# Beluga Observational Studies on Eagle River Flats, Fort Richardson, Alaska 2009

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## Introduction

In 2004, USAG-Alaska entered into a settlement agreement with plaintiffs requiring Army environmental personnel to, among other things, monitor the health and behavior of beluga whales (*Delphinapterus leucas*) in and around Eagle River Flats (ERF) within the boundaries of Fort Richardson, Alaska. Beluga whales were first observed by USAG-Alaska personnel in 2005 and 2006. Most of these observations were opportunistic as personnel conducted other duties out in ERF. A more concerted effort to observe belugas specifically was started in 2007 using an *ad libitum* sampling methodology (USAG-Alaska 2007). A more systematic sampling methodology was begun in 2008 (USAG-Alaska 2008) and refinements were made for the 2009 field season (see Appendix A).

Detailed observations of whales were conducted during the summer of 2009 and the details of these observations are described in this document. USAG-Alaska intends to continue using the current observational protocols with adjustments as needed into the foreseeable future.

## Background

Eagle River Flats is a 2,140 acre estuarine salt marsh located at the mouth of Eagle River on Fort Richardson Army Post. Glacially-fed Eagle River flows through the flats before discharging into Eagle Bay of Knik Arm in Upper Cook Inlet (Figure 1).

A complex interaction of physical forces exists on the flats including those exerted by a high tidal range, glaciofluvial influences from Eagle River, sedimentation from the turbid waters of Knik Arm and Eagle River and the subarctic coastal climate of southcentral Alaska (Lawson et al.1996). Anthropogenic influences on the flats include military training, both historic (Army artillery impact area since 1949) and current (winter firing of artillery into flats) as well as activities associated with the remediation of white phosphorus residues.

Beluga whales gather in Eagle Bay between the months of May and November (Huntington, 2000) and have been observed in Eagle River from June to October as far inland as 1.25 miles upstream of the river mouth (CH2M Hill 1997). The whales have been observed chasing fish (thought to be salmon) onto the river bank. It is likely that salmon are indeed the main prey items pursued by the whales in Eagle River, but given the opportunistic nature of belugas they also likely eat other species of fish.

The Cook Inlet population of beluga whales experienced dramatic declines between 1994 and 1998 (Hobbs et al., 2000). As a result, the Fisheries Service branch of NOAA had proposed that the species be listed under the Endangered Species Act. Annual surveys have shown a steady decline in this species population. The beluga whale was listed as endangered in October of 2008.

The U.S. Army has used Eagle River Flats as an artillery impact area since World War II and it currently remains crucial for training and maintaining the military readiness of an ever increasing troop size on base. The presence of an endangered species within Eagle River presents unique challenges to resource managers charged with balancing the conservation of natural resources with the training needs of soldiers during a time of war.

## Methods

Although whales were observed from several locations including artillery observations posts and Eagle Bay, the majority occurred at the mouth of Eagle River. This location is advantageous for beluga observations as the whales often linger in the area prior to entering the river and also pass close by when travelling further up Knik Arm.

The 2009 field season was the second year in which a modified data collection protocol was used. Observations were carried out using a systematic sampling design consisting of a group follow protocol and focal group sampling method. Observers followed a group of whales over the course of a 20 minute sampling round using 12X45 power binoculars and/or high powered spotting scopes. Group activity was defined as what most (>50%) of a whale group was engaged in during the course of the sampling round. All whale behaviors were strictly defined prior to sampling to minimize any ambiguities and variation between observers (see Appendix A, pages 18-20 for behavioral definitions). Whales were classified as white, gray or calf and the location of whale groups at the start and end of each sampling round was classified using a grid superimposed on a map of Eagle Bay and Eagle River (see Figures 2 and 3). Within each sampling round, whale numbers were estimated using instantaneous scans over the course of the round, though estimates were usually made within the first ten minutes of the round after an attempt was made to count all of the individuals in a group while trying to minimize double counting. At the end of each day, an estimate of the total number of whales was made by adding up the total number of individuals counted across all independent whale observations per the study protocol (see Appendix A, page 17 for guidance on minimizing pseudoreplication and a more detailed discussion on the methodologies used).

The use of the modified sampling protocol has several limitations that should be mentioned. Quantifying whales into color classes will always be biased towards "white" animals due to easier detectability and is heavily influenced by prevailing survey conditions (e.g. visibility, precipitation, light conditions). In addition, calves may be underrepresented due to difficulty in distinguishing between young and "gray" animals, especially at long distances. Group follow protocol may also be biased towards more obvious behaviors or more visible animals as well (Mann 1999). In addition, behavioral sampling is limited to activities above the water line due to the extreme turbidity of Knik Arm. Finally, military training in nearby ranges often prevented our access to Eagle River Flats and because of this, observations were not evenly distributed over the course of the summer and fall.

Statistical analysis of whale data was carried out using the program STATA version 10 (StataCorp 2007). Statistical analysis of data was carried out in three phases. Summary statistics for each metric of interest were the first thing to be generated. After this, the sample size required to carry out a given analysis was estimated and finally the statistical test itself was run. Any test failing to meet minimum sample size requirements was excluded from analysis.

For analysis, t-tests were run to compare beluga abundance estimates between years for all belugas and for color classes of whales as well. In addition, t-tests were used to compare percentages of whale color classes between 2008 and 2009. For a given statistical test, it is assumed that data are normally distributed and are free to vary widely about the mean with no imposed limits. This is not true of percentages, which cannot be less than 0 or greater than 100. Therefore, all percentages were converted to arcsine values, which were then used for purposes of statistical analysis.

In addition to these efforts, remote infrared, motion sensitive digital cameras were used to collect information on belugas during times when observers were not present. Two separate cameras were used. One was mounted to a data logger tripod near the mouth of Eagle River, while the other was mounted on a structure approximately 200 yards upriver and on the north bank of the river. Camera cards were switched out every two weeks. Both cameras were set on time-lapse mode with a one minute time increment between shots and the motion detection feature was enabled on both cameras.

## Results

Observations for beluga whales occurred between June 1 to October 28, 2009. Observers were present for 80 observational days during the 2009 field season. This is an increase from 50 observational days in 2007 and 2008. Observers did not encounter the large number of range closures experienced in previous years, allowing for greater access to ERF and hence, more observation days. During the observational time period between 1 June and 29 October, range closures prevented access to the observation area 32 days out of a possible 112 days or 29% of the time.

In 2009 the majority of observations of belugas occurred during the months of August and September. Unlike in past years, belugas were not observed during the months of June and July. Whales were first observed on 14 August and the last whales were observed on 21 October. A total of 322 hours was spent on this observational effort.

The average length of observations over the course of the field season was 251 minutes and the average length of time that whales were observed was 25 minutes. The average number of whales seen over all observation days was 8.8 (4.3 white, 2.4 gray, and 0.87 calf). Although whales arrived later in 2009 and this resulted in more zeros in the dataset, thereby lowering the average count for the season, the mean number of whales observed **when whales were present** was also lower in 2009 ($\bar{x} = 11.5$) than in 2008 ($\bar{x} = 24.5$). The maximum number of whales observed in a day ranged from 7 to 71 individuals. Group color composition ranged from 35-75% white belugas, 14-50% gray

belugas and 0-25% calves. Statistical analysis showed a significant difference between percentages of whites ($t(126) = 4.49$, $p < .007$), and calves ($t(90) = 2.76$, $p < .003$) between 2008 and 2009, but not for grays ($t(98) = .77$, $p = .21$).

Observational rates for whales showed a steady decline over the course of the summer season (Figure 8). This decline was true for all color classes of whales as well with the exception of grays in 2008 (Figure 9). Observational rates for calves were lowest among all classes in both years (Figures 9 and 10). Data for 2007 was not included in the analysis because calves were not noted during observations at that time and because of the different sampling methodology used that year.

As in past years, there was a steady decline in the numbers of belugas observed as the season progressed. The mean number of belugas observed per month decreased steadily after August in both 2008 and 2009 (Figure 7). The mean number of whales observed in 2008 was 15.4 and 8.8 in 2009. These numbers were significantly different, $t(116) = 2.04$, $p < .02$, between years. Analysis of behavioral budgets was not carried out due to insufficient sample sizes.

Analysis was also used to examine differences in the observed whale color classes between 2008 and 2009. The mean number of white whales in 2008 was 8.84 and 4.3 in 2009. The mean number of grays was 3.2 in 2008 and 2.4 in 2009, while the mean number of calves observed in 2008 was .86 and 1.6 in 2009. There was a significant difference between 2008 and 2009 for whites ($t(139) = 3.01$, $p < .001$) and for calves ($t(82) = 1.90$, $p < .03$), but no significant difference between years for grays ($t(139) = 1.01$, $p = .15$).

Whale behavior was quantified for the 2009 field season using the modified sampling design first used in 2008. Analysis focused on the period from August through October, during which the majority of whales were observed. Milling and travelling accounted for the greatest proportion of observed behaviors, just as in 2008 (Figure 4). As in 2008, the proportion of time whales spent travelling increased throughout the course of the season (Figure 5). Milling behavior was more commonly seen during the morning hours, while the proportion of time spent travelling increased over the course of the day (Figure 6). These results also mirror last year's data.

Remote camera data has been analyzed for the field season from August to September and yielded a total of 33,446 useable images. Of these, only 13 yielded possible beluga sightings. Of these 13, only two images were confirmed to be whales.

## Discussion

There was a noticeable delay in the first sighting of beluga whales in Eagle Bay and Eagle River in 2009 despite similar sampling effort as in past years. The first whales were not spotted until mid August. In 2007 and 2008, whales were first observed in mid June and late July respectively. The reasons for the late arrival of whales in 2009 are unclear. Observational conditions were superior to those in 2008 (fewer days of rainy

cloudy weather) and yet, whales were seen three weeks earlier than in 2009. Many of the same observers from 2008 were also present in 2009, so differences in observer ability should have been negligible.

Year to year variations in fish runs may have played a role in the later arrival of belugas into Eagle Bay and Eagle River. Information on fish runs in the inlet is not yet available, but stronger runs in other drainages could have delayed the arrival of belugas into our area of interest. There may have also been a temporal component to beluga presence in Eagle Bay. If animals were utilizing the bay in the evening hours when observers were not present and beyond the viewing range of the remote cameras, their presence would not have been detected. However, partial analysis of remote camera data for the 2009 field season does not show whales utilizing the areas within the range of the cameras during times when observers were not present.

Group color composition differed between 2008 and 2009 for whites and calves. Whites were almost always the most common color class observed, though it is difficult to say if this was because of more whales of this coloration being present in the population utilizing Knik Arm, or because of observer bias in detecting these animals. Calf composition and numbers continue to be the lowest represented color class in Eagle River and Eagle Bay. Differences in color class ratios between years may be largely due to observer bias and not any actual change in group composition between years. Calves are notoriously hard to detect even at relatively close distances due to their tendency to stay in close, oftentimes physical contact with their mothers and this may explain the differences between years for this color class. Since white whales are the most easily detectible color class, explaining the differing percentages between years for these animals is more difficult.

Whale behaviors closely mirror what has been observed in past years. Milling and travelling continue to be the most commonly observed behaviors. Much of the behavior that we have classified as milling may well be feeding, though the turbid nature of the water precluded us from confirming feeding activity. It was common to see several whales milling at the mouth of Eagle River and then observing large wakes, indicating whales were pursuing prey in the area. Again, since our definition of feeding behavior required visual confirmation of prey in a whale's mouth, this behavior was necessarily underrepresented in the dataset. It is not surprising that travelling was a commonly observed behavior as well. Whales were most often seen travelling during the later hours of the observation day and this was most likely in response to tidal influences. Travelling behavior increased as the season progressed as well.

A significant decline in the mean numbers of whales observed and for some color classes was found between 2008 and 2009. In addition, the number of white whales observed in 2009 was significantly lower than last year, and since this color class is the least likely to be missed during counts, this adds confidence to the observed reduction in whale numbers between the two years. The reasons for this decline are unclear, but mirror the continued decline in the Cook Inlet beluga population.

## Future Directions

USAG-AK conservation will continue beluga observations in ERF for the 2010 field season. Large numbers of military personnel have returned from deployment and we anticipate an increased training tempo. Because of this, access to the observation areas may be more limited than last season. Every effort will be made to maximize the number of observational days in ERF, but access is out of the hands of the conservation department. Though there will be no firing into ERF itself during the summer of 2010, access roads leading to our observation posts can be closed due to unit training.

USAG-AK conservation continues to work closely with the National Marine Fisheries Service (NMFS) to insure that our activities are not disturbing Cook Inlet belugas and that our methodologies are sound and repeatable. To date, NMFS has given its approval of our sampling methodology and analysis techniques. We will continue to refine our techniques as conditions change.

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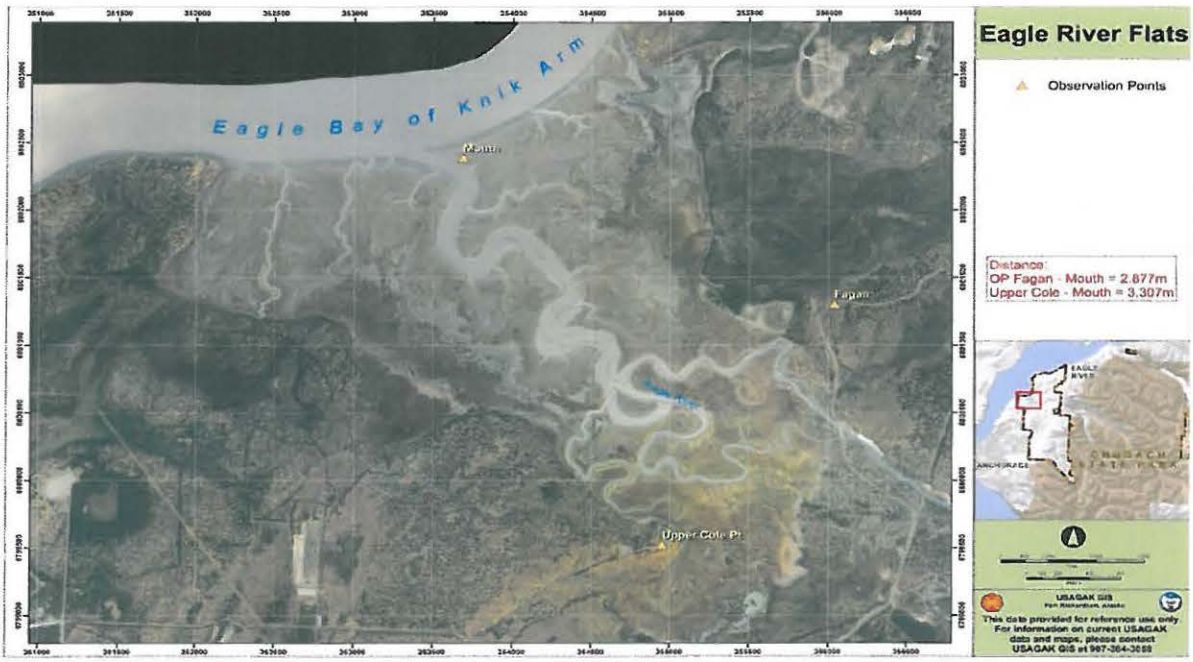


Figure 1. Location of beluga whale studies, Eagle River Flats, Fort Richardson, Alaska.

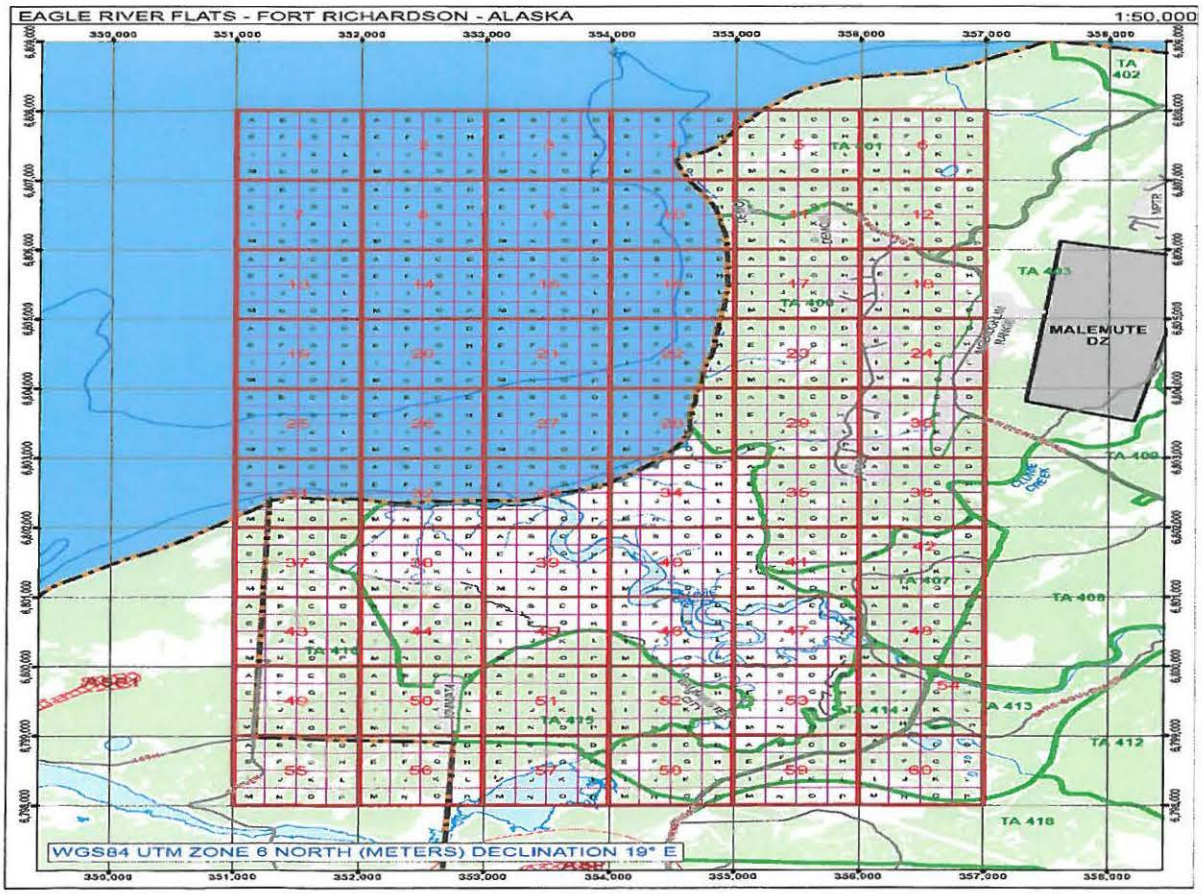


Figure 2. Superimposed grid for recording beluga whale locations.

Cook Inlet Beluga Observations – Eagle Bay and Eagle River, Alaska

Observer: Garner / Battle / McKee / Dushane / Mustin / Padilla  Location: OP Vital /OP FAGAN /ER Mouth / Coast of EB  Date

| Grid #/Compass Bearing Start/Finish | Sampling Round/Time Interval | White/Gray/Calf | Survey Conditions (Poor, Fair, Good, Excellent) | Behavior 1° | Behavior 2° |
|---|---|---|---|---|---|
| | | W G C | | | |
| | | W G C | | | |
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Estimated Total Number of Whales:  Page_____ of _____

| Time Start | Time End |
|---|---|
| Total Time | |

Behavior Legend
Traveling (T)
Milling (M)
Prey Pursuit (PP)
Diving (D)
Feeding (F)
Other (see notes)

Figure 3. Data sheet for beluga whale observations in Eagle River Flats, Fort Richardson, Alaska, 2009.

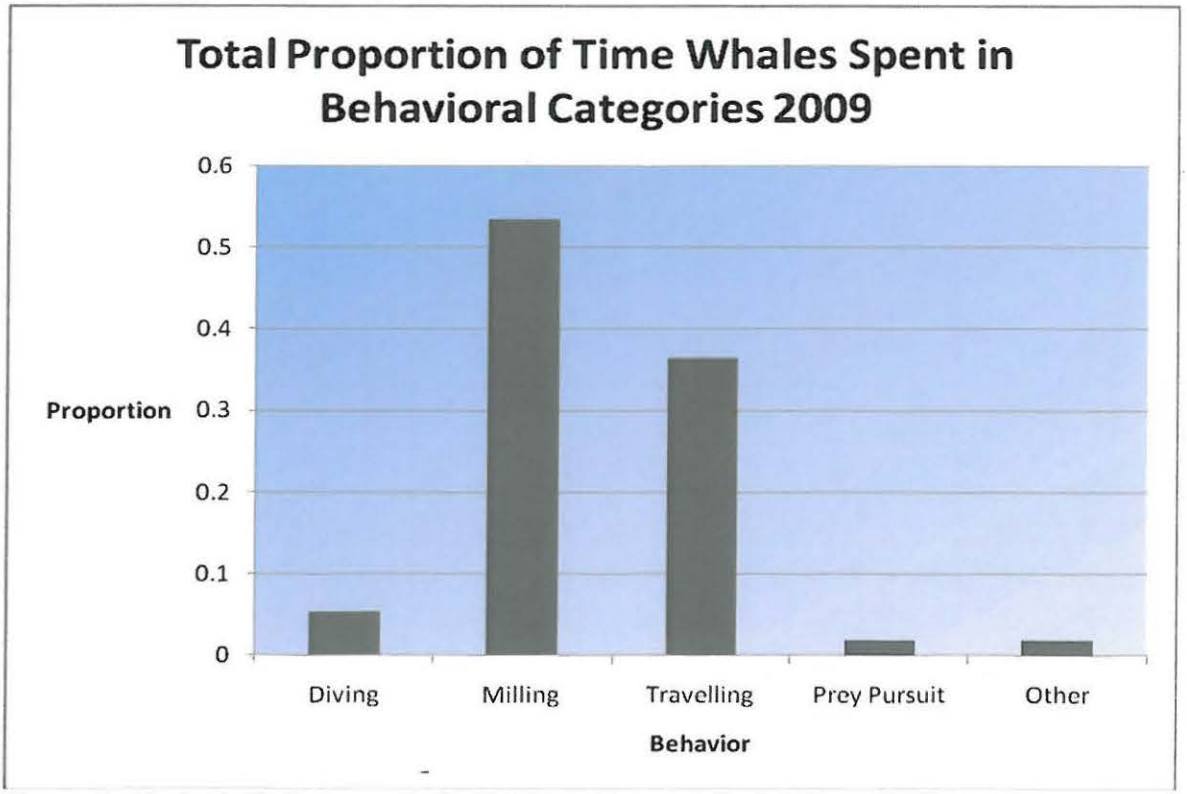


Figure 4. Budgets for beluga whales in Eagle Bay and Eagle River, 2009.

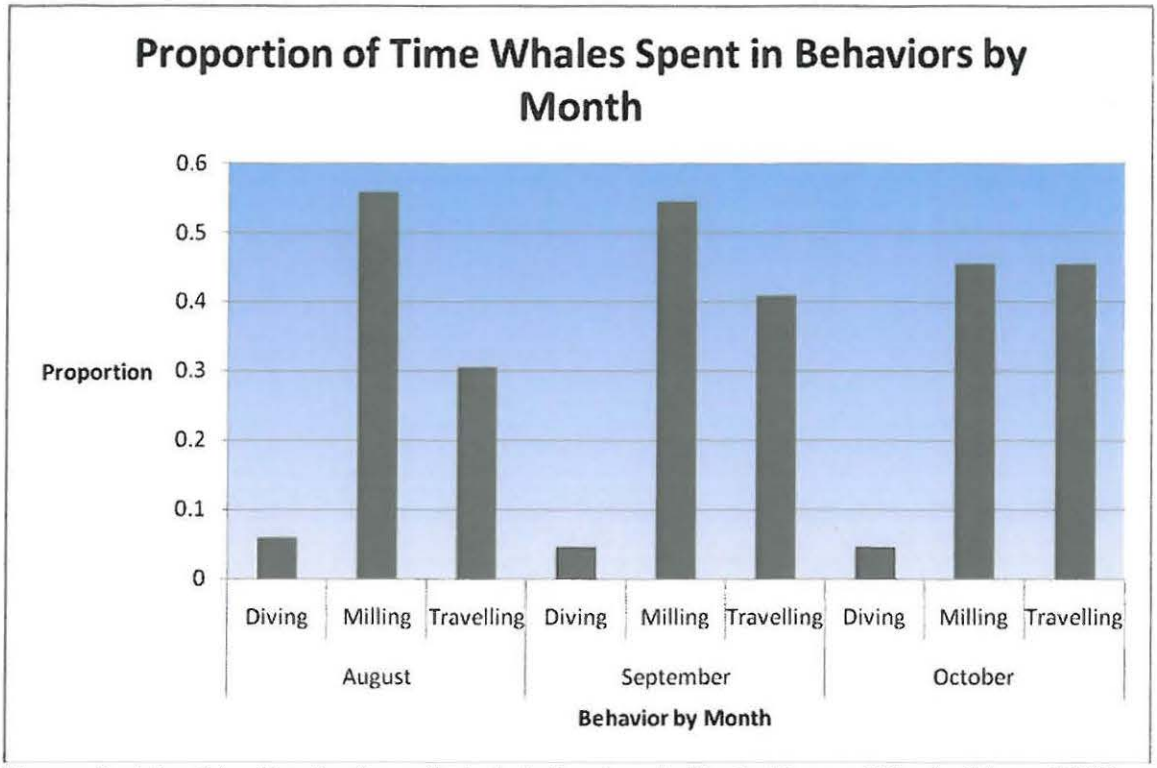


Figure 5. Monthly distribution of whale behaviors in Eagle Bay and Eagle River, 2009.

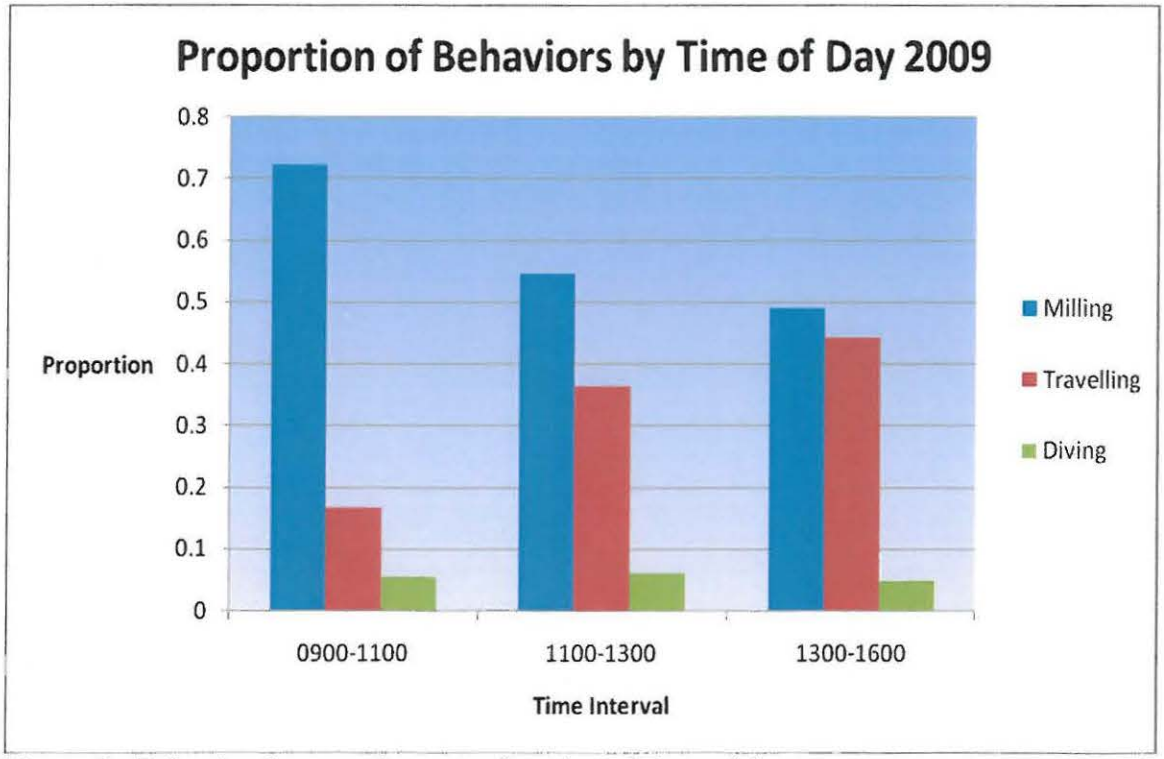


Figure 6. Behavioral proportions as a function of time of day.

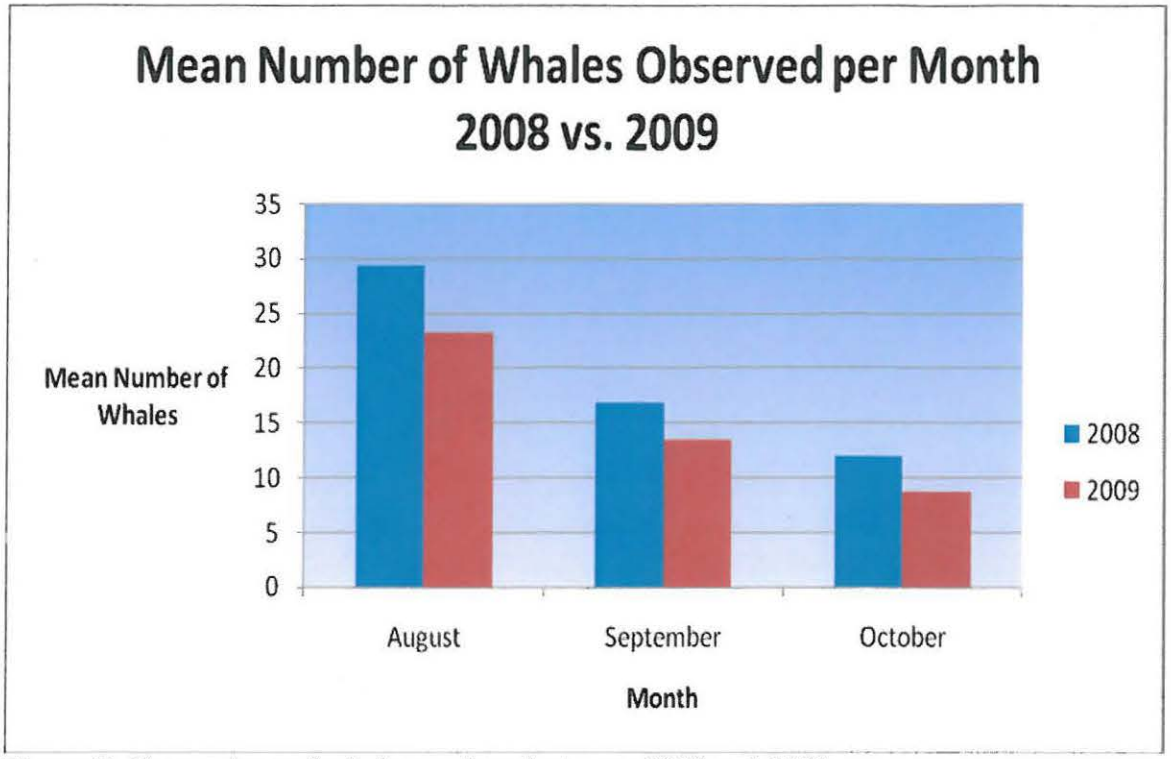


Figure 7. Comparison of whale numbers between 2008 and 2009.

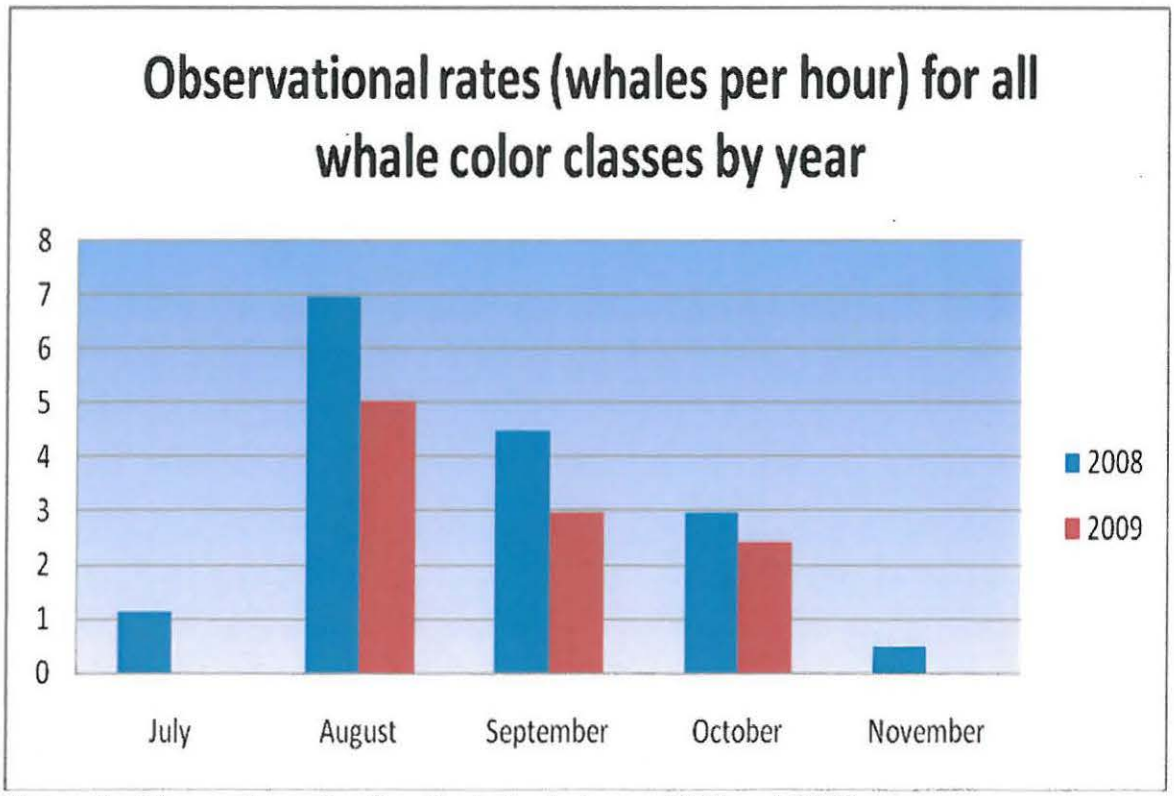


Figure 8. Observation rates for all whales between 2008 and 2009.

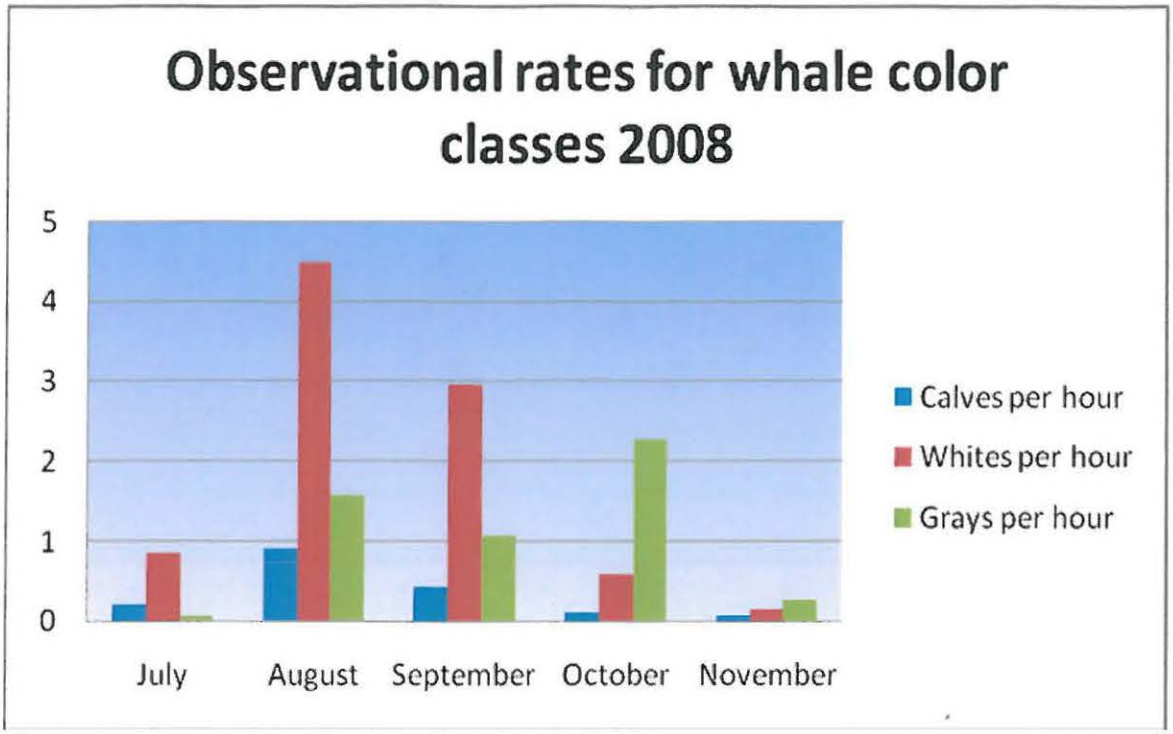

Figure 9. Observation rates by color class for 2008.

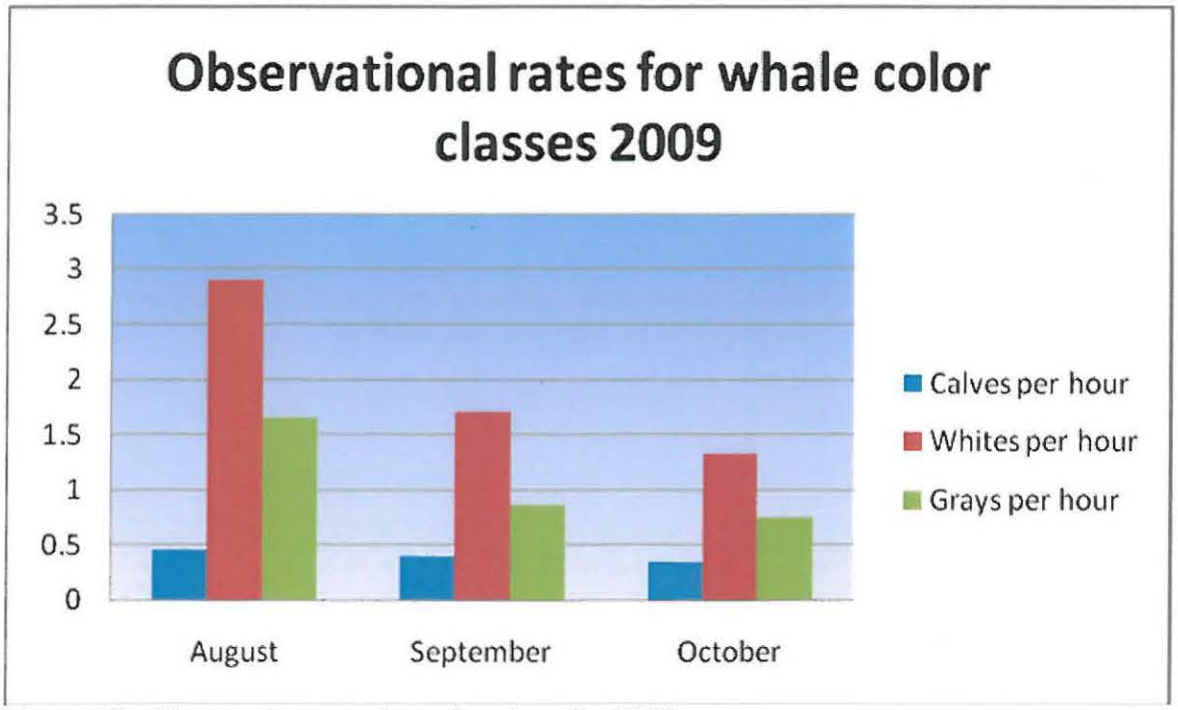

Figure 10. Observation rates by color class for 2009.

Appendix A. Beluga study protocol for the 2009 field season.

# COOK INLET BELUGA WHALE OBSERVATIONAL STUDY PROTOCOL- EAGLE RIVER and EAGLE BAY

## Introduction

Pursuant to the Eagle River Flats Settlement Agreement, the U.S. Army Alaska (USARAK) agreed to conduct field monitoring to observe the apparent health, behavior and movements of belugas in and around Eagle River Flats (ERF) during periods of frequent whale use.

During the months of July – October, USARAK also agreed to monitor for beluga presence before, during and after firing events (artillery) in ERF. The intention of this surveillance is to ensure that beluga whales are not harmed during such a firing event. Currently, USARAK does not fire artillery into the ERF during the ice-free months, but if such firing occurs in the future, this requirement will be fulfilled.

## Objectives

In order to best fulfill the terms of the Eagle River Flats Settlement Agreement, the following objectives were developed:

Objective 1: *Determine temporal and seasonal*[1] *usage of Eagle River and Bay (henceforth called "the area") by belugas.*

Objective 2: *Estimate the number of belugas using the area.*

Objective 3: *Determine relative age class of belugas using the area.*

Objective 4: *Determine spatial distribution of belugas using the area.*

Objective 5: *Determine beluga activities while in the area.*

Objective 6: *Determine the effect of firing activities occurring in ERF on belugas. Note that this objective is not addressed in this protocol except to acknowledge that should artillery firing into ERF occur during the ice-free months (currently not allowed), that USARAK will indeed proceed with the required monitoring.*

[1] Note that the field portion of this protocol starts in April or May and runs through November, so this is not a true look at seasonal usage throughout the year but rather a look at usage in the spring, summer and fall months.

# Methods

***Study Area and Observation Points:***
ERF is a 2,140 acre estuarine salt marsh located at the mouth of Eagle River on Fort Richardson Army Post (see figures 1 and 2). Glacially fed Eagle River flows through the flats before discharging into Eagle Bay of Knik Arm in Upper Cook Inlet, southcentral Alaska.

ERF has been characterized into seven major physiographic zones and 15 vegetation classes based on physiography and vegetation (representing 67 species of vascular plants). The physiographic zones include: Coastal (littoral coastline of ERF along Eagle Bay), Riverine (Eagle River and banks), Mudflat/tidal gully (silt-covered mudflats directly bordering Eagle River and along the coast), Interior Lowland (well vegetated low embankment occupying southern 30% of ERF), Sedge Meadow (narrow band of continuous sedge meadow between mudflats along river and pond/marsh), Pond/marsh (area of lower elevation along the middle and outer edges of the flats characterized by permanently inundated ponds and associated marshes) and Border (abrupt upland border of ERF) (Racine and Brouillette, 1995).

A complex interaction of physical forces acts on the flats including those exerted by a high tidal range, glaciofluvial influences from Eagle River, sedimentation from the turbid waters of Knik Arm and Eagle River and the subarctic coastal climate of southcentral Alaska (Lawson et al.1996). Anthropogenic influences on the flats include military training, both historic (Army artillery impact area since 1949) and current (winter firing of artillery into flats), activities associated with the remediation of white phosphorus residues and activities involved with study of Cook Inlet beluga whales in and around ERF. The combination of these forces presents a complex and dynamic environment to organisms living within and around ERF. Despite this challenging physical environment, this area supports a variety of birds (approximately 68 species), mammals, fish and macroinvertebrates (approximately 30 species of benthic macroinvertebrates) (Racine et al. in press) and is an important staging area for spring and fall waterfowl migrations.

Beluga whales gather in Eagle Bay between the months of May and November (Hobbs *et al*, 2005) and have been observed in Eagle River from June to October as far inland as 1.25 miles upstream of Eagle Bay (CH2M Hill 1997). The whales have been observed chasing fish (thought to be salmon) onto the river bank in Eagle River.

The best area for observations of belugas entering Eagle River and moving in Eagle Bay is from the mouth of Eagle River. A less desirable observation point for belugas entering the river, but a great place for observations of belugas entering Eagle Bay from the West, is Observation Post (OP) Vital. Most observations will be from the mouth unless observers are precluded from entering the flats, at which time they will observe from OP Vital, if possible (see figure 2).

***Schedule for Observations:***
Observations will be conducted on as many days as possible during the months of May-November. Technicians assigned to the beluga project will be prepared to conduct observations every work day and some weekends. Before the observation season at the mouth of Eagle River can begin, a trail must be cleared by Explosives Ordnance Demolition (EOD) personnel. Alternate trails will also be established leading from the main trail around the ends of tidal channels, to allow for egress during average high tide events (28-30 feet). Anyone accessing the mouth across the flats must have the appropriate training (see below), coordinate with Range Control, retain positive radio communication with Range throughout the entirety of the stay on the ERF and must walk only on the trail cleared and marked by EOD.

Observation start times will be as close to 0800 as possible with end times around 1600. These are loose guidelines however, as ambient light (especially in the fall) and tidal state conditions (high tides often cover the routes cleared by EOD and thus preclude entrance into the impact area) will often dictate the true start time. Also, there may be times when tidal conditions will preclude leaving the flats until well after 1600.

Observations will be coordinated as far in advance as possible with Range Control, noting, however, that the Range schedule usually does not extend beyond a couple of days to a week at the maximum. The number of days in which sampling can occur in ERF is directly related to military training activities. Any military training involving "live fire" exercises may block use of access roads used to enter ERF if they are within the firing fan of the training at hand. The firing fan is that area in which there is a one in a million chance of a live round of ammunition landing outside of the surface danger zone. The amount of data that can be collected over the course of the field season is therefore directly related to these activities. Currently, no firing is taking place during the field season.

***Viewshed Analysis:***
A viewshed analysis has been conducted for this project. This analysis determined which areas of ERF will be visible from a variety of observation points. The analysis used high resolution elevation data derived from LIDAR (Light Detection and Ranging) to calculate line-of-sight visibility from a given location. Running this analysis for multiple observation points allows us to determine a combination of points that provides the maximum visibility of targets during live fire exercises to aid us in determining whether or not belugas are present in the area.

***Training:***
All field observers will attend the following safety courses: First aid/CPR (unless possessing current certification), Unexploded Ordnance training, Eagle River Flats safety briefing and bear safety. All field observers will read, at a minimum, section I of the National Marine Fisheries Service document, "Conservation Plan for the Cook Inlet Beluga Whale *(Delphinapterus leucas)*, 2008"
http://www.fakr.noaa.gov/protectedresources/whales/beluga/mmpa/final/cp2008.pdf .

Field observers will also undergo supervised training by experienced (minimum of two years of directed beluga observations) permanent staff regarding data collection procedures and identifying defined whale behaviors. Observers will be exposed to the full variety of typical behaviors exhibited by beluga whales in Eagle River and Eagle Bay. A minimum of 40 hours of supervised training will take place before observers will be allowed to collect data on their own. Most of the time, at least one experienced member of the permanent staff will be present throughout the field season. A minimum of two observers will always be present during whale observations.

***Observations and Data Collection:***

**Follow protocol:** Group follow
**Sampling Method:** Focal group sampling.
**Length of Sampling Round:** 20 minutes
**Parameter of Interest:** Beluga abundance (# of individuals or # of whale groups).
**Estimator:** mean number of belugas, mean number of whale groups

Once at the observation point, one observer will scan for belugas in Eagle Bay using high quality binoculars (Zeiss and Swarovski 12x45) and spotting scope (Swarovski 20-60X)[2] while the other observer scans the river using the naked eye. Scans will be broken down into 20 minute sampling rounds. Once whales are spotted, observers will follow a single group of whales for 20 minutes or until the group can no longer be seen due to distance or environmental conditions.

All observations will be noted on a standardized data sheet (figures 3 and 4). The observer will define group activity based on their assessment of what most (>50%) of the whale group is engaged in during the course of the sampling round. Up to two behaviors can be recorded during the sampling round, with one being designated as the primary ($1^{o}$) activity and the other designated as the secondary ($2^{o}$) activity. Any unusual behaviors during sampling rounds will be noted in the comments section on the back of the datasheet (see figure 4).

Behavioral budgets of belugas (a proportion, calculated as time spent in a behavioral state/total time focal group follow) will be calculated. Budgets can also be determined on a daily scale, at 1-hour intervals over the course of the day (average proportion of time spent per behavioral state per 1-hour interval). Beluga behavioral budgets will allow us to examine the range of activities whales engage in over the course of the day in a systematic fashion and whether or not these behaviors change over the course of the field season (Objective 5). Focal group sampling is subject to several biases such as attention being drawn to more obvious behaviors and differential visibility of group members due to their activity (Mann 2000), but there are a few reasons why this sampling methodology is being used in ERF. First, focal animal sampling for belugas is not possible as individuals are very hard to identify and following them at any distance in the turbid conditions of Eagle Bay and Eagle River is not practical. Second, two years of whale

[2] Inclusion of specific company names or products in this document does not indicate endorsement by the U.S. Army or any other entity named herein.

observation from ERF has shown that belugas tend to move as one cohesive group into and out of the observation area over the course of the day, with relatively small inter-individual distances, which lends itself very well to group sampling. In addition, because of this cohesive behavior, rare behavioral events can be recorded without losing track of the primary behavior of the group itself.

Over the course of each sampling round counts of whales will be made, distinguishing between white, gray, and calves. *Only whales actually seen will be counted. There will be no attempt to account for whales that might be under water.* These estimates will be averaged to come up with an estimate of the total number of whales observed over the course of the day. Since most observations over the course of a day are of the same group of whales, the number of animals observed will usually increase as the whales move closer to the observation point, allowing for more accurate counts. Summary statistics will be calculated for the mean number of whales observed for each day, week and month (Objective 2). Single factor analysis of variance will be used to determine if there are significant differences in the mean number of belugas observed in and around ERF from month to month (May-October) and over the course of the day (Objective 1). Sample size requirements needed to obtain a 95% confidence interval for multisample means analysis will follow Zar (1984).

Environmental conditions can mask the true color of an individual. Under some lighting conditions for instance, some gray animals appear much lighter than they actually are. For this reason, observers should, to the greatest extent possible, compare the size of gray animals to that of associated white animals. Additionally, while beluga calves are primarily dark in color, calves ranging from pinkish-brown to almost pure white have been observed in Knik Arm. Since observed whale groups tend to move closer to the observation point throughout the day as they move up Eagle Bay, more accurate enumeration of age class composition will be possible (Objective 3), helping to minimize observation biases associated with distance. Furthermore, based on past observations, the ability to count and classify whales decreases dramatically on the west (far) side of Eagle Bay sandbar. Because of this, enumeration and classification of whales will only be recorded for animals sighted on the east (near) side of the sand bar, which should further help to minimize distance bias. Environmental conditions will be recorded at the start of every sampling round (Figure 21). Any sampling round in which conditions are rated as poor will be truncated from the data set and excluded from analysis.

An alpha-numeric grid superimposed over a map of the area (figures 5 and 22) will be used to record the location of a whale group at the start and end of the sampling round. A compass bearing to the whale(s) position relative to the observation site should also be noted to help refine the location (Objective 4). Depending upon funding, a theodolite may be purchased in order to more accurately denote whale locations.

The time covered by each sampling round will be noted (in 24 hr. mode). This will allow for further analysis of whale numbers over the course of the day. Unusual behaviors or other species of wildlife observed will be recorded in the notes section. Any signs of a beluga in distress (signs of entanglement, strandings, etc) will be reported immediately to

the NMFS [(907)360-3481)]. Any harassment of belugas by boats must be reported to NMFS enforcement division [( 907) 250-5188]. Pictures (especially video) of such incidents and recording of boat numbers and detailed descriptions will be taken to aid in carcass recovery, rescue, or law enforcement efforts. Responses (if any) of belugas to boats or aircraft flying over the study area should also be noted. The presence of other marine mammals (such as harbor seals) should always be recorded in the notes section as well.

*Observers will only follow one group at a time per sampling round.* If a group can no longer be observed, then it is permissible for the observer to move on to another group, making sure to note the sampling round and whale count in the next row on the data sheet. Each whale group will be given its own unique sampling round number to distinguish between separate samples. Separate data sheets will be used for each distinct whale group. If more than one group is present at the same time, more than one observer will be needed. If groups converge, they will be treated as one group for the duration of the sampling round. Observers should make a note of converging groups in the comments section on the back of the datasheets. If a target whale group goes out of sight during any point of a sampling round and whales are seen again before the end of the same round, then this observed group will be considered the same group if seen in same general grid area of the previous sighting. If a whale group goes out of sight and stays out of sight for more than 20 minutes, it will be treated as a separate sample group if spotted after that time period and given its own unique sampling round number.

***Statistical Note: In this study, the sample is each distinct group of belugas. If one group of whales is followed for one or several sampling rounds, then our sample size is still only N = 1. This is an important distinction for purposes of analysis and to avoid pseudoreplicaton.***

***Remote Camera Operation:***

In addition to direct observations of whales, remote color motion-sensitive cameras with infrared illumination at low light (Reconyx PC 85)[3] are used to collect presence/absence data on belugas during times when observers cannot be present. A minimum of two cameras will be deployed on the north bank of Eagle River- one at the mouth facing SSW (perpendicular to water flow) and one approximately 200 M upstream from the mouth facing W). Cameras will be set on time-lapse mode with a one minute time increment between shots and with the motion-detection feature enabled. Camera times will be synched with each other and all other devices used to record time during the observational period (watches, video cameras, etc). Each camera will be serviced (change card and batteries) every two weeks and checked for obvious external problems (alignment change, lens fouling, etc) every day when feasible.

Camera cards will be stored in a waterproof container while in the field. The data from cards will be downloaded onto an external hard drive dedicated solely to this project and

[3] Inclusion of specific company names or products in this document does not indicate endorsement by the U.S. Army or any other entity named herein.

backed up on a redundant drive. Analysis of the images (see figures 19 and 20) from each card will be completed as soon as possible after removal from the field with a general time limit of two weeks from removal to analysis. Data will be entered into a Microsoft Access database.

Analysis will be performed by one experienced team member (having analyzed at least one full seasons worth of camera data (or at least 30,000 images) or two team members that have analyzed less than 30,000 images each. Analysis of the images will include searching photos[4] for presence of beluga whales and harbor seals in the river. Analysts will indicate camera number, folder name,[5] starting time and date of the folder, presence of beluga(s) or other marine mammals, any other unusual event (e.g. boat passage, other mammalian presence, etc), and the date and end time of each folder. When an entry is made about the presence of a beluga, the analyst must note the following information: date, time, image number, number of whales, color of whales, and tidal state[6].

At the end of the folder, the analyst will then subtract the number of unusable images (night images, images taken while servicing camera, etc) from the gross number of images and record the resulting figure as the total number of usable images. The analyst will also note if observers were present on the flats during the dates covered in a folder and if so during which times. The presence/absence data from both the camera and the observational studies will then be compared. This comparison will allow a measure of how effective the cameras are at recording the actual presence/absence of whales.

## Definitions

**Diving:** (figure 9) surfacing whale bends its dorsal surface at an acute downward angle, slipping beneath the surface of the water with the tail flukes usually emerging completely out of the water and being the last part of the whale to be seen prior to complete submergence. This action can be slow, almost casual, or it can be rapid and accompanied by significant surface disturbance from the beating tail flukes.

**Feeding**: (figure 11) whale usually observed engaging in "prey pursuit" just prior to feeding. The distinction between the two is that in a pursuit situation, the prey is not observed, while during a feeding event the whale is observed with the prey item in its

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[4] Images are named using an alpha-numeric scheme, are numbered sequentially, and ordered sequentially in the folder created by the camera. Images taken under the motion-detection mode are named with a number proceeded by an "M" (e.g. M000101.jpg). These images are placed at the beginning of the sequence of images in a particular folder, even if they were the last images taken. Images taken under the time-lapse mode are named with a number proceeded by a "T" (e.g. T000101.jpg) and are placed after the images taken by the motion-detection images.

[5] Folders will be named using the following convention: ERFCamera#_start date-end date. Thus a group of images taken with Camera number 3 during from 1 July to 1 August, 2009 would be archived in a folder called "ERFCam3_1July-1Aug09"

[6] i.e. low tide, ¼ flood/ebb, ½ flood/ebb, ¾ flood/ebb, full tide—these are based on comparison to a series of photos indicating physical landmarks associated with each tidal stage.

mouth. *The turbid waters of Knik Arm coupled with the tendency for belugas to ingest whole prey makes such direct visual observation of prey in a whale's mouth extremely rare. In an effort to capture events where there is deemed to be a greater than average chance that feeding is occurring we have also added the following language to define a feeding event:* whale prey-pursuit that drives a prey item onto land AND a whale or pursuit wake is observed at the point of prey re-entry into the water AND the observer has more than 50% confidence that the prey item was captured. Note that all three conditions must be met for this secondary definition to apply.

**Milling**: (figure 7) whales surfacing in a more or less constantly varying direction, especially in relation to each other. They may remain in the same area or drift/move with the tide or current.

**Prey Pursuit**: (figure 8) whale exhibits sudden or explosive movements, often forward but may include rapid changes in direction and depth. Observation of prey pursuit in the turbid waters of Knik Arm are always associated with a fast appearing linear wake, violent disturbance of water or a combination of the two.

**Side-scanning[7]:** (figure 10) whale swims (often very slowly) or floats (moving with the current) at the surface with the lateral aspect of its body visible. The pectoral flipper, lateral surface of the body, tail fluke, or a combination of these parts, are visible, often for 30 seconds – several minutes. This behavior is often followed by explosive movements of the tail as the animal moves rapidly forward in pursuit of prey. **This behavior excluded from datasheet and included as a note when observed.**[8]

**Spy Hopping**: (figure 12) whale emerges from the water such that its head is held vertically above the water, at least to above the eye level, but never so that the pectoral flippers are observed AND remains in this position for several seconds at a minimum before submerging such that the head is the last body part to slip beneath the surface. The eyes are usually noted in a spy-hopping beluga. **This behavior excluded from datasheet and included as a note when observed.**

**Snorkeling**: (figure 13) a surfacing whale lifts head gently to the surface in such a manner that only the melon, blowhole and a small portion of the dorsal surface just posterior to the blowhole are visible. After gas exchange has occurred, the whale then gently lowers its head below the surface. The dorsal ridge is never seen during a snorkeling event. Note that this behavior often makes detection of whales difficult from a distance as it reveals only a small portion of the whale and leaves a rapidly dissipated, relatively small (several feet diameter), concavity at the surface of the water . **This behavior excluded from datasheet and included as a note when observed.**

**Travelling**: (figure 6) whale or whales moving in a consistent, unidirectional fashion relative to other individuals in a group. Often travelling whales appear to move in a

[7] Note this is a novel term used to describe a behavior often noted during the months of July and Aug (when salmon are running) in the Eagle River. It is not used elsewhere that we are aware of.
[8] This scenario would be noted as "side-scanning" transitioning into "prey pursuit".

purposeful, coordinated manner. A single traveling whale moves forward with few to no lateral deviations in course.

**Whale group**: group of whales engaged in more or less coordinated behavior(s). Inter-individual distances may increase while travelling, especially among large groups.

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# Appendix

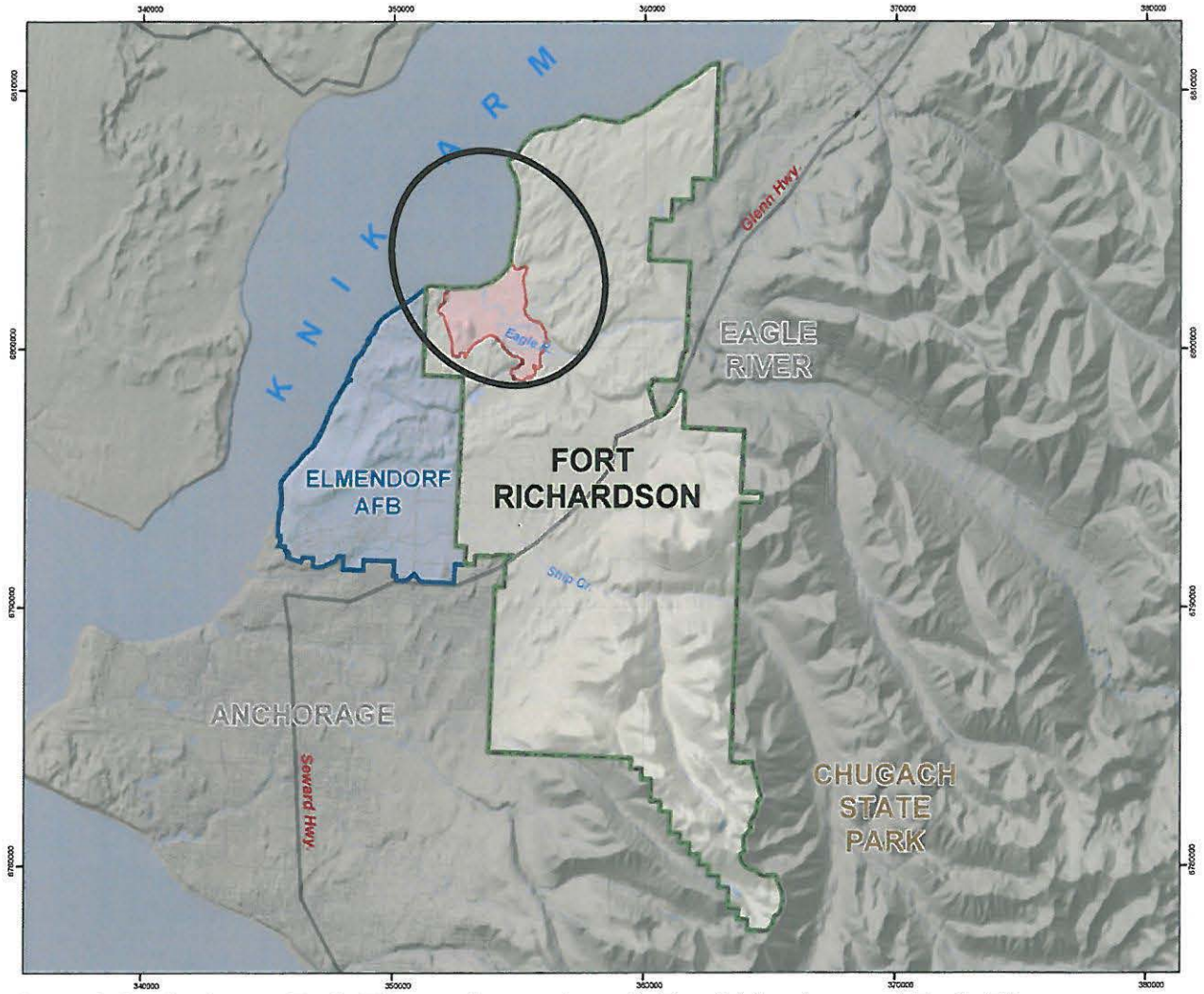


Figure 1. Study Area – Eagle River as it runs through Fort Richardson and Eagle River Flats, discharging into Eagle Bay of Knik Arm, Upper Cook Inlet, southcentral Alaska.

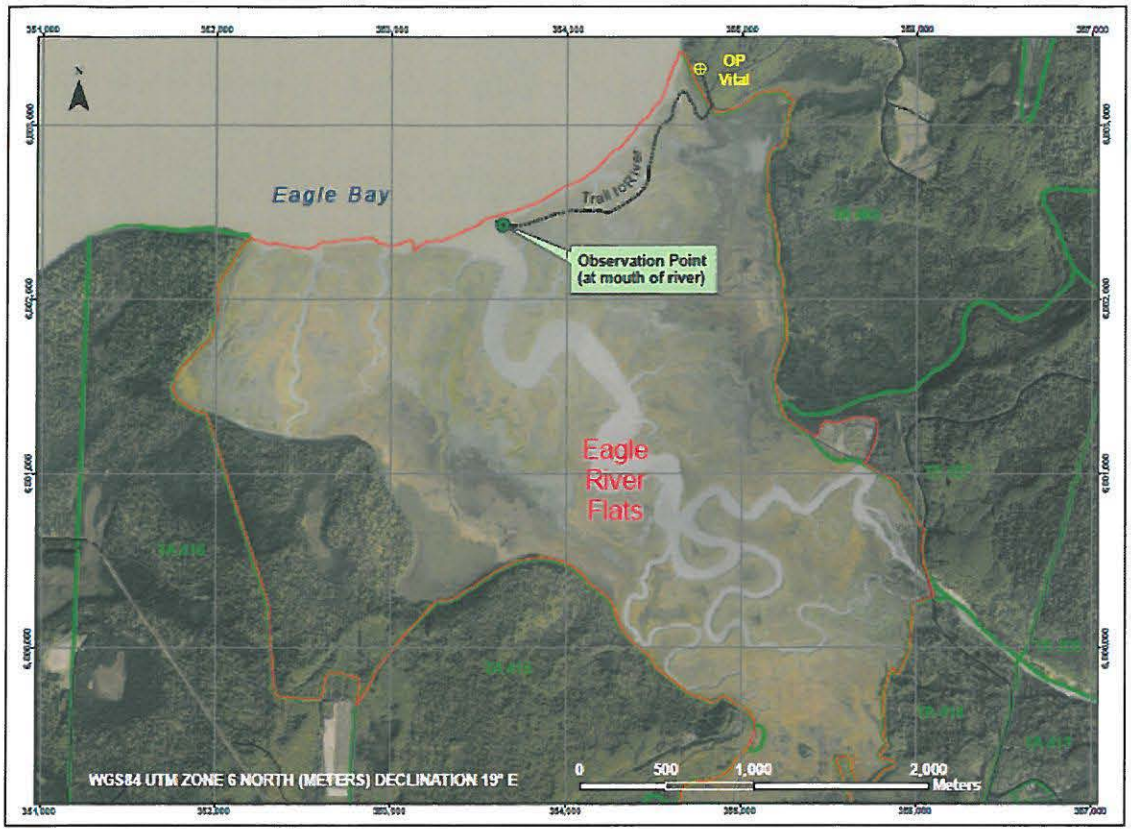


Figure 2. Overall map of Eagle River Flats with primary observation points and the trail used to access the mouth observation point.

## Cook Inlet Beluga Observations – Eagle Bay and Eagle River, Alaska

Observer: Garner / Battle / McKee / Dushane / Mustin / Padilla  Location: OP Vital /OP FAGAN /ER Mouth / Coast of EB  Date

| Grid #/Compass Bearing Start/Finish | Sampling Round/Time Interval | White/Gray/Calf | Survey Conditions (Poor, Fair, Good, Excellent) | Behavior | |
|---|---|---|---|---|---|
| | | | | 1° | 2° |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |
| | | W G C | | | |

| Time Start | Time End |
|---|---|
| Total Time | |

**Behavior Legend**

Traveling (T)

Milling (M)

Prey Pursuit (PP)

Diving (D)

Feeding (F)

Other (see notes)

**Estimated Total Number of Whales:**  Page_____ of _____

Figure 3. Front page Beluga observation data sheet for Eagle Bay.

Additional Comments:

| Sampling Round | Comments |
|---|---|
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| Survey Conditions | | | | | |
|---|---|---|---|---|---|
| Time | Beaufort Scale | Visibility | Tidal Stage | Precip | Overall |
| | 0 1 2 3 4 5 6 | | Flood/Ebb | 0 1 2 3 | P F G E |
| | 0 1 2 3 4 5 6 | | Flood/Ebb | 0 1 2 3 | P F G E |

Figure 4. Back page Beluga observation data sheet for Eagle Bay.

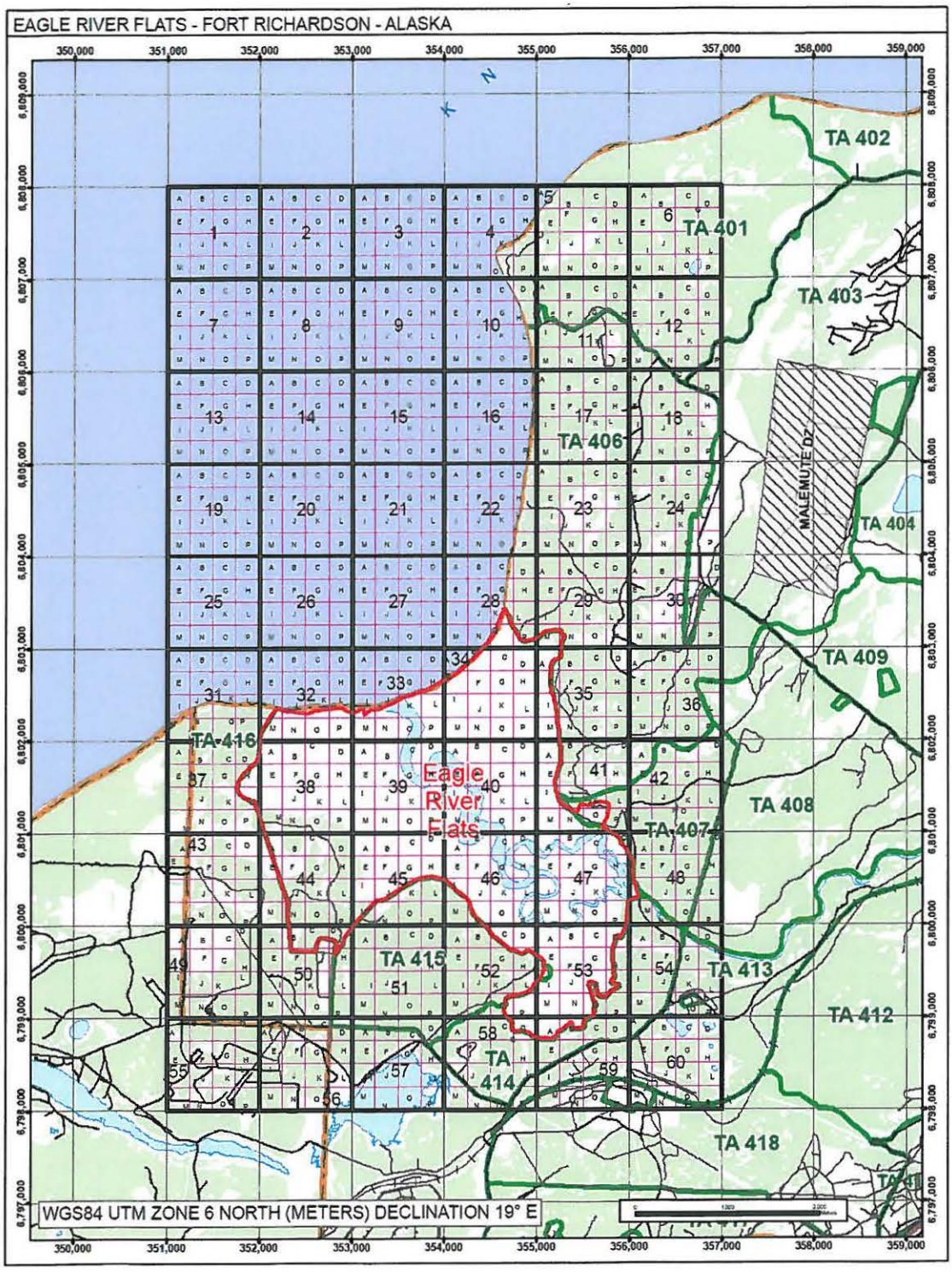


Figure 5. Grid for determination of beluga position

## Photos of Behaviors Commonly Observed in Eagle River and Bay

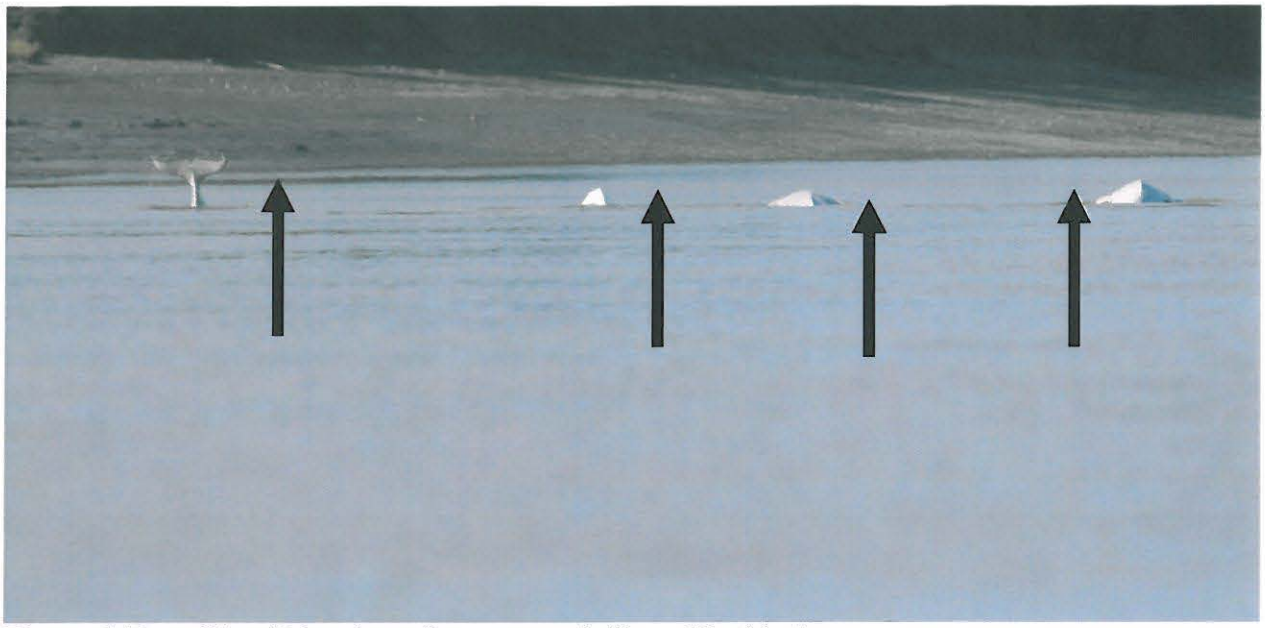

Figure 6. Travelling. Direction of movement indicated by black arrows.

Figure 7 . Milling. Direction of movement indicated by black arrows.

Figure 8. Prey pursuit. Vigorous forward activity but no prey item sighted. Compare to "Feeding"

Figure 9. Diving

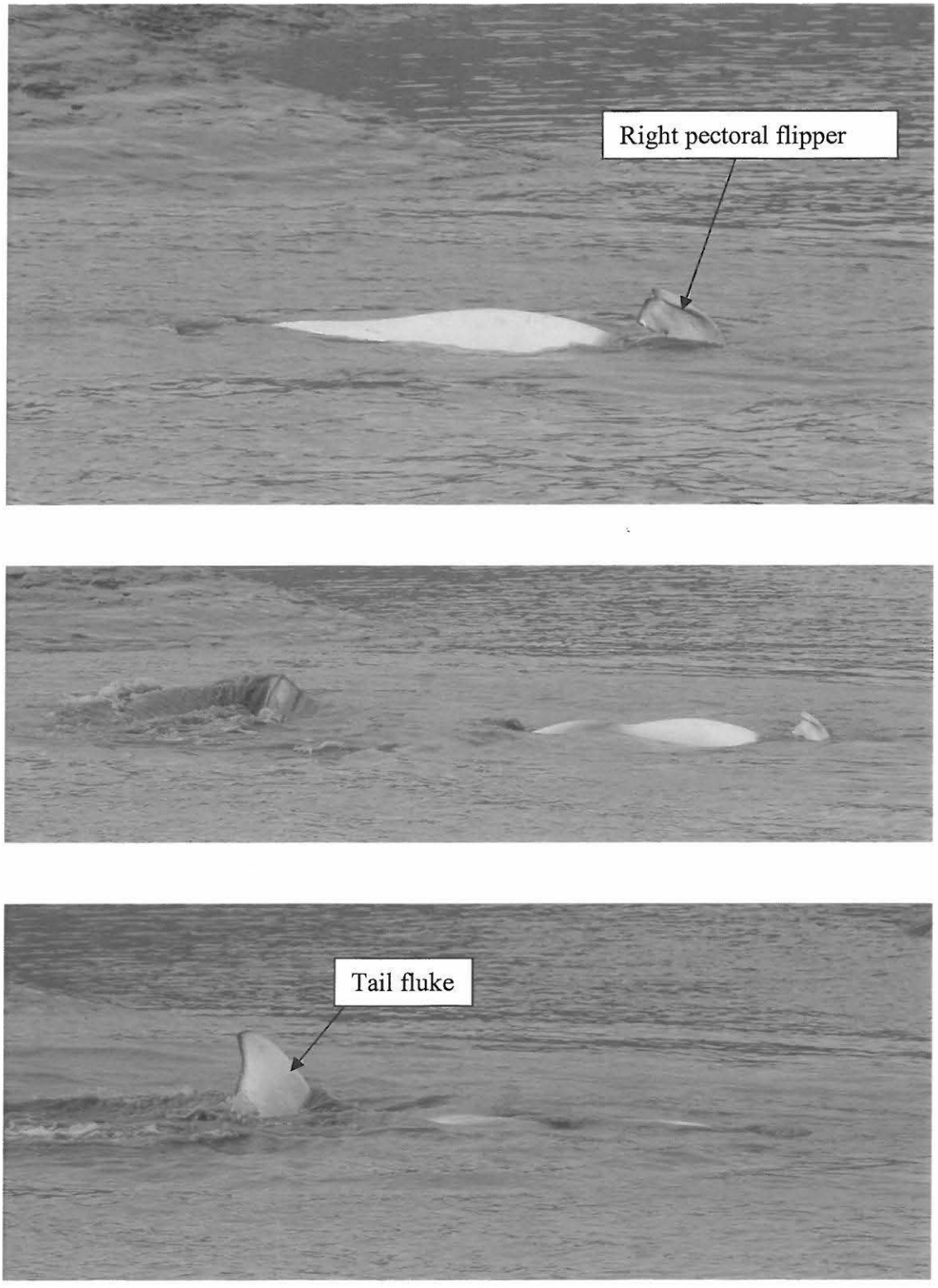


Figure 10. "Side-Scanning"


Figure 11. Feeding- note the salmon in the middle picture has been driven onto the bank and is then presumed to be taken immediately after entering the water again.

## Photos of CI Beluga Whale Behavior not commonly Seen in Eagle River or Eagle Bay

Figure 12. Spy-hopping

Figure 13. Snorkeling

**Photos of Differing Age Classes (presumed) of CI Belugas Based on Coloration**

Figure 14. Adult ("White")

Figure 15. Immature ("Gray")

Figure 16. Immature ("Gray") and adult ("White") – note, that the immature animals often appear smaller than the adult whites but not as small as calves

Figure 17. Calf (dark gray) with adult (white)

Figure 18. Calf (dark gray). The whale accompanying this calf is gray but, assuming that this calf belongs to this animal, is most likely a sexually mature female that has not yet turned white.

## Photos from Time-Lapse Cameras Deployed on Eagle River


Figure 19 Example of possible whale (ring at water surface) but not scored as "whale present" due to lack of observable animal.

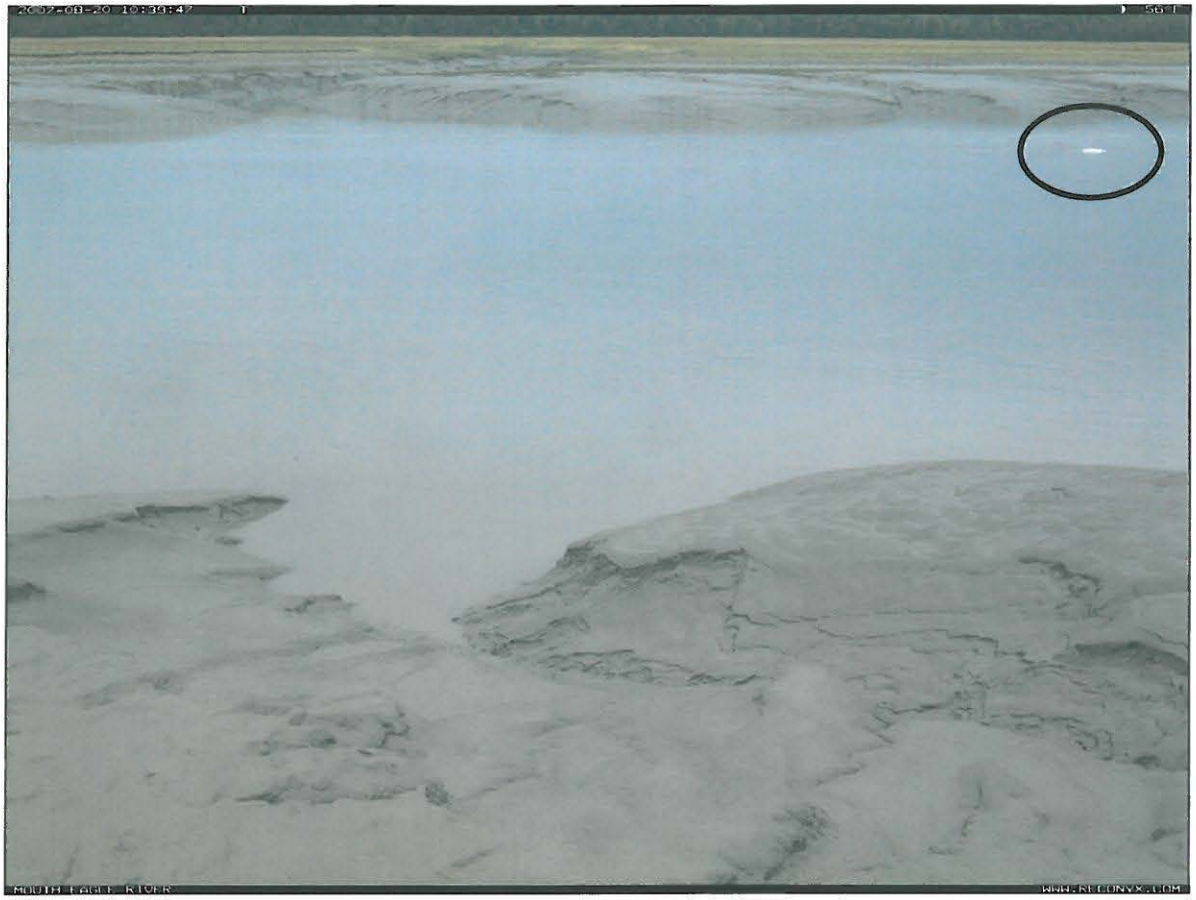

Figure 20. Example of photo scored as "whale present"

# Beaufort Scale

| Force | Speed | | | Name | Conditions at Sea | Conditions on Land |
|---|---|---|---|---|---|---|
| | knots | km/h | mi/h | | | |
| 0 | < 1 | < 2 | < 1 | Calm | Sea like a mirror. | Smoke rises vertically. |
| 1 | 1-3 | 1-5 | 1-4 | Light air | Ripples only. | Smoke drifts and leaves rustle. |
| 2 | 4-6 | 6-11 | 5-7 | Light breeze | Small wavelets (0.2 m). Crests have a glassy appearance. | Wind felt on face. |
| 3 | 7-10 | 12-19 | 8-11 | Gentle breeze | Large wavelets (0.6 m), crests begin to break. | Flags extended, leaves move. |
| 4 | 11-16 | 20-29 | 12-18 | Moderate breeze | Small waves (1 m), some whitecaps. | Dust and small branches move. |
| 5 | 17-21 | 30-39 | 19-24 | Fresh breeze | Moderate waves (1.8 m), many whitecaps. | Small trees begin to sway. |
| 6 | 22-27 | 40-50 | 25-31 | Strong breeze | Large waves (3 m), probably some spray. | Large branches move, wires whistle, umbrellas are difficult to control. |

# Precipitation

0 - No precipitation. Sunny or cloudy skies.
1 - Light sprinkles or occasional drizzle
2 - Sustained light rain
3 - Heavy downpour

Figure 21. Survey conditions form.

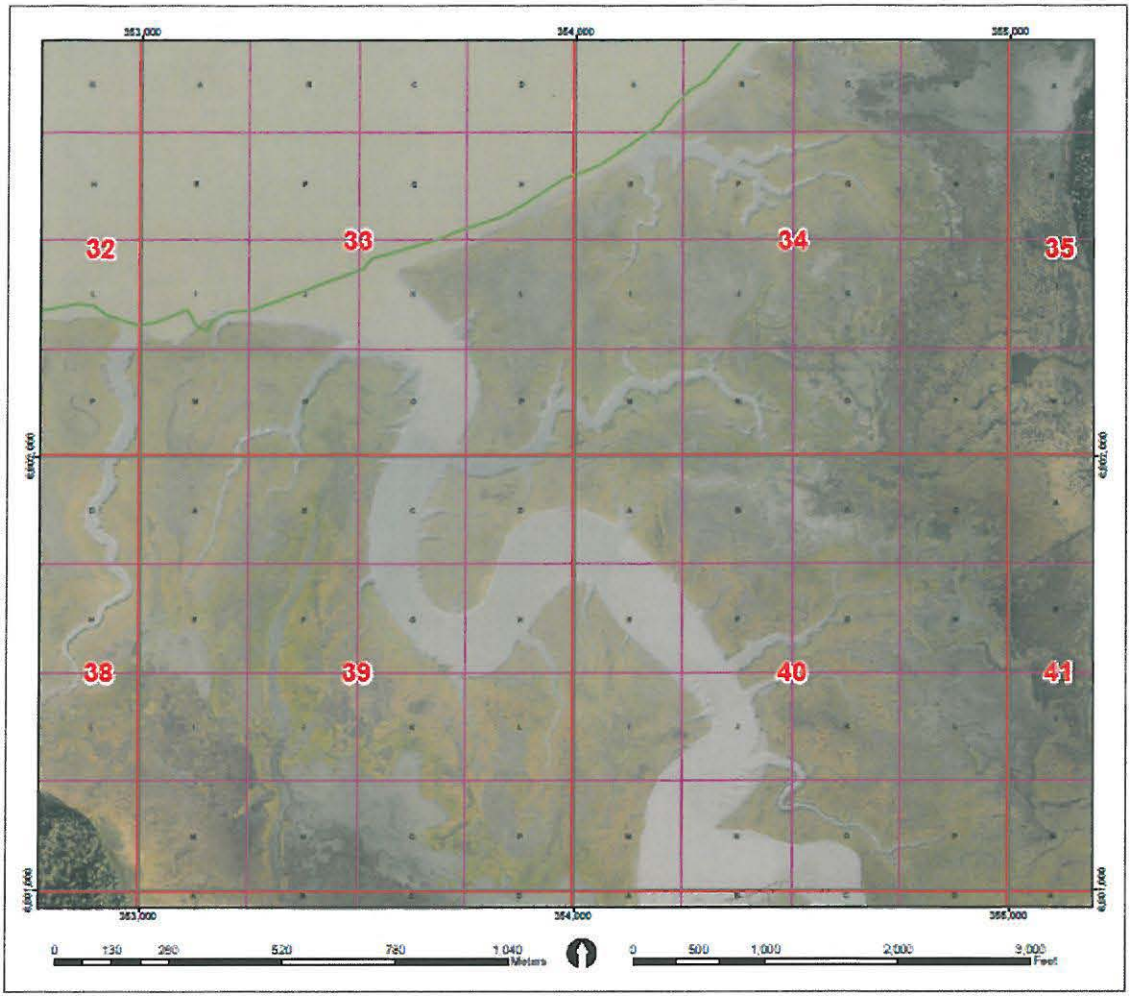

Figure 22. Gird overlay of Eagle River within ERF.