Distribution, Habitat Use, and Behavior of Cook Inlet Beluga Whales in Knik Arm, Fall 2007

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List of Acronyms

APU	Alaska Pacific University
EAFB	Elmendorf Air Force Base
ESA	Endangered Species Act
ICRC	Integrated Concepts and Research Corporation
LGL	LGL Alaska Research Associates, Inc.
MARAD	Maritime Administration
MMPA	Marine Mammal Protection Act
MTR	Marine Terminal Redevelopment
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

1.0 Introduction

This report summarizes the study conducted by Alaska Pacific University (APU) during October 9 through November 20, 2007, in conjunction with the Beluga Whale Monitoring Program (Monitoring Program) developed for the Marine Terminal Redevelopment (MTR) Project in Anchorage, Alaska. Implementation of this program is one of the conditions of the permit issued by the U.S. Army Corps of Engineers for Phase II of the MTR Project, one of the projects under the Port of Anchorage Intermodal Expansion Project. The Monitoring Program was developed by the U.S. Department of Transportation, Maritime Administration and the Port of Anchorage (POA) in consultation with the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS). APU conducted beluga whale monitoring under contract with Integrated Concepts and Research Corporation (ICRC), prime contractor for the MTR Project. The monitoring effort included data collection on the presence, habitat use and behavior of the Cook Inlet beluga whale (*Delphinapterus leucas*) during in-water construction work.

In addition to monitoring and research, APU observers provided real-time beluga whale sighting information to in-water construction crews, including proximity of whales to the construction site. This information supplemented the required shore-based observations of the construction contractor. Whale sightings recorded by APU observers and construction contractors, as well as the sightings reported by POA employees, visitors and tenants, will be added to data on the Cook Inlet beluga whale previously compiled by LGL Alaska Research Associates, Inc. (LGL). APU will analyze these data to establish patterns of beluga whale distribution, habitat use and behavior in the area of Upper Cook Inlet surrounding the footprint of the MTR Project.

During whale monitoring and data collection activities, particular emphasis was placed on documenting the frequency of beluga whale presence within and near the construction area, and also on evaluating the potential responses of beluga whales to in-water construction activities.

2.0 Program Objectives

The Monitoring Program was developed to meet the following objectives:

1. Estimate the frequency at which beluga whales are present near the project footprint.
2. Characterize habitat use and behavior of beluga whales during ice free months in the Knik Arm of Upper Cook Inlet, near the Port of Anchorage (Port).
3. Observe, analyze, and document potential changes in behavior in response to in-water construction work, including pile driving and fill placement. Observe, analyze and document potential changes in beluga whale behavior in response to other Port activities.
4. Inform the Construction Contractor Person-in-Charge (PIC) of in-water construction activities of the proximity of beluga whales to the construction area, so that construction activities may be shut down prior to beluga whales entering the NOAA/MNFS-established safety zones of 650 meters (m) (2,145 feet) from the construction site for pile driving activities and 50 m (165 feet) from the construction site for in-water placement of fill materials.

APU field observers, under the direction of Dr. Leslie Cornick, Associate Professor, documented beluga whale locations and behavior for up to five days per week, in shifts up to 4 hours once or twice per day from the shore station located immediately north of the Port, Cairn Point on Elmendorf Air Force Base (EAFB). Ms. Lindsey Kendall, graduate student in the Environmental Science Program, was field supervisor, trainer, and the additional point of contact for field observers.

3.0 Methods

3.1 Study Area and Observation Station

The study area included all portions of Upper Cook Inlet visible from the Cairn Point Monitoring Station. Observations were conducted facing south, overlooking the MTR Construction Area (Figure 3.1). At least two observers were on site during all observation shifts. An observation platform at the site provided height above sea level near the shoreline. The added height of the platform maximized the probability of detecting beluga whales in and around the Port area. Cairn Point was selected as the

location for the observation station based on the recommendation of LGL, who had used this location for previous beluga observations. The Port received a right of entry from EAFB to access Cairn Point for the purpose of conducting whale monitoring activities. APU observers cooperated with the Port and EAFB personnel and underwent all necessary training to ensure compliance with Port and EAFB safety and security policies.

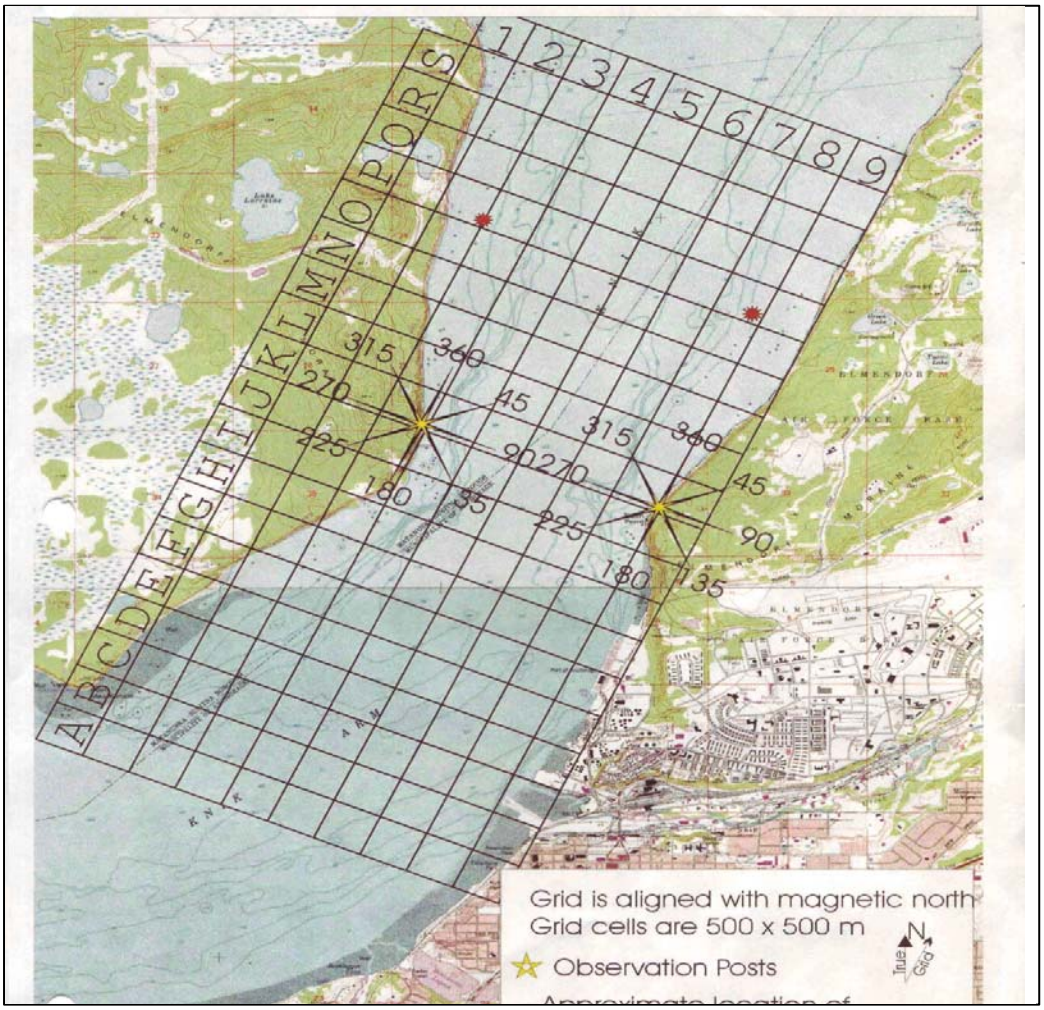

Figure 3.1. Map of study area with 500 x 500 m grid overlay. Grid cells representing the location of the project footprint are D9 – I9. The Cairn Point Observation Station is located in the area represented by grid cell J9.

3.2 Sampling Effort

Monitoring was conducted up to 5 days per week for 4 hour shifts once or twice per day, to cover the full range of tidal cycles, as practicable, during hours of access to the observation station (Monday through Friday 07:00 – 19:00, Saturday 10:00 – 18:00). Afternoon observation hours were adjusted accordingly as daylight hours decreased. A total of 139.42 hours of observation was completed from October 9 through November 20, 2007 (85.75 hours in October, 53.67 hours in November). Monitoring days were scheduled to provide a sample of beluga whale use of the area under varying conditions (e.g., noise, vessel traffic, environmental conditions), while accommodating the logistical, safety and security concerns of the Port, EAFB, ICRC and APU.

3.3 Sampling Protocols

3.3.1 Environmental Conditions

Environmental data pertaining to sighting conditions were logged hourly during observation sessions. These conditions included air temperature, wind speed, sea state (Beaufort Scale), glare (when present), percent cloud cover and precipitation.

3.3.2 Marine Traffic and MTR Project Activities

The number, type and activity of vessels at the Port were documented during observation sessions throughout the observation period. A combination of interval sampling and continuous monitoring was used to monitor vessels. Project activities, including pile driving, were noted at regular intervals during all observation periods in order to facilitate examination of beluga whale occurrence and behavior with respect to these activities.

3.3.3 Beluga Whale Observations

Beluga whale observations were conducted following the method described by Prevel Ramos *et al*. (2006). Observers systematically scanned the study area at 20-minute intervals with the naked eye, and also using Bushnell 7 x 50 binoculars with an internal compass. When beluga whales were observed, the following information was documented: date, time, number of whales sighted, age class (adult, sub-adult, calf; estimated by color), heading, activity, location and group swimming formation (Funk *et al*. 2005).

In addition to basic sighting information (date, time and number of whales), detailed data were collected as feasible and practicable regarding the locations, movements and behavior of beluga whales near the Port according to the protocol developed by Funk *et al*. (2005). A grid-cell mapping system, with distances estimated by eye, was used to estimate beluga whale distribution and location. Focal group sampling was used to document whale behavior.

3.3.4 Theodolite Tracking

During the fall 2007 construction season, a surveyor's theodolite was not used to track beluga whale movement patterns because the height of the observation station, which is required for triangulation of locations, was not obtained from LGL in time to complete this task. Theodolite tracking will be resumed during the 2008 construction season following the same protocols as in previous years (Prevel Ramos *et al*. 2006).

3.3.5 Grid System

To maintain consistency in data collection and analysis throughout the MTR Project, APU continued to employ the grid system originally developed by LGL to monitor the locations and movements of beluga whales in Knik Arm (Funk *et al*. 2005). This technique is well-suited to analyses of habitat use on a broad scale. This system allowed documentation of whale group location and movements on a coarse scale (500 by 500 m or 1 by 1 km grids). Observers used a combination of compass bearings taken from binoculars and landmarks to place the locations of whale groups in their representative grid cells during each sampling interval. Grid cell locations were updated as the whales moved through the area. The footprint of the MTR Project is represented by cells D9 to I9 of the grid (Markowitz and McGuire 2007).

3.3.6 Group Size, Composition and Behavioral Sampling

Detailed focal group behavior was sampled using 20-minute interval sampling (Martin and Bateson 1986, Mann 2000). When whales were sighted, they were observed continuously until out of view. Behavioral state (traveling, milling, resting, feeding), swimming formation, inter-individual distance/group spread, and noteworthy behavioral events (e.g., spy hopping, vocalizations, rapid chases) were documented for each group.

3.4 Data Entry and Analysis

All observations including marine mammal activity, environmental conditions, and vessel activity were documented on standardized datasheets developed by LGL. Data were then checked for accuracy and entered into a statistical analysis package (SPSS Version 14 for Windows) and/or Microsoft Excel for Windows for storage and analysis.

3.4.1 Temporal Distribution

Beluga whale sightings were summarized by time of day, month and tidal stage. Because of the delayed start of the monitoring season (October 9), seasonal patterns could not be analyzed (the entire duration of the observations occurred within the fall season). Seasonal patterns for spring, summer and fall will be revisited for the 2008 season. One-way ANOVA or chi-squared goodness-of-fit tests were used to examine differences in mean durations of observations (ANOVA) and number of groups and total number of whales (chi-squared) across time of day and tidal stage. Alpha levels were set at $p < .05$. All values are reported as mean ± 1 standard error unless otherwise noted. Sampling intervals were classified into their observational hour by the start time of the interval. Observational hours were defined as each hour on the hour from 09:00 – 19:00 in order to encompass the entire range of observational effort hours.

Tidal stages for Upper Cook Inlet were derived from the J-Tides tidal prediction program (<http://www.arachnoid.com/JTides>). This program incorporates a worldwide database of tide and current reporting stations; the Anchorage (Knik Arm) NOAA reporting station located at the Port was used for the purposes of this study. Daily tidal heights were classified into six stages; each stage was two hours long and defined as hours before (-) or after (+) low tide (Figure 3.2).

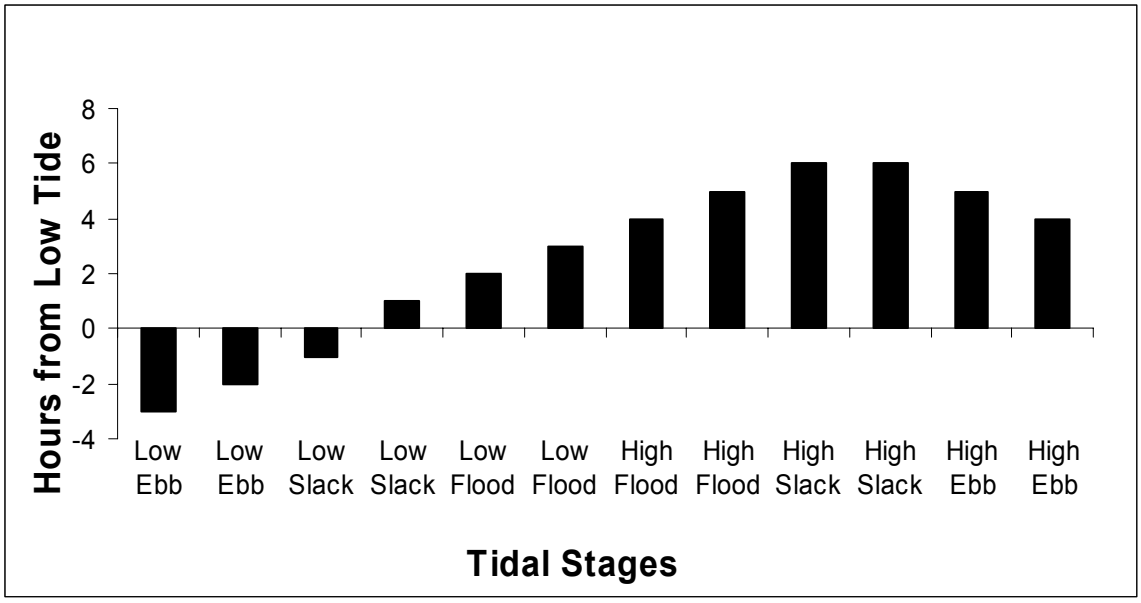

Figure 3.2. Classification of daily tide heights into six stages of two hours each. The stages are defined as hours from low tide.

3.4.2 Spatial Distribution

Sightings were summed for all grid cells in which beluga whales were observed during the observation period. Sightings were classified according to whether the whales were observed outside, adjacent to or within the project footprint (Grid Cells D9 – I9). The time that whales spent in each location (represented by grid cells) was calculated as number of groups sighted, total number of whales and total observation time. Because theodolite tracking was not used during the 2007 season, whale locations and movements were not analyzed using the Global Information System (GIS). However, general movement patterns were tracked visually and summarized for each whale group observed.

3.4.3 Group Size and Structure; Behavior

Mean group size and structure were analyzed for all sightings according to whether the whales were observed outside, adjacent to or within the MTR Project footprint. Behavioral states were summarized for all whale groups observed and unusual behaviors were noted.

3.4.4 Environmental Conditions

Environmental conditions were summarized for each month in order to characterize the predominant viewing conditions. The following variables were collected: temperature, precipitation (none, rain, fog, snow), wind direction and speed, percent cloud cover, glare (presence or absence; compass bearing), Beaufort sea state (0 = mirror-like; 1 = ripples without foam crest; 2 = small wavelets, crests do not break; 3 = large wavelets, scattered white caps; 4 = small waves, fairly frequent white caps), visibility and overall condition rating (excellent, good, poor).

4.0 Results

4.1 Temporal Distribution

4.1.1 Beluga Whale Sightings by Time of Day

Shifts ranged from as early as 09:00 to as late as 18:30, with shifts scheduled as either morning (usually 09:00 to 13:00) or afternoon (either 13:00 – 17:00 or 14:00 – 18:30). Monitoring hours were, in general, evenly distributed across this time range, with some tapering of the earliest morning and latest afternoon hours in November as light levels decreased. The fewest monitoring hours were during the period of 13:00 – 14:00, which was the hour when shift changes were often taking place.

Sightings were evenly distributed across time of day (Figure 4.1). The earliest observations occurred in the 10:00 hour, and the latest in the 17:00 hour. The lack of sightings during the 13:00 hour are likely an artifact of the reduced effort during that hour. The mean number of beluga whales per sighting increased from 12:00 – 17:00, but this trend was not statistically significant. There were no significant differences in the mean duration of observations across time of day.

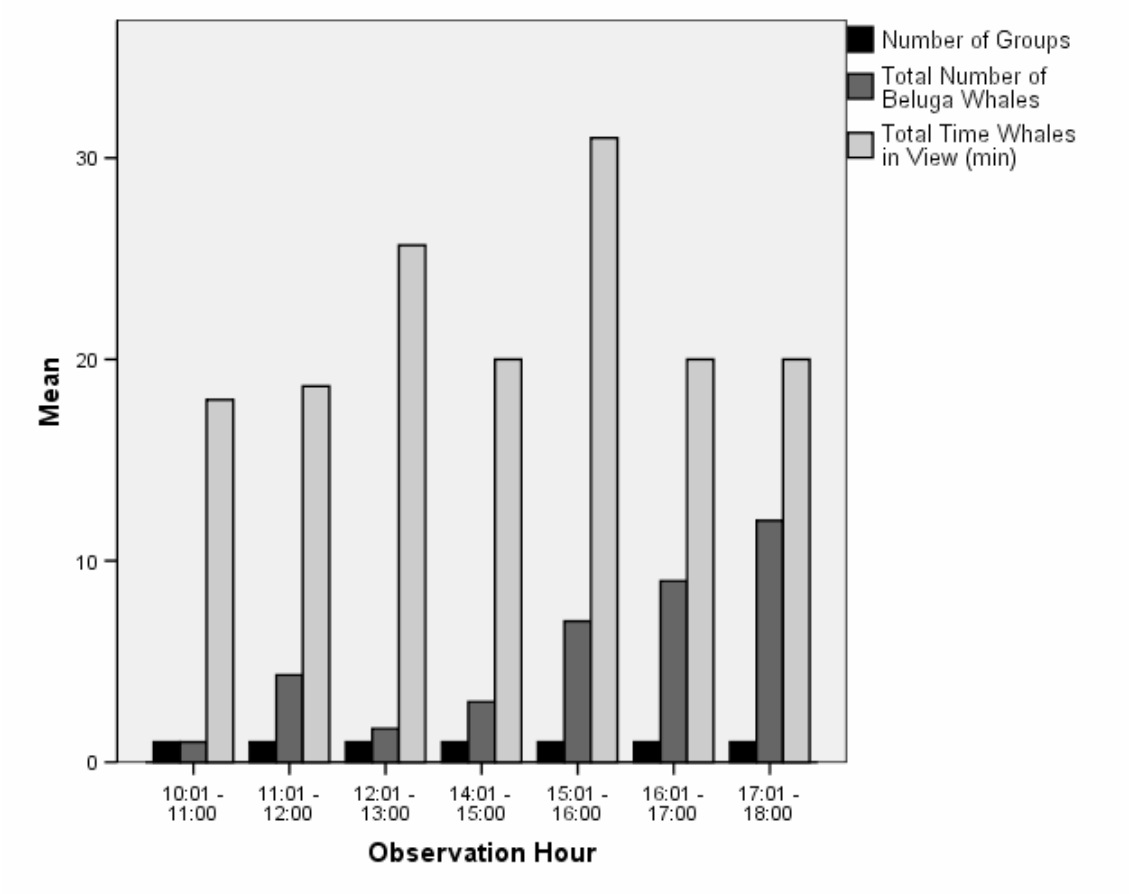

Figure 4.1. Beluga whale observations by time of day.

4.1.2 Beluga Whale Sightings by Month and Season

Sampling effort and beluga whale sighting rates during the period October 9 through November 20 are summarized in Table 4.1. Beluga whales were observed during 9 of the 28 days of monitoring (5 days in October and 4 days in November). A total of 10 groups were seen in each month, which included a total of 34 whales in October and 52 whales in November.

Table 4.1. Summary of Observational Effort and Beluga Whale Sightings by Month.

2007	Observational Effort		Number of Sightings			Sighting Rates	
Month	Days	Hours	Number of Days Whales Seen	Number of Whales Counted	Number of Groups	Whales/Hour Effort	Groups/Hour Effort
Oct	17	85.75	5	34	10	0.40	0.12
Nov	11	53.67	4	52	10	0.97	0.19
Total	**28**	**139.42**	**9**	**86**	**20**	**0.62**	**0.14**

4.1.3 Beluga Whale Sightings by Tidal Stage

Whales sightings (number of groups and total numbers of whales) were evenly distributed across ebb and slack tidal stages (Figure 4.2). Whales were observed for longer periods during ebb tides ($\overline{X}$ = 25.5 ± 12.6 and 26.0 ± 7.2 min for low ebb and high ebb, respectively; $\overline{X}$ = 17.8 ± 2.3 and 20.0 ± 0.0 min for low slack and high slack, respectively), but these differences were not statistically significant. Whales were never observed during flood tidal stages (low or high).

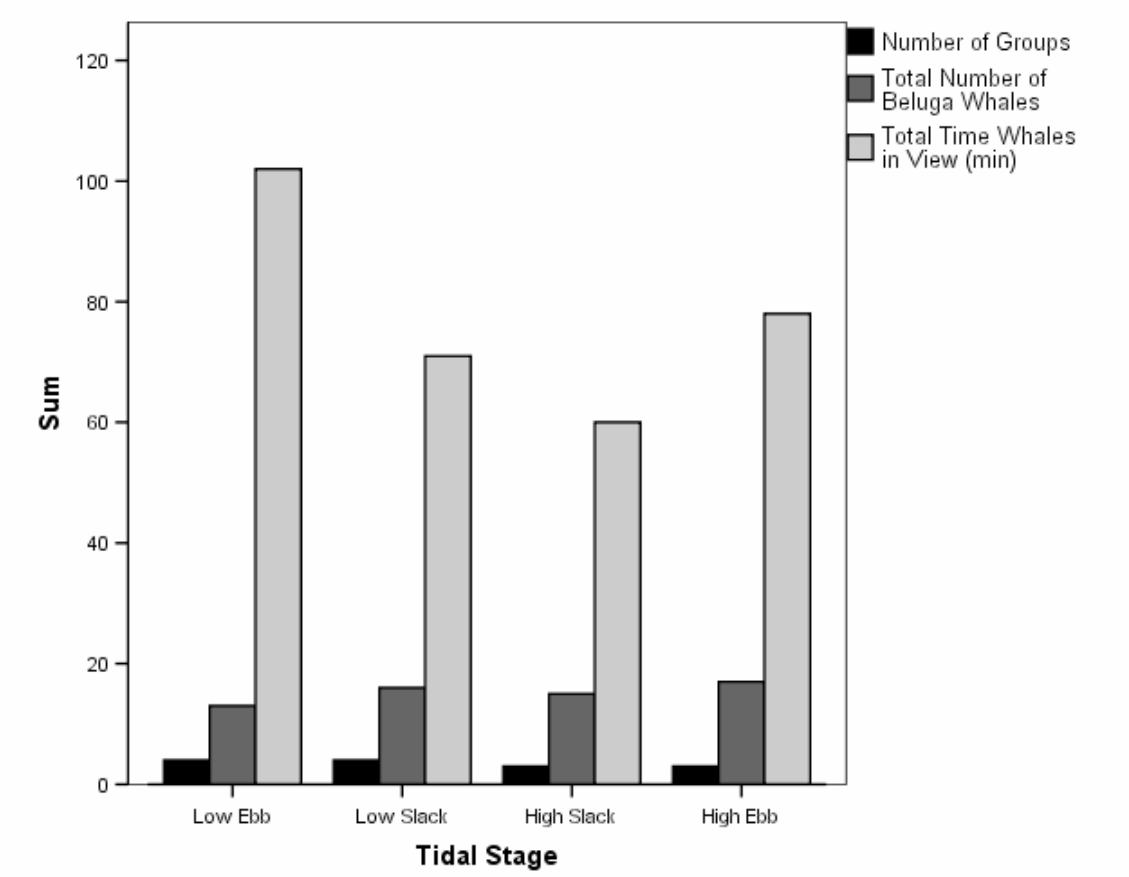

Figure 4.2. Beluga whale sightings by tidal stage. Whales were never observed during low flood or high flood stages.

4.2 Spatial Distribution

This section discusses the spatial distribution of the Cook Inlet beluga whales, including distribution by date and tidal stage near the MTR Project construction area October 9 through November 20, 2007.

4.2.1 Spatial Distribution Summary

Beluga whales were observed within the study area on 14 occasions during the 139.42 hours of total observation time from October 9 through November 20, 2007 (Table 4.2). Four of the sightings (approximately 29 % of the total sightings) were observed within the footprint of the MTR Project. The total time belugas spent adjacent to the MTR construction area at the Port or within the Project footprint was approximately 1.97 hours (118 minutes; approximately .014 % of the total observation time).

Table 4.2. Summary of Beluga Whale Sightings.

Date	Grid Cell	Time	Duration of observation (min)	Time within footprint (min)	Group Composition				
					Adult	Subadult	Calf	Unknown	Total
11.10.07	I5, K6, K5	11:58-13:00	62	0	1	0	0	0	1
16.10.07	K3	11:20-11:40	20	0	4	1	3	0	8
23.10.07	J8, K8	11:04-11:20	16	0	1	0	0	2	3
23.10.07	G6	12:36-12:40	4	0	0	0	0	3	3
27.10.07	H3	11:40-12:00	20	0	2	0	0	0	2
30.10.07	H9	14:20-14:40	20	20	1	4	0	0	5
30.10.07	H9	16:20-16:40	20	20	3	6	0	0	9
01.11.07	J5	14:30-14:50	20	0	1	0	0	0	1
01.11.07	K8	17:10-17:30	20	0	5	3	4	0	12
06.11.07	I7, J7	12:19-12:30	11	0	1	0	0	0	1
06.11.07	I9	15:40-16:20	40	40	1	0	0	0	1
07.11.07	I9, J9	15:18-15:40	22	22	5	8	0	0	13
15.11.07	J7	10:05-10:25	20	0	1	0	0	0	1
15.11.07	K7	10:49-11:05	16	0	1	0	0	0	1

Highlighted rows indicate sightings within the project footprint.

4.2.2 Spatial distribution and movements by date

October 2007

Observations began 9 October and continued through 31 October, for a total of 85.75 observation hours. There were seven beluga whale sightings in the study area during October, including two sightings adjacent to the MTR construction area (Table 4.2).

On 11 October, one adult whale was observed between the narrows (the area between Point MacKenzie and Cairn Point) for approximately 62 minutes (Grid Cells I5, K6, and K5 during a low ebb tide). The observed behaviors included a primary activity of diving and a secondary activity of milling as it slowly moved north.

On 16 October, a group of eight whales (four adults, one sub-adult, and three calves) was observed moving north along the shore near Port MacKenzie (Grid Cell K3). The group was observed for approximately 20 minutes. Documented behaviors included a

primary activity of diving and a secondary activity of traveling or moving. The group was tightly packed with the parallel axis of the group longer than the perpendicular axis.

On 23 October, two groups of whales were observed. During the first sighting, a group of three whales (one adult and two whales of unknown age) were observed for approximately 16 minutes moving north past Cairn Point (Grid Cells J8 and K8). This group of whales moved up through the narrows during a high ebb tide. The observers documented the whales' behavior as primarily traveling or moving and secondarily diving. The second sighting of three whales of unknown age lasted approximately four minutes. This group was moving north (through Grid Cell G6) during the low ebb tide. The documented behaviors were primarily traveling or moving and secondarily diving.

On 27 October, a group of two adult whales were observed for approximately 20 minutes during the low slack tide. The group was observed traveling north along the shore near Point MacKenzie (through Grid Cell H3). The primary behavioral activity was traveling or moving; the secondary activity was suspected feeding.

On 30 October, there were two separate sightings of whales, both during the high slack tide. The first sighting was of a group of five whales (one adult and four sub-adults) observed for approximately 20 minutes. The belugas were observed moving north adjacent to the MTR Construction Area (Grid Cell H9). The observers documented the whales' activities as primarily traveling or moving and, secondarily, suspected feeding.

The second sighting was a group of nine whales (three adults and six sub-adults) observed for approximately 20 minutes moving south adjacent to the MTR Construction Area (Grid cell H9). The observers noted the group of whales were in a similar location as the previously observed group, adjacent to the MTR Construction Area. Their primary activity was traveling or moving and, secondarily, suspected feeding. The group was tightly packed, with the parallel axis longer than the perpendicular axis.

November 2007

During the month of November, observations occurred from 1 November through 20 November, for a total of 53.67 hours of effort. There were seven beluga whale sightings in the study area, including two sightings adjacent to the MTR Construction Area (Table 4.2).

On 1 November, two groups of whales were observed, both during the low slack tide. One adult whale was observed for approximately 20 minutes moving north between the

narrows (Grid Cell J5). Feeding was suspected as the primary activity and diving was noted as the secondary activity. A second group of 12 whales (five adults, three sub-adults, and four calves) was observed for approximately 20 minutes moving south (Grid Cell K8). The primary group activity was traveling or moving and the secondary activity was suspected feeding. The group was more loosely packed than those previously observed, with the parallel and perpendicular axes similar in length.

On 6 November, two lone adult whales were observed on separate occasions; one sighting was adjacent to the MTR Construction Area. One whale was observed for approximately 11 minutes (Grid Cells I7 and J7) during the low slack tide. The whale was moving north through the narrows. The primary activity observed was diving and the secondary activity was milling. Another lone adult whale was observed for approximately 40 minutes moving south along the edge of the MTR Construction Area (Grid Cell I9) at the transition between the high ebb and low slack tides. The observers noted the whale's primary activity as traveling or moving and the secondary activity as suspected feeding.

On 7 November, a group of 13 whales (five adults and eight sub-adults) was observed during the high ebb tide for approximately 22 minutes, moving north (Grid Cells I9 and J9) immediately adjacent to the MTR Construction Area. The behaviors of the group of whales were documented as primarily traveling or moving and secondarily as diving. One adult whale was observed milling and diving near shore, directly below and west of the Cairn Point Observation Station, several meters north of the MTR Construction Area, before it resumed traveling north. The group's composition was tightly packed, with the parallel axis longer than the perpendicular axis.

On 15 November, two lone adult whales were observed on separate occasions. The first adult whale was observed for about 20 minutes moving north (Grid Cell J7 during the high slack tide. The primary activity documented was traveling or moving; the secondary activity was diving. The second lone adult whale was observed shortly after the first whale, for about 16 minutes, moving south (Grid Cell K7) during the low ebb tide. The primary activity was traveling or moving; the secondary activity was diving. The observers noted that this whale appeared to be a yellowish color, not as white as the whales previously observed..

4.2.3 Spatial Distribution Relative to the MTR Project Footprint

Five groups of beluga whales were observed within or adjacent to the project footprint (n = 31 whales), for a total observation time of 118 minutes. The majority of sightings (64 %, n = 9 groups, 30 whales, 193 min), occurred outside the Project footprint (Figure 4.3).

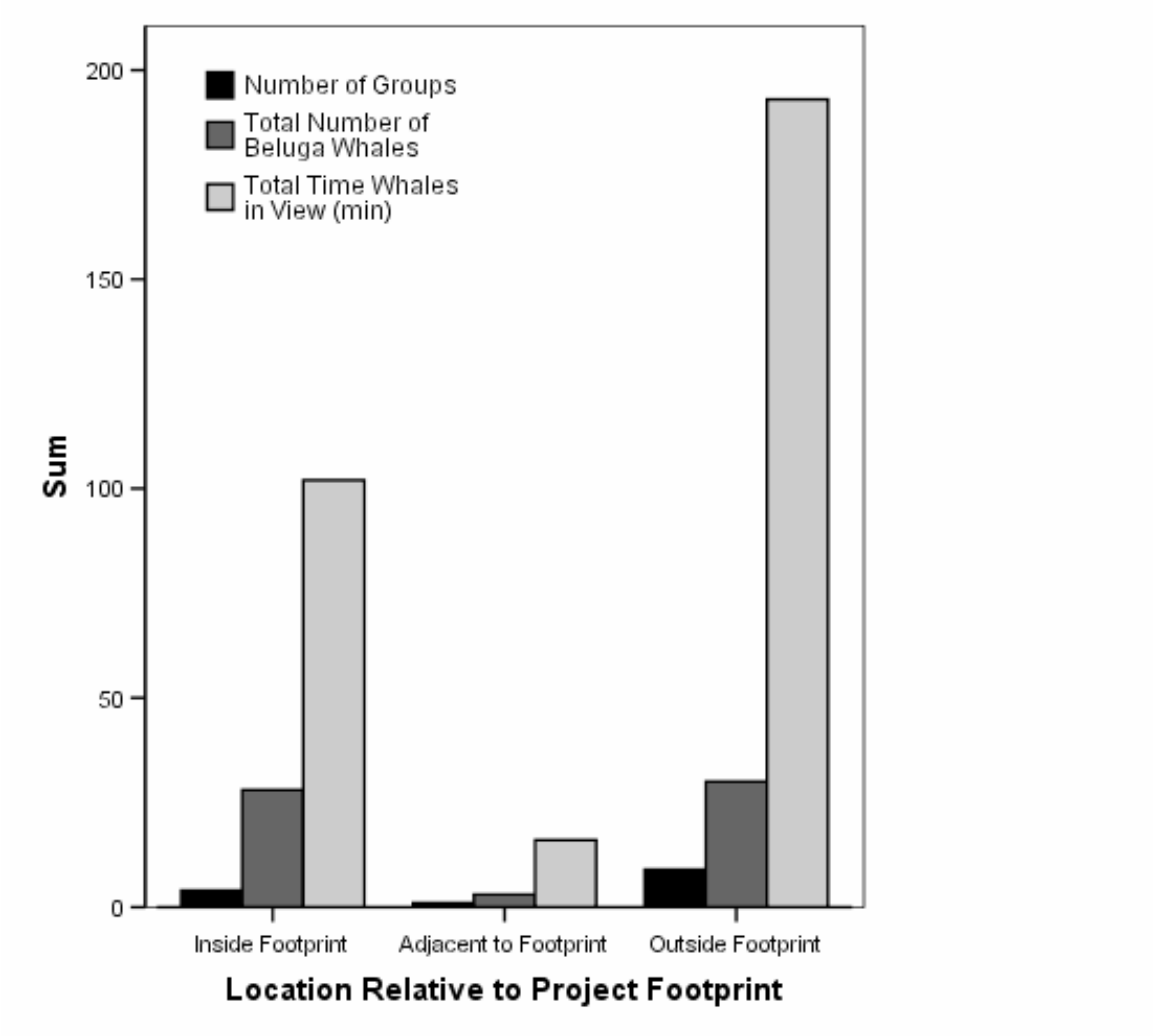

Figure 4.3. Spatial distribution of beluga whales relative to project footprint. 64% of observations occurred outside the project footprint.

4.2.4 Spatial Distribution by Tidal Stage

Beluga whales only entered the project footprint during high slack and high ebb tides, and were adjacent to the MTR Project Footprint only during high ebb tides (Figure 4.4).

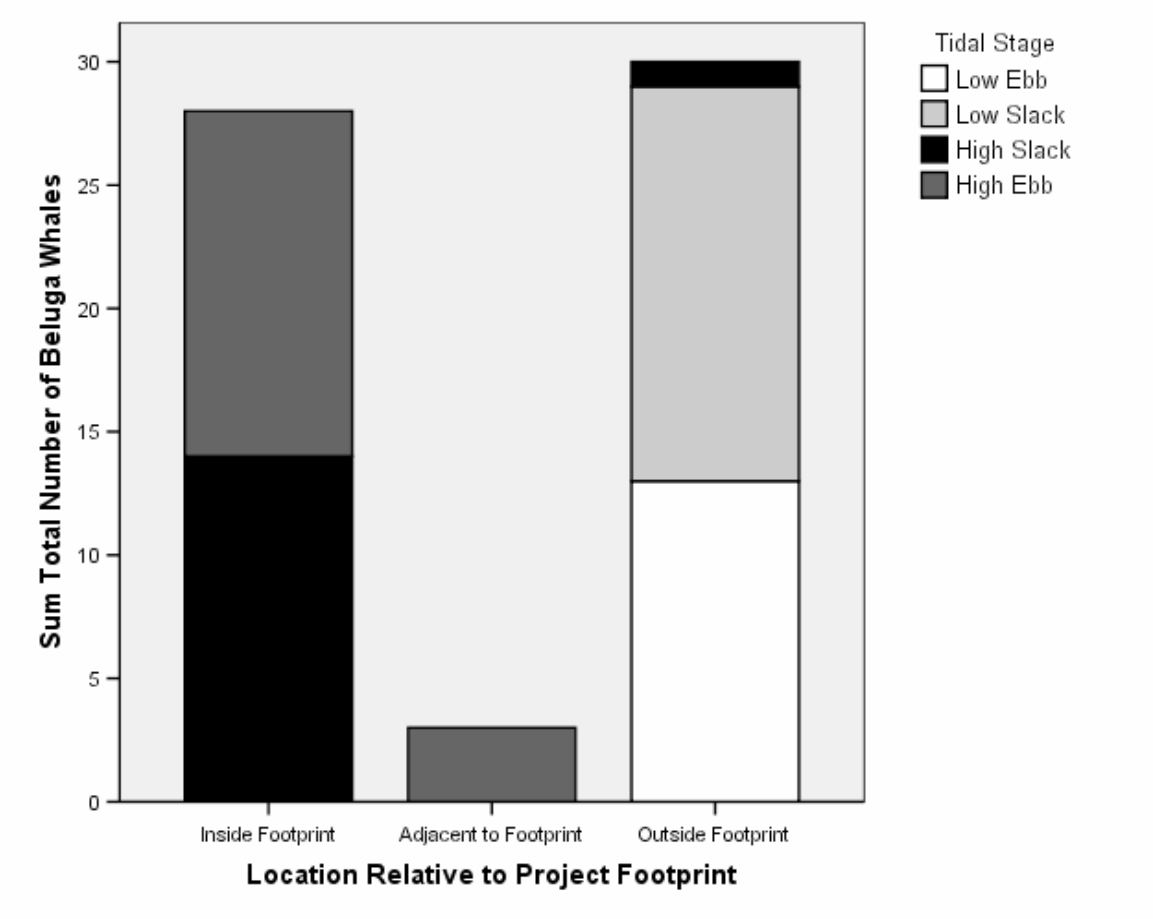

Figure 4.4. Spatial distribution relative to the MTR Project Footprint across tidal stages.

4.3 Group Size and Structure

A total of 27 adults, 22 sub-adults, 7 calves, and 5 animals of unknown age class were observed during the period October 9 through November 20, 2007. Mean group size was 4.36 ± 1.16 individuals. Only two groups contained calves, and only groups with adults and sub-adults entered the MTR Project Footprint (Figure 4.5).

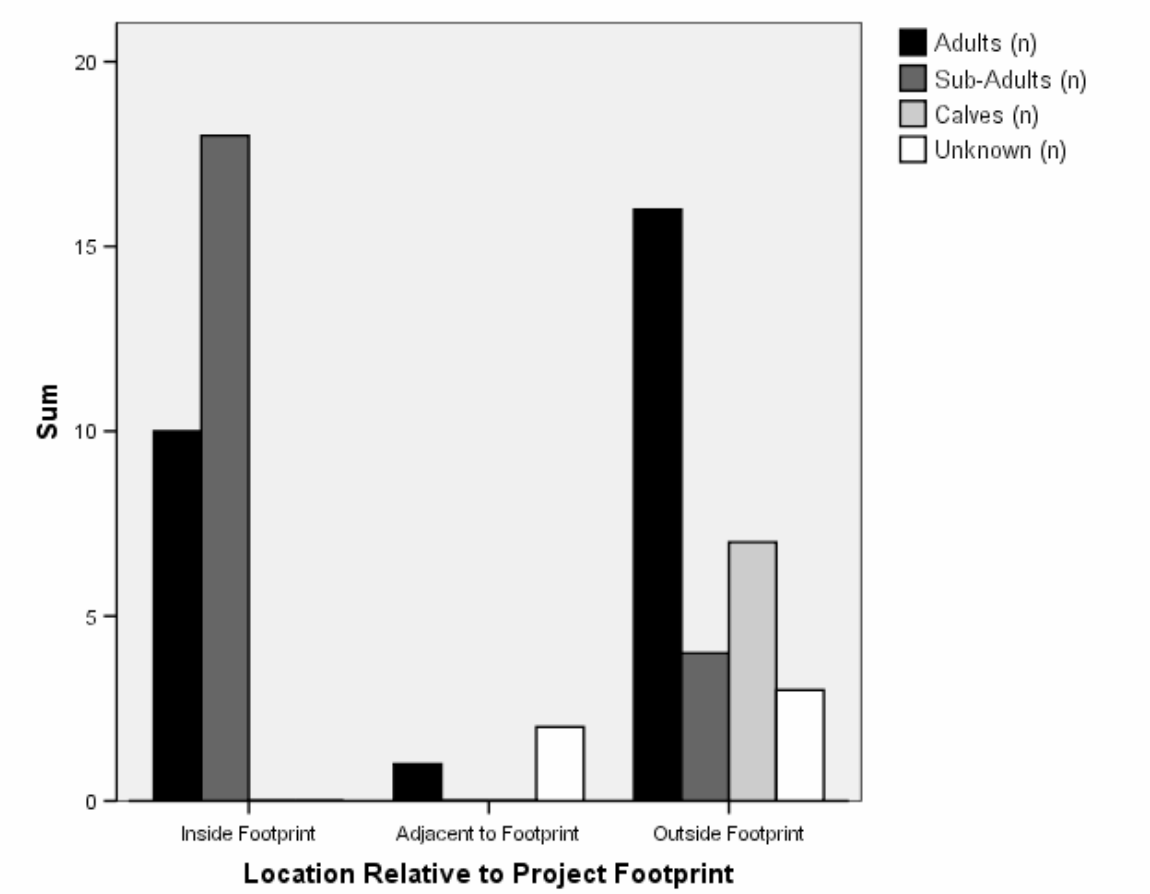

Figure 4.5. Number of beluga whales in each age class relative to appearance within the MTR Project Footprint.

4.4 Movements and Behavior

Whales were primarily observed moving north through the study area. Diving was observed frequently (n = 12), and feeding was suspected on seven occasions but never confirmed. No unusual behavioral events (e.g., abrupt directional changes, rapid descents) were observed during the study period. All of the groups with more than one individual were tightly packed and moving in a unified pattern.

4.5 Environmental Conditions

Overall sighting conditions during the months of October and November were classified as excellent. Rarely were conditions rated poor. During both months, the sea state was most often rated as a 2 (small wavelets where crests do not break) on the Beaufort Scale. In October, the mean wind speed was 3.9 kilometers per hour (km/hr), with a maximum speed of 20.1 km/hr. The average temperature was 3.7 degrees Celsius (ºC).

The mean visibility was approximately 10 km, with an average of 62 % cloud cover. In November, the mean wind speed was 4.0 km/hr, with a maximum of 13.7 km/hr. The average temperature was 1.0 °C, the mean visibility was approximately 10 km, and the average cloud cover was 75 %. Fog was observed frequently during both months and glare sufficient to obstruct sightings was present during 12 days of observations. However, whales were observed on five of the days when glare was reported, suggesting that glare did not substantially affect the results.

4.6 Discussion and Summary

4.6.1 Temporal Distribution

Due to the shortened monitoring season, it is difficult to broadly compare temporal patterns observed during 2007 with the patterns reported in previous studies of beluga whales in Knik Arm. However, within the fall 2007 season, sighting rates (0.12 and 0.19 groups per hour of effort in October and November, respectively) were substantially higher than those reported for 2006 (0.02 and 0.00 groups per hour of effort in October and November, respectively; Markowitz and McGuire 2007), despite comparable observational effort in October. Observational hours were greater in November 2007 due to a longer period of ice-free conditions. This likely also explains the increased sighting rates in November, as whales were not forced to leave Upper Cook Inlet due to increasing ice until well into November.

Markowitz and McGuire (2006) did not specifically analyze the temporal distribution of whales across observational hours, but did note that sighting rates appeared constant at approximately 0.05 beluga whale groups per hour throughout the study period of April through November. During the fall of 2007, sighting rates were also consistent across the two months of observation with respect to the number of groups observed per hour. However, APU did observe an increasing trend in the mean group size from midday through the afternoon. While this trend was not statistically significant, analysis of diurnal patterns during longer sampling periods, will continue in future years.

Observations were conducted over all six tidal stages. However, because observations occurred only in the fall season, it is necessary to use caution when comparing 2007 observations to previous observations that include spring and summer. Tidal and seasonal influences on habitat use may be tightly coupled due to their influence on prey resources in Knik Arm. In 2007, whales were observed evenly across both low and high

ebb and slack tides, and never during flood stages. Markowitz and McGuire (2006) also reported high sighting rates during low ebb and slack tides, which is comparable to the present study, but they reported much lower sighting rates during high ebb and slack tides. Whales were never observed during the high flood stage in either study, but Markowitz and McGuire (2006) did report a low number of sightings during the low flood stage. This difference is very likely due to the lack of spring and summer observations during 2007. During the present study, whales were mostly observed moving north through the study area, which primarily corresponded with low ebb and slack tides. Whales were only observed moving south (n = 4 groups) during slack tides. These patterns appear comparable to those observed in previous years; however, as previously noted, tidal stage comparisons must be interpreted with caution due to the shortened observation period in 2007.

4.6.2 Spatial Distribution

Contrary to 2006, the vast majority (64%) of observations of beluga whales in 2007 occurred outside the MTR Project Footprint; only five groups were observed within or adjacent to the footprint. Observations within or adjacent to the footprint did not differ with the type of construction activity being conducted, although no whales were observed during test pile-driving operations. Observations outside the project footprint were evenly distributed across grid cells representing the narrows, with two observations in grid cells representing locations near the far shore. Although whales were observed in the Project Footprint on only four occasions, there were four additional observations in shoreline grid cells immediately north of the Project Footprint. This pattern is roughly comparable to previous observations of whales having a fairly concentrated use of the area closest to shore, within 0.5 km of the Project Footprint. However, during the 2007 observation period, beluga whale use of areas within or adjacent to the project footprint only occurred during high ebb and slack tides, contrary to observations during 2006. Again, these comparisons must be made with caution, since in 2007 observations were conducted only during the fall, and given the increased observational effort during November of 2007, when half of the observations of whales within the Project Footprint occurred.

4.6.3 Group Size, Structure and Behavior

Mean group size during 2007 (~ 4 whales) was comparable to 2006 (~ 3 whales; Markowitz and McGuire 2007). Only two groups with calves were observed during 2007, and only outside the Project Footprint. Comparisons of age, class structure, and use of the project footprint across years are prohibitive, as there were no whales observed during November of 2006, and only two adults were observed during October 2006. Group dispersion during 2007 was comparable to 2006, with all groups >1 individual being tightly spaced.

Suspected feeding and diving were frequently observed during the 2007 season and were observed equally in lone animals and groups with and without calves. Diving and suspected feeding were evenly distributed across tidal cycles, but only took place within the Project Footprint during high slack and ebb tides. During October 2006, diving was frequently observed but feeding was never suspected or observed (Markowitz and McGuire 2007), and no whales were observed during November 2006. Feeding was never confirmed by direct observation during 2007. These differences likely reflect the longer ice-free period during 2007, which may have resulted in greater prey availability. It is also likely that longer ice-free periods will become more common as effects of climate change continue to impact local conditions in Cook Inlet. Detailed behavioral comparisons during the fall in future years will be important to determine potential changes in habitat use in Knik Arm as conditions change.

5.0 Planned Improvements for 2008

Because the 2007 season was the first season that APU provided whale monitoring services for the MTR Project, and in part due to the truncated season, APU spent a substantial amount of time determining what improvements and updates could be made to the monitoring program. It was also important for APU to ensure continuity between LGL's previous monitoring efforts and APU's monitoring efforts, in order to maintain consistency in the data collected. With that in mind, APU used the data sheets, maps and protocols laid out in LGL's final report for 2006. This section presents proposed changes to existing whale monitoring protocols.

5.1 Improvements to Sampling Protocols

5.1.1 Theodolite Tracking

To maximize the resolution of analyses of beluga whale occurrence and habitat use in the project footprint, theodolite tracking will be resumed in 2008. A theodolite measures horizontal and vertical angles, which can be used to triangulate whale location. Distance of whales from vessels in the Port area and from MTR construction activities will be measured using this technique, with a high level of accuracy in real time. Theodolite tracking data will also be used to detail whale movement patterns and habitat use. Theodolite tracking will be conducted in a manner consistent with the data collected by LGL during Phase I of the MTR Project (Markowitz and McGuire 2007).

In short, horizontal (azimuth) and vertical (declination) readings from the theodolite will be used to calculate the position of whales and vessels. Accurate assessment of whale group locations will be facilitated by precise measurement of height and location of the station and input of tide tables to account for tidal variation during the observation period. Measurement error generally decreases based on the following factors:

- An increase in the height of the observation station
- A decrease in the distance from the observation station to the object being fixed
- A decrease in short-term variation of sea surface height (Würsig *et al*. 1991)

The addition of a raised observation platform at Cairn Point should increase the precision of these measurements over measurements collected in previous years.

Successive location fixes of moving objects will provide estimates of parameters related to movement patterns (e.g., speed, linearity, re-orientation rate, bearing). Fixes of multiple objects will provide information on distance between objects (e.g., whales and vessels) and orientation (toward, away from, neutral). A laptop computer will be linked to the theodolite to allow instantaneous download and time stamping of horizontal and vertical angle-fix information, input of other observations (e.g., group size, behavior and environmental parameters), and rapid, real-time longitude-latitude position and movement pattern calculations. GIS-compatible whale tracks will facilitate the estimation of distances between whales and shore and the sources of noise and vessels, as well as increased analytical power for examining sighting data and whale responses to project activities.

Equipment for theodolite tracking will include a tripod-mounted surveyor's theodolite (TopCon DT205), a computer-download cable connecting the theodolite to a laptop computer, and a laptop computer with long-life batteries that allow six hours of continuous data collection. Data will be collected and collated using *Pythagoras* software (http://www.tamug.edu/mmrp/pythagoras/) to display position, movement, and distance in real time. This GIS-compatible software also allows input of sighting, environmental, and behavioral data for more detailed analyses than were possible during the 2007 season.

5.1.2 Sampling During Pile Driving

APU concurs with the conclusions of Markowitz and McGuire (2007) that pile driving should be scheduled in order to avoid low tides during the fall, particularly given the increased use of areas adjacent to the project footprint observed during 2007 related to the longer ice-free period during those months.

5.1.3 Improvements to Data Collection and Analysis

J Tides was used to analyze tidal stages in this report and was also used by LGL for previous reports. Beginning with the 2008 monitoring season, NOAA Tides and Currents (http//:tidesandcurrants.noaa.gov/) will be incorporated into the tidal-stage analysis. The NOAA website provides data on observed tidal heights, which will allow more precise analyses. Data sheets will also be updated to increase the precision of observations and to facilitate more detailed examination of beluga whale use of the project footprint across time of day, month, season and tidal stage. Maps of the study area will also be updated.

5.2 Effects of an ESA Listing for Cook Inlet Beluga Whales

In the event that the Cook Inlet beluga whale is listed as an endangered species under the Endangered Species Act (ESA), monitoring requirements and safety radii may change. If this should occur, ICRC, APU and the MTR Construction Subcontractor should meet to discuss any changes to the monitoring protocol.

5.3 Communication and Observer Training

An initial meeting of ICRC, the MTR Construction Subcontractor and the APU Beluga Observation Team should be held prior to the start of the 2008 construction season to

clarify pertinent information that needs to be communicated between the Project Manager, construction crew and the APU Team. In the meeting, contacts should be identified and notification protocols should be established. Additional meetings may be necessary to clarify protocols. Regular cell phone communication should continue between ICRC, the MTR Construction Subcontractor and the APU team during observation periods.

At least two observers from the 2007 season will be employed during 2008 in order to assist in the training of new observers and to ensure continuity of data collection and other procedures. Training will be conducted two weeks prior to the anticipated start of observations, and will include at least one "test" observation shift for all new observers under the direct supervision of Dr. Cornick and/or Ms. Kendall.

6.0 Summary

Although the 2007 season presented a number of challenges, APU believes that the transition between the LGL Observation Team and the APU Observation Team was relatively smooth, and presents an outstanding educational and service opportunity for APU students. With the opportunity to complete a full observation season in 2008, and anticipated access to raw data from previous years, APU anticipates more detailed analyses of beluga whale use of the areas surrounding the Port and the MTR Project Footprint, and an increased understanding of the potential effects of construction activities on beluga whales.

Ms. Kendall's master's thesis project will focus on the potential acoustic impacts to beluga whales of in-water construction, particularly pile driving. This will provide valuable data for planning purposes as the MTR Project moves forward, particularly in the event of an ESA listing of Cook Inlet beluga whales.

Future APU master's thesis projects will continue to provide detailed long-term analyses of beluga whale habitat use and behavior in Knik Arm, analyses which will be published in peer-reviewed scientific literature. These on-going projects will provide valuable data for the conservation and management of beluga whales, while facilitating continued managed development in Upper Cook Inlet.

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