Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 2017-09
doi:10.7289/V5/AFSC-PR-2017-09

Aerial Surveys, Abundance, and Distribution of Beluga Whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016

June 2017

This document should be cited as follows:

Shelden, K. E. W., R. C. Hobbs, C. L. Sims, L. Vate Brattström, J. A. Mocklin, C. Boyd, and B. A. Mahoney. 2017. Aerial surveys, abundance, and distribution of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016. AFSC Processed Rep. 2017-09, 62 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Available at http://www.afsc.noaa.gov/Publications/ProcRpt/PR2017-09.pdf

AERIAL SURVEYS, ABUNDANCE, AND DISTRIBUTION OF BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) IN COOK INLET, ALASKA JUNE 2016

Kim E.W. Shelden[1], Roderick C. Hobbs[1], Christy L. Sims[2], Linda Vate Brattström[2], Julie A. Mocklin[2], Charlotte Boyd[2], and Barbara A. Mahoney[3]

[1]National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center,
Marine Mammal Laboratory
7600 Sand Point Way N.E.
Seattle, WA 98115-6349

[2]Joint Institute for the Study of the Atmosphere and Ocean
University of Washington
Marine Mammal Laboratory
7600 Sand Point Way N.E.
Seattle, WA 98115

[3]National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Protected Resources Division,
222 West 7th Avenue, Box 43
Anchorage, AK 99513

June 2017

ABSTRACT

The National Marine Fisheries Service (NMFS) has conducted aerial surveys to estimate abundance of the beluga population in Cook Inlet, Alaska, each June, July, or both from 1993 to 2012, after which biennial surveys began in 2014. The current document presents survey results and subsequent analyses yielding an abundance estimate and population trend based on data collected during June 2016. Surveys occurred May 31 – June 9, 2016 (49.2 flight hours). All surveys were flown in twin-engine, high-wing aircraft (i.e., an Aero Commander) at a target altitude of 244 m (800 ft) and speed of 185 km/hour (100 knots), consistent with NMFS' surveys of Cook Inlet conducted in previous years. Tracklines were flown 1.4 km from the shoreline, along the entire Cook Inlet coast, including islands. Additionally, sawtooth pattern tracklines were flown across the inlet in 2016. These aerial surveys effectively covered 40% of the total surface area of Cook Inlet and 100% of the coastline. In particular, most of the upper inlet, north of the East and West Foreland where beluga whales are consistently found, was surveyed seven times (out of seven attempts). Paired, independent observers searched on the coastal side of the plane, where most beluga sightings occur, while a single observer searched on the inlet side. A computer operator/data recorder periodically monitored distance from the shoreline (1.4 km) with a clinometer (angle 10°). After finding beluga groups, a series of aerial passes allowed all observers to each make independent counts of every group. In addition, whale groups were video recorded for later analysis and more precise counts in the laboratory.

Belugas were not seen in lower Cook Inlet (south of East and West Foreland) nor in the upper inlet south of North Foreland and Moose Point. Much of the survey period occurred during negative low tides, which expose vast expanses of mudflats and typically line up whales within the deeper channels. Beluga groups were found from Beluga River to the Little Susitna River in the Susitna Delta, along offshore tracklines from North Foreland to Point Possession, near Moose Point shoals south of Point Possession, from Burnt Island to the bluffs approaching Point Possession in Chickaloon Bay, and in Turnagain Arm. The annual sums of medians from aerial counts provide an index of relative abundance, not corrected for estimates of whales missed.

Daily overall medians ranged from 194 to 300 whales. The annual median index count of 300 whales fell within the range of median counts collected to date for this project.

Corrected group sizes ranged from 1 to 230 whales (mean = 46, SD = 60). Similar to the past six survey years, whales were not found in Knik Arm. More groups were found on the west side of the upper inlet (Beluga River to Little Susitna River): 24 groups, average group size = 59, range: 1 – 230, compared to Chickaloon Bay-Turnagain Arm: 19 groups, average groups size = 28, range: 2 - 76). The abundance estimate was based on 5 days of surveys (2, 3, 5, 7, and 9 June) where coverage of the upper inlet was complete and observer were able to obtain counts of all groups. Counts with (11 groups) and without (20 groups) video recordings were obtained for every beluga whale group observed. The abundance estimate of 328 (CV = 0.083, 95% CI = [279,386], N_{min} = 306) falls within the range of abundance estimates from the last 10 survey years (284 - 375 whales). The 10-year trend (2006-2016) was -0.5% /year with a SE of 1.0% (i.e., a declining trend: P (< 0.0) = 70%). During the period since management of the hunt began (1999-2016), the trend was -0.4% /year with a SE of 0.6% (i.e., a declining trend: P (< 0.0) = 73%).

The contraction in range first documented in Rugh et al. (2010) has persisted. Since 2008, on average 81% of the total population occupied the Susitna Delta in early June during the aerial survey period, compared to roughly 50% in the past. The 2009-2016 range was estimated to be only 29% of the range observed in 1978-79, a slight increase from 25% for the period 2009-2014

CONTENTS

INTRODUCTION

Beluga whales (*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 (O'Corry-Crowe et al. 1997, Allen and Angliss 2013). The most isolated of these is the Cook Inlet stock, separated from the others by the Alaska Peninsula (Laidre et al. 2000). Beluga whales in Cook Inlet gather in river mouths and bays during the summer months (Rugh et al. 2000a, 2005a, 2010). The small population size (fewer than 400 whales; Hobbs et al. 2000a, 2015) and geographic and genetic isolation of the whales in Cook Inlet (O'Corry-Crowe et al. 1997, Laidre et al. 2000, Rugh et al. 2000a), in combination with their strong site fidelity, has made this stock vulnerable to anthropogenic impacts. Until 1999, these whales were subject to an unregulated Native subsistence hunt (Mahoney and Shelden 2000), but on 31 May 2000, the stock of belugas in Cook Inlet was designated as depleted under the U.S. Marine Mammal Protection Act (65 Fed. Reg. 34590) and is now managed with a small, regulated, subsistence hunt by Alaska Natives (65 Fed. Reg. 59164). The Cook Inlet population was designated a Distinct Population Segment and listed as endangered under the U.S. Endangered Species Act (73 Fed. Reg. 62919) in October 2008.

Each June, July, or both from 1993 to 2012, the National Marine Fisheries Service (NMFS) conducted annual aerial surveys to study the distribution and abundance of beluga whales in Cook Inlet (Withrow et al. 1994, Rugh et al. 1995, 1996, 1997a, 1997b, 1999, 2000a, 2001, 2002, 2003, 2004; 2005a, 2006, 2007, Shelden et al. 2008, 2009, 2010, 2011, 2012). Results from 1993 to 2000, 2001 to 2004, and 2005 to 2012 were published in Rugh et al. (2000b, 2005b) and Shelden et al. (2013), respectively. After 2012, NMFS adopted a biennial survey schedule (Hobbs 2013) resuming abundance estimates with the June 2014 survey (Shelden et al. 2015a). Surveys were conducted in cooperation with the Cook Inlet Marine Mammal Council (CIMMC) and the Alaska Beluga Whale Commission (ABWC). Aerial surveys have proven to be an efficient method for collecting distribution and abundance data for beluga whales in Cook Inlet and were used for many years prior to the start of the NMFS surveys, though no complete systematic census had been conducted (e.g., Klinkhart 1966,

Murray and Fay 1979, Calkins 1984, Shelden and Mahoney 2016). The NMFS studies have been the most thorough and intensive in terms of coverage and effort (Shelden et al. 2015b). The primary objectives for the current study were to document sighting locations and count beluga whales in Cook Inlet while maintaining continuity with preceding studies to allow for inter-year trend analyses. This document presents data collected in June 2016, the second year of surveys after adopting a biennial survey schedule for this project (Hobbs 2013).

Study Area

Cook Inlet is a major inland sea in south-central Alaska covering approximately 20,000 km^2 (Fig. 1). The southern boundary, which opens to the Gulf of Alaska, is approximately 85 km across from Cape Douglas to Elizabeth Island. The northern limit, at the Susitna River, is 315 km north of Cape Douglas. From there two substantial tidal estuaries extend to the northeast (Knik Arm, roughly 55 km long) and southeast (Turnagain Arm, 75 km long). The shoreline of Cook Inlet (1,810 km) is highly irregular and interrupted by many rivers and creeks which contribute considerable freshwater input 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) and Goetz et al. (2007, 2012a). Anchorage, the largest city in Alaska, served as the base of operations for these aerial surveys.

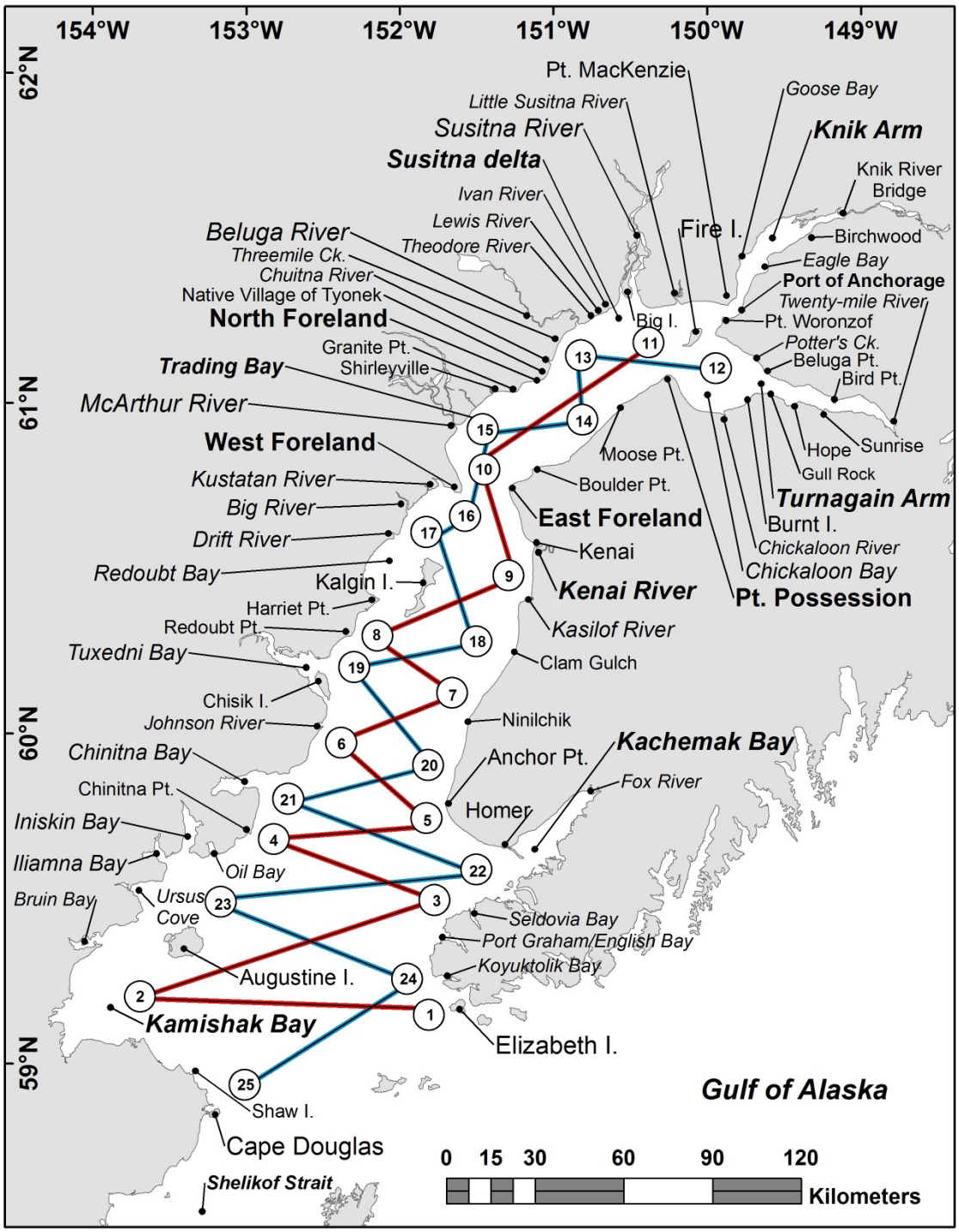

Figure 1. -- Cook Inlet, Alaska, with place names mentioned in text, and mid-inlet sawtooth tracklines with waypoints (numbers) flown during beluga whale surveys in June 2016.

METHODS

Aircraft and Data Entry

In June 2016, the survey aircraft was a twin engine, high wing Aero Commander 690 (tail number: *N840TW*) with 6- to 8-hour flying capability. Bubble windows were inserted at the forward observer positions to maximize the search area. The left-rear observer window was flat (Fig. 2). 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 most beluga whales were seen. A single observer searched on the mid-inlet side of the aircraft because of the paucity of beluga sightings more than 3 km from the coast. 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 2. -- Twin engine, high wing Aero Commander 690 survey platform used during Cook Inlet beluga whale aerial surveys, June 2016 (photo courtesy of Clearwater Air, Inc.).

An intercom system provided communication among the observers, data recorder, and pilots. Seating positions were noted each time the survey team changed positions and tasks (i.e., video recording, data recording, observing/counting). Location data were collected from a portable global positioning system (GPS) interfaced with the laptop computer used to enter sighting data. Data entries included 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), glare (on the coastal and offshore sides of the plane), and visibility (on the coastal and mid-inlet 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. Only the typical search area (e.g., > 10° below the horizon and 10° to 60° horizontally) was considered when selecting a visibility category.

Tracklines

Coastal surveys were conducted approximately 1.4 km from the shoreline or exposed mudflat edge. The objective was to search all nearshore, shallow waters where belugas are typically seen in late spring/early summer (Rugh et al. 2000b, 2005b; Shelden et al. 2013). The trackline distance from shore was monitored with a clinometer to keep the shoreline 10° below horizontal while the aircraft was at the standard altitude of 244 m (800 ft). Ground speed was approximately 185 km/hour (100 knots). 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 hunters who have flown with us in the past.

In addition to the coastal surveys, systematic transects were flown across the inlet (Fig. 1). During past surveys, mid-inlet tracklines were designed to run the length of Cook Inlet or in a sawtooth pattern across it, minimizing overlap from year to year.

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 kept beluga groups confined along the mudflat edge in more compact groups, rather than dispersing across the flats, and reduced the area that would need to be searched, as a large proportion of upper Cook Inlet has exposed mudflats only at low tide that would otherwise have 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. When beluga groups are in deeper water, they tend to be more scattered making counting and video recording more difficult.

Whales seen near Anchorage usually could not be circled (see Counting Protocol) due to aircraft traffic in the vicinity of the Ted Stevens Anchorage International Airport. Turnagain Arm was usually surveyed in the morning when wind speeds were often slower allowing for better survey conditions and smoother flights. 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 early June (just prior to the summer solstice) 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, whale travel direction, 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. An important component of the survey protocol was the independence of the paired observers (i.e., observers do not cue each other to their sightings). After a group of whales 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. This allowed each observer an opportunity to independently sight and report whale groups. The pilots and data recorder did not cue the observers to the presence of a whale group until the whale group 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, then recording (i.e., marking) the group perimeters. The flight pattern used to count a whale group involved an extended oval around the longitudinal axis of the group with turns made well beyond the ends of the group (Fig. 3). Counts of whales were usually made 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 long axis of the oval. There were typically eight or more separate counting opportunities per whale group, with two observers counting during each pass then rotating positions after four good counts to allow another pair of observers to count. Counts began and ended on a cue from the front observer, starting when the leading edge of the group was close enough to be counted and ending when the trailing edge went behind the wing of the aircraft. This provided a precise record of the duration of each counting pass. The paired observers each made independent counts and wrote down their results along with date, time, pass number, and quality of the count.

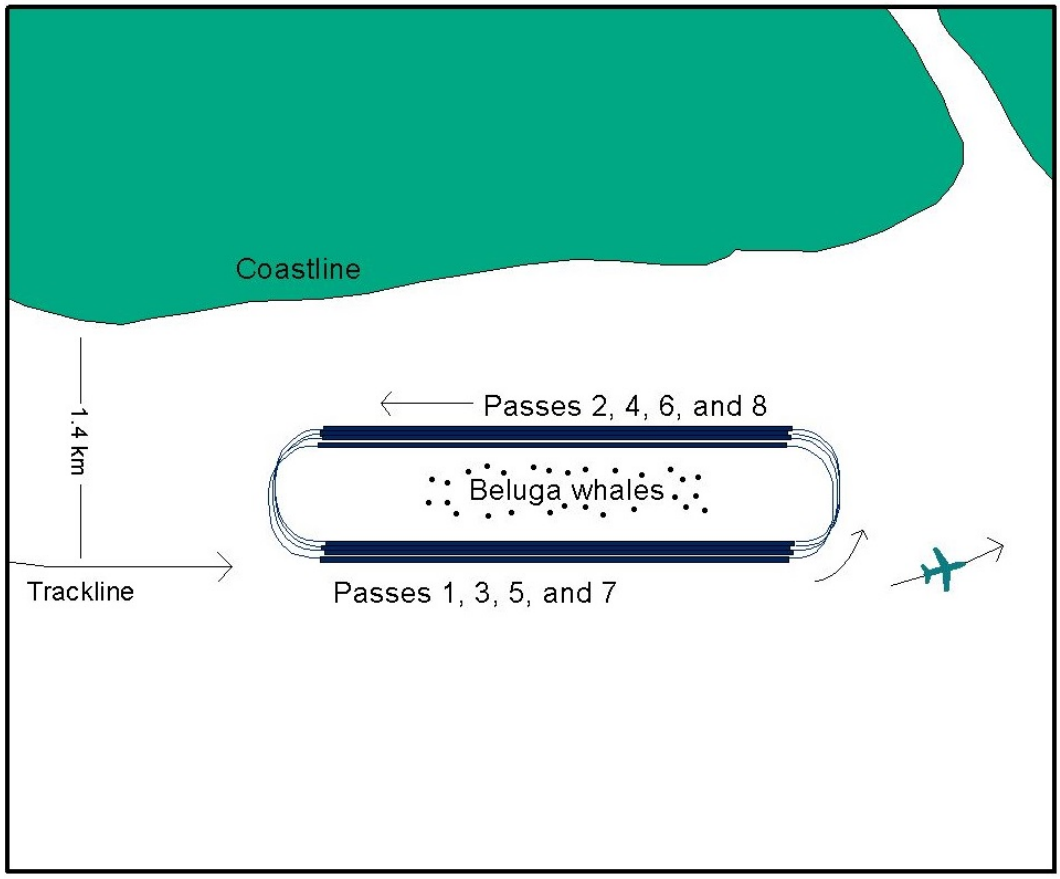

Figure 3. -- Racetrack pattern flown during counting passes of Cook Inlet beluga whales.

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 on the respective pass). Only quality A and B estimates were used in the median count calculations and abundance estimate analysis. Only whales that were at the surface during a pass were counted; mud plumes or ripples from subsurface whales were not counted. Count records were not shared among aerial team members until each season's surveys were complete in order to maintain the independence of each observer's counts.

Most whale groups were counted on four different aerial passes, some larger groups up to eight passes, and because two observers were counting during each pass, there were at times 16 counts made per group per day, not including counts made later from video recordings (Hobbs

et al. 2000b, 2015). The daily aerial counts were represented by medians of each of the four observers' median counts on multiple passes over a group. The process of 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. Medians were also more appropriate than maximums when counts were corrected for missed whales (see Abundance and Trend Analyses section).

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 taken from the highest daily sum. This procedure of using the highest daily median sum for the index ameliorates problems with partially or totally missing whale groups in certain areas on some days (Rugh et al. 2005b). Previously, the highest median count for each area (e.g., Susitna Delta, Knik Arm, Turnagain Arm, Chickaloon Bay, Trading Bay, lower inlet) was used as the annual index count irrespective of survey day (Rugh et al. 2000b). However, 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 (with the exception of sightings made in the lower inlet since it 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.

Cameras

Two digital video cameras mounted on a board were operated together on most counting passes (Fig. 4). The "standard" camera was adjusted to keep the entire group of belugas in view (generally at maximum wide angle). Magnification was kept constant throughout a pass. The second "zoomed" camera was kept at maximum optical zoom (12×). The zoomed video was used to determine correction factors for missed animals (Hobbs et al. 2000b, 2015) and to examine color ratios of white adults relative to dark juveniles (Litzky 2001, Sims et al. 2003). Paired Sony HXR-NX5U HD digital video cameras with 1920 × 1080 pixel resolution were used during the June 2016 survey. We also tested two GoPro cameras mounted to the top of the HD cameras. The GoPros were also set to a wide-angle and zoomed setting.

A.

B.

Figure 4. -- Video and counting passes of Cook Inlet beluga whales. Observers counted from the left-forward position (A. hidden behind the camera operator) and left-rear position (B. opposite the computer display) while pass number and flight path were recorded by the computer operator.

Each video counting pass was reviewed for quality and rated on a scale (excellent, good, fair, poor, and unacceptable). Video passes rated excellent and good were analyzed using a computer-aided system (introduced in 2004). With this program (called "Beluga Dots"), analysts were able to count and catalog the individual whale images found in the survey video, track the images across the computer screen, and measure image size and color. All of these data were stored in a text file used by the program (Fig. 5). Video counts were then used to calculate abundance estimates[1] (Hobbs et al. 2015). Images from the camera kept at maximal zoom were examined for whale surfacings that did not show up in the standard video, and for color ratios (white adults vs. dark juveniles) within the respective groups (as described in Litzky 2001).

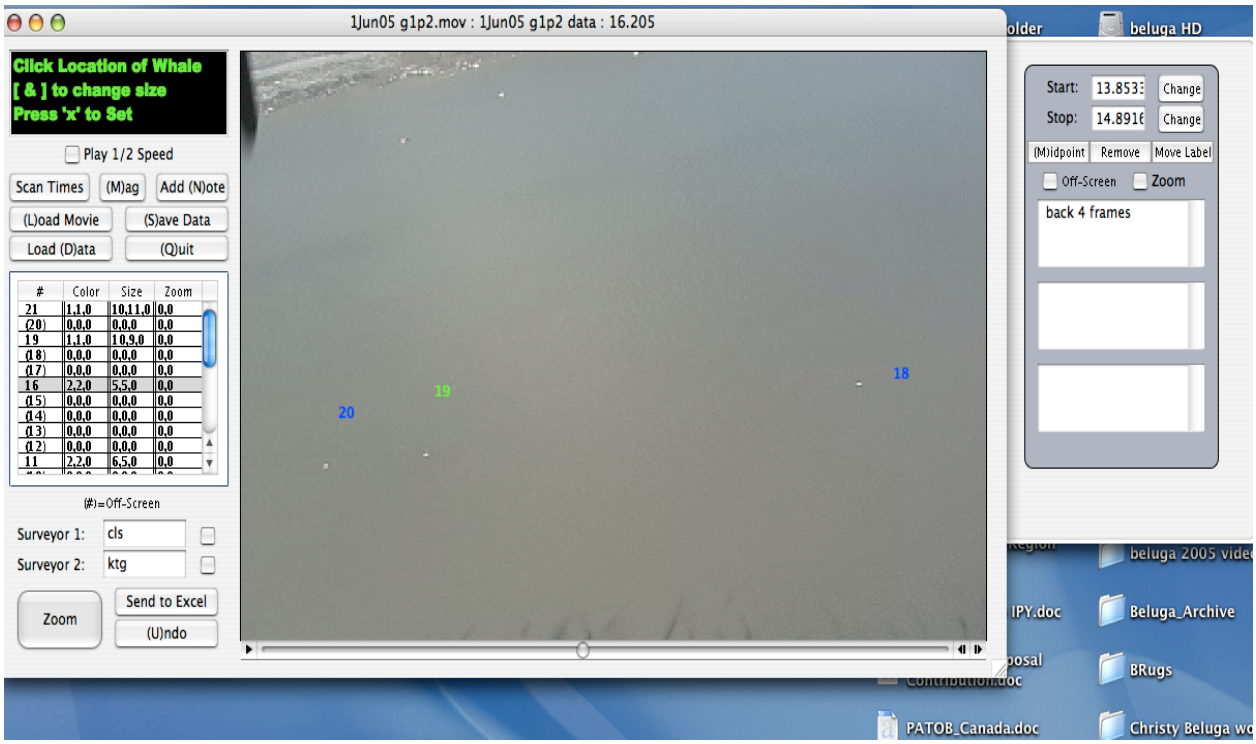

Figure 5. -- Computer screen shot of "Beluga Dots" program used to catalog individual beluga whale images found in the Cook Inlet survey video.

[1]Although whale counts made from video were used in abundance estimates, the median counts made by observers in the aircraft provided a quick, efficient approximation of relative abundance. Aerial counts could also be used as a proxy (with appropriate corrections relative to each observer and group density) for video counts when video was inadequate for a particular group.

Abundance and Trend Analyses

Analysis of both the aerial counts and counts from the video recordings are described in Hobbs et al. (2000b) for data from 1994 to 2000, and Hobbs et al. (2015) for all years through 2012. The following excerpt from Hobbs et al. (2015) explains changes made to the analyses presented in Hobbs et al. (2000b):

Beginning in 2004, the number of survey days was increased [from one week to two weeks] and the northeast and northwest sectors in the upper inlet [bisecting Trading Bay/Susitna Delta/Knik Arm from Chickaloon Bay/Turnagain Arm/Point Possession] were combined so that the inlet was divided into two sectors (upper and lower [separated by East and West Foreland]) rather than three sectors" (see Hobbs et al. (2000a:Fig. 1)). We also note that both the upper and lower inlet includes an offshore area that is surveyed using line transect methods. The lack of sightings in the offshore areas means that, in practice, the abundance is estimated entirely from the coastal surveys. Therefore, the current estimate uses only the coastal surveys with the understanding that should offshore sightings occur in the upper and lower inlet then line-transect density estimates would be used to estimate the abundance in those areas. These equations replace the equations in Hobbs et al. (2015), which had subscripting omissions. The abundance is then estimated by

$$\hat{N}_{j,s,y} = \sum_{i=1}^{G_{j,y}} \hat{n}_{i,j}\,, \qquad Var(\hat{N}_{j,s,y}) = \sum_{i=1}^{G_{j,s,y}} Var(\hat{n}_{i,j})$$

$$\hat{N}_{s,y} = \frac{\hat{K}_y}{J_{s,y}} \sum_{j=1}^{J_{s,y}} \hat{N}_{j,s,y}\,, \qquad Var(\hat{N}_{s,y}) = (see\,below)$$

$$\hat{N}_y = \sum_{s=1}^{S} \hat{N}_{s,y}\,, \qquad Var\,(\hat{N}_y) = \sum_{s=1}^{S} Var\,(\hat{N}_{s,y}) \qquad ,$$

where

$\hat{N}_{j,s,y}$ = the estimated number of belugas in groups found in survey *j* of sector *s* in year *y*,

$G_{j,s,y}$ = the number of groups found in survey *j* of sector *s* in year *y*,

$\hat{n}_{i,j}$ = the estimated number of belugas in the *ith* group found in survey *j*,

$\hat{N}_{s,y}$ = the estimated number of belugas in sector *s* in year *y*,

$\hat{K}_y$ = the multiplicative correction for belugas in groups that were missed,
$J_{s,y}$ = the number of usable surveys in sector s year y.
S = the number of sectors in year y.
$\hat{N}_y$ = the estimated number of belugas in year y.

Continuing the excerpt from Hobbs et al. (2015), "Estimates from each survey day were summed, and only survey days with complete surveys of the upper inlet were used to estimate abundance in the upper inlet. This addressed the concern that groups of whales might move from one sector to another in the upper inlet between days during the 2-week period of the surveys, but it required more survey days and flight hours to complete.

For survey days with unusually low estimates (e.g., less than about 60% of the highest daily estimate), the flight paths were reviewed to determine if a group seen on other survey days could have been missed either because the area was unavailable due to weather or air traffic, or if the group could have moved to an adjacent area that was not surveyed. If this was the case, these survey days were not included in the abundance estimate to reduce the possibility of biasing the estimate downward.

The estimate of the variance of the abundance in each sector equation, presented in Hobbs et al. (2000b) under the heading Abundance Estimate, was revised to use the squared standard error of the average for the sector in place of the variance of the abundance estimate (*CV*) and the measurement error. In Hobbs et al. (2000b), both measurement error and the standard deviation were included to avoid underestimation of the variance; at that time it was thought that there were significant variations in behavior from year to year that could not be corrected for with existing methods.

With the recent trend results it is clear that the variance is overestimated by the method of Hobbs et al. (2000b). Examining the standard deviation of the residuals of abundance estimates from 1999 to 2011 around the trend line, we have an upper bound for the average *CV* of 11%. The residuals include both the variation resulting from the estimation and any variation in the dynamics of the population from year to year. Using the equation in Hobbs et al. (2000b), the average *CV* (square root of the mean of CV^2) for 1999-2011 was 17%, indicating that *CV* had

been overestimated by this equation. The revised estimate of variance (shown below) accounts for the variation in behavior explicitly and uses the standard error which takes advantage of the increased sampling effort of the recent surveys.

Using the notation of Hobbs et al. (2000b), the variance is now [as follows]:

$$Var\left(\hat{N}_{s,y}\right) = \frac{1}{\left(J_{s,y}-1\right)J_{s,y}} \sum_{j=1}^{J_{s,y}} \left(\hat{N}_{s,y} - \hat{K}_{y} \sum_{i=1}^{G_{j,s,y}} \hat{n}_{i,j} \right)^2 + \left(CV^{2}(T_{I,y}) + CV^{2}(\hat{K}_{y})\right)\hat{N}_{s,y}^{2} \quad ,$$

where,

$\hat{N}_{s,y}$ = the estimated number of beluga whales in groups found in sector *s* (northwest, northeast or south 1994-2003, and upper or lower 2004-[present]) of year *y*,

$J_{s,y}$ = the number of surveys of sector *s* during year *y*.

$\hat{K}_{y}$ = the multiplicative correction for beluga whales in groups that are missed,

$G_{j,s,y}$ = the number of groups found in survey *j* of section *s* of year *y*,

$\hat{n}_{i,j}$ = the estimated number of beluga whales in the *i*th group found in survey *j*,

CV = the coefficient of variation (standard error/mean) of an estimate (c.f. Hobbs et al. 2000b), and

$T_{I,y}$ = the annual mean of the average dive interval (time from the end of one dive to the end of the next) resulting from variation in average behavior of groups from year to year.

Confidence interval limits and N_{min} are calculated as the 2.5, 97.5 and 20th percentiles of the log-normal distribution ($N_X = N \exp(X(\ln(1+[CV(N)]^2)]^{½})$) with X = -1.96, 1.96, and -0.842, respectively. Trends were estimated using weighted linear regression of the natural logarithms of the abundance estimates with the weights being the squared inverse of the coefficients of variation of the estimates. We considered the end of the unregulated subsistence hunt in 1999 to be the point in the time series where change in Cook Inlet beluga whale population dynamics may have occurred. To examine the impact of a trend in $T_{I,y}$ with survey dates, we regressed the residuals of the trend analysis against the median date for each survey.

RESULTS AND DISCUSSION

Survey Effort

The June 2016 survey included 12 flights which ranged from 0.7 to 5.8 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 49.2 hours for the season. Systematic search effort, not including time spent circling whale groups, deadheading without search effort, or periods with poor visibility was 29.3 hours. Poor visibility interfered with search effort during 0.5 hours (1% of the search effort). This is 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 2016 aerial survey provided a thorough coverage of the coast of Cook Inlet (1,810 km) for most of the area within approximately 3 km of shore. Including mid-inlet tracklines, survey coverage totaled 40% of the 20,943 km^2 of Cook Inlet surface area (assuming a 2.0 km transect swath: 1.4 km on the left plus 1.4 km on the right, less the 0.8 km blind zone beneath the aircraft). Most of upper Cook Inlet was surveyed seven 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). The other observers have flown on three to nine of the surveys (LVB, CLS, JAM). Differences between observers' sighting performances (whether or not an observer found whale groups seen by others and how high or low that observer's counts were relative to the other observers) are incorporated into correction factors for the abundance estimates (see Abundance and Trend section below).

Summary Counts and Daily Reports

Median counts of beluga groups for each area are shown in Table 1. Typically, there were four good counts made by each observer 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. The median index count for all observers for 2016 was 300, which falls within index counts generated to date for this project (Table 2). These summary counts do not reflect any correction for missed whales or groups (see Abundance and Trend section for correction factors and groups used in the abundance estimate for 2016). Day-by-day survey effort and marine mammal sighting locations are summarized below.

Table 1. -- Beluga counts made during aerial surveys of Cook Inlet in June 2016. Counts are medians from multiple counts of each whale group. 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. If more than one group was found within a location, the median for each group was added together (see Daily Reports for specific group locations).

Location	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	6/9
Turnagain Arm	---	---	0	4	0	5	---	0	5	4
Chickaloon Bay/ Point Possession	---	b	72[c]	40	23	45	---	59	50	49
Point Possession to Moose Point/ East Foreland	---	---	0	0	0	16	---	0	0	0
Mid-inlet east of Trading Bay	0	0	---	---	0	---	---	0	2	0
East Foreland to Homer	0	---	---	---	---	---	---	---	---	---
Kachemak Bay to Elizabeth Island	0	---	---	---	---	---	---	---	---	---
West side of lower Cook Inlet	---	0	---	---	---	---	---	---	---	---
Redoubt Bay	---	0	---	---	---	---	---	---	---	---
Trading Bay	---	---	0	0	---	0	---	0	---	---
Susitna Delta [a]	---	b	129[d]	178	52[e]	191	---	241	48[e]	141
Knik Arm	---	---	0	0	0	0	---	0	0	0
Fire Island	---	---	0	0	0	0	---	0	0	0
Index counts	0	0[b]	201[c,d]	222	75[e]	257	f	**300**	105[e]	194

[a] The coast between North Foreland and Point MacKenzie is defined as the Susitna Delta.

[b] Belugas were seen near the ends of the northernmost mid-inlet trackline (Waypoints 12-13) near Point Possession and Beluga River. A small group was observed near the bluffs in Chickaloon Bay while off effort during the return flight to Anchorage.

[c] Four groups (1-4): between Burnt Island and Chickaloon River, Chickaloon River and the bluffs, along the bluffs, and off Point Possession.

[d] Three groups (5-7): spread from Beluga-Theodore rivers and off mud plume, east of the mouth of the Little Susitna, and in the Little Susitna River. Collected only counts as group 5 was scattered and other groups were small.

[e] Counts/video compromised by widely scattered whales in the Susitna Delta which we were unable to count.

[f] Survey cancelled because of high winds, rain, and low ceilings.

Table 2. -- Summary of index counts made during aerial surveys of belugas in Cook Inlet in June/July 1993-2016. Highest median counts of belugas in each of six zones are shown. The sum of these high counts does not necessarily equal the index counts because, in the latter case, highest daily sums were used, not highest counts per zone (e.g., see Table 1).

Year	Index count	Zones in Cook Inlet (highest median count per zone per survey)					
		1	2	3	4	5	6
1993	302	1	9	169	80	8	49
1994	276	10	1	248	0	6	17
1995	322	14	4	287	1	0	18
1996	287	0	0	368	29	0	41
1997	261	1	0	73	161	0	29
1998	192	0	0	109	93	0	42
1999	217	0	0	160	28	0	30
2000	184	0	0	114	42	0	28
2001	210	2	0	114	127	10	34
2002	181	0	0	93	97	0	11
2003	174	0	0	41	94	25	65
2004	187	0	0	99	0	50	176
2005	192	0	0	155	43	21	66
2006	153	0	15	126	9	0	60
2007	224	0	0	152	27	76	50
2008	126	0	0	103	0	0	33
2009	303	0	0	290	0	0	40
2010	291	0	0	160	0	4	131
2011	208	0	0	187	0	0	72
2012	319	7	21	286	0	2	30
2014	352	0	0	333	0	0	51
2016	300	0	16	241	0	5	72

ZONES:

1) Lower Cook Inlet, including all areas south of East and West Foreland.

2) Mid-inlet, bordered on the south by East/West Foreland and north by Point Possession/North Foreland.

3) Susitna Delta, bordered by Beluga River and Point MacKenzie, including Fire Island.

4) Knik Arm, with a southern boundary defined by Point MacKenzie and Point Woronzof.

5) Turnagain Arm, including waters east of Fire Island, but not Chickaloon Bay.

6) Chickaloon Bay, bordered by Point Possession and Burnt Island.

31 May 2016

Lower inlet surveys were planned for the beginning of the project because tides were more favorable (negative low tides later in the day) for upper inlet surveys starting June 3rd. The plane departed Anchorage and flew the eastern coastline from East Foreland to Elizabeth Island where mid-inlet tracklines were flown in a sawtooth pattern north to Kachemak Bay for a refueling stop. Mid-inlet tracklines were then surveyed to Kalgin Island where we briefly departed the line to circle the island before surveying the remaining lines to Anchorage.

While no belugas were observed, marine mammal sightings included a probable minke whale (*Balaenoptera acutorostata*) in Kachemak Bay, harbor seals (*Phoca vitulina,* 2 sightings, 232 animals) in Kachemak Bay and near Elizabeth Island (1 seal in the water); one unidentified pinniped in Kachemak Bay, sea otters (*Enhydra lutris,* 50 sightings, 1,691 animals [biased downward as sightings and group sizes were lumped together and estimated at times at great distances from the plane]) south of Ninilchik, along the shoreline from Anchor Point to Elizabeth Island, and along mid-inlet tracklines in Kamishak Bay and south of Kalgin Island; humpback whales (*Megaptera novaeangliae,* 1 sighting, 2 animals) near Waypoint 3, an unidentified large whale south of Augustine Island; and one harbor porpoise (*Phocoena phocoena*) near Waypoint 7 (Fig. 6, also see Appendix). Sea states ranged from Beaufort sea state 1 to 5, with brief periods of poor visibility (0.2 hours) during the 7-hour survey.

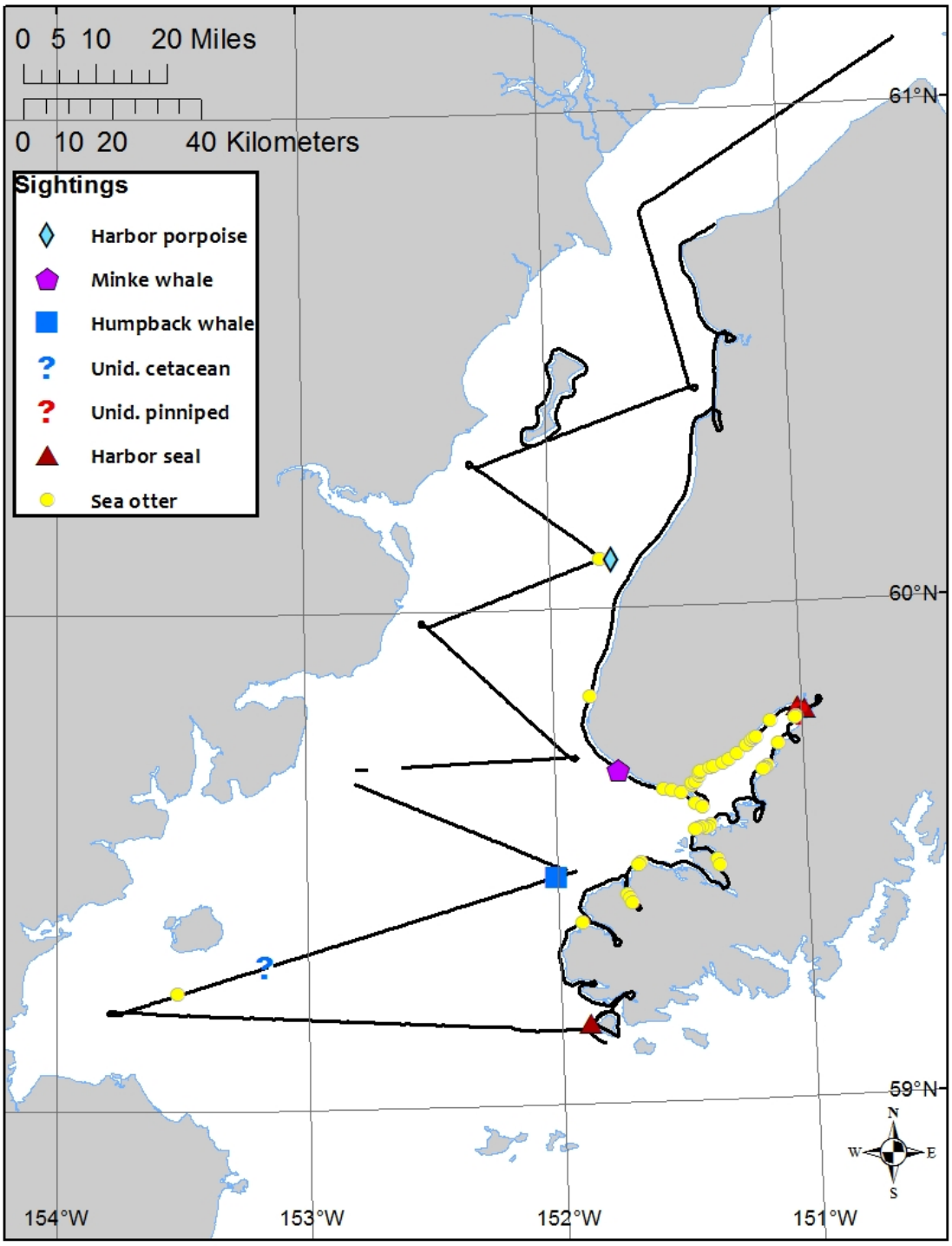

Figure 6. -- On-effort trackline and marine mammal sightings on 31 May during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

1 June 2016

Lower inlet surveys continued for a second day, following mid-inlet sawtooth transects (Waypoint 12) that ended in Kachemak Bay (Waypoint 22) (Fig. 1), at which point we flew to Homer to refuel. We continued the sawtooth pattern (from Waypoint 22) ending at the waypoint north of Cape Douglas (Waypoint 25). At Cape Douglas, we began the coastal survey heading north with a brief transit mid-inlet to circle Augustine Island. The survey ended at West Foreland and we deadheaded back to Anchorage.

Belugas were observed at the start of the survey on the upper inlet trackline (Waypoints 12-13) near Point Possession and Beluga River, and at the end of the survey in Chickaloon Bay near the bluffs when deadheading back to Anchorage (5 sightings, 12 belugas) but nowhere in the lower inlet. Harbor porpoise (13 sightings, 16 animals) were seen on mid-inlet tracklines south of Kalgin Island and north of Kachemak Bay, with one sighting between Bruin Bay and Ursus Cove (Fig. 7, Appendix). Sea otters (52 sightings, 144 animals) were seen on mid-inlet tracklines, in Kamishak Bay, around Augustine Island, in Bruin Bay, Ursus Cove, and Iliamna Bay. Steller sea lions (*Eumetopias jubatus*) (2 sightings, 71 animals) were seen near Shaw Island and Chinitna Point. Humpback whales (4 sightings, 4 animals) were seen along mid-inlet tracklines south of Kachemak Bay, including one animal displaying bubble netting feeding behavior. Harbor seals (12 sightings, 176 animals) were hauled out or in the water in Kamishak Bay, Iliamna Bay, Iniskin Bay, Chinitna Bay, and Redoubt Bay. Viewing conditions were excellent to fair during much of the 6.8-hour survey, with brief periods of poor visibility due to glare and sea state (0.2 hours). Winds were mostly calm (Beaufort sea states ranged from 1 to 4) throughout much of the survey area, with brief periods of Beaufort sea state 5.

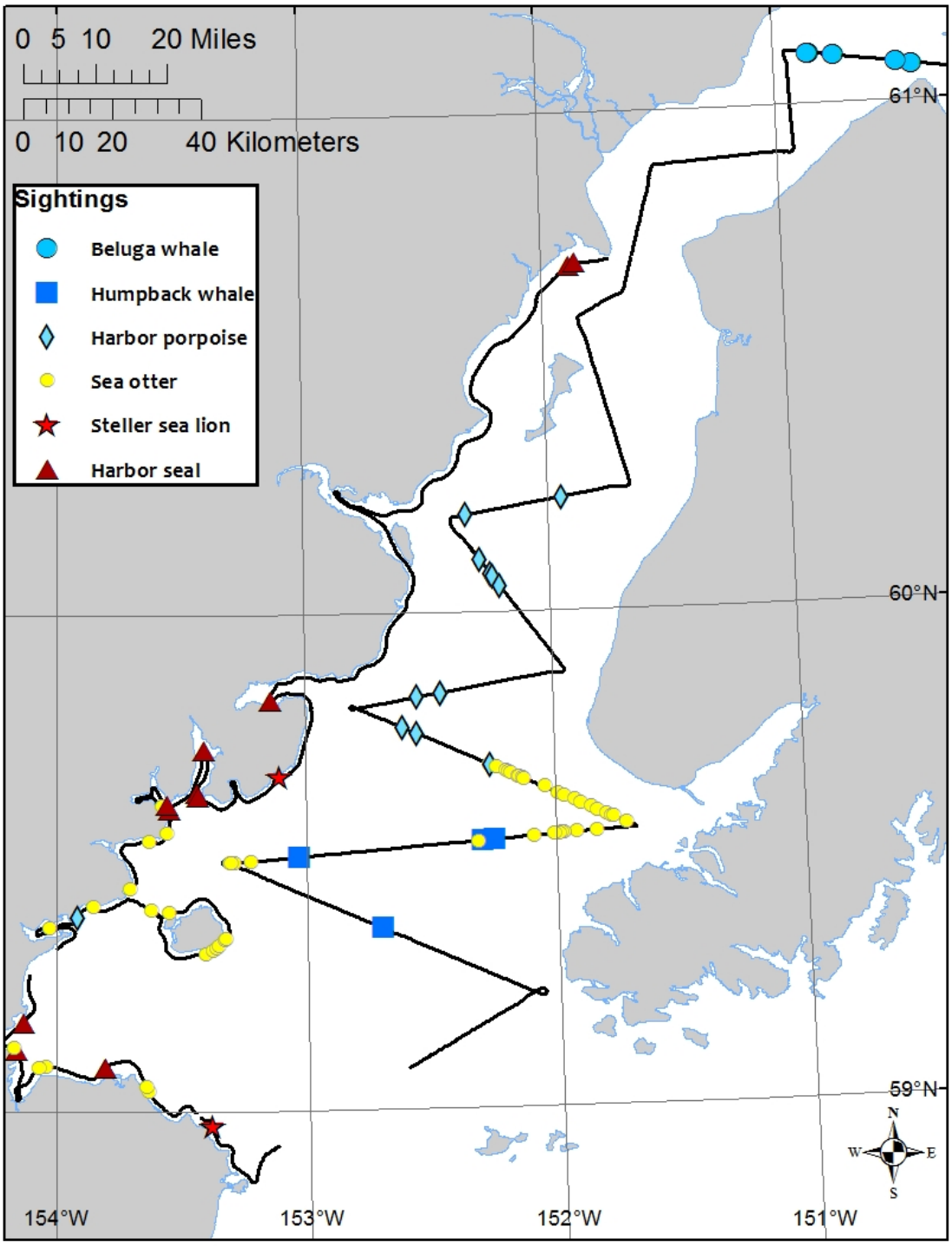

Figure 7. -- On-effort trackline and marine mammal sightings on 1 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

2 June 2016

The first survey of upper Cook Inlet included all coastal areas north of East and West Foreland. Low tide was predicted at 0.08 ft at the Anchorage (Knik Arm) station at 11:53 AKDT. We departed Anchorage and circled the west shore of Fire Island before entering Turnagain Arm. We surveyed the entire Arm and continued the survey into Chickaloon Bay where we observed the first group of belugas west of Burnt Island. As the whales swam toward Chickaloon River, we conducted video and counting passes. After surveying up Chickaloon River and resuming the coastal survey, we observed Group 2 swimming toward the bluffs. Group 3 was encountered along the bluffs between the shore and the mudflats. Group 4 was encountered west of Point Possession as the whales swam into Chickaloon Bay (Fig. 8). We resumed the coastal survey from Point Possession to East Foreland, crossing the inlet to West Foreland then headed north.

Whales were not found in Trading Bay. In the Susitna Delta, Group 5 was spread from the mouths of the Beluga and Theodore rivers to just beyond the edge of the river mud plume. We surveyed up the Susitna River then approached the Little Susitna River where Group 6 was seen west of the river mouth and Group 7 was in the river. We continued the coastal survey diverting over land before reaching Point MacKenzie (due to airport traffic) before returning to Knik Arm. We landed in Anchorage after surveying Knik Arm. Other marine mammal sightings included harbor seals hauled out on the Chickaloon River mudflats and hauled out on the Susitna River mudflats (7 sightings, 196 animals) (Fig. 8, Appendix). Sea states ranged from Beaufort sea state 1 to 4. Sighting conditions were fair to excellent during the 5.2-hour survey.

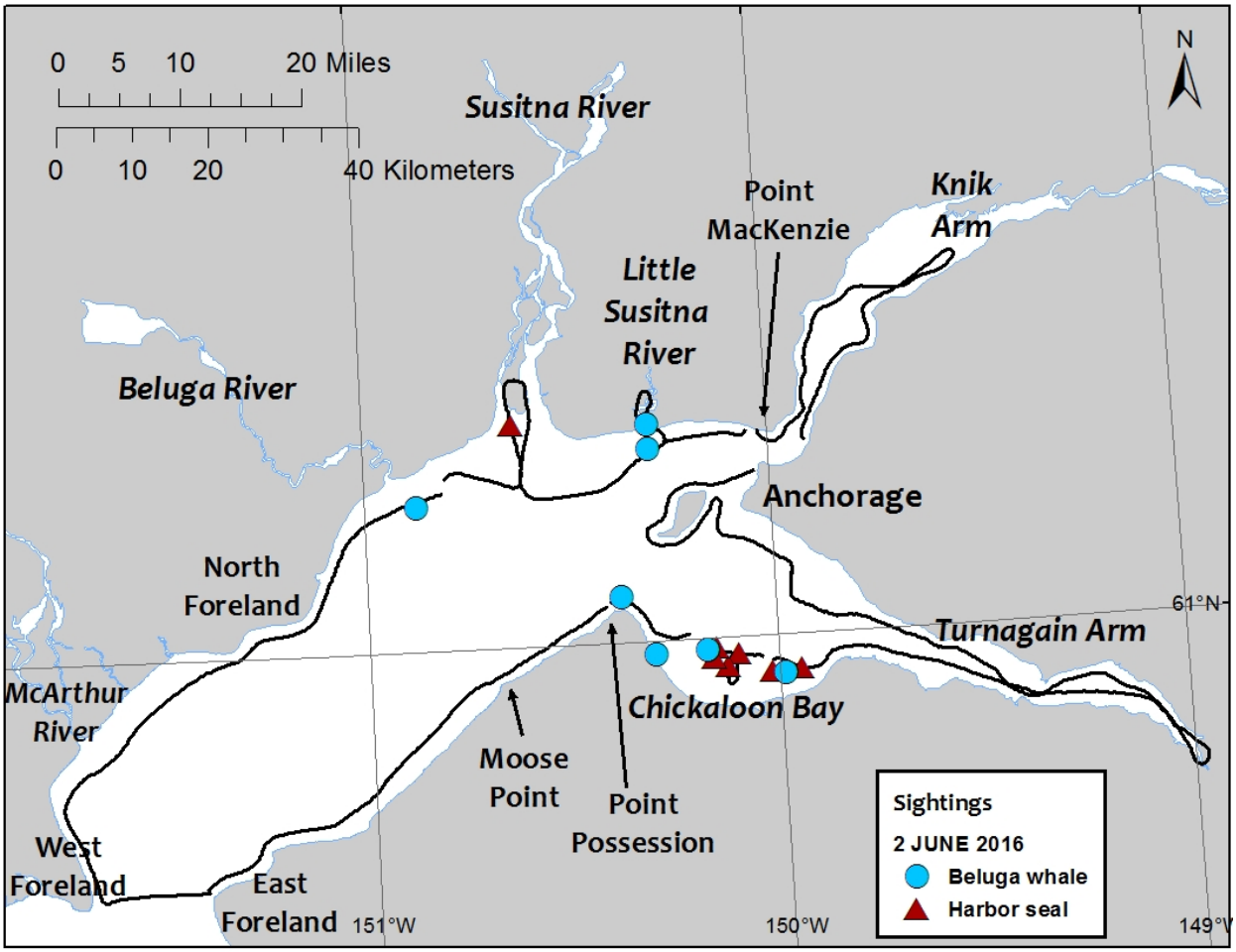

Figure 8. -- On-effort trackline and marine mammal sightings on 2 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

3 June 2016

The negative low tide (-2.13 ft) was predicted for 12:44 AKDT at Anchorage. Due to heavy air traffic between the Susitna Delta and Knik Arm during the 2 June afternoon, we began the survey in Knik Arm before transiting to Fire Island and Chickaloon Bay. We encountered the first beluga group west of Beluga Point in Turnagain Arm. Group 2 was initially in the mouth of the Chickaloon River but as counting/video passes progressed the group spread along the mudflats heading east toward Turnagain Arm. Group 3 was in the same location as on 2 June, between the bluffs and mudflats east of Point Possession. We continued the coastal survey to

Moose Point, then began an offshore transect to the McArthur River. The coastal survey resumed after circling the mouth of the McArthur River.

Group 4 was west of the mouth of the Beluga River while Group 5 was spread from the Theodore to the western tributary of the Susitna River. We did not survey upriver at the McArthur, Beluga, or Susitna rivers as mudflats exposed during the low tide prevented belugas from accessing the rivers. Group 6 was west of the Little Susitna River, which we surveyed to the first bend before determining it was also too shallow for belugas to enter. The coastal survey terminated at Point MacKenzie. Other marine mammal sightings included harbor seals (7 sightings, 656 animals), most hauled out in Chickaloon Bay and the Susitna Delta. Sightings conditions were excellent to fair with Beaufort sea states ranging from 1 to 3. Total survey time was 5 hours.

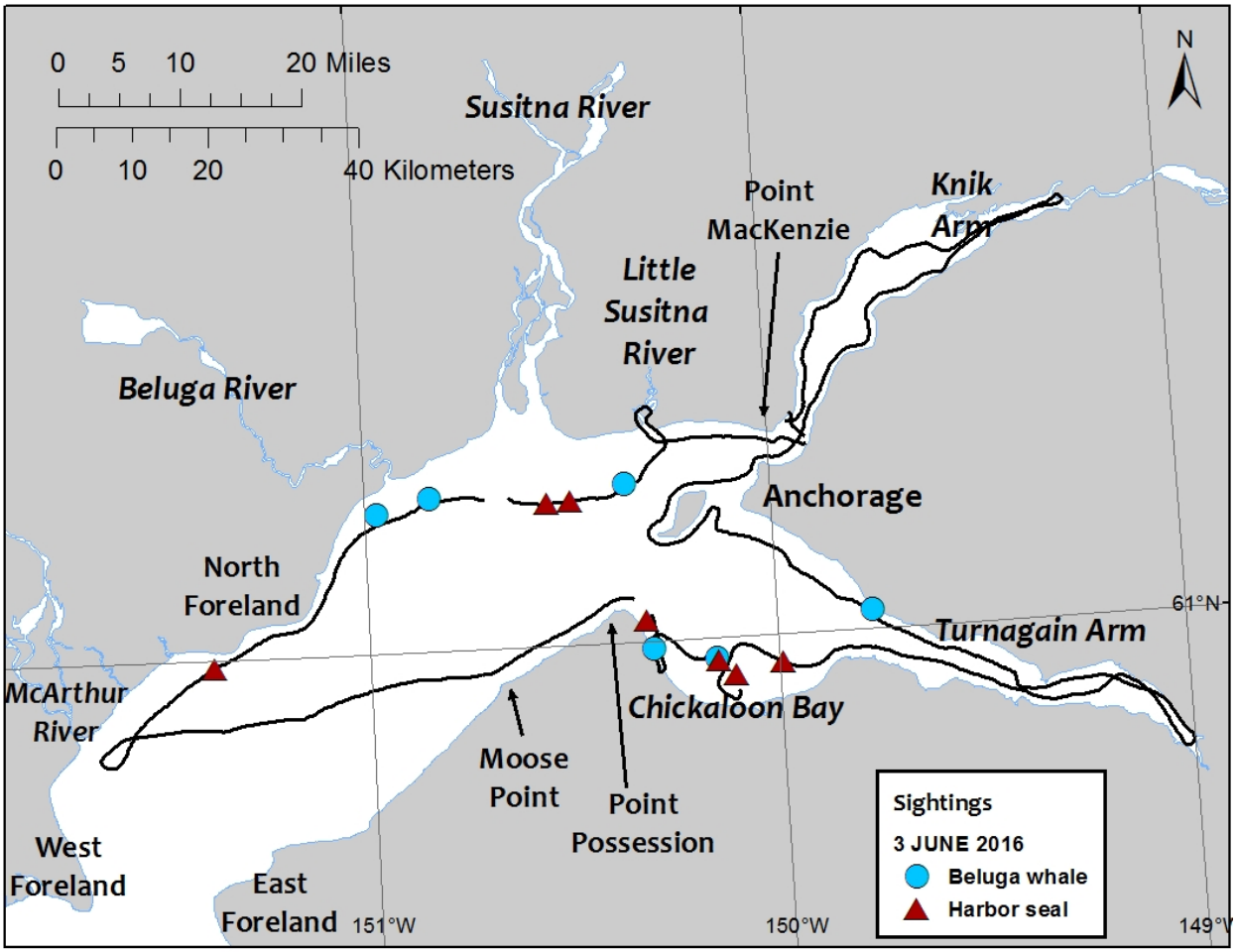

Figure 9. -- On-effort trackline and marine mammal sightings on 3 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

4 June 2016

We started the survey in Knik Arm to take advantage of the low tide in the Susitna Delta (-3.7 ft. at 13:00 AKDT), following the shoreline clockwise to Moose Point before crossing the inlet to North Foreland and concluding the survey at the Little Susitna River. The first group of belugas was near Chickaloon Bluffs (Fig. 10). The second group of belugas was scattered across the mouth of the Beluga River. Two passes were attempted before deciding to continue the coastal effort to the Little Susitna River while waiting for the tide to continue to fall. We observed Group 3 at the western tributary of the Susitna River. After completing video/counting passes of Group 3, we returned to Beluga River. Unfortunately, sighting conditions had

deteriorated and we were unable to locate the large, scattered group (Group 2). We terminated the 4.4-hour flight because of poor visibility due to higher sea states. Other marine mammal sightings included harbor seals (1 sighting, 50 animals) near Chickaloon River (Fig. 10, Appendix).

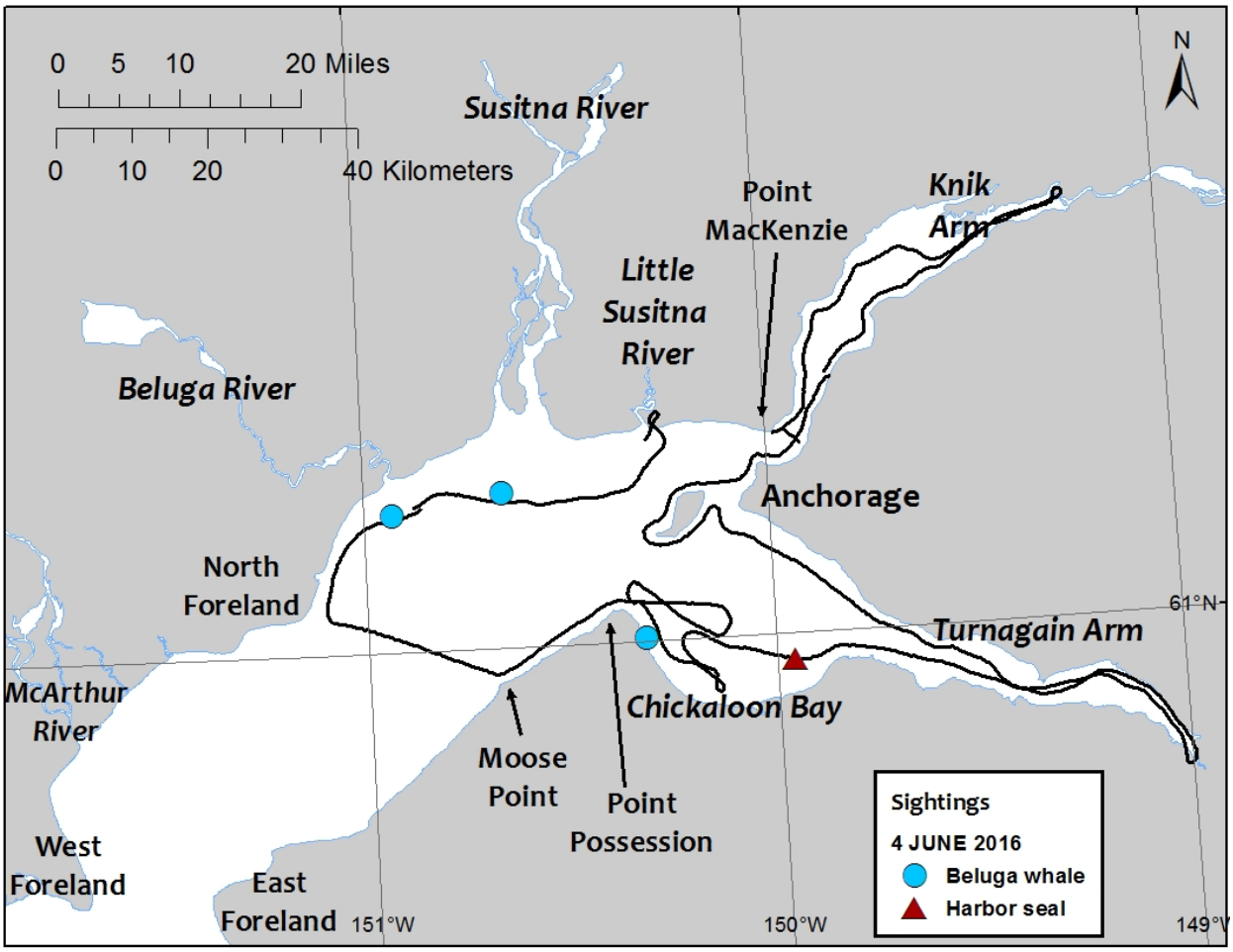

Figure 10. -- On-effort trackline and marine mammal sightings on 4 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

5 June 2016

We started the survey in Knik Arm to take advantage of the low tide in the Susitna Delta (-4.5 ft. at 14:15 AKDT), following the shoreline clockwise to Moose Point before crossing the inlet to McArthur River and concluding the survey at Point MacKenzie. We encountered the first

beluga group west of Sunrise/Sixmile Creek in Turnagain Arm (Fig. 11). Group 2 was near the mouth of the Chickaloon River. Group 3 was between the bluffs and mudflats east of Point Possession. We continued the coastal survey to Moose Point, where we encountered Group 4 along the western edge of the Moose Point shoals (exposed during the low tide). We then continued off effort deadheading across the inlet to the McArthur River. The coastal survey resumed after circling the mouth of the McArthur River.

Group 5 was west of the mouth of the Beluga River while Group 6 was spread from the Theodore to the western tributary of the Susitna River. We did not survey upriver at the McArthur, Beluga, Susitna, or Little Susitna rivers as mudflats exposed during the low tide prevented belugas from accessing the rivers. After completing a series of counting passes on Group 6, we found the group had split, so we counted the portion of the group near the Theodore River (Group 6a) then counted the group that was closer to the Ivan River (Group 6b). Group 7 was clustered near the exposed tidal flats along the eastern tributary of the Susitna River. Finally, Group 8, a lone beluga, was found when circling off effort east of the Little Susitna River while awaiting clearances to proceed to Point MacKenzie. We saw a decaying humpback whale carcass on the mudflats near this whale. The coastal survey terminated at Point MacKenzie. Other marine mammal sightings included harbor seals (3 sightings, 166 animals), most hauled out in Chickaloon Bay (Fig. 11, Appendix). Sightings conditions were excellent to fair with Beaufort sea states ranging from 1 to 4 during the 5.4 hour survey.

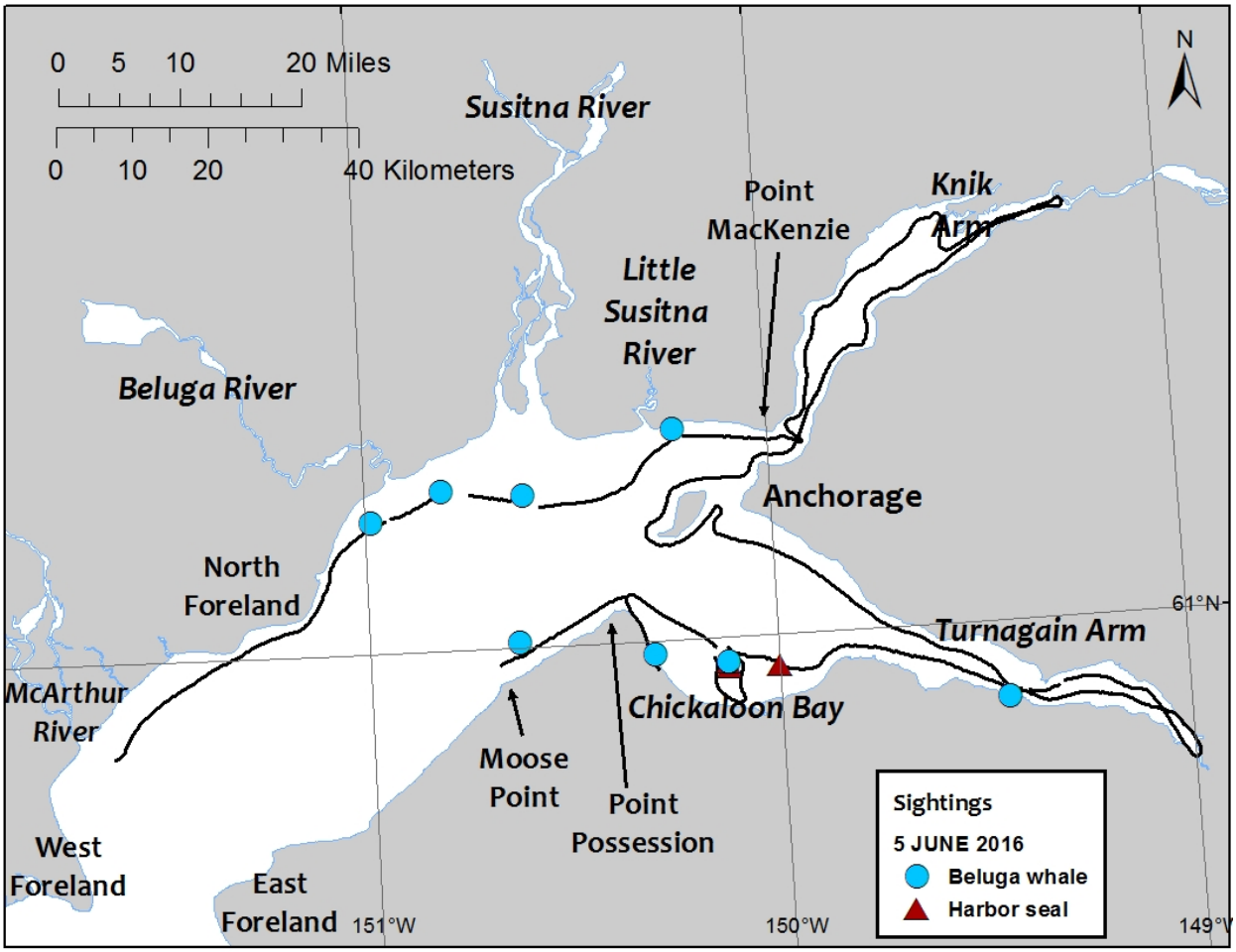

Figure 11. -- On-effort trackline and marine mammal sightings on 5 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

6 June 2016

The weather forecast for the day was not promising: winds gusting up to 15 knots in Turnagain Arm and scattered showers. After arriving at Merrill Field, heavy rain and mist obscured the view of Anchorage. The predicted forecast for the afternoon called for further deteriorating conditions. We called it a down day due to inclement weather.

7 June 2016

We started the survey in Knik Arm to take advantage of the low tide in the Susitna Delta (-3.6 ft. at 15:30 AKDT), following the shoreline clockwise to Moose Point before crossing the

inlet to McArthur River and concluding the survey at Point MacKenzie. Group 1 was between the bluffs and mudflats east of Point Possession in Chickaloon Bay (Fig. 12). We continued the coastal survey to Moose Point, also surveying along the western edge of the Moose Point shoals that were exposed as the tide ebbed. We then continued on effort across the inlet to the McArthur River. The coastal survey resumed after circling the mouth of the McArthur River.

Group 2, a lone whale, was at the mouth of the Beluga River. Group 3 was offshore of the Theodore River while Group 4 was spread from the Ivan River to the western tributary of the Susitna River. After initiating counting/video passes, we found that Group 4 was splitting into two groups – Group 4b swimming toward the Little Susitna River and Group 4a near the Ivan where it had joined Group 3. Group 5 was between the Susitna and Little Susitna rivers swimming toward Group 4b. We were able to complete counting/video passes before the groups merged. We did not survey upriver at the McArthur, Beluga, Susitna, or Little Susitna rivers as mudflats exposed during the low tide prevented belugas from accessing the rivers. The coastal survey terminated at Point MacKenzie. Other marine mammal sightings included harbor seals (7 sightings, 249 animals), most hauled out in the Susitna Delta (Fig. 12, Appendix). Sightings conditions were excellent to poor with Beaufort sea states ranging from 0 to 5 during the 5.1-hour survey (of which 0.09 hours were affected by glare and sea states).

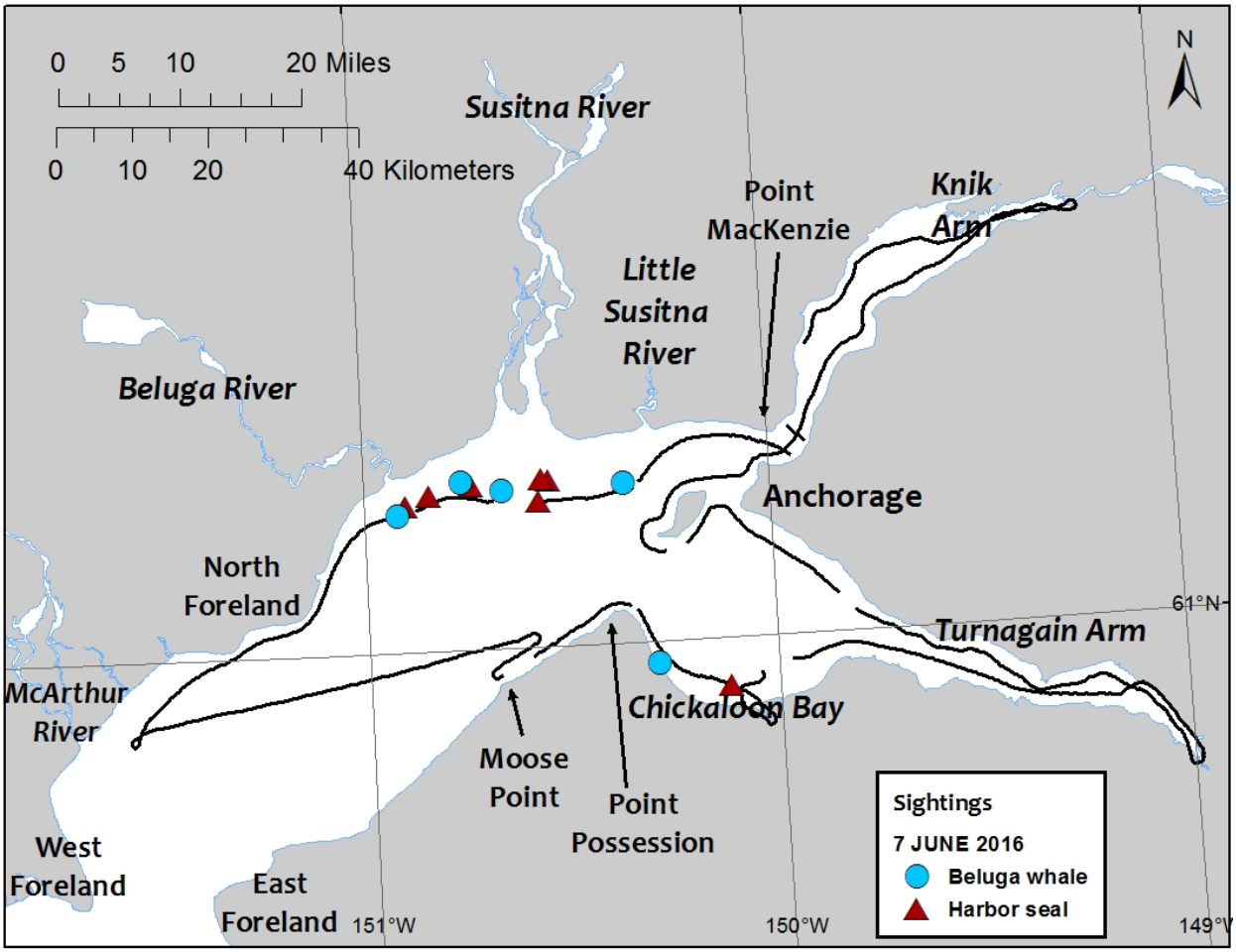

Figure 12. -- On-effort trackline and marine mammal sightings on 7 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

8 June 2016

We started the survey in Knik Arm to take advantage of the low tide in the Susitna Delta (-2.01 ft. at 16:15 AKDT), following the shoreline clockwise to Moose Point then surveyed the Moose Point shoals before surveying across the inlet between Point Possession and North Foreland to resume the coastal survey which concluded at Point MacKenzie. Group 1 was along the mudflats south of Girdwood in Turnagain Arm (Fig. 13). Group 2 was offshore of the bluffs in Chickaloon Bay while Group 3 was again between the bluffs and mudflats east of Point Possession. We attempted counting passes on Group 2 but found they were getting closer to Group 3, so we continued the coastal survey to Moose Point and the offshore shoals,

encountering a lone beluga at Point Possession (Group 4). We then returned to count the now combined groups.

We resumed the survey crossing the inlet between Point Possession and North Foreland, where we encountered Group 5 just east of the oil platform (Phillips "A", also known as Tyonek or Beluga platform). Back on the coastal survey, Group 6 was southwest of the mouth of the Beluga River. Group 7 was strung along the shoreline between the Beluga and Theodore rivers. Group 8 was scattered from the Theodore to the west tributary of the Susitna River. After counting Groups 6 and 7, attempts were made to count Group 8 but the whales were too dispersed. We resumed the coastal survey, observing Group 9 along the flats of the Susitna River. We decided to head in and refuel then come back to try to count and video these groups. We did not survey upriver at the Beluga, Susitna, or Little Susitna rivers as mudflats exposed during the low tide prevented belugas from accessing the rivers. The coastal survey terminated at Point MacKenzie. Other marine mammal sightings included harbor seals (2 sightings, 49 animals), most of which were hauled out in Chickaloon Bay with the exception of two seals swimming along the offshore trackline (Fig. 13, Appendix).

We returned directly to Beluga River and began a coastal survey to determine if the groups had joined together. Groups 6 and 7 appeared to be in their original locations as was Group 8. But Group 8 was still far too dispersed to obtain accurate counts or collect video so we terminated the flight and returned to Merrill Field. Sightings conditions were excellent to poor with Beaufort sea states ranging from 0 to 5 during the 5.8-hour survey (of which 0.06 hours were affected by glare and sea states).

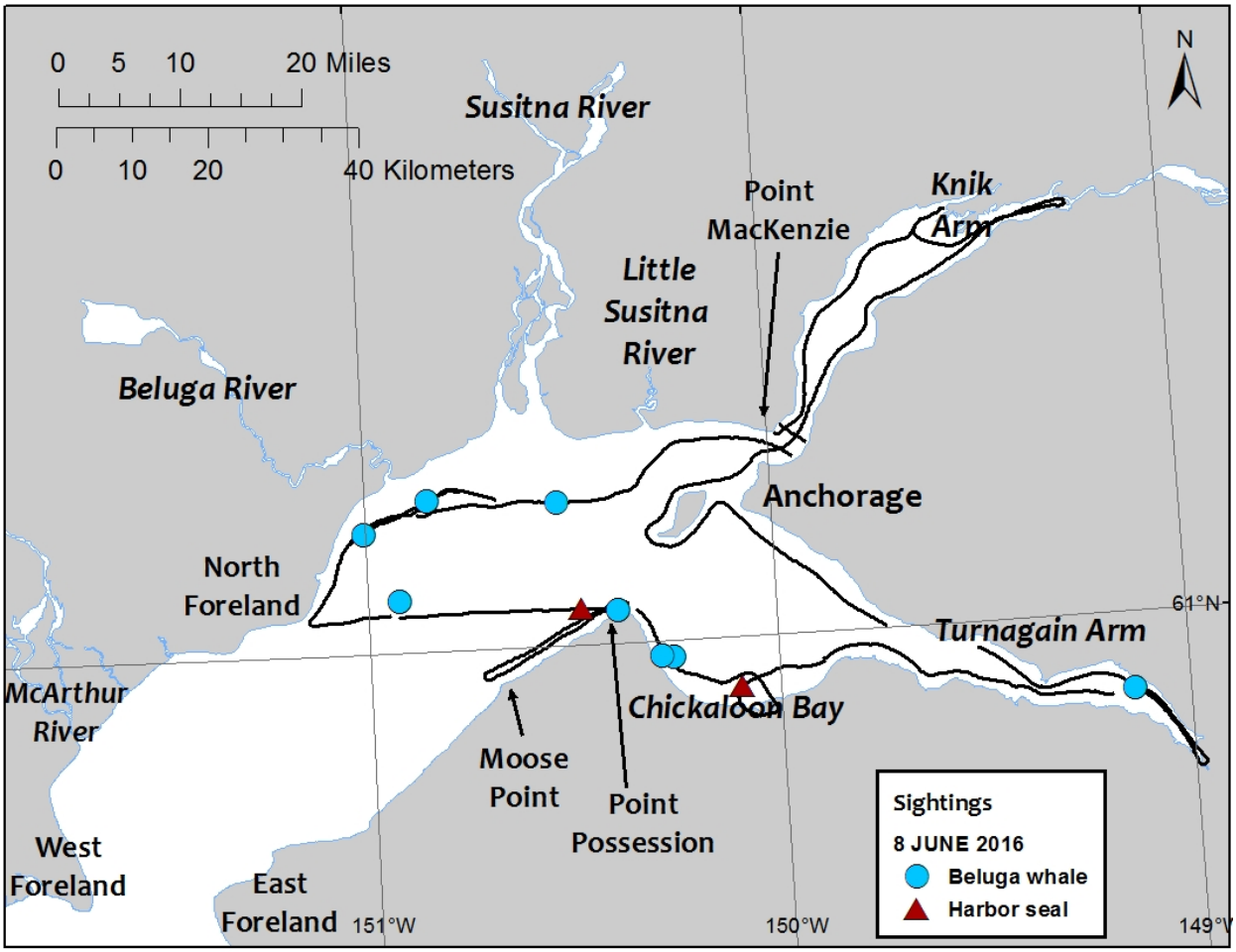

Figure 13. -- On-effort trackline and marine mammal sightings on 8 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

9 June 2016

We completed a full survey of the upper inlet north of Moose Point and North Foreland, following a clockwise pattern beginning at Point No Name and ending at Point MacKenzie (Fig. 14). Beluga groups were near Girdwood in Turnagain Arm (Group 1), the Chickaloon Bay bluffs (Groups 2 and 3), along the shore from Beluga River to Ivan River (Group 4), and in the mouth of the Little Susitna River (Group 5) (Fig. 14). Sighting conditions were mostly excellent to fair with sea states ranging from Beaufort sea state 0 to 4 during the 4.7-hour survey. Other marine mammal sightings included harbor seals (5 sightings, 134 animals) hauled out near

Chickaloon River, a seal in the water near Fire Island and another swimming in the Susitna Delta (Fig. 14, Appendix).

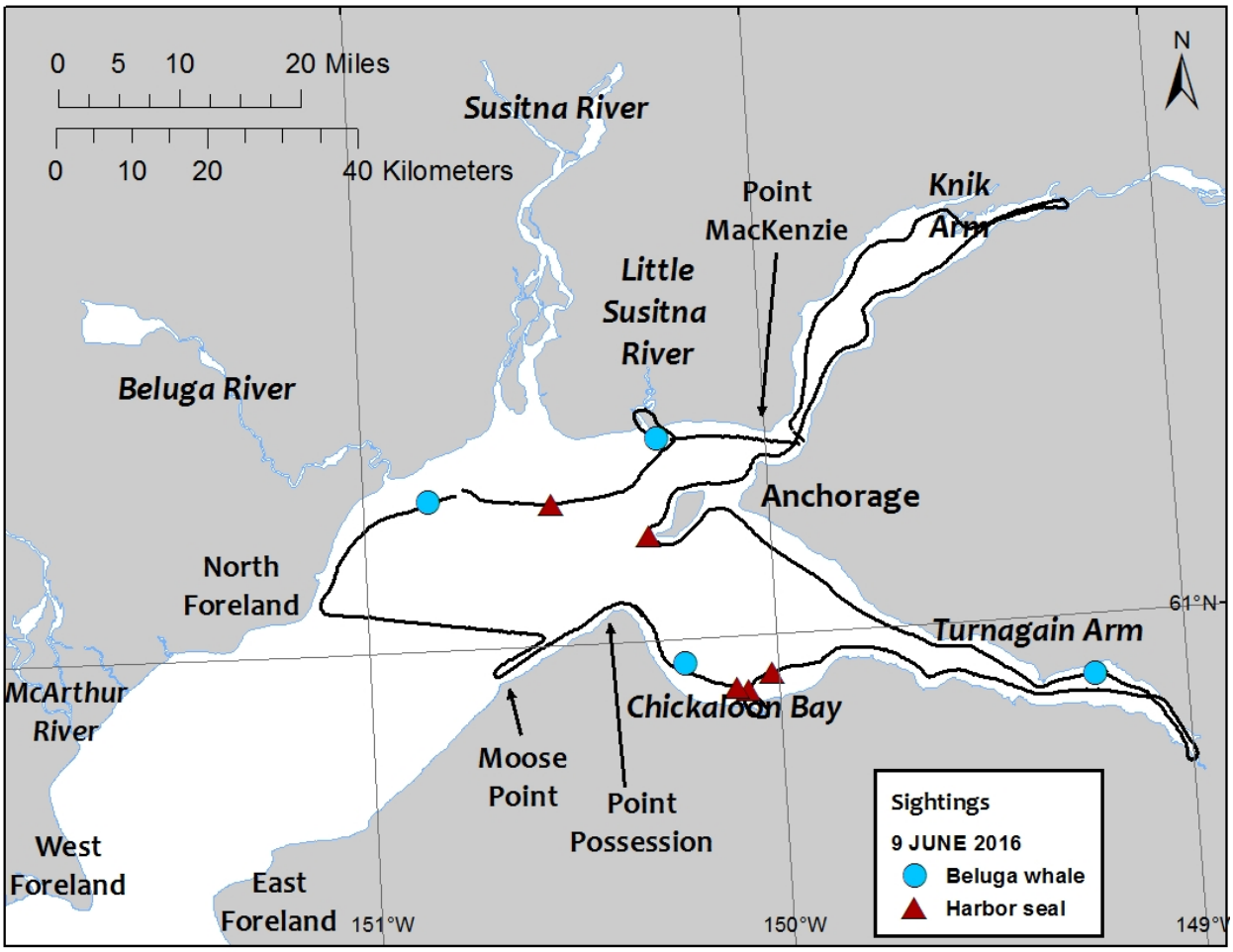

Figure 14. -- On-effort trackline and marine mammal sightings on 9 June during the 2016 beluga whale aerial abundance survey, Cook Inlet, Alaska.

Summary

In 2016, the daily medians ranged from 194 to 300 (Table 1). The 2016 index count (the median count from the best survey day) of 300 belugas, falls within the range of index counts made annually since 1993 (Table 2). Similar to past years, belugas were found in the Susitna Delta, Turnagain Arm, and Chickaloon Bay. None were seen in Knik Arm, Trading Bay, or the lower inlet, despite fair to excellent sighting conditions in these regions (see Appendix for all other marine mammal sightings).

While counts in the Susitna Delta have remained fairly constant during the 20+-year span of these surveys, whales have not been observed in Knik Arm the past seven survey years (2008-2012, 2014, 2016: Table 2). Belugas found in Chickaloon Bay were typically near the south shore, most often in an area 3 km southeast of Point Possession between the bluffs and Chickaloon River. Annual counts in Chickaloon Bay have been in the range of 20-60 belugas (Table 2). 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; that is, when counts were low in the Susitna area, they were high in Chickaloon Bay and vice versa (Rugh et al. 2005a). Similar apparent exchanges were seen in 2010 and 2011, and possibly in 2016 when we observed small groups between the Susitna Delta and Point Possession (Tables 1 and 2).

Abundance and Trend

The index is developed directly from the observer counts each survey year. The abundance estimates are on average 1.7 times greater than the index counts; however, in recent years, the index counts have been very near or above the abundance estimate (Fig. 16). The index counts are not corrected for variables such as whale group density, survey personnel, individual observer performance, search time, and whale surfacing behavior which may change from year to year and over time. These corrections were applied to estimate the abundance for June 2016.

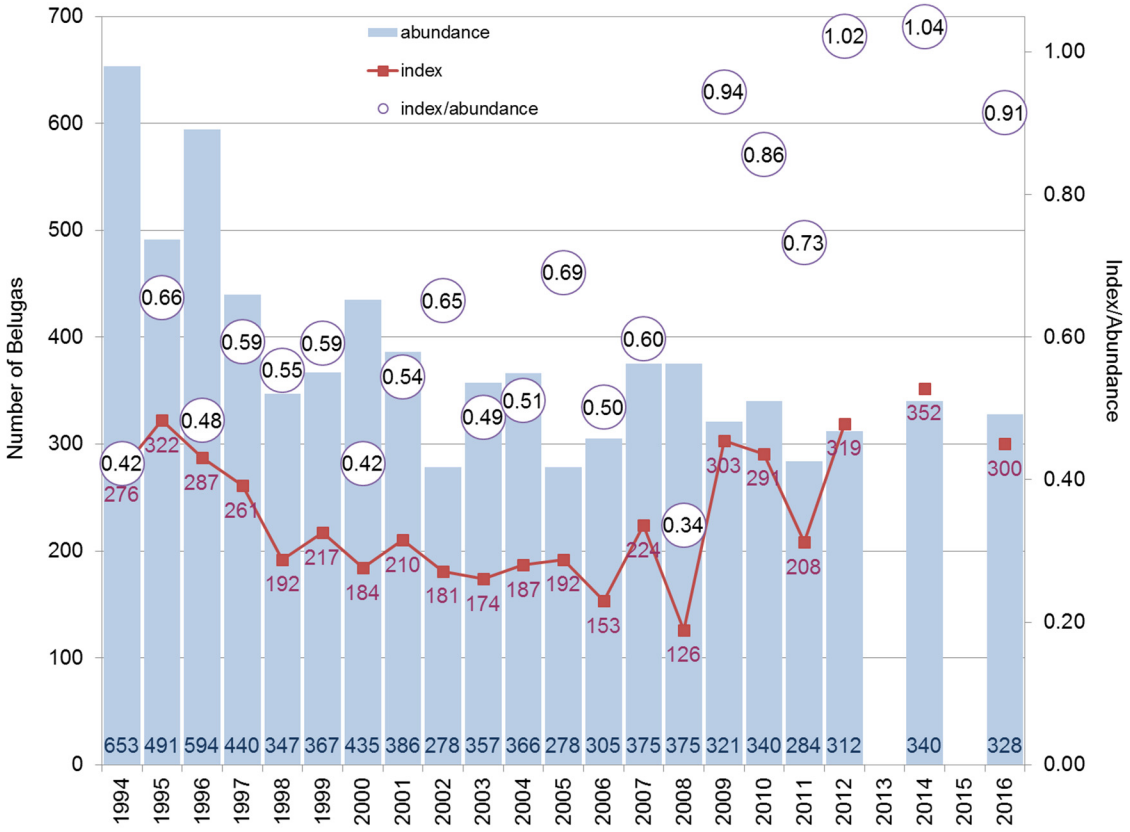

Figure 16. -- Annual abundance estimates (bars) and median index counts (line) for beluga aerial surveys, Cook Inlet, Alaska, 1994-2016. Circles show index counts divided by abundance estimates.

Seven of the days in June 2016 resulted in complete surveys of beluga habitat in the upper inlet (out of seven attempts); and 2 days included surveys of the lower inlet (31 May and 1 June). We did not survey one day due to inclement weather and 2 days we were unable to collect adequate video/counts in the Susitna Delta. This season there was a fairly typical presentation of beluga groups, with one or more large groups in the Susitna area and one or more smaller groups in Chickaloon Bay. Of the seven upper inlet surveys, five were used in the abundance estimate (2, 3, 5, 7, and 9 June). Although the team was able to successfully survey the entire upper inlet on 4 and 8 June, sighting conditions compromised counts and video recording on 4 June and beluga group behavior (widely scattered) did not meet criteria for counting protocols on 8 June (Table 3).

Of the 32 groups found and counted on the 5 days used in the abundance estimate, we had video of sufficient quality to estimate group sizes for 11 groups. This is a smaller percentage (35%) of the total groups used for the abundance estimate than in previous years (44%-89% for 2001-2014; Hobbs et al. 2015). However, it does include all of the large groups seen on the days with good video, representing 89% of the whales estimated on those days, and 56% of the overall estimate. The remaining groups were estimated using corrections developed from the groups with both video and observer counts following the methods of Hobbs et al. (2000b) (Table 3). Glare, whitecaps, missing part of a group, and poor image quality were the most frequent conditions that rendered video quality too poor to count.

A total of 2,010 whale images were detected during analysis of 40 video sequences. Image sizes in the standard video ranged between 5 pixels and 15 pixels. Following the methods of Hobbs et al. (2000b), standard video image sizes were estimated for whales found in the zoomed video. Logistic regression estimated that the probability of being seen was 50% for images averaging 4.5 pixels and > 95% for images of 7 pixels in size. The average correction for belugas missed at the surface due to image size was 1.51 (Table 3). In Hobbs et al. (2000b), a value of 1.5 was used as a cutoff for this correction because the variance of the correction increases rapidly for corrections above this value. However, this year the 1.5 cutoff removed more than half of the video sequences and resulted in very few estimated group sizes; consequently the cutoff was relaxed to 1.7 to allow at least two video results for each group

analyzed. In all cases, the estimated CV of the average correction was less than 13% of the CV of the group size estimate, and represented less than 1% of the variability of the estimate. The average correction for individual whales missed in the video because they were below the surface of the muddy waters of the upper inlet was 1.48 (based on an average time at surface of 1.683 from video analysis and surfacing interval of 24.1 (Lerczak et al. 2000)).

The group size estimates from the video were used with the observer counts for those same groups to estimate corrections for the observer counts following the methods described on Hobbs et al. (2000b: p. 53). The regression results indicated that the correction of counts by two of the observers were improved when the density of belugas was included in the correction formula; *i.e.*, the $\hat{b}_{o,2}$ parameter in Hobbs et al. (2000b: p. 53) was significantly different from zero. The correction parameters were used with the correction formulas for observer counts for all groups on survey days other than 5, 7, and 9 June, and eight smaller groups on 5, 7 and 9 June.

Table 3. -- Beluga whale groups in Cook Inlet, Alaska, June 2016, used to estimate abundance and/or corrections for missed groups. "Est. group size" is the corrected estimate for the respective group. CV = coefficient of variation. Obs. pass refers to counts resulting from observer estimates when the group was not circled.

Date	Group ID	Number of counts averaged	Location	Correction for missed whales	Correction for sub-surface whales	Est. group size	CV (%)	Counting method	Used in abundance estimate
6/2/16	1	10	Chickaloon Bay			17	37%	observer	Yes
6/2/16	2	12	Chickaloon Bay			22	41%	observer	Yes
6/2/16	3	12	Chickaloon Bay			43	20%	observer	Yes
6/2/16	4	8	Point Possession			29	26%	observer	Yes
6/2/16	5	8	Theodore to Beluga			139	47%	observer	Yes
6/2/16	6	8	Little Susitna River			17	46%	observer	Yes
6/2/16	7	8	Little Susitna River			7	67%	observer	Yes
6/3/16	1	8	Turnagain Arm			6	47%	observer	Yes
6/3/16	2	8	Chickaloon Bay			15	34%	observer	Yes
6/3/16	3	8	Chickaloon Bay			35	36%	observer	Yes
6/3/16	4	8	W. of Beluga River			4	37%	observer	Yes
6/3/16	5	8	Theodore to Susitna			214	41%	observer	Yes
6/3/16	6	11	Little Susitna River			10	50%	observer	Yes
6/4/16	1	8	Chickaloon Bay			30	38%	observer	No
6/4/16	2	3	Beluga River			15	15%	obs. pass	No
6/4/16	3	16	Susitna River			87	61%	observer	No
6/5/16	1	11	Turnagain Arm			8	57%	observer	Yes
6/5/16	2	2	Chickaloon Bay	1.50	1.49	43	23%	video	Yes
6/5/16	3	2	Chickaloon Bay	1.47	1.51	14	29%	video	Yes
6/5/16	4	2	Moose Point Shoals	1.45	1.40	23	25%	video	Yes
6/5/16	5	8	W. of Beluga River			8	33%	observer	Yes
6/5/16	6a[1]	6	Theodore to Susitna	1.42	1.81	212	11%	video	Yes
6/5/16	6b[1]	9	Theodore to Susitna			10	59%	observer	Yes
6/5/16	7	3	Susitna River	1.37	1.67	26	20%	video	Yes
6/5/16	8	2	Little Susitna River			1	24%	observer	Yes
6/7/16	1	15	Chickaloon			76	34%	observer	Yes
6/7/16	2	1	Beluga River			1	6%	observer	Yes
6/7/16	3+4a[2]	2	Ivan to Susitna	1.62	1.31	111	20%	video	Yes
6/7/16	4b[2]	5	Ivan to Susitna	1.54	1.04	150	13%	video	Yes
6/7/16	5	3	Susitna River	1.57	1.14	20	22%	video	Yes
6/8/16	1	10	Turnagain Arm			6	66%	observer	No
6/8/16	2	9	Chickaloon Bay			62	35%	observer	No
6/8/16	4	1	Point Possession			2	6%	observer	No
6/8/16	5	1	S of Beluga River			3	6%	observer	No
6/8/16	6	5	SW of Beluga River			6	62%	observer	No
6/8/16	7	6	Beluga to Theodore			33	32%	observer	No
6/8/16	8	1	Theodore to Susitna			100	10%	obs. pass	No
6/8/16	9	1	Susitna River			13	28%	obs. pass	No
6/9/16	1	9	Turnagain Arm			9	41%	observer	Yes
6/9/16	2	3	Chickaloon Bay	1.52	1.63	53	18%	video	Yes
6/9/16	3	3	Chickaloon Bay	1.47	1.90	43	18%	video	Yes
6/9/16	4	4	Beluga to Ivan	1.63	1.34	230	14%	video	Yes
6/9/16	5	8	Little Susitna River			7	73%	observer	Yes

[1] Group 6 split during the counting passes. 6a was estimated from video, 6b by observers.
[2] Groups 3 and 4 were identified at the same time, group 4 then split into 4a and 4b before counting commenced. Group 4b was counted first. Group 4a had joined with group 3 when counting of Group 4b was completed and 3 and 4a were counted as a single group.

Calculations for whale groups missed during the Cook Inlet beluga aerial surveys and estimates of abundance are described in detail in Hobbs et al. (2000a, b; 2015). Very few groups were missed by either observer. Of the 41 groups sighted, five were on the right side of the plane and not available to the left side observers. Of the groups available to the left side observers, six were missed by one observer, five of which were missed by the observer at the aft flat window, which has a smaller field of view than the bubble window. The missed group correction of 1.022 (CV = 0.006) was similar to recent missed group corrections (e.g., 1.012 (in 2009), 1.031 (in 2010 and 2011), and 1.001 (in 2012), 1.036 (in 2014)).

Groups found during each survey day (Table 3), were summed to complete the total for that day. The surveys on 4 June and 8 June included poor sighting conditions and widely dispersed groups during part of the survey day that may account for the low number of whales (Table 4).

Table 4. -- Sums by day for complete surveys of the upper Cook Inlet during the June 2016 beluga whale aerial survey. The dates 4 and 8 June were not used in the abundance estimate because of poor surveying/counting conditions. CV = coefficient of variation.

Survey day	Sum of group sizes	CV (%)	Used in abundance estimate
2-Jun-16	275	17%	Yes
3-Jun-16	285	29%	Yes
4-Jun-16	132	32%	No
5-Jun-16	345	19%	Yes
7-Jun-16	358	17%	Yes
8-Jun-16	225	16%	No
9-Jun-16	342	27%	Yes
Overall abundance*	328	8.3%	

* Average abundance after including missed group correction (1.022).

The overall estimate of abundance for June 2016 was 328 (CV = 0.083, 95% CI: 279 to 386, Nmin = 306). The 10-year trend (2006-2016) was -0.5% /year with a SE of 1.0% (i.e., a declining trend: P (< 0.0) = 70%). During the period since management of the hunt began (1999-2016), the trend was -0.4% /year with a SE of 0.6% (i.e., a declining trend: P (< 0.0) = 73%) (Fig. 17).

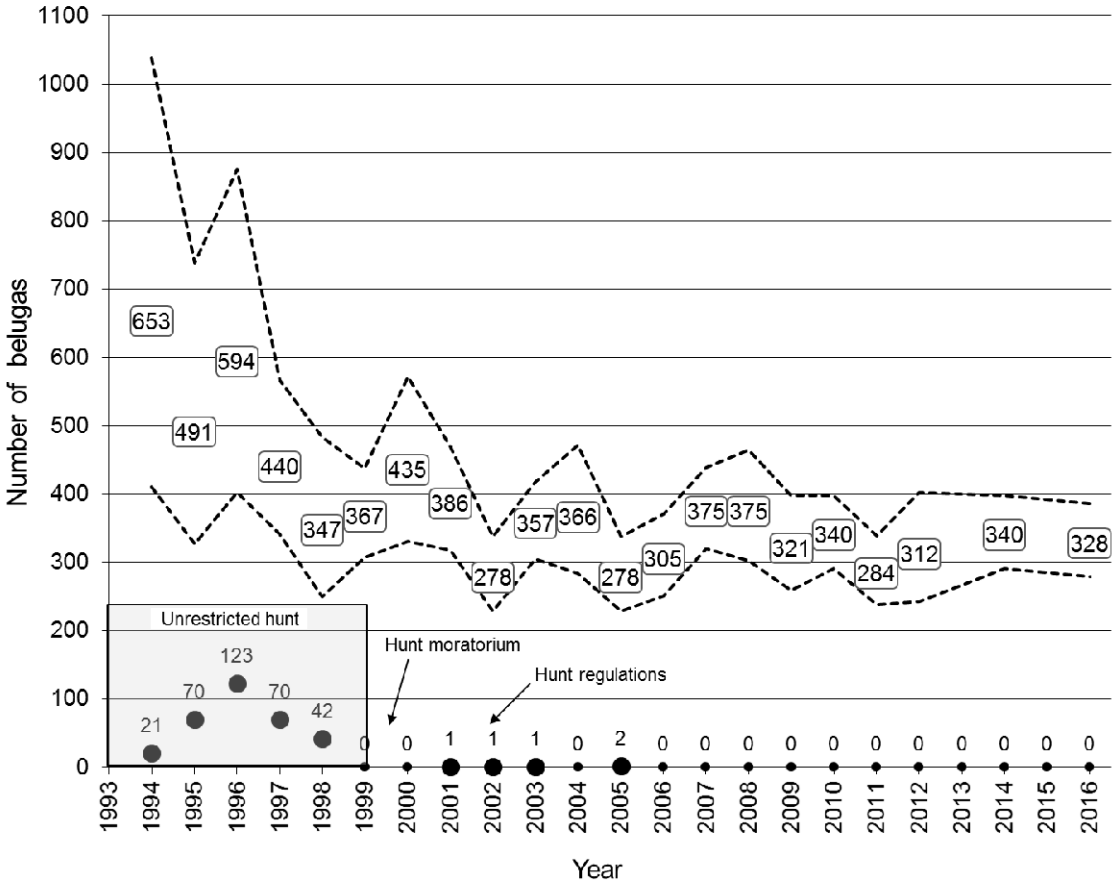

Figure 17. -- Abundance estimates for beluga whales in Cook Inlet with 95% confidence intervals for revised coefficients of variation (CVs) (dashed lines). From 1994 to 1998, when the harvest was unrestricted, the annual rate of decline was -13.7% (SE = 4.5%) per year. In the years since a hunting quota has been in place (1999-2016), the rate of decline was -0.4% (SE = 0.6%) per year. The 10-year trend (2006-2016) was -0.5% (SE = 1.0%) per year.

Throughout each abundance survey, beluga whales were seen near the coast and within river mouths in all years, and after 2000, nearly all of the sightings occurred in the northernmost portions of the inlet (Hobbs et al. 2015, Shelden et al. 2015a). Belugas were found in the Susitna Delta region (defined as the area between Point MacKenzie and the Beluga River) throughout the survey time series. Whales were also seen in large numbers in Knik Arm from 1997 to 2003, with a few observations continuing until 2007, after which none were found in this region during

the June surveys (Fig. 18). From 2004 to 2007, more whales were observed in the Chickaloon Bay–Turnagain Arm region, coincident with the lower numbers seen in Knik Arm. Belugas (group sizes ranging from 1 to 27 whales) have been observed in areas south of North Foreland and Point Possession (Fig. 19), but not consistently.

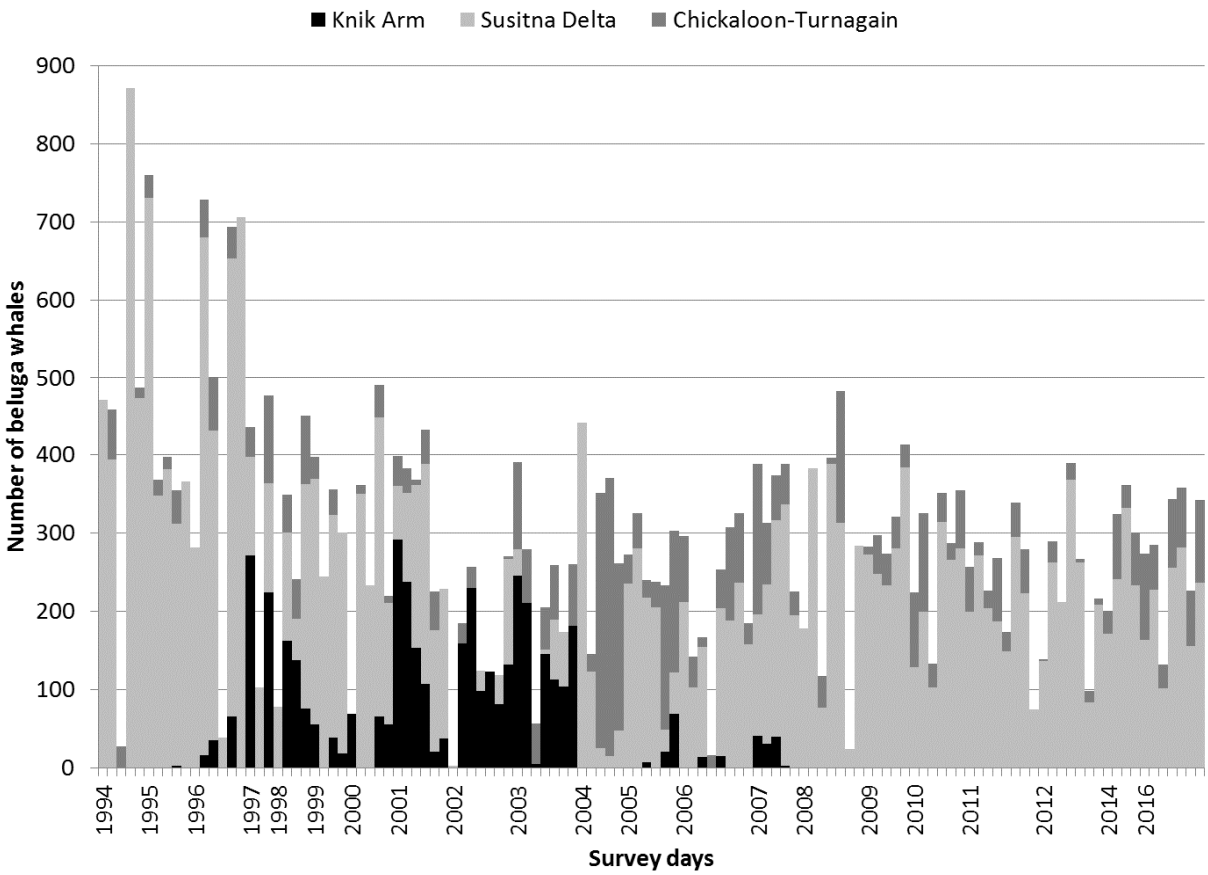

Figure 18. -- Regions occupied by beluga whales in upper Cook Inlet, Alaska, north of North Foreland and Point Possession: Knik Arm, Chickaloon Bay–Turnagain Arm, and the Susitna Delta (defined as the area between Beluga River and Point MacKenzie) from 1994 to 2016. Each survey day is represented as 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).

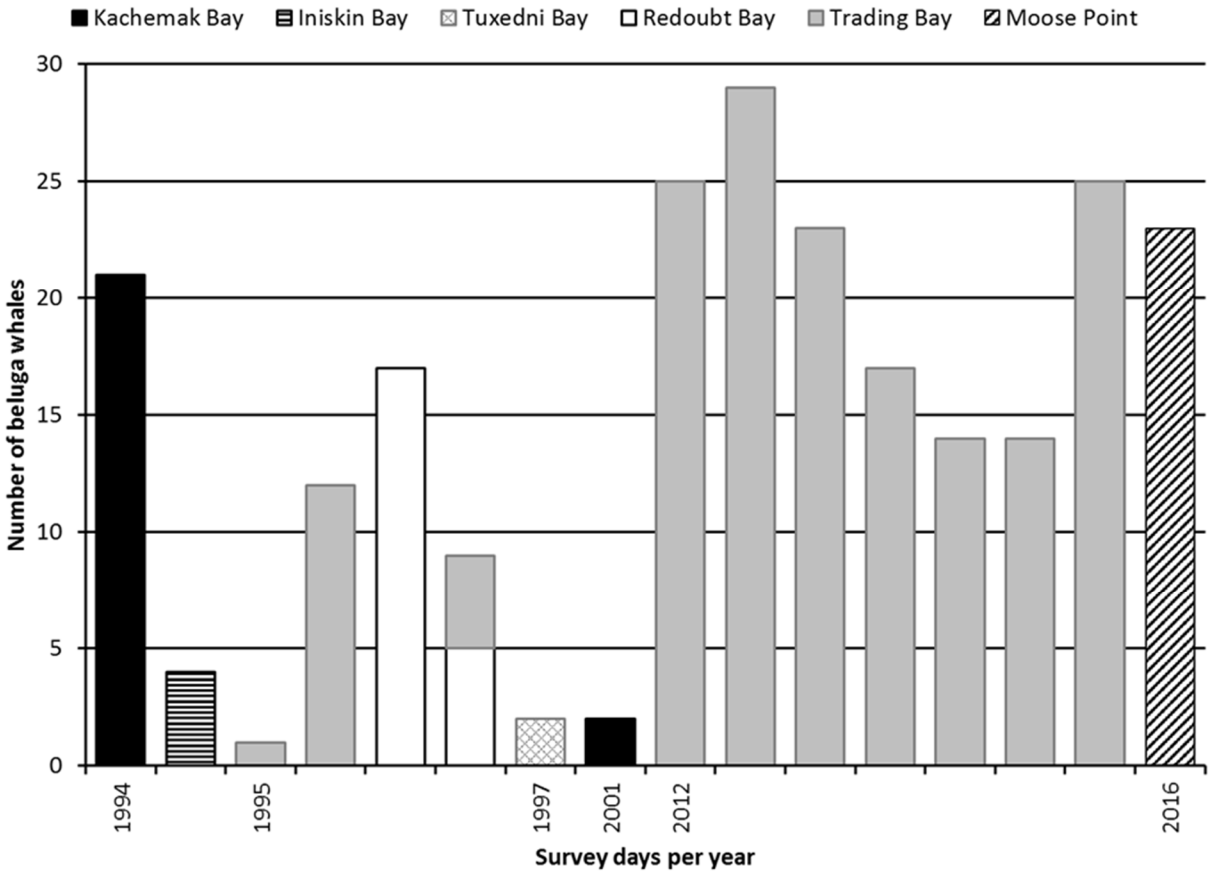

Figure 19. -- Regions occupied by beluga whales in Cook Inlet, Alaska, south of North Foreland and Point Possession: Kachemak Bay, Iniskin Bay, Tuxedni Bay, Redoubt Bay, Trading Bay, and Moose Point, from 1994 to 2016. Each survey day is represented as a single bar above and following the year indicated on the x-axis. (Originally published in Hobbs et al. 2015 for the period 1994-2012).

The contraction in range first documented in Rugh et al. (2010) has persisted. Since 2008, on average 81% of the total population occupied the Susitna Delta in early June during the aerial survey period, compared to roughly 50% in the past (1978-79, 1993-97, 1998-2008) (Fig. 20). The 2009-16 range was estimated to be only 29% of the range observed in 1978-79 (Fig. 21), a slight increase from 25% for the period 2009-14 (Shelden et al. 2015).

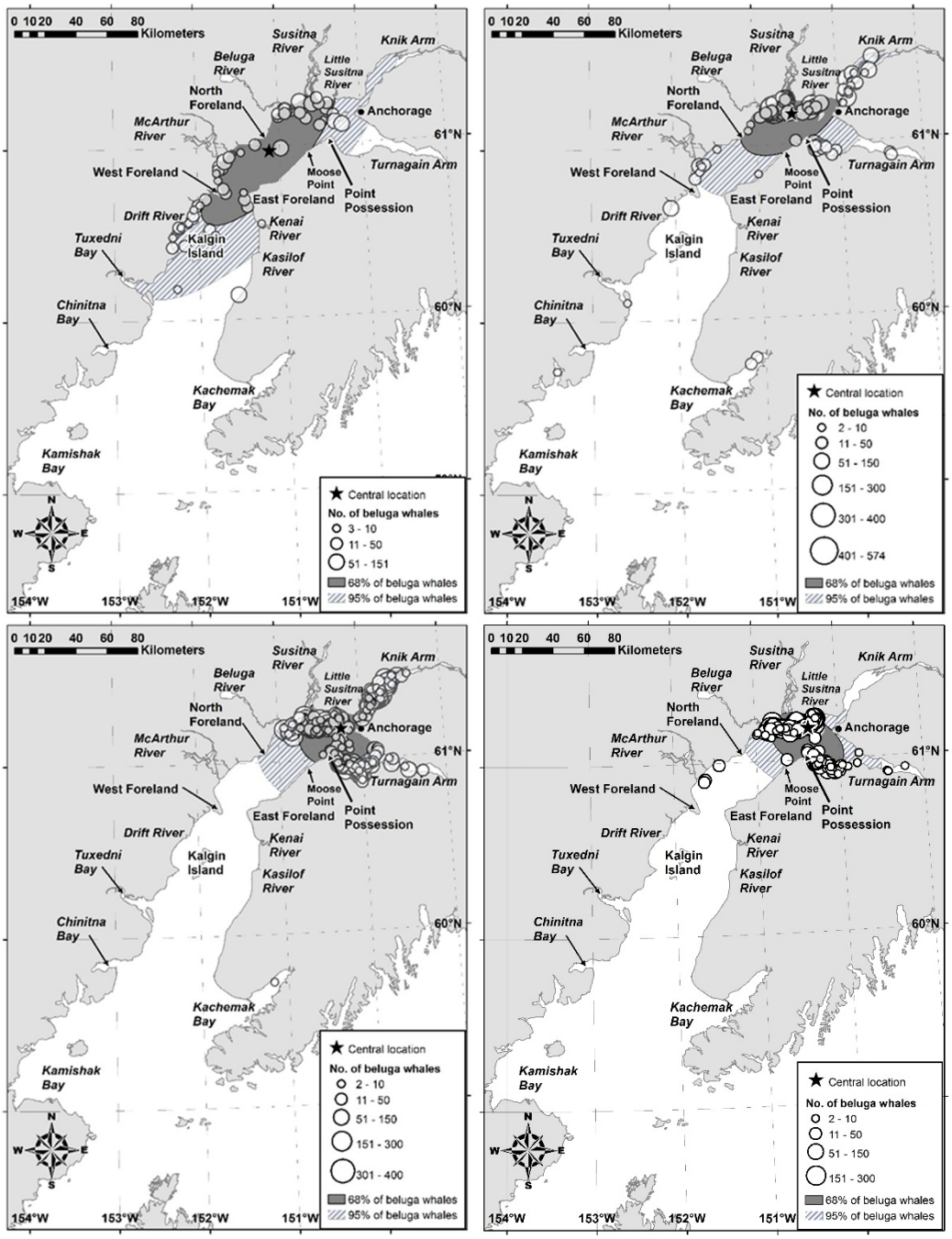

Figure 20. -- Areas occupied by beluga whales in Cook Inlet, Alaska, during systematic aerial surveys in 1978–79 (upper left panel), 1993–97 (upper right panel), 1998–2008 (lower left panel), and 2009–16 (lower right panel). The distribution of beluga whales around each central location for each period was calculated at 1 and 2 SD (capturing ca. 68% and 95% of the whales; shaded regions). (Originally published in Shelden et al. 2015 for the period 1978-2014).

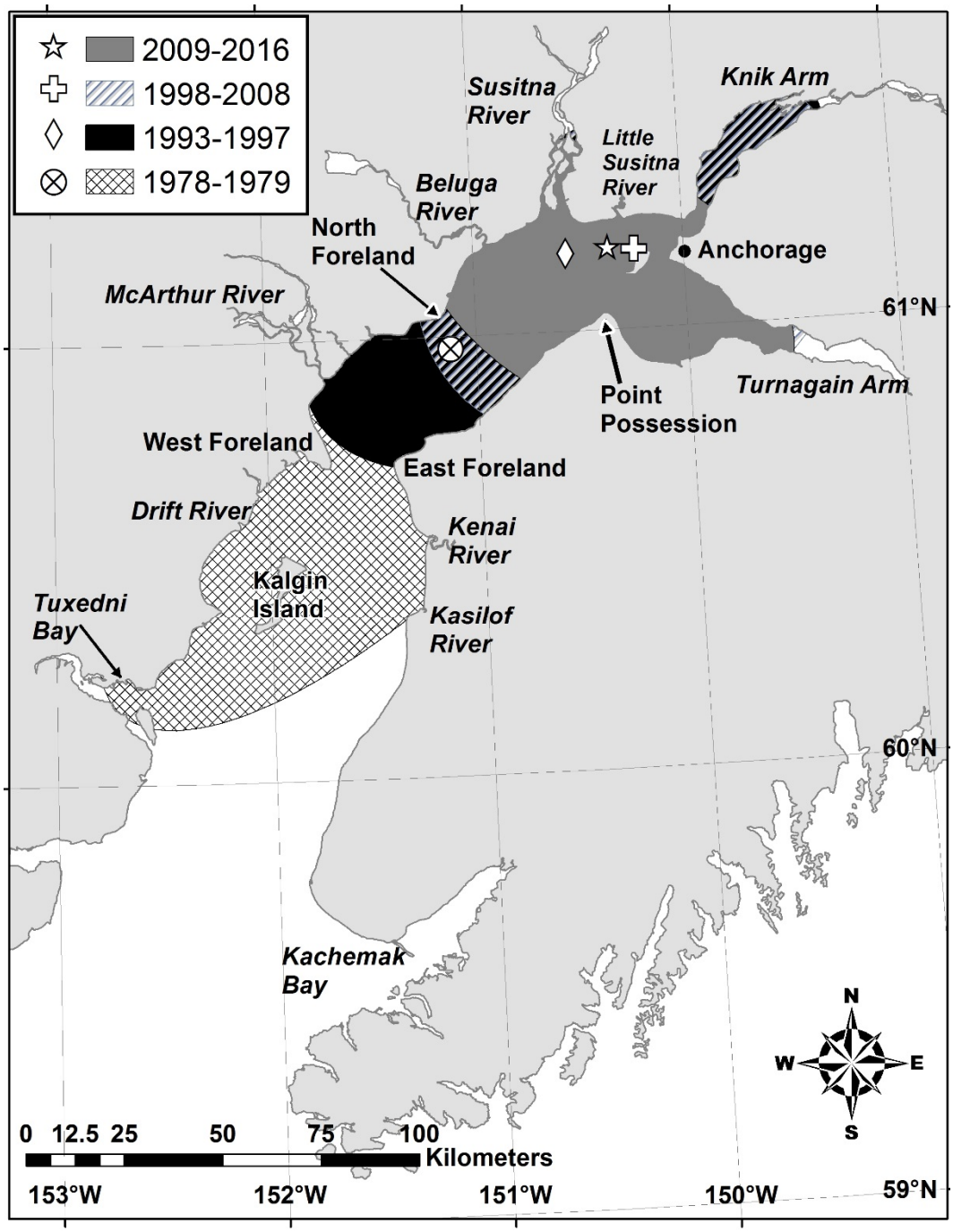

Figure 21. -- Areas occupied by beluga whales in Cook Inlet, Alaska, during systematic aerial surveys in 1978–79, 1993–97, 1998–2008, and 2009–16. The distribution of beluga whales around each central location (shaded regions next to symbols) for each period was calculated at 2 SD (capturing ca. 95% of the whales). The 95% core summer distribution contracted from 7,226 sq. km in 1978–79 to 2,131 sq. km in 2009–16 (29% of the 1978–79 range).

CONCLUSIONS

In Cook Inlet, belugas concentrate near river mouths or shallow bays during late spring and early summer in the northernmost reaches of the inlet, especially in the Susitna Delta, Knik Arm, and Chickaloon Bay (Rugh et al. 2000b, 2005b; Shelden et al. 2013, 2015a). These concentrations usually last from mid-May to July or later and are very likely associated with the migration of anadromous fish, particularly eulachon (*Thaleichthys pacificus*) and several species of Pacific salmon (*Oncorhynchus* spp., Moore et al. 2000). Research protocol and coverage area for the June aerial surveys of Cook Inlet have been kept consistent to minimize variables in inter-year analyses. The type of aircraft, window configuration, altitude, air speed, and coastal search patterns were constant, and most of the observers have been on many or all of the surveys, maintaining continuity in effort. On all but one of these 22 surveys, flights were in the first half of June. Each year there have been at least 4-6 replicate flights around upper Cook Inlet with the difference that in 2004 and subsequent years additional survey days were included. The large number of flights per year across many years and the consistency of effort have helped us detect patterns of whale distribution and identify changes that have occurred.

Historically many belugas were seen in both upper and lower Cook Inlet in June and July (Rugh et al. 2000b, Shelden et al. 2015b). However, between 1993 and 1995, during the first 3 years of the NMFS surveys, very few belugas (less than 3% of all of the annual sightings) were in the lower inlet, south of East Foreland and West Foreland (Table 2), and in subsequent years, 1996-2011, hardly any (one whale in Tuxedni Bay in 1997 and two in Kachemak Bay in 2001) were seen in the lower inlet during these surveys. Many other marine mammal species were seen in the lower inlet throughout the study period: sea otters, harbor seals, harbor porpoise, fin whales, humpback whales, and Steller sea lions (Appendix), which indicates the lack of beluga sightings was not due to poor visibility.

Furthermore, in the southern half of the upper inlet, south of North Foreland and Point Possession, sighting rates dropped from an annual average of 1.5% during the period 1993-1995, to zero for all subsequent years until June 2012. Sighting conditions have generally been ideal during these aerial surveys, but with the exception of June 2012 (when a group was repeatedly

found in Trading Bay) the only places where belugas were consistently found were waters north of North Foreland and Moose Point, which was the case again in June 2016 (Table 2). A steep decline in the number of June sightings in both Knik Arm and Turnagain Arm also occurred after 2007 (Table 2).

Although these aerial surveys provide a broad-scale picture of the whale distribution each June, satellite-tagging provides much more detail over longer time periods, albeit of only a few whales (e.g., 14 belugas: see Hobbs et al. 2005, Goetz et al. 2012b, Shelden et al. 2015b). Results from tagged whales (from 1999 to 2003) show that the beluga distribution seen during the June aerial surveys is representative of most of the summer through late autumn, with whales remaining in waters north of East and West Foreland (Shelden et al. 2015b). In winter, some of the tagged whales dispersed into deeper waters and a few explored waters farther south (Chinitna Bay) before returning to the upper inlet, but they never left Cook Inlet (Hobbs et al. 2005, Goetz et al. 2012b, Shelden et al. 2015b).

Median estimates presented in Table 1 are a rough index of relative abundance; however, calculated abundances with their respective *CV*s (Hobbs et al. 2015, Shelden et al. 2015a) include corrections for whales missed within the viewing range of observers, whales missed because they were beneath the surface throughout an aerial counting pass, as well as density corrections. The abundance estimates, with their associated *CV*s, are the appropriate values to use in inter-year trend analyses. The abundance estimates show a steep decline until 1998 and then a gradual decline from 1999 to the present (Fig. 17). In the past 10 years, abundance has dipped to as few as 284 whales (in 2011) but also as many as 375 whales (in 2007 and 2008), thus trends over shorter time periods can vary, and may be positive for some periods although the long-term trend continues to show a decline. The 10-year trend (2006-16) indicates the population is still gradually declining. Also, when considering the trend line, the reader should be aware that this represents an average rate of change and that a more detailed population model and additional data would be required to determine what portion of the changes in estimated abundance from survey to survey is explained by statistical error or actual changes in abundance. The next biennial survey is scheduled for June 2018.

Acknowledgments

Phillip Clapham served as Program Leader of the Cetacean Assessment and Ecology Program during the conception, preparation, and conduct of the 2016 survey. Rod Hobbs, Task Leader for the Cook Inlet beluga studies, helped coordinate funding for this project.

Clearwater Air, Inc., provided the aircraft and crew. Our pilots in 2016 were Jake Turner, Channing Wilson, Dirk Bowen, and Tomo Spaic. Our pilots filled a critical role in keeping the aircraft at the preferred altitude and distance from shore, while flying precise patterns over moving whales and watching for aircraft in an exceptionally busy airspace. This survey was conducted under MMPA Scientific Research Permit No. 14245.

Survey data were entered using a software program specifically developed for the Cook Inlet beluga aerial survey by Niel and Kimberly Goetz. Video analyses were conducted by Christy Sims and Linda Vate Brattström.

Reviews of this document were provided by Janice Waite (NMML). Technical edits were provided by James Lee of the Alaska Fisheries Science Center's Communication Program. The findings and conclusions in this paper are those of the author(s) and do not necessarily represent the views of the National Marine Fisheries Service, NOAA.

CITATIONS

Allen, B. M., and R. P. Angliss. 2013. Alaska marine mammal stock assessments, 2012. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-245, 282 p.

Calkins, D. G. 1984. Belukha whale. Vol. IX in: Susitna hydroelectric project; final report; big game studies, Alaska Dep. Fish Game Doc. No. 2328, 17 p.

Goetz, K. T., D. J. Rugh, A. J. Read, and R. C. Hobbs. 2007. Habitat use in a marine ecosystem: beluga whales *Delphinapterus leucas* in Cook Inlet, Alaska. Mar. Ecol. Prog. Ser. 330:247-256.

Goetz, K. T., R. A. Montgomery, J. M. Ver Hoef, and R. C. Hobbs. 2012a. Identifying essential habitat of the endangered beluga whale in Cook Inlet, Alaska. Endang. Species Res. 16:135-147.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012b. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle, WA 98115.

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. In J. W. Lentfer (editor), Selected marine mammals of Alaska: Species accounts with research and management recommendations. Mar. Mammal Comm., Washington D.C.

Hobbs, R. C. 2013. Detecting changes in population trends for Cook Inlet beluga whales (*Delphinapterus leucas*) using alternative schedules for aerial surveys. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-252, 25 p.

Hobbs, R. C., D. J. Rugh, and D. P. DeMaster. 2000a. Abundance of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, 1994-2000. Mar. Fish. Rev. 62(3):37-45.

Hobbs, R. C., J. M. Waite, and D. J. Rugh. 2000b. Beluga, *Delphinapterus leucas*, group sizes in Cook Inlet, Alaska, based on observer counts and aerial video. Mar. Fish. Rev. 62(3):46-59.

Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska. Arctic 58:331-340.

Hobbs, R. C., K. E. W. Shelden, D. J. Rugh, C. L. Sims, and J. M. Waite. 2015. Estimated abundance and trend in aerial counts of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, 1994-2012. Mar. Fish. Rev. 77(1): 11-31. (doi: 10.7755/MFR.77.1.2).

Klinkhart, E. G. 1966. The beluga whale in Alaska. Alaska Dep. Fish and Game, Juneau, Fed. Aid Wildl. Restor. Proj. Rep. Vol. VII, Proj. W-6-R and W-14-R. 11 p.

Laidre, K. L., K. E. W. Shelden, D. J. Rugh, and B. A. Mahoney. 2000. Beluga, *Delphinapterus leucas*, distribution and survey effort in the Gulf of Alaska. Mar. Fish. Rev. 62(3):27-36.

Lerczak, J. A., K. E. W. Shelden, and R. C. Hobbs. 2000. Application of suction-cup attached VHF transmitters to the study of beluga, *Delphinapterus leucas*, surfacing behavior in Cook Inlet, Alaska. Mar. Fish. Rev. 62 (3):99-111.

Litzky, L. K. 2001. Monitoring recovery status and age structure of Cook Inlet, Alaska belugas by skin color determination. Masters Thesis, Univ. Washington, Seattle. 76 p.

Mahoney, B. A., and K. E. W. Shelden. 2000. Harvest history of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):124-133.

Moore, S. E., K. E. W. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):60-80.

Murray, N. K., and F. H. Fay. 1979. The white whales or belukhas, *Delphinapterus leucas*, of Cook Inlet, Alaska. Unpubl. Doc. (SC/31/SM12) submitted to the Sub-committee on Small Cetaceans, IWC Scientific Committee, June 1979. 7 p.

O'Corry-Crowe, G. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.

Rugh, D. J., R. P. Angliss, D. P. DeMaster, and B. A. Mahoney. 1995. Aerial surveys of belugas in Cook Inlet, Alaska, June 1994. Unpubl. Doc. (SC/47/SM10) submitted to the IWC Scientific Committee, June 1995. 14 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Rugh, D. J., K. E. W. Shelden, R. P. Angliss, D. P. DeMaster, and B. A. Mahoney. 1996. Aerial surveys of beluga whales in Cook Inlet, Alaska, July 1995. Unpubl. Doc. (SC/48/SM8) submitted to the IWC Scientific Committee, May 1996. 21 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Rugh, D. J., K. E. W. Shelden, J. M. Waite, R. C. Hobbs, and B. A. Mahoney. 1997a. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1996. Unpubl. Doc. (SC/49/SM19) submitted to the IWC Scientific Committee, Sept. 1997. 22 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Rugh, D. J., R. C. Hobbs, K. E. W. Shelden, and J. M. Waite. 1997b. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1997. Unpubl. Doc. (SC/49/SM20) submitted to the IWC Scientific Committee, Sept. 1997. 17 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Rugh, D. J., R. C. Hobbs, K. E. W. Shelden, B. A. Mahoney, and L. K. Litzky. 1999. Surveys of beluga whales in Cook Inlet, Alaska, June 1998. Unpubl. Doc. (SC/51/SM11) submitted to the IWC Scientific Committee, May 1999. 11 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Rugh, D. J., K. E. W. Shelden, B. A. Mahoney, L. K. Litzky, R. C. Hobbs, and K. L. Laidre. 2000a. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1999, p. 1-10. In A. L. Lopez and D. P. DeMaster (editors), Marine Mammal Protection Act and Endangered Species Act implementation program 1999. AFSC Processed Rep. 2000-11, 195 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Rugh, D. J., K. E. W. Shelden, and B. A. Mahoney. 2000b. Distribution of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska, during June/July 1993-2000. Mar. Fish. Rev. 63(3):6-21.

Rugh, D. J., K. E. W. Shelden, B. A. Mahoney, and L. K. Litzky. 2001. Aerial surveys of belugas in Cook Inlet, Alaska, June 2000, p. 1-11, In A. L. Lopez and R. P. Angliss (editors), Marine Mammal Protection Act and Endangered Species Act implementation program 2000. AFSC Processed Rep. 2001-06, 115 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Rugh, D. J., B. A. Mahoney, L. K. Litzky, and B. Smith. 2002. Aerial surveys of beluga in Cook Inlet, Alaska, June 2002. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE Seattle WA 98115. 12 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2005b)].

Rugh, D. J., B. A. Mahoney, C. L. Sims, B. K. Smith, and R. C. Hobbs. 2003. Aerial surveys of belugas in Cook Inlet, Alaska, June 2003. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE Seattle WA 98115. 13 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2005b)].

Rugh, D. J., K. E. W. Shelden, C. L. Sims, B. A. Mahoney, B. K. Smith, and R. C. Hobbs. 2004. Aerial surveys of belugas in Cook Inlet, Alaska, June 2004. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 16 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2005b)].

Rugh, D. J., K. T. Goetz, B. A. Mahoney, B. K. Smith, and T. A. Ruszkowski. 2005a. Aerial surveys of belugas in Cook Inlet, Alaska, June 2005. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 18 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Rugh, D. J., K. E. W. Shelden, C. L. Sims, B. A. Mahoney, B. K. Smith, L. K. Litzky, and R. C. Hobbs. 2005b. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-149, 71 p.

Rugh, D. J., K. T. Goetz, C. L. Sims, K. E. W. Shelden, O. Shpak, B. A. Mahoney, and B. K. Smith. 2006. Aerial surveys of belugas in Cook Inlet, Alaska, June 2006. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle ,WA 98115. 17 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Rugh, D. J., K. T. Goetz, J. A. Mocklin, B. A. Mahoney, and B. K. Smith. 2007. Aerial surveys of belugas in Cook Inlet, Alaska, June 2007. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 16 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Rugh, D. J., K. E. W. Shelden, and R. C. Hobbs. 2010. Range contraction in a beluga whale population. Endang. Species Res. 12:69-75.

Shelden, K.E.W., and B.A. Mahoney. 2016. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1991. AFSC Processed Rep. 2016-02, 22 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Shelden, K. E. W., D. J. Rugh, K. T. Goetz, L. Vate Brattström, and B. A. Mahoney. 2008. Aerial surveys of belugas in Cook Inlet, Alaska, June 2008. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 18 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Shelden, K. E. W., D. J. Rugh, K. T. Goetz, C. L. Sims, L. Vate Brattström, and R. Hobbs. 2009. Aerial surveys of belugas in Cook Inlet, Alaska, June 2009. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 18 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Shelden, K. E. W., K. T. Goetz, L. Vate Brattström, C. L. Sims, D. J. Rugh and R. C. Hobbs. 2010. Aerial surveys of belugas in Cook Inlet, Alaska, June 2010. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 18 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Shelden, K. E. W., K. T. Goetz, L. Vate Brattström, C. L. Sims, and R. C. Hobbs. 2011. Aerial surveys of belugas in Cook Inlet, Alaska, June 2011. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 18 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Shelden, K. E. W., C. L. Sims, L. Vate Brattström, J. A. Mocklin, and R. C. Hobbs. 2012. Aerial surveys of belugas in Cook Inlet, Alaska, June 2012. Unpubl. Doc., Alaska Fisheries Science Center, Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 18 p. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Shelden et al. (2013)].

Shelden, K. E. W., D.J. Rugh, K.T. Goetz, C.L. Sims, L. Vate Brattström, J.A. Mocklin, B.A. Mahoney, B.K. Smith, and R.C. Hobbs. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-263, 122 p.

Shelden, K. E. W., C. L. Sims, L. Vate Brattström, K. T. Goetz, and R. C. Hobbs. 2015a. Aerial surveys of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2014. AFSC Processed Rep. 2015-03, 55 p.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015b. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: Results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2): 1-31. (doi: dx.doi.org/10.7755/MFR.77.2.1).

Sims, C. L, R. C. Hobbs, and D. J. Rugh. 2003. Developing a calving rate index for beluga in Cook Inlet, Alaska using aerial videography and photography. Abstract (poster) in the Fifteenth Biennial Conference on the Biology of Marine Mammals. Greensboro, North Carolina. 14-19 Dec. 2003.

Withrow, D. E., K. E. W. Shelden, D. J. Rugh, and R. C. Hobbs. 1994. Beluga whale, *Delphinapterus leucas*, distribution and abundance in Cook Inlet, 1993, p. 128-153. In H. Braham and D. DeMaster (editors), Marine Mammal Assessment Program: Status of stocks and impacts of incidental take; 1993. Annual Rept. submitted to Office of Protected Resources, Natl. Mar. Fish. Serv., 1335 East-West Highway, Silver Spring, MD 20910. [This field report contained data considered provisional and has subsequently been revised and published in the peer-review literature as Rugh et al. (2000b)].

Appendix.--Sighting data for other marine mammals observed during 2016 beluga abundance survey.

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Fin whale	1	5/31/2016	59.671	-151.746	11:16:02	1	Btwn Anchor Pt and Homer
Humpback whale	2	5/31/2016	59.459	-152.009	14:10:58	1	Mid-inlet off Kachemak Bay
Humpback whale	1	6/1/2016	59.541	-152.249	14:18:55	4	Mid-inlet off Kachemak Bay
Humpback whale	1	6/1/2016	59.539	-152.294	14:25:48	4	Mid-inlet off Kachemak Bay
Humpback whale	1	6/1/2016	59.511	-153.030	14:42:34	4	Mid-inlet off Ursus Cove
Humpback whale	1	6/1/2016	59.366	-152.703	14:59:59	4	Btwn Augustine I. and Port Graham
Harbor porpoise	1	5/31/2016	60.098	-151.745	17:22:52	2	Offshore from Ninilchik
Harbor porpoise	1	6/1/2016	60.227	-151.940	10:48:39	3	Mid-inlet south of Kalgin I.
Harbor porpoise	1	6/1/2016	60.196	-152.336	10:55:17	3	Mid-Inlet off Tuxedni Bay
Harbor porpoise	1	6/1/2016	60.104	-152.282	10:59:44	3	Mid-Inlet off Tuxedni Bay
Harbor porpoise	3	6/1/2016	60.076	-152.239	11:00:53	3	Mid-Inlet off Tuxedni Bay
Harbor porpoise	1	6/1/2016	60.070	-152.230	11:01:12	3	Mid-Inlet off Tuxedni Bay
Harbor porpoise	1	6/1/2016	60.052	-152.203	11:02:02	3	Mid-Inlet off Tuxedni Bay
Harbor porpoise	1	6/1/2016	59.838	-152.452	11:18:18	3	Btwn Chinitna Bay and Anchor Pt
Harbor porpoise	1	6/1/2016	59.838	-152.455	11:18:21	3	Btwn Chinitna Bay and Anchor Pt
Harbor porpoise	1	6/1/2016	59.830	-152.551	11:20:03	3	Btwn Chinitna Bay and Anchor Pt
Harbor porpoise	2	6/1/2016	59.769	-152.609	11:28:53	3	Btwn Chinitna Bay and Anchor Pt
Harbor porpoise	1	6/1/2016	59.757	-152.552	11:29:57	3	Btwn Chinitna Bay and Anchor Pt
Harbor porpoise	1	6/1/2016	59.692	-152.261	11:35:35	3	Mid-inlet off Kachemak Bay
Harbor porpoise	1	6/1/2016	59.391	-153.917	16:20:37	4	Kamishak Bay
Steller sea lion	70	6/1/2016	58.969	-153.385	15:43:11	4	Near Shaw Island
Steller sea lion	1	6/1/2016	59.674	-153.108	17:14:29	4	SW of Chinitna Pt
Sea otter	1	5/31/2016	59.822	-151.850	11:10:06	1	North of Anchor Pt
Sea otter	200	5/31/2016	59.631	-151.569	11:27:13	1	Btwn Anchor Pt and Homer
Sea otter	40	5/31/2016	59.626	-151.538	11:27:50	1	Btwn Anchor Pt and Homer
Sea otter	20	5/31/2016	59.621	-151.498	11:28:35	1	Btwn Anchor Pt and Homer
Sea otter	1	5/31/2016	59.599	-151.444	11:29:58	1	Kachemak Bay
Sea otter	2	5/31/2016	59.591	-151.415	11:30:38	1	Kachemak Bay
Sea otter	400	5/31/2016	59.635	-151.456	11:32:46	1	Kachemak Bay
Sea otter	10	5/31/2016	59.641	-151.454	11:33:02	1	Kachemak Bay
Sea otter	50	5/31/2016	59.642	-151.441	11:33:18	1	Kachemak Bay
Sea otter	1	5/31/2016	59.654	-151.426	11:33:50	1	Kachemak Bay
Sea otter	55	5/31/2016	59.661	-151.423	11:34:03	1	Kachemak Bay
Sea otter	350	5/31/2016	59.663	-151.419	11:34:10	1	Kachemak Bay
Sea otter	250	5/31/2016	59.669	-151.379	11:34:55	1	Kachemak Bay
Sea otter	1	5/31/2016	59.672	-151.368	11:35:09	1	Kachemak Bay
Sea otter	9	5/31/2016	59.677	-151.326	11:35:54	1	Kachemak Bay
Sea otter	24	5/31/2016	59.685	-151.304	11:36:21	1	Kachemak Bay
Sea otter	17	5/31/2016	59.697	-151.270	11:37:03	1	Kachemak Bay
Sea otter	2	5/31/2016	59.711	-151.230	11:37:55	1	Kachemak Bay
Sea otter	4	5/31/2016	59.711	-151.229	11:37:58	1	Kachemak Bay
Sea otter	3	5/31/2016	59.721	-151.211	11:38:26	1	Kachemak Bay
Sea otter	5	5/31/2016	59.722	-151.207	11:38:31	1	Kachemak Bay
Sea otter	2	5/31/2016	59.725	-151.198	11:38:43	1	Kachemak Bay
Sea otter	38	5/31/2016	59.728	-151.190	11:38:54	1	Kachemak Bay
Sea otter	2	5/31/2016	59.760	-151.128	11:40:30	1	Kachemak Bay
Sea otter	20	5/31/2016	59.766	-151.023	11:47:23	1	Kachemak Bay
Sea otter	50	5/31/2016	59.764	-151.027	11:47:30	1	Kachemak Bay
Sea otter	1	5/31/2016	59.714	-151.098	11:51:34	1	Kachemak Bay
Sea otter	1	5/31/2016	59.669	-151.148	11:53:21	1	Kachemak Bay
Sea otter	1	5/31/2016	59.666	-151.157	11:53:31	1	Kachemak Bay
Sea otter	20	5/31/2016	59.664	-151.162	11:53:37	1	Kachemak Bay
Sea otter	4	5/31/2016	59.663	-151.167	11:53:42	1	Kachemak Bay
Sea otter	2	5/31/2016	59.555	-151.386	12:05:27	1	Kachemak Bay
Sea otter	1	5/31/2016	59.550	-151.392	12:05:38	1	Kachemak Bay
Sea otter	8	5/31/2016	59.549	-151.408	12:05:54	1	Kachemak Bay

Appendix. -- Cont.

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Sea otter	1	5/31/2016	59.551	-151.422	12:06:09	1	Kachemak Bay
Sea otter	6	5/31/2016	59.549	-151.438	12:06:26	1	Kachemak Bay
Sea otter	1	5/31/2016	59.546	-151.446	12:06:35	1	Kachemak Bay
Sea otter	2	5/31/2016	59.484	-151.361	12:10:17	1	Sadie Cove, Kachemak Bay
Sea otter	25	5/31/2016	59.473	-151.352	12:10:41	1	Sadie Cove, Kachemak Bay
Sea otter	3	5/31/2016	59.484	-151.671	12:18:38	1	Entrance of Kachemak Bay
Sea otter	1	5/31/2016	59.479	-151.681	12:18:53	1	Entrance of Kachemak Bay
Sea otter	16	5/31/2016	59.420	-151.727	12:21:22	1	Seldovia Bay
Sea otter	6	5/31/2016	59.419	-151.726	12:21:26	1	Seldovia Bay
Sea otter	8	5/31/2016	59.413	-151.718	12:21:41	1	Seldovia Bay
Sea otter	17	5/31/2016	59.403	-151.706	12:22:03	1	Seldovia Bay
Sea otter	1	5/31/2016	59.367	-151.909	12:36:31	1	Port Graham, near English Bay
Sea otter	1	5/31/2016	59.235	-153.521	13:36:34	1	South of Augustine I.
Sea otter	1	5/31/2016	60.097	-151.796	17:21:51	2	Offshore from Ninilchik
Sea otter	1	5/31/2016	60.097	-151.795	17:21:53	2	Offshore from Ninilchik
Sea otter	6	5/31/2016	60.095	-151.753	17:23:00	2	Offshore from Ninilchik
Sea otter	1	6/1/2016	59.692	-152.262	11:35:33	3	Mid-inlet off Kachemak Bay
Sea otter	4	6/1/2016	59.686	-152.236	11:36:03	3	Mid-inlet off Kachemak Bay
Sea otter	14	6/1/2016	59.678	-152.200	11:36:42	3	Mid-inlet off Kachemak Bay
Sea otter	9	6/1/2016	59.676	-152.191	11:36:53	3	Mid-inlet off Kachemak Bay
Sea otter	3	6/1/2016	59.673	-152.178	11:37:08	3	Mid-inlet off Kachemak Bay
Sea otter	3	6/1/2016	59.667	-152.153	11:37:36	3	Mid-inlet off Kachemak Bay
Sea otter	1	6/1/2016	59.666	-152.145	11:37:44	3	Mid-inlet off Kachemak Bay
Sea otter	3	6/1/2016	59.663	-152.134	11:37:57	3	Mid-inlet off Kachemak Bay
Sea otter	3	6/1/2016	59.661	-152.126	11:38:05	3	Mid-inlet off Kachemak Bay
Sea otter	2	6/1/2016	59.644	-152.045	11:39:38	3	Mid-inlet off Kachemak Bay
Sea otter	5	6/1/2016	59.631	-151.994	11:40:40	3	Mid-inlet off Kachemak Bay
Sea otter	1	6/1/2016	59.624	-151.967	11:41:12	3	Mid-inlet off Kachemak Bay
Sea otter	1	6/1/2016	59.616	-151.927	11:41:57	3	Entrance of Kachemak Bay
Sea otter	1	6/1/2016	59.610	-151.902	11:42:24	3	Entrance of Kachemak Bay
Sea otter	2	6/1/2016	59.601	-151.861	11:43:12	3	Entrance of Kachemak Bay
Sea otter	1	6/1/2016	59.595	-151.837	11:43:40	3	Entrance of Kachemak Bay
Sea otter	2	6/1/2016	59.586	-151.798	11:44:24	3	Entrance of Kachemak Bay
Sea otter	1	6/1/2016	59.582	-151.780	11:44:45	3	Entrance of Kachemak Bay
Sea otter	1	6/1/2016	59.580	-151.774	11:44:52	3	Entrance of Kachemak Bay
Sea otter	1	6/1/2016	59.568	-151.719	11:45:57	3	Entrance of Kachemak Bay
Sea otter	4	6/1/2016	59.554	-151.838	14:11:44	4	Entrance of Kachemak Bay
Sea otter	3	6/1/2016	59.552	-151.920	14:13:08	4	Entrance of Kachemak Bay
Sea otter	1	6/1/2016	59.550	-151.974	14:14:12	4	Mid-inlet off Kachemak Bay
Sea otter	1	6/1/2016	59.550	-151.975	14:14:13	4	Mid-inlet off Kachemak Bay
Sea otter	10	6/1/2016	59.550	-151.982	14:14:21	4	Mid-inlet off Kachemak Bay
Sea otter	1	6/1/2016	59.549	-151.993	14:14:32	4	Mid-inlet off Kachemak Bay
Sea otter	3	6/1/2016	59.548	-152.010	14:14:48	4	Mid-inlet off Kachemak Bay
Sea otter	1	6/1/2016	59.546	-152.090	14:16:07	4	Mid-inlet off Kachemak Bay
Sea otter	2	6/1/2016	59.537	-152.315	14:30:12	4	Mid-inlet off Kachemak Bay
Sea otter	7	6/1/2016	59.503	-153.226	14:46:03	4	Mid-inlet off Ursus Cove
Sea otter	1	6/1/2016	59.501	-153.291	14:47:08	4	Mid-inlet off Ursus Cove
Sea otter	1	6/1/2016	59.501	-153.309	14:47:25	4	Mid-inlet off Ursus Cove
Sea otter	2	6/1/2016	59.500	-153.304	14:48:44	4	Mid-inlet off Ursus Cove
Sea otter	1	6/1/2016	59.041	-153.638	15:48:19	4	Kamishak Bay
Sea otter	6	6/1/2016	59.050	-153.648	15:48:37	4	Kamishak Bay
Sea otter	1	6/1/2016	59.092	-154.042	15:56:11	4	Kamishak Bay
Sea otter	1	6/1/2016	59.088	-154.070	15:56:39	4	Kamishak Bay
Sea otter	5	6/1/2016	59.130	-154.170	16:03:17	4	Kamishak Bay
Sea otter	1	6/1/2016	59.371	-154.029	16:18:24	4	Kamishak Bay
Sea otter	1	6/1/2016	59.413	-153.856	16:22:05	4	Kamishak Bay
Sea otter	1	6/1/2016	59.407	-153.625	16:26:32	4	near Augustine I.
Sea otter	1	6/1/2016	59.316	-153.410	16:32:34	4	Augustine Island
Sea otter	5	6/1/2016	59.324	-153.379	16:33:09	4	Augustine Island
Sea otter	2	6/1/2016	59.329	-153.368	16:33:24	4	Augustine Island
Sea otter	1	6/1/2016	59.334	-153.356	16:33:38	4	Augustine Island
Sea otter	3	6/1/2016	59.344	-153.332	16:34:10	4	Augustine Island
Sea otter	13	6/1/2016	59.347	-153.328	16:34:16	4	Augustine Island

Appendix. -- Cont.

Common name	Group size	Date	Latitude	Longitude	Time	Flight No.	General location
Sea otter	2	6/1/2016	59.401	-153.554	16:40:19	4	Augustine Island
Sea otter	1	6/1/2016	59.450	-153.707	16:43:44	4	Kamishak Bay, Tignagvik Pt.
Sea otter	1	6/1/2016	59.544	-153.631	16:48:39	4	Ursus Cove
Sea otter	1	6/1/2016	59.561	-153.562	16:50:05	4	North of Ursus Cove
Sea otter	1	6/1/2016	59.615	-153.578	16:52:10	4	Iliamna Bay
Harbor seal	12	5/31/2016	59.788	-151.018	11:42:54	1	Kachemak Bay
Harbor seal	220	5/31/2016	59.783	-150.990	11:43:30	1	Kachemak Bay
Harbor seal	1	5/31/2016	59.163	-151.889	12:53:41	1	Elizabeth Island
Harbor seal	7	6/1/2016	59.089	-153.811	15:52:10	4	Kamishak Bay
Harbor seal	48	6/1/2016	59.088	-153.812	15:52:12	4	Kamishak Bay
Harbor seal	26	6/1/2016	59.125	-154.159	16:03:04	4	Kamishak Bay
Harbor seal	1	6/1/2016	59.180	-154.134	16:06:16	4	Kamishak Bay
Harbor seal	2	6/1/2016	59.609	-153.550	16:51:41	4	Iliamna Bay
Harbor seal	7	6/1/2016	59.619	-153.562	16:57:17	4	Iliamna Bay
Harbor seal	8	6/1/2016	59.728	-153.409	17:02:10	4	Iniskin Bay
Harbor seal	9	6/1/2016	59.642	-153.443	17:05:28	4	Iniskin Bay
Harbor seal	25	6/1/2016	59.634	-153.437	17:05:47	4	Iniskin Bay
Harbor seal	8	6/1/2016	59.826	-153.142	17:23:44	4	Chinitna Bay
Harbor seal	20	6/1/2016	60.691	-151.888	18:13:12	4	SW of West Foreland
Harbor seal	15	6/1/2016	60.698	-151.860	18:13:43	4	SW of West Foreland
Harbor seal	12	6/2/2016	60.959	-149.946	10:24:31	5	Chickaloon Bay
Harbor seal	25	6/2/2016	60.957	-150.016	10:26:08	5	Chickaloon Bay
Harbor seal	60	6/2/2016	60.980	-150.098	10:52:26	5	Chickaloon Bay
Harbor seal	22	6/2/2016	60.966	-150.125	10:53:12	5	Chickaloon Bay
Harbor seal	10	6/2/2016	60.988	-150.151	10:56:13	5	Chickaloon Bay
Harbor seal	2	6/2/2016	60.976	-150.157	10:59:23	5	Chickaloon Bay
Harbor seal	65	6/2/2016	61.264	-150.629	13:38:58	5	Susitna Delta
Harbor seal	50	6/3/2016	60.968	-149.990	10:46:12	6	Chickaloon Bay
Harbor seal	100	6/3/2016	60.956	-150.106	10:52:24	6	Chickaloon Bay
Harbor seal	4	6/3/2016	60.974	-150.147	10:57:46	6	Chickaloon Bay
Harbor seal	1	6/3/2016	61.025	-150.318	11:43:14	6	Pt Possession
Harbor seal	1	6/3/2016	60.992	-151.384	12:33:40	6	Granite Pt
Harbor seal	300	6/3/2016	61.169	-150.550	13:41:08	6	Susitna Delta, offshore
Harbor seal	200	6/3/2016	61.171	-150.492	13:42:02	6	Susitna Delta, offshore
Harbor seal	50	6/4/2016	60.969	-149.956	11:25:43	7	Chickaloon Bay
Harbor seal	36	6/5/2016	60.964	-149.998	12:31:54	8	Chickaloon Bay
Harbor seal	40	6/5/2016	60.965	-150.123	12:35:05	8	Chickaloon Bay
Harbor seal	90	6/5/2016	60.970	-150.123	12:35:15	8	Chickaloon Bay
Harbor seal	40	6/7/2016	60.943	-150.120	12:54:38	9	Chickaloon Bay
Harbor seal	1	6/7/2016	61.173	-150.899	14:21:31	9	offshore Beluga River
Harbor seal	2	6/7/2016	61.195	-150.734	14:32:18	9	offshore Theodore-Lewis R.
Harbor seal	2	6/7/2016	61.185	-150.840	14:38:50	9	offshore Beluga River
Harbor seal	80	6/7/2016	61.172	-150.571	15:42:51	9	Susitna Delta, offshore
Harbor seal	4	6/7/2016	61.197	-150.543	15:47:22	9	Susitna Delta, offshore
Harbor seal	120	6/7/2016	61.198	-150.562	15:47:42	9	Susitna Delta, offshore
Harbor seal	47	6/8/2016	60.942	-150.093	13:38:45	10	Chickaloon Bay
Harbor seal	2	6/8/2016	61.043	-150.477	15:16:35	10	Pt Possession
Harbor seal	1	6/9/2016	61.124	-150.300	13:29:24	12	Fire Island
Harbor seal	3	6/9/2016	60.955	-150.015	14:31:56	12	Chickaloon Bay
Harbor seal	1	6/9/2016	60.935	-150.075	14:33:11	12	Chickaloon Bay
Harbor seal	50	6/9/2016	60.939	-150.101	14:36:44	12	Chickaloon Bay
Harbor seal	80	6/9/2016	61.168	-150.536	16:53:03	12	Susitna Delta, offshore