GROUP COUNT ESTIMATES AND ANALYSIS OF SURFACING BEHAVIOR OF BELUGA WHALES FROM AERIAL VIDEO IN COOK INLET, ALASKA, 1994

Janice M. Waite and Roderick C. Hobbs

National Marine Mammal Laboratory
National Marine Fisheries Service, NOAA
7600 Sand Point Way NE
Seattle, Washington 98115, U.S.A.

ABSTRACT

Videotapes of beluga whale groups were collected during aerial survey work in Cook Inlet, Alaska, from 1-5 June 1994. From these aerial videotapes, thirteen whale groups were counted to correct counts made by airborne observers. These correction factors were then used in the abundance estimate in Hobbs *et al.* (this report). In addition, the aerial videos provided the time that whales spent at the surface (190 whales were measured from five different groups), a variable in the correction for whales under the surface during a count. The color and size of whales on the monitor screen were also measured (155 from three groups). Surface times were not significantly different between two passes of the same whale group for all three color categories, but were significantly different for two of the three color categories between whale groups. The surface times of the different color groups were compared to surface times of different color groups measured in videotape taken during vessel work. Surface times measured from the vessel were significantly different from one aerial group, but not from another. The proportion of color groups was also compared to the proportion of color groups from a photograph of a stranded beluga whale group. There was a similar proportion of gray animals in the aerial video and in the stranding photograph. Because of this and because surface times were not shorter than measured in the vessel video, it appears that all or most whales are being counted in the aerial video. However, because these results are based on small sample sizes, and comparisons are made between very different views of whales, more analysis needs to be done before we can be confident about the proportion of whales that are seen in the aerial video.

INTRODUCTION

During the 1994 aerial survey of Cook Inlet (Rugh *et al*. 1995), video records were collected concurrently with observer counts of beluga whale (*Delphinapterus leucas*) groups. Over 45 minutes of video tape recording (hereafter referred to as video) was taken. From these tapes several types of analysis have been conducted, including:

- Accurate counts of all visible surfacings in a group over a measured period of time.
- Accurate measurement of time whales were visible at the surface (start to end of a surfacing).

- Apparent size estimates of whales as seen in the aerial video.
- Color classification for whales as seen from the aerial video.

Group size estimates based on aerial video counts are considered to be accurate when corrected for animals below the surface or animals that have surfaced twice during a count. These can then be compared to the observer's counts made during the aerial survey to devise a correction factor for animals that were available at the surface but missed during a count.

To correct for animals under the surface during a count and animals that surfaced twice during a count period, an average time visible at the surface was needed (see Hobbs *et al*. 1995 for more detail). The aerial video provides a precise way to measure the time that whales spend at the surface. The surface times measured in the aerial video represent the same vantage point as an observer during an aerial count.

Small whales or whales whose color may be camouflaged against the color of the water are more likely to be missed in the aerial counts and in counts made from aerial video. The size and color of animals in a group can also be measured from the aerial video. In addition to aerial video, beluga whales were videotaped from a vessel during tagging operations (Shelden 1995) and an aerial photograph of a mass stranding on the Susitna River delta was obtained. Vessel video analysis provided surface time data for different color classes of beluga whales in Cook Inlet, while analysis of the stranding photograph provided an estimate of the proportion of gray to white animals in a group. By comparing the surface times of the different color categories in the vessel and aerial video, it may be possible to evaluate whether a portion of the beluga whale population is not represented in the aerial analysis.

METHODS

Counting beluga whales

To count from the videotape, a video cassette recorder capable of advancing and reversing the tape frame by frame and a Panasonic monitor were used. Each frame corresponds to 1/30th of a second. Groups were counted in two different ways according to group size. For small groups, whales were counted directly from the monitor screen as the video played at regular speed. Independent counts were made by three different people, and an average was used. For large groups, whale locations were "captured" by stopping the video every 0.5 seconds (15 frames). Transparency sheets placed on the monitor screen allowed marks ('dots') to be made for each visible beluga whale. The sheets were then examined by placing one on top of the next and determining which whales were resighted from one sheet to the next. If a new dot appeared, it was marked as a new whale. Each sheet was checked by a second person, and any discrepancies about whether dots represented new animals or were resightings were discussed until an agreement was made. The number of whales on the first sheet plus the number of "new" whales on each successive sheet were then added to derive a total count for the pass.

This method of counting beluga whales from video was developed in several steps of learning. Two people viewed an aerial pass together with open discussion about which dots represented actual beluga whales. Then a second count was made by three people independently (including the two who had made the first count together). This count was then examined sheet by sheet (every half-second) by all three reviewers. Discrepancies between reviewers were discussed, and a consensus was made concerning whether a dot on the screen could be considered a whale or not. We found that a bird could be mistaken for a beluga but learned through this process how to distinguish them.

The aerial video was taken in two different ways. For some passes, the camera was pointed at the group and was moved to keep the whales in the field of view until they were out of sight. For other passes the camera was held perpendicular to the trackline and scanned across a group (Figure 1). To determine a correction factor, the time spent counting was needed. This was determined differently depending on how the video was taken. For the 'single point' groups, the amount of time that the group was in view was used. For the 'scanned' groups, we measured the amount of time an object on the water was in view across the screen during the pass.

Time at the surface

To measure the time that whales were visible on the surface, a sample of whales from different passes were examined. Transparency sheets from the group counts were used to ‘grab’ a random group of whales (one or two sheets were used depending on the length of the pass). The dots on these sheets were copied onto new transparency sheets, and each dot was numbered. It was then possible to follow each whale using the slow frame-by-frame mode on the video cassette recorder from the time the whale appeared to the time it disappeared. Counter numbers were used to determine the time spent at the surface for each whale. Because there are 30 video frames per second, the error in timing was at most 0.07 seconds.

Whale size (magnitude) and color scale

To determine the distribution of apparent whale sizes visible from the aerial video, each whale that was measured for time at the surface was also measured for visual size and given a color rating. The halfway point in each whale's time at the surface was determined, and measurements were taken at that time for each whale. A plastic metric ellipse template was used as a scale for size. The template was reduced by half using a photocopier to match the range of sizes of the whales. Each ellipse was classified with an angle (describing the shape of the ellipse from almost a circle to a flat oval) and a size (the length of the major axis). The template was held up to the monitor screen for each whale, and a best match was determined. Two independent assessments were made. Using the angle and size for each whale, the magnitude, *m*, (area in mm^2 on the screen) was calculated for each whale:

where a = the angle, and b = the size in mm. The area was calculated for both independent measurements and these were averaged for each whale. To determine a color rating for each whale, three color shades were used: white, gray, and dark. Two independent assessments were made. If there was a disagreement, the two reviewers discussed the color and came to an agreement.

Stranding photograph

On 14 June, 1994, a group of approximately 190 beluga whales stranded on a mud flat near the Big Susitna River mouth. A photographer from The Anchorage Daily News took an aerial photograph which included most of the stranded individuals (186 total). We obtained a 10 x 15 print of the photograph. From the photograph, an assessment of the distribution of sizes and colors was possible. Each whale in the photograph was given a size rating from four size categories (small, medium, large, and very large) and a color rating from four color categories (dark gray, light gray, off-white, and white). Two independent assessments were made, differences were discussed, and a consensus reached for each whale. It was then possible to compare the relative frequency of gray animals to white animals in this large group of beluga whales to the color distributions found in the aerial video of large beluga groups.

Comparison of aerial and vessel video

Beluga whale surfacing behavior was also analyzed from videotape taken from boats during tagging operations (Shelden 1995). Whales were classified into three categories based on coloration and behavior: white animals, gray animals, and head lifts. Surface times were measured for each whale. A t-test was used to compare all surface times measured from the vessel video to all surface times measured from two different groups in the aerial video. Next, the three color categories classified in the vessel analysis were paired to and compared to the three color categories classified in the aerial analysis.

RESULTS

Video counts

A total of thirteen passes were counted using aerial video (Table 1). Passes that were lacking a count time during the aerial survey (due to computer failure in the field) and passes that were rated as poor quality on the video were not counted (see Rugh *et al.* 1995 for rating descriptions). Three out of eight passes with a 'fair' rating were counted. Of the thirteen passes counted, four were counted directly from the screen (without use of transparencies) and nine were counted by "capturing" whales every half a second using transparency sheets on the screen.

Time at the surface

Of the thirteen passes counted from video, five were sampled for the length of time whales were visible at the surface. Average times per pass ranged from 1.91 ± 0.12 sec to 2.99 ± 0.10 sec (Table 1). Two of the five were different passes of the same group (6/1/94, Group 1). The mean surface time for these two passes did not differ significantly (t-test, P = 0.18). The surface times from this group were used in the equation to derive a correction factor for missed whales under the water surface (Hobbs *et al.* 1995) because we felt that the video for this group was the best for measuring surface times. Other groups were further from the plane and so less clear.

Of these five passes, three were measured for whale magnitude and color (Table 1). Two of these were different passes of the same group (6/1/94, Group 1, Passes 2 and 6, Big Susitna River), and the third was a group counted on a different day (6/4/94, Group 4, Pass 4, west of the Little Susitna River). For each of these three passes, surface times were split into the three color categories (white, gray, and dark). Surface times from each color class were compared between passes. First, the two passes from 6/1/94, Group 1 were compared. No significant differences were found for all three color categories (t-test; P = 0.61, P = 0.46, and P = 0.81, respectively). Because the surface times from the two passes of 6/1/94, Group 1 were not different, these two passes were pooled and then compared to the third pass. The white and gray color categories were significantly different between 6/1/94, Group 1 and 6/4/94, Group 4 (t-test; P = 0.055 and P = 0.002, respectively), but the dark color category, a smaller sample, was not (P = 0.11).

Magnitudes

Differences in magnitudes (i.e., size of an animal) were tested between the two passes of the same group for all colors combined and then for each color category separately. Pass 2 and Pass 6 (6/1/94, Group 1) were significantly different overall (t-test, P = 0.04). Magnitudes of white whales and dark whales were not significantly different (t-test, P = 0.70 and P = 0.69, respectively), but magnitudes of gray whales between passes were significantly different (P = 0.02).

The whales from the two passes of 6/1/94, Group 1 were combined and their magnitudes were compared to 6/4/94, Group 4. Overall, there was a highly significant difference between groups (t-test, $P = 7.29 \times 10^{-7}$). Broken down by color, white whales from the two groups were significantly different in size (P = 0.04), but grays and darks were not different (P = 0.53, and P = 0.55, respectively).

Relationship between surface times and magnitudes

Surface times were plotted against magnitudes for the two passes of 6/1/94, Group 1, combined. Each beluga whale color classification was plotted separately (Figure 2). Each color group was clustered, but clusters overlapped between groups.

Stranding photograph

Of the 186 whales counted in the stranding photograph, 180 were rated for color and size. It was not possible to judge the size of the remaining six because they were partially obscured by other whales and/or water. The distribution of colors for the 180 stranded beluga whales was nearly uniform between the four color categories (Table 2). Combining the two gray categories and the two white categories produced nearly equal numbers of gray and white animals (48% to 52%). Four times as many medium and large whales were found as small and very large whales. There was an obvious relationship between size and color (Figure 3), with small and medium whales comprising most of the dark and light gray whales, and large and very large whales comprising most of the off-white and white whales.

Comparison of vessel and aerial video

The surface times of all whales measured in the vessel video and all whales measured in the aerial video of Group 1 from 6/1/94 were significantly different (t-test, $P = 3.59 \times 10^{-8}$) (Table 3). Broken down by color category, vessel whites and aerial whites, and vessel grays and aerial grays were significantly different ($P = 2.00 \times 10^{-4}$, $P = 1.02 \times 10^{-6}$, respectively). The surface times of vessel head lifts, however, were not significantly different than aerial dark whales ($P = 0.10$).

The surface times of all whales measured in the vessel video and all whales measured in the aerial video of Group 4 from 6/4/94 were not significantly different (t-test, $P = 0.11$) (Table 3). In addition, all three color comparisons were also not significantly different (vessel whites and aerial whites: $P = 0.48$; vessel grays and aerial grays: $P = 0.35$, and vessel head lifts and aerial darks: $P = 0.97$).

DISCUSSION

Aerial video proved to be a valuable tool for examining counts made from aircraft. By using the stop motion feature of a video cassette recorder, it was possible to get a very precise count of a beluga group. These counts were used in the abundance estimate derived in Hobbs *et al.* (1995). For large groups, the aerial video count was almost always much higher than the airborne observer count (Rugh *et al.* 1995) , although these counts have not been corrected for time spent counting and so do not imply group size estimates. It was very difficult for an observer to see and count each individual whale. Therefore, observers made assessments by quickly tallying whales as best as they could, or by counting in fives or tens (Rugh *et al.* 1995). Data from video counts indicate that for these large groups too many whales were present for observers to mentally register, and therefore, negatively biased counts were made. Interestingly, small group counts (less than 50 whales) were larger from the aircraft than from the video. Observers had more time to count individuals in small groups, and so counts were more likely to be accurate. Video counts may have been lower for these small groups because the whales may have been spread out over a large area making it difficult to capture all whales on video.

In making corrections from video analysis, it was necessary to have a measure of what portion of a group of whales were actually visible. The stranding of the whales in the Susitna River delta gave an unexpected opportunity to accurately quantify the proportion of different colored animals in one large group. Approximately half of this group was comprised of gray whales and half white whales. The proportion of beluga whales in the Canadian Arctic estuaries was found to be similar, with 42% white whales (Smith *et al*. 1994). For Group 1 from 6/1/94, more than 50% of the group was classified as gray or dark, suggesting that all animals were visible. On the other hand, it is possible that white animals appeared gray in the video due to resolution limitations of the monitor. To test for this, surface times were compared to surface times measured from the vessel video. Surface times from Group 1 (6/1/94) and Group 4 (6/4/94) were actually longer in the aerial video than the vessel video; however, Group 4 surface times were not significantly different from the vessel times. This indicates that animals were not being missed in the aerial video. Surface times may have appeared shorter in the vessel video because animals were hidden by small waves, where they would still be visible from the air.

The measure of surface times was necessary as a component in the correction factor for animals missed (those underwater during all or part of a count) and for animals counted twice during a pass. We found differences in surface times between whale groups, although two passes from the same group had similar surface times. There are several possible reasons for these differences: The behavior of the animals may have been different between groups (or in the same group on different days). Whales may have faster surfacing times when they are active (feeding or traveling) than when at rest. However, it was difficult to determine the behavior of a whale group from the air, other than being clumped or spread out. Surface times may also be different between groups due to differences in distance from the aircraft. The further the group is from the aircraft, the smaller whales would appear. They would, therefore, be less distinct for measuring surface times. The brightness of the day and the sea condition may also have affected how well animals were seen. These weather conditions affect how whales contrast against the background water color. There could also have been a difference in the brightness settings of the video monitor during analysis. Because the surface times of the two passes from the Group 1 were not significantly different, the analysis methods were probably consistent between passes.

Differences in surface times and proportions of colors and size were found between Group 1 (6/1/94) and Group 4 (6/4/94). The differences were consistent with Group 4 being further from the camera so that the beginning and ending of surfacings were most likely lost due to low resolution of the camera. Animals may have appeared darker as a function of increased distance from the camera. Surface times were shorter in Group 4 and there was a much higher proportion of gray and dark animals.

ACKNOWLEDGMENTS

We thank Robyn Angliss, Douglas DeMaster, Barbara Mahoney, and David Rugh for operating the video camera during aerial surveys. D. Rugh and Kim Shelden counted beluga whales from videotape. D. DeMaster, D. Rugh, and K. Shelden provided reviews of the manuscript.

LITERATURE CITED

Hobbs, R.C., J.M. Waite, D.J. Rugh, and J.A. Lerczak. 1995. Preliminary estimate of the abundance of beluga whales in Cook Inlet based on NOAA's June 1994 aerial survey and tagging experiments. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995.

Lerczak, J.A. 1995. Radio-tagging of beluga whales in Cook Inlet, Alaska, June 1994. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995.

Rugh, D.J., R.P. Angliss, and D.P. DeMaster. 1995. Aerial surveys of beluga in Cook Inlet, Alaska, June 1994. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995.

Shelden, K.E.W. 1995. Impacts of vessel surveys and tagging operations on the behavior of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, 1-22 June 1994. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995.

Smith, T.G., M.O. Hammill, and A.R. Martin. 1994. Herd composition and behavior of white whales (*Delphinapterus leucas*) in two Canadian arctic estuaries. Meddr Grønland, Biosci. 39:175-184.

Table 1. Type of video and count made for aerial passes, counts from video, elapsed time, time at surface, whale magnitude on screen, and ratio of whale colors for each pass.

Date	Group	Pass	Type of video	Method of countin g	Count	Elapsed Time (seconds)	Mean time at surface in seconds (SE)	Mean size (magnitude) in mm^2 (SE)	Ratio of colors (white:gray:dark)	Sample sizes for measurements
6/1/94	1	2	Point	Sheets	127.7	12.93	2.77 (0.14)	3.67 (0.18)	15:25:7	47
6/1/94	1	6	Point	Sheets	156	15.50	2.99 (0.10)	4.22 (0.18)	25:32:4	61
6/1/94	1	8	Point	Sheets	149	22.00				
6/1/94	1	10	Point	Sheets	190	21.50				
6/1/94	2	2	Point	Sheets	145	14.00				
6/4/94	3	2	Point	Sheets	178	14.00	2.82 (0.19)		7:10:4	21
6/4/94	3	3	Point	Sheets	132	15.93				
6/4/94	4	1	Point	Sheets	158	19.23				
6/4/94	4	4	Scan	Sheets	123	11.50	1.91 (0.12)	3.10 (0.11)	6:20:21	47
6/5/94	2	3	Scan	Screen	16	17.60				
6/5/94	3	5	Point	Screen	15.7	19.80				
6/5/94	5	3	Point	Screen	29.3	31.47	1.99 (0.11)			14
6/5/94	7	3	Scan	Screen	6	25.43				

Table 2. Number (and percentages) of stranded belugas in each color and size category.

	Whale Size				
Color	Small	Medium	Large	Very large	Total
Dark Gray	20 (11%)	23 (13%)	1 (1%)	0	44 (24%)
Light Gray	1 (1%)	36 (20%)	9 (5%)	0	46 (26%)
Off-white	0	10 (6%)	30 (17%)	2 (1%)	42 (23%)
White	0	6 (3%)	28 (16%)	14 (8%)	48 (27%)
Total	21 (12%)	75 (42%)	68 (38%)	16 (9%)	180

Table 3. Mean surface times (seconds) of beluga whales from aerial and vessel video.

	Aerial				Vessel		
	6/1/94, Group 1		6/4/94, Group 4				
Color	Mean (SE)	Sample size	Mean (SE)	Sample size	Color/ Behavior	Mean (SE)	Sample size
White	3.22 (0.11)	40	2.83 (0.15)	6	White	2.71 (0.07)	21
Gray	2.86 (0.10)	57	2.32 (0.23)	20	Gray	2.17 (0.08)	18
Dark	1.83 (0.30)	11	1.26 (0.14)	21	Head lifts	1.26 (0.10)	13