ESTIMATED ABUNDANCE OF BELUGA WHALES IN COOK INLET, ALASKA, FROM AERIAL SURVEYS CONDUCTED IN JUNE 2009

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Abstract

The National Marine Fisheries Service (NMFS) conducted aerial surveys of the beluga population in Cook Inlet, Alaska, 2-9 June 2009 as a continuum of surveys conducted since 1993. Five of the days in 2009 resulted in complete surveys of the beluga habitat in the upper inlet (north of East Foreland and West Foreland); and the remaining three days included surveys of the lower inlet and a compulsory day off for the pilots. During the five surveys of the upper inlet, 17 beluga groups were observed, and 5 to 12 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 on each survey day. No beluga groups were found in Knik Arm, Turnagain Arm, or elsewhere in Cook Inlet. The five complete surveys were considered to be of sufficient quality to use for estimation of abundance. The estimated abundance for June 2009 is 321 (CV 18%; 95% CI 226 to 456; Nmin = 276).

Introduction

NMFS began comprehensive, systematic aerial surveys of the beluga population in Cook Inlet in 1993 (Rugh et al. 2000). Unlike previous efforts, these surveys included the upper, middle, and lower sections of the inlet. These 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 Native subsistence take of belugas was regulated for the first time, and although beluga numbers no longer declined rapidly, they have not increased in the subsequent decade. Considering how few whales were taken between 1999 and 2008 (a total of 5 whales), NMFS anticipated that the population would begin to recover. Instead, the population has continued to decline by 1.45% per year during this period (Hobbs and Shelden 2008). Accordingly, NMFS established that Cook Inlet belugas are *endangered* as defined by the U.S. Endangered Species Act (ESA). This has meant it is paramount to continue these standardized aerial surveys and conduct abundance analyses to document any significant trends over time.

Methods

Flights take place for approximately two weeks each summer, usually in June, generally for 40-60 flight hours each year. Surveys are flown at 800 ft (244 m) altitude at approximately 100 knots (185 km/hr), generally 1.4 km offshore (Rugh et al. 2000). Coverage is thorough around all coastal areas of Cook Inlet but also includes transects across offshore waters. The intent is to find and count all belugas within Cook Inlet. In order to maximize the opportunities of an accurate count, multiple aerial passes are made near the whale group until each observer has 4 good counts.

The survey aircraft used in June 2009, an Aero Commander 680 (*N98UP*), has twin-engines, high-wings, and more than 8-hour flying capability (Shelden et al. 2009). Bubble windows were at the right forward, left forward, and left rear observer positions, maximizing the search area. A window behind the left rear observer position was opened during counting passes to provide unobstructed video recordings of the beluga groups. The intercom system provided communication among the observers, data recorder, and pilots, but a selective listening device was used to aurally isolate the left observer positions. This allowed for independent search efforts on the coastal side of the aircraft where almost all whale groups are seen. The data recorder used a laptop computer to record sighting data and download location data from a portable Global Positioning System (GPS). Data entries included routine updates of time, locations, percent cloud cover, sea state (Beaufort scale), glare (on the left and right sides of the aircraft), and visibility (on the left and right sides). Visibility was documented in five subjective categories from excellent to useless; conditions rated poor or useless were considered unsurveyed. Each start and stop of a transect leg was recorded.

Immediately upon seeing a beluga group, each observer independently reported the sighting to the data recorder. After a beluga group was reported, the trackline was maintained until the group was well behind the aircraft. This allowed each observer an opportunity to independently sight and report whale groups, and helped identify which beluga groups were missed by an observer. Subsequently, each whale group was circled using an extended oval around the longitudinal axis of the group. Whale counts were made on each pass down the long axis of the oval, with the observers and video cameras on the same side of the aircraft. The paired observers made independent counts. Daily count records were not shared within the aerial team until the survey effort was completed to maximize the independence of each observer's counts.

Paired High Definition (HD) video cameras were used to document beluga groups; one camera had a lens set at wide angle to view the entire beluga group, and the second camera lens was zoomed to magnify individual whales in the group. The zoomed video is used to determine correction factors for missed animals (see Hobbs et al. 2000b) and to examine color ratios of white adults relative to dark juveniles (Litzky 2001; Sims et al. 2003, 2006).

Each video sequence was analyzed by a primary analyst who cataloged individual whales, surfacing and diving times, and 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, make any necessary adjustments to the count and provide second measurements of the size and color of each whale image. If changes were made to the primary count, the primary analyst or a qualified third party was consulted to confirm the accuracy of the changes. If questions were not resolved during the second analysis, a third analyst reviewed the unresolved question to make a final determination.

The abundance calculation based on the June 2009 results followed the methods of Hobbs et al. (2000a,b). An abundance trend has been estimated using annual estimates following the same methods with three notable exceptions:

1) In the years 1994 to 2000, four years of data were used to estimate some correction factors. Since then, only data collected during the respective survey season were used to generate the correction factors for that specific season. The exception to this was the application of surfacing interval data, as described in Lerczak et al. (2000), which is the same correction factor applied in all years.

2) For surveys conducted before 2001, the upper inlet was divided into four sectors (Hobbs et al. 2000a), an average abundance was estimated for each sector, and these estimates were summed for the overall abundance estimate. After 2001, group count results from each survey day were summed, and only days with complete surveys of the upper inlet were used to generate an abundance estimate. This reduced the impact of a large group moving from one area (i.e., sector) to another during the two-week period of the surveys.

3) In 2004, a computer program designed to analyze video of beluga groups replaced the earlier system which used plastic transparencies to hand count whales found in the survey video. This program catalogs the individual whale images found in the survey video, tracks the images across the screen and provides tools for measuring image size. The video analyst is able to review each video pass, frame by frame or in slow motion, and make changes to the corresponding saved data an unlimited number of times.

The trend for the years 1999 to 2009 was determined using a weighted log linear least squares with the weights being the inverse of the square of the coefficient of variation (CV) (Hobbs and Shelden 2008).

Results and Discussion

The 2009 survey, flown 2-9 June (39.4 flight hours) provided thorough coverage of all coastal areas around Cook Inlet (including islands) and 1074 km of transects across the Inlet, effectively searching 28% of Cook Inlet's total area (Shelden et al. 2009). Of the 17 groups of belugas seen during this period, 15 had video of sufficient quality to estimate group sizes (Table 1). A total of 3,418 beluga whale images were found in 63 video sequences. The remaining 2 groups were estimated using corrections to observer counts (following the methods of Hobbs et al. (2000b)). For the two groups where observer counts were used, poor video viewing conditions due to glare and whitecaps, rendered the video unusable for analysis. A total of 62 good to excellent quality video passes were analyzed with 2 to 7 video passes counted per beluga group. Zoomed video included 336 usable beluga images for estimation of the number of animals missed on the unzoomed video, with 5 belugas missed due to their proximity to other belugas and 51 belugas missed due to image size. In all,

approximately 925 hours were spent on Cook Inlet beluga video analysis which included hours worked by three analysts on a variety of duties from editing and quality-grading video to counting and measuring whales and summarizing the results to be used in the abundance estimate.

The computerized video analysis program allows for slower, more methodical, counting of whales in a group as compared to counting real-time during the aerial survey. This advantage in counting becomes especially important when large, high-density groups are encountered. The computer program also allows for different analysts to review the same data and make corrections to counts, as needed, so that each count is as accurate as possible. The computer program has been in use since 2004, and although it was refined in winter 2008/2009, the changes were for streamlining procedures within the program and did not change the basic way the program functions.

Density correction accounts for the effect of large, compact groups of belugas on the counting behavior of the observer (the correction was used with the linear correction as described in Hobbs et al. (2000b)). For three of the observers, the density correction was significant; however, the correction needed to be applied to only two beluga groups because all of the other groups were adequately documented by video cameras.

Groups found during each survey day were summed to complete the total for that day (Table 2). Ten groups were found by paired observers during periods of independent survey effort; eight were found by both observers, and two were found by only one of the two. Analysis following Hobbs et al. (2000a) resulted in a missed group correction multiplier of 1.012 (CV = 0.027). The correction was applied to the average of daily totals for each of the days on which beluga counts were made. Accordingly, the abundance estimate from the June 2009 survey is 321 beluga (CV = 0.18, 95% CI = [226, 456], Nmin = 276) (Table 2).

The population abundance time series from 1999 to 2009 indicates a declining trend at a rate of -1.49% per year (SE = 0.0114) (Fig. 1) with a probability of 77% that the growth rate is declining (i.e., less than zero) and a 99% probability that the growth rate is less than +2% per year.

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Table 1. Estimated group sizes of beluga groups found during surveys of Cook Inlet in June 2009. The source column indicates whether the estimate was derived from video counts or observer counts.

Date	Group*	Number of counts averaged	Average correction for missed at the surface	Average correction for missed below the surface	Estimated group size	CV %	Source
2-Jun-09	1	5	1.23	1.90	183	10%	Video
2-Jun-09	2	5	1.19	1.93	90	10%	Video
2-Jun-09	3	2	1.13	1.90	10	30%	Video
3-Jun-09	1	7	1.23	1.61	248	8%	Video
3-Jun-09	2	4	1.16	1.81	19	17%	Video
3-Jun-09	3	3	1.20	1.91	30	17%	Video
4-Jun-09	1	5	1.25	1.52	87	10%	Video
4-Jun-09	2	5	1.23	1.65	146	10%	Video
4-Jun-09	4	2	1.16	1.79	39	19%	Video
5-Jun-09	1	4	1.16	1.73	30	14%	Video
5-Jun-09	2	3	1.13	1.90	11	23%	Video
5-Jun-09	3	18			99	6%	Observer
5-Jun-09	4	5	1.19	1.55	181	10%	Video
9-Jun-09	5	6	1.17	2.15	118	9%	Video
9-Jun-09	6	4	1.26	1.55	14	19%	Video
9-Jun-09	7	2	1.21	1.61	252	15%	Video
9-Jun-09	8	9			29	22%	Observer

* see Shelden et al. (2009) for daily logs describing beluga groups, group numbering, and their locations.

Table 2. Abundance estimates of belugas by day for complete surveys of upper Cook Inlet.

Date	Abundance estimate	CV %
6/2/09	283	7%
6/3/09	297	7%
6/4/09	272	7%
6/5/09	321	6%
6/9/09	413	9%
Overall estimate*	321	18%

*Overall estimate is the average of the daily estimates multiplied by the correction for missed groups (1.012).

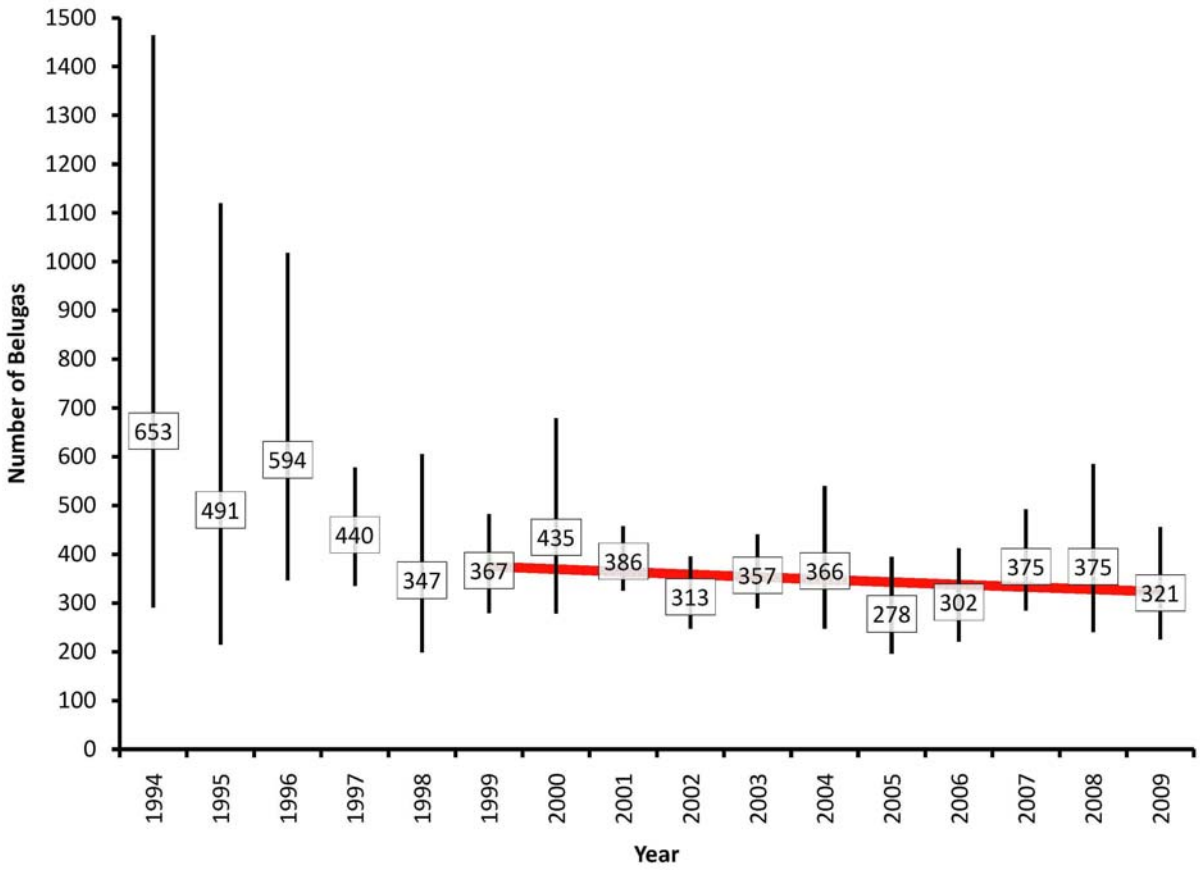

Figure 1. Abundance estimates for belugas in Cook Inlet with 95% confidence intervals (vertical bars). In the years since a hunting quota was in place (1999-2009), the rate of decline (red trend line) has been -1.49% per year.

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