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Distribution of Belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2021 and June 2022

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Distribution of Belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2021 and June 2022

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EXECUTIVE SUMMARY

The National Marine Fisheries Service (NMFS) has conducted aerial surveys to estimate the abundance of the beluga population in Cook Inlet, Alaska, between late May and early July from 1993 to 2012, after which biennial surveys began in 2014. However, the survey scheduled for 2020 was postponed until 2021 due to Covid-19, leading to consecutive surveys in 2021 and 2022. The current document presents survey data collected during late June 2021 and early June 2022, that will be used to produce an abundance estimate and population trend that will be made available in a subsequent publication.

Surveys occurred from 19 June to 1 July 2021 (~59 flight hours) and 6 – 18 June 2022 (~52 flight hours). All surveys were flown in a twin-engine, high-wing aircraft (i.e., an Aero Commander 690) at a target altitude of 244 m (800 ft) and speed of 220 km/hr (119 kts), consistent with NMFS' surveys of Cook Inlet conducted in previous years. The coastal survey track was positioned approximately 1 km offshore and included the entire Cook Inlet coast north of Ursus Cove and English Bay. We did not survey Kamishak Bay, Augustine Island, and Elizabeth Island as in previous years to allow additional time for sampling offshore in the upper inlet. A distance sampling experiment similar to that conducted in 2018 included a series of tracklines running perpendicular to the shoreline of Chickaloon Bay and the Susitna River delta with an additional series of tracklines in Trading Bay.

Most of the upper inlet north of East and West Foreland, where belugas are consistently found, was surveyed on 6 of 9 days in 2021 and 5 of 8 days in 2022. An additional 3,688 km of effort was spent surveying distance sampling tracklines. During the standard coastal survey, paired observers searched on the coastal side of the plane, while a single observer searched on the inlet side. A computer operator/data recorder periodically monitored the aircraft's distance from the shoreline (1 km) with a clinometer (angle 14°).

After finding beluga groups during a standard coastal survey, the aircraft conducted a series of aerial passes and two observers made independent counts of every group. Whale groups were video recorded for later analysis and more precise counts. Video was not recorded during the distance sampling experiment.

Belugas were not seen in lower Cook Inlet (south of East and West Foreland) nor in the upper inlet south of Moose Point on the east side and the McArthur River on the west side in 2021, while a lone beluga was observed near the bridge in Kenai River during the 2022 survey. Surveys of the Susitna River delta were timed to coincide with the negative low tides when possible. Low tides expose vast expanses of mudflats and typically cause whales to line up within the deeper channels. Unfortunately, gale force winds and fog prevented surveys from occurring during most of these optimal tide cycles in 2021, though that was not the case in 2022. In 2021, beluga groups were found between the McArthur River and North Foreland in Trading Bay, from North Foreland to east of the Little Susitna River, in Knik Arm, in Turnagain Arm, in Chickaloon Bay, and near Moose Point. A similar pattern was observed in 2022, although whales were not present in Knik Arm or near Moose Point, but they were present off the south tip of Fire Island.

The annual sums of medians from aerial counts, uncorrected for estimates of whale missed, provide an index of relative abundance. In 2021, daily overall observer count medians on two days with complete coverage of the upper inlet ranged from 100 to 124 whales. The annual median index count of 124 whales fell below the range of median counts collected to date for this project. Unfortunately, bad weather coincided with many of the lowest low tide days. Minus tides (-3 ft. or more) that expose the tidal mudflats for extended periods are preferable for collecting video group size data because the whales aggregate along the edge of the mudflats until the rising tide allows them to access the channels and rivers. It is preferable to obtain at least 3-5 days for the abundance estimate.

The timing of the survey in late June may have affected counts as well. From experience, this timing has not been optimal as the whales typically begin to disperse from the river mouths following the peak of eulachon and Chinook salmon runs in late May and early June. When whales are dispersed, it is more difficult to collect the video data for every group.

In 2022, daily overall observer count medians on three days with complete coverage of the upper inlet ranged from 186 to 224 whales. The annual median index count of 224 whales fell within the range of median counts collected to date for this project. Unlike 2021, we were able to survey during three of the lowest low tide days (> -4 ft.). Estimates of abundance from the 2022 survey will be compared to those obtained in 2021 and published together. In this respect, any issues regarding the 2021 estimates can be viewed in the context of the 2022 survey which should be more comparable to previous survey years.

CONTENTS

INTRODUCTION

Belugas (*Delphinapterus leucas*) inhabit waters surrounding Alaska from Yakutat Bay to the Alaska/Yukon Territory boundary (Hazard 1988). Five stocks are recognized in this region: Cook Inlet, Bristol Bay, Eastern Bering Sea, Eastern Chukchi Sea, and Beaufort Sea (Muto et al. 2021). The Cook Inlet stock (hereafter CIBs) is the most isolated. Their small population size (fewer than 300 whales; Wade et al. 2019) and geographic and genetic isolation from other stocks (O'Corry-Crowe et al. 1997; Laidre et al. 2000); in combination with their strong site fidelity (Rugh et al. 2000, 2010; Shelden et al. 2018; McGuire et al. 2020a); makes this stock vulnerable to natural and anthropogenic impacts (Norman et al. 2015; Castellote et al. 2018; McGuire et al. 2020a, b, 2021). CIBs were designated a Distinct Population Segment (DPS) and listed as endangered under the U.S. Endangered Species Act (NOAA 2008) in October 2008. Critical Habitat was designated in 2011 (NOAA 2011) and in 2015, NOAA Fisheries selected the Cook Inlet DPS as one of its eight Species in the Spotlight.

CIBs gather in upper Cook Inlet near river mouths and in bays. Aerial surveys have proven to be an efficient method for collecting distribution and abundance data for CIBs and were used sporadically before the start of surveys conducted by the National Marine Fisheries Service (NMFS) in the 1990s (reviewed in Shelden et al. 2015a), though no complete systematic census had been conducted until 1994. The NMFS studies have been the most thorough and intensive in terms of coverage and effort (Shelden et al. 2015a, b; 2017; 2019). The primary objectives for this study were to document sighting locations and count CIBs while maintaining continuity with preceding surveys to allow for inter-year trend analyses. This document presents data collected during the June 2021 and June 2022 aerial surveys.

METHODS

Aircraft and Data Entry

In June 2021 and June 2022, an aerial survey was conducted using a twin engine, high wing Aero Commander 690 (tail number: *N222ME*) with 6-hour flying capability. Bubble windows were inserted at the forward observer positions to maximize their field of view. The left-rear observer window was flat (Fig. 1). An opening window allowed for video recording and photography. Two observers were positioned on the coastal side of the aircraft providing independent search effort on the side where belugas are typically seen. Because there are typically fewer beluga sightings greater than 3 km from the coast, a single observer searched the right side of the aircraft. A data recorder sat at a computer desk in the rear portion of the aircraft. The data recorder and pilots also searched for belugas but were instructed not to alert observers until a sighting was beyond view.

Figure 1. -- Twin engine, high wing Aero Commander 690 survey platform used during Cook Inlet beluga aerial surveys, June 2021 (photo courtesy of Clearwater Air, Inc.).

Headsets provided communication among the observers, data recorder, and pilots. Seating positions were noted each time the survey team changed positions and/or tasks (i.e., video recording, data recording, observing/counting). Location data were collected from a handheld global positioning system (GPS) interfaced with the laptop computer. A custom-built software program was used to record routine updates of time, location (latitude/longitude), beginning and end of search effort, percent cloud cover, sea state (Beaufort sea state scale as a function of the wind on the water surface, on the coastal side of the plane), glare (on the coastal and offshore sides of the plane), and visibility (on the coastal and offshore sides of the plane).

Visibility was documented in five subjective categories from excellent to useless. Best counting conditions (excellent visibility) were when Beaufort sea state was less than 3 (no white caps), there was a light overcast (reduced glare), the sun was well above the horizon (good lighting), windows were clean (no dust particles or smears to distract from sighting effort), and the observer was comfortable (no back pain, air sickness, etc., which can reduce search effort). Areas where visibility was considered poor or useless (as determined by the left-forward observer) were treated in the analysis as unsampled.

Study Area

Cook Inlet is a major inland sea in south-central Alaska covering approximately 20,000 km^2 (Fig. 2). The southern boundary, which opens to the Gulf of Alaska, is approximately 85 km across from Cape Douglas to Elizabeth Island. The Susitna River delta is 315 km north of Cape Douglas. From there, two substantial tidal estuaries (roughly 50 km long) extend to the northeast (Knik Arm) and southeast (Turnagain Arm). The shoreline of Cook Inlet (1,810 km) is highly irregular and interrupted by many rivers and creeks, which input considerable freshwater and glacial melt into the inlet.

Detritus from glacial erosion and strong tidal fluxes keep the waters of upper Cook Inlet (north of East Foreland and West Foreland) extremely turbid and nearly opaque with silt. A description of beluga habitat in Cook Inlet can be found in Moore et al. (2000), Goetz et al. (2007, 2012), and McGuire et al. (2020a). Aerial surveys were based out of Anchorage, the largest city in Alaska.

Figure 2. -- Cook Inlet with place names mentioned in the text.

Tracklines

Coastal surveys were conducted approximately 1 km from the shoreline or exposed mudflat edge. The objective was to search all nearshore, shallow waters where belugas are typically seen in late May/early June (Rugh et al. 2000, 2005; Shelden et al. 2013, 2015a,b, 2017, 2019). The trackline distance from shore was monitored with a clinometer to keep the shoreline 14° below horizontal while the aircraft was at the standard altitude of 244 m (800 ft). Ground speed was approximately 220 km/hr (119 kt). This coastal survey included searches up rivers until the water appeared to be less than 1 m deep, based on the appearance of rapids or riffles or as recommended by Alaska Native beluga hunters who have flown with us in the past. In addition to the coastal surveys, systematic transects were flown across the inlet to document offshore distribution of marine mammals in the study area (Fig. 3). Mid-inlet tracklines were designed to run the length of Cook Inlet or in a sawtooth pattern across it. On occasion, when belugas were scattered rather than clumped within the study area (e.g., from Beluga River to the Little Susitna River, hereafter referred to as the Susitna Delta), strip transects along the mudflat/shoreline and positioned at roughly 2-km intervals parallel to shore were conducted to obtain counts for groups too dispersed to video. While informative, days when this occurred were not used to estimate abundance.

Similar to distance sampling experiments conducted in 2018 (Shelden et al. 2019), tracklines angled perpendicular from the shore in the Susitna Delta, Chickaloon Bay, and Trading Bay, were spaced 2 km apart (Fig. 3). Lines began or terminated at the waterline edge, which varied depending on tide height and extended offshore to just beyond the 10 m depth contour (as few sightings have occurred mid-inlet). Sightings were reported in passing mode without breaking from the trackline to circle or video. Sampling in Knik Arm, Turnagain Arm, and the coast from Point Possession to East Foreland followed coastal survey protocols.

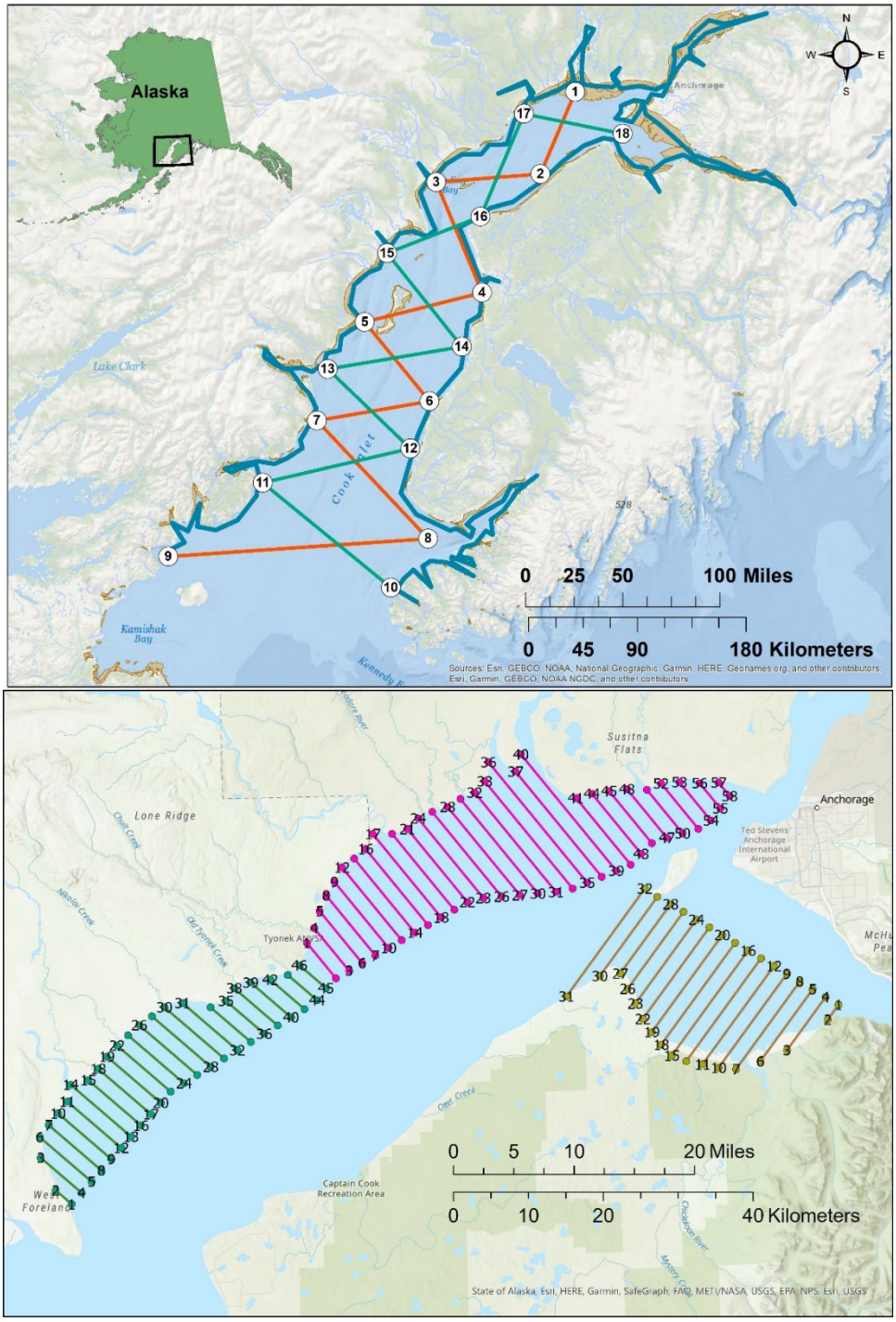


Figure 3. -- Cook Inlet, Alaska, coastline and mid-inlet sawtooth tracklines (upper panel) and distance sampling experiment tracklines (lower panel) proposed for the June 2021 and 2022 survey with waypoints (numbers).

Tides and Light

The broad geographical range of these surveys in conjunction with rapidly changing tide heights -- as much as 9.5 m (30 ft) -- made it impractical to survey at specific tidal conditions (such as at low tide) throughout Cook Inlet. However, there was an attempt to synchronize flights with low tides in the Susitna Delta. Lower tides typically keep beluga groups confined along the mudflat edge in more compact groups, rather than dispersing across the flats. Additionally, surveying at low tide reduces the area that needs to be searched, as a large proportion of upper Cook Inlet has exposed mudflats only at this time that would otherwise need to be surveyed. Increased emphasis on surveying during preferred tidal conditions is thought to improve the efficiency of the aerial surveys but probably does not significantly affect the visibility of whales, as long as the whales are still over shallow waters. Whales seen near Anchorage usually cannot be circled (see Counting Protocol) due to aircraft traffic in the vicinity of the Ted Stevens Anchorage International Airport. The timing of aerial surveys in areas south of Point Possession and North Foreland was a function of weather, not tides.

Daylight hours in the Cook Inlet area during June cover about 19 hours between sunrise and sunset, though light levels become low enough to limit our survey to hours between 07:30 and 20:30 AKDT. The flight schedule for every survey day was designed to take advantage of tidal patterns, as described above, relative to workable daylight hours.

Counting Protocol

Immediately upon seeing a beluga group, an observer independently reported the sighting to the data recorder. As the aircraft passed abeam of the whales, the observer informed the data recorder of the clinometer angle and notable behaviors when possible, but not group size. With each sighting, the observer's position (left-forward, left-rear, or right-forward) was also recorded. After a beluga sighting was reported, the trackline was maintained until the group was well behind the wing; then the aircraft returned to the group to mark its location and begin a circling routine for counting and video recording.

The pilots, data recorder, and the back left observer did not cue the front two observers to the presence of a whale group until it was behind the plane and it was clear as to whether an observer had seen the group. The location of each whale group was established at the onset of the aerial counting passes by flying directly over the group and recording (i.e., marking) the group perimeters. The flight pattern used to count a whale group is an extended oval around the longitudinal axis of the group (Fig. 4). Counts of whales occurred on each pass down the long axis of the oval unless poor visibility (usually due to glare) limited counts to only one side of the oval. There were typically four or more passes per whale group with two observers counting.

To record the duration of each counting pass, counts began and ended with a start/end count cue from the front left observer. Counts started when the first whale(s) of the group were close enough to be counted and ended when the last whale(s) went behind the wing of the aircraft. The two observers counted independently and reported their count along with the date, time, pass number, and quality of the count. The position of each counter was also noted as the back left observer was positioned at a flat window versus a bubble window at the front left position, and the engine cowling on the wing could at times obstruct views of the shoreline and potentially whales nearshore.

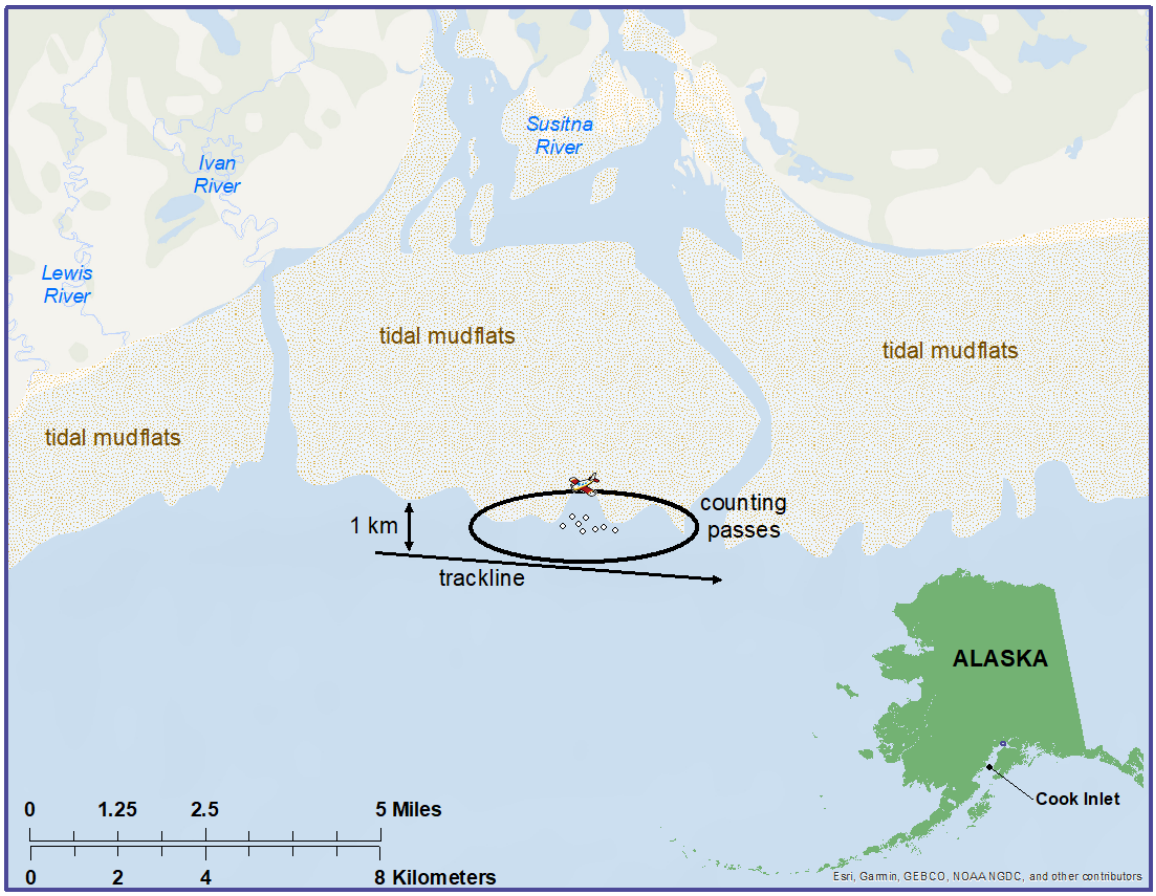


Figure 4. -- Racetrack pattern flown during counting passes of Cook Inlet belugas.

The quality of a count was not dependent on whales being present at the surface during a pass (i.e., a count could be zero and still used if other factors did not compromise visibility). Ratings were A (if glare, whitecaps, or distance did not compromise the counting effort) through F (if it was not practical to count whales due to poor/obstructed visibility). Only quality A and B estimates were used in the median count calculations and subsequent abundance estimate. Only whales that were at the surface during a pass were counted; mud plumes or ripples from subsurface whales were not counted.

Most whale groups were counted on four different aerial passes, not including counts made later from video recordings. The daily aerial counts were represented by medians of each of the observers' median counts on multiple passes over a group. Using medians instead of maximums or means reduces the effect of outliers (extremes in high or low counts) and makes the results more comparable to other surveys which lack multiple passes over whale groups. When a median for a group of whales included decimals, the median was rounded up to the next whole number.

After median counts were calculated for each location (e.g., Chickaloon Bay, Susitna Delta) on each day, the annual index count for the survey was determined from the highest daily sum. Using the highest daily median sum for the index reduces problems with partially or totally missing whale groups in certain areas on some days (Rugh et al. 2005). Because of the evident movement of whales between these areas in upper Cook Inlet on some days, over- counting was avoided by not adding counts from different days (except for sightings made in the lower inlet since it typically takes two days to complete a lower inlet survey). To date, movements have not been observed between the lower and upper inlet during the counting period.

Marking, circling, and video collection did not occur during strip transect and distance sampling experiments, instead estimated group size and clinometer angle were obtained for these observations in passing mode. A single observer was positioned at a bubble window on each side of the aircraft. Observers scanned the field of view from beneath the aircraft (90°) to the horizon (0°) and ahead of the aircraft to abeam. Belugas within five whale lengths of one another were counted as one group with a clinometer angle taken at mid-distance (i.e., between whales distant and close to the plane). Similar to the coastal survey, evidence of submerged whales (mud plumes, wakes, bubble rings) were not included in the count. Observations typically lasted 2-5 seconds depending on wind speed.

Cameras

One full view (standard) digital video camera and one narrow view (zoomed) digital video camera mounted side by side were operated together on most counting passes. The "standard" camera is generally at maximum wide angle to keep the entire group of belugas in view. This wide angle video is used to count the total number of whales surfacing during the video pass. The second "zoomed" camera is kept at maximum optical zoom (10×) and its video was used to determine correction factors for missed whales (Hobbs et al. 2015). Once recording is started, the zoom setting for each camera was set and left unchanged throughout a counting pass so that magnification of the video was consistent.

In 2021, a "standard" camera (Sony HXR-NX5U HD with 1920 × 1080 pixel resolution) was paired with a "zoomed" camera (Panasonic HC-X1 with 3840 × 2160 (4K) pixel resolution but set to the same resolution as the Sony camera). This was the same camera set up used during the 2018 abundance survey, with the Panasonic replacing one of the paired Sony cameras used during the 2016 survey. Plans at the time had been to test the 4K resolution against the older cameras but this did not occur in 2018 or 2021 as other experiments such as distance sampling became a priority.

In 2022, smaller 4K resolution video cameras were introduced to improve the quality of video data collection. The Sony FDR-AX700 video handycams (3840 × 2160 pixel resolution) replaced the larger video cameras allowing for easier handling and positioning for capturing video. A new aluminum based camera mounting system was created with tripod mounts for the two video cameras (Fig 5a). The mounting system had adjustable brackets which allowed for side by side (Fig. 5b) or stacking (Fig. 5c) of cameras so alignment could be customized based on camera size. A series of video passes were collected to compare the 1080p resolution of the Sony HXR-NX5U used in 2021 to 4K resolution of the new Sony FDR-AX700 cameras used in 2022 (Fig. 5c). Preliminary review of comparison video shows the 4K resolution increases edge definition and clarity of whale images.

Figure 5. -- Video and counting passes of Cook Inlet belugas. A. Comparison of cameras used during surveys prior to 2022 (Sony HXR-NX5U HD camera mounted above new camera). B. Observers counted from the left- forward position (shown) and left-rear position (not shown) while group/pass number and flight path were recorded by the video. C. modified mount for side-by-side cameras.

After the field season, each video counting pass was reviewed for quality and rated as excellent, good, fair, poor, or unacceptable. Video passes rated excellent and good were analyzed using a computer-aided system called "Beluga Dots" (introduced in 2004). Using Beluga Dots (Fig. 6), analysts counted and cataloged the individual whale images found in the survey video, tracked the images across the computer screen, and measured image size and color. Data were stored in a text file and exported for use in calculating the annual abundance estimate. Images from the zoomed camera were examined for whale surfacings that could not be seen in the standard video, either due to a partial surfacing, small size, or cryptic body coloration within the respective groups. The annual abundance estimate is based on estimates of the size of detected groups, using Bayesian methods to account for: 1) availability bias due to diving behavior; 2) proximity bias due to whales concealed by other whales in the video data; 3) perception bias due to whales not detected because of small image size in the standard video; and 4) individual observer bias in visual observer data (see Boyd et al. (2019) for a complete description of methods).

Figure 6. -- Computer screen shot of "Beluga Dots" program used to catalog individual beluga images found in the Cook Inlet survey video.

Determination of Acceptable Survey Days

Following the 2018 abundance survey and the revised analyses of group size estimates from the 2004 to 2016 surveys (Boyd et al. 2019), Wade et al. (2019) reviewed and defined criteria for "acceptable days" to be used when calculating abundance estimates. These include the following:

1. Good to excellent sighting conditions throughout the survey area, including little to no fog, little glare, and sufficiently low wind speeds that there were little to no whitecaps on the water.
2. Whales seen in medium to large size groups were sufficiently compact or linear (not widely scattered in many small subgroups) to allow for video pass recording of the group during a "standard" survey day. Though noting this need not be the case on distance sampling days.
3. The survey represented "complete" coverage of the upper Cook Inlet survey area north of East and West Foreland.

RESULTS

Survey Effort

The June 2021 survey included 17 flights during 9 survey days in the Aero Commander, which ranged from 1.4 to 4.9 hours in duration from takeoff to landing. Flight time, the sum of time spent in the air, whether or not a search effort was underway, totaled 58.7 hours for the season. Systematic search effort, not including time spent circling whale groups, deadheading without search effort, or periods with poor visibility was 27.6 hours. Poor visibility interfered with search effort for 1.1 hours (the sum of time spent in the air when glare, fog, white caps, or similar problems interfered with the survey effort, as determined by the left-forward observer). The June 2022 survey included 15 flights during 8 survey days, which ranged from 0.7 to 5.2 hours in duration from takeoff to landing. Flight time totaled 51.4 hours for the season. Systematic search effort was 25.2 hours on-effort after excluding transit, circling, and brief periods of poor visibility.

The 2021 and 2022 aerial surveys provided thorough coverage of the coast of Cook Inlet north of Augustine Island for most of the area within approximately 2.0 km of shore. Most of upper Cook Inlet was surveyed five (2022) to six (2021) times, especially areas where belugas have consistently been found in the past – such as the Susitna Delta, Knik Arm, and Chickaloon Bay.

One of the primary observers (authors of this report) has flown with this project on almost all of these surveys since 1993 (KWS). Other observers have flown on multiple prior surveys (KTG: 2005-2011, 2014; CLS: 2003-2018), and two experienced cetacean observers joined the beluga survey for the first time in 2021 (AAB, ALW) and one returned in 2022 (AAB).

2021 Summary Counts and Daily Reports

Median counts of beluga groups for each area are presented in Table 1. Typically, there were four good counts made by two observers for each group. The use of medians (instead of means or maximum counts) and the consistency of the observation team have meant that changes in index counts between years are probably not a function of observer performance. In 2021, two of the six standard survey days – 26 and 27 June -- included complete coverage of the upper inlet following video/counting protocols. The maximum median index count was 124 belugas on 27 June, which falls below index counts generated to date for this project (Hobbs et al. 2015; Shelden et al. 2015b, 2017, 2019). These summary counts do not reflect any correction for missed whales or groups.

Day-by-day survey effort and marine mammal sighting locations are summarized below. Lower inlet surveys were planned for the beginning or end of the project in order to prioritize upper Cook Inlet surveys when tides were more favorable (negative low tides later in the day).

Table 1. -- Beluga counts made during aerial surveys of Cook Inlet in June-July 2021. Counts are the median sum of multiple counts from each whale group except for distance sampling days (*) which are the total count including off-effort sightings and Susitna Delta sampling on 22 and 28 June. Dashes (---) indicate no survey effort and zeroes (0) indicate that the area was surveyed but no whales were seen. Locations are listed in a clockwise order around Cook Inlet starting with Turnagain Arm with shaded rows indicating lower Cook Inlet. If more than one group was found within a location, the median for each group was summed (see Daily Reports for specific group locations and counts). Note: all median group counts were rounded up when the final median included a "partial" whale.

Location	6/19	6/21	6/22	6/26	6/27	6/28	6/29	6/30*	7/1*
Turnagain Arm	---	---	---	2	6	0	---	1	0
Chickaloon Bay	6b	---	d	12	10	18	---	10	5
Pt. Possession-E. Foreland	---	---	0	0	0	4	---	1	0
Mid-inlet tracklines	0	---	d	0	0	---	0	0	---
E. Foreland-English Bay	---	0c	---	0e	---	---	0g	---	---
Ursus Cove-Harriet Pt.	0	---	---	---	---	---	---	---	---
Redoubt Bay	0	---	---	---	---	---	---	---	---
Trading Bay	---	---	19	23	69	13	---	9	9
Susitna Delta (a)	---	c	143d	58	36	81f	---	84	99
Knik Arm	---		1d	5	3	6	---	0	1
Fire Island	---		d	0	0	0	---	0	0
Index count	---	---	163d	100	124	122	---	105	114

a. Region from North Foreland to Point MacKenzie
b. Conducted practice video passes along the bluffs in Chickaloon Bay before surveying offshore tracklines and the west coast of lower Cook Inlet.
c. Began lower inlet survey south of Kenai River and surveyed Kasilof River but aborted south of Kasilof due to low clouds and high winds. Belugas encountered from Chuitna Creek to Little Susitna River (no counts). Conducted practice video passes on a group of belugas in the Little Susitna River.
d. Belugas scattered from Chuitna Creek to Little Susitna River, conducted two long counting passes, one 1 km from shore heading south to north, the second offshore heading north to south, resulting in 46 sightings of 143 whales (potential resightings as track offset was done spontaneously). Belugas were seen in Knik Arm but circling was not possible due to military air traffic. The second flight of the day was terminated due to high winds in Turnagain Arm and Chickaloon Bay and resulted in an incomplete survey of the upper inlet.
e. Surveyed to Kenai River and into the river to ensure no belugas in the area before returning to areas north of East and West Foreland (upper inlet survey).
f. Belugas scattered from Chuitna Creek to Little Susitna River, conducted multiple counting passes along lines spaced 1 km apart resulting in 47 sightings of 81 whales.
g. Began survey south of Kasilof River since areas between East Foreland and the Kasilof River were surveyed on 21 and 26 June.

19 June 2021

The Aero Commander 690 (*N222ME*) departed Merrill Field in Anchorage at 10:00 AKDT to conduct the first flight of the 2021 survey (Fig. 7). To prepare for video collection during counting passes, we searched for belugas in Chickaloon Bay to have the two new video camera operators practice aligning the standard and zoom cameras. A small group of about six whales was scattered between Chickaloon River and the bluffs. After completing a series of passes, we crossed the upper inlet to the Susitna River to begin offshore sawtooth tracklines at Waypoint 1 (Fig. 7). Marine mammal sightings included: 2 harbor porpoises (*Phocoena phocoena*) at Waypoint 5 in Redoubt Bay; a minke whale (*Balaenoptera acutorostrata*) between Waypoints 6 and 7; and 3 more sightings of harbor porpoises (4 porpoises total), 2 harbor seals (*Phoca vitulina*), another minke whale, and numerous sea otters (*Enhydra lutris*)(running count: 73 otters) between Waypoints 7 and 8 (Appendix). Sighting conditions were excellent to fair with Beaufort sea states ranging from 2 to 4. We landed in Homer to fuel the aircraft. Total flight time: 2.8 hours.

We resumed the survey (Flight 2) at Waypoint 8 crossing the inlet to Waypoint 9, then continuing to shore to survey the west coastline north to West Foreland (Fig. 7). Harbor porpoises (2 sightings, 4 porpoises) were seen in offshore of Kachemak Bay and off Augustine Island, and a few unidentified pinnipeds (2 total) and another running count of sea otters (384 otters total) were seen between Waypoints 8 and 9 (Appendix). Marine mammal sightings along the coastline included: a harbor porpoise near Iniskin Bay, two harbor porpoises off Harriet Point, and one harbor porpoise when heading offshore to circle Kalgin Island; and sea otters near Ursus Cove, Chinitna Point – Chinitna Bay, and Kalgin Island (9 otters total). Haulouts of harbor seals were near Iniskin Bay, in Tuxedni Bay, and in Redoubt Bay (13 sightings of 962 seals total). At West Foreland, we crossed the inlet to Boulder Point and continued surveying offshore heading north on the return to Anchorage. Sighting conditions were excellent to fair with Beaufort sea states ranging from 0 to 4. Total flight time: 3.5 hours.

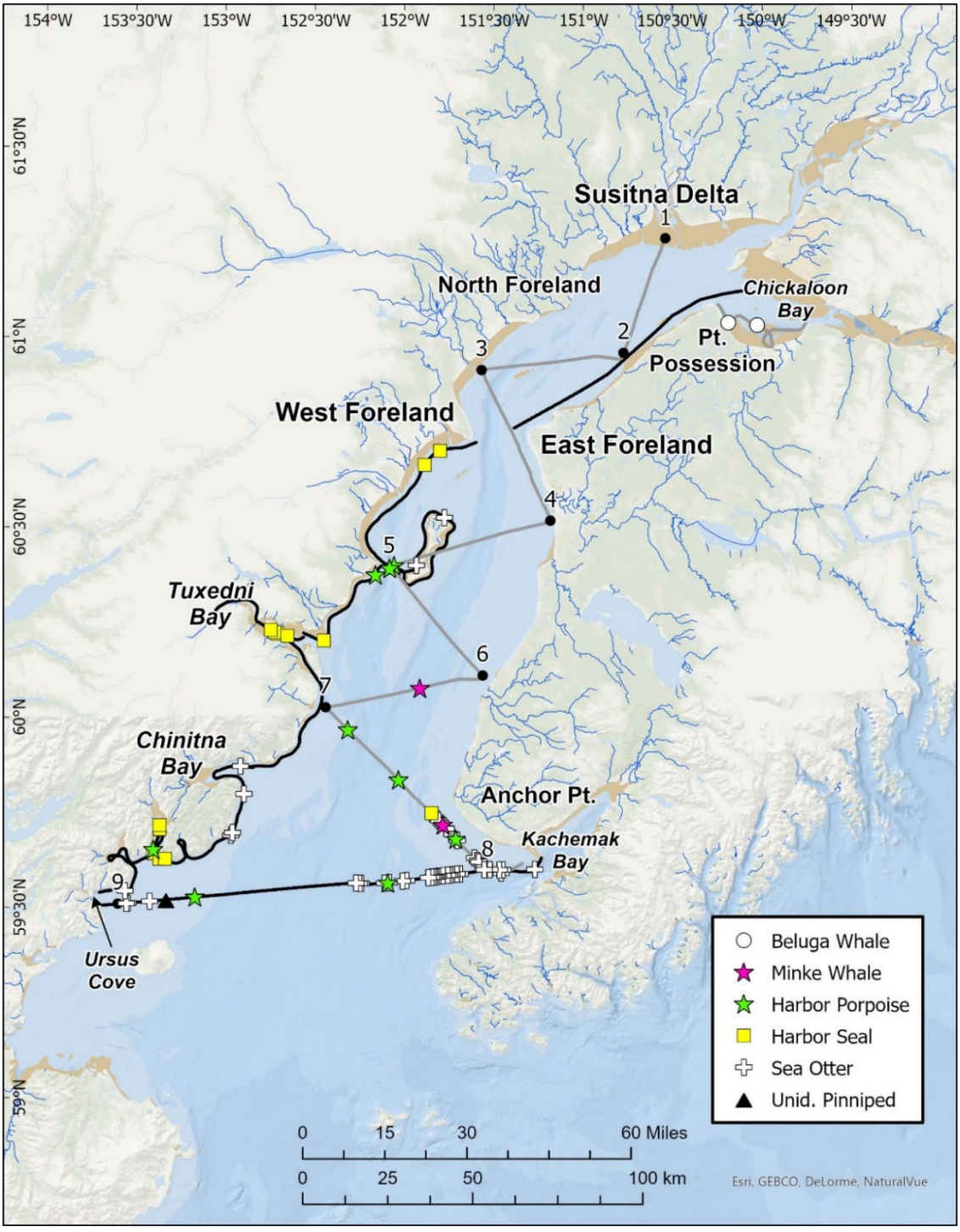


Figure 7. -- On-effort trackline and all observed marine mammal sightings on 19 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Solid black dots indicate trackline waypoints. Gray and black tracklines depict Flights 1 and 2, respectively. Tan areas indicate mudflats.

20 June 2021

Down day. Conditions included high winds in Turnagain Arm and lower Cook Inlet. The team worked on cameras and updating reports.

21 June 2021

We attempted to complete the lower inlet survey following the coastline from East Foreland to English Bay (Fig. 8). The survey aircraft departed Merrill Field in Anchorage at 11:18 AKDT and deadheaded to East Foreland where we encountered a low-lying cloudbank that extended across the inlet. We were able to access the shoreline south of the Kenai River and surveyed up the Kasilof River before encountering an extensive cloudbank that covered the lower inlet. We terminated effort for Flight 3 and returned to the upper inlet, flying to the Susitna Delta where belugas were observed off-effort near Chuitna Creek, Beluga River, Theodore River, the eastern tributary of the Susitna River, and at the mouth and in the Little Susitna River as far as the first bend in the river. A group of 200 harbor seals were hauled out along the mudflats (Appendix). Sighting conditions were not optimal for an upper inlet survey, instead the team was able to test the paired cameras on the beluga group in the Little Susitna River (8 video passes, no observer counts) before terminating the flight and heading back to Anchorage. Total flight time: 3.4 hours.

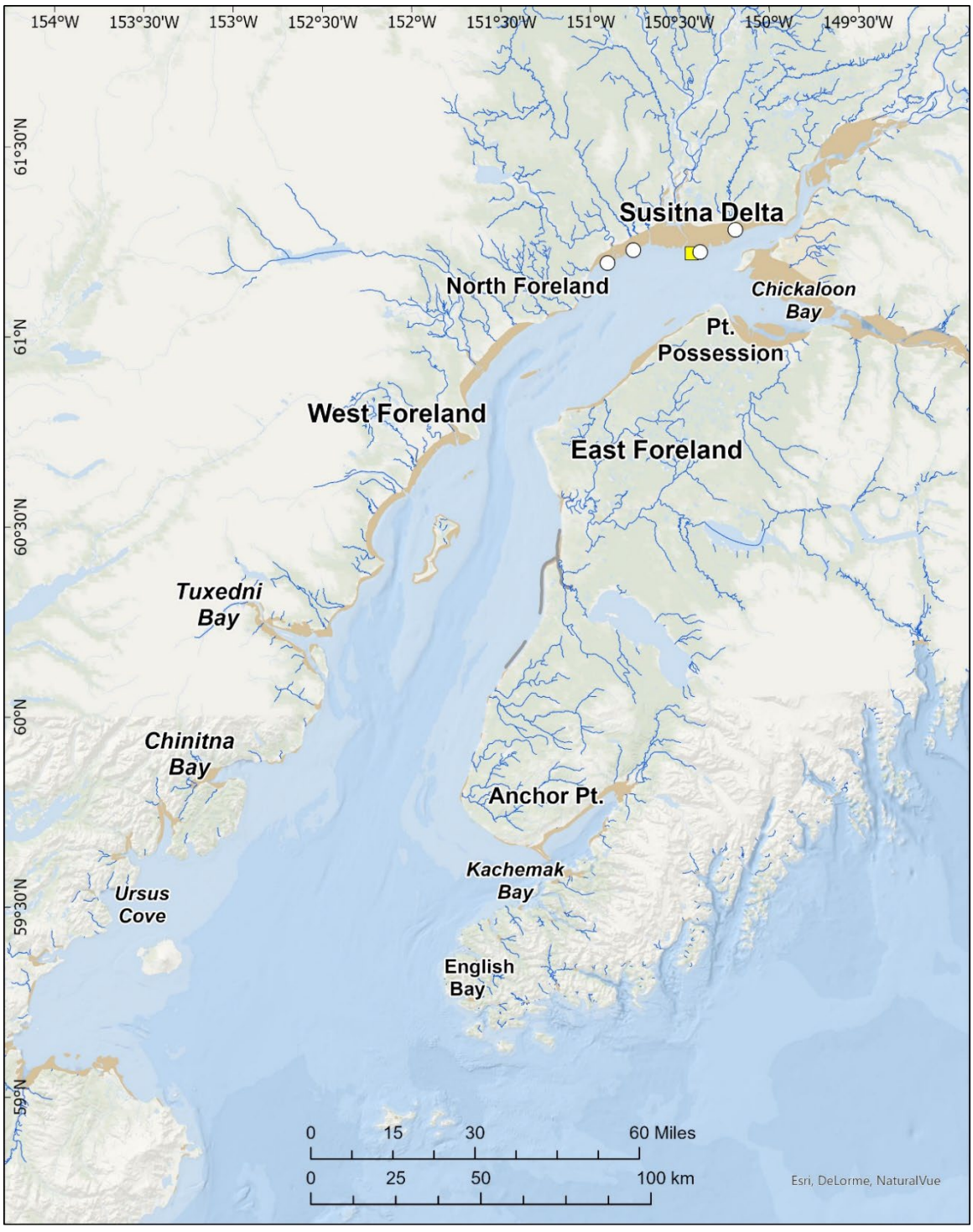


Figure 8. -- On-effort trackline (gray) for Flight 3 and all observed marine mammal sightings (off effort) on 21 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Tan areas indicate mudflats.

22 June 2021

With the start of negative low tides in the upper inlet (-2.7 ft at Fire Island at 11:55 AKDT), we began standard abundance estimation surveys (Flight 4). We departed Merrill Field in Anchorage at 09:55 AKDT and transited to Point Possession to start the coastline survey. From Point Possession, we headed south to the Kenai River, surveying the river before returning to the upper inlet at West Foreland to begin the western coastline survey, including surveying the McArthur River (Fig. 9). In Trading Bay, belugas were north of McArthur River (5 video/counting passes; median group size: 10 whales), and south of the dock at North Foreland (5 video/counting passes; median group size: 9 whales). In the Susitna Delta, belugas were scattered along shore and offshore from Chuitna Creek to the Little Susitna River. Unable to video the whales, we ran a transect line along the shore from south to north noting clinometer angle and group size, then repeated the line from north to south offshore from the first line (total: 46 sightings of 143 belugas, although resightings may have occurred as the offset from the previous trackline was determined spontaneously in-flight). At this point, we needed to land for fuel. Overall, sighting conditions were good to excellent, with Beaufort sea states ranging from 1 to 2. Total flight time: 4.6 hours.

After fueling, we departed Merrill Field for Knik Arm at 15:31 AKDT (Flight 5). Air traffic and military operations in the area resulted in numerous diversions from the survey track and we were unable to circle a beluga group observed between Eagle Bay and Goose Bay. We attempted to survey Fire Island, Turnagain Arm, and Chickaloon Bay but high winds (gust to 40 kt) precluded further survey effort. Other marine mammal sightings included 20 harbor seals near Chickaloon River – 3 reacted to the plane by heading into the water (Appendix). Sighting conditions ranged from good to unacceptable, with Beaufort sea states ranging from 5 to 7 which resulted in termination of the survey after a brief survey of Chickaloon River (Fig. 9). Total flight time: 1.4 hours.

Figure 9. -- On-effort trackline and all observed marine mammal sightings on 22 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Gray and black tracklines depict Flights 4 and 5, respectively. Beluga sightings are shown as white circles. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

23-25 June 2021

High winds persisted through the next 3 survey days effectively grounding the aircraft (Fig. 10) during what would be optimal negative low tides for surveying (> -5 ft mid-afternoon at Fire Island). C. Garner (JU.S. Army, Elmendorf-Richardson) was able to retrieve and re-deploy acoustic moorings at the mouth of Eagle River on 24 June and did not observe any belugas during operations.

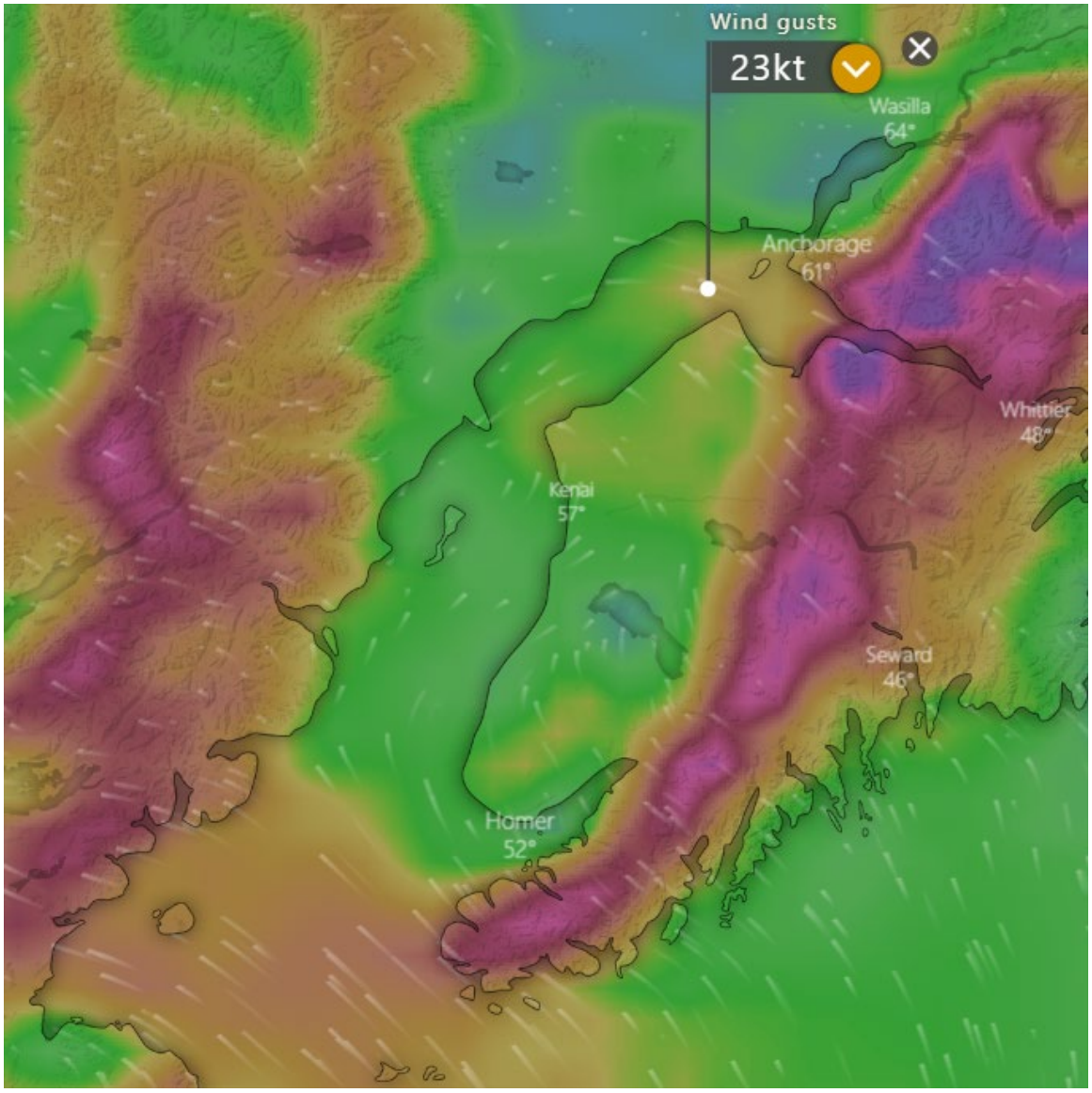


Figure 10. -- Weather conditions on 23-25 June during the 2021 beluga aerial survey, Cook Inlet, Alaska.

26 June 2021

Winds diminished overnight to 5 kt in Turnagain Arm. We departed Merrill Field at 08:29 AKDT and began Flight 6 in Turnagain Arm (Fig. 11). Belugas were near Gull Rock on the outbound survey trackline leaving Turnagain Arm (Group 1: 7 video/counting passes; median group size: 2 whales). Group 2 was a single whale near Chickaloon River (no video). Group 3 was near the bluffs along the south shore of Chickaloon Bay (5 video/counting passes; median group size: 11 whales). The survey continued to Point Possession then south to East Foreland where we crossed the inlet to West Foreland. We continued into Trading Bay, encountering Group 4 near Middle River (4 video/counting passes; median group size: 16 whales). Group 5 was near the mudflats off Old Tyonek (4 video/counting passes; median group size: 5 whales) and Group 6 included at least two whales south of North Foreland (no video). Other marine mammal sightings included 12 harbor seals hauled out in Trading Bay (Appendix). Sighting conditions were fair to excellent with Beaufort sea states ranging from 1 to 3, and light rain at times. Total flight time: 4.5 hours.

After landing to fuel and wait for the low tide in the Susitna Delta (15:15 at Fire Island, -5 ft), we returned to North Foreland to continue the survey (Flight 7). A single whale was near Chuitna Creek (Group 7, no video). A large group was near Threemile Creek (Group 8: 5 video/counting passes; median group size: 30). A small, compact group was near the west tributary of the Susitna River (Group 9: 2 video/counting passes; median count: 2 whales) but was lost on a third pass when Group 10 was encountered offshore while off effort (5 whales, no video) followed by Group 11 which was near the mudflats (two whales, no video). Continuing the survey east, Group 12 was found between the west tributary of the Susitna River and the Little Susitna River (7 video/counting passes; median group size: 15 whales). Group 13 was between the Little Susitna River and Point MacKenzie. Conflict with air traffic in the area meant aborting video/counting passes after the first pass (median group size: 3 whales).

We continued into Knik Arm, encountering Group 14 moving with the flood tide into Eagle Bay (no video; only counting passes: 3 whales). The final group of the day was near a tug south of the boat ramp near the Port of Alaska (two whales, no circling or video). A circuit of Fire Island and the north shoreline of Chickaloon Bay to Potter Marsh completed the upper inlet survey (Fig. 11). Other marine mammal sightings included harbor seals hauled out at the Susitna River (300 and 20 seals; Appendix). Sighting conditions were excellent to fair with a very brief period of poor in Chickaloon Bay, with Beaufort sea states ranging from 1 to 3. Total flight time: 3.5 hours.

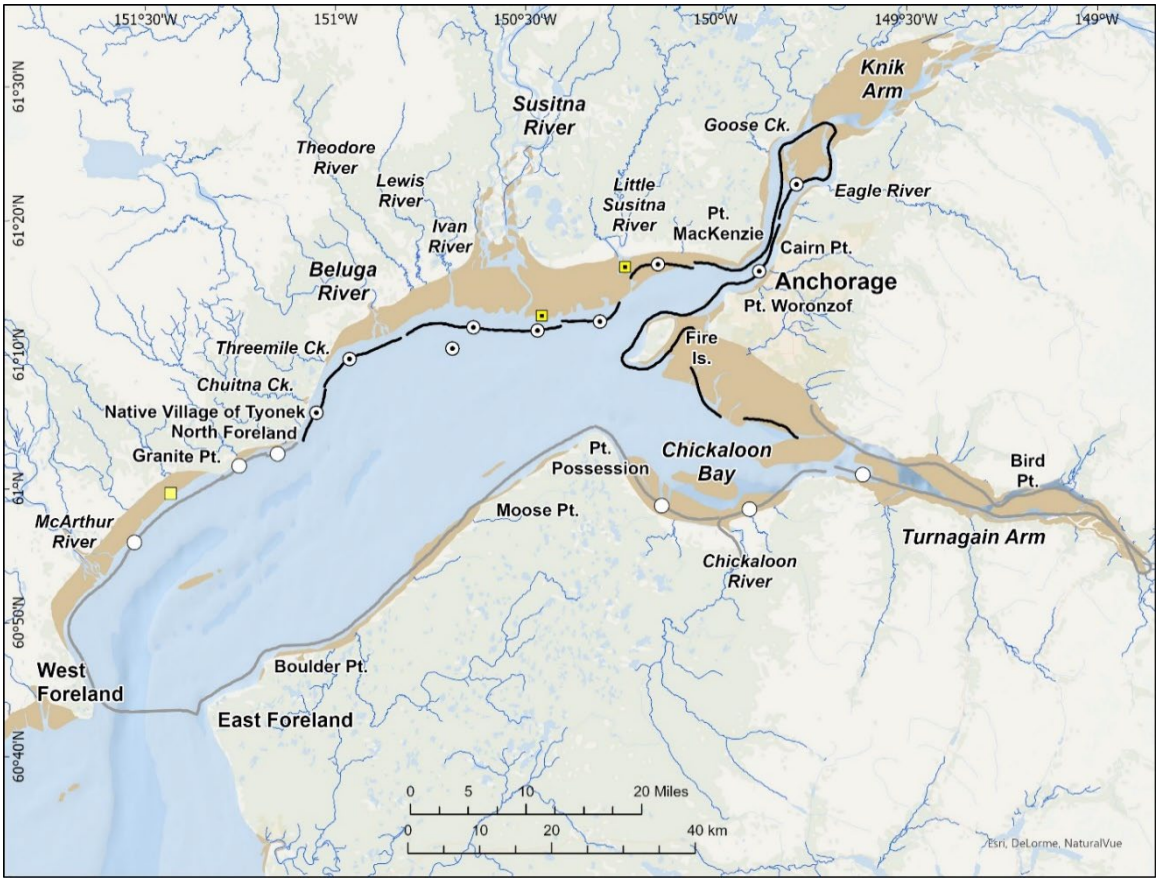


Figure 11. -- On-effort trackline and all observed marine mammal sightings on 26 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 6 and 7, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

27 June 2021

The second complete survey of upper Cook Inlet included all coastal areas north of East and West Foreland. Low tide was predicted at -3.9 ft at the Fire Island station at 16:03 AKDT. We departed Merrill Field at 09:05 (Flight 8) and began the on-effort coastal survey in Turnagain Arm at Potter Marsh (Fig. 12). After seeing belugas near McHugh Creek (Group 1) we found the GPS was not working with the survey program so we went off effort to fix the problem. We resumed the survey and conducted four video/counting passes of Group 1 (median group size: 6 whales). We surveyed the entire Arm to Twenty Mile River but low clouds and rain kept us from Portage/Palmer. In Chickaloon Bay, we observed belugas (Group 2) swimming west of Chickaloon River heading toward the Chickaloon Bay bluffs (5 video/counting passes; median count: 7 whales). An off-effort sighting of belugas in Indian Creek just east of Chickaloon River occurred during the end of the first video pass on Group 2. We did not video Group 3 but counts (median group size: 3 whales) occurred as we lined up for the east and west passes for Group 2.

We continued the survey to East Foreland, crossed the inlet to West Foreland, and entered Trading Bay heading north. Group 4 was north of the McArthur River (4 video/counting passes; median group size: 12 whales), Group 5 near Nikolai Creek (4 video/counting passes; median group size: 17 whales), and Group 6 was transiting into Trading Bay under the dock at North Foreland (4 video/counting passes; median group size: 40 whales). We encountered Group 7 at Threemile Creek (5 video/counting passes; median group size: 13 whales). Two additional off-effort sightings of 1 and 8 belugas were made but whales were too scattered for video/counting passes. Other marine mammal sightings included 70 harbor seals hauled out at the mouth of the Beluga River (Appendix). The tide was still ebbing so we returned to Merrill Field to fuel and wait for the low tide. Except for small portions of Turnagain Arm, sighting conditions were fair to excellent, with Beaufort sea states ranging from 1 to 3. Total flight time: 4.8 hours.

We departed Merrill Field at 15:21 AKDT, traveling over land until arriving at the Ivan River (Flight 9). Group 8 was between the Beluga and Theodore rivers, we attempted 5 video/counting passes (median group size: 10 whales) during which the support mount for the paired cameras broke. Whales began to scatter, so we aborted further attempts on Group 8. The videographer handheld the camera system during four counting passes on Group 9 (found between the east and west tributary of the Susitna River; median group size: 13 whales). A small group in Knik Arm in Goose Bay was circled for counting but not video (3 whales). The survey ended with a circuit of Fire Island and the shoreline to Potter Marsh (Fig. 12). The only other marine mammals observed were harbor seals hauled out (1 and 120 seals) at the eastern tributary of Susitna River (Appendix). Sighting conditions were fair to excellent, with Beaufort sea states ranging from 1 to 3. Total flight time: 3.5 hours.

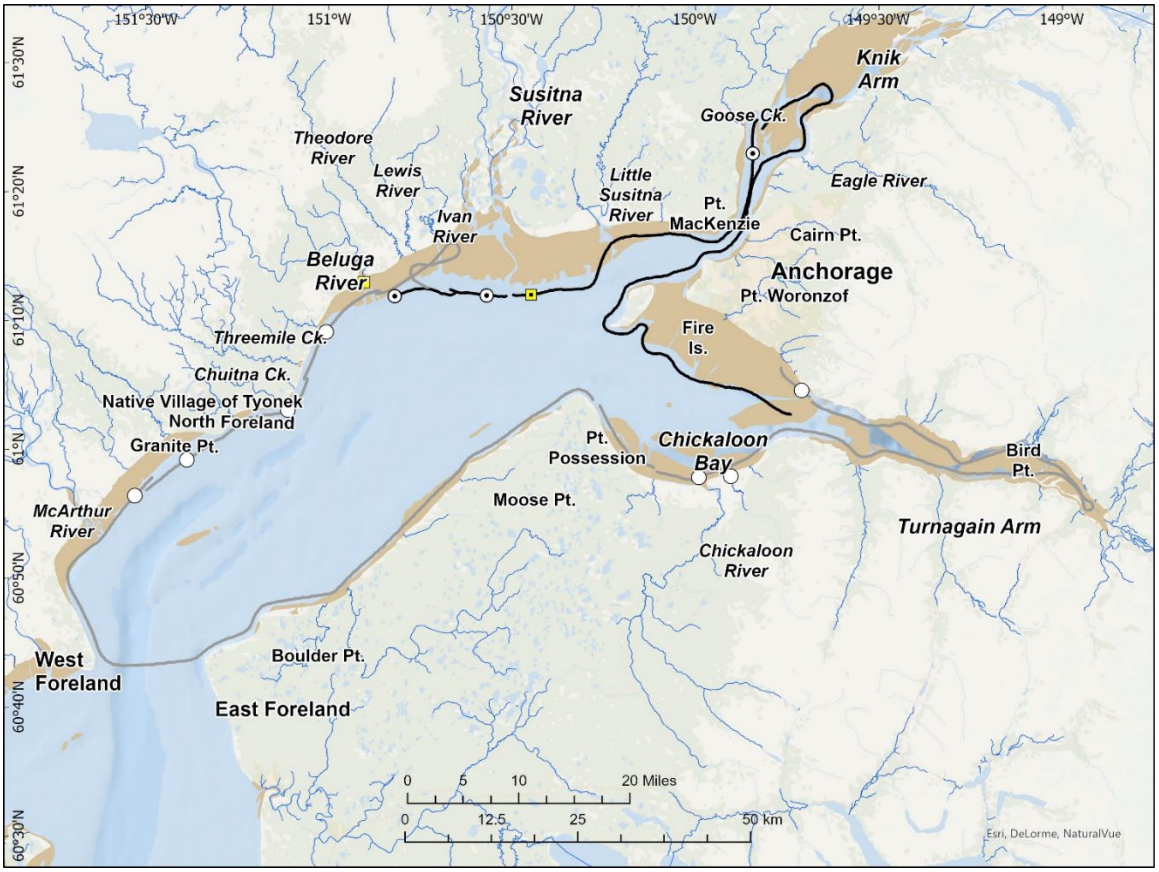


Figure 12. -- On-effort trackline and all observed marine mammal sightings on 27 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 8 and 9, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

28 June 2021

The negative low tide (-2.2 ft) was predicted for 16:51 AKDT at Fire Island. We departed Merrill Field at 09:55 AKDT (Flight 10) and began the survey in Turnagain Arm (Fig. 13). Unlike the previous two days, no whales were in the Arm. Group 1 was encountered at Chickaloon River (5 video/counting passes; median group size: 10 whales). Group 2 was approaching the Chickaloon Bay bluffs (4 video/counting passes; median group size: 8 whales). We continued the coastal survey to Moose Point where Group 3 was observed (5 video/counting passes; median group size: 4 whales).

After transiting across the inlet off effort from East to West Foreland due to low clouds, Group 4 was sighted north of McArthur River (5 video/counting passes; median group size: 12 whales). We could not survey the shoreline between Granite Point and North Foreland due to low clouds. Belugas were again scattered in the Susitna Delta. After attempting video passes on Group 5 from Chuitna to Beluga River (4 video/counting passes; median group size 10 whales), we decided to return closer to the low tide. We picked up the coastal survey east of the Little Susitna River and surveyed Knik Arm. Group 6 was departing Eagle Bay in Knik Arm (no video passes but the group was circled to get a best estimate of 6 whales). We completed the survey with a circuit of Fire Island and the shoreline to Potter Marsh. Other marine mammal sightings included 8 harbor seals hauled out at Chickaloon River (Appendix). Sighting conditions ranged from excellent to poor (due to low clouds), with Beaufort sea states ranging from 0 to 3. Total flight time: 4.7 hours.

After fueling at Merrill Field, we returned to Granite Point and continued the coastal survey (Flight 11). A lone beluga was near North Foreland (only seen once: Group 7). Unfortunately, belugas were still scattered nearshore and offshore in the Susitna Delta. We completed a series of transects parallel to the shore and offset at about 1 km strip widths (Fig. 13). Overall, there were 47 sightings of 81 whales between the Little Susitna River and Chuitna Creek.

We also observed a liquefied natural gas (LNG) vessel transiting through the area very close to the offshore beluga sightings during the survey. Sighting conditions were fair to excellent with Beaufort sea states ranging from 2 to 3. Total flight time: 2.5 hours.

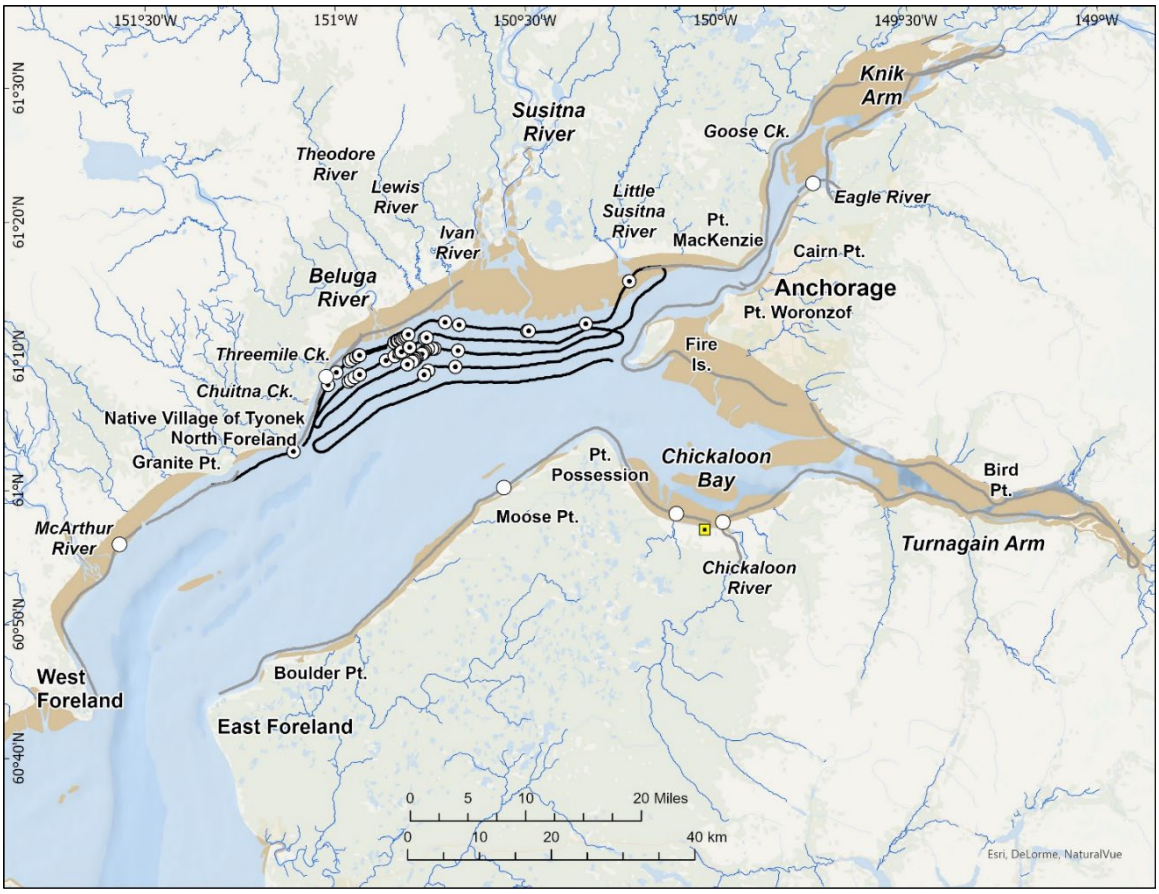


Figure 13. -- On-effort trackline and all observed marine mammal sightings on 28 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 10 and 11, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

29 June 2021

Conditions were favorable for a lower inlet survey to complete the east coast to English Bay and offshore sawtooth waypoints 10-18. We departed Merrill Field in Anchorage at 10:06 AKDT (Flight 12) and transited to the Kasilof River (Fig. 14). We briefly diverted to check on an aircraft seen upside down near a lake about 23 miles north of Kenai. The accident happened on the 28th and all on board were safe. We began the coastal survey at Kasilof River and ended in English Bay. Marine mammal sightings (Appendix) included numerous sea otters (54 sightings of 1,143 otters, including several running counts), harbor seals hauled out at Fox River and in coves (9 sightings of 399 seals), and an unidentified whale as we entered Kachemak Bay. We then transited to Waypoint 10. High seas states and glare resulted in poor sighting conditions at the beginning of the trackline. Conditions improved and there were multiple sightings of harbor porpoises (17 sightings of 24 porpoises) and one minke whale during the survey from Waypoints 10-12. We landed in Homer to fuel before continuing the sawtooth heading north. Sighting conditions ranged from excellent to poor (due to glare and high sea states) with Beaufort sea states ranging from 1 to 4. Total flight time: 3.0 hours.

High sea states continued to effect visibility near the eastern shoreline as we began the survey from Waypoint 12 (Flight 13, Fig. 14). There was one sighting of two harbor porpoises on the line from Waypoint 12 to 13 (Appendix). Another harbor porpoise was sighted on the line from Waypoint 13 to 14. Except for a jumping fish (silvery-white) seen on the line from Waypoint 14 to 15, no other sightings occurred on the remainder of the sawtooth tracklines. The survey ended at Waypoint 18 in Chickaloon Bay. Sighting conditions ranged from excellent to poor (due to glare and high sea states) with Beaufort sea states ranging from 2 to 5. Total flight time: 1.6 hours.

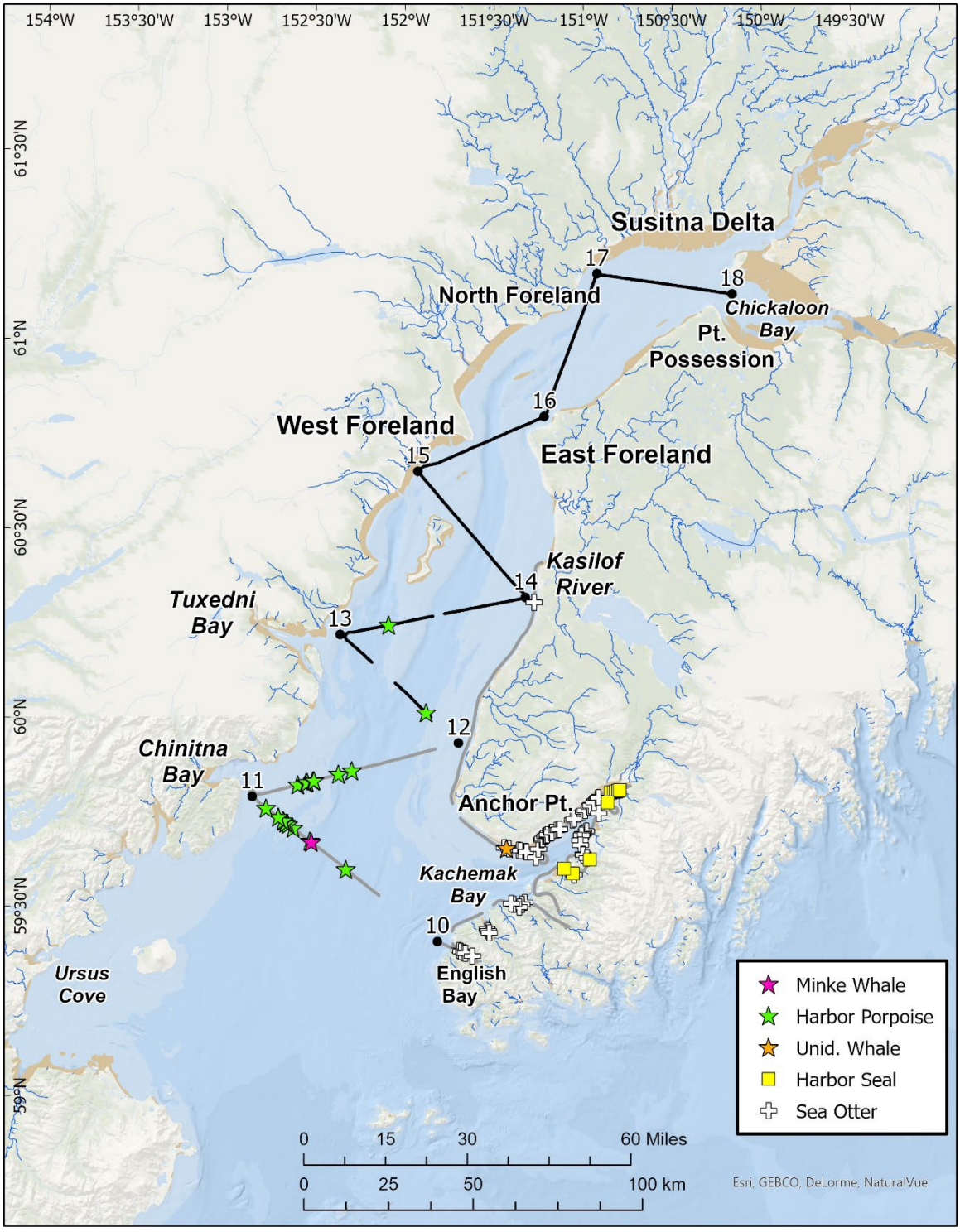


Figure 14. -- On-effort trackline and all observed marine mammal sightings on 29 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 12 and 13, respectively. Tan areas indicate mudflats.

30 June 2021

Given belugas were found predominantly in small groups and scattered from shore to waters deeper than 10 m in the Susitna Delta on previous flights (i.e., Flights 4 and 11) during the 2021 survey; we opted to set up distance sampling strata similar to those first tested during the 2018 survey with the addition of lines in Trading Bay. The study area was divided into the following areas and strata: Knik Arm (standard coastal survey), Turnagain Arm (standard coastal survey), Chickaloon Bay (distance strata), Trading Bay (distance strata), Susitna Delta (distance strata), Point Possession – Boulder Point (standard coastal survey), and Campbell Point – Potter Marsh (standard coastal survey) (Fig. 15). We planned to survey the Susitna strata on the high tide but low clouds (500 ft) prevented us from surveying Trading Bay and the Susitna in the morning. Instead, we surveyed Turnagain Arm (1 sighting of 1 beluga near Hope) including the Placer River, the Chickaloon Bay stratum (9 sightings of 11 whales), Knik Arm (no whales), and Campbell Point – Potter Marsh (no whales) (Flight 14). No other marine mammals were observed. Sighting conditions were fair to excellent with Beaufort sea states ranging from 0 to 4. Total flight time: 3.8 hours.

After fueling, we transited to Point Possession to begin surveying south to Boulder Point (1 whale near Moose Point) before crossing the inlet to West Foreland to survey the Trading Bay stratum (7 sightings of 9 whales including one off effort), and the Susitna Delta stratum (23 sightings of 82 whales). The afternoon survey (Flight 15) was conducted on the low tide (+2 ft). Other marine mammal sightings included harbor seals hauled out near Theodore River (25 seals), and in the Susitna (200 seals) (Appendix). Sighting conditions ranged from excellent to poor (due to high sea states, glare, and low clouds), with Beaufort sea states ranging from 0 to 5. Total flight time: 4.0 hours.

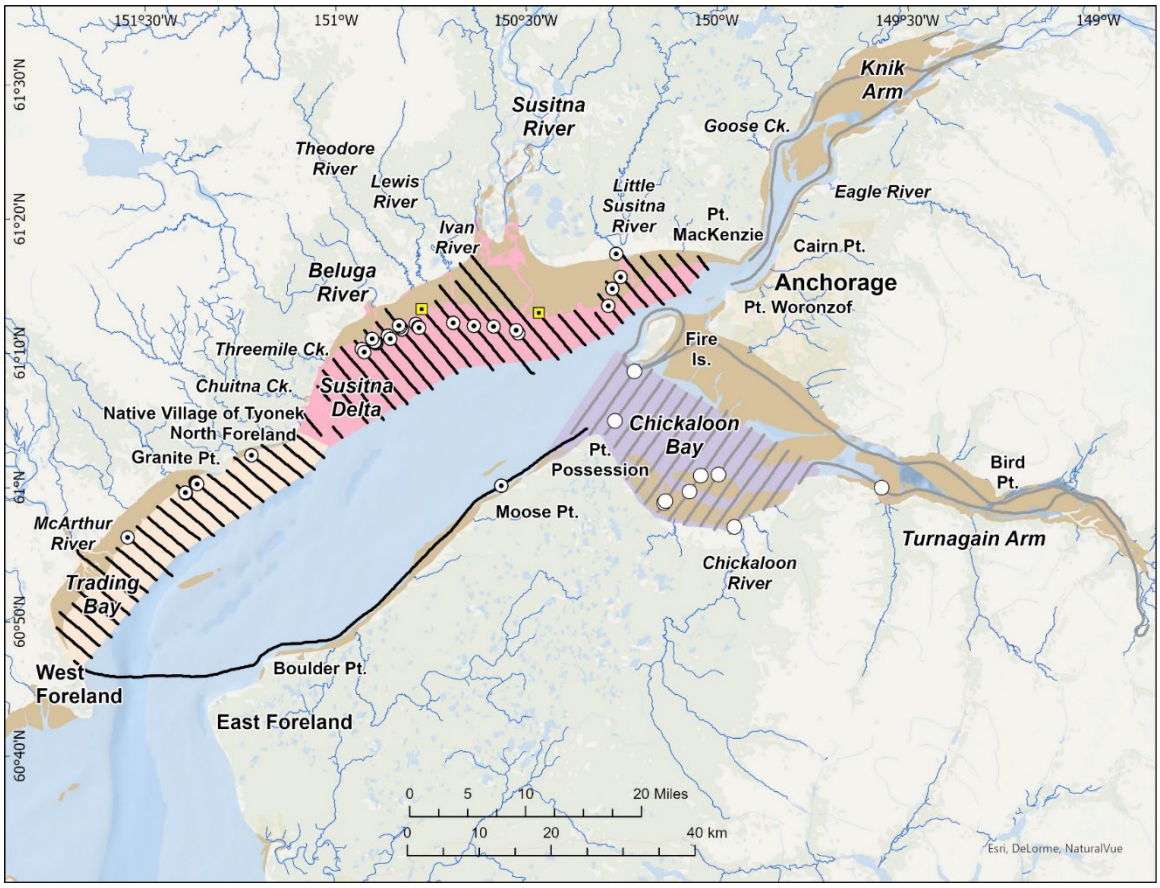


Figure 15. -- On-effort trackline and all observed marine mammal sightings on 30 June during the 2021 beluga aerial survey, Cook Inlet, Alaska. Beluga whale sightings are shown as white circles. Gray and black lines indicate Flights 14 and 15, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats. Yellow, pink, and purple areas represent the three distance strata in Trading Bay, the Susitna Delta, and Chickaloon Bay, respectively.

1 July 2021

We conducted a second day of distance sampling, reversing the strata to survey Susitna on the high tide. We departed Merrill Field at 09:42 AKDT (Flight 16) and began with the Trading Bay stratum (5 sightings of 9 whales) and ended with the Susitna Delta stratum (37 sightings of 110 whales including 4 off-effort sighting of 16 whales when transiting to the next line) before landing to fuel (Fig. 16). The survey also included the major rivers until depth appeared shallow: McArthur, Beluga, Susitna, and Little Susitna. Other marine mammal sightings included harbor seal haulouts (10 and 100 seals) on the Theodore and Lewis rivers and in the Susitna Delta (50 seals) (Appendix). Sighting conditions were excellent to fair, with Beaufort sea states ranging from 1 to 4.
Total flight time: 4.9 hours.

The second flight included Knik Arm (1 sighting of 1 whale), Fire Island – Potter Marsh (no whales), Turnagain Arm (no whales), the Chickaloon Bay stratum (2 sightings of 7 whales including one off effort sighting), and Moose Point – Boulder Point (no whales). Much of the survey (Flight 17) occurred on the low tide except for Knik Arm. Sighting conditions in Turnagain Arm were affected by 35 kt wind gusts across the shallows in some areas, otherwise Beaufort sea states ranged from 0 to 4, with excellent to fair visibility (Fig. 15). Other marine mammal sightings include harbor seals hauled out and in the water (60 seals) in Chickaloon Bay (Appendix). Total flight time: 3.6 hours.

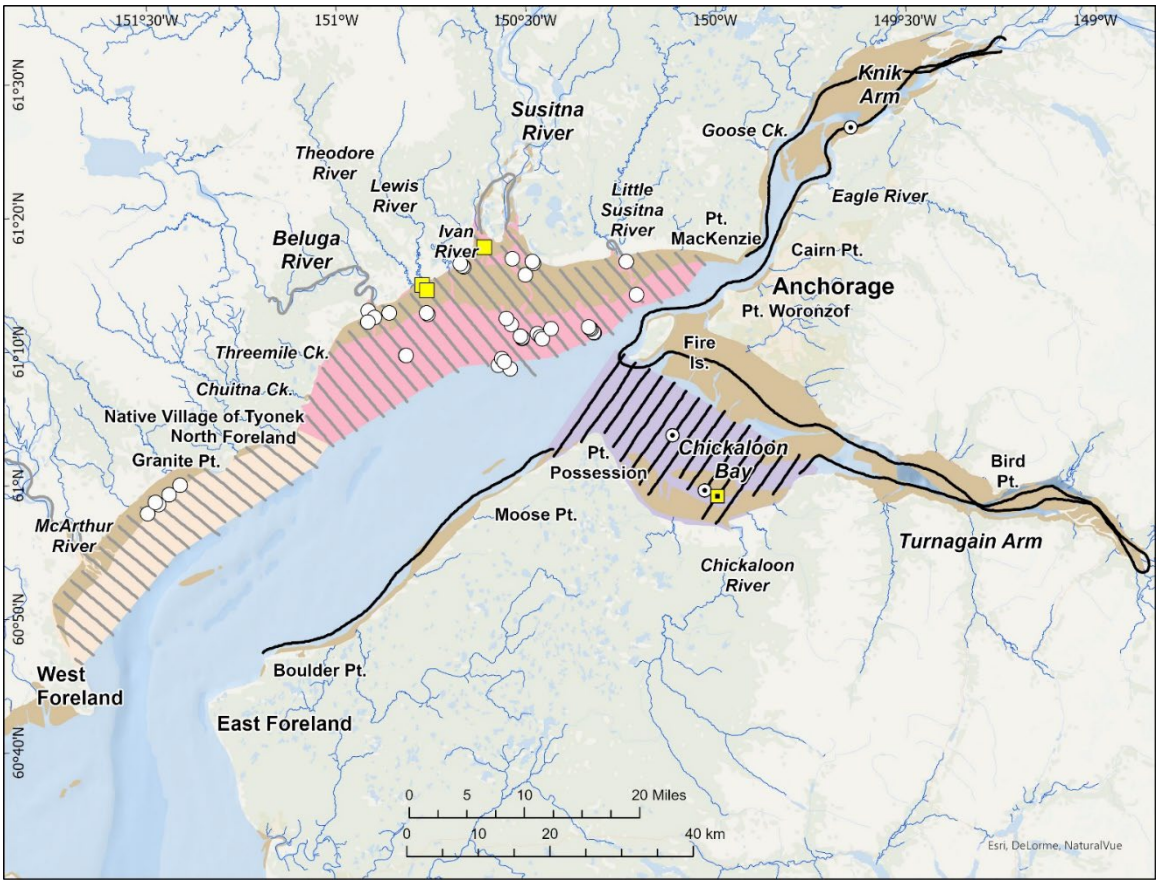


Figure 16. -- On-effort trackline and all observed marine mammal sightings on 1 July during the 2021 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 16 and 17, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats. Yellow, pink, and purple areas represent the three distance strata in Trading Bay, the Susitna Delta, and Chickaloon Bay, respectively.

2022 Summary Counts and Daily Reports

Median counts of beluga groups for each area are presented in Table 2. Typically, there were four good counts made by two observers for each group. The use of medians (instead of means or maximum counts) and the consistency of the observation team have meant that changes in index counts between years are probably not a function of observer performance. In 2022, all three of the standard survey days -- 15-17 June -- included complete coverage of the upper inlet following video/counting protocols. The maximum median index count was 224 belugas on 17 June, which falls within index counts generated to date for this project since 2004 (Wade et al. 2019). These summary counts do not reflect any correction for missed whales or groups.

Day-by-day survey effort and marine mammal sighting locations are summarized below. Lower inlet surveys were planned for the beginning or end of the project in order to prioritize upper Cook Inlet surveys when tides were more favorable (negative low tides later in the day).

Table 2. -- Beluga counts made during aerial surveys of Cook Inlet in June 2022. Counts are the median sum of multiple counts from each whale group except for distance sampling days (*) which are the total count including off-effort sightings. Dashes (---) indicate no survey effort and zeroes (0) indicate that the area was surveyed but no whales were seen. Locations are listed in a clockwise order around Cook Inlet starting with Turnagain Arm with shaded rows indicating lower Cook Inlet. If more than one group was found within a location, the median for each group was summed (see Daily Reports for specific group locations and counts). Note: all median group counts were rounded up when the final median included a "partial" whale.

Location	6/6*	6/8	6/9*	6/12	6/15	6/16	6/17	6/18
Turnagain Arm	0	---	0	---	3	0	0	--
Chickaloon Bay	8	---	30	---	4	10	3	---
Pt. Possession-E. Foreland	0	---	0	---	0	0	0	---
Mid-inlet tracklines	---	0	---	---	0	---	---	21c
E. Foreland-English Bay	---	---	---	---	---	---	---	1d
Ursus Cove-Harriet Pt.	---	0	---	---	---	---	---	---
Redoubt Bay	---	0	---	---	---	---	---	---
Trading Bay	0	---	0	---	42	45	29	---
Susitna Delta (a)	110	---	197	104b	103	169	150	---
Knik Arm	0	---	0	---	0	0	0	---
Fire Island	0	---	0	---	0	0	4	---
Index count	118	0	227	---	152	224	186	22

a. Region from North Foreland to Point MacKenzie
b. Conducted practice video passes on a group of whales spread from North Foreland to Beluga River. The Cook Inlet Beluga Whale Photo-ID team was working with another beluga group along the tributaries of the Susitna River.
c. Belugas seen along the trackline near Waypoint 17 in the upper inlet off Beluga River.
d. One beluga near the bridge on the Kenai River. Low clouds south of Kachemak Bay prevented us from surveying all the way to English Bay and to Waypoint 10. Line 10 to 11 was picked up mid-inlet.

6 June 2022

Given the tides were not predicted to be low enough for aggregating belugas until the following week, we opted to fly the distance sampling lines that were created last year within three strata: Chickaloon Bay, Trading Bay, and the Susitna Delta (Flight 1) (Fig. 17). Additionally, the entire upper coast of Cook Inlet was surveyed to ensure that belugas were not present outside the three strata. Due to low winds in Turnagain Arm, with predictions to increase later in the day, we started the survey at Potter's Marsh and completed the entirety of Turnagain Arm before flying lines in the Chickaloon Stratum. No sightings were reported in Turnagain Arm but there were 5 beluga sightings (8 whales) just west of Chickaloon River. After completing survey lines in the Chickaloon strata, we finished the flight by circling Fire Island and surveying Knik Arm (no belugas found). Due to air traffic, the small section of the coastline between Eagle Bay and Point Woronzof could not be surveyed. No other marine mammals were observed. Sighting conditions were fair to excellent with Beaufort sea states ranging from 0 to 3. Total flight time: 3.4 hours.

After fueling, we transited to Point Possession to begin surveying south to East Foreland before crossing the inlet to West Foreland to survey the Trading Bay and Susitna Delta stratum (Flight 2). No belugas were found along the coast or within the Trading Bay stratum. However, one sighting of 30 hauled-out harbor seals was documented near McArthur River. Within the Susitna strata, there were: 4 beluga sightings (20 whales) south of Beluga River, 4 beluga sightings (9 whales) near Beluga River, 15 beluga sightings (36 whales) between Theodore and Ivan rivers, 20 beluga sightings (43 whales) in the Susitna Delta, and 2 beluga sightings (2 whales; one whale was seen off effort in the mouth of the little Susitna River) near the Little Susitna River for a total of 110 belugas. Other marine mammal sightings included harbor seals hauled out near the Lewis and Ivan rivers (32 seals), and in the Susitna (450 seals) (Appendix). Sighting conditions were fair to excellent, with Beaufort sea states ranging from 1 to 4. Total flight time: 3.5 hours.

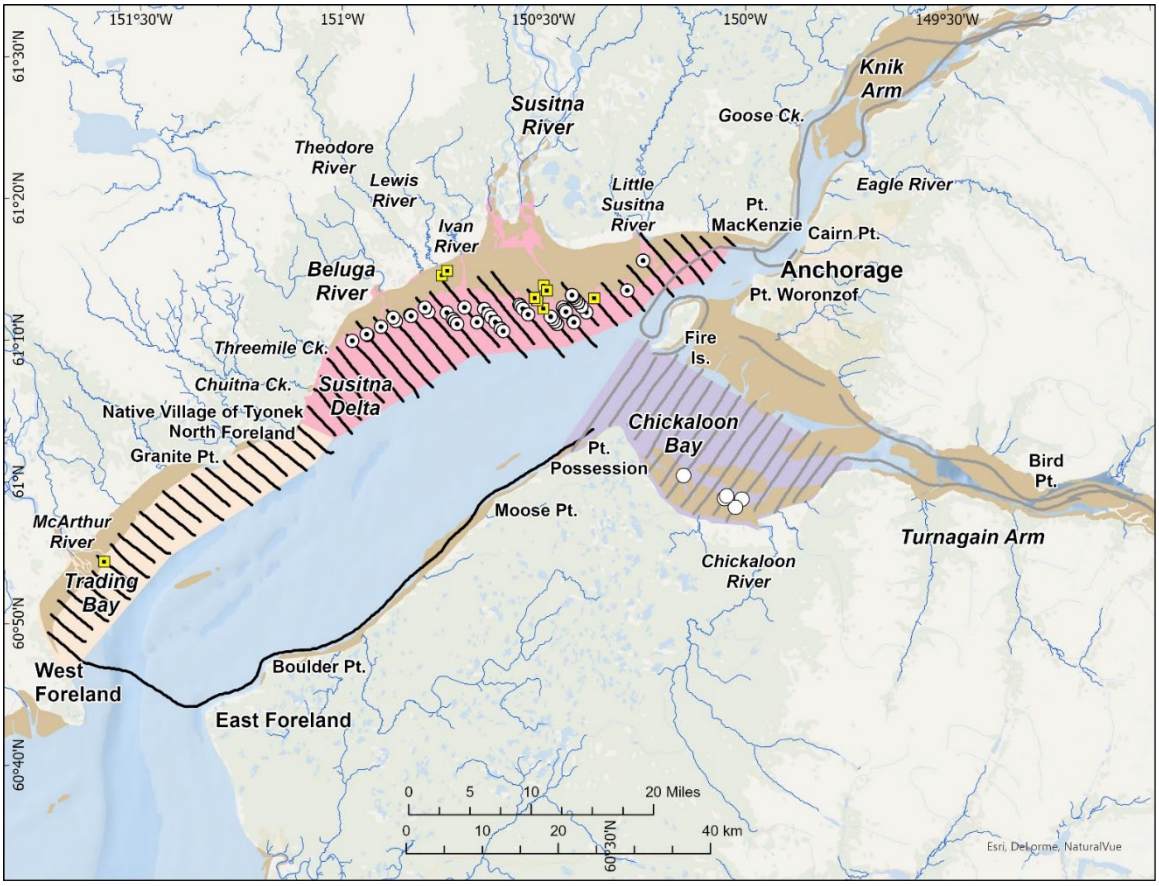


Figure 17. -- On-effort trackline and all observed marine mammal sightings on 6 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 1 and 2, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats. Yellow, pink and purple areas represent the three distance strata in Trading Bay, the Susitna Delta, and Chickaloon Bay, respectively.

7 June 2022

Down day due to high winds and rain throughout the Inlet (Fig. 18).

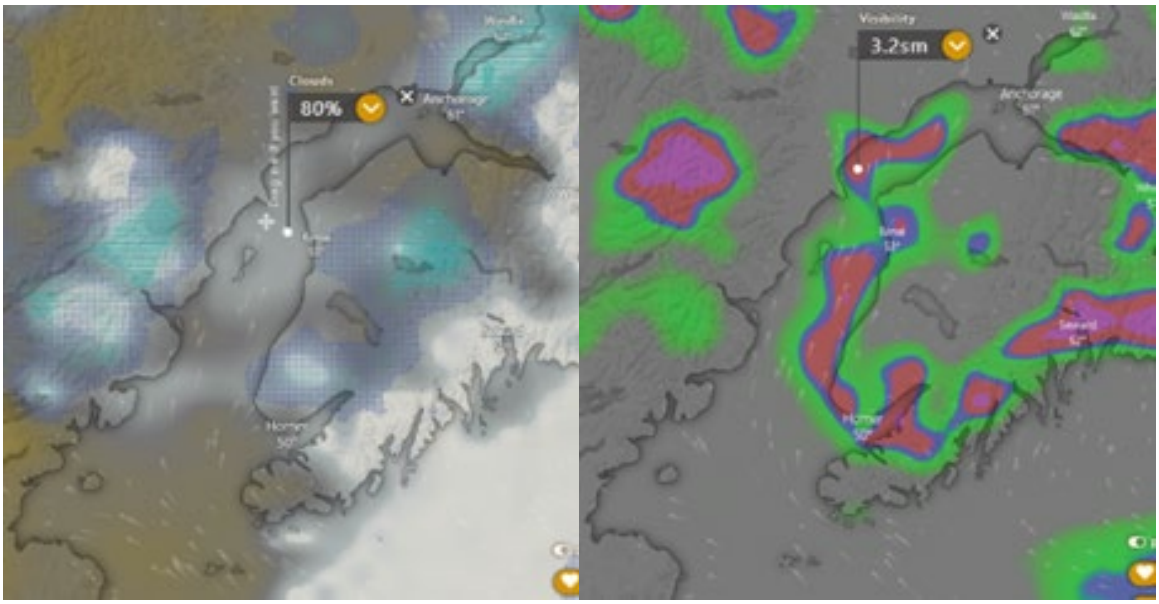


Figure 18. – Weather conditions on 7 June during the 2022 beluga aerial survey, Cook Inlet, Alaska.

8 June 2022

Due to favorable conditions, we conducted a survey of lower Cook Inlet, flying offshore transects from the Susitna Delta down to Homer (Flight 3), followed by an additional offshore transect across the inlet (Flights 4-5), and a coastal survey of the western side of lower Cook Inlet on the way back to Anchorage (Flight 5) (Fig. 19). After departing Anchorage, we completed offshore tracklines (waypoints 1-8) before stopping in Homer to refuel. Two sea otter sightings (3 otters total) and one harbor seal sighting (2 seals) were reported on the line running between waypoints 6-7, and 19 sightings of sea otters (98 otters) were documented on the line between waypoints 7-8. The trackline between waypoints 7-8 also included 3 killer whale sightings (4 whales) and one humpback whale sighting (3 whales) in the same vicinity of each other (Fig. 19).

After circling the area, the number of killer whales was estimated at 20-30, dispersed within smaller sub-groups. At least one mom/calf pair and two large bulls were seen in different subgroups. Throughout the encounter, the three humpback whales appeared to separate with two humpbacks headed in one direction and a single humpback headed in a different direction. Killer whales appeared to be headed towards the humpback whales, but ecotype could not be determined. Effort was resumed until reaching waypoint 8, after which we landed in Homer to refuel. Sighting conditions were good to excellent, Beaufort sea states ranged from 2 to 3. Total flight time: 2.4 hours.

After refueling in Homer, the flight team resumed effort at waypoint 8, heading to waypoint 9 (Flight 4). However, due to power issues resulting in the computer battery not charging, we returned to Homer after 0.4 hours to troubleshoot the issue. During this short flight, 25 sea otter sightings (241 otters total) and 3 humpback whale sightings (3 whales) were reported. Once power issues were resolved, we departed Homer a second time (Flight 5) and resumed the transect line across the inlet from waypoint 8 to 9. Towards the end of the line, 2 harbor porpoises and 11 sea otter sightings (47 otters total) were reported as we approached the western side of lower Cook Inlet. Once across the inlet, a coastal survey was conducted from Ursus Cove to West Foreland and around Kalgin Island. Coastal sightings included 9 sea otter sightings (16 otters), one harbor porpoise, and 10 harbor seal sightings (343 seals). Sighting conditions were fair to excellent with Beaufort sea states ranged from 1 to 4. Total flight time: 2.9 hours.

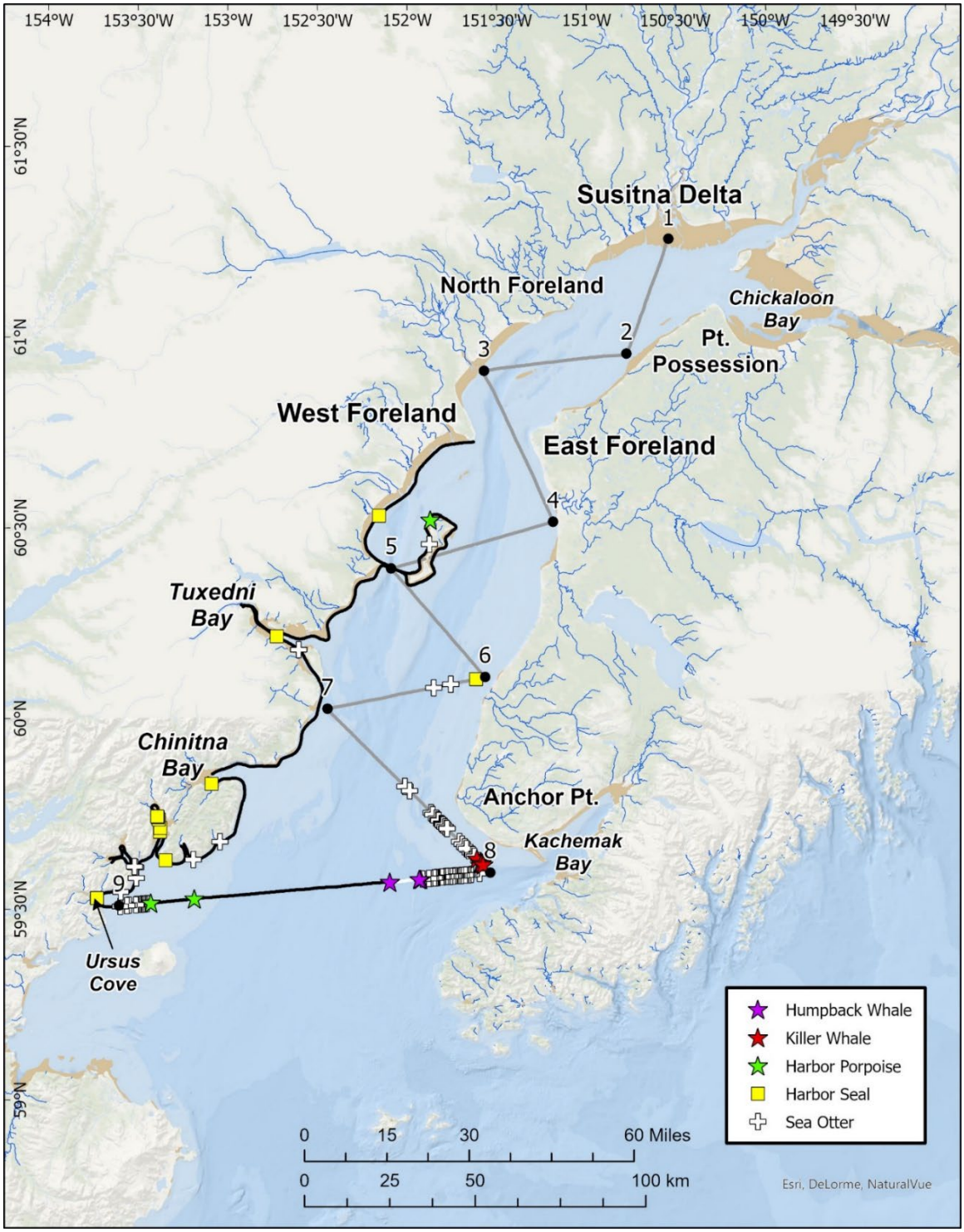


Figure 19. -- On-effort trackline and all observed marine mammal sightings on 8 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray, white, and black lines indicate Flights 3, 4, and 5, respectively. Tan areas indicate mudflats.

9 June 2022

We flew a second day of distance sampling lines in three stratum in addition to coastal surveys to obtain complete survey coverage of upper Cook Inlet. During the first flight (Flight 6), a coastal survey was conducted from Point Possession to East Foreland before crossing the inlet and starting the line transect survey in the Trading Bay stratum (Fig. 20). No sightings were reported in the Trading Bay stratum, and we continued into the Susitna stratum where all transect lines were completed. Belugas were scattered both east and west of the Beluga River for a total of 43 sightings (163 whales). Three beluga sightings were reported near the Ivan River (4 whales), 4 sightings near Susitna River (11 whales), and one sighting in the Little Susitna River (8 whales). One off effort beluga sighting (11 whales) was reported mid-inlet, just beyond the transect line, while transiting to the following line. Other sightings in the Susitna stratum include 6 harbor seal groups (226 seals). After completing transect lines in the Susitna stratum, we conducted a coastal survey of Knik Arm, around Fire Island, and along Potters Marsh before landing in Anchorage to refuel. No additional sightings were reported during the coastal survey. Sighting conditions were good to excellent with Beaufort sea states ranging from 0-3. Total flight time: 5.1 hours.

After refueling in Anchorage, we conducted a second flight (Flight 7) to complete survey coverage of upper Cook Inlet. After departure, we flew a coastal survey of Turnagain Arm (no sightings) before starting transect lines in the Chickaloon Bay stratum. Four beluga sightings (7 whales) were reported near Chickaloon River and additional 11 sightings were reported in the western portion of stratum (23 whales). Sighting conditions were good to excellent with Beaufort sea states ranging from 1-2. Total flight time: 2.3 hours.

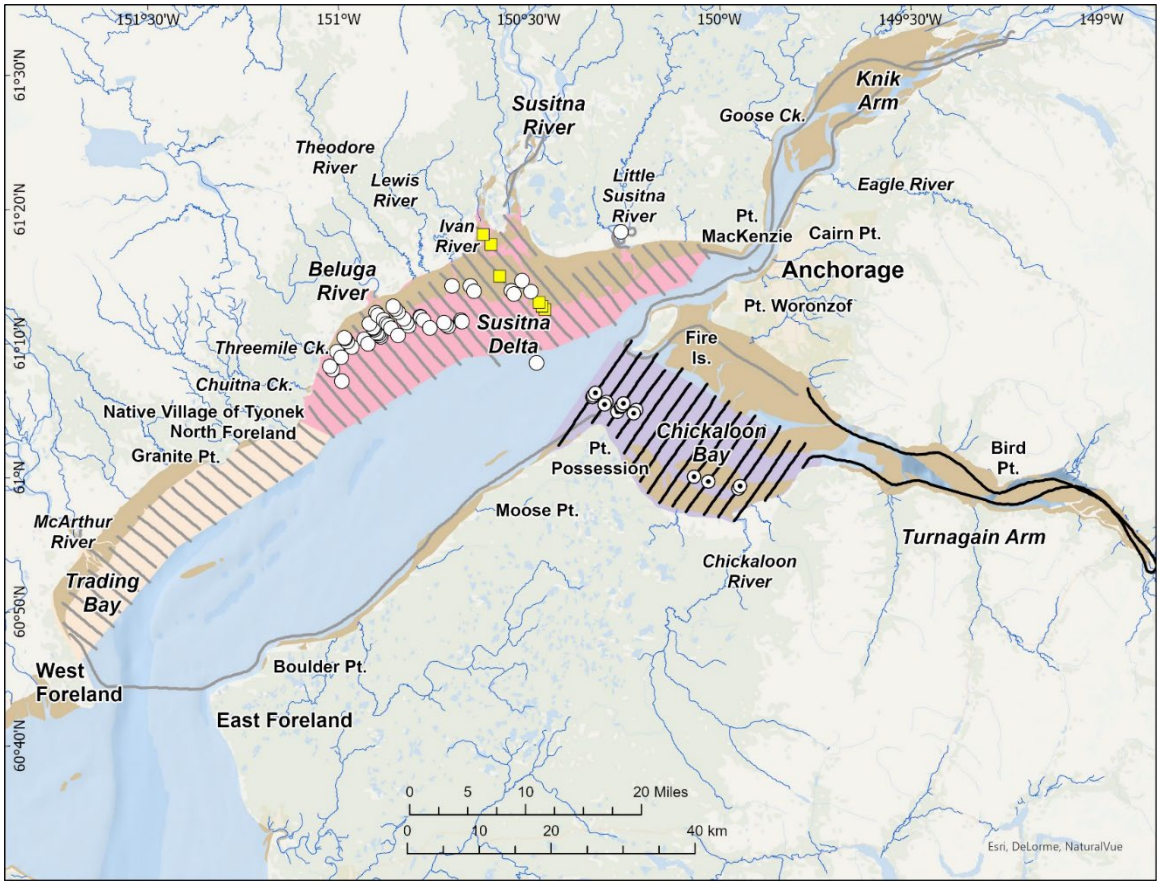


Figure 20. -- On-effort trackline and all observed marine mammal sightings on 9 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 6 and 7, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats. Yellow, pink and purple areas represent the three distance strata in Trading Bay, the Susitna Delta, and Chickaloon Bay, respectively.

10-11 June 2022

Down days due to high winds, low clouds, and fog throughout the inlet (Fig. 21). Haze from multiple fires began to affect visibility by 12 June.

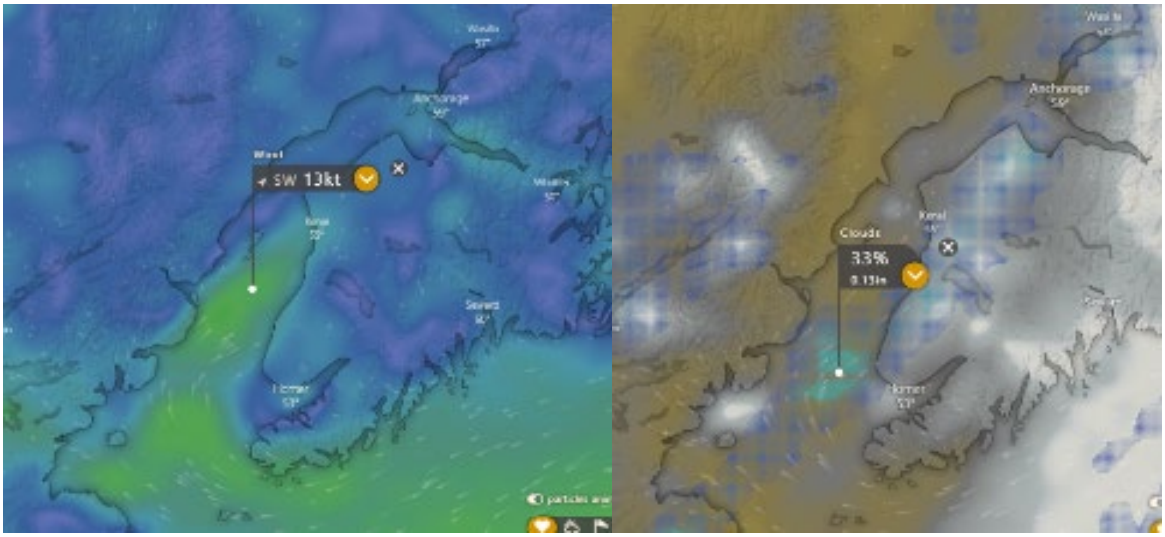


Figure 21. – Weather conditions on 10-11 June during the 2022 beluga aerial survey, Cook Inlet, Alaska.

12 June 2022

Flight 8 was devoted to testing the new mounting system for the video cameras. The survey was timed to take advantage of the -2.4 ft tide in the Susitna Delta (Fig. 22). Two groups of belugas were observed. Group 1 was spread from Threemile Creek to the Ivan River (~70 whales). Group 2 was along the east and west tributaries of the Susitna River (~34 whales). The Cook Inlet Beluga Whale Photo-ID Project boat was collecting data on whales within Group 2, therefore, we did not collect video/counting data on this group.

Figure 20. -- Off-effort trackline and all observed marine mammal sightings on 12 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray line indicates Flight 8. Beluga whale sightings are shown as white circles. Tan areas indicate mudflats.

13-14 June 2022

Scheduled down day on 13 June due to aircraft availability. Weather also would have affected this survey day due to winds increasing throughout the day and low clouds in the lower inlet. Non-scheduled down day on 14 June due to aircraft delayed returning from Utqiagvik.

15 June 2022

15 June was the first day with negative low tides (> -5 ft.) to conduct a coastal abundance survey and collect video and counting passes. We planned to survey Turnagain Arm and Chickaloon Bay on the flood tide, continue the coastal survey to East and West

Foreland, and complete Trading Bay (flight 9) before returning to Merrill Field to refuel and return to the Susitna Delta and Knik Arm for the low tide around 14:30 (Flight 10). Flight 9 was conducted as outlined above and extended into the Susitna Delta where belugas were encountered between the Beluga and Ivan rivers before survey effort was terminated and returning to Merrill Field to refuel (Fig. 21). Beluga groups were observed in Turnagain Arm swimming from Bird Point east toward Hope (Group 1: 5 video/counting passes; median group size: 3 whales), near the Chickaloon Bay bluffs (Group 2: 4 video/counting passes; median group size: 4 whales), and in Trading Bay (Group 3: 6 video/counting passes, median group size: 42 whales). Belugas were encountered between Threemile Creek and Ivan River before terminating the survey to refuel at Merrill Field (no video/counting passes). Other marine mammal sightings included a single harbor seal swimming off Chickaloon River. Sighting conditions were excellent to fair with Beaufort sea states ranging from 0 to 4, with brief instances up to 5 in Turnagain Arm. Total flight time: 4.1 hours.

Flight 10 resumed survey effort at North Foreland. Beluga groups were between Threemile Creek and Ivan River (Group 4: 4 video/counting passes, median group size: 67 whales), along the tributaries of the Susitna River (Group 5: 4 video/counting passes, median group size: 30 whales), and between Little Susitna River and Point MacKenzie (Group 6: 5 video/counting passes, median group size: 6 whales). Survey effort included Knik Arm, Fire Island, and ended at Potters Marsh, completing the upper inlet coastline. Other marine mammal sightings included one harbor seal swimming off Chickaloon River and two harbor seal groups hauled out on the Susitna River mudflats (15 and 200 seals). Sighting conditions were excellent to fair with Beaufort sea states ranging from 1 to 4. Total flight time: 3.9 hours.

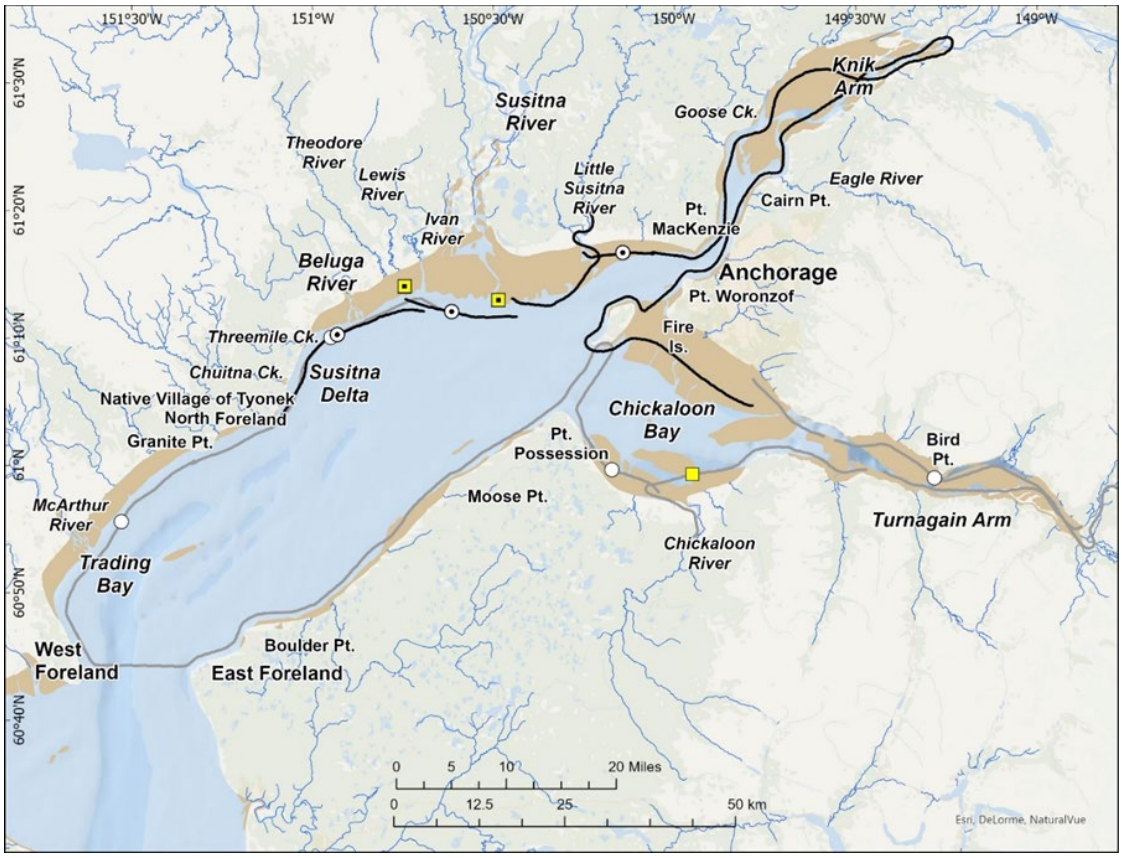


Figure 21. -- On-effort trackline and all observed marine mammal sightings on 15 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 9 and 10, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

16 June 2022

16 June was the second day with negative low tides (> -5 ft.) to conduct a coastal abundance survey and collect video and counting passes. We planned to fly the same pattern as on 15 June: Turnagain Arm and Chickaloon Bay on the flood tide, continue the coastal survey to East and West Foreland, and complete Trading Bay (Flight 11) with the possibility of continuing into the Susitna Delta and counting groups if whales were aligned along the mudflats before the low tide around 15:30. The survey was conducted as planned (Fig. 22), and beluga groups were observed east of Chickaloon River (Group 1: 6 video/counting passes; median group size: 5 whales), near the Chickaloon Bay bluffs

(Group 2: 6 video/counting passes; median group size: 5 whales), in Trading Bay between the McArthur River and Nikolai Creek, south of Granite Point (Group 3: 4 video/counting passes, median group size: 44 whales), and between Granite Point and North Foreland (Group 4: 5 video/counting passes: median group size: 1 whale). Belugas were once again encountered between Chuitna Creek and Ivan River (Group 5) but no counting passes were conducted as the tide was continuing to fall and belugas were still spread out within the mouth of the Susitna River (Fig. 22). Other marine mammal sightings (off effort) included a group of harbor seals (20 hauled out) at the Theodore River. We returned to Merrill Field to refuel and wait for the low tide. Sighting conditions were excellent to fair, with Beaufort sea states ranging from 1 to 3. Total flight time: 3.5 hours.

Survey effort resumed at North Foreland (Flight 12). Belugas groups were observed between Chuitna Creek and Ivan River (Group 5: 4 video/counting passes, median group size: 76 whales), and along the tributaries of Susitna River (Groups 6, 7 and 8: 4 video/ counting passes per group, median group sizes: 53, 23, and 17 whales, respectively). Survey effort included Knik Arm, Fire Island, and ended at Potters Marsh, completing the upper inlet coastline. Other marine mammal sightings (off effort) included four groups of harbor seals hauled out on the Susitna River mudflats (200, 10, 20, and 20 seals, totaling 250). Sighting conditions were excellent to fair with Beaufort sea states ranging from 1 to 3, and brief instances of Beaufort 4 near Fire Island. Total flight time: 3.3 hours.

Figure 22. -- On-effort trackline and all observed marine mammal sightings on 16 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 11 and 12, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

17 June 2022

Third day with negative low tides (> -4 ft.) to conduct a coastal abundance survey and collect video and counting passes. With the low tide predicted at 16:25 at Fire Island, we planned to first survey Knik Arm, Fire Island, Turnagain Arm, and Chickaloon Bay on the flood tide, then land to refuel and wait for the low tide (Flight 13). The survey would resume at Point Possession, continue down the coast to East Foreland then cross the inlet to survey the west coastline northbound and terminate at Point MacKenzie (Flight 14).

The survey was conducted as outlined above; however, because we were ahead of schedule rather than terminating the flight at Point Possession, we continued the survey to East Foreland, crossing the inlet to West Foreland, before returning to Anchorage to refuel (Fig. 23).

During Flight 13 (Fig. 23), beluga groups were encountered off the south tip of Fire Island (Group 1: 5 video/counting passes, median group size: 2 whales, and Group 2 [off effort sighting by computer operator]: 5 video/counting passes, median group size: 2 whales), and west of the mouth of Chickaloon River (Group 3: 7 video/counting passes, median group size: 3 whales). Sighting conditions were excellent to fair, with Beaufort sea states ranging from 1 to 4. Total flight time: 3.8 hours.

Flight 14 survey effort resumed at West Foreland following the coast north to Point MacKenzie (Fig. 23). Beluga groups were encountered in Trading Bay near Nikolai Creek, south of Granite Point (Group 4: 5 video/counting passes, median group size: 4 whales), in Beshta Bay near Granite Point (Group 5: 4 video/counting passes, median group size: 23 whales), at North Foreland (Group 6: 4 video/counting passes, median group size: 2 whales), off Chuitna Creek (Group 7: 1 whale, no video/counting passes), from Threemile Creek to Theodore River (Group 8: 4 video/counting passes, median group size: 80 whales), from Ivan River along the west tributary of the Susitna River (Group 9: 5 video/counting passes, median group size: 55 whales), at the east tributary of the Susitna River (Group 10: 4 video/counting passes, median group size: 2 whales), between the shoals and Fire Island offshore of the Little Susitna River (Group 11: 6 video/counting passes, median group size: 7 whales), and at the mouth of the Little Susitna River (Group 12: 4 video/counting passes, median group size: 5 whales). Other marine mammal sightings included harbor seals hauled out at Lewis River and along the Susitna River mudflats (243 seals total). Sighting conditions were excellent to fair, with Beaufort sea states ranging from 2 to 4. Total flight time: 3.8 hours.

Figure 23. -- On-effort trackline and all observed marine mammal sightings on 17 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray and black lines indicate Flights 13 and 14, respectively. Beluga whale and harbor seal sightings are shown as white circles and yellow squares, respectively. Black dots inside symbols indicate the second flight of the day. Tan areas indicate mudflats.

18 June 2022

The 2022 survey ended with a second day of surveying the lower inlet (Fig. 24). During Flight 15, belugas were encountered in the Kenai River (1 whale) and in the upper inlet near Waypoint 17 (17 sightings, 21 whales total). Other marine mammal sightings included one humpback whale (between Waypoints 12-13), 4 harbor porpoises (1 in Kachemak Bay, 1 near Waypoint 11, 1 between Waypoints 11-12, and 1 between Waypoints 12-13), harbor seals in Kenai River (1 sightings, 2 seals total), south of Anchor

Point (1 sighting, 2 seals total), hauled out at Fox River in Kachemak Bay (3 sightings, 79 seals total), hauled out on mudflats south of Kalgin Island (2 sightings, 60 seals total), and hauled out in Redoubt Bay near Big River (2 sightings (one off effort while turning onto the next transect line), 165 seals total). Sightings of sea otters occurred south of Kasilof River near Clam Gulch (1 otter), north of Kachemak Bay (2 otters), off Waypoint 12 (2 otters), and a running count of otters in Kachemak Bay (1,477 otters total).

Low clouds were encountered as we began the coastline exiting Kachemak Bay, preventing us from surveying Seldovia and English bays and having to begin the line between Waypoints 10 and 11 midway through the lower inlet (Fig. 24). Sighting conditions ranged from excellent to poor, with Beaufort sea states ranging from 1 to 5. Total flight time: 5 hours.

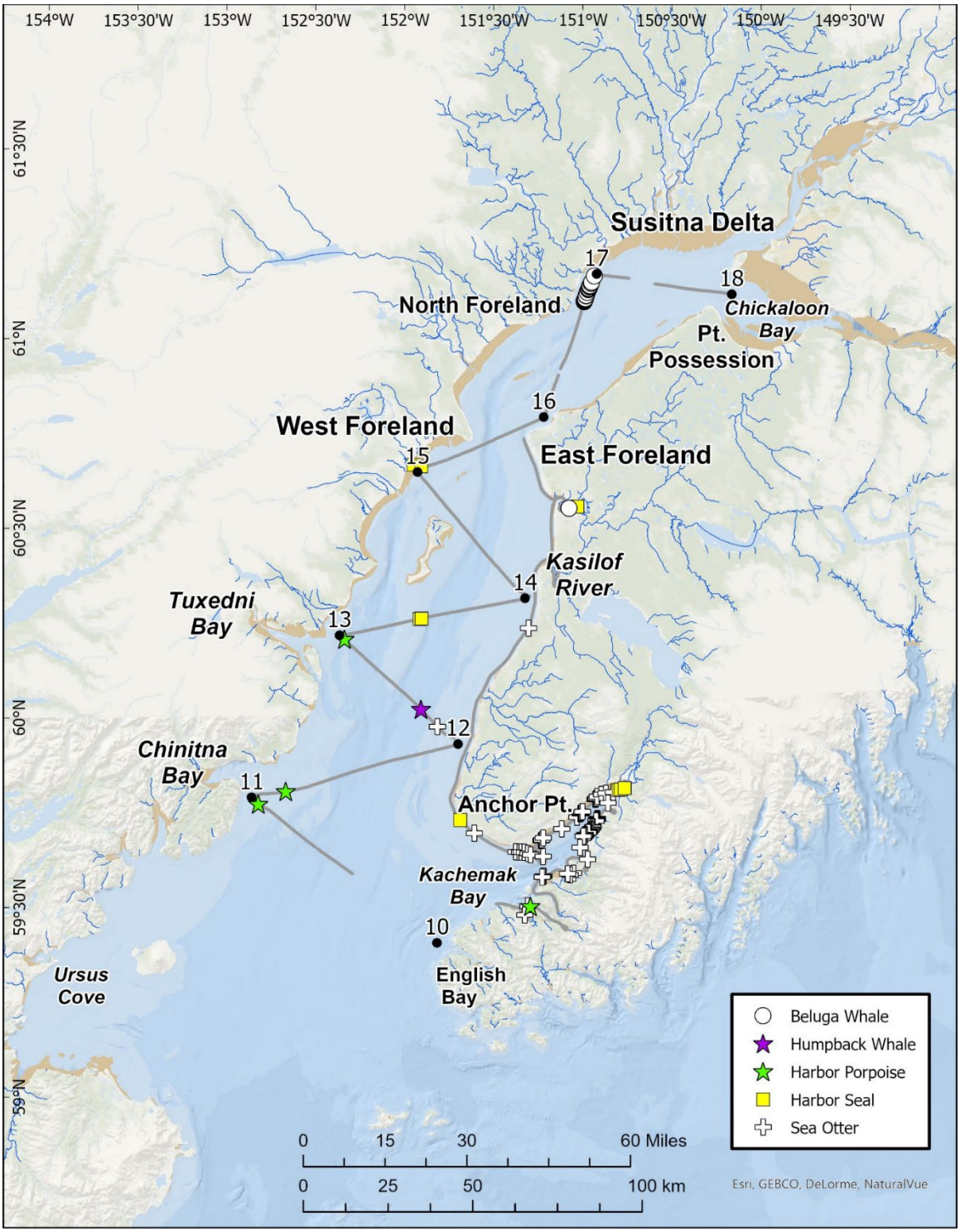


Figure 24. -- On-effort trackline and all observed marine mammal sightings on 18 June during the 2022 beluga aerial survey, Cook Inlet, Alaska. Gray line indicates Flight 15. Tan areas indicate mudflats.

Acceptable Survey Days

In 2021, 37 beluga whale groups were detected over the four standard survey days (June 22, 26, 27, 28). Only two of the four standard survey days were considered acceptable survey days for abundance estimation (i.e., June 26 and 27). On June 22 and 28, belugas were too scattered within the Susitna Delta to obtain video. Instead, a series of offshore transects were flown to sample the area and obtain a count. At this time, we do not feel it is appropriate to attempt to combine the two methodologies to obtain a daily abundance estimate for these two days until further analyses of the distance sampling data collected in 2018, 2021, and 2022 are completed.

On the two acceptable standard survey days, a total of 25 groups were detected; 15 on June 26 and 10 on June 27. The number of groups detected per day was similar to those observed in 2018 (9 and 12 groups). From 2004 to 2016, the number of groups per day on acceptable survey days ranged from 1 to 12 (median: 4) (Boyd et al. 2019). Observers were able to make one or more excellent/good counts on 25 groups (Table 3). Excellent/good video data were obtained for 14 of these groups which was within the range of video per groups collected since biennial surveys began in 2012 (Table 4).

In 2022, 26 beluga groups were detected over three standard survey days (June 15-17). The number of groups detected per day was similar to past surveys: 6 on June 15, 8 on June 16, and 12 on June 17 (Table 5). Observers were able to make one or more excellent/good counts on all groups with usable video data obtained on all but two groups (Table 5). Again, this percentage of video to observer counts fell within the range of past survey years (Table 4).

Table 3. -- Beluga whale groups in Cook Inlet, Alaska, June 2021, included in the index of median counts for the two "acceptable" survey days. Note: median group counts were rounded up when the final median included a "partial" whale. V/O = number of passes with video/observer counting passes used to determine corrected group size estimates (Boyd et al. 2019).

Date	Flight	Group	Total Passes	Location	Effort	Median count	V/O
6/26/2021	6	1	7	Turnagain Arm	On	2	2/7
6/26/2021	6	2	1	Chickaloon Bay	On	1*	0/0
6/26/2021	6	3	5	Chickaloon Bay	On	11	2/5
6/26/2021	6	4	5	Trading Bay	On	16	3/4
6/26/2021	6	5	4	Trading Bay	On	5	2/4
6/26/2021	6	6	1	North Foreland	On	2	0/1
6/26/2021	7	7	1	Chuitna Creek	On	1	0/1
6/26/2021	7	8	5	Beluga River	On	30	3/5
6/26/2021	7	9	5	Susitna River	On	2	0/2
6/26/2021	7	10	1	Susitna River	On	5	0/1
6/26/2021	7	11	1	Susitna River	On	2	0/1
6/26/2021	7	12	7	Little Susitna River	On	15	2/6
6/26/2021	7	13	2	Little Susitna River	On	3	0/2
6/26/2021	7	14	1	Cairn Point	On	3	0/1
6/26/2021	7	15	1	Ship Creek	On	2	0/1
6/27/2021	8	1	4	McHugh Creek	On	6	1/4
6/27/2021	8	2	5	Chickaloon Bay	On	7	2/5
6/27/2021	8	3	5	Indian Creek	On	3	0/5
6/27/2021	8	4	4	McArthur River	On	12	4/4
6/27/2021	8	5	4	Shirleyville	On	17	3/4
6/27/2021	8	6	4	North Foreland	On	40	4/4
6/27/2021	8	7	5	Beluga River	On	13	2/5
6/27/2021	9	8	5	Lewis to Susitna R.	On	10	3/5
6/27/2021	9	9	4	Susitna River	On	13	4/4
6/27/2021	9	10	1	Goose Bay	On	3	0/1

*= no counting passes

Table 4. – Percentage of Cook Inlet beluga groups for which video counts were obtained, 2012-2022.

Year	Groups	Video	Percentage
2012	17	16	94
2014	15	11	73
2016	32	11	34
2018	33	26	79
2021	25	14	56
2022	26	24	92

Table 5. -- Beluga whale groups in Cook Inlet, Alaska, June 2022, included in the index of median counts for the three "acceptable" survey days. Note: median group counts were rounded up when the final median included a "partial" whale. V/O = number of passes with video/observer counting passes used to determine corrected group size estimates (Boyd et al. 2019).

Date	Flight	Group	Total Passes	Location	Effort	Median count	V/O
6/15/2022	9	1	5	Turnagain Arm	On	3	3/5
6/15/2022	9	2	4	Chickaloon Bay	On	4	3/4
6/15/2022	9	3	6	Trading Bay	On	42	5/6
6/15/2022	10	4	4	Beluga to Ivan R.	On	67	3/4
6/15/2022	10	5	4	Susitna River	On	30	3/4
6/15/2022	10	6	5	E. of Little Susitna	On	6	3/5
6/16/2022	11	1	6	Chickaloon Bay	On	5	3/6
6/16/2022	11	2	6	Chickaloon Bay	On	5	6/6
6/16/2022	11	3	4	Trading Bay	On	44	4/4
6/16/2022	11	4	5	Trading Bay	On	1	0/5
6/16/2022	12	5	4	Beluga to Ivan R.	On	76	4/4
6/16/2022	12	6	4	Susitna River	On	53	4/4
6/16/2022	12	7	4	Susitna River	On	23	4/4
6/16/2022	12	8	4	Susitna River	On	17	4/4
6/17/2022	13	1	5	Fire Island	On	2	4/4
6/17/2022	13	2	5	Fire Island	Off	2	2/5
6/17/2022	13	3	7	Chickaloon Bay	On	3	4/5
6/17/2022	14	4	5	Trading Bay	On	4	5/5
6/17/2022	14	5	4	Beshta Bay	On	23	4/4
6/17/2022	14	6	4	North Foreland	On	2	3/4
6/17/2022	14	7	1	Chuitna Creek	On	1*	0/0
6/17/2022	14	8	4	Beluga-Theodore R.	On	80	4/4
6/17/2022	14	9	5	Susitna River	On	55	4/4
6/17/2022	14	10	4	Susitna River	On	2	1/1
6/17/2022	14	11	6	Little Susitna River	On	7	2/5
6/17/2022	14	12	4	Little Susitna River	On	5	3/4

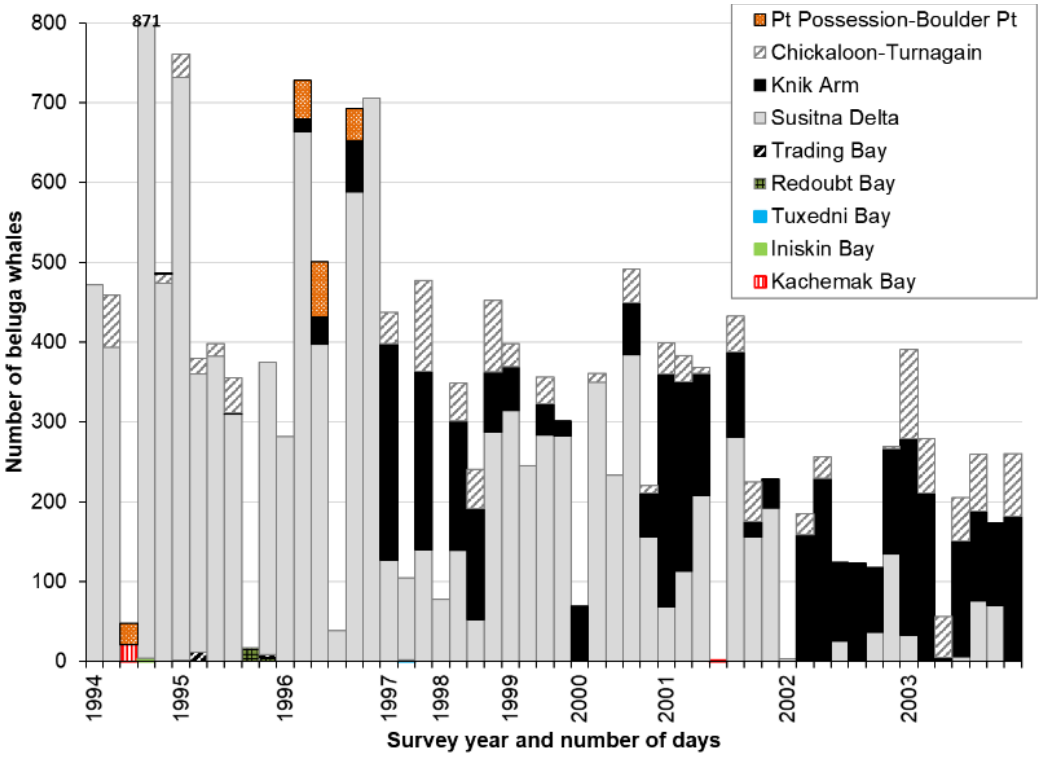
*= no counting passes

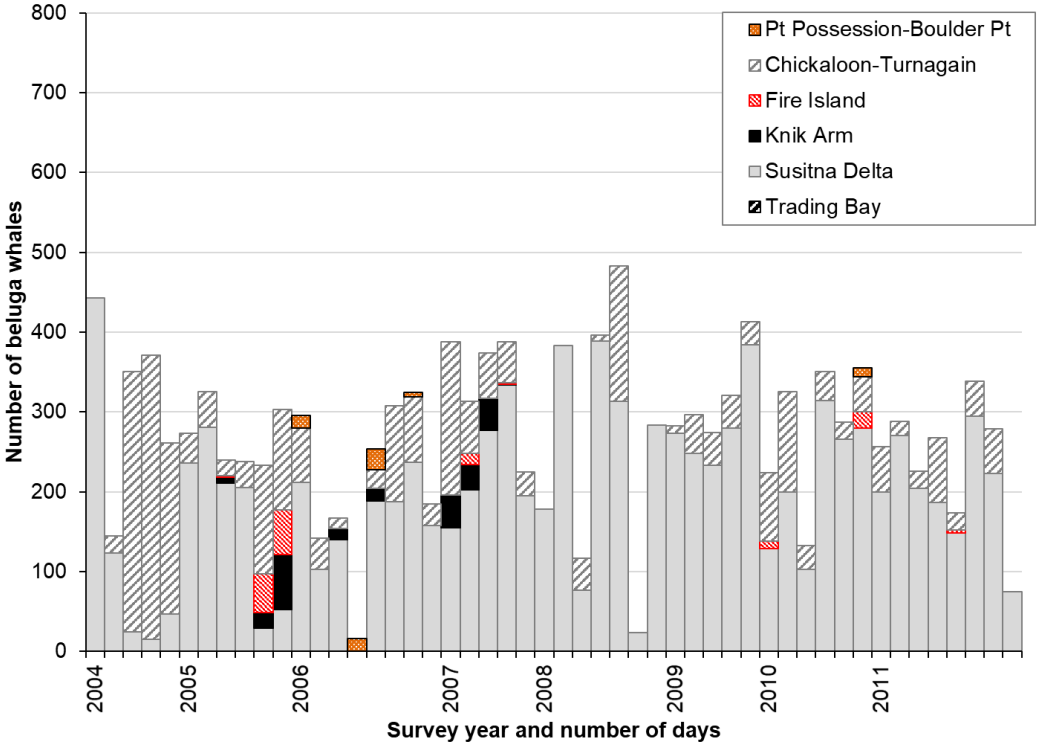
DISCUSSION

Historically, many belugas were seen in both upper and lower Cook Inlet in June and July (Rugh et al. 2000, 2010; Shelden et al. 2015b). However, between 1993 and 1995, during the first 3 years of the NMFS surveys, few belugas (less than 3% of all of the annual sightings) were in the lower inlet, south of East Foreland and West Foreland (Rugh et al. 2000). Only three belugas were seen in the lower inlet during subsequent surveys; one beluga in Tuxedni Bay in 1997 and two in Kachemak Bay in 2001 (Fig. 25). Opportunistic sightings of single belugas in the lower inlet have been reported in June, but not large groups of whales (Shelden et al. 2015b). In 2016, a single beluga was seen off Clam Gulch on June 1, the day after the aerial team had surveyed that portion of the lower inlet (Shelden et al. 2017). In 2022, a single beluga was observed in the Kenai River on June 18 during the aerial survey (Fig. 25) and a report of a single whale off Salamatof Beach north of Kenai River was received by NMFS on June 11. As in past surveys, other marine mammal species were seen in the lower inlet in 2021 and 2022: sea otters, harbor seals, harbor porpoises, minke whales, humpback whales, and killer whales (Appendix), which indicates the lack of beluga sightings was not due to poor visibility.

Belugas were in the Susitna Delta region throughout the survey time series (Fig. 25). Distance sampling experiments, initiated in 2018 (Shelden et al. 2019), documented beluga distribution during high and low tides and will undergo further analyses. Of note, tracklines should be extended farther offshore (e.g., July 1, 2021 and June 9, 2022) to document any whales transiting between the Susitna and Chickaloon strata.

Large numbers of belugas were in Knik Arm from 1997 to 2003, with a few observations continuing until 2007, after which none were found in this region during surveys conducted in early June (Fig. 25). From 2004 to 2007, more whales were observed in the Chickaloon Bay–Turnagain Arm region, coincident with the lower numbers seen in Knik Arm. The small group in Knik Arm in 2021 was expected given the later timing of this survey.


871
Pt Possession-Boulder Pt
Chickaloon-Turnagain
Knik Arm
Susitna Delta
Trading Bay
Redoubt Bay
Tuxedni Bay
Iniskin Bay
Kachemak Bay
Number of beluga whales
0
100
200
300
400
500
600
700
800
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Survey year and number of days


Pt Possession-Boulder Pt
Chickaloon-Turnagain
Fire Island
Knik Arm
Susitna Delta
Trading Bay
Number of beluga whales
0
100
200
300
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2004
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2006
2007
2008
2009
2010
2011
Survey year and number of days

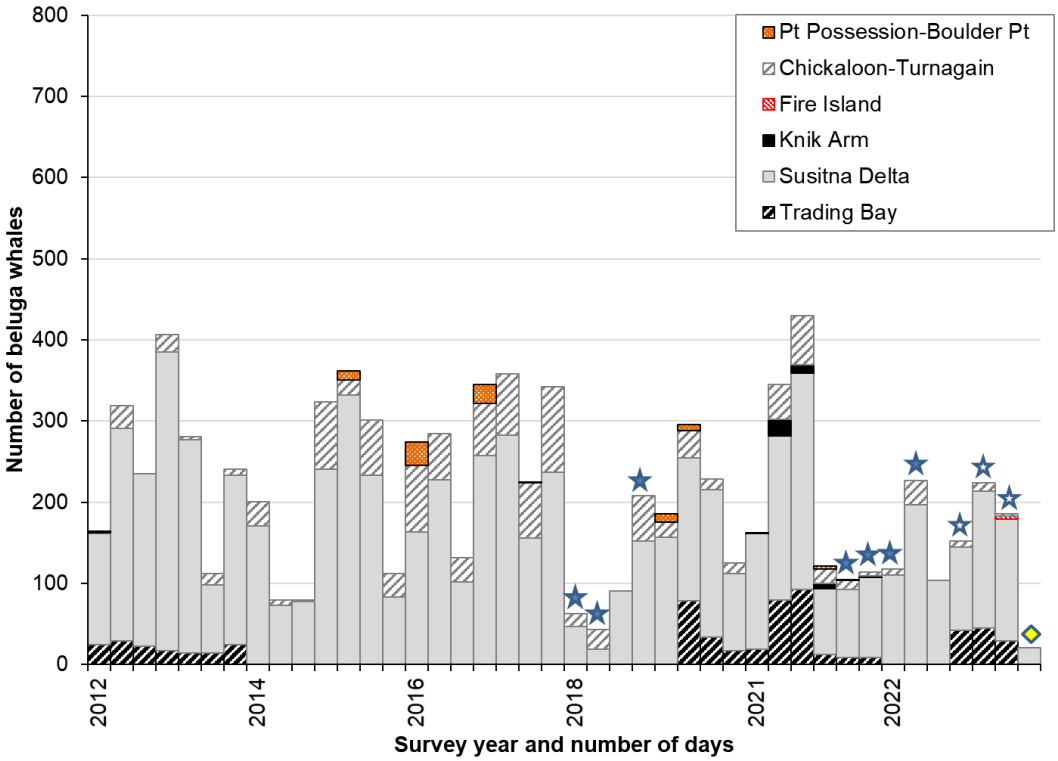

Figure 25. -- Regions occupied by belugas in upper Cook Inlet, Alaska, from 1994 to 2022. Each survey day when belugas were observed is represented as a single bar above and following the year indicated on the x-axis. (Originally published in Hobbs et al. (2015) for the period 1994-2012). Closed star symbols indicate distance sampling days (uncorrected raw counts – analyses in progress), open stars indicate standard survey days not yet corrected for group sizes (Boyd et al. 2019). The diamond symbol represents a single beluga observed at the Kenai River.

Belugas found in Chickaloon Bay were typically near the south shore, most often in the area 3 km southeast of Point Possession between the bluffs and Chickaloon River. Annual counts in Chickaloon Bay typically were in the range of 20-60 belugas during the surveys prior to 2004. However, in 2004, counts were as high as 176, and for the first time there appeared to be exchanges of belugas between the Susitna Delta and Chickaloon Bay/Turnagain Arm within the timeframe of the survey (Rugh et al. 2005); that is, when counts were low in the Susitna area, they were high in Chickaloon Bay and vice versa.

Similar apparent exchanges were seen in 2010 and 2011, and possibly in 2016 and 2018 between the Susitna Delta and Point Possession (Fig. 25). Similar to 2018, in 2021 and 2022, counts in Chickaloon Bay were low while Trading Bay had some of the highest counts recorded in recent times (Fig. 25). Belugas (group sizes ranging from 1 to 27 whales) have been observed in areas south of North Foreland and Point Possession, but not consistently. In 2018 and 2021, groups were once again observed near Moose Point and, similar to the 2012 survey, in Trading Bay. We also observed belugas north and south of North Foreland and near the Native Village of Tyonek in 2018, 2021, and 2022.

Unfortunately, bad weather coincided with many of the lowest low tide days during the 2021 survey. Minus tides (-3 ft. or more) that expose the tidal mudflats for extended periods are preferable for collecting video group size data because the whales aggregate along the edge of the mudflats until the rising tide allows them to access the channels and rivers. It is preferable to obtain at least 3-5 days for the abundance estimate. The timing of the survey in late June in 2021 may have affected counts as well. From experience, this timing has not been optimal for collection of video as the whales typically begin to disperse from the river mouths following the peak of eulachon and Chinook salmon runs in late May and early June. When whales are dispersed, it is more difficult to collect the video data for every group. In 2022, it was possible to obtain video on nearly every beluga group encountered during the minus low tide (> -4 ft.) survey days. Estimates of abundance from the 2022 survey will be compared to those obtained in 2021 and published together. In this respect, any issues regarding the 2021 estimates can be viewed in context of the 2022 survey which should be more comparable to previous survey years.

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APPENDIX

Other marine mammals observed during the 2021and 2022 beluga abundance surveys.

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Minke whale	1	6/19/2021	60.060	-152.030	12:00:05	1	Clam Gulch-Tuxedni/ mid-inlet
Minke whale	1	6/19/2021	59.700	-151.930	12:25:05	1	Tuxedni-Kachemak/ mid-inlet
Minke whale	1	6/29/2021	59.662	-152.629	12:24:08	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	2	6/19/2021	60.380	-152.140	11:44:05	1	Redoubt Bay
Harbor porpoise	2	6/19/2021	59.950	-152.410	12:13:46	1	Tuxedni-Kachemak/ mid-inlet
Harbor porpoise	1	6/19/2021	59.820	-152.150	12:19:44	1	Tuxedni-Kachemak/ mid-inlet
Harbor porpoise	1	6/19/2021	59.660	-151.860	12:26:44	1	Tuxedni-Kachemak/ mid-inlet
Harbor porpoise	3	6/19/2021	59.550	-152.220	13:49:14	2	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/19/2021	59.520	-153.230	14:04:29	2	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/19/2021	59.650	-153.450	14:25:37	2	Iniskin Bay
Harbor porpoise	2	6/19/2021	60.360	-152.250	15:43:52	2	Harriet Point
Harbor porpoise	1	6/19/2021	60.370	-152.170	15:45:34	2	Kalgin Island
Harbor porpoise	1	6/29/2021	59.588	-152.451	12:20:38	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.665	-152.636	12:24:16	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.700	-152.723	12:25:55	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.710	-152.750	12:26:24	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	2	6/29/2021	59.714	-152.761	12:26:37	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.719	-152.772	12:26:49	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.720	-152.775	12:26:52	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.730	-152.799	12:27:19	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	2	6/29/2021	59.730	-152.800	12:27:20	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.754	-152.864	12:28:28	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	2	6/29/2021	59.814	-152.694	12:34:10	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.819	-152.650	12:34:50	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.820	-152.644	12:34:56	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	3	6/29/2021	59.824	-152.613	12:35:25	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.824	-152.608	12:35:29	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	1	6/29/2021	59.840	-152.478	12:37:27	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	3	6/29/2021	59.848	-152.407	12:38:30	12	Kachemak -Ursus/ mid-inlet
Harbor porpoise	2	6/29/2021	59.996	-152.005	13:46:53	13	Clam Gulch-Tuxedni/ mid-inlet
Harbor porpoise	1	6/29/2021	60.230	-152.191	13:59:17	13	Clam Gulch-Tuxedni/ mid-inlet
Sea otter	1	6/19/2021	59.720	-151.960	12:24:13	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	8	6/19/2021	59.710	-151.960	12:24:26	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	8	6/19/2021	59.710	-151.950	12:24:36	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	20	6/19/2021	59.690	-151.910	12:25:30	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	19	6/19/2021	59.690	-151.910	12:25:32	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	1	6/19/2021	59.660	-151.860	12:26:50	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	4	6/19/2021	59.650	-151.850	12:26:54	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	2	6/19/2021	59.610	-151.770	12:29:07	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	2	6/19/2021	59.600	-151.750	12:29:30	1	Tuxedni-Kachemak/ mid-inlet

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Sea otter	4	6/19/2021	59.600	-151.750	12:29:42	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	2	6/19/2021	59.580	-151.720	12:30:27	1	Tuxedni-Kachemak/ mid-inlet
Sea otter	2	6/19/2021	59.560	-151.630	12:32:04	1	Kachemak Bay
Sea otter	1	6/19/2021	59.570	-151.450	13:38:14	2	Kachemak Bay
Sea otter	3	6/19/2021	59.570	-151.620	13:40:22	2	Kachemak Bay
Sea otter	1	6/19/2021	59.570	-151.640	13:40:36	2	Kachemak Bay
Sea otter	1	6/19/2021	59.570	-151.690	13:41:14	2	Kachemak Bay
Sea otter	2	6/19/2021	59.570	-151.720	13:41:37	2	Kachemak -Ursus/ mid-inlet
Sea otter	55	6/19/2021	59.570	-151.840	13:43:22	2	Kachemak -Ursus/ mid-inlet
Sea otter	25	6/19/2021	59.570	-151.860	13:43:35	2	Kachemak -Ursus/ mid-inlet
Sea otter	11	6/19/2021	59.570	-151.860	13:43:36	2	Kachemak -Ursus/ mid-inlet
Sea otter	20	6/19/2021	59.560	-151.890	13:44:00	2	Kachemak -Ursus/ mid-inlet
Sea otter	4	6/19/2021	59.560	-151.900	13:44:10	2	Kachemak -Ursus/ mid-inlet
Sea otter	40	6/19/2021	59.560	-151.910	13:44:19	2	Kachemak -Ursus/ mid-inlet
Sea otter	2	6/19/2021	59.560	-151.930	13:44:42	2	Kachemak -Ursus/ mid-inlet
Sea otter	50	6/19/2021	59.560	-151.960	13:45:04	2	Kachemak -Ursus/ mid-inlet
Sea otter	15	6/19/2021	59.560	-151.970	13:45:13	2	Kachemak -Ursus/ mid-inlet
Sea otter	40	6/19/2021	59.560	-151.980	13:45:20	2	Kachemak -Ursus/ mid-inlet
Sea otter	20	6/19/2021	59.560	-151.980	13:45:27	2	Kachemak -Ursus/ mid-inlet
Sea otter	15	6/19/2021	59.560	-151.990	13:45:37	2	Kachemak -Ursus/ mid-inlet
Sea otter	30	6/19/2021	59.560	-152.010	13:45:53	2	Kachemak -Ursus/ mid-inlet
Sea otter	4	6/19/2021	59.550	-152.130	13:47:41	2	Kachemak -Ursus/ mid-inlet
Sea otter	1	6/19/2021	59.550	-152.150	13:48:01	2	Kachemak -Ursus/ mid-inlet
Sea otter	5	6/19/2021	59.550	-152.220	13:49:08	2	Kachemak -Ursus/ mid-inlet
Sea otter	3	6/19/2021	59.550	-152.240	13:49:30	2	Kachemak -Ursus/ mid-inlet
Sea otter	5	6/19/2021	59.550	-152.360	13:51:21	2	Kachemak -Ursus/ mid-inlet
Sea otter	7	6/19/2021	59.550	-152.370	13:51:29	2	Kachemak -Ursus/ mid-inlet
Sea otter	1	6/19/2021	59.550	-152.390	13:51:45	2	Kachemak -Ursus/ mid-inlet
Sea otter	6	6/19/2021	59.510	-153.470	14:08:00	2	Kachemak -Ursus/ mid-inlet
Sea otter	14	6/19/2021	59.510	-153.580	14:09:40	2	Ursus Cove
Sea otter	1	6/19/2021	59.510	-153.590	14:09:48	2	Ursus Cove
Sea otter	1	6/19/2021	59.540	-153.600	14:15:31	2	Ursus Cove
Sea otter	2	6/19/2021	59.680	-153.040	14:42:12	2	Chinitna Point
Sea otter	2	6/19/2021	59.690	-153.030	14:42:29	2	Chinitna Point
Sea otter	1	6/19/2021	59.790	-152.970	14:45:53	2	South of Chinitna Bay
Sea otter	1	6/19/2021	59.860	-152.980	14:52:30	2	South of Chinitna Bay
Sea otter	1	6/19/2021	60.380	-152.030	15:48:09	2	Kalgin Island
Sea otter	1	6/19/2021	60.500	-151.870	15:54:18	2	Kalgin Island
Sea otter	1	6/29/2021	60.277	-151.409	10:40:08	12	Kachemak Bay
Sea otter	40	6/29/2021	59.633	-151.616	11:04:00	12	Kachemak Bay
Sea otter	40	6/29/2021	59.630	-151.592	11:04:21	12	Kachemak Bay
Sea otter	30	6/29/2021	59.625	-151.541	11:05:05	12	Kachemak Bay
Sea otter	10	6/29/2021	59.624	-151.532	11:05:13	12	Kachemak Bay
Sea otter	30	6/29/2021	59.621	-151.504	11:05:37	12	Kachemak Bay
Sea otter	50	6/29/2021	59.620	-151.500	11:05:40	12	Kachemak Bay
Sea otter	1	6/29/2021	59.604	-151.453	11:06:31	12	Kachemak Bay
Sea otter	1	6/29/2021	59.604	-151.452	11:06:32	12	Kachemak Bay
Sea otter	20	6/29/2021	59.626	-151.437	11:09:00	12	Kachemak Bay

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Sea otter	3	6/29/2021	59.650	-151.418	11:09:51	12	Kachemak Bay
Sea otter	2	6/29/2021	59.653	-151.413	11:09:57	12	Kachemak Bay
Sea otter	2	6/29/2021	59.659	-151.400	11:10:12	12	Kachemak Bay
Sea otter	1	6/29/2021	59.661	-151.393	11:10:19	12	Kachemak Bay
Sea otter	30	6/29/2021	59.663	-151.387	11:10:25	12	Kachemak Bay
Sea otter	20	6/29/2021	59.668	-151.366	11:10:44	12	Kachemak Bay
Sea otter	20	6/29/2021	59.669	-151.362	11:10:48	12	Kachemak Bay
Sea otter	20	6/29/2021	59.674	-151.338	11:11:09	12	Kachemak Bay
Sea otter	220	6/29/2021	59.675	-151.329	11:11:17	12	Kachemak Bay
Sea otter	27	6/29/2021	59.676	-151.321	11:11:24	12	Kachemak Bay
Sea otter	180	6/29/2021	59.699	-151.252	11:12:33	12	Kachemak Bay
Sea otter	3	6/29/2021	59.702	-151.243	11:12:43	12	Kachemak Bay
Sea otter	50	6/29/2021	59.720	-151.192	11:13:35	12	Kachemak Bay
Sea otter	70	6/29/2021	59.723	-151.183	11:13:44	12	Kachemak Bay
Sea otter	100	6/29/2021	59.732	-151.160	11:14:07	12	Kachemak Bay
Sea otter	1	6/29/2021	59.735	-151.153	11:14:15	12	Kachemak Bay
Sea otter	4	6/29/2021	59.743	-151.134	11:14:36	12	Kachemak Bay
Sea otter	1	6/29/2021	59.753	-151.115	11:14:58	12	Kachemak Bay
Sea otter	60	6/29/2021	59.755	-151.110	11:15:04	12	Kachemak Bay
Sea otter	1	6/29/2021	59.714	-151.112	11:27:13	12	Kachemak Bay
Sea otter	1	6/29/2021	59.668	-151.181	11:29:07	12	Kachemak Bay
Sea otter	6	6/29/2021	59.664	-151.195	11:29:22	12	Kachemak Bay
Sea otter	9	6/29/2021	59.661	-151.203	11:29:31	12	Kachemak Bay
Sea otter	40	6/29/2021	59.658	-151.208	11:29:39	12	Kachemak Bay
Sea otter	1	6/29/2021	59.645	-151.217	11:30:04	12	Kachemak Bay
Sea otter	1	6/29/2021	59.632	-151.215	11:30:26	12	Kachemak Bay
Sea otter	1	6/29/2021	59.608	-151.204	11:31:09	12	Kachemak Bay
Sea otter	1	6/29/2021	59.606	-151.203	11:31:14	12	Kachemak Bay
Sea otter	2	6/29/2021	59.597	-151.183	11:31:38	12	Kachemak Bay
Sea otter	1	6/29/2021	59.554	-151.255	11:37:35	12	Kachemak Bay
Sea otter	1	6/29/2021	59.487	-151.519	11:52:03	12	Kachemak Bay
Sea otter	2	6/29/2021	59.482	-151.533	11:52:19	12	Kachemak Bay
Sea otter	5	6/29/2021	59.482	-151.534	11:52:20	12	Kachemak Bay
Sea otter	5	6/29/2021	59.475	-151.548	11:52:37	12	Kachemak Bay
Sea otter	10	6/29/2021	59.483	-151.578	11:53:16	12	Kachemak Bay
Sea otter	1	6/29/2021	59.485	-151.590	11:53:28	12	Kachemak Bay
Sea otter	10	6/29/2021	59.420	-151.721	11:57:43	12	Kachemak Bay
Sea otter	1	6/29/2021	59.415	-151.715	11:57:54	12	Kachemak Bay
Sea otter	1	6/29/2021	59.410	-151.710	11:58:04	12	Kachemak Bay
Sea otter	2	6/29/2021	59.366	-151.870	12:05:42	12	Kachemak Bay
Sea otter	1	6/29/2021	59.363	-151.861	12:05:51	12	Kachemak Bay
Sea otter	1	6/29/2021	59.360	-151.847	12:06:05	12	Kachemak Bay
Sea otter	1	6/29/2021	59.358	-151.838	12:06:13	12	Kachemak Bay
Sea otter	1	6/29/2021	59.350	-151.802	12:06:46	12	Kachemak Bay
Harbor seal	2	6/19/2021	59.730	-151.980	12:23:45	1	Tuxedni-Kachemak/ mid-inlet
Harbor seal	17	6/19/2021	59.700	-153.410	14:27:25	2	Iniskin Bay
Harbor seal	50	6/19/2021	59.710	-153.410	14:27:44	2	Iniskin Bay
Harbor seal	30	6/19/2021	59.640	-153.450	14:30:49	2	Iniskin Bay

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Harbor seal	4	6/19/2021	59.620	-153.410	14:31:53	2	Iniskin Bay
Harbor seal	11	6/19/2021	59.620	-153.390	14:32:23	2	Iniskin Bay
Harbor seal	100	6/19/2021	60.210	-152.780	15:14:25	2	Tuxedni Bay
Harbor seal	10	6/19/2021	60.210	-152.790	15:14:40	2	Tuxedni Bay
Harbor seal	11	6/19/2021	60.220	-152.810	15:14:59	2	Tuxedni Bay
Harbor seal	7	6/19/2021	60.200	-152.720	15:30:54	2	Tuxedni Bay
Harbor seal	20	6/19/2021	60.190	-152.530	15:36:24	2	Tuxedni Bay
Harbor seal	200	6/19/2021	60.640	-151.960	16:16:08	2	Redoubt Bay
Harbor seal	500	6/19/2021	60.680	-151.880	16:17:56	2	Redoubt Bay
Harbor seal	200	6/21/2021	61.176	-150.508	12:35:04	3	Susitna River
Harbor seal	20	6/22/2021	60.941	-149.928	16:18:44	5	Chickaloon River
Harbor seal	12	6/26/2021	60.987	-151.484	11:28:44	6	Trading Bay
Harbor seal	300	6/26/2021	61.187	-150.503	15:53:16	7	Susitna River
Harbor seal	20	6/26/2021	61.242	-150.280	16:23:00	7	Little Susitna River
Harbor seal	70	6/27/2021	61.198	-150.942	12:59:20	8	Beluga River
Harbor seal	1	6/27/2021	61.199	-150.555	16:53:07	9	Susitna River
Harbor seal	120	6/27/2021	61.171	-150.492	16:55:00	9	Susitna River
Harbor seal	8	6/28/2021	60.912	-150.112	11:00:27	10	Chickaloon River
Harbor seal	20	6/29/2021	59.767	-151.045	11:16:04	12	Kachemak Bay
Harbor seal	225	6/29/2021	59.768	-151.027	11:16:19	12	Kachemak Bay
Harbor seal	25	6/29/2021	59.769	-151.016	11:16:28	12	Kachemak Bay
Harbor seal	1	6/29/2021	59.771	-151.005	11:16:38	12	Kachemak Bay
Harbor seal	1	6/29/2021	59.773	-150.996	11:16:46	12	Kachemak Bay
Harbor seal	60	6/29/2021	59.742	-151.063	11:23:54	12	Kachemak Bay
Harbor seal	10	6/29/2021	59.593	-151.170	11:31:52	12	Kachemak Bay
Harbor seal	17	6/29/2021	59.558	-151.261	11:37:26	12	Kachemak Bay
Harbor seal	40	6/29/2021	59.572	-151.307	11:39:29	12	Kachemak Bay
Harbor seal	25	6/30/2021	61.201	-150.815	17:21:22	15	Theodore-Lewis Rivers
Harbor seal	200	6/30/2021	61.189	-150.512	17:52:41	15	Susitna River
Harbor seal	10	7/1/2021	61.230	-150.811	12:43:14	16	Theodore-Lewis Rivers
Harbor seal	100	7/1/2021	61.223	-150.799	12:43:30	16	Theodore-Lewis Rivers
Harbor seal	50	7/1/2021	61.273	-150.644	13:22:55	16	Susitna River
Harbor seal	60	7/1/2021	60.947	-150.074	17:29:13	17	Chickaloon Bay
Unid. Pinniped	2	6/19/2021	59.510	-153.380	14:06:48	2	Kachemak-Ursus/ mid-inlet
Unid. Cetacean	1	6/29/2021	59.631	-151.604	11:04:11	12	Kachemak Bay

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Harbor porpoise	1	6/8/2022	59.525	-153.246	13:48:06	5	N. of Augustine Is.
Harbor porpoise	1	6/8/2022	59.515	-153.472	13:51:09	5	N. of Augustine Is.
Harbor porpoise	1	6/8/2022	60.505	-151.960	15:27:56	5	Kalgin Island
Harbor porpoise	1	6/18/2022	59.479	-151.488	10:22:35	15	Kachemak Bay
Harbor porpoise	1	6/18/2022	59.768	-152.901	10:50:33	15	E. of Chinitna Bay
Harbor porpoise	1	6/18/2022	59.800	-152.755	10:55:40	15	E. of Chinitna Bay
Harbor porpoise	1	6/18/2022	60.198	-152.426	11:33:55	15	E. of Tuxedni Bay
Humpback whale	3	6/8/2022	59.604	-151.753	10:19:34	3	W. of Kachemak Bay
Humpback whale	1	6/8/2022	59.564	-152.067	11:52:01	4	W. of Kachemak Bay
Humpback whale	1	6/8/2022	59.564	-152.074	11:52:08	4	W. of Kachemak Bay
Humpback whale	1	6/8/2022	59.559	-152.228	11:58:29	4	W. of Kachemak Bay
Humpback whale	1	6/18/2022	60.008	-152.029	11:18:26	15	W. of Ninilchik
Killer whale	2	6/8/2022	59.613	-151.771	10:19:13	3	W. of Kachemak Bay
Killer whale	1	6/8/2022	59.601	-151.748	10:19:41	3	W. of Kachemak Bay
Killer whale	1	6/8/2022	59.597	-151.740	10:19:50	3	W. of Kachemak Bay
Sea otter	1	6/8/2022	60.073	-151.879	9:54:46	3	W. of Ninilchik
Sea otter	2	6/8/2022	60.065	-151.969	9:56:03	3	W. of Ninilchik
Sea otter	1	6/8/2022	59.809	-152.136	10:11:39	3	Off Anchor Pt.
Sea otter	3	6/8/2022	59.797	-152.112	10:12:08	3	Off Anchor Pt.
Sea otter	3	6/8/2022	59.738	-152.003	10:14:27	3	Off Anchor Pt.
Sea otter	2	6/8/2022	59.733	-151.995	10:14:37	3	Off Anchor Pt.
Sea otter	2	6/8/2022	59.723	-151.976	10:15:02	3	Off Anchor Pt.
Sea otter	3	6/8/2022	59.719	-151.969	10:15:10	3	Off Anchor Pt.
Sea otter	1	6/8/2022	59.717	-151.964	10:15:16	3	Off Anchor Pt.
Sea otter	1	6/8/2022	59.709	-151.950	10:15:33	3	Off Anchor Pt.
Sea otter	1	6/8/2022	59.707	-151.946	10:15:38	3	Off Anchor Pt.
Sea otter	2	6/8/2022	59.705	-151.942	10:15:43	3	Off Anchor Pt.
Sea otter	5	6/8/2022	59.700	-151.932	10:15:55	3	Off Anchor Pt.
Sea otter	2	6/8/2022	59.696	-151.924	10:16:05	3	Off Anchor Pt.
Sea otter	1	6/8/2022	59.695	-151.922	10:16:07	3	Off Anchor Pt.
Sea otter	17	6/8/2022	59.660	-151.859	10:17:26	3	Off Anchor Pt.
Sea otter	16	6/8/2022	59.653	-151.846	10:17:42	3	Off Anchor Pt.
Sea otter	3	6/8/2022	59.646	-151.833	10:17:58	3	Off Anchor Pt.
Sea otter	33	6/8/2022	59.641	-151.824	10:18:09	3	Running count
Sea otter	1	6/8/2022	59.624	-151.791	10:18:49	3	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.620	-151.784	10:18:57	3	W. of Kachemak Bay
Sea otter	5	6/8/2022	59.575	-151.760	11:47:12	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.573	-151.804	11:47:51	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.572	-151.817	11:48:03	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.572	-151.826	11:48:11	4	W. of Kachemak Bay
Sea otter	7	6/8/2022	59.572	-151.833	11:48:17	4	W. of Kachemak Bay
Sea otter	7	6/8/2022	59.572	-151.835	11:48:19	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.571	-151.856	11:48:39	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.571	-151.869	11:48:51	4	W. of Kachemak Bay
Sea otter	2	6/8/2022	59.571	-151.879	11:49:01	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.571	-151.886	11:49:07	4	W. of Kachemak Bay
Sea otter	2	6/8/2022	59.571	-151.891	11:49:12	4	W. of Kachemak Bay
Sea otter	2	6/8/2022	59.570	-151.899	11:49:19	4	W. of Kachemak Bay
Sea otter	3	6/8/2022	59.570	-151.912	11:49:32	4	W. of Kachemak Bay
Sea otter	5	6/8/2022	59.570	-151.913	11:49:33	4	W. of Kachemak Bay
Sea otter	30	6/8/2022	59.570	-151.927	11:49:46	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.570	-151.936	11:49:55	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.569	-151.950	11:50:08	4	W. of Kachemak Bay

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Sea otter	1	6/8/2022	59.569	-151.958	11:50:16	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.568	-151.979	11:50:36	4	W. of Kachemak Bay
Sea otter	1	6/8/2022	59.568	-151.984	11:50:41	4	W. of Kachemak Bay
Sea otter	6	6/8/2022	59.567	-151.989	11:50:46	4	W. of Kachemak Bay
Sea otter	3	6/8/2022	59.567	-151.996	11:50:53	4	W. of Kachemak Bay
Sea otter	8	6/8/2022	59.566	-152.017	11:51:13	4	W. of Kachemak Bay
Sea otter	50	6/8/2022	59.566	-152.025	11:51:21	4	W. of Kachemak Bay
Sea otter	100	6/8/2022	59.565	-152.057	11:51:52	4	W. of Kachemak Bay
Sea otter	5	6/8/2022	59.514	-153.492	13:51:25	5	N. of Augustine Is.
Sea otter	2	6/8/2022	59.513	-153.502	13:51:33	5	N. of Augustine Is.
Sea otter	10	6/8/2022	59.513	-153.509	13:51:38	5	N. of Augustine Is.
Sea otter	1	6/8/2022	59.513	-153.515	13:51:43	5	N. of Augustine Is.
Sea otter	2	6/8/2022	59.512	-153.524	13:51:50	5	N. of Augustine Is.
Sea otter	2	6/8/2022	59.512	-153.532	13:51:56	5	N. of Augustine Is.
Sea otter	4	6/8/2022	59.512	-153.537	13:52:00	5	N. of Augustine Is.
Sea otter	4	6/8/2022	59.512	-153.545	13:52:06	5	N. of Augustine Is.
Sea otter	1	6/8/2022	59.511	-153.550	13:52:10	5	N. of Augustine Is.
Sea otter	8	6/8/2022	59.510	-153.586	13:52:38	5	N. of Augustine Is.
Sea otter	8	6/8/2022	59.509	-153.597	13:52:47	5	N. of Augustine Is.
Sea otter	1	6/8/2022	59.507	-153.631	13:53:13	5	Ursus Cove.
Sea otter	1	6/8/2022	59.545	-153.628	13:57:19	5	Ursus Cove
Sea otter	1	6/8/2022	59.581	-153.547	13:59:17	5	Iliamna Bay
Sea otter	6	6/8/2022	59.609	-153.550	14:00:10	5	Iliamna Bay
Sea otter	1	6/8/2022	59.611	-153.556	14:00:16	5	Iliamna Bay
Sea otter	2	6/8/2022	59.628	-153.249	14:24:03	5	Oil Bay
Sea otter	1	6/8/2022	59.674	-153.109	14:26:58	5	Chinitna Pt.
Sea otter	1	6/8/2022	60.174	-152.678	14:51:57	5	Tuxedni Bay
Sea otter	2	6/8/2022	60.442	-151.969	15:30:11	5	Kalgin Island
Sea otter	1	6/18/2022	60.212	-151.442	9:18:35	15	Clam Gulch
Sea otter	2	6/18/2022	59.677	-151.768	9:34:24	15	N. of Kachemak Bay
Sea otter	2	6/18/2022	59.624	-151.553	9:38:06	15	Kachemak Bay
Sea otter	30	6/18/2022	59.623	-151.535	9:38:22	15	Kachemak Bay
Sea otter	50	6/18/2022	59.623	-151.525	9:38:31	15	Kachemak Bay
Sea otter	105	6/18/2022	59.622	-151.509	9:38:45	15	Kachemak Bay
Sea otter	20	6/18/2022	59.619	-151.491	9:39:02	15	Kachemak Bay
Sea otter	120	6/18/2022	59.615	-151.477	9:39:17	15	Kachemak Bay
Sea otter	1	6/18/2022	59.609	-151.412	9:41:20	15	Kachemak Bay
Sea otter	2	6/18/2022	59.651	-151.420	9:43:08	15	Kachemak Bay
Sea otter	1	6/18/2022	59.653	-151.415	9:43:14	15	Kachemak Bay
Sea otter	647	6/18/2022	59.658	-151.407	9:43:26	15	Running count
Sea otter	10	6/18/2022	59.680	-151.308	9:45:04	15	Kachemak Bay
Sea otter	2	6/18/2022	59.709	-151.226	9:46:34	15	Kachemak Bay
Sea otter	2	6/18/2022	59.718	-151.208	9:46:58	15	Kachemak Bay
Sea otter	3	6/18/2022	59.719	-151.204	9:47:03	15	Kachemak Bay
Sea otter	5	6/18/2022	59.721	-151.201	9:47:08	15	Kachemak Bay
Sea otter	1	6/18/2022	59.723	-151.195	9:47:15	15	Kachemak Bay
Sea otter	1	6/18/2022	59.754	-151.126	9:48:52	15	Kachemak Bay
Sea otter	4	6/18/2022	59.755	-151.123	9:48:57	15	Kachemak Bay
Sea otter	1	6/18/2022	59.757	-151.120	9:49:03	15	Kachemak Bay
Sea otter	1	6/18/2022	59.761	-151.114	9:49:14	15	Kachemak Bay
Sea otter	1	6/18/2022	59.766	-151.092	9:49:40	15	Kachemak Bay
Sea otter	5	6/18/2022	59.769	-151.068	9:50:07	15	Kachemak Bay
Sea otter	10	6/18/2022	59.771	-151.029	9:50:48	15	Kachemak Bay

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Sea otter	3	6/18/2022	59.743	-151.059	9:55:05	15	Kachemak Bay
Sea otter	1	6/18/2022	59.703	-151.118	9:58:18	15	Kachemak Bay
Sea otter	1	6/18/2022	59.701	-151.121	9:58:24	15	Kachemak Bay
Sea otter	1	6/18/2022	59.699	-151.124	9:58:28	15	Kachemak Bay
Sea otter	1	6/18/2022	59.697	-151.126	9:58:32	15	Kachemak Bay
Sea otter	23	6/18/2022	59.682	-151.144	9:59:07	15	Kachemak Bay
Sea otter	2	6/18/2022	59.680	-151.146	9:59:11	15	Kachemak Bay
Sea otter	1	6/18/2022	59.676	-151.152	9:59:21	15	Kachemak Bay
Sea otter	43	6/18/2022	59.674	-151.154	9:59:25	15	Kachemak Bay
Sea otter	1	6/18/2022	59.671	-151.161	9:59:34	15	Kachemak Bay
Sea otter	20	6/18/2022	59.669	-151.165	9:59:38	15	Kachemak Bay
Sea otter	30	6/18/2022	59.667	-151.170	9:59:44	15	Kachemak Bay
Sea otter	275	6/18/2022	59.662	-151.186	10:00:03	15	Running count
Sea otter	2	6/18/2022	59.661	-151.187	10:00:04	15	Kachemak Bay
Sea otter	1	6/18/2022	59.660	-151.190	10:00:08	15	Kachemak Bay
Sea otter	5	6/18/2022	59.658	-151.197	10:00:16	15	Kachemak Bay
Sea otter	2	6/18/2022	59.629	-151.216	10:01:19	15	Kachemak Bay
Sea otter	2	6/18/2022	59.597	-151.179	10:05:07	15	Kachemak Bay
Sea otter	3	6/18/2022	59.562	-151.256	10:08:20	15	Kachemak Bay
Sea otter	1	6/18/2022	59.558	-151.274	10:08:54	15	Kachemak Bay
Sea otter	1	6/18/2022	59.561	-151.287	10:09:10	15	Kachemak Bay
Sea otter	1	6/18/2022	59.557	-151.412	10:11:30	15	Kachemak Bay
Sea otter	1	6/18/2022	59.557	-151.415	10:11:33	15	Kachemak Bay
Sea otter	30	6/18/2022	59.555	-151.421	10:11:40	15	Kachemak Bay
Sea otter	1	6/18/2022	59.480	-151.502	10:22:49	15	Kachemak Bay
Sea otter	1	6/18/2022	59.457	-151.519	10:25:35	15	Kachemak Bay
Sea otter	2	6/18/2022	59.961	-151.945	11:16:34	15	W. of Ninilchik
Harbor seal	30	6/6/2022	60.902	-151.642	16:05:50	2	Trading Bay
Harbor seal	20	6/6/2022	61.222	-150.788	17:33:00	2	Ivan River
Harbor seal	12	6/6/2022	61.227	-150.774	17:33:15	2	Ivan River
Harbor seal	200	6/6/2022	61.177	-150.543	17:49:01	2	Susitna River
Harbor seal	10	6/6/2022	61.187	-150.557	17:49:21	2	Susitna River
Harbor seal	150	6/6/2022	61.190	-150.563	17:49:29	2	Susitna River
Harbor seal	50	6/6/2022	61.204	-150.539	17:50:59	2	Susitna River
Harbor seal	20	6/6/2022	61.198	-150.532	17:51:10	2	Susitna River
Harbor seal	20	6/6/2022	61.186	-150.417	17:58:44	2	Susitna River
Harbor seal	2	6/8/2022	60.084	-151.744	9:52:52	3	W. of Ninilchik
Harbor seal	20	6/8/2022	59.529	-153.752	13:55:10	5	Ursus Cove
Harbor seal	50	6/8/2022	59.702	-153.422	14:10:40	5	Iniskin Bay
Harbor seal	30	6/8/2022	59.712	-153.420	14:10:59	5	Iniskin Bay
Harbor seal	2	6/8/2022	59.734	-153.428	14:11:40	5	Iniskin Bay
Harbor seal	4	6/8/2022	59.740	-153.433	14:11:52	5	Iniskin Bay
Harbor seal	50	6/8/2022	59.742	-153.435	14:11:56	5	Iniskin Bay
Harbor seal	22	6/8/2022	59.627	-153.394	14:18:32	5	Iniskin Bay
Harbor seal	20	6/8/2022	59.826	-153.149	14:35:13	5	Chinitna Bay
Harbor seal	45	6/8/2022	60.210	-152.793	14:53:41	5	Tuxedni Bay
Harbor seal	100	6/8/2022	60.520	-152.234	15:39:54	5	Redoubt Bay
Harbor seal	20	6/9/2022	61.225	-150.616	11:39:03	6	Susitna River
Harbor seal	20	6/9/2022	61.181	-150.503	11:45:00	6	Susitna River
Harbor seal	100	6/9/2022	61.185	-150.510	11:45:09	6	Susitna River
Harbor seal	6	6/9/2022	61.190	-150.517	11:45:19	6	Susitna River
Harbor seal	55	6/9/2022	61.265	-150.634	11:47:55	6	Susitna River
Harbor seal	25	6/9/2022	61.278	-150.653	11:48:20	6	Susitna River

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Harbor seal	1	6/15/2022	60.947	-150.030	10:46:16	9	Chickaloon Bay
Harbor seal	15	6/15/2022	61.213	-150.785	15:22:50	10	Lewis River
Harbor seal	200	6/15/2022	61.189	-150.531	16:06:19	10	Susitna River
Harbor seal	20	6/16/2022	61.217	-150.820	12:28:14	11	Theodore River
Harbor seal	200	6/16/2022	61.187	-150.527	16:01:56	12	Susitna River
Harbor seal	10	6/16/2022	61.189	-150.551	16:02:17	12	Susitna River
Harbor seal	20	6/16/2022	61.187	-150.575	16:02:40	12	Susitna River
Harbor seal	20	6/16/2022	61.192	-150.442	16:12:14	12	Susitna River
Harbor seal	40	6/17/2022	61.218	-150.780	16:26:16	14	Lewis River
Harbor seal	200	6/17/2022	61.179	-150.518	16:31:10	14	Susitna River
Harbor seal	3	6/17/2022	61.185	-150.476	17:14:17	14	Susitna River
Harbor seal	2	6/18/2022	60.527	-151.153	8:59:36	15	Kenai River
Harbor seal	2	6/18/2022	59.713	-151.840	9:32:46	15	S. of Anchor Pt.
Harbor seal	20	6/18/2022	59.776	-151.000	9:51:20	15	Fox River
Harbor seal	50	6/18/2022	59.777	-150.990	9:51:30	15	Fox River
Harbor seal	9	6/18/2022	59.780	-150.968	9:51:53	15	Fox River
Harbor seal	40	6/18/2022	60.246	-152.022	11:42:59	15	S. of Kalgin Is.
Harbor seal	20	6/18/2022	60.247	-152.012	11:43:09	15	S. of Kalgin Is.
Harbor seal	65	6/18/2022	60.653	-152.030	12:10:04	15	Redoubt Bay
Harbor seal	100	6/18/2022	60.648	-151.989	12:10:43	15	Redoubt Bay

U.S. Secretary of Commerce
Gina M. Raimondo

Under Secretary of Commerce for Oceans and Atmosphere
Dr. Richard W. Spinrad

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September 2022

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