

Attitudes and behaviors toward Amazon River dolphins (*Inia geoffrensis*) in a sustainable use protected area

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Abstract Negative interactions between fishers and the Amazon River dolphin (*Inia geoffrensis*), or boto, have increased substantially in the last few decades. Herein, we investigate these interactions with focus on assessing fisher perceptions, attitudes, and behaviors toward botos. Moreover, we evaluate the effect that the Mamirauá Sustainable Development Reserve (MSDR) in the Brazilian Amazon, and related programs, has had on fisher attitudes and behaviors toward botos. The results suggest that interactions between fishers and botos, such as depredation and incidental entanglement, are frequent, and that the illegal harvest for botos, for use as bait, occurs in the majority of the study communities. However, the assessment revealed that most fishers have positive attitudes toward botos and that these attitudes have been influenced by participation in the MSDR activities such as research and ecotourism. Our results also highlight the importance of community-based enforcement in addressing the issue of boto harvesting. The MSDR programs have

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successfully promoted positive attitudes toward botos and have likely played a role in limiting boto mortality through behavioral controls, though the scope of influence of these programs has been restricted to a small geographical area. The current extent of these programs is insufficient to prevent the decline of the boto population; therefore, we suggest the MSDR model be used to improve and expand boto conservation efforts with communities in the region.

Keywords Boto · Fishery interactions · Mamirauá Sustainable Development Reserve · *Piracatinga* · *Calophysus macropterus*

Introduction

Interactions with fisheries are considered a primary threat to cetacean populations worldwide (Vidal 1993; Smith and Smith 1998; Hall and Donovan 2001; Read et al. 2006; Read 2008; Robards and Reeves 2011). Through depletion of fish stocks (DeMaster et al. 2001), incidental capture in fishing gear (Read et al. 2006), and targeted harvesting (Robards and Reeves 2011), fishing activities may increase cetacean mortality. Interactions are also potentially detrimental to fishers, who may experience financial losses in the form of gear or catch damage and depletion of fish stocks (Hall and Donovan 2001). Every species of cetacean is likely to experience conflicts with fishers to some extent but a lack of data prohibits an assessment of the type, degree and effects of these interactions on many populations and fisheries (Northridge 1984).

Although interactions between fishers and Amazon River dolphins, or botos (*Inia geoffrensis*), likely date back thousands of years, they have not been studied in most areas of the Amazon. However, sufficient information does exist to describe the most common types of interactions and their negative effects. From the perspective of maintaining a viable boto population, the primary interaction of concern is the direct harvest of botos that has developed in the last two decades. Since around the mid-1990s, botos have been harvested to be used as bait in the fisheries for the catfish known as *piracatinga*, *mota*, *simi*, *zamurito*, or *mapurite* (*Calophysus macropterus*; Gómez et al. 2008; Loch et al. 2009; Trujillo et al. 2010; da Silva et al. 2011; Pinto de Sa Alves et al. 2012; Iriarte and Marmontel 2013a). Although killing botos is illegal in most Amazonian countries, the practice appears to be increasing to meet growing demands for this food fish in Colombia and Brazil. Recent evidence suggests the harvest may be unsustainable in and around the Mamirauá Sustainable Development Reserve (MSDR) in the Brazilian Amazon (da Silva et al. 2011; Mintzer et al. 2013), where the harvest began approximately in 2000 (da Silveira and Viana 2003; Estupiñán et al. 2003).

Aside from the direct harvest, entanglement in fishing gear is another interaction of concern. Previous studies have shown that botos may become entangled in seine nets and gillnets and consequently drown (Best and da Silva 1989, 1993; Leatherwood and Reeves 1994; da Silva and Best 1996; Martin et al. 2004; Brum 2011; Iriarte and Marmontel 2013b). In the Central Amazon, da Silva and Best (1996) determined that lampara seine is the most lethal type of net for botos accounting for over 80 % of fishery-caused deaths. Seines are commonly used along beaches where botos take advantage of the net and use it as a wall to corral fish. If botos are foraging close to the seine when it is closed, they may become trapped in the net or purse. Gillnets appear to be less of a threat, because botos can

take fish from them without causing considerable damage to the net. If they do become entangled, most adults can tear free from a gillnet (da Silva and Best 1996).

From the perspective of the fisher, several forms of interactions with botos are unfavorable. Botos may disrupt fishing operations and cause financial losses by frightening fish, taking fish from nets, and becoming entangled (Best and da Silva 1989, 1993; Leatherwood and Reeves 1994; da Silva and Best 1996; Loch et al. 2009; Martin et al. 2004; Pinto de Sa Alves et al. 2012). Recent reports from the Brazilian Amazon suggest local fishers have negative attitudes toward botos, believing that they are “bad-tempered,” competitors, and a threat to fishing operations (Loch et al. 2009; Iriarte and Marmontel 2011; Pinto de Sa Alves et al. 2012; Iriarte and Marmontel 2013a, b). As a result, some fishers kill botos intentionally, even though they will not use the carcass for bait (da Silva and Best 1996; Loch et al. 2009).

Most fishery–cetacean interaction studies, including those on the boto, have focused on describing and quantifying the physical characteristics (i.e., gear type, seasonality, location) and degree or impact of the interactions on the cetacean (i.e., catch numbers, changes in demographic parameters; e.g., Díaz López 2006; Brotons et al. 2008; Mintzer et al. 2013), with limited or no focus extended to the fisher attitudes and behaviors that may fuel these interactions. However, as with other natural resource conservation issues, this human–wildlife conflict is a combination of social, economic, and environmental factors, and solutions with realistic potential need to be informed by both biophysical and social science research (Ostrom 2007, 2009; McShane et al. 2011). Identifying and evaluating the anthropological components may be especially important in the case of Amazon fisheries where enforcement is challenging (Peres and Terborgh 1995; Peres and Lake 2003) and human livelihoods are at stake (Bayley and Petrere 1989; Batista et al. 1998; Gram et al. 2001).

In this study, we aimed to better understand the nature of fishery–boto conflicts from a primarily human perspective. Specifically, our main objectives were to investigate attitudes and behaviors of fishers toward botos and identify the factors that affect these attitudes and behaviors. Moreover, through these objectives we evaluated if and how the MSDR, a sustainable use protected area in the Brazilian Amazon, and related programs, has been effective in promoting positive fisher attitudes toward botos, and the effect, if any, of these changes in attitudes on behaviors. In light of the harvest for botos, a pressing need exists to develop conservation strategies that address conflicts between fishers and botos, and understanding fisher attitudes and behaviors toward botos will be essential in formulating successful conservation tactics and improving existing ones.

Methods

Study setting

The MSDR

We conducted this study in communities and towns located in or in close proximity (≤ 31 km) to the southern segment of the MSDR. The MSDR is located at the intersection of the Solimões and Japurá Rivers in the Brazilian state of Amazonas, approximately 30 km upstream of Tefé (Fig. 1). The MSDR is located within a floodplain, or *várzea*, with water levels rising up to 15 m during the wet period. It is comprised of a focal area of about 260,000 ha, where management efforts are in place, and a subsidiary area of approximately

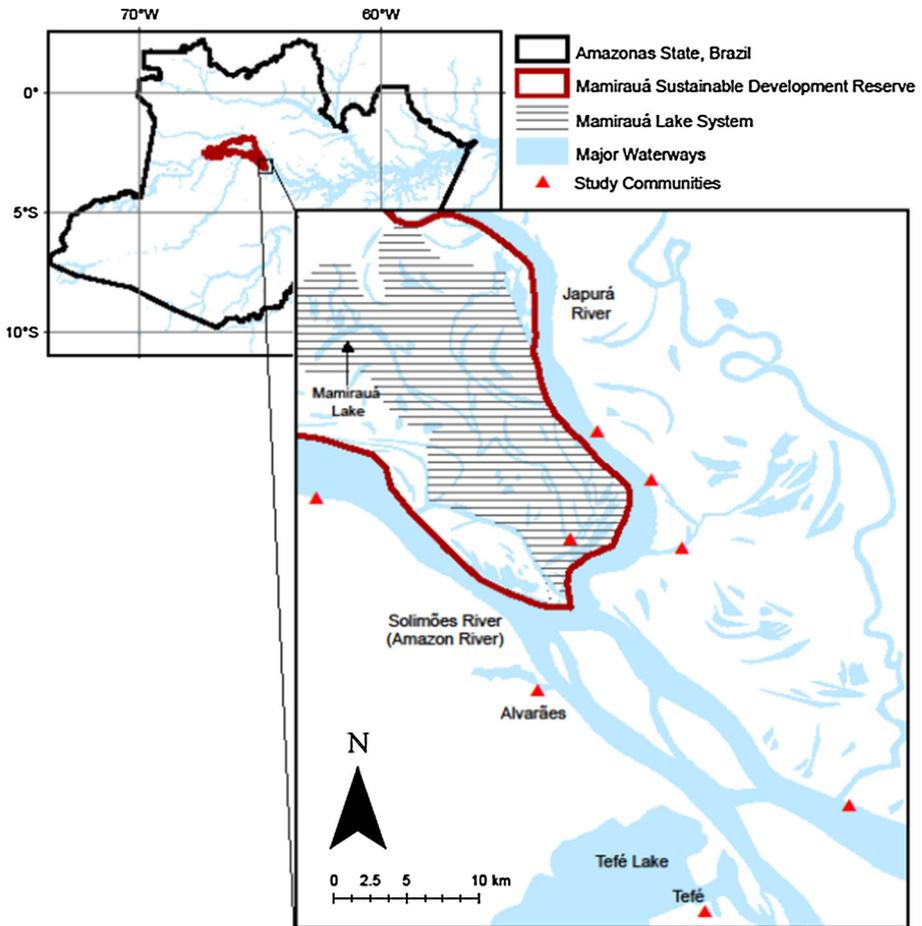


Fig. 1 Map of the study area: the southern segment of the Mamirauá Sustainable Development Reserve and surrounding areas in Amazonas, Brazil (GIS layers: IUCN and UNEP 2010, DCW and GADM downloaded from www.diva-gis.org)

864,000 ha (Koziell and Inoue 2006). Because the study area was limited to the southernmost segment of the focal area of the MSDR and adjacent areas, the results herein should not be generalized to the entire reserve.

The MSDR was established in 1996 as the first Reserva de Desenvolvimento Sustentável or Sustainable Development Reserve (SDR) in Brazil, a category of protected area with the objective of reconciling the conservation of nature and economic development (<http://www.mma.gov.br>). According to the SDR mandate, inhabitants of SDRs should actively participate in management decisions and in the monitoring of the SDR. Currently, there are nine administrative zones in the focal area of the MSDR, each of which has a local coordinator who is responsible for organizing regular meetings to discuss management issues. General meetings are held annually and are the vehicle through which decisions are voted on. This model of community participation was chosen by the MSDR residents (Sociedade Civil Mamirauá-SCM 1996).

The main institution responsible for the management of the MSDR is the Mamirauá Sustainable Development Institute (MSDI), an entity of the Brazilian Ministry of Science, Technology, and Innovation, that was established in 1999. The MSDI's main goals are the protection of ecosystems, the conservation and sustainable use of natural resources, and the sustainable development of local populations. Specific programs facilitated by the MSDI include: Management of Agroecosystems, Community Management, Fishing Management, Community Forest Management, Quality of Life, and Community-based Tourism (visit <http://mamiraua.org.br> for program details).

Most current inhabitants of the MSDR are considered *caboclos* or *ribeirinhos*, terms used to describe the traditional rural inhabitants of the Brazilian Amazon (Lima 2009). As of 2011, the focal area of the reserve was inhabited by 1,852 people, residing in over 20 communities. Additionally, 3,114 people classified as reserve users resided in communities neighboring the focal area (Instituto de Desenvolvimento Sustentável Mamirauá-IDSMD 2012). One of the principal economic benefits that the MSDR offers its residents and users is the conservation of *várzea* fish, the most important source of income and protein in the region (Barthem 1999; Viana 2004). In general, fishing pressure in the MSDR is low largely due to access restrictions that the MSDR communities place on nearby commercial fishers (Barthem 1999; Queiroz 1999; Crampton et al. 2004; Viana 2004).

Mamirauá's botos and Projeto Boto

Although botos are found in a variety of aquatic habitats throughout the Orinoco and Amazon basins, they show preference for whitewater floodplains like Mamirauá. In 2000, it was estimated that roughly 13,000 botos occurred in the MSDR and adjacent waterways (Martin and da Silva 2004b) but since then numbers have been declining (da Silva et al. 2011; Mintzer et al. 2013). The seasonal water fluctuations determine what habitats within the MSDR are available for the botos. At high water, botos may enter submerged forests and swim freely throughout the MSDR. On the other hand, at low water, botos are only found in the deepest channels and lakes (Martin and da Silva 2004a, b).

Projeto Boto, a not-for-profit research project supported by the MSDI and the Instituto Nacional de Pesquisas da Amazônia (INPA), has been active in the focal area of the MSDR since its inception. Projeto Boto focuses on collecting data related to the life history, behavior, ecology, and physiology of botos. The project is based in a floating field base located in the focal area of the MSDR. Because of the proximity of the base to the MSDR communities, Projeto Boto researchers interact with locals both formally and informally throughout the year. Observational work, when researchers are actively monitoring the area for botos, takes place throughout the year in and around the southern segment of the MSDR, primarily the Mamirauá Lake System and surrounding waterways (Fig. 1) where approximately 260 botos occur year-around (Martin and da Silva 2004b). Furthermore, since 1994, three weeks each year have been dedicated to the capture and marking of botos. When captured, botos are weighed, measured, and freeze-branded with a unique code that allows for subsequent identification of the individual. Tissue and blood samples are also obtained. Approximately 20 local fishers are employed by Projeto Boto to assist with the capturing, releasing and handling of botos. Details on Projeto Boto protocols are available in da Silva and Martin (2000), Martin and da Silva (2004a, b), Martin et al. (2004), and Mintzer et al. (2013).

Interview protocol and questionnaire

We conducted structured oral interviews in six rural communities and two towns located in or near the southern segment of the focal area of the MSDR (Fig. 1). The communities were selected because they were located within Projeto Boto's study area and because the majority of inhabitants rely on fishing as their main source of income (determined during preliminary interviews with community leaders). Interviews were carried out in October and November 2012. The interviewer (VJM) was accompanied by a local guide and a Brazilian assistant. Communities were visited between three and ten times throughout the data collection period. During the initial visit we conducted preliminary interviews with the president of the community and/or another elected representative and sought permission to return. All community leaders granted permission to carry out the research.

During subsequent visits, we invited all fishers that were present and accessible to participate in the study. Upon arrival at each community, we visited meeting areas and houses to recruit initial fishers. Using a snowball sampling approach (Goodman 1961), after each interview, we asked for suggestions on other fishers to interview and we were usually guided and introduced to the next fisher, and so on, until no more fishers were present or available. Our intent was to interview as many diverse fishers as possible, not to target those actively engaged in killing botos. Interviews were conducted in the fisher's house, in a shaded location outside, or in a community structure (e.g., school). All interviews conducted within the two towns took place at the offices of the Colônia de Pescadores.

The questionnaire consisted of both closed and open-ended questions. In some cases, visual aids (e.g., maps, picture of marked boto) were used in conjunction with questions. The questionnaire was designed to gather the following information on each fisher: (1) background and fishing techniques, (2) involvement in the MSDR and Projeto Boto activities, (3) perception of the boto population and illegal harvest, (4) frequency, type, location, and timing of interactions with botos, (5) mythological beliefs, (6) attitudes toward botos, and (7) behaviors exhibited toward botos. We analyzed the closed-ended responses using standard parametric and non-parametric statistical tests. For the open-ended questions, we used coding and categorizing, where we grouped and summarized responses according to their similarities and inclusion of key words or phrases.

Attitude assessment

We defined attitude as beliefs about an object or situation that influence one's response toward that object or situation (Rokeach 1968). The fishers expressed their attitudes toward botos by replying to four close-ended questions (Table 1). Descriptions of the explanatory variables that we tested and rationale for their selection are provided below and summarized in Table 2, and relationships are expressed in a flow chart in Fig. 2. We used Fisher's Exact Test to determine which explanatory factors were significantly correlated with positive attitudes. The Fisher's Exact Test was appropriate given the categorical nature of the variables and small sample sizes. Additionally, open-ended questions explored the reasons behind the answers provided for the attitude questions. Results of the quantitative analyses were used in conjunction with the responses to the open-ended questions to assess the factors underlying the attitudes expressed.

Socioeconomic and demographic variables

Education level Previous studies have shown that educated people may better understand the short and long-term benefits of conservation (Infield 1988; Heinen 1993; Fiallo and

Table 1 Questions and responses included in questionnaire to determine fisher attitudes toward botos

Questions	Responses		
	Like	Neutral	Dislike
Do you like or dislike botos? (%)	37	23	25
	Yes	No	Don't know
Do you think botos are an important animal in the Amazon? (%)	84	7	9
Do you think botos should be protected from being killed? (%)	89	2	8
Will the Amazon change if botos become extinct? (%)	63	20	16

Table 2 Explanatory variables included in the attitude assessment

Variable names	Types	Categories
Socio-economic variables		
Fisher age group	Ordinal categorical	≤29, 30–39, 40–49, ≥50
Education level	Ordinal categorical	None, 1–5 years, 6–9 years, 9<
Dependency on fishing	Categorical	Main source, shared, not main source
Interactions		
Frequency of boto entanglement	Ordinal categorical	Never, 1, 2+
Frequency of boto depredation	Ordinal categorical	Never, sometimes, always
Positive interaction	Binary	Experienced positive interaction Has not experienced positive interaction
Effect of protected area		
Community type/location	Categorical	Focal MSDR, reserve-user MSDR, non-reserve
Participation in the MSDR activities	Categorical	Not involved, meetings/projects, employed
Mythology		
Belief in legend	Categorical	Believer, unsure, non-believer

Jacobson 1995; Lee and Zhang 2008). For example, the level of acceptance of a protected area among residents is positively correlated with their level of education (Heinen 1993; Fiallo and Jacobson 1995). Education is also an important factor in determining local attitudes toward wildlife (Akama et al. 1995; Selebatso et al. 2008). Consequently, we expected that more educated fishers would demonstrate more positive attitudes toward botos.

Dependency on fishing Fishers that rely on fishing as their main source of income are likely to spend more time on the water and consequently interact with botos on a regular basis. Their income will be affected more proportionally by these interactions. Conflict with wildlife has been determined as an important factor in determining negative attitudes toward wildlife (Parry and Campbell 1992; Oli et al. 1994; De Boer and Baquete 1998; Mehta and Kellert 1998; Gillingham and Lee 1999). Therefore, we expected that participants who rely on fishing financially would have more negative attitudes toward botos.

Fisher age Several authors have reported that botos were protected for many generations due to local legends (see “[Mythology: belief in the legend of the *encantado*](#)” section; da

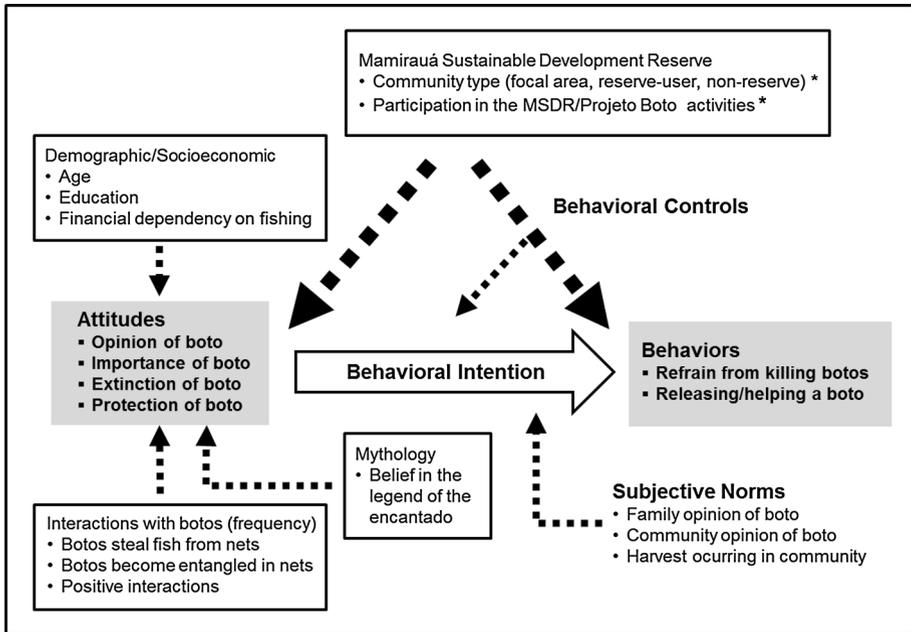


Fig. 2 Flow chart of the independent/explanatory variables and dependent variables included in the fisher attitude and behavior assessment. The explanatory variables that were significantly correlated with the attitude variables are denoted with an *asterisk*

Silva and Best 1996; Cravalho 1999; da Silva 2008; da Silva et al. 2011). However, the popularity and effect of these stories is declining among the current generations (da Silva and Best 1996; da Silva et al. 2011; Pinto de Sa Alves et al. 2012). Consequently, we expected a difference in attitudes between fishers of varying age.

Interaction variables

Frequency of depredation and entanglement Depredation refers to a predatory attack and in this case describes the act of botos removing or biting fish from nets. Depredation may result in a decrease in the value of the catch and damage to fishing gear (Lauriano et al. 2004; Read 2005; Rocklin et al. 2009). Similarly, boto entanglement in gear may interrupt fishing operations and cause net damage (Lauriano et al. 2004; Rocklin et al. 2009). Because conflict may determine attitudes toward wildlife, we expected that fishers who have experienced frequent depredation and entanglement would have more negative attitudes toward botos.

Positive interactions Although many interactions between dolphins and fishers are detrimental, accounts from various parts of the world suggest that positive interactions do occur (e.g., Pryor et al. 1990; Neil 2002). In eastern Australia, for example, Aboriginals cooperate with bottlenose dolphins and orcas during fishing activities and this collaboration has emotional and spiritual implications for the fishers (Neil 2002). Based on these accounts, we expected that fishers that have experienced a positive interaction with botos would have a more positive attitude toward botos.

Effect of protected area

Participation in the MSDR and Projeto Boto activities Involvement of local communities is recognized as an essential component of successful conservation initiatives (Bawa 2006; Vermeulen and Sheil 2006; Kainer et al. 2009). Positive attitudes toward protected areas and conservation are highly influenced by the level of involvement in management or research programs (Fiallo and Jacobson 1995; Mehta and Heinen 2001; Kideghesho et al. 2007). Active participation can lead to feelings of “ownership” of the environment, increase knowledge about wildlife, and promote understanding of natural resource management issues (Campbell and Vainio-Mattila 2003; Evans et al. 2008). Programs that provide economic benefits can also encourage attitudes and behaviors that better align with conservation goals (Infield 1988; Lewis et al. 1990; Gillingham and Lee 1999; Archabald and Naughton-Treves 2001; Holmes 2003; Gadd 2005).

As expected from the SDR model, some of the interviewees have been involved in activities coordinated by the MSDR and Projeto Boto, including management meetings, conservation lectures, ecotourism, research, and monitoring. We considered three levels of participation: “no participation”, meaning the fisher had never participated in the MSDR or Projeto Boto activities; “meeting or project participation”, indicating the fisher had attended management or conservation meetings or had participated in a specific project; and “employment”, referring to fishers who had worked in conservation, ecotourism, research, monitoring, or enforcement. Employment related to wildlife has been associated with more positive attitudes toward wildlife and conservation (Parry and Campbell 1992); therefore, we expected that “employment” fishers would show the most positive attitudes toward botos. Due to their lack of involvement, we expected fishers in the “no participation” category to have the least positive attitudes.

Community type The fishers interviewed in this study reside in communities belonging to one of the following categories: focal area, reserve-user, and non-reserve. The focal area is where the MSDR outreach, research and conservation efforts have been focused (SCM 1996). The reserve-user communities are located outside the MSDR but have access to the MSDR resources and may participate in the MSDR meetings and management decisions. Non-reserve communities are located outside the MSDR with no access to the MSDR resources. We expected that fishers from focal area communities would have the most positive attitudes toward botos due to the heavy exposure that these communities have had to the MSDR activities (SCM 1996). Moreover, focal area and reserve-user communities have received concrete benefits from the MSDR, like participation in ecotourism, so we expected fishers from these communities to have more positive attitudes than fishers from non-reserve communities.

Mythology: belief in the legend of the encantado

The mythology surrounding botos speak to sources of misfortune, the afterlife, and the relationship between men and women (Slater 1994). According to one common legend, botos can shape-shift into a handsome young man, the *encantado*, who seduces women (Cravalho 1999; Ortiz 2012). Prior to the *piracatinga* fishery there was no widespread hunt directed at botos, and several authors have suggested that due to the legends, and the supernatural powers attributed to these animals, botos were respected and feared and consequently protected for many generations (e.g., da Silva and Best 1996; Cravalho 1999;

da Silva 2008; Brum 2011; da Silva et al. 2011). In Peru, for example, botos are regarded with “superstitious dread” and fishers do not want to handle a dead boto because of possible consequences to their families (Leatherwood and Reeves 1994). In Indonesia, where mythological beliefs also surround dolphins, positive attitudes toward dolphins are linked with the belief that dolphins have human origins (Kreb and Budiono 2005). Whether belief in the *encantado* legends should have a positive or negative effect on attitudes is not clear. While some fishers may fear botos and consequently dislike them (Pinto de Sa Alves et al. 2012), others may respect botos and favor their protection.

Behavior assessment

According to the “Theory of Planned Behavior”, behavior is closely guided by behavioral intention which is a result of three components: attitudes toward the behavior, subjective norms, and perceived behavioral control (Ajzen 1991). Although previous research has made connections between conservation attitudes and resource use (Abbot et al. 2001; Adams and Infield 2001; Holmes 2003) the exact circumstances or motivators that lead to behavioral changes related to resource use are unclear (Holmes 2003). Nevertheless, these studies have suggested that improved attitudes as a result of outreach initiatives and economic benefits may lead to more conservation-friendly behaviors (Abbot et al. 2001; Adams and Infield 2001; Holmes 2003).

In this study, we assessed if positive attitudes toward botos were manifested as positive behaviors. We quantified one specific behavior (releasing/rescuing a living entangled boto from a net) and used Fisher’s Exact Test to examine if the attitude variables (Table 1) correlated with this behavior. We expected that if positive attitudes toward botos affect behavior toward botos, fishers that expressed positive attitudes should release/help botos.

Through open-ended questions, we also investigated the impacts of behavioral controls (i.e., enforcement) on two behaviors: refraining from killing botos and releasing/rescuing an entangled boto. We directly asked fishers if they have ever killed a boto and the reasons behind their action. To examine the potential influence of the MSDR on this behavior, we also asked the fishers “Would you kill (more) botos if you were not fishing in (or near) the MSDR?” and “Do you think other people in your community would kill (more) botos if they were not fishing in (or near) the MSDR?”. We asked him/her to explain the reason(s) for the expected change. If a fisher stated that he/she had disentangled a boto, we asked them to explain their reason for helping the boto.

Finally, we explored the role of subjective norms primarily by asking fishers if their families’ and other people in their community like, dislike, or feel neutral toward botos. We then tested for correlations between these opinions and fishers’ behavior. Furthermore, we tested for a relationship between the fisher’s behavior and the behaviors of others in their community (i.e., do others in the community refrain from killing botos and help/release botos).

Results

Overview of participants

We conducted a total of 57 structured interviews. The average age of the participants was 42 (sd = 12.15) ranging from 18 to 74. They have lived in their current community or town an average of 23 years (sd = 16.60) and have fished in the area surrounding their

community or town an average of 20 years ($sd = 14.17$). Fifty-six participants were male. We targeted male fishers because the preliminary interviews suggested that boto interactions occur more frequently with the types and size of nets used by men (women typically use weaker nets). Moreover, women do not kill botos intentionally due to the physical strength and danger associated with this activity. One woman was included because she replaces her husband as the primary fisher in the family when her husband works in a nearby town.

The fishers had used over 10 different types of fishing gear in the last year (Fig. 3). The most common type of fishing gear used was the *malhadeira* (gillnet). Many fishers made the distinction between two general types of gillnet. The *tramalha* was described as a relatively new type of gillnet, used primarily for the capture of small fish, commonly bait fish, in shallow areas. The term *malhadeira* alone was commonly used to describe a stronger gillnet used in the capture of larger fishes such as the *tambaqui*. Brum (2011) recorded the same distinction made by fishers in the region.

Fisher attitudes toward botos

When we asked fishers their opinion of the boto, 21 fishers replied that they liked botos (37 %) and 14 (25 %) replied that they disliked (Table 1). The only variables that were significantly correlated with opinion were “Community Type” (Fisher’s Exact Test, p value = 0.001) and “Participation in MSDR or Projeto Boto activities” (Fisher’s Exact Test, p -value = 0.008; Figs. 2, 4, 5). As expected, fishers that have actively been involved in activities related to conservation, ecotourism, management, and research, have a more positive opinion of botos compared to those unexposed to such activities (Fig. 4).

Almost 60 % ($n = 33$) of fishers stated that their opinion about botos has not changed with time, while 26 % ($n = 15$) of fishers claimed their opinions have changed. Eleven of the latter (73 %) claim to have developed a more positive opinion and five of them attributed this difference to their exposure to research and ecotourism. Over 70 % ($n = 8$) of fishers with altered opinions reside in the community located within the MSDR boundaries, in closest proximity to the Projeto Boto field base. Four of these eight fishers

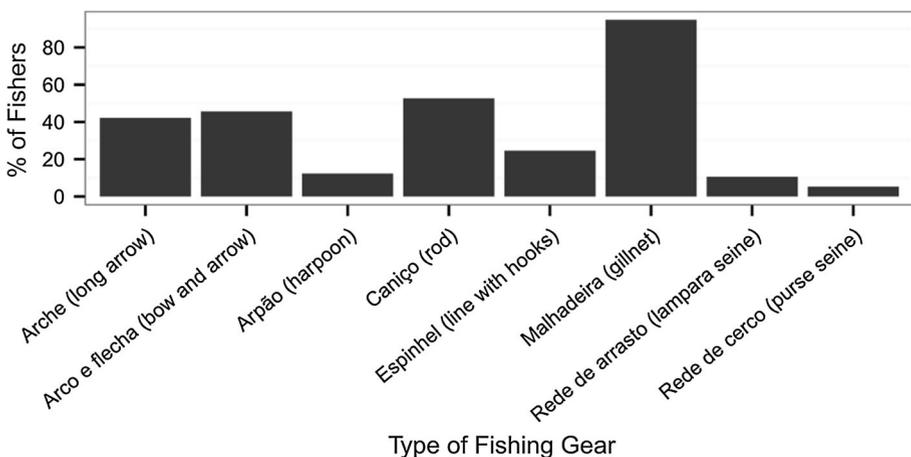


Fig. 3 Primary types of fishing gear used by participating fishers. Data were collected in eight communities in and surrounding the Mamirauá Sustainable Development Reserve in the Brazilian Amazon

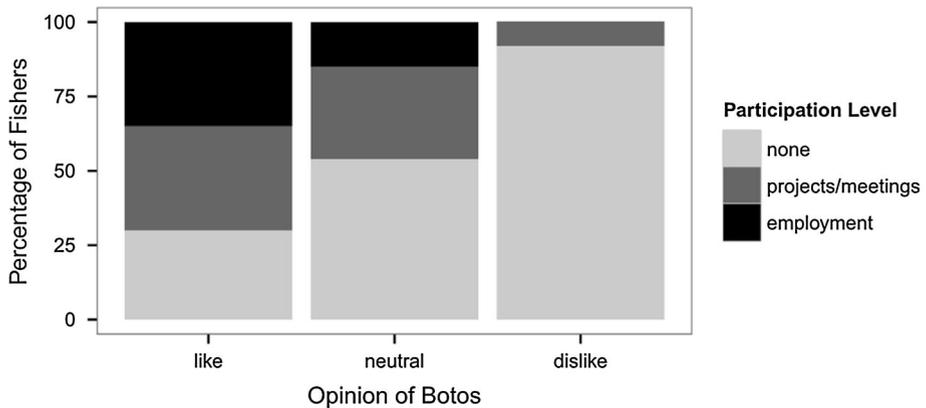


Fig. 4 Fishers' opinion of boto grouped by level of participation in the Mamirauá Sustainable Development Reserve and Projeto Boto activities. Three levels of participation were considered

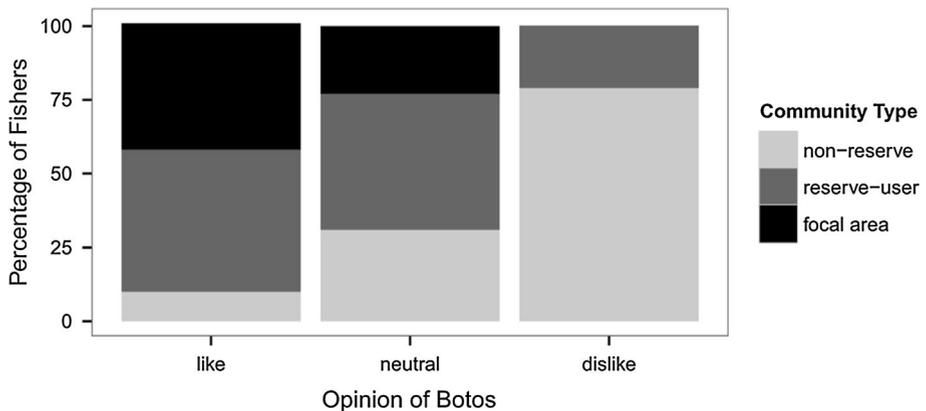


Fig. 5 Fishers' opinion of boto grouped by community type in which fishers reside. Fishers were interviewed in focal area, reserve-user, and non-reserve communities located in and surrounding the Mamirauá Sustainable Development Reserve in the Brazilian Amazon

attributed their changes in opinion to their exposure to the research, claiming the research has taught them about the importance of the species and they now “understand the boto better”.

We asked fishers if they consider boto to be an important animal in the Amazon. Forty-eight fishers (84 %) replied affirmatively and provided 15 different reasons for their answer (Table 3). Additionally, we asked fishers if boto should be protected from being killed; 89 % ($n = 51$) of fishers replied favorably and provided 20 reasons for their affirmation (Table 4). Because such a high rate of fishers responded affirmatively to these questions, we refrained from conducting a statistical test with the explanatory variables.

When we asked fishers if they believe the Amazon would change if boto were to become extinct, 32 fishers replied affirmatively (56 %), while 10 (18 %) did not believe it would change. Some fishers would consider it a good change because there would be more fish available to them. Others noted it would be more difficult to fish because boto help

Table 3 Reasons reported by fishers for why they believe botos are an important animal in the Amazon

Reasons	Percent of fishers (n = 44)
(1) It is not dangerous/harmful	27
(2) It serves a purpose in nature	20
(3) It is alive/it exists	14
(4) It is important to researchers	11
(5) It is God's creature	7
(6) It is a companion	7
(7) It is a pretty animal	7
(8) It protects fish	5
(9) It helps with fishing	5
(10) It is unique to the Amazon	2
(11) It is important for people that fish <i>piracatinga</i>	2
(12) It is important for tourism	2
(13) It is intelligent	2
(14) It is useful in children's therapy	2
(15) Everything is important	2

Table 4 Reasons reported by more than one fisher for why they believe it is important to protect botos from being killed

Reasons	Percent of fishers (n = 45)
(1) It is not dangerous/harmful	27
(2) It needs protection/more people would kill	16
(3) No good reason to kill a boto ("We don't eat it, so why kill it?")	13
(4) It deserves to live	9
(5) It is a pretty animal	7
(6) Everything should be protected	7
(7) For the research	4
(8) It is part of nature	4

fish and are good for the environment. Because the explanations varied greatly, and some can be interpretative as counterintuitive of positive attitudes, we did not conduct statistical tests with the explanatory variables.

Self-reported fisher behaviors toward botos

We did not find any statistically significant correlation between the attitude variables and the behavior of releasing/rescuing an entangled boto (Fig. 2). Whether a fisher expressed like or dislike toward botos was not correlated with this behavior (Fisher's Exact Test, p -value = 0.413). Unexpectedly, almost half of fishers that have disentangled a boto from their net (46 %, $n = 6$) claim to dislike botos. Reasons provided for releasing a boto included: "it is a life" ($n = 4$), "it is not valuable dead" ($n = 3$), "it is a crime to kill a boto" ($n = 2$), "it will rot and smell if it dies" ($n = 1$), "I was in a conservation area" ($n = 1$), and "I have worked with Projeto Boto and understand the research and botos" ($n = 1$).

Six fishers (10 %) stated that they would ($n = 4$) or might ($n = 2$) kill botos if they were not fishing in or near the MSDR. Fishers mentioned research, lectures, ecotourism, and enforcement as reasons for not killing botos. One fisher admitted to having killed a boto before moving to the area and stated that he would “never kill a boto now.” Thirty percent ($n = 17$) of fishers believed people (or more people) in their community would kill botos if they were not fishing in or near the MSDR. The fishers explained that the MSDR provides enforcement and researcher presence that discourages people from killing. We refrained from conducting a statistical analysis between fisher behavior and community type (theoretically focal area communities have more enforcement presence so we would expect fishers in focal area communities to exhibit more positive behaviors), because enforcement agents have specifically targeted some of the study communities outside the focal area and therefore results would be biased.

Primarily, botos are killed to be used a bait, but they are also killed because they disturb fishing operations. Two fishers admitted to having deliberately killed a boto. One of these fishers killed a boto because it had become badly entangled in his net and he did not want to make the effort to save it. Another older fisher stated that he killed roughly 10 botos because they were “messing with him” while he fished.

We found no significant correlation between the behavior of releasing/helping a boto and positive family opinions (Fisher’s Exact Test, p -value = 0.2862) or positive community opinions of botos (Fisher’s Exact Test, p -value = 0.5301). However, our sample size for these tests was greatly reduced because many fishers explained that they do not know others’ opinions of botos. We also did not find a significant correlation between fishers that have released/helped a boto and whether their community refrains from killing botos (Fisher’s Exact Test, $p = 0.193$).

Fishery–boto interactions

Although none of the “Interaction” variables were found to be statistically correlated with the attitude variables, the survey responses provided a comprehensive overview of the type and frequency of interactions. Ninety-three percent of fishers ($n = 53$) had observed depredation behavior by botos. Of these fishers, 30 % ($n = 16$) indicated that botos depredate every time they go fishing. Fifteen percent ($n = 8$) stated that this occurred every time only when they fish in a particular location, primarily river or bay habitat. Forty percent ($n = 23$) had found at least one boto accidentally entangled in their nets. Interactions with botos can occur with any type of fishing gear used (Fig. 3); however, 74 % ($n = 17$) of fishers were using a *malhadeira* when a boto became entangled.

When we asked fishers if their interactions with botos have increased, decreased, or stayed the same since they began to fish in the area near their community, 56 % ($n = 32$) of fishers stated they have increased, 18 % ($n = 10$) indicated a decrease, and 14 % ($n = 8$) claimed they have been stable. Of the fishers that indicated an increase in interactions, half ($n = 16$) attributed this change to an increase in botos. A couple of fishers ($n = 2$) noted that they were forced to change fishing location when the MSDR was established (from lakes to river habitat) and interact more with botos now because there are more botos in the river. Of the fishers who claimed that interactions with botos have decreased, 40 % ($n = 4$) explained that botos have become afraid of the nets and try to avoid them (a behavioral change attributed to the Projeto Boto capture expedition).

When asked if they have ever experienced a positive interaction with a boto, 46 % ($n = 26$) of fishers replied affirmatively. The most common positive interaction mentioned by fishers ($n = 11$) was that botos helped them to find fish (“Where there are botos, there

are fish”). Other incidents described included a boto pushing fish to nearby land or to a net ($n = 4$), a boto biting off a fish’s tail and then leaving the fish for the fisher ($n = 4$), and a boto bringing a fish to the fisher ($n = 4$).

When we asked interviewees if they have heard of botos being killed to be used as bait to catch *piracatinga*, 98 % ($n = 56$) replied affirmatively. Although no one we interviewed stated that they have killed a boto for this purpose, 17 participants (30 %) acknowledged that they were aware of botos having been killed in their community and seven confirmed that the botos were used for bait. Most fishers (67 %, $n = 38$) identified at least one community (their own or elsewhere) where killings were occurring for bait. From this information, we gathered that fishers from at least three communities and the two towns, out of eight settlements visited, were killing botos to be used as bait at the time of the interviews. Additionally, the fishers identified nine other communities and towns where they believe the harvest for botos was occurring and in some cases, increasing. These settlements are primarily located in the Solimões River, North West of our study area, where management, research, and enforcement presence is limited.

When we asked fishers if they thought more, less or the same number of botos were killed in the mid-2000s compared to 2011, over 80 % ($n = 28$) of fishers that could identify a trend stated that more botos were killed during the mid-2000s. Some interviewees explained that enforcement agents from the MS DR or the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) visited communities with active harvests and the killings decreased subsequently. In one community, the harvest decreased after community members asked the poachers to stop because they were severely affecting the water quality of the channel in front of the community (due to the excess blood). One fisher attributed the decrease to a visit by Projeto Boto’s researchers.

When we asked each fisher if it would be easy for them to kill a boto to use it for bait, over 77 % ($n = 44$) stated that it would not be easy. Fishers explained that botos are “smart” and “unfriendly” and can evade capture. Others noted that they do not have the appropriate hunting materials or expertise, and that it is a dirty and dangerous job. When we asked if killing a boto for use as bait would be a profitable activity for them, 86 % ($n = 49$) replied “No.” Most fishers explained a boto carcass would be no good to them because they do not fish *piracatinga*. Most fishers who stated that the boto harvest was occurring in their community identified only a few community residents as the poachers, typically those living in floating houses close to the entrance of channels, who fish primarily *piracatinga*. It appears that the activity requires time, courage, and most likely an initial monetary investment for hunting gear.

We asked fishers if they think the boto population in the area is declining, increasing, or stable. Forty-five fishers (79 %) replied that the number is increasing, three (5 %) replied that it is decreasing, and seven (12 %) believe the number is stable. When we asked why the numbers are increasing, 49 % ($n = 22$) replied that they now see a lot or more botos when they are fishing. Others explained that less botos are being killed in recent years (24 %, $n = 11$). Some fishers specifically mentioned enforcement (4 %, $n = 2$), the presence of the MS DR (4 %, $n = 2$), and research (7 %, $n = 3$), as the main factors responsible for the population increase. The fishers who claimed that the boto population is decreasing attributed the decline to botos being killed in nearby areas and to botos moving away.

The legend of the *encantado*

While mythological beliefs were not found to be statistically correlated with attitudes, familiarity with the legends was widespread among participants. Ninety-eight percent of

fishers ($n = 56$) replied that they knew the legend and over 60 % ($n = 36$) described the legend in varying levels of detail. Of these fishers, over 80 % ($n = 29$) stated that according to the legend botos are shapeshifters. Some fishers elaborated by saying botos attend parties in their human form ($n = 3$), seduce or impregnate women when in human form ($n = 5$), and wear white when human ($n = 7$).

Almost 30 % ($n = 16$) of the fishers interviewed stated that they believe in the legend(s). As expected, we found that the average age of fishers that believe in the legend (46.56 ± 15.61 years) was greater than those that do not believe in the legend (40.71 ± 11.06 years); however, this difference was not statistically significant (two-sample $t(23) = 1.714$, $p = 0.097$). Five fishers (9 %) described personal encounters with the *encantado*, or shapeshifter boto. Additionally, another seven (12 %) told a story where a close relative had an encounter. The setting of the stories varied (e.g., beach, lake, floating house) and involved anywhere from one to three male botos.

Of fishers that believe in the legend(s), eight (50 %) affirmed that these beliefs affect their behaviors toward botos. Over half of these fishers explained that they do not trust botos or are afraid of them and therefore try to avoid them. Two fishers, on the other hand, claimed that they feel a sense of respect toward botos because of the stories. Four fishers mentioned that their wives are afraid of botos due to the legend and one explained that his wife does not canoe alone due to this fear.

Discussion

Interactions

Almost all fishers reported that they have experienced depredation by a boto and almost half have had a boto become entangled in their net. Most entanglement incidents occurred with *malhadeiras*. Our results suggest that while gillnets made of weaker materials (i.e., *tramalhas*) do not appear to pose a direct threat to botos, stronger gillnets do. However, interactions such as depredation are common with *tramalhas* (Brum 2011) so their importance should not be ignored. The difference in findings regarding gillnets between da Silva and Best (1996) and the more recent studies is likely explained by the rising number of gillnet fishers, proliferation of nylon, increases in net length, variations in mesh size, and changes in fishing locations that have occurred in the region in the last two decades.

Fish depredation by botos in our study is higher than that reported in other artisanal fishery–boto studies within the Amazon. In Manacupuru, for example, only 63 % of fishers reported depredation (Pinto de Sa Alves et al. 2012). However, considering that many of the habitats with high fish densities in our study area (i.e., beaches, bays) are frequented both by fishers and botos (Martin et al. 2004), the levels of depredation reported herein are not surprising. Particularly during the dry season, the decrease in the overall amount of aquatic habitat physically forces fishers and botos to be in close proximity to each other.

It is possible that fishers are overestimating the frequency of their interactions. In other similar studies, fishers have overestimated interactions because they perceive potential benefits from exaggerating their problems. For example, Bearzi et al. (2011) reported that fishers perceived interviews as an opportunity to influence decision-making related to monetary compensation. To ameliorate this concern, the objectives of our study were made clear to the fishers before the start of each interview, and we explicitly stated that we did not have connections to decision-making or enforcement agencies. Nevertheless, it is likely some fishers exaggerated the frequency of depredation to justify their negative actions.

Almost half of the fishers stated that they have experienced a positive interaction with a boto. Several studies have described similar or more elaborate types of cooperation between fishers and other species of dolphins (Pryor et al. 1990; Neil 2002; Zappes et al. 2011); however, this is the first time positive interactions have been reported to occur with botos. This is noteworthy given the numerous negative anecdotes and stigma that surround botos as competitors and pests (e.g., Loch et al. 2009; Iriarte and Marmontel 2011, 2013a, b; Pinto de Sa Alves et al. 2012).

Although several authors have noted that fishers “hate” botos because of negative interactions (e.g., Loch et al. 2009; Pinto de Sa Alves et al. 2012), our results suggest that there is not a clear relationship between frequency of depredation and entanglement, and negative attitudes toward botos. Some fishers explained that while botos are annoying, they understand that “it needs to eat” and do not “blame it” for its behaviors. Moreover, while botos’ behaviors disrupt fishing operations, it may not be as costly to the fishers as previously suspected, although quantitative data are lacking on the economic loss resulting from such interactions.

Perception of the boto population and harvest

Almost half of interviewees stated that the boto population has increased since they first began to fish in or near the MSDR. This perception is inconsistent with recently reported data that suggest boto abundance has been decreasing (da Silva et al. 2011). This incongruity could be a result of several factors. First, many of the fishers attributed this increase to a decrease in the harvest in recent years, since they believe more botos were killed in the mid-2000s. This result is consistent with boto survival probabilities that were estimated to be lowest for 2003–2006 (Mintzer et al. 2013). Thus, it is possible that fishers replied affirmatively to this question based only on a perceived relative increase in the boto population in recent years. Second, many fishers believe the boto population is increasing because they see more botos when they are fishing, a result consistent with the majority perception that interactions have increased. However, interactions may have increased due to changes in fishing locations or because botos have learned to depredate effectively without getting entangled (explanations provided by fishers). Moreover, changes in boto habitat preference or movement could be responsible for the perception of population increase. Finally, it is possible that fishers are exaggerating an increase in the boto population to appease what they perceive as a concern for the researchers.

Regardless of the sensitivity of the subject, most interviewees were forthcoming with information about the illegal harvest. According to fishers’ perceptions, the harvest for botos is widespread, occurring in five out of the eight communities we visited. It appears that only a few fishers in each community engage in the killing of botos, an activity that, in most cases, is not supported by the communities as a whole. However, it is important to stress that the study area included only a small segment of the MSDR, an area where management and research presence is substantial. The hunting of botos is more prevalent in other sectors of the MSDR that are further from Tefé, MSDI, and Projeto Boto (e.g., Iriarte and Marmontel 2013b). Beyond the study communities, fishers identified nine communities where they believe the harvest has been occurring. One of the communities most commonly mentioned was an indigenous community. The indigenous status of the community may pose a challenge to conservation efforts, because it limits researcher and enforcement presence. Overall, it appears that the harvest has been migrating upstream on the Solimões, away from the focal areas targeted by the MSDR and Projeto Boto, and may

be more intense in communities rarely visited by researchers and enforcement agents. These areas now require special attention by natural resource managers.

Several interviewees who denied that botos were being harvested for bait in their communities explained that only caimans (*Melanosuchus niger*) are used for this purpose. Previous studies have noted that caiman are used as bait in *piracatinga* fisheries (da Silveira and Viana 2003; Brum 2011; Iriarte and Marmontel 2013a). Among residents of the participating communities, there appears to be a general consensus that it is “acceptable” to kill caiman because they are dangerous while the boto is harmless and should be protected. Iriarte and Marmontel (2013a) also found that fishers justified the killing of caimans based on their perception that caiman are dangerous.

Positive attitudes and the effect of the MSDR

Based on the frequency of negative interactions between fishers and botos, we did not expect most participants would be in favor of protecting botos. The reasons provided for the importance and protection of botos suggest that the existence value of botos, and the fact that it is not perceived as a dangerous animal, trump the annoyances caused by the animal. Additionally, as we discuss below, the presence of the MSDR has encouraged positive attitudes toward botos. Although we recognize that biases could exist if fishers did not tell the truth, the major patterns that speak to favorable attitudes and the effect of the MSDR appear to be consistent and robust.

Our findings suggest that the MSDR and Projeto Boto have had a significant effect in promoting positive attitudes toward botos. Primarily through involvement with ecotourism and scientific research, fishers have learned to appreciate botos as an important animal in the Amazon ecosystem and recognize it as an animal that others value (i.e., researchers). In a study conducted in the Manacapuru region in the Amazon, an area with no spatial protection status, the majority of the respondents stated that it is not important to protect botos (Pinto de Sa Alves et al. 2012). The difference in attitudes toward botos between these two studies is likely a reflection of the overall effect of the MSDR and Projeto Boto on fishers.

Fisher behaviors toward botos

Most fishers included in this study stated that they have refrained from killing botos and many that have had a boto become entangled in their net have helped/released the boto before the animal drowned. Although the reasons behind these positive behaviors toward botos remain unclear, fisher responses suggest that these behaviors are likely a result of a combination of factors, including attitudes and behavioral controls.

More research is needed to determine if positive attitudes toward botos generally translate to more positive behaviors. Two fishers, one who resides within the MSDR and one who resides in a reserve-user community, claim to have stopped killing botos. One of these fishers, who has worked in the MSDR ecotourism lodge, distinctly attributes his change in behavior to the current importance he sees in botos as an ecotourism attraction. Moreover, some fishers stated that they would kill botos if they were not fishing in or near the MSDR because they would not have learned the importance of botos. These explanations imply that, in at least some cases, changes in attitudes encouraged by the MSDR may lead to more positive behaviors toward botos.

Fisher explanations also suggest that behavioral controls play a role in determining their behaviors. Some fishers released botos because they recognize that it is illegal to kill a boto

and because they are in a protected area. Moreover, a third of fishers believe that people in their community would kill more botos if they were not in or near the MSDR because the reserve provides enforcement and researcher presence. Enforcement was also a common explanation as to why they believe the harvest has decreased.

Harming a boto, according to Brazilian Law, is punishable by up to five years in jail (Brazilian Law 7.643, 1987; Lodi and Barreto 1998). However, enforcement of natural resource protection laws in the Amazon is often compromised as a consequence of institutional deficiencies (e.g., Peres and Terborgh 1995). In our study region, only four federal officials have been available to enforce natural protections laws in an area greater than 251,000 km² (Peres and Lake 2003). Although two fishers in our study mentioned federal enforcement as a reason for the perceived decrease in the harvest, other fishers referred to enforcement coordinated by the MSDR.

The MSDR facilitates an enforcement agent program in which community residents are trained to become enforcement agents (Koziell and Inoue 2006). These agents are responsible for reporting infractions in communities in their sectors. Although this program has been criticized based on the notion that residents are not going to report their own families and friends, anecdotes provided by the fishers in our study suggest otherwise. Perhaps because the killing of botos appears to be a specialized activity that is not supported by most members of these communities, reprimands by these enforcement agents may be effective.

Effect of the legends

Most fishers were able to describe details associated with boto legends and almost a third of fishers believe in the stories. Unlike previous studies that suggest that these legends no longer provide protection for botos (e.g., Brum 2011; Pinto de Sa Alves et al. 2012), our results suggest otherwise since half of the fishers that believe in the legend claimed to avoid harming botos because of the superstitions. Furthermore, although other studies claim that present generations no longer believe in these legends (e.g., Brum 2011; Pinto de Sa Alves et al. 2012; Iriarte and Marmontel 2013a), our study shows that a considerable number of younger fishers do believe in the legends.

Conclusion

Although botos are embedded deeply in Amazonian culture through rich mythology, negative interactions between botos and local Amazonian fishers have increased substantially in the last few decades. Interactions such as depredation and entanglement are common, and the harvest of botos for bait was reported in the majority of the communities visited. Although boto survival estimates (Mintzer et al. 2013) and fisher perception suggest the harvest may be decreasing in the study area (the southernmost segment of the MSDR), the harvest appears to be increasing in neighboring areas where there is less protected area management presence. The current scale of influence of the protected area initiatives is insufficient to prevent boto population decline (da Silva et al. 2011; Mintzer et al. 2013). Based on the results of our study that suggest that the MSDR programs are having a positive effect on fisher attitudes toward botos, we recommend that the management model and community-based initiatives that have been developed in the study area (a relatively small geographical area) be expanded to neighboring areas. Furthermore, increasing community-based enforcement coordinated by the MSDI may be a good

strategy to limit or decrease the harvest. Programs focused on community-based management, involvement of communities in wildlife research, continuous education and outreach initiatives, and training of community enforcement agents, could be replicated in other SDRs where the same basic management schemes are already in place. Expanding the MSDR model both at the local and regional level could have a positive impact in decreasing or limiting the harvest which is becoming increasingly prevalent throughout the Amazon basin.

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