Surprising Humpback Whale Songs in Glacier Bay National Park

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Humpback whales migrate from Alaska to Hawaii for their winter mating and calving season. Humpback whale song is typically associated with the mating season, but research at Glacier Bay has revealed that whales frequently sing in Alaska in the fall.

Left: In the past decade, there has been growing concern about disturbance and other effects of man-made noise on marine mammals. Aerial behaviors like this head-slap are used as a social signal among whales, but can also indicate disturbance.

National Park Service photograph

Exciting research in Glacier Bay National Park is leading researchers to reevaluate previous concepts about humpback whale singing. Prior to the present research, humpback whales were thought to sing rarely in their summer feeding areas, and songs were predominantly associated with the winter mating season. With the installation of an underwater acoustic monitoring system in May 2000, researchers have found that humpback whales sing frequently in Alaskan waters, in late summer and early fall. The acoustic monitoring system, intended primarily to record ambient noise and vessel traffic, has provided many hours of humpback and killer whale vocalizations relevant to a variety of research interests. By describing Alaska whale songs and comparing them with recordings made in Hawaii, advances will hopefully be made in current knowledge about the functions of the songs and the humpback whale mating system.

Natural History of Humpback Whales

Humpback whales *(Megaptera novaeangliae)* are migratory baleen whales that spend summers in high latitude feeding grounds and in the winter migrate to tropical mating and calving grounds. For southeastern Alaska humpbacks, the winter migration entails a 2,500-mile swim to the Hawaiian Islands, the largest of three main wintering areas in the North Pacific. The other wintering areas in the North Pacific are near the Baja Peninsula in Mexico and near Japan and the Philippines. The greatest numbers of humpbacks occur in Hawaiian waters from January to April each year, although some whales can be found as early as November and as late as June. In the mid-twentieth century, biologists employed by commercial whalers examined thousands of carcasses, discovering that humpbacks do not feed in their winter grounds, and that both male and female reproductive organs are inactive in the summer *(Chittleborough 1955, 1958, Nishiwaki 1959)*.

Why Whales Sing in the Mating Season

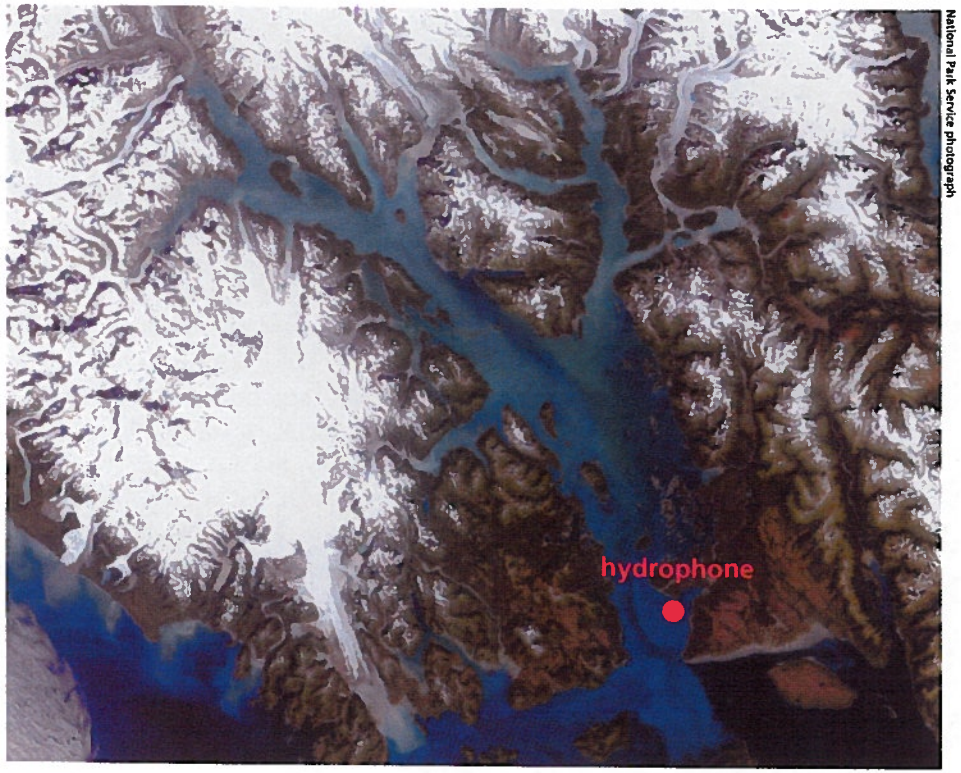
Humpback whale song is among the longest and most complex vocalizations made by any animal. Essentially, a song is a series of sounds made in a predictable order. In the case of humpback whales, the song is typically about 15 minutes long, punctuated when the whale surfaces to breathe. It is thought to be a mating-related display because it primarily occurs during the winter and is performed only by males. All males in a breeding ground sing essentially the same song, but singers make improvisations that others adopt, resulting in progressive change in the song. Despite much research in the years since songs were first scientifically described *(Payne and McVay 1971)*, the functions of the songs remain unclear. Male humpbacks may sing as a sexual advertisement to females, for male-male coordination, or as maintenance of space between competing males.

Based on the sex ratio of calves *(Glockner 1983)*, we assume that there is nearly a 1 to 1 ratio of adult males to females in the population. Male-male competition is a key feature of the humpback whale mating system because most females give birth every other year, causing the ratio of available males to females to be at least 2 to 1. Many researchers believe that song may be a form of acoustic competition, analogous to the vigorous and sometimes injurious physical competition among

males for females. Although scientists do not fully understand song function, its importance in humpback whale social life is clear, given that an individual male will sing for hours, and a chorus of whale song can be heard all day and night during the winter in Hawaii.

Processing and Recording Alaska Songs

The humpback whale songs reported here were recorded during acoustic monitoring to characterize ambient noise in Glacier Bay National Park, a steep-walled glacial fjord system in southeastern Alaska. The seafloor in the area is the remnant of a glacial moraine, which is flat and sporadically rocky at a depth of 40-60 meters. Glacier Bay and the surrounding area is inhabited by 50 to 100 humpback whales between June and August, and a much smaller number of whales from September through May *(Gabriele et al. 1999)*. Since 1985, approximately 355 different humpbacks have been individually identified in the area, including at least 36 known adult males. Although the Park has a long-term population monitoring program that focuses on individually identified whales, we monitored songs remotely. Therefore, no opportunities to determine the identity of individual singers existed nor if different song episodes were made by the same whale.



National Park Service photograph

Satellite photograph of Glacier Bay, showing the location of the hydrophone. Population monitoring shows that Glacier Bay hosts 40-60 humpback whales in the summer, and smaller numbers in the fall.

Alaska Recordings: We listened to and made digital recordings of underwater sound using an anchored hydrophone and computerized monitoring system near the mouth of Glacier Bay. A submerged cable, five miles long, connects the hydrophone to a custom built computer and Digital Audio Tape (DAT) recorder at Park Headquarters. Using this system we recorded humpback whale vocalizations directly onto the computer hard disk (80 kHz sampling rate) or onto the DAT recorder (48 kHz sampling rate). All of the recordings were archived onto compact disks for future use and analysis.

From May 20, 2000 - March 8, 2001 and July 13, 2001 - June 20, 2002, the acoustic monitoring system was automated to make 30-second ambient noise recordings on a set schedule. Longer recordings of whale songs could only be made if a person was present to detect the song and make a recording. The monitoring was variable during the summer months since staff were in the field several days per week. From September through mid-January, monitoring occurred approximately 30-40 hours per week. No acoustic monitoring was possible between March and late June 2001, due to equipment problems. However, monitoring between March and mid-June 2002 detected no whale song as the animals moved into the area, suggesting the same was probably true in 2001.

Comparison to Hawaii Recordings: We chose the highest quality Alaska recordings to compare with songs recorded of whales in the Hawaiian islands in winter 2000 and 2001, and measured their degree of similarity on a variety of acoustic parameters. We extracted individual song units (notes) from the digitized recordings using customized detectors written in Matlab computer software. We used the computer program Acoustat *(Fristrup and Watkins 1993)* to quantitatively make 97 measurements of each unit's frequency, temporal and contour characteristics.

Description of Song Recordings

We discovered that humpback whales frequently sing while they are in the Glacier Bay area from August through November *(Table 1)*; however we heard no songs earlier than August, despite the presence of whales. After November, no songs were heard in the Park, probably due to the absence of whales. Humpbacks do sing after November in other areas, resulting in the songs heard during migration by investigators monitoring vocalizations in the open ocean *(Clapham and Mattila 1990, Abileah et al. 1996, Norris et al. 1999, Watkins*

The songs recorded in the Park were solos, not the multiple-whale chorus that is typical in wintering grounds. Non-song whale vocalizations in the background were rarely heard, although feeding whales can be quite vocal.

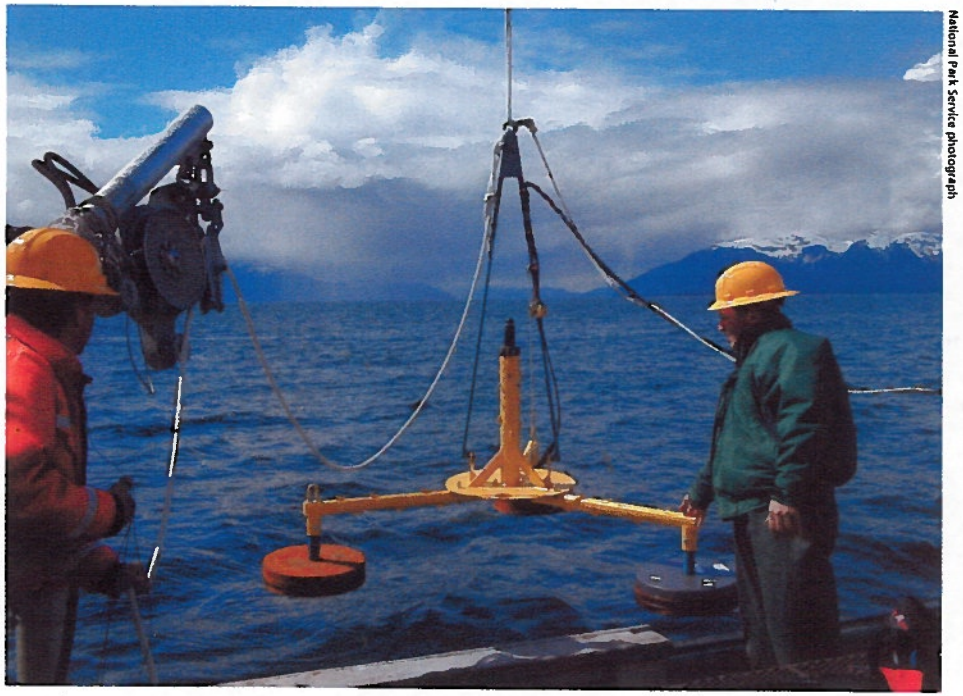
et al. 2000, Charif et al. 2001). Acoustic monitoring continued through mid-January in both 2001 and 2002, but no additional whale songs were heard. During the spring of 2002, as whales began to migrate back in the area, no songs were heard.

The songs recorded in the Park were solos, not the multiple-whale chorus that is typical in wintering grounds. Non-song whale vocalizations in the background were rarely heard, although feeding whales can be quite vocal. Song sessions were sometimes preceded by or ended with episodes of unstructured vocalizations. Song sessions were considerably shorter than reported in the Hawaii wintering grounds, where whales often sing continuously for hours. The longest song session observed during this study was 4.5 hours, on November 8, 2000, but most sessions were much shorter *(Table 1).* The sessions were quite variable in length and were significantly longer in 2000 than in 2001. Based on the apparent loudness and quality of the recordings, singers recorded in 2001 also tended to be farther away from the hydrophone than singers in 2000. The apparent decrease in singing in 2001 and the whales increased distance from the hydrophone were probably due to lack of whales in the area, which is known based on population monitoring during the summer and fall *(Doherty and Gabriele 2001).*

Differences from Previous Studies

Prior to this study, humpback whale songs had rarely been recorded in Alaska waters. In southeastern Alaska, Baker et al. (1985) reported hearing singing from a group of whales in late December 1979 and early January 1980. McSweeney et al. (1989) detected only two occurrences of humpback whale song in five summers of effort (August 25, 1979 and September 3, 1981), and concluded that whale song in southeastern Alaska was a rare occurrence. Two factors may account for the difference from our results. First, although the dates of their acoustic monitoring were not specified, we suspect that these investigators did not monitor in September and October. Secondly, our study used a remote hydrophone, which allowed us a much greater flexibility with regard to weather, sea conditions and daylight than would be feasible with vessel-based monitoring.

The humpback whale songs we recorded in Glacier Bay occurred earlier and were more prevalent than songs previously documented in any feeding area. Humpback whales sang quite commonly in late summer and fall in Glacier Bay, corroborating findings from Stellwagen Bank, a feeding area off Cape Cod in the North Atlantic, where whale songs were recorded in November and May *(Mattila et al. 1987).* However, it is unclear why whale song in southeastern Alaska began in late August while those in Stellwagen Bank were 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.



National Park Service photograph

Installing the hydrophone, mounted on its customized aluminum anchor, near the mouth of Glacier Bay. The hydrophone anchor sits on the sea floor at 30 meters deep and is connected by a five-mile cable to a listening station at Park headquarters.

Singing in Feeding Grounds

It appears that (presumably male) humpbacks sing sporadically in between feeding bouts in the autumn. Since there were no visual observations of the singers recorded, very little can be said about their behavior or the presence, proximity, or identity of other whales in the vicinity. In mid-summer, humpback whale song

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

Table 1. Statistics on song occurrences in Glacier Bay 2000 and 2001

National Park Service photograph

appears to be rare or non-existent although other vocalizations are heard. Although the monitoring effort was less in the summer, this does not account for the lack of songs in May through late August.

With a sufficient acoustic monitoring effort we believe that song recordings could be made in any area where humpback whales congregate in the autumn. 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 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. Overt observations, however, have included singing and aggressive behavior between whales in Sitka Sound *(J. Straley pers. comm.)* and a known mature male apparently pursuing a known mature female in Glacier Bay *(J. Doherty pers. comm.)*.

The prevalence of humpback whale song in Alaska may indicate that the full range of mating behavior can occur in the autumn and winter in northern waters. Some humpback whales of mixed ages and sexes have been observed wintering in southeastern Alaska *(Straley 1999)*. We do not know whether autumn whale songs or other behaviors directly result in reproductive success. The occurrence of humpback whale singing and other behavior typical of the mating season may indicate that even when males and females forgo migration, they may not be sacrificing the opportunity to mate. Even in light of new discoveries, it seems likely that humpback whale song will retain its mysteries for years to come.

Implications for Human Impacts on Whale Habitat

In the past several years, there has been growing concern about the effects of man-made noise on marine mammals *(National Research Council 1994, 2000)*. The underwater acoustic monitoring program that made these discoveries possible originated from concerns that vessel-generated noise could harm endangered humpback whales in Glacier Bay. These whales could be considered 'auditory specialists', because acute hearing appears essential to their ability to navigate, socialize, detect predators, find food and find mates. The whales rely on sounds, which can travel for miles, since vision is limited by underwater visibility. This visibility may be several body lengths or less, especially in the plankton-rich feeding habitats.

Man-made noises added to typical ocean noise can make it more difficult for whales to hear vocalizations, may interfere with listening for predators or prey, and may cause changes in vocal behavior. Studies have shown increases in humpback whale song tempo and length in the presence of vessel noise and other man-made sources *(Norris 1995, Miller et al. 2000)*. Now that it is known humpbacks sing in Glacier Bay, we must consider the potential effects of vessel noise on singers and listeners. Most readers have probably not considered underwater noise pollution as an important form of habitat degradation for marine species. As natural soundscape issues gain attention in National Parks across the country, we hope that attention to preservation of natural sound environments in underwater habitats will result as well.

To hear recordings of humpback whale sounds recorded during this study, visit the Park's website at:
http://www.nps.gov/glba/learn/preserve/projects/acoustics/index.htm.

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