

# An update on analyses of bowhead whale aerial photographs obtained in 2003-2005.

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## ABSTRACT

Aerial photographic surveys were conducted near Point Barrow, Alaska, from 12 April to 6 June in 2003, from 18 April to 7 June in 2004, and from 6-9 September 2005, and in the Bering Sea, Alaska, from 9 April to 2 May 2005. Approximately 1,157, 1,443, 105, and 454 photographs containing 1,606, 1,974, 114 and 965 images, respectively, were obtained. The 2003 survey had the temporally most complete photographic coverage of whales passing Barrow during spring of any survey to date, and the 2004 survey covered the main migration well although poor weather resulted in poor coverage of the mother/calf migration late in the season. The photographs from these studies will permit calculation of a population estimate for comparison with the estimate from ice based counts (George *et al.*, 2004) and better precision in the calculation of bowhead whale life-history parameters. The 2005 spring survey photographed bowheads during the later part of the bowhead migration, which includes a higher proportion of medium- and large-sized whales that are well marked. These photographs will be compared to 1981–2003 photographs to determine whether the recapture rate for Bering Sea bowheads differs from the rate at Barrow in 2004. Sizes of recaptured whales and their timing in those two areas will also be examined. A power analysis indicates that we will not be able to reliably detect the existence of a second stock that makes up less than 30% of the Bering Sea photographs. A small set of photographs was obtained near Barrow in early September 2005 which is before the main migration from the Beaufort Sea reaches Barrow.

**KEYWORDS: BOWHEAD WHALE; ARCTIC; NORTH PACIFIC; PHOTO-ID; POPULATION ESTIMATION; PHOTOGRAMMETRY; RECAPTURE; MIGRATION; TIMING**

## INTRODUCTION

The photographic database of the Bering-Chukchi-Beaufort Seas (BCBS) population of bowhead whales (*Balaena mysticetus*) contains 12,192 images for the years before 2001 (Koski *et al.*, In Press). About 86% (10,437) of these images were obtained during slightly more than a decade of relatively intensive photographic surveys from 1982 to 1992. About 54% of the 10,336 images that have been classified for image quality to date are of adequate quality to determine if the whales are marked. All of the images in the database, but particularly the better quality images, have provided useful information on life-history parameters including calving intervals (Miller *et al.*, 1992; Rugh *et al.*, 1992a), growth rates (Koski *et al.*, 1992, 1993), population structure (Davis *et al.*, 1983; Koski *et al.*, 1993, In press; Angliss *et al.*, 1995), population size (Rugh, 1990; da Silva *et al.*, 2000; Schweder, 2003) and survival rates (Whitcher *et al.*, 1996; Zeh *et al.*, 2002). On-going studies continue to use these data to further describe various parameters of bowhead whale life history and population dynamics.

The size of the bowhead photographic database has increased to the point where collection of new photographs results in a relatively high probability of re-sighting a previously photographed marked whale. This is because the proportion of the population that has been photographed has increased, and consequently, the likelihood of photographing a whale that has been photographed during previous studies has increased dramatically. Thus new photographs at this time provide much more information on individual whales than the

same number of photographs did during the early years of bowhead whale photography studies. This point is emphasized by the substantial information provided by the relatively small photographic effort during the 1998–2000 bowhead feeding study (15 new inter-year re-identifications spanning 4 to 15 years among photographs of 70 different marked whales).

Aerial photographic studies were conducted during the spring migrations of 2003–5 and during fall of 2005. The major objective of the 2003–4 aerial photography project was to obtain a population estimate that can be compared to the 2001 ice-based census of bowheads (George *et al.*, 2004). The major objective of the 2005 spring project was to determine if some whales that migrate through the northern Bering Sea in spring do not pass Barrow. The 2005 fall project was conducted to attempt to document the origin of whales seen near Barrow in late August–early September before the main movements from the eastern Beaufort Sea have reached the Barrow area.

Mark-recapture analysis of the 2003–4 photographs (da Silva *et al.*, 2000) will provide a completely independent abundance estimate to compare to the current "best" estimates (George *et al.*, 2004; Zeh and Punt, 2004). The aerial photography approach to estimating abundance is less sensitive to vagaries in ice cover than is the ice-based survey, yet both methods provide estimates with similar accuracy: SE = 1,450 - 1,915 for ice-based results in 1985 and 1986 and SE = 1,696 - 2,017 for photographic results in the same years (da Silva *et al.*, 2000). Secondary objectives of the project were to obtain a length-frequency distribution of the population to compare with earlier length-frequency distributions estimated by Angliss *et al.* (1995) and Koski *et al.* (In press) and to obtain additional photographic data that can be used to refine existing estimates of life-history parameters such as calving intervals, growth rates and survival rates.

Aerial photographs from the 2005 studies will be compared to photographs from previous studies. The recapture rates and sizes of recaptured whales in the Bering Sea photographs from 2005 will be compared with the corresponding recapture rates and sizes in the 2003 and 2004 photographs from Barrow. Differences in the recapture rates or the sizes of whales that are recaptured will be used to assess whether different bowheads are present in the two different areas. In addition, the timing of passage past Barrow will be compared to timing past St Lawrence Island for whales that are photographed in the two areas. The timing information may provide hints about different stocks or sub-populations, if they exist.

Other objectives of the current studies were to expand the photographic collections at NMML and LGL to contain images that were not present at both locations and to update the database with data that were missing in earlier versions of the database. We also intend to develop a computer-assisted matching program to increase the efficiency of finding matches both within season and between studies.

## METHODS

The 2003–5 aerial photography studies were conducted jointly by LGL Limited (LGL), the North Slope Borough Department of Wildlife Management (NSB-DWM) and the National Marine Mammal Laboratory (NMML). The methods were similar to those of earlier studies (Koski *et al.*, 1992; Angliss *et al.*, 1995) and are described in Koski *et al.* (2005).

Following the 2003 and 2004 field seasons, the film was developed, labelled, duplicated and stored in acid-free archive sheets for future analyses. The data documenting each photograph were entered into an Excel spreadsheet for future integration into the "Bowhead Whale Photography Database" described in Koski *et al.* (In press). During the 2004 field season, images obtained in 2003 were digitized at 4000 dots per inch; some of the digitized images were cropped and printed to nearly fill 12.7cm × 17.8cm (5in. × 7in.) colour prints (Table 1), which are suitable for comparing photographs to identify matches (Rugh *et al.*, 1992b). During February and March 2005, the 2004 images were digitized and cropped so that they were ready to print. Following the 2005 field studies, the film was developed, labelled, scanned and the data documenting each photograph were entered into an Excel spreadsheet. Then all images were printed and checked versus the film and the data files to ensure that all were scanned and printed.

Researchers at LGL and NMML have shared all subsequent analyses tasks. NMML researchers have taken the lead on scoring images for photo quality and identifiability (Rugh *et al.*, 1998), doing within-year matching of 2004 images for verification of LGL matches, and final determination of within year matches. LGL researchers have taken the lead on within-year matching for all four studies, assembling the database, and measuring whales. Both groups are doing matching to find between study matches independently, and when complete, their results will be compared and a final set of matches will be determined.

## RESULTS

### Analyses of Photographs

Table 1 shows the progress on each of the general tasks as of 15 May 2006. The images from all studies have been scanned, cropped, printed, scored for identifiability and image quality, filed, and within study comparisons have been completed.

### **Computer-assisted Matching Program**

Funds have been supplied by U.S. Minerals Management Service (MMS) to develop and test a computer-assisted matching program for bowhead whales similar to the ones used for dolphins and gray whales. The personnel assigned to this program developed the earlier programs “Finscan”, a widely distributed photo-ID system for identifying marine animals by notching patterns in dorsal fins (Markowitz *et al.*, 2003); “Flippermatch,” a program for photo-ID of Steller sea lions; and software for identifying sea otters by scarring patterns on the nose and for identifying gray whales by scarring patterns on the flukes (Hillman *et al.*, 2003). The fluke scarring problem is the closest to the bowhead whale matching problem, and it is that program that will be modified and adapted to the present need. The bowhead matching specialists at NMML and LGL will conduct the testing and help with the fine tuning of the program.

### **Population Estimate**

The between study matching of the 2003 and 2004 photographs has started at both LGL and NMML. It is expected to be completed and the matches verified by the middle of July. The finalization of the 2004 within season matches by LGL and NMML will be completed by mid-May. The LGL 2003 within season matches have been completed, but the verification matching by NMML, which is required to determine the precise number of different whales photographed in 2003, is not planned this year. Only a preliminary estimate of the number of “usable” 2003 images will be available for the data availability deadline for the 2007 IWC meeting. This may permit a preliminary estimate of the population size using the 2003 and 2004 photos. Photo quality was better in 2003 and 2004 (0.144 and 0.283, respectively, useable photos with marked whales/photo) than in studies conducted 1981–2000 (0.122/photo). When the matching is completed, a reliable population estimate should be possible using the photographs and mark-recapture methods.

Funds have been secured to further refine the mark-recapture model used in the earlier study by da Silva *et al.* (2000). The refinements to this program will begin later this year.

### **Stock Structure Analyses**

LGL has conducted matching of the 2003 spring photographs with the 2005 spring and fall photographs, and started to match 2004 spring photographs with 2005 spring and fall photographs. NMML has started independent verification matching and will complete that task by fall. These between study matches will be confirmed and the database updated by late fall. This will permit preliminary examination of recapture rates at Barrow vs. the Bering Sea using the 2003 dataset as the marked whales. Matching of 2004 Barrow and 2005 Bering Sea whales with earlier years will not be started before 2007 due to a funding shortfall.

Preliminary results suggest that we will not be able to detect the existence of a second stock among our 2005 photographs from the Bering Sea. Although the whales in the photographs were well marked, high winds reduced the quality of the photos and only 0.081 useable photos with marked whale/photo were obtained. This is lower than the 0.122/photo in 1981–2000, and much lower than in 2003 and 2004.

### **Database**

The data fields in the photography database (BOWPHOT) are being filled in for each of the 2003–5 studies as analyses are being conducted. Thus the data will be available for preliminary analyses shortly after the matching and validation matching are completed this fall.

## **DISCUSSION**

Despite delays in obtaining funding, good progress has been made on analyses of the 2003–5 photographs. Whale images from all projects have been printed and distributed to the study team, and within-year matching is complete for each of these four studies; however, verification matching is only complete for one of the four studies (2004) and is not expected to be conducted for the other three studies in the near future. Other analyses of these images are well underway at both NMML and LGL. Between-study matching will be completed by mid July and verification of between study matching by fall. This will allow a preliminary estimate of population size and preliminary examination of recapture rates between photographs obtained at Barrow in spring 2003 with those at Barrow in 2004 and with those in the Bering Sea in spring 2005. Power analyses have suggested that the 1981-2003 vs 2005 spring and 1981-2003 vs 2004 comparisons may not provide sufficient numbers of recaptures to detect a difference between Bering Sea and Barrow recapture rates, and so matching of 1981-2000 vs 2004 and 1981-2000 vs 2005 spring photos will likely be required to detect differences in recapture rates between the Bering Sea and Barrow, if any differences are present and can be detected. A current funding short-fall for 2006-7 will not permit all earlier-planned analyses to be completed for the 2007 IWC meeting, and will require decisions on priorities for analyses to be conducted during the next nine months.

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Table 1

Status of analyses of bowhead whale photographs obtained during 2003–5 studies near Barrow, AK and the 2005 study in the Bering Sea as of 15 May 2006.

Priority	Task	2003	2004	2005 Bering	2005 Fall
	Number of Images	1606	1974	965	114
	Number of Images Printed	1469	1969	955	114
	Number of Potentially Marked whale images*	231	559	78	25
	Number of Potentially Marked Different Whales	?	?	?	13
1	Images Scanned and Cropped	100%	100%	100%	100%
1	Images Printed	100%	100%	100%	100%
1	Images Filed	100%	100%	100%	100%
1	Images Scored for Quality and Identifiability	100%	100%	100%	100%
1	Images Compared Within-year	100%	100%	100%	100%
1	Images Scored for Composite Id & Qual	50%	0%	0%	100%
1	Images Compared Between 2003 and 2004	1%	1%	NA	NA
1	Images Compared Between 2003 and 2005Spr	50%	NA	0%	NA
1	Images Comp'd Bet'n 2005Fall and 03-05 Spring	50%	100%	0%	NA
2	Between Year Matching Checks 2003-2005	0%	0%	0%	0%
2	Images Compared Between 1981-2000	0%	<1%	0%	0%
3	Images Measured and Calibrated	10%	100%	0%	100%
3	Best Lengths for Each Whale	0%	0%	0%	100%
4	Within Year Matching Check	0%	80%	0%	0%
1	Data Entered into Database	Up-to-date	Up-to-date	Up-to-date	Up-to-date

\* Whales with at least one zone with markings M- or better and image quality 2+; based on scoring of single images; more whales will be included as marked when composite scoring is complete.