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Artisanal fishers' perceptions of the ecosystem services derived from a dolphin-human cooperative fishing interaction in southern Brazil

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ABSTRACT

Incorporating the perception and attitudes of key stakeholders into conservation management can contribute to biodiversity conservation and has the potential to resolve human-wildlife conflicts. To this end, there is scope to enhance conservation outcomes by improving the capture and analysis of stakeholders perceptions and translating these into the management decision making process. Here, an ecosystem services approach (i.e. the benefits people obtain from nature) is used to assess the societal benefits derived from a specialized and rare behavior exhibited by bottlenose dolphins (*Tursiops truncatus gephyreus*) that cooperatively forage with artisanal fishers in Laguna, southern Brazil. From interviews, we identified ecosystem services based on the perception of artisanal fishers who take part in this interaction. The perceived benefits of cooperative fishing with dolphins, identified from these interviews, were grouped into eight ecosystem services assigned into cultural (n = 7) and provisioning (n = 1) related services. The results showed that experienced fishers were more likely to identify multiple and diverse ecosystem services, while fishers exposed to tourists tended to focus on tourism and recreation leisure as benefits from fishing with dolphins. Our findings show that the human component is a key element in this system and support the proposal that future conservation decisions and management plans of Laguna's bottlenose dolphins should involve artisanal fishers to be more effective. Our findings indicate that an ecosystem services approach could help decision-makers to better integrate social, economic and cultural aspects of human-wildlife interactions into conservation and management strategies for wildlife in a wider context.

1. Introduction

Fishers often interact with marine wildlife and as such have a broad knowledge of species biology, behavior and resource management practices (Damasio et al., 2015; Herbst and Hanazaki, 2014; Souza and Begossi, 2007). However, conflicts can emerge from such interactions with marine wildlife. For example, damage to fishing gear, competition for prey and incidental bycatch can drive negative attitudes to wildlife and can induce fishers to perceive marine wildlife as a threat to fisheries (Engel et al., 2014; Read, 2008). The impact caused by wildlife on fisheries, however, might not be as high as the fishers perceive (Machado et al., 2016). But fishers can also have positive perceptions towards marine wildlife (Busnel, 1973; D'Lima et al., 2014; Pelletier, 1975; Zappes et al., 2011) and can understand, even indirectly, the role of wildlife in the health of natural, social and economic systems. In this context, understanding how people perceive and benefit from nature is a timely challenge, with potential benefits to biodiversity conservation (Gelcich and O'Keeffe, 2016). However, management and conservation strategies can, in turn, have implications for the fishers and influence their perceptions. Therefore, the assessment of fishers' perceptions is integral to the monitoring of the efficacy of management and conservation strategies (e.g. Leleu et al., 2012). These perceptions can be described by ethnoecological studies as the assessment of local ecological knowledge in order to provide a comprehensive understanding of human beliefs, practices, and knowledge about natural resources (Begossi et al., 2004). However, in order to improve the integration of

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stakeholder views into management strategies and reduce human-wildlife conflicts we need to improve the measurement and quantification of stakeholder perceptions.

Ecosystem services frameworks, defined by the Millennium Ecosystem Assessment (MEA) as "the benefits people obtain from ecosystems" (Millenium Ecosystem Assessment, 2005), have been used to increase awareness of human dependence on nature (Costanza et al., 2017). Several works discuss the concept of ecosystem services (e.g. Boyd and Banzhaf, 2007; Díaz et al., 2018; Fisher et al., 2009; Pascual et al., 2017; Wallace, 2007), but the interest in integrating ecology and economics has gained more attention (Costanza et al., 2014, 1997). Economic values are important in order to translate the importance of ecosystems into tangible terms and to help decision makers to allocate resources for conservation (Beaumont et al., 2008). However, conducting an economic valuation of nature is a challenging task and might not completely capture the complexity of the human and cultural relationship with the environment (Jax et al., 2013). People's perceptions of cultural and intrinsic aspects of their relationship with the environment are often misrepresented in economic approaches but have an important role in motivating public support (Daniel et al., 2012; Kumar and Kumar, 2008; Plieninger et al., 2015). A more comprehensive view of the value of nature is required to establish successful conservation and management strategies. Thereby, decision makers must focus on improving their understanding of stakeholders' perceptions of their environment (Gelcich et al., 2005), incorporating multiple stakeholder values including local, cultural and societal elements as well as economic value (Brown, 2013). Ultimately, ecosystem services valuation needs to include cultural values as well as economic values and integrated approaches are needed to reflect the complexity of interactions and interests of multiple stakeholders (Jacobs et al., 2016).

In Laguna, southern Brazil (Fig. 1), artisanal fishers carry out small-scale fishing throughout the year and one of the most important target species is the mullet (*Mugil liza*) (Simões-Lopes et al., 1998) which migrate from Uruguay and Argentina to the coastal waters of southern Brazil during their reproductive cycle (Vieira and Scalabrin, 1991). A small population of coastal bottlenose dolphins (*Tursiops truncatus gephyreus*) is resident in the lagoon system adjacent to Laguna (Daura-Jorge et al., 2013), and a subset of this dolphin population has an unusual foraging tactic that comprises a cooperative behavior with local cast-net artisanal fishers (Pryor et al., 1990; Simões-Lopes, 1991). These cooperative dolphins drive mullet shoals towards a line of fishers and then display stereotyped behavioral cues (e.g. back presentation, head slap, tail slap), that fishers understand as a signal to cast their nets. Fishers catch more and larger fish when fishing with dolphins and, in turn, dolphins catch the fish disoriented by the nets (Simões-Lopes et al., 1998). Although all dolphins can interact with fishers, not all dolphins frequently do so. The same occurs with fishers and not all fishers in the area are engaged in cooperative fishing with dolphins. There are almost 4300 fishers officially registered, who mainly use gillnet, bottom longline, traps and *tarrafa*, a circular nylon cast net. However, no more than 300 fishers use cast net fishing in cooperation with dolphins. Despite the low cost of fishing with dolphins, fishers need to know stereotyped cues and get access to a place where the cooperative fishing occurs. Fishers who engage in cooperative fishing with dolphins regulate who uses each site to cast their nets, but this system can vary according to fishing spots (Peterson et al., 2008). Currently, this informal self-regulation ensures resource sharing and the exclusion of non-locals from cooperative fishing spots (Peterson et al., 2008). Also, the rarity of this dolphin-human interaction is an attraction for tourists and generates indirect revenue to the local community via increased local tourism, with benefits to local restaurants and accommodations for example (Hoyt and Iñíguez, 2008).

The population size (about 60 dolphins) and the high residency pattern (i.e. individuals habits the area throughout the year) of Laguna's bottlenose dolphin population have led to concerns about the long-term viability of this population (Bezamat et al., 2018). Dolphins in Laguna are exposed to habitat change caused by multiple and increasing anthropogenic threats including, boat traffic, gillnet entanglement, constructions and chemical and biological pollutants (see Agrelo, 2017; Daura-Jorge et al., 2013). Local environmental groups have demanded protection measures for the dolphins, such as stricter regulation or even prohibition of fishing activities, and the regulation of vessel traffic. However, these demands have not been acted on by local authorities and there is some resistance amongst the local artisanal fishing community to increased regulation. Meanwhile, dolphin mortality from unnatural causes remains high, with gillnet bycatch posing the biggest threat to this small dolphin population. Only 12 of a total of 24 carcasses found between 2013 and 2018 were examined by veterinarians, of which 6 had signs consistent with entanglement in fishing gear (Castilho, personal communication). To date, we are not aware of local proposals to test alternative fishing gear or fitting bycatch reduction devices to fishing gear (e.g. Bordino et al., 2013; Fletcher, 2018). Recently, however, a municipal law was approved to prohibit gillnet fisheries in areas of concentrated use by dolphins (Laguna, municipal law number 1.998/2018). Self-policing is crucial if this law is to be effective and if fishers perceive the societal benefits of dolphin conservation, they may be encouraged to actively engage in supporting local conservation laws and practices.

In order to provide evidence of the economic and cultural benefits of dolphin conservation we used an ecosystem services based approach to identify the key benefits to local artisanal fishers derived from this dolphin-human interaction. To facilitate the incorporation of stakeholder perceptions into management actions, we planned a study designed to triangulate fishers' perceptions, obtained using directed interviews, against a set of pre-defined ecosystem services, in order to identify the relevant values and elements that need to be considered in conservation management planning. We tested whether a suite of ecosystem services could be used to represent fishers' reported perceptions. To address this goal, we interviewed fishers using a set of standard questions and, (1) matched their responses against a set of pre-defined ecosystem services perceived and (2) tested the influence of various characteristics of the fishers themselves on the number and diversity of ecosystem services they perceived.

2. Material and methods

2.1. Study area

Laguna (28°20′S, 48°50′W) is adjacent to one of the largest lagoon complexes in southern Brazil (Fig. 1). The Santo-Antônio-Imaruí-Mirim lagoon system is fed by the Tubarão River, which flows into the Atlantic Ocean through an inlet channel. Fishing is one of Laguna's most significant economic activities, with a high diversity of techniques and target species. The dolphin-cooperative fishing activity frequently occurs in eight fishing spots through the lagoon system, but most of the cooperation occurs at five spots close to the Tubarão River and the inlet channel (Fig. 1). These five fishing spots comprise the diversity of fishing strategies used with dolphins. Fishers at Tubarão River, Lagamar and Balsa always fish from dugout canoes, fishers at Toca da Bruxa sometimes fish from dugout canoes, or on foot, and fishers at Praia da Tesoura fish only on foot (see Peterson et al., 2008).

2.2. Data collection

To assess the ecosystem services perceived by the artisanal fishers who take part in the dolphin-human cooperative fishing, we conducted semi-structured interviews with 53 local artisanal fishers. Interviews took place from May to September 2014. Pilot interviews preceded data collection to refine the questionnaire. Participants were selected using the snowball method, whereby participants recommend other potential contributors (Bernard, 2006). We conducted the interviews at the five main cooperative fishing spots (Fig. 1). When participants could not be

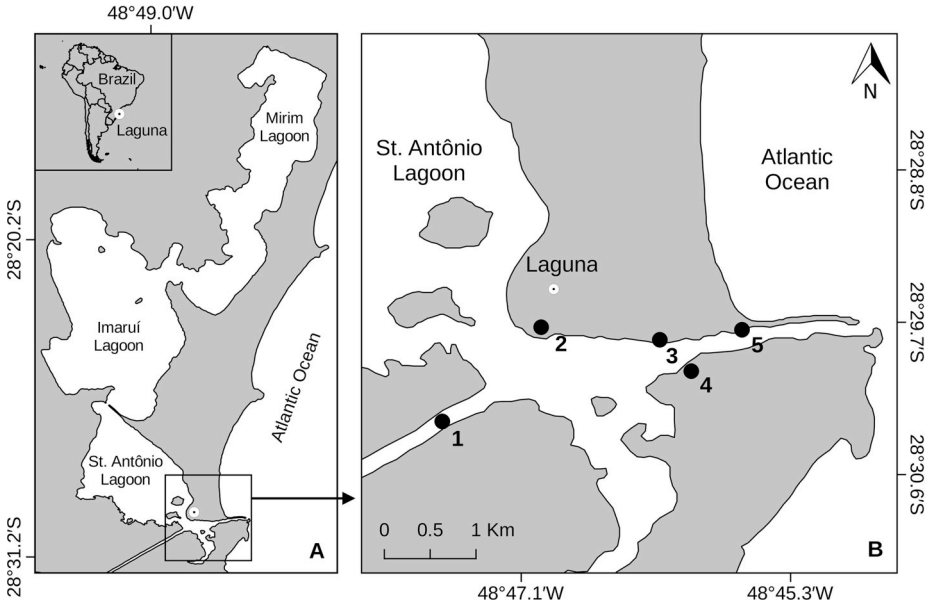

Fig. 1. A) Location of the St. Antônio-Imaruí-Mirim lagoon complex and the study area in southern Brazil. B) Fishing spots where fishers were interviewed: 1. Tubarão River (n = 8); 2. Lagamar (n = 10); 3. Toca da Bruxa (n = 9); 4. Balsa (n = 5); 5. Praia da Tesoura (n = 21 fishers). Praia da Tesoura is the only fishing spot where tourists can easily watch the cooperative fishing with dolphins in Laguna.

found at cooperative fishing spots, the interviews took place at their homes (in these cases, the main fishing spot used by the participant was confirmed during the interview). All fishers interviewed were active members in the cooperative fishing with dolphins, since these fishers are those that have a more local affinity and better knowledge of the local scene than fishers who does not engage in cooperative fishing with dolphins. Participants were interviewed individually and asked to sign a consent and data release form.

We used a semi-structured interview protocol with 19 questions designed to assess fishers' perceptions and to classify them into socio-economic profiles (Huntington, 2000; see questionnaire in Appendix A). We started the interviews asking about fishers' individual characteristics (age, main fishing spot, their main source of income). Then, we focused on open-ended questions such as: (i) “How important is it for you to engage in cooperative fishing with dolphins? And why?” (ii) “Is it important to maintain the cooperative fishing with dolphins? And why?”; (iii) “What would you be doing if there were no dolphins in Laguna?”. These questions focused on fishers' perceptions about the importance of cooperative fishing with dolphins and fisher's willingness to leave or continue fishing even in the absence of dolphins in alternative scenarios. In this way, we aimed to assess the benefits fishers perceive from their cooperative fishing with dolphins.

Although the precise number of fishers who routinely participate in cooperative fishing with dolphins is not known, based on our observations over the last 10 years, we estimate that this number is not higher than 300 (almost twice the maximum counted in one day of fishery activity). Therefore, our sample size (n = 53) is likely to be representative and is similar to other ethnoecological studies working with cooperative fishers' Local Ecological Knowledge in southern Brazil (see Peterson et al., 2008; Zappes et al., 2016). Based on previous local studies with cooperative artisanal fishers in Laguna, no audio or video was recorded to avoid inhibiting informants from participating.

2.3. Data analysis

Praia da Tesoura was the only fishing spot with easy access for tourists, while the other four fishing spots (Tubarão River, Balsa, Lagamar, and Toca da Bruxa) are areas with difficult access for non-locals and tourists. Therefore, for subsequent analysis, we collapsed fishers' responses from the four less accessible fishing spots into a single group (Inlet/Lagoon). We classified fishers into socio-economic profiles according to their source of income and willingness to leave or continue fishing activities even in the absence of dolphins and mullet.

After addressing the semi-structured questionnaire, we qualitatively analyzed the perceptions of fishers, checking for patterns in the answers that could be assigned to the ecosystem services described in the MEA (Millenium Ecosystem Assessment, 2005). The MEA typology comprises provisioning (e.g. food, water, fuel), regulating (e.g. water filtering, climate regulation, pollination), cultural (e.g. cultural diversity, cultural heritage values, sense of place, social relations, recreation and ecotourism, aesthetics, knowledge systems) and supporting (e.g. soil formation, photosynthesis, nutrient cycling) ecosystem services. In our qualitative analysis of fishers' perceptions from interviews, we focused on questions about the importance of cooperative fishing with dolphins and the stated preferences of fishers in alternative scenarios (see questions 3, 5, 6, 15, 17 and 18 in Appendix A), in which dolphins no longer exist in Laguna and fishers would need to look for other activities to fulfill their needs. These questions were addressed to assess most evident perceptions towards cooperative fishing with dolphins. Then, we conducted the ‘translation process’, analyzing the local ecological knowledge data in tandem with scientific knowledge in order to assign fishers' perceptions to the ecosystem services as described in the Millennium Ecosystem Assessment (2005). We built a binary matrix of n fishers by m ecosystem services. The total number of ecosystem services perceived by a fisher was given by the sum of all ecosystem services perceived. The methodological step from interviews to the dataset is presented in Fig. 2.

We used Generalized Linear Models (GLMs) with a binomial distribution to test the influence of fishers' individual characteristics (i.e. experience, socio-economic profiles, and preferred fishing spot) on the ecosystem services assigned based on their responses to the questionnaire (Table 1). The response variable was the proportion of the total number of ecosystem services perceived (n) by the respondent and the total number of ecosystem services that a fisher did not perceive (8 – n). The predictive variables were fishers' socio-economic profile (professional, opportunistic, and amateur fishers), fishing spot (Praia da Tesoura or Inlet/Lagoon) and experience in cooperative fishing with dolphins (years). Such characteristics reflect the variation in fishers' social, cultural and economic aspects, factors shown from other studies to influence the way people perceive nature (e.g. Silva and Lopes, 2015).

We excluded five fishers from analyses due to incomplete questionnaire data. We also excluded one fisher who perceptions could not be assigned to any ecosystem service from the MEA classification.

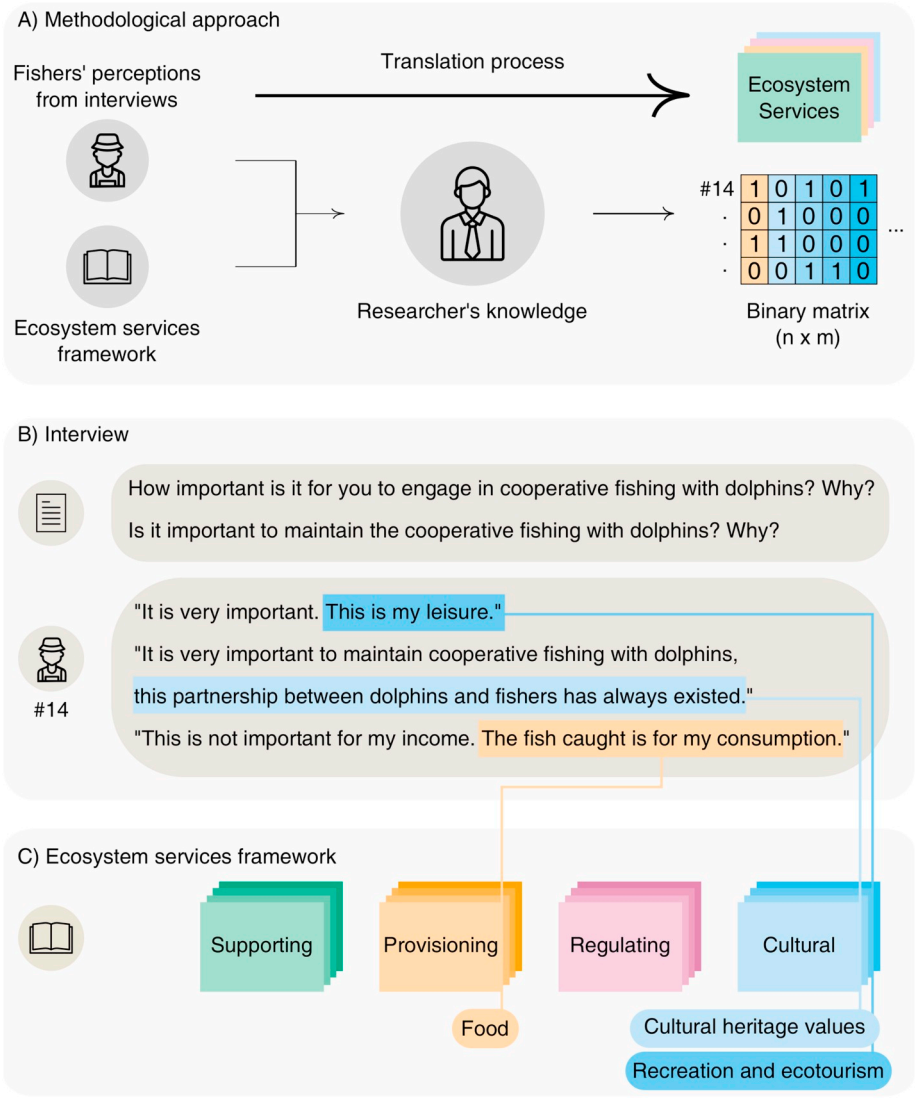

Fig. 2. Description of the methodological step from interviews to the dataset (A). Fishers' perceptions were qualitatively analyzed to identify patterns that could reflect benefits or positive relations from cooperative fishing with dolphins (B). To assign fishers perceptions to ecosystem services, the translation process depends on how researchers comprehend, compare and assign the fishers' perceptions to the ecosystem services framework (C). In A, B and C, each color represents a different class of ecosystem service with different shading representing specific ecosystem services within this class. The notation #14 refers to the identity of a specific fisher. The icons used in this figure were made by Freepik©. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Model fit was conducted through a stepwise procedure, using backward elimination. All independent effects were included, and the effect that contributed the least to the model was removed at each step. Then, interactions between variables were tested. The Akaike's Information Criterion (AIC) was used to rank models. All statistical analyses were conducted in the R environment (R Development Core Team, 2017), with *MASS* (Venables and Ripley, 2002), *MuMIn* (Barton, 2016), *AICcmodavg* (Mazerolle, 2017) and *car* (Fox and Weisberg, 2016) R packages. Code is available as supplementary material (see Appendix B).

To test the influence of the level of experience of cooperative fishing, preferred fishing spot and fishers socio-economic profiles on the ecosystem services perceived by fishers, we used multivariate generalized linear models (GLM_{mv}) with binomial structure (presence or absence of an ecosystem service), with a cloglog link function (cf. Wang et al., 2017), using 999 permutations. We used the *mvabund* R Package (Wang et al., 2017) to run multivariate generalized linear models. We conducted model fit with the same stepwise procedure used in the GLMs, as described above. Adjusted p-values were used to check for statistical significance of the variables. The sum of Akaike Information Criterion (AIC) was used to rank models. Model assumptions were checked using residual plots (see Fig. S1 in supplementary material for residuals of the GLM_{mv}). To visualize the effects of individual characteristics on the composition of ecosystem services perceived by

Table 1
Description of the variables used in Generalized Linear Models (GLM) to categorize ecosystem services perceived by fishers cooperatively fishing with dolphins.

Variable	Level	Influence
Ecosystem services perceived	Continuous Variable	Response variable
Experience in cooperative fishing with dolphins	Continuous variable	Time in years since the fisher started fishing with dolphins
Fishing spot	Praia da Tesoura	Praia da Tesoura is accessible to tourists and outsiders
	Lagoon fishing spots	Fishing spots less accessible to tourists and outsiders
Fishers profile	Professional fisher	Fishing activity is the main source of income
	Opportunistic fisher	Fishing activities as a supplementary source of income
	Amateur fisher	No economic interest in fishing with dolphins

fishers, a non-metric multidimensional scaling (nMDS) was used based on a Jaccard dissimilarity matrix. The *Vegan* R package (Oksanen et al., 2016) was used to calculate distance matrices and plot the nMDS.

3. Results

3.1. Characteristics of cooperative fishers

Fifty-three fishers were interviewed, all male, aged between 20 and 77 years old (Median 54 ± 13.52). Fishers had a minimum of five and a maximum of 56 years (Median 30 ± 14.13) of experience of cooperative fishing with dolphins. Most respondents lived in Laguna (94%) and only three lived in adjacent towns. Fishers were classified into three socio-economic categories; 1) 'Professional' fishers are registered in local institutions and rely on fishing activity as the main source of income (n = 26; 49%); 2), 'Opportunistic' fishers are mainly part-time fishers who use cooperative fishing with dolphins as a complementary economic source of income for retirement or informal jobs (n = 20; 38%). Some opportunistic fishers leave their formal jobs during the mullet season to spend three months fishing with dolphins; 3), and 'Amateur' fishers who use cooperative fishing with dolphins as a leisure activity (n = 7; 13%). Amateur fishers were observed only at *Praia da Tesoura* (n = 6) and *Toca da Bruxa* (n = 1). Amateur fishers are not always registered in local institutions. They are usually retired or have another job as their main source of income. Unlike opportunistic fishers, amateur fishers are more likely to engage in cooperative fishing with dolphins all year long as a hobby. The focus on profit varies between fishers.

3.2. Fishers' perceptions and ecosystem services

Fishers' perceptions were grouped into eight ecosystem services assigned into cultural (n = 7) and provisioning (n = 1) related services (Table 2). Fishers perceived a minimum of one and a maximum of seven ecosystem services (Median 3 ± 1.45). More than half of all fishers had the opportunity to develop a 'Sense of Place' (66%). Also, the ecosystem service "Recreation and ecotourism" was frequently perceived (66%), indicating that fishers derive pleasure from engaging in the dolphin-human interaction and also have positive perceptions towards the associated tourism. These perceptions are supported by statements like "*I come for leisure (participant #19, aged 65)*", "*This is a hobby (participant #10, aged 51)*" and "*This fishery is a tourist attraction. If there are no dolphins, the tourists will not come (participant #36, aged 61)*".

Most fishers (90%) perceived cooperative fishing with dolphins as an important source of income. The presence of tourists at *Praia da Tesoura* and other employment aspects influenced fishers' perceptions of economic issues. For example, a fisher from *Toca da Bruxa* said "*if outsiders and tourists could come here, we could sell fish at higher prices. However, only local people can come here (participant #38, aged 45)*". Fishers from different fishing spots shared such perceptions: "*Tourists pay too much, while the middleman pays too little (Praia da Tesoura, participant #32, aged 36)*".

3.3. Factors influencing fishers' perceptions

A fisher's level of experience of cooperative fishing with dolphins was significantly related to the number of ecosystem services they perceived (z = 2.225, df = 46, P = 0.026). More than one model supported data variation (ΔAIC < 2; cf. Burnham and Anderson, 2002), but only experience in cooperative fishing with dolphins had a significant influence on fishers' perceptions of ecosystem services (Table 3). Fishers' profiles influenced the composition of ecosystem services perceived (see Table S1 in the supplementary material for all coefficients and p-values of the selected GLM_{mv}). Fishing in a spot easily accessed by tourists positively influenced the perception of the "Recreation and ecotourism" ecosystem service (Score Value = 10.54,

Table 2
Ecosystem services perceived by artisanal fishers in a cooperative artisanal fishing with dolphins in Laguna, southern Brazil.

Ecosystem service classification	Ecosystem Service	Description	Frequency (n)	Fishers' perceptions
Provisioning	Food	Benefits from the fish caught in cooperation with dolphins	49% (n = 23)	"There is no need to buy meat. We like the fish from here." (Praia da Tesoura, participant #27)
Cultural	Sense of Place	Characteristics of the environment related to the presence of dolphins that fishers recognize as benefits	66% (n = 31)	"The dolphin brings fish to us. Here, in this land, the dolphins are born to do it." (Lagamar, participant #36)
	Recreation and ecotourism	Recreation and tourism opportunities generated by cooperative fishing with dolphins	66% (n = 31)	"If it weren't for the dolphins, there would be no beauty in Laguna. Most tourists come for the dolphins." (Praia da Tesoura, participant #28)
	Social relations	Cooperative fishing with dolphins positively influences the social relations of fishers	34% (n = 16)	"We do this for a long a time … I was raised with the dolphins" (Lagamar, participant #29)
	Cultural diversity	The diversity of practices and knowledge in cooperative fishing with dolphins	26% (n = 12)	"Each dolphin gives the signal in a different way, and one need to know (the different stereotyped signals) in order to catch the fish" (Praia da Tesoura, participant #32)
	Cultural heritage values	Maintenance of cultural aspects of cooperative fishing with dolphins	34% (n = 16)	"We do this for a long time. We know the dolphins since we were little." (Lagamar, participant #43)
	Aesthetics	Aesthetic values of cooperative fishing with dolphins	11% (n = 5)	"This is beautiful. It doesn't happen everywhere." (Praia da Tesoura, participant #23)
	Knowledge systems	Opportunities to increase knowledge around cooperative fishing with dolphins	6% (n = 3)	"… it is important because of tourism, research …" (Praia da Tesoura, participant #32)

Table 3
Variables used and results of the binomial Generalized Linear Models (GLMs) considering the ecosystem services perceived (n) and ecosystem services not perceived (8 - n) by each fisher as respondent variable for fishers' perceptions of ecosystem services. Values in bold indicate significance at $P < 0.05$.

	Intercept	Experience	Local	Profile	experience: local	experience: profile	local: profile	Deg. of freedom	Log Lik	AICc	ΔAICc	Weight	R2
M3	−1.082	**0.01721**						2	−80.25	164.8	0	0.276	9.2
M5	−1.575	**0.02797**	+		+			4	−77.99	164.9	0.158	0.255	17.4
M2	−0.664	**0.01899**		+				4	−78.07	165.1	0.317	0.235	17.1
M1	−0.8433	**0.01932**	+	+				5	−77.85	167.2	2.376	0.084	18.0
M6	−0.3866	0.007292		+		+		6	−76.63	167.4	2.583	0.075	22.4
M4	−0.5565							1	−82.76	167.6	2.838	0.066	–
M7	−8.646e-16		+	+			+	6	−79.17	172.4	7.669	0.005	13.1

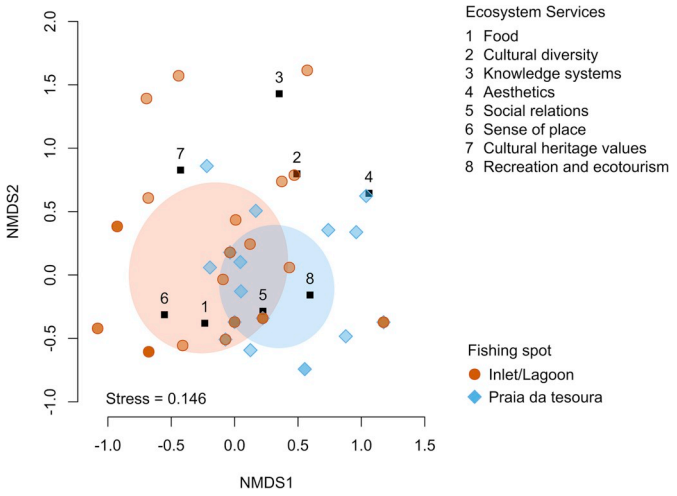

Fig. 3. Non-metric multidimensional scaling (nMDS) of fishers' perceptions of ecosystem services in artisanal cooperative fishing with dolphins. Fishers from Praia da Tesoura were more likely perceive the presence of "Recreation and ecotourism" service. These ordinations are for visualization. The coefficients of the multivariate generalized linear models are in Table S1. Orange circles represent fishers from Praia da Tesoura and blue diamonds represent fishers from other fishing spots. Numbered black squares are the ecosystem services, numbered according to the legend on the right. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

$P_{adj.} = 0.008$; Fig. 3).

4. Discussion

Here, for the first time, an ecosystem services approach is used to describe how artisanal fishers perceive a dolphin population and their behavior. We found that local artisanal fishers have a positive perception towards Laguna's bottlenose dolphins and, through eight ecosystem services, provide a broad understanding of how this unusual and specialized cooperative foraging tactic is related to the fishers' well-being. Fishers are seeking material and tangible market benefits, such as food and economic viability, but they also perceive other non-market benefits and non-material aspects of well-being, such as recreation, social relationships, and intrinsic values. This study demonstrates the potential for ecosystem services approaches in assessing stakeholders' perceptions towards animal populations. We also provide evidence of the importance to take both the fishers and the dolphins' well-being into account when constructing conservation plans.

4.1. Fishers' perceptions towards the cooperative fishing with dolphins

Fishers with more experience in cooperative fishing with dolphins perceived more of the ecosystem services the dolphins provide. This result may have arisen in two distinct ways. First, by personal experience whereby the more experienced fishers reported a more diverse perspective of the environment than less experienced fishers. In addition, experienced fishers have had more time to change their interests, social and economic characteristics. In this context, experienced fishers had more opportunities to broaden their perception via opportunities to share experiences, use different fishing spots, and even retire from professional fishing and become a hobbyist, for example. A second plausible explanation is that cooperative fishing with dolphins could have provided more benefits in the past, that only experienced fishers, with the memory of past, could perceive and share.

Fishers at Praia da Tesoura, the only fishing spot that tourists can access easily, tended to identify "Recreation and ecotourism" ecosystem service more frequently. Fishers at Praia da Tesoura were mainly classed as 'Amateurs' (n = 6, 29%) or 'Opportunistic' (n = 12, 57%) and may be motivated by the touristic aspects of the interaction. With less dependence on cooperative fishing with dolphins as a source of income, fishers at this site may identify the cooperative fishing with dolphins as a tourist attraction and a leisure activity more readily. The influence of tourists on the market chain still needs to be explored, such as the influence of cooperative fishing with dolphins on adding value to the fish landed. Yet, selling fish directly to the final consumer can certainly increase fishers' income (Lopes et al., 2015).

Despite the difference in the perception of ecosystem services related to the experience of fishers and differences between fishing spots, fishers, in general, had similar perceptions of ecosystem services. Individual characteristics can have a key role in people's perceptions and attitudes towards wildlife (e.g. Pont et al., 2016). Cultural, educational and behavioral aspects can also influence people's perceptions of ecosystem services (Blayac et al., 2014). However, fishers who participate in cooperative fishing with dolphins tend to belong to the same cultural group, using the same resources, sharing knowledge and common practices (Peterson et al., 2008; Simões-Lopes et al., 1998), which is likely to facilitate a homogenization of perceptions.

4.2. Ecosystem services and challenges for conservation

The ecosystem services perceived by fishers indicate how they perceive the benefits from the specialized foraging behavior of Laguna's bottlenose dolphins. The perceptions of provisioning ecosystem services are very clear, being directly associated with fish captures. Fishers can catch more and larger fish through cooperative fishing with dolphins (Simões-Lopes et al., 1998), potentially increasing their incomes. But fishers also have an overall perception that they provide benefits to dolphins and that they have an important role in maintaining the social, cultural, and the ecological aspects of the cooperative behavior (people asset). Indeed, dolphins who cooperatively forage with fishers seem to have slightly higher survival rates than non-cooperative dolphins and smaller home ranges areas (Cantor et al., 2018; Bezamat et al., 2018). The removal of human agents from dolphin-human interactions can directly affect the social relationships between dolphins and the dynamic of this bottlenose dolphin population (e.g. Ansmann et al., 2012). Therefore, to ensure the maintenance of ecosystem services provisioning, local decision makers must focus conservation efforts on maintaining the interaction between dolphins and fishers, the 'people

asset'. In doing so, they are contributing to the conservation of the bottlenose dolphin population of Laguna.

Laguna's bottlenose dolphin population is an important tourist attraction and a local source of income (Hoyt and Iñíguez, 2008; Simões-Lopes et al., 1998). The whale and dolphin watching industry expanded globally in recent decades (O'Connor et al., 2009). Whale-watching tourists are often interested in learning more about dolphins and whales, which contributes to raising awareness about conservation issues (Lück, 2015) and this could be further explored in Laguna. However, boat-based dolphin-watching could negatively affect the foraging behavior of dolphins (Bejder et al., 2006; Pirotta et al., 2015). Instead, Laguna's decision makers and stakeholders have the rare opportunity to focus on enhancing sustainable land-based dolphin watching activities. The dolphins and the cooperative fishing interaction are easily observed from the shore and island-based observations occur routinely at *Praia da Tesoura*, but without any infrastructure or information program dedicated to increase the volume or quality of tourism activity. Tourism can increase people's awareness of wildlife and provide positive outcomes for local management and conservation policies, engaging both visitors and residents (Garla et al., 2015). However, to use tourism activities as a sustainable and efficient conservation tool, local decision makers must focus on involving the local community in planning and management of tourism projects (Krüger, 2005).

Most of fishers' perceptions of benefits from the cooperative-fishing with dolphins were assigned to cultural ecosystem services demonstrating non-market values. For example, aesthetic values can be a source of inspiration for media production (e.g. Coscieme, 2015). Film production is a valuable tool to increase the audience awareness about biodiversity conservation (Silk et al., 2017). Indeed, the cooperative fishing with dolphins has been the subject of many local and international documentaries. It generates an affinity with wild dolphins and an increased sense of stewardship among the local human community. The cooperative fishing with dolphins has the potential to raise awareness of dolphin foraging strategies and to promote positive interactions between animal and humans at a wider scale.

Lastly, fishers who take part in the cooperative fishing with dolphins have a strong 'sense of place' identity and attachment to their role in this activity. Fishers are proud of their status in the high public profile that cooperative fishing with dolphins has established. The cultural and societal aspects, perceived as benefits, influence their actions towards the environment and wildlife, thus establishing a positive relationship between nature and people's health and well-being (Sandifer et al., 2015; White et al., 2017). In this context, human-nature interactions become part of a person's identity, shaping their sense of place and connecting their attitudes with the production of ecosystem services (Fischer and Eastwood, 2016). This sense of place influences pro-environmental behavior and increases the support of conservation strategies (Hernández Bernardo et al., 2010; Larson et al., 2013; Raymond et al., 2017). By using an ecosystem services framework, we were able to focus on the human-nature interaction and highlight the importance of a sense of place and place-based benefits to fishers in the cooperative fishing with dolphins. Our results may serve as evidence to motivate decision makers to engage fishers into management and conservation strategies, and to motivate researchers to give more attention to understand the perceptions of stakeholders.

5. Conclusions

Here, we applied an ecosystem services approach to investigate fishers' perceptions of a bottlenose dolphin population and its specialized foraging interaction. We found that fishers have an overall positive perception towards cooperative fishing with dolphins, and identified economic, cultural and social benefits. More importantly, fishers play an important role in the maintenance of this specialized foraging behavior and the value of this local bottlenose dolphin population. The ecosystem services approach can translate the perceptions of stakeholders into tangible concepts to aid decision makers, especially to avoid human-wildlife conflicts and establish successful conservation and management strategies. Our results suggest that the 'people asset' is a key element in the cooperative fishing with dolphins. Although we still need more information, we believe Laguna's bottlenose dolphin population would benefit from alternative conservation strategies that involve local stakeholders, such as a co-management process – involving artisanal fishers in the monitoring of prohibited fisheries, dolphins and strandings.

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Appendices A and B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2019.03.003.

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