ASSESSMENT OF THE EFFECT OF WHALE WATCHING ON THE BEHAVIOR OF THE SOUTHERN RIGHT WHALE (*Eubalaena australis*): BUILDING EVIDENCE TO SUPPORT TOURISM MANAGEMENT IN THE APA DA BALEIA FRANCA/ICMBIO MARINE RESERVE

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Introduction

Whale Watching (WW) is a commercial activity aimed at observing any species of whale, dolphin, or porpoise from a boat, airplane, or even land in their natural habitat (Hoyt 2009). It has been promoted as an economically viable and sustainable activity, becoming one of the fastest-growing tourist activities in the world (O'Connor *et al.* 2009). However, if managed inadequately, it can result in adverse effects on cetaceans, leading to alterations in their behavior and physiology (Christiansen and Lusseau 2014). Although the long-term consequences are poorly understood (Bain *et al.* 2014), such alterations can negatively impact survival and reproductive success (Christiansen and Lusseau 2014, Machernis *et al*. 2018), potentially leading to population-level consequences.

Boat-based WW took place in the Right Whale Environmental Protection Area (APABF; acronym in Portuguese), Santa Catarina, Brazil, from 1999 to 2012, when the activity was prohibited by the courts. The resumption of WW operations in the APABF depends on research to assess its effects on the behavior of the whales. This study aims to assess the short-term effect of boat-based WW on the behavior of southern right whales (*Eubalaena australis*) in the APABF and to evaluate the effectiveness of ICMBio (Chico Mendes Institute for Biodiversity Conservation; the institution responsible for the management of federal Protected Areas in Brazil) Law No. 1112, created to regulate this activity and ensure adequate protection for the whales.

This law defines the following regulations: i) only one vessel at a time with a group of whales; ii) approaches must be made diagonally only from the lateral posterior side, and the vessels must maintain a parallel course to any movement by the group of whales (tangential approach); iii) maximum speed of 5 knots when whales are within 300 meters; iv) vessels must not approach closer than 120 meters to a group of whales (sighting distance); and v) vessels must not stay with a group of whales for longer than 30 minutes. Although some rules can be generalized to other species or locations, such as the tangential approach (see Carlson 2012), others, such as the sighting distance, are context-dependent and vary by species, location, and activity states (e.g., resting, feeding). Therefore, evaluating the effectiveness of these rules in light of the particularities of each context is crucial.

Materials and Methods

Land-based theodolite observations were conducted during the reproductive season of southern right whales between July and November 2022/2023 to monitor the movement and behavior of mother/calf pairs in the absence and presence of boats. The mothers of the surveyed groups were photo-identified through drone flights, carried out only in the 2023 season (Figure 1). Approaches to whale groups were conducted in accordance with the first three items of ICMBio Law No. 1112, using a 7-meter boat equipped with a 90 HP outboard engine (Figure 2). The sighting distances to which the pilot was instructed to approach were 120 or 200 meters (estimated visually). After being measured in the laboratory, the sighting distances were categorized as follows: 61-100, 101-140, and 141-180 meters. The observation time for each surveyed group ranged from 10 to 20 minutes.

Figure 1. Whale photo-identified by drone during focal group monitoring.

Figure 2. Boat used to approach whale groups.

We used swimming speed, linearity, reorientation rate, activity budgets (time allocated for each behavioral state: resting, traveling, surface activity, and socialization), and frequency of behavioral events (*e.g.*, flipper slapping, lob-tailing, breaching, blow) as metrics to compare behavior patterns in the absence and presence of boats. Two sampling designs were used: "control and treatment" and "during and after" comparisons. The first design consisted of comparing the behavior patterns of different groups of whales in the absence (control) and presence (treatment) of boats, while the second consisted of comparing the behavior patterns of the same group of whales during and after boat approaches.

We used the non-parametric Mann-Whitney and Wilcoxon tests to compare the metrics between control and treatment, and between during and after, respectively. Only swimming speed, linearity, and reorientation rate were analyzed for the three distance categories and compared against the control group. For this analysis, the Kruskal-Wallis statistical test was applied, followed by the Dunn post hoc test. All tests used a significance level of 0.05.

Results and Discussion

During 38.18 hours of observation, we tracked 45 groups in the absence (control) and 39 in the presence of boats (treatment), and 13 during and after boat approaches. In the 2023 season, 25 whales were photo-identified, two of which were re-sighted once and one five times. The average re-sighting rate was 0.009 (SD = 0.02).

For the control/treatment design, significant differences were observed for swimming speed ($p = 0.0003$), linearity ($p = 0.0032$), and reorientation rate ($p = 0.0473$). For the first two metrics, higher values were observed in the presence of boats, while for the latter, lower values were observed in the presence of boats. Regarding the frequency of behavioral events of mothers and calves, significant differences were observed for the mother's blow ($p = 0.0346$) and the calf's surface rise ($p = 0.0231$), with higher and lower values in the presence of boats, respectively. For the during/after sampling design, only the frequency of the mother's head exposure event showed a significant difference ($p = 0,0421$), with higher values in the presence of boats. Although these results suggest the use of avoidance tactics/vigilance to evade boats (Machernis *et al.* 2018), the time allocated to different energy-relevant activities, such as energy conservation (*e.g.*, resting) and energy consumption (*e.g.*, traveling), did not differ in the absence and presence of boats for both sampling designs.

Considering the categories of sighting distances, a significant difference was observed only for swimming speed ($p = 0.0064$), with higher values recorded in the 61-100 and 101-140 categories compared to the control group (Figure 3). No significant difference was observed between the 141-180 category and the control group. Although an increase in swimming speed does not necessarily imply an increase in the animals' energy expenditure (*e.g.*, Villagra *et al*. 2021), based on our results, we suggest adopting a precautionary approach and recommend increasing the sighting distance from 120 to 160 meters to minimize the effect of boats on swimming speed.

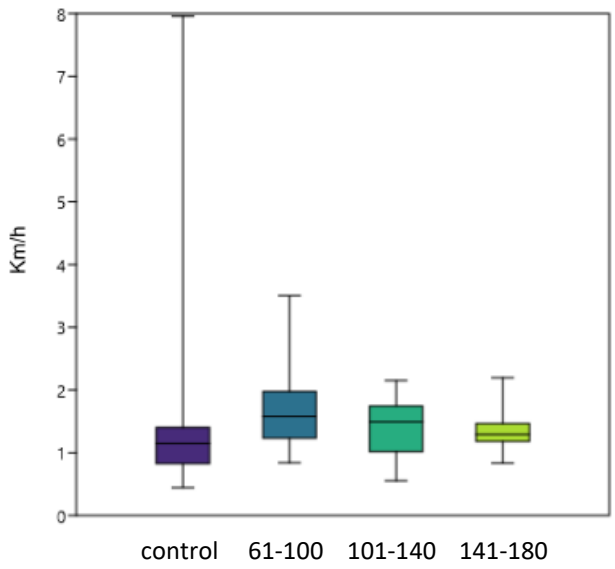

Figure 3. Whale swimming speed in the presence of boats across three sighting distance categories and control group (absence of boats).

The results presented in this work will be extremely relevant to assist in the management of the activity in the APBF. Based on the information obtained from the research, it will be possible to establish more adequate procedures to ensure the well-being of the animals.

The results presented in this study are part of a master's thesis conducted at the State University of Maringá (UEM). The subsequent steps of the study include: i) expanding data collection, while also considering the sample design before, during, and after boat presence (BDA); ii) evaluating additional sighting distance thresholds; iii) evaluating comparisons between sighting distance categories and the control group across all metrics; iv) extending the effort of photo-identification to assess habituation and sensitization phenomena; v) employing drones to evaluate the effects of WW on whales; and vi) comparing drone and theodolite sampling methods; and vii) to evaluate the soundscape in the APABF during the southern right whale's breeding season.

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