

**Monitoring beluga whale (*Delphinapterus leucas*)
distribution and movements in Turnagain Arm
along the Seward Highway**

Final Report

By

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Introduction

A monitoring program along the Seward Highway was established to document the presence, habitat use and behavior of beluga whales (*Delphinapterus leucas*) in Turnagain Arm, Upper Cook Inlet, Alaska during May through November 2006 (Figure 1, p.8). The objective of this monitoring was to provide baseline data on beluga whale use of the project area prior to improvements to the highway planned by the Alaska Department of Transportation and Public Facilities. Data collected during the period provided information on beluga whale presence and behavior from mile 75 to mile 90 and from mile 99 to 115 of the Seward Highway (Figure 2, p.9).

Cook Inlet beluga whales are considered a depleted stock under the marine mammal protection act (MMPA). Marine mammals are protected under the MMPA which prohibits the “taking” of marine mammals. Taking is defined in the MMPA as “to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal.” The 1994 amendments to the MMPA distinguished two types of harassment, Level A and Level B. Level A harassment is “any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild.” Level B harassment is “any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.”

Although beluga whales can be found in the Upper Cook Inlet through much of the year, aerial surveys and satellite tracking by the National Marine Fisheries Service (NMFS) and shore-based monitoring by LGL indicate they are most prevalent in Turnagain Arm during the late summer and fall. At this time of year, beluga whales routinely move into the upper ends of Turnagain and Knik Arms around the high tide, and are found in the lower parts of the arms around the low tide. In Turnagain Arm, whales can be found regularly traversing the near shore channels along the highway and foraging at the mouths of rivers and streams around the high tide. Shore-based monitoring for

beluga whales in Turnagain Arm, adjacent to proposed road improvements was focused seasonally, peaking in the fall, and tidally, especially around high tide. The relatively easy access to suitable observation stations along the highway facilitated effective monitoring of beluga whales in the project area.

Study Area

All monitoring sessions were conducted along the Seward Highway southeast of Anchorage, Alaska, with a focus on the uppermost portion of Turnagain Arm (Figure 1). Monitoring sessions were conducted at five sites west of Bird Point, four sites between Bird Point and Girdwood, and five sites between Girdwood and the Placer River (Figure 2, p. 9). Sites were chosen based on accessibility and vantage.

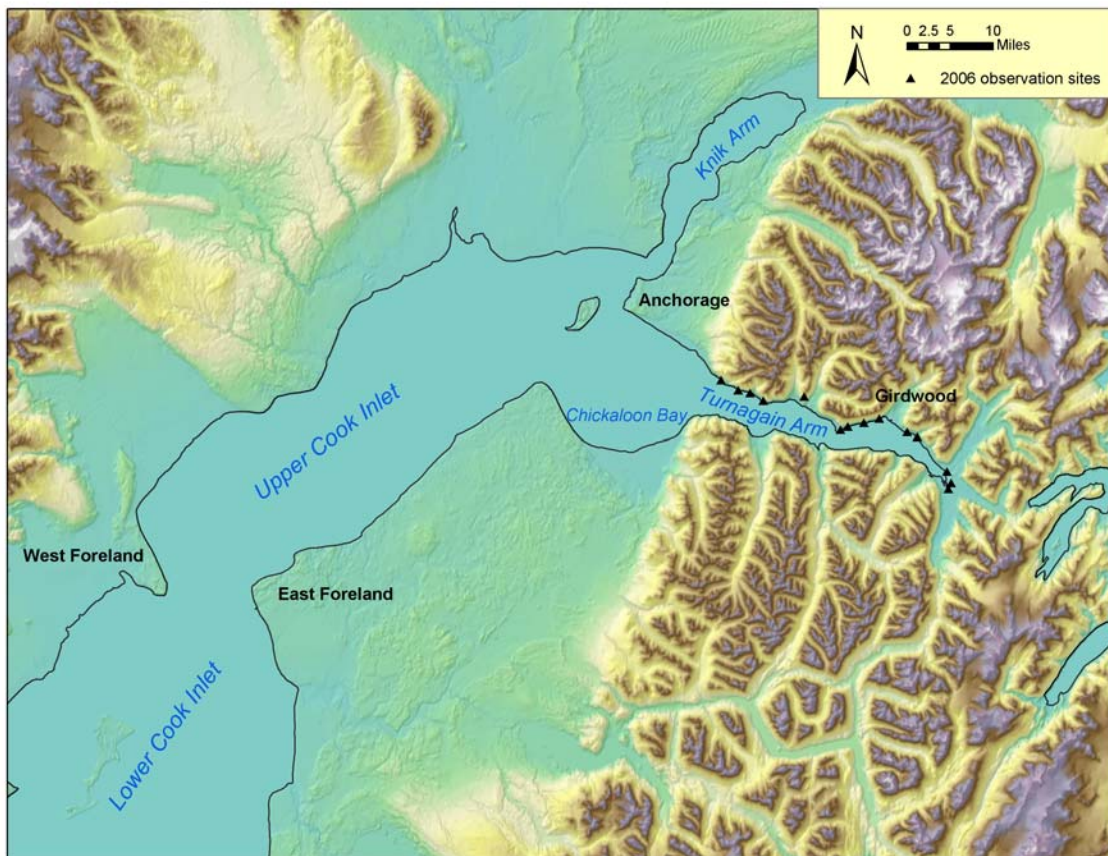


Figure 1. Small scale map of Cook Inlet. This study was conducted in Turnagain Arm. Black triangles represent observation sites.

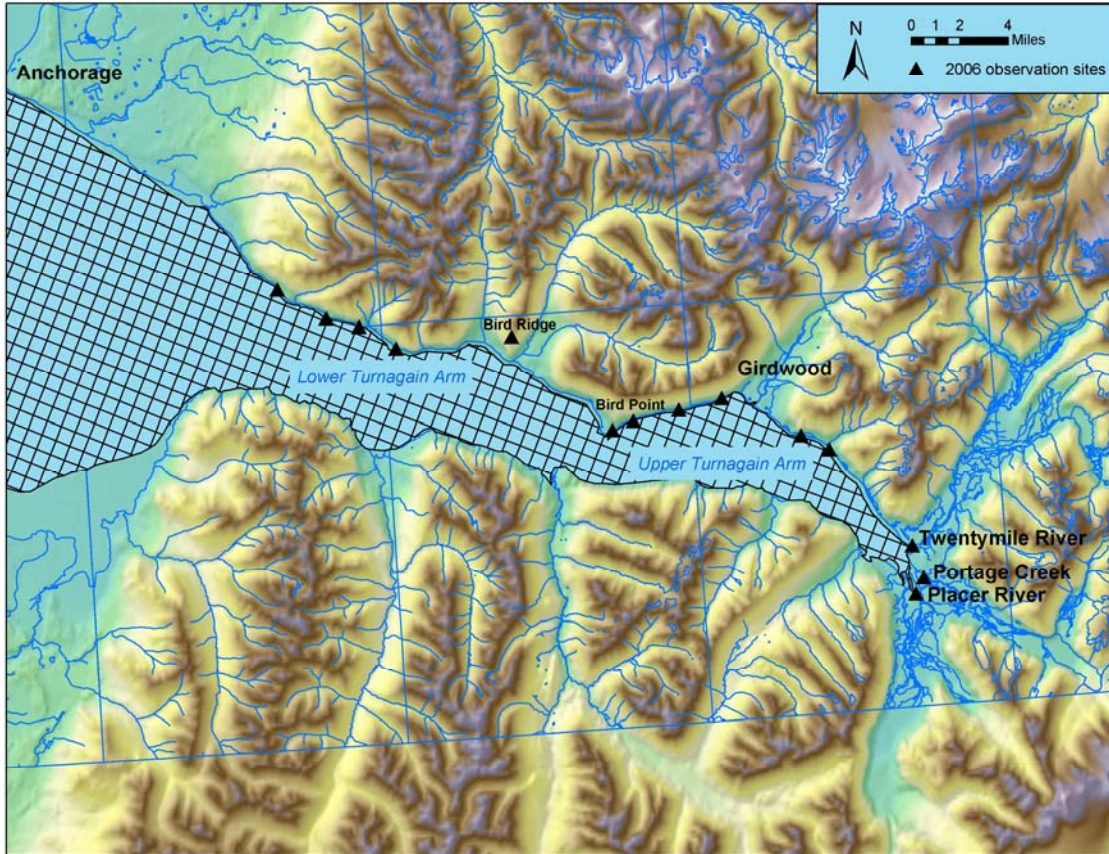


Figure 2. This 0.6 mi x 0.6 mi grid cell map of Turnagain Arm was used to document the locations of beluga whale groups sighted during May-November 2006. Black triangles indicate the locations of monitoring stations along the Seward Highway.

Objectives

The monitoring program had four primary objectives:

1. Estimate the frequency at which beluga whales are present in the project area around high tide by month.
2. Examine the proximity of whales to the Seward Highway and whale distribution in Turnagain Arm with respect to the planned highway improvements.
3. Document the timing of beluga whale passage between Lower and Upper Turnagain Arm with respect to high tide.
4. Characterize habitat use and behavior of beluga whales in the project area.

A secondary objective was to identify and record the locations of other marine mammals observed in the project area.

Methods

Monitoring Effort

Monitoring took place over a 7 month period, from May through November 2006. In total, 136 monitoring sessions were completed, with a total of 748 hours of monitoring effort logged. Mean monitoring session length was 5.5 hours (s.e. 0.08 hours; s.e. refers to standard error of the mean).

Upper Turnagain Arm

In total, 102 days (540 hours) of monitoring effort were completed in Upper Turnagain Arm. During these monitoring shifts, a single observer conducted 5-15 minute monitoring sessions, using binoculars and systematic naked eye scans, at 9 stations along the Seward Highway from Bird Point to the Placer River (Figure 2, p.9).

Lower Turnagain Arm

In total, 34 days (208 hours) of monitoring effort were completed in Lower Turnagain Arm. During these monitoring shifts, a single observer conducted 5-15 minute monitoring sessions, using binoculars and systematic naked eye scans, at 4 stations along the Seward Highway between Potter Creek and Indian Valley (Figure 2, p.9). The remainder of the 6 hour monitoring period was spent monitoring from an elevated station on Bird Ridge, providing a wider view of Lower Turnagain Arm including the near shore from Bird Point to Windy Corner and the mid-channel (Figure 2, p.9).

Data Collected

Data collected at each monitoring station included start and end time, environmental conditions (including Beaufort sea state; Table 1), beluga whale sighting information (group number, time of sighting, location on a 0.6 mi x 0.6 mi grid cell map, number and age class of whales, behavioral state, heading relative to Turnagain Arm, swimming formation, and inter-individual distance). All other marine mammal sightings were similarly noted. A digital single-lens reflex (SLR) camera was used to provide

photographic confirmation of beluga whale and other marine mammal sightings. A standardized datasheet was used to record this information (Appendix 1, p.42).

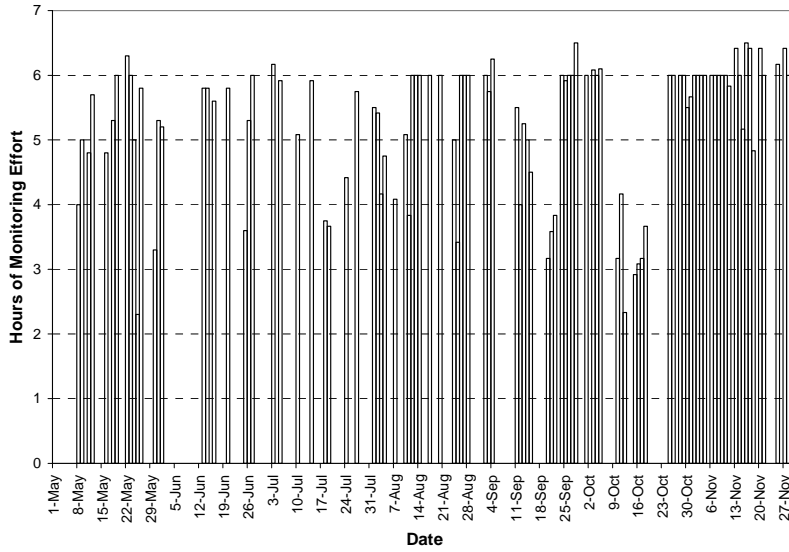
Table 1. The Beaufort Wind Force Scale used to categorize sea state.

Beaufort Value	Windspeed (mi/hr)	Sea Condition	Over Water	Over Land
0	0-1	Calm	Sea like a mirror	Calm; smoke rises vertical.
1	1-3	Light air	Ripples but without foam crests	Direction of wind shown by smoke drift, but not by wind vanes.
2	4-7	Light Breeze	Small wavelets. Crests do not break	Wind felt on face; leaves rustle; ordinary vanes moved by wind.
3	8-10	Gentle Breeze	Large wavelets. Perhaps scattered white horses	Leaves and small twigs in constant motion; wind extends light flag.
4	11-12	Moderate Breeze	Small waves. Fairly frequent white horses.	Raises dust and loose paper; small branches are moved.
5	13-17	Fresh Breeze	Moderate waves, many white horses	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	18-24	Strong Breeze	Large waves begin to form; white foam crests, probably spray	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
7	25-31	Near Gale	Sea heaps up and white foam blown in streaks along the direction of the wind	Whole trees in motion; inconvenience felt when walking against the wind.
8	32-40	Gale	Moderately high waves, crests begin to break into spindrift	Breaks twigs off trees; generally impedes progress.
9	41-50	Severe Gale	High waves. Dense foam along the direction of the wind. Crests of waves begin to roll over. Spray may affect visibility	Slight structural damage occurs (chimney-pots and slates removed).
10	51-63	Storm	Very high waves with long overhanging crests. The surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock like. Visibility affected	Seldom experienced inland; trees uprooted; considerable structural damage occurs.

Monitoring by Month

Monitoring of Upper Turnagain Arm from Bird Point to the Placer River was conducted on 14 days in May, 8 days in June, 8 days in July, 17 days in August, 16 days in September, 17 days in October, and 22 days in November (Figure 3a). Monitoring of Lower Turnagain Arm between Potter Creek and Bird Point was conducted on 5 days in September, 16 days in October, and 13 days in November (Figure 3b).

a. Upper Turnagain Arm



b. Lower Turnagain Arm

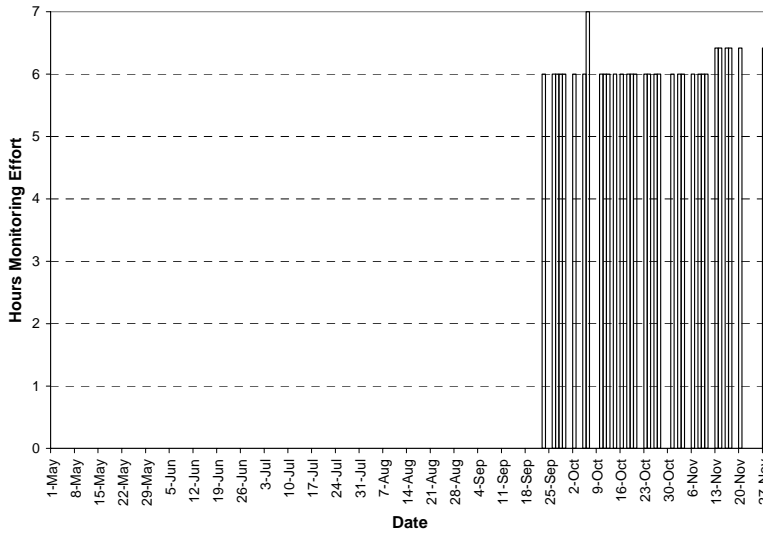
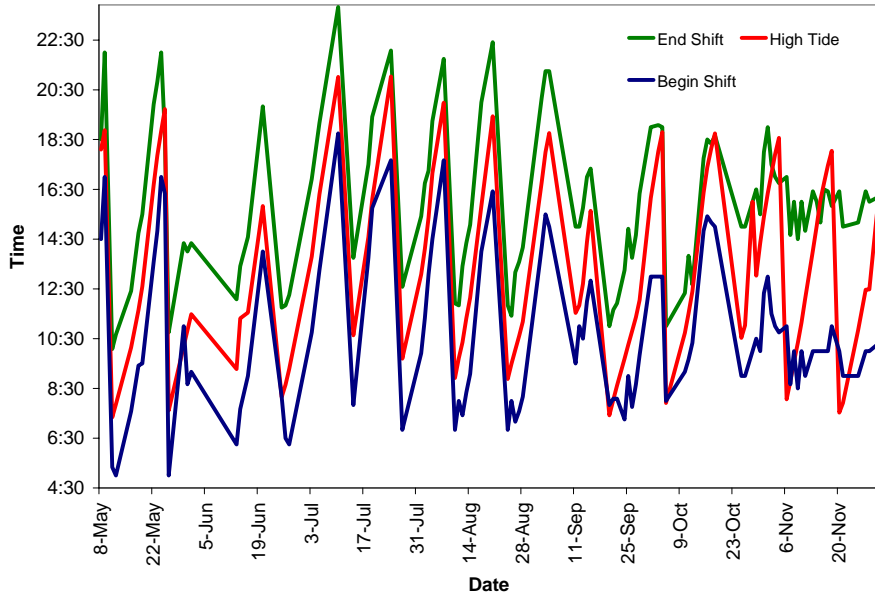


Figure 3. Monitoring effort is shown by date for (a) Upper and (b) Lower Turnagain Arm.

Monitoring by Tidal Stage

Monitoring shifts along Upper Turnagain Arm were scheduled around the high tide at Sunrise/Bird Point (Figure 4a). Monitoring shifts along Lower Turnagain Arm and from Bird Ridge were scheduled around the mid-to-high tide (Figure 4b).

a. Upper Turnagain Arm (high tide effort)



b. Lower Turnagain Arm (mid-high tide effort)

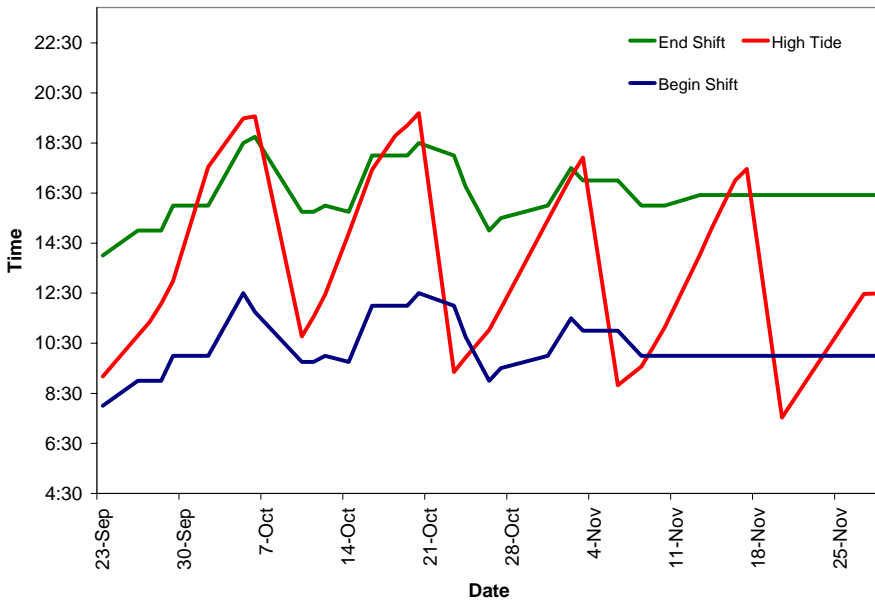
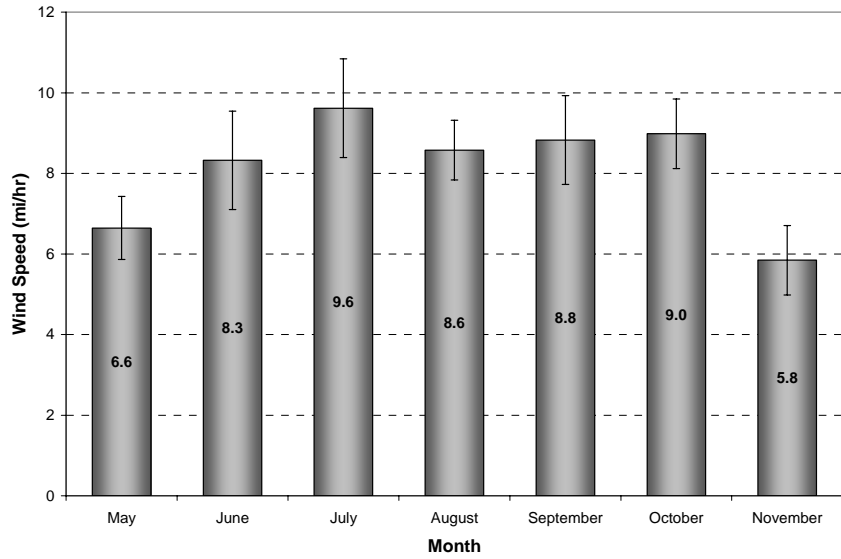


Figure 4. Lines indicate the start and end times for monitoring shifts along (a) Upper and (b) Lower Turnagain Arm by date relative to the time of high tide.

Environmental Conditions

Mean wind speed (Kruskal-Wallis, $H = 15.402$, $P < 0.02$) and Beaufort sea state (Chi-square = 46.630, $P < 0.001$) varied by month, with higher winds and sea states noted during June through October than during May and November (Figure 5).

a. Mean Wind Speed (with error bars) by month (Turnagain Arm)



b. Variation in Beaufort Sea State by month (Turnagain Arm)

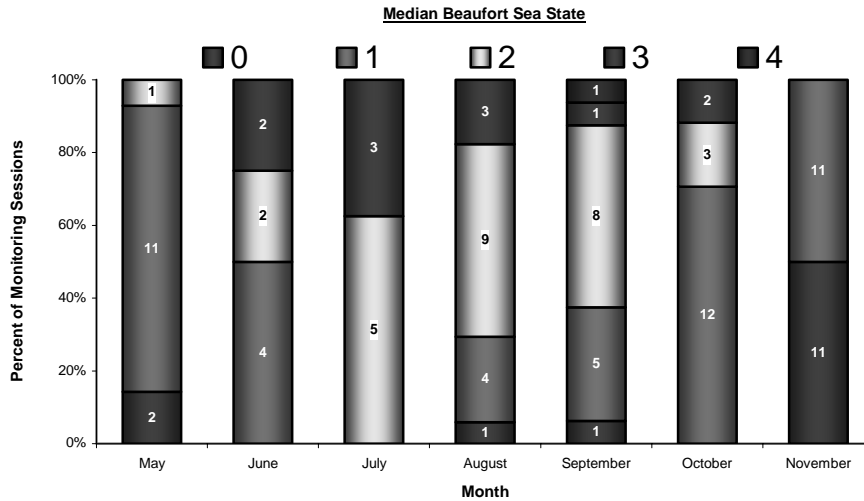


Figure 5. (a) Mean wind speed (error bars indicate how widely the data vary from the mean) and (b) median Beaufort sea state (numbers within cells represent the number of monitoring sessions) are compared by month for highway surveys of Turnagain Arm.

Mean estimated maximum distance of visibility was 2 miles and did not vary significantly between months (Kruskal-Wallis, $H = 11.960$, N.S.). Within the visible range, sighting conditions were generally ranked good to excellent on most days, and were rated best in the late spring/early summer and worst in the autumn (Figure 6). Median environmental condition scores were good to excellent on all days in May and June, and fair to excellent on all days in July, August, and October. Median environmental condition scores of poor or unacceptable were only noted on 5 days (2 in September and 3 in November, Figure 6). Precipitation was noted on 21% of days during which observations were conducted in May, 75% of days in June, 25% of days in July, 76% of days in August, 69% of days in September, 76% of days in October, and 18% of days in November.

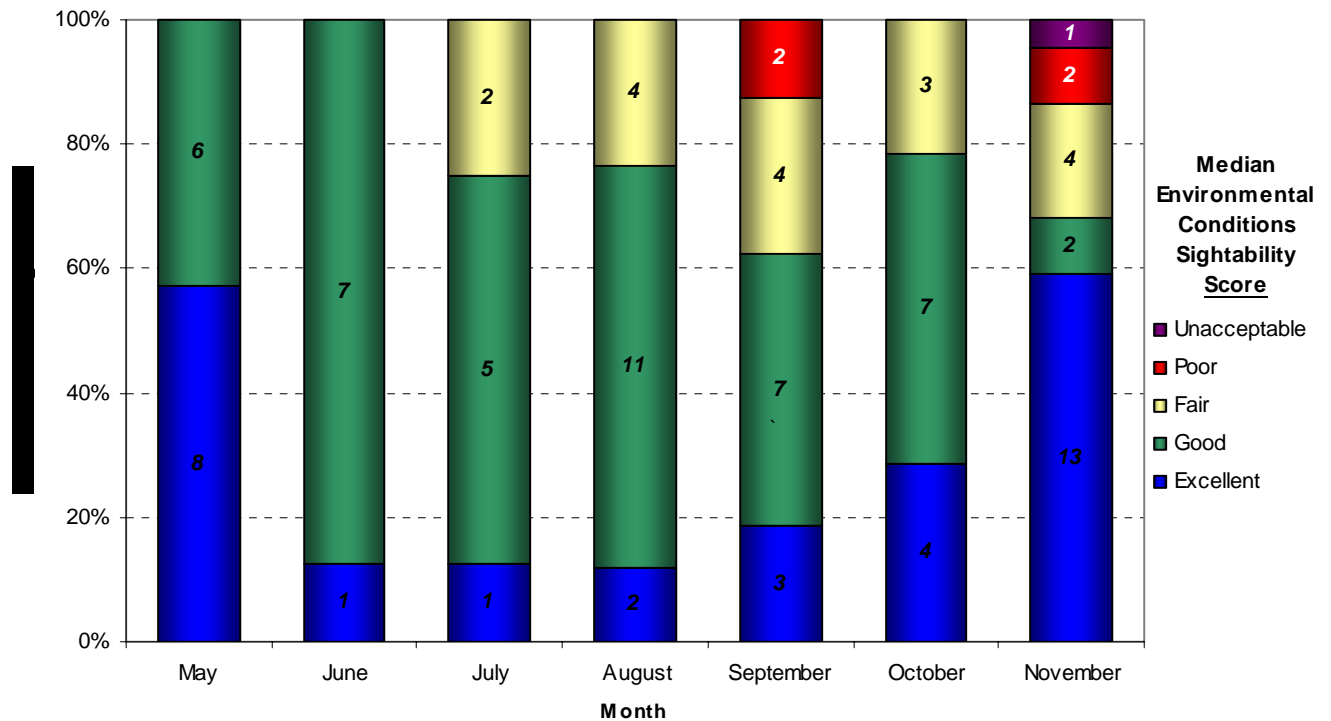


Figure 6. The distribution of environmental condition scores (sighting conditions ranked from excellent to unacceptable) is shown by month for monitoring sessions of Upper Turnagain Arm conducted along the Seward Highway from May-November 2006. Numbers within cells represent number of monitoring sessions.

Environmental Conditions Detailed by Month (Figure 6, p.15)

Sighting conditions were ranked from good to excellent on all days in May. Mean estimated maximum sighting distance was 2 miles. Mean wind speed was 7 miles per hour, with daily mean values ranging from 2-10 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 1. Precipitation (rain) was noted on 11 of 14 monitoring shifts (79%).

June sighting conditions were ranked from excellent to good. Mean estimated maximum sighting distance was 2 miles. Mean wind speed was 8 miles per hour, with daily mean values ranging from 6-14 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 2. Precipitation was noted on 6 of 8 monitoring shifts (75%).

July sighting conditions were ranked from excellent to fair. Median estimated maximum sighting distance was 2 miles. Median wind speed was 8 miles per hour, with daily mean values ranging from 7-16 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 2. Precipitation was noted on 2 of 8 monitoring shifts (25%).

August sighting conditions were ranked from excellent to fair. Median estimated maximum sighting distance was 1 mile. Median wind speed was 8 miles per hour, with daily mean values ranging from 6-14 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 2. Precipitation was noted on 13 of 17 monitoring shifts (76%).

September sighting conditions in Upper Turnagain Arm were ranked from excellent to fair on most days, but poor on 2 days. Median estimated maximum sighting distance was 2 miles. Median wind speed was 7 miles per hour, with daily mean values ranging from 6-18 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 2. Precipitation was noted on 11 of 16 monitoring shifts (69%). Sighting conditions were consistently ranked excellent during monitoring of Mid-to-Lower Turnagain Arm from Bird Ridge in September. Estimated maximum sighting distance was 2.5 miles. Median wind speed was 6 miles per hour, with daily mean values ranging from

6-9 miles per hour. Seas were generally calm, with a Beaufort Sea State of one. Precipitation was noted on 2 of 5 monitoring shifts (40%).

October sighting conditions in Upper Turnagain Arm were ranked from excellent to fair on all days. Mean estimated maximum sighting distance was 2 miles. Mean wind speed was 9 miles per hour, with daily mean values ranging from 6-17 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 1. Precipitation was noted on 13 of 17 monitoring shifts (76%). Sighting conditions were ranked excellent or good during monitoring of Mid-to-Lower Turnagain Arm in October. Mean estimated maximum sighting distance was 2.5 miles. Mean wind speed was 7 miles per hour, with daily mean values ranging from 6-12 miles per hour. Seas were generally calm, with a mean Beaufort Sea State of 1. Precipitation was noted on 7 of 16 monitoring shifts (44%).

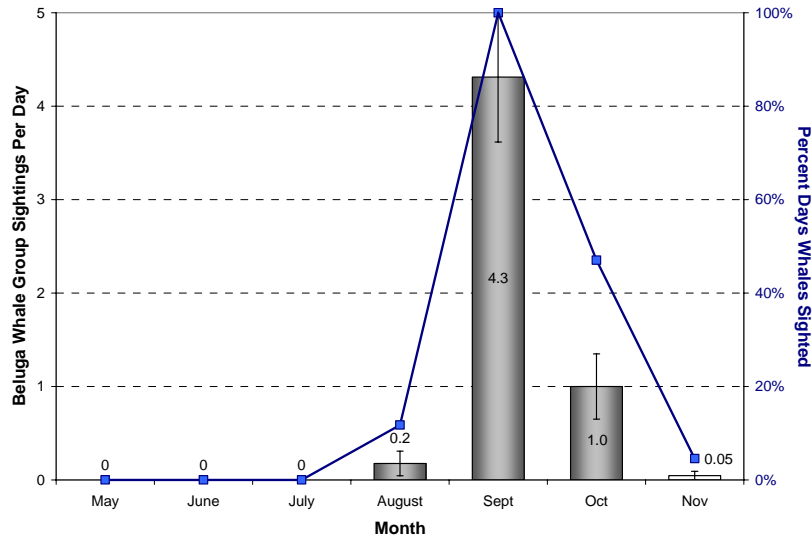
November sighting conditions in Upper Turnagain Arm were ranked from excellent to unacceptable, but were rated fair or better on 19 of 22 days. Mean estimated maximum sighting distance during surveys of Upper Turnagain Arm was 2.5 miles. Mean wind speed was 6 miles per hour, with daily mean values ranging from 0-15 miles per hour. Seas were generally calm, with a median Beaufort Sea State of 0. Precipitation was noted on 4 of 22 monitoring shifts (18%). Sighting conditions were ranked excellent or good during monitoring of Mid-to-Lower Turnagain Arm in November. Mean estimated maximum sighting distance was 2.5 miles on all days. Mean wind speed was 7 miles per hour, with daily mean values ranging from 6-16 miles per hour. Seas were generally calm, with a mean Beaufort Sea State of 0. Precipitation was noted on just 1 of 13 monitoring shifts (8%).

Results

Sighting Rates

Beluga group sighting rates in Upper Turnagain Arm differed significantly among months (Kruskal-Wallis $H = 71.978$, $P < 0.001$), peaking in September (Figure 7a). Most sightings occurred between late August and early November (Figure 7b).

a. Mean number of beluga whale group sightings per day compared by month



b. Number of beluga whale group sightings per day

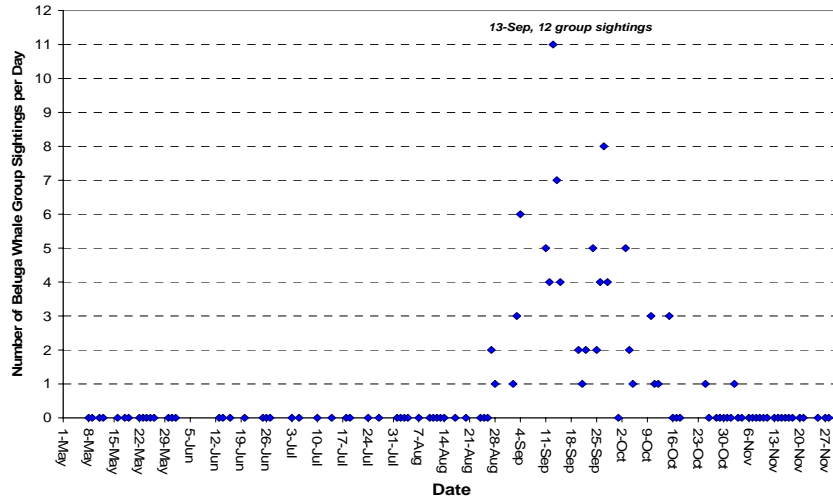
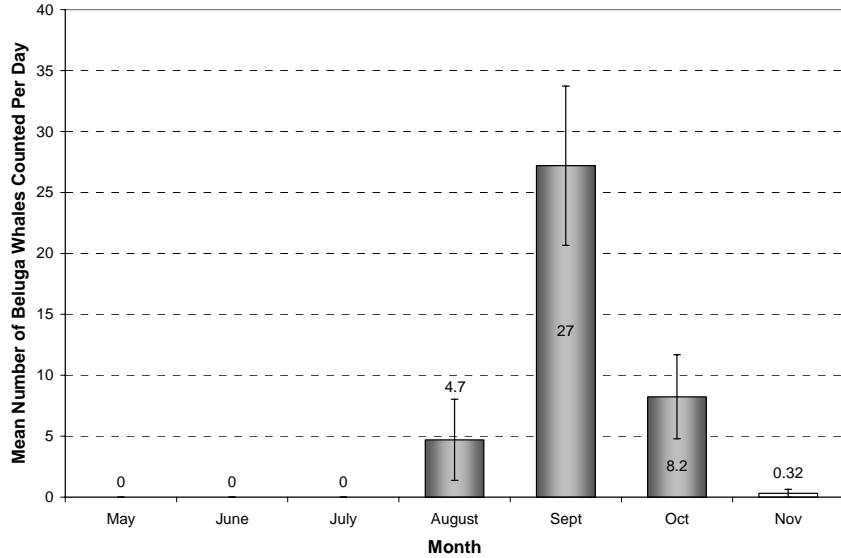


Figure 7. Sighting rates of beluga whale groups in Upper Turnagain Arm along the Seward Highway are compared (a) by month (mean values with standard errors) and (b) by day.

The total number of beluga whales counted per day in Upper Turnagain Arm varied significantly by month (Kruskal-Wallis H = 67.367, $P < 0.001$), with the highest number of whales per day counted in September (Figure 8a). The greatest number of whales per day was observed during late August through early November, with a maximum of 52 whales counted on September 27 (Figure 8b).

a. Mean number of beluga whales counted per day compared by month



b. Total number of beluga whales counted per day

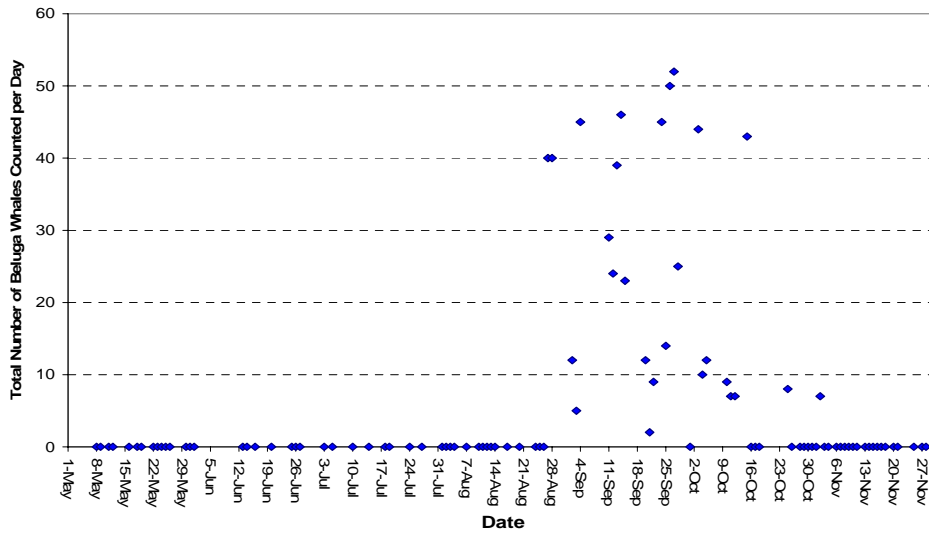


Figure 8. The number of beluga whales observed in Upper Turnagain Arm are compared (a) by month (mean values with standard errors) and (b) by day.

Group Size and Age Class Distribution

Table 2 shows the number of beluga whale group sightings and the total number of whales per day with sightings in Upper Turnagain Arm. Group size averaged 9 whales (s.e. = 1.5 whales) and did not vary significantly between months (Kruskal-Wallis H = 6.899, N.S.). Mean daily group size ranged from 2 to 40 whales. Beluga whale groups were sighted on just 2 days in Lower Turnagain Arm (a group of 10 whales on September 11 and a group of 2 whales on September 28).

Table 2. The number of beluga whale group sightings and total number of beluga whales by age class counted per day are shown by date for monitoring sessions conducted along the Seward Highway from Bird Point to Placer River during May through November, 2006. Days and months without sightings are not included in this table.

Date	Sightings	Adults	Subadults	Calves	Unknown	Total
27-Aug	2	29	10	1	0	40
28-Aug	1	30	4	6	0	40
2-Sep	1	3	2	2	5	12
3-Sep	3	2	2	1	0	5
4-Sep	6	20	10	5	10	45
11-Sep	5	15	7	3	4	29
12-Sep	4	13	6	3	2	24
13-Sep	12	10	6	0	23	39
14-Sep	7	26	15	5	0	46
15-Sep	4	19	2	2	0	23
20-Sep	2	8	1	1	2	12
21-Sep	1	1	0	1	0	2
22-Sep	2	6	1	1	1	9
24-Sep	5	18	4	0	23	45
25-Sep	2	11	2	0	1	14
26-Sep	4	37	10	3	0	50
27-Sep	8	40	4	2	6	52
28-Sep	4	17	6	2	0	25
3-Oct	5	29	6	9	0	44
4-Oct	2	9	0	1	0	10
5-Oct	1	4	0	0	8	12
10-Oct	3	4	1	1	3	9
11-Oct	1	3	4	0	0	7
12-Oct	1	7	0	0	0	7
15-Oct	3	35	2	1	5	43
25-Oct	1	1	6	1	0	8
2-Nov	1	6	0	0	1	7

Overall, whale groups were comprised of 58% adults, 17% subadults, 8% calves, and 17% whales of unknown age class. Subadults and calves were not noted in November but represented 20-30% of whales observed in other months (Figure 9).

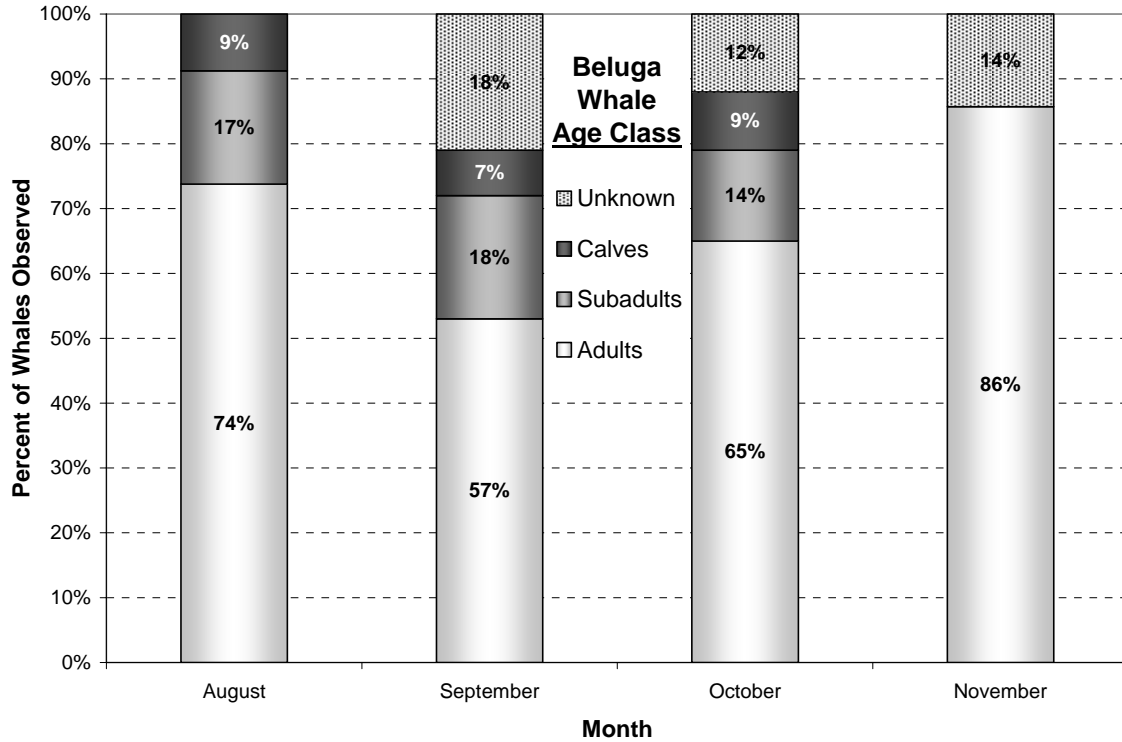
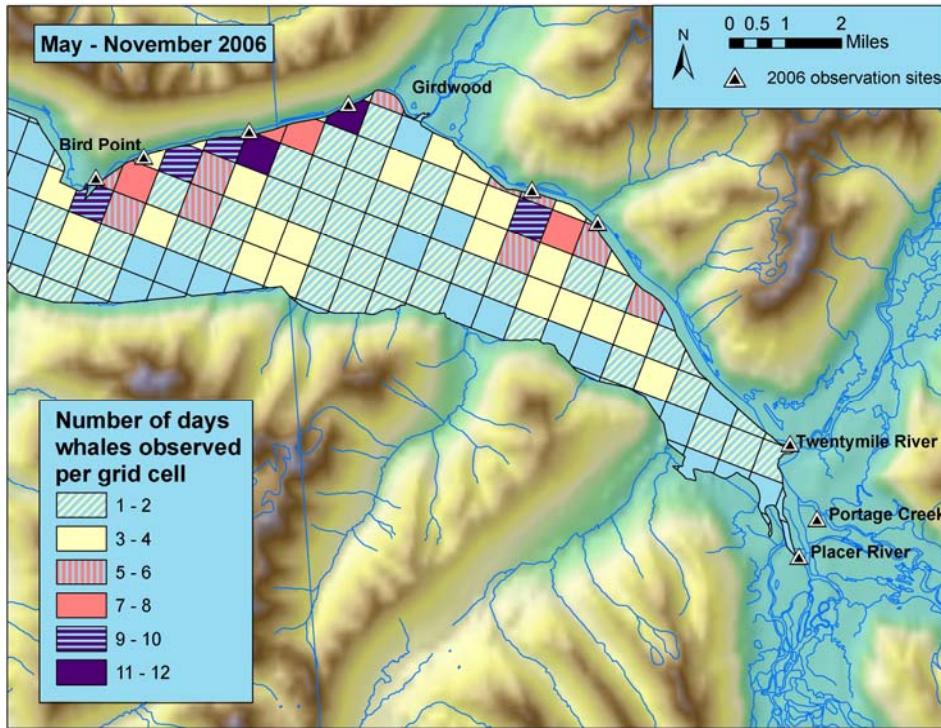


Figure 9. The estimated age class distribution from minimum field counts is compared by month for beluga whales sighted in Turnagain Arm during August through November 2006.

Beluga Whale Locations and Near Shore Habitat Use

Beluga whales were most often sighted immediately along the shoreline between Bird Point and just east of Girdwood (Figure 10, p.22). Whales were sighted on relatively few days in the Twentymile River/Portage Creek/Placer River area, and on just 2 days in Lower Turnagain Arm (Figure 10, p.22). The total number of group sightings per grid cell showed a similar pattern in beluga whale distribution (Figure 11, p.23). On average, less than 1 whale per day was observed in most grid cells, with a slightly higher average (1-3 whales per grid cell per day) along the coastline from Bird Point to Girdwood (Figure 12, p.24).

a. Upper Turnagain Arm



b. Lower Turnagain Arm

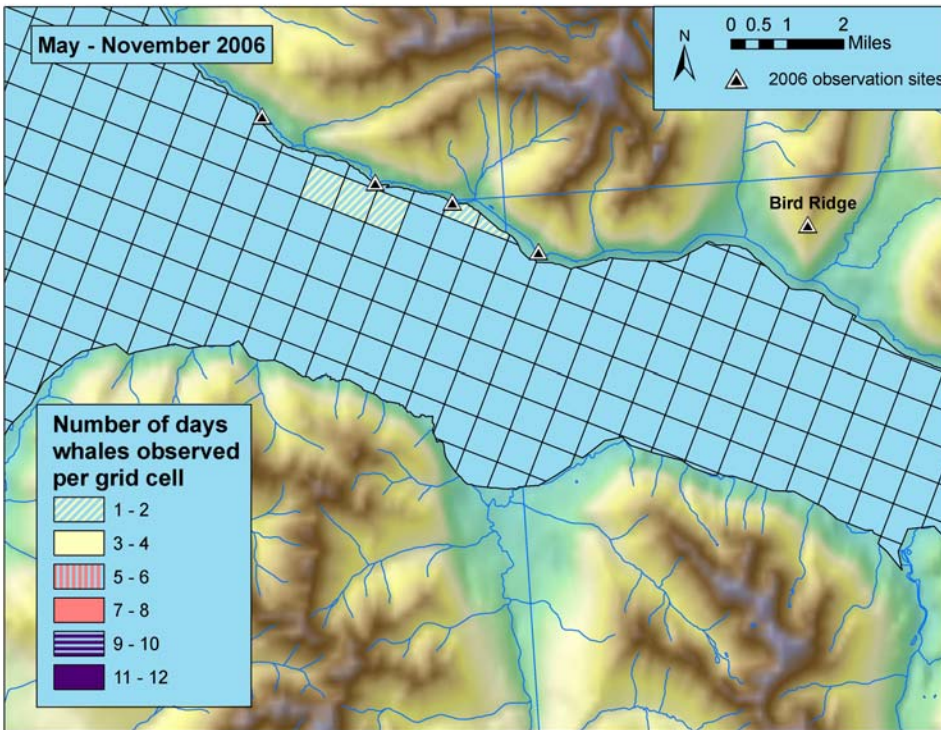
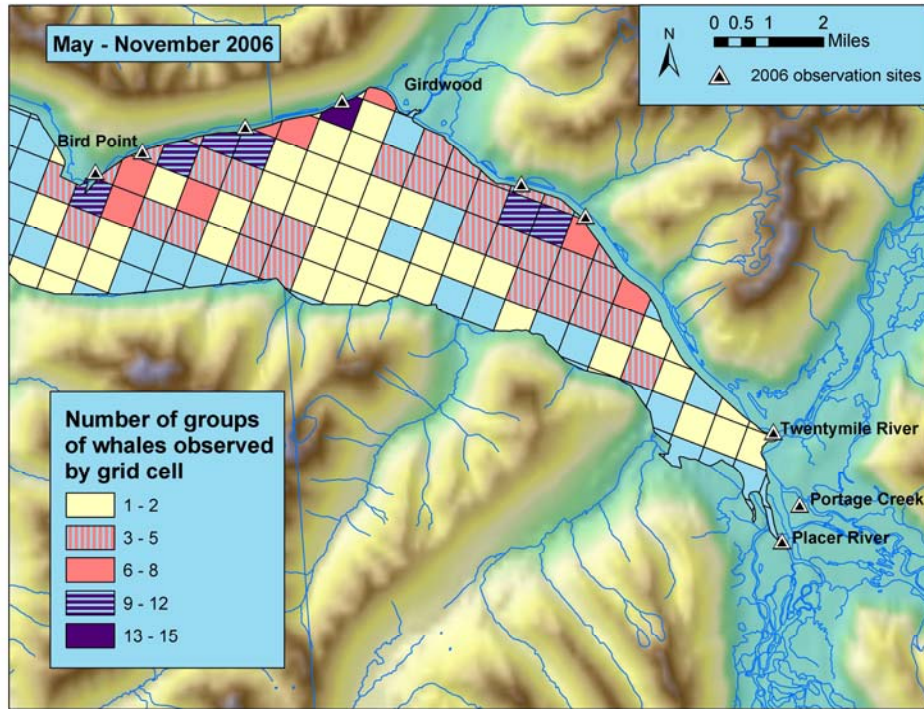


Figure 10. The number of days beluga whales were sighted between May and November 2006 is indicated by color for each 0.6 mi x 0.6 mi grid cell in (a) Upper Turnagain Arm (n = 102 days of monitoring effort) and (b) Lower Turnagain Arm (n = 34 days of monitoring effort). Triangles represent observation sites.

a. Upper Turnagain Arm



b. Lower Turnagain Arm

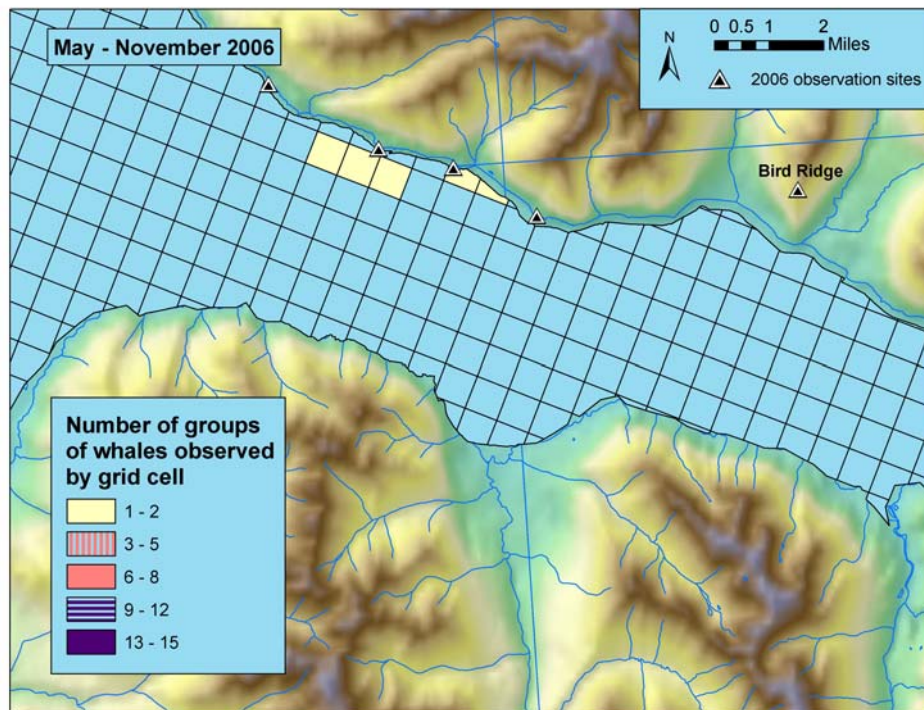
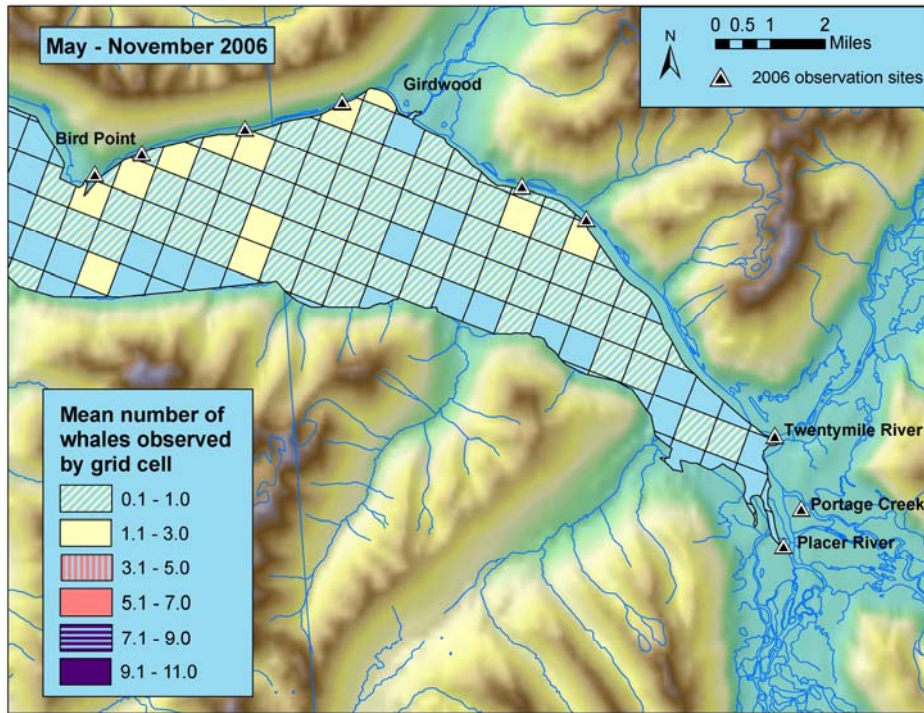


Figure 11. The total number of beluga whale group sightings per grid cell between May and November 2006 is indicated by color for each 0.6 mi x 0.6 mi grid in (a) Upper Turnagain Arm ($n = 102$ days of monitoring effort) and (b) Lower Turnagain Arm ($n = 34$ days of monitoring effort). Triangles represent observation sites.

a. Upper Turnagain Arm



b. Lower Turnagain Arm

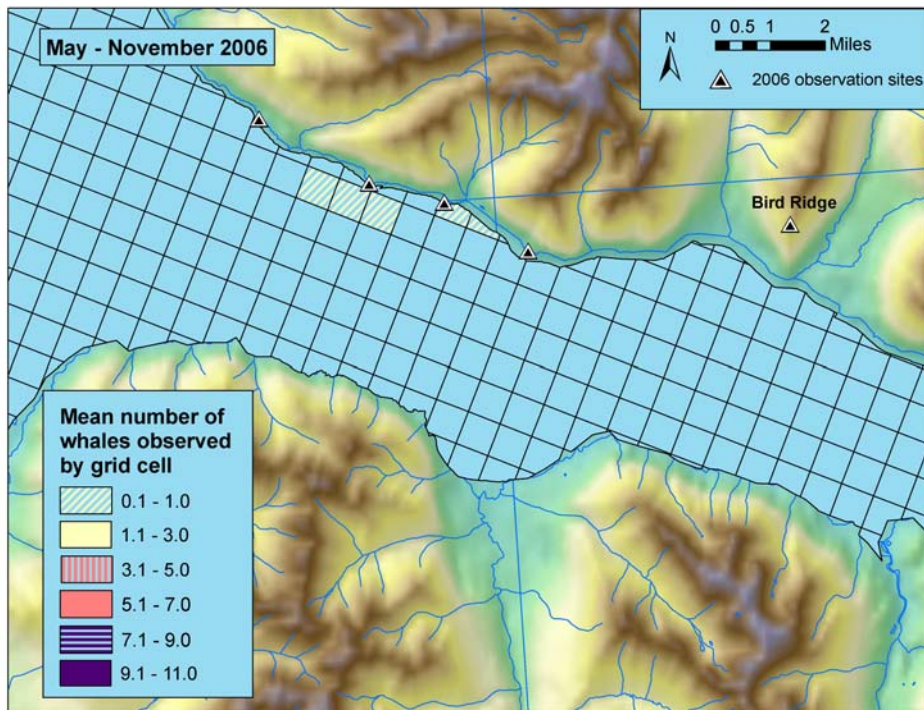
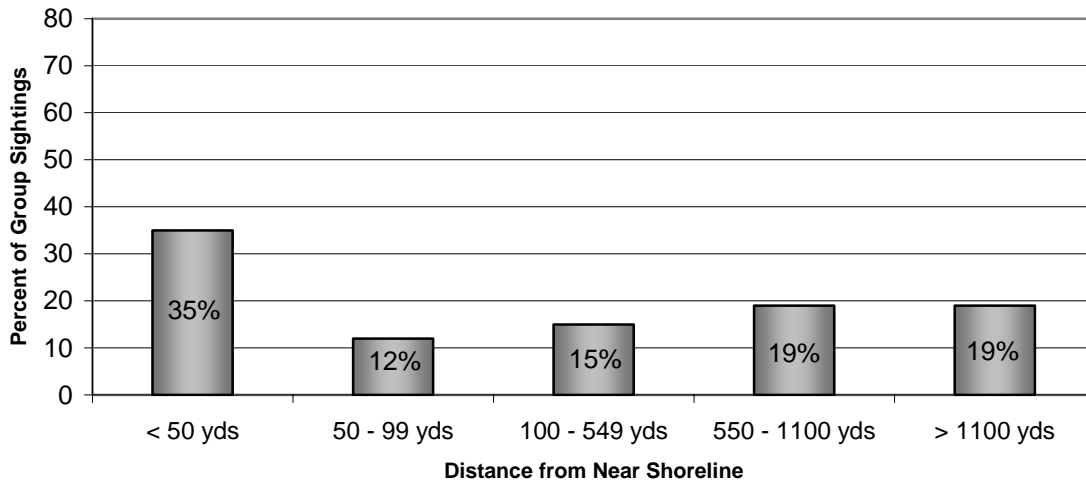


Figure 12. The mean number of beluga whales sighted per day between May and November 2006 in (a) Upper Turnagain Arm ($n = 102$ days of monitoring effort) and (b) Lower Turnagain Arm ($n = 34$ days of monitoring effort) is indicated by color code for each 0.6 mi x 0.6 mi grid cell location. Triangles represent observation sites.

A high proportion of sightings occurred near shore (Figures 10-12, p.22-p.24). This pattern was further substantiated by examination of the estimated distance of the whales to shore. When sighting rates were highest in September and October, most beluga whale groups were seen within 1056 yards of the shoreline. One third of groups in September and two thirds of groups in October were observed within 50 yards of the shoreline (Figure 13).

a. September 2006



b. October 2006

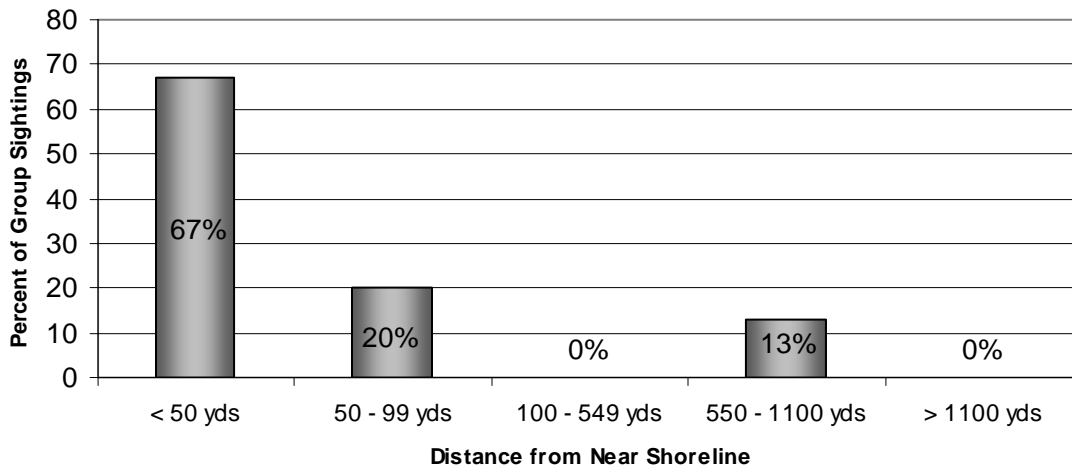


Figure 13. The proportion of beluga whale groups sighted at estimated distances of <50, 50-99, 100-549, 550-1,099 and >1,100 yards from the near shoreline are compared during (a) September and (b) October 2006.

Beluga Whale Group Activity

Traveling was the predominant activity for beluga whale groups during all months (Figure 14). Foraging (suspected feeding) and diving activity that might also indicate searching for prey were noted in September and October, coinciding with the highest beluga sighting rates.

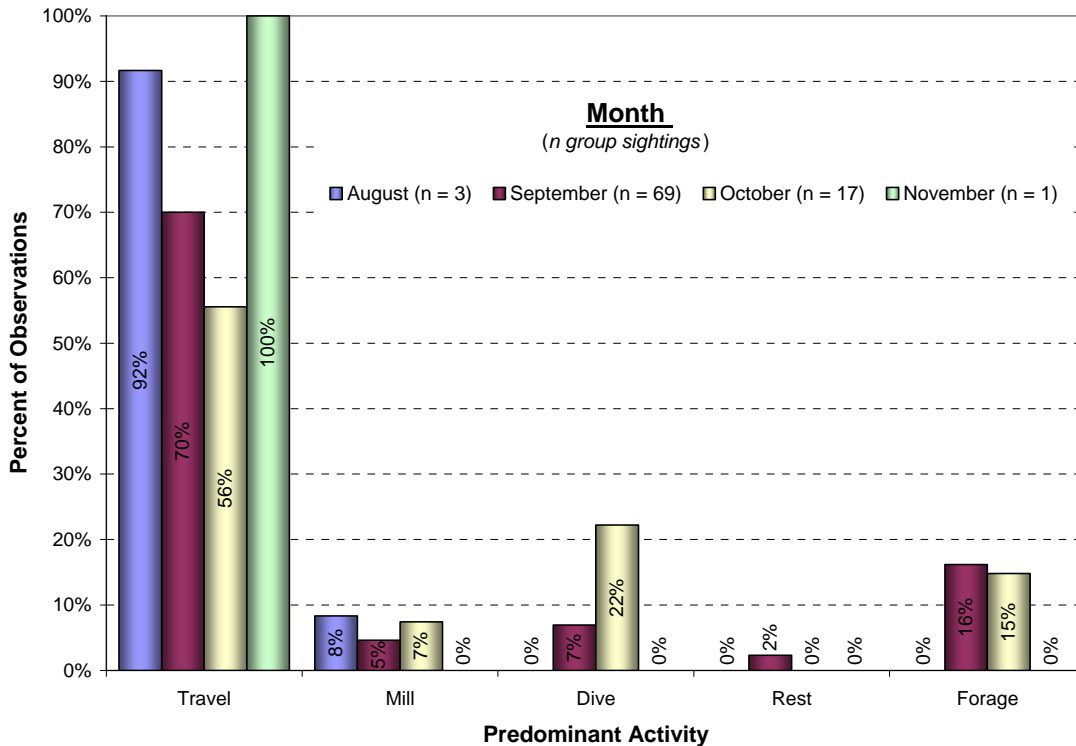


Figure 14. Predominant beluga whale group activities are compared by month.

Beluga whale groups were often spread out widely within Turnagain Arm. Mode inter-individual distance was estimated to be greater than 12 adult body lengths (about 165 feet) more than half the time (56%) and less than one body length (about 13 feet) just 3% of the time (1 to 3 body lengths 16%; 4 to 7 body lengths 16%; 8 to 12 body lengths 8%).

Much of the time (61%), beluga whale groups observed did not swim in a clear formation. When there was a clear swimming formation, it was most often linear (27%), with the group stretched further from front to back than from side to side. Whale group swimming formation was less often parallel (8%), circular (3%), or echelon (1%).

Beluga Whale Group Movements with the Tide

Beluga whale groups sighted before high tide (rising tide) were most often moving up (from west to east) Turnagain Arm, and groups sighted after high tide (falling tide) were most often moving down (from east to west) the arm (Figure 15). Whale groups tended to move offshore slightly more often on the falling tide than on the rising tide (9% versus 2%, Figure 15). On average, movements “against the tide” occurred within 0.6 hours (36 minutes) of the high tide, and may therefore have occurred when the tide was relatively slack (Figure 16, p.28). Movements “with the tide” were noted on average 1.5 hours before and 1.7 hours after the high tide (Figure 16, p.28). Whale group location also varied with the tide, with sightings of whales in Upper Turnagain Arm (i.e., east of Bird Point) occurring closer to high tide than those further down the arm (Figure 17, p.28).

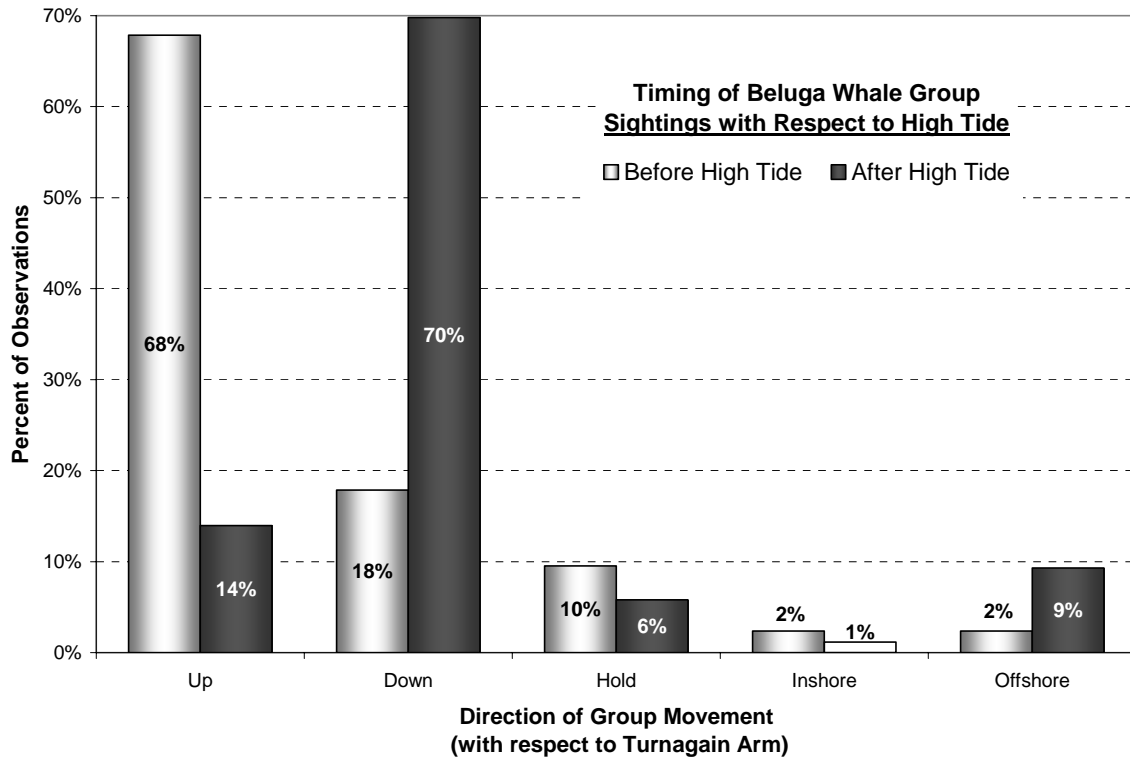


Figure 15. The heading of beluga whale groups is compared before and after high tide. Headings refer to the direction of group travel relative to Turnagain Arm (Up = heading up the arm, Down = heading down the arm, Hold = holding steady, Inshore = moving toward the near shoreline, Offshore = heading away from the near shoreline). Values represent the percent of beluga whale group observations.

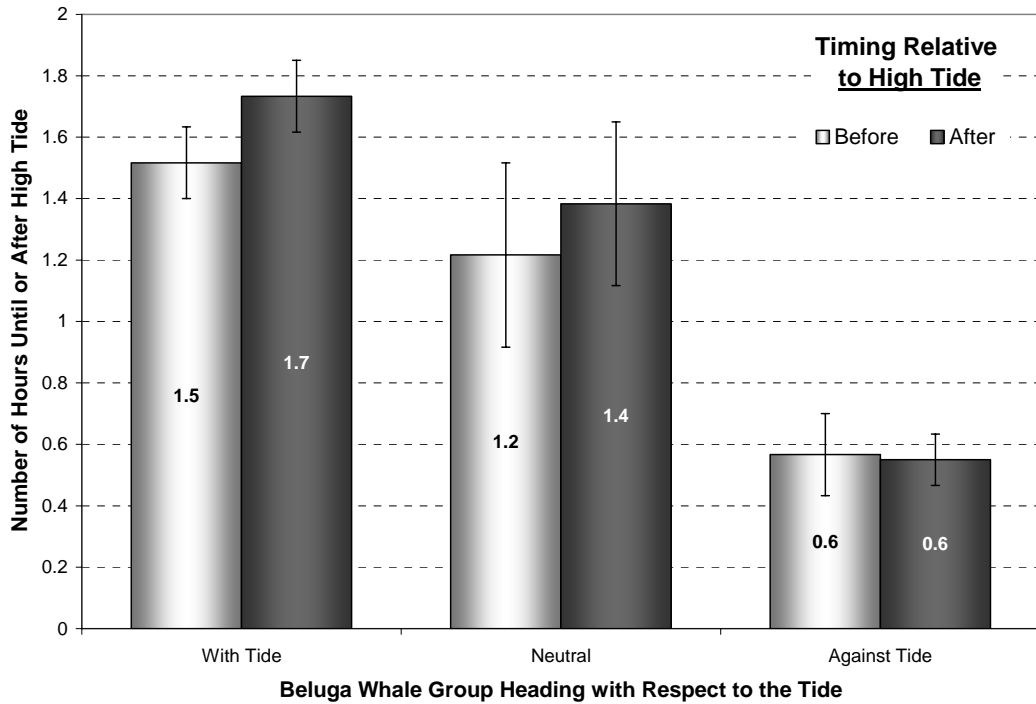


Figure 16. The time between beluga whale sightings and high tide is compared for groups moving with the tide, neutral (holding, moving inshore or moving offshore), and against the tide. Bars show mean values with standard errors.

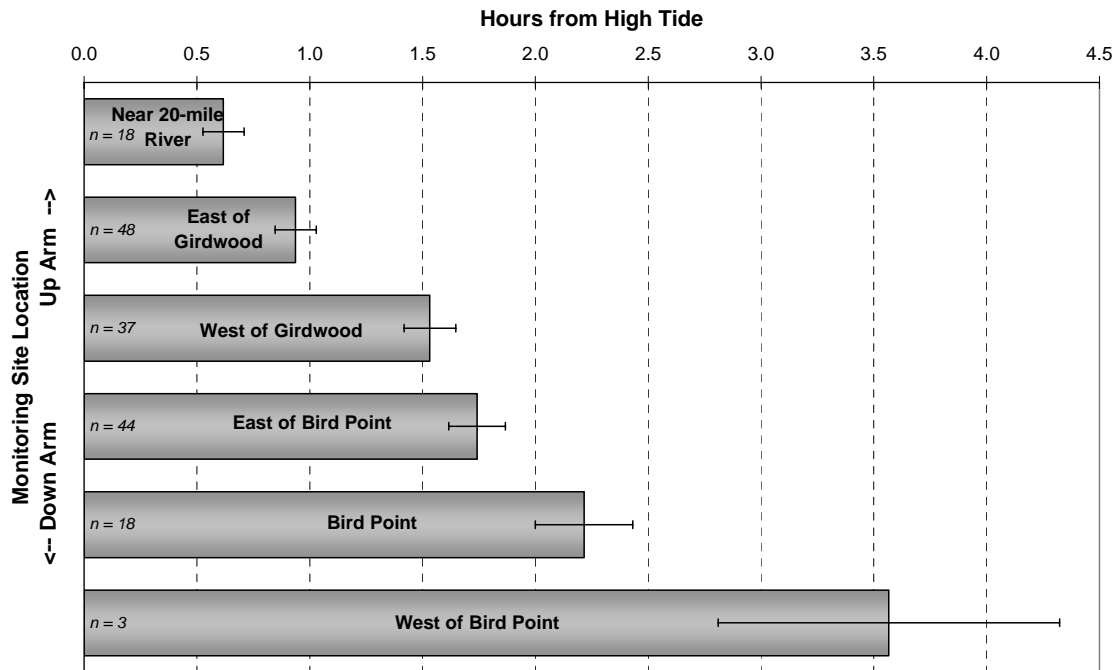


Figure 17. The mean number of hours (and standard error) from high tide of beluga whale sightings is shown by relative location of monitoring sites along Turnagain Arm. n=number of whale sightings from each site.

Details of Beluga Whale Sightings by Month

May – July 2006

Monitoring began May 8. Beluga whales were not observed during monitoring shifts in May, June, or July.

August 2006 (Figure 18, p.30)

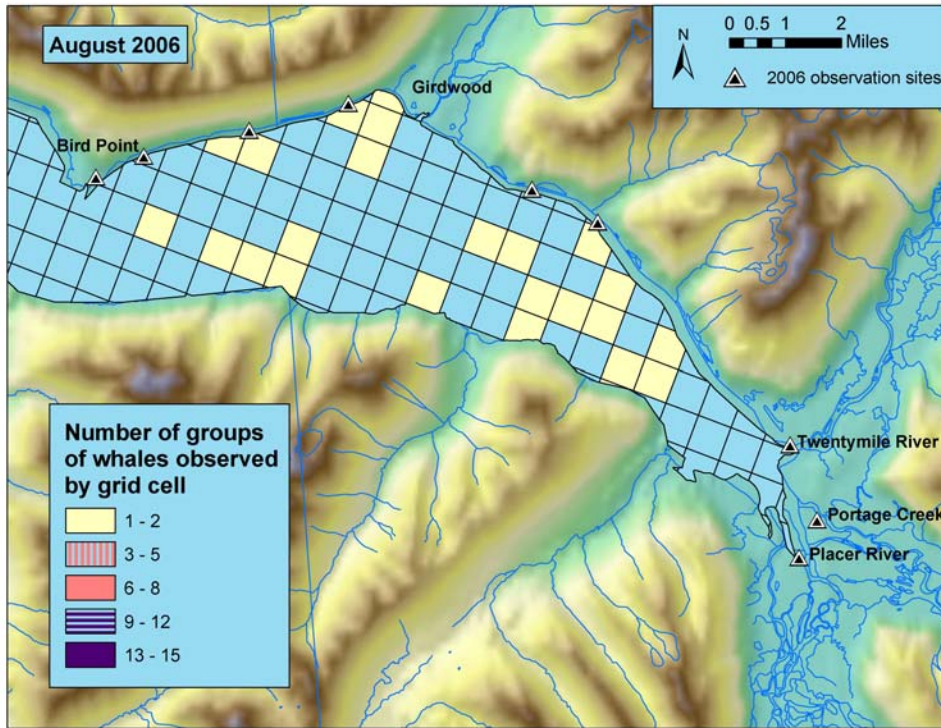
Beluga whales were observed in the project area on 2 days (12%) in August. On August 27, 1 group of 20 whales (including 4 sub-adults and 1 calf) and another group of 20 whales (including 6 sub-adults) were monitored for 6 hours as they moved between Bird Point and Peterson Creek. On August 28, a group of 40 whales (including at least 4 sub-adults and 6 calves) was monitored for 6 hours. All 3 whale groups were observed to travel up Turnagain Arm with the tide, then travel back down the Arm with the out-going tide.

September 2006 (Figure 19, p. 31; Figure 20, p. 32)

Beluga whales were observed in the project area on all days that Upper Turnagain Arm (from Bird Point to Placer River) was surveyed in September ($n = 16$ days). The number of beluga whale groups sighted per day ranged from 1 to 11, averaging 4, and the number of whales counted per day ranged from 2 to 52, averaging 27 (Table 2, p. 20). The average age class distribution of whales observed per day was 57% adults, 18% subadults, 7% calves, and 18% whales of unknown age class (Figure 9, p. 21).

Beluga whales were sighted in most parts of Upper Turnagain Arm during September, with sighting rates and number of whales counted generally highest along the near shore from Bird Point to Peterson Creek. Whales were sighted at the mouth of Twentymile River on 1 of 16 days (6%).

a. Number of Group Sightings



b. Average Number of Whale Sightings per Day

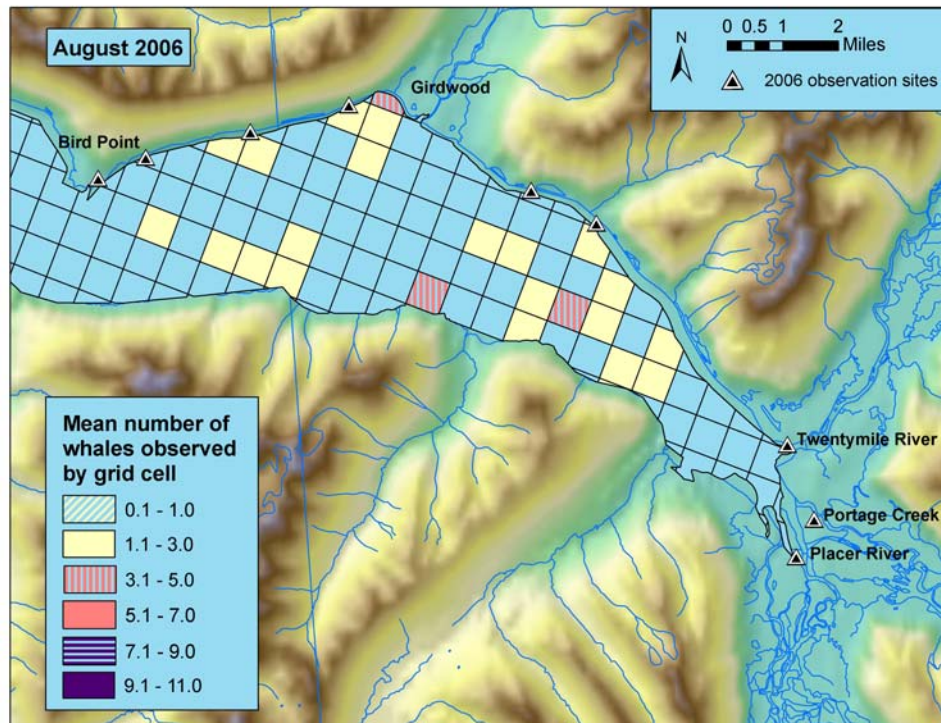
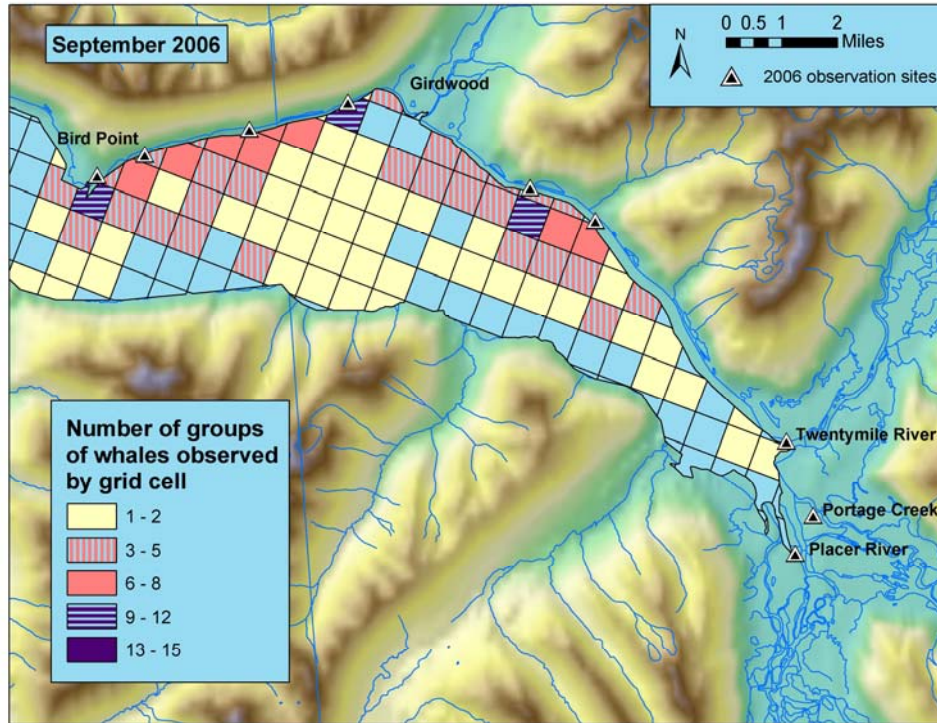


Figure 18. (a) The number of whale group sightings per grid cell and (b) the number of belugas sighted per day in August are indicated by color for each 0.6 mi x 0.6 mi grid.

a. Number of Group Sightings



b. Average Number of Whale Sightings per Day

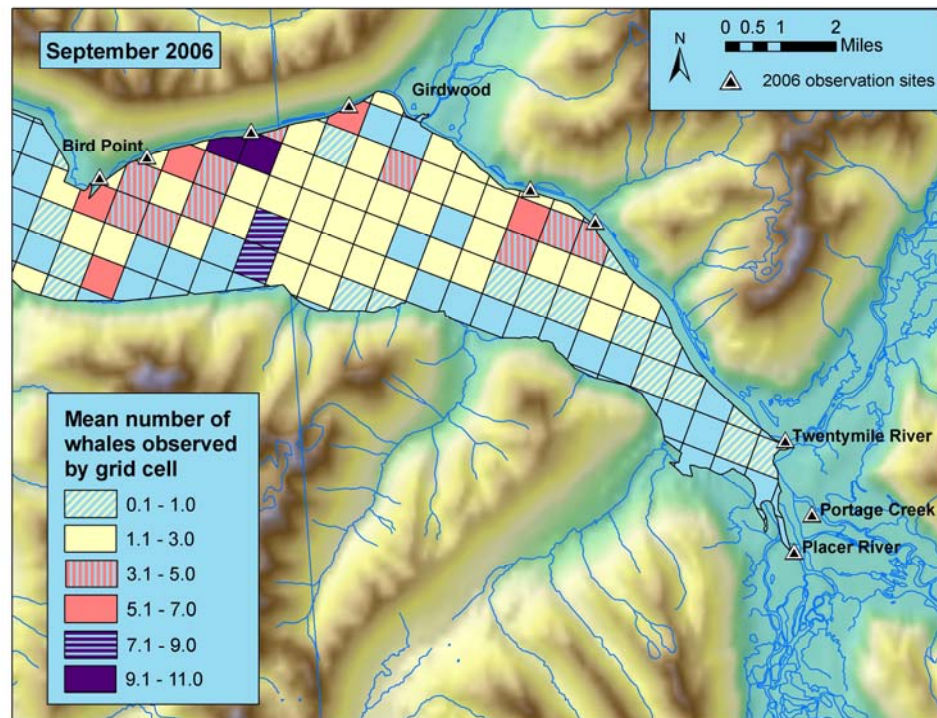
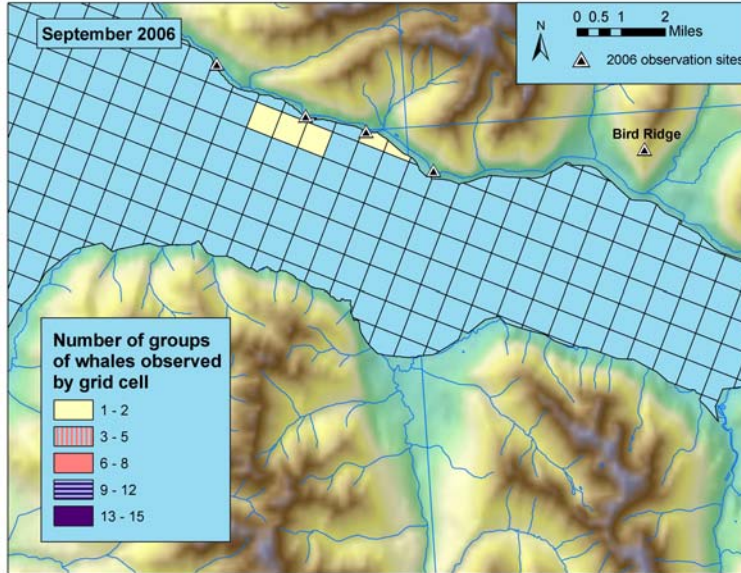


Figure 19. (a) The number of beluga whale group sightings per grid cell and (b) the number of beluga whales sighted per day in September are indicated by color code for each 0.6 mi x 0.6 mi grid in Upper Turnagain Arm.

Whales were sighted in Lower Turnagain Arm on 2 days in September. On September 11, a group of 5 adults, 3 subadults, and 3 calves was observed within 547 yards of shore off Beluga Point, swimming down Turnagain Arm on the falling tide 4.8 hours after high tide. On September 27, 2 adult whales were observed in a similar location, moving down Turnagain Arm on the falling tide 2.9 hours after the high tide.

a. Number of Group Sightings



b. Average Number of Whale Sightings per Day

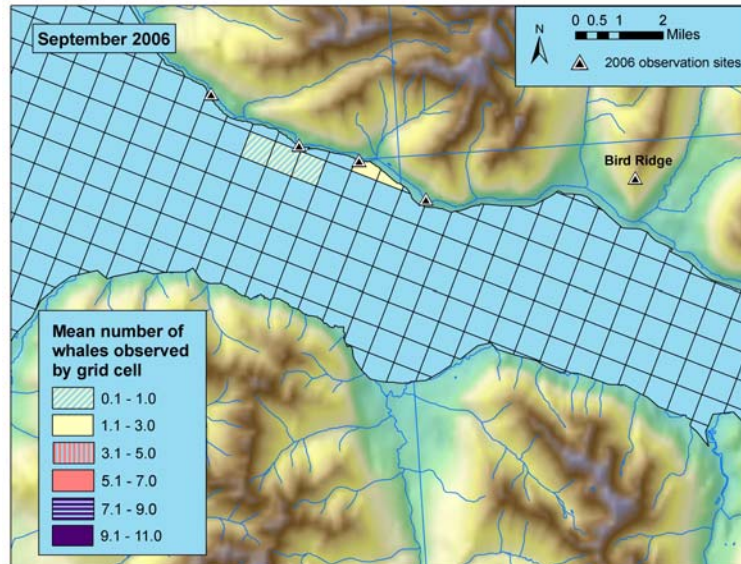


Figure 20. (a) The number of beluga whale group sightings per grid cell and (b) the number of beluga whales sighted per day in September are indicated by color code for each 0.6 mi x 0.6 mi grid in Lower Turnagain Arm.

The most commonly noted whale activity was traveling (67%), followed by foraging (20%), diving (7%), milling (4%), and resting (2%). Beluga whales generally were spread out over a large area, with mode inter-individual distance exceeding 13 body lengths during 63% of observations. The whales were spread 8-12 body lengths apart during 8%, 4-7 body lengths apart during 12%, 1-3 body lengths apart during 14%, and <1 body length apart during 3% of observations. Group swimming formation was most often linear (68% of the time) or parallel (20% of the time), with circular and echelon formations noted during only 7% and 5% of group encounters. Beluga whale groups were most often observed heading up (37%) or down (47%) Turnagain Arm, moving with the tide. Whales held their position steady during 4% of observations, moved offshore during 9% of observations and moved inshore during 2% of observations.

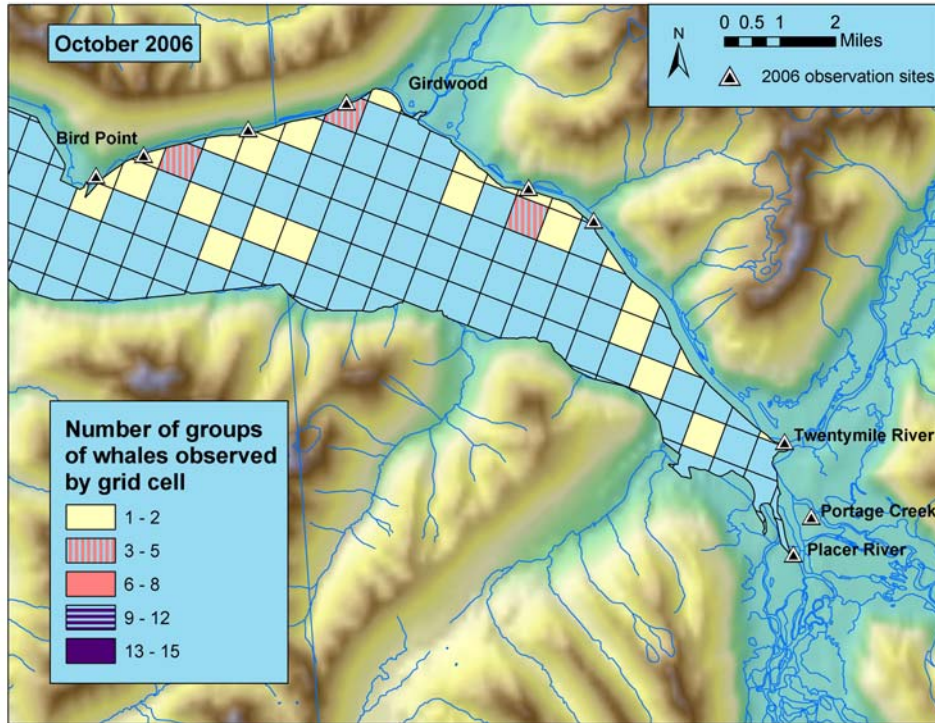
October 2006 (Figure 21, p.34)

Beluga whales were observed in Upper Turnagain Arm (from Bird Point to Placer River) on 8 of 17 days (47 %) in October. The number of beluga whale groups sighted per day ranged from 0 to 5, averaging 1, and the number of whales counted per day ranged from 0 to 44, averaging 9 (Table 2, p.20). The average age class distribution of whales observed per day was 65% adults, 14% subadults, 9% calves, and 12% whales of unknown age class (Figure 9, p. 21).

Beluga whales were sighted in most parts of Upper Turnagain Arm in October, with sighting rates and number of whales counted generally highest along the near shore from Bird Point to Peterson Creek. Whales were sighted as far up Turnagain Arm as the mouth of Twentymile River.

The most commonly noted whale activities were traveling (40%) and diving (40%), followed by milling (13%) and foraging (7%). Beluga whales were spread more than 13 body lengths apart from other whales in the group during 36% of observations, and were 8-12 body lengths apart during 14% of observations, 4-7 body lengths apart during 29% of observations, and 1-3 body lengths apart during 21% of observations.

a. Number of Group Sightings



b. Average Number of Whale Sightings per Day

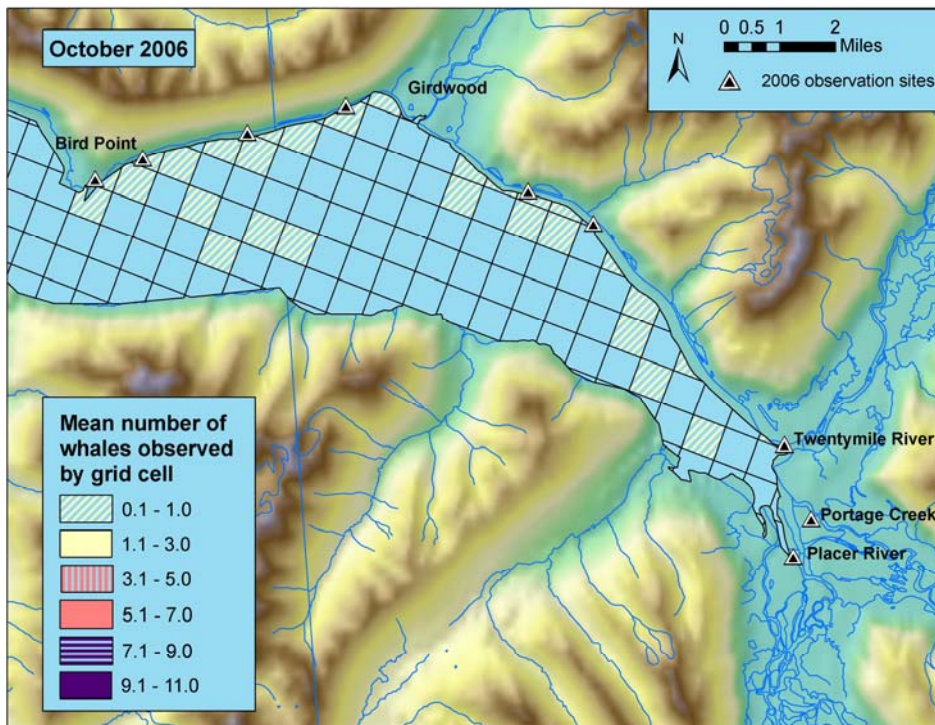


Figure 21. (a) The number of whale group sightings per grid cell and (b) the number of belugas sighted per day in October are indicated by color for each 0.6 mi x 0.6 mi grid.

Whale groups sighted in October had no swimming formation for 66% of observations, although parallel formations were observed 27% of the time, and linear formations were observed 7% of the time. Beluga whale groups were observed heading up (67%) or down (6%) Turnagain Arm, moving with the tide. Groups were observed to hold their position steady during 27% of observations.

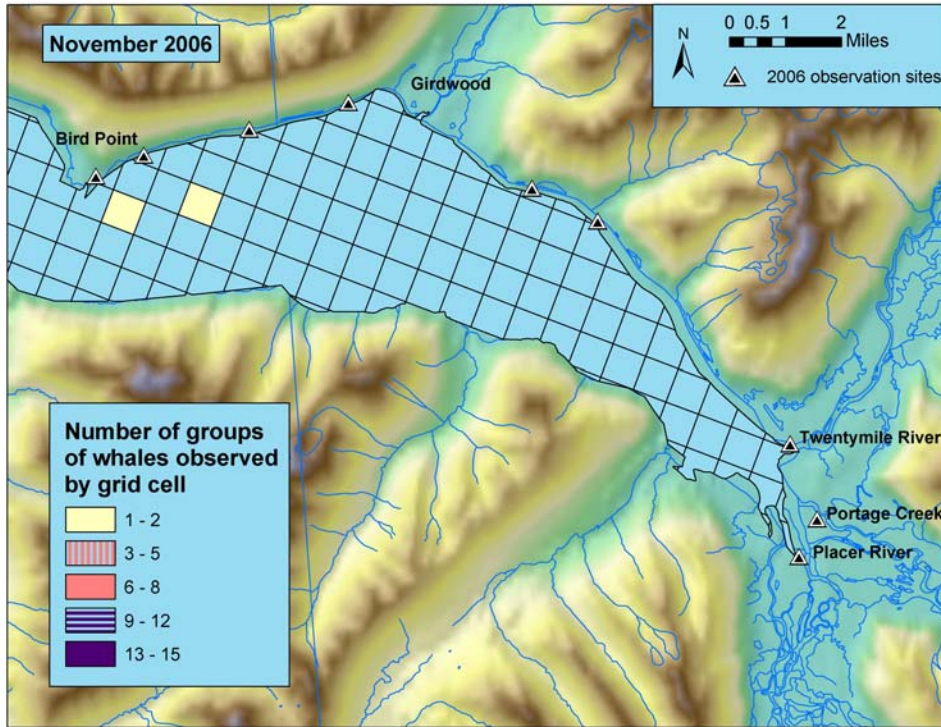
Whales were not sighted in Lower Turnagain Arm during October. This discrepancy may be due to whales spreading out over a larger area, moving across the arm where they were more difficult to observe, or moving through this area at a less predictable time with respect to the tide.

Roughly 2 out of 3 beluga whale groups observed in October came within 54 yards of the near shoreline. Only 13% of groups were observed further than 546 yards away from the shoreline in October, and no groups were observed more than 1094 yards away from the shoreline nearest the observer (Figure 13b, p. 25).

November 2006 (Figure 22, p.36)

Beluga whales were observed in the project area on 1 of 22 days (5%) in November. A single group was observed on November 2 within 1094 yards of the shoreline near Bird Point. This group, comprised of 6 adults and 1 whale of unknown age class, was observed traveling up Turnagain Arm. The whales were spread >13 body lengths apart in linear formation. Whales were not sighted in Lower Turnagain Arm during November.

a. Number of Group Sightings



b. Average Number of Whales per Day

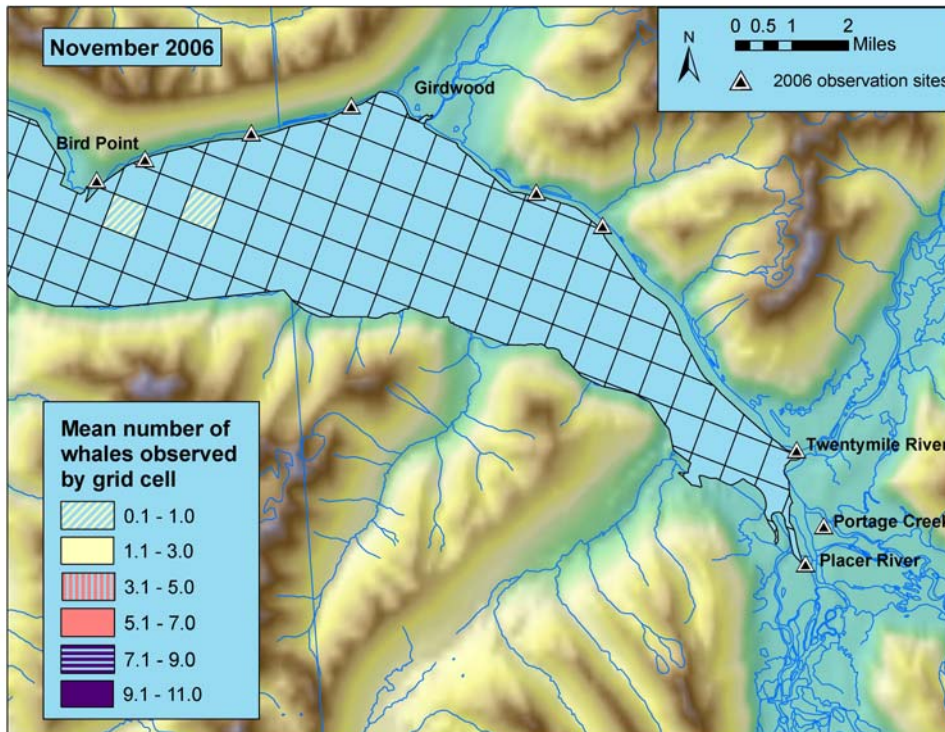


Figure 22. (a) The number of whale group sightings per grid cell and (b) the number of belugas sighted per day in November are indicated by color for each 0.6 mi x 0.6 mi grid.

Other Marine Mammal Sightings

Gray Whale

On May 9, a lone gray whale (*Eschrichtius robustus*) was observed in the study area, swimming within approximately 165 feet of the coastline. The whale was dark in color with relatively few barnacles, suggesting it was an immature gray whale (Figure 23).



Figure 23. This lone, apparently sub-adult, gray whale was photographed from a pull-out along the Seward Highway near Girdwood on May 9 2006 (photo by Tim Markowitz).

The whale was monitored for thirteen minutes (18:22 to 18:35, within 20-30 minutes of the high tide at 18:53), as it traveled alongshore 1 to 2 miles west-southwest of Girdwood, heading down Turnagain Arm against the tide, toward Bird Point. Following consultation with HDR, this sighting information was provided to NMFS.

Harbor Seals

Harbor seals were sighted on 1 day in August (August 2), 5 days in September (September 2, 3, 4, 12, and 28) and on 1 day in October (October 1). All harbor seal sightings took place between Bird Point and Girdwood. Six of the sightings were of lone seals and one was of a pair of seals. In two cases the seals were seen in the company of beluga whales, and in one case a seal was observed feeding near whales that had been apparently foraging (Figure 24).



Figure 24. This harbor seal was observed feeding near some beluga whales that were apparently foraging near Girdwood on September 12 (photos by Tim Markowitz).

Discussion

The seasonal pattern in sighting rates of beluga whales along the Seward Highway during this study generally agreed with findings from past aerial survey and satellite tracking work by NMFS showing highest use of Turnagain Arm by belugas in the fall (Rugh et al. 2004, Hobbs et al. 2006, NMFS 2005). Sighting rates peaked in September, the same month that sightings of beluga whales have been observed to peak in Knik Arm (Funk et al. 2005, Prevel Ramos et al. 2006). Movement of beluga whales from the Susitna River area in summer into both Knik Arm and Turnagain Arm in the fall has long been noted as the predominant seasonal pattern (NMFS 2005). During September, over 30 whale sightings per day were recorded during road based surveys of Upper Turnagain Arm, with as many as 52 whale sightings recorded in a single day. Because individual belugas were not identified, individual belugas may have been re-sighted several times during the course of a day and during the study.

Observations of whales apparently foraging and harbor seals confirmed feeding in the vicinity of whales suggest prey availability may have been a factor in the high numbers of whales sighted in Turnagain Arm in September and early October. Seasonal movement patterns and site fidelity of beluga whales in Cook Inlet appear to be closely linked to prey availability, with the whale distribution coinciding with salmon (*Onchorynchus spp.*) and eulachon (*Thaleichthys pacificus*) concentrations (Moore et al. 2000). Prior to the onset of the monitoring program in early May, beluga whales were noted anecdotally in Upper Turnagain Arm at the mouth of Twentymile River, possibly feeding on eulachon.

The system of roadside monitoring stations and grid cell mapping by a mobile observer appeared to be effective for monitoring beluga whales along Seward Highway in Upper Turnagain Arm from Bird Point to the Placer River. Centering monitoring shifts on the high tide increased the likelihood that most whales entering Upper Turnagain Arm on the rising tide, especially those along the near shore closest to the Seward Highway, would be included in the daily observations.

Sighting rates in Lower Turnagain Arm were substantially lower than those in Upper Turnagain Arm. Whales were sighted in Lower Turnagain Arm on just two days in September, out of 34 total days of monitoring effort for the 2006 season. This discrepancy

may be due to whales spreading out over a larger area, moving across the arm where they were more difficult to observe, or moving through this area at a less predictable time with respect to the tide. Movements of whales offshore with the falling tide might have caused them to be out of sight across the wider section of Turnagain Arm. Observations from Bird Point of whales in the distance, on the far side of Turnagain Arm, hint at this possibility. Data from NMFS aerial surveys indicate that beluga whales often gather at Chickaloon Bay around low tide (Rugh et al. 2004). Given estimated maximum sighting ranges averaging 2 miles, it is not surprising that whales on the far shore (>4 miles away) would often not be visible from stations along the Seward Highway on Lower Turnagain Arm (between Potter Creek and Bird Point).

The timing of the two sightings in Lower Turnagain Arm (roughly 3 and 4.5 hours off the high tide) suggests whales may be more likely to occur along this section of the Seward Highway closer to mid-to-low tide rather than mid-to-high tide. Given the less predictable pattern of beluga whale occurrence in Lower Turnagain Arm with respect to the tide, future monitoring of this area might be most effective with a spread of hours around all tides.

The distribution of age classes based on field counts generally indicated groups were comprised of roughly 66-75% adults, 15-20% subadults, and 7-9% calves. Whales of all age classes were observed close to shore along the Seward Highway. It is likely that difficulty seeing whales at a distance contributed to higher sighting rates near shore and fewer sightings offshore (Funk et al. 2005). More than 80% of sightings occurred less than 0.6 mile from the shoreline closest to the observer, and most of these sightings were estimated to be within 0.1 mile. These sightings were well within the mean maximum sighting distance of approximately 2 miles. Therefore, it seems unlikely that the effect of distance on detection probability alone could account for the preponderance of sightings occurring close to shore.

Whales generally were observed to travel along the near shore channel, moving up and down Turnagain Arm with the tides. A similar pattern of movement with respect to the tides has been shown for beluga whales in the adjacent Knik Arm during the fall (Funk et al. 2005). The relatively small groups observed from monitoring stations along the

Seward Highway (mean = 9 whales) tended to be widely dispersed, most often either traveling without a clear swimming formation or in a linear formation with a large spread between the leader(s) and the last whales following behind.

Sighting rates were highest, and the greatest number of whales was sighted, along the Seward Highway from Bird Point to Girdwood and just past Girdwood heading toward Peterson Creek. The lack of adequate roadside pull-outs between mile 86 and Twentymile River likely reduced sighting rates along this stretch of the highway. Sighting rates were also low at Twentymile River and no whales were observed in either Portage Creek or Placer River (although there were anecdotal reports of whales in the Placer River).

Sightings of other marine mammals in Turnagain Arm along the Seward Highway were fairly rare, with harbor seals sighted on 7 days, and a gray whale sighted on 1 day. These marine mammal species might be described as occasional or infrequent visitors, while beluga whales were found in Turnagain Arm throughout September and on most days in October.

In conclusion, beluga whales were most commonly found near shore along Turnagain Arm in the late summer and fall. During the late spring to mid-summer, beluga whales were rarely sighted, despite excellent sighting conditions. During the late summer and fall (especially September), beluga use of Upper Turnagain Arm, from Bird Point to Placer River, was noted fairly consistently around high tide, with whales moving down into Lower Turnagain Arm and across the arm as they passed Bird Point at mid-to-low tide. The observed seasonal and tidal pattern was consistent with findings from past research by NMFS, although it should be noted that these studies show considerable inter-annual variability in seasonal movements and habitat use patterns of beluga whales in Upper Cook Inlet. Nevertheless, data from the 2006 baseline monitoring program can provide a foundation for incorporating the spatial and temporal distribution of beluga whales into likelihood models for future monitoring and mitigation plans related to planned improvements of the Seward Highway. The development of monitoring protocols from roadside monitoring stations will also have continued utility for future studies.

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