SC/69B/HIM/16

Sub-committees/working group name: HIM

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INTERNATIONAL
WHALING COMMISSION

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ABSTRACT

Mortality due to fisheries bycatch in gillnets is the main threat to marine mammals globally. Gillnet fisheries are also the main challenge for the conservation of franciscana dolphins (*Pontoporia blainvillei*), the most threatened cetacean in the western South Atlantic Ocean. The purpose of this study was to evaluate the effectiveness of upcycled plastic drink bottles as acoustic reflectors and low-cost mitigation method to reduce dolphin bycatch and their potential impact on target species catch. Observed trials with (treatment) and without (control) plastic bottles in bottom set trammel nets and gillnets recording dolphin bycatch and target species catch were conducted between November 2020 and February 2024. A total of 251 sets (130 control and 121 treatment) resulted in a bycatch of six franciscana dolphins and two bottlenose dolphins (*Tursiops* sp.) in control sets and one franciscana dolphin bycatch in treatment sets. GLM results showed a statistically significant negative effect on dolphin bycatch using plastic bottles (z-value = -1.979, $p = 0.0478$) and a non-significant positive effect on target fish catch using plastic bottles (t-value = 0.965, $p = 0.335$). Passive acoustic monitoring (using F-POD) logged 2,522 h (964 h control, 1,558 treatment) and showed that franciscana dolphins and other odontocetes were present near control and treatment sets. The results showed that upcycled plastic bottles used as acoustic reflectors in bottom set trammel nets and gillnets reduced the bycatch of dolphins (including franciscana) and had no effect on target species catch compared to control sets. Given these positive results we strongly encourage colleagues to trial plastic bottle acoustic reflectors as a low-cost bycatch mitigation method in other sub-surface gillnet fisheries.

INTRODUCTION

Mortality due to fisheries bycatch in gillnets is the main threat to marine mammals globally (Read et al. 2006). The restricted distribution of franciscana dolphins (*Pontoporia blainvillei*) to shallow coastal waters of Brazil, Uruguay and Argentina makes the species vulnerable to incidental mortality in fishing gear, especially coastal gillnets (Secchi et al. 2003; Danilewicz et al. 2009). The franciscana is regarded as one of the most threatened cetacean species in the western South Atlantic Ocean due to likely unsustainable fisheries bycatch (Secchi et al. 2021). The species is currently listed as Vulnerable (VU) by the IUCN Red List of Threatened Species (Zerbini et al. 2017), and as Critically Endangered (CR) by the Brazilian Ministry of the Environment (MMA/ICMBio 2022).

A number of approaches to reduce franciscana bycatch have been attempted, including the use of electronic alarms (pingers), increased acoustic reflectivity of gillnets by infusion of barium sulphate ($BaSO_4$), increased flexural stiffness of the gillnet nylon twine and other modifications of the fishing techniques (Bordino et al. 2002, 2013; Berninsone et al. 2020; Jimenez et al. 2023). To date, only the use of electronic pingers has resulted in a reduction of franciscana bycatch events (Bordino et al. 2002; Jimenez et al. 2023), but they have not yet been implemented in the small-scale fisheries along the species' range. The cost of purchasing and maintenance of the pingers has been identified as the primary barrier to pinger implementation (Bordino et al. 2013; Berninsone et al. 2020).

Simple and cost-effective methods are therefore needed as alternatives to electronic pingers, especially in developing countries and small-scale fisheries. The purpose of this report is to present an update on trials testing the effectiveness of upcycled plastic drink bottles as acoustic reflectors and a low-cost method (Berggren et al. 2020) to reduce dolphin bycatch in bottom set gillnets and their potential effect on target species catch off Torres and Passo de Torres, southern Brazil (Sucunza et al. 2023).

METHODS

This research was conducted in the small and medium-scale fishing community of Torres and Passo de Torres (29º19'S, 49º43'W, Fig. 1), southern Brazil, and was focused on coastal bottom set trammel nets and gillnets. These nets have been identified as the major threat to franciscana dolphins in the area (Ott et al. 2002; Larre et al. 2019). The fishing community includes a total of 55 vessels (ranging from 9.2 to 20.4 m in length, and from 40 to 366 hp in engine power) and currently fishing mainly with trammel nets and gillnets and is regarded as one of the main small and medium-scale fishing fleets of southern Brazil (Moreno et al. 2009; Larre et al. 2021).

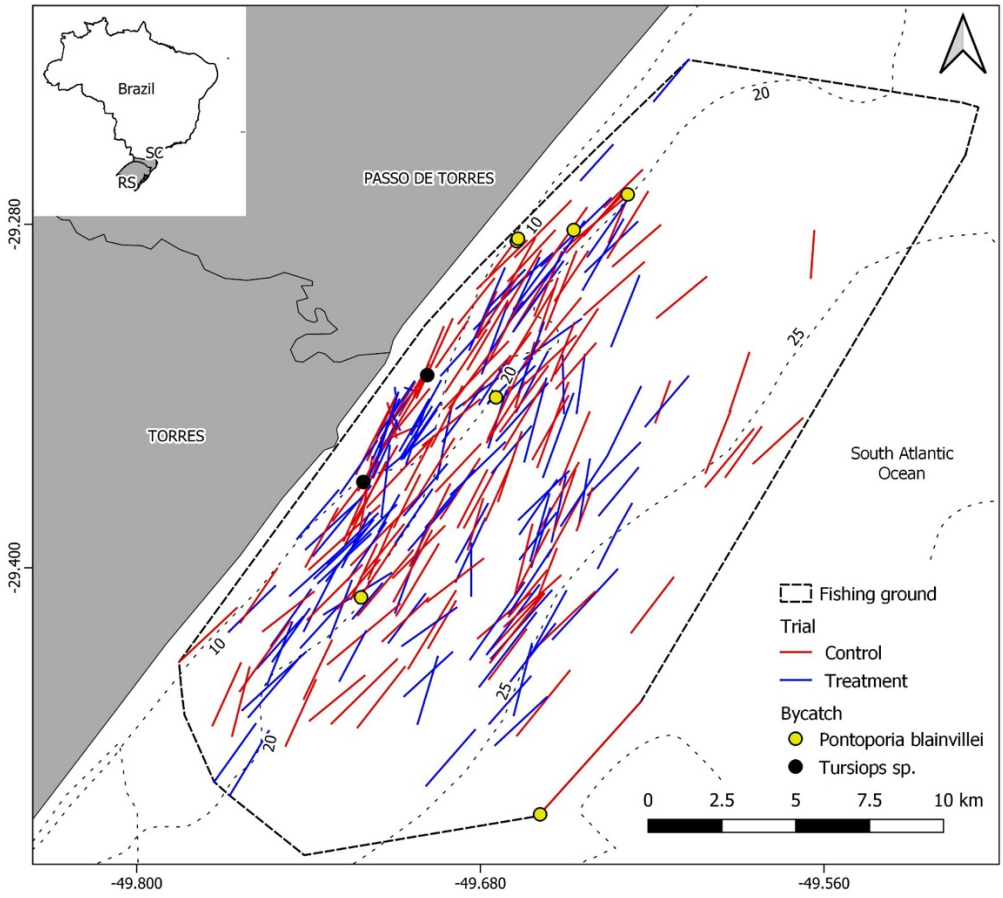

Figure 1. Map of the study area showing the fishing ground of two small-scale 9 m gillnet fishing vessels monitored during experimental trials conducted off the northern coast of Rio Grande do Sul (RS) and the southern coast of Santa Catarina (SC) states, southern Brazil. Control (no plastic bottles on the net) and treatment (plastic bottles attached to the net) sets monitored by onboard observers are shown by the red and blue lines, respectively. Dots indicate bycatch events of franciscana dolphins (yellow) and bottlenose dolphins (black) reported in this study.

Experimental trials were conducted aboard two small-scale 9 m gillnet fishing vessels. Both vessels conducted single-day fishing trips and fished with bottom set trammel nets (60 panels of 50 m length each, 3,000 m total length, 2 m height and mesh size of 18 or 20 cm of the inner netting between two layers of 60 cm) and gillnets (60 panels of 50 m length each, 3,000 m total length, 2 m height and mesh size of 18 or 20 cm). The fishing ground is located close to Torres and Passo de Torres and has an area of 418 km^2 between the coast and the isobath of 30 m (Fig. 1). Upcycled plastic 250 ml bottles were tested as acoustic reflectors to enhance the acoustic backscatter of the nets and detectability by the dolphins (Berggren et al. 2020). Bottles (empty but with air) were attached every ~130 m on the headline of bottom set trammel nets and gillnets. In addition, one F-POD (Chelonia Ltd.) was attached at the ends of the net of each vessel to record acoustic occurrence of franciscana dolphins near the net in presence/absence of plastic bottles. F-POD data were processed using F-POD.exe software and KERNO-F classifier (Chelonia Ltd., 2022) and exported as detection positive minutes (DPM).

Each fishing trip had an independent onboard observer that recorded the fishing location (lat/long), soak time, environmental conditions and catch of target and non-target species. In addition, since December 2023 Shellcatch Virtual Observer cameras (https://web.shellcatch.com) have been used in fishing trips with onboard observers. Trial effort was randomized per each fishing trip (control = no bottles on the net or treatment = upcycled plastic drink bottles attached to the net) by tossing a coin prior to the trip (Berggren et al. 2020). The randomization was done in pairs so if the first coin toss resulted in a control trip, then the following trip was a treatment. However, due to environmental conditions and/or to practical work of the fishers, treatment net could not be used in some sets, resulting in a higher effort with control sets.

Due to the small number of sets with gillnets (n = 30), analyses were conducted for both net types together. Catch per unit of effort (CPUE) was computed as the number of dolphins per fishing effort. Fishing effort was computed as the product of net length and fishing hours. Generalized Linear Models (GLM) with Poisson and Gaussian distributions, respectively, were used to statistically investigate potential effects of nets (control and treatment) and fishing effort on dolphin bycatch and target fish catch.

RESULTS

In the trial, during 233 fishing trips (51 with Shellcatch Virtual Observer camera) a total of 251 (130 control, 121 treatment) sets with bottom set trammel nets and gillnets were monitored by onboard observers between November 2020 and February 2024 (Fig. 1). Targeted catch of both bottom set trammel nets and gillnets were flounders (*Paralichtys* spp.) and the whitemouth croaker (*Micropogonias furnieri*) (Table 1).

Six (CPUE = 0.0005 franciscanas *x* 1000 [km of net*fishing hours]$^{-1}$) franciscana dolphins and two (CPUE = 0.0002 bottlenose dolphins *x* 1000 [km of net*fishing hours]$^{-1}$) bottlenose dolphins (*Tursiops* sp.) were recorded as bycatch in the control sets and one (CPUE = 0.0001 franciscanas *x* 1000 [km of net*fishing hours]$^{-1}$) franciscana dolphin was recorded in treatment sets (Table 1). CPUE, computed for both species together, reduced by 85% from control (CPUE = 0.0007 dolphins *x* 1000 [km of net*fishing hours]$^{-1}$) to treatment (CPUE = 0.0001 dolphins *x* 1000 [km of net*fishing hours]$^{-1}$) nets. The GLM analysis showed a statistically significant negative effect on dolphin bycatch using plastic bottles (z-value = -1.979, $p = 0.0478$). Target fish catch showed a non-significant increase in nets equipped with plastic bottles (mean = 106 kg, SD = 143 kg) compared to control nets (mean = 97 kg, SD = 84 kg) (t-value = 0.965, $p = 0.335$).

Sets with the F-POD attached to the net logged 2,522 h (964 h control, 1,558 treatment), and the acoustic occurrence of franciscana dolphins and other odontocetes was recorded near control and treatment nets. Average DPM for franciscana dolphins was non-significantly higher in control nets (DPM = 0.0144, SD = 0.1189) than in treatment nets (DPM = 0.0134, SD = 0.1150) (t.test, $p = 0.1287$).

Table 1. Total number of fishing sets, average net length in meters, average fishing hours, average catch of target species in kilograms and total bycatch of franciscana dolphins (*Pontoporia blainvillei*) and bottlenose dolphins (*Tursiops* sp.) recorded in the trial testing the effectiveness of plastic bottles (treatment) to reduce bycatch on bottom set trammel nets and gillnets in southern Brazil. Standard deviation (SD) in parenthesis. Control = no plastic bottles attached to the net. CPUE = catch per unit of effort.

Trial	Sets	Mean (SD) net length	Mean (SD) fishing hours	Mean (SD) target species catch weight	#Franciscana bycatch	#Bottlenose dolphin bycatch	CPUE (dolphins *x* 1000 [km of net*fishing hours]$^{-1}$)
Control	130	2,762 (511)	32 (17)	97 (84)	6	2	0.0007
Treatment	121	2,605 (447)	31 (17)	106 (143)	1	0	0.0001

DISCUSSION

This ongoing study reports positive results from using upcycled plastic bottles as a mitigation method to reduce bycatch of dolphins (including franciscana) in sub-surface gillnets. In addition, there was no indication that plastic bottle treatment sets had any negative impact on the catch of target species compared to control sets without bottles. Acoustic monitoring confirmed the presence of franciscana dolphins and other odontocetes (e.g. *Tursiops* sp., *Steno bredanensis*) in the vicinity of the nets. Given the similar prevalence of franciscana dolphins in the vicinity of control and treatment sets as indicated by the acoustic monitoring, and the higher bycatch rate in the control sets, it is possible that the upcycled plastic bottles increased net detectability and allowed dolphins to detect nets and avoid net entanglement.

It is imperative to minimize bycatch rates of franciscana and bottlenose dolphins (Fruet et al. 2016, Secchi et al. 2021), and continued trials are necessary to fully evaluate the effectiveness of upcycled plastic bottles. Although records from independent onboard observers are crucial for the evaluation process, remote electronic monitoring technologies could be used to increase fleet coverage and minimize risks for onboard observers. In this sense, a comparison between onboard

observers and Shellcatch cameras will provide us with information regarding the feasibility of using these cameras to expand the trial to the entire fleet and to promote reproducibility and comparability of fisheries monitoring programs.

Acknowledgments

The authors are very grateful to the artisanal fishing community of Torres and Passo de Torres for allowing us to follow their daily work, especially the vessels' captains Valtamir "Nenê" and Benjamin "Benja". This research was supported by an environmental offset measure established through a Consent Decree/Conduct Adjustment Agreement between Petrorio and the Brazilian Ministry for the Environment, with the Brazilian Biodiversity Fund – FUNBIO as implementer, the Society for the Protection of Aquatic Mammal Species of Latin America – YAQU PACHA E.V., NOAA BREP Award NA18NMF4720298 and the Marine Mammal Commission grant award MMC18-162. F-PODs were provided by Chelonia Limited and Shellcatch Virtual Observer cameras by Shellcatch Incorporated as in-kind contributions for this research. Assistance from the following individuals working at various stages of this study is greatly appreciated: Gabriel Machado, Leonardo Martins Pinheiro, Mauricio Lang dos Santos, Moises Ubiratã and Roberto Rosa.

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