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Low-cost solutions to cetacean bycatch in global gillnet fisheries

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Abstract

Gillnets are used in many small-scale fisheries around the world. Cetaceans often occur as bycatch in gillnets which threaten population health. Bycatch mitigation strategies that work for large commercial fisheries may not be workable in small-scale fisheries because they are costly. This project tested the effectiveness of a simple, low-cost bycatch reduction method known as glass bottle alarms in a small-scale drift gillnet fishery in Peru. The bottle alarms, made from a glass drink bottle with a bolt inside, produce a sound, similar to that of a commercial "pinger", that should allow dolphins to more effectively detect a gillnet and avoid capture. The results suggest that glass bottle alarms do not significantly reduce bycatch of dolphins or turtles in gillnets. Further, the alarms did not affect the catch of target fish except for a reduction in the occurrence of shark catch events. Another potential low-cost technology, plastic bottle acoustic reflectors, will be tested in the coming months in the same fishery.

Introduction

Bycatch poses the single largest threat to cetacean populations at the global level (Read et al. 2006). Despite this, bycatch assessment and mitigation does not attract proportionate levels of research effort, practical implementation or the political will to make measureable and effective progress (Read et al. 2006, Reeves et al. 2011). The majority of mitigation efforts are restricted to large-scale commercial fisheries, whereas many bycatch problems occur in small-scale fisheries (SSF). Of all the fishing gears used by both large-scale and SSF, bottom-set, surface-set and drift gillnets, both monofilament and multifilament, are widely accepted to pose the greatest bycatch risk to cetaceans, thus it is the impacts of these gears where priority actions must be taken. Existing bycatch reduction technologies for cetaceans have focussed primarily on the acoustic component, with electronic alarms (pingers) having been shown to reduce bycatch rates for some dolphin species in gillnet fisheries (Amir 2010; Mangel et al. 2013), though they have not been universally successful (Mangel et al. 2013). The primary barrier to their, and any other potential solution, implementation in SSF is cost. Commercially available alarms cost US$35-100 per 100m of net, which is prohibitively costly for most small-scale fishers. Further, fishers have raised concerns about potential effects on target catch.

This project evaluates novel low-cost (USD$0-0.50 per 100m net) mitigation methods to reduce cetacean bycatch in gillnet fisheries and their effects on target and other non-target catch. The outcomes of the project have application for bycatch reduction in global small scale gillnet fisheries, with potential for scaled application in semi-industrial and industrial sectors if successful. There are many challenges when developing, testing and implementing potential bycatch mitigation measures. In developing country fisheries these primarily relate to economic cost and potential effects on target species catch, but other barriers also exist. This project conducts comprehensive observed trials to evaluate the effectiveness of novel low-cost mitigation methods, 1) glass bottle alarms, and 2) plastic bottle acoustic reflectors, in reducing bycatch of dolphins in gillnet fisheries for which there are documented high bycatch rates. Here we report on trials of glass bottle alarms in a pelagic driftnet fishery off Salaverry, Peru.

Methods

The study was conducted between March 2019 and January 2020 under normal fishing conditions aboard two small-scale drift gillnet fishing vessels departing from the port of Salaverry (8° 12'S, 78° 58'W Fig. 1). The small-scale vessels have a maximum length of 15m and rely on manual work during fishing operations. The fishing area is up to approximately 100nm off Salaverry. Target species are primarily elasmobranchs including smooth hammerhead sharks (*Sphyrna zygaena*), blue sharks (*Prionace glauca*) and eagle rays (*Myliobatis spp.*) However, the fishery is somewhat opportunistic and also catches other species such as tuna (*Thunnus spp*.), dolphinfish (*Coryphaena hippurus*) and other Osteichthyes (Alfaro-Shigueto et al. 2010).

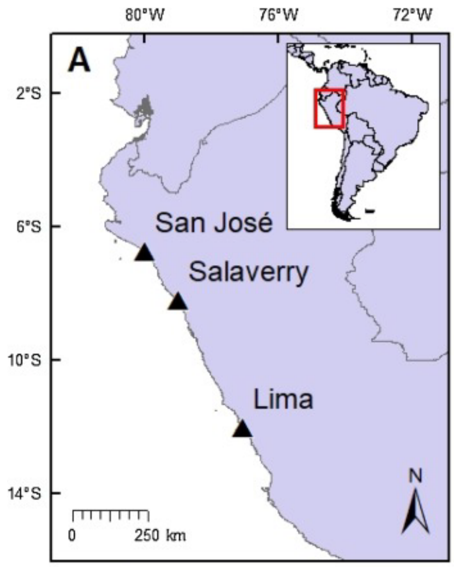

Fig.1. The location of Salaverry the port of the fishing vessels that participated in the trial using glass bottle alarms as a potential mitigation method to reduce dolphin bycatch in driftnets.

The glass bottle alarm is a regular 350ml glass drink bottle with a bolt suspended on a string inside the bottle, attached by a screw to a rubber stopper (Berggren et al. *In review*). The bottles are mounted vertically with the neck of the bottle tied to the net head rope and the bottom of the bottle to the net mesh. When the bottle moves, the string inside acts as a pendulum to provide mechanical amplification, making the bolt hit the side of the bottle even with little motion (Fig. 2a-c). This creates an acoustic signal with a mean of 120 (95% CI 117-123) dB re 1uPa/√Hz @ 1m at 10 kHz (measured in a sound tank at Newcastle University, UK). The sound produced by the glass bottle alarms should allow dolphins to detect nets, if equipped with the bottles, in time to avoid entanglement. Bottles were attached every $\bar{x}$ =93m (SD=5m) on the headrope of the driftnet.

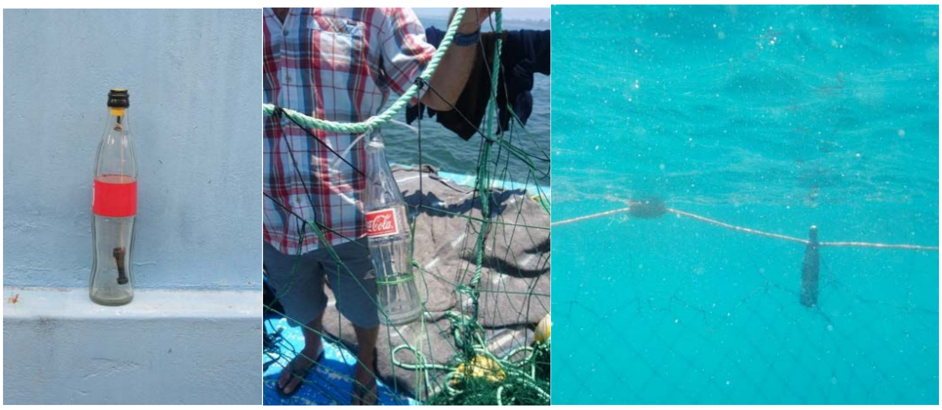

Fig. 2a-c. The glass bottle alarm is a regular 350ml glass drink bottle with a bolt suspended inside by a string attached to the stopper. The bottles are mounted vertically on the net head rope and when the bottle moves, the string acts as a pendulum making the bolt hit the side of the bottle producing an acoustic signal.

Two fishing vessels were used during the trial using the same type of net (multifilament 3km driftnet) and net configuration ($\bar{x}$ =33 panels of $\bar{x}$ =93m length and $\bar{x}$ =13.7m height with 8 or 9 inch mesh size). Each vessel had an independent observers aboard that recorded fishing effort and catch during all sets. Vessels were typically at sea for one week (a fishing trip) before returning to port with their catch. Each fishing trip consisting of multiple sets. Each vessel randomised their trial effort per fishing trip (control=no bottles on the net or treatment=glass bottles attached to the net) by tossing a coin prior to the trip. The randomisation was done in pairs so if the first coin toss resulted in a control trip then the following trip was treatment. The outcome for the next two trips were then decided by a new coin toss. Vessels were either control or treatment for the duration of each trip.

Data analyses

We used Generalized Linear Hurdle Models, with the truncated negative binomial distribution assumed for the conditional portion of the model, to assess the two-step potential effect of glass bottle alarms on: 1) the likelihood of presence/absence of taxa in driftnet net sets, and 2) the level of catch in those sets where catches were present. This was considered appropriate as it allows for the simultaneous exploration of two potential modes of change in catches that could result from gear modification. The analyses presents the fixed effect of treatment on resultant catch, whilst accounting for fishing trip, season, captain, and observer as random effects and includes fishing effort as a model offset.

Results

In the trial, 120 driftnet sets were conducted for both control nets and treatment nets with glass bottle alarms for a total of 4146 hours fished and at an average net length of $\bar{x}$= 3.06km (SD ±0.61km). Catches were recorded by the onboard observers for bycatch (dolphin, sea turtle) and target catch (sharks, rays, teleosts) taxa. Summary data on effort and catch during the trial is presented in Table 1.

Table 1. Summary of the results from the trial testing impact of glass bottle alarms on catch in driftnets.

Treatment	Sets	Fishing Hours		Net Length	Sharks			Hammerheads			Rays			Teleosts			Turtles			Dolphins		
		Total	Mean	Mean km	Events	Catch	Mean	Events	Catch	Mean	Events	Catch	Mean	Events	Catch	Mean	Events	Catch	Mean	Events	Catch	Mean
Control	120	1968	16 ± 2.8	3 ± 0.9	94	3958	42 ± 87	74	3617	49 ± 95	24	1274	53 ± 69	15	179	12 ± 10	16	19	1 ± 0.4	13	16	1 ± 0.4
Bottles	120	2178	18 ± 3.7	3 ± 0.4	114	3598	32 ± 35	92	3379	37 ± 37	7	305	44 ± 43	15	1023	68 ± 83	21	24	1 ± 0.5	16	18	1 ± 0.3

Initial results suggest no significant ($p>0.05$) effects of glass bottles alarms on the presence, or subsequent level given presence, of catches for dolphins, turtles, rays or teleosts in driftnet sets. A significant negative effect of glass bottles alarms on the presence of sharks in driftnet catches was found but no effect was seen on the subsequent level of shark catches given presence. There was no significant effect of glass bottle alarms if only catches of smooth hammerheads (*Sphyrna zygaena*), which make up 92.5% of shark catches by number, were considered. These contrasting results suggest that glass bottle alarms may affect the likelihood of some other shark species being caught.

Discussion

We tested a low-cost potential dolphin bycatch mitigation device developed from upcycled glass drink bottles. The bottle alarms used share similar acoustic properties with commercially available electronic pingers but with shorter, more variable and wider spectral energy (Berggren et al. *In Review*). The glass bottle alarms therefore have signal characteristics with the potential to mitigate bycatch of a range of cetacean species. Upcycled devices offer a vast cost saving option compared to using commercially available pingers and would remove the current economic obstacle for SSF fishers to implement bycatch mitigation.

The trial conducted in the driftnet fishery off Salaverry, Peru, suggests that glass bottle alarms do not significantly reduce bycatch of dolphins or turtles in gillnets. Dolphin bycatch in nets with bottles occurred at a distance of $\bar{x}$=34m (sd=16m) from the next bottle in the net. Only three of the total 18 dolphin bycatches occurred close to bottles in the net (at 6, 9 and 18m from the nearest bottle, respectively) indicating that any future trials with the glass bottles should consider a closer spacing between bottles.

Further, the alarms did not affect the catch of target teleost fish or rays. A reduction in the presence of sharks in gillnet hauls was observed, but in those hauls with shark catches that number of animals caught did not differ between control and treatment hauls. When considering only hammerheads, which make up 92.5% of shark catches by number, no difference was seen in their presence in gillnet hauls nor subsequent number of animals caught in those hauls with hammerhead catches. These contrasting results suggest that non-hammerhead shark catches may have a disproportionate effect on the presence/absence component of the model, relative to their contribution to overall shark catches. This possibility is supported when we consider that hauls containing sharks, but no hammerheads, constitute 20.2% of the total hauls with sharks, despite non-hammerheads representing <8% of all shark catch. The potential effects of glass bottle alarms on non-hammerhead shark species will receive further attention in future analyses.

Participating fishers did not perceive any negative impacts of the bottles on their fishing catches. Some initial breakages of glass bottles was mitigated by adjusting hauling speeds when net sections with bottles approached the boat.

The next step in our efforts to develop low cost mitigation solutions to cetacean bycatch in gillnet fisheries will be to test plastic drink bottles as acoustic reflectors in gillnets. Tank tests with 500ml plastic bottles produced strong reflections (-27 dB target strength) to simulated dolphin clicks (Berggren et al. In Review) representing a 100-1000 fold increase in target strength compare to typical gillnet (-62 to -46dB) and should help dolphins detect gillnets in time to prevent entanglement. The trials will be conducted in the same Peruvian driftnet fishery as used in the glass bottle trials, however the start of these new trials has been delayed due to the Covid-19 pandemic. These trials will commence as soon as the situation improves.

Acknowledgement

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