

The Song of the Southeast Pacific Humpback Whale (*Megaptera novaeangliae*) off Las Perlas Archipelago, Panama: Preliminary Characterization

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Abstract

Humpback whales (*Megaptera novaeangliae*) aggregate in winter breeding and calving grounds in tropical waters. Acoustic features of song produced by males in breeding wintering areas remain unknown for many breeding sites such as those located in Central America. In other areas, recordings of humpback whale songs in wintering grounds have been used to establish geographical differences among populations. Previous investigations have revealed that geographically isolated populations produce distinctive songs. This study represents the first efforts to record and analyze songs from the Southeastern Pacific stock of *M. novaeangliae* in the tropical wintering grounds off Central America. The aim of this study was to characterize underwater sounds of whales recorded in Las Perlas Archipelago, Panama. The acoustical structure of the themes for years 2006 and 2007 was typical of songs recorded in other wintering areas. As a result of this analysis, Las Perlas Archipelago should be identified as a critical area for breeding humpback whales.

Key Words: songs, Southeast Pacific stock, Panama, humpback whale, *Megaptera novaeangliae*

Introduction

Humpback whales (*Megaptera novaeangliae*) aggregate in winter breeding and calving grounds along continental margins, coastal islands, or archipelagos located in tropical waters. Migration to these breeding sites requires a long journey from northern feeding areas in temperate and circumpolar latitudes. The humpback whale's habitat preference is generally restricted to coastal areas, and their tendency to concentrate in specific

locations to reproduce exposes them to anthropogenic threats such as fishing, coastal development, water pollution, and marine traffic.

For sustainable management of the humpback whale population in the Southeastern Pacific region, it is necessary to unravel the still unknown aspects of its biology, natural history, and conservation status (Flórez-González et al., 2007). Acoustic features of the song produced by humpback whale males in breeding wintering areas remain unknown for many breeding sites such as those located in Central America.

Male humpback whales emit a long series of sounds, or a song. These sound sequences are organized in a predictable structure composed of a hierarchy of components, ranging from individual sounds (units) through phrases and themes; they are repeated several times in the course of a song session (Payne & McVay, 1971). All singers in an area will sing the same song at any point in time, but the song changes progressively between breeding seasons (Payne & Payne, 1985).

Underwater recordings of humpback whale songs in wintering grounds have been used to establish geographical differences among populations. Previous investigations revealed that geographically isolated populations produce distinctive songs. Humpback whales from different ocean basins sing very different songs, whereas whales of the same ocean basin sing similar songs, even though they may be separated by a considerable distance (Winn et al., 1981; Helweg et al., 1998). Of the songs studied in the Southern Hemisphere, the majority have been collected from wintering areas in the Southwestern Pacific ocean basin (Cato, 1991; Mednis, 1991; Helweg et al., 1998).

To our knowledge, the study reported herein represents the first efforts to record and analyze songs from the Southeastern Pacific stock of

M. novaeangliae in the tropical wintering grounds off Central America. The aim of this study was to characterize sound elements of humpback whales recorded in Las Perlas Archipelago, Panama, between the years 2006 and 2007.

Materials and Methods

Study Area

Las Perlas Archipelago (N 08° 20'00" W 079° 00'00") is a group of islands located off the Gulf of Panama. The shallow waters of the archipelago provide an important breeding ground for Southeastern Pacific humpback whales. The location of this wintering site just off the area of influence of the Panama Canal subjects whales in this site to increases in boat traffic. Furthermore, the islands themselves are a prime tourist destination and a key site for real estate investment; thus, they are a target for coastal development.

Song Recording and Analysis

When whales were first encountered, protocols for individual photo-identification were undertaken. If a solo animal (or a group of whales) was observed, the hydrophone was lowered to evaluate whether the whale was singing. If singing was heard, an inflatable hard-bottom boat was positioned approximately 100 to 300 m away from the putative singer, and underwater recording of the song was initiated. Recordings were made using a combination of tape recorder (Sony TCD D-5 digital tape recorder) and hydrophone (NSF-PW, SCH40), all with a frequency response within ± 5 dB (12.0 Hz to 35.0 kHz). Locations of singers were equated with the location of the recording vessel, and GPS readings were registered at each whale sighting. A total of 18 samples were recorded from September of 2004, 2006, and 2007; data included songs from solitary and multiple singers recorded during the breeding season.

Four recordings (two in 2006 and two in 2007, totaling two hours of songs) were of sufficient quality and duration for analysis according to the criteria used by Mercado et al. (2003) and Green et al. (2007)—that is (1) these songs contained recognizable patterns, and (2) they were structurally comparable to humpback whale songs described in many prior reports. A third recording from 2006 and three more from 2007 (all from 9 September) were incomplete, but some important structures were clearly identifiable and helped with the perceptual analysis. The other samples were characterized by marginal signal-to-noise (S/N) conditions that rendered them unsuitable for acoustical analysis. However, the theme sequences remained identifiable by aural monitoring. Spectrograms produced through *Cool Edit Pro*, Version 2.1,

software were obtained from the selected best samples to differentiate between themes, phrases, and units as elements and sub-elements of each humpback whale sound. Parameters such as duration of units and maximum and minimum frequency were accounted. Due to small sample size, inter-individual and inter-annual variations of whale sounds in this particular wintering ground could not be established.

Results

2006 Song Structure

Table 1 summarizes the basic features of the songs analyzed in 2006 such as duration of units and minimum and maximum frequencies. Each unit in a song was designated as a letter between A and L. The song session recorded on 5 September consists of three song cycles, whereas the one recorded on 10 September has one entire cycle plus two incomplete cycles. Songs consist mostly of six phrases (Figure 1) arranged into an average of four themes (five in the case of 10 September) that account for a total of 1,130 units. Within phrases, the rate of repetition of units was highly variable. For instance, the phrases CDEF evidenced changes in sequencing and repetition between subsequent themes.

Amplitude-modulated (AM) calls constituted a major proportion of all song cycles. However, the quantity of frequency-modulated (FM) calls, specifically units F and G, seemed to have increased within the 5-d interval between the recordings of singers one and two.

2007 Song Structure

The units identified within the song sessions from 2007 were labeled with numbers instead of letters. However, the same letter nomenclature was used for units that were aurally similar to those identified in the 2006 season (C and D, respectively). Units with a variable aural pattern were tagged by symbols, letters, or a combination of numbers and symbols. The 2007 sample comprised two song sessions with two song cycles from two different singers on the same date: 589 units were identified constituting 32 phrases arranged in eight themes (Table 2). Since both song sessions were recorded on 9 September, we have no way to evaluate the temporal progression of the recordings corresponding to 2007.

Discussion

The acoustical structure of the themes for both years was comparatively typical of songs recorded in other wintering areas (Cato, 1991; Mednis, 1991; Helweg et al., 1998; Razafindrakoto et al.,

Table 1. Acoustical features of the song sessions from 2006; FG* is a transitional FM unit.

Unit type	Maximum frequency (Hz)	Minimum frequency (Hz)	Duration (s)	<i>n</i>	%
A	2,545.7 (±35.8)	275.6 (±21.9)	1.79 (±0.07)	107	9.47
B	2,879.6 (±522.4)	575.7 (±278.9)	1.05 (±0.58)	107	9.47
C	2,212.0 (±329.6)	129.2 (±0.2)	5.50 (±0.55)	68	6.02
D	2,217.4 (±353.6)	129.2 (±0.1)	0.79 (±0.18)	77	6.81
E	1,845.8 (±326.1)	129.1 (±0.1)	1.66 (±0.11)	275	24.34
F	2,399.7 (±141.6)	419.8 (±59.8)	1.52 (±0.46)	144	12.74
G	2,615.7 (±355.7)	401.6 (±181.1)	1.43 (±0.25)	94	8.32
H	2,233.1 (±80.1)	156.0 (±22.3)	0.60 (±0.05)	58	5.13
I	2,111.0 (±275.2)	129.2 (±0.3)	4.77 (±0.60)	7	0.62
J	1,673.6 (±42.6)	128.8 (±0.7)	4.12 (±0.41)	96	8.50
K	1,151.7 (±221.5)	129.2 (±0.3)	1.33 (±0.30)	25	2.21
L	1,647.7 (±143.1)	128.9 (±0.7)	2.88 (±0.22)	57	5.04
FG*	2,615.7 (±355.7)	401.6 (±181.1)	1.43 (±0.25)	15	1.33

Song sessions: 2

Song cycles: 4

Themes: 8

Phrases: ABC, CDEF, DDEG, DEHH, IJK, JL

2001). The diversity of the composition of humpback whale units within a song produced at Las Perlas Archipelago was 13 to 15 unit types in a cycle; this is similar to the songs recorded in the Southwestern Pacific, where a song is composed of 12 to 15 units (Cato, 1991). In contrast, the Southern Atlantic songs from Brazil consist of 24 units (Arraut & Viellard, 2004). However, the effect of sample size in diversity should be considered.

The song phrases recorded in 2006 and 2007 had a lengthy structure. The duration of several phrases in the sample were long (i.e., ABC: 26 s) in comparison with other reported descriptions of phrases from Southern Pacific humpback whales (Helweg et al., 1998). Therefore, these data provide a preliminary indication that songs from humpback whales in Las Perlas Archipelago could

show structural differences from songs emitted by whales in other areas of the Southeastern Pacific region.

Implications for Conservation and Management

Humpback whale songs as a feature to identify ocean basin populations and migration routes (Clapham & Mattila, 1990) could be used to determine cultural transmission between substocks in the breeding areas off Central America. It would be particularly interesting to know if any features are shared between songs recorded in wintering sites of the northern and southern humpback whale stocks; if so, it could lead to evidence supporting genetic exchange between the populations.

Areas where humpback whales gathered to sing off Panama Bay are subject to great anthropogenic pressure; certainly boat traffic and coastal

Table 2. Acoustical features of the song sessions from 2007; “?” is a transitional unit, while “X” and “Y” are aberrant units used by singer two (9 September 2007).

Unit type	Maximum frequency (Hz)	Minimum frequency (Hz)	Duration (s)	<i>n</i>	%
1	3,595.7 (±1,120.6)	559.7 (±253.9)	1.43 (±0.18)	99	17.48
2	3,990.3 (±982.9)	1,061.6 (±272.6)	1.07 (±0.17)	41	7.28
3	2,518.7 (±85.3)	172.3 (±27.2)	11.40 (±0.20)	63	11.19
4	4,130.5 (±109.4)	947.4 (±35.2)	2.01 (±0.36)	31	5.51
5	2,978.2 (±202.4)	373.2 (±96.9)	0.76 (±0.11)	99	17.58
6	2,992.5 (±152.0)	236.8 (±30.4)	4.59 (±0.22)	20	3.55
7	2,683.7 (±252.5)	243.9 (±24.8)	0.93 (±0.27)	75	13.32
8	4,866.0 (±155.0)	846.9 (±174.1)	1.78 (±0.23)	15	2.66
9	4,370.5 (±30.4)	1,076.0 (±60.8)	0.66 (±0.19)	6	1.07
3*	3,315.7 (±195.9)	172.3 (±0.4)	1.99 (±0.26)	43	7.64
C	2,432.5 (±82.3)	204.5 (±95.5)	4.57 (±0.27)	28	4.97
D	2,541.5 (±79.8)	290.6 (±21.5)	0.97 (±0.33)	20	3.55
?	2,507.7 (±230.2)	150.6 (±24.9)	0.88 (±0.08)	15	2.66
X*	2,368.0 (±60.8)	129.0 (±0.1)	3.65 (±0.07)	4	0.71
Y*	2,260.5 (±91.2)	172.2 (±0.1)	2.72 (±0.17)	4	0.71

Song sessions: 2

Song cycles: 2

Themes: 8

Phrases: 12C, 32C, 34C, DD3*1, DD? 55, 6777, 889, 1? C

development are major threats in Las Perlas Archipelago. Thus, such important locations should be identified as critical areas for breeding humpback whales. There are currently plans elsewhere in Central America to establish or strengthen marine protected areas focused on critical habitat for *M. novaeangliae*, but regional efforts toward

increasing conservation within migratory routes, and targeting strict measures in those sites, would likely have a greater impact. The continuity in acoustic sampling with an equal effort between months within the breeding season is suggested in order to establish inter-individual variation and progression of the season's song.

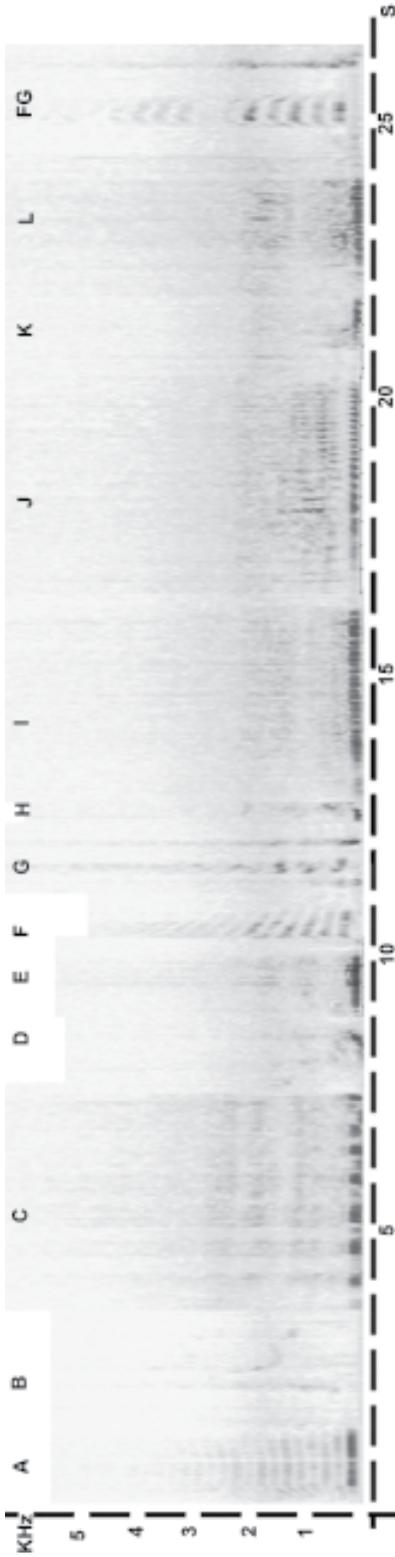


Figure 1. Spectrogram patterns of the 13 units identified in 2006; each unit is designated by letters A to L, plus FG, as a transitional FM unit.

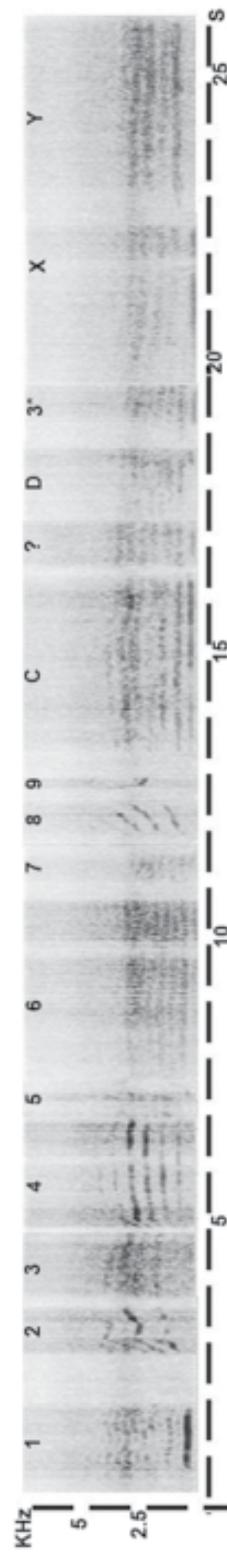


Figure 2. Spectrogram patterns of the 15 units identified in 2007; each unit is designated by numbers from 1 to 9, plus C and D (aurally similar to C and D units of 2006). All other units (? , 3*, X, Y) have a variable aural pattern.

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