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

Final Report of Field Activities in 2008

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Chevron
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ABSTRACT

Alaska's Cook Inlet beluga whale (CIBW) population (*Delphinapterus leucas*) was listed as endangered in October 2008, and as a result, critical habitat for the survival and recovery of the population must be designated. Land- and vessel-based photo-identification surveys can be used to characterize distribution and movement patterns of individual beluga whales, which can augment critical habitat information from aerial surveys and tagging studies. Photo-identification data describing CIBW residency and movement patterns, habitat use by mothers and calves, and assessment of behavior will aid in the identification of critical habitat, including movement corridors and locations of grounds for feeding, calving, and rearing of young.

The CIBW photo-identification study has been ongoing since 2005. The study has demonstrated that a large number of beluga whales in Upper Cook Inlet possess distinct natural marks that persist across years, and that these marks can be effectively identified and re-sighted with digital photography. This report provides a summary of field effort and photo-identification survey data results from 2008. Results of 2008 photo-analyses will be presented in a second report, due May 15, 2009. This second report will contain information about whales identified in 2008, their habitat associations, movement patterns, group associations, and reproductive information. A third report will be issued in the fall of 2009, presenting results of a population estimate derived from information about individuals photographed in 2008. The three reports will be compiled into a single comprehensive report summarizing all data collected 2005-2008, to be issued October 2009.

Dedicated surveys and opportunistic sampling of Upper Cook Inlet were conducted from a small vessel and from shore. Standardized data forms were used to record beluga whale sightings and environmental conditions. Photographs of beluga whales were collected using a digital camera and zoom lens. Figures were prepared showing survey routes, whale group location, group size, and group color composition for each survey conducted in 2008. Primary and secondary behaviors of beluga whale groups, group size and color composition, and presence of calves and neonates were compared among the Susitna River Delta, Turnagain Arm, Knik Arm, Chickaloon Bay, and the Port of Anchorage.

Forty-six beluga whale groups were counted and photographed during 29 survey days in 2008. Mean group encounter rates were highest in Knik Arm and lowest at the Port of Anchorage. Mean group size was 26.8 whales. Whale groups did not appear to be stratified by color or age-class. Our observations of newborns indicated that calving for CIBW begins in late July. We did not detect localized areas for calf rearing, as calves were seen in all locations surveyed. Feeding was the most-frequently observed primary behavior in the Port of Anchorage and Knik Arm. Travel was the most-frequently observed primary behavior in the Susitna River Delta, Turnagain Arm, and Chickaloon Bay. The field work completed in 2008 brings the project total to 128 days of photo-identification surveys conducted over four field seasons (2005-2008). In all, 362 whale groups have been encountered and photographed. The strength and utility of the photo-identification project grows with the proportion of the CIBW population that is photographed and identified.

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INTRODUCTION

Alaska's Cook Inlet beluga whale (CIBW) population (*Delphinapterus leucas*) is considered a distinct population segment (DPS) by the National Marine Fisheries Service (NMFS) and was listed by NMFS as endangered in October 2008 (NMFS 2008a). As a result of the Endangered Species Act listing, NMFS is required to designate critical habitat for CIBWs. This designation identifies valuable habitat deemed necessary for the survival and recovery of the population. Currently available sources of information that will be 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 will play a key role in characterizing habitat needs, as will 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. 2008a) can be used to characterize distribution and movement patterns of individual beluga whales, which can augment critical habitat information from aerial surveys and tagging-tracking studies.

The CIBW photo-identification study has been ongoing since 2005, and has demonstrated that a large number of beluga whales in Upper Cook Inlet possess distinct natural marks that persist across years, and that these marks can be effectively identified and re-sighted with digital photography (McGuire et al. 2008a). The photo-identification catalog and associated surveys from four field seasons (2005-2008) have provided information about the distribution and movement patterns of dozens of individually identified beluga whales, including mothers with calves.

The original objectives of this study were to:

1. assess the feasibility and utility of photo-identification for studying CIBWs,
2. build a photo-identification catalog of distinctively marked individuals, describing re-sight rates and discoveries of new individuals over time,
3. describe population characteristics of beluga whales in Upper Cook Inlet, including age-class distribution, residency/movement patterns, behavior, and social group structure, and
4. develop abundance estimates of CIBWs using mark-recapture models.

A fifth objective, added in 2007, was to:

5. determine life history characteristics of CIBWs.

This report provides a summary of field effort and photo-identification survey results from 2008. In addition to presenting results from field activities conducted from May through October 2008, it describes additions to photo-identification field methods implemented in 2008. Results of analyses of photos taken in 2008 will be presented in a second report due May 15, 2009. This second report will contain information about whales identified in 2008, their habitat associations, movement patterns, group associations, and reproductive information. A third report will be issued in the fall of 2009, presenting results of a population estimate derived from information about individuals photographed in 2008. The three reports will be compiled into a single comprehensive report, to be issued October 2009.

METHODS

Field Surveys

Survey effort

Dedicated surveys and opportunistic sampling of Upper Cook Inlet, Alaska (Figure 1) were conducted from a small vessel and from shore. Surveys 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 & McGuire 2007, McGuire et al. 2008a, 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. Knik Arm (Figure 2) was surveyed primarily in late summer/fall (August-October) during low tide. The Susitna River Delta (Figure 3) was surveyed in summer (May-August) during low tide. Turnagain Arm (Figure 4) was surveyed from the Seward Highway in late summer/fall (August-October) during high tide. Vessel-based surveys of Chickaloon Bay (Figure 5) were made when wind conditions along Turnagain Arm were safe for boat activity. The Port of Anchorage (defined as the area bounded by Cairn Point, Port MacKenzie, Point Woronzoff, and Point MacKenzie) was surveyed during all vessel-based surveys because the survey vessel was always launched from the small boat ramp at the Port of Anchorage.

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 Zodiak 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. Surveys were not line-transect surveys designed to estimate abundance. 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. If whales approached within approximately 2 m of the boat, the engine was put into neutral and/or turned off. Researchers noted the position of whales relative to the vessel and GPS-logged tracks were used to estimate approximate whale group position. Approach distances and amount of time spent with each whale group are reported in Appendix B. All vessel surveys were conducted under General Authorization # LOC 481-1795-01. Vessel-based surveys were suspended during NMFS aerial surveys.

Land-based surveys

Photographs were also taken from shore. A single observer drove south and east from Anchorage along the Seward Highway, generally beginning three hours before high tide. Stopping at pullouts along the highway, the observer searched with binoculars and the naked eye for marine mammals. When beluga whales were seen, the observer attempted to follow them up Turnagain Arm as they moved with the tide. Most photographs were taken from sites between Bird Point and Girdwood (Figure 4) because whales approached closest to shore here, and because of easy highway access to these sites. Although the majority of photographs from shore were taken along Turnagain Arm, on a few occasions photographs of whales were taken from shore near Ship Creek at the Port of Anchorage. These whales had been sighted while observers were preparing to launch the survey vessel, and photos were taken from shore rather than from the vessel in order to minimize possible disturbance to the whales.

Field data (vessel and land-based surveys)

Standardized data forms were used to record beluga whale sightings and environmental conditions. For each beluga whale group sighting, observers recorded: time of day, group size, GPS position of the vessel, magnetic compass bearing to the group, estimated distance of the vessel from the group (distance at first detection, and minimum distance to individual whales), water depth (under the vessel), group formation, direction of travel, movement patterns, average distance between individuals, and any human activities near the sighting. For groups with multiple records on a single day, the best record was selected at the end of the survey, which was either the highest count (for groups that merged), or the count considered by both observers to be the most accurate. Group size was usually difficult to determine and counts provided estimates rather than actual number of whale in the group. Behavioral data were collected using focal group sampling (Mann 2000) and behavior was classified into primary and secondary activities. Primary activities were behaviors that appeared to be the dominant behavior of the group, and secondary activities were behaviors that occurred sporadically during primary activities. Behavioral activities were defined as follows:

Travel	movement in a linear or near-linear direction, transiting through an area
Dive	movement directed downward through the water column

Feed	chasing or apparently chasing prey, as evidenced by bursts of speed and/or focused diving in a particular location, or by fish jumping out of the water
Rest	little or no movement, body of animal was visible at or near the surface
Mill	non-linear, weaving or circular movement within an area
Socialize	interactions among whales

Body color and relative size of whales in the group were recorded as "white", "gray", and "calf". Calves were usually dark gray, relatively small, and usually swimming within one body length of an adult-sized beluga. Observers noted if any of the 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. Environmental data were collected hourly or when conditions changed. Environmental variables recorded included Beaufort Sea State, swell height, cloud cover, wind speed and direction, air temperature, water temperature at the surface, water depth, visibility, and habitat type (e.g., mudflat, bay, mid-channel, river mouth, depositional bank, erosional bank, island, and shoal).

Digital photographs of beluga whales were collected using a Nikon D70, 6.1 megapixel digital SLR camera, with Nikkor 70-400 mm zoom telephoto auto focus lens. Typical settings included shutter speed priority, dynamic auto-focus, 800 ISO, and shutter speed of 1,000 or greater. Images were underexposed (setting at -1 or lower exposure bias value) to increase contrast and show otherwise faint marks in images of white animals (Robert Michaud, personal communication). Photographs were taken in RAW (not compressed) format and stored on compact flash memory cards.

Innovations to field work in 2008

Following the materials and methods described in Durban and Parsons (2006), two green-beam laser pointers were mounted on either side of the camera's zoom lens in a custom-made holder. The two resulting points of light projected onto the bodies of photographed beluga whales were of a known distance apart, allowing for measurement of natural marks on photographed whales and for estimation of body length.

A standard photographic white/gray balance card (18% gray) was photographed at least once per survey, and often several times throughout a survey, to document the variability in the camera's ability to accurately capture the true color of whales given the daily (and often hourly) variation in lighting conditions caused by changing environmental factors such as clouds, glare, ocean conditions, and fog.

Processing and Cataloging of Photographs

Photographs were downloaded from the camera's compact flash memory card onto a computer hard drive, uploaded into the project database program, and burned onto DVDs for backup. Methods of photo processing and analyses will be described in the May 2009 project report.

Analyses of Data from Field Surveys and Database Development

Positions of beluga whale sightings and survey routes were mapped in ArcGIS ™ Version 9.1 (http://www.esri.com) and figures were prepared showing survey routes, group location, group size, and group color composition for each survey conducted in 2008. Primary and secondary behaviors of beluga whale groups, group size and color composition, and presence of calves and neonates were compared among the Susitna River Delta, Turnagain Arm, Knik Arm, Chickaloon Bay, and the Port of Anchorage. A summary of database development in 2008 is provided in Appendix C.

RESULTS

Surveys

Survey effort and number of whales and whale groups encountered

Forty-six beluga whale groups were counted and photographed during 29 survey days in 2008 (Table 1). Mean group encounter rates were highest in Knik Arm and lowest at the Port of Anchorage. Across all areas a mean of 1.6 groups per survey was observed. Survey effort was unequal among locations and seasons (Table 2). Survey effort was highest at the Port of Anchorage and lowest in Chickaloon Bay. A total of 85 hours was spent in vessel surveys (each vessel survey was 2.7-6.3 hours in duration, with a mean of 5 hours). A total of 22 hours was spent in land-based surveys (each land-based survey was between 3 hours and 9 minutes in duration, with a mean of 1.8 hours). Duration of surveys depended on hours of daylight, tidal conditions, if whale groups were encountered, and size and behavior of whale groups. Mean minimum sighting distance between whale groups and the research vessel was 50.7 m, although individual whales often swam up to the vessel (Appendix B). Mean minimum sighting distance (the closest whales came to the survey vessel or shore-based observer) was 12.2 m in the Susitna River Delta, 71.2 m in Knik Arm, 61.2 m at the Port of Anchorage, 2 m in Chickaloon Bay, and 109 m along Turnagain Arm.

The number of whales sighted per survey was variable among surveys, even after stratifying by month and location (Tables 3-7). Total number of belugas sighted per survey varied between 0 and 121. The largest groups were seen in the following locations and months: July in the Susitna River Delta; August at the Port of Anchorage; August and September in Knik Arm; and September in Turnagain Arm and Chickaloon Bay (Tables 3-7). Maps of whale group sighting locations and survey routes from the vessel and from land in 2008 are presented in Appendix A.

Group size, color composition, and age class of groups encountered during surveys

The most-frequently encountered group size was five whales, and groups ranged from one to 121 whales (Figure 6 and Appendix A). Mean group size was 26.8 whales (Table 1). Relative color composition of groups varied with location and survey method

(Table 8). Group composition ranged between 36% and 65% white belugas, 14% and 38% gray belugas, and 4% and 14% calves.

Belugas of unknown color comprised between 0 and 46% of groups, and the highest percentage occurred in Turnagain Arm. Relative color compositions of all beluga groups observed during surveys in 2008 was comparable to color composition of groups observed in 2007 (Figure 7). A greater percentage of belugas of unknown color were observed in 2008 and 2007 than in 2005 and 2006 (Figure 7).

Calves were seen throughout the period when beluga groups were encountered during the 2008 field season (Table 3-7). Calves (not neonates, but young animals probably born in 2007 or earlier) were first seen on June 19 and last seen on October 28, although neonates were not observed until July 24 and were last observed September 30. Calves and neonates were seen in all locations where beluga groups occurred. The percentage of each group composed of calves and neonates varied according to location, as did the percent of groups containing calves and neonates. All of the beluga groups seen in the Susitna River Delta contained calves, whereas roughly 50% of groups encountered in Knik Arm, Turnagain Arm, and the Port of Anchorage contained calves. Only one group was observed in Chickaloon Bay, and it contained calves and neonates. Neonates were observed in 30% of all beluga groups encountered in 2008. Neonates were found in approximately half of the groups seen in Knik Arm, a third of the groups in the Susitna Delta, a quarter of the groups at the Port of Anchorage and in the one group seen in Chickaloon Bay (all of these areas were surveyed from vessels). Only 7% of groups in Turnagain Arm contained neonates, although there were two occasions when calves were seen, but were too far away for observers to determine if these calves were also neonates.

Behavior of whales

Feeding was the most-frequently observed behavior in the Port of Anchorage and Knik Arm (Figure 8). Travel was the most-frequently observed primary behavior in the Susitna River Delta, Turnagain Arm, and Chickaloon Bay. By location, the most-frequently observed secondary behaviors were feeding in the Susitna River Delta and Turnagain Arm, travel in the Port of Anchorage and Knik Arm, and milling in Chickaloon Bay.

Total Project Field Effort to Date

The field work completed in 2008 brings the project total to 128 photo-identification surveys conducted over four annual field seasons (Table 9). In all, a total of 83,537 photographs were taken of whales sighted in 362 groups.

DISCUSSION

Whales Encountered During Surveys

Whales were photographed in the Susitna River Delta in the summer and in Knik Arm and Turnagain Arm in the late summer and fall. The presence of whales in these areas during these time periods was consistent with seasonal whale distribution patterns found in previous years of this study (McGuire et al. 2008a) and in other studies (Moore et al. 2000, Funk et al. 2005, Hobbs et al. 2005, Markowitz and McGuire 2007, Nemeth et al. 2007). Photo-identification survey routes and seasonal schedules used in 2008 were similar to those used in previous years (McGuire et al. 2008a). The maximum number of beluga whales encountered in a single survey day was never more than 121, which indicates that some of the population was elsewhere (population estimated at 375 in 2008; NMFS 2008a).

Group sighting rates (number of groups encountered per survey) were somewhat lower in 2008 than in previous years (1.5 in 2008, 2.0 in 2007, 4.9 in 2006, and 2.4 in 2005). Average group size was 27 whales in 2008 and 14 in 2007. Shelden et al. (2008) also report larger and fewer groups of beluga whales seen during aerial surveys in June 2008 compared to June 2007. Although inter-observer differences in defining groups may contribute to differences in group size recorded, the LGL photo-id research team remained the same in these two field seasons.

Color and Age Composition of Groups

Whale groups did not appear to be stratified by color or age-class, and all but one of the groups contained white and gray whales. Relative color composition of groups varied, but no spatial or temporal patterns were apparent. Color composition was most difficult to determine in Turnagain Arm, where whales were generally far from land-based observers.

Although not quantified, observers on the survey vessels had the impression that white whales were more likely to be detected than gray whales, as gray whales tended to blend in with the turbid gray waters of Cook Inlet. This suspected bias in detection towards white whales seemed greater with distance between whale and observer. Behavioral differences between white and gray belugas, however, may have resulted in an opposite bias. Gray animals were more likely to both approach the survey boat and to remain near the boat. Therefore, although white belugas were more likely to be detected at a distance, gray whales may have been more likely to be photographed from vessels, possibly resulting in better photographs of gray individuals.

Environmental conditions and photographic settings (most notably ambient light and camera exposure settings) influenced where whales were classified on the gray-to-white scale (McGuire et al. 2008a), and therefore the color assigned to a whale during a field survey may not match the color assigned to the photograph once the photograph is cataloged. Analysis of gray-scale card photographs taken during surveys in 2008 will occur in early 2009, and results will be reported in May 2009.

The timing and location of beluga whale calving in Cook Inlet is not well documented in the literature (Hobbs et al. 2008). Groups of belugas in the Canadian Arctic were found to have seasonal differences in proportions of calves, juveniles, and adults (Smith et al. 1994), which were used to determine seasonality of calving. Based on the presence of calves sighted in summer aerial surveys, Calkins (1983) speculated that calving might occur between mid-June and mid-July in the larger estuaries of upper western Cook Inlet. Our observations indicate that calving for CIBWs begins in late July. In 2008, neonates were first seen July 24, and in 2007 neonates were first seen July 27.

In both years the first neonates of the season were seen at the Susitna River Delta. We did not detect localized areas for calf rearing, as calves were seen in all locations surveyed. Groups seen in the Susitna River Delta were more likely to contain calves compared to groups seen in other areas, although neonates were more likely to be seen in groups found in Knik Arm. Seasonal differences in survey location may confound patterns between locations, season, and occurrence of neonates.

Sighting distance between observer and beluga groups may also have had an effect on ability to detect neonates in a group. For example, compared to other locations, fewer groups in Turnagain Arm contained neonates and mean sighting distances were greater. This effect may only be significant for land-based observations however, because neonates were more likely to be found in Knik Arm than in the Susitna River Delta, although the mean sighting distances in Knik Arm was almost 6 times greater than in the Susitna River Delta (Susitna River Delta and Knik Arm were both surveyed from vessels).

The "calf" category used during field surveys 2005-2006 did not differentiate newborn calves from those now known to be one- and two-year old calves (determined photographically by sighting histories of calves of identified mothers; McGuire et al. 2008a), which suggested that any peak in newborn calf numbers may not have been captured in the data recorded during these field surveys. The first year we sub-classified calves as neonates was 2007. Identification of individual whales photographed in 2008 will allow us to develop sighting histories of mothers identified with calves in previous years, as well as create sighting histories for new mothers in 2008. Sighting histories will allow us to examine birth rates, calf survival, duration of mother/calf bonds, and age estimates of calves. These results will be presented in the report to be issued May 2009.

Behavior

Traveling and feeding were the predominant behaviors observed for groups encountered in the Susitna River Delta (surveyed during the summer) and in Knik Arm, and Turnagain Arm (surveyed primarily during the fall). Feeding, traveling, and milling were the predominant behaviors for groups encountered at the Port of Anchorage (surveyed throughout the field season). The distinction between behavioral categories was somewhat artificial as the terms only described behaviors seen when the whales were briefly at the surface. In reality, whales were often probably simultaneously feeding, diving, and traveling as they pursued and captured prey. The largest group recorded during the study was of 121 beluga whales encountered on 29 July 2008, traveling and socializing along the Susitna River Delta. Observers noted that the whales seemed

exceptionally vocal and playful with one another and the survey boat. In the previous field season, the largest group of the year (74 whales) was encountered on 27 July 2007, diving, traveling, and feeding along the Susitna River Delta. This large group was presumed to be pursuing salmonids, based on observations of fish jumping near the whales.

Feeding was not observed in Chickaloon Bay, where whales appeared to mill during low tide, then travel rapidly up Turnagain Arm with the rising tide. On a few occasions in September, whales traveling rapidly east along Turnagain Arm with the incoming tide were observed to suddenly circle near the north shore rip-rap approximately 1 km east of Bird Point (presumably in pursuit of fish) and then continue traveling rapidly eastward.

Whales were much easier to photograph when feeding or traveling than when diving. Feeding and traveling animals remained at the surface longer, had higher surfacing profiles, and exhibited less response (attraction or avoidance) to the survey vessel, whereas diving animals often remained submerged for long periods of time and were unpredictable in their surfacing locations and patterns.

Progress Made in 2008 and Dissemination of Project Results

Progress made in 2008 may be measured in terms of number of field surveys, number of groups of whales photographed, and improvements in survey and data processing techniques. Project results are disseminated in annual meetings with NFWF, Chevron, and ConocoPhillips, and in reports distributed to NFWF and project partners, NMFS (local, regional, and national offices), the National Marine Mammal Laboratory, the Alaska Department of Fish and Game, the Alaska SeaLife Center, NGOs such as Defenders of Wildlife, the Friends of the Anchorage Coastal Refuge, the Alaska Center for the Environment, and the Cook Inlet Keepers. Project reports are available to the general public at http://www.fakr.noaa.gov/protectedresources/whales/beluga/research.htm#ci. Results from the 2007 Annual Report were presented as talks and posters at scientific and stakeholder meetings, including a poster at the Alaska Marine Science Symposium (Kaplan et al. 2008b), a talk and two posters at the Alaska Chapter Meeting of the Wildlife Society (Blees et al. 2008, Kaplan et al. 2008a, McGuire et al. 2008b), an invited talk at the Alaska Beluga Whale Committee meeting (Kaplan et al. 2008c), and a meeting about CIBW research hosted by the Alaska SeaLife Center.

Communication of project results and collaboration with colleagues are more productive with each continuing year of the project. Examples of existing partnerships we plan on maintaining and expanding in the future include: exchange of information with NMFS about beluga locations during aerial (NMFS) and vessel (LGL) surveys during the field season; informing NMFS-AK of dead belugas (in some cases securing the carcass until NMFS is able to respond) and assisting with necropsies; informing the NMFS Office of Law Enforcement of suspected cases of beluga poaching and harassment; circulating photographs of injured or infected belugas to the Alaska Marine Mammal Stranding Network for expert opinion; exchange of whale sighting reports, photographs, and sighting history with wildlife biologists employed by the U.S. Army at Fort Richardson; pairing our visual observations of CIBWs with acoustic recordings of

belugas collected by the Alaska SeaLife Center, the Alaska Department of Fish and Game, and the University of Hawaii; and sharing our beluga observation, data recording, and observer training expertise with the Friends of the Anchorage Coastal Refuge and Defenders of Wildlife's "Anchorage Coastal Beluga Survey Citizen Science Project".

Future Work

Fieldwork from 2008 was completed in the last week of October, and we are in the process of analyzing photographs and working with a team of database specialists to further develop our system of data processing and archiving. Cataloging of images from 2008, data analysis, and report preparation will continue through spring 2009, and a report of cataloging results will be released in May 2009. This report will contain information about whales identified in 2008, and their habitat associations, movement patterns, group associations, and reproductive information. A third report will be issued in the fall of 2009, presenting results of a population estimate derived from information about individuals photographed in 2008. The three reports will be compiled into a single comprehensive report to be issued in October 2009.

Additional plans for 2009 include an increase in the scope of photo-identification survey effort with a more-even distribution of survey effort throughout different locations. Increased sampling in those areas (Chickaloon Bay/Southeast Fire Island, Middle Cook Inlet) and in those seasons which have had patchy survey effort in the past will provide the sample sizes necessary to rigorously test patterns that are beginning to emerge but have not been tested statistically.

The strength and utility of the photo-identification project grows with the proportion of the CIBW population that is photographed and identified. Photo-identification surveys from the existing four years of uninterrupted effort will continue to provide information about the distribution, habitat associations, behavior, color, and age-class compositions of CIBW groups, while identification of whales photographed during the surveys will continue to provide information about movement patterns, social structure, and life history characteristics of individually identified beluga whales.

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Table 1. Photo-identification survey effort and beluga whale groups encountered in 2008 in Upper Cook Inlet, Alaska.

	Surveys from Vessels				Surveys from Land	
2008	Susitna River Delta	Knik Arm	Chickaloon Bay	Port of Anchorage	Turnagain Arm	Total for All Locations
Number of Surveys	8	10	2	17	12	29* survey days
Total Number of Beluga Whale Groups	9	17	1	4	15	46
Total Number of Beluga Whale Sightings	566	328	42	23	276	1235
Mean Number of Groups per Survey	1.1	1.7	0.5	0.2	1.3	1.6
Mean Number of Whales per Survey	70.8	32.8	21.0	1.4	23.0	42.6
Mean Number of Whales per Group	62.9	19.3	42.0	5.8	18.4	26.8

* survey numbers not additive because multiple sites may have been surveyed on a single survey day

Table 2. Distribution of photo-identification effort by month, week, and location in 2008 in Upper Cook Inlet, Alaska. Numbers in the table are survey days.

Month	Week	Susitna River Delta	Knik Arm	Chickaloon Bay	Turnagain Arm	Port of Anchorage
May	1					
	2					
	3	1	1			1
	4					
June	1					
	2					
	3	2		1		2
	4					
July	1					
	2					
	3	1				1
	4	2				2
	5	1	1			1
August	1	1				1
	2					
	3		2		1	2
	4		1		2	1
September	1		1		2	1
	2				1	
	3		2		1	2
	4		1	1	3	2
October	1					
	2				1	
	3				1	
	4		1			1

Table 3. Group size, color, composition, and total belugas sighted during vessel surveys in the Susitna River Delta in 2008. (Unk = beluga of unknown color/size. Neonates included in calf total.)

Date	# Groups	# White	# Gray	# Calves	# Unk	Total Belugas Sighted	# Neonates
21-May-08	0	0	0	0	0	0	0
17-Jun-08	0	0	0	0	0	0	0
19-Jun-08	1	40	10	8	0	58	0
15-Jul-08	1	35	23	5	0	63	0
22-Jul-08	3	63	28	7	0	98	0
24-Jul-08	1	53	48	7	0	108	2
29-Jul-08	1	68	44	9	0	121	0
6-Aug-08	2	65	45	8	0	118	2
Total	9	324	198	44	0	566	4

Table 4. Group size, color composition, and total belugas sighted during vessel surveys in Knik Arm during 2008. (Unk = beluga of unknown color/size. Neonates included in calf total.)

Date	# Groups	# White	# Gray	# Calves	# Unk	Total Belugas Sighted	# Neonates
21-May-08	0	0	0	0	0	0	0
17-Jun-08	0	0	0	0	0	0	0
18-Aug-08	2	29	17	6	0	52	2
22-Aug-08	3	26	10	5	5	46	3
27-Aug-08	3	21	26	6	0	53	4
2-Sep-08	1	20	15	12		47	4
12-Sep-08	2	17	15	4	0	36	1
15-Sep-08	4	25	22	5	0	52	3
26-Sep-08	1	5	3	2	0	10	1
28-Oct-08	1	15	11	6	0	32	0
Total	17	158	119	46	5	328	18

Table 5. Group size, color, composition, and total belugas sighted during land surveys of Turnagain Arm in 2008. (Unk = beluga of unknown color/size. Neonates included in calf total.)

Date	# Groups	# White	# Gray	# Calves	# Unk	Total Belugas Sighted	# Neonates
22-Aug-08	1	18	5	2	0	25	0
25-Aug-08	2	11	5	1	0	17	0
29-Aug-08	2	17	5	1	0	23	0
5-Sep-08	1	2	1	1	0	4	0
7-Sep-08	1	0	0	1	25	26	1
12-Sep-08	1	10	2	0	0	12	0
21-Sep-08	1	5	1	2	0	8	0
27-Sep-08	1	0	0	0	65	65	0
28-Sep-08	2	0	0	0	35	35	0
29-Sep-08	1	20	10	1	0	31	0
8-Oct-08	1	12	8	3	2	25	0
22-Oct-08	1	4	1	0	0	5	0
Total	15	99	38	12	127	276	1

Table 6. Group size, color, composition, and total belugas sighted during vessel surveys in Chickaloon Bay in 2008. (Unk= beluga of unknown color/size. Neonates included in calf total.)

Date	# Groups	# White	# Gray	# Calves	# Unk	Total Belugas Sighted	# Neonates
17-Jun-08	0	0	0	0	0	0	0
30-Sep-08	1	21	16	5	0	42	2

Table 7. Group size, color, composition, and total belugas sighted during vessel and land surveys at the Port of Anchorage in 2008. (Unk = beluga of unknown color/size. Neonates included in calf total.)

Date	# Groups	# White	# Gray	# Calves	# Unk	Total Belugas Sighted	# Neonates
21-May-08	0	0	0	0	0	0	0
17-Jun-08	0	0	0	0	0	0	0
19-Jun-08	0	0	0	0	0	0	0
15-Jul-08	0	0	0	0	0	0	0
22-Jul-08	0	0	0	0	0	0	0
24-Jul-08	1	4	0	0	0	4	0
29-Jul-08	0	0	0	0	0	0	0
6-Aug-08	0	0	0	0	0	0	0
18-Aug-08	2	7	5	2	0	14	1
22-Aug-08	1	4	1	0	0	5	0
27-Aug-08	0	0	0	0	0	0	0
2-Sep-08	0	0	0	0	0	0	0
12-Sep-08	0	0	0	0	0	0	0
15-Sep-08	0	0	0	0	0	0	0
26-Sep-08	0	0	0	0	0	0	0
30-Sep-08	0	0	0	0	0	0	0
28-Oct-08	0	0	0	0	0	0	0
Total	4	15	6	2	0	23	1

Table 8. Percent color composition of beluga whale sightings from surveys conducted in 2008 from vessels and land in Upper Cook Inlet, Alaska, according to location surveyed.

Area	Survey Method	# Beluga Sightings	White	Gray	Calves	Unk
Susitna River Delta	vessel	566	57%	35%	8%	0%
Knik Arm	vessel	328	48%	36%	14%	2%
Chickaloon Bay	vessel	23	65%	26%	9%	0%
Port of Anchorage	vessel and land	42	50%	38%	12%	0%
Turnagain Arm	land	276	36%	14%	4%	46%
All Areas 2008		1235	50%	30%	9%	11%

Table 9. Total project survey effort and beluga whale group encounters 2005-2008, Upper Cook Inlet, Alaska.

	2005	2006	2007	2008	Total
Number Photo-identification survey days	49	33	17	29	128
Number Photos taken	44,878	21,244	4,193	13,222	83,537
Range of Surveys	14 April -21 Oct	12 May- 5 Oct	28 June - 27 Oct	21 May-28 Oct	
Span	6 months	5 months	4 months	5 months	20
Number Groups Photographed	120	162	34	46	362
Areas Surveyed	Knik Arm, Susitna Flats, Turnagain Arm	Knik Arm, Susitna River Delta, Turnagain Arm	Knik Arm, Susitna River Delta, Turnagain Arm, Chickaloon Bay	Knik Arm, Susitna River Delta, Turnagain Arm, Chickaloon Bay	

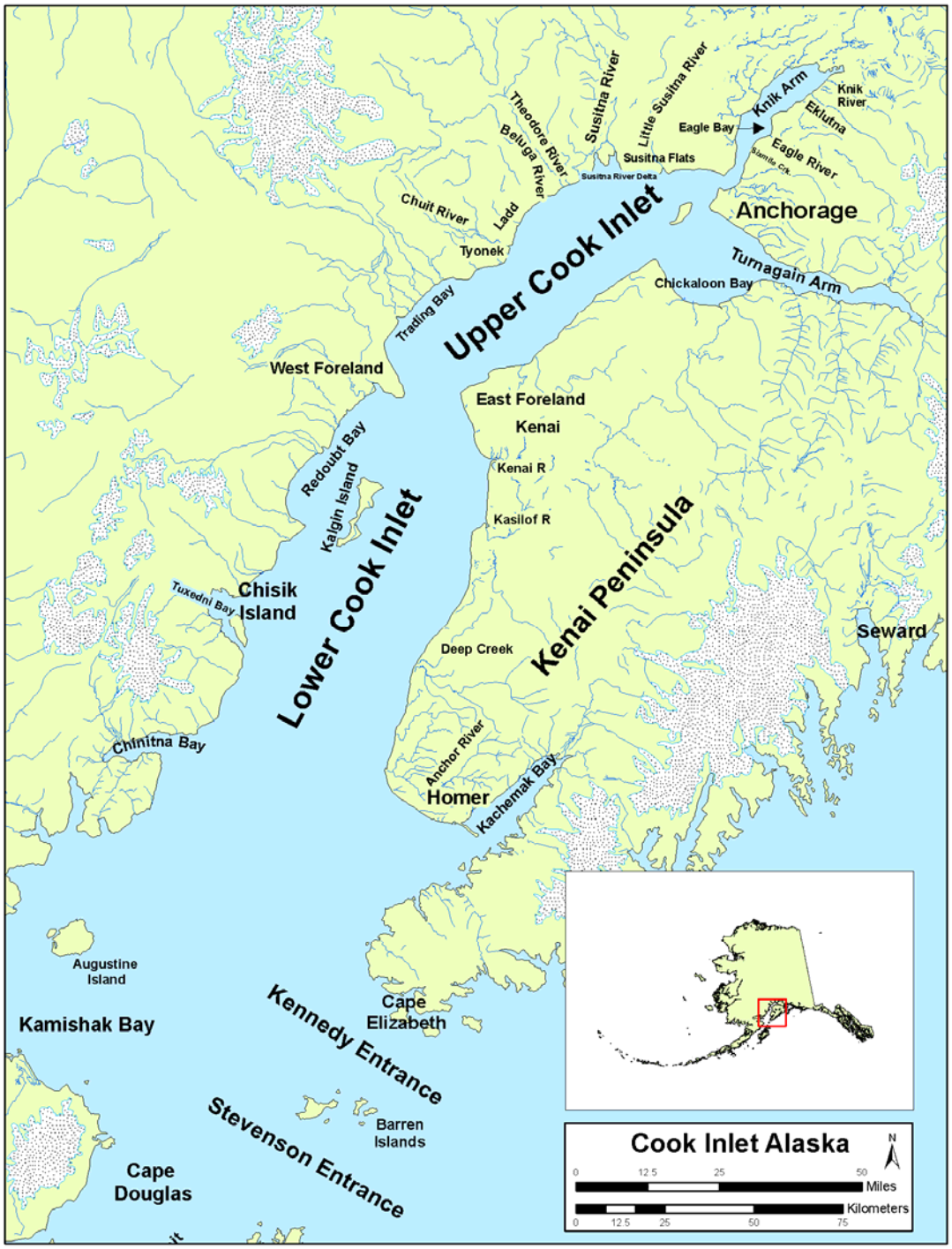

Figure 1. Map of Cook Inlet, Alaska, showing major features discussed in the text.

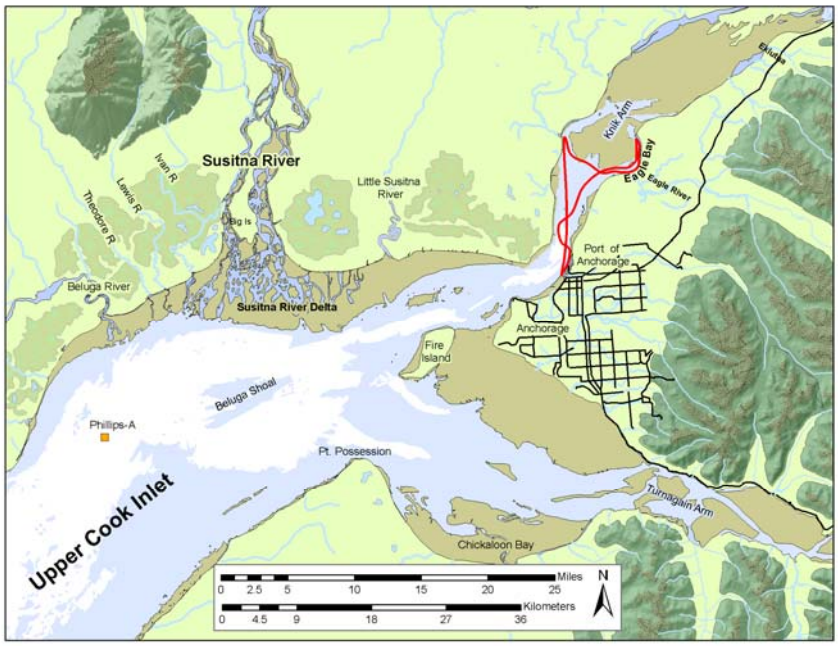

Figure 2. Knik Arm vessel survey route (red) used in 2008 to observe and photograph beluga whales.

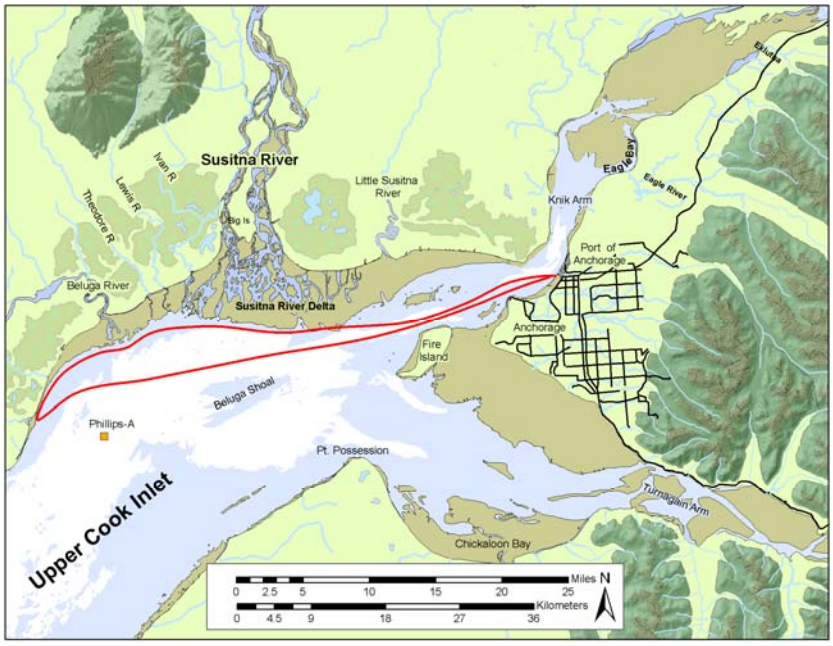

Figure 3. Susitna River Delta vessel survey route (red) used in 2008 to observe and photograph beluga whales.

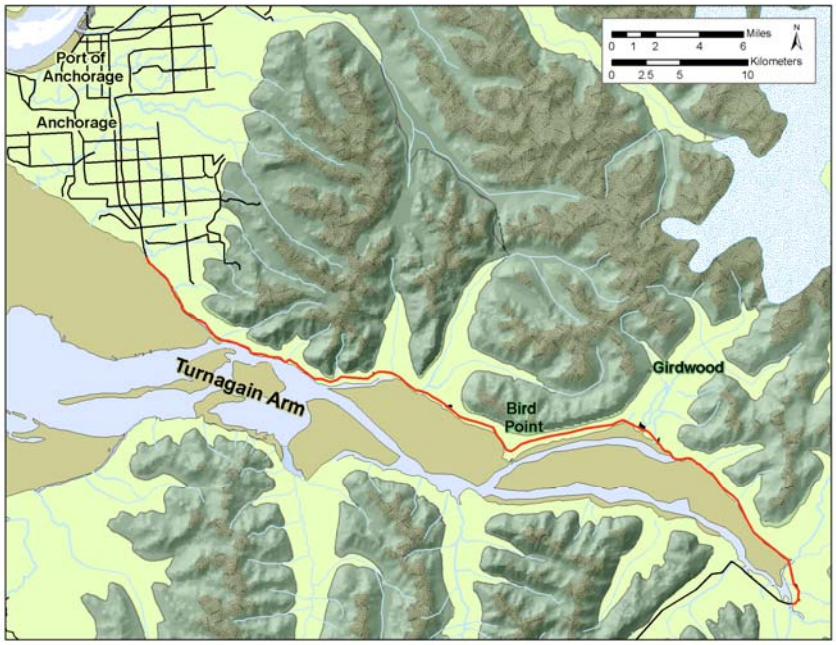

Figure 4. Turnagain Arm land survey route (red) along the Seward Highway, used in 2008 to observe and photograph beluga whales.

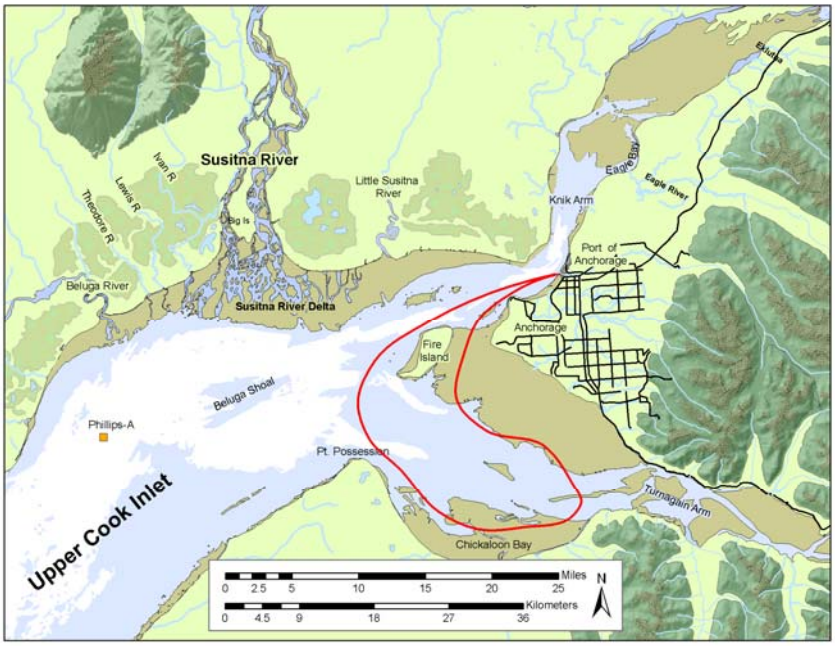

Figure 5. Chickaloon Bay vessel survey route (red) used in 2008 to observe and photograph beluga whales.

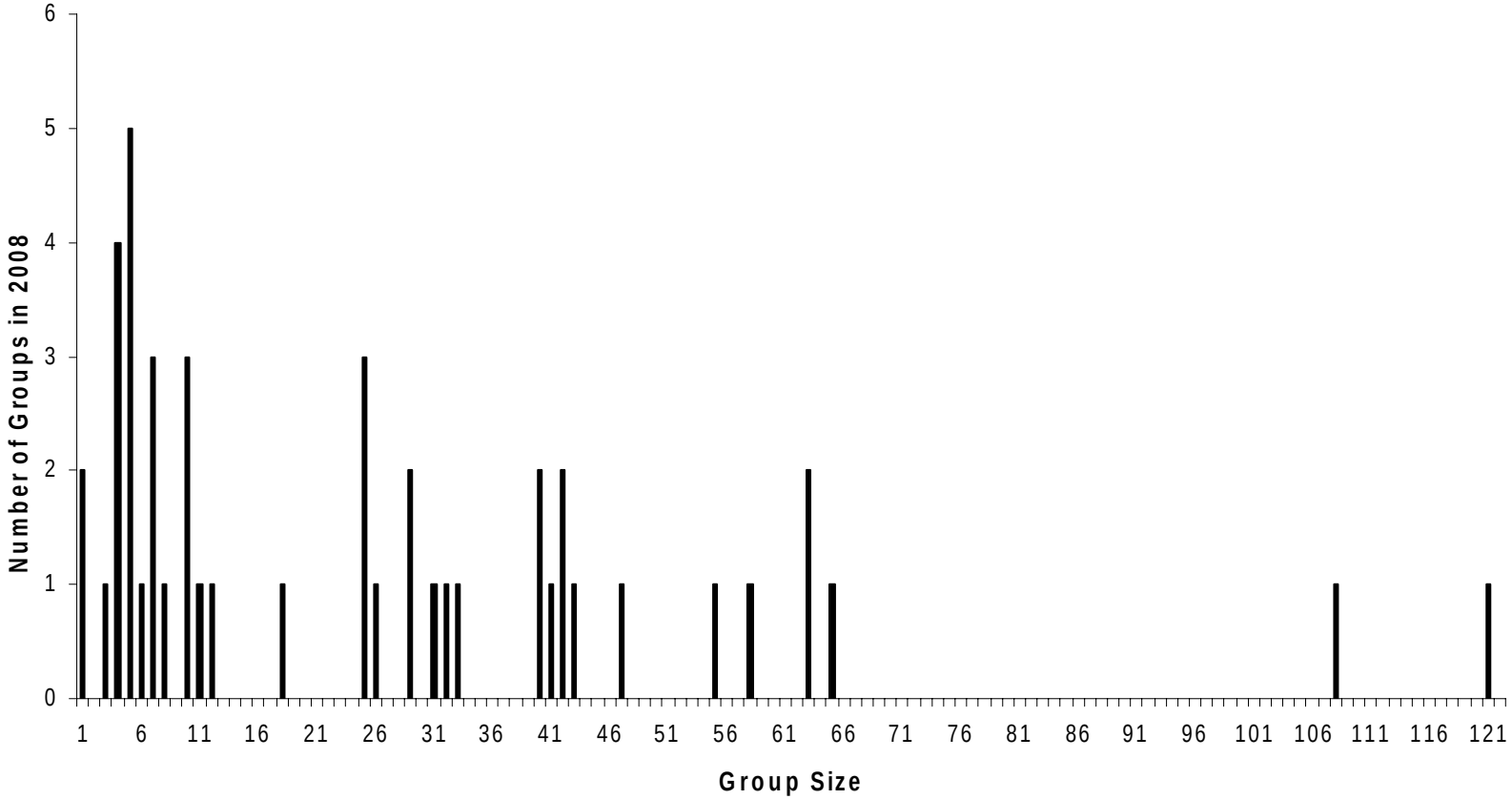

Figure 6. Group-size frequency distribution of beluga whales encountered during photo-identification surveys of Upper Cook Inlet conducted from land and vessels in 2008 (n = 46 groups).

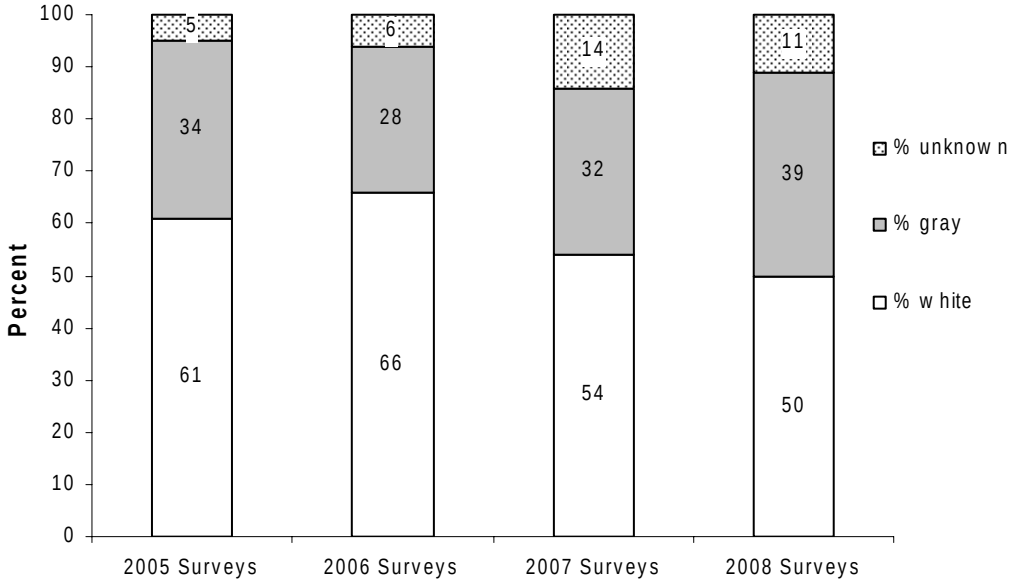

Figure 7. Color composition (percent) of whale groups observed during photo-identification surveys of Upper Cook Inlet, Alaska in 2005, 2006, 2007, and 2008.

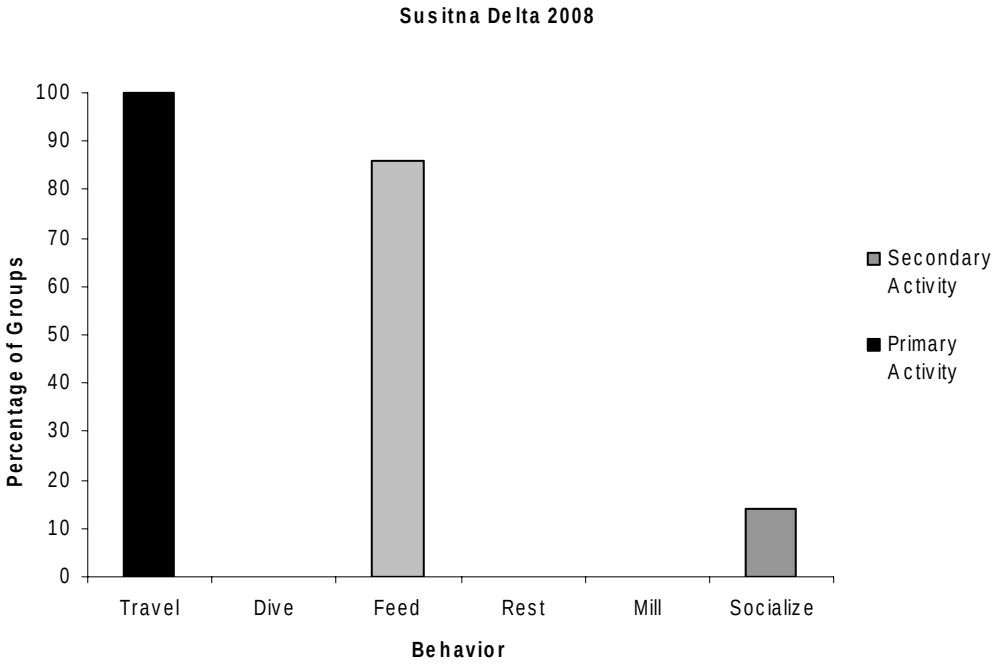

Figure 8a. Summary of behavior of beluga groups encountered in 2008 during vessel and land surveys in the Susitna Delta.

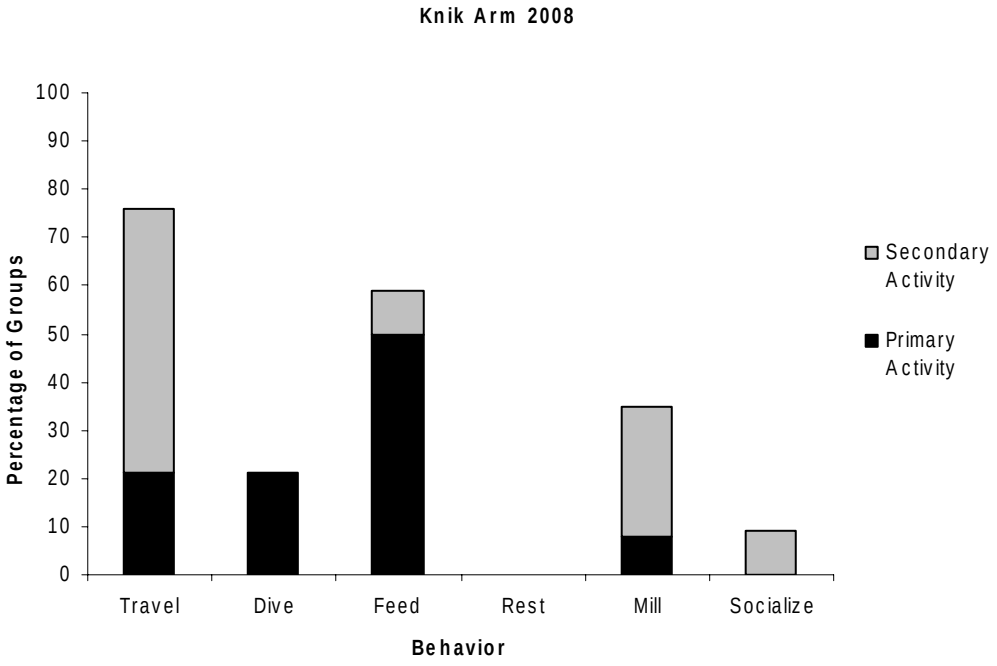

Figure 8b. Summary of behavior of beluga groups encountered in 2008 during vessel and land surveys in Knik Arm.

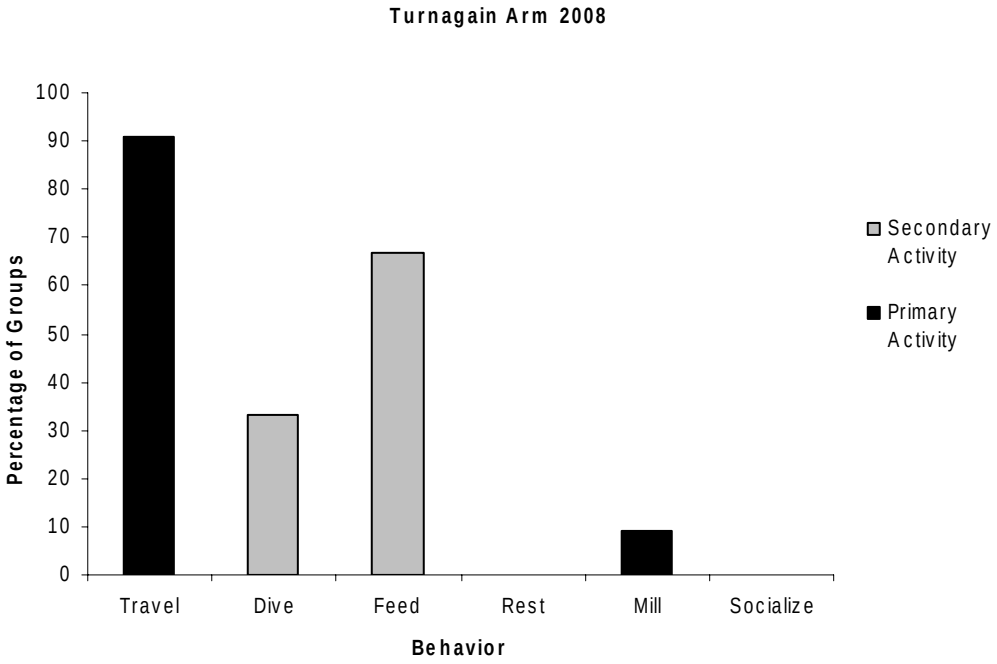

Figure 8c. Summary of behavior of beluga groups encountered in 2008 during vessel and land surveys in Turnagain Arm.

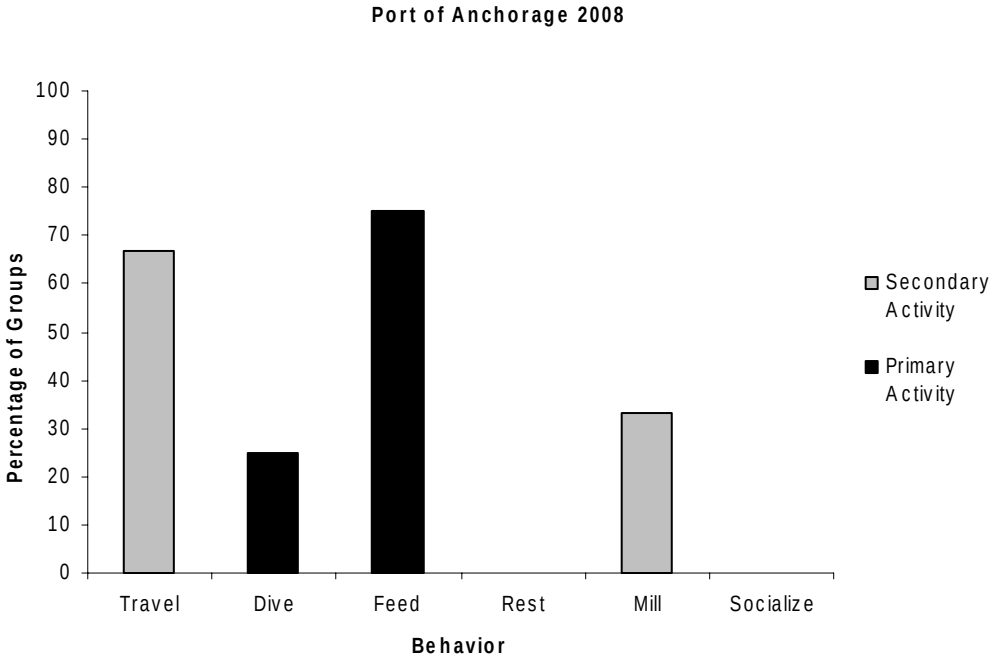

Figure 8d. Summary of behavior of beluga groups encountered in 2008 during vessel and land surveys at the Port of Anchorage.

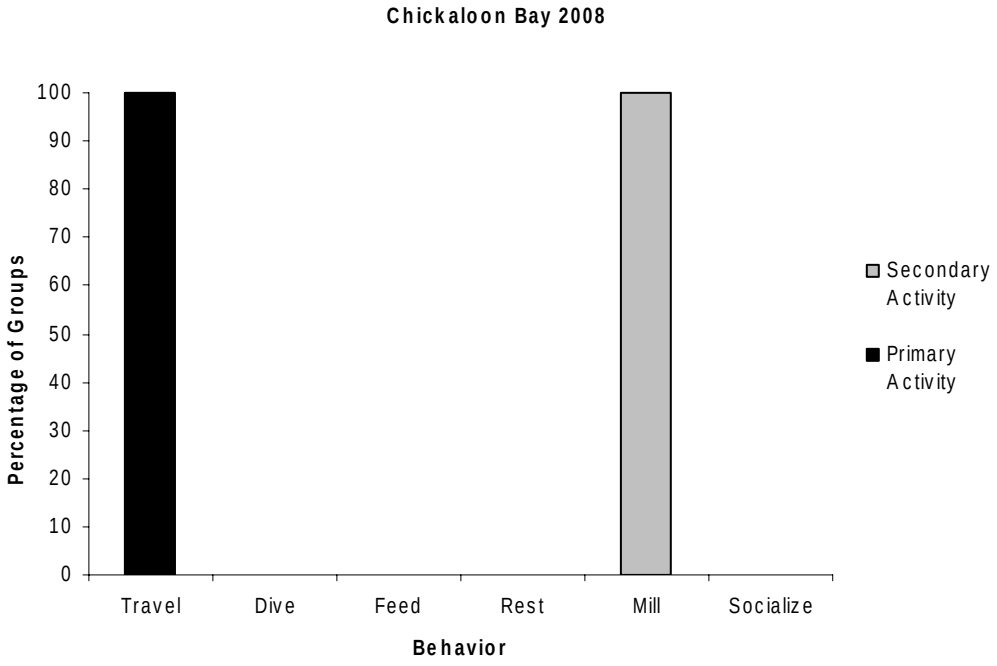

Figure 8e. Summary of behavior of beluga groups encountered in 2008 during vessel and land surveys in Chickaloon Bay.

APPENDIX A.

BELUGA WHALE GROUPS ENCOUNTERED DURING LAND- AND VESSEL-BASED SURVEYS CONDUCTED IN UPPER COOK INLET, ALASKA: DAILY SURVEY TRACKS AND LOCATIONS OF WHALES, 2008 FIELD SEASON

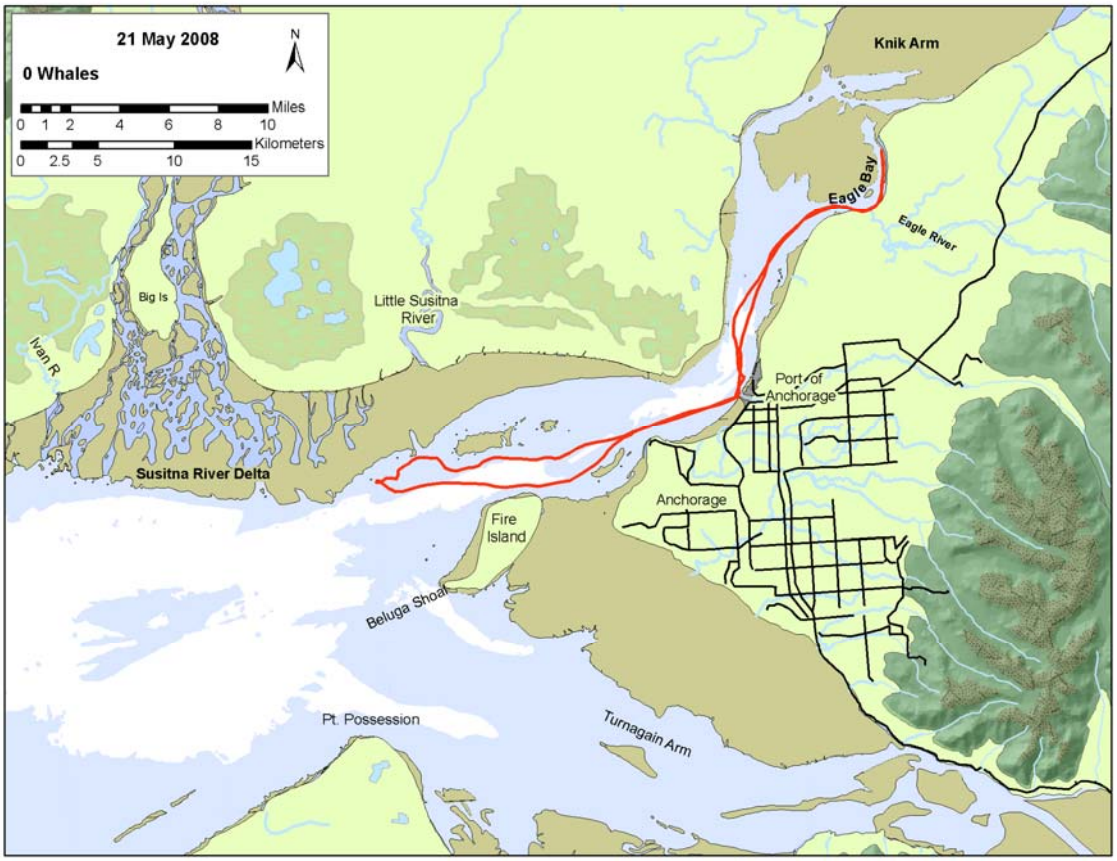

Figure A1. Beluga whale groups encountered and route of 21 May 2008 vessel-based survey of Upper Cook Inlet, Alaska. No whales were encountered on this day.

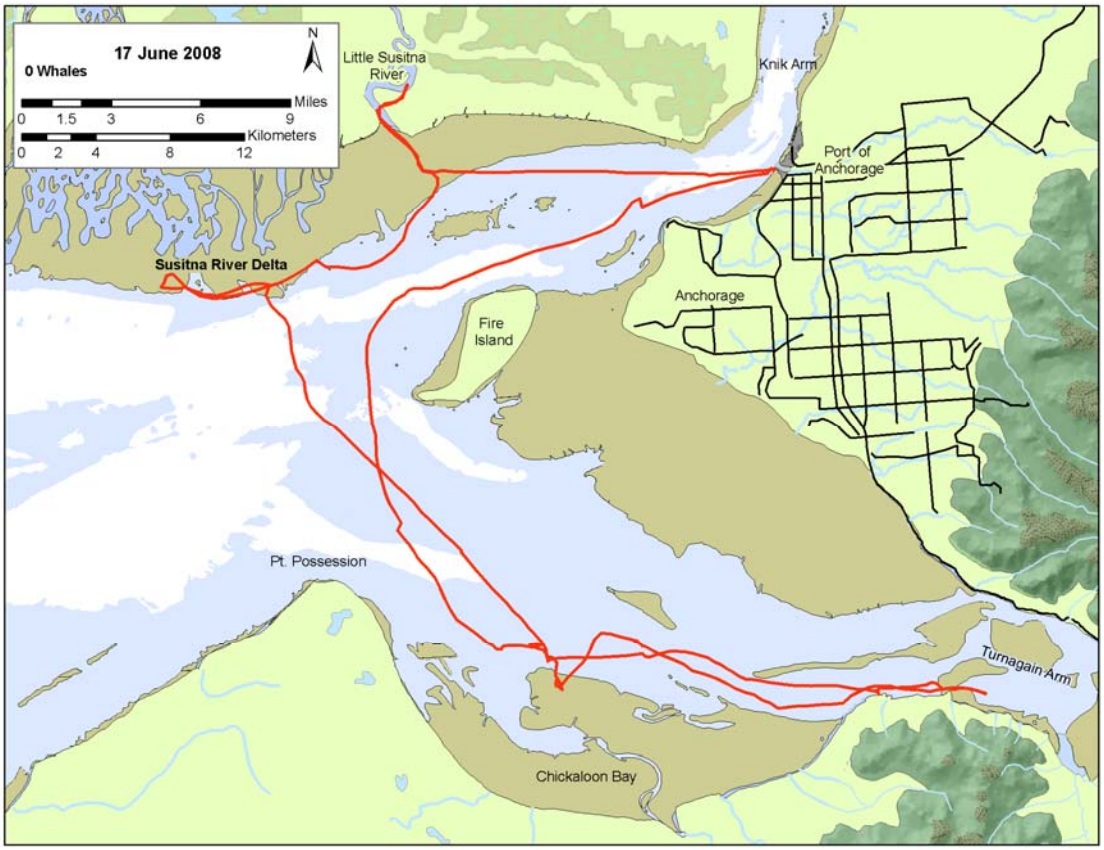

Figure A2. Beluga whale groups encountered and route of 17 June 2008 vessel-based survey of Upper Cook Inlet, Alaska. No whales were encountered on this day.

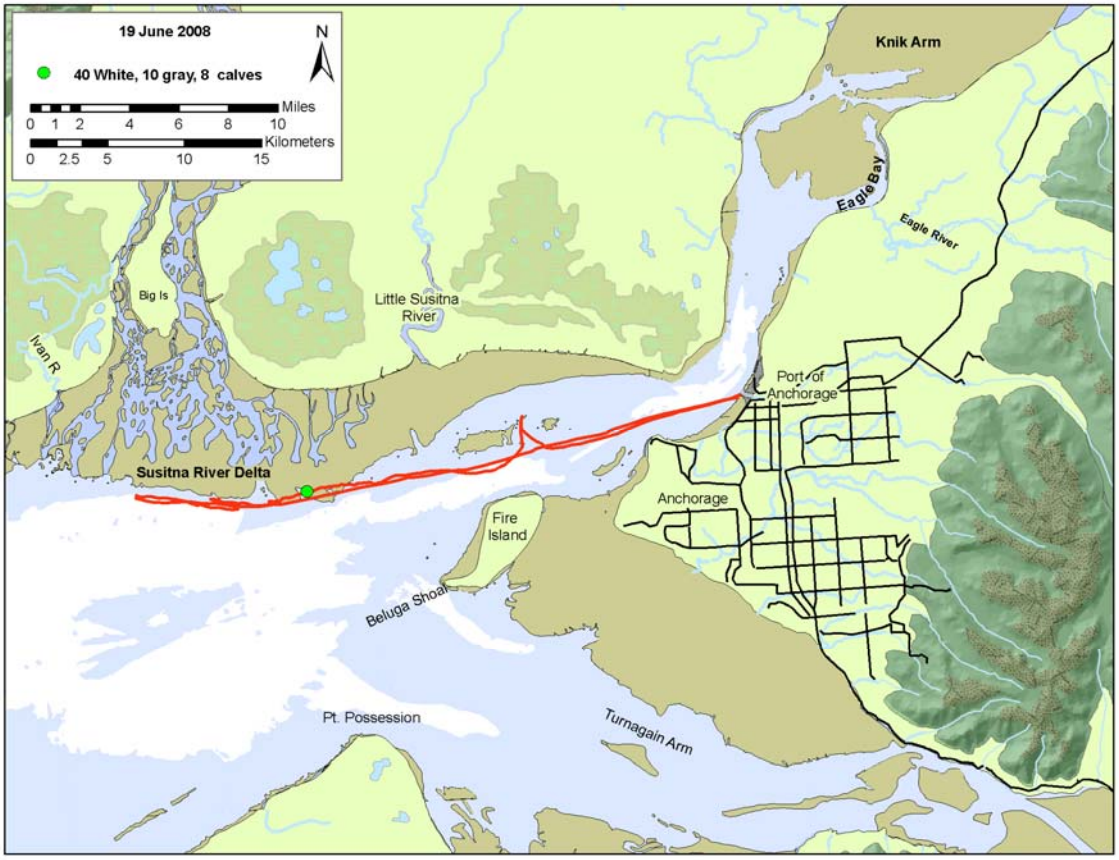

Figure A3. Beluga whale groups encountered and route of 19 June 2008 vessel-based survey of Upper Cook Inlet, Alaska.

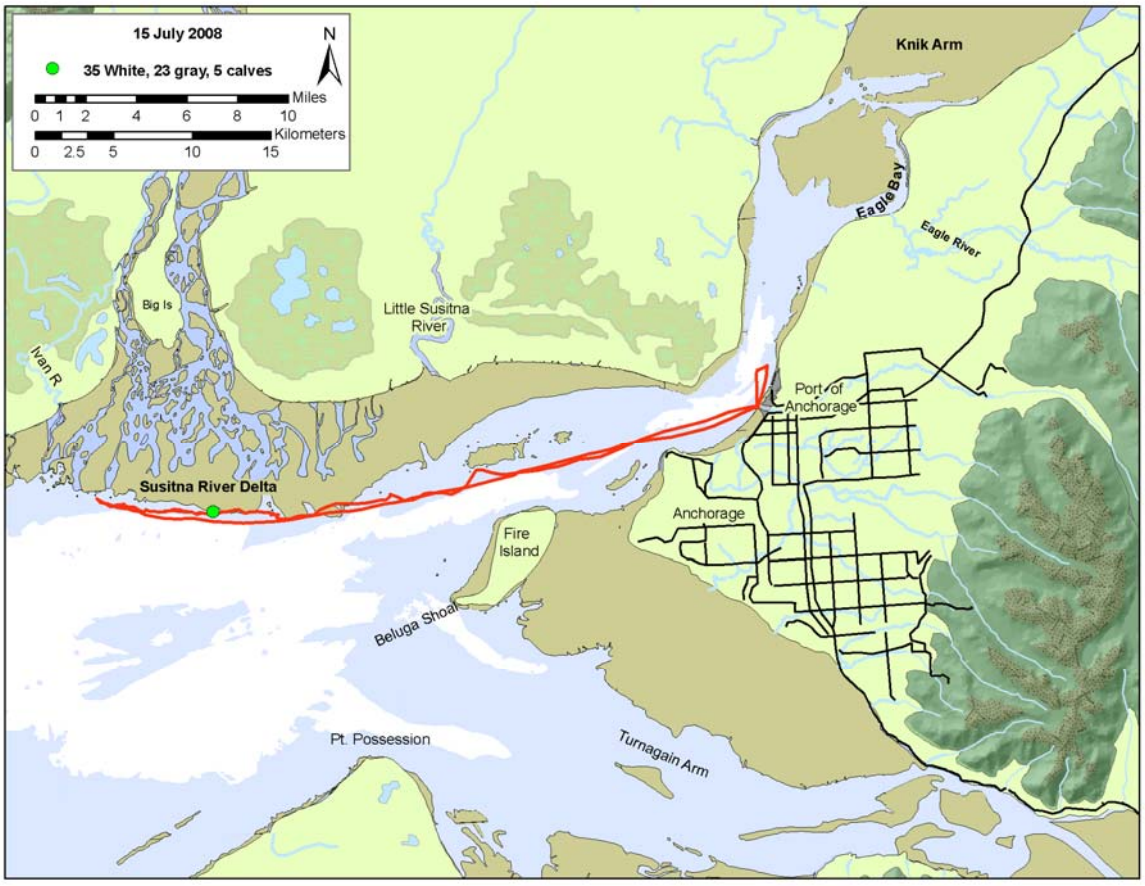

Figure A4. Beluga whale groups encountered and route of 15 July 2008 vessel-based survey of Upper Cook Inlet, Alaska.

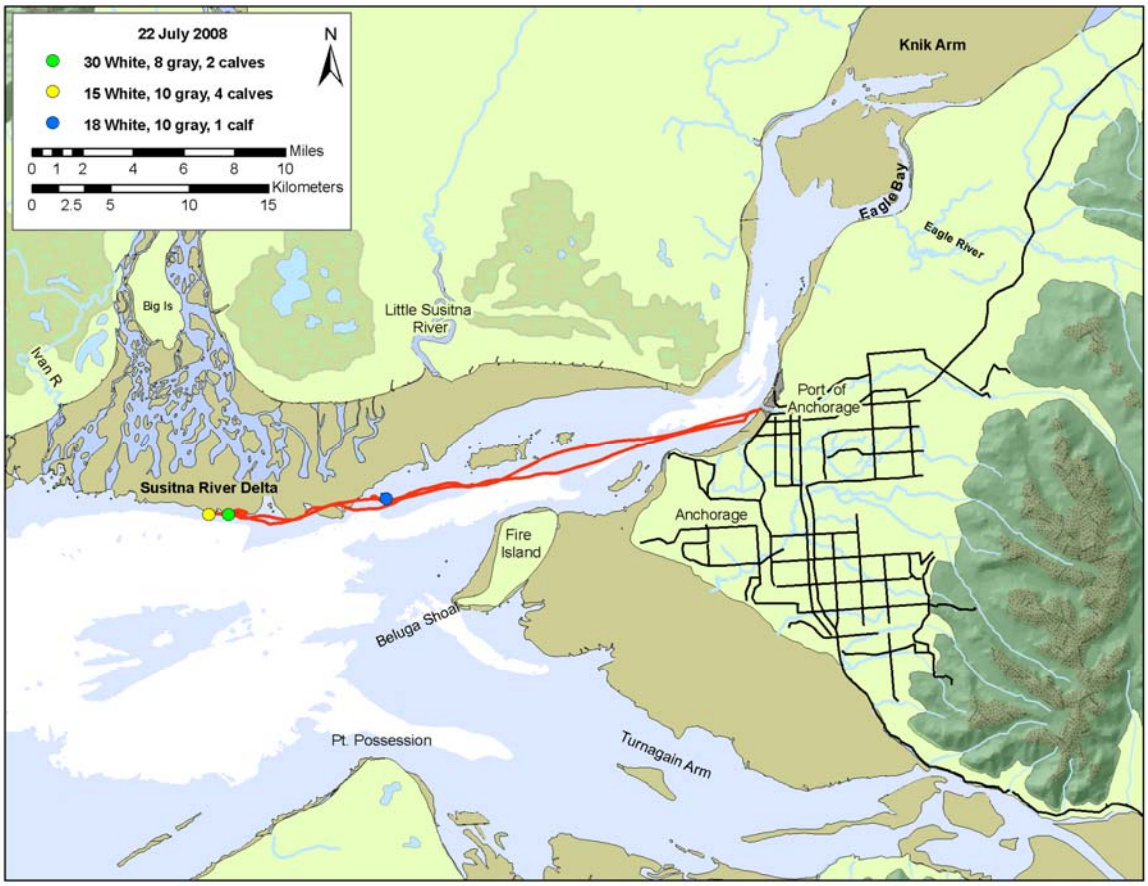

Figure A5. Beluga whale groups encountered and route of 22 July 2008 vessel-based survey of Upper Cook Inlet, Alaska.

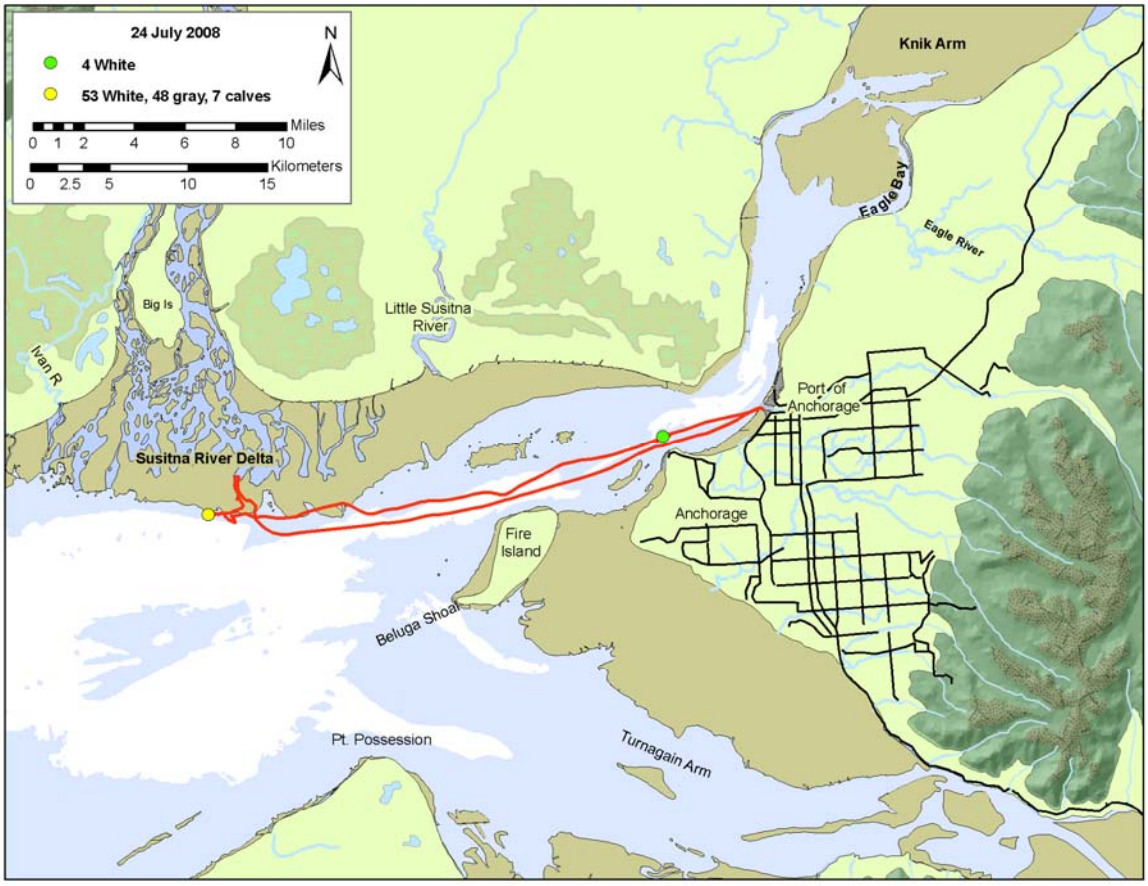

Figure A6. Beluga whale groups encountered and route of 24 July 2008 vessel-based survey of Upper Cook Inlet, Alaska.

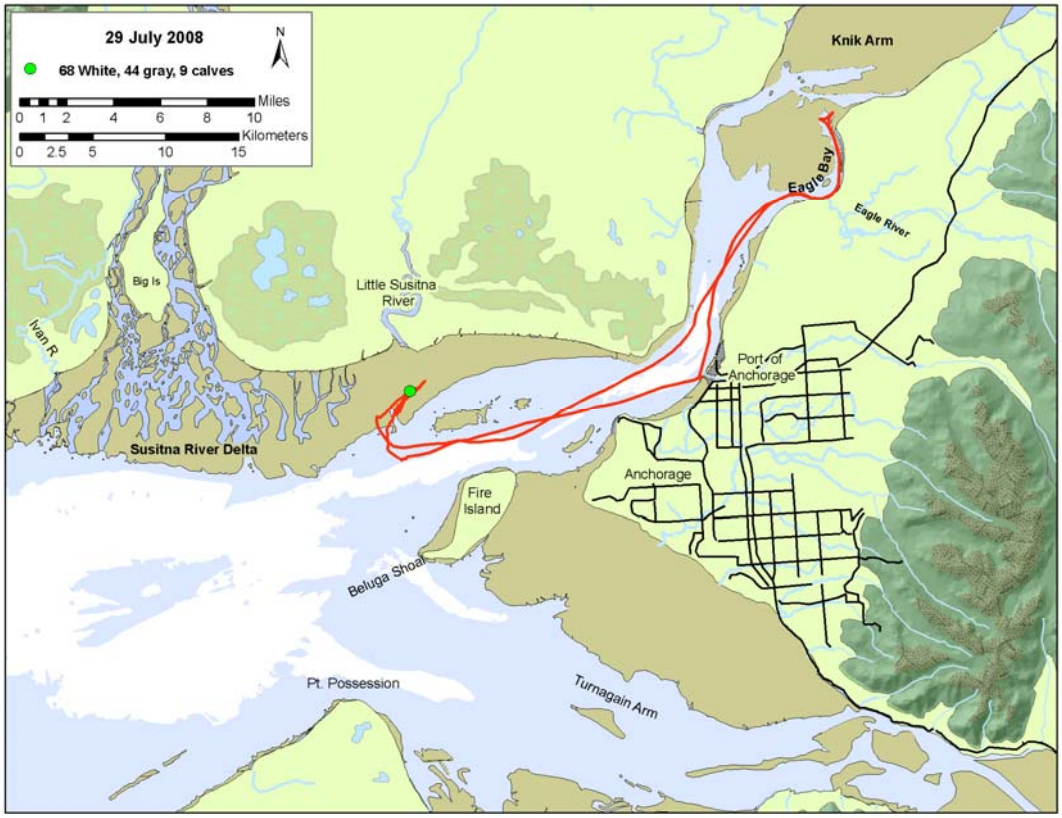

Figure A7. Beluga whale groups encountered and route of 29 July 2008 vessel-based survey of Upper Cook Inlet, Alaska.

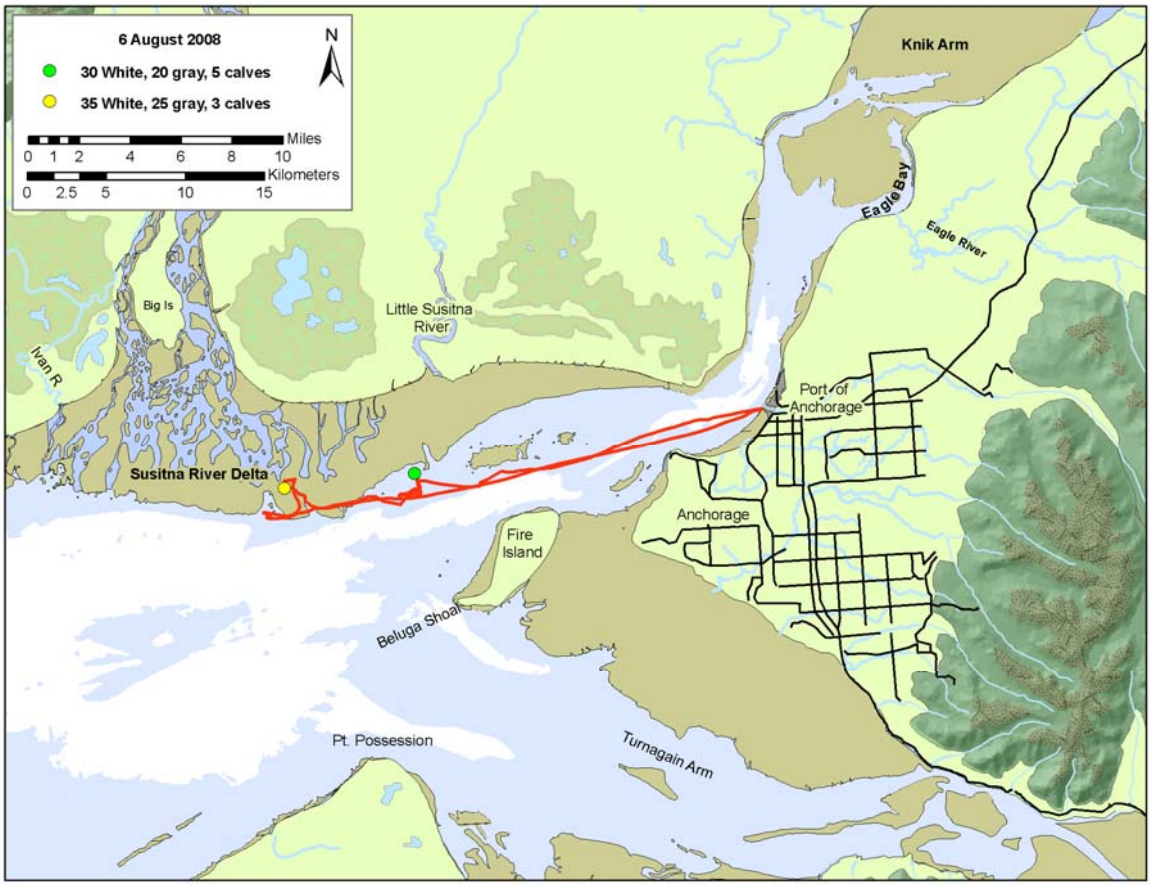

Figure A8. Beluga whale groups encountered and route of 6 August 2008 vessel-based survey of Upper Cook Inlet, Alaska.

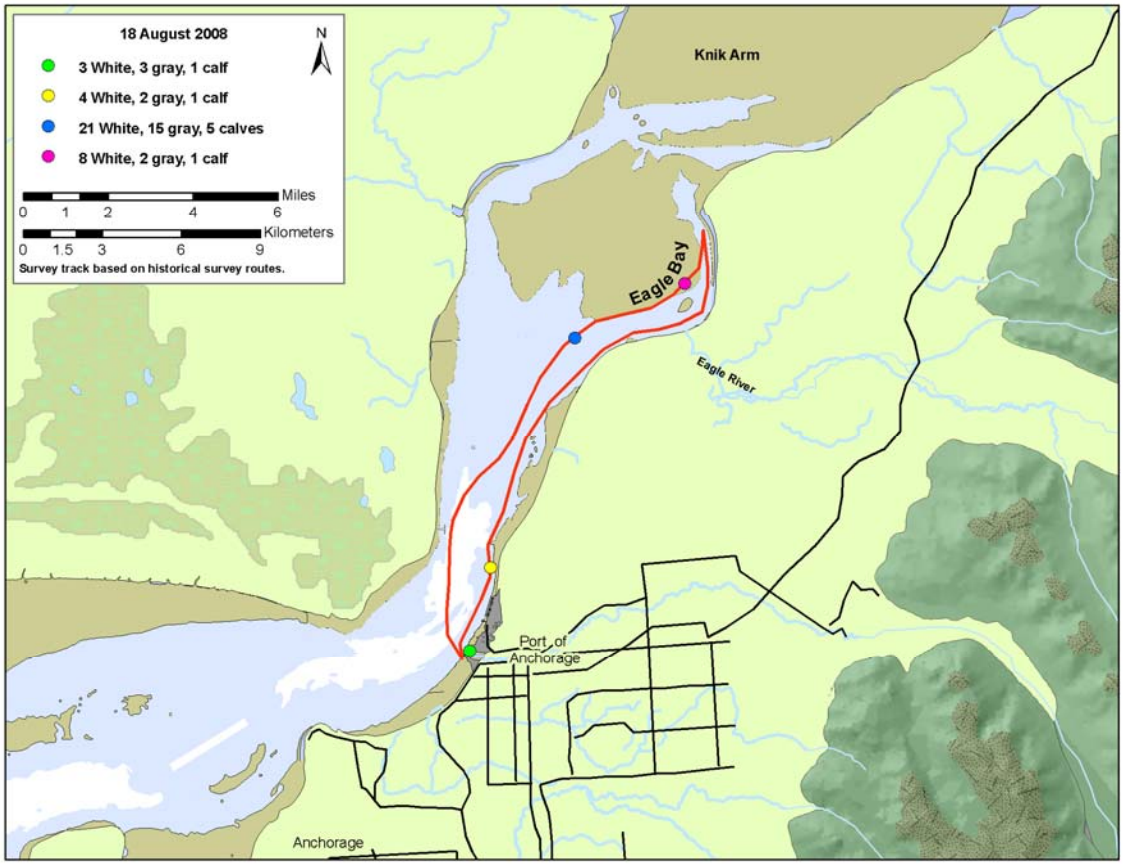

Figure A9. Beluga whale groups encountered and route of 18 August 2008 vessel-based survey of Upper Cook Inlet, Alaska.

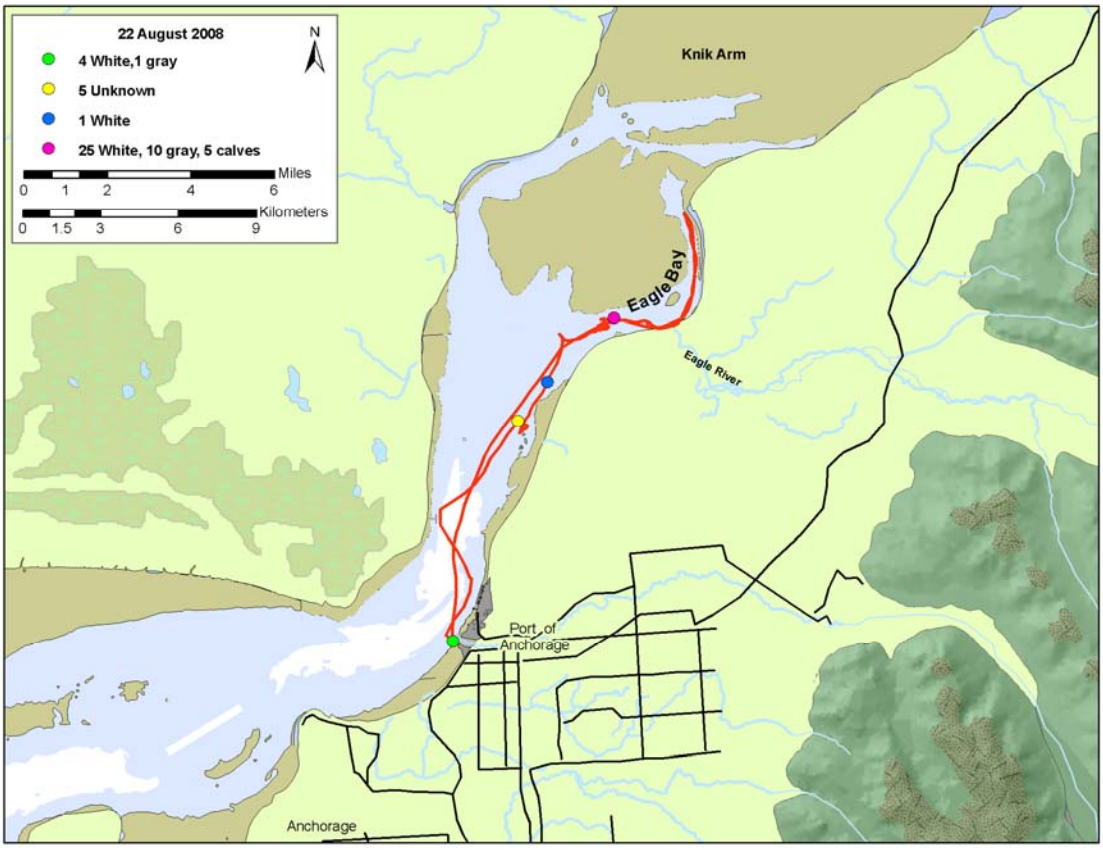

Figure A10. Beluga whale groups encountered and route of 22 August 2008 vessel-based survey of Upper Cook Inlet, Alaska.

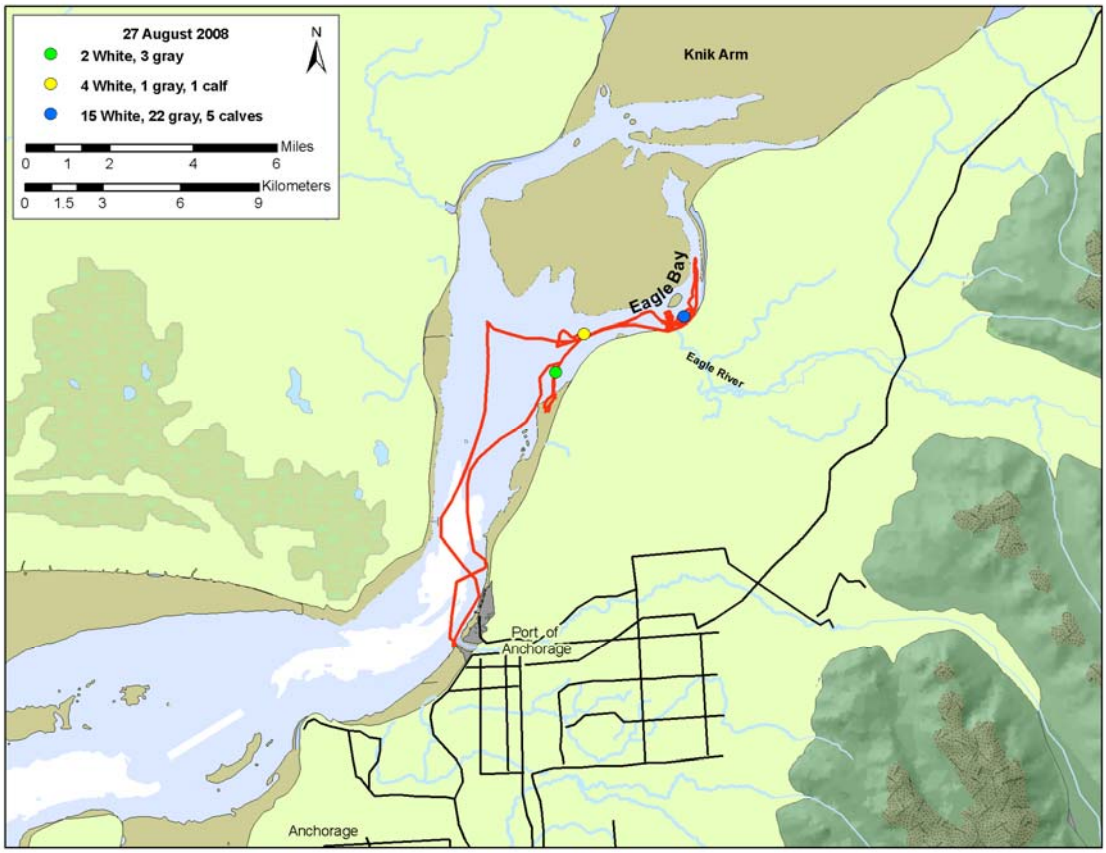

Figure A11. Beluga whale groups encountered and route of 27 August 2008 vessel-based survey of Upper Cook Inlet, Alaska.

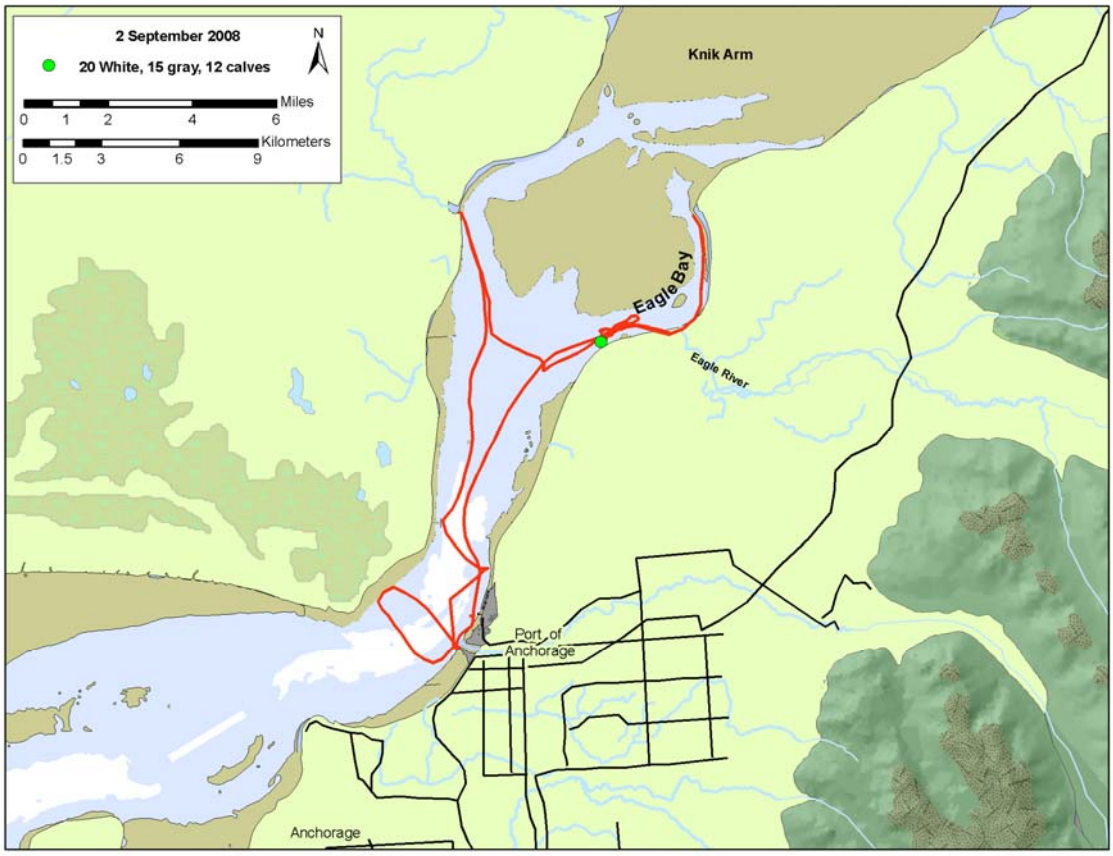

Figure A12. Beluga whale groups encountered and route of 2 September 2008 vessel-based survey of Upper Cook Inlet, Alaska.

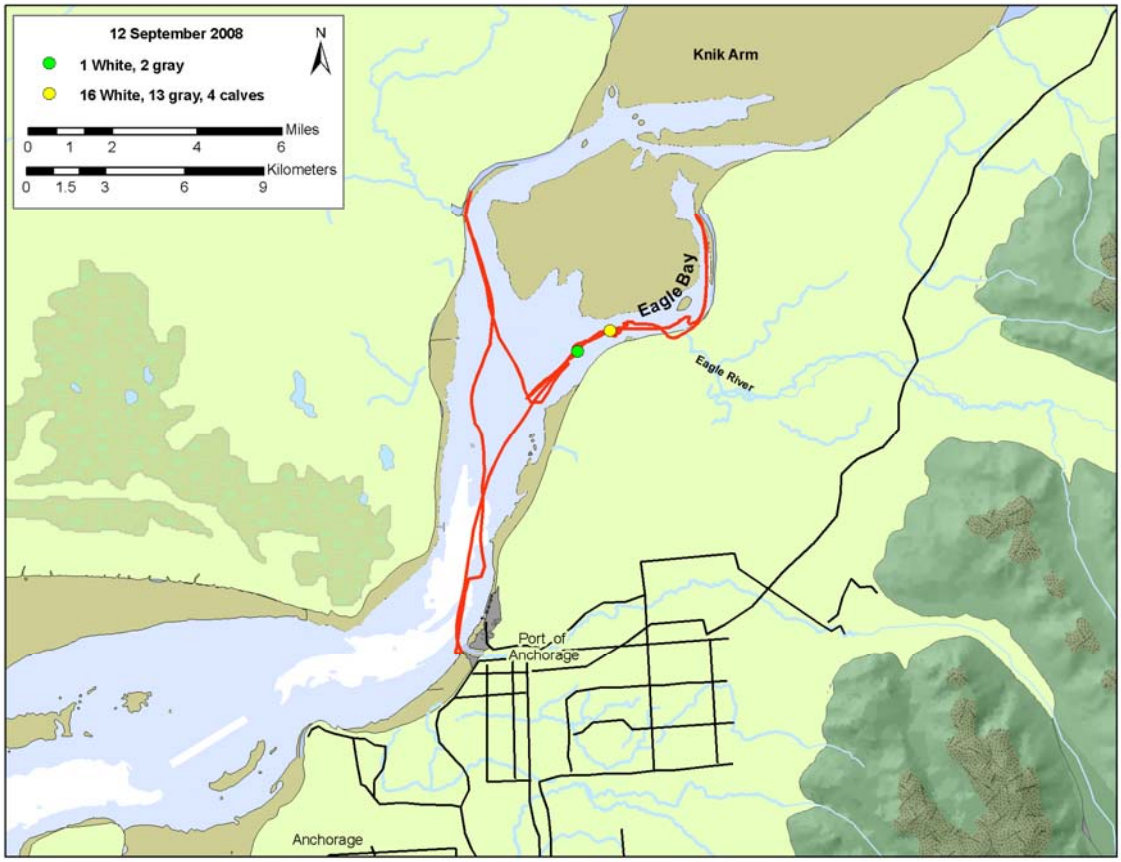

Figure A13. Beluga whale groups encountered and route of 12 September 2008 vessel-based survey of Upper Cook Inlet, Alaska.

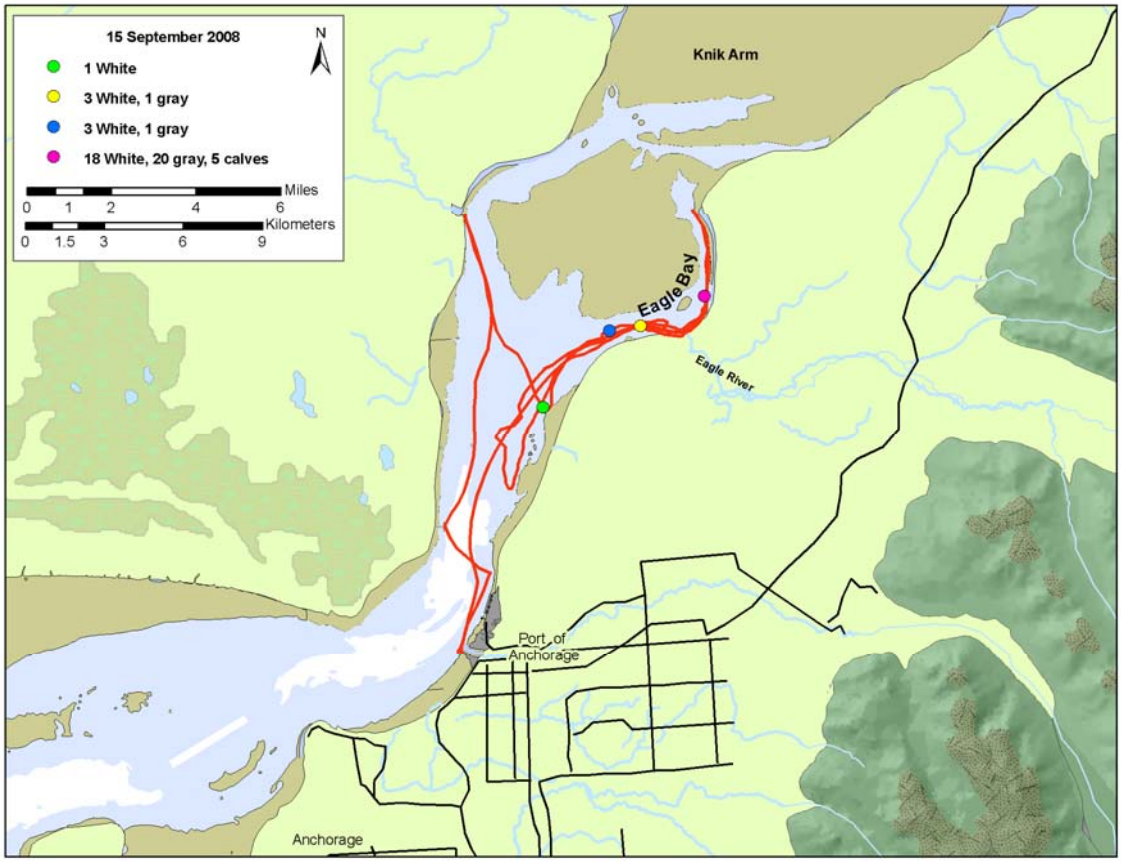

Figure A14. Beluga whale groups encountered and route of 15 September 2008 vessel-based survey of Upper Cook Inlet, Alaska.

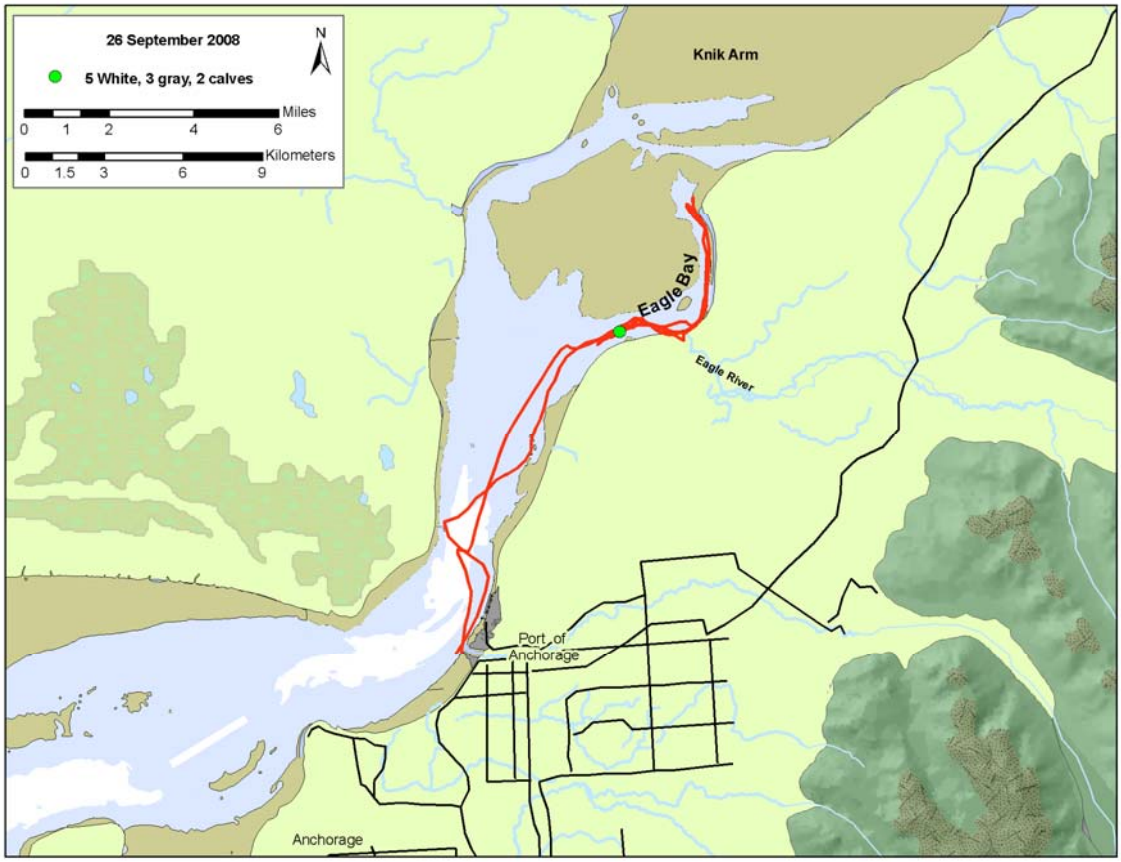

Figure A15. Beluga whale groups encountered and route of 26 September 2008 vessel-based survey of Upper Cook Inlet, Alaska.

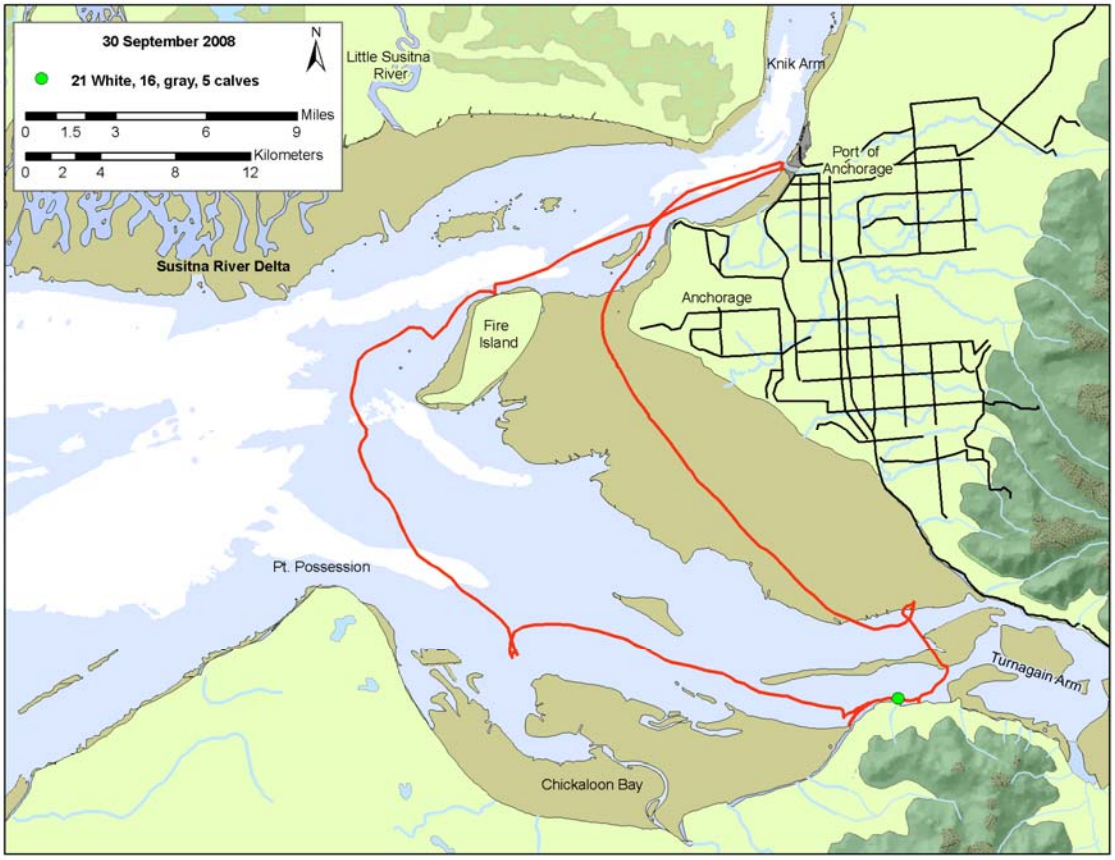

Figure A16. Beluga whale groups encountered and route of 30 September 2008 vessel-based survey of Upper Cook Inlet, Alaska.

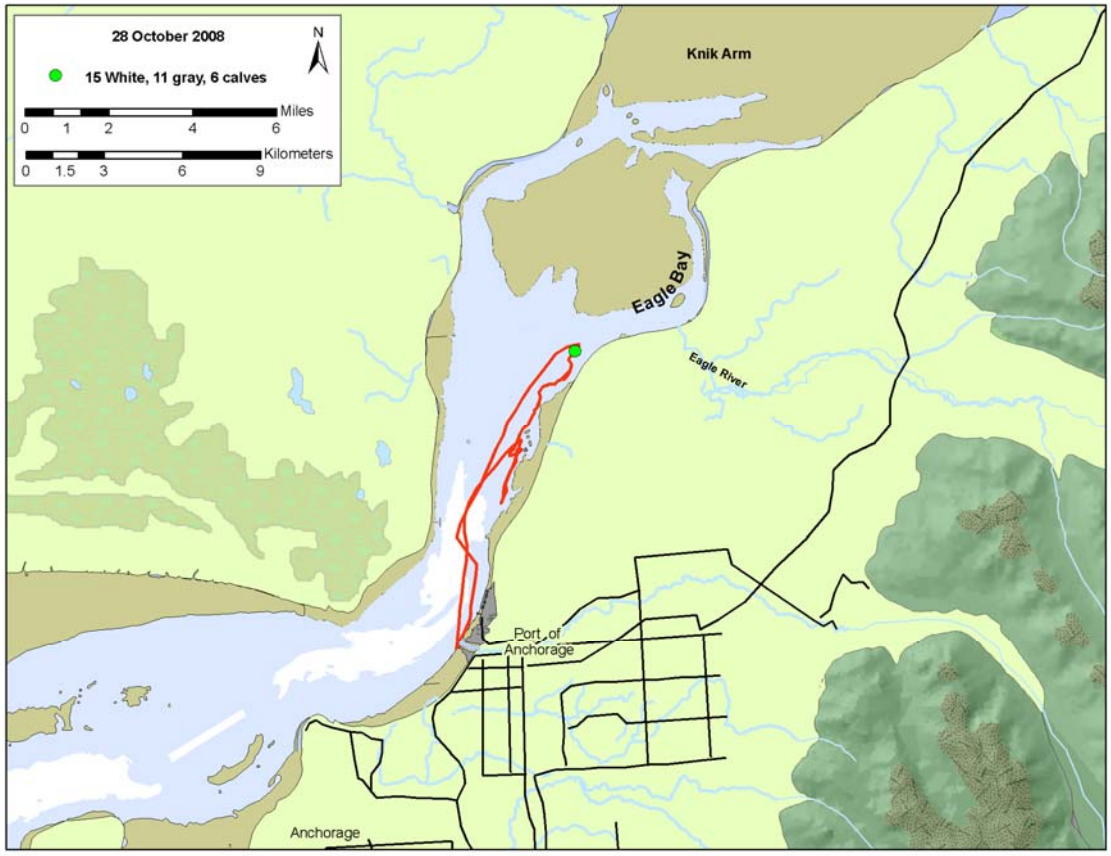

Figure A17. Beluga whale groups encountered and route of 28 October 2008 vessel-based survey of Upper Cook Inlet, Alaska.

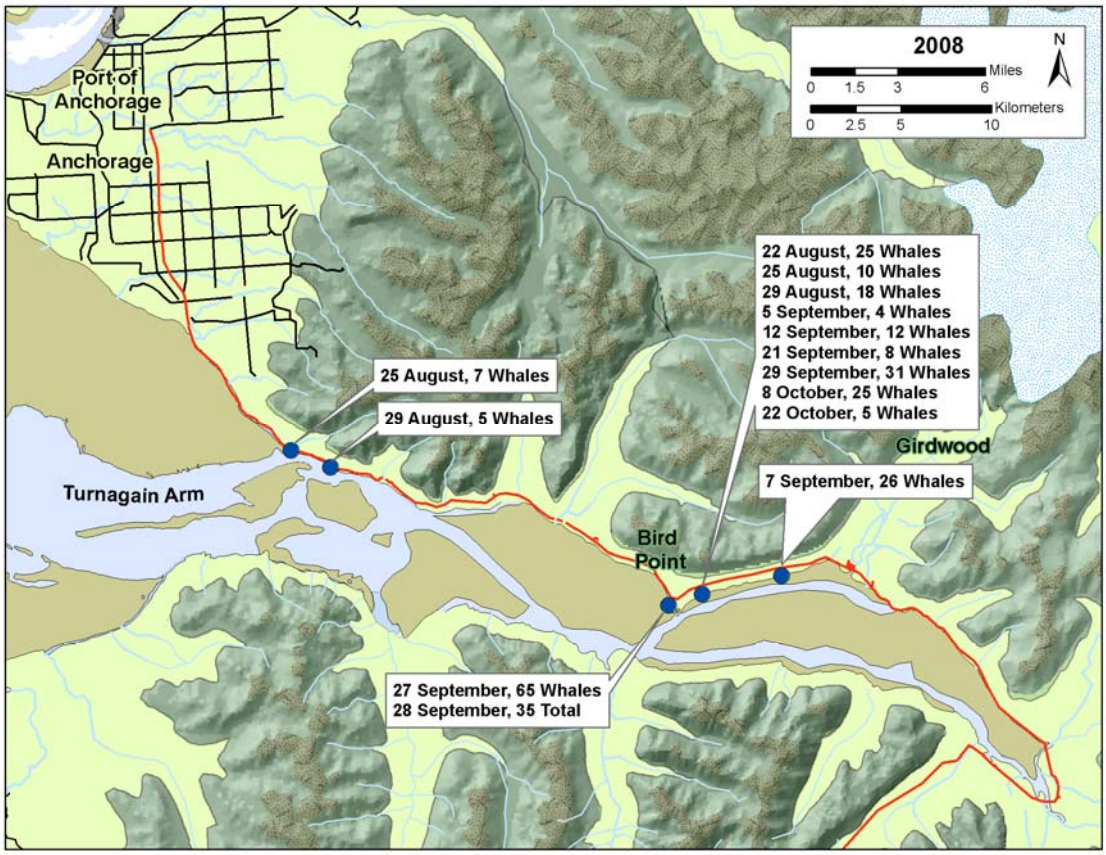

Figure A18. Beluga whale groups encountered and general survey route of all 2008 land-based surveys along Turnagain Arm, Upper Cook Inlet, Alaska.

APPENDIX B.

ANNUAL REPORT OF ACTIVITIES CONDUCTED IN 2008 UNDER GENERAL AUTHORIZATION, LETTER OF CONFIRMATION NO. 481-1795

ANNUAL REPORT OF ACTIVITIES CONDUCTED UNDER GENERAL AUTHORIZATION, LETTER OF CONFIRMATION NO. 481-1795

Submitted to NMFS, Office of Protected Resources

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November 12, 2008

Summary of research activities conducted in 2008

Vessel-based photo-identification surveys for beluga whales (*Delphinapterus leucas*) were conducted in Upper Cook Inlet from 21 May through 28 October of 2008. All surveys were conducted with the on-site supervision of the principal investigator (PI: McGuire) or co-investigator (CI: Kaplan) named on the letter of intent and in the LOC. The NMFS Regional Administrator was informed in writing more than two weeks before initiation of on-site activities. Vessel surveys were not conducted on days when the PI was notified that NMFS was conducting aerial surveys for Cook Inlet beluga whales.

Whale groups were approached by the survey vessel once per encounter, then followed slowly, parallel to the group, matching the speed and heading of the group in order to obtain images of lateral sides of all individual whales while minimizing disruption to the group. Data collected during beluga whale group encounters included counts of the estimated minimum group size, minimum number of whales present by color-class, group behavior, and digital photographs for individual whale identification. These data will be presented in the 2008 final field report, due January 2009. A final copy of the 2008 field report will be provided to NMFS.

Whales were encountered on 15 of 17 days in which photo-identification surveys were conducted from vessels (Table 1). In total, 29 groups of whales were observed, and 31.2 hours were spent in whale observations from vessels.

Potential disturbance to beluga whales during photo-identification surveys

Beluga whales were approached by the photo-identification survey vessel at no-wake speed, and paralleled during observations. At no time were whales approached at full throttle, and whales were never chased. Mean duration of encounter with groups of whales was 64.6 min/group (for a mean of 1.9 min/whale encountered), but varied greatly depending on group size range (1-178 min/group). Beluga groups were first detected from the research vessel at a mean distance of 281.4 meters (range 50-700 meters), and the mean minimum distance between beluga whales and the research vessel was 50.7 meters (range 1-300 meters).

In 2007, we spent a mean of 3.2 min/beluga, whereas in 2008 we reduced the time to a mean of 1.9 min/beluga. More boat-based surveys were conducted in 2008 than in 2007 (17 surveys and 7 surveys, respectively), and more groups were encountered (29 groups in 2008 and 20 groups in 2007).

Although there is no question that whales could hear the motor at low idle, they generally appeared habituated to the presence of the vessel. For example, photographs taken during the photo-identification project show repeated sightings of individuals on multiple days, supporting the notion that the whales had the opportunity to habituate to the vessel over time. In addition, very few perceptible possible short-term responses to the vessel were noted, the most common being apparent affiliative or play behavior, such as approaching the vessel and bubble blowing, which was exhibited most often by gray beluga whales. When whales approached within ~2 m of the boat, the engine was put into neutral and/or turned off. Whales were not displaced from any of the areas where they were regularly observed from the boat or land, and were consistently observed near and within concentration areas such as Eagle Bay and the Susitna, Little Susitna, and Beluga Rivers.

Research activities did not result in taking which exceeded Level B harassment. Level B harassment may have occurred on three occasions in 2008 (August 6, group 1; September 15, group 2; and Oct. 28, group 1). In all of these instances, whales seemed difficult to approach and photograph; in all instances this difficulty was noted during the initial observation of the group. Whales were seen to breath at the surface of the water, but were not observed to display a typical "arch and roll", nor did they appear to dive. Although whales appeared to avoid the survey boat, they remained within the vicinity (<500 m from original sighting). In such instances, observers decided to move the vessel away and search for other whale groups. On August 18, group 2 was approached by another vessel that appeared to pursue the group and approached <100 m. We documented the registration number of the boat, moved away from the group, and reported the incident to NMFS Office of Law Enforcement.

Potential disturbance to other marine mammals

Harbor seals were occasionally observed during surveys, but were not approached in the course of this research. No other marine mammal species were seen.

Progress in meeting research objectives

We made progress toward meeting the research objectives stated in the Letter of Intent, adding to knowledge of beluga whale use of Upper Cook Inlet, Alaska. As described in the Letter of Intent, this includes research conducted "in Cook Inlet to examine patterns of beluga whale occupancy and use".

Use of data and photographs

Photographs and data collected in 2008 under this permit will be used in the annual project report (a final copy will be sent to NMFS in January 2009). In addition, some photographs were included in an invited talk (Kaplan et. al 2008) presented to the Alaska Beluga Whale Committee. A photograph taken in July 2008 of a beluga whale with a large lesion was circulated to NMFS-AK, NMML, biologists with the US Army at Fort Richardson (AK), and several veterinarians associated with the Alaska Marine Mammal Stranding Network.

All 2008 photographs used in reports, posters, and publications were taken by Tamara McGuire (PI), Chris Kaplan (CI), or Megan Blees (CI). All photographs were/will be accompanied by a statement referring to the General Authorization, including the file number provided by NMFS in the confirmation letter.

Literature cited

Kaplan, Chris C., Tamara L. McGuire, Megan K. Blees, Guy D. Wade, and Michael R. Link. 2008. PHOTO-IDENTIFICATION STUDIES OF COOK INLET BELUGA WHALES: METHODS AND APPLICATIONS. Invited talk to the Alaska Beluga Whale Committee, Nov. 4, 2008. Anchorage, Alaska.

Table 1. Survey dates, number of groups, group size, encounter duration, and sighting distances of beluga whales encountered during vessel-based photo-identification surveys of Upper Cook Inlet, Alaska in 2008. Table does not include groups sighted from land.

	Vessel survey date	Group #	Group size	Encounter duration (min)	Mean distance (meters) from vessel of first group sighting	Minimum distance (meters) of belugas from research vessel
	21-May-08	0	x	x	x	x
	17-Jun-08	0	x	x	x	x
	19-Jun-08	1	58	96	300	25
	15-Jul-08	1	63	139	150	2
	22-Jul-08	1	40	11	300	10
	22-Jul-08	2	29	35	200	5
	22-Jul-08	3	29	10	60	50
	24-Jul-08	1	4	30	150	100
	24-Jul-08	2	108	62	300	1
	29-Jul-08	1	121	178	250	1
	6-Aug-08	1	55	50	300	5
	6-Aug-08	2	63	87	300	2
	18-Aug-08	2	7	14	500	75
	18-Aug-08	3	41	81	700	50
	18-Aug-08	4	11	37	500	50
	22-Aug-08	2	5	14	100	30
	22-Aug-08	3	1	1	50	50
	22-Aug-08	4	40	141	250	5
	27-Aug-08	1	5	34	300	150
	27-Aug-08	2	6	15	150	15
	27-Aug-08	3	42	130	350	5
	2-Sep-08	1	47	98	250	2
	12-Sep-08	1	3	1	300	300
	12-Sep-08	2	33	79	350	50
	15-Sep-08	1	1	1	300	300
	15-Sep-08	2	4	30	150	75
	15-Sep-08	3	4	9	250	75
	15-Sep-08	4	43	107	350	1
	26-Sep-08	1	10	119	500	30
	30-Sep-08	1	42	92	300	2
	28-Oct-08	1	32	172	200	5
Total	17 survey days 15 surveys with whales	29 groups	947 beluga sightings	1873 min with belugas (31.2 hrs)		
Mean			32.6 belugas/group	64.6 min/group (1.9 min/beluga)	281.4	50.7
Range			1-121 belugas/group	1-178 min/group	50-700	1-300

APPENDIX C.

SUMMARY OF DATABASE DEVELOPMENT (AXIOM)

DATABASE DEVELOPMENT AND CONSOLIDATION EFFORTS

Shane StClair
Axiom Consulting & Design
Anchorage, Alaska

BACKGROUND

The LGL beluga photo identification project collects large amounts of data that must be analyzed and summarized at the end of each season. In addition to this field data, the project maintains an ever evolving set of whale identities consisting of linked photos from multiple survey efforts. In past years the human effort involved in manually managing and analyzing this data has been formidable, and as the project's dataset grew it became apparent that a more automated solution was needed. In addition to the massive effort that organizing the growing data required, human management of the data was introducing inconsistencies that made subsequent analysis time consuming and laborious. A standardized, computer managed data repository was needed to allow project biologists to focus on high level analysis and interpretation of their data.

Axiom Consulting was hired in 2007 to perform data summaries over several distinct datasets spanning four years and being stored in disparate formats. A simple unified database structure was developed to allow for this summary, but only data applicable to the summaries being performed were imported into the new structure. In 2008 the beluga ID team decided to pursue a comprehensive data management system for their project.

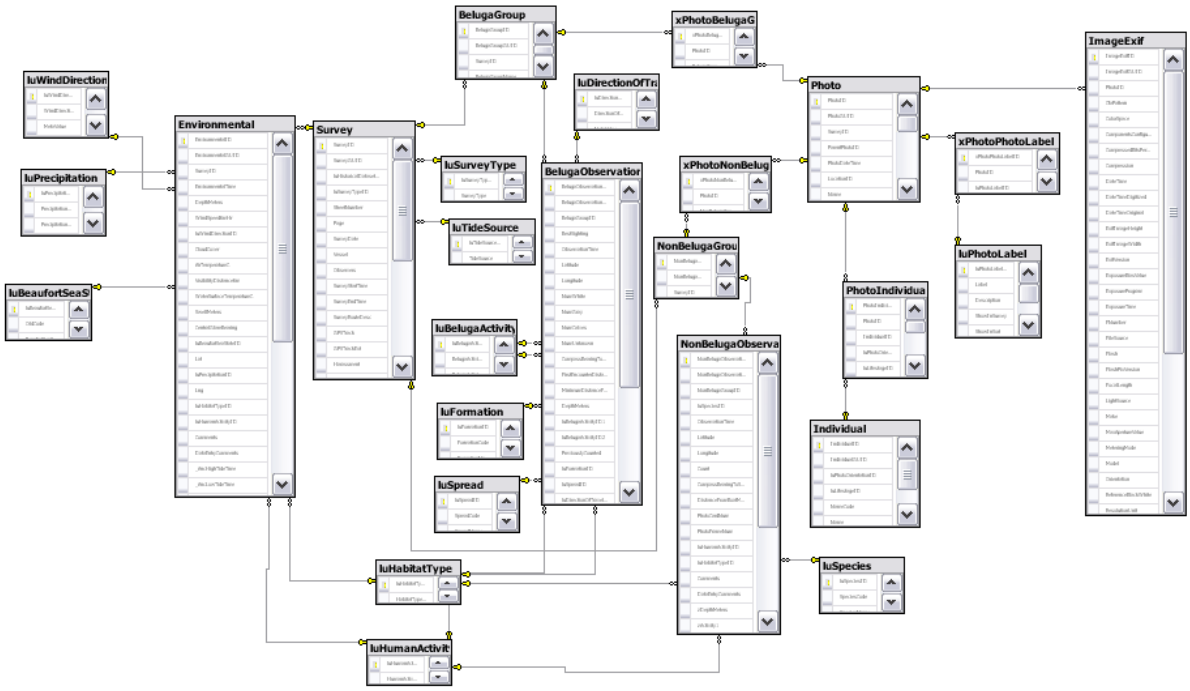
SUMMARY OF WORK PERFORMED IN 2008

Database development

The first stage in developing a comprehensive data management solution for the beluga ID project was to construct a logical data model. As with any data model, the objective is to store real world entities such as survey efforts and observations as discreet objects in a database system. Data integrity was ensured by enforcing standardized data values, eliminating ambiguities, and ensuring that data are stored in singular locations rather than duplicated in several places. The simplified database structure developed by Axiom in 2007 was used as a starting point for developing the current more comprehensive structure. Microsoft SQL Server was again chosen as the database platform due to its stability and scalability.

Logical entity tables were created to store the following collected data objects: survey efforts, observed animal groups, animal observations, environmental observations, photos, and individual whales. Explicitly enumerated data values, which allow for standardization and error reduction, were created for the following fields: survey types, habitat types, human activities, tide information source, wind direction, precipitation, Beaufort Sea state, species, beluga formation, beluga spread, beluga activity, beluga direction of travel, and photo categories.

Another important aspect of database design is the definition of relationships between the logical entities that mirror their real world relationships. Hierarchical relationships were defined for the following: survey efforts and environmental observations, survey efforts and observed animal groups, observed animal groups and animal observations, and surveys and photos. More complex many to many relationships, in which each entity can be linked to multiple instances of its related entity, were defined for the following pairs of objects: animal observation groups and photos, photos and photo categories, and photos and individuals.



Beluga ID database structure

Historical data aggregation, transformation, and correction

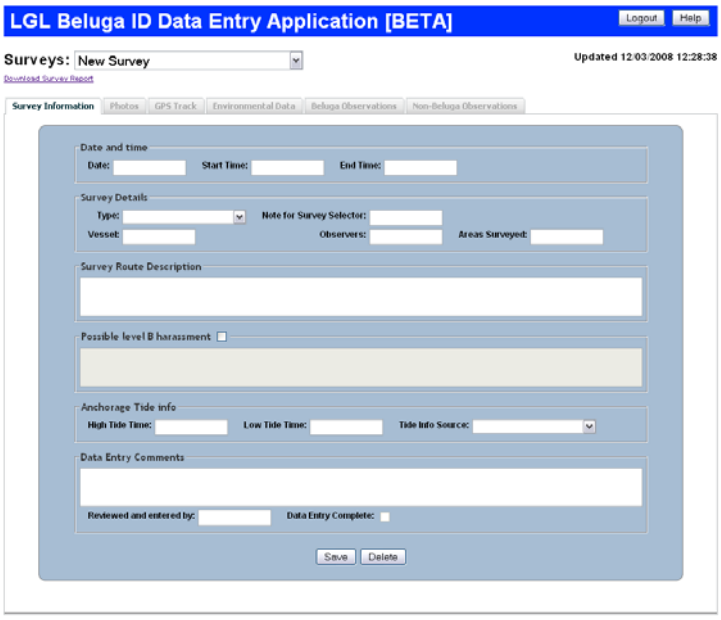
Due to the redesign of the unified database, historical beluga id datasets from 2004 - 2007 had to be re-imported into the new structure. This processing allowed for the inclusion of all data fields from each dataset that were determined to be relevant to the project. Because the datasets were collected over a span of four years by distinct projects, many used dissimilar sets of standardized codes in their collection. These had to be detected, in some cases through statistical analysis and cross-dataset comparison, and translated to the current code set before the datasets could be combined. Obvious data problems or omissions were reported to LGL beluga biologists, who provided historical insight or checked values against paper collection forms. Because not all fields in the unified data model were collected by all historical projects, it was especially important to specify what a null value means. For example, null values could indicate a 0 quantity, false, a missing value, a not applicable value, a value other than the standardized options allow for, or a value that was not collected. Null values were replaced with values

indicating said possibilities wherever possible to eliminate ambiguities and allow for more meaningful interpretations and analyses of the data.

Server setup

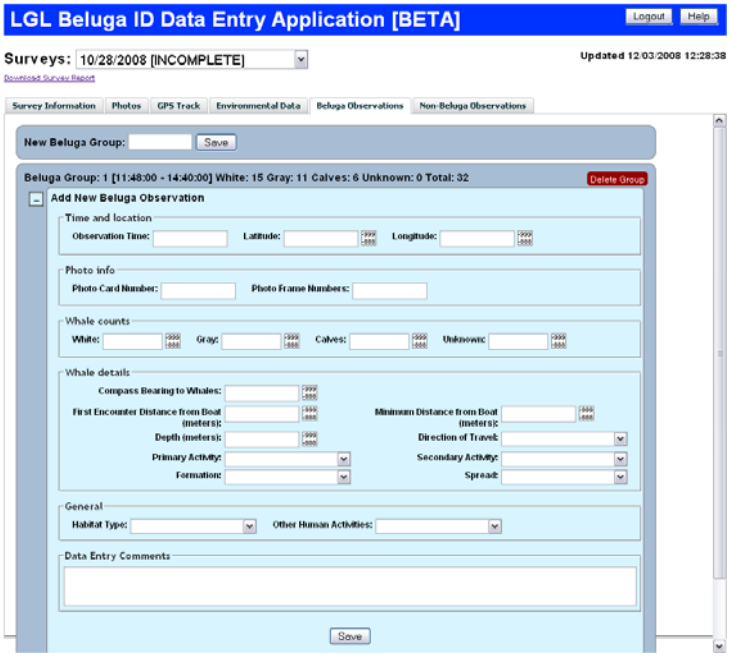
The beluga id project involves the processing, comparison, and manipulation of thousands of high quality digital photos. The activities are highly resource intensive, and require high connectivity speeds between users and the data management system. Because of this requirement it was determined that the data management system should be hosted at the Anchorage LGL office and connected to the local network. The prices of modern servers have fallen drastically over the past few years, and it was decided that the relatively cheap purchase price of a new server would be well worth the benefits of extra speed, stability, and customization that a dedicated system would allow. A Dell server was purchased and installed in the LGL office. The server also provides a convenient unified location to store the project's working file directories, which will help to avoid duplication and versioning problems that can occur when project members store redundant copies of files in various stages of revision on their personal office computers. A protocol to backup server data to an external hard drive that can be stored offsite was also developed. The installation of virtual networking software allows Axiom developers to remotely access, update, and monitor the LGL server.

Data entry interface



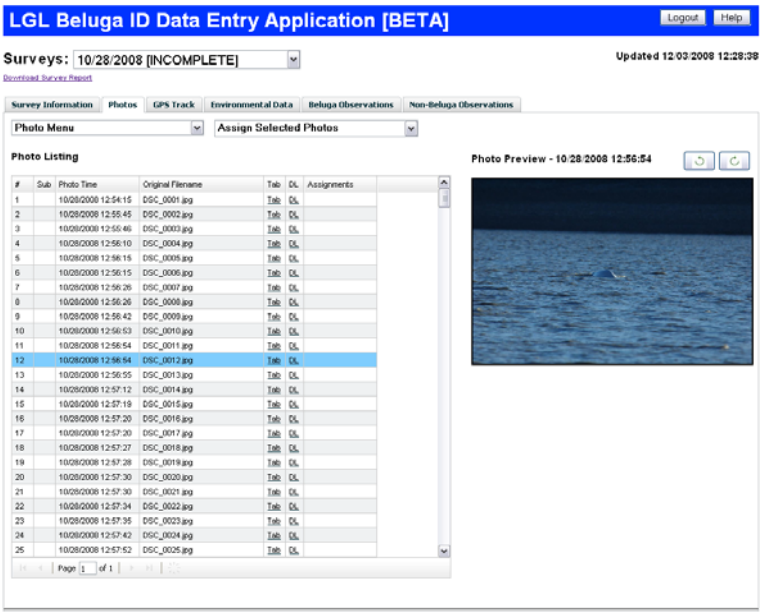
A data entry interface was developed to allow project biologists to add to and interact with the data in the new data repository. The developers chose to create a web based data entry application based on many factors. In recent years web based technologies like AJAX have blurred the boundaries between traditional desktop applications and web based application by allowing for highly interactive and fluid user interfaces. Web based applications are ideally built according to universal web standards and can be accessed from any computer using a browser that adheres to these standards. These standards based applications can be accessed from Windows, Apple, and Linux based machines, unlike most desktop applications which are tied to a particular architecture. With AJAX technologies, user interfaces are accessed through web browsers, which in turn communicate with the centralized server where data is stored. Any intensive data processing is left to the dedicated server, while client machines are focused on managing the user interface. Because the area of web browser development has become increasingly competitive,

users will be able to take advantage of browser speed optimizations in the future provided they choose a standards compliant browser. Because the code for the user interface is centrally stored on the server, new versions of the application can easily be deployed to a single location rather than having to install updates on each client computer.



The user interface was created using standards compliant html and css code. A combination of the AJAX enabled javascript framework jQuery and Coldfusion 8 user interface elements were used to add interactivity to the interface. Coldfusion 8 was also used to create the background data processing code that runs on the server.

The user interface layout and data entry forms themselves were created with logical flow and ease of use in mind. Objects with hierarchical relationships are presented as nested, expandable data forms whenever possible. Repetitive data entry tasks, such as typing colons when entering times, were also automated whenever possible. Custom data validation rules are defined for each column, and live feedback is provided to the user when entered values violate these rules. Data records are automatically checked for completeness when data entry is marked as finished, and the user is provided with an overridable warning about any missing fields. Field with standardized, enumerated value options are presented as selectable lists with options to indicate descriptive metavalues such as "not applicable" or "other." Data fields restricted to numbers have a small menu attached to allow users to indicate metavalue codes for these fields as well. Project staff can also upload GPS track files for each survey.



In addition to data entry forms, the interface includes a photo management pane. Users can scan a designated folder

on the server for photos and upload them to a survey. When a batch of photos are uploaded, the application extracts metadata values such as the time the photo was taken from each photo and stores them in the database. Once the upload is complete the application beings building small preview photos in the background to allow for increased user interface performance. When the upload process is complete, biologists can select photos in a grid, view previews or original photos, rotate photos, zoom in on parts of photos, apply category labels, and link photos with observation groups either manually or automatically by time.

Bulk photo sort

Although the development of a database and web application interface brings the benefits of organization and standardization to the workflow of the beluga ID project, it is also apparent that not all processing should be performed through an interface of the application. During the post season photo sort, biologists have to quickly scan through thousands of photos and sort them into categories. Additionally, many photos need to be cropped and some must be digitally processed to expose subtleties. Project biologists need fast access to these photos, and must be able to easily open and alter them in any photo processing program of their choosing. Each biologist has developed a personal workflow over several cycles of the sort process, and it was decided that the best approach to capturing the resulting data was to work around the established procedure.

With the developed procedure, biologists move, copy, and process photos into categorically labeled subfolders as normal. Once the sort is completed, a template folder structure is downloaded from the application and the sorted folders are copied into this structure. The template structure is then placed into a designated directory on the server and the sort analysis procedure is initiated. The system matches folders in the structure to sort categories and examines the photos inside them. Once the system has examined all the photos in the file structure, the results are stored in memory and a report is returned to the user. The user can then either execute the import, which links matched photos with sort categories and uploads altered photos, or make adjustments to the file structure as needed and restart the analysis process. Because the bulk photo sort import is a complicated process that occurs once annually, Axiom staff will mediate the process this year to ensure proper function.

Reporting

One of the greatest benefits of storing data in a database is the speed and ease with which complicated report summaries can be generated. Data validation and large scale manipulation, analysis, and correction of datasets allow for meaningful reporting. Standardized report outputs can be set up once and then generated instantly an unlimited number of times with no additional human effort. A summary report detailing location and best beluga count for each survey and observation group was developed and added to the application interface. More reports will be developed and made available as needed by project biologists.

FUTURE WORK TO BE PERFORMED

Some facets of the beluga ID application remain to be developed. Primary among these are the beluga photo id catalog display and whale management tools. Project biologists need to be able to view existing whale photo sets, create new whales, merge existing whales, and perform other similar tasks. As with the photo sort import, biologists need to be able to use any tools they are accustomed to when matching photos to whales, and a mechanism to import an organized folder structure end product must be developed rather than forcing biologists to work exclusively via the application's user interface. Lastly, analysis of survey GPS tracks and a map display with the survey track and photo locations would add high level geographical displays to the project.