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ESTIMATED ABUNDANCE OF BELUGAS IN COOK INLET, ALASKA, FROM AERIAL SURVEYS CONDUCTED IN JUNE 2012

Roderick C. Hobbs, Christy L. Sims and Kim E.W. Shelden

National Marine Mammal Laboratory
Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA
7600 Sand Point Way NE
Seattle, Washington 98115

Abstract

The National Marine Fisheries Service (NMFS) conducted aerial surveys of the beluga population in Cook Inlet, Alaska, from 29 May to 7 June 2012 as a continuation of surveys conducted since 1993. Six of the days in 2012 resulted in complete surveys of the beluga habitat in the upper inlet (north of East Foreland and West Foreland); and three days included surveys of the lower inlet. One other survey day included an incomplete survey of the upper inlet that was cut short due to poor weather conditions. During the six surveys of the upper inlet, 30 beluga groups were observed, and up to 11 counting passes were made per group. This season there was a fairly typical presentation of beluga groups, with two or more large groups in the Susitna area and a few smaller groups in Chickaloon Bay and Turnagain Arm. A beluga group was also observed just south of West Foreland headed toward Trading Bay where this group remained (near the mouth of the McArthur River) for the duration of the survey period. This is the first time belugas have been found consistently in Trading Bay since the July 1995 survey. No beluga groups were found in Knik Arm, or elsewhere in Cook Inlet. The estimated abundance for June 2012 is 312 (CV = 0.13, 95% CI: 242 to 402, Nmin = 280) with a ten-year trend (2002-2012) of -0.6% per year (SE = 1.1%). The trend since the management of the hunt began in 1999 (i.e. 1999-2012) is -1.3% per year (SE = 0.8%).

Introduction

NMFS began comprehensive, systematic aerial surveys of the beluga whale (*Delphinapterus leucas*) population in Cook Inlet in 1993 (Rugh et al. 2000). These surveys included the upper, middle and lower sections of the inlet. The surveys documented a decline in abundance of nearly 50% between 1994 (when systematic abundance effort began) and 1998, from an estimate of 653 whales to 347 whales (Hobbs et al. 2000a). In 1998, the Alaska Native subsistence take of belugas was regulated for the first time. Although few whales (a total of 5)

were taken between 1999 and 2008, the Cook Inlet beluga population had continued to decline by an estimated 1.45% per year during this period (Hobbs and Shelden 2008). Accordingly, the Cook Inlet beluga distinct population segment was listed as *endangered* as defined by the U.S. Endangered Species Act (ESA). The continued decline and endangered listing has meant that it is critical to continue these standardized aerial surveys and to conduct abundance analyses of the Cook Inlet beluga stock to document any significant trends over time.

Methods

Analysis followed the methods of Hobbs et al. (2000a,b) with three notable exceptions:

- 1) Since 2004, the video analysis has been conducted by analysts using a Macintosh computer-based program which catalogues the individual whale images, tracks the images across the screen and provides tools for measuring image size. This computer program replaces the earlier system of using plastic transparencies to hand-count whales found in the survey video. The video analysis program allows the analyst to review the video frame by frame or in slow motion play and to make changes to the corresponding saved data an unlimited number of times. Each video sequence was analyzed by a primary analyst who cataloged individual whales, surfacing and diving times and also measured whale images for size and color. A second analyst used the same video and corresponding data file to review the primary analyst's whale count and provide second measurements of each whale image size and color. While refinements to the program were made in 2010 to accommodate video resolution and to streamline procedures within the program, the basic program functions remained the same and it is therefore unlikely that the program changes would have resulted in any bias in this year's analysis.

- 2) Only data collected during this year's survey (with the exception of surfacing interval data) were used to generate the corrections used to estimate group sizes.

- 3) The group count results of each survey day were summed and only complete survey days were used to generate an abundance estimate. For estimates of abundance derived before 2001, the inlet was divided into three sectors; an average abundance was estimated for each sector and survey (see Table 1 in Hobbs et al. (2000b)), and these estimates were summed for the overall abundance estimate (Hobbs et al., 2000b). From 2001 to 2003, an average abundance was estimated for each sector and then summed for the overall abundance estimate. Similar to estimates in Hobbs et al. (2000b), sectors on some survey days were excluded if estimates were unreliable (e.g. because of poor surveying conditions, incomplete coverage, or estimates that were below 60% of the highest estimate for the sector during the survey period). Beginning in 2004, estimates from each survey day were summed, and only days with complete surveys of the upper inlet were used to generate an abundance estimate. This addresses the concern that whales might move from one sector to another between days during the two-week period of the surveys. Similarly to the sector analysis, for survey days with unusually low estimates (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 because 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.

To calculate abundance estimates for the years 2004 to 2012, the equations in Hobbs et al. (2000b, under the heading “Abundance Estimate”) were modified slightly to remove the sector analysis portion, because no belugas have been seen outside of the upper inlet in recent years. Thus each survey day of the upper inlet was treated as a complete survey of the population. The useable survey days were then averaged (Hobbs et al. in review)

4) . The estimate of the variance of the abundance equation in Hobbs et al. (2000b) was revised to use the squared standard error of the average for the abundance estimates in place of the variance of the abundance estimate and the measurement error (Hobbs et al. in review). Using the notation of Hobbs et al. (2000b), the variance is then:

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

Where:

$J_{s,y}$ = the number of surveys of section s (the upper inlet) during year y .

\hat{K}_y = the multiplicative correction for beluga whales in groups that were missed,

$G_{j,s,y}$ = the number of groups found in survey j of section s (the upper inlet) of year y ,

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

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

$T_{l,y}$ = 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 (Hobbs et al. in review).

The trends for the last 10 years (2002 to 2012) and for the overall period (1999 to 2012) 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 (CV) of the estimates.

Results and Discussion

Six of the survey days in 2012 resulted in complete surveys of the beluga habitat in the upper inlet (north of East Foreland and West Foreland); and three days included surveys of the lower inlet. During the remaining surveys of the upper inlet, 30 beluga groups were observed, and up to 11 counting passes were made per group. This season there was a fairly typical presentation of beluga groups, with two or more large groups in the Susitna area and a few smaller groups in Chickaloon Bay and Turnagain Arm. No beluga groups were found in Knik

Arm, but belugas were observed just south of West Foreland headed into Trading Bay and on subsequent survey days were found near the mouth of the McArthur River in Trading Bay. Consistent sightings of belugas in Trading Bay have not occurred during this survey since July 1995.

A total of 3253 whale images were found in 58 video sequences. Of the 17 groups that were video-taped, 16 had video of sufficient quality to estimate group sizes (Table 1), the remaining were estimated using corrections developed from the groups with both video and observer counts following the methods of Hobbs et al. (2000b). Glare, whitecaps, missing part of a group, and poor image quality were the most frequent conditions that rendered video quality too poor to count.

In 2011, video camera upgrades were made that improved video resolution from 720p (1280 x 720 pixels) to 1080p (1920 x 1080 pixels) and increased the field of view for the survey cameras. The airplane used for the survey platform had an opening window allowing for video to be recorded without the impediment of Plexiglas.

Images sizes that were found in the counting video between 2 pixels and 7 pixels had increasing probability of being seen with the 50% probability falling between 3 and 4 pixels. Images greater than 8 pixels had a probability >98% of being seen. The average correction for belugas missed due to image size was 1.18

The density of animals in the groups resulted in a density correction for one of the observers, which was significant. The correction was used with the linear correction as described in Hobbs et al. (2000b).

Observers were visually and aurally isolated on all survey days to allow collection of independent survey effort; very few groups were missed by either observer resulting in a missed group correction of (1.001; CV = 0.001).

Groups found during each survey day, were summed to complete the total for that day (Table 2). The surveys on 1, 3 and 6 June included poor sighting conditions during part of the survey day that may account for the low number of whales and were not included in the estimate.

The overall estimate of abundance for June 2012 is 312 (CV = 0.13, 95% CI: 242 to 402, Nmin = 280). The ten-year trend, 2002 to 2012, was -0.006/year with a SE of 0.011 (i.e., a declining trend of -0.6% per year (SE = 1.1%)). During the period since management of the hunt began in 1999 (i.e., 1999-2012), the trend has been -0.013/year with a SE of 0.008 (i.e., a declining trend of -1.3% per year (SE = 0.8%)) (Fig. 1).

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Table 1. Estimated sizes of groups found during the abundance surveys of Cook Inlet in June 2012. “Source” indicates whether the estimate was derived from video counts or observer counts.

Date	Group	Number of counts averaged	Correction for beluga missed due to image size	Correction for beluga missed below the surface	Group Size	CV	Source
1-Jun-12	1	1			1	0%	observer
1-Jun-12	2	1			1	0%	observer
1-Jun-12	3	1			8	0%	observer
1-Jun-12	4	5	1.26	1.43	129	4%	video
1-Jun-12	5	3	1.16	1.95	25	8%	video
2-Jun-12	1	1			1	0%	observer
2-Jun-12	2	1			1	0%	observer
2-Jun-12	3	2	1.09	1.88	26	8%	video
2-Jun-12	4	2	1.07	2.07	29	7%	video
2-Jun-12	5	7	1.15	1.83	119	3%	video
2-Jun-12	6	4	1.25	1.89	143	4%	video
3-Jun-12	1	3	1.16	1.77	23	9%	video
3-Jun-12	2	1			3	0%	observer
3-Jun-12	3	3	1.22	1.95	209	4%	video
4-Jun-12	1	8			22	9%	observer
4-Jun-12	2	3	1.21	1.70	17	7%	video
4-Jun-12	3	4	1.13	2.06	128	5%	video
4-Jun-12	4	3	1.21	1.95	173	5%	video
4-Jun-12	5	1	1.17	1.96	67	13%	video
5-Jun-12	1	7			4	12%	observer
5-Jun-12	2	2	1.22	1.48	14	13%	video
5-Jun-12	3	7	1.21	1.50	263	3%	video
6-Jun-12	1	6			14	6%	observer
6-Jun-12	2	5			14	6%	observer
6-Jun-12	3	1			84	5%	observer
7-Jun-12	1	3			1	47%	observer
7-Jun-12	2	4			7	12%	observer
7-Jun-12	3	2	1.13	1.50	25	23%	observer
7-Jun-12	4	4	1.10	2.43	54	14%	video
7-Jun-12	5	3	1.15	2.25	154	14%	video

Table 2. Sums by day for complete surveys of the upper inlet. The dates 1, 3 and 6 June were not used in the abundance estimate because there were poor conditions for surveying or counting some groups on those days.

Survey day	Sum of Group Sizes	CV	Used in Abundance Estimate
6/1/12	165	3%	no
6/2/12	318	2%	yes
6/3/12	234	4%	no
6/4/12	407	4%	yes
6/5/12	280	3%	yes
6/6/12	112	4%	no
6/7/12	241	10%	yes

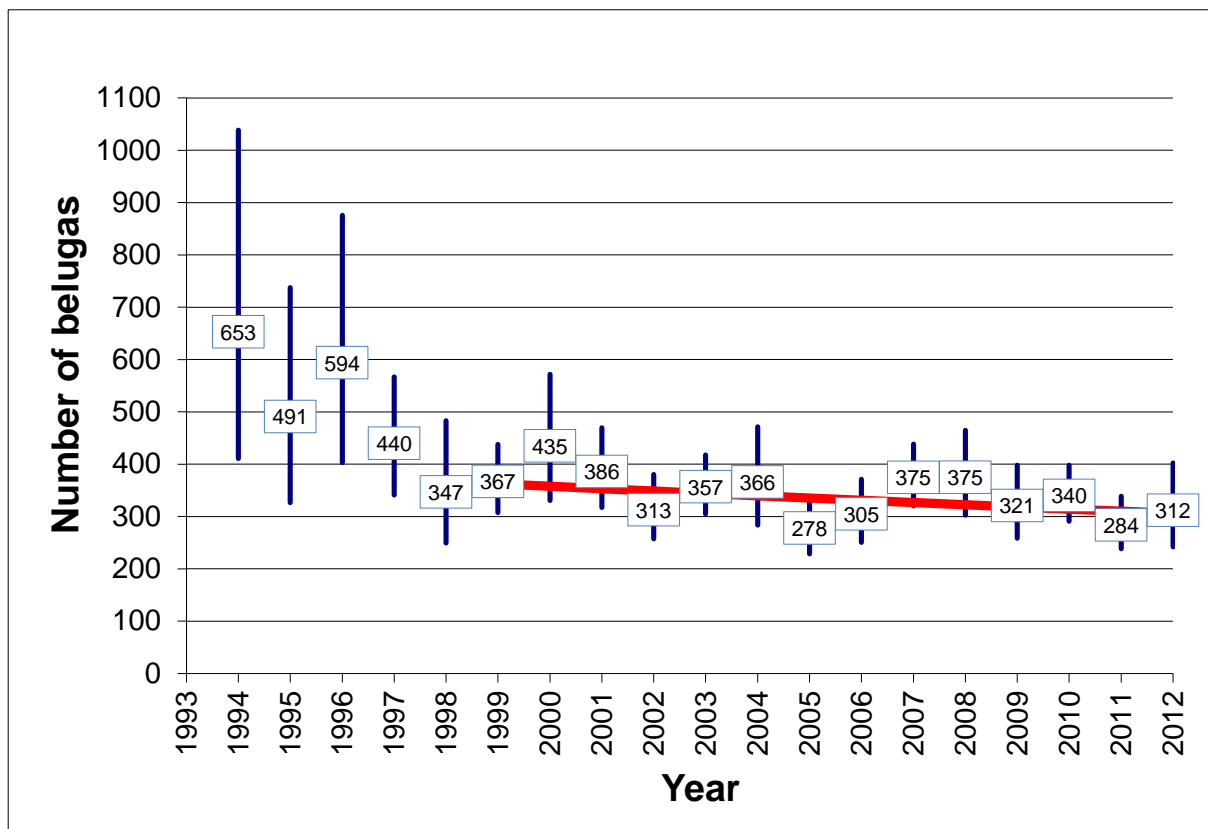


Figure 1. Abundance estimates for Cook Inlet belugas, 1994-2012. The vertical bars represent 95% confidence intervals for each estimate. The red line is the trend for the years 1999-2012.