Interyear re-identifications of bowhead whales during their spring migration past Barrow, Alaska, 1984 - 1994.

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ABSTRACT

Aerial photography of bowhead whales in the 1900s resulted in >12,000 images, of which 5,600 were taken near Point Barrow during the spring migration. Among the photographs from the Point Barrow area, 40 different whales were seen more than once between years, and of these, two were seen on three different years, making for a total pair-wise sample size of 44 interyear matches. Differences in resighting dates ranged from 1 to 31 days ($\bar{x}$ = 12 days: SE = 1.2) comparing month and day only, irrespective of year. Most (85%) of the photographs have been taken between 22 April and 26 May, a range of 34 days. Therefore, the resightings are well dispersed across this period. Immature whales appear to have less change in migration dates, but mature whales have a wide range in dates. All of the available evidence indicates that mature bowheads are not restricted to particular dates during the spring migration; instead, on subsequent years they may appear on almost any date within the normal migratory period (mid-April to early June).

INTRODUCTION

Individual bowhead whales (*Balaena mysticetus)* have unique markings, some of which are genetically acquired, and some of which are acquired through trauma such as contact with sea ice. In many cases, markings on dorsal surfaces are distinct enough to be recognized in aerial photographs (Rugh *et al*. 1992; Koski *et al*., 1992). Data from individually identified bowhead whales have been used in population abundance estimates (e.g., Rugh, 1990; DaSilva, *et al*., 2000; Schweder, 2003), survival analysis (e.g., Whitcher *et al.* 1996; Zeh *et al*., 2002), determination of calving intervals (Miller *et al*., 1992; Rugh *et al*. 1992) and analyses of whale lengths through photogrammetry (e.g., Koski *et al*., 1993; Angliss *et al*. 1995). The objective of this paper is to examine dates of reidentifications made of bowhead whales during their spring migration past Point Barrow, the northernmost tip of Alaska. In particular, differences in passage dates of the same whales in different years are of interest to answer questions about the uniformity of the stock of bowheads photographed in this area between mid-April and early June.

METHODS

Aerial photographs of bowhead whales have been collected systematically during the spring migration near Point Barrow in many years during the past two decades, particularly between 1984 and 1994. Procedures for collecting these aerial photographs have been described in Rugh (1990), Rugh *et al*. (1992) and Koski *et al*. (1993). Techniques for categorizing and reidentifying images have been summarized by Rugh *et al.* (1992) and Rugh *et al*. (1998). Following each field season, systematic searches were conducted among the images to find whales photographed more than once; then comparisons were done between years. No equivocal matches are included in the data set (13 potential matches were not included because they were not definitely of the same whale). Each match was confirmed by three different researchers (DJR, WRK, and Gary Miller of LGL Limited). Data used in this study were limited to the area near Point Barrow (between 160°W and 153°W longitude) during the spring migration (April – June).

Proportions of the bowhead population passing Point Barrow during one-week periods (5-23 Apr, 24-30 Apr, 1-7 May, 8-14 May, 15-21 May, 22-28 May, and 29 May-7 Jun) were obtained by averaging the corresponding proportions for each of the respective years (1981-83, 1985-86, 1988, 1993, 2001) when ice-based counts were conducted for abundance estimates (George et al. 2004). Each weekly proportion was obtained by summing daily census estimates for the respective week and dividing by the sum of daily estimates for the whole season, assuming that by averaging and giving each year equal weight a portion of the population missed in any one year would be balanced by sampling effort in other years.

RESULTS AND DISCUSSION

Aerial photography of bowhead whales has resulted in >12,000 images collected between 1976 and 2001 (Koski *et al*. 2004). Among these photographs, over 1,330 individual whales have sufficient marks to be considered identifiable, and 157 interyear reidentifications have been made of 118 different whales seen in two different years, 19 seen in three years, and 2 seen in four years. Many of the photographs were taken near Point Barrow during the spring migration (n = 5,596), all of which were between 15 April and 7 June ($\bar{x}$ = 5 May). Of 4,382 images rated for identifiability, 1,351 (31%) had some portion of their dorsal surface sufficiently visible and marked to make it possible to recognize the whale in subsequent photographs in other years. Among these images taken during the spring migration, 40 whales were seen more than once between years, and two of these whales were seen on three different years, making for a total pair-wise sample size of 42 interyear matches (Table 1). Figure 1 traces the matches between paired sightings of the respective whales.

Differences in resighting dates ranged from 1 to 31 days ($\bar{x}$ = 11.1 days; SE = 1.2) comparing dates, irrespective of year. Only 3 whales were resighted within 2 days of their original sighting date, but many (52%) were resighted within 11 days (Fig.2). This is not surprising given that more than half of the migration (55%) passes Point Barrow within only a 2 week period from 1-14 May on an average year (Table 2).

When lengths were compared relative to differences in resighting dates (Fig. 4), it appears that smaller whales (<11m) may be less variable in the date that they pass Point Barrow (ΔT = 2-3 days) than larger whales (>12m), which have a wide range in dates (ΔT = 1-31 days). Although the sample size of immature whales is very small (n = 3), if it is representative, it supports the consistent observation that immature whales tend to pass Barrow early in the migration (Nerini *et al*., 1984; Rugh, 1990; Zeh *et al*., 1993; Angliss *et al*., 1995). Because bowheads acquire marks over time, young whales have a low probability of being identifiable in aerial photographs. It is likely that there are many unrecognized resightings of small whales among our photographs.

Of 42 pairs of resightings (Table 1), 5 had a calf in one year. These 5 whales had differences in migration dates that ranged from 3 to 21 ($\bar{x}$ = 14.0, SE =3.8), compared to 1-31 days for the other 37 resightings of whales without calves ($\bar{x}$ = 10.7; SE = 1.2). Whether or not an adult was accompanied by a calf did not seem to affect inter-year differences in migratory timing (t-test p = 0.22), in part because all of the bowheads had a wide range in date differences. The pattern of migratory timing was tested by comparing the observed frequency distribution of differences in arrival dates versus: 1) a uniform distribution (equal probability of a resighting occurring in any 5-day bin throughout the season); 2) all resightings occurring within 5 days of the original sighting date (i.e., all resightings occurring within one 5-day bin); and 3) the sighting frequency as recorded during ice-based censuses (sorted 5-day bins). An F-test for variances showed that the data did not match a uniform distribution ($p << 0.001$), nor did the whales tend to return to Barrow on the same date each year ($p = 0.006$), but differences in arrival dates did match the sorted frequency of sighting rates based on census data ($p = 0.375$). Therefore, resightings occurred more as a function of the generalized distribution of whale passage rates throughout the season than of the date an individual whale previously migrated past Barrow.

In another test, differences between sighting dates were compared to a random distribution through the season. On the first day of this sample set (19 April), there are theoretical possibilities of a paired match from the same day (difference = 0) to the last day (difference = 49). The average of these two possibilities is 24.5, so we treat this as the random chance of a date difference for a sighting made on the first day. By keeping each pair of matched dates chronological (i.e., irrespective of year, such that a resighting can only be later in the season), we can see that on the last day (6 June), the only chance a whale might be seen again would be on the same day (difference = 0). Between the first and last dates, the average possibility of an "expected" difference in dates is plotted as a line in Figure 3. Among the resighting data, there were 20 values that fell above the expected line and 24 below. Using the null hypothesis that there were no differences between expected and observed date differences, a Wilcoxon distribution-free rank sum test (Hollander and Wolfe, 1973) shows we should accept the null hypothesis ($W = 0.371$; $P = 0.356$). Therefore, the distribution of resightings through the migration approaches a random expectation.

All of the resightings reported here occurred during the spring migrations from 1984 to 1994. The timing of most of these migrations was about the same, generally starting in the first week of April and continuing into the first or second week of June centered around 7 May (Table 2). However, the migration in 1985 was relatively late (Fig. 5). Koski *et al*. (2004) compared the chronology of migration of whales of various lengths between years (small whales come early in the season and adults with calves are the last to migrate) and suggested that the migration was delayed by >10 days in 1985. More comprehensive tests were later run on bowhead length distributions, and it became evident that 1985 was delayed 9 days (Zeh, pers. comm.)

Comparing dates among the six years (1985-86, 1989-92) with sufficient sample sizes ($n > 6$) of whales that have been seen in different years, there were significant differences in passage dates ($P = 0.003$; ANOVA), but when data from 1985 were removed, differences were no longer significant ($P = 0.384$; ANOVA). The mean date for photos of resighted whales in 1985 ($\bar{x} = 25$ May; SE = 2.2 days) was 11 days later than in 1986-92 ($\bar{x} = 14$ May; SE = 1.4 days).
In another test, using dates of all bowhead photographs in the study area, whether or not they were resighted, the mean date in 1985 ($\bar{x} = 21$ May; SE = 0.23) was 10 days later than the mean date in any other year (range 7 to 15 May; $\bar{x} = 11$ May; SE = 1.4). Therefore, the late dates of the reidentifications in 1985 can be explained by a generalized delay in the migration that year. Aerial photography of bowhead whales in the Point Barrow area has occurred as early as 15 April and as late as 7 June, covering much of the spring migration (Table 2). These dates spread across a 53-day period. However, most (85%) of the photographs have been taken between 22 April and 26 May, a range of 34 days. It is remarkable, then that some bowheads have been photographed as much as 31 days apart in different years. This wide mixing in dates is demonstrated in Fig. 1 (treated here as our null hypothesis with no significant difference from a random distribution). The alternate (failed) hypothesis is that bowhead whales do not significantly change travel dates between migrations, which would mean interyear resightings

would be only a few days apart. Instead, the wide mixing and near-random distribution of resighting dates of larger whales throughout the spring migration is indicative of a single stock of whales that have a somewhat plastic schedule[1].

ACKNOWLEDGMENTS

The National Marine Mammal Laboratory (NMML) and LGL Ltd. (LGL) have been the organizations that have led in the bowhead aerial photography projects. Many researchers have been involved at many different levels. We appreciate the dedication and help from co-principal investigators for field projects, including Mary Nerini (NMML), David Withrow (NMML), John Richardson (LGL) and Rolph Davis (LGL). Photographic assistance in different years was provided by Robyn Angliss, Laurie Briggs, Dan Cheng, Rich Ferrero, Camille Goebel, Merrill Gosho, Bryan Herczeg, Wayne Perryman, Kim Shelden, Kathleen Strickland and Larry Tsunoda of NMML and Gary Miller of LGL. Gary Miller has also conducted most of the interyear matchings of images. Lisa Baraff and Julie Mocklin did the categorization of thousands of images for quality and identifiability. Document reviews, insights and assistance were provided by Julie Mocklin (NMML), Rod Hobbs (NMML), Dinara Sadykova (University of Oslo) and Judy Zeh (University of Washington). The NMML operated under Permit Number 580, and LGL operated under Permit Numbers 517, 518, 670 and 481-1464, all issued under the provisions of the US Marine Mammal Protection Act and Endangered Species Act.

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[1] Smaller whales (<11m) might migrate past Barrow in a tighter timeframe than larger (>12m) whales, but we are limited by a small sample size (n = 3).

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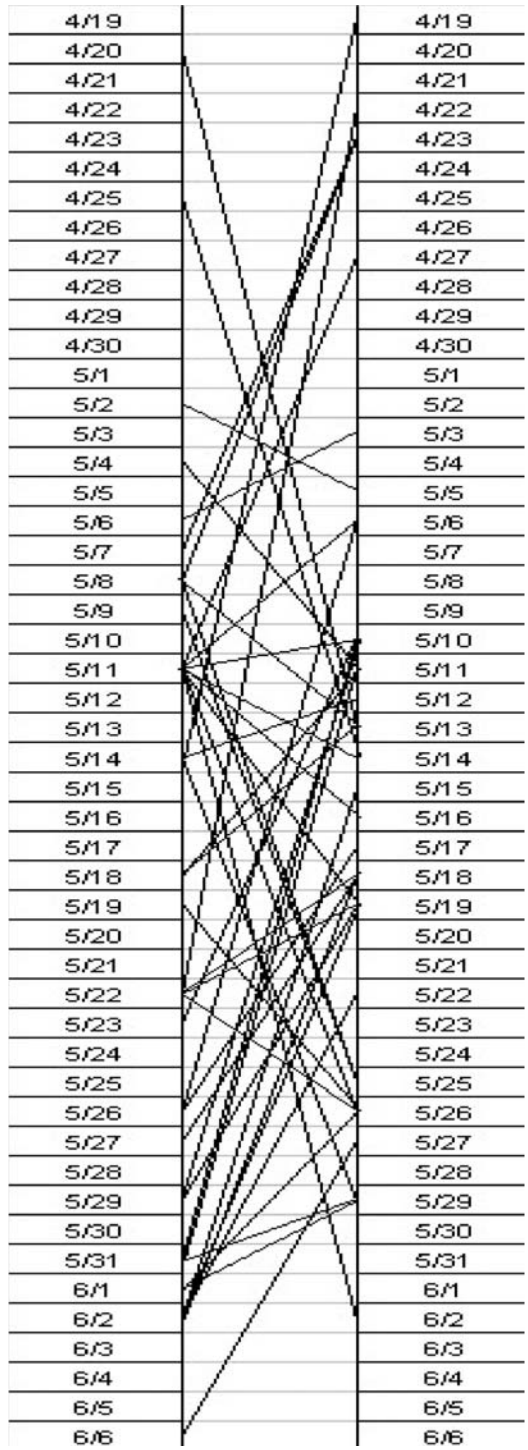
Table 1. Bowhead whales resighted during the spring migration past Pt Barrow, Alaska. Whale numbers are as defined in the database. Differences in dates (ΔT) are irrespective of year.

Whale no.	**Sighting 1**	**Sighting 2**	**ΔT**
84506491	5/8/1984	4/23/1992	15
1921	5/2/1985	5/5/1990	3
1937	5/11/1985	4/27/1992	14
3963	5/11/1986	5/14/1992	3
2024	5/14/1985	5/12/1986	2
2037	5/171985	5/29/1986	12
1058	5/18/1985	5/13/1986	5
2200	5/22/1985	5/26/1991	4
2217	5/23/1985	5/10/1991	13
2246	5/26/1985	5/6/1989	20
2247	5/26/1985	5/17/1989	9
2291	5/27/1985	5/18/1989	9
2312	5/29/1985	5/19/1990	10
2347	5/31/1985	5/11/1986	20
2371	6/1/1985	5/26/1992	6
2374	6/1/1985	*5/29/1986	3
2384	6/2/1985	5/15/1989	18
2392	6/2/1985	5/22/1986	11
2392	6/2/1985	‘5/18/1989	15
2403	6/2/1985	5/19/1986	14
2428	6/6/1985	5/27/1989	10
7946	5/6/1986	5/3/1989	3
4020	5/11/1986	5/6/1989	5
8002	5/11/1986	5/10/1991	1
8015	5/11/1986	*6/2/1990	22
8026	5/11/1986	5/16/1992	5
8033	5/11/1986	5/19/1990	8
8090	5/14/1986	4/19/1989	25
8622	5/19/1986	*5/26/1989	7
8135	5/22/1986	4/21/1989	31
8142	5/22/1986	5/19/1990	3
8250	5/4/1987	5/11/1990	7
1184	5/7/1987	4/23/1992	14
8288	5/8/1987	*5/25/1991	17
8312	5/18/1987	5/11/1990	7
8744	4/20/1989	5/13/1992	23
8824	4/25/1989	5/14/1992	19
9304	5/31/1989	5/29/1990	2
9304	5/31/1989	‘*5/10/1991	21
1880	5/8/1991	5/13/1992	5
10573	5/11/1991	5/26/1992	15
5149	5/9/1992	5/25/1994	16

*Accompanied by a calf.
‘Third sighting.

Figure 1. Differences in dates when individual bowhead whales were photographed migrating past Point Barrow, Alaska, through the spring migration. The lines connect the pair of dates for resightings of each whale.



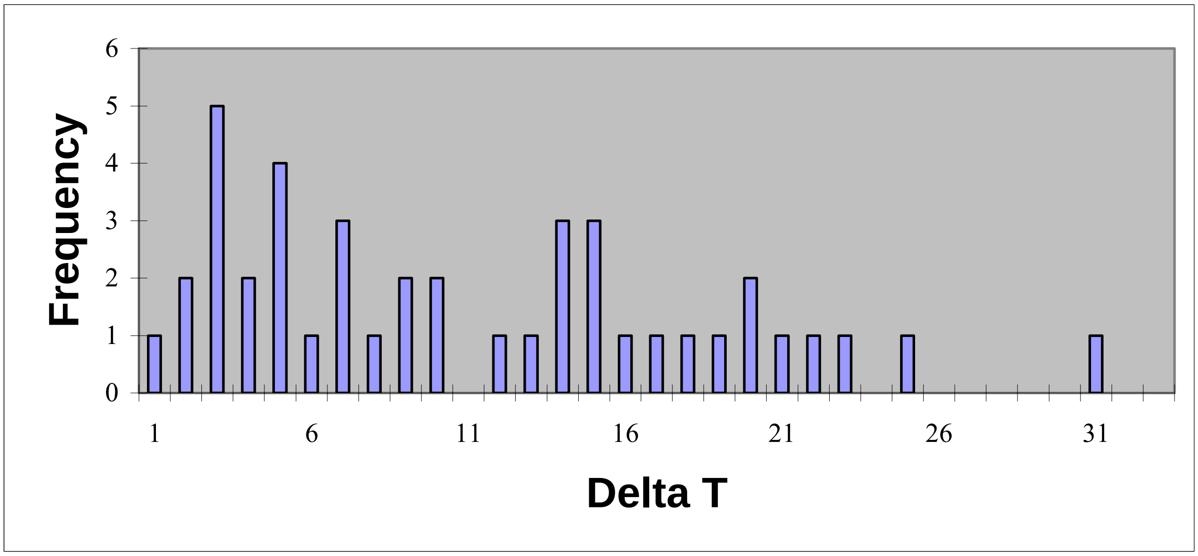


Fig 2. Histogram showing ΔT in days (absolute value) between a whale's initial sighting and its resighting in a subsequent year.

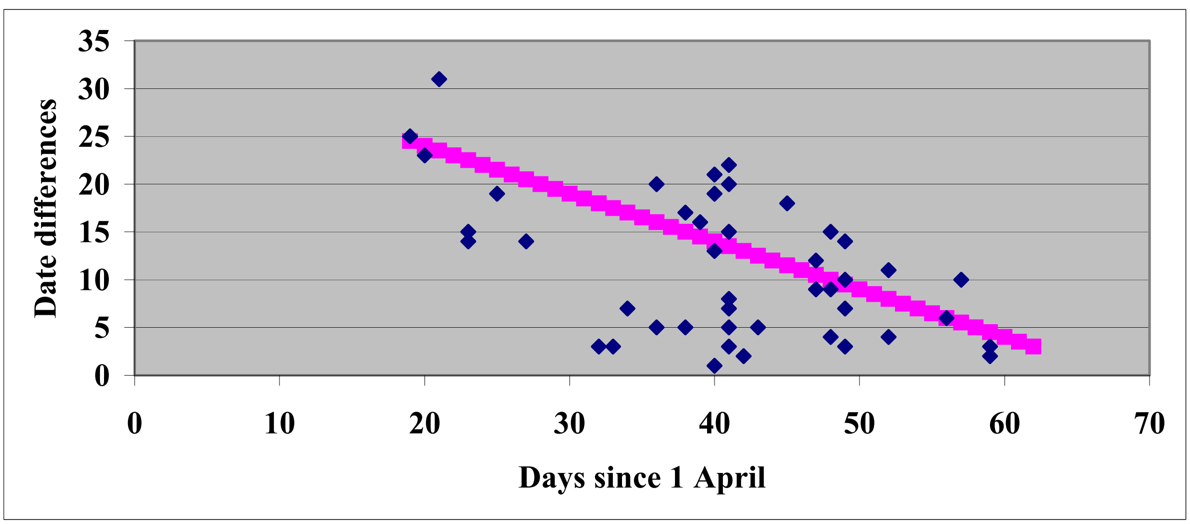


Figure 3. Days between sightings of bowhead whales photographed during more than one spring migration near Point Barrow. Alaska. The horizontal scale represents the date on which the first of two sightings occurred, and the vertical axis shows how many days there were between the sightings, irrespective of year. The line shows the halfway points between extreme options in resighting dates.

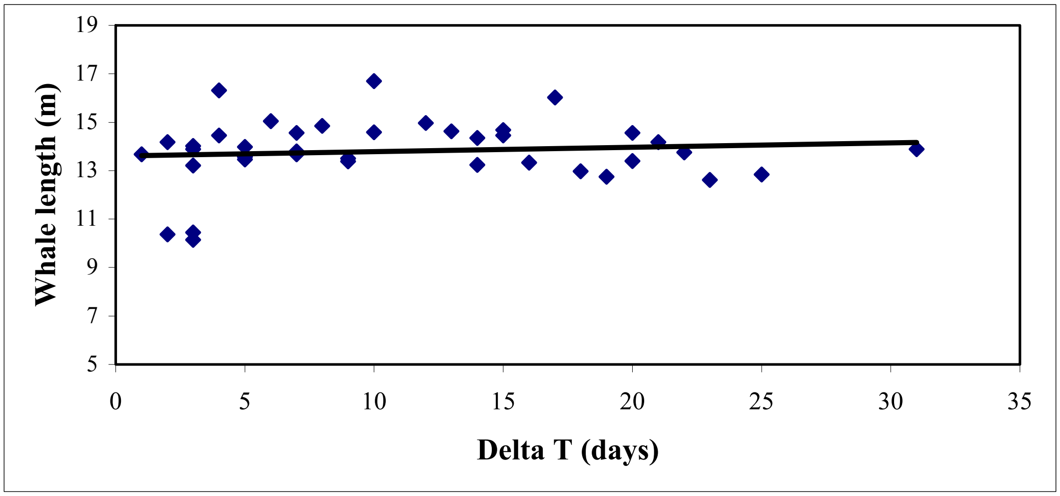


Figure 4. Plot of whale length by ΔT (absolute value of change in sighting date near Point Barrow). Smaller whales (<11m) appear to be less variable in their migration date (2-4 days) than mature whales (>12m), ranging 1-31 days.

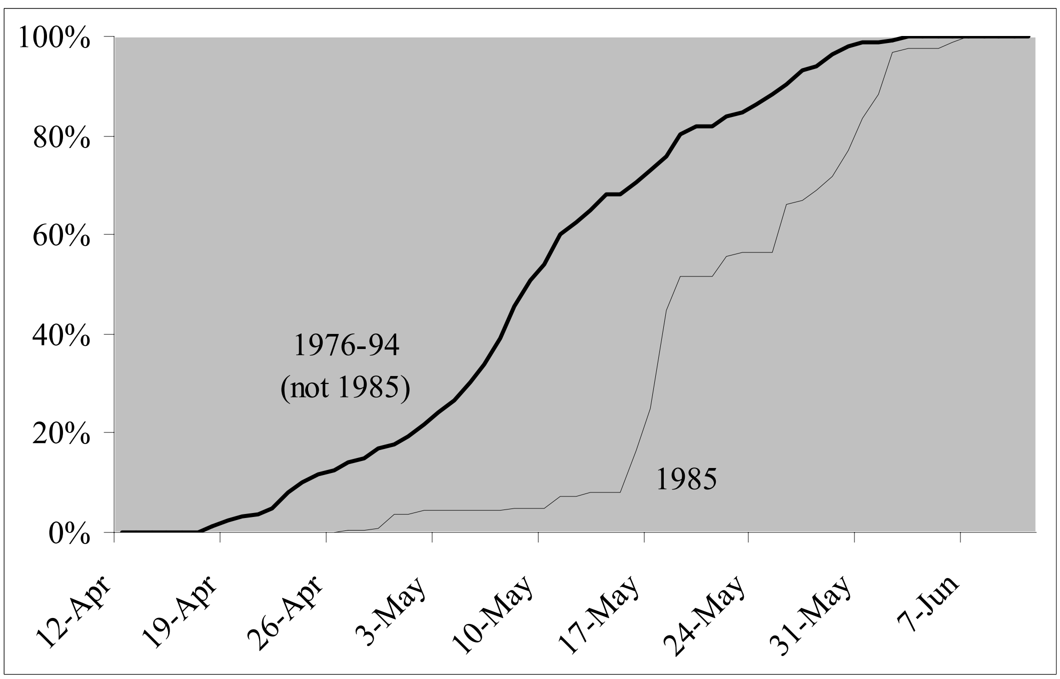


Fig. 5. Cumulative percentile frequencies of bowhead photographs by date showing that the sampled migration in 1985 was significantly later (9 days) than the average of other years.

Table 2. Proportions of whale sightings from the ice-based census and photographs of bowhead whales through the spring migration near Point Barrow, Alaska (Zeh, pers comm.).

	Proportions		
Date bins	Census	Photos	Difference
<24 Apr	0.056	0.078	0.02
24-30 Apr	0.165	0.065	-0.10
1-7 May	0.249	0.168	-0.08
8-14 May	0.301	0.267	-0.03
5-21 May	0.123	0.188	0.07
22-28 May	0.066	0.131	0.06
>28 May	0.040	0.104	0.06