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Coexisting in the Peruvian Amazon: Interactions between fisheries and river dolphins

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Abstract The freshwater tucuxi (*Sotalia flluviatilis*) and the Amazon River dolphin (*Inia geoffrensis*) are endemic to the Amazon-Orinoco river basin. Their conservation is hindered by human disturbance and uncertainty about total population size and distribution. In this study, we used rapid assessment questionnaires to identify threats to river dolphins found in Peru and to identify priority areas for their further study and conservation. We administered questionnaires to fishers (surveyed 2010 n=162, 2015 n=251) and community members (surveyed 2015 only; n=118) at 12 landing ports of the Peruvian Amazon, asking questions about their knowledge, perception and interactions with river dolphins. Dolphins were

observed by interviewed fishers based across all ports except for Aguaytia port, which was subsequently excluded from further analysis. Across the sampled ports in 2010, an average of 86% of fishers (range: 59-100%; n=8 ports) associated dolphins with negative economic impacts, largely due to net damage, with similar findings in the more extensive survey in 2015 (74%, 27-100%; n=11 ports). Bycatch of dolphins was also reported in 11 ports, with a higher incidence in the state of Loreto, where up to 10 bycaught individuals per fisher per year were reported for both time periods. The use of dolphins as bait has been practised from at least 2010 (2010: 31% of fishers, 11-57%; 2015: 31%, 0-63%) and is prevalent (>40%) in four of the surveyed ports (Caballococha, Bagazan, Requena and Manantay). Our study can be used as a first reference to guide monitoring of river dolphin populations in priority areas. Future efforts should revisit and extend this survey to other ports in Peru. Doing so will enable detection of trends in fisheries conflicts with river dolphins and improve the estimation of bycatch and direct take of dolphins in the Peruvian Amazon.

Keywords Bycatch, Bait, Small cetacean, Dolphin, Conservation, Small-scale fisheries

Introduction

Fishing is one of the leading economic activities in the Peruvian Amazon basin, with landings of up to 80,000 tonnes and revenue of 80 million USD annually (Tello & Bayley, 2001; Garcia et al., 2009). Amazon fisheries can be divided into subsistence and commercial fisheries (RM No 147-2001-PE, 2001). Subsistence fishing is an activity practiced by most families living in riverside settlements (Tello-Martin & Montreuil-Frias, 1994) where they capture resources to meet their basic needs and sell the surplus of fresh fish in local markets, or salt and dry it for sale to merchants that operate in larger cities (Vargas et al., 2012). A total of 75% of the landings are for subsistence, as fish is the primary source of animal protein in local communities (Tello & Bayley, 2001; Vargas et al., 2012). The other 25% of landings is from the commercial fleet, dominated by fisheries for three target species (boquichico *Prochilodus nigrians*, llambina *Potamorhina altamazonica*, ractacara *Curimata spp*), supplying regional markets in cities of the states of Loreto and Ucayali (Garcia et al., 2009). Despite their importance to the local and regional economy, these freshwater fisheries remain under-studied in comparison with Peruvian marine fisheries (Alfaro Shigueto et al., 2010; FAO, 2010; Fréon et al., 2014).

Fisheries interactions are a severe threat to many long-lived and slowly reproducing species (Crowder et al., 2008; Alfaro Shigueto et al., 2011; Crawford et al., 2017). Marine mammals, specifically, are vulnerable to targeted fisheries and as bycatch within industrial and small-scale fisheries (Read et al., 2006; Reeves et al., 2013; Avila et al., 2018). Cetaceans that have limited distributions and small population sizes are particularly vulnerable to the impacts of human activities (Avila et al., 2018). An example of this is the vaquita (*Phocoena sinus*), a porpoise found exclusively in the Gulf of Mexico, now close to extinction, with estimates of fewer than 30 individuals remaining (Jaramillo-Legorreta et al., 2019; Rojas-Bracho et al., 2019).

Another vulnerable group of aquatic mammals are the freshwater dolphins inhabiting large rivers systems. Their freshwater habitats are among the most threatened ecosystems in the world (Pavanato et al., 2016; Anderson et al., 2018) and, as human populations grow, the strain on rivers and lakes increases. Factors such as pollution, infrastructure (e.g. dams, artificial waterways) and fisheries pressure can diminish freshwater habitat quality (Revenga et al., 2005; Pavanato et al., 2016; Latrubesse et al., 2017). The baiji (*Lipotes vexillifer*) was endemic to the Yangtze River and was proposed functionally extinct in 2007 (Turvey et al., 2007). Its decline was attributed to the high incidence of bycatch in fishing gear and the industrialization of the Yangtze river ecosystem (Turvey et al., 2007, 2013). The Ganges River dolphin (*Platanista gangetica*) and the Indus River dolphin (*Platanista gangetica ssp. minor*) are both listed as Endangered by the International Union for Conservation of Nature (IUCN), while the Irrawaddy dolphin (*Orcaella brevirostris*) is considered Vulnerable (Reeves et al., 2008; Braulik et al., 2012; Smith et al., 2012). These three species overlap with fisheries in their habitats and are reported to occur as bycatch (Sinha, 2002; Baird & Beasley, 2005; Smith et al., 2006; Brownell et al., 2019). Additionally, there is a direct take of Indus and Ganges dolphins driven by the use of blubber oil as bait in catfish fisheries (Sinha, 2002).

The freshwater tucuxi dolphin *(Sotalia flluviatilis*) (hereafter referred to as *Sotalia*) and the Amazon River dolphin, also known as boto (*Inia geoffrensis*) (hereafter referred to as *Inia*) are endemic to the Amazon-Orinoco river basin (Jefferson et al., 2008). Currently *Inia* is listed as Endangered and *Sotalia* as Data Deficient by the IUCN (Secchi, 2012; Da Silva, Trujillo, et al., 2018). South American river dolphins have been recorded as having been used as bait in the catfish (commonly known as piracatinga or mota; *Calophysus macropterus*) fisheries in Brazil (Loch et al., 2009; Mintzer et al., 2013; Brum et al., 2015), Colombia (Mosquera-Guerra & Trujillo, 2015) as well as in Bolivia and Venezuela (Aliaga-

Rossel, 2003; Bolaños-Jiménez et al., 2015). The illegal harvest of Amazon river dolphins for this purpose has undoubtedly contributed to their population decline (Williams et al., 2016; da Silva et al., 2018; Mintzer et al., 2018). Additionally, traditional beliefs of dolphins enchanting, kidnapping and impregnating women have created an image of *Inia* as a mischievous being, and as such, people harvest their body parts to use as love charms and amulets in Brazil (Alves & Rosa, 2008; Siciliano et al., 2018). To date, research has primarily focused on the utility of protected areas for conserving dolphin populations (e.g. McGuire, 2010; McGuire et al., 2014) and in generating population estimates, distribution and density maps in Brazil and Colombia (Martin & da Silva, 2004; Gomez-Salazar et al., 2012). Data on the status and threats faced by these two legally protected species in Peru are particularly lacking (Anon., 1996; Campbell et al., 2017).

Here we report the results of two surveys undertaken five years apart, using a rapid, interview-based method modified from studies applied in other marine and riverine locations (Moore et al., 2010; Turvey et al., 2015). Our aims were to: (1) generate information on the perceptions and the interactions of Peruvian fishers and river dolphins, (2) to determine the practice of using dolphins as bait in Peruvian fisheries, and (3) to assess other factors (e.g. bycatch, traditional use) that may affect the conservation of these species.

Methods

Study area

Our study was conducted from April-June, 2010 and May-July, 2015 in ports and landing sites in the states of Loreto and Ucayali in the Peruvian Amazon (Fig 1). Loreto and Ucayali yield most of the continental fish products of Peru, with 28 054 tonnes and 8635 tonnes landed in 2015 in the two states, respectively (PRODUCE, 2015). Landings in these regions may come from the Amazon and Ucayali rivers as well as the Marañon, Huallaga, Napo, Tigre, Putumayo, Nanay, Yavari and Morona rivers. Sampled ports in Loreto state were: Nauta, Requena, Bagazan, Nanay, and Puerto Pesquero and Productores in Iquitos city. In Ucayali state, we sampled Calleria, and Yarinacocha ports (Fig 1). We chose these ports because they are the main landing sites for fish products, and they provide a wide spatial coverage of Peruvian Amazon fisheries. In 2015, we extended the study to include the following sites: Caballococha and Puerto Masusa in Loreto, and Manantay and Aguaytia in Ucayali state, thus covering 46% of major landing sites in the Peru Amazon (PRODUCE, 2015).

Questionnaires were administered to fishers who lived and fished near each landing site. We surveyed between 6 and 12% of fishers registered in each sampled area. The total number of fishers from each port was obtained from national census data (PRODUCE, 2013) or for ports that were not included in census data, we visited local government agencies for current estimations. We interviewed a total of 162 (81% Loreto, 19% Ucayali) and 251 (69% Loreto, 31% Ucayali) fishers in 2010 and 2015, respectively. In 2015, we also interviewed 118 community members (79% Loreto, 21% Ucayali).

Questionnaires were conducted by trained local scientists with previous experience relevant to this study. The survey was designed to evaluate fishing habits, fisher interactions with dolphins, and fisher perceptions of *Sotalia* and *Inia*. Specifically, the 33 questions (see SOM 1) addressed: Fishery practices and areas, areas of presence/absence of river dolphins, conflicts between fisheries and dolphins, and traditional uses and beliefs related to dolphins. Each questionnaire took approximately 30 minutes to complete. Twenty-three of the questions were closed-ended. Participants were approached at ports, close to their boats, or at shops close to piers. At the beginning of each interview, respondents were informed about the general objectives of the study and were assured that the data would be collected and stored anonymously. Surveys were administered once participants gave their verbal consent and confirmed they were boat captains. The questionnaires were carried out 1:1 to the captains of each vessel to assure that only one fisher per vessel participated. As fishing is practised almost exclusively by men, all interviewed fishers were male and no particular age group or type of fisher (commercial, subsistence, or type of fishing gear used) was targeted. No problems were identified with fisher participation in surveys (zero refusal rate). In 2015, in addition to fishers, we also surveyed community members who were not directly involved in fishing activities at each sample site to better understand what residents of local communities know about river dolphins. These participants were approached in markets and city plazas, in the early hours of the afternoon. No gender or age group was targeted specifically. These surveys had 12 questions addressing river dolphins, beliefs and commerce of dolphin body parts, and perceptions relating to these species. These surveys took about 20 minutes and were also anonymous. We aimed to have at least ten participants at each site.

All responses from fisher and community interviews were annotated on printed survey sheets and entered into a spreadsheet database. For open-ended questions, we initially read through all respondents' answers and identified where a similar response was repeated by multiple participants. These responses were categorised into selected themes and assigned a code.

Close-ended questions had multiple choices where each answer represented a code. Codes from both questions were then analysed as percentages. To gain a synthetic view of bycatch a minimum estimate was created per landing site by summing the estimates for all surveyed fishers.

Results

Fishery and fisher description

Most respondents were under 50 years of age (2010: 67% on average across all ports, range 32-93% at individual ports; 2015: 77%, range 57-100%) (from herein, average value for all ports is shown first, followed by a range of averages across the individual ports), most were between 30 to 50 years of age with less than 20 years of experience in the fishing sector (2010: 68% 32-86%; 2015: 59% 18-90%). Fishers most often reported using "*peque peque*" boats, canoes with outboard motors of up to 12 horsepower (HP) (2010: 72.5%, 28-100%; 2015: 60.3%, 0-100%). The boats used by fishers included larger vessels, which simultaneously transport food, construction materials, passengers and other resources to the ports from other riverine communities. These boats have engines with a maximum of 20 HP (2010: 24.6% range 0-64%; 2015: 31.3% 0-100%). Fishers also used boats without motors (2010: 2.9%, 0-10%; 2015: 8.3%, 0-100%).

The most commonly used fishing gear recorded in both survey years were gillnets "*agallera*" (Table 1, 2010: 30%, 4-54%; 2015: 56%, 0-100%) or "*honderas*", similar to a purse seine (2010: 31%, 9-42%; 2015: 32%, 0-100%). Other frequently reported gears were hooks (2010: 8%, 0-19%; 2015: 10%, 0-27%) and traps (2010: 24%, 0-42%; 2015: 2%, 0-11%). Most respondents reported being opportunistic fishers (2010: 23%, 13-33%; 2015: 38%, 0-100%), meaning they catch what they can find. A variety of target catch species were recorded, the most frequently mentioned species was the boquichico (*Prochilodus nigricans*) (2010: 20%, 11-31%; 2015: 30%, 0-50%), followed by the palometa (*Mylossona sp.)* (2010: 13%, 5-19%; 2015: 18%, 0-50%) and the catfish zúngaro (*Brachyplatystoma spp.)* (2010: 11%, 2-25%; 2015: 5%, 0-23%). A minority of fishers from all ports responded that they targeted catfish piracatinga specifically (2010: 2.4%, 0-6%; 2015: 3%, 0-15%). Ports such as Pesquero and Productores contained higher concentrations of fishers who targeted piracatinga (12% and 15% of interviewed fishers, respectively) in 2015, in contrast to results from 2010 where the port with the highest percentage was Productores, at 6% of interviewed fishers.

In 2015, we added questions to the survey about the number of crew members and duration of fishing trips. Respondents reported fishing alone (SOM 2, 31%, 0-100%), with up to three crew members (2015: 26%, 0-100%), or larger crews of up to 10 members (24%, 0-81%). Trips lasted from one day (2015: 33%, 0-100%), up to five days (2015: 31%, 0-71%) or longer than 10 days (18%, 0-95%). These longer trips with more crew members were concentrated in Pesquero, Productores in Loreto and Calleria, Ucayali.

Dolphin-fisher interactions

We initially asked if the fishers had observed dolphins and if they knew how to differentiate between the two species, *Inia* and *Sotalia* (Table 2). Only the fishermen interviewed in Aguaytia answered that they had not seen dolphins in that region and therefore could not distinguish between the two species. Therefore, values from Aguaytia are excluded from all following analyses. In the other ports, most fishermen reported seeing both species in their lifetimes (2010: 94%, 67-100%; 2015:97%, 80-100%) and were able to distinguish between them (2010: 91%, 65-100%; 2015: 99%, 89-100%). This was confirmed by asking fishers what characteristics they use to differentiate species (size and/or coloration).

Most fishers interviewed reported conflicts with dolphins in their fishing areas (2010: 86%, 59-100%; 2015: 74%, 27-100%) (no difference between study years, Wilcoxon test $P > 0.05$). When asked what the problem was, in order of frequency the responses were entanglements in nets (dolphins break or damage fishing gear, 2010: 79%, 54-93%; 2015: 87%, 67-100%) followed by dolphins stealing fish (2010: 12%, 0-30%; 2015: 6%, 0-14%). Both options affect fishers economically. The third most frequent response was that *Inia* are aggressive towards boats (2010: 8%, 0-23%; 2015: 7%, 0-24%). Regarding this response, one participant noted that when many *Inia* were aggregated, they "*try to turn the boats, hit the boat or follow us on our return to port".*

When asked about river dolphin bycatch, approximately half of fishers reported having at least one incident of river dolphin bycatch, either released dead or alive, during their fishing trips within the last year (2010: 58%, 5-100%; 2015: 68%, 45-100%) (Fig 2a). Respondents from some ports had higher reported incidence of bycatch: Loreto: Nauta (2010: 68%; 2015: 75%) Pesquero (2010: 68%; 2015:63%) Productores (2010: 56%; 2015: 80%) Requena (2010: 100%; 2015: 60%) and Ucayali: Calleria (2010: 50%; 2015: 75%). We asked fishers how many individuals were bycaught per year. For both periods of the study, one capture per year was the most common answer (2010: 27%, 6-61%; 2015: 25%, 0-100%). The number of fishers that reported more than 3 dolphins a year was small (2010: 19%, 3-34%;

2015: 11%, 0-40%), but still at a level important for overall dolphin conservation. Respondents indicated that most entangled dolphins were found alive (2010: 72%, 43-88%; 2015: 89%, 77-100%). Also, the majority of respondents answered that *Inia* is caught more frequently than *Sotalia* (2010: 59% 17-88%; 2015: 64% 27-92%).

Calculating the minimum estimate from our 2015 questionnaire results, we can roughly estimate that the 251 fishers we surveyed from the studied ports (encompassing approximately 10% of vessels) have an approximate annual bycatch of 182 dolphins (Table 3).

Use of river dolphins

Regarding the fates of the entangled dolphins, most of the respondents reported that dolphins were released, either alive or dead (2010: 84%, 55-100%; 2015: 81%, 67-100%). However, some fishers did reply that in some cases when dolphins are found entangled alive, they are killed and sold (2010: 5%, 0-18%; 2015:7%, 0-16%) or killed and discarded (2010: 4%, 0-18%; 2015: 3%, 0-17%). Both in 2010 and in 2015, approximately a third of fishers (2010: 31%, 11-57%; 2015: 31%, 0-63%) reported that they knew of someone using dolphin parts as bait, with considerable variation in the frequency of dolphin bait among sites (Fig 2b). No significant difference was found comparing between years for use of dolphins as bait (Wilcoxon test, $P > 0.05$), but some ports are worth highlighting as having high frequency of use of dolphin bait: Caballococha (2015: 46%), Bagazan (2015: 41%) Requena (2015: 63%) and Manantay (2015: 50%).

Community surveys

In 2015, we also surveyed community members. Aguaytia was again excluded from further analysis as dolphins were not known in the area. Ninety percent of respondents knew of river dolphins (range: 60-100%), and 76% reported seeing dolphins in their locality (60-100%). When asked where they had learned about river dolphins, 37% (0-72%) of respondents answered community surroundings, followed by family (30%, 7-100%), media and press (23% 0-60%), and at educational institutions (14%, 0-40%). When asked about the sale of dolphin parts, 56% (20-100%) of respondents indicated that they knew where dolphin parts were sold. When asked what the parts were used for, the most frequent answers were for bait (49%, 0-100%) and for traditional use (31%, 0-100%). In terms of their conservation, 81% (50-100%) of respondents thought that river dolphins are endangered and 26% (0-84%) reported knowing that they are legally protected species.

Discussion

This study is the first in Peru to assess and analyse perceptions of fishers and local community members regarding river dolphin occurrence and fishery interactions and our findings offer valuable insights into the current status of threats that both dolphin species face. Our research shows that fishers from the Peruvian Amazon are well acquainted with river dolphins. They correctly identified how to differentiate between species. In general, respondents had a more negative perception of *Inia*, which they considered to be an aggressive species. These perceptions could be related to legends of enchantment and kidnapping shared with other Amazon regions that lead to the use of dolphin body parts as love charms (Alves & Rosa 2008, Mintzer et al. 2015, Siciliano et al. 2018).

Bycatch

We can conclude that there is river dolphin bycatch in all the ports surveyed, with the exception of Aguaytia. For 2015, we estimate that a minimum of 182 dolphins were bycaught annually in surveyed ports. In these ports we surveyed the captains of 251 fishing vessels with approximately 3 fishers per boat. Given there are an estimated 9735 fishers working across in Ucayali and Loreto (PRODUCE, 2013), bycatch numbers could, therefore, be at least an order of magnitude higher. This is a conservative estimate given fisheries census data are seven years old. Also, as catching river dolphins is forbidden, it is also possible that the number of dolphins captured was underreported by respondents. This tendency to under-report is common in cases where the study species are protected (Turvey et al., 2013). Our results demonstrate that bycatch occurs (and likely at higher levels than reported here) and point to potential conservation priority areas, where higher rates of bycatch occur.

River dolphin bycatch was first reported in Peru by Leatherwood and Reeves (1994) and was highlighted as the primary conservation concern at that time, demonstrating that pressure from fishing interactions has existed at least for the past two decades. There is no information on abundance available for either of the dolphin species in this part of the Peruvian Amazon basin (Secchi, 2012; Da Silva, Trujillo, et al., 2018). Therefore, it is not possible for us to conclude whether the reported differences in bycatch incidence are related to variations in river dolphin abundance. There were higher rates of bycatch reported in the state of Loreto than in Ucayali, specifically in locations far from urban areas, such as Bagazán, Requena, and Caballococha. Loreto sees the landing of most of the freshwater hydrobiological resources of Peru (PRODUCE, 2015), this could indicate that there is greater fishing pressure in Loreto, which in turn could result in a higher bycatch rates. Freshwater fisheries have also changed in the last decade. Between 2005 and 2015, commercial species such as the pirarucu *Arapaima gigas* or the dorado *Brachyplatystoma rousseauxii* went from 7% to less than 1.5%

of the total landings, with new species now dominating landings (Garcia Dávila et al., 2018). The widespread subsistence fisheries have also shifted, going from more selective gears such as harpoons or hook and line to less selective small mesh nets (Sueiro & De la Puente, 2015). The proliferation of nets in the Amazon could also be related to the frequency of bycatch. Most of the fishers interviewed in this study used either gillnets or purse-seines. Previous studies on river dolphin bycatch (Whitty, 2015, 2016; Dewhurst- Richman et al., 2019) have shown higher incidence of bycatch in areas that overlap with gillnet fishing areas.

Use as bait & the piracatinga fishery

Regarding the use of river dolphins as bait for the piracatinga fishery, our results show that, in 2010, the practice was already occurring in some areas of Peru and this continued in 2015. Using river dolphins as bait is illegal in Peru and we suspect that some of the participants feared legal repercussions if they confirmed the use of these protected species in their fishing communities. The use of river dolphins as bait is consistent with reports from other countries in the region, including Colombia and Brazil, where *Inia* and caimans have been reported as used as bait in the piracatinga fishery over the last decade (Salinas et al., 2014; Cunha et al., 2015; Mosquera-Guerra & Trujillo, 2015). Mintzer et al. (2015) found that 98% of interviewed fishers knew of the use of dolphins as bait, and 67% of them could identify at least one community, theirs or elsewhere, where directed take was occurring. A study developed in the western Brazilian Amazon monitored the piracatinga fishery and found that both dolphin species were used as bait in 30% of the fishing events (Iriarte & Marmontel, 2014). These results are higher than those reported in our study for Peru, which could be caused by underreporting or actual differences in the frequency of use of dolphin bait. The Brazilian government announced a 5-year moratorium on the commerce and trade of piracatinga effective January 2015 (Instrução Normativa Interministerial n° 6, of July 17th, 2014). As the effects of this moratorium in Peru are unknown, close monitoring of these issues in Peru could help generate more data to support our findings and generate actions to prevent this problem from increasing in frequency or expanding to other areas.

In the last 10 years there has been an increase in piracatinga landings, with consistently high landings reported between 2008 and 2011 averaging 216 tons a year (Garcia Dávila et al., 2018). These landings continue to increase, with 331 tons registered in 2016 for Loreto (Garcia Dávila et al., 2018). Among our respondents, there were a few who reported piracatinga as their main target fish and indicated the use of dolphins as bait. This could suggest that there is a growing market for piracatinga. Two respondents commented that these specialized fishers were foreigners, that "*came to instruct local fishers on piracatinga*

fishing techniques" (pers. comm.) and that the catch was exported. The Peruvian customs authority (SUNAT) has not yet assigned codes to differentiate piracatinga from other species of catfish, making it impossible to track its importation or exportation.

Research in global context and next steps

Surveys with fishers and community members have helped us develop a first assessment of the incidence of river dolphin bycatch events in Peruvian Amazon fisheries. Our results suggest that fishery interactions in the forms of dolphin bycatch and deliberate take should be prioritized as a main conservation threats to *Sotalia* and *Inia* in the Peruvian Amazon. The use as bait was the main reason that IUCN red list status for *Inia* was changed to endangered (Da Silva, Trujillo, et al., 2018), with steep population declines seen within protected areas in Brazil (Da Silva, Freitas, et al., 2018). If bycatch and aquatic mammal bait are combined with other existing (Mosquera-Guerra & Trujillo, 2015; Pavanato et al., 2016) and potential threats such as infrastructure development (Finer & Jenkins, 2012; Alfaro Shigueto et al., 2018), the negative effect on population numbers could be substantial (Williams et al., 2016; Da Silva, Freitas, et al., 2018).

An important next step will be to more accurately define bycatch rates and overall numbers of dolphins killed as bycatch. This would be best accomplished with a more intensive monitoring program. For example, onboard observer and community landing site observer programmes have been successfully implemented in artisanal fisheries elsewhere for marine vertebrates (Mangel et al., 2010; Humber et al., 2011) and could potentially be implemented in the Amazon. Bycatch mitigation techniques should be tested and implemented in areas with high bycatch. Pingers have been successful for reducing interactions between fishing gear and other cetacean species (Barlow & Cameron, 2003; Dawson et al., 2013). Studies focusing on pingers in freshwater habitats are limited, but they were tested on *Sotalia* in Brazil and individuals were found to be responsive to the acoustic alarms (Avila & Andrade, 2004). Further work could be done to see if this mitigation technique is viable in freshwater ecosystems.

We recommend that interviews with Amazon fishers be revisited in the near future. In addition, these could be expanded to other ports of Peru as well as administered during the dry season to see if our responses were affected by retrospective bias caused by the very different water levels during the wet season. The Brazilian moratorium on piracatinga fishing expired in January 2020 and through similar questionnaires we could obtain insights into how this legislation has affected fisheries in Peru. New legislation prohibiting piracatinga commerce and trade in Colombia (R1710-August 2017) could also affect demand and

feasibility of exportations from Peru (e.g. legal, illegal or underreported commerce). By administering these questionnaires, we will be able to detect longer-term trends in the use of dolphins as bait and of the piracatinga fishery.

Author contributions E.C., J.C.M., and J.A.S. designed and performed the study. All authors interpreted data and contributed to writing the manuscript and gave final approval for publication.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conflicts of interest None.

Ethical standards This project was approved by the Ethics Committee at the University of Exeter (eCORN001707).

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TABLE 1 Demographic and fishing activity characteristics of fishers who participated in the study. Caballococha, Masusa, Manantay and Aguaytia ports were not included in the 2010 study. Gear types refer to Honderas (Hond), Agalleras (Agall).

		2010								2015							
		% of Fishers >50 years old	% of fishers fishing >20 years	% of fishers with vessels			% of fisher using			% of fishers >50	% of fishers fishing >20 years	% of fishers with vessels			% of fisher using		
				No engine	≤12 HP	>12 HP	Hond	Agall	Hooks			No engine	≤12 HP	>12 HP	Hond	Agall	Hooks
Loreto	Bagazan	59	86	0	77	23	48	4	0	59	54	0	80	20	15	85	0
	Pesquero	59	86	0	77	23	30	37	19	69	18	0	19	81	100	0	0
	Nanay	78	63	5	69	26	42	32	16	83	44	0	78	22	22	56	22
	Nauta	71	68	0	92	8	18	38	18	96	54	0	83	17	21	54	25
	Productores	56	56	0	100	0	31	23	0	100	60	0	53	47	47	40	13
	Requena	32	32	10	90	0	9	36	5	80	74	0	93	7	23	73	4
	Caballococha									75	71	0	70	30	36	64	0
	Masusa									87	80	0	91	9	13	53	27
Ucayali	Calleria	92	76	0	47	53	29	54	4	70	50	0	0	100	85	15	0
	Yarinacocha	93	75	8	28	64	41	12	0	57	68	0	57	43	21	54	14
	Manantay									60	90	0	100	0	0	75	20
	Aguaytia									90	50	100	0	0	0	100	0
	Mean	**68**	**68**	**3**	**73**	**25**	**31**	**30**	**8**	**77**	**59**	**8**	**60**	**31**	**32**	**56**	**10**
	Minimum	**32**	**32**	**0**	**28**	**0**	**9**	**4**	**0**	**57**	**18**	**0**	**0**	**0**	**0**	**0**	**0**
	Maximum	**93**	**86**	**10**	**100**	**64**	**42**	**54**	**19**	**100**	**90**	**100**	**100**	**100**	**100**	**100**	**27**

TABLE 2 Summary results of fishers interactions with river dolphins. All values are the percentage of fishers that responded to that option, with the exception of the column describing bycaught individuals per year. Caballococha, Masusa, Manantay and Aguaytia ports were not included in the 2010 study.

		2010											
		Do dolphins cause problems?	Type of problems			Bycatch during 2010	Dolphin is found alive	*Sotalia* is more frequent as bycatch	*Inia* is more frequent as bycatch	Bycaught dolphins per year			Use as bait
		Yes	Net damage	Steal fish	Aggressive					1	2-3	>3	
Loreto												N	
	Bagazan	100	92	4	4	5	50	0	22	NR	NR	R	11
	Pesquero	100	93	0	7	68	79	67	17	61	6	11	37
	Nanay	92	88	0	12	80	83	8	88	39	0	30	15
	Nauta	88	71	13	6	68	72	8	83	36	9	15	32
	Productores	78	86	14	0	56	43	42	42	8	0	3	43
	Requena	86	61	30	9	100	77	26	53	13	0	34	31
Ucayali	Calleria	84	54	23	23	50	88	12	88	22	0	22	57
	Yarinacocha	59	86	14	0	35	85	8	77	6	0	21	19
	Mean	**86**	**79**	**12**	**8**	**58**	**72**	**21**	**59**	**26**	**2**	**19**	**31**
	Minimum	**59**	**54**	**0**	**0**	**5**	**43**	**0**	**17**	**6**	**0**	**3**	**11**
	Maximum	**100**	**93**	**30**	**23**	**100**	**88**	**67**	**88**	**61**	**9**	**34**	**57**
		2015											
Loreto	Bagazan	100	92	8	0	67	88	56	44	12	12	19	41
	Pesquero	94	86	7	7	50	77	7	79	38	38	15	38
	Nanay	72	67	13	20	67	88	12	88	12	12	6	17
	Nauta	88	76	0	24	75	96	25	75	17	17	8	17

Ucayali	Productores	40	83	0	17	80	100	8	92	8	8	0	33
	Requena	73	93	7	0	60	91	27	73	14	14	18	63
	Caballococha	82	91	9	0	61	92	10	45	16	16	40	46
	Masusa	27	100	0	0	100	87	22	67	0	100	0	0
	Calleria	55	93	7	0	45	85	27	27	28	28	6	7
	Yarinacocha	82	82	14	4	64	85	47	53	33	33	7	32
	Manantay	100	95	5	0	75	88	44	56	0	0	0	50
	Aguaytia	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	**74**	**87**	**6**	**7**	**68**	**89**	**26**	**64**	**25**	**12**	**11**	**31**
	Minimum	**27**	**67**	**0**	**0**	**45**	**77**	**7**	**27**	**0**	**0**	**0**	**0**
	Maximum	**100**	**100**	**14**	**24**	**100**	**100**	**47**	**92**	**100**	**21**	**40**	**63**

TABLE 3 Total number of fishers, interviewed fishers at each port in 2010 and 2015. Percentages are the number of participants from each port from total participants, totalling 100% vertically. Data regarding the minimum estimate of bycatch of river dolphins (both species) in surveyed ports in 2015 are presented.

Region	Port	Total fishers per port	Fisher interviews 2010 n (%)	Fisher interviews 2015 n (%)	Minimum bycatch estimate
Loreto	Bagazan	87	22 (14%)	27 (11%)	23
	Pesquero	72	11 (7%)	16 (6%)	16
	Nanay	143	27 (16%)	18 (7%)	5
	Nauta	107	30 (19%)	24 (10%)	10
	Productores	116	20 (12%)	15 (6%)	6
	Requena	13	21 (13%)	30 (12%)	29
	Caballococha	276		28 (11%)	41
	Masusa	28		15 (6%)	12
Subtotal		*842*	*131*	*173*	*140*
Ucayali	Calleria	18	14 (9%)	20 (8%)	10
	Yarinacocha	84	17 (10%)	28 (11%)	23
	Manantay	52		20 (8%)	100
	Aguaytia	17		10 (4%)	Not Included
Subtotal		*171*	*31*	*78*	*42*
Total			162	251	182

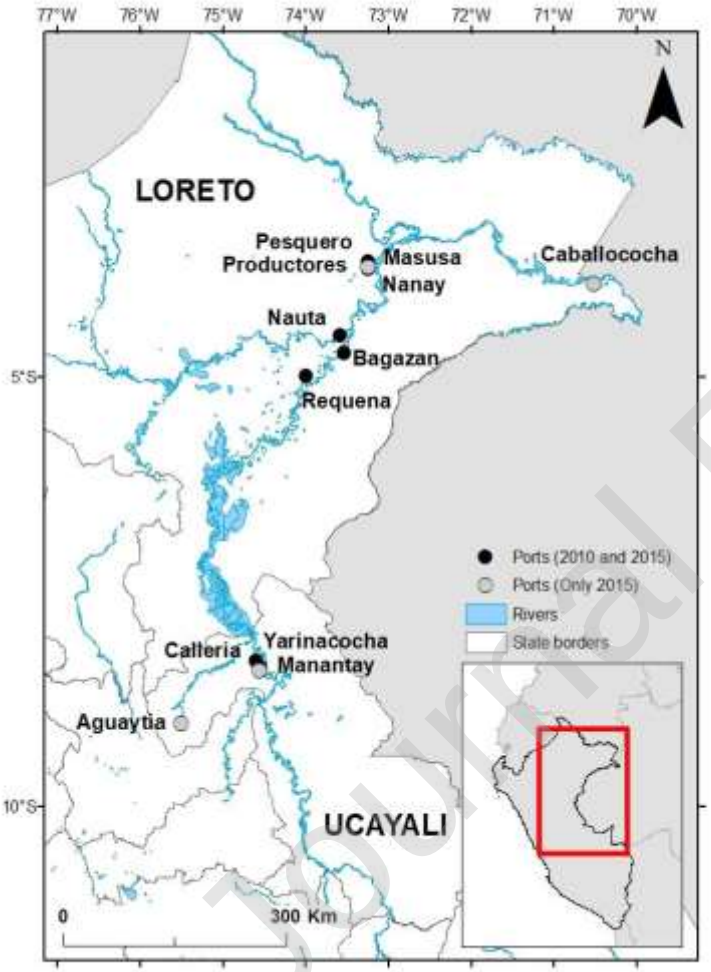


FIG. 1 Location of ports visited for survey administration in the states of Loreto and Ucayali.

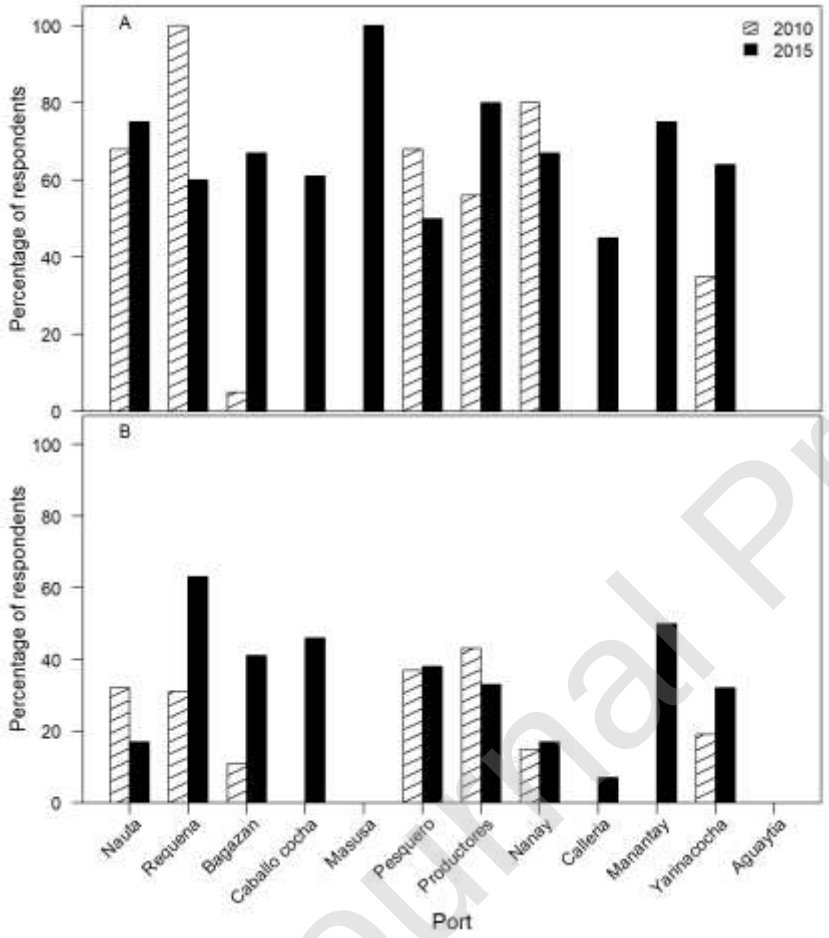
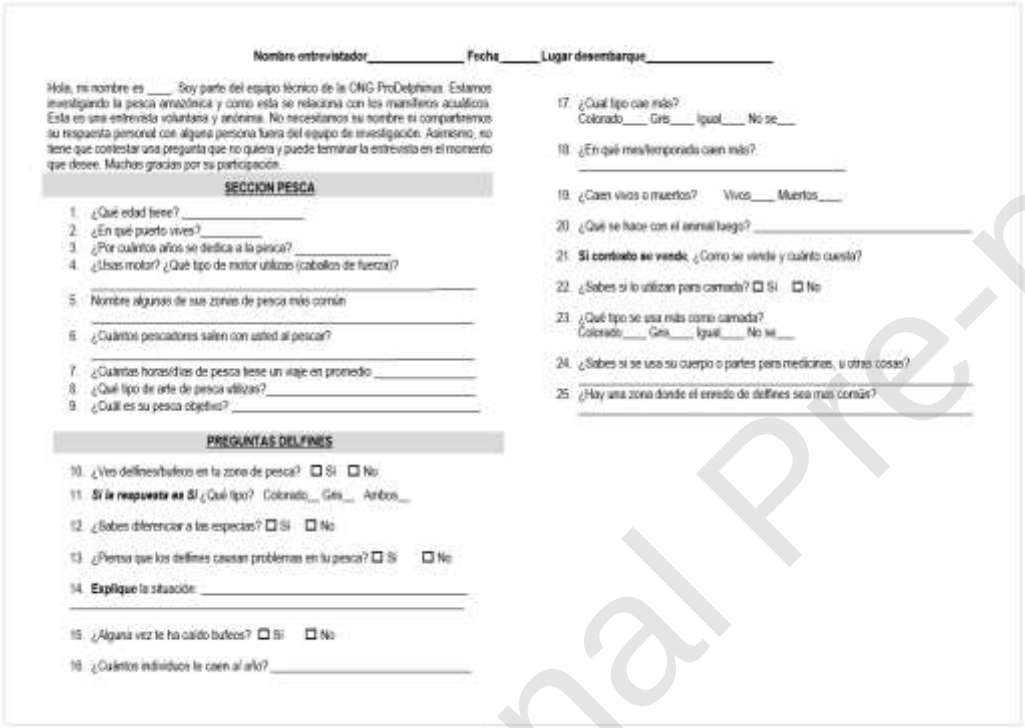


FIG. 2 Frequency of response from fishers interviews of A) river dolphin bycatch during study year and B) use of dolphin as bait for the catfish fishery in all sampled ports. No significant difference was found comparing between years for use of dolphins as bait (Wilcoxon test, $P > 0.05$).

SUPPLEMENTAL



Nombre entrevistador_____ **Fecha**_____ **Lugar desembarque**_____

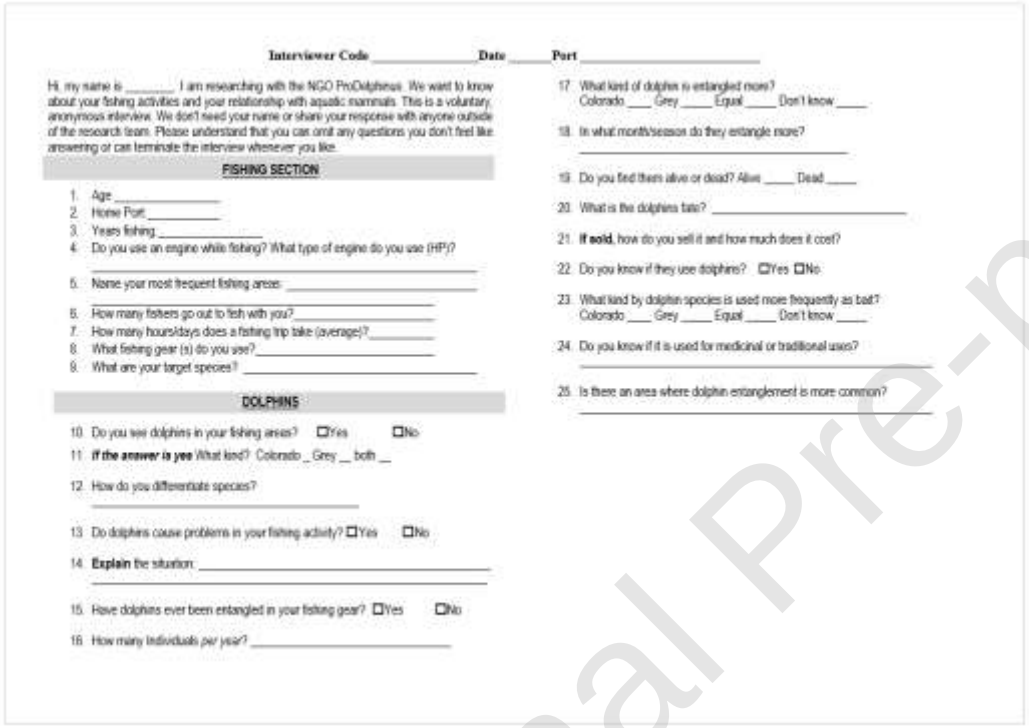
Hola, mi nombre es ____. Soy parte del equipo técnico de la ONG ProDelphinus. Estamos investigando la pesca amazónica y como esta se relaciona con los mamíferos acuáticos. Esta es una entrevista voluntaria y anónima. No necesitamos su nombre ni compartiremos su respuesta personal con alguna persona fuera del equipo de investigación. Asimismo, no tiene que contestar una pregunta que no quiera y puede terminar la entrevista en el momento que desee. Muchas gracias por su participación.

SECCION PESCA

1. ¿Qué edad tiene? _____
2. ¿En qué puerto vives? _____
3. ¿Por cuántos años se dedica a la pesca? _____
4. ¿Usas motor? ¿Qué tipo de motor utilizas (caballos de fuerza)? _____
5. Nombre algunas de sus zonas de pesca más común _____
6. ¿Cuántos pescadores salen con usted al pescar? _____
7. ¿Cuántas horas/días de pesca tiene un viaje en promedio _____
8. ¿Qué tipo de arte de pesca utilizas? _____
9. ¿Cuál es su pesca objetivo? _____

PREGUNTAS DELFINES

10. ¿Ves delfines/bufeos en la zona de pesca? ☐ Si ☐ No
11. ***Si la respuesta es Si*** ¿Qué tipo? Colorado__ Gris__ Ambos__
12. ¿Sabes diferenciar a las especies? ☐ Si ☐ No
13. ¿Piensa que los delfines causan problemas en tu pesca? ☐ Si ☐ No
14. **Explique** la situación: _____
15. ¿Alguna vez le ha caído bufeos? ☐ Si ☐ No
16. ¿Cuántos individuos le caen al año? _____
17. ¿Cual tipo cae más?
    Colorado____ Gris____ Igual____ No se___
18. ¿En qué mes/temporada caen más? _____
19. ¿Caen vivos o muertos? Vivos____ Muertos____
20. ¿Qué se hace con el animal luego? _____
21. **Si contesto se vende**, ¿Como se vende y cuánto cuesta?
22. ¿Sabes si lo utilizan para carnada? ☐ Si ☐ No
23. ¿Qué tipo se usa más como carnada?
    Colorado____ Gris____ Igual____ No se___
24. ¿Sabes si se usa su cuerpo o partes para medicinas, u otros cosas? _____
25. ¿Hay una zona donde el enredo de delfines sea mas común? _____



Interviewer Code _____ **Date** _____ **Port** _____

Hi, my name is _____. I am researching with the NGO ProDelphinus. We want to know about your fishing activities and your relationship with aquatic mammals. This is a voluntary, anonymous interview. We don't need your name or share your response with anyone outside of the research team. Please understand that you can omit any questions you don't feel like answering or can terminate the interview whenever you like.

FISHING SECTION

1. Age _____
2. Home Port: _____
3. Years fishing: _____
4. Do you use an engine while fishing? What type of engine do you use (HP)? _____
5. Name your most frequent fishing areas: _____
6. How many fishers go out to fish with you? _____
7. How many hours/days does a fishing trip take (average)? _____
8. What fishing gear (s) do you use? _____
9. What are your target species? _____

DOLPHINS

10. Do you see dolphins in your fishing areas? ☐Yes ☐No
11. **If the answer is yes** What kind? Colorado _ Grey __ both __
12. How do you differentiate species? _____
13. Do dolphins cause problems in your fishing activity? ☐Yes ☐No
14. **Explain** the situation: _____
15. Have dolphins ever been entangled in your fishing gear? ☐Yes ☐No
16. How many individuals *per year*? _____
17. What kind of dolphin is entangled more? Colorado ___ Grey ____ Equal ____ Don't know ____
18. In what month/season do they entangle more? _____
19. Do you find them alive or dead? Alive ____ Dead ____
20. What is the dolphins fate? _____
21. **If sold**, how do you sell it and how much does it cost?
22. Do you know if they use dolphins? ☐Yes ☐No
23. What kind by dolphin species is used more frequently as bait? Colorado ___ Grey ____ Equal ____ Don't know ____
24. Do you know if it is used for medicinal or traditional uses? _____
25. Is there an area where dolphin entanglement is more common? _____

SOM 1 Original questionnaire in Spanish and a version translated to English that was administered to fishers in 12 ports of the Peru Amazon in 2010 and 2015.

		2015							
		Number of days fishing				Crew members			
		1 day	2-5 days	6-10 days	>10 days	Alone	2-3	4-6	6- 10
Loreto	Bagazan	78	15	7	0	37	33	15	15
	Pesquero	0	6	13	81	0	0	19	81
	Nanay	39	50	6	6	11	50	11	28
	Nauta	13	71	17	0	37	33	13	17
	Productores	7	43	50	0	7	40	7	47
	Requena	37	33	27	3	30	27	23	20
	Caballococha	32	14	25	29	54	21	14	0
	Masusa	33	60	7	0	20	47	13	20
Ucayali	Calleria	0	0	5	95	0	0	93	7
	Yarinacocha	21	39	18	4	21	25	11	43
	Manantay	30	35	35	0	50	40	5	5
	Aguaytia	100	0	0	0	100	0	0	0
	Mean	33	31	18	18	31	26	19	24
	Minimum	0	0	0	0	0	0	0	0
	Maximum	100	71	50	95	100	50	93	81

SOM 2. Additional fisher characteristics from the 2015 survey.