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Abstract: The resident bottlenose dolphin community at Dolphin Bay in Bocas del Toro sustains the largest dolphin watching (DW) industry in Panama. Our previous work shows that dolphins significantly respond to DW boat presence by modifying their whistle frequency and duration particularly when engaged in foraging activities. The usual assumption is that the noise associated with the DW boats is responsible for the change in whistle parameters. In this study we evaluate the effect of noise levels on whistles acoustic structure by analyzing recordings obtained in 2007, 2008 and 2012 under various boat interactions. We measured ambient noise levels (RMS values, 100Hz to 48kHz) for each of these recordings and for each whistle within those recordings we measured a number of standard frequency variables and duration. Noise levels increased with boat presence; however, there was also significant variation among years. After adjusting the level of significance for multiple comparisons to α= 0.006, our results indicate that 8% of the variation in whistles minimum frequency is explained by the interaction between noise levels and year. In contrast, 16%, 22%, and 11% of the variation in whistle ending frequency, peak frequency, and duration was explained by year, respectively. In agreement with recent studies these results indicate that while annual variations in noise levels can significantly affect dolphin communication, dolphins show great plasticity in coping with these changes. Furthermore, it is important to highlight that changes in noise levels only explained a small percent of the variation observed in dolphin whistle structure suggesting that other cues (e.g., mode of approach) and other sensory modalities (e.g., vision) associated with these boat-dolphin interactions may be more important contributors to changing dolphin acoustic behavior.

Introduction

Bottlenose dolphins like many other marine mammals rely on sound for a number of behavioral activities essential for their survival and reproduction (NRC, 2003). Because coastal dolphin populations are increasingly exposed to high levels of boat traffic there is concern about the potential of signal masking and the biological consequences of masking in their fitness (e.g., Morisaka et al., 2005; Sims et al., 2012; Rako et al., 2013b). A number of studies have shown how boat traffic affects dolphin acoustic communication (Haviland-Howell et al., 2007; May-Collado and Wartzok 2008; Holt et al., 2009).

May-Collado and colleagues have monitored the resident population of Bocas del Toro (BDT) for a decade. During this time the DW industry has grown rapidly and in a disorganized manner from two to 39 boats interacting with the same group of dolphins within a period of 1h. In SC64WW2, May-Collado and Wartzok 2008, and May-Collado and Quinones-Lebron showed that dolphins significantly respond to boat presence by increasing whistle duration and lowering their minimum and ending frequency, particularly when engaged in foraging activities. In all these studies the assumption has been that noise associated with dolphin watching boats is responsible for this change in dolphin whistle parameters. In this study we evaluate the effect of noise levels on whistles acoustic structure and behavior under various boat interactions by analyzing recordings obtained in 2007, 2008 and 2012 for which noise levels could be properly measured. Understanding how noise levels change the soundscape of this bottlenose dolphin population and thus how they use their habitat is key in planning proper management

Methods

Recordings were made using a Reson 4033 hydrophone (sensitivity -203 dB ± 2 dB 1Hz to 80 kHz) connected through a charge amplifier to Avisoft UltraSoundGate 116Hb data acquisition hardware with adjustable, discrete gain settings. The digital output was stored on a laptop computer. We used the PAMGuide.R package[5] to measure ambient noise levels (RMS values, 100Hz to 48kHz) for each of these recordings (Merchant et al. 2015). Recordings for analysis were chosen from those not dominated by snapping shrimp. For each whistle within those recordings we measured standard variables: minimum, maximum, start, end, peak, delta frequencies (kHz) and duration (s).

Results

Noise increased with the number of boats as shown in Fig. 2 (χ^2=9.68, df=2, p=0.0079). However for dolphin whistles, only ending frequency was significantly lower (χ^2=14.4, df=2, p=0.0008) in the presence of more than 6 boats. After adjusting the level of significance for multiple comparisons to α=0.006, our results indicate that 8% of the variation in whistles minimum frequency is explained by the interaction between noise levels and year (F=5.52, df=2, p=0.005). In contrast, 16%, 22%, and 11% of the variation in whistle ending frequency (F=7.81, df=2, p=0.0006), peak frequency (F=17.3, df=2, p<0.0001), and duration (F=4.28, df=5, p=0.001) was explained by year, respectively.

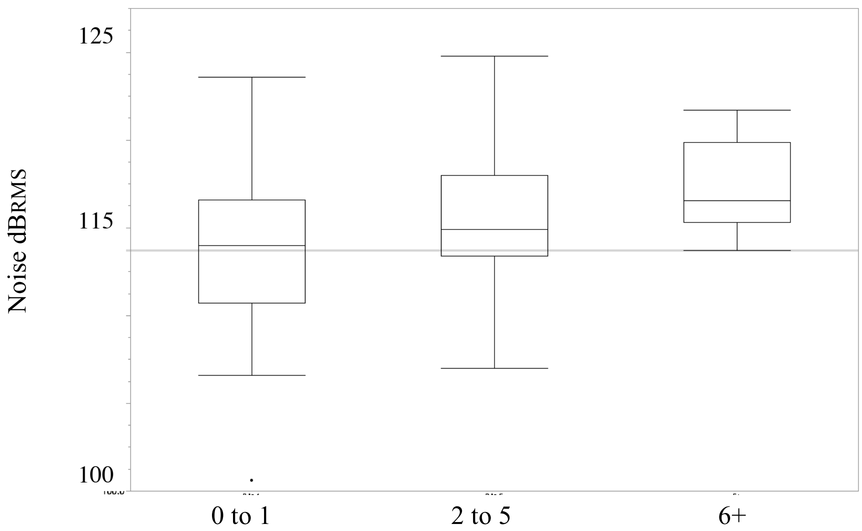

Figure 2. Noise dB_{RMS} mean values increase with number of dolphin watching boats.

Discussion

These results indicate that noise levels are associated with increased presence of boats. This association has been reported in multiple studies (e.g., Holt et al. 2009). However, while noise increases with number of boats, noise per se only explained a small percent of the variation observed in dolphin whistle structure. This suggests that other aspects of dolphin watching boats could be affecting dolphin whistles. Dolphins could be using vision as well as hearing to integrate factors such as mode of approach, increase in quantity of boats, and noise generated by the boats. May-Collado (see report on impact of different watercraft activities) compared whistle frequency or duration in the presence of transport, research, and dolphin watching boats, three watercraft activities that vary in mode of approach and length of exposure. The study found that dolphins in the presence of transport and research boats emit whistles similar in frequency and duration, while in the presence of dolphin watching boats dolphin's whistles are significantly modified. A recent study by Pirotta et al. (2015) also found that dolphin foraging acoustic signals variation was not explained by increasing noise levels and like this study concludes that is boat physical presence and behavior that plays a major role in dolphin disturbance not just noise.

It is important to highlight that noise levels can also elicit changes in signal amplitude, a variable that we did not measured. For example, Holt et al., (2009) found that killer whales do not increase call duration in the presence of boats; instead they showed an increased in their call amplitude by 1dB for every 1dB increase in background noise levels. Increasing signal amplitude to compensate for noise has energetic costs, as shown by a recent study by Holt et al., (2015). Thus future studies assessing the impact of increasing noise levels in Bocas dolphins should include estimations of signal amplitude.

References

Haviland-Howell, G., Frankel, A. S., Powell, C. M., Bocconcelli, A., Herman, R. L., & Sayigh, L. S. 2007. Recreational boating traffic: A chronic source of anthropogenic noise in Wilmington, North Carolina Intracostal Waterway. J. Acoust. Soc. Am. **122**, 151-160.

Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K. & Veirs, S. 2009. Speaking up: killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. J. Acoust. Soc. of Am. 125, EL27–EL32.

Holt, M. M., Noren, D. P., Dunkin, C.R., & Williams, T. 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. J. Exp. Biol. 122424.

May-Collado, L.J. 2015. The acoustic behavior of Bocas del Toro dolphins varies with watercraft activity. SC/66/WW

May-Collado, L.J. & S. Quinones-Lebron. 2014. Accepted. Dolphin changes in whistle structure with watercraft activity depends on their behavioral state. Journal of the Acoustical Society of America Express Letter 135, EL193-198.

May-Collado, L. J., Barragán-Barrera, D. C., Quiñones-Lebrón, S. G, & W. Aquino-Reynoso1. 2012. Dolphin watching boats impact on habitat use and communication of bottlenose dolphins in Bocas delToro, Panama during 2004, 2006-2010. International Whaling Commission. SC/64/WW2.

May-Collado, L. J. & D. Wartzok. 2008. A comparison of bottlenose dolphin whistle in the Western Atlantic Ocean: insights on factors promoting whistle variation. Journal of Mammalogy. 89:205-216.

Merchant, N. D., Fristrup, K. M., Johnson, M. P., Tyack, P. L., Witt, M. J., Blondel, P., Parks, S. E. (2015). Measuring acoustic habitats. Methods in Ecology and Evolution. doi: 10.1111/2041-210X.12330

Morisaka, T., Shinohara, M., Nakahara, F., & Akamatsu, T. 2005. Effects of ambient noise on the whistles of Indo-Pacific bottlenose dolphin populations. J. Mammal. 86, 541–546

Rako, N., Fortuna, C. M. , Holcer, D., Mackelworth, P., Nimak-Wood, M., Pleslic, G., Sebastianutto, L., Vilibiác, I., Wiemann, A., & Picciulin, M. 2013. Leisure boating noise as a trigger for the displacement of the bottlenose dolphins of the Cres-Loîsinj archipelago (northern Adriatic Sea, Croatia). Mar. Pollut. Bull. 68, 77–84.

Picotta, E., Merchant, N.D., Thompson, P.M., Barton, T.R., &D. Lusseau. 2015. Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. Biological Conservation. 181:82-89.