Aerial photography of bowhead whales near Barrow, Alaska, during the 2011 spring migration

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ABSTRACT

Aerial photographic surveys for bowhead whales were conducted near Point Barrow, Alaska, from 19 April to 6 June in 2011. Approximately 4,594 photographs containing 6,801 bowhead whale images were obtained (not accounting for resightings). The 2011 field season was very successful: we flew 36 out of 49 available days and conducted 49 flights in that time; we were grounded due to weather on 13 days. The longest period of time that we were grounded due to weather (low ceilings/fog) was three days. This occurred after the migration had slowed down, during a time when few whales passed the ice perches according to the ice-based visual survey. The 2011 migration was steady with several peaks (30 April, 4-5 May, 12 May), and then the migration rate slowed down considerably after 14 May. The photographs taken in 2011 are a significant contribution to the bowhead whale photographic catalogue. They will be used to calculate a population estimate that may be used for comparison with the 2011 ice-based estimate and will provide better precision in estimates of bowhead whale life-history parameters.

KEYWORDS: BOWHEAD WHALE; ARCTIC; SURVEY-AERIAL; PHOTO-ID; POPULATION ESTIMATION

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INTRODUCTION

The photographic collection of bowhead whales (*Balaena mysticetus*) from the Bering-Chukchi-Beaufort (B-C-B) Seas population currently contains over 18,000 images (Mocklin *et al.* In Press). The utility of using these aerial photographs to identify individual whales has been well documented, and applications include mark-recapture abundance estimation (Rugh 1990; da Silva *et al.* 2000; Schweder 2003; George *et al.* 2004; Koski *et al.* 2010), estimation of survival rates (Zeh *et al.* 2002), calving intervals (Miller *et al.* 1992; Rugh *et al.* 1992a), and measurement of individual growth rates (Koski *et al.* 1992, 1993).

Each additional season of photographic data contributed to the bowhead whale photographic database increases the probability of obtaining inter-year re-identifications and improves estimates of abundance, calving intervals, survival rate and other parameters. Therefore, photographs collected in 2011 provide more information on individual whales than the same number of photographs did during the early years of bowhead whale photography studies (Koski *et al.* 2004a).

The last directed effort to collect photographs of the B-C-B bowhead whale population was during the 2003-2004 aerial abundance surveys, which were conducted to derive the last population estimate. A primary objective of the 2003-2004 aerial surveys was to obtain a population estimate to be compared to the 2001 ice-based estimate of bowhead whales (George *et al.* 2002). Estimating abundance through mark-recapture analysis using paired samplings (as per da Silva *et al.* 2000), provided an independent corroboration of the ice-based estimate (Koski *et al.* 2004a), with results consistent between the two surveys (Koski *et al.* 2010). However, at a time when aerial surveys may eventually need to replace the ice-based survey due to hazardous ice conditions resulting from arctic climate warming, managers and co-authors decided there was scientific merit to repeat this experiment with another abundance estimate. In 2011, we were fortunate to successfully complete both an aerial and ice-based survey of the bowhead whale population. Deriving and comparing abundance estimates from these two platforms in the same year provides a great opportunity to further test the aerial method of estimating abundance before solely relying on that platform in the future. Aerial photographic capture-recapture surveys are less sensitive to ice conditions than the ice-based surveys (Koski *et al.* 2010), which will likely become increasingly important in a warming Arctic. Of equal importance to an abundance estimate, additional photographic data can be used to refine existing estimates of life-history parameters such as calving intervals, growth rates and survival rates (Koski *et al.* 2004a). Initial results from the aerial survey are presented here.

METHODS

The 2011 spring aerial abundance survey was conducted jointly by the North Slope Borough Department of Wildlife Management (NSB-DWM) and the National Marine Mammal Laboratory (NMML). Methodology was similar to earlier studies (Koski *et al.* 1992; Angliss *et al.* 1995). Surveys were conducted in an Aero Commander 690 with bubble windows in the two forward observer positions. The aircraft flew at an average air speed of ~217km/h (117kts) and altitude of 200m (656ft), and flew directly over bowhead whales during photographic passes. Photographs were taken with a Canon Mark III-1DS digital camera affixed with a Zeiss 85mm fixed f/1.4 Planar T* lens pointed directly downward through the aircraft's ventral camera port that was covered with optical quality glass. Shutter speed was typically 1/2500th second or faster. Aircraft altitude was recorded every 2 seconds with a handheld Garmin 76CSx GPS unit and saved on a laptop computer; these data will later be linked to the photographic data. Additionally, Robogeo software will be used to embed latitude, longitude and altitude into the Exif metadata of each photograph. Calibration targets of known dimensions were photographed twice during the season, at the beginning and end of the survey. These calibration photographs were taken from the same altitudes flown during survey effort. Additionally, each flight began with a photographic pass over a table of known dimensions at a set altitude of 152m (500ft) to act as a daily check of altimeter performance.

The search technique in 2011 was conducted as it has been during earlier abundance surveys near Barrow, Alaska. Similar to Koski *et al.* (2004a), we did not attempt to minimize duplicate photographs of whales. The aircraft frequently returned to locations where whales had been photographed earlier in the day to maximize the number of photographs collected and new animals documented as they traveled past Barrow. Effort was focused along leads in the ice to maximize the probability of finding and photographing whales.

Following the 2011 field season, we began to process the digital photographs by selecting the best image of each whale per photographic pass, and cropping and labeling those images to be evaluated for quality and identifiability.
digitized images are being cropped to 12.7cm × 17.8cm (5in × 7in) color prints, which are suitable for comparing photographs to identify matches (Rugh et al. 1992b). We intend to make prints of all photographs for matching purposes but may match with the cropped digital images if we lack funding or if the automated matching program developed by Gil Hillman obviates the need. The data associated with each photograph will later be integrated into the ‘Bowhead Whale Photography Database’ described in Koski et al. (2004b).

RESULTS
Flights to photograph bowhead whales were conducted on 36 of 49 days from 19 April to 6 June, 2011 (Fig. 1). Surveys lasted less than one hour on six flight days due to weather, predominantly low ceilings and fog. The longest period of time we were grounded was three days due to fog and low ceilings (Fig. 2). A total of 143.7 hours were flown and 4,594 photographs containing 6,801 bowhead whale images were collected (see Table 1 for a comparison to the 2003 and 2004 surveys). The number of photographs obtained by date is shown in Fig. 2, along with the number of individuals seen by day as recorded in the aerial survey data (i.e., not accounting for resightings). The 2011 migration increased steadily and reached a peak on 30 April. There was then a short lull on 2-3 May, but the migration rate rapidly increased with the highest peaks of the season on 4 and 5 May. There was another peak on 12 May, but then the migration rate slowed down considerably after 14 May and remained slow with a small peak on 28 May. This pattern of peaks, or pulses, in passage rates is typical, as described by Zeh et al. (1993).

Although we are at the early stages of processing photographs from the 2011 survey, initial photo-analysis has resulted in significant contributions to life history data. Unique circumstances documented include one photograph of a well-marked yearling, one entangled whale and one whale with a spinal irregularity that we speculate may be scoliosis; all are considered rare photographic events. Additionally, we have found one match to a whale photographed in 2004 (whale number 13088). Based on our qualitative review of the photographs, it appears that 2011 captured many photographs of highly marked whales and we expect to find numerous matches to previous years.

DISCUSSION
In 2003, bowhead whales passed Point Barrow steadily throughout the spring period with only one major peak of movement, which occurred on 2 May (Koski et al. 2004a). Overall good weather conditions in 2003 allowed for no periods longer than one day without surveying (Koski et al. 2004a). In 2004, similar to 2011, bowhead whales appeared to pass Point Barrow in pulses, which is typical of the spring migration (Zeh et al. 1993; George et al. 1995). The first peak in 2004 occurred on 27-28 April and the second on 11-12 May (Koski et al. 2004a). This is similar to the 2011 survey, which had peaks on 30 April, 4-5 May, and 12 May, with the migration rate slowing down considerably after 14 May and remaining slow with a small peak on 28 May. Unlike 2003, weather was more of a limiting factor in 2004 and 2011, resulting in groundings of two to three day periods (Koski et al. 2004a). As a result, the photographic sample obtained in 2003 remains the most complete data set in terms of consistent migration coverage. Despite this reduced effort when compared to 2003, the 2011 survey was more successful in terms of number of photographs obtained (Table 1).

In summary, the 2011 bowhead whale aerial abundance survey was highly successful both in terms of photographing large numbers of bowhead whales and obtaining fairly consistent coverage of the migration. Nevertheless, whales migrating both pre- and post-survey effort were not captured during this period. The first whales that were seen by the ice-based crew were on 9 April, a full ten days prior to the start of the aerial survey; the ice-based team observed a peak in the migration on 16 April, also prior to the aerial survey (see SC/64/AWMP7). Whale hunters reported some whales even earlier in March. Therefore, it may be prudent to start future aerial surveys earlier than 19 April. As Koski et al. (2004a) points out, it is unknown whether the migration period has become more protracted as a result of an increasing population size and changes in ice conditions (George et al. 2004), or whether similar proportions of whales passed before the start and after the end of earlier studies. The photographs taken in 2011 are a significant contribution to the bowhead whale photographic catalogue. They may be used to calculate a population estimate using capture-recapture techniques that will complement the ice-based abundance estimate. Additional photographs also aid in refining existing estimates of bowhead whale life-history parameters such as calving intervals, growth rates, and survival rates. The photos will also be useful for estimating health assessment parameters.
associated with scaring, entanglement rates in fishing/crabbing gear, and ship or propeller wounds (Reeves et al. 2012).

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REFERENCES


Table 1. Summary of survey effort and photographic success from the last three aerial abundance surveys of bowhead whales.

<table>
<thead>
<tr>
<th>Year</th>
<th>Days Flown</th>
<th>Hours flown</th>
<th>Photographs taken</th>
<th>Bowhead images*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>51 of 55</td>
<td>161.8</td>
<td>1157</td>
<td>1561</td>
</tr>
<tr>
<td>2004</td>
<td>41 of 50</td>
<td>142.5</td>
<td>1443</td>
<td>2098</td>
</tr>
<tr>
<td>2011</td>
<td>36 of 49</td>
<td>143.7</td>
<td>4594</td>
<td>6801</td>
</tr>
</tbody>
</table>

*Note: “bowhead images” refers to the number of whales in a photograph, i.e., there may be numerous bowhead images in a single photograph. This number does not reflect individual whales. Only matching of the photographs will determine the number of individual bowhead whales that were photographed in 2011.
Figure 1. Top map shows all aerial survey tracks and bowhead whale sightings during the 2011 spring survey. Bottom map shows a detailed view of bowhead sightings (note some sightings to the west of Barrow were cut off to encompass the majority).
Figure 2. Photographs obtained and number of individual bowhead whales recorded per day by the aerial survey, not accounting for resightings (i.e., prior to matching). The survey was grounded for 13 days due to weather; those days are included here to provide a complete visual reference of the survey season.