of data collection. We were unable to use the left-side catalog to develop abundance estimates of CIBW using mark-recapture models. We had initially thought that a simple two-event mark-recapture model would be sufficient for estimating abundance from photographs of CIBW. In such a case, the marked animals could be represented by those whales in the photo-id catalog and the second or "sampling" event would be represented by the photographs taken in later surveys. It became clear that generating a robust abundance estimate for CIBW would require more sophisticated models than a simple two-event mark-resight study. This was unknown to us in 2008 when we proposed this work to NPRB. In 2009, we developed an abundance estimate from the right-side catalog, funded by NFWF. The process for developing an abundance estimate required several steps (LGL 2009). We characterized the identifiability and permanency of marks on Cook Inlet beluga whales. Every photograph of every whale in the right-side catalog was divided into body segments, and then each segment received one score for photo-quality and one score for mark quality. An estimation model was developed that could incorporate sightings of both marked and unmarked animals and that was robust to potential biases caused by differences in behavior among individuals. The final model used was the zero-truncated Poisson log-normal mixed effects model (ZPNE; McClintock et al. 2009). The work needed to process the photographs in the left-side catalog to make them useable for mark-recapture models is well beyond the scope (in time and money) of the grant for this 1-year NPRB project. In the future, we will be able to use the combined (left and right) catalog to generate abundance estimates using the ZPNE mark-recapture model; cataloging all left-side photographs was a critical first-step in this process (Table 1, page 23).

We were successful in meeting Objective 3, although it is an ongoing process. We have described the general age-class distribution of CIBW groups encountered during boat- and land-based surveys conducted 2005-2008, and we are able to describe the age-class distribution of groups in which individually-identified beluga whales were found (Table 11, page 76). We have sighting records for 186 individually identified whales in the left-side catalog, and for each of these whales we have information on residency/movement patterns, habitat associations, and social associations (Figures 8-28, pages 25-46; Table 6, page 40; Table 7, page 48; Table 9, page 53; Figure 33, page 52; Table 10, page 55; Figure 34, page 54; Figures 36-54, pages 56-74; Figure 55, page 75). We also collected information on group behavior during boat- and land based surveys (behavioral data are not presented in this report, but can be found in McGuire et al. 2008, McGuire and Kaplan 2009, McGuire et al. 2009, 2011).

We are making progress in achieving Objective 4, although it will require several more years of study, given these are long-lived mammals. We have preliminary data on mother/calf bonds, and frequency of reproduction (Table 7, page 48; Table 8, page 51). Survivorship information is derived from individuals seen throughout the duration of the study (Table 11, page 76), from sighting records of whales tagged with satellites in 1999-2002 (Table 6, page 40), and from identifying dead belugas as individuals in the catalog. In addition, we are documenting evidence of skin disease and trauma, including marks from vessel strikes, gunshot wounds, predation attempts, and debris entanglement (Figures 56-67, pages 77-81).

It should be noted these four objectives are not limited to the 1-year NPRB project to catalog the left-side photographs taken 2005-2008, but are also the objectives of the larger LGL Cook Inlet Beluga Whale Photo-identification Project that includes the combined catalog and all surveys conducted 2005-2010 (and hopefully into 2011 and beyond).

METHODS

Field Surveys

Survey effort

Dedicated surveys and opportunistic sampling of portions of Upper Cook Inlet, Alaska (Figures 1 and 2) were conducted from a small vessel and from shore 2005-2008. Survey schedules varied according to those combinations of season, location, and tide that provided the greatest likelihood of detecting whales. These combinations were determined by results from NMFS aerial surveys (Hobbs et al. 2008) and other studies of CIBWs (Funk et al. 2005, Markowitz et al. 2007, Markowitz and McGuire

2007, McGuire et al. 2008, Nemeth et al. 2007, Prevel-Ramos et al. 2006). General routes were followed for each area, although deviations were made to each route depending on where beluga groups were encountered. The Susitna River Delta (Figure 2) was surveyed in summer (June-August) during low tide. Knik Arm (Figure 2) was surveyed primarily in late summer/fall (August-October) during low tide. Turnagain Arm (Figure 2) was surveyed from the Seward Highway in late summer/fall (August-October) during high tide. Vessel-based surveys of Chickaloon Bay (Figure 2) were made when wind conditions along Turnagain Arm were safe for boat activity. The Port of Anchorage was surveyed during all vessel-based surveys because the survey vessel was always launched from the small boat ramp at the Port of Anchorage.

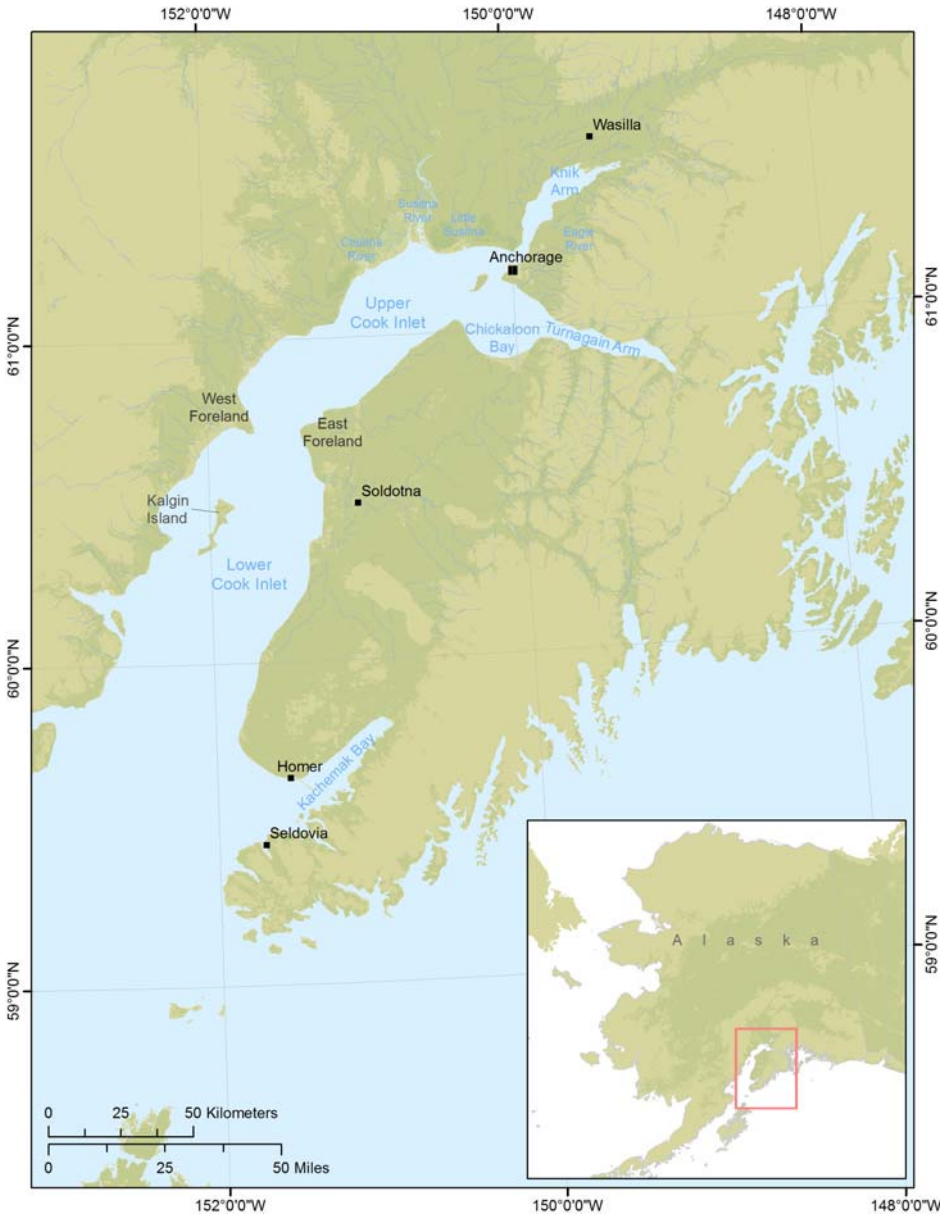

Figure 1. Map of Cook Inlet, Alaska, showing major features discussed in text.

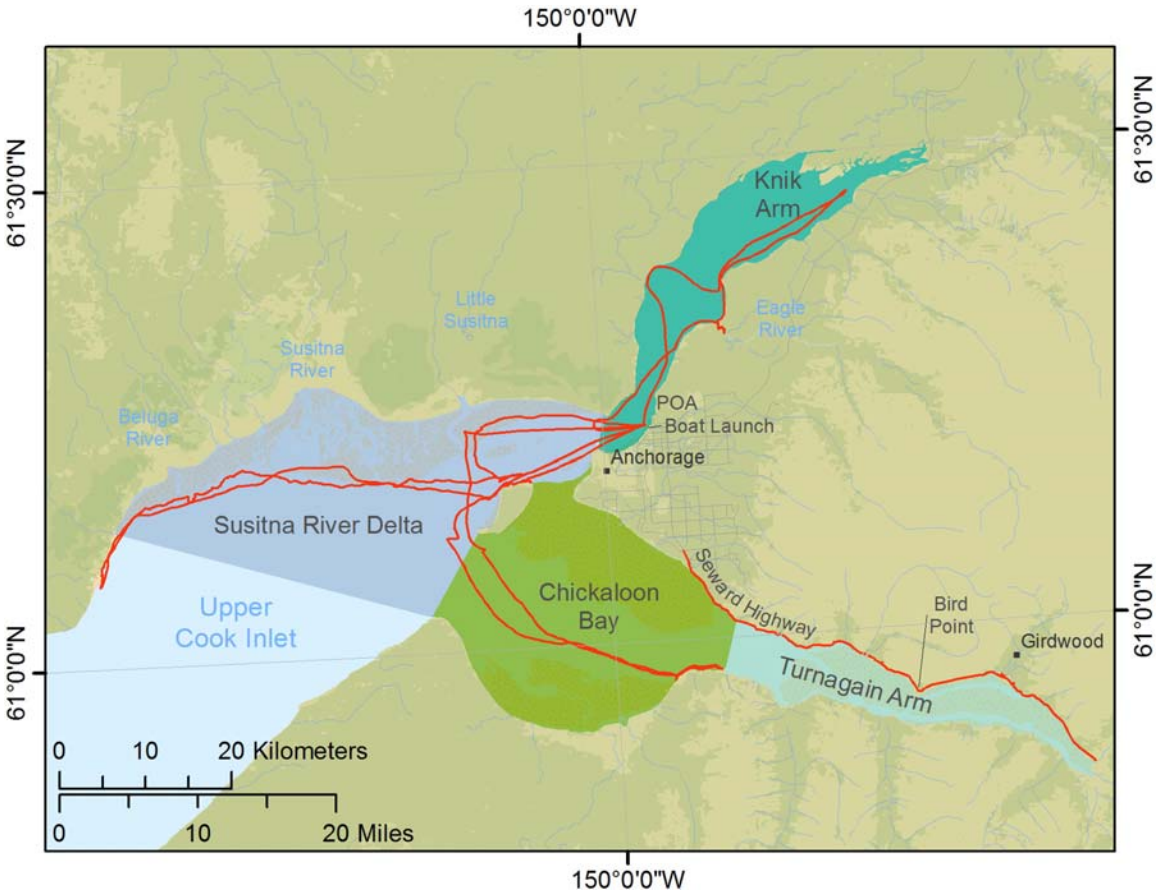

Figure 2. Upper Cook Inlet, Alaska, showing boundaries of sub-areas within the study area and the vessel- and land-based survey routes used 2005-2008.

Vessel surveys

Most photographs were taken from vessels. Vessel surveys were conducted from the *R/V Leucas*, a 4.9 m (16 ft) inflatable Proman 9 Zodiac® powered by a 4-stroke 50 hp Yamaha® motor. The *Leucas* usually carried one skipper and one crew member. Vessel position was recorded at 2-minute intervals with a Garmin™ GPS (Global Positioning System) Map 76C. Survey routes were determined by tidal stage, water depth, and navigational hazards, and were designed to maximize the probability of encountering whales. Whale groups were approached once per survey and followed in the manner described by Würsig and Jefferson (1990). The research vessel approached slowly, parallel to the group, matching group speed and heading in order to obtain images of lateral sides of individuals while minimizing disruption of the group. Researchers noted the position of whales relative to the vessel and GPS-logged tracks were used to estimate approximate whale group positions. Vessel-based surveys were suspended during NMFS aerial surveys. All vessel surveys were conducted under NMFS MMPA/ESA Research Permit # 14210.

Land-based surveys

Photographs were also taken from shore. A single observer drove south and east from Anchorage along the Seward Highway, generally beginning 3 hours before high tide. The observer, while stopping at pullouts along the highway, searched with binoculars and the naked eye for marine mammals. When beluga whales were seen, the observer attempted to follow them along Turnagain Arm as they moved with the tide. Most photographs were taken from sites between Bird Point and Girdwood (Figure 2) because whales approached closest to shore here, and because of highway access to these sites.

Field data (vessel and land-based surveys)

Standardized data forms were used to record beluga whale sightings. For each beluga whale group sighting, observers recorded: time of day, group size, GPS position of the vessel, magnetic compass bearing to the group, and estimated distance of the vessel from the group (distance at first detection, and minimum distance to individual whales). 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 both observers to be the most accurate.

Body color and relative size of whales in all groups were recorded as "white", "gray", "calf", and "neonate". Calves were usually dark gray, relatively small (i.e., <2/3 the total length of adult belugas), and usually swimming within one body length of an adult-sized beluga. 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 due to the presence of fetal folds, and uncoordinated swimming and surfacing patterns.

Digital photographs of beluga whales were collected using a Nikon D70, 6.1 megapixel digital SLR camera and Nikkor 70-400 mm zoom telephoto auto focus lens. Typical settings included shutter speed priority, dynamic auto-focus, 800 ISO, and a shutter speed of 1,000 or greater. Photographs were taken in RAW (not compressed) format and stored on compact flash memory cards.

Analyses of Data from Field Surveys

Locations of beluga whale sightings and survey routes were mapped in ArcGIS™ Version 10 (http://www.esri.com) and figures were prepared showing survey routes, group location, group size, and group color composition for each survey conducted in 2009. Beluga whale group size, color composition, and presence of calves and neonates were compared among the Susitna River Delta, Knik Arm, Turnagain Arm, and Chickaloon Bay.

Processing of Photographs

All RAW format photographs were downloaded from the camera's memory card onto a computer hard drive and archived to DVDs to preserve the original data before any further processing. Copies of photographs were then reformatted into JPEGs (JPEG files are smaller than RAW files) for more-efficient processing. 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 features of marks were obvious even in poor quality photographs, the photo was considered for inclusion in the catalog.

When an original field photograph contained two or more whales, each whale was cropped individually and given a separate file name. Cropped images were separated into left and right sides of whales. After 2005 and prior to the award of the NPRB research grant to develop a left-side catalog, only photographs of the right sides of the whales were further processed and cataloged, and left-side images were archived in order to conserve project funds. The left-side catalog of photographs was created in 2009 and 2010 with the NPRB grant that allowed for the cataloging of archived left-side photographs taken during National Fish and Wildlife Foundation-sponsored field surveys 2005-2008.

Daily photo samples (i.e., all cropped photos taken on a single survey day) were sorted into temporary folders. Each temporary folder contained all of the cropped images taken of the same individual beluga on a single day, and was comprised of 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. 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.

Cataloging of Photographs

Markings used for photo-identification of individual beluga whales consist of natural marks from conspecifics, pigmentation patterns, scars from injury or disease, and marks left from satellite tags attached by NMFS 1999-2002 (our research project does not apply marks to whales). Mark-type categories were created in order to facilitate cataloging. Locations of all visible marks were assigned to sections of the body (Figure 3) of each individual within the catalog. Computer software specialized for this species was developed 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 were most useful for matching marks used to identify individual whales. Profile images were divided into 11 sections along the right half of the whale (Figure 3); sections containing the head, tail and ventral half of the whale were less commonly captured in photographs and were therefore less likely to provide identifying marks. "Profile completeness" was determined by the number of sections with high quality images; a 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 to the base of the tail. Whales with complete profile sets were considered to be 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 2 or more years were matched. All matches in the existing catalog were reviewed and verified by at least three experienced analysts (one to catalog, one to confirm all results, and a third to review all work and be a "tie-breaker" when the first two analysts disagree).

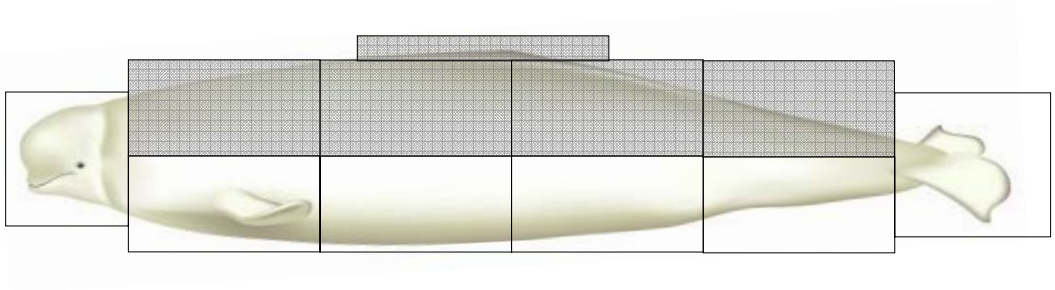

Figure 3. Body segments used when cataloging. The five shaded areas were the critical sections used in matching marks. Beluga illustration courtesy of Uko Gorter.

Sighting Histories

Sighting histories (i.e., dates and locations of sightings) were compiled for all belugas in the left-side catalog in order to examine residency and movement patterns. Sighting histories of a subset of the left-side catalog, consisting of all belugas that were photographed in all 4 years of the study (2005-2008), all belugas bearing scars from previous satellite tags, and all belugas identified in both the right- and left-side catalogs (i.e., the "dual-side" whales) were plotted and presented graphically. Dual-side whales were identified by marks on both sides of their bodies and by marks that spanned both sides of the bodies (Figures 4 and 5). Locations of cataloged beluga whale sightings were mapped in ArcGIS™ Version 10 (http://www.esri.com). The study area was divided into subareas (Figure 2), and occurrence and movements of identified belugas among subareas were examined.

Figure 4. Photographs of beluga 'Kenai', showing the left side (a), right side (c), and "dual" side (b) images that were used to link images and sightings records from the left and right sides of this whale. The "dual-side" image (b) is of the whale facing away from the photographer.

Figure 5. Dual-side photograph of beluga 'Catepillar' used to link images and sightings records from the left and right sides of this whale. The image is of the whale facing away from the photographer.

Classification of Mothers and Calves in Photographs

Identified belugas were classified as mothers in photographs if they appeared in the same cropped photo-frame with a calf or neonate alongside. Belugas were classified as calves in photographs if they were dark gray (although light-gray calves were also observed), relatively small (i.e., <2/3 the total length of adult belugas), and photographed swimming and surfacing in synchrony alongside a larger 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 left-cataloged mothers and calves. Sighting records for 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.

Indices of Association between Cataloged Belugas

A coefficient of association (COA) is a measure of the association between beluga A and beluga B:

(Eqn 1) $COA=N_{ab}/N_a+N_b$

where N_{ab} is the number of times beluga A and beluga B were found in the same group, and N_a and N_b are the total of group sightings for A and B, respectively. COAs were calculated for pairs of individuals, where a COA=0.0 indicates beluga A and B were never seen together and a COA=1.0 indicates that beluga A and B were always seen together.

COAs were calculated for the whales seen in all 4 years of the study (2005-2008). This subset of the left-side catalog was selected because each whale had been re-sighted for the duration of the study, thus eliminating the possibility of a missed sighting due to mark loss or significant mark change. Whales were considered to be associated if they were sighted in the same group on the same day. COAs and all related analyses of association were calculated with the software program SOCPROG 2.3 for MATLAB 7.4 (Whitehead 2008). COAs were calculated using a simple-ratio index (rather than a half-weight ratio index; Cairns and Schwager 1987), because association was defined as presence in the same group on the same day (Whitehead 2008). Because the majority of calves could not be identified independently of their mothers, COAs for mother-calf pairs were not calculated.

The COA matrix for each subset of cataloged belugas was displayed in a dendrogram, in which rows represent individual belugas in the subset and the lines and the distances connecting the rows represents the COA between two individuals (Whitehead 2008).

Additional Information Provided by the Study

Causes of markings

Many photographs of CIBWs in the right-side catalog contain marks indicative of disease and injury (LGL 2009). Using the cataloging tools within the database application, marks were labeled according to mark type and body segment in which they occurred (Figure 3). Beluga researchers, beluga hunters, orca researchers, and/or members of the Marine Mammal Stranding Network were consulted about possible sources of marks in photographs.

Database Development

In cooperation with Axiom Consulting, we consolidated all left-side photo-identification data and photographs from 2005-2008 into a single unified database and interface (Figure 6). Survey data included amount of effort, survey route, environmental conditions, and sighting information such as whale locations, group size, color and age-class, 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 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, the number of unmatched temporary files, and the number of photos of whales with few or no visible markings. In addition to consolidating the data, all sorted and cropped left-side photographs of useable quality were imported into the database.

Significant modifications were made to the photo-identification database application to aid in the management of photos during left-side cataloging and to streamline the process (Figure 7). Modifications included the addition of tools to create/edit/merge photos of cataloged whales within the application, the creation of a feature to view the "best photos" selected of each whale for a quick-reference interface of cataloged whales, and a function to export detailed reports of various data listed above. In addition, an advanced photo-tagging system has been developed for this application. The user can create, edit, and delete custom photo-tag definitions that correspond to mark patterns commonly observed on whales. These tags can then be applied to a specific section of a whale's body or to the entire whale in general. Once the tags have been applied, they can be used in various combinations as a powerful way to search for existing animals based on mark combinations. A "view in context" feature was added to view cropped photographs in their original, uncropped form and also within the sequence of the other photos taken on the same day. This can be very helpful in the cataloging process because sequential photographs of the same whale are occasionally separated from each other by photographs of other whales in the group.

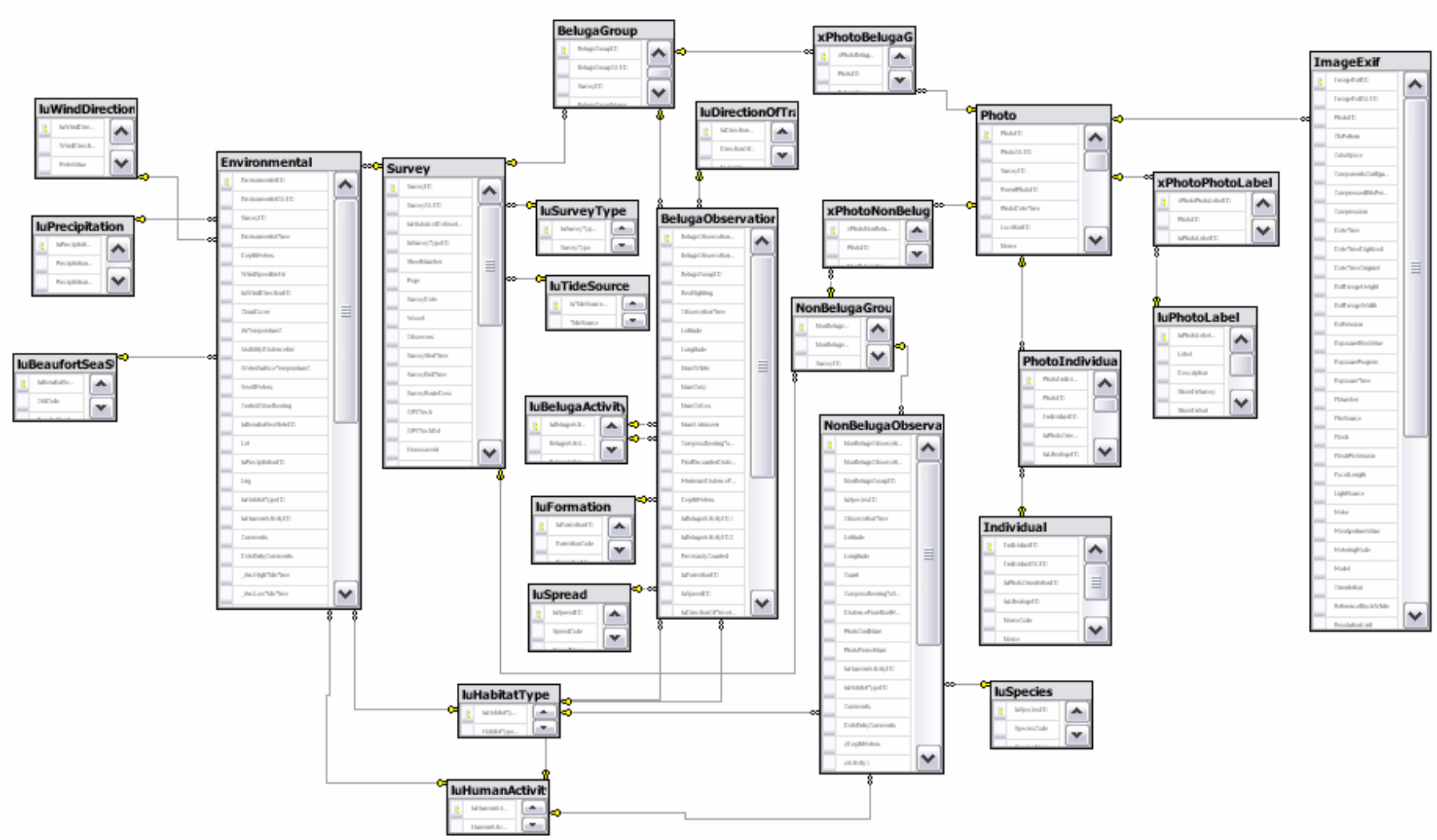

Figure 6. The structure of the beluga photo-id database.

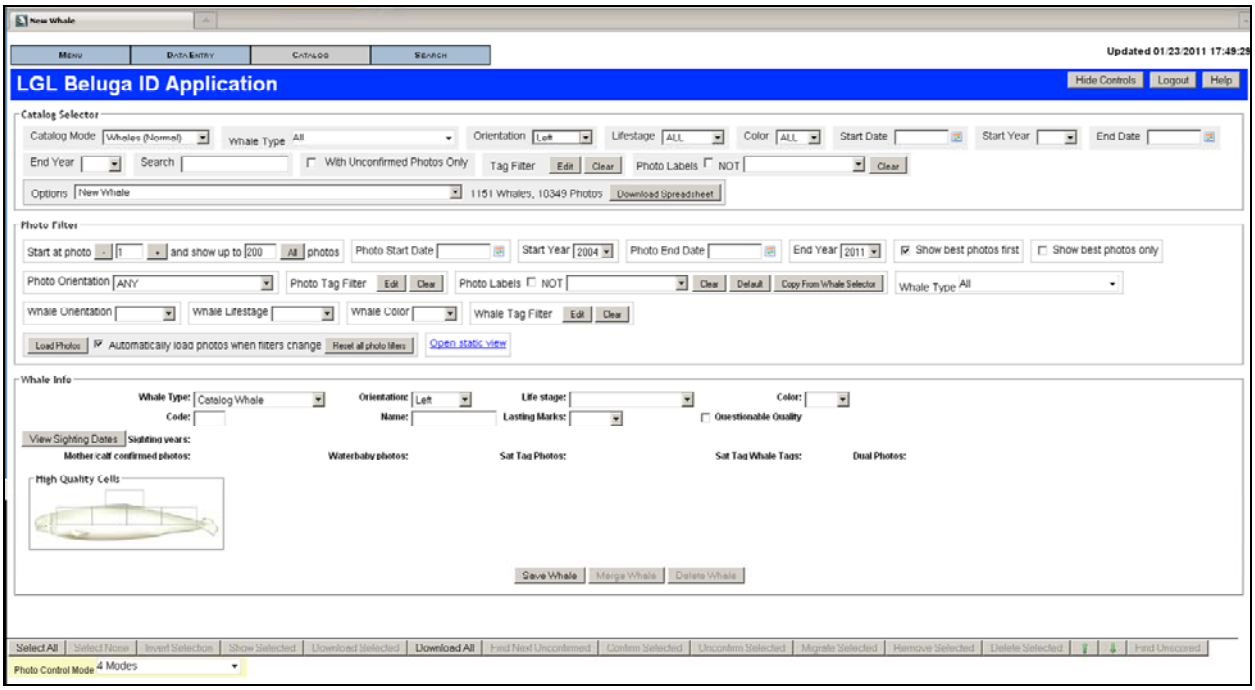

Figure 7. The individual whale information page for left-side whales in the beluga photo-id application.

RESULTS

Catalog Development and Current Status of the 2005-2008 Left-Side Catalog

We have completed cataloging left-side photographs taken 2006-2008 and have added them to the pre-existing left-side catalog of photographs taken in 2005. In total, 10,619 photographs of whales were examined and inventoried. After identifying and removing photographs of unacceptable quality (*n*=1,936), unacceptable coverage (i.e., insufficient body coverage; *n*=264) or images of right sides (*n*=271), 8,148 cropped and sorted left-side images were organized into folders in preparation for cataloging. The cataloging process was greatly facilitated by the development of the photo-identification database. Consolidation of all project files and the right- and left-side catalogs into a single database and catalog has been completed.

The current left-side catalog contains 5,089 photographs taken during 142 surveys conducted between 2005 and 2008 in Upper Cook Inlet, Alaska (Tables 1 and 2), and consists of 186 individually-identified whales. The left-side catalog also includes one photograph from an opportunistic sighting in 2004. The work funded by NPRB allowed us to add a total of 76 new individually-identified whales (photographed 2006-2008) to the left-side catalog that had originally contained 110 left-side whales photographed in 2005 (Table 1). The funding also allowed us to add to the sighting histories of whales originally identified in 2005; 82 (75%) of the whales photographed in 2005 were also seen in following

years. In addition to the catalog, the 2005-2008 left-side photo-id database contains folders of whales that are considered "temporary matches" (i.e., cannot be matched to images of cataloged whales and cannot be classified as cataloged individuals because of incomplete profile sets and/or single-year sightings).

Three hundred and twenty eight whale groups were photographed during 142 surveys in 2005-2008 (Table 2). From these groups, 186 belugas were matched with belugas previously identified in the 2005-2008 left-side catalog (Table 1). Survey effort was unevenly distributed among years and locations in Upper Cook Inlet (Table 3); additional details on survey locations, survey effort, and group encounter rates, size, color/age composition, and behavior are presented in McGuire and Kaplan (2009). Survey effort was greatest in 2005 and more belugas were added to the catalog in 2005 than in following years (Table 1). The identification rate (number of beluga identifications/survey) was highest in Kink Arm, followed by the Susitna Delta, and was much lower in Chickaloon Bay and Turnagain Arm (Table 4).

Table 1. Number of photo-id surveys, number of photographs, and individual whales added to the left-side photo-id catalog, 2005-2008.

Year	Photo-id Surveys	Photos Added	New Whales Added
*2005	49	1,730	110
2006	38	1,926	42
2007	23	750	22
2008	32	684	12
Total	***142***	***5,090***	***186***

*Includes one photo of one whale from an incidental sighting in 2004.

Table 2. Total project survey effort and beluga whale group encounters 2005-2008, Upper Cook Inlet, Alaska. (Chickaloon Bay = Chickaloon Bay/Southeast Fire Island).

	2005*	2006	2007	2008	*Total*
Number Photo-identification survey days	49	38	23	32	***142***
Number Photos taken	44,878	21,244	4,193	13,222	***83,537***
Number Groups Encountered	140	96	42	50	***328***
Range of Surveys	14 Apr- 21 Oct	12 May-5 Oct	28 Jun-27 Oct	21 May-28 Oct	
Season Survey Span (Months)	6	5	4	5	
Areas Surveyed	Susitna River Delta, Knik Arm, Turnagain Arm	Susitna River Delta, Knik Arm, Turnagain Arm, Chickaloon Bay	Susitna River Delta, Knik Arm, Turnagain Arm, Chickaloon Bay	Susitna River Delta, Knik Arm, Turnagain Arm, Chickaloon Bay	

*Includes one photo of one whale from an incidental sighting in 2004.

Table 3. The number of photo-identification surveys conducted in Upper Cook Inlet, Alaska between 2005 and 2008, according to area.

	Year				
Area	**2005**	**2006**	**2007**	**2008**	***Total***
Survey days	49	38	23	32	***142***
Susitna River Delta	17	21	4	8	***50***
Knik Arm	33	15	10	12	***70***
Turnagain Arm	1	6	8	12	***27***
Chickaloon Bay/Southeast Fire Island	0	1	1	2	***4***

Table 4. The number of photo-identification surveys, number of sightings of catalog whales by side, and sighting rate by side for each area surveyed from 2005 to 2008.

Area	Surveys 2005-2008	Sightings of Right-side Catalog Whales 2005-2008	Sightings of Left-side Catalog Whales 2005-2008	Right-side Sighting Rate (Catalog Sightings/ Surveys)	Left-side Sighting Rate (Catalog Sightings/ Surveys)
Susitna River Delta	50	365	221	7.3	4.4
Knik Arm	70	661	455	9.4	6.5
Turnagain Arm	27	15	19	0.6	0.7
Chickaloon Bay/ SE Fire Island	4	6	7	1.5	1.8
Total	***151****	***1047***	***702***	***6.9***	***4.6***

* Total number of surveys (151) is > number of survey days (142) because multiple areas were sometime surveyed on the same day.

Sighting Histories

Sighting histories of belugas 2005-2008

Of the 186 cataloged whales, 68 (37%) were identified in a single year, 74 (40%) were identified in 2 years, and 30 (16%) were identified in 3 years. Fourteen individual belugas were identified in all 4 years of the study, and their individual sighting histories and photographs are presented in figures 8-21. Forty-seven whales first identified in 2005 were resighted in 2008.

Of the 14 individually identified belugas sighted in each of the 4 years of the study (Table 5), none were photographed exclusively in one survey area. All 14 belugas were photographed in both Knik Arm and the Susitna River Delta; fifty percent of these were also seen in Turnagain Arm, and one was also seen in the Chickaloon Bay/Southeast Fire Island area. All of the belugas identified in Turnagain Arm were also identified in Knik Arm and the Susitna River Delta.

The highest total encounter rate (number of sightings for all field seasons combined) during the course of the study was for two identified belugas that were each sighted on 20 different days during 2005-2008 (Figure 22). Forty-two whales were sighted on one day only, 41 whales were sighted on two days, and 101 whales were sighted three or more days. Identified belugas were rarely photographed in more than one group per survey day, and were never photographed in more than two groups per survey day.

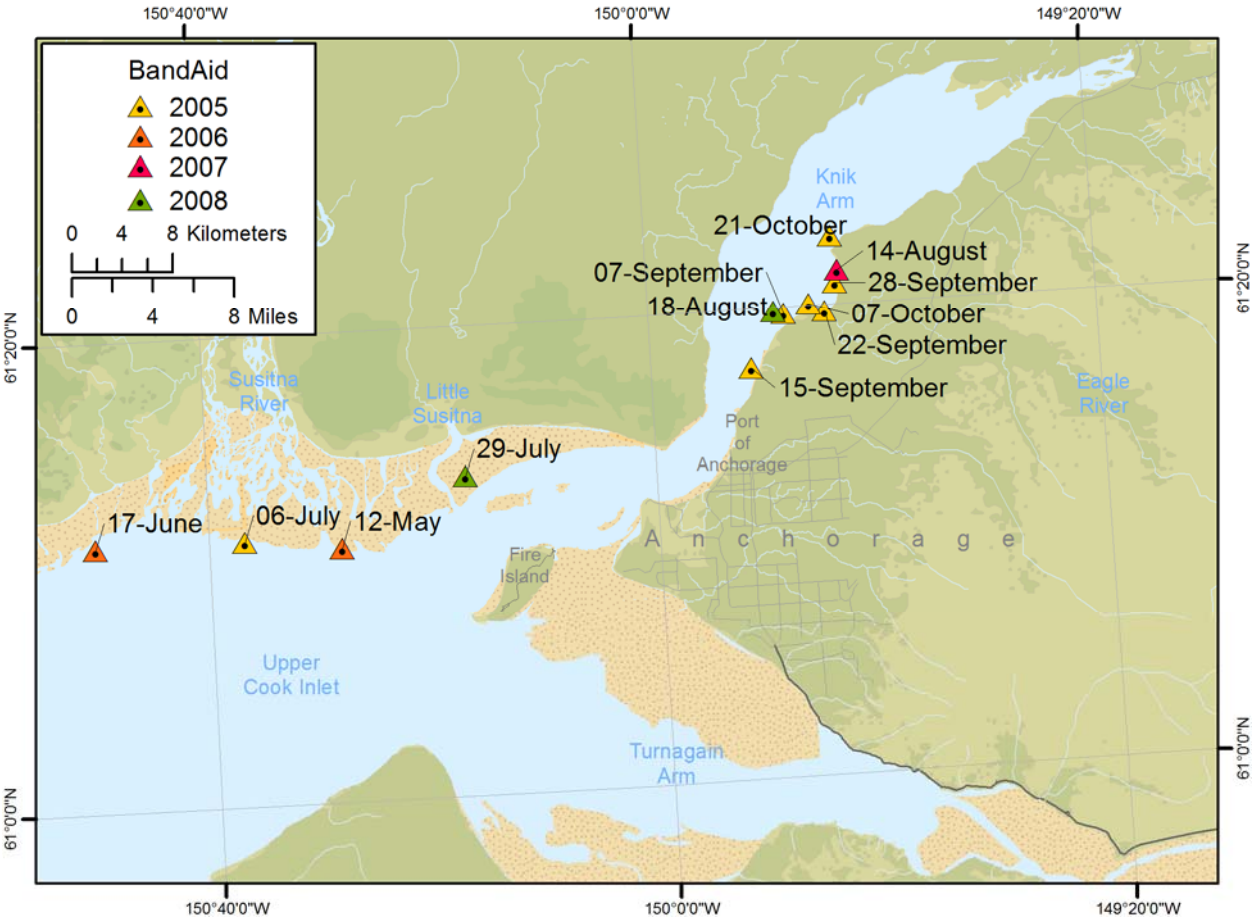

Figure 8. Sighting history and photograph of beluga 'Bandaid'. This beluga is a presumed mother based on photographs with an accompanying calf.

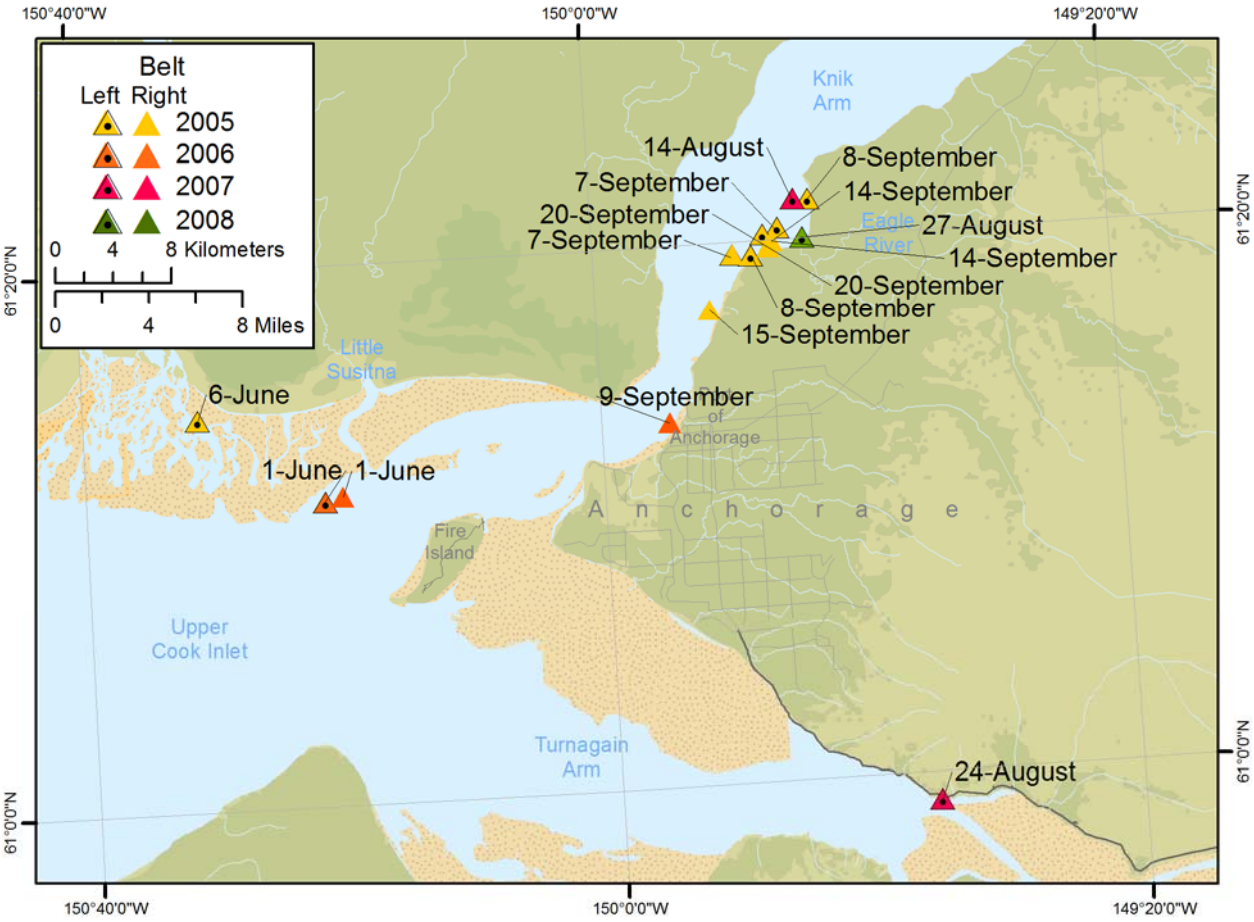

Figure 9. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Belt'. This beluga is a presumed mother based on photographs with an accompanying calf.

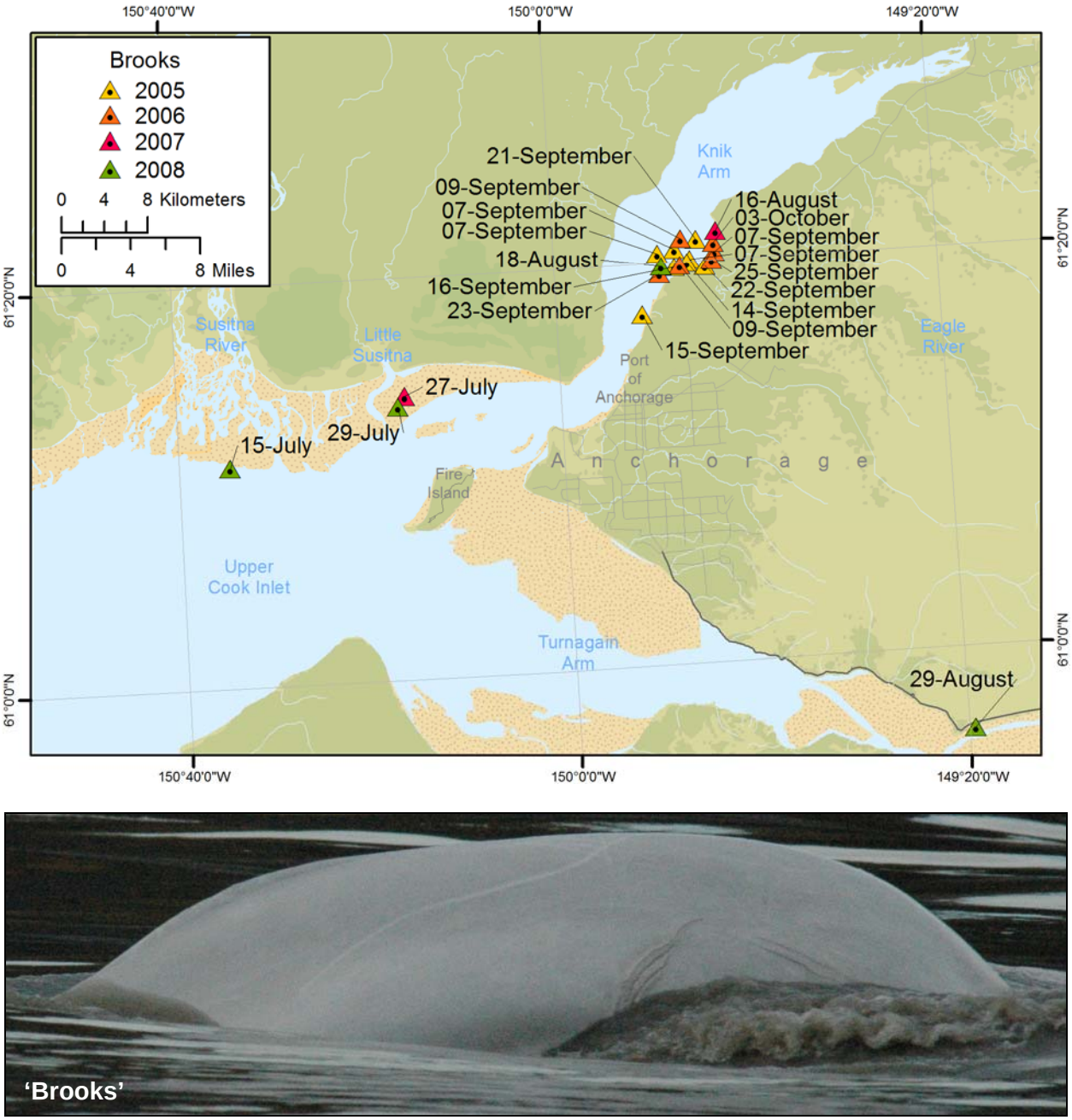

Figure 10. Sighting history and photograph of beluga 'Brooks'. This beluga is a presumed mother based on photographs with an accompanying calf.

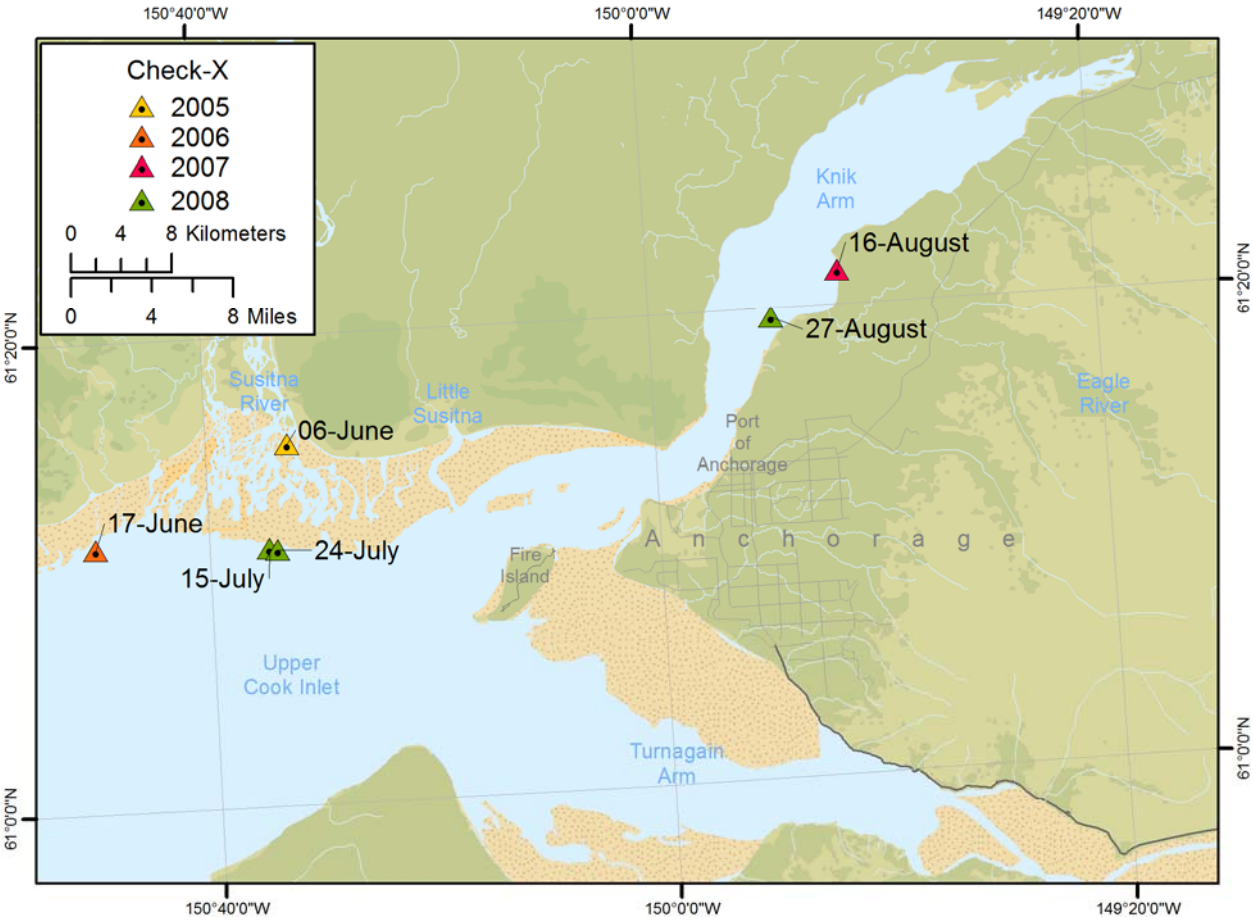

Figure 11. Sighting history and photograph of beluga 'Check-X'. This beluga is a presumed mother based on photographs with an accompanying calf.

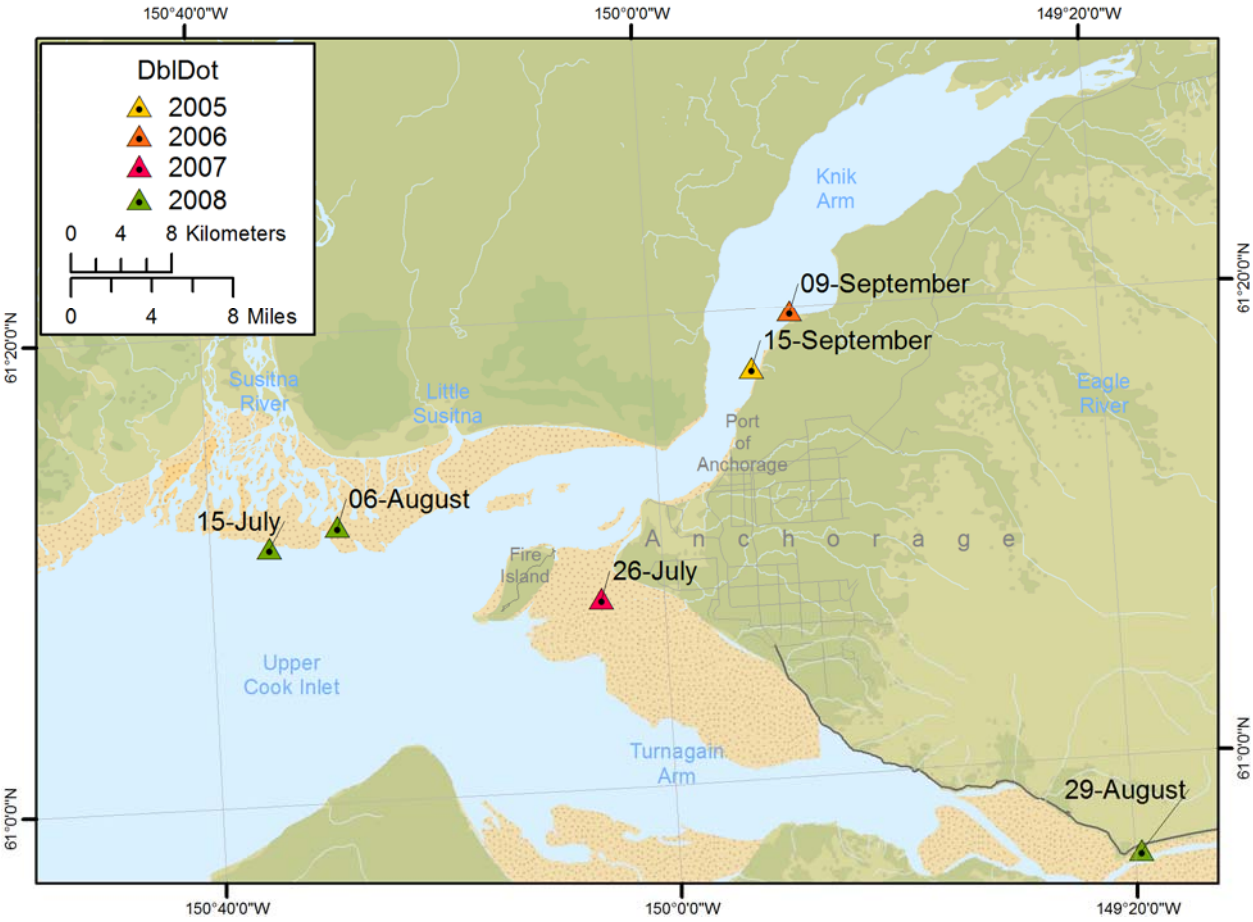

Figure 12. Sighting history and photograph of beluga 'DblDot'.

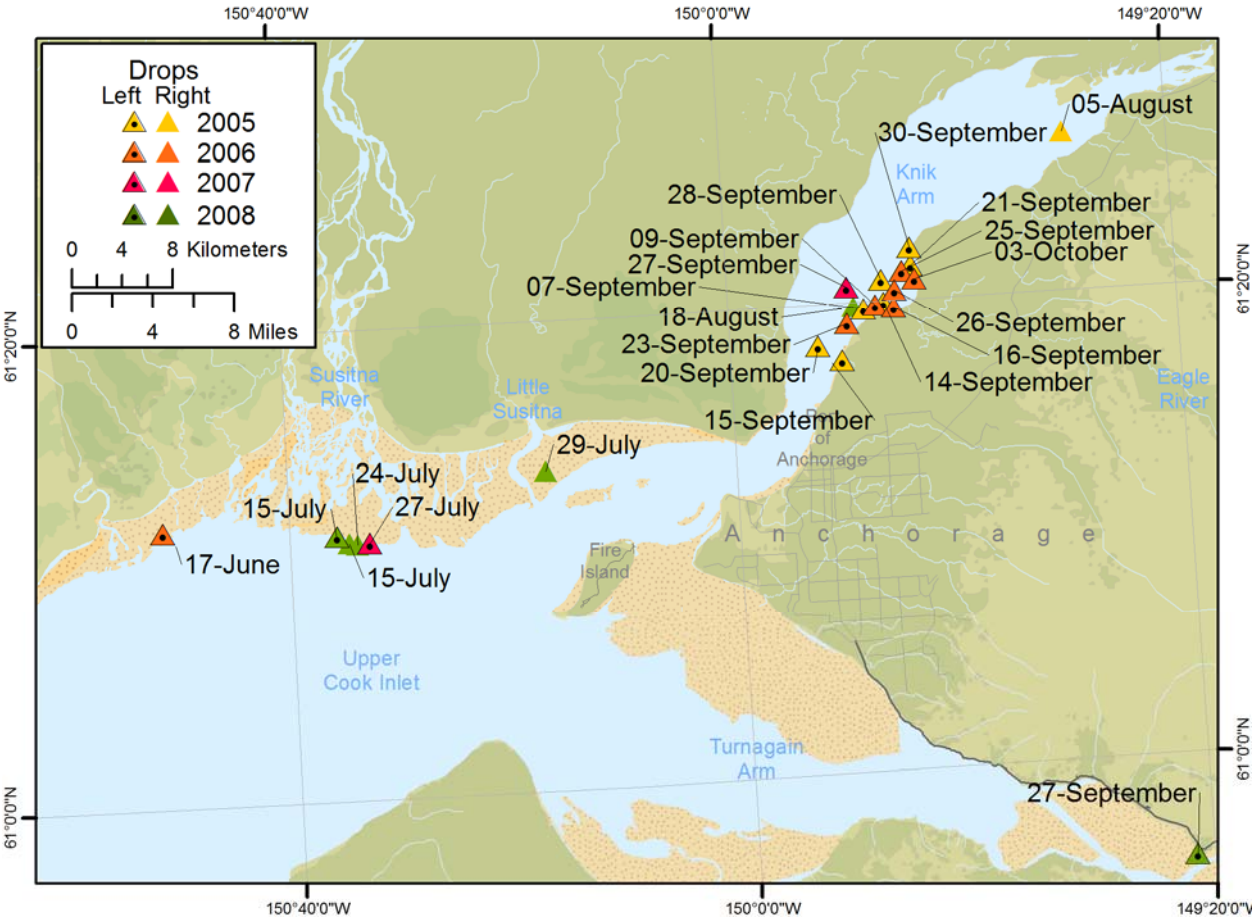

Figure 13. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Drops'. This beluga is a presumed mother based on photographs with an accompanying calf.

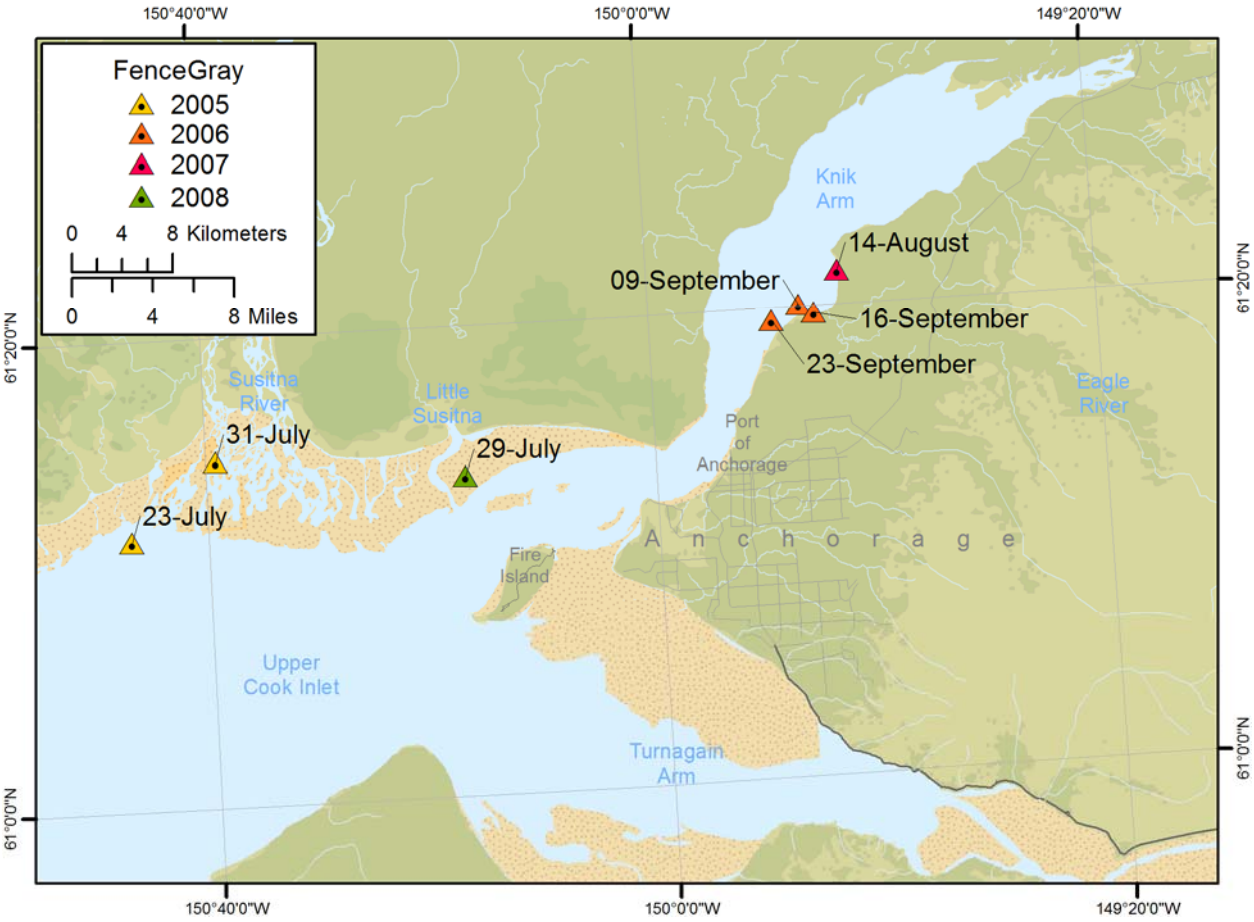

Figure 14. Sighting history and photograph of beluga 'FenceGray'.

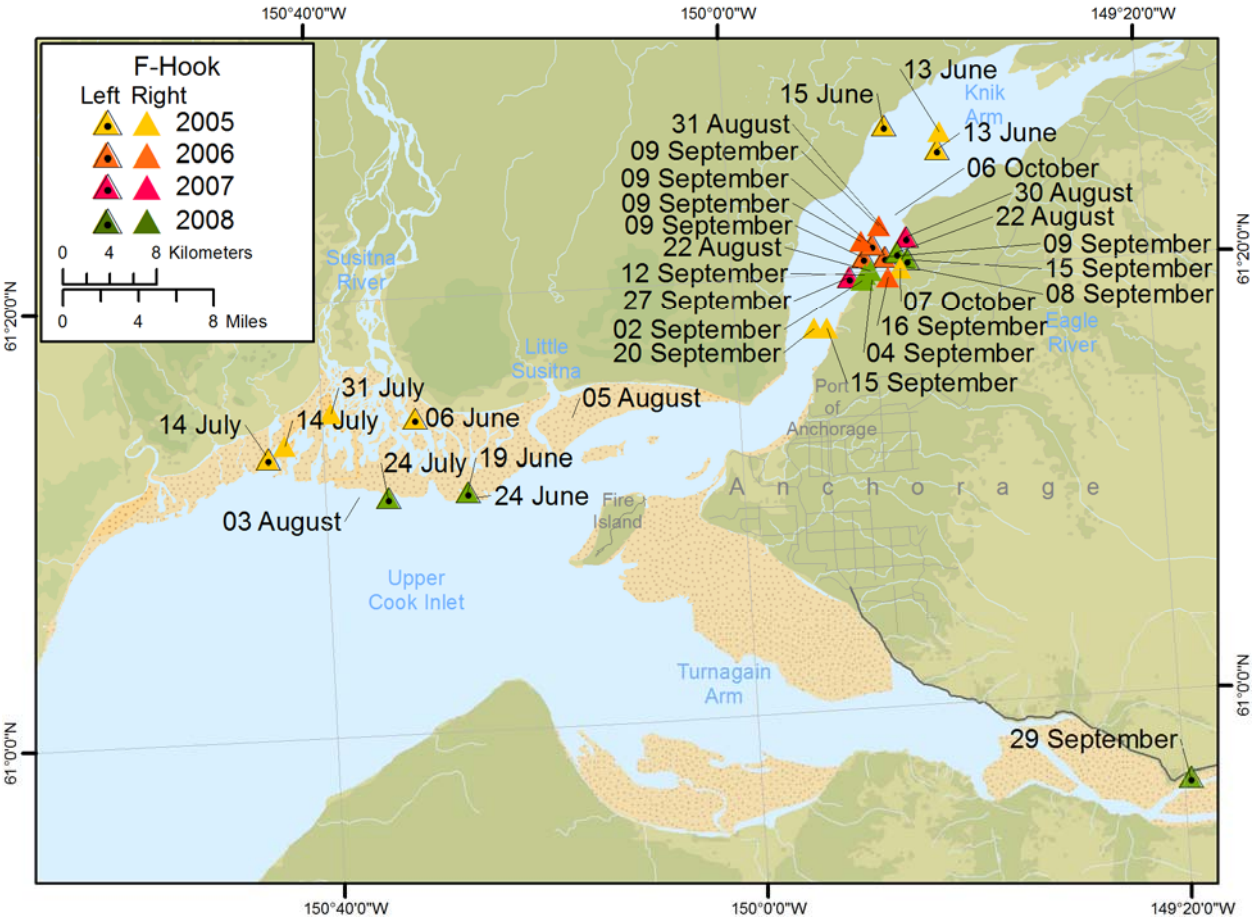

Figure 15. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'F-Hook'. This beluga is a presumed mother based on photographs with an accompanying calf.

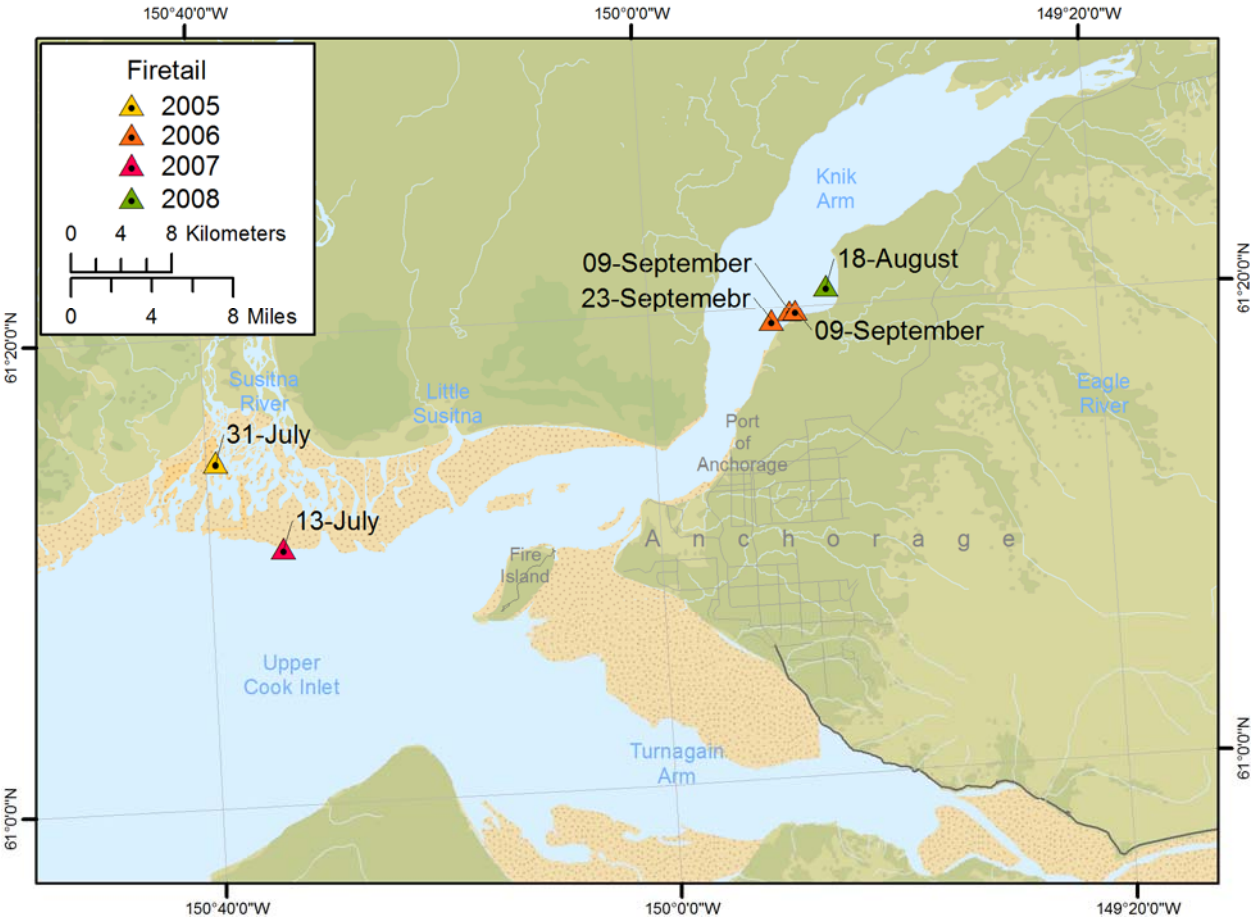

Figure 16. Sighting history and photograph of beluga 'Firetail'. This beluga is a presumed mother based on photographs, such as this one, with an accompanying calf.

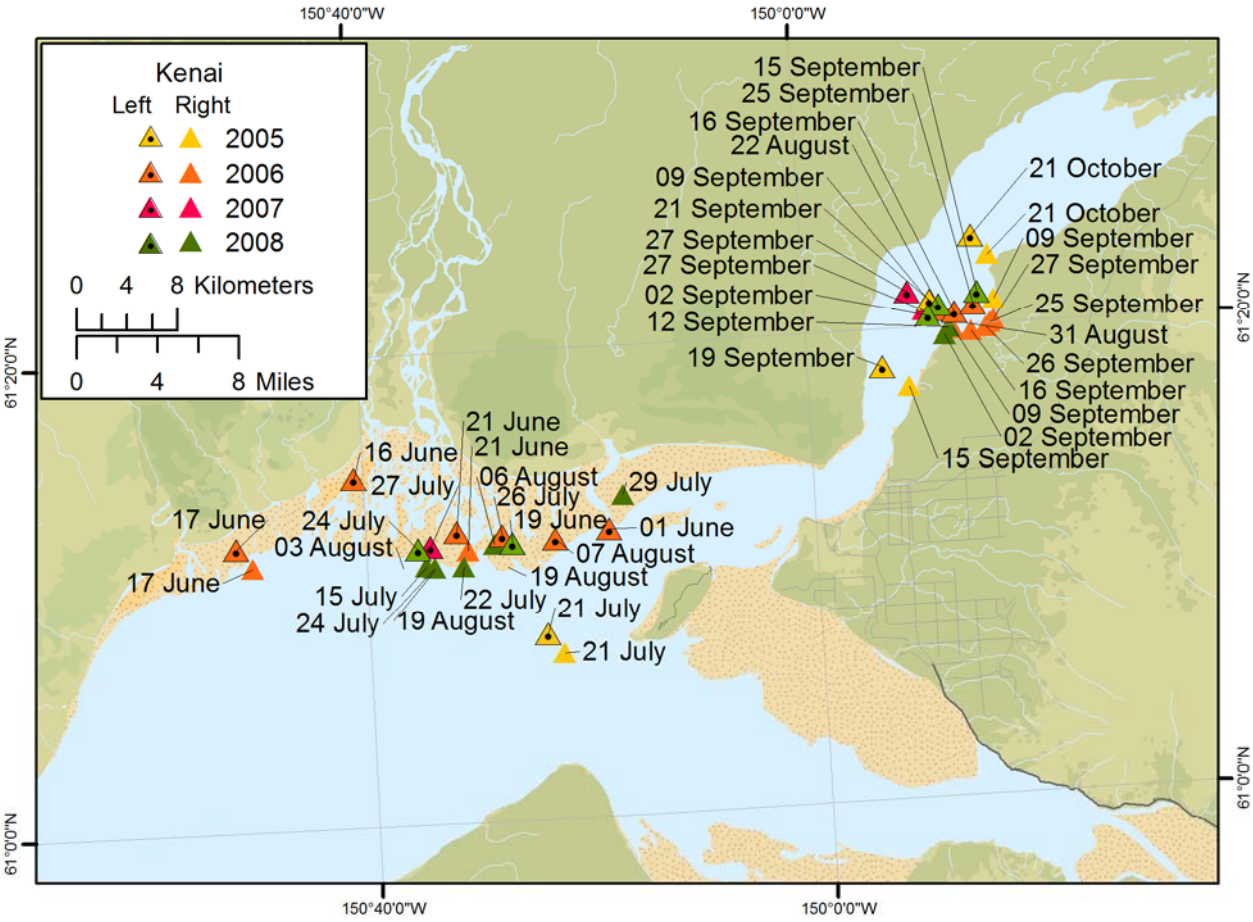

Figure 17. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Kenai'. This beluga is a presumed mother based on photographs with an accompanying calf.

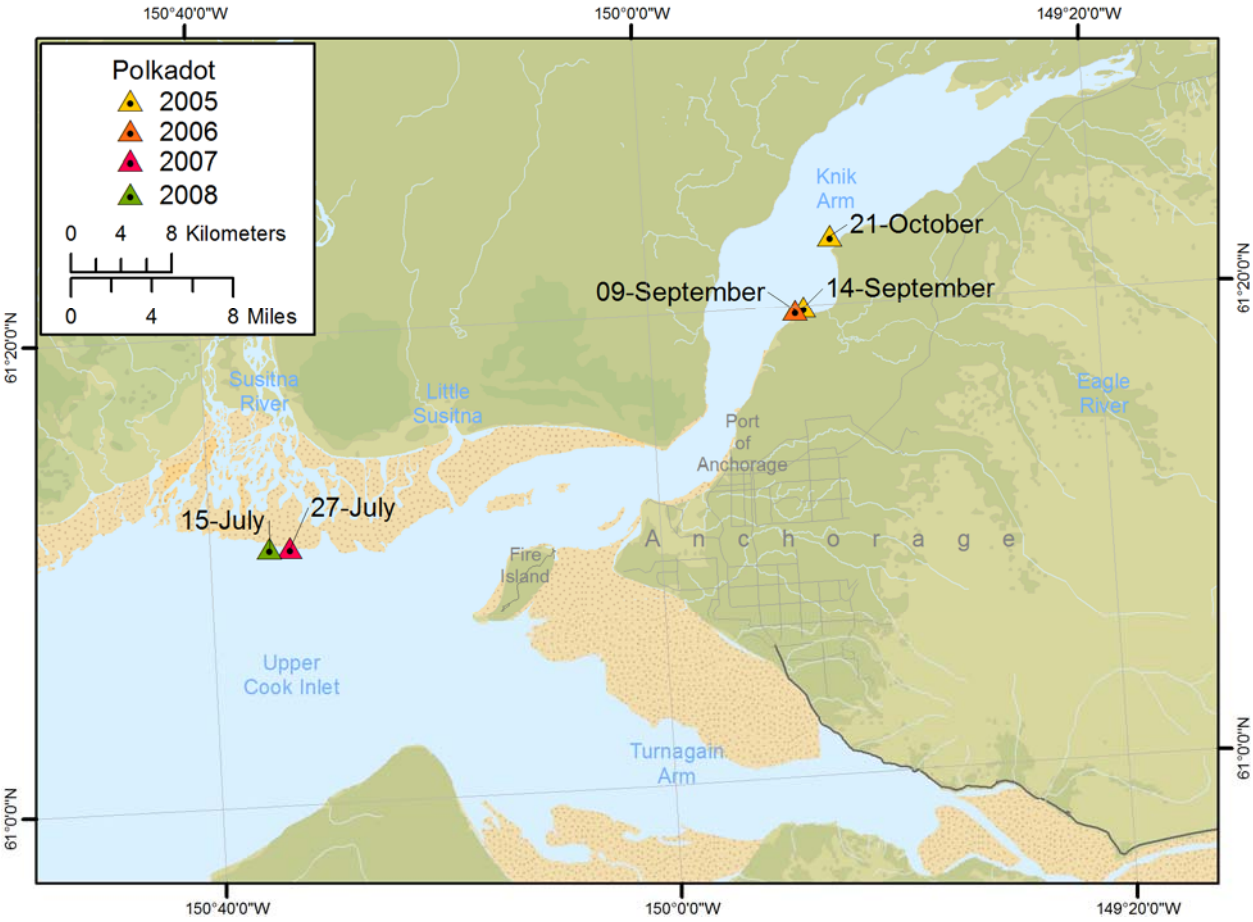

Figure 18. Sighting history and photograph of beluga 'Polkadot'. This beluga is a presumed mother based on photographs with an accompanying calf.

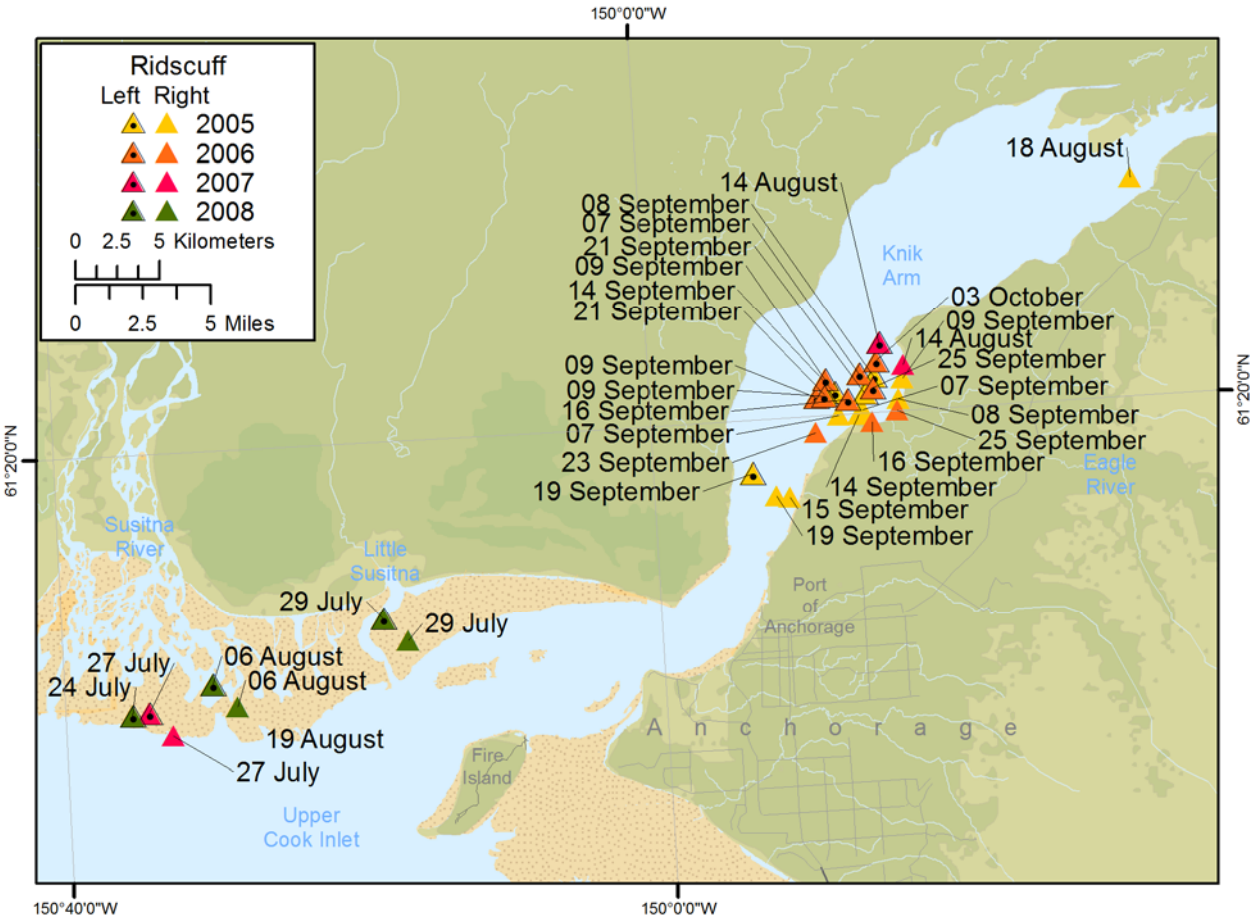

Figure 19. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Ridscuff'. This beluga is a presumed mother based on photographs with an accompanying calf.

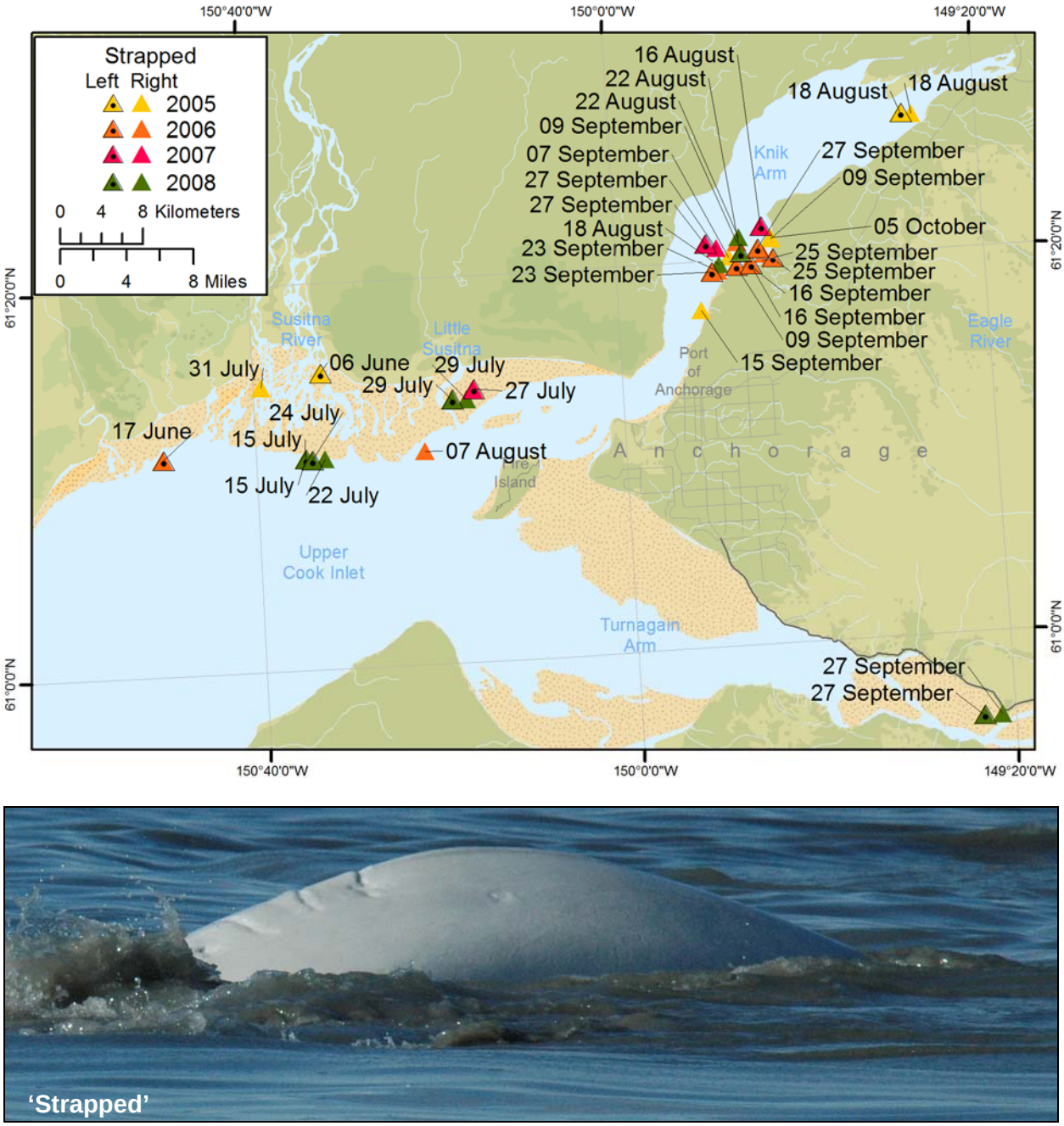

Figure 20. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Strapped'. This beluga was tagged by NMFS sometime between 1999 and 2002 and is a presumed mother based on photographs with an accompanying calf.

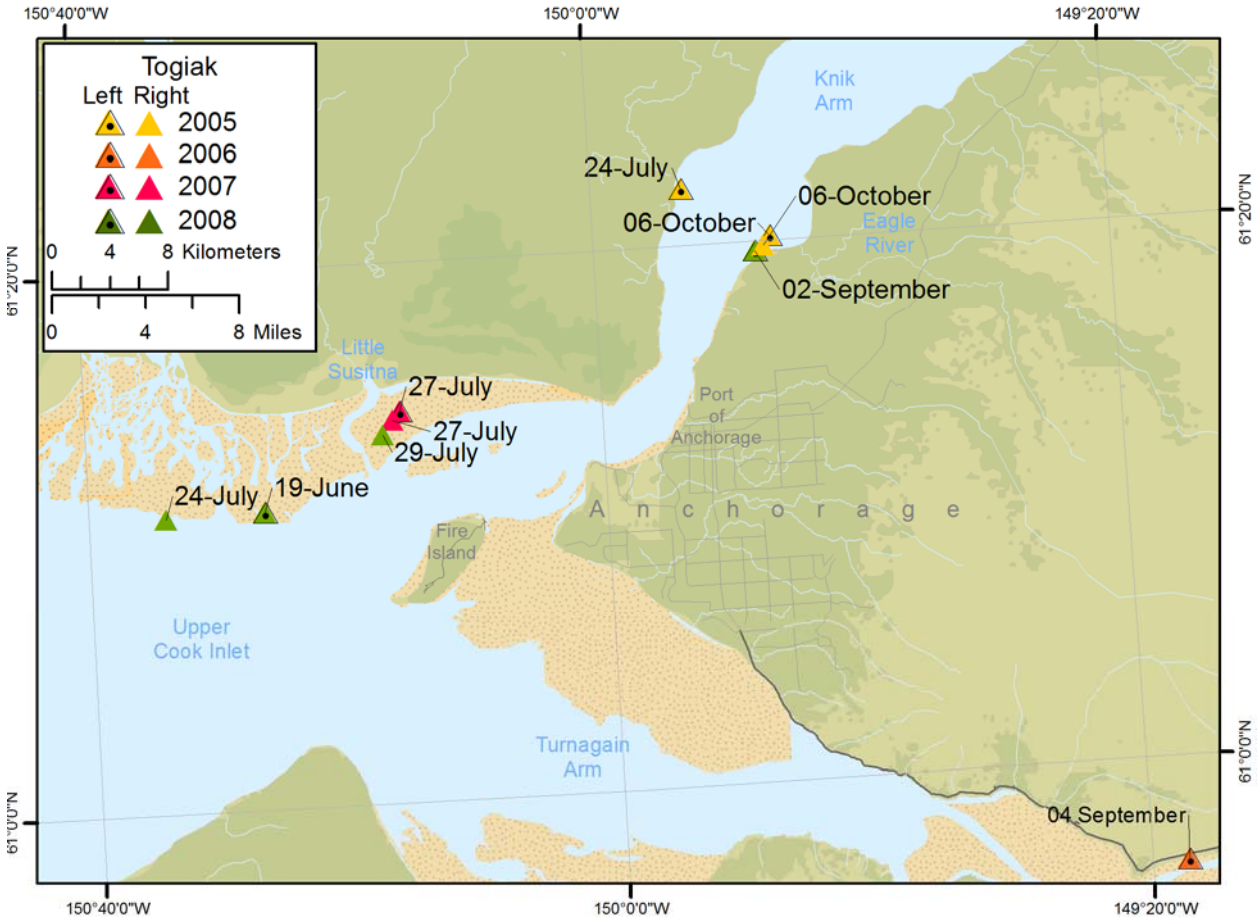

Figure 21. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Togiak'. This beluga is a presumed mother based on photographs with an accompanying calf.

Table 5. Sighting records of 14 individual belugas identified and cataloged each year from 2005 to 2008 according to year and location. (P = photographed)

	Knik Arm				Susitna River Delta				Turnagain Arm				Chickaloon Bay/ SE Fire Island			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
	# of Surveys				# of Surveys				# of Surveys				# of Surveys			
Whale ID	**32**	**15**	**10**	**12**	**17**	**21**	**4**	**8**	**1**	**6**	**8**	**12**	**0**	**1**	**1**	**2**
BandAid-L	P		P	P	P	P		P								
Belt-L	P		P	P	P	P	P				P					
F-Hook-L	P	P	P	P	P			P				P				
firetail		P		P	P		P									
Kenai-L	P	P	P	P	P	P	P	P								
LA035 Drops-L	P	P	P			P	P	P				P				
LA063 Polkadot	P	P					P	P								
LA130 Togiak	P			P			P	P		P						
LA132 Strapped-L	P	P	P	P	P	P	P	P				P				
LA136 Brooks	P	P	P	P			P	P				P				
LA206 Check-X			P	P	P	P		P								
LS020 DblDot	P	P						P				P			P	
LS042 FenceGray		P	P		P			P								
Ridscuff-L	P	P	P				P	P								

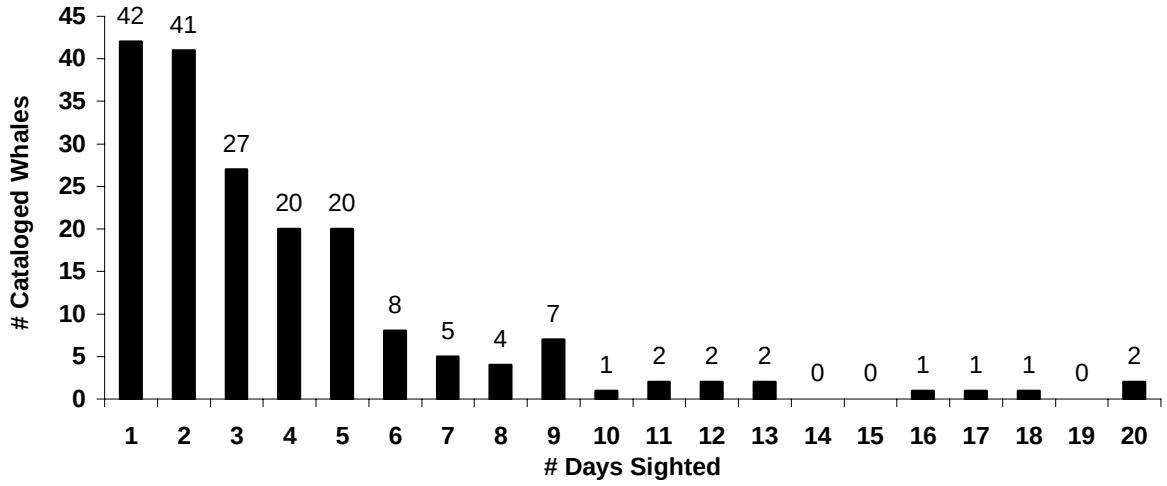

Figure 22. The number of days left-side cataloged whales were resighted from 2005-2008.

Sighting histories of belugas identified by satellite tag scars

Six belugas photo-identified by their left sides had unique scars from satellite tags affixed between 1999 and 2002. These individuals were identified based on a combination of natural marks and the tag scars to avoid mistakenly matching similar scar patterns caused by the same tag type. Five of these previously whales were also identified by marks on the right side of their bodies, and by marks that spanned the right and left sides of the body. Four previously tagged belugas were photographed on the

left side and were with calves (Table 6). Four previously tagged belugas were photographed in Knik Arm, the Susitna River Delta, and Turnagain Arm. One previously tagged beluga was seen only in Knik Arm; no previously tagged belugas were seen only in the Susitna River Delta or only in Turnagain Arm. No previously tagged animals were photographed in Chickaloon Bay/Southeast Fire Island during the four surveys conducted in the area. Individual sighting histories and photographs of previously tagged belugas are presented in figures 23-28.

Table 6. Sighting records of six individual belugas that were identified by left-side scars from satellite tags applied by NMFS between 1999 and 2002, according to year and location. (P = Photographed, C = Photographed with a calf).

	Susitna River Delta				Knik Arm				Turnagain Arm				Chickaloon Bay/ SE Fire Island			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
	# of Surveys				# of Surveys				# of Surveys				# of Surveys			
Whale ID	**17**	**21**	**4**	**8**	**32**	**15**	**10**	**12**	**1**	**6**	**8**	**12**	**0**	**1**	**1**	**2**
Humperdink	P			C	P											
JabbaTheHut		P	P	P			P	P		P						
Sash	P		P		P		P					P				
Sashtoo	P		P	C	P		P	P		P						
Strapped	P	P	P	P	P	P	C	C				P				
Tag-2foreholes						C										

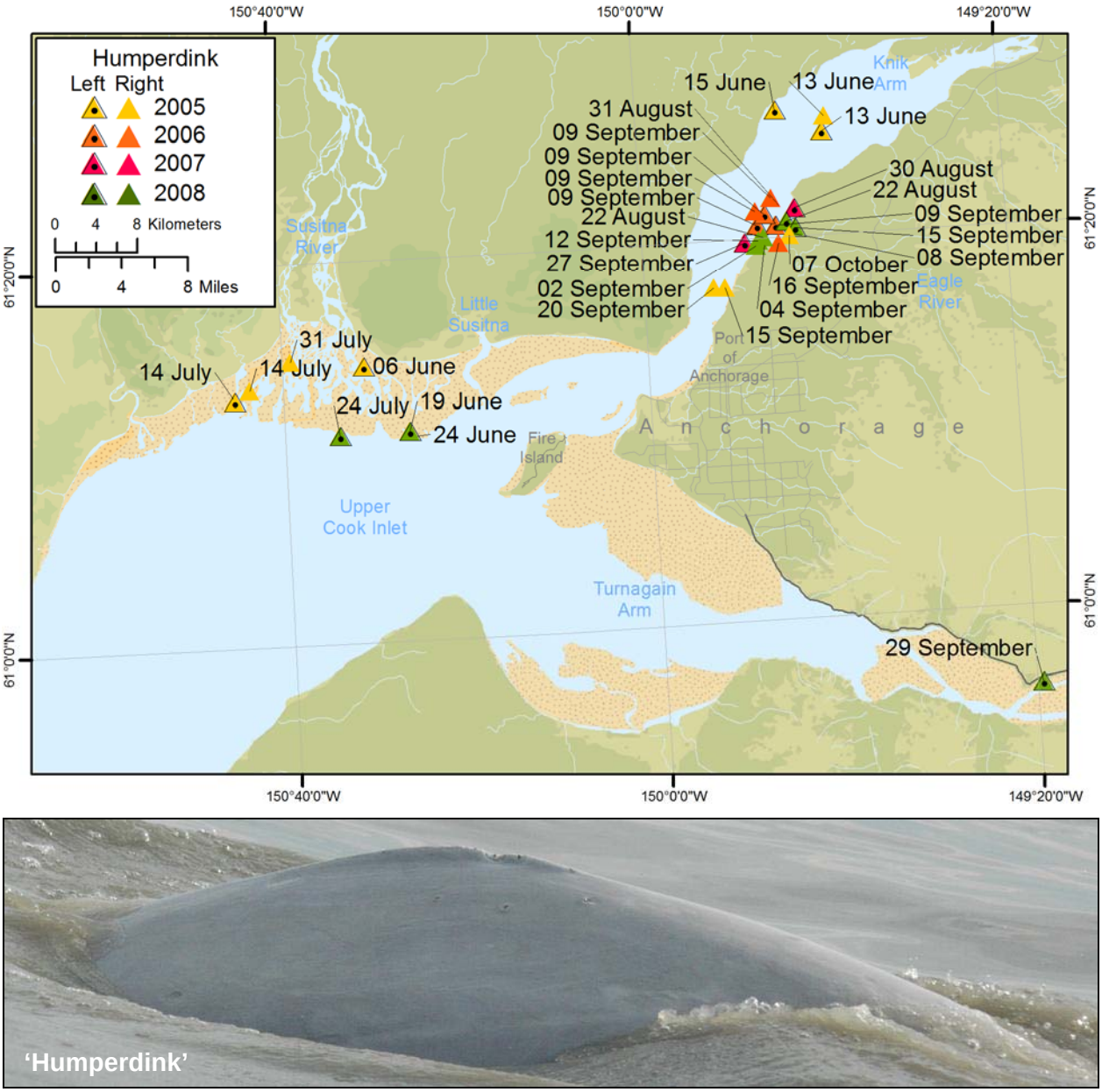

Figure 23. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Humperdink'. This beluga is a presumed mother based on photographs with an accompanying calf.

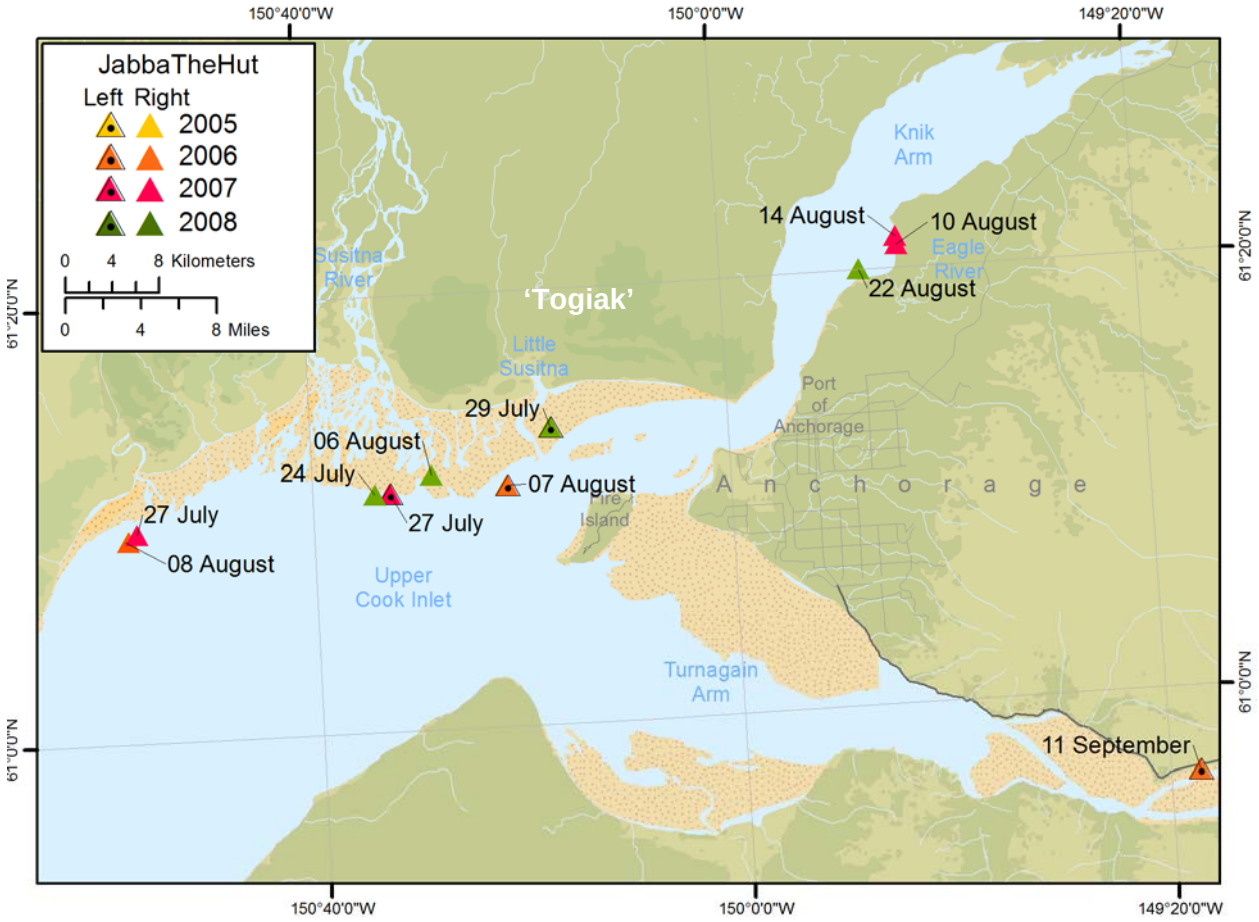

Figure 24. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'JabbaTheHut'.

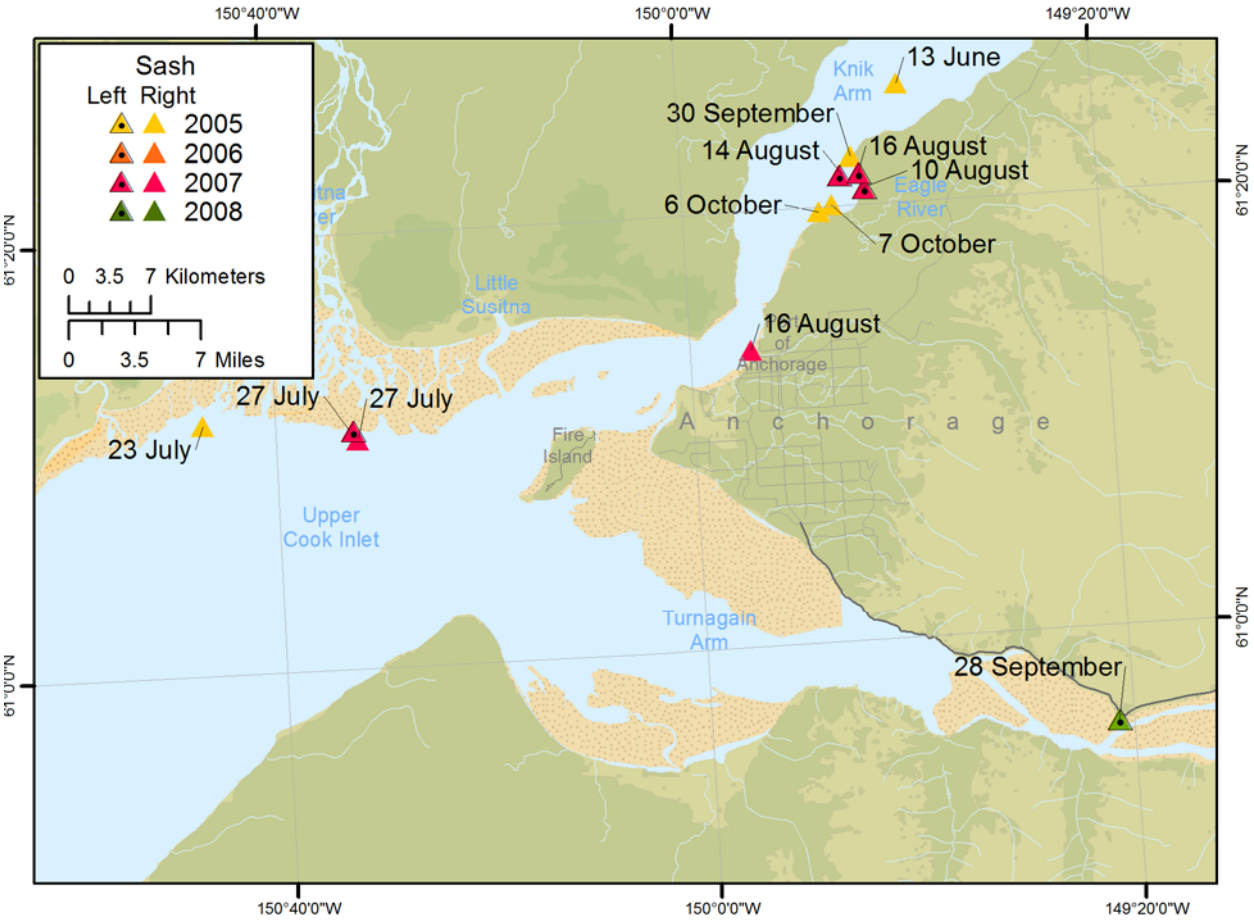

Figure 25. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Sash'.

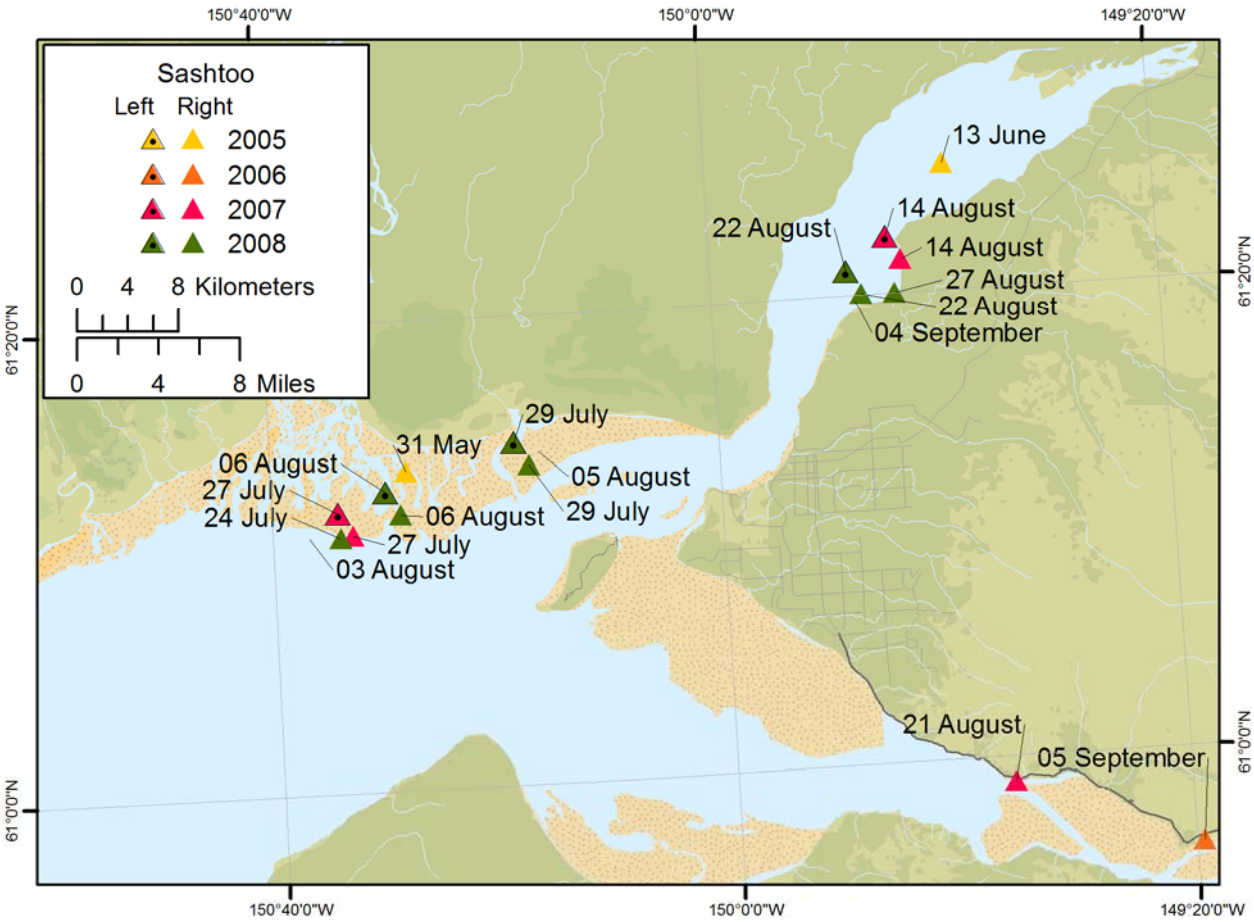

Figure 26. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Sashtoo'. This beluga is a presumed mother based on photographs with an accompanying calf.

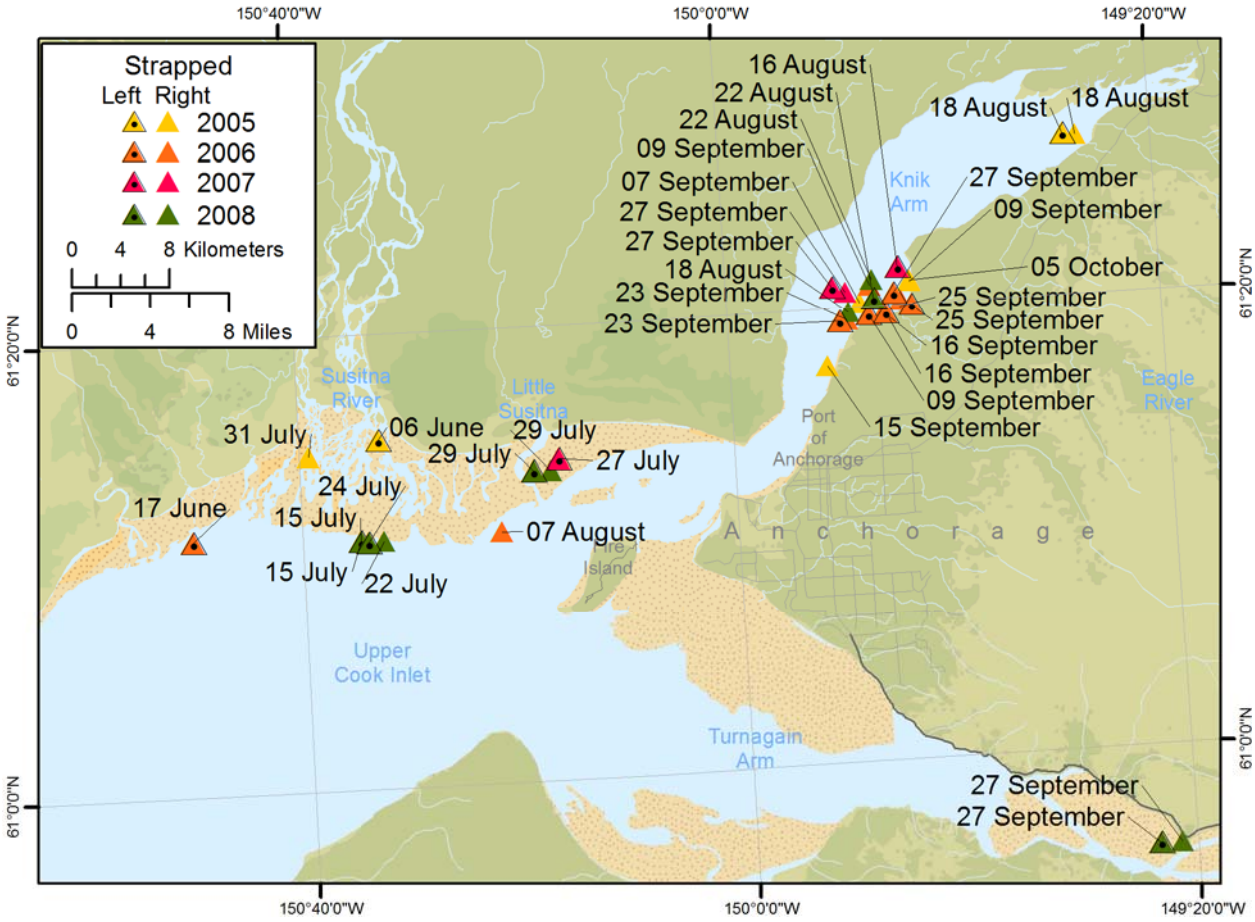

Figure 27. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Strapped'. This beluga was photographed every year from 2005 to 2008 and is a presumed mother based on photographs with an accompanying calf.

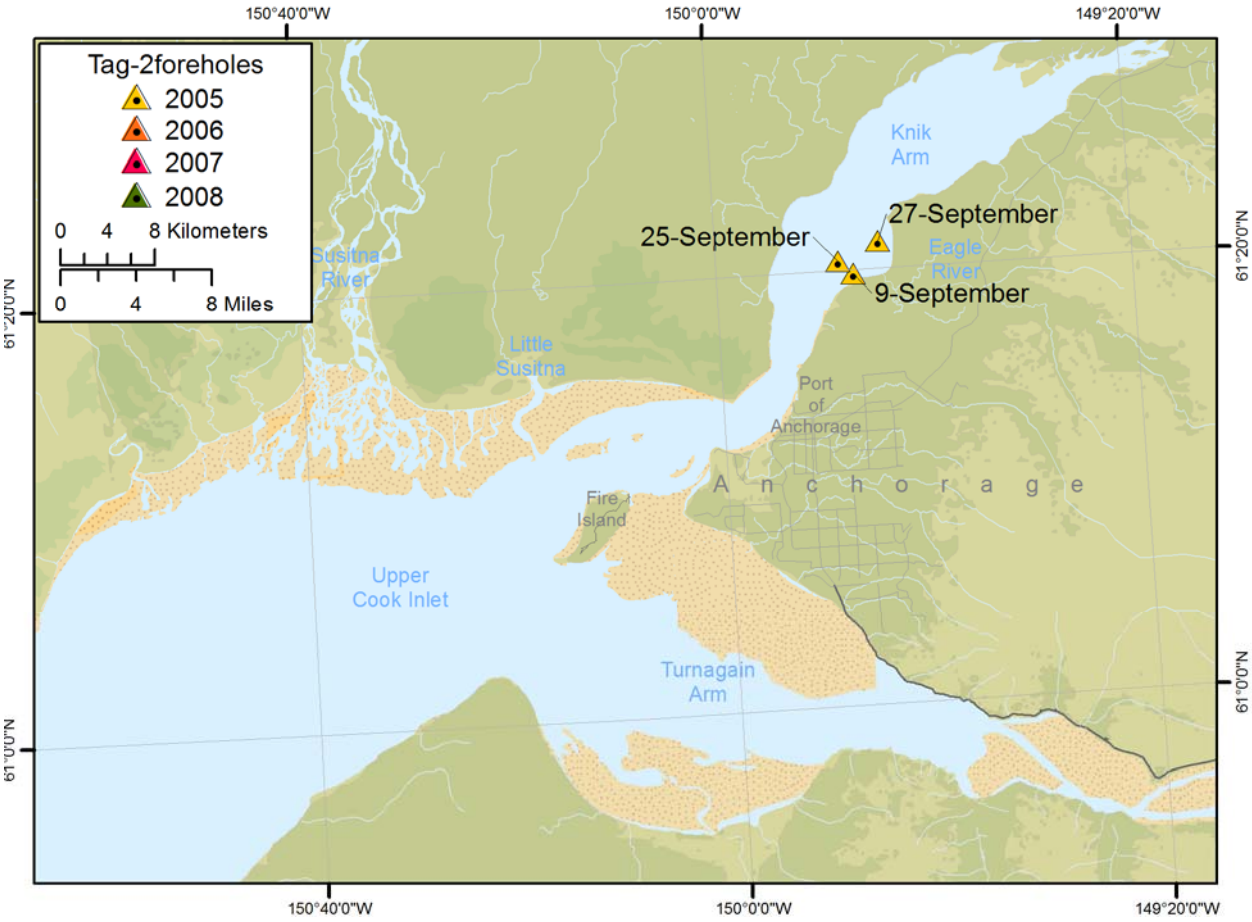

Figure 28. Sighting history and photograph of beluga 'Tag-2foreholes'. This beluga is a presumed mother based on photographs with an accompanying calf.

Sighting histories of mothers and their calves

Fifty-eight identified belugas were presumed to be reproductive adult females; this presumption was based on left-side photographs taken of these females from 2005 to 2008 in which they were closely accompanied by calves (Table 7). The position of the calf relative to the presumed mother was either the "neonate position", in which the calf surfaced just above the mother's midline (Figure 29), or the "calf position" alongside the posterior half of the mother (Figure 30). Position descriptions are based on those

described for bottlenose dolphins *Tursiops* sp. by Mann and Smuts (1999), and for belugas by Krasnova et al. (2009).

Fifteen identified belugas were photographed with calves in more than one year (Table 7); fourteen were seen with calves in 2 years, and one identified beluga was seen with a calf in 3 years. Nine identified belugas were seen with calves in consecutive years. Five identified belugas each had a 2-year gap between sightings with calves, and three had a 3-year gap between sightings with calves. Six identified belugas were photographed with maturing calves (i.e., 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; Figure 31). Two identified belugas were each first seen with a larger calf, then 1 or 2 years later, were seen with a much smaller calf (which were assumed to be a new calves; Figure 32).

The majority of calves could not be identified as individuals because they were either not marked or they were never photographed with enough of the body above water to allow marks to be seen. Four calves were individually identified between 2005 and 2008 (Table 8). All of these calves were large (i.e., 2/3 the body length of an adult) and each was photographed with a larger, lighter-colored beluga assumed to be the mother.

Calves and neonates were seen in all areas of Upper Cook Inlet where beluga groups were encountered during photo-identification surveys in 2005-2008 (Figure 33), although groups with neonates were seen more often (after standardizing for unequal survey effort among areas) in Knik Arm than in other areas. Groups with calves and neonates were generally closer to shore than groups without. Details of group compositions of calves and neonates according to area and date are described in McGuire and Kaplan 2009.

Table 7. Yearly sighting records of 58 individual beluga whales presumed to be mothers based on the close accompaniment of a calf at least once during 2005-2008 (C = photographed with a calf, P = photographed without a calf, N = not photographed).

	# of Surveys					
	49	38	23	32	# Years Seen with a Calf	Calf Age Information Inferred from Individuals seen with Calves in >1 year (CBD=Could not be determined)
Whale ID	**2005**	**2006**	**2007**	**2008**		
BandAid	P	P	C	P	1	
Barbwire	N	N	C	P	1	
Basket	N	N	C	P	1	
Belt	C	P	C	C	3	CBD
Brooks	P	C	P	C	2	maturing; 2 years between sightings
Brownridge	N	N	N	C	1	
Caterpillar	P	N	P	C	1	
ChalkLine	P	N	C	P	1	
Check-X	P	P	P	C	1	
Cleaved	C	N	N	C	2	maturing; 3 years between calf sightings
Cloudy	N	N	C	P	1	
Coalridge	N	N	N	C	1	
Crossroad	C	C	N	P	2	CBD
Dent	N	C	N	P	1	
Dhole	P	C	N	P	1	
Ducky	P	C	N	C	2	new calf in 2008; 2 years between calf sightings
Ell	N	C	N	P	1	
Elseven	P	P	N	C	1	
Ess	P	N	N	C	1	
Fence	P	P	N	C	1	
F-Hook	C	P	P	P	1	
Firetail	P	C	P	C	2	maturing; 2 years between calf sightings
Fisheye	C	C	N	N	2	CBD
ForecurveminiTaftblack	N	C	N	N	1	
Hole	P	C	N	P	1	
Humperdink	P	N	N	C	1	
Itchy	C	N	N	C	2	CBD
Jewelry	N	P	C	N	1	
Jughead	P	C	N	N	1	
Kaspian	C	N	N	P	1	
Kwood	C	N	N	N	1	
Lucky7	P	N	C	N	1	
Notch-Huge	N	P	N	C	1	
NotWhiskersLeft	N	N	N	C	1	
Parallel	P	C	N	N	1	
Peek	C	C	N	N	2	maturing; 1 year between calf sightings
Pocker	C	C	N	N	2	CBD
Polkadot	P	C	P	P	1	
RacinStripes	N	C	P	C	2	maturing; 2 years between sightings
Rainbow	N	P	N	C	1	
Ridscuff	C	P	P	P	1	
Roark	P	C	N	N	1	
Rubicon	P	C	N	P	1	
Rumpscratch1	N	C	N	N	1	
RumpX	N	C	N	P	1	
Scratchy	P	N	C	P	1	
Semicolon	P	N	N	C	1	
Smiley	N	N	P	C	1	
Spot	C	C	N	P	2	CBD
SubtleT	N	C	N	N	1	
Tag-2foreholes	N	C	N	N	1	
Tbone	C	N	N	N	1	
Togiak	P	P	C	C	2	maturing; 1 year between calf sightings
TripleTrack	N	P	N	C	1	
TwoLane	C	N	P	P	1	
Vee	P	C	N	P	1	
Vgrin-aka-Whiskers	C	C	P	N	2	new calf in 2006; 1year between calf sightings
Wrapper	C	C	N	N	2	CBD

Figure 29. Example of a calf swimming alongside the front half of the presumed mother, in the "neonate" position. Image is of the right side of both whales.

Figure 30. Example of a calf swimming alongside the rear half of the presumed mother, in the "calf position". Image is of the left side of both whales.

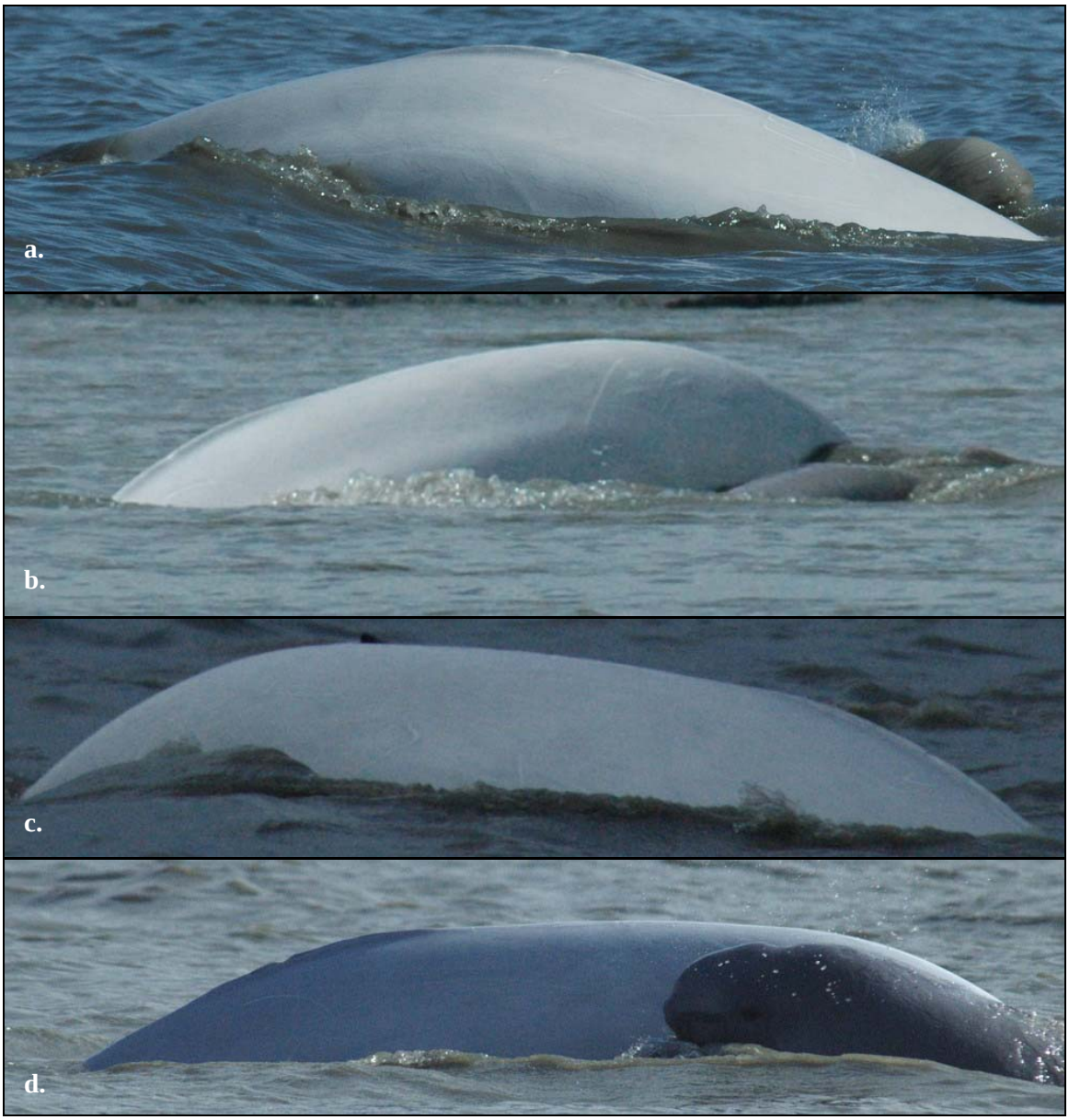

Figure 31. Adult beluga 'Togiak' accompanied by a calf in 2007 (a, b) and 2008 (c, d). Left-side images (b, d) indicate the calf is maturing (i.e., larger with each year); right side images (a, c) do not show enough of the calf to detect changes in size.

Figure 32. Adult beluga 'F-Hook' accompanied by a calf in 2005 (a, left side), in 2006 (b, right side), and by a smaller younger calf in 2008 (c, right side).

Table 8. Yearly sighting records of seven individual beluga whales assumed to be calves based on the close proximity of a larger, whiter beluga at least once during 2005-2008. (N = calf not photographed, C = calf photographed).

	# of Surveys						
	49	38	23	32		# Years	
Whale ID	**2005**	**2006**	**2007**	**2008**	**2009**	**Calf Seen**	**Size Estimates**
Bird-formerlywhitecleanscalf	N	N	C	N	N	1	Large calf (=2/3 length associated adult)
BleachEyes	C	N	N	C	N	2	Large calf (=2/3 length associated adult)
Cake	C	C	N	N	N	2	Large calf (=2/3 length associated adult)
Pockscratch	N	C	N	N	N	1	Large calf (=2/3 length associated adult)

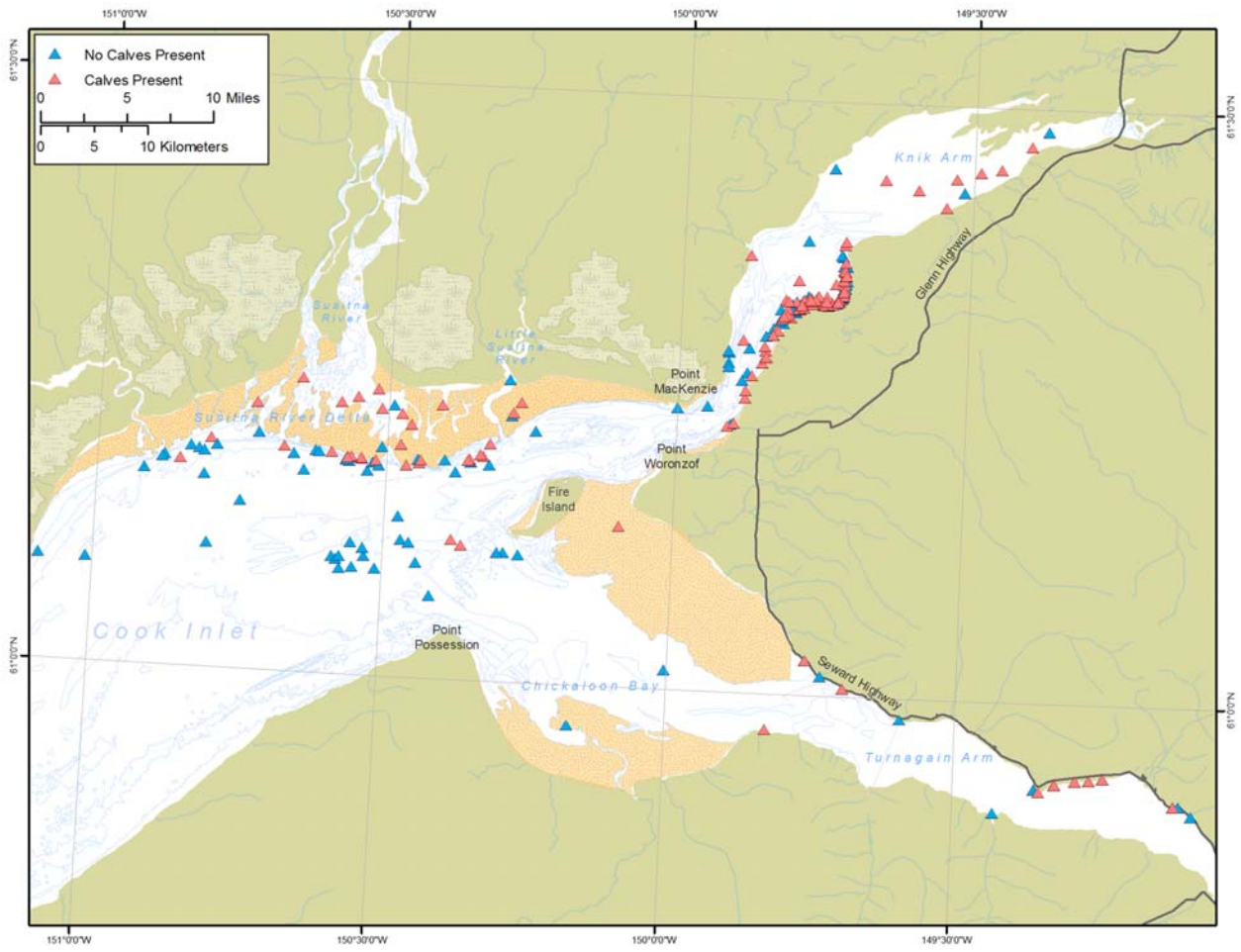

Figure 33. Locations of groups with and without calves (i.e., calves and neonates) encountered during boat- and land-based photo-identification surveys of Upper Cook Inlet, Alaska, 2005-2008.

Sighting histories of belugas identified on both right and left sides

Twenty whales identified as individuals in the 2005-2008 left-side catalog were also identified as individuals in the 2005-2008 right-side catalog (McGuire et al. 2009; Table 9). Combing data from the right- and left-side catalogs for the 20 "dual" side whales provided additional information about sighting histories, including sighting years, records of mothers and calves, and known ranges of individuals.

Eight dual-side whales gained additional years of sighting records from the addition of left-side photographs (Table 9). For example, the whale named "Drops" had sighting records from 2005 and 2008 in the right-side catalog, but was photographed on the left side in 2005, 2006, 2007, 2008, which added two additional years (2006 and 2007) to its sighting history.

Fifteen of the dual-side whales were presumed to be mothers, based on the close accompaniment by calves (Table 10). Seven of these whales were identified as mothers from only right-side photos, and five were identified as mothers from both left and right-side photos. Three dual-side whales were identified as mothers because of the addition of left-side photographs to their sighting histories.

Ten dual-side whales had areas added to their known range with addition of left-side photographs to their sighting histories. For example, right-side records for the beluga 'RacinStripes' showed a range of the Susitna River Delta; the addition of left-side photographed expanded the range to Knik Arm (Table 9; Figure 34). Eight whales had their ranges expanded to include Turnagain Arm (Figure 35; Table 9) with the inclusion of left-side photographs to their sighting histories; all of these whales seen in Turnagain Arm were also seen in both the Susitna River Delta and in Knik Arm).

Within areas, there were differences between right-and left-side sightings (Figure 35). Within Knik Arm, left-side images were most likely to be taken in Eagle Bay than elsewhere within the Arm, while right-side images were taken the length of Knik Arm. Within the Susitna River Delta, left side images were more likely to be taken west of the Susitna River, while right-side images were more likely to be taken between the Susitna and Little Susitna rivers.

All twenty of the dual-side whales were seen in both the Susitna River Delta and in Knik Arm (Table 9). All dual-side whales seen in Turnagain Arm (*n*=9) were also seen in both the Susitna River Delta and Knik Arm. Individual sighting histories and photographs of these dual-side whales are presented in figures 34 and 36-54.

Table 9. Sighting records per year of 20 individual belugas that were identified and cataloged for both right and left-sides from 2005 to 2008 according to year and location. (L = photographed on left side, R = photographed on right side).

	Susitna River Delta				Knik Arm				Turnagain Arm				Chickaloon Bay/ SE Fire Island			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
	# of Surveys				# of Surveys				# of Surveys				# of Surveys			
Left Whale ID	**17**	**21**	**4**	**8**	**32**	**15**	**10**	**12**	**1**	**6**	**8**	**12**	**0**	**1**	**1**	**2**
Basket			L	R			L	L								
Belt	L	L, R	L		L, R	R	L	L			L					
BigCleft			R	L, R	L, R	L, R										
Caterpillar	L, R		R	L	L, R		L	L, R								
Drops		L	L	L, R	L, R	L	L	R				L				
F-Hook	L, R			L	L, R	L, R	L	L, R				L				
Hillbilly	L, R			R	L, R			L, R								
Humperdink	L		R	L, R	L, R											
JabbaTheHut		L, R	L, R	L, R			R	R		L						
Kenai	L, R	L, R	L	L, R	L, R	L, R	L, R	L, R								
RacinStripes			L	L, R		L		L								
Ridscuff			L, R	L, R	L, R	L, R	L, R									
Sash	R		L, R		R		L, R					L				
Sashtoo	R		L, R	L, R	R		L, R	L, R		R	R					
Strapped	L, R	L, R	L	L, R	L, R	L, R	L, R	L, R				L, R				
Tailring		R		L	L, R		R	L, R								L
Togiak			L, R	L, R	L, R			L		L						
Treasure	L	R	R	L, R	L, R	L, R		L, R				L				
Tudor	R			L	L, R		L, R									
Twofer				L	R		L, R	L								

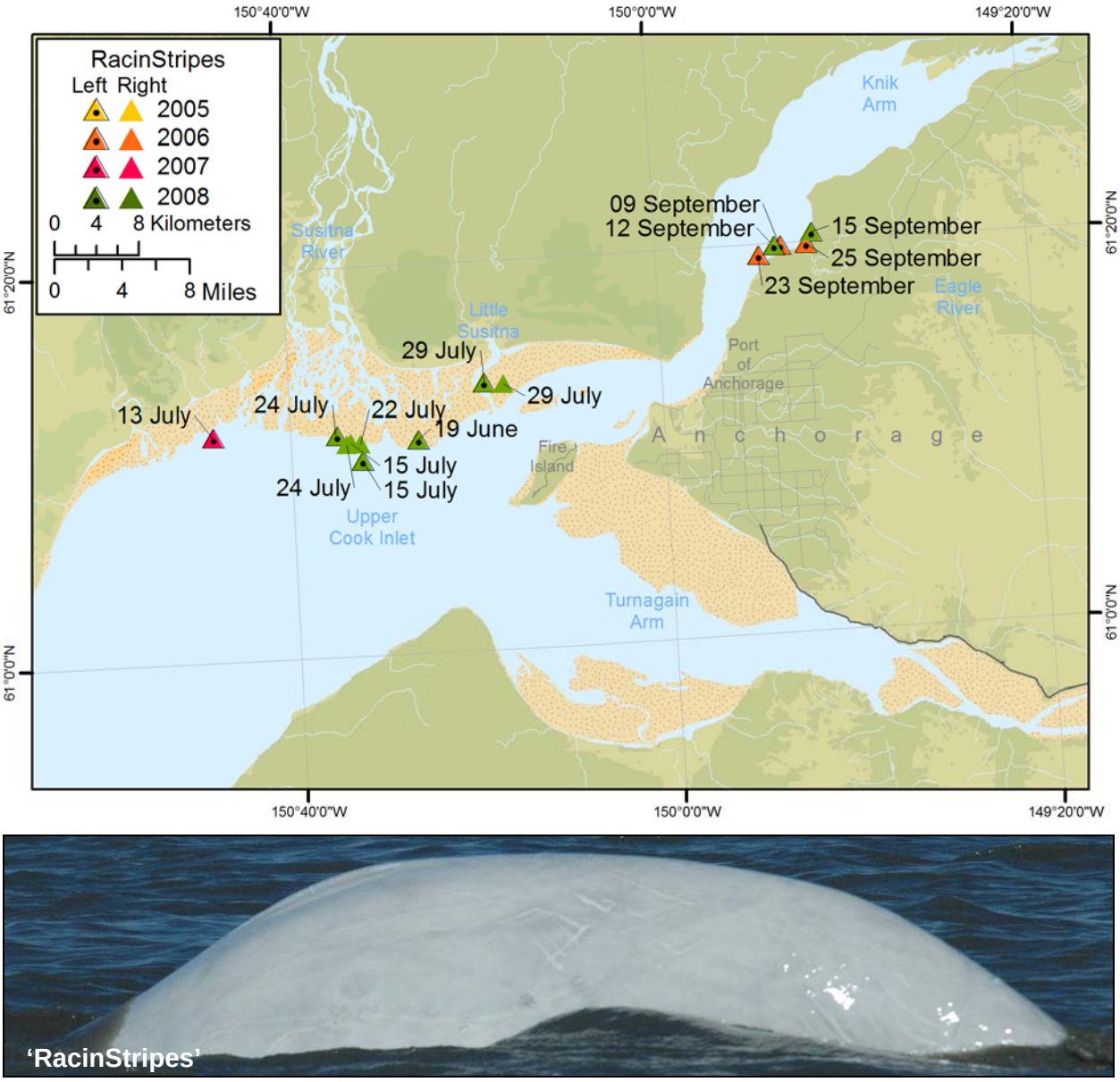

Figure 34. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'RacinStripes'. This beluga is a presumed mother based on photographs with an accompanying calf.

Table 10. Yearly sighting records of 15 "dual-side" individual beluga whales presumed to be mothers based on the close accompaniment of a calf at least once during 2005-2008. (C = photographed with a calf, P = photographed without a calf, R = photographed on the right side, L = photographed on the left side).

Whale ID	2005	2006	2007	2008	# Years Seen with a Calf	Side Identified as a Mother
Basket			LC	LP, RP	1	Left
Belt	LC ,RP	LP	LC, RC	LC, RC	3	Both
BigCleft	RC, LP	RC, LP	RC	RC, LP	4	Right
Caterpillar	LP, RP		LP, RP	LC, RP	1	Left
Drops	RP, LP	LP	LP	RC, LP	1	Right
F-Hook	LC, RP	LP, RC	LP	RC, LP	3	Both
Humperdink	LP, RP		RP	LC, RP	1	Left
Kenai	RP, LP	RC, LP	RP, LP	RC, LP	2	Right
RacinStripes		LC	LP	LC, RC	2	Both
Ridscuff	LC, RC	LP, RC	LP, RP	LP, RC	3	Both
Sashtoo	RP	RP	RP, LP	RC, LP	1	Right
Strapped	RP, LP	RP, LP	RC, LP	RC, LP	2	Right
Tailring	RC	RP	RP	RP, LP	1	Right
Togiak	LP, RP	LP	LC, RC	LC, RC	2	Both
Treasure	RC, LP	RC, LP	RP	RP, LP	2	Right

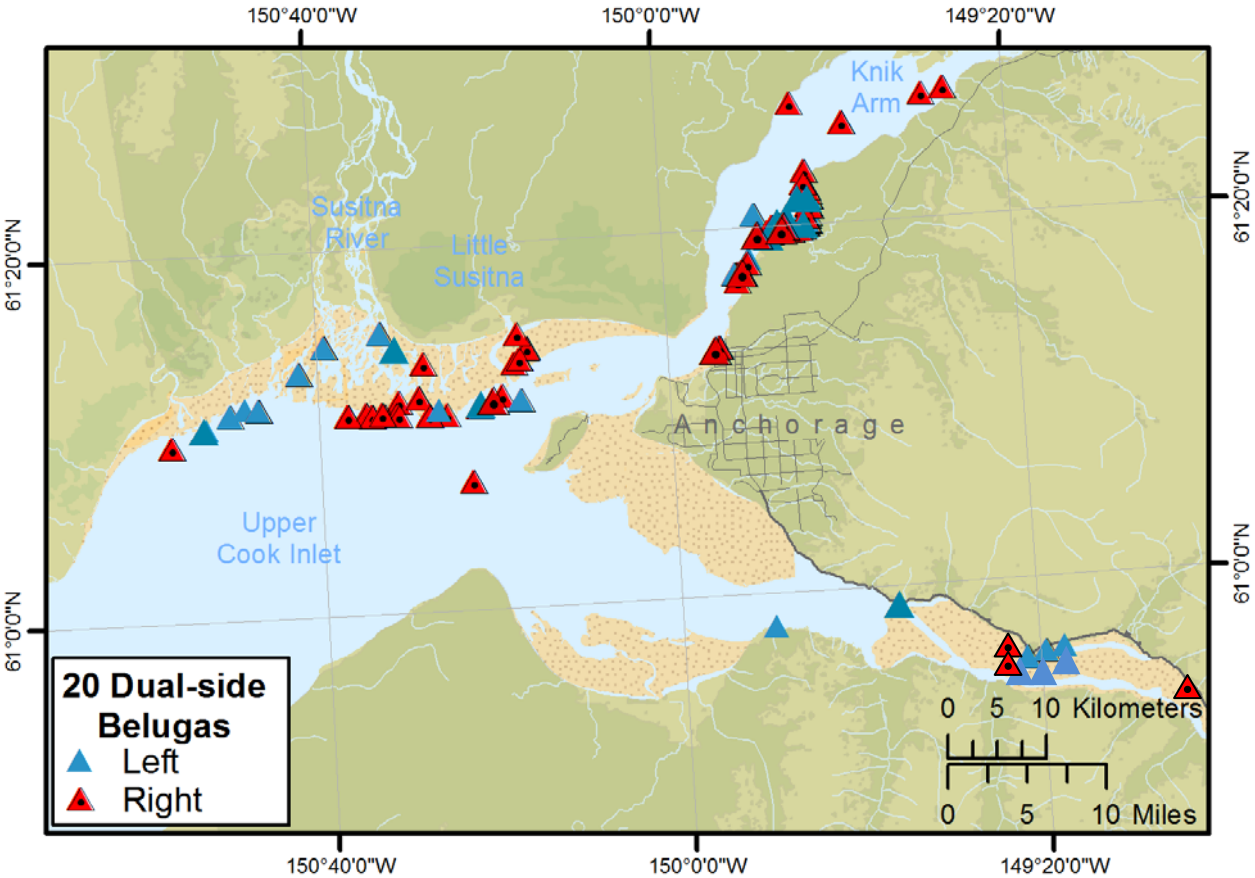

Figure 35. Locations of 20 belugas identified from both their right and left sides during photo-identification surveys in Upper Cook Inlet, Alaska, 2005-2008.

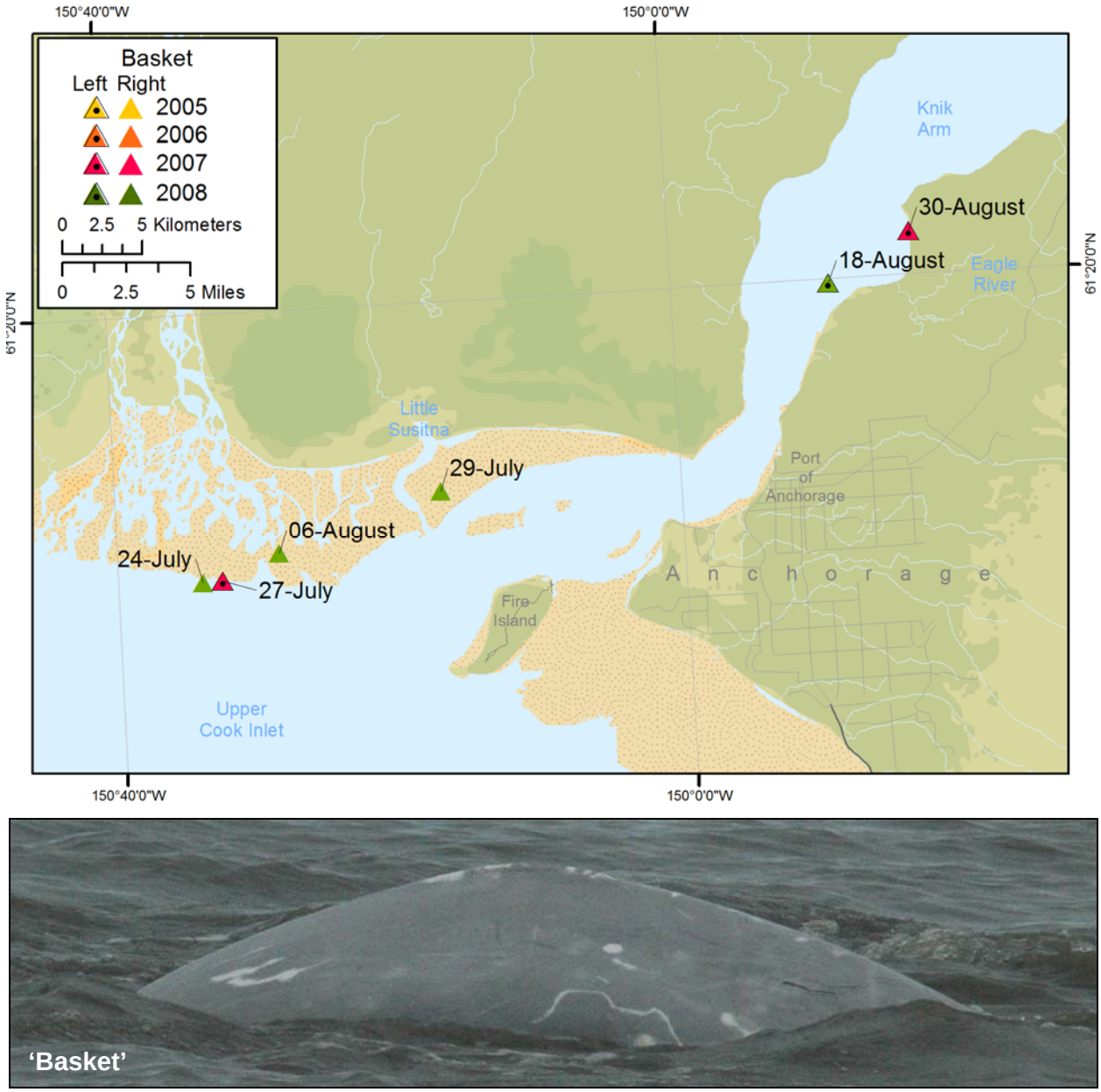

Figure 36. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Basket'. This beluga is a presumed mother based on photographs with an accompanying calf.

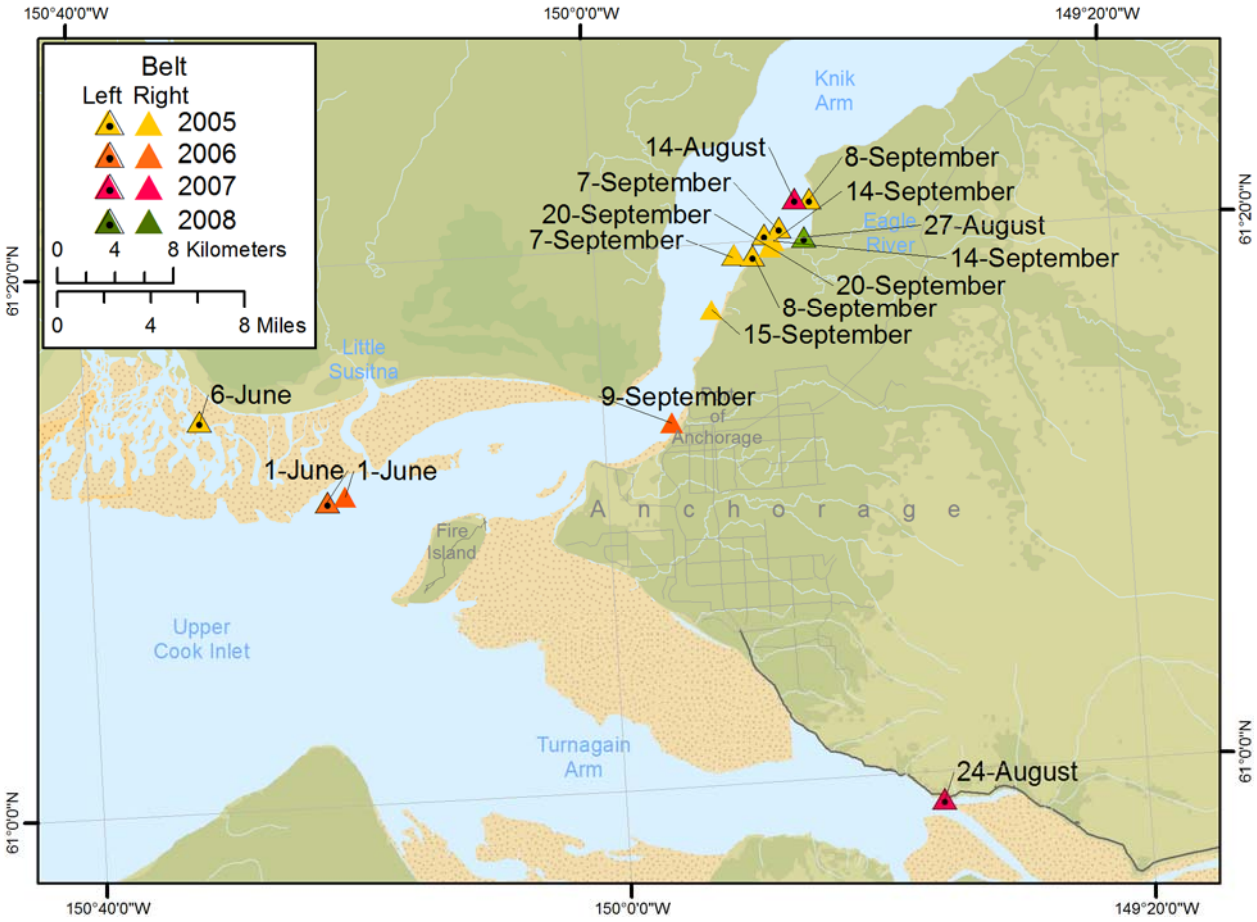

Figure 37. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Belt'. This beluga was photographed every year from 2005 to 2008 and is a presumed mother based on photographs with an accompanying calf.

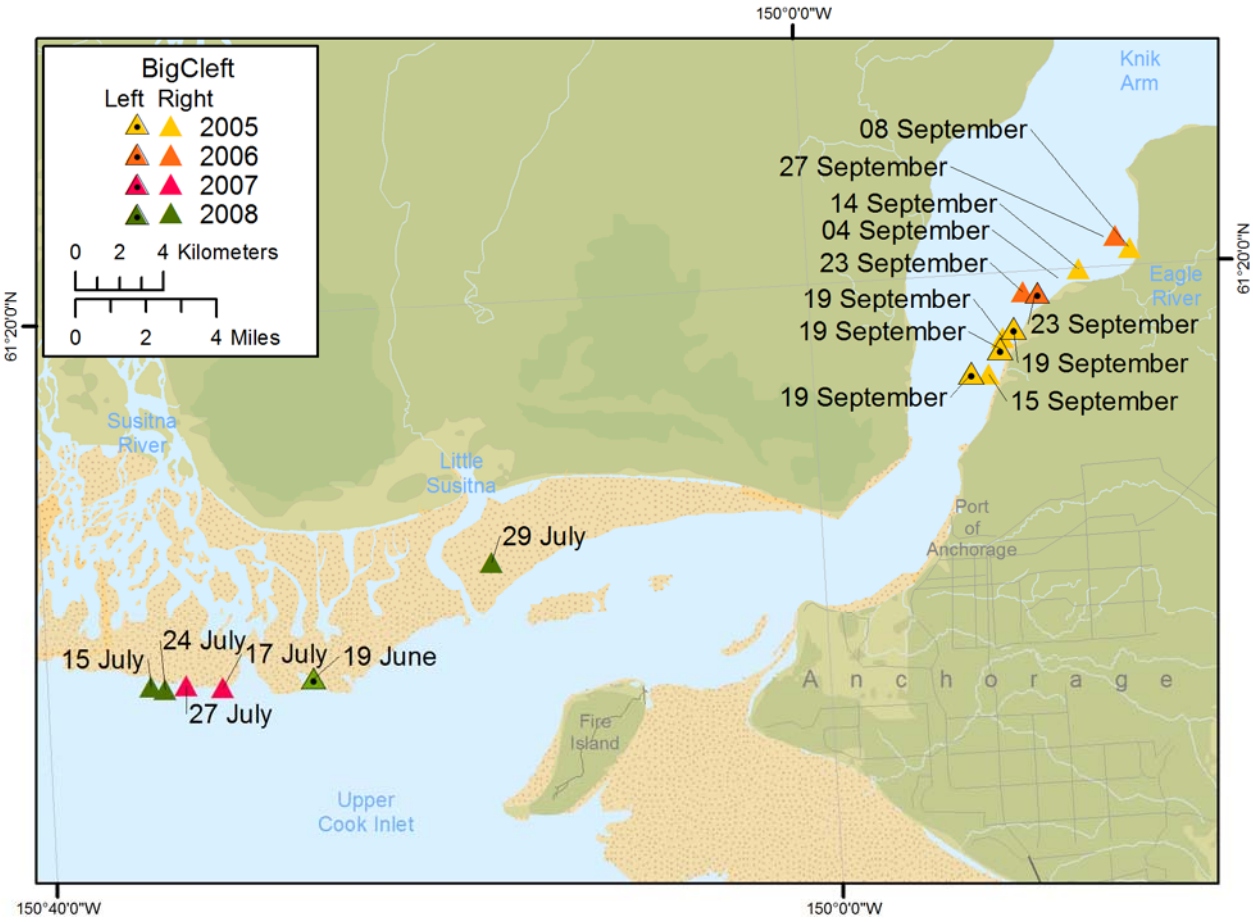

Figure 38. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'BigCleft'. This beluga is a presumed mother based on photographs with an accompanying calf.

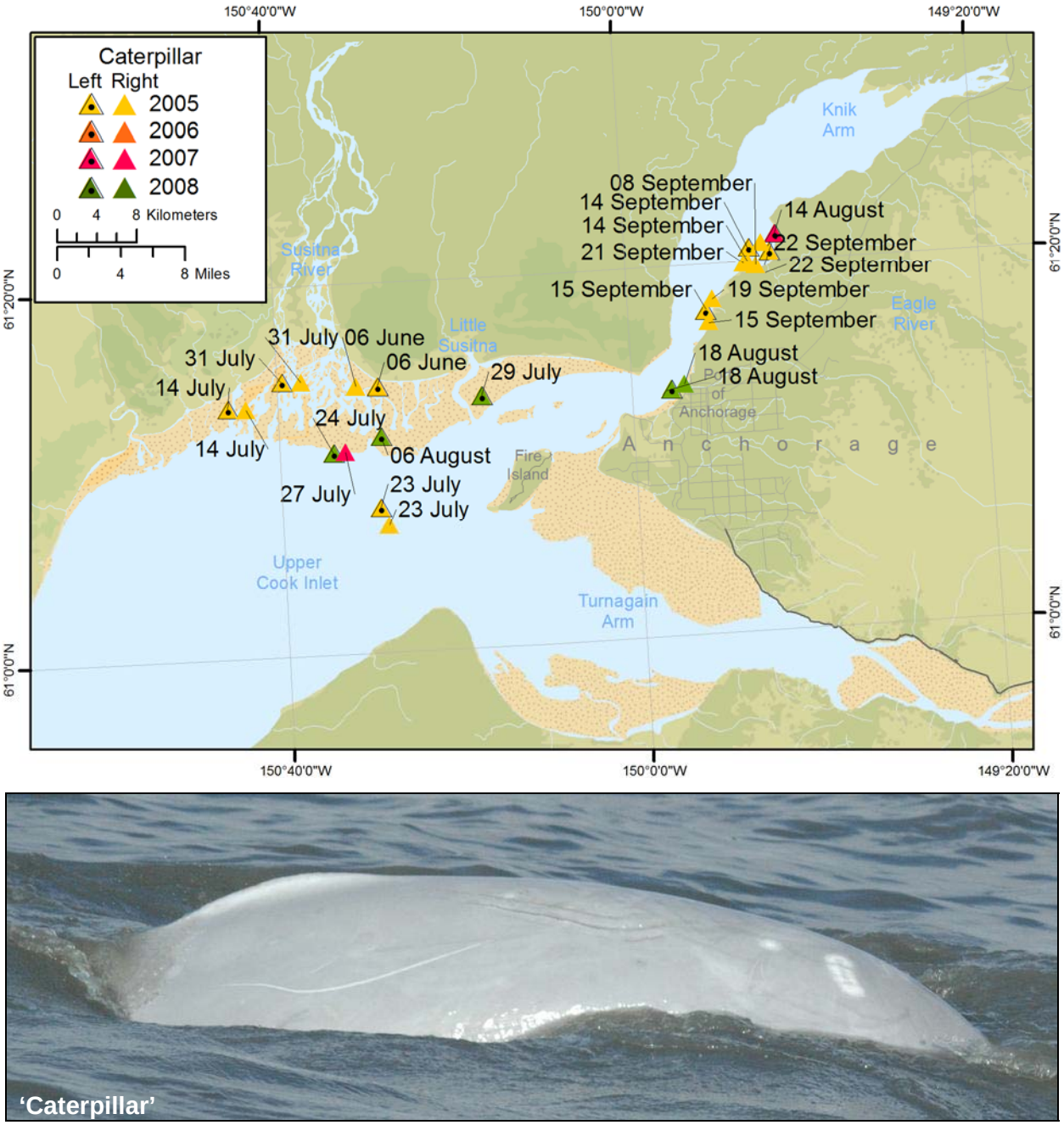

Figure 39. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Caterpillar'. This beluga is a presumed mother based on photographs with an accompanying calf.

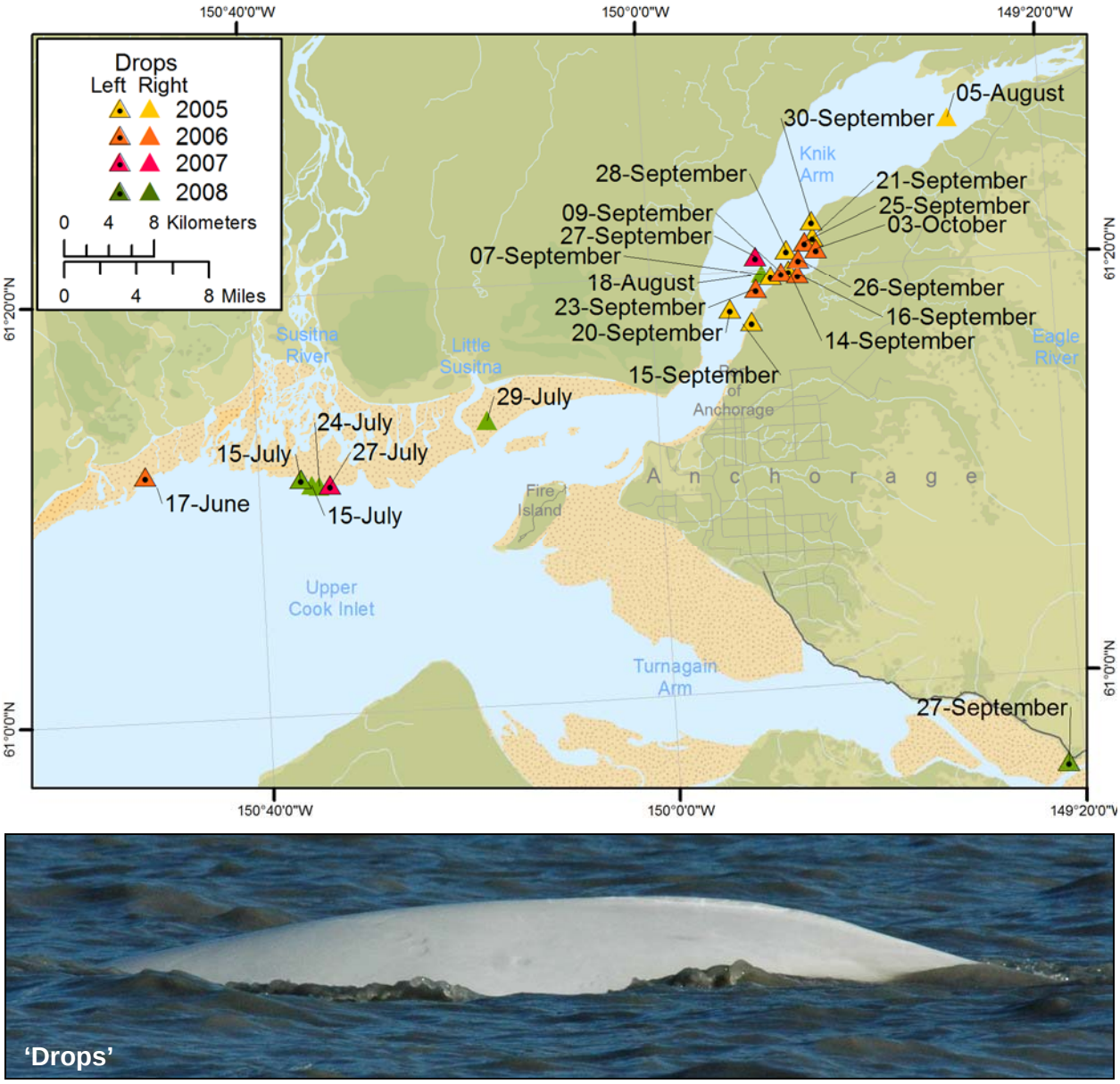

Figure 40. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Drops'. This beluga was photographed every year from 2005 to 2008 and is a presumed mother based on photographs with an accompanying calf.

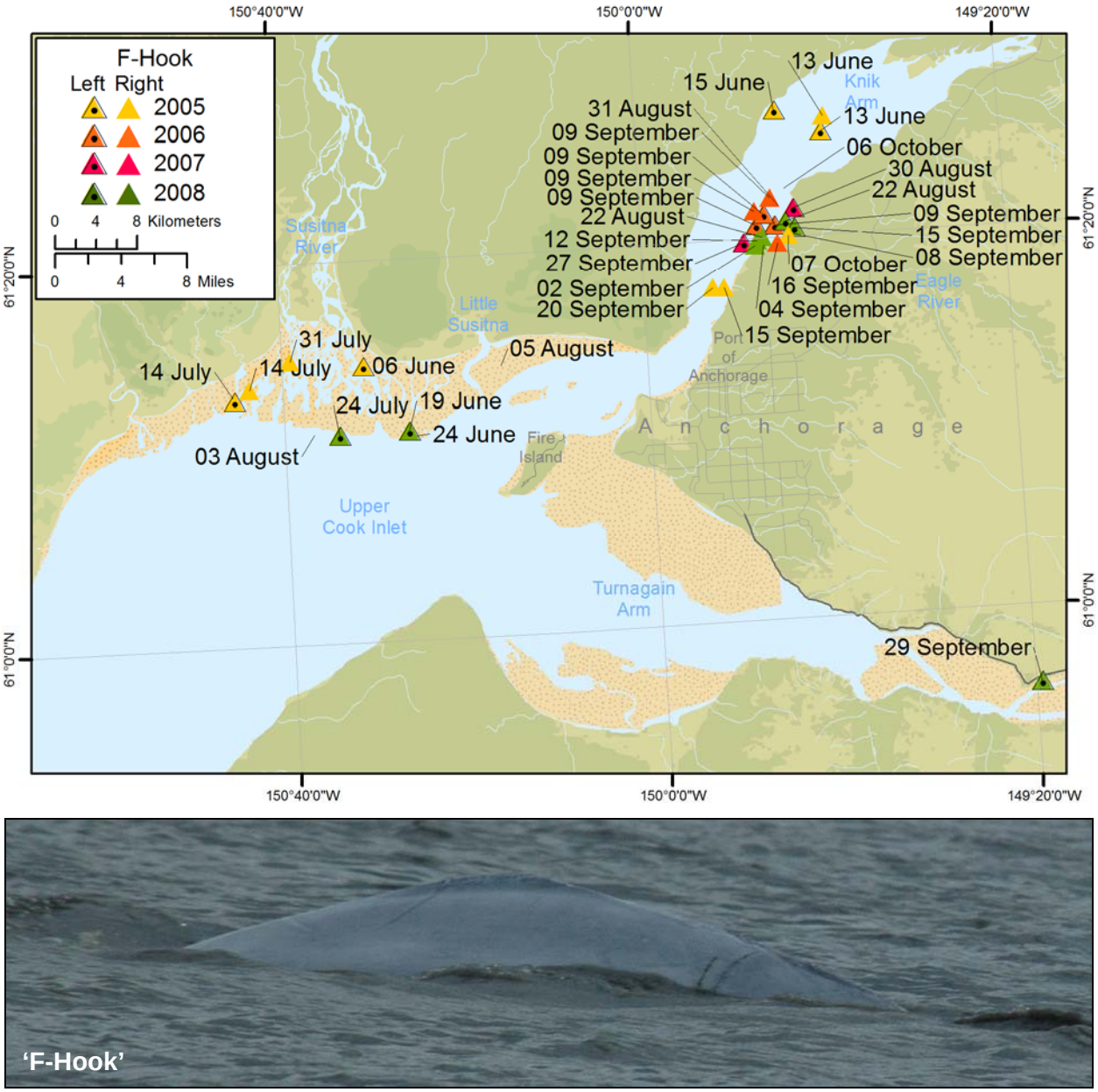

Figure 41. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'F-Hook'. This beluga was photographed every year from 2005 to 2008 and is a presumed mother based on photographs with an accompanying calf.

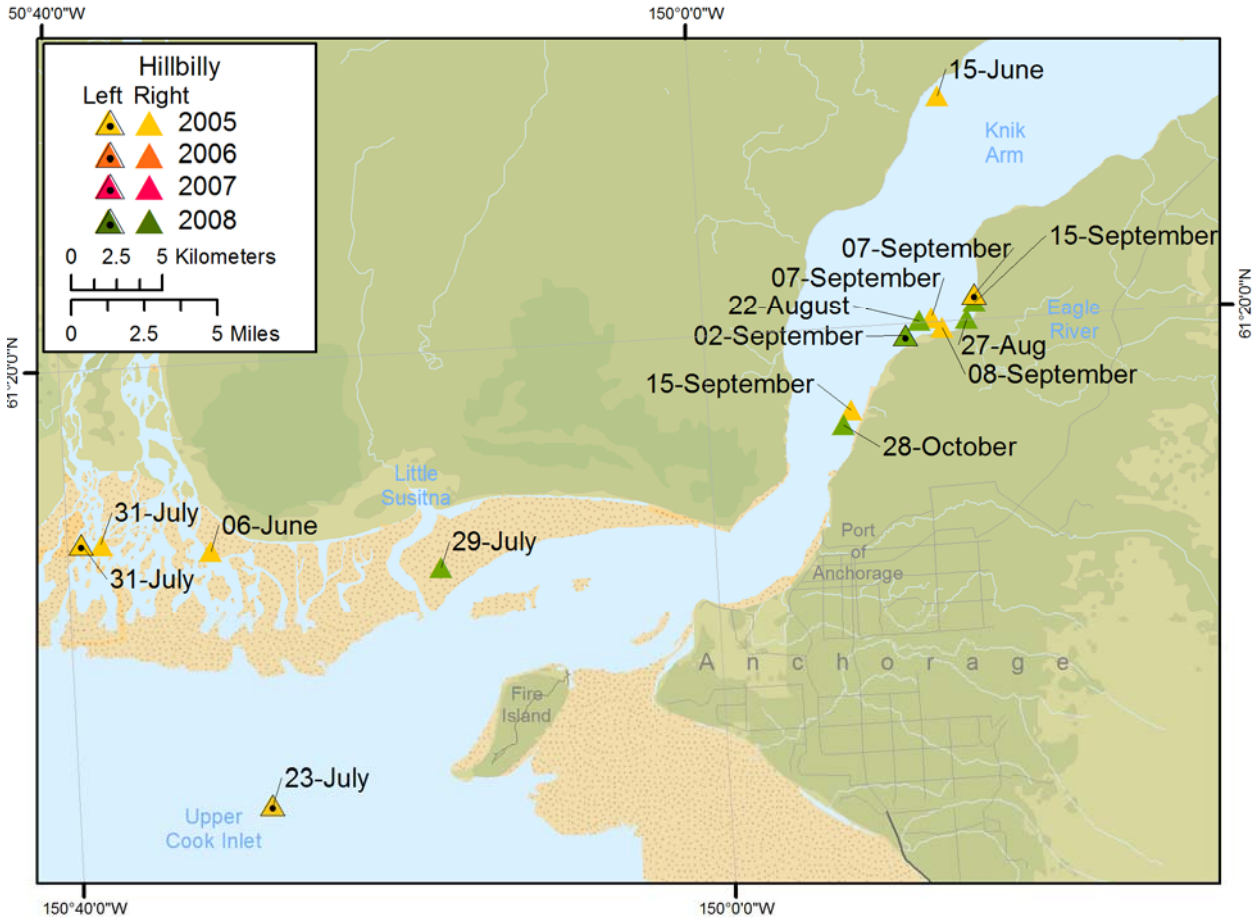

Figure 42. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Hillbilly'.

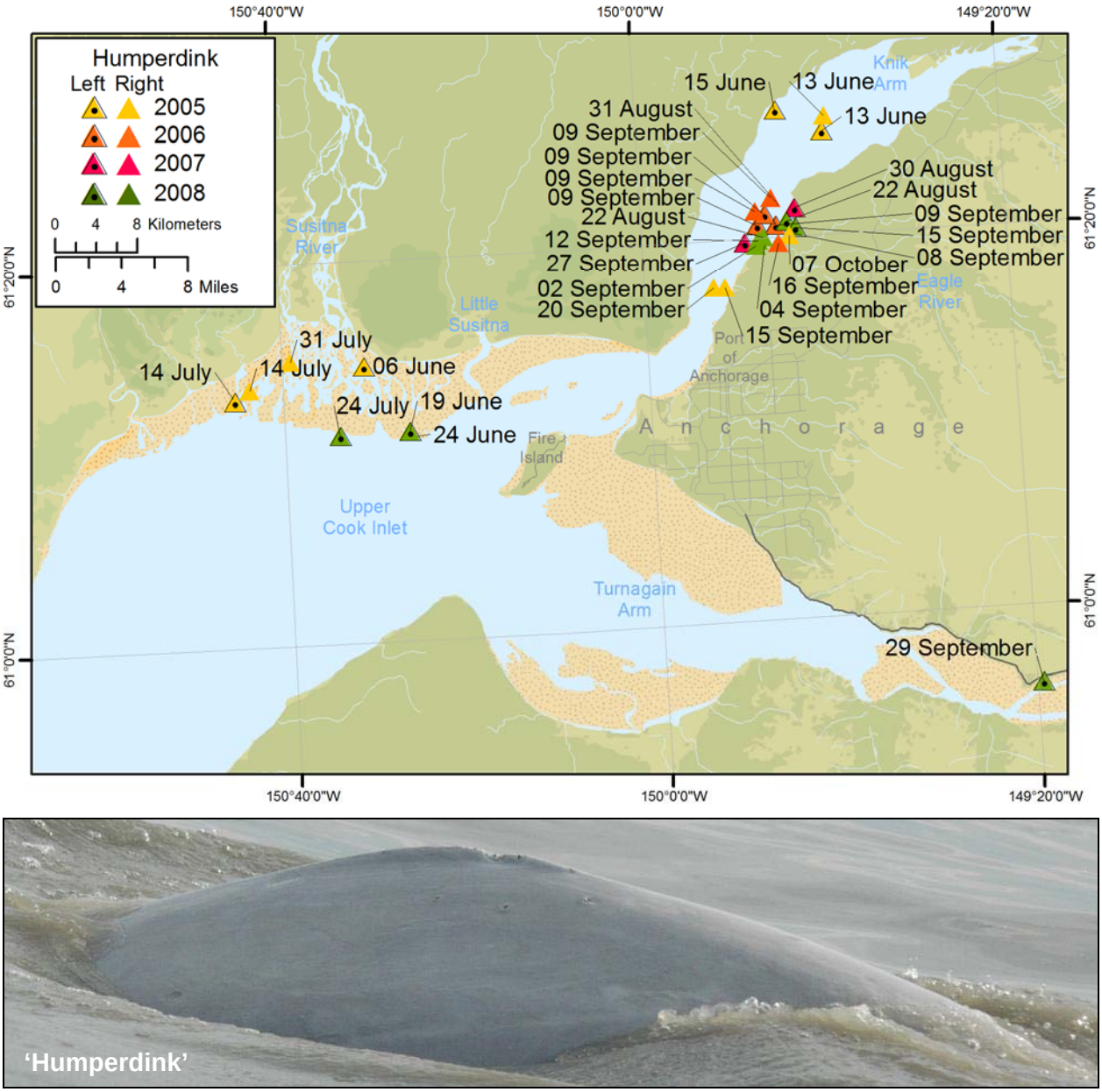

Figure 43. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Humperdink'. This beluga is a presumed mother based on photographs with an accompanying calf. This beluga was tagged by NMFS in 2002.

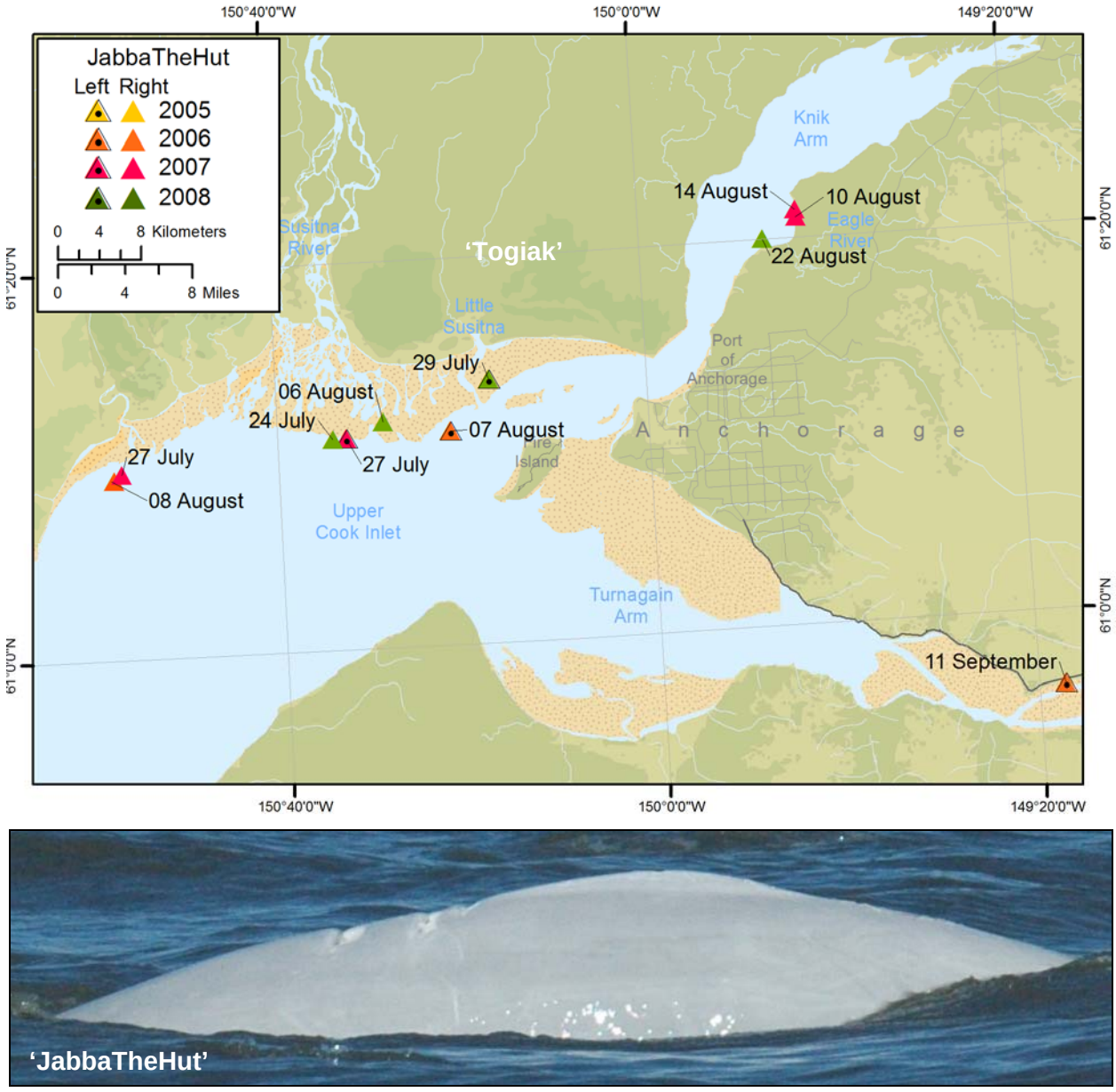

Figure 44. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'JabbaTheHut'. This beluga was tagged by NMFS sometime between 1999 and 2002.

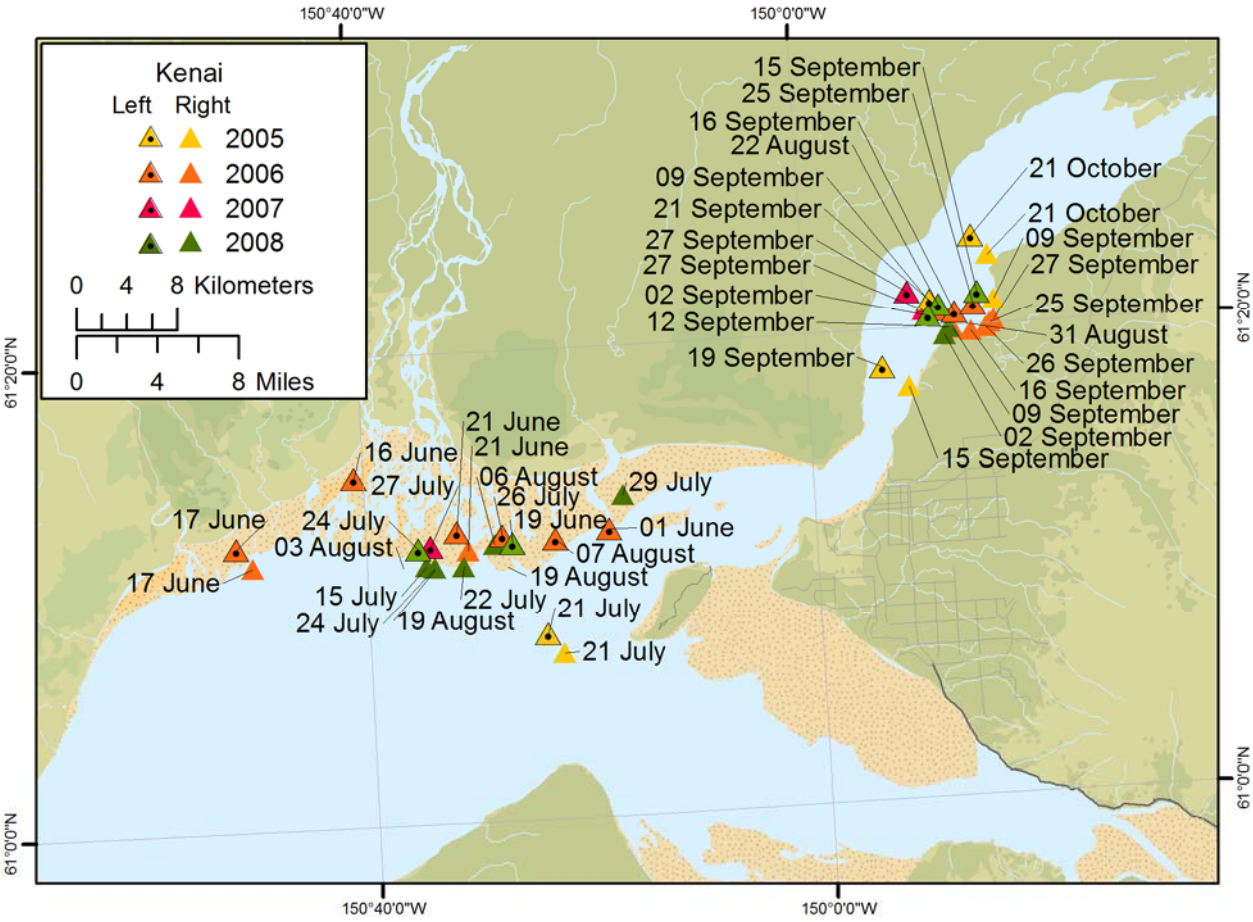

Figure 45. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Kenai'. This beluga was photographed every year from 2005 to 2008 and is a presumed mother based on photographs with an accompanying calf.

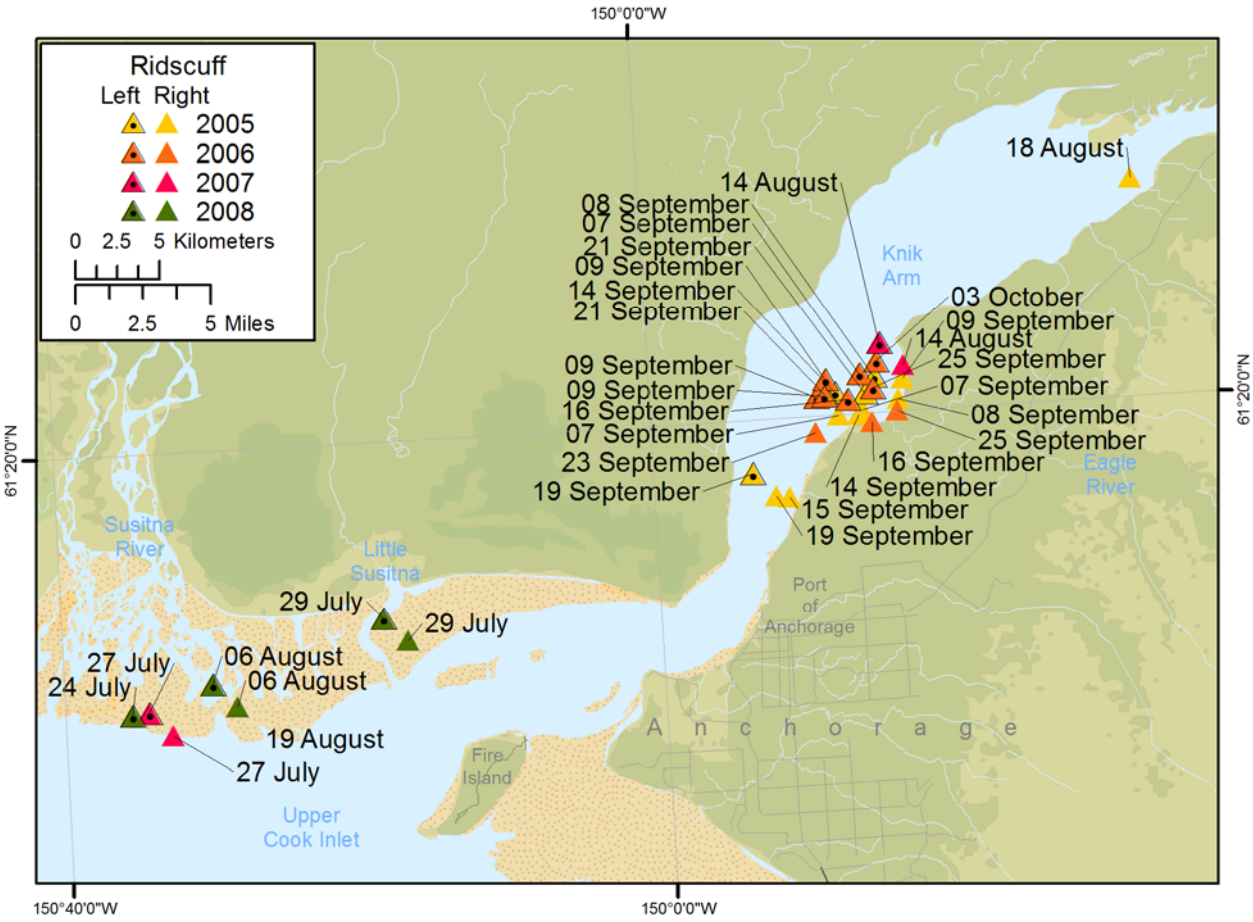

Figure 46. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Ridscuff'. This beluga was photographed every year from 2005 to 2008 and is a presumed mother based on photographs with an accompanying calf.

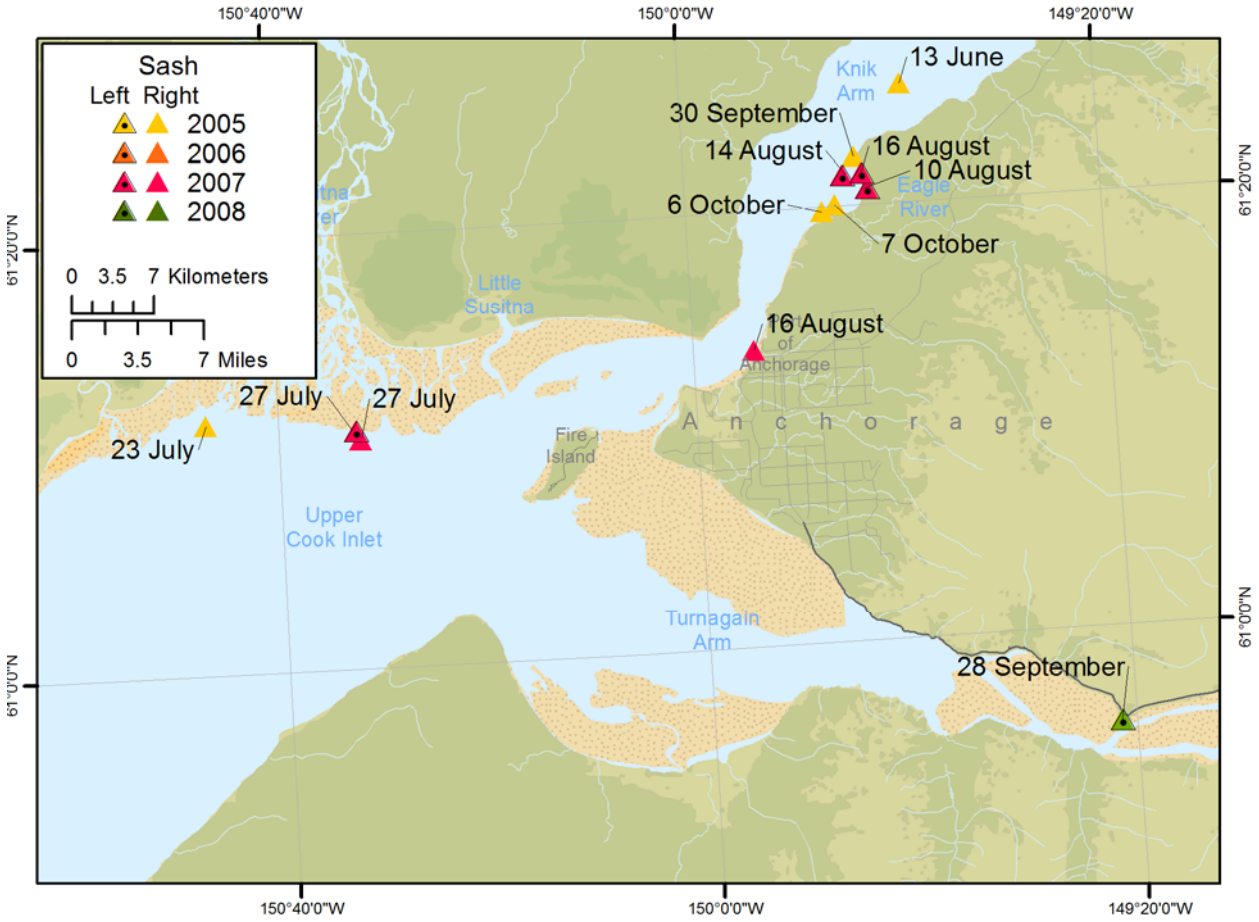

Figure 47. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Sash'. This beluga was tagged by NMFS sometime between 1999 and 2002.

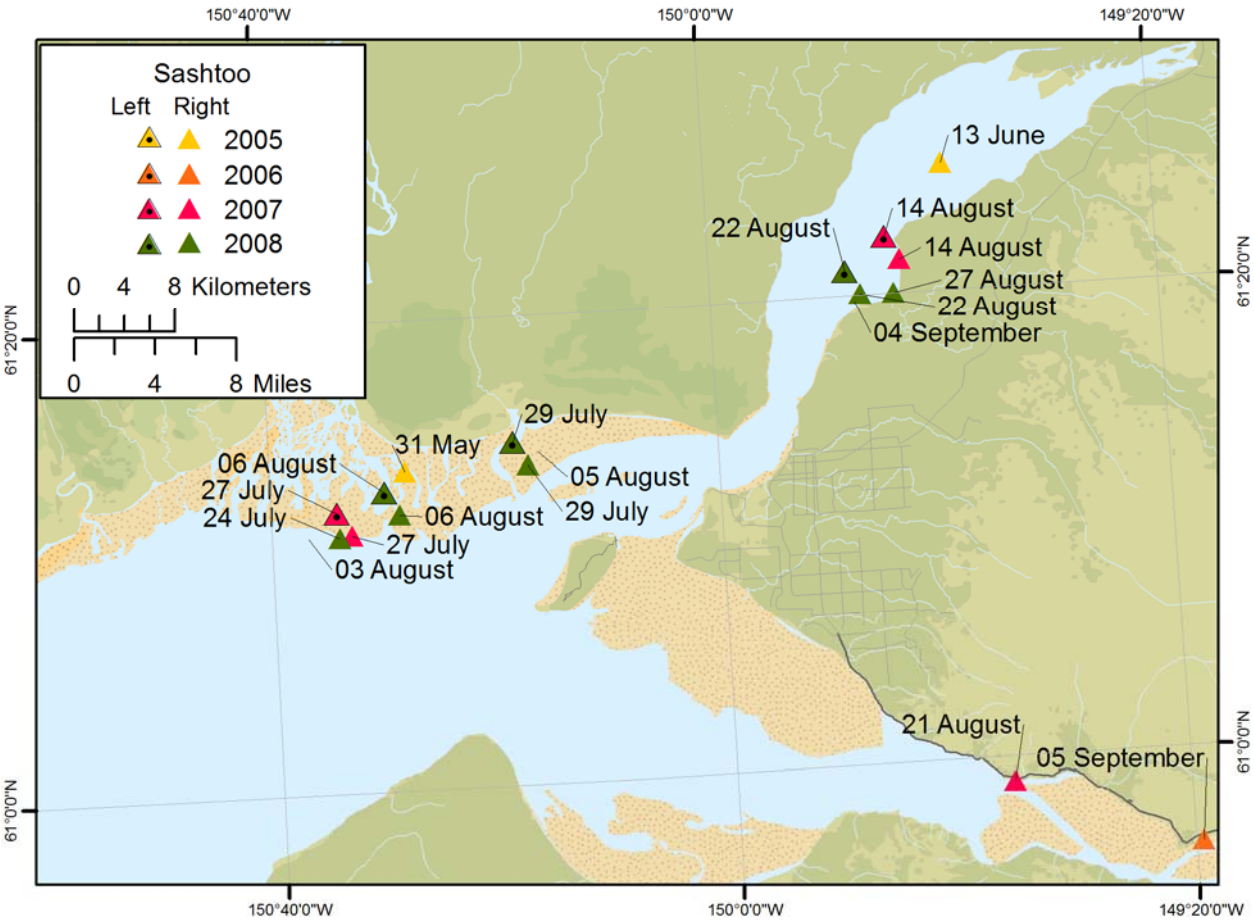

Figure 48. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Sashtoo'. This beluga was tagged by NMFS sometime between 1999 and 2002 and is a presumed mother based on photographs with an accompanying calf.

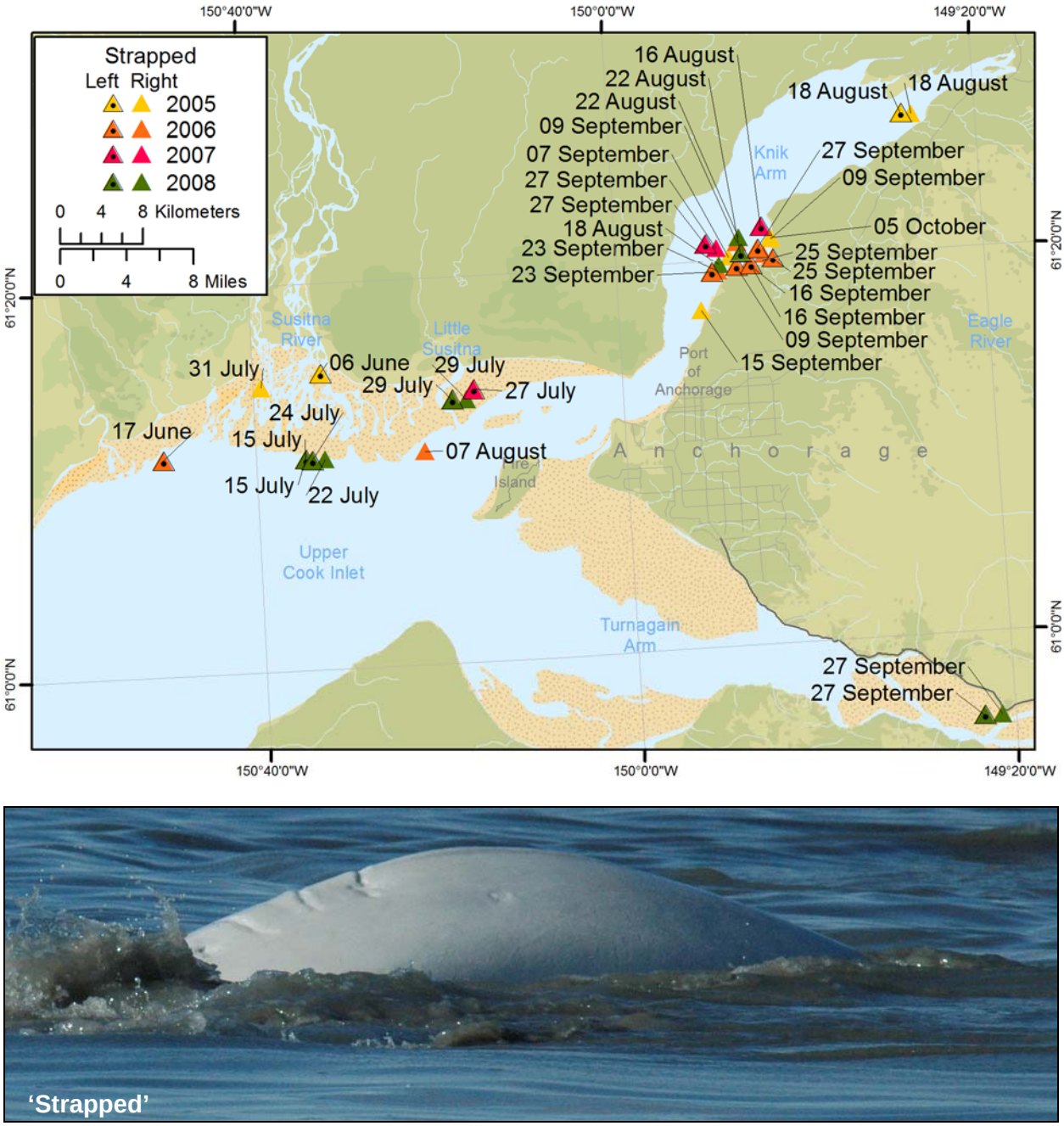

Figure 49. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Strapped'. This beluga was photographed every year from 2005 to 2008, was tagged by NMFS sometime between 1999 and 2002 and is a presumed mother based on photographs with an accompanying calf.

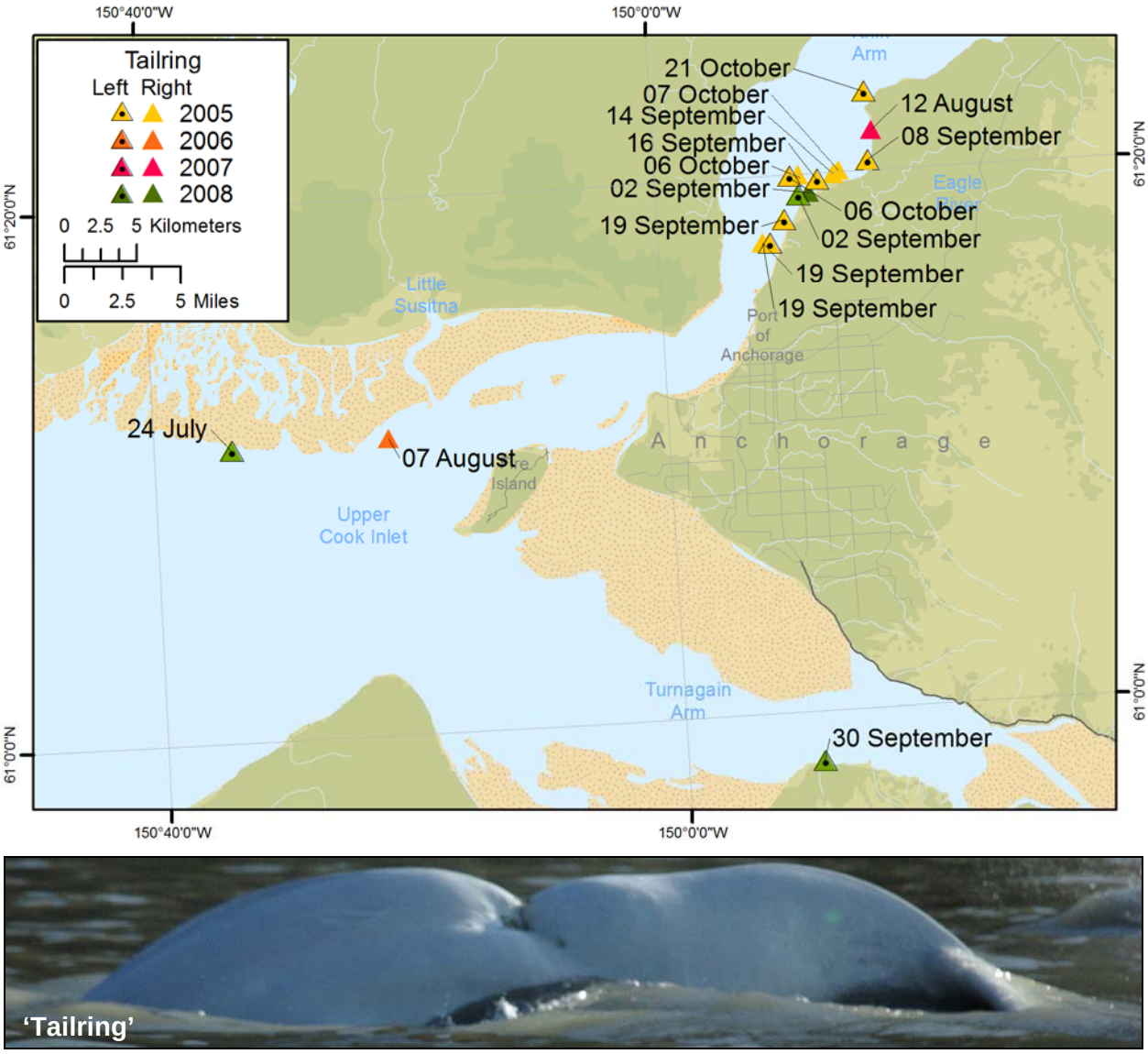

Figure 50. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Tailring'. This beluga is a presumed mother based on photographs with an accompanying calf.

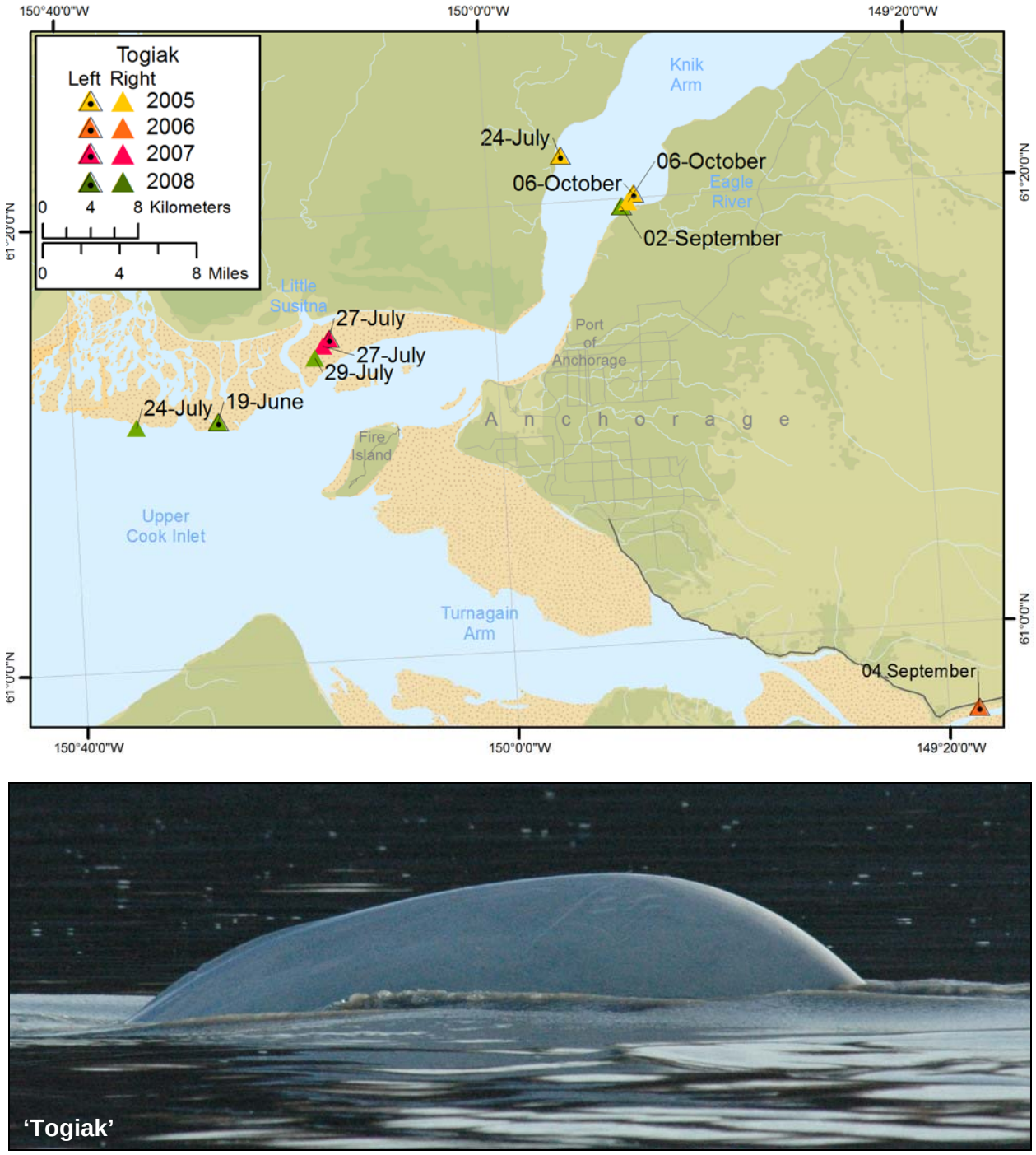

Figure 51. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Togiak'. This beluga was photographed every year from 2005-2008 and is a presumed mother based on photographs with an accompanying calf.

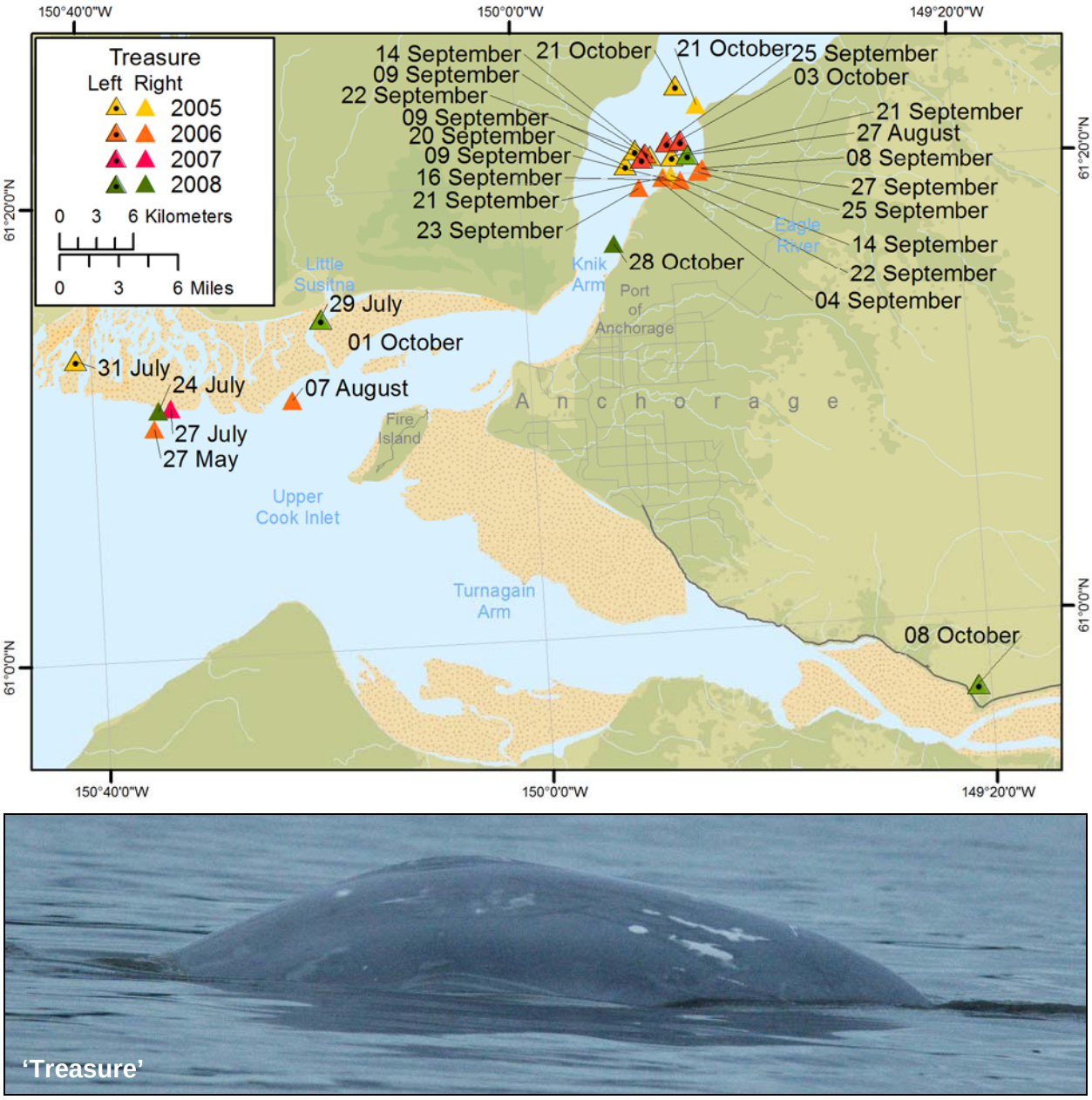

Figure 52. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Treasure'. This beluga is a presumed mother based on photographs with an accompanying calf.

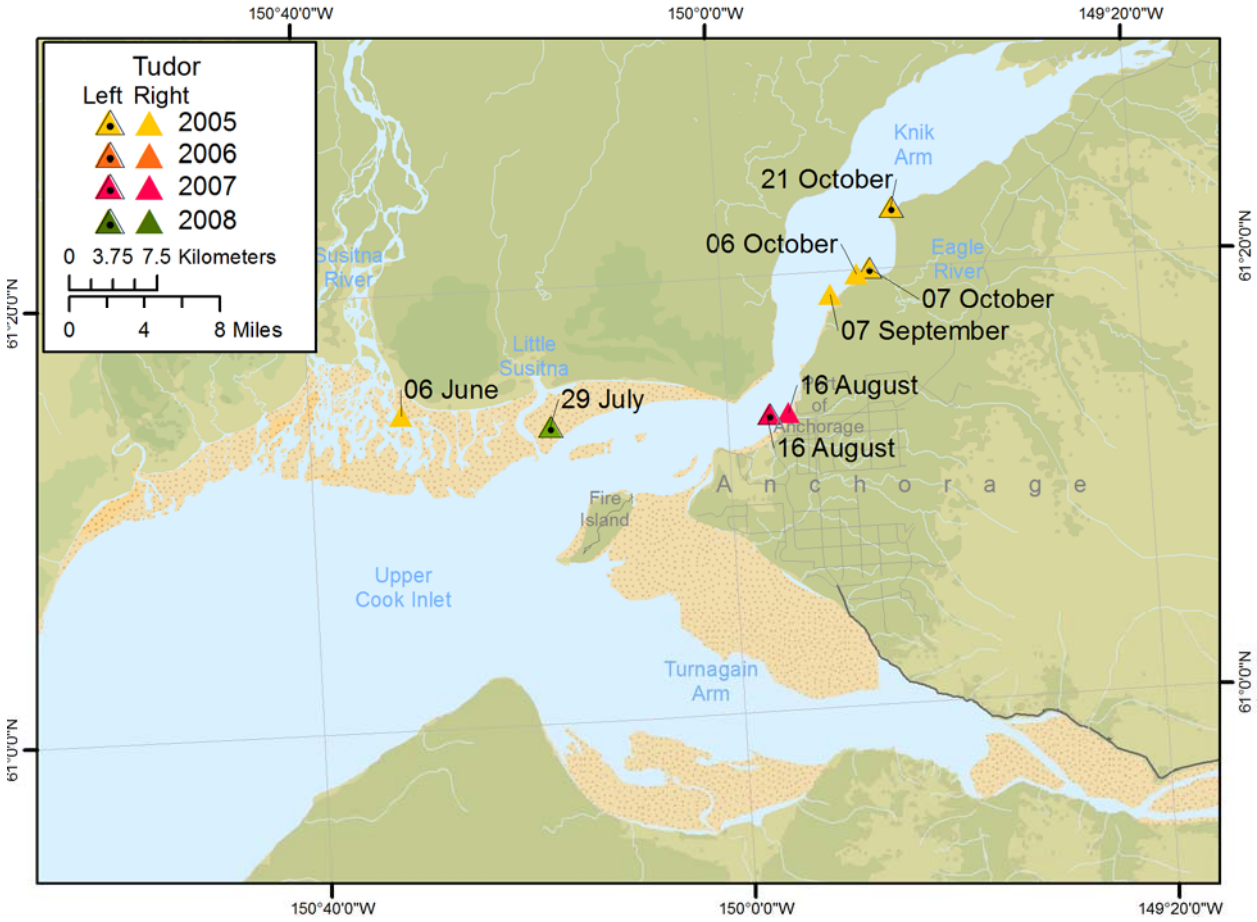

Figure 53. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Tudor'.

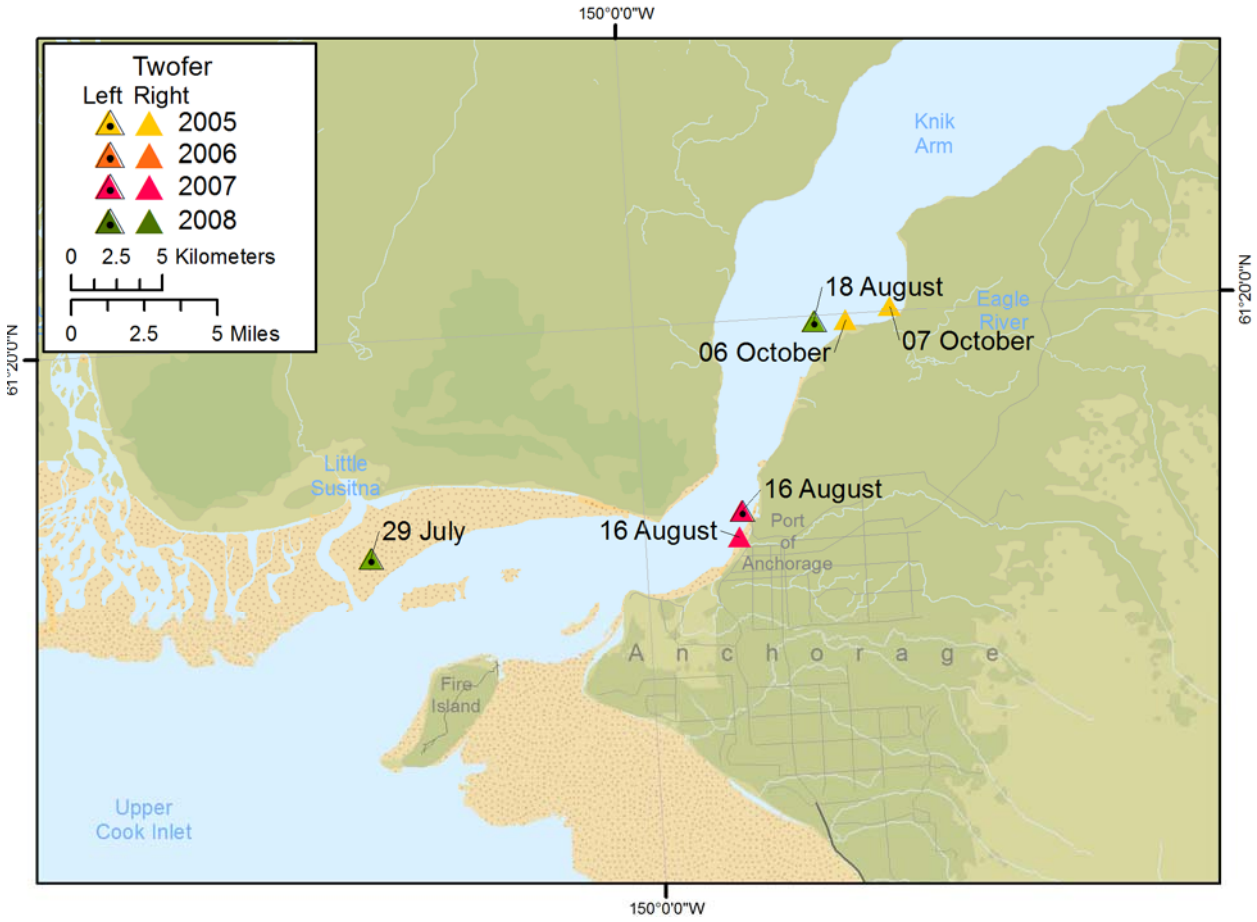

Figure 54. Sighting history (including sightings from both right- and left-side photographs) and photograph of beluga 'Twofer'.

Associations among identified belugas

A dendrogram was created (Figure 55) that represents the strength of the pair-wise associations among the 14 individual belugas identified in every year of the study. The maximum COA occurred between beluga 'Drops' and beluga 'Brooks' and was 0.4, indicating that these two belugas were sighted together in 40% of the groups in which they were individually sighted. The minimum COA was 0.05,

indicating that this pair of individuals was seen together in only 5% of the groups in which they were each sighted.

Mean group attributes (age class, color composition, presence of calves, group size) were calculated for the groups in which each of the 14 belugas seen in all 4 years of the study was photographed (Table 11). None of these belugas were found in groups that were comprised of solely white or gray animals, and all of these belugas were found in groups that contained calves. The mean group size in which these 14 belugas were seen was 46.4, with a mean of 25.5 white belugas, 15.8 gray belugas, and 4.2 calves (the calf category includes calves and neonates).

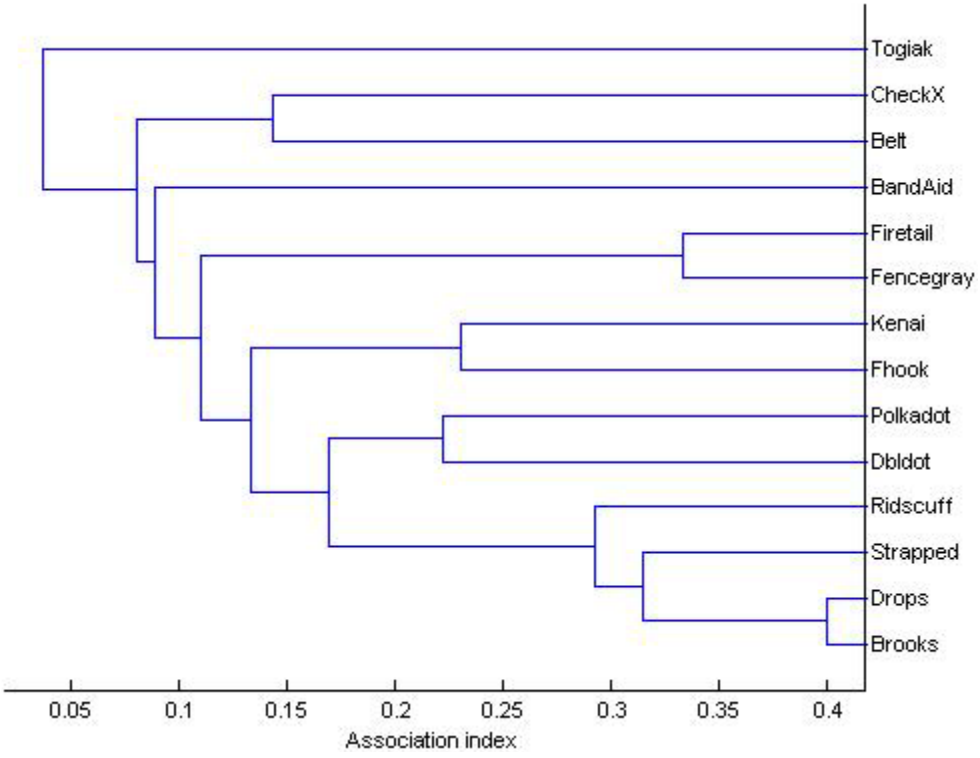

Figure 55. A dendrogram of the 14 left-side catalog belugas seen in four years of the left-side catalog (2005-2008), graphically displaying the association index for pair-wise comparisons among individuals. The association index is the COA referred to in the text.

Table 11. Mean group color composition, number of calves, and group size for groups in which each of the 14 belugas sighted in all 4 years of the study were photographed.

Whale ID	Mean # White Belugas/Group	Mean # Gray Belugas/Group	Mean # Calves/Group	Mean # Unknown Belugas/Group	Mean # Total Belugas/Group
Bandaid	22.6	15.0	3.7	0.1	41.3
Belt	18.1	15.8	4.1	0.0	38.0
Brooks	22.9	14.4	4.0	0.2	41.5
Check-X	34.3	30.5	5.8	0.0	70.5
DblDot	20.2	13.0	3.0	0.7	36.8
Drops	17.9	11.2	3.1	5.7	35.9
FenceGray	53.5	18.7	3.8	4.2	80.2
F-Hook	24.3	16.2	4.3	0.0	44.8
Firetail	24.7	12.0	4.0	0.7	41.3
Kenai	25.8	13.5	4.2	0.5	44.0
Polkadot	29.8	19.6	5.4	0.0	54.8
Ridscuff	29.2	20.8	4.7	0.3	55.0
Strapped	29.9	20.2	5.1	4.6	55.9
Togiak	21.4	9.4	6.0	0.0	36.8
Total	25.5	15.8	4.2	0.0	46.4

Dead belugas

Photographs of four belugas found dead between 2005 and 2008 were examined by LGL biologists, but none of these whales could be matched to identified whales in the photo-identification catalog, either because advanced skin decomposition prevented recognition of marks used for identification, or because the animals were beached in such a way that the left sides of the bodies were not visible. All dead belugas were reported to NMFS.

Causes of markings

Categories of markings that were assigned to marks on photographed whales included those presumed to be caused by natural sources such as disease (Figures 56 and 57) and predation (Figures 58 and 59), as well as anthropogenic sources such as satellite tags (Figures 60 and 61), bullets (Figures 62 and 63), ship strikes (Figures 64-66), and entanglement (Figures 65 and 67).

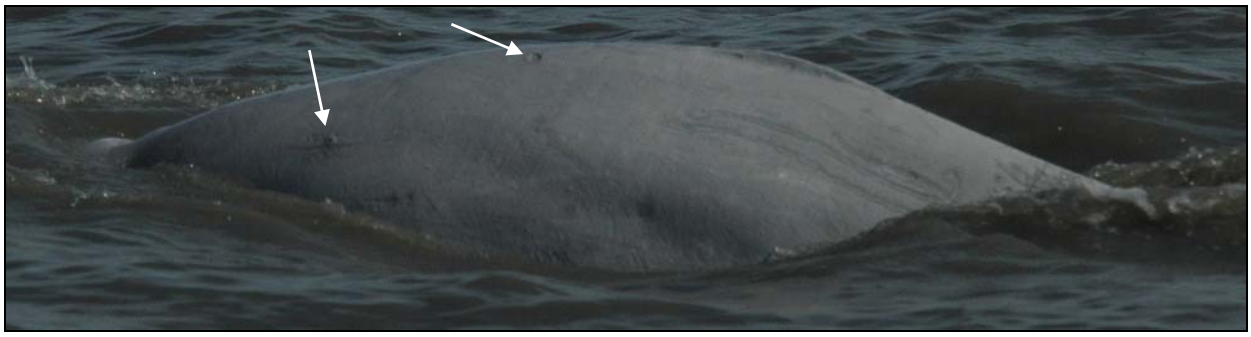

Figure 56. Photograph of the left side of beluga 'Fishhook' in 2006 showing marks that appear to be lesions.

Figure 57. Photograph of the left side of beluga 'Hillbilly' in 2005 showing marks that appear to be skin infection.

Figure 58. Photograph of the left side of beluga 'Rainbow' in 2006 with what appear to be healed tooth-rake marks that may have been caused by a predator (possibly an orca *Orcinus orca*).

Figure 59. Photograph of the left side of beluga 'Itchy' in 2008 with what appear to be healed tooth-rake marks that may have been caused by a predator (possibly an orca *Orcinus orca*). This whale is accompanied by a calf in this photograph.

Figure 60. Photograph of the left side of beluga 'Strapped' in 2007 showing marks made by previous satellite tags.

Figure 61. Photograph of the left side of beluga 'Sash' in 2007 showing marks made by previous satellite tags.

Figure 62. Photograph of the left side of beluga 'Holey' in 2007 showing a suspected bullet wound.

Figure 63. Photograph of the left side of beluga 'Spot' in 2008 showing a suspected bullet wound.

Figure 64. Photograph of the left side of beluga 'BigCleft' in 2005 with a wound possibly caused by a ship strike.

Figure 65. Photograph of the left side of beluga 'Tailring' in 2005 with a wound possibly caused by a ship strike or line entanglement.

Figure 66. Photograph of the left side of beluga 'Brandon' in 2005 with vertical marks that may have been made by a propeller strike.

Figure 67. Photographs of an unidentified beluga whale with an unknown object encircling the upper body. This whale was seen in Knik Arm in 2005 and has not been seen again. The two upper images (a, b) are of the left side of the body, the lower image (c) is of the right side.

DISCUSSION

The hypothesis that photo-identification methods can provide unique and useful biological information about individual and population characteristics of CIBWs was upheld. The development of a left-side catalog provided sighting histories for 186 individually identified whales photographed between 2005 and 2008. Combining the histories of whales in the left-side catalog with histories of 255 individuals in the right-side catalog (McGuire et al. 2011) allowed us to increase the strength of the inferences that can be made about the CIBW population from patterns of sighting histories of individuals. Although the general patterns derived from sighting histories in the left-side catalog support results from the right-side catalog, the development of a left-side catalog contributed unique information about CIBW. For example, the sighting histories of individuals in the left-side catalog increased the total number of sighting histories for CIBWs seen in Turnagain Arm. CIBWs swim from west to east up Turnagain Arm with the incoming tide along a deep channel that parallels the Seward Highway on the north shore of the Arm (Markowitz et al. 2007). The position of this channel provided a highway-based photographer a view of the left sides of CIBWs as they travel up the Arm. CIBWs generally cross over to the south shore of the Arm when they exit with the falling tide and are out of range of a highway-based photographer; consequently the right-side catalog contains relatively few records of individual whales in Turnagain Arm (McGuire et al. 2011). The inclusion of sighting histories of individual CIBWs in Turnagain Arm has provided important evidence that belugas found in Turnagain Arm are also found in the Susitna River Delta and in Knik Arm, and do not appear to form a sub-population endemic to Turnagain Arm.

Individual CIBWs identified by their left sides did not display fidelity to any single area of Upper Cook Inlet. Distribution and movement patterns were examined for individual whales sighted in all four years of the study, for whales identified by satellite tag scars, and for whales identified on both sides of their body. Sighting histories of these whales indicated they moved among different areas of Upper Cook Inlet. All of these whales were photographed in Knik Arm and the Susitna River Delta, and some were also photographed in Turnagain Arm and Chickaloon Bay/Southeast Fire Island. This same pattern held true for whales in the right-side catalog (McGuire et al. 2011), and for the dual-side whales (whales cataloged by photographs of both right and left sides). There was no indication that whales occurred in discrete subgroups endemic to any of the Upper Cook Inlet study areas; there was no evidence of a "Susitna River Delta group", a "Knik Arm group", a "Chickaloon Bay group" or a "Turnagain Arm group".

Beluga whales encountered during photo-identification surveys were rarely observed traveling between areas, but were instead encountered in distinct areas (i.e., along the Susitna River Delta, in Eagle Bay in Knik Arm, or traveling up and down Turnagain Arm). Similar patterns of localized aggregations

and rapid and directed travel among areas of localized aggregations have been reported for satellite-tagged CIBWs (Hobbs et al. 2005) and beluga whales in Norway (Lydersen et al. 2001). CIBWs are not distributed uniformly throughout Upper Cook Inlet, therefore the distinct areas in which they are found (i.e., the Susitna River Delta, Turnagain Arm, and Knik Arm, particularly Eagle Bay) should warrant increased management and protection. Results of this study support the locations of the designated areas of "Type 1" CIBW critical habitat proposed by NMFS (2009).

Whales traveling among distinct areas of Upper Cook Inlet increase their likelihood of exposure to multiple potential threats that may be localized in particular areas. For example, the same individual whale might be exposed to noise from seismic exploration in the Susitna River Delta, vessel traffic in the shipping lanes for the Port of Anchorage, military exercises in Knik Arm's Eagle Bay, and physical habitat alteration and noise from in-water highway expansion activities in Turnagain Arm. Anthropogenic activities with the potential to affect CIBW should not be considered in isolation, but rather the cumulative effects of all activities in the range of CIBW and their potential to affect the entire population must be taken into account when making management decisions.

CIBWs also face natural threats such as mass strandings and predation events. These events have been reported to occur more often in Turnagain Arm and Knik Arm than elsewhere in Cook Inlet (NMFS 2008b). The knowledge that most or all of the CIBW population uses these areas at some time during the year underscores the threat that such events pose to the entire population, and should prompt managers to have site-specific stranding response plans ready to activate should such events occur.

The compilation of long-term sighting histories of individual mothers and calves is beginning to provide the data necessary to determine several aspects of their life history, including calving interval (minimum time period between calving events), calving frequency (how often females give birth), period of maternal care/association, and survival rates of calves. It will be important to monitor these life history parameters over time, because a decline in population abundance is sometimes associated with a decrease in female age at maturity and a decrease in calving interval (Fowler 1984). The age of the CIBW photo-identification catalog is currently less than or equal to the length of time we would predict for calving intervals, calving frequency, and the period of maternal care, based on information from other beluga populations (Hobbs et al. 2008). The four-year period of the left-side catalog does not encompass enough time to determine life history attributes of such long-lived mammals, but the data from the catalog of individual CIBWs lays the foundation for determining these attributes with continued years of study. For example, one identified mother was photographed with a maturing calf during three field seasons. This mother was last seen with a calf in 2008, which was also the final year of the left-side catalog; it may be

that once a left side catalog is created for 2009 and beyond, we will find that the maturing calf is still with the mother during a fourth field season or longer.

Additional years of photo-identification effort are needed to not only determine how long calves remain with their mothers, but also how often identified mothers give birth to new calves, and if variation exists among individual mothers. Although several mothers were photographed with neonates, calving interval cannot be determined until these same mothers are photographed with new neonates. Two mothers seen with relatively large calves in one year were photographed with smaller calves in subsequent years, but because none of the original calves was photographed as a neonate, the number of years between births cannot be determined at the present time. Combining data from the right- and left-side catalogs for the 20 dual-side whales provided more complete information about mothers and calves. Calves were seen on the right and left sides of their mothers, and the use of only one catalog sometimes resulted in calves being missed in photographs, although they were detected in photographs from the other catalog during the same time period.

Four calves have been identified by their own marks rather than by those of their mothers, which allow them to be tracked independently of their mothers. The mothers of most of these calves have not yet been identified. A long-term project goal is to be able to calculate COAs between identified mothers and identified calves, but this can only be done when both mother and calf have been identified. Evidence of decreasing COAs over time between a mother-calf pair has been used to quantify the weakening of the mother-calf bond and to help to define the period of maternal care and association. For example, COAs between bottlenose dolphin mothers and their calves were near 1.0 for the calves in the first 3 years of life, but declined in most cases when the mother became pregnant again (Connor et al. 2000). Future efforts will also compare how often an identified calf is photographed with an identified mother to how often the mother and calf are photographed in the same group but are not in close physical proximity (i.e., seen in the same group, but not photographed together). The current method of defining mother-calf pairs at the level of 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. 2006).

With the exception of a few whales first photographed as young-of-the-year calves, the ages of most of the whales in the catalog are unknown. Eighteen CIBWs were satellite tagged by NMFS between 1999 and 2002 (Hobbs et al. 2005). Six identified belugas have marks on their left sides caused by satellite tags, and six have tag marks on their right sides (four of these have tag marks on both sides); although the satellite tags are no longer present, we are still able to photographically track and obtain survivorship data from these eight individuals 3-10 years later. Knowledge of the years in which the

satellite tags were applied would enable us to assign a relative age to re-sightings of these previously-tagged whales; we know that none of the whales were calves at the time of tagging. Details from the time of capture/tagging such as total body length and girth may provide more information about the relative age of these whales, however the photographs taken at the time of tagging were useful for photo-identification. Satellite tag type and attachment method varied among years (Rod Hobbs and Barbara Mahoney, NMFS, personal communication) and it may be possible to assign a capture/tagging date based on scar type, which in turn would provide information on survivorship, wound healing, and longevity of these mark types. We hope to continue to collaborate with NMFS to assign year of capture to these previously tagged CIBWs.

To date, the photo-identification study has not found evidence that beluga groups in Upper Cook Inlet are highly structured in terms of individual association patterns, color, age-class, location, or sex. Although results are preliminary, all re-sighting information so far indicates that the portion of the population we have identified is homogenous with respect to these factors. While some CIBWs were more likely to be seen with certain individuals, these patterns were not widespread, strong, or consistent enough to allow the population to be divided into subgroups. Future studies will examine if subgroups exist on a seasonal scale (e.g., do the large groups seen in the summers in the Susitna River Delta break into smaller subgroups during other seasons and in other locations?).

Groups encountered during surveys were rarely comprised exclusively of white or gray animals, but generally had both colors present. The 14 identified whales seen in 2005-2008 had roughly equal rates of occurrence in groups with calves, and none were found in groups of exclusively white adult animals, groups of solely mother-calf pairs, or groups of only small gray animals; the same pattern was true for individual CIBWs seen in each year of the right-side catalog (McGuire et al. 2009). Groups containing calves and neonates were seen in all parts of the study area, although these groups were seen with greatest frequency (after standardizing for unequal survey effort among areas) in Knik Arm.

It is unknown if groups of CIBWs are sexually segregated for all or even part of the year. Association patterns within a single season will be examined in the future. In both the left- and right-side catalogs, we have not been able to identify any belugas as male, and have only been able to infer a beluga was female if it was accompanied by a calf. Smith et al. (1994) identified adult males by their “large size and heavy lateral musculature”. We have photographed several large, white, well-muscled belugas, but at least two of these animals were closely accompanied by calves and were classified as females. Elsewhere in their range, outside of the breeding seasons this species segregates into groups comprised of maternal pods of adult females, calves, juveniles, and subadults, and smaller groups of adult males (Smith et al. 1994, Krasnova et al. 2009); it is unknown if this pattern also occurs in CIBWs. If adult males roam

Cook Inlet as singles or in small segregated groups, the possibility exists that we are not encountering and identifying them due to a survey schedule designed to locate and photograph large conspicuous aggregations. Adult male belugas, perhaps because they were once the target of hunting, may also be more wary of vessels and may have left the area when the survey vessel approached.

Several photographs of CIBWs contained marks indicative of disease and trauma. Marks from trauma were attributed to predation attempts, gunshots, ship strikes, and entanglement in debris. By continuing to document the occurrence and frequency of these marks and attempting to identify mark sources, more can be learned about the incidence of risk factors that may be preventing the recovery of the endangered CIBW population. In the future, we hope to conduct a more-detailed examination of marks, their sizes, locations, and possible causes. By collaborating with other investigators, particularly those authorized to investigate CIBW mortalities (NMFS, stranding groups, and subsistence users) and to collect samples (e.g., skin biopsies, skin swabs) for veterinary diagnostics, we will learn more about the sources of these skin lesions. We have created and distributed a protocol for photographing beluga mortalities (McGuire et al. 2009) that was made as a guide for stranding responders who are willing to photo-document markings on beluga mortalities. Matching photographs of dead belugas with photographs of identified individuals in the catalog will provide information necessary for understanding survivorship and population dynamics.

We were unable to use the left-side catalog from 2005-2008 to develop a CIBW population estimate using mark-recapture models, although significant progress has been made that will allow us to do so in the future. The number of individuals in the left-side catalog (n=186) may be viewed as a rough minimum abundance estimate, although the number of individuals in the right side catalog (n=255) is a more accurate estimate because the sample size represents more years of data (McGuire et al. 2011). We are unable to simply add the number of individuals in the two catalogs to estimate population size for CIBWs because, with the exception of the 20 dual side whales, we do not know how many of the 186 left-side whales are the same individuals as the 255 right-side whales. If skin biopsies for genetic analysis of CIBWs were collected concurrently with photographs of both sides, such a determination would be possible, but biopsy research is not permitted at the present time and the catalogs must be considered separately for population estimates.

We had initially thought that a simple two-event mark-recapture model would be sufficient for estimating abundance from photographs of CIBWs. In such a case, the marked animals could be represented by those whales in the photo-id catalog and the second or “sampling” or recovery event would be represented by the photographs of these same whales taken during later surveys. It became clear that generating a robust abundance estimate for CIBWs would require a more sophisticated model

than a simple two-event mark-recapture study. This was unknown to us in 2008 when we proposed this work to NPRB. In 2009, we developed an abundance estimate from the right-side catalog, funded by NFWF. The process for developing an abundance estimate required several steps (LGL 2009) in which we characterized the identifiability and permanency of marks on CIBWs. Every photograph of every whale in the right-side catalog was divided into body segments, and then each segment received one score for photo-quality and one score for mark quality (each photograph was examined and scored independently by two photo-analysts). An estimation model was developed that could incorporate sightings of both marked and unmarked animals and that was robust to potential biases caused by differences in behavior among individuals. The final model used was the zero-truncated Poisson log-normal mixed effects model (ZPNE; McClintock et al. 2009, LGL 2009). The work needed to process the photographs in the left-side catalog to make them useable for this mark-recapture model is well beyond the scope (in time and money) of the grant for this 1-year NPRB project. In the future, we will be able to use the combined (left and right) catalog to generate abundance estimates using the ZPNE mark-recapture model; cataloging all left-side photographs was a critical first-step in this process.

CONCLUSIONS

We developed a left-side photo-identification catalog that provided sighting histories for 186 individually identified whales photographed between 2005 and 2008. These individual CIBWs did not display fidelity to any single area of UCI. Whales traveled among distinct areas of UCI, thereby increasing their likelihood of exposure to multiple potential threats. CIBWs are not distributed uniformly throughout UCI, therefore the distinct areas in which they are found (i.e., the Susitna River Delta, Turnagain Arm, and Knik Arm, particularly Eagle Bay) warrant maximum management and protection.

There was no indication that whales occurred in discrete subgroups. To date, the photo-identification study has not found evidence that beluga groups in UCI are highly structured in terms of individual association patterns, color, age-class, or location. Although results are preliminary, all re-sighting information thus far indicates the portion of the population we have identified is homogenous with respect to these factors and that all CIBWs use the same areas of UCI.

The compilation of long-term sighting histories of individual mothers and calves is beginning to provide the data necessary for the determination of several aspects of life history, including calving interval (minimum time period between calving events), calving frequency (how often females give birth), period of maternal care/association, and survival rates of calves; more years of data are needed to determine these life-history parameters for these long-lived mammals and to monitor them over time.

Combing data from the right- and left-side catalogs provides more complete information about mothers and calves than either catalog alone.

Several photographs of CIBWs contained marks indicative of disease and trauma. Marks from trauma were attributed to predation attempts, gunshots, ship strikes, and entanglement in debris. By continuing to document the occurrence and frequency of these marks and attempting to identify mark sources, more can be learned about the incidence of risk factors that may be preventing the recovery of the endangered CIBW population.

In the future, we will be able to use the combined (left and right) catalog to generate abundance estimates using a complex mark-recapture model; cataloging all left-side photographs was a critical first-step in this process.

While not all objectives in the statement of work were fully met during the period of work for this 1-year NPRB project to catalog the left-side photographs taken 2005-2008 (see "Objectives", pages 9-11 of this report), the stated objectives are also the objectives of the larger LGL CIBW Whale Photo-identification Project that includes the combined right-and left-side catalog and all surveys conducted 2005-2010 (and hopefully into 2011 and beyond). All objectives are being met in the greater scope of the larger project.

PUBLICATIONS

This project does not currently have any peer-reviewed publications or manuscripts in review, submission, or in preparation. We plan to include results from this project in a manuscript that combines the right-side catalog, the left-side catalog, and seven years of surveys (2005-2011), to be submitted mid-2012 (following cataloging and data analysis of photographs from the 2011 field season).

OUTREACH

Web Page Developed

www.cookinletbelugas.com and www.cookinletbelugas.org

Exhibits/Demonstration Project Developed

None

Conference Presentations

January 2010: Poster presentations about the Cook Inlet Beluga Whale Photo-Identification Project at the Alaska Marine Science Symposium.

Blees, M.K., McGuire, T.L., and Kaplan, C.C. 2010. Color analysis of Cook Inlet Beluga Whales in the 2008 photo-id catalog. Poster.

Kaplan, C.C., White, G.C., McGuire, T.L., Brandon, J.R., Raborn, S., Link, M.R., and Blees, M.K. 2010. Application of mark-resight methods to estimate abundance of Cook Inlet Beluga Whales. Poster.

McGuire, T.L., Kaplan, C.C., and Blees, M.K. 2010. Group structure of Cook Inlet Beluga Whales: insights from photo-identification. Poster.

October 2010: Poster and invited talk on the Cook Inlet Beluga Whale Photo-Identification project at the NMFS Beluga Whale Science Conference.

Blees, M.K., McGuire, T.L., and Kaplan, C.C. 2010. Color analysis of Cook Inlet Beluga Whales in the 2008 photo-id catalog. Poster.

McGuire, T.L., Kaplan, C.C., and Blees, M.K. 2010. Group structure of Cook Inlet Beluga Whales: insights from photo-identification. Poster.

McGuire, T.L., Kaplan, C.C., and Blees, M.K. 2010. Photo-identification as a tool to study disease, injury, and survivorship of Cook Inlet Beluga Whales. Poster.

McGuire, T.L., Blees, M.K., and Kaplan, C.C. 2010. The use of photo-identification to study associations and distribution of beluga whale mothers and calves in Upper Cook Inlet, Alaska. Poster.

McGuire, T.L., Blees, M.K., and Kaplan, C.C. 2010. Photo-identification of Cook Inlet Beluga Whales. Invited talk.

November 2010: Abstracts submitted and accepted for posters about the Cook Inlet Beluga Whale Photo-Identification Project at the Alaska Marine Science Symposium (January 2011).

Blees, M.K., and McGuire, T.L. 2011. Development of a catalog of left-side digital images of individually-identified Cook Inlet Beluga Whales (*Delphinapterus leucas*).

McGuire, T.L., Blees, M.K., and Goertz, J. 2011. Tracking whales through time: the use of photo-identification to continue to track Cook Inlet beluga whales that were satellite-tagged a decade earlier.

Community Meetings

February 2010

- McGuire gives invited presentations to staff at ConocoPhillips, Anchorage office and Kenai LNG plant, about Cook Inlet Beluga Whales and the Photo-id Project. The presentation included a component on how the public can best record beluga sightings and how they can

share these sightings and photos with the project. McGuire also discussed how the project shares these sightings with NMFS.

Spring 2010

- Advised Friends of the Anchorage Refuge on their citizen science Anchorage Coastal Beluga Survey.

Spring/Summer/Fall 2009, 2010

- Collected reports and photographs from the public about sightings of Cook Inlet beluga whales. Compiled reports in project incidental sighting database, and also forwarded complied reports to NMFS.

Summer/Fall 2010

- Distributed copies of the Cook Inlet Beluga Whale Photo-Identification Project brochure to fishermen, recreational boat users and hunters at the Anchorage Small Boat Launch; distribute pamphlets to tourists and residents as they beluga-watched along the Seward Highway along Turnagain Arm.

Presentations at Festivals/Events

None

Workshop Participation/Conservation Application

Spring 2010

- Provided comments to NMFS about Beluga Critical Habitat, based on data from the Cook Inlet Beluga Whale Photo-id Project.
- McGuire gave invited presentation on the Cook Inlet Beluga Whale Photo-id Project to the Cook Inlet Beluga Whale Recovery Team (Stakeholder and Science Panels).

Winter 2010

- McGuire gives symposium on Cook Inlet Beluga Whale Photo-id Project to faculty, staff, students (graduate and undergrad) and public at Hatfield Marine Science Center, Oregon State University, Newport Oregon (January 2011).

Presentations in Schools (k-12, undergraduate)

February 2010

- McGuire gives invited presentation on math and beluga whale studies for the Anchorage School District's "Middle School Girls Math Conference".

Summer 2010

- Worked with a middle-school student volunteer who helped to review all photographs in the catalog for mothers and calves. Volunteer first learned of the project during the February 2010 presentation at the Middle School Girls Match Conference. Volunteer was included as a co-author on project poster presentation at the 2011 Alaska Marine Science Symposium.

Press Articles

None

Factsheets Produced

Informational pamphlet updated (Figure 68).

Video Produced

None

Radio/Television Interviews

None

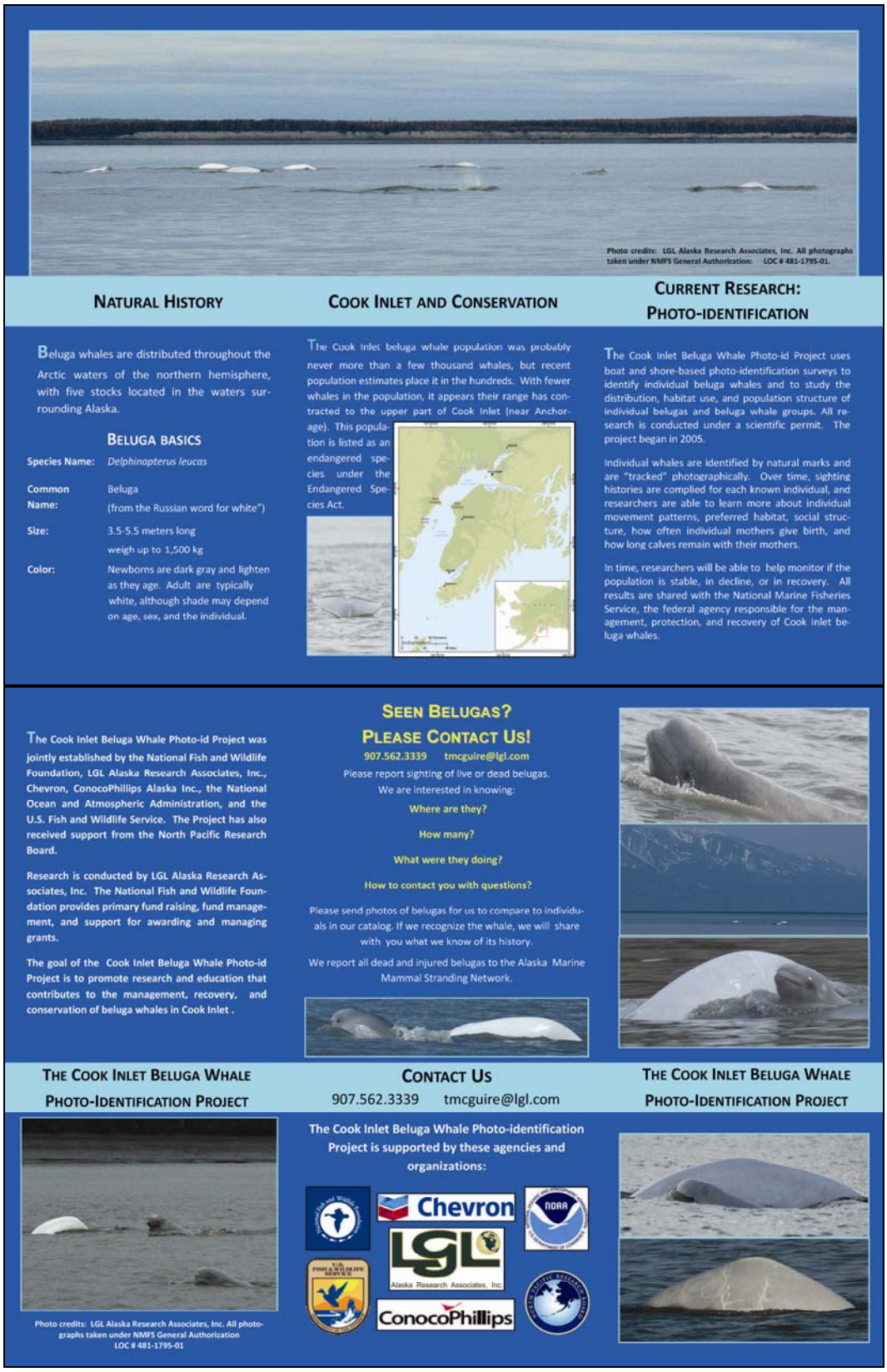

Figure 68. Educational pamphlet about the Cook Inlet Beluga Whale Photo-identification Project.

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ConocoPhillips Alaska, Inc.

NOAA

USFWS

LGL Alaska Research Associates, Inc.

Research Coordination

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