FREQUENT HUMPBACK WHALE SONGS RECORDED IN GLACIER BAY, ALASKA IN FALL 2000 and 2001

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ABSTRACT

Humpback whale songs have rarely been recorded in Alaska waters. High-latitude humpback whale songs that occur outside the presumed winter mating season are interesting because song is thought to be a male mating-related display. Using a bottom-mounted hydrophone and computerized monitoring system in Glacier Bay, southeastern Alaska (58 °25' N, 135° 55' W) we recorded 25 hours of humpback whale song on 29 different days between August and November in both 2000 and 2001. We compared the best Alaska recordings with songs recorded off the whales' winter range in the Hawaiian islands in winter 2000 and 2001, and measured their degree of similiarity on a variety of acoustic parameters. Individual song units were extracted from the recordings, and computer program 'Acoustat' quantitatively measured 97 attributes of each unit's frequency, temporal and contour characteristics. The dimensionality of the measurements was reduced with a principal components analysis to determine which measurements accounted for the most song unit variance. The first 18 principal components, accounting for 80% of the variance of the original measurements, were classified with a discriminant analysis by year and region. We found significant differences between units by region and year, but also found that the model could correctly classify units into the proper region and year. Most song sessions were less than one hour long, although a few sessions of up to 270 minutes were observed. The absence of song prior to August suggests that song is quite rare in mid-summer, whereas song absence later than November probably resulted from whale movement out of the study area. We surmise that we recorded many more humpback whale songs than previous Alaska studies (*e.g.* McSweeney *et al.* 1989) because remote monitoring allowed us greater acoustic monitoring effort in the fall regardless of limited daylight and inclement weather. We speculate that the increase in song in late summer and fall may correspond with the beginning of seasonal hormonal activity in male humpbacks prior to the migration to the winter grounds.

INTRODUCTION

Humpback whale (*Megaptera novaeangliae*) song is thought to be a mating-related display that is performed by males on their tropical wintering grounds. This poster describes numerous observations of humpback whale song on the southeastern Alaska feeding grounds in late summer and autumn 2000 and 2001.

Previous studies in the North Atlantic and North Pacific have detected high-latitude humpback whale song during migration (Clapham and Mattila 1990, Abileah *et al.* 1996, Norris *et al.* 1999, Watkins *et al.* 2000, Charif *et al.* 2001). Song was also detected fairly often in the North Atlantic on the Stellwagen Bank feeding grounds in November and May (Mattila *et al.* 1987).

In southeastern Alaska, Baker *et al.* (1980) reported hearing singing from one or more whales in a group in late December 1979 and early January 1980. McSweeney *et al.* (1989) detected only 2 occurrences of humpback whale song in 5 summers of effort, and concluded that whale song in southeastern Alaska was a rare occurrence.

METHODS

Figure 2. ITC 8215A hydrophone mounted on a customized aluminum anchor, being installed in Glacier Bay.

Study Area: Humpback whales songs were recorded **during passive acoustic monitoring** to characterize ambient noise in Glacier Bay National Park (58 ° 25' N, 135° 55' W) , a glacial fjord system in southeastern Alaska (Fig. 1). The seafloor in the area is remnant of a glacial moraine which is flat at **depths of 40-60 meters**.

50-100 humpback whales inhabit the study area between June - August, and much smaller numbers of whales in September - May. 347 different humpbacks have been individually identified in the area, including at least 36 known mature males.

Dates of Acoustic Monitoring: **May 20, 2000 - March 8, 2001 and July 13, 2001 to November 24, 2001.** Equipment problems prevented monitoring March - June 2001, so we missed the chance to detect singing as whales arrived in the area. The acoustic monitoring system automatically collected hourly samples, but recordings of whale vocalizations could only be made if a person was there to listen and make a recording. Acoustic monitoring effort was variable during the summer, but occurred approximately **30-40 hours per week** in September through March.

Acoustic Monitoring System: We monitored underwater sound (**0 to 40 kHz**) using a bottom-mounted (**depth = 52m**), **calibrated ITC 8215A hydrophone** and preamplifier near the mouth of Glacier Bay (Figure 1, 2). A submersible **9.1 km cable** connects the hydrophone to a custom built computer control unit that provides DC power to the hydrophone and is the electrical interface between the hydrophone, the computer and the DAT recorder. The computer is equipped with a **National Instruments 4451** Digital Signal Analyzer FFT board to amplify and convert hydrophone signals to digital samples, displayed as a spectrogram on the computer screen.

Alaska Song Recordings: We recorded humpback whale vocalizations opportunistically with a Sony TCD-D1- Pro II Digital Audio Tape recorder/player (**48 kHz sampling rate**) or directly onto the computer hard disk (**80 kHz sampling rate**). Recordings were digitized (DAT only) and archived onto CD for later analysis.

Hawaii Song Recordings: The winter 2000 humpback whale song sample was recorded and **generously donated for this study** by Dolphin Discoveries, a commerical ecotourism company in Kona, Hawaii. The 2001 humpback whale song was opportunistically recorded aboard a Dolphin Discoveries charter on February 14, 2001.

Data Analysis: Most previous studies have used song phrase- or theme-level analysis, but more recent studies have examined **song units** showing regional and inter-individual differences (Frankel, submitted). We extracted song units from digitized recordings, using customized energy detectors written in Matlab. **A song unit is defined as** the shortest unit of continuous sound discernable by human ear, which are arranged into **phrases** containing a series of units (Payne and McVay 1971). We used the computer program 'Acoustat' (Fristrup and Watkins 1993) to make **97 measurements of each unit's frequency, temporal and contour characteristics**. We used a SAS principal components analysis to reduce the dimensionality of the measurements, determining how many principal components accounted for 80% of song unit variance. A SAS discriminant analysis classified the resulting 18 principal components by year and region.

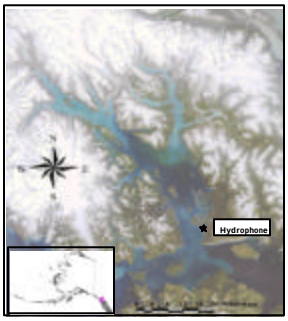


Figure 1. Hydrophone location in Glacier Bay, Alaska

Table 1. Statistics on Song Occurrences in Glacier Bay

Year	# Days Song Observed	# Hours of Song Observed	Date of First Song	Date of Last Song	Mean session length in minutes (std dev)	Maximal session length in minutes
2000	18	21.9	29-Aug	16-Nov	73.1 (62.7)	270
2001	11	2.8	23-Aug	9-Nov	15.7 (13.1)	48

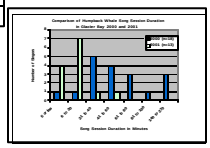


Figure 3. Humpback whale song session durations were shorter in 2001 than 2000.

RESULTS

Humpback whales frequently sing while they are in the Glacier Bay area in August – November (Table 1). We heard **no song earlier than August** despite the presence of whales. We heard **no song later than November**, probably due to the absence of whales. The songs we heard were **solos**, not the chorusing that is typical in wintering grounds. We rarely heard other whale vocalizations in the background, although feeding whales can be quite vocal.

Song sessions were considerably shorter than reported in the Hawaii wintering grounds (Frankel 1994), where whales commonly sing continuously for hours. The longest song session observed during this study was 4.5 hours, on November 8, 2000 when a single whale sang almost continuously from 12:17-18:43, but most sessions were much shorter (Table 1). **Song sessions were quite variable in length** and were significantly longer in 2000 than in 2001, (Mann-Whitney U =23.5, p = 0.0002, Figure 3). Song sessions were sometimes (n=8) **preceded by or ended with episodes of unstructured vocalizations.**

The apparent decrease in singing in 2001 (Table 1) was probably due to lack of whales in the area, based on population monitoring in lower Glacier Bay during the summer and fall. Singers recorded in 2001 also tended to be farther away from the hydrophone than singers in 2000, based on the apparent loudness and quality of the recordings.

Song units from Hawaii and Alaska 2000 and 2001 songs were distinct from one another as shown by the discriminant analysis Mahalanobis Distances between songs from each year and area (Table 2). The similarity between the highest sample size areas of Alaska 2000 & 2001 (Table 3) argues against individual differences accounting for all the variance shown.

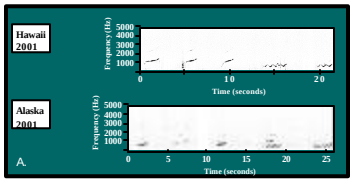
Song units from Hawaii 2001 and Alaska 2000 & 2001 were similar to one another as shown by the number of times that song units from one area and year were misclassified as being from a different area or year (Table 3). Posterior probabilities of misclassifications show that Alaska 2000 and 2001 were the most frequently mistaken for one another. Hawaii 2000 song units were so distinct from the other areas and years that they were rarely misclassified. Small sample sizes of Hawaii song (n=1 recording for each year) prevent definitive conclusions on which areas and years were most similar to eachother.

	Alaska-2000	Alaska-2001	Hawaii-2000	Hawaii-2001
Alaska-2000	0	1.6 (0.021)	20.6 (0.0001)	2.3 (0.047)
Alaska-2001	1.6 (0.021)	0	21.8 (<0.0001)	3.5 (0.0748)
Hawaii-2000	20.6 (0.0001)	21.8 (<0.0001)	0	22.4 (<0.0001)
Hawaii-2001	2.3 (0.047)	3.5 (0.0748)	22.4 (<0.0001)	0

Table 2. Song unit distinctiveness by region and year shown by discriminant analysis Mahalanobis Distances (and their probabilities). All region-year combinations were statistically significant except Alaska 2001 vs. Hawaii 2001, probably due to small Hawaii sample size.

FROM \ TO-->	Alaska-2000	Alaska-2001	Hawaii-2000	Hawaii-2001
Alaska-2000	605 (60.87)	238 (23.94)	0 (0)	151 (15.19)
Alaska-2001	7 (33.33)	14 (66.67)	0 (0)	0 (0)
Hawaii-2000	9 (9.00)	3 (3.00)	86 (86.00)	2 (2.00)
Hawaii-2001	4 (30.77)	2 (15.38)	1 (7.69)	6 (46.15)

Table 3. Song unit similarity by region and year shown by principal components classification of song units. Cells contain the number (and %) of observations classified from each region-year (rows) to all other region-years (columns). Misclassifications of song units from one region-year into a different region-year indicate similarity. Song units for a given region-year were correctly classified 46-86% of the time. Hawaii 2000 song units were rarely misclassified.



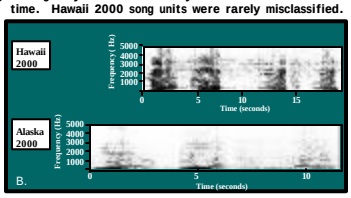


Figure 4A & 4B. Similarity of phrases from Alaska and Hawaii 2000 and 2001 humpback whale songs.

DISCUSSION

COMPARISON WITH OTHER STUDIES OF HIGH-LATITUDE SONG

The humpback whale songs we recorded in Glacier Bay occurred **earlier** and were **much more prevalent** than songs previously documented in any feeding area. We found that humpback whales appear to sing quite commonly in late summer and fall in the study area, corroborating findings from Stellwagen Bank (Mattila *et al.* 1987). However, it is not clear why the song in southeastern Alaska began in late August while the Stellwagen Bank song was not observed until November, since humpbacks are present in both areas throughout that time period. Details of acoustic monitoring effort in the Stellwagen Bank study may reveal the source of this difference.

Humpback whale **song in mid-summer appears to be rare or non-existent** although other vocalizations are heard. Although acoustic monitoring effort was lower in the summer, we do not believe this accounts for the lack of songs in May through late August. In contrast, **humpbacks probably continue to sing after November** after leaving the study area, resulting in the songs heard during migration by other investigators monitoring vocalizations in the open ocean (Clapham and Mattila 1990, Abileah *et al.* 1996, Norris *et al.* 1999, Watkins *et al.* 2000, Charif *et al.* 2001).

We predict that with moderate acoustic monitoring effort, **song recordings could be made in any area where humpback whales congregate in the autumn.** It appears that (presumably male) humpbacks sing sporadically in between feeding bouts in the autumn. Since we have no visual observations of the singers we recorded, we can say very little about their behavior or the presence, proximity or identity of other whales in the vicinity.

Two aspects of our methods likely account for differences from previous work in southeastern Alaska by McSweeney *et al.* (1989). First, we suspect that these investigators did not continue monitoring in September and October, although the dates of their acoustic monitoring effort were not specified. Secondly, our study used passive acoustic monitoring of a remote hydrophone, which allowed us a much greater acoustic monitoring effort and gave us much greater flexibility with regard to weather, sea conditions and daylight.

WHY DO HUMPBACKS SING IN THE FEEDING GROUNDS?

We speculate that the increase in song in late summer and fall **corresponds with the beginning of seasonal hormonal activity in male humpbacks** prior to the migration to the winter grounds. Studies of the reproductive tracts of male humpbacks revealed that testis weights in the wintering areas are much greater than in the feeding areas (Chittleborough 1955, Nishiwaki 1959). Behavioral indications of increased male hormonal activity in the autumn are probably often subtle, but overt observations have included singing and agonistic behavior between whales in Sitka Sound in December and January (J. Straley pers. comm.) and a known mature male apparently pursuing a known mature female in Glacier Bay in September (J. Doherty pers. comm.).

We do not know whether autumn humpback whale songs or other behaviors directly result in reproductive success. The prevalence of humpback whale song in Alaska **may also indicate that the full range of mating behavior occurs in the autumn and winter in high-latitude waters**. It has been suggested that overwintering of females in high latitudes may account for sighting biases against females in the winter grounds (Brown *et al.* 1995, Craig and Herman 1997), but this hypothesis is not consistent with the mixed age-sex classes of overwintering humpbacks in southeastern Alaska (Straley 1999). The occurrence in southeastern Alaska of humpback whale singing and other behavior typical of the mating season may indicate that even when mature males and females forgo migration they may not be sacrificing the opportunity to mate.

ACKNOWLEDGMENTS

The Glacier Bay National Park underwater acoustic monitoring program is conducted in cooperation with the U.S. Navy Naval Surface Warfare Center in Bremerton, Washington. Funding for this project came from the National Park Service Fee Demonstration Program.
We gratefully acknowledge the expertise of Blair Kipple (NSWC) and Russ Dukek (Mantech Inc.) for system design and for their creativity and good humor during those bleak times when cable repair seemed impossible. Numerous staff at Glacier Bay National Park helped with the installation and maintenance of the system, proving that it takes a village to maintain a hydrophone. Hawaii humpback whale songs were made available by the generosity of Claudia Merrill, of Dolphin Discoveries in Kona, Hawaii. Composite satellite photograph and bathymetric image of Glacier Bay courtesy of USGS-BRD Glacier Bay Field Station.

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