The dolphin watching industry of Bocas del Toro continues impacting the resident bottlenose dolphin population.

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The bottlenose dolphins of Dolphin Bay, in the Archipelago of Bocas del Toro sustain the largest dolphin watching industry in Panama. Since the establishment of this project 10 years ago, we have observed a rapid and disorganized development of the tourism infrastructure and dolphin-watching (DW) activities. These activities continue to growth without a management plan that can prevent short and long-term negative impacts. The present study is a follow up of the SC64WW2 and SC/65a/SM15 studies presented to the IWC 2012 in Panama. Our results indicate a significant annual increase in the number of DW boats interacting with a group of dolphins within a span of an hour. This increase is significantly affecting how dolphins use their habitat. Overall, dolphin negative reactions increased with number of DW boats present. These reactions included increase in diving and travel frequency, and decrease in foraging and social frequencies. These patterns were intensified when calves were present in the group. Based on these results we recommend no more than two DW boats interacting with a dolphin group and a resting time of 30 minutes between interactions. Although, Scientific Committee recommended to the government of Panama in 2012 to enforce and promote adherence to whale-watching regulations there has been no progress in this respect. Plans for renovation of the current airport in the near future may increase number of flights. Without the proper management plan any future increase in tourism will have serious consequences on this dolphin population. Rapid action is urgently needed not just to ensure adherence to conduct guidelines but training of operators, awareness, and *in situ* control.

INTRODUCTION

The resident population of bottlenose dolphins of the Archipelago of Panama is small and highly predictable, two characteristics that have lead to the development of the most important dolphin watching (DW) industry in Panama. Profitable wildlife observation can mutually benefit humans and wild animal populations, resulting in successful conservation. However, high observation intensities may not be sustainable, and negatively affect animals, and eventually the DW industry itself. Despite the existence of national regulations for DW conduct, mandatory training of boat operators, and a recommendation from the IWC (Panama, 2012) to minimize impact on dolphins, the Bocas DW boat fleet continues to grow at a fast pace. The Bocas DW growth is rapid and disorganized, without management plan that can prevent short and long-term impacts by the industry to the local dolphin population. The two major factors contributing to the high number of DW boats are tour offers at similar schedules and targeting of the same dolphin area. This situation is leading to competition among boat captains that have resulted in aggressive and sometimes fatal interactions with the dolphins.

In SC64WW2 we showed how the presence of multiple DW boats caused changes in their whistle acoustic structure typically used by dolphins to avoid signal masking by engine noise. Recently, we have found that these changes in whistle structure are more likely to happen when dolphins are engage in important activities such as foraging (May-Collado and Quinones-Lebron 2014). In SC/65a/SM15 we documented the genetic structure of this population reporting a unique control region haplotype on this population not described anywhere in the Caribbean. This haplotype was shared between males and females suggesting high philopatry, increasing their vulnerability to unsustainable dolphin watching practices.

Following the Scientific Committee recommendations in continuing our research to monitor the impacts of dolphin watching activities on this population (IWC 2013b, p.80), here we present results on the effect of number of boats on dolphin habitat use.

METHODS

The Archipelago of Bocas del Toro is located in the Caribbean coast of Panama. Our survey effort covered approximately 79.2 km2 within the inner part of the Archipelago, which is characterized by shallow and clear waters and bottom substrates consisting of sea grass, coral, and sand. The main mode of transportation between the islands and mainland is through powered boats with 50 and 150 hp engines and canoes. Our study focused on Bocas Torito Bay also known as Dolphin Bay. This is a closed bay with resident dolphins that are highly predictably attracting most of the dolphin watching operators. Visiting schedules are similar among tour operators arriving approximately at 9:30 a.m., 12:30 p.m., 1:30 p.m. and 2:30 p.m. It is important to note that our fieldwork took placed during the low tourism season (April to October); during high season (November to March) more than 100 dolphin-watching boats can be out in the Archipelago at the same time (unpublished data).

Dolphin behavioral information was collected in 2006, 2007, 2009, and 2012 were considered in this study. The general procedure was to arrive at Dolphin Bay, before the arrival of dolphin watching boats around 7 a.m. Once a group of dolphins was encountered the boat was approached slowly and in a parallel position to avoid dolphin disturbance (Resolution ADM/ARAP NO. 01, 2007). We maintained a distance of 30-50 m distance to the group before turning the engine off to initiate data collecting and photo-ID. Groups with less than 20 min of observation were not considered in the analysis resulting in a sample size of 132 dolphin groups and a total of 2155 3-min. The behavioral protocol consisted of following a 'focal group' and noting the occurrence of surface behaviors (Mann 1999) at each 3-min interval. Behavioral observations ended when sea state conditions deteriorated, the group was lost, or to many boats were present and observations were difficult.

Behavioral categories per 3-min interval were mutually exclusive and only those behaviors with sufficient sample size for statistical analysis were considered: foraging, socializing, traveling, and diving. For each behavioral scanning point we also documented the number of boats present and the overall response of the dolphin to its presence as neutral, negative, or positive (e.g., Crosti and Arcangeli 2001, Pereira et al. 2007). Because we cannot account for all potential effects of our research boat (even if minimal) we limited this study to comparisons between the research and dolphin watching boats activities. It is also important to note that 'focal groups' represent different combinations of the same 105 individuals identified using photographs of natural marks in their dorsal fins. Therefore, this study is based on multiple observations of virtually the same individuals under different behavioral contexts and boat interactions.

A decision tree analysis was used to associate categories of dolphin response (negative, positive, neutral) with number of dolphin watching boats using the statistical software SPSS 21 (IBM Corporation, 2012). We used a cross-validation method with default number of sample folds set to 10 and the Chi-squared Automatic Interaction Detection (CHAID) criteria, which selects for discrete variables (type of response and behavior category) with the strongest interaction with the dependent variable, in this case number of boats. We used the Pearson chi-square statistics with a significance level at 0.05 for splitting nodes and adjusted significance level using Bonferroni. To determine the effect of number of boats on dolphin behavior we obtained the frequency of behaviors by counting the occurrence of each behavior and divided it by the total of observations per boat number category. We then tested for correlation between the number of boats and the frequency of behaviors fitting a linear regression model using R.

RESULTS

The number of boats interacting with the same group of dolphins within a period of 1h increased from 2 to 39 boats (R^2=95, p<0.05) (Fig.1). There were significant differences in dolphin reaction to the research and dolphin watching boats (X^2= 310.5 df=3, p<0.0001, Fig. 2). About 93.6% of the interactions between the research boat and dolphin groups were neutral, not sudden changes of behavioral states or avoidance of boats were noticed. Neutral reactions to dolphin watching boats dropped from 80.6% in the presence of one dolphin boat to 39. 7% when more than three boats were present. Accordingly, negative reactions to boat presence increased from 13.1% with one dolphin watching boat to 56.7% with more than three boats (Fig.2). When accounting for calf presence, negative reactions significantly increase with boat presence from 14.2% with one boat to 51% with multiple boats (X^2= 169.8 df=3, p<0.00010). Same pattern was observed in adult groups, but percent of negative reaction were slightly lower than groups with calves, ranging from 10.1% with one boat to 41.5% (X^2= 171.7 df=3, p<0.0001) with multiple boats.

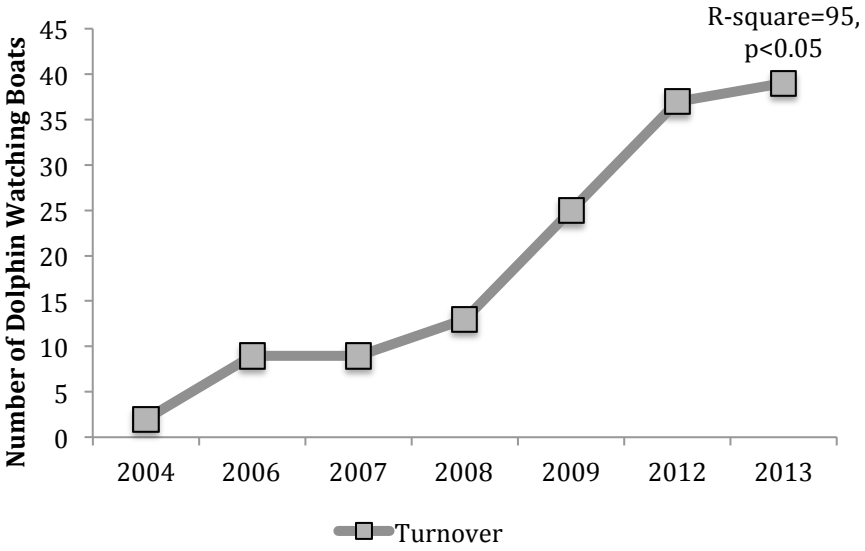

Figure 1. Annual increase of number of DW boats interacting with the same group of dolphins within 1-hour period.

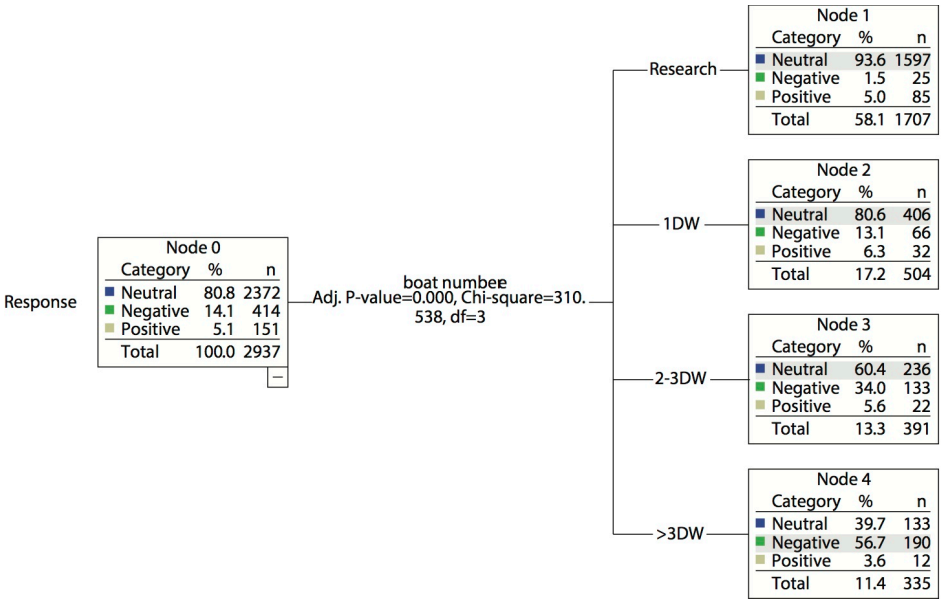

Figure 2. Decision tree analysis for dolphin responses to number of dolphin-watching boats (cross validation estimate=0.311, std error=0.013).

When dolphins were only in the presence of the research boat, dolphins spent significantly more time foraging than any other behavior (X^2= 23.2, df=3, p<0.0001). When multiple boats were present, we found a significant positive correlation between diving frequency (F_{Diving}=66.25, df=15, p<0.0001, Fig. 3a) and boat presence. In contrast, foraging and social frequencies were negatively correlated with increase in boat presence ($F_{Foraging}$=104.7, F_{Social}=102.9, df=15, p<0.0001, Fig 3b-c). Traveling showed a decrease, but it was not significant (p > 0.05) (Fig.3d). However, groups with calves significantly increased travel frequency when more than three boas were present (Yates= 12.68, df=3, p=0.0004).

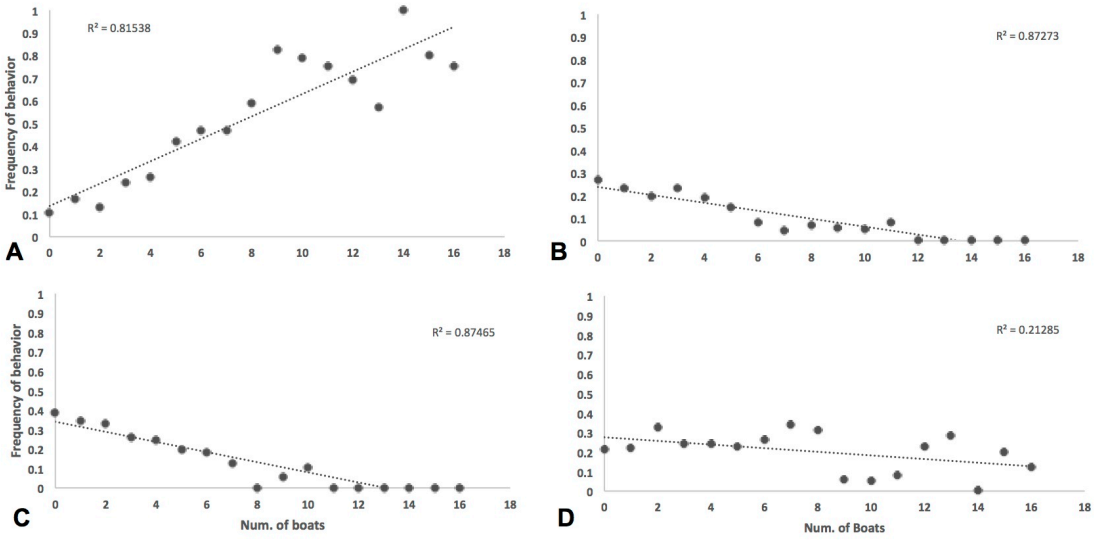

Figure 3. Regression of the frequency of each behavioral activity in relation to number of boats present. (A) Diving, (B) Social, (C) Foraging, and (D) Travel.

DISCUSSION

In this study we found that bottlenose dolphins from Bocas del Toro react negatively to multiple dolphin watching boats. Overall, the presence of multiple dolphin watching boats increased diving frequency and decreased foraging and social activities. Groups with and without calves reacted similar to boat presence, however, when more than three boats were present, groups with calves showed a significant increase in travel frequency. The short and long-term effects of multiple dolphin watching boats on dolphin behavioral ecology have been demonstrated in several studies (i.e., Steckenreuter 2012, Bejder 2006).

The resident bottlenose dolphin population of the entire Archipelago of Bocas del Toro is probably less than 250 dolphins (unpublished data), but the dolphin community of Dolphin Bay consists of only 105 animals. These dolphins are exposed daily to multiple interactions with dolphin watching boats. When a dolphin watching operator sights a group of dolphins, all the rest of the boats in the vicinity follows it moving towards the same dolphin group, as new arriving boats enter the bay they joined those already in the bay. During this study we documented a total of 39 boats interacting with the same group within a span of an hour, with no resting times between interactions. As the dolphin watching boat fleet congregates around these dolphins, there is an inherent decrease in the probability of watching dolphins because of the disrupted visibility. This creates competition among boat captains causing close range and aggressive movements towards the dolphins and an increase in engine noise levels reducing the acoustic communication range among dolphins (May-Collado and Quiñones-Lebrón 2014). It is important to note that the data collected for this study was collected during low tourism season. Based on unpublished data from interviews to local tour operators we predict that during the high tourism season 100 or more boats can be simultaneously out. The number of tourists is expected to grow considerable in the next year. Ten new daily flights are scheduled to arrive this year and plans for a new airport is expected to accommodate even more flights.

The accumulation of boats around the same group of dolphins results in an escalation of negative responses by the dolphins. Even one dolphin watching boat is causing a tenfold increase in negative reactions when compared to negative reactions towards the research boat (Fig. 2). Bocas dolphins responded negatively to boat presence immediately by terminating their activities and switching to avoidance behaviors such as diving and traveling. Diving was the most commonly displayed avoidance behavior, while traveling was primarily important when calves were in the group and more than three dolphin watching boats were present.

Calves limitations in diving time may hinder their escape from boats, in which case horizontal avoidance may be a more efficient way to avoid interaction with boats. Stensland and Berggren (2007) also found that dolphin movement pattern was not affected when one or two boats were present, but as the number of boats increased so did the travel frequency in groups with calves. They proposed that such increase in movement was likely reducing nursing time for calves. Although, nursing females experience influence considerably calf survival, the combination of a reduction in female foraging time and increment in avoidance behaviors that minimized calf nursing, may have significant negative effects on the condition and survival of their calves.

Increasing boat presence interrupted importance behaviors such as foraging and socializing. Previous studies have found that dolphins engage in foraging and social activities are easily disrupted by boat presence (e.g., Dans et al., 2008, Papale et al., 2011, Steckenreuter et al. 2012). Dolphins could be compensating foraging disturbance by accessing other in areas in the Archipelago or shifting foraging to later hours. However, the high re-sighting frequency of many of these dolphins in the Dolphin Bay suggest that even when boat interactions may be detrimental to them, the bay is an important part of their home range during daytime, and they spend at least of six hours at day in the presence of multiple dolphin watching boats, highlighting the pressure that these dolphins are under every day and the need for more stringent management measures.

Worldwide, dolphin watching guidelines and regulations have a number of stipulations to minimizing boat impact during encounters, one of the most important stipulations is number of boats (Carlson 2012). Panamanian regulations allow only two boats to interact with dolphins simultaneously for a maximum period of 30 min followed by a 30 min break before the next interaction. Other boats are expected to be in a waiting zone before approaching the dolphins. Because of the lack compliance to regulations dolphins are been exposed to about 16 times the number of boats allowed by Panamanian regulations for at least six hours at day.

This study provides further evidence that dolphin behavioral responses to boat presence in Bocas are density-dependent. Dolphin avoidance behaviors increased with boat number, and as the number of boats in the study will continue to grow, there is concern that these avoidance behaviors will translate into avoidance of Dolphin Bay and nearby areas. As we discussed before, Dolphin Bay is a major part of the home range of at least 105 dolphins inhabiting the Archipelago. However, in 2012 and 2013 we observed sightings of about 20% of these dolphins in areas where they have not seen before and that have similar survey effort. The unsustainable way in which dolphin watching activities are taking place in Dolphin Bay, may be reaching a threshold where stress caused by boat interactions may become energetically expensive to these dolphins (i.e., more time avoiding than feeding or nursing) forcing them to move to suboptimal areas in order to escape the energy costs of boat impact (Lusseau 2003).

Based on these results we recommend a maximum of two dolphin watching boats following the same group of dolphins. Arriving boats should remain at a waiting distance of minimum 300 m, and give 30 min resting time to the dolphins before approaching them after a previous interaction. We also recommend that arriving boats either stop at the waiting zone if other boats are already present or move to other parts of the bay to look for a different group of dolphins. In addition to these measures, we belief a better control of the quotes for dolphin watching licensing given by the Panamanian government is urgently needed. Presently, any person that owns a boat is taking tourists to see the dolphins, we recommend limitations on licensing to a number of dolphin watching associations for which boat fleet growth should be limited and re-evaluated yearly. We also recommend this process to be accompanied of high quality training and a certification for best DW practices.

Acknowledgments

IWe thank STRI Bocas del Toro Research station staff: Rachel Collin, Gabriel Jácome, Plinio Góndola, Eric Brown, Demetrio, Arnulfo and Christian Harris, Morris, Marlon Smith, Urania, Zurenayka, Marcela, and Orelis. Several people assisted in the field: J. D. Palacios, E. Taubitz, J. May Barquero, I. Agnarsson, D. Wartzok, A. Kassamali-Fox, S. Caballero, A. Sitar, M. Acosta, M. Gamboa-Poveda, L. Trejjos. This study was carried out with permission from the Government of Panama (ANAM; permit SE/A-101-07). Funding for this project came from a Latin American Student Field Research Award from the American Society of Mammalogy, Cetacean International Society, Project Aware, Chris Parson Lab, Whale and Dolphin Conservation Society, the Russell E. Train Education Program–World Wildlife Fund, and a Dissertation Year Fellowship, Florida International University, and Panaceacea to LJMC 2004-2013. Cetacean International Society, Society for Marine Mammalogy and Proyecto Semilla of Universidad de los Andes to DCBB 2009-2012, Bridge to the Doctorate, PR-LSAMP, and Society for Marine Mammalogy to SQL 2009-2012, and Rufford Small Grant to DCBB and SQL 2012-2013.

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