Beluga Whale and Other Marine Mammal Occurrence in Upper Cook Inlet between Point Campbell and Fire Island, Alaska August – November 2011 and April – July 2012

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Abstract

Land-based observations were conducted from August 3 to November 15, 2011 and again from April 2 to July 31, 2012 to document the occurrence of beluga whales and other marine mammals in Upper Cook Inlet between the mainland and Fire Island for Cook Inlet Regional Corporation (CIRI). The April through November study period coincided with the time most of the beluga population inhabits the Upper Inlet; the population winters in the mid-Inlet. Visual observations aided by binoculars were conducted by experienced observers every day from sunrise to sunset from a promontory located about 82 m (269 ft) above the water at Point Campbell in Kincaid Park, Anchorage, Alaska. The site provided observers a 260º view of the study area. The study area is bounded by Turnagain Arm to the south and Knik Arm to the north. Fire Island is about 5.5 km (3.4 mi) from Point Campbell. The study area is tidally influenced with most of it becoming exposed mudflats during low stages of the daily tidal cycle.

The results show that beluga whales occurred in the study area during each month of the almost eight-month study but use was typically infrequent and short in duration. Sighting rates, counts, and group sizes were highest from late summer through fall with peak numbers of belugas recorded during September. Beluga numbers were much lower during spring to mid-summer. Beluga occurrence was intermittent throughout each month, but belugas were observed on only seven or fewer days in every month except during May, August, and September. During these months they were observed on about one-third (August) to one-half (May and September) of the survey days. In addition, most belugas stayed in the study area for less than about 1 hr, typically travelling. Very little behavior that could be classified as feeding was observed.

Use of the study area by belugas was influenced by the tides, with sightings increasing with increasing water depths. Much of the area was not occupied at water depths below 5 ft (1.5 m) due to extensive areas of exposed mudflats flats. Belugas tended to expand into the study area from deeper water along the north and south edges of the study area as water depth increased with changing stages of the tide. In addition, belugas increasingly concentrated along the coastline from Point Campbell southeast toward Turnagain Arm and occasionally northeast to Knik Arm as water depths went from 10 ft (3 m) to over 20 ft (6 m). Direction of movement of visually-tracked beluga groups was more often toward Turnagain Arm during summer and fall and Knik Arm or Susitna Flats during spring, although some belugas also traveled in opposite and other directions during most weeks of the study.

Comparing the results to those of other studies in the region suggests the study area is primarily used by a relatively small number of beluga whales that transit, repeatedly and rather quickly, between Knik/Susitna Flats and Turnagain Arms from April into November. During late summer most belugas move from the Susitna Flats to Knik and Turnagain Arms, where they feed on fish off the rivers flowing into the arms. There are no rivers flowing into the study area. Studies show most belugas remain in these arms from August to November, moving up the arms on rising tides and down on falling tides, since the upper reaches become shallow or exposed mudflats at low tidal stages. This

pattern is consistent with relatively low use of the study area by belugas, since most belugas would be in the lower reaches of the arms at low tidal stages, near the study area, when most of the study area is too shallow to be occupied by belugas. Movements of belugas into the arms and the subsequent retreat from the arms during winter appear to be primarily but not entirely around the outside of Fire Island rather than through the study area. This was reflected in the sighting rates which were much lower in the study area than reported in the two arms and supported by 20 years of aerial survey data (National Marine Fishery Service) based on the concentrations and locations of beluga sightings. Sightings of belugas in the study area were likely lower during the study period given studies have shown that satellite-tracked individuals repeatedly and rapidly moved back and forth between the two arms, indicating monthly counts in the study area were likely inflated by recounting some groups. As with other studies, movements by belugas into and out of the study area followed the tidal cycle with little use during lower tidal stages and most use during higher tidal stages. Consequently, movement patterns reported for Knik and Turnagain Arms, combined with our results, suggest a similar seasonal pattern but much lower magnitude of use by belugas in the study area.

The only other marine mammals observed in the study area were one group of 3 harbor porpoises and 19 single harbor seals. Other researchers have reported similarly low numbers of these two species in Knik and Turnagain Arms.

Introduction

Fire Island is located in the Upper Inlet where beluga whales concentrate from spring through fall (Hobbs et al. 2008, 2011; Rugh et al. 2010). Fire Island is about 5.5 km (3.4 mi) west of Point Campbell between the entrances to Knik and Turnagain Arms, which contain rivers supporting fish populations seasonally eaten by belugas (Hobbs et al. 2008). Belugas reportedly use Knik Arm, Turnagain Arm, and Chickaloon Bay primarily from June to November. The National Marine Fisheries Service (NMFS) reported that satellite-tagged beluga whales used these areas as late as November (Hobbs et al. 2005). In September and November beluga whales move between Knik Arm, Turnagain Arm, and Chickaloon Bay (Hobbs et al. 2005). Studies by the Knik Arm Bridge and Toll Authority (KABATA) also reported most beluga observations in Knik Arm were during August through November, with few made during the rest of the year (Funk et al. 2005). Similarly, studies in Turnagain Arm reported most belugas occurred from late August through late October, and none were observed in May, June, or July (Markowitz et al. 2007). A few whales reportedly made occasional excursions into Knik Arm and Turnagain Arm in February and March to May (McGuire and Bourdon 2012), All of the studies found that beluga movements were timed with the tides, moving into the arms on a rising tide and departing on a falling tide.

The only surveys of beluga use in the general vicinity of the area between Knik and Turnagain Arms were conducted by the NMFS during annual surveys of the Inlet conducted since 1992. The concentrations and locations of belugas observed during these surveys suggest most beluga occur considerably south and north and to a lesser degree west of Fire Island (Rugh et al. 2010). However, the survey results were incomplete, since the Federal Aviation Administration precluded the NMFS from flying specifically between the island and mainland because of its close proximity to the Anchorage International Airport. Most but not all of the surveys were conducted during lower stages of the tidal cycle when belugas concentrate in the Upper Inlet and they are more easily surveyed (Rugh et al. 2010, Hobbs et al. 2011). During low tide much of the area between Fire Island and the mainland becomes extensive mudflats, not accessible to belugas except for two short, narrow, dead-ended channels near the mainland and Fire Island and accessed from Knik Arm. Since the NMFS or other investigators may have not adequately surveyed the area between Fire Island and the mainland during higher stages of the tidal cycle, information is largely lacking on beluga use of this area. Studies of satellite-tagged belugas do confirm some belugas transit the study area from August to November (Hobbs et al. 2005).

The purpose of this report is to document the results of land-based surveys conducted by the Cook Inlet Regional Corporation (CIRI) to determine beluga and other marine mammal use of the area between Fire Island and the mainland. The surveys took place from August to freeze-up in mid-November 2011 and from spring break-up in early April through July 2012. The beluga population concentrates in the Upper Inlet from April to November, after which most belugas migrate to the mid-Inlet to winter.

Methods, Procedures, and Study Design

Scientifically accepted methods and procedures were used during field observations to detect and record marine mammals and environmental conditions. The methods, procedures, and sampling design, which are described below, were reviewed and discussed with Brad Smith and his associates of the NMFS before initiation of the 2011 field program.

Marine Mammal Observer (MMO) Training

Classroom training sessions for MMOs were held on August 2, 2011 and April 1, 2012 in Anchorage by the field team leads from 61 North Consulting LLC. Training was provided by Drew Lenz and Melanie Wahl, who have extensive experience conducting beluga whale and other marine mammal surveys in Cook Inlet. All MMOs had multiple seasons of field experience observing belugas and other marine mammals in Alaska waters. The project manager, Jay Brueggeman of Canyon Creek Consulting LLC, participated via telephone. Mr. Brueggeman has over 35 years of experience conducting marine mammal studies in waters off Alaska including Cook Inlet. The training included a project overview, data collection protocols, review of the data forms, and identification of marine mammal species, behaviors, groups, and sex/age (where appropriate). After each classroom training session, a field session was held at the observation site. During the field session, the equipment was set up and all MMOs were trained or reintroduced (2011 team members) in the use of the clinometer, compass, spotting scope, and reticle

7X50 binoculars. The 2012 training included a review of the past field season so potentially new and returning team members could benefit from experience gained in 2011. Ultimately, the 2012 field team was largely staffed with 2011 team members to ensure continuity between years.

Description of Observation Site

The observation site (see photo below) chosen for this project was within 5 ft (1.5 m) of a bluff near Point Campbell located in Kincaid Park in the Municipality of Anchorage, Alaska. The bluff is 82.5 m (269 ft) in height above mean sea level (MSL) and overlooks the waters of Cook Inlet between Point Campbell and Fire Island. The site allowed for excellent visibility of the entire shoreline below, as well as all of the eastern shore of Fire Island (see photo below). Fire Island is approximately 5.5 km (3.4 mi) off shore of Point Campbell and the observation site. The site had approximately a 260° swath of visibility (from the SE at 120° to the NNE at 20° true). There were some obstructions in the form of trees, bluffs, and shoreline features from about 305° to 20° that made observations spotty from the northwest to the north, but they did not affect observations between Fire Island and the mainland. The lat/long position of the site is: N 61 09 07.9, W 150 03 50.7. No other site in the area offered the height required for visibility to Fire Island. Early in the study it became clear that a shelter (see photo below) was needed for some weather conditions. Observations in the wind and rain were difficult. In 2011 and 2012 a small 4’ by 4’ shelter was erected on the bluff. The shelter had a window facing southward toward Turnagain Arm, another window facing westward toward Fire Island and the mouth of Knik Arm, and a door to the north that could be opened for a better view of Knik Arm. The 24”x 28” windows were “open air,” with no glass or Plexiglas hindering visibility.

View of study area from observation site.


Observation shelter used by observers during periods of high wind and heavy rain.

Sampling Design

Duration

MMOs were deployed to the observation site for all daylight hours, seven days a week, from August 3, 2011 through November 15, 2011 and again from April 2 through July 31 2012 with some minor exceptions. MMOs arrived at Kincaid Park about 15 minutes before sunrise. The hike from the parking lot to the observation site was approximately 15 minutes. Set-up of equipment took about another 15 minutes. Observations generally started within about 15 – 30 minutes of sunrise. At the end of the day, the MMO ceased observations near sunset (sometimes earlier if overcast reduced light to effectively see marine mammals), tore down and stored equipment, then hiked back to the parking lot with enough daylight to see the trails clearly. Each MMO conducted observations in 4-6 hr shifts and rarely 8 hr, which was occasionally necessary because of the long day-lengths during early to mid-summer. MMOs overlapped observation times during shift changes to maintain continuity and transfer information. MMOs took 15 min breaks every 2 hr, and a 1 hr break was added for shifts over 6 hr to reduce eye strain and fatigue.

Initially in 2011 it was thought that when the tide fell below three feet, observation would be fruitless because shallow waters between Point Campbell and Fire Island turn to mudflats. While true, several channels to the north of the mudflats retained sufficient water to support belugas as reported by Brad Smith (pers. com. NMFS). After August 5, 2011 and throughout the 2012 field season surveys were conducted during the entire tidal cycle with few exceptions. There were occasional weather events such as high winds, lightning, and heavy rain/snow that caused the cessation of observation.

Observation Technique

MMOs were instructed to systematically scan the project area, alternating between the use of the Fujinon 7X50 reticle binoculars and the naked eye approximately every 5 minutes. A 20x spotting scope was used to verify accuracy (e.g., group size) or obtain more detail (e.g., behavior) of an observation whenever possible. Observers also initially used a range finder, targeting vessels or stationary structures, to gauge the estimated distances to marine mammals.

The primary focus was on the water between Point Campbell and Fire Island, but all visible areas were watched, and any animals present were documented. Early in the study, beluga whales were occasionally seen along the far shoreline by the mouth of the Little Susitna River. This is approximately 14 km (9 mi) from the observation site. Only white animals could be detected at that distance and it was nearly impossible to determine group size, behavior, and group composition. Sightings of this nature were only documented in the notes, and were not included in the data form or discussed in the report.

Data Collection Protocol and Field Equipment

Environmental Data

Environmental data describing sighting conditions were recorded approximately every 15 minutes or whenever they changed. Environmental data were also recorded at the start and end of each shift, the start and end of each break, as well as for every marine mammal sighting. Environmental data collected included sea state, prevailing weather conditions, sightability in km, whether or not Fire Island was visible, sea ice concentration, and glare. “Sightability” distance differs from visibility in that it accounts for the combined effect that visibility and sea state have on the ability to see a marine mammal. For the purposes of this study, the study area was loosely defined as the water within a radius of about 10 km (6.2 mi) from the observation site.

Sighting Data

Sighting data were recorded when a single animal or group of animals were seen within the study area. A new line of data was recorded for any major change in behavior or direction of travel, every 15 minutes or so even if there was no major change, and for the final sighting of the animal(s). Sighting data included date, time, species, group size, count reliability, behavior code, direction of travel, a compass bearing on the nearest animal, clinometer angle, and comments. A unique number was assigned to each new group of marine mammals to minimize duplicate counts and for tracking behavior and other features of a given group. The numbers were recorded consecutively on the field data form.

Animal counts were divided into age categories based on species type. Belugas were classified as “white (adults),” “gray (juvenile),” “dark gray (calf),” or “unknown.” Some recent studies use the “juvenile” classification instead of “gray.” However, some gray animals have been documented with calves and may not technically be juvenile. Also, occasionally glare from the sun or extremely flat light would prevent classification, and the “unknown” category would be used. Calves or pups were recorded for other marine mammal species whenever possible.

The “count reliability” code was a measure of the MMOs’ confidence in their counts and category classification. Single animals and small groups generally were assigned the “positive” code, while medium to large groups were initially assigned the “probably” or “maybe” reliability code until a more accurate number was obtained from multiple counts to reassign these groups to a “positive” code. Multiple counts were recorded for almost all of the groups, with the count most repeatedly recorded assumed to be the estimated group size used in the analysis. This procedure provided a high level of confidence in the estimated group sizes, and increased the number of belugas categorized by age (color) for each group.

The bearing was taken using the compass in the Fujinon 7X50 binoculars or using the compass on the Suunto Tandem clinometer/compass. The clinometer was used to measure the angle below the horizon (or more accurately, the angle below the plane perpendicular to gravity) of the nearest animal of the group. The clinometer has graduations in one degree increments, but the MMOs were instructed to record within the nearest tenth of a degree. The space between degree graduations is great enough that tenths were estimated. Initially, it was thought that the reticles in the Fujinon binoculars could be used to measure the angle below the horizon in certain circumstances, but it was unworkable because the landmass in Cook Inlet interfered with the horizon.

The primary behavior category was recorded for each group of animals. The observer on duty also made notes on secondary behaviors displayed. Behaviors were selected from Table 1 below:

Table 1 Behavior codes

Code	Name	Description
MA	Mating	Unlikely to be observed in silty waters of Cook Inlet – make comments if observed
DI	Dive	Only record if a fluke is shown prior to a sounding

		dive, or if long periods of time elapse (>10 min) between surfacings in the same general area
LO	Look	Only record if an animal is aware of your presence and looks in your direction (unlikely at 80 meters above water)
TR	Travel	Animals moving together in a consistent direction while all pointed in the same direction are considered to be traveling
BR	Breach	Behavior where animal vaults itself nearly completely out of water and splashes on the surface
LT	Lobtail	Lifting of fluke out of water and slapping on surface (AKA fluke slapping)
SH	Spyhop	When an animal rises vertically out of water as if to “look around” but does not breach completely
FE	Feeding	Animal seen feeding or evidence of prey is observed near animal (e.g. fish, numerous birds over water, etc.)
SFE	Feeding Suspected	Evidence of prey is absent but other behaviors like successive long dives in one location indicate feeding
RE	Resting	Animal is motionless at the surface or on land
MI	Milling	Animals are staying in one localized area, body directions are not uniform within group, moving slowly at surface, changing directions often
SW	Swim	Animal seen swimming at the surface and no other behavior listed fits pattern
OT	Other (describe)	None of the above – describe with comment
NO	None (sign seen only)	Use when only a sign of a marine mammal is seen and no behavior fits
UN	Unknown	Not possible to determine behavior
BL	Blow	Use only if blow is the only sighting cue
BO	Bow Riding	When animal rides the bow wave of a boat or ship
FS	Flipper Slap	When animal slaps flipper on surface of water causing a splash

Field Equipment

The following is a list of equipment utilized during the study:

- Data forms on Rite-in-the-Rain paper
- Rite-in-the-Rain notebooks
- Clipboard and pencils
- Fujinon 7X50 FMTRC-SX reticle binoculars
- Vortex 20X spotting scope and tripod

- Suunto “Tandem” clinometer/compass
- Laser range finder for distance estimation practice
- Watch
- Shelter for inclement weather
- Safety equipment: bear spray, polarized sunglasses, first aid kit
- Personal gear: weather-proof pants, coats, hats, gloves, boots, sunscreen

Analytical Procedures

Preparation of Field Data for Analysis

Quality Assurance

Data were recorded in the field onto a legal size data form in pencil by the MMOs. The data forms were collected every day or two and then entered into an Excel spreadsheet. The data were checked by a second project lead to correct typos, look for outlier entries, identify missing data, and assure general quality. Data were further checked by running a series of programs targeting inconsistent numerical sequences or incorrect data codes. All errors were corrected except where there was no source(s) to validate a correction. These occurrences were rare because the field team reviewed the data at the end of each day or shortly thereafter when the day’s events were fresh in their memories. Un-validated data were not included in the analysis, but they were retained in the data set.

Tide Height, Tidal Stage, and Observer Height

A number of additional fields were entered or calculated for each line of sighting data. The first additional field entered was the height of tide (in feet) at the time stamp of the sighting entry. The National Oceanic and Atmospheric Administration (NOAA) publishes tide prediction data for Fire Island at: http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=9455912

It should be noted that the tide station at Fire Island only offers “predicted” tide levels. Actual tide levels are influenced by atmospheric and other events and can vary by upwards of $\pm$ 2 ft (0.6 m) from predicted levels. For this study, variations of 2 ft (0.6 m) in height had minimal impact on the accuracy of distance and tidal depth estimations.

A third-party utility called “Tide Graph ©” was used to extract the predicted tide height for any given time. The free, web-based utility can be found here: http://www.tidegraph.com/page-support-widget.php. The utility is also available as an iPhone application, which was primarily used. Tide Graph © uses data published by NOAA, but has the added feature of a “slider” that you can move over the graph to determine tidal height at any given time. It should be noted that Tide Graph © only lists predictions in 6-minute intervals. The time nearest to our time stamp was used to enter the tide in feet. Even with the large tides of Cook Inlet, a difference of 3 minutes from the time stamp to the nearest predicted level had minimal influence on the accuracy.

With the tide height in feet entered, the next field in the Excel file converted the tide height to meters. Using this level, the MMO's height above current sea level was calculated. The tide station at Fire Island gives the tide height in feet above the mean lower low water (MLLW). MLLW at Fire Island is 4.537 m (15 ft) (below mean sea level (MSL) as published under "Tidal Datums" here: http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=9455912%20Fire%20Island,%20AK&type=Bench%20Mark%20Sheets.

The MMO's elevation above MSL was determined using a GPS unit. The unit was left in one position near the average height of eye of an observer and several elevations were recorded. The average elevation was 82.5 m (269 ft) above MSL. Using this, the predicted tide level, and the MLLW (4.537 m (15 ft) below MSL) for Fire Island, the height above sea level was determined with the following equation: 82.5 m (269 ft) + 4.537 m (15 ft) – predicted tide height in meters = observer's height above sea level.

Using published high and low tide events, the tidal stage at the time of each sighting was also entered. Tidal stages are defined in Table 2 below.

Table 2 Tidal stage definitions

Tidal Stage	Description
Low slack	+/- one hour from low tide
Low flood	Two hours following low slack
High flood	End of low flood to one hour before high slack
High slack	+/- 1 hour from high tide
High ebb	Two hours following high slack
Low ebb	From end of high ebb to one hour before low slack

Distances, Bearing, and Location

The National Marine Mammal Laboratory (NMML) publishes a series of "user defined" Excel functions useful in calculating distance and latitude/longitude, published here: http://www.afsc.noaa.gov/nmml/software/excelgeo.php.

With the height above sea level known, the distance to each group of marine mammals was calculated using the clinometer angle reading. Using the function "ClinoArcDist" which accounts for the curvature of the earth, the distance to the group was calculated with the height above sea level and the clinometer angle reading. This function provides the result in nautical miles, and this was converted to meters by multiplying by 1852 m/nautical miles.

As mentioned, a magnetic compass bearing to the group was also recorded. This result was converted to the "true" bearing by adding the magnetic declination of 18.4°. Declination for any given location can be determined by several commercially available websites. For example, a compass bearing of 180° would be converted to 198.4°.

Using the calculated distance and the calculated true bearing, the latitude and longitude of the group were calculated. Again the NMML-published Excel functions were used. For the latitude, the function "NewPosLat" was used and for the longitude the function "NewPosLong" was used. With this information, the sighting data for each week were plotted onto a map of the study area. Using the time stamps of each sighting point, the general direction of travel of each marine mammal group was also illustrated on the map.

Statistics

Elements of the data were analyzed using the Analysis of Variance (ANOVA), Kruskal-Wallis, and the Chi-square statistics. The latter statistic was used for analyzing the relationship between beluga sightings and tidal cycle stages, sea state, and distance from shore (within months). The ANOVA statistic was used for analyzing beluga occurrence relative to distance from shore (between months), Kruskal-Wallis test for residency time in the study area and group size. All statistics were tested at the 0.05 probability level. A $P<0.05$ means the null hypothesis is rejected because the result is statistically significant. More details about the analysis are provided in the results section under specific elements of the data. Metric units were used in the analysis except when the data source provided the information in English units of measure; both metric and English are provided in the report. A group of belugas was defined as a collection of whales traveling as a cohesive unit during the entire observation period. A group included one or more individuals for the purpose of analysis. Distance of belugas from shore was determined using ArcInfo GIS. Distance was categorized into fairly broad categories (1000 m, 3280 ft) to capture any imprecision in the measurements, which was likely $\pm$ 50 m (164 ft).

Results

The results are presented in two ways below because the data were collected over two separate but sequential years. The two years of study cover the eight-month period (April-November) beluga whales inhabit the Upper Inlet, and therefore, possibly also the study area. Each topic in the results presents the two different years of data in the order they were collected, the August through November, 2011 and then the April through July, 2012. All of the graphs and maps are presented in this fashion. It is important to discuss them separately, because environmental and biological conditions during 2011 may not be representative of those in 2012. However, the reason for adding the 2012 season of study was to provide a picture of beluga occurrence in the study area from April to November; CIRI was not able to initiate the 2011 studies until August. The two data sets, therefore, are first discussed separately under each topic and then discussed as one continuous time period for that topic. The historical data (NMFS) for the Upper Inlet generally supports this approach, since the periods and levels of use by belugas of the Upper Inlet are generally consistent across different years.

Species Composition and Total Sightings

Three species of marine mammal were observed in the study area including beluga whales, harbor seals, and harbor porpoises. Beluga whales were the most common and harbor porpoises the least common. Sightings included 757 beluga whales in 100 groups, 19 solitary harbor seals, and 3 harbor porpoises in one group. Harbor seals were recorded during one (September) of the four months surveyed in 2011 and three (May-July) of the four months surveyed in 2012. Between 2 and 9 seals were observed during each of these months. The single group of harbor porpoises was recorded in September. The counts of belugas and seals should not be interpreted as absolute numbers, since some animals may have been repeatedly counted. The counts only represent marine mammal sightings and not total number of animals in the study area.

Survey Effort

A total of 3065 hours of observation for marine mammals occurred in the study area (Table 3). Observations began at approximately sunrise and ended at sunset each day, interrupted by regularly scheduled breaks to reduce observer fatigue. Daily effort averaged about 14 hr in August, 11 hr in September, 9 hr in October, and 7 hr in November in 2011 and 14 hr in April, 16 hr in May, 17 hr in June, and 16 hr in July 2012. Changes in daily and monthly effort were due to the decreasing or increasing day length over the study period. Effort was discontinued only during periods of poor visibility (heavy rain, snow, or fog) or high winds (> sea state 6). As shown by the daily and monthly effort, conditions terminating observations were rare. Survey effort in 2011 ended on November 15 due to extensive ice cover over the study area and deteriorating observation conditions. It resumed in 2012 on April 2 when sea ice began to clear from the study area during spring break-up.

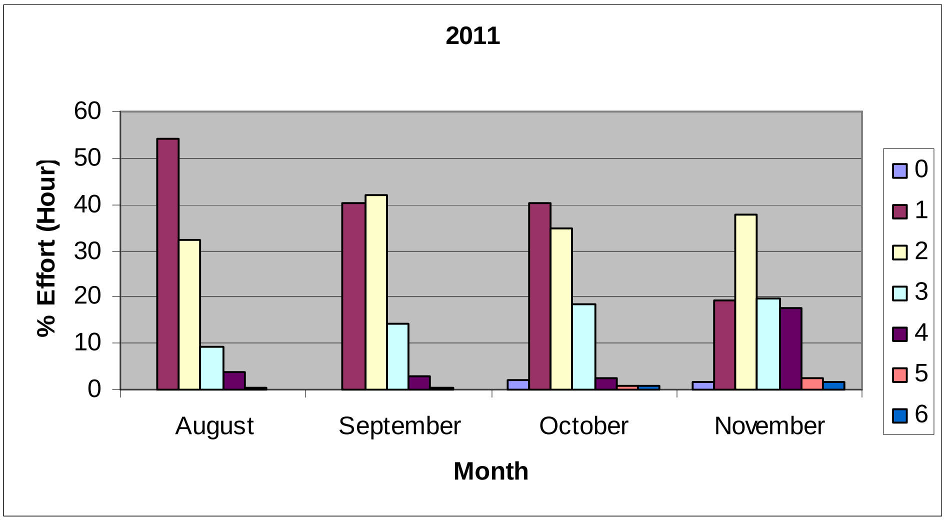
Table 3 Observation effort in study area, August-November 2011 and April-July 2012

Year	Survey Period	Observation Effort (hr)	Observation Effort (%)
2011	August	402	36
	September	342	31
	October	272	24
	November	98	9
Subtotal		**1114**	**100**
2012	April	409	21
	May	510	26
	June	521	27
	July	511	26
Subtotal		**1951**	**100**
Total		**3065**	

Survey Conditions

Sea state, sightability, and glare were recorded to gauge observation conditions during the marine mammal study. High sea states, poor sightability, and severe glare can substantially reduce the effectiveness of detecting marine mammals, subsequently influencing the results of survey activities (e.g., sighting rates). Sea ice cover was also recorded because it affects the effectiveness of sighting seals, porpoises, and most belugas; ice cover formation in November corresponds with the time these species typically migrate from the Upper Inlet to the mid-Inlet to winter, and ice cover melt in April corresponds to their return to the Upper Inlet, although some belugas may also occur year-round.

Sea state conditions of six or less are typically considered acceptable for surveying marine mammals (Barlow 2006). While marine mammals are detectable during sea states 0-6, detection distances decrease with increasing sea states (Barlow 2006). Sea states between 0-2 represent sea surface conditions with no whitecaps, which are most effective for detecting belugas across the entire study area (Figure 1). Sea states of these magnitudes occurred most of the observation time for all months including 86% of the time in August, 82% in September, 77% in October, and 59% in November in 2011, and 92% in April, 65% in May, 81% in June, and 73% in July in 2012. Sea states above 3 were uncommon. November had the greatest proportion (22%) of observation time in the higher (4-6) sea states. These results are consistent with monthly wind and sea state conditions reported for Anchorage International Airport, where aircraft approach and depart over the study area (http://www.windfinder.com/windstats/windstatistic_anchorage_intl_airport.htm).



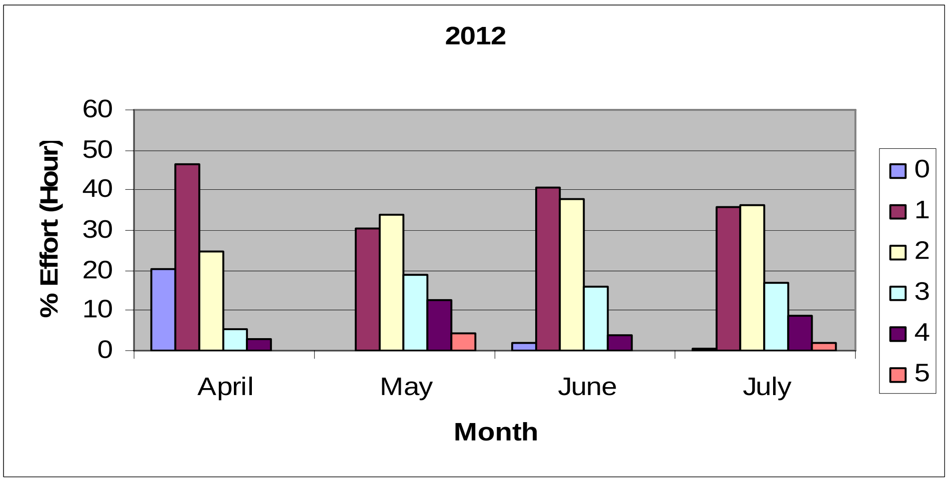


Figure 1 Sea states (0-6) in study area during the survey period, August-November 2011 and April-July 2012

Sightability was quantified by estimating the distances observers could see a marine mammal from the observation site including seeing Fire Island (i.e., essentially the entire study area). Sightability exceeded the distance (> 5.5 km, 3.4 mi) to Fire Island most (>90%) of the time during each month except for November (80%) (Figure 2). Unlimited ($\geq$ 9-10 km, 5.6-6.2 mi) sightability occurred most (59-84%) of the observation time during each month except again for November (23%). Fog, rain, or snow confined sightability to nearshore (0-2 km, 0-1.2 mi) from the observation site only during 0-5% of the observation time each month during the study. Zero visibility from fog intermittently occurred during parts of only two days of observations in early April, representing less than 2% of the observation time and occurring several weeks before belugas were first sighted in the project area. Observers maintained watch on these days, since there were frequent opportunities to see belugas during breaks in the fog. Consequently, sightability conditions were suitable for observers to effectively detect belugas in the study area most of the time.

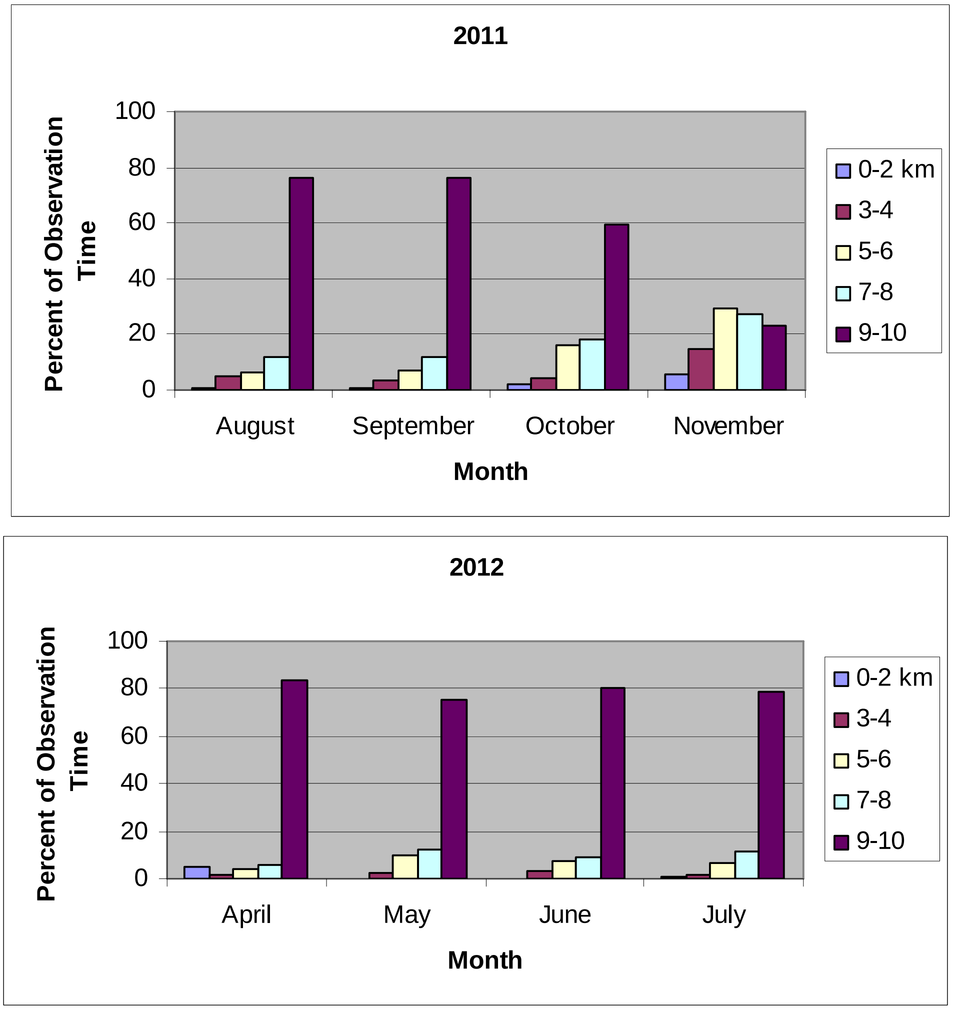


Figure 2 Sightability in study area during the survey period, August-November 2011 and April-July 2012

Glare had minimal effect on the observers' abilities to detect beluga whales in the study area. Over 69% of the time there was little to no glare to hinder observations, and it exceeded 86% during all months except September, October, and November. When glare was severe, it was generally limited to a small section (primarily W for Aug, SW for Sept-Nov, and N for April to July) of the total study area for relatively short periods of the days.

Sea ice was briefly present in low concentrations in the study area during spring and fall. Sea ice initially formed in early November 2011, but it remained light until three days before observations were terminated on November 15. During that time, sea ice cover increased from about 30% to 70% and correspondingly weather rapidly deteriorated in the study area. Five groups of belugas were observed in the presence of sea ice during November. When surveys resumed in April of 2012, sea ice remained in the study area until April 23. Ice cover in open water was essentially 20% or less during this time, except for a 6-day period from April 6-12 when ice cover ranged higher, briefly reaching 60%. Shorefast ice initially covered most of the mudflats but broke off during high tides and disappeared at a similar rate as that in open water. Two groups of belugas were observed in the presence of sea ice during April. The presence of sea ice probably did not negatively affect the detection of belugas and more likely, improved detections by limiting scanning of the study area to the open water available for belugas to surface.

Beluga Use of Study Area

A variety of factors was analyzed to describe how belugas used the study area over the study period. These included changes in the number, frequency, and rate of beluga sightings; residency time; distribution, distance from shore, and direction of travel; and response to stages of the tidal cycle. Each is analyzed below.

Number, Frequency, and Sighting Rate

Beluga whales were observed in the study area during every month, most weeks, but relatively few days of the study period. Beluga whales occurred in the study area every month of the study period (Table 4). Relatively high numbers of belugas observed during August 2011 (152) increased almost two-fold in September to 285 whales, and then declined almost four-fold in October and November to around 50 whales. When surveys resumed in 2012, a relatively small number (26) of belugas observed in April increased almost six-fold in May to 149 whales before dropping to fewer than 30 whales during June and July. Combining the months from the two years into one continuous time period shows relatively low numbers for most months except for a spike in beluga numbers in May and brief build-up of beluga numbers in August and September.

Weighting the monthly sightings of groups by survey effort provides a better month-to-month comparison but somewhat different result, because raw counts do not account for effort. The highest sighting rate of beluga groups was in November, followed by September, May, and then August (Figure 3) compared to the highest sighting rate of individual belugas, which was in September followed by November, August, and May; sighting rate based on groups typically provide a better comparison than sighting rate of individuals because it eliminates biases caused by unequal group sizes. The November sighting rates may have been biased by the shortness of the month, resulting in a relatively small amount of effort (15 days versus 30-31 days for each of the other months) inflating the sighting rate. Differences in beluga monthly occurrence in the study area were significantly different ($P<0.05$, Chi Square). Sighting rates were not adjusted for observation conditions (visibility, glare, and sea state) because conditions were largely acceptable for detecting beluga whales; beluga sighting rates did not differ significantly by sea state because survey conditions were predominantly acceptable (< 5 sea state) for detecting belugas during the survey period (Figures 1 and 4). These results show belugas occurred in the study area throughout the study period, but use, as described by sighting rates and actual counts, was higher in May, August, September, and November than in the other months. Differences between the sighting rates and counts were due to variation in the group sizes per month (i.e., November had more groups with fewer whales per group compared to May, that had more individuals in fewer groups). Monthly sighting rates ranged between 0.01-0.08 beluga groups/hr or 1-8/100 hr.

Table 4 Monthly marine mammal sightings during study period, August-November 2011 and April-July 2012

Year	Month	Belugas		Harbor Seal		Harbor Porpoise	
		Number	Groups	Number	Groups	Number	Groups
2011	August	152	14	0	0	0	0
	September	285	21	5	5	3	1
	October	51	5	0	0	0	0
	November	53	8	0	0	0	0
Subtotal		**541**	**48**	**5**	**5**	**3**	**1**
2012	April	26	7	0	0	0	0
	May	149	32	2	2	0	0
	June	13	5	3	3	0	0
	July	28	8	9	9	0	0
Subtotal		**216**	**52**	**14**	**14**	**0**	**0**
TOTAL		**757**	**100**	**19**	**19**	**3**	**1**

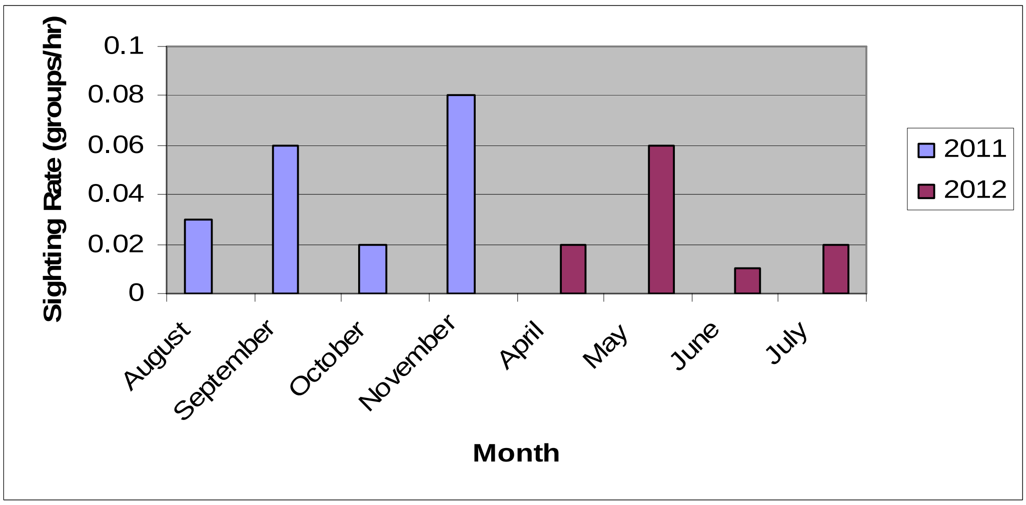


Figure 3 Monthly sighting rates of belugas in study area, August-November 2011 and April-July 2012

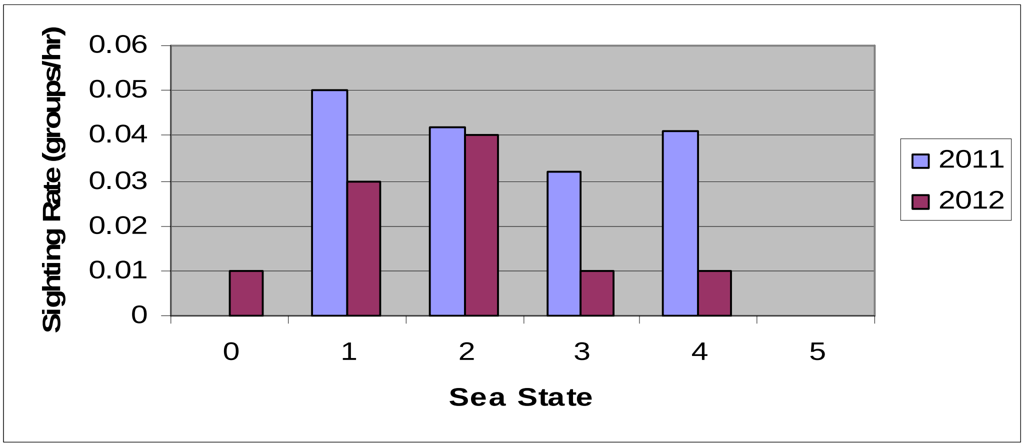


Figure 4 Sighting rates of belugas by sea state in study area, August-November 2011 and April-July 2012

Belugas were observed in the study area during 23 of the 35 (66%) weeks of the study period (Figure 5). There were no periods exceeding two consecutive weeks without encountering belugas. Two-week gaps in observing belugas occurred four times including one period in each of August and October in 2011 and again in April and July in 2012. If the 2011 and 2012 surveys were representative of one continuous season from April to November then the longest period without recording belugas in the study area was four weeks covering the last two weeks of July and the first two weeks of August. These results suggest belugas occurred in the study area during most weeks during each month of the study period with occasional weeks (4, 1-week and 4, 2-week) with no sightings. The period from mid-July to mid-August may be a time few to no belugas use the study area.

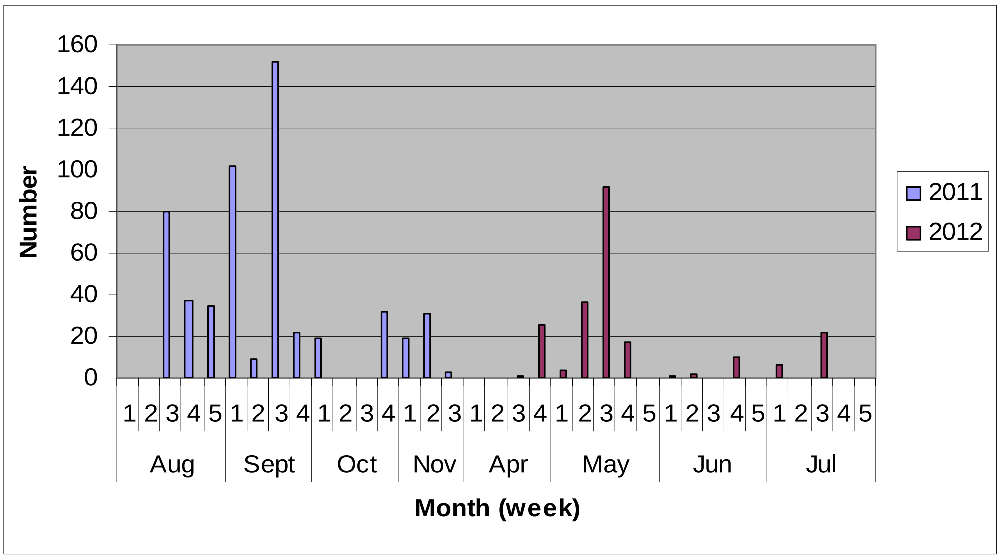


Figure 5 Number of beluga whales observed each week in study area, August-November 2011 and April-July 2012

Belugas were recorded on 33 (31%) of the total 105 survey days in 2011 and 31 (26%) of the total 121 survey days in 2012 (Figure 6). Belugas were observed on seven or fewer days in each month except during May, August, and September. Belugas were observed on slightly less than half of the days in May (48%) and September (43%) and about one-third (30%) of the days in August; surveys occurred during all days each month except for 1-2 days in the beginning of August and April. These results suggest the frequency of beluga daily occurrence in the study area was low each month except for moderate use during May and September and to a lesser extent August.

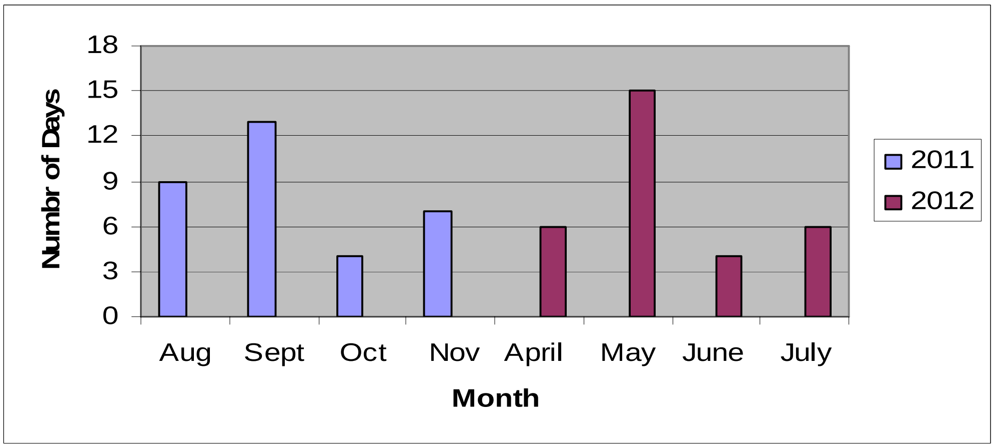


Figure 6 Number of days each month belugas were sighted in the study area, August-November 2011 and April-July 2012

Residency Time

When belugas occurred in the study area, they typically stayed for a relatively short period of time. Residency time was defined as the time between the first and last observations of a specific group of belugas in the study area. Residency time of belugas averaged less than a little more than one hour per group for all months except October (Figure 7). October had a small number (5) of observations and one group remained in the study area for an unusually long period of time of almost 5 hr. Removing this value from the observations resulted in an average residency time (68 min) similar to the other months. Average residency time during May was affected by 7 of the 32 observations of groups remaining in the study area for 2-5 hr. Combining the two years into one continuous time series suggests a weak pattern in residency time centered on May and October. However, the monthly residency times were not significantly different (df=7, P>0.05) from the means, suggesting the differences among the means were too small or the variances were too high to show a definite trend. The results indicate belugas rapidly moved through the study area each month with only a few exceptions.

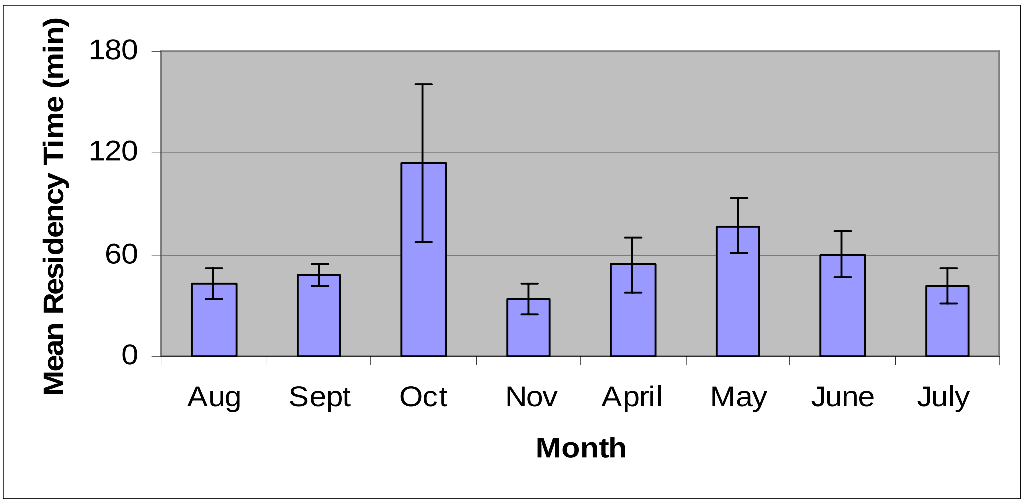


Figure 7 Mean and standard error (bars) of beluga whale residency time in the study area, August-November 2011 and April-July 2012

Behavior

Beluga whales displayed a variety of behaviors but traveling was the most common for most months (Figure 8). Over 80% of the groups of beluga whales passing through the study area were recorded as traveling for every month except October and November. Milling was observed equally (4 sightings in October and 2 in November) as often as traveling during these two consecutive months. Suspected feeding was the most prominent behavior for one of the five groups observed in October before traveling out of the study area. While the graph is based on the behavior represented by the greatest proportion of the total time a given group of belugas was observed in the project area, whales occasionally engaged in multiple behaviors. Traveling behavior was occasionally interrupted by milling and rarely diving or suspected feeding behavior. Observers recorded some fish activity during the latter half of July, but there was no observed associated feeding by belugas. These results indicate that belugas recorded in the project area use it for transiting between Turnagain Arm and the Susitna Flats/Knik Arm and not for feeding, breeding, or calving.

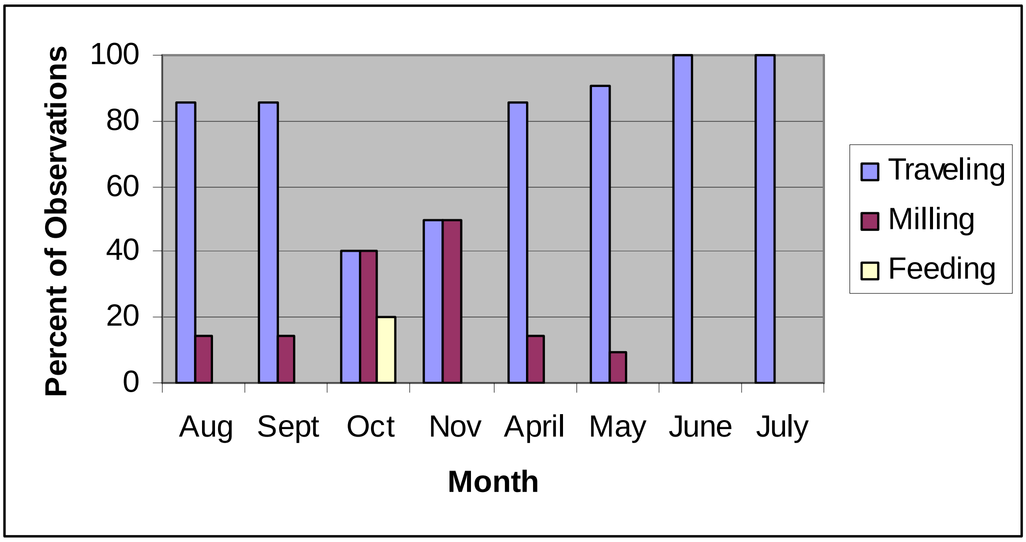


Figure 8 Behavior of belugas in the study area, August-November 2011 and April-July 2012

Monthly Distribution, Distance from Shore, and Direction of Travel

Belugas were widely distributed in the study area with areas of concentration (Figure 9). Belugas were generally evenly spread in an east-west orientation across the study area except near the mainland. Near the mainland belugas were concentrated along an area of the coast in a southeast direction from Point Campbell during each month of August to November in 2011 and April, June, and July of 2012 but not May. They were more concentrated from Point Campbell northward during May. Scarcity of sightings in the more distant parts of the study area may have been partly due to the observers' difficulty in consistently detecting belugas at long distances.

The nearshore affinity of belugas was reflected in their average distance from shore, and percentages of belugas in six distance categories extending from shore at mean high water each month. In the former case, belugas averaged between about 1100 and 1700 m (3609-5577 ft) from shore each month (Figure 10). While the variation around the averages was wide, most belugas occurred within 1000 m (3281 ft) of the shoreline each month, particularly during November (Figure 11). Average distances were not significantly different among months (df=8, P>0.05), but they were among distance categories for each month (df = 5; P<0.05). The much higher counts of whales in the 0-1000 m (0-3281 ft) than in the 1000-2000 m (3281- 6562 ft) categories clearly shows a nearshore preference by belugas. Moreover, subdividing the 0-1000 m (0-3281 ft) category into two equal distances had a majority of belugas within 500 m (1640 ft) of shore, further confirming a nearshore preference by belugas.

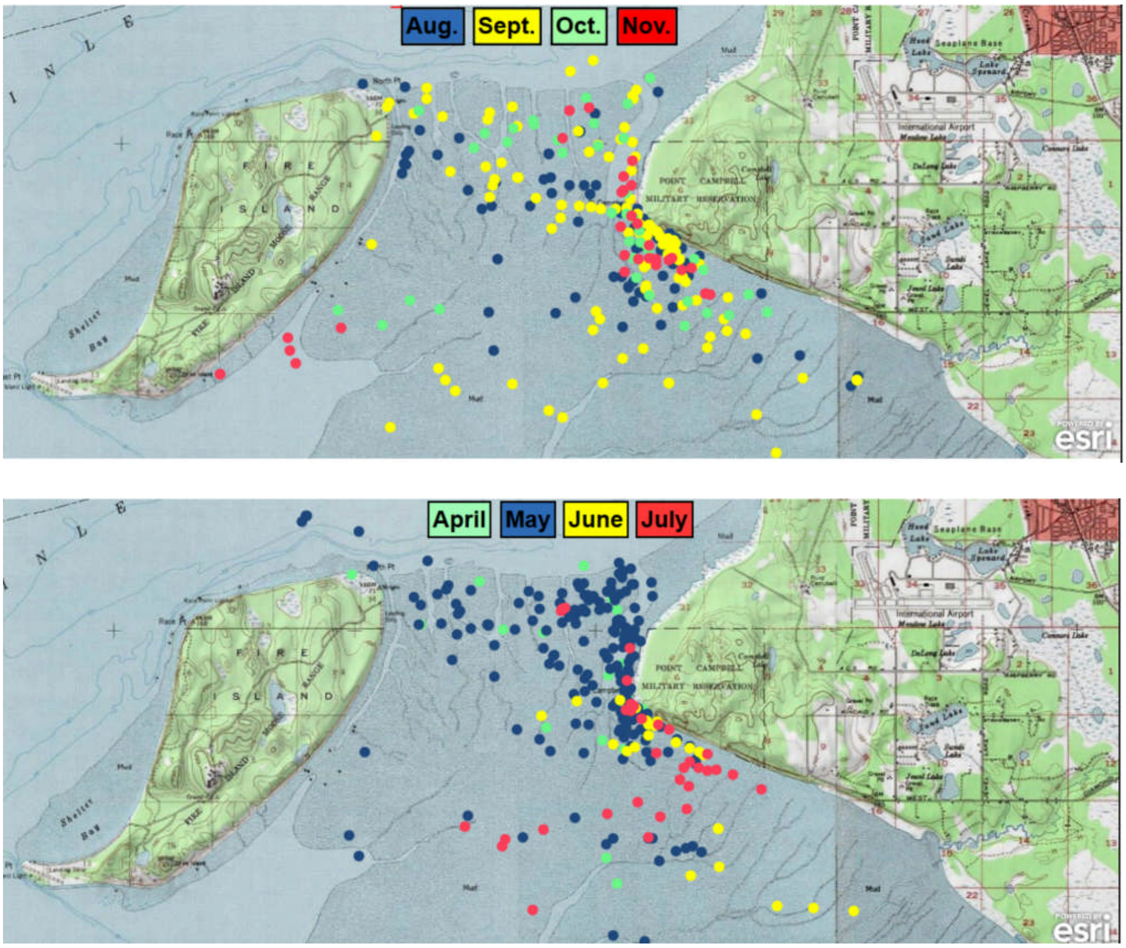


Figure 9 Monthly locations of beluga whales in the study area, 3 August–15 November 2011 (upper map) and 2 April-31 July 2012 (lower map).

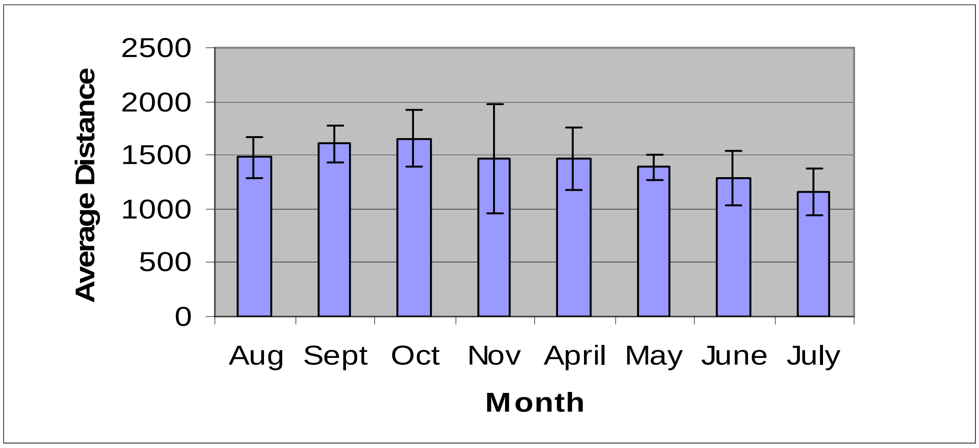


Figure 10 Average distance (m) and standard error of belugas from the mainland shoreline at mean high water, August-November 2011 and April-July 2012

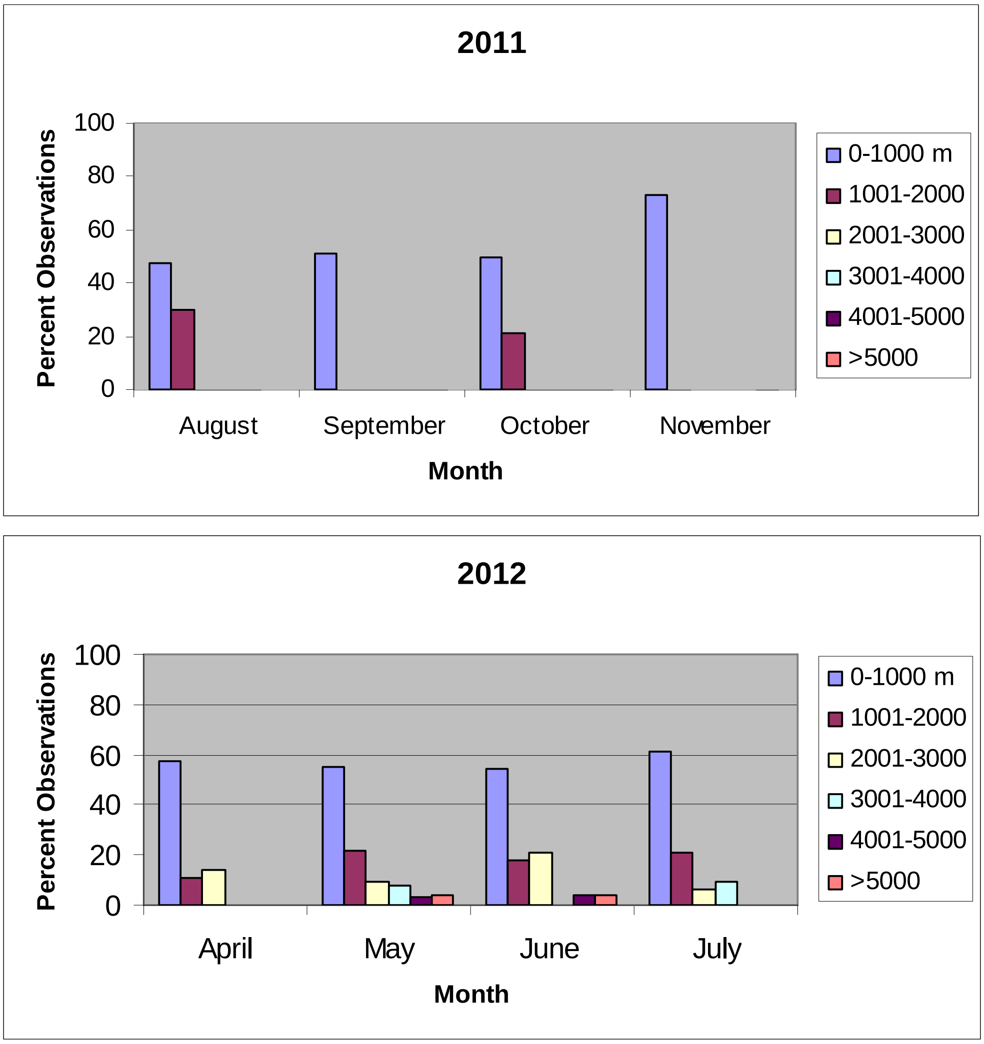


Figure 11 Percentage of belugas observed in six distance categories from the mainland shoreline at mean high water, August-November 2011 and April-July 2012

Direction of travel provided a metric for determining if belugas showed a preference when transiting through the study area. Direction of travel was based on connecting multiple location points for specific beluga groups relative to the times of observations as shown in Figures 12-23 for 2011 and Figures 24-34 for 2012; no belugas were observed during weeks 1 and 2 in August or 3 and 4 in October during 2011, and weeks 1 and 2 in April, 5 in May, 3 and 5 in June, or 2, 4, and 5 in July during 2012. Beluga groups were tracked by observers until they disappeared from view. Inspection of the 2011 weekly maps shows many beluga groups tended to follow the coast around Point Campbell, most often oriented in a direction toward Turnagain Arm during August through November. While the 2012 weekly maps also show many belugas followed the coast around Point Campbell, they were most often oriented in the other direction toward Knik Arm and the Susitna Flats during April through mid-June, after which the orientation was more often toward Turnagain Arm; there were exceptions to these patterns most weeks of each month where belugas traveled in the opposite and other directions. In addition, travel patterns were typically not unidirectional but variable as the groups moved through the study area. Combining the two years of data into one continuous eight-month period shows a modest shift in travel directions from Susitna Flats and Knik Arm toward Turnagain Arm in mid-June and July and continuing this pattern through the fall. These patterns generally persisted for most weeks during each month of the study and suggest seasonal movements of belugas to each of the two arms coupled with back and forth movements through the study area.

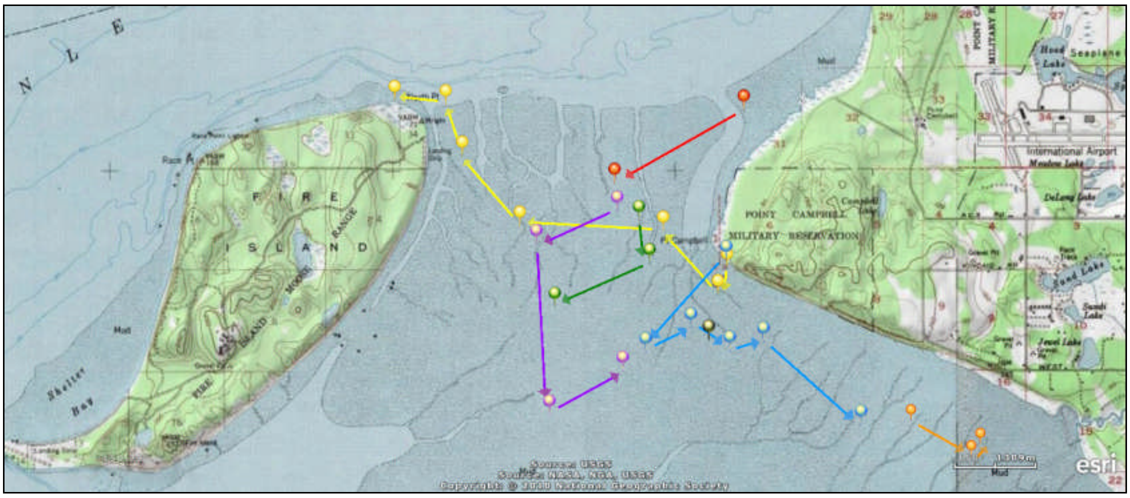


Figure 12 Beluga direction of travel August (week 3) 2011

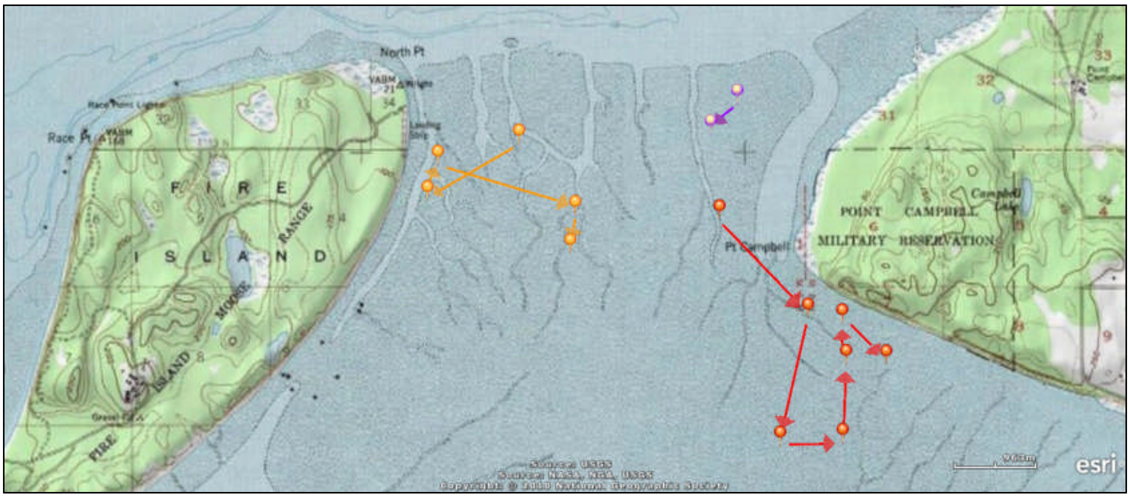


Figure 13 Beluga direction of travel August (week 4) 2011

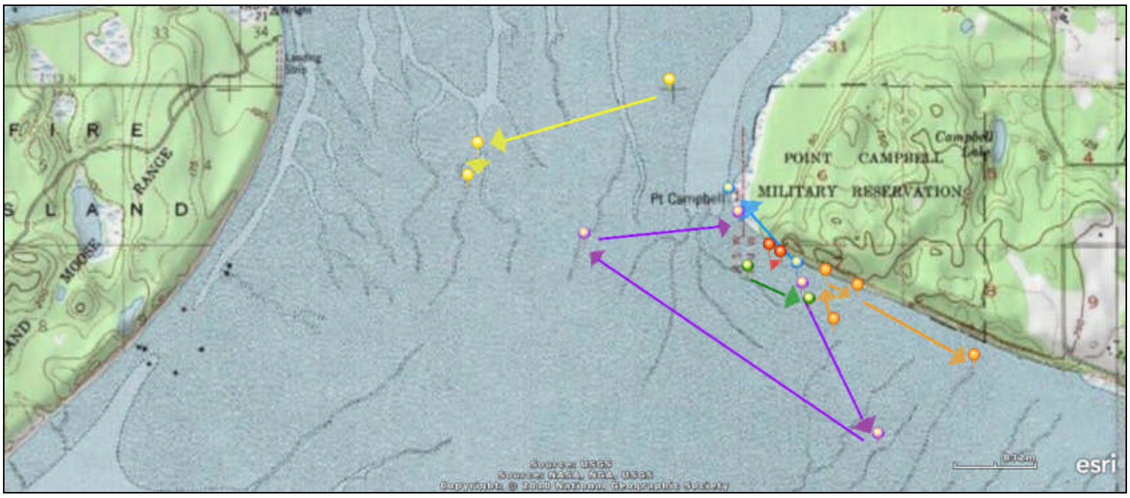


Figure 14 Beluga direction of travel August (week 5) 2011

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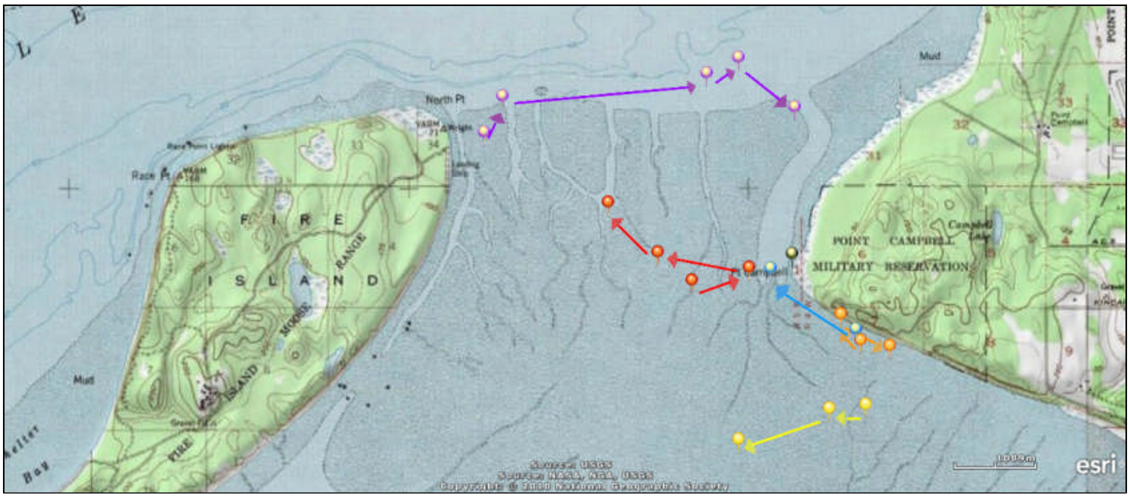


Figure 15 Beluga direction of travel September (week 1) 2011

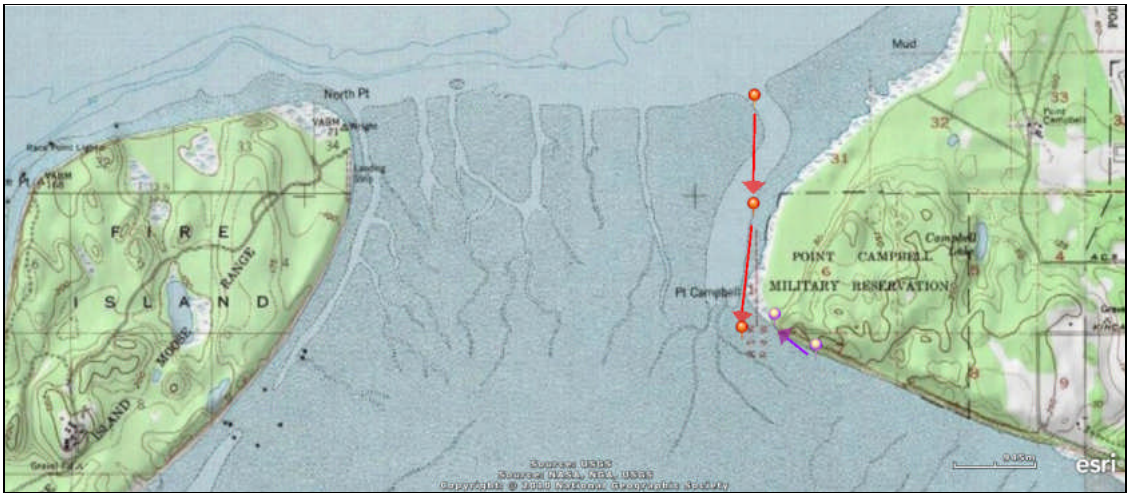


Figure 16 Beluga direction of travel September (week 2) 2011

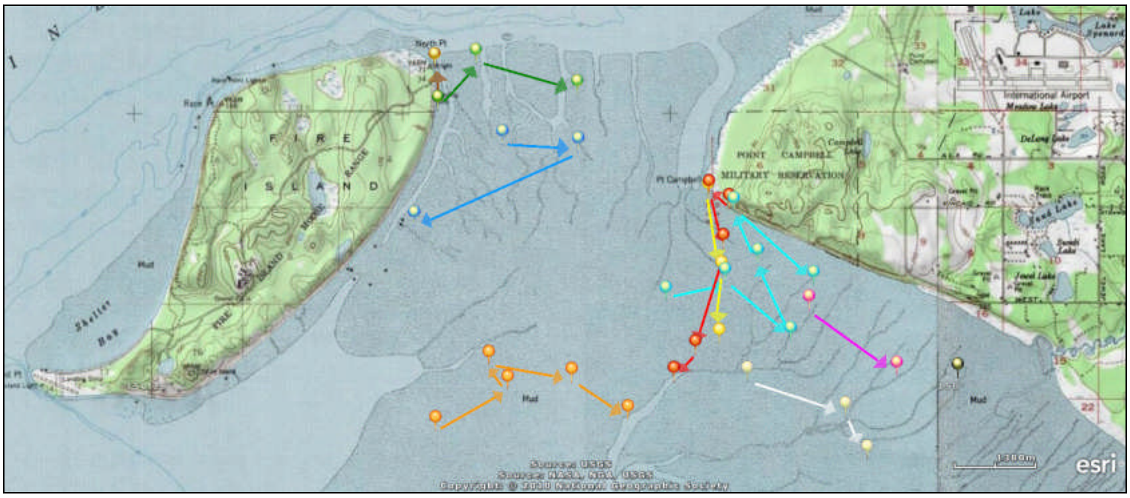


Figure 17 Beluga direction of travel September (week 3) 2011

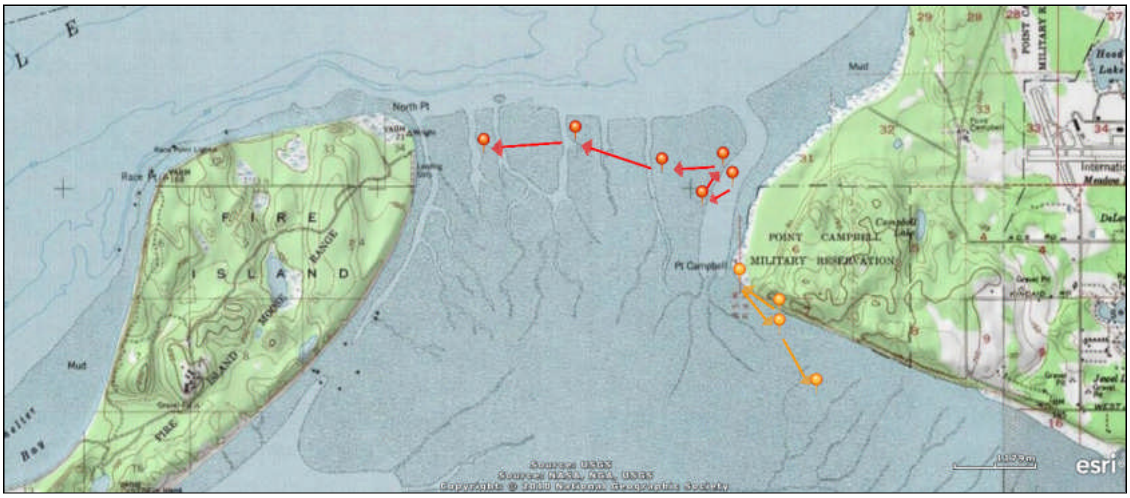


Figure 18 Beluga direction of travel September (week 4) 2011

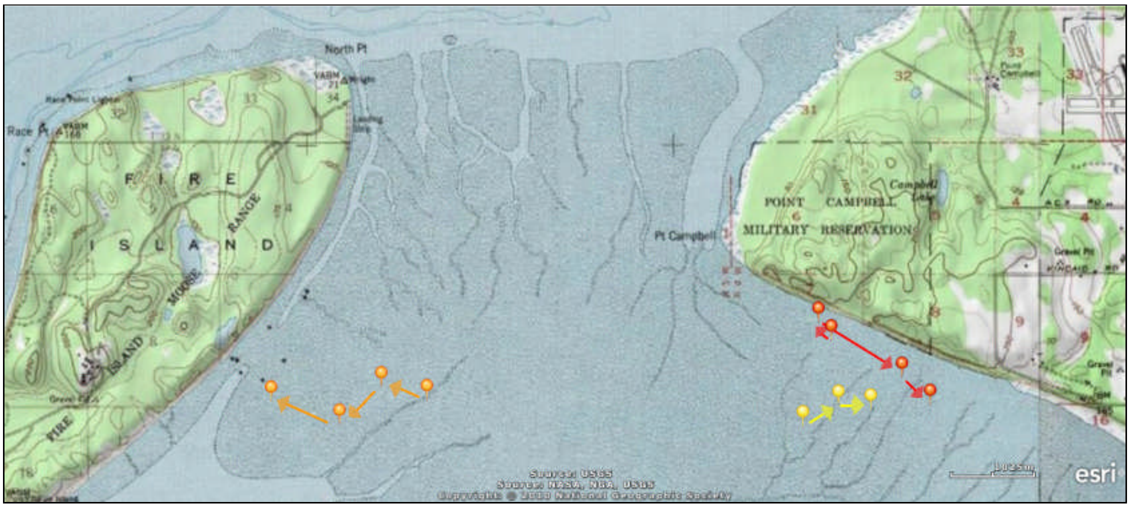


Figure 19 Beluga direction of travel October (week 1) 2011

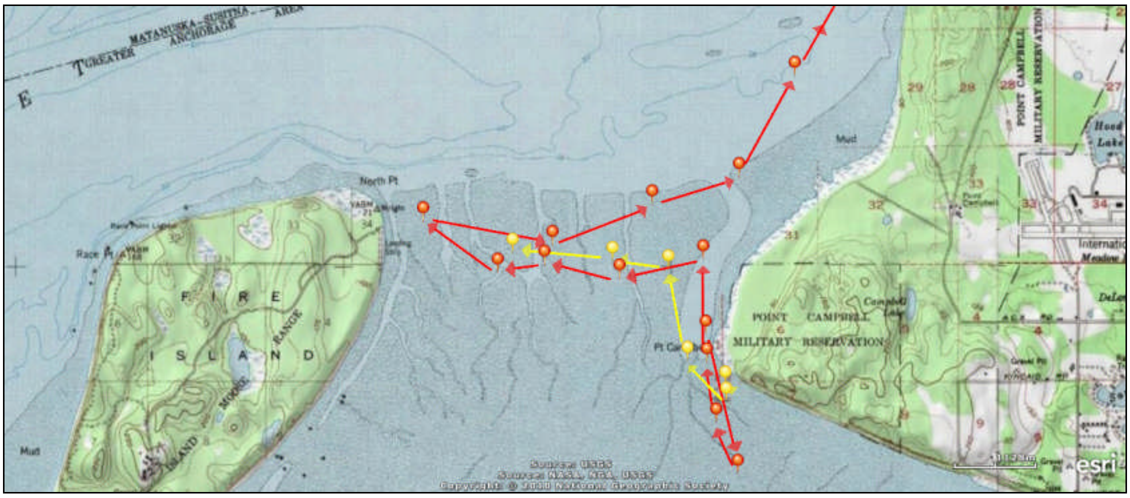


Figure 20 Beluga direction of travel October (week 4) 2011

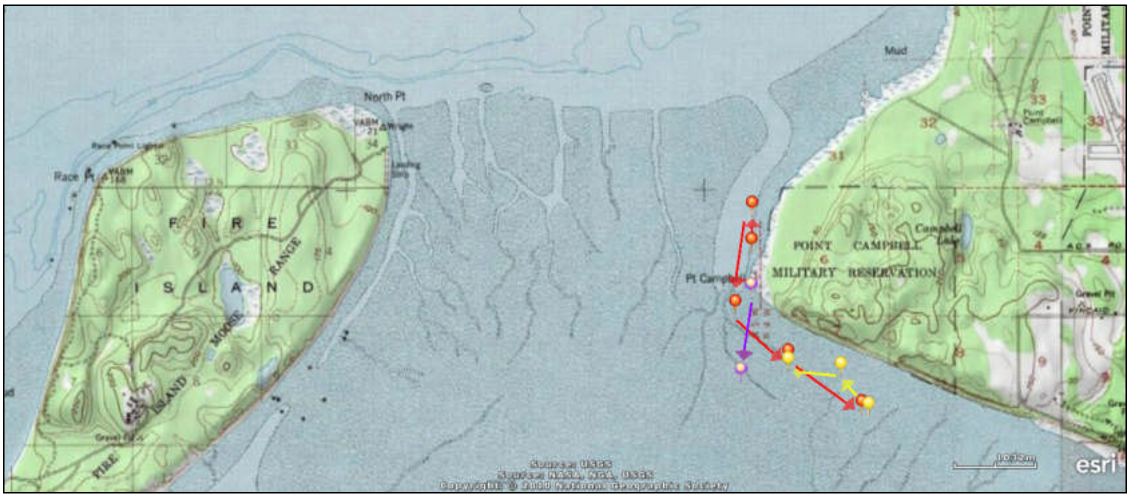


Figure 21 Beluga direction of travel November (week 1) 2011

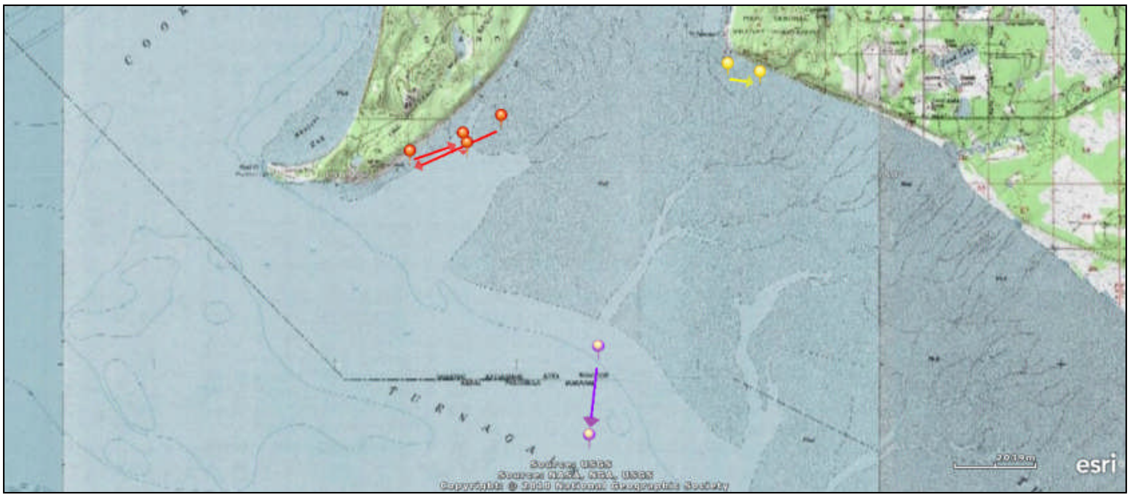


Figure 22 Beluga direction of travel November (week 2) 2011

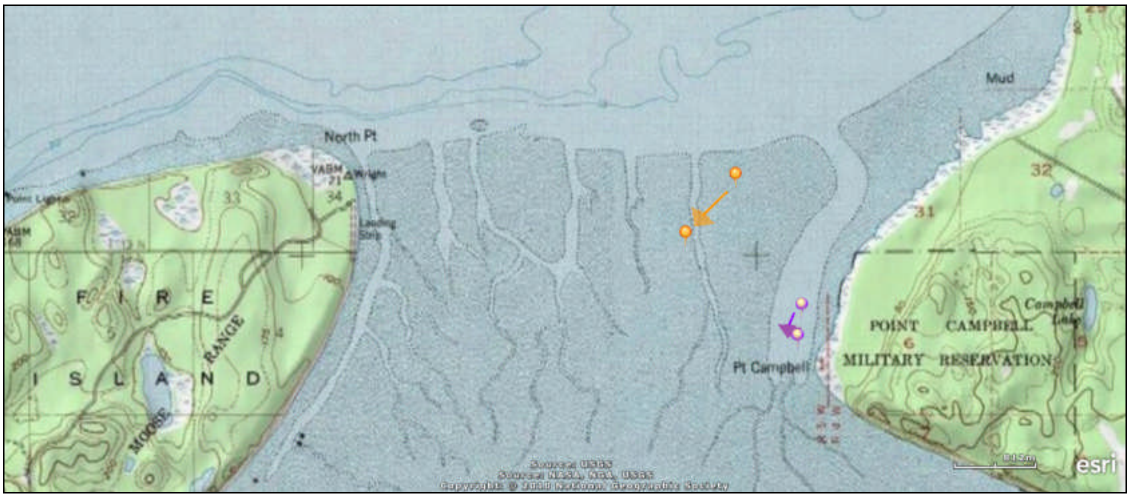


Figure 23 Beluga direction of travel November (week 3) 2011

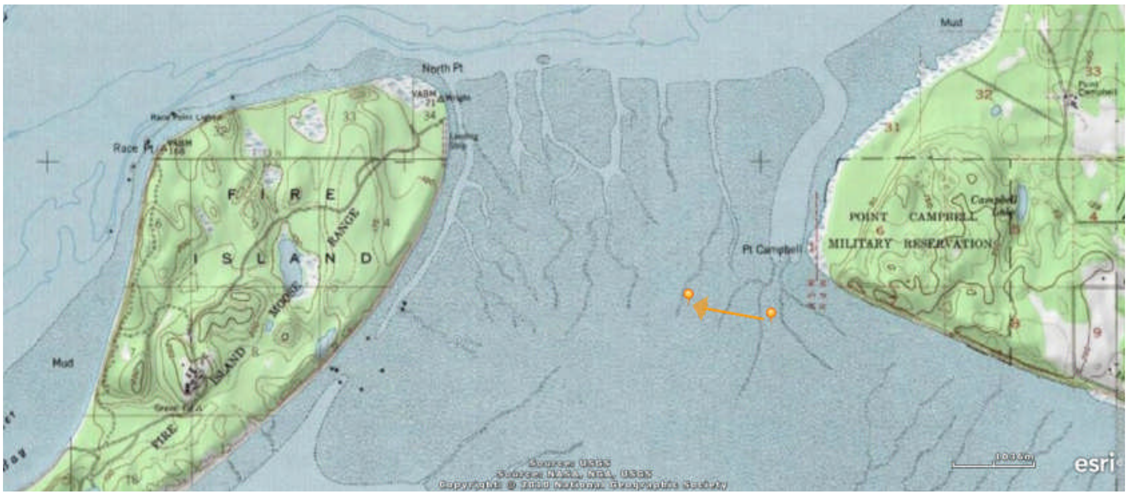


Figure 24 Beluga direction of travel April (week 3) 2012

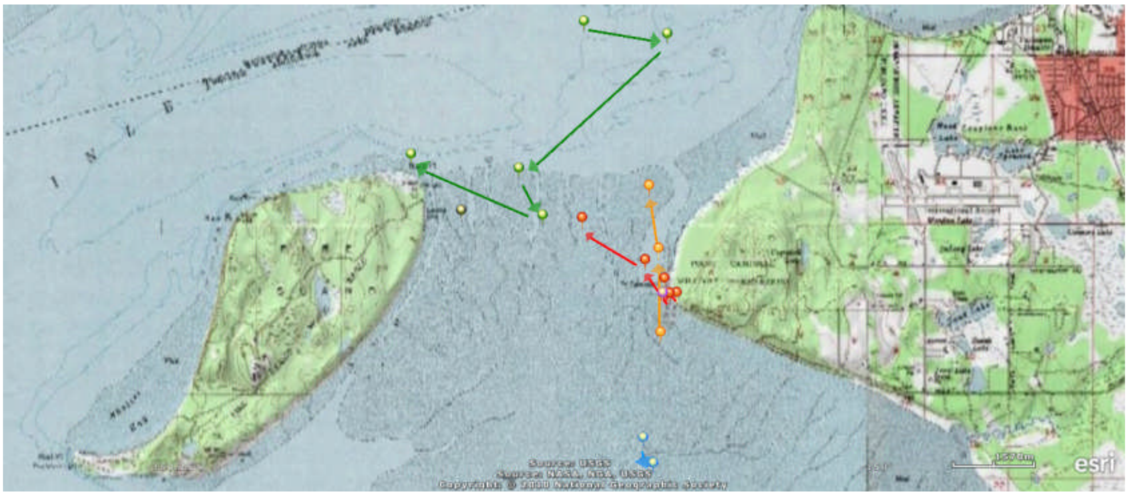


Figure 25 Beluga direction of travel April (weeks 4 & 5) 2012

Figure 26 Beluga direction of travel May (week 1) 2012

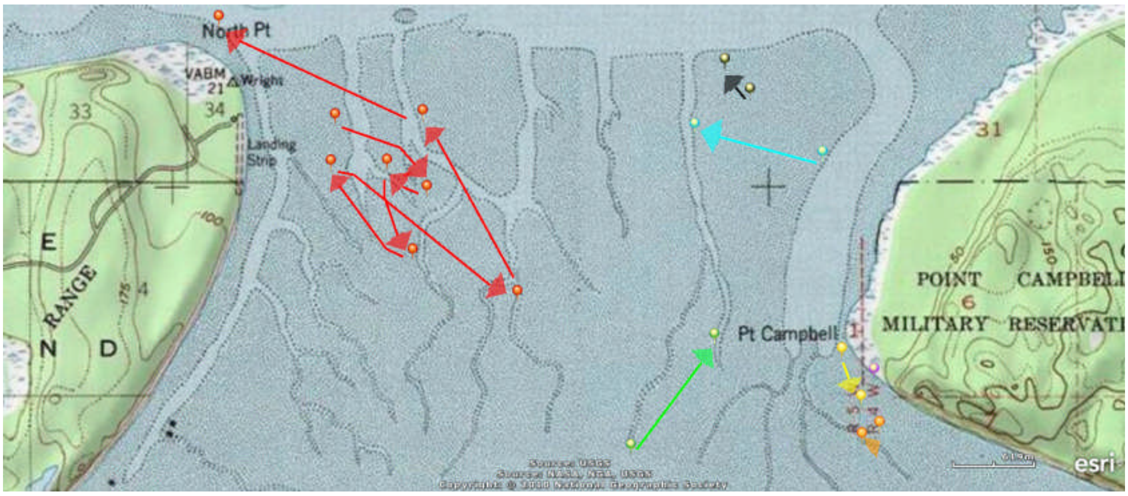


Figure 27a Beluga direction of travel May (week 2, results are shown on the following two maps to minimize overlap of travel directions from the large number of sightings) 2012

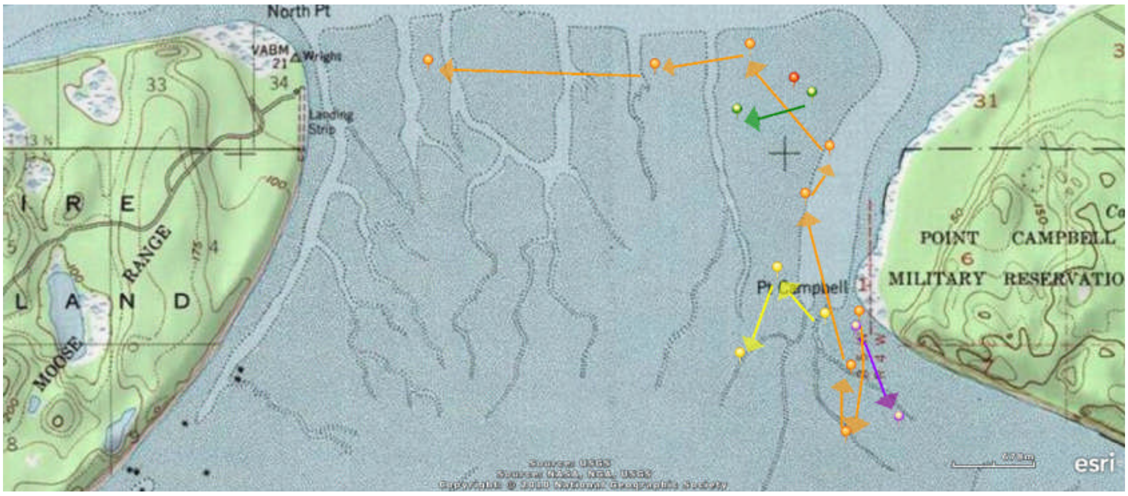


Figure 27b Beluga direction of travel May (week 2) 2012

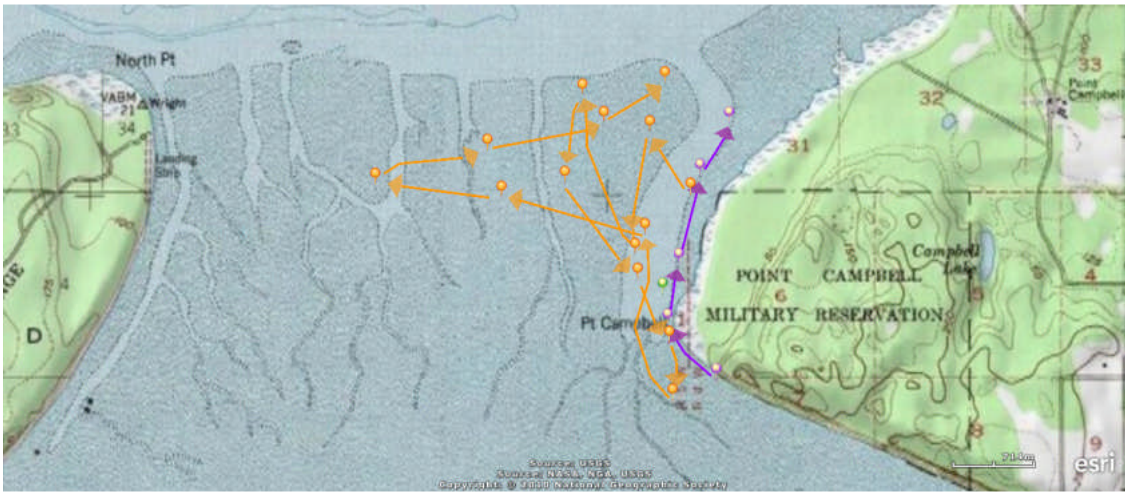


Figure 28a Beluga direction of travel May (week 3, results are shown on the following four maps) 2012

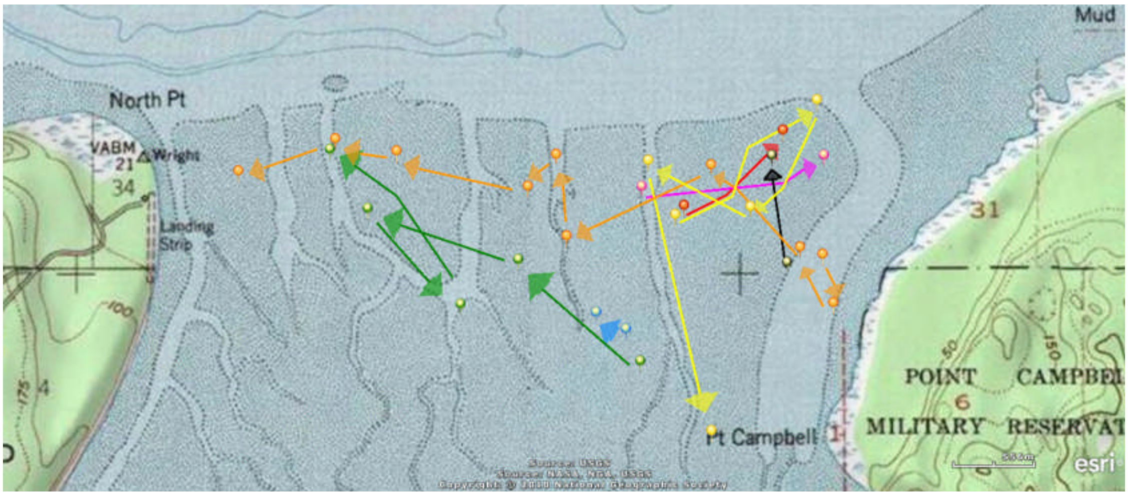


Figure 28b Beluga direction of travel May (week 3) 2012

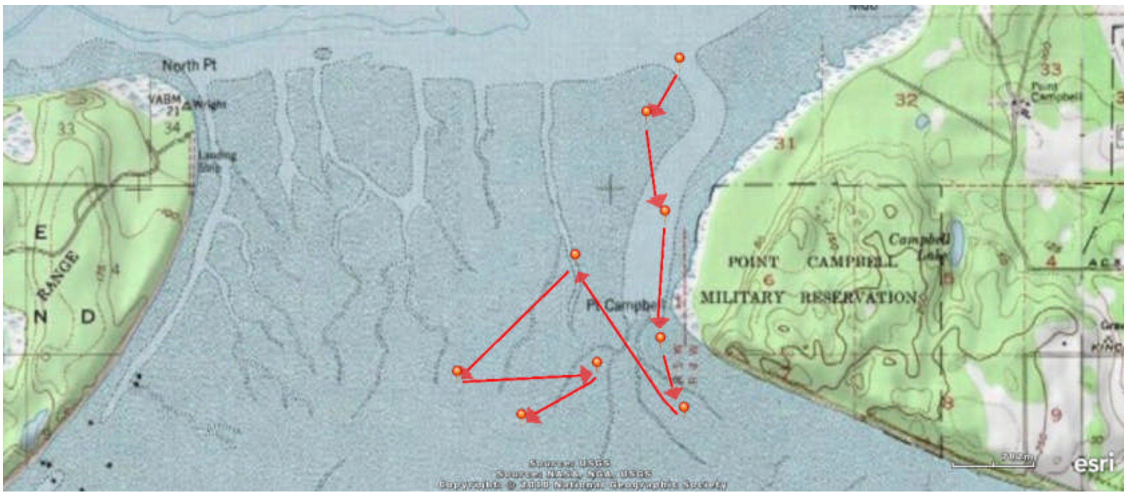


Figure 28c Beluga direction of travel May (week 3) 2012

Figure 28d Beluga direction of travel May (week 3) 2012

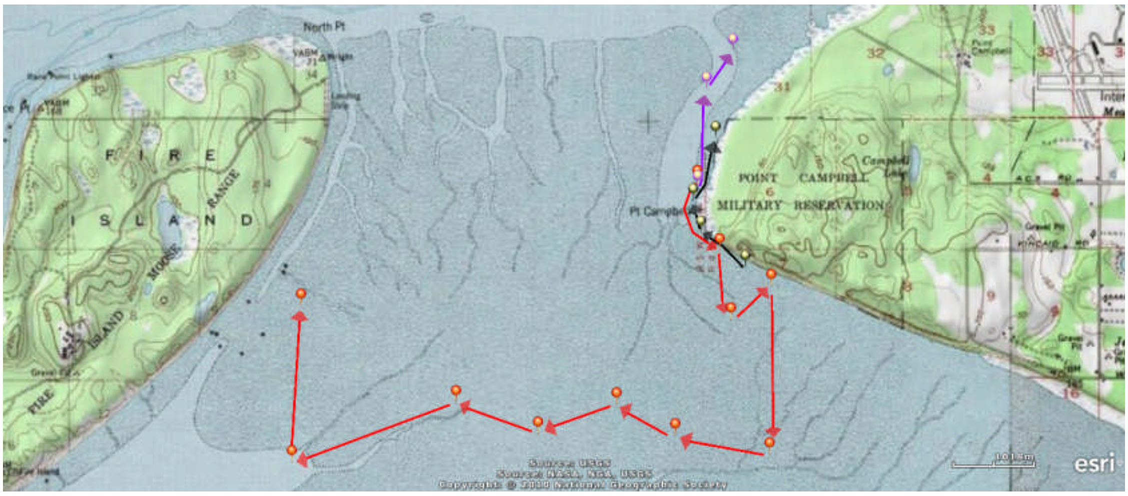


Figure 29 Beluga direction of travel May (week 4) 2012

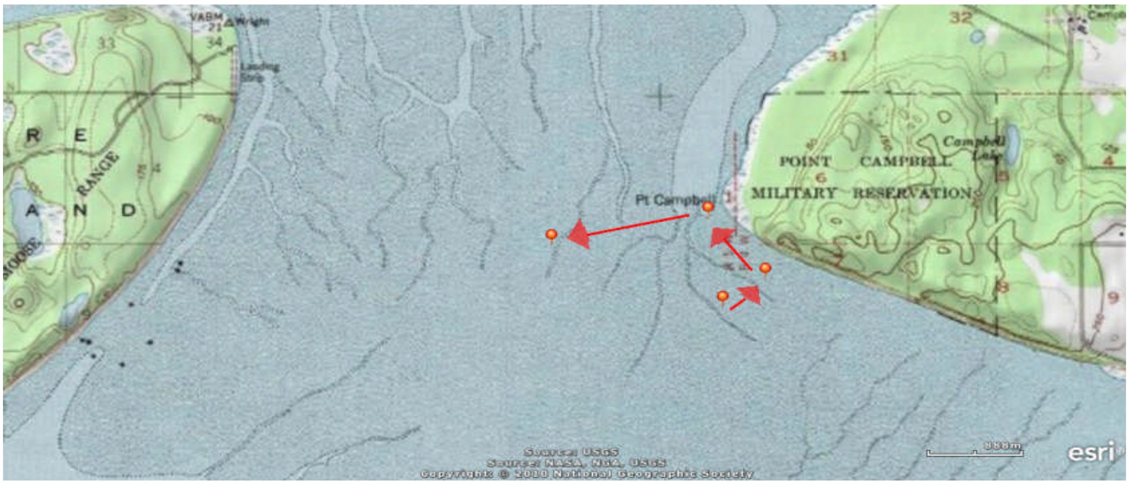


Figure 30 Beluga direction of travel June (week 1) 2012

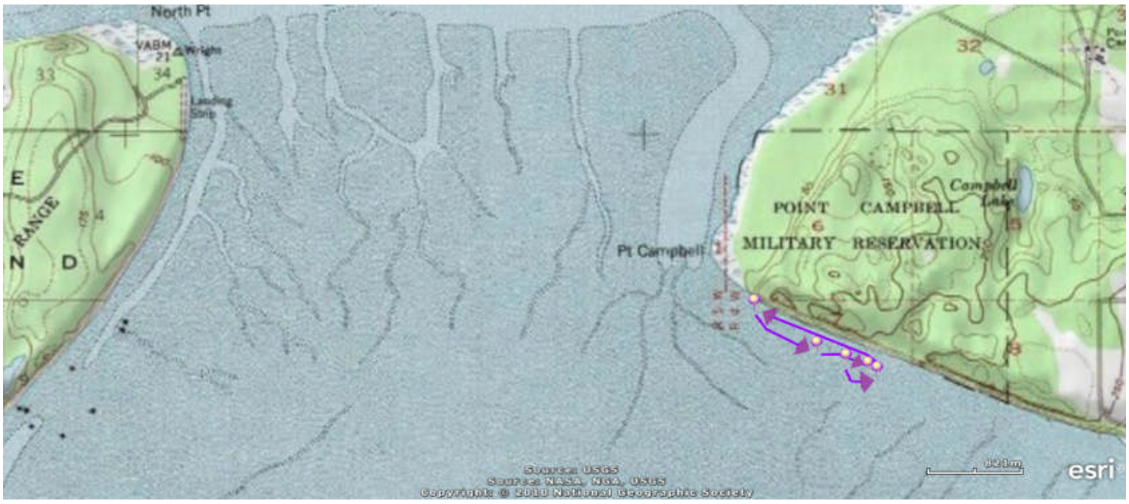


Figure 31 Beluga direction of travel June (week 2) 2012

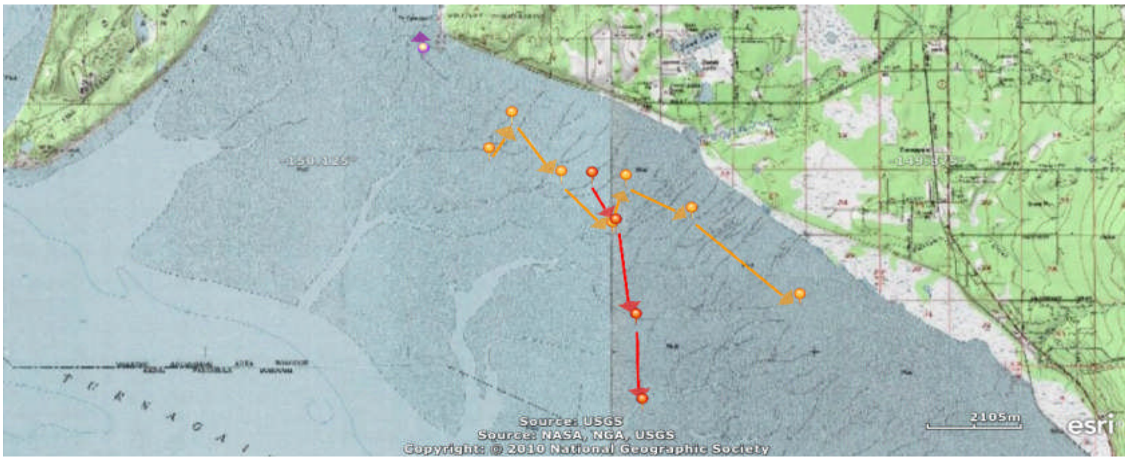


Figure 32 Beluga direction of travel June (week 3) 2012

Figure 33 Beluga direction of travel July (week 1) 2012

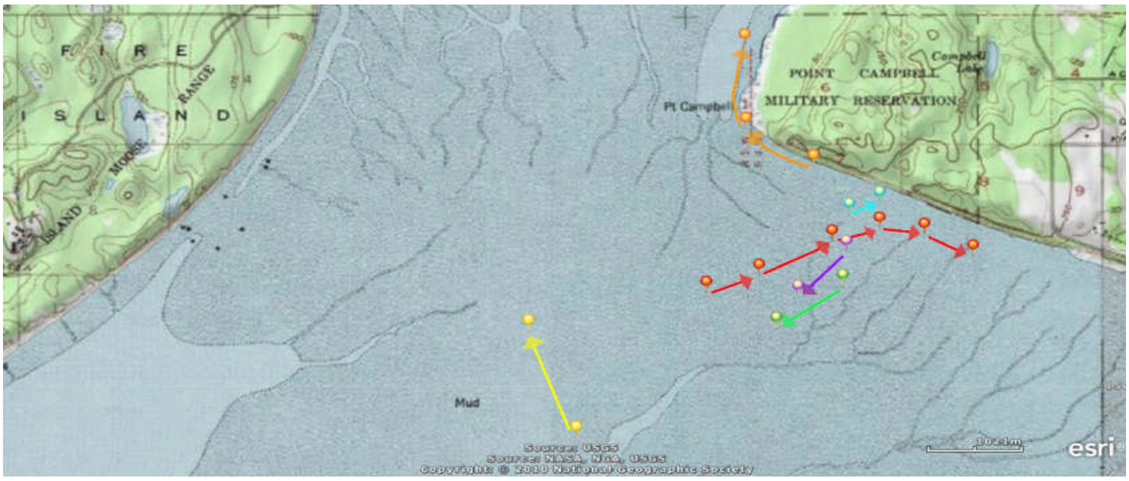


Figure 34 Beluga direction of travel July (week 3) 2012

Tidal Stage

Tidal stages provided a metric for determining the effect of water depth and current on beluga distribution in the study area. The distribution pattern relative to water depth changes was similar between 2011 and 2012 for the two four-month periods extending from April to November, described as follows. At water depths below approximately 5 ft (1.5 m), belugas occurred in a narrow band along the northern edge of the mudflats between Fire Island and the mainland; the southern edge was not visible from the observation site because it extends south a considerable distance (Figures 35, 36). Belugas showed a similar distribution pattern in water depths below approximately 10 ft (3 m), but there were more of them and they occurred in a wider band between the island and mainland and also deeper into the study area from the northern and southern edges (Figures 37, 38). However, with rare exception belugas still did not occur in the central area of the study area at these water depths. Between water depths of approximately 10-20 ft (3-6 m) belugas were distributed across the entire study area, but they were more concentrated nearshore to the mainland (Figures 39, 40). The concentration of belugas nearshore to the mainland was more evident when the water depth exceeded approximately 20 ft (6 m), particularly from Point Campbell southeast (Figures 41, 42). The only noticeable difference between 2011 and 2012 was that a few groups of belugas penetrated more deeply into the study area near Campbell Point at water depths below approximately 10 ft. These groups were in several nearshore channels surrounded by exposed mudflats at that water depth. Water gradually fills these and other channels as the tide rises but before flooding the mudflats.

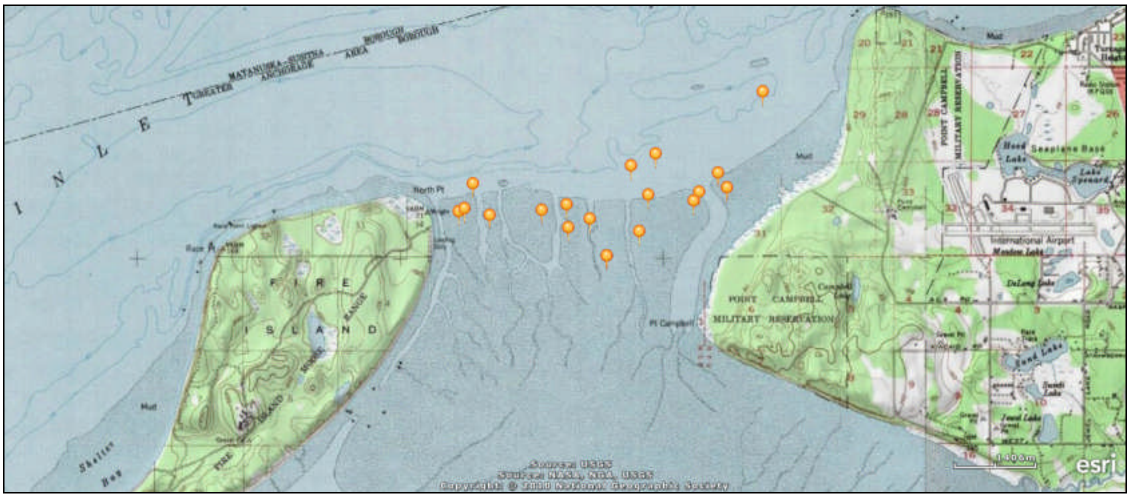


Figure 35 Beluga sightings during tides less than ≈ 5 ft (1.5 m), August–November 2011

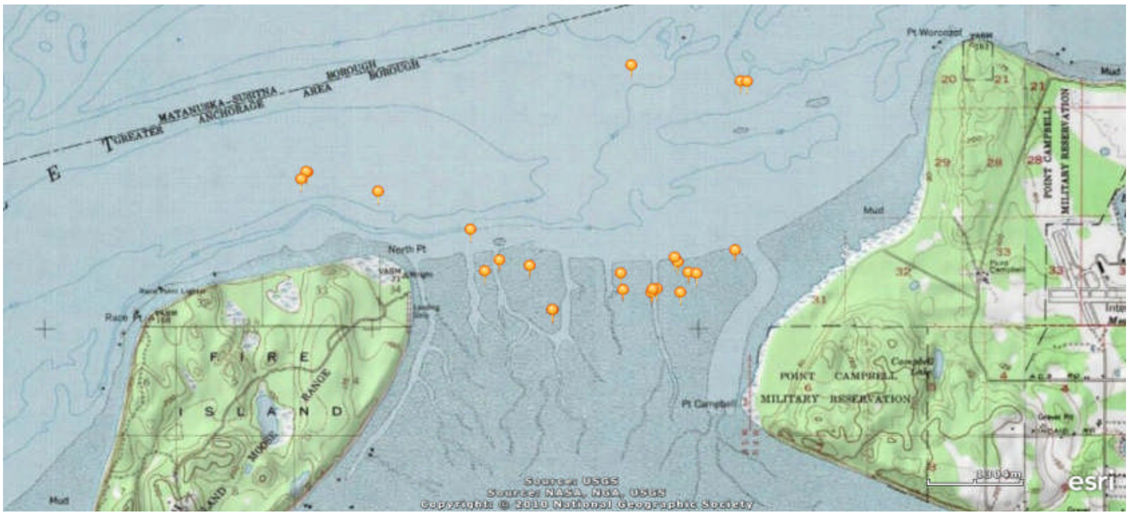


Figure 36 Beluga sightings during tides less than ≈ 5 ft (1.5 m), April-July 2012

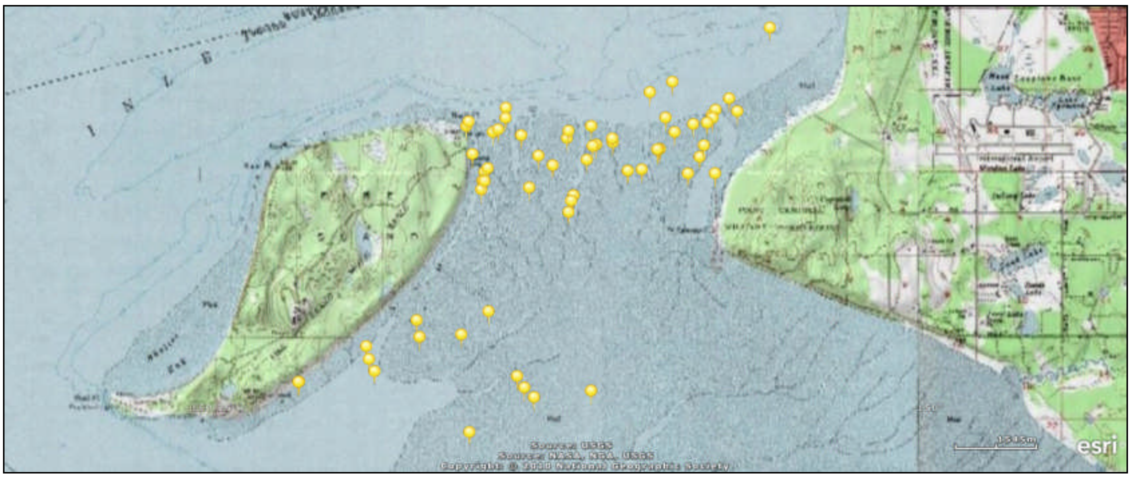


Figure 37 Beluga sightings during tides less than ≈ 10 ft (3 m), August-November 2011

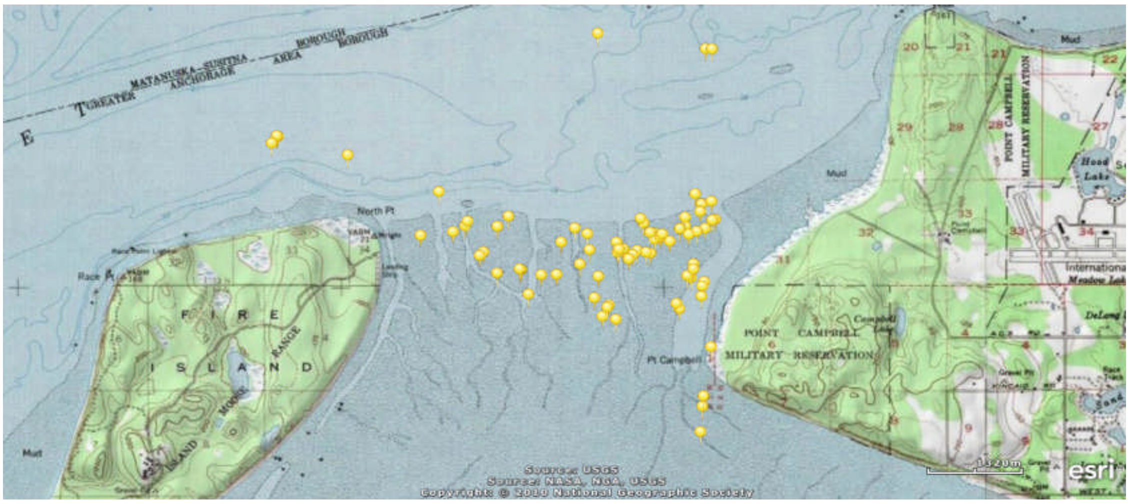


Figure 38 Beluga sightings during tides less than ≈ 10 ft (3 m), April-July 2012

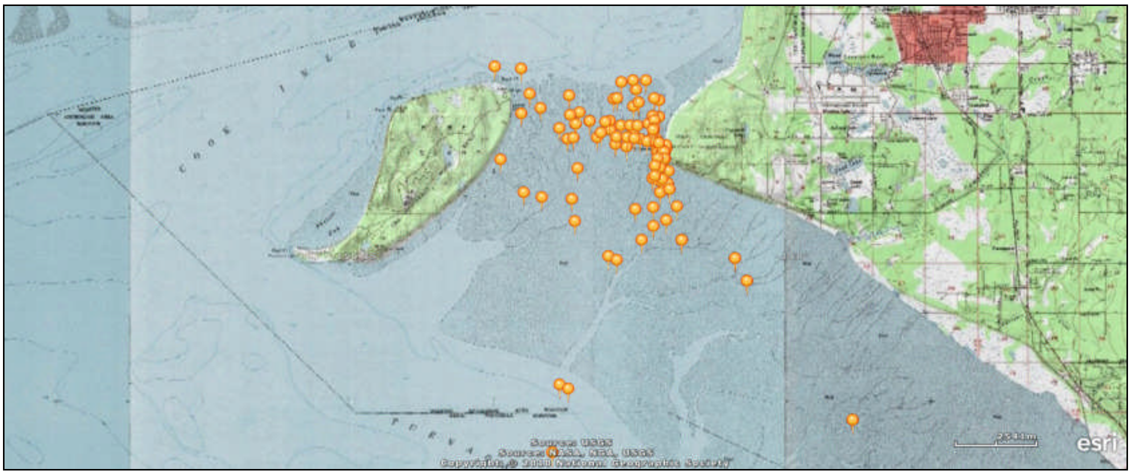


Figure 39 Beluga sightings during tides between ≈ 10 and 20 ft (3 and 6 m), August-November 2011

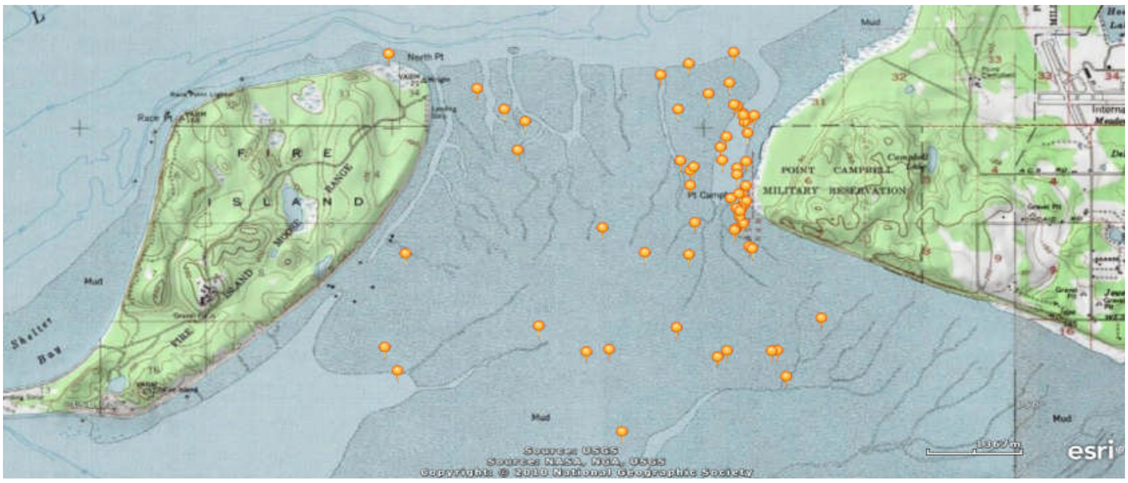


Figure 40 Beluga sightings during tides between ≈ 10 and 20 ft (3 and 6 m), April-July 2012

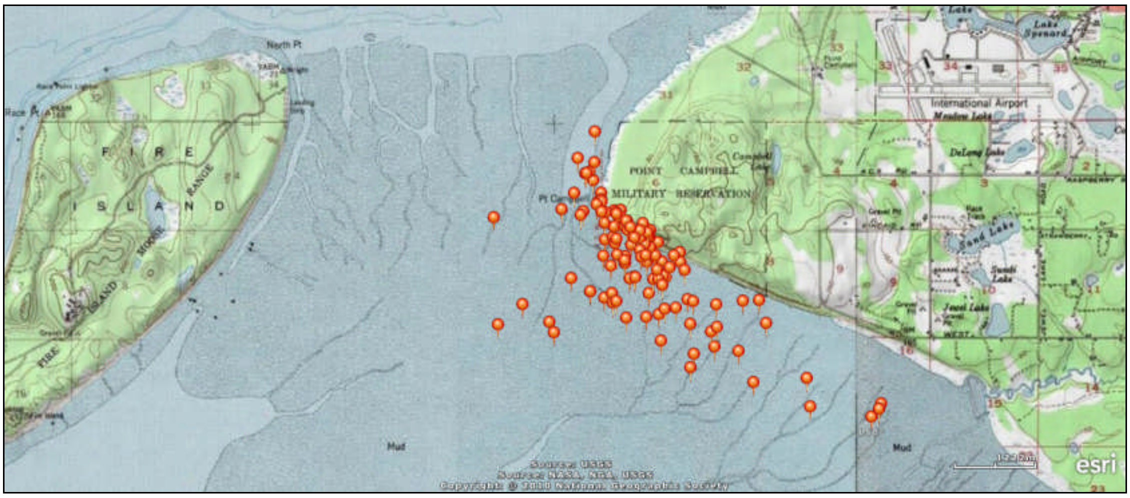


Figure 41 Beluga sightings during tides over ≈ 20 ft (6 m), August-November 2011

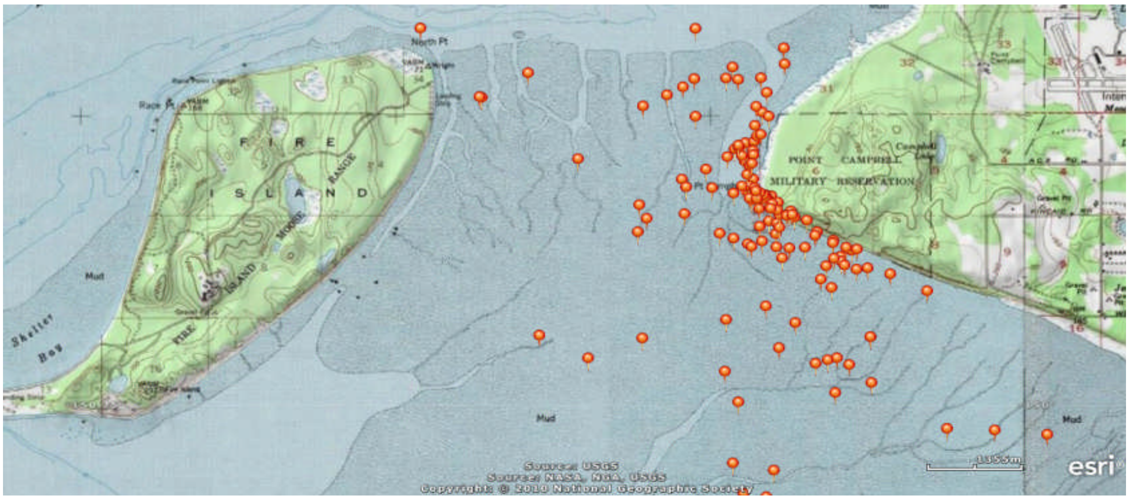


Figure 42 Beluga sightings during tides over ≈ 20 ft (6 m), April-July 2012

Tidal stage was used to determine effect of current speed and direction on beluga distribution in the study area. Ebb stages of the tide reflected water depth decreasing, flood increasing, and slack no or little change. Ebb and flood stages also reflected strongest currents during the tidal cycle. Sighting rates of beluga groups (and individuals) were highest during the three stages of high tide for the period from late summer to late fall of 2011 and as well as the period from early spring to mid-summer of 2012 (Figure 43). This pattern was generally consistent among months for each year. However, the sighting rates were significantly different (df = 5, P<0.0.5) among the tidal stages in 2012, primarily due to the high sighting rate during high slack tide in May. There was no significant difference (df = 5, P>0.05) in 2011, suggesting there was no preference by belugas among the tidal stages. This result was due to belugas occurring in deeper waters along the northern edge of the mudflats (southern edges could not be seen from observation site) and the two channels extending into the mudflats from Knik Arm at low tide (water depth $\leq$ 5 ft, 1.5 m), and not in the central portion of the study area, where most of it is exposed mudflats or shallow. If the analysis only considered the area comprising the mudflats the differences in sighting rates between high tidal and low tidal stages would obviously have been significant. These results suggest beluga movements into and out of the study area directly corresponded to rising and falling tides. Movements did not appear to be influenced by direction of currents associated with the ebb (outgoing) and flood (incoming) stages of the tidal cycle

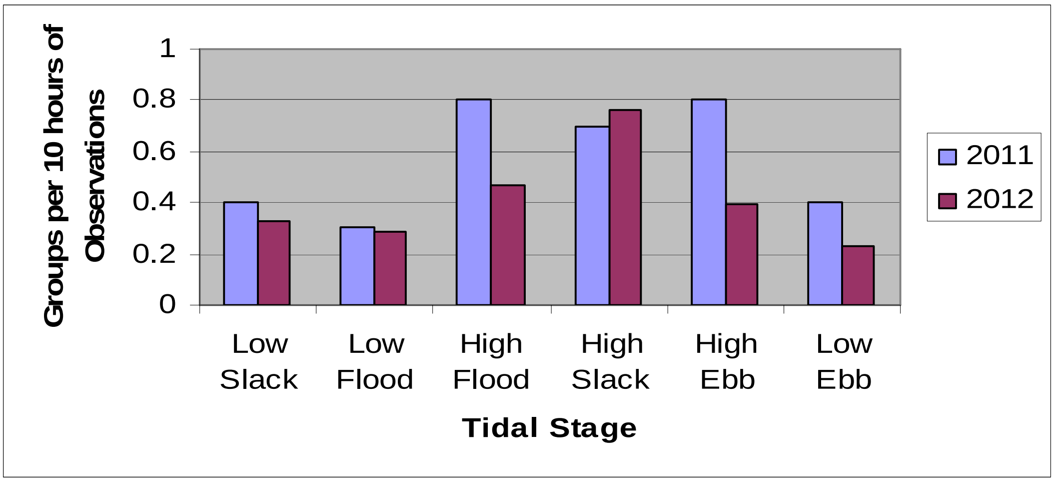


Figure 43 Sighting rates of beluga whale groups during each stage of the tidal cycle in the study area, August-November 2011 and April-July 2012

Population Parameters

Group Size

Mean group size was determined by estimating the number of whales for each group observed in the study area. The most frequent number recorded during multiple counts of each group was used to derive the average group size. Only one group was observed to split into two groups.

Mean group size of beluga whales was consistently higher in late summer and fall of 2011 than in spring and mid-summer of 2012 (Figure 44). The monthly mean group size ranged from about 2 belugas in June to14 in September. The monthly differences in group size were statistically significant ($P < 0.05$). Combining the two years into one continuous time period from spring to fall shows mean group size more than doubled from less than 5 belugas during April through July to over 10 during August through October before declining to 7 in November. Correspondingly, the largest groups were observed in August (30), September (66), and October (30), while solitary whales were most frequent during April through July. The results suggest an upward shift in group size from spring-mid-summer to late summer-fall followed by a decline in November.

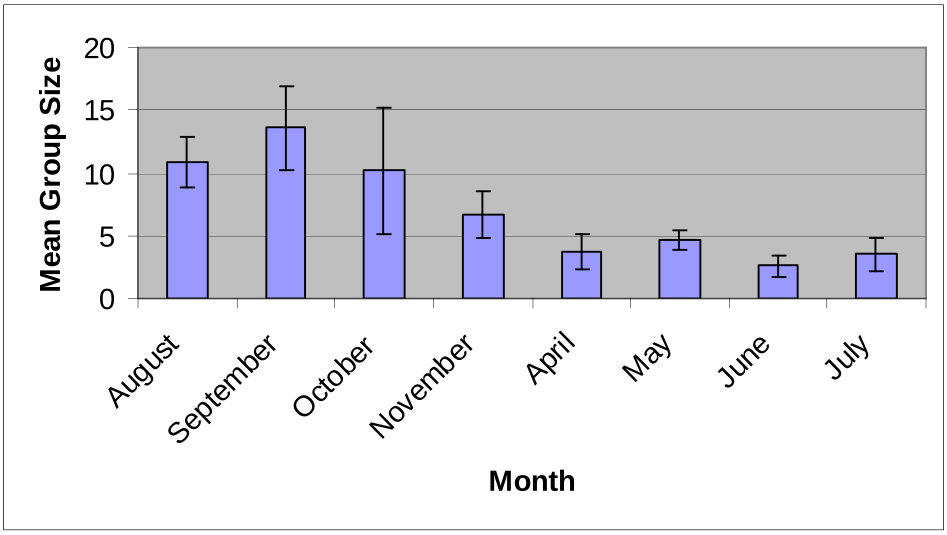
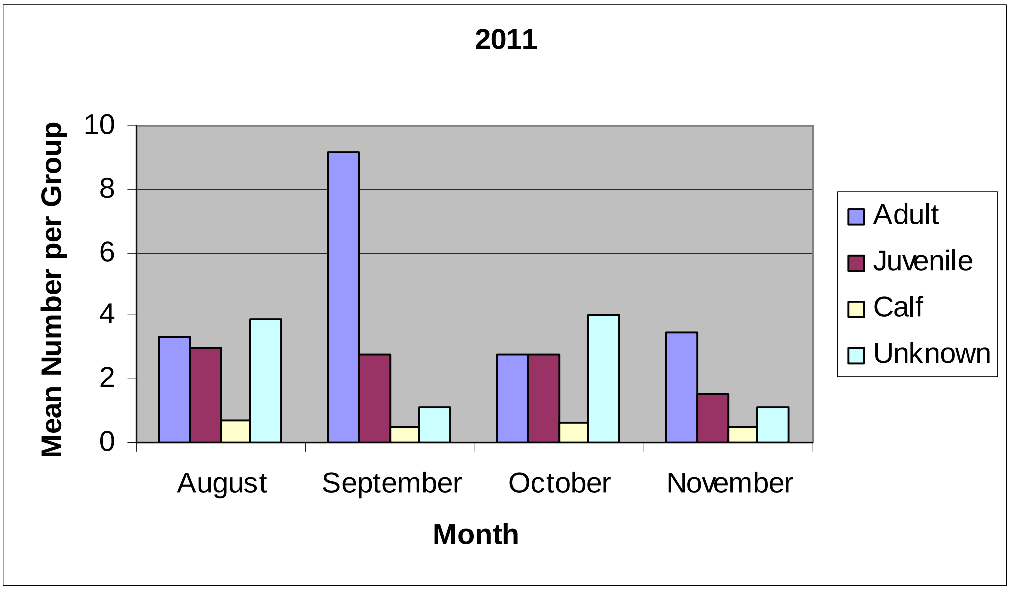


Figure 44 Mean group size and standard error (bars) for beluga whales in the study area for August-November 2011 and April-July 2012

Age Composition

Age composition of groups of belugas varied by month, but the trend was generally similar (Figure 45). Adults were typically the most abundant age category in a group, followed by juveniles, and lastly calves for each month. Ten or fewer calves were observed each month, except for 14 calves recorded in May and no calves in June. Calves averaged about one per two groups for most months. Variability in the age composition among months was likely biased by the number of belugas not classified by age; i.e., those listed as unknown. This was most evident in August and October, where the mean numbers of adults and juveniles per group were similar. The months (June, July, and September) with the least number of unknowns likely represent the best estimate of the age composition per group in the study area because most if not all of the animals were aged. Factors responsible for belugas not color classified to age by observers were weather, glare, distance, or time of whale on the surface of the water. Overall, adults represented 52%, juveniles 23%, calves 5%, and unknown 20% for the August through November period in 2011. The age composition for the April to July period in 2012 was essentially identical to the 2011 period and included 53% adults, 20% juveniles, 10% calves, and 18% unknowns. These results suggest the age composition of belugas was relatively consistent except for minor adjustments due to changing numbers of calves.



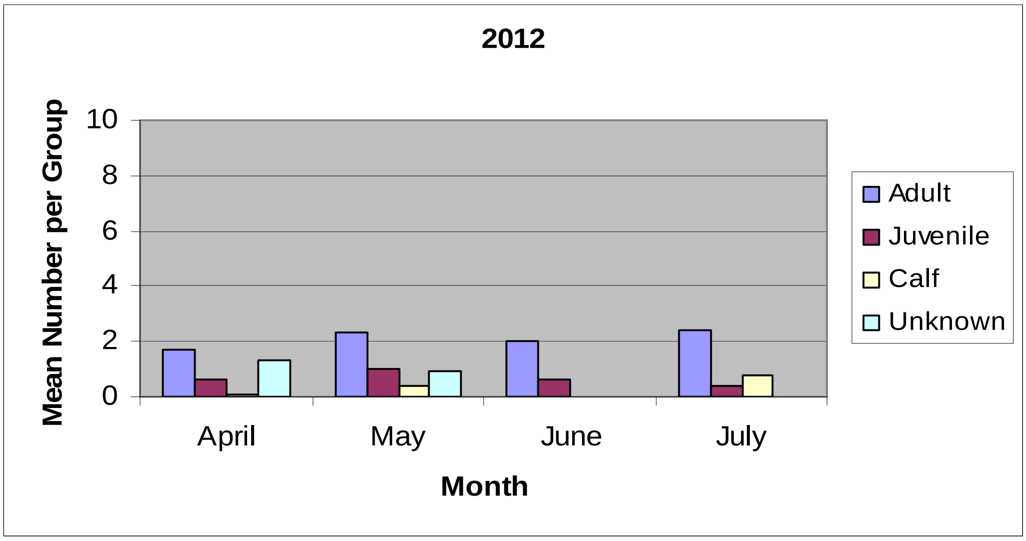


Figure 45 Age composition of groups of beluga whales recorded in the study area, August-November 2011 and April–July 2012

Discussion

Beluga Whales

Beluga whales occurred in the study area each month and most weeks of the eight-month project, but the number of days they were observed per month was generally low. There were no periods greater than two weeks without belugas occurring in the study area during either 2011 or 2012. A two-week gap at the end of July in 2012 and again at the beginning of August in 2011 suggests a longer period (4 weeks) of beluga absence from the study area than other periods if combining the two months from two different but consecutive years into one continuous period accurately reflects beluga use of the study area. While beluga occurrence was widespread over most months, they were only observed on seven or fewer days in each month except during May, August, and September. During these months they were observed on about one-third (August) to one-half (May and September) of the survey days. Similarly, the highest counts and sighting rates of belugas occurred during these months and also November; however, the shortened survey effort in November may have artificially inflated the sighting rate. While the sighting rates were higher during these months than others, they indicate the intensity of use in the study area was still low given only 3 to 8 groups per 100 hr of observation were recorded for these months. The results show relatively lower use of the project area by belugas during the spring through mid-summer months than during the late summer through fall months. An unusual spike in beluga use occurred during May.

These results largely correspond to the periods and patterns of use by belugas reported for Knik and Turnagain Arms except beluga use was much lower and less frequent in the study area (Funk et al 2005, Markowitz et al. 2007, NMFS 2005). Funk et al. (2005) reported beluga use of Knik Arm was highest (0.8-3.0 whales/20 min or 2.4-9 whales/hr vs. 0.19-0.54 whales/hr in our study) in late summer and fall (August through November), peaking in September, lowest in winter (December through February), and remained low in spring and mid-summer (March through July). They attributed the change in use to a distributional shift of belugas from the Susitna River area in May-July to Knik Arm during August-November. Similarly, Markowitz et al. (2007) reported that beluga use of Turnagain Arm was highest from August through November and lowest from May through July, when no whales were observed. Others report low but occasional use by belugas of Turnagain Arm during April through May (McGuire and Bourdon 2012). The highest counts of belugas in Turnagain Arm also occurred in September. These results suggest a pattern similar to what we report including a peak in sightings during September. We also report a spike in beluga use during May, a time when beluga use is reported to be low in the two arms. These patterns of beluga use are likely timed with the availability of prey in the region. August and September correspond to the time of peak salmon numbers in Turnagain and Knik Arms, and May corresponds with high numbers of eulachon and smelt in the Upper Inlet, although we did observe eulachon washed up on the shore, we did not observe any confirmed feeding by belugas in the study area (http://www.adfg.alaska.gov/static-sf/Region2/pdfpubs/anchorage.pdf, http://www.alaskaoutdoorjournal.com/Reports/Fishreport/anglerreport1.1.12-5.7.htmlNMFS 2005, Barrett et al. 1984, and Spangler et al. 2003,).

Belugas appeared to use the study area to transit between Knik Arm and Turnagain Arm, a finding supported by satellite-tagged belugas tracked by the NMFS (Hobbs et al. 2005). Several of 16 tagged belugas moved back and forth between the two arms and Chickaloon Bay between summer and early autumn (Figure 46). One individual tracked in 2001 moved back and forth between Knik Arm, Chickaloon Bay/Turnagain Arm, and offshore seven times in a three-month period. Studies in Knik and Turnagain Arms suggest most belugas do not transit the study area to access either arm (Funk et al. 2005, Markowitz et al. 2007, Hobbs et al. 2005). These studies suggest most belugas appear to access Knik and Turnagain Arms from the Susitna Flats area, where they occur during spring and summer, and then depart from them in the late fall and winter to the mid-Inlet (Figures 47, 48). Seasonal movements are believed to correspond with prey availability in rivers flowing into these areas, which are absent in the study area (Moore et al. 2000, Goetz et al. 2012). While most belugas access the arms more directly from the Susitna Flats, some belugas in each arm transit through the study area from spring through fall. Moreover, the study results show belugas transit multiple directions between Fire Island and the mainland each month, but there appears to be a seasonal pattern where some belugas transit in the direction of Turnagain Arm in summer to fall and Knik Arm/Susitna Flats in the spring. The number of beluga sightings reported in the study area likely included a potentially high number of repeat sightings, and therefore a much smaller number of belugas passing through the study area, as witnessed by Hobbs et al. (2005) of a satellite-tagged whale reported above.

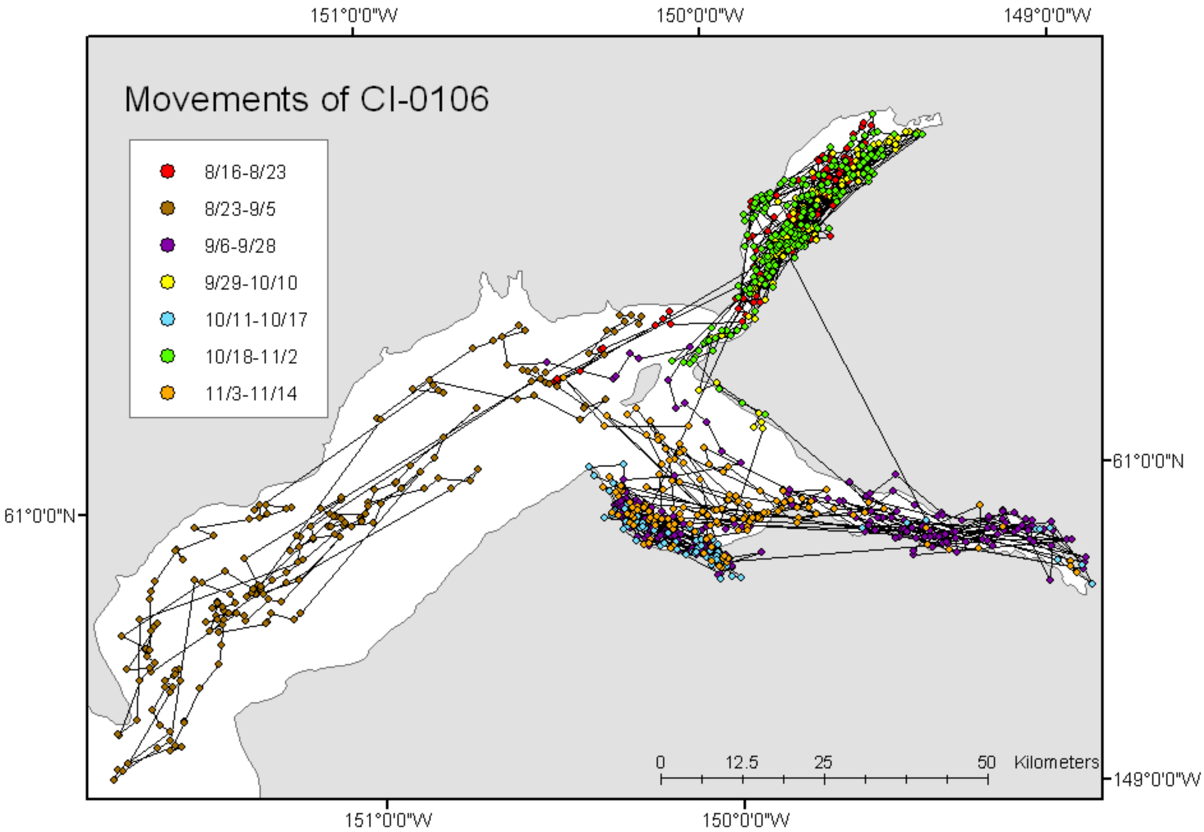


Figure 46 Movements of one satellite-tagged beluga (CI-0106) in Upper Cook Inlet between August and November 2001 reported by Hobbs et al. (2005). Each color represents a stationary period in a particular area, generally at river mouths or bays. Fire Island is highlighted in gray near center of map.

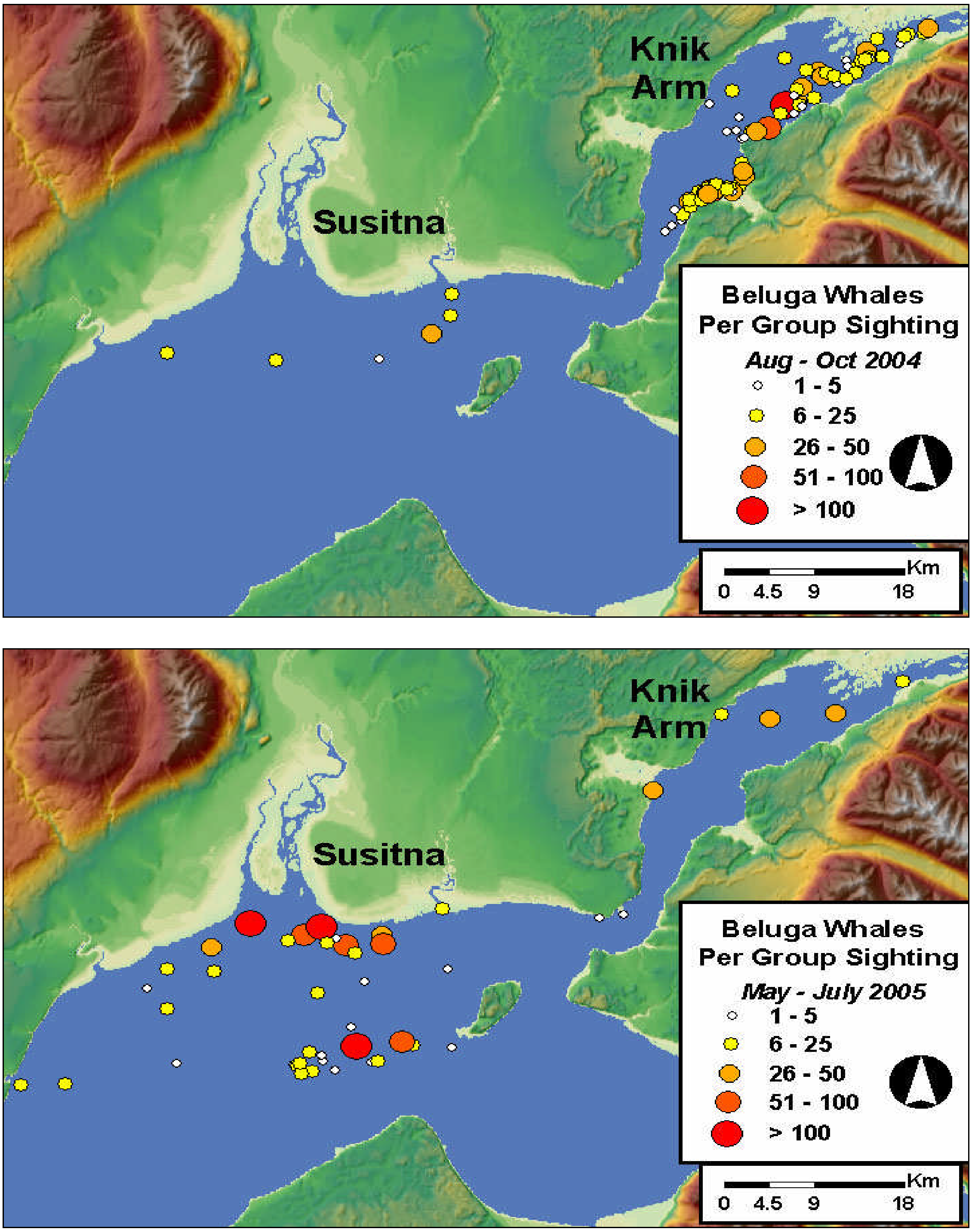


Figure 47 Locations of beluga whale groups and number of whales per group recorded during surveys conducted in the fall (August-October 2004) and summer (May-July 2005) in Knik Arm (Funk et al. 2005)

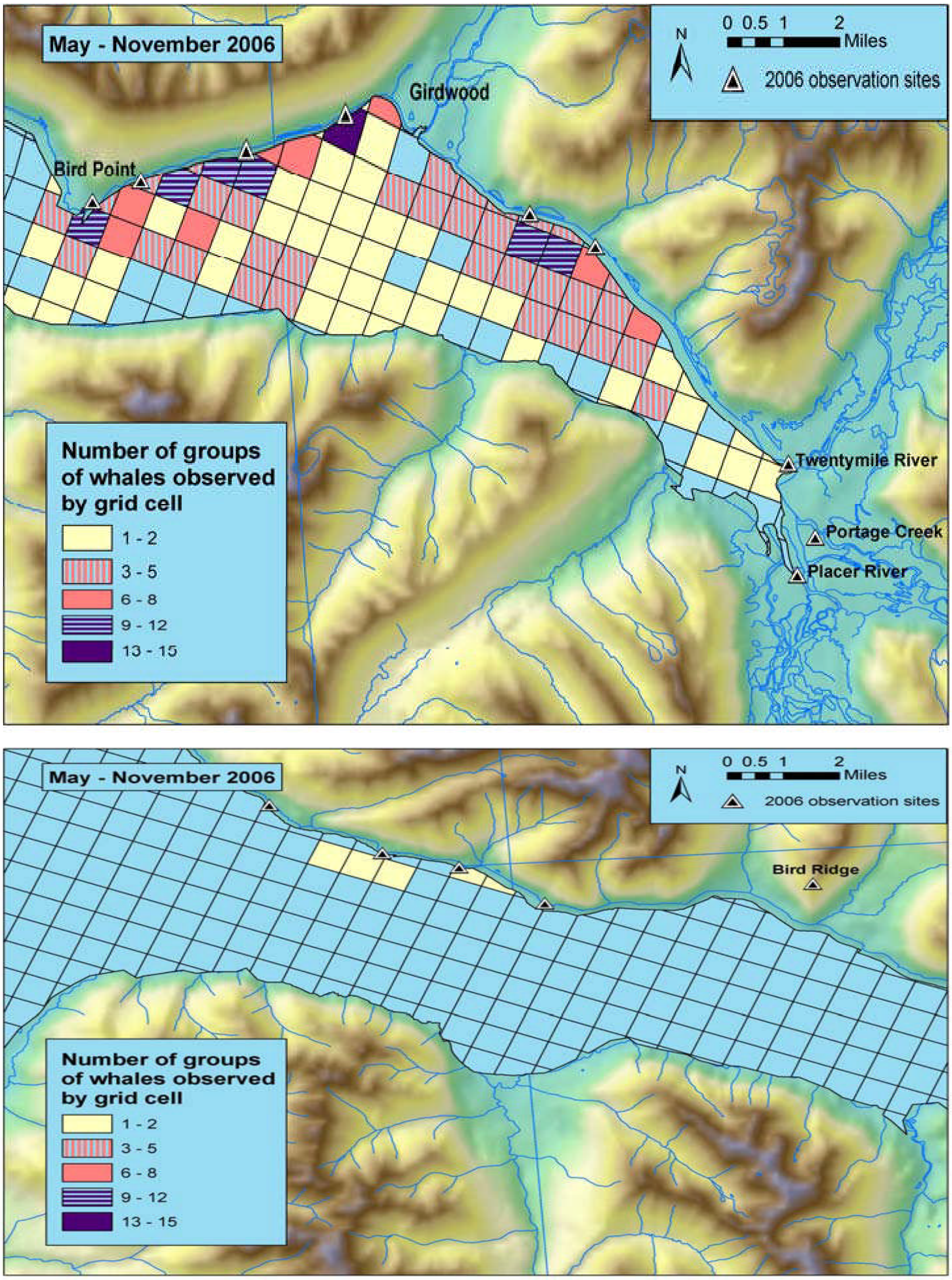


Figure 48 Number of beluga whale group sightings per grid cell between May and November 2006 in (1st map) Upper Turnagain Arm and (2nd map) Lower Turnagain Arm (2nd map ends about same location Figure 24 begins at Turnagain Arm). All sightings on maps occurred from August through November, since no belugas were observed during other months (Mark Markowitz et al. (2007).

Use of the study area was most noticeable during the higher stages of the tidal cycle (>10 ft (3 m)), particularly during stages with water depths exceeding 20 ft (6 m), regardless of the tidal direction (rising vs. falling) for all months. While belugas could not access most of the study area during low stages of the tidal cycle ($\leq$ 5ft, $\leq$1.5 m)) due to the exposure of the extensive mudflats or shallow water, they did occur along the northern and southern borders of the mudflats in deeper water or in the channels extending into the mudflats from Knik Arm. Access to the study area expanded with increased water depth associated with changes in the tidal cycle. Studies in Knik and Turnagain Arms show beluga movements are timed with the tidal stages. Belugas move up the arms on a rising tide (water depths $\geq$ 10-15 ft, 3-4.5 m) and down on a falling tide (Pers. com., Kim Goetz, NMML). This pattern would be inconsistent with high beluga use of the study area, since belugas would be in the lower sections of the arms during lower stages of the tidal cycle when access to the study area would be limited or prevented by shallow water or exposed mudflats. Conversely, at higher stages of the tidal cycle, when belugas could access the study area, most would be in the upper portions of the arms. This supports the suggestion that a small proportion of the belugas remaining in the lower sections of Knik and Turnagain Arms during higher stages of the tidal cycle pass through the study area.

Belugas passing through the study area typically followed the coastline and moved through rather quickly during each month of the study. This was reflected in the high percentage of belugas observed within 1000 m (0.6 mi) of the shoreline, short time (monthly mean < ≈1 hr) that beluga groups occurred in the study area, and high percentage of beluga behavior categorized as traveling compared to behavior (feeding and milling) suggestive of life history functions requiring longer use. Hobbs et al. (2005) reported that belugas traveled repeatedly and rapidly between Knik Arm, Turnagain Arm, and Chickaloon Bay, moving to the west or, less often, to the east of Fire Island, a finding supported by almost 20 years of aerial surveys of belugas conducted by the NMFS in the Upper Inlet (Figure 49). Belugas using Knik and Turnagain Arms and elsewhere in the Upper Inlet (Prevel-Ramos et al. 2008, Brueggeman et al. 2007a,b) traveled primarily along the shoreline similar to those passing through the study area, suggesting belugas have a nearshore affinity when traveling in the Upper Inlet. This affinity for coastal areas is likely due to feeding strategies and may also correlate with protection from predators (i.e., killer whales) or inclement weather (Goetz et al. 2012).

Group size varied seasonally, a finding other investigators have reported in studies conducted elsewhere in Cook Inlet (Funk et al. 2005). Mean group size in the study area was significantly different with higher group sizes in the late summer to fall, particularly during September, than in the spring to mid-summer. Funk et al. (2005) observed a similar pattern in Knik Arm but did not provide an explanation for the differences. Group size was still relatively small compared to those associated with feeding aggregation (Rugh et al. 2000). The relatively small average group size observed in our study is consistent with behavior of traveling or resting (Hobbs et al. 2005). Age composition within the groups was similar to that reported in Turnagain Arm (Markowitz et al. 2007) and Knik Arm (Funk et al. 2005), where adults represented about half of the sightings, juveniles about a quarter, and calves less than 10%, with the remaining percentage being whales not classified to age (color). These results collectively support the suggestion by other researchers (Burns and Seaman 1985, Mahoney and Shelden 2000, Huntington 2000) that the age structure of the population may have shifted toward younger animals since the 1970s (Murray and Fay 1979).

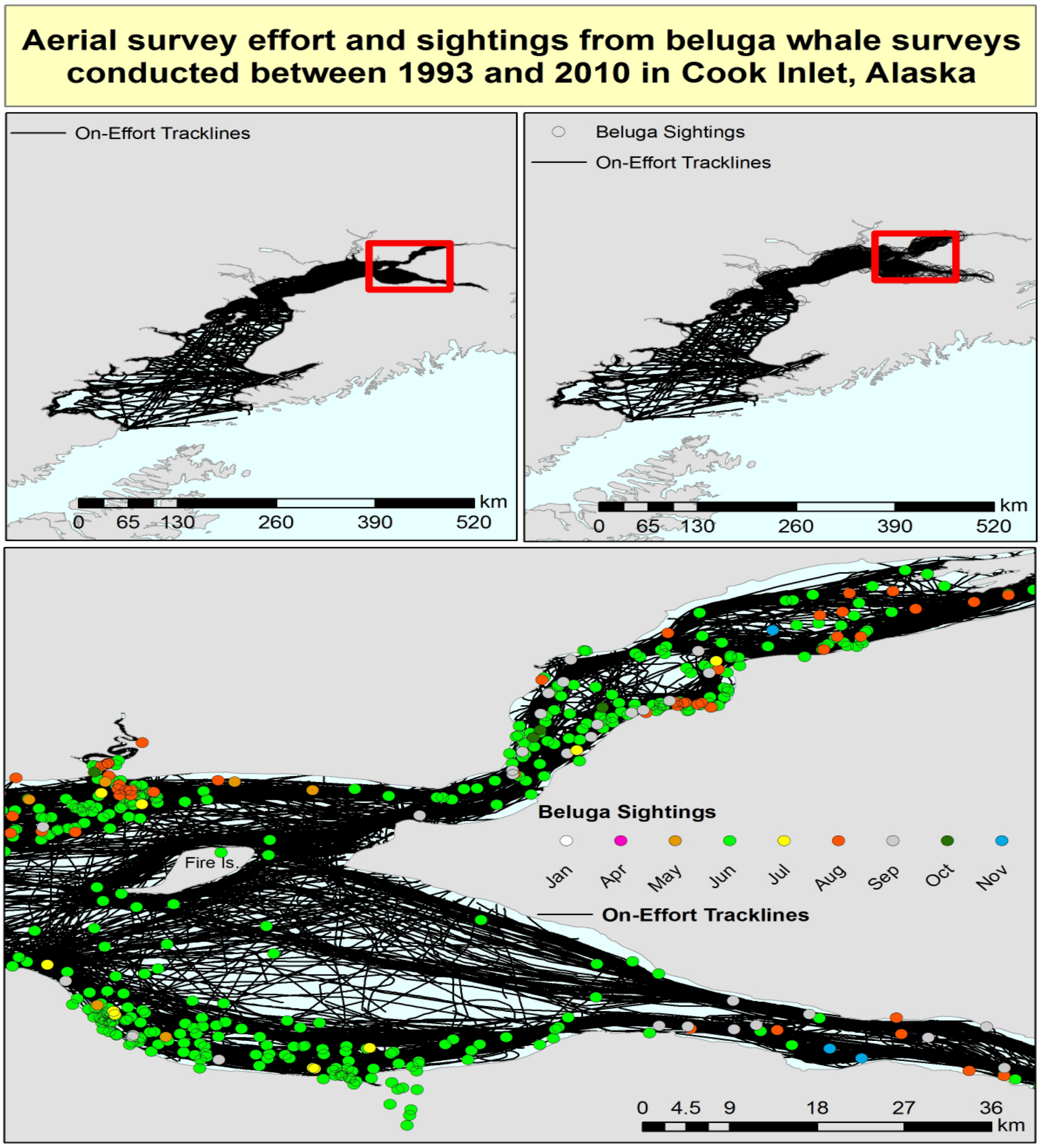


Figure 49 Beluga whale distribution map was provided by the National Marine Mammal Laboratory. Survey effort spanned May through August but concentrated on June and August. Surveys occurred during most stages of the tidal cycle but focused on low tide when whales were more concentrated in the Upper Inlet. Also, the NMFS could not fly surveys between Fire Island and the mainland because of low flying, incoming and outgoing aircraft from the Anchorage International Airport. However, the concentrations and locations of belugas suggest transit between the two arms mostly occurs west of Fire Island.

Other Marine Mammals

The scarcity of sightings of harbor seals (19 singles during 226 days of observation) and harbor porpoises (3 in one group) suggests the study area received little use by these species. Studies in nearby Knik Arm also reported few harbor seals (1 during 47 days of observation) and no harbor porpoises (Funk et al. 2005). More but still a small number of harbor seals (< 20) and harbor porpoises (5) were recorded during a two-year study in Knik Arm off the Port of Anchorage (ICRC 2009). Most harbor seals appear to primarily occur in the region of the Susitna Flats (Sheldon et al. 2011), while a small number of harbor porpoises appear to be widespread in the Upper Inlet.

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