SC/66a/WW/6

The acoustic behavior of Bocas del Toro dolphins varies with watercraft activity

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INTERNATIONAL
WHALING COMMISSION

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Laura Johanna May-Collado[1,2]
[1]*Panacetacea.org*
[2]*Departament of Biology, University of Vermont.*

Abstract: In Dolphin Bay, dolphins form a tight and small social unit that is daily exposed to high noise levels from dolphin watching (DW) boats. However, noise levels associated with boat presence seem to explain very little of the variation previously documented in whistle duration and frequency (see May-Collado and Wartzok report). Therefore, other factors associate with dolphin watching boats such as mode of approach may be a more important contributor to changing dolphin acoustic behavior. Here I compare dolphin whistle acoustic structure during three watercraft activities that vary in their mode of approach and intensity: research (low impact, long exposure), transport (low impact, short exposure), and dolphin watching (high impact, long exposure). Our results indicate that dolphins emit whistles similar in acoustic structure in the presence of the research and transport boats. In contrast, dolphins in the presence of dolphin watching boats emitted whistles that were highly modulated, longer, lower in ending and peak frequency, and wider in frequency range (delta frequency) than those emitted in the presence of the research/transport boats. Understanding how different watercraft sources affect dolphin communication is crucial in managing and protecting dolphin habitat.

Introduction

The acoustic environment of many coastal dolphin populations is largely dominated by watercraft noise (Rako et al. 2013). However, it remains unclear if dolphins respond acoustically the same or more strongly to some sources of noise than to others. For example Buckstaff (2004) did not found significant changes in dolphin whistle acoustic structure during interactions with passing boats while Rako et al. (2013) found that dolphins reacted more 'strongly' to boats that target them directly and that spend long-periods of time following them than those that did not (Rako et al. 2013).

In Bocas del Toro (BDT) boat traffic, and particular dolphin watching boat traffic has grown exponentially in the past decade. May-Collado and Wartzok (see report on noise levels) found that although increasing presence of dolphin watching boats is associated with an increase in noise levels, this increase in noise explained very little of the variation in whistle frequency and duration previously reported by SC/64/WW2, May-Collado and Wartzok (2008), and May-Collado and Quinones-Lebron (2014). The authors suggested that other cues (e.g., mode of approach) and other sensory modalities (e.g., vision) associated with dolphin watching boat-dolphin interactions may be more important contributors to changing dolphin acoustic behavior.

Here I evaluate if dolphins respond acoustically different to three watercraft activities that vary in their mode of approach and intensity: research (low impact, long exposure), transport (low impact, short exposure), and dolphin watching (high impact, long exposure).

Methods

We recorded dolphin signals using a broadband system consisting of a RESON hydrophone (-203 dB re 1V/μPa, 1 Hz to 140 kHz) connected to AVISOFT recorder and Ultra Sound Gate 116 (sampling rate 400-500 kHz 16 bit) that sent the signals to a laptop. Recordings were made continuously and saved into wav files of one to three minutes at a sampling rate of 384 kHz. Dolphins were recorded under three watercraft interactions that vary in time of exposure and impact (group directly targeted or not). These watercraft activities were: research (low impact, long exposure), transport (low impact, short exposure), and dolphin watching (high impact, long exposure). Interactions between the research and the dolphins were low impact but dolphins were exposed to the research boat presence for 30min to 1h. Transport boats, were low impact and short exposure since these boats have established routes and schedules, the interaction with the dolphins is minimal and not directed at them. Dolphin-watching boats, these recording were made under the presence of 2 to 17 dolphin watching boats, with a turnover of up 37 boats within a period of one hour. Dolphin-watching boats interactions varied considerably in intensity (number of boats present and often very intrusive interactions).

All recording sessions included in this study were in the presence of small dolphin groups ranging from 2 to 10 individuals that were photo-identified during this study. Thus, the recordings come from the same individuals but recorded under behavioral context and boat interactions. Because recordings were made with the engine noise off, dolphins tended to move away from the research boat (and during interactions with other watercraft), thus distance of the focal group during a recording session varied considerably within and between groups, considerably limiting whistle recording.

A total of 501 whistles (Research=251, Transport=42, Dolphin-watching=208) with a clear contour were manually selected and analyzed using the program Raven 1.1 (Cornell Laboratory of Ornithology, New York) with a FFT size of 1024 points, an overlap of 50%, and using a 512-522 sample Hann window. The following standard whistle parameters were measured: starting frequency (SF), ending frequency (EF), minimum frequency (MinF), maximum frequency (MaxF), delta frequency (DF), peak frequency (PF), duration (s), number of inflection points and number of harmonics. The statistical software JMP ® 9 (SAS Institute Inc.) was used for statistical analyses. Descriptive statistics were performed to provide mean, standard deviation, frequency range, and coefficient of variation values for each whistle. The Kruskal–Wallis test was used to test what acoustic variables vary with watercraft activity.

Results

Table 1 summarizes the descriptive statistics of standard whistle acoustic parameters for the BDT dolphins. Dolphin whistles emitted in the presence of transport and research boat were not significantly different in frequency or duration. In contrast, in the presence of dolphin watching boats dolphins emitted significantly longer whistles (t=2.99, df=49, p=0.002) with high delta frequency (t=-3.6, df=248, p<0.0001), low ending frequency (t=4.1, df=248, p<0.0001) and peak frequency (t=3.1, df=248, p=0.002), and higher modulation (x^2=8.4, df=1, p=0.003) than the other watercraft activities.

Table 1. Summary of descriptive statistics of whistle acoustic parameters for bottlenose dolphin whistles emitted in the presence of the research, transport, and dolphin watching boats (MinF=minimum frequency, MaxF=maximum frequency, DF=delta frequency, SF=start frequency, EF=ending frequency, PF=peak frequency, Dur=duration, IP=inflection points). The * indicates significant differences between variables among boat type at a significant level of $p \leq 0.002$

Type of Boat presence	Stats	MinF	MaxF	DF*	SF	EF*	PF*	Dur*	IP*
Research Boat N=251	*Mean±SD* *Range*	6.1±*2.4* *1.6-25.5*	15.1±*3.7* *1.7-29.4*	9.0±*3.7* *1.3-20.8*	10.0±*3.7* 2.5-25.9	9.2±*4.3* *1.6-29.1*	9.9±*3.6* *3.5-29.3*	0.88±*0.58* *0.05-3.3*	2.8±*3.5* *0-18*
Transport boats n=42	*Mean±SD* *Range*	6.7±*2.34* *10.7-13.6*	14.2±*2.8* *6.0-20.7*	7.4±*3.4* *0.8-17.0*	10±*3.7* *3.5-19.5*	10±*3.7* *3.4-18.6*	10.7±*3.6* *5.3-20.5*	0.84±*0.74* *0.06-2.96*	2.6±*3.6* *0-13*
dolphin watching Boats N=208	*Mean±SD* *Range*	5.6±*1.8* *2.4-12.6*	15.4±*3.8* *5.8-24.8*	9.8±*4.0* *1.1-20.1*	10±*3.8* *3.0-23.0*	7.7±*3.3* *3.2-21.0*	8.9±*3.4* *3.2-22.4*	1.11±*0.59* *0.05-3.8*	4.1±*4.0* *0-20*

Frequency parameters in kHz
Duration (s)

Discussion

In this study we found that the mode of approach and intensity of the interaction of dolphin watching boats are important contributors to changing Bocas dolphin acoustic behavior. Dolphin whistle acoustic structure was practically the same in the presence of the research and transport boats. These watercraft activities have relatively low impact on the animals. In contrasts the conditions at which dolphins were recorded during dolphin-watching activities involved a dynamic change in the number of boats (up to 37 boats within a period of 1 ½ hour), speed of approach, and directness towards the group in most cases exposing the dolphins to long and invasive interactions. In response to this type of encounters dolphins emitted long and low frequency modulated whistles that presumably enhance communication under noisy soundscapes and invasive situations. Photo-identification data collected during each recording seasons reveals that a large proportion of the recording sessions with the research, transport, and dolphin watching boats were made with the same 37 individuals. Therefore, the observed variation in dolphin whistle structure is an acoustic response to dolphin-watching boats, and not to other factors. Dolphin watching boats may have significant cumulative effects on Bocas dolphins fitness by reducing habitat quality and increasing stress.

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