

# The human dimension of the conflict between fishermen and South American sea lions in southern Brazil

Ana Carolina Pont · Silvio Marchini · Mônica Tais Engel ·  
Rodrigo Machado · Paulo Henrique Ott · Enrique A. Crespo ·  
Mariano Coscarella · Marina Schmidt Dalzochio ·  
Larissa Rosa de Oliveira

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**Abstract** We analysed the fishermen's perceptions on the South American sea lions (*Otaria flavescens*) and its interactions with the local fishery close to the Wildlife Refuge of *Ilha dos Lobos*, a marine protected area in southern Brazil. Sea lions prey upon the same resources targeted by the fishermen. They repeatedly hunt on the nets and consequently damage them. In response, fishermen persecute sea lions. However, in conflicts with high-profile animals, the perceived damage often exceeds the actual evidence. Results from 100 interviews revealed that fishermen's perception of damage and their attitudes were affected by

age, hierarchical position in the crew, if fishing was the only source of income, and level of formal education. Greater perception of damage and more negative attitude were found among older, less educated sailor fishermen who had no other source of income besides fishing. The average fisherman had a relatively good knowledge about sea lions, but also a negative attitude towards them. We recommend actions addressing these negative attitudes through environmental education, with emphasis on adjusting exaggerated perceptions of impact and the potential of the species for wildlife tourism, as a vital step towards the conciliation of sustainable fisheries and *O. flavescens* conservation in the Brazilian coast.

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A. C. Pont · M. T. Engel · L. R. de Oliveira (✉)  
Laboratório de Ecologia de Mamíferos, Universidade do Vale do Rio dos Sinos, Av. Unisinos, 950, São Leopoldo, RS 93022-000, Brazil  
e-mail: larissaro@unisinos.br

S. Marchini  
Ciências Florestais Departamento, Luiz de Queiroz  
Faculdade de Agricultura, Universidade de São Paulo,  
P.O. Box 09, Piracicaba, SP 13418-900, Brazil

M. T. Engel  
Geography Department, Memorial University, 384  
Elizabeth Ave., St. John's, NL A1B 3X9, Canada

R. Machado · P. H. Ott · L. R. de Oliveira  
Grupo de Estudos de Mamíferos Aquáticos do Rio Grande do Sul, Rua Machado de Assis, 1456, Osório, RS 95520-000, Brazil

R. Machado  
Pós-Graduação em Biologia Animal, Universidade Federal do Rio Grande do Sul (UFRGS), Av. Bento Gonçalves, 9500, Bloco IV, Prédio 43435, Sala 219, Porto Alegre, RS 91509-900, Brazil

P. H. Ott  
Laboratório de Ecologia e Conservação de Organismos e Ambientes Aquáticos (ECOAqua), Universidade Estadual do Rio Grande do Sul (UERGS), Unidade do Litoral Norte, Rua Machado de Assis, 1456, Osório, RS 95520-000, Brazil

E. A. Crespo · M. Coscarella  
Laboratorio de Mamíferos Marinos, Centro Nacional Patagónico (CENPAT-CONICET) and Universidad Nacional de la Patagonia, Blvd. Brown 3600, 9120 Puerto Madryn, Chubut, Argentina

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## Introduction

Interactions between pinnipeds (i.e. walrus, seals, sea lions and fur seals) and fishermen resulting in economic losses for fisheries, or in the incidental catching or deliberate harassment, injury or death of these animals, are well documented worldwide (e.g. Wickens, 1995; Lavigne, 2003). The conflict between South American sea lions (*Otaria flavescens*) (Shaw, 1800) (hereafter referred mostly as sea lions) and fishermen is considered to be the main threat to the conservation of this species (e.g. Crespo et al., 2012), which is currently still regarded as Least Concern in terms of the International Union for Conservation of Nature’s Red List (IUCN, 2014). Sea lions prey upon the same resources that are targeted by the fishermen and persistently feed from fishing nets, often damaging them in the process. Consequently, fishermen frequently persecute sea lions (e.g. Rosas et al., 1994; Machado et al., 2015a, b). Conflicts involving *O. flavescens* and fishermen have been reported along the entire coast of South America, involving various types of fisheries (see Crespo et al., 2012 for a review). Conflict between sea lions and salmon farming has also been documented (Sepúlveda & Oliva, 2005). Studies have focused on the description of these conflicts, economic impacts on fisheries (Wickens, 1995; Szteren & Páez, 2002; Sepúlveda et al., 2007; Crespo et al., 2012; Machado et al., 2015b) and on ecological implications of preventive and retributive killing of sea lion by fishermen (Rosas et al., 1994). However, they have largely overlooked the social and personal motivations behind the hostility shown by fishermen towards sea lions.

In southern Brazil, the Wildlife Refuge of *Ilha dos Lobos* (WRIL) is a strictly protected area (equivalent to IUCN’s category III—Silva, 2005), distant about

2 km from shore. South American sea lions and fur seals (*Arctocephalus australis*) haul out seasonally at the island, during austral winter and spring months (Sanfelice et al., 1999). The island, which they use as a resting site (Sanfelice et al., 1999), is in close proximity to an important fishing zone (Engel et al., 2014). The pinnipeds on the island are a tourist attraction, but also a problem to the local fishing community. Engel et al. (2014) reported that the local fishermen harbour negative attitudes towards the marine protected area (MPA) and the sea lions. They regard sea lions as competitors because they prey upon the same fish species that they target (Rosas et al., 1994; Machado et al., 2015a, b).

In human-wildlife conflict, however, persecution is not always a simple function of any damaging effects of wildlife. The reason for this is twofold. First, there may be a discrepancy between actual and perceived damage. What ultimately drives human behaviour is not necessarily the reality itself, but how reality is perceived. In conflicts with high-profile animals such as top predators, the perceived damage and risk often exceed the actual evidence (Conover, 2002; Marchini & Macdonald, 2012). Moreover, factors not directly related to the impacts of wildlife on human livelihoods may also influence the persecution of wildlife. Dickman et al. (2013) discuss how such factors at the individual level (e.g. experience, skills, knowledge and values) and societal/cultural level (e.g. income sources, folklore and religion) affect human behaviour toward wildlife (e.g. wildlife killing).

In this sense, the inclusion of human dimensions into conservation decisions regarding sea lions in southern Brazil could assist managers and decision makers with understanding of the issues faced by the fishing community, and guide actions to mitigate problems. Accordingly, assessment of the fishermen’s perspective of their conflict with sea lions, including which factors most influence their perceptions and attitudes, can be informative for designing effective strategies both for sea lion conservation and the sustainable management of the fishing activity on the southern coast of Brazil (Butler et al., 2011; Graham et al., 2011).

We hypothesized that the fishermen’s perception of damage—defined as “a belief, whether rational or irrational, held by an individual, group, or society about the chance of occurrence of a risk (or any impact) or about the extent, magnitude, and timing of its effect(s)” (Swim et al., 2009)—caused by sea lions

M. S. Dalzochio  
Universidade Feevale, Pró-Reitoria de Assuntos  
Comunitários – PROACOM, Rodovia RS-239, 2755,  
Prédio Amarelo, Sala 306, São José, Novo Hamburgo,  
RS 93352-000, Brazil

to the fisheries is affected by socio-demographic and psychological variables, such as age, education, work experience and knowledge about the sea lions. We also evaluated whether the attitudes of fishermen towards the species is affected by perception and by the same socio-demographic and psychological variables. Attitude is defined as “the unfavourable or favourable judgments an individual has about a person, situation, action or object” (Kamradt & Kamradt, 1999; Vaske & Donnelly, 1999; Manfredo, 2008; Vaske, 2008).

The present study is the first to address the human dimensions of the conflict between fishermen and *O. flavescens*. We selected the fishing community next to WRIL—Torres/Passo de Torres—to conduct this study because of a set of characteristics that makes the site particularly suitable for both research and management of human-sea lion conflicts. These characteristics are: (a) the historical records of conflicts between sea lions and fishermen (Rosas et al., 1994; Oliveira et al., 2008; Oliveira, 2013; Machado et al., 2015b), (b) it is one of the main important fishery communities from southern Brazil (Moreno et al., 2009; Cardoso & Haimovici, 2011), (c) current economic problems, including depletion of fishing stocks (Haimovici et al., 1996) and impoverishment of local fishing community (Oliveira et al., 2008), (d) proximity to WRIL (<2 km), and (e) the fact that WRIL still lacks a management plan and a participatory council (Engel et al., 2014).

## Materials and methods

### Study area and coastal fishing

The present study was conducted in the fishing community of Torres/Passo de Torres (29°19'S; 49°43'W), situated near the Mampituba River mouth, at the border of the states of Santa Catarina (SC) and Rio Grande do Sul (RS) (Fig. 1). This region is considered to be one of the most important fishing areas in southern Brazil (Haimovici et al., 1996; Isaac et al., 2006; Cardoso & Haimovici, 2011). According to the local fishermen association, the community currently comprises of approximately 350 fishermen and 33 active vessels. The fishing vessels in this area are regarded as forming part of a medium-scale fishery, with a maximum storage capacity of 50 tons,

9–20 m length, 90–360 hp engine, a crew size of 4–12 fishermen and a maximum of 20 fishing days per trip. This local fleet operates mainly in coastal marine waters with gillnets (surface driftnets and bottom nets) at between 10 and 50 m of depth (Moreno et al., 2009; Machado et al., 2015b). However, trawling and bottom long-lining by vessels from other areas of the country also take place in the study area (Cardoso & Haimovici, 2011). Six of the eight fish species that are known to be preyed upon by *O. flavescens* in the study area are also targeted by the local fishermen, namely bluefish *Pomatomus saltatrix*, weakfishes *Cynoscion guatucupa* and *Macrodon atricauda*, hake *Urophycis brasiliensis*, whitemouth croaker *Micropogonias furnieri* and Argentine croaker *Umbrina canosai* (Oliveira et al., 2008; Machado, 2013).

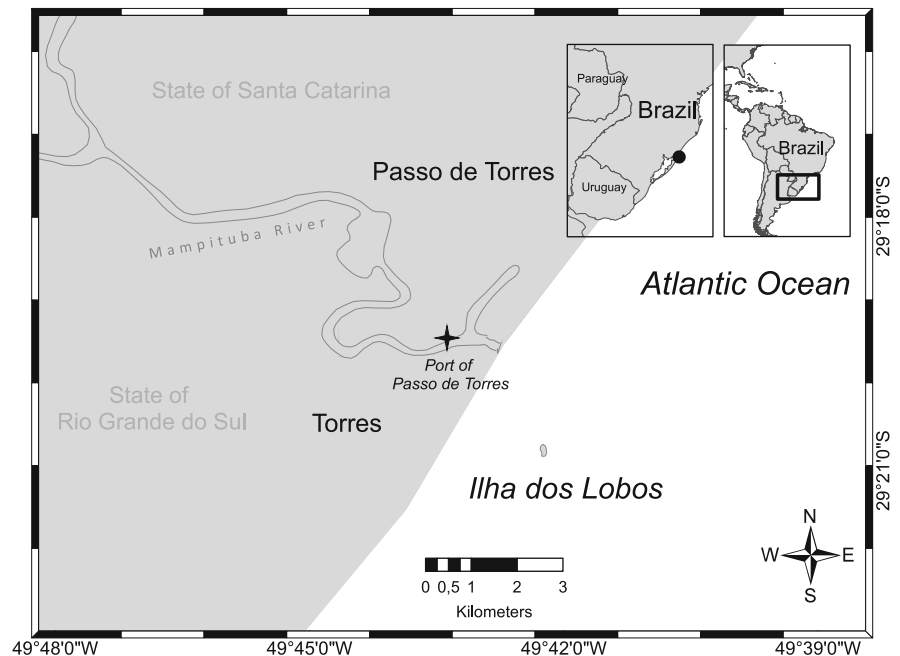
At present, the Brazilian Ministry of Environment (*Ministério do Meio Ambiente-MMA*) is the agency responsible for the management of the *Ilha dos Lobos* (29°20'S; 49°43'W), which was designated as a national MPA in 1983. During austral winter-spring months each year, this small island accommodates numerous species of shorebirds and marine mammals (Gliesh, 1925), including dozens of *O. flavescens* and *A. australis* which use this island as a resting site between foraging trips (Rosas et al., 1994; Sanfelice et al., 1999). Due to its biological diversity and the role it plays as a refuge for these marine species, this island is considered by the MMA to be part of an area of extreme biological importance along the Brazilian coast (MMA, 2007).

### Interviews

One hundred face-to-face interviews were conducted with members of the Torres/Passo de Torres fishing community in May 2012 (austral autumn) ( $n = 33$ ) and February 2013 (austral summer) ( $n = 67$ ). Interviews were always conducted by three researchers (ACP, RM and ME), one of them being a local interlocutor (RM) who facilitated the contact with the fishing community.

The sampling method was that of random cluster sampling (Newing, 2011), whereby a few fishermen at every dock (cluster) along the Mampituba River were randomly selected. We only interviewed crew members from fishing vessels that use gillnets, because it was the main type of gear in use by local fishermen. The interviews were carried out individually and their mean

**Fig. 1** Study area. Torres/Passo de Torres and Wildlife Refuge of *Ilha dos Lobos*, in the southern Brazilian coast



duration was approximately 20 min. More than one fisherman from the same boat could be interviewed on the same day. No selection criteria were applied to fishermen, other than they had to be part of a fishing crew. Any important information that was mentioned other than the closed-answer was noted down.

The questionnaire had 16 closed-ended questions and each fisherman had to select only one of multiple pre-defined answers for each question, following the standard approach for this type of study (Huntington, 2000; White et al., 2005; Vaske, 2008). These questions were distributed in five different categories: (1) socio-economic variables (questions 1–5); (2) knowledge about sea lions (questions 6–10); (3) attitude towards sea lions (questions 11–12); (4) behavioural intention (question 13) and (5) perception of the damage caused by sea lions (questions 14–16) (see details below). The options for the responses to some of the socio-economic questions were modified after considering the responses given during a pilot survey; for example by the addition of different age categories and hierarchical levels of the crew.

Knowledge about *O. flavescens* was assessed through five closed-ended questions (see questions 6–10 in Table 1): two questions had five possible answers (only one was correct) (questions 6 and 7) and the remaining questions (8, 9 and 10) had three

possible answers. In all cases, fishermen could only choose one answer.

To assess attitudes, we applied two closed-ended questions (see questions 11–12 in Table 1) with five possible answers on a Likert scale. This scale can be used for questions that are associated with more nuanced possible responses, because it measures the level of concordance or positioning for each issue. The response options range from extremely positive (+2) to extremely negative attitude (−2) in relation to each question (see details about the answers in Table 1) (Vaske, 2008). Fishermen could only select a single answer (see Table 1). However, when a respondent chose more than one option, then the valid response was considered to be the first one, following the instructions of Vaske (2008).

Behavioural intention was assessed through only one question (question 13 in Table 1) with five possible answers on a Likert's scale.

Perceptions of the damage caused by sea lions were assessed through three closed-ended questions (see questions 14–16 in Table 1) with suggested answers. Damage was defined by any kind of financial loss suffered by the fishermen due to the interactions with sea lions, including catch loss and damage to fishing gear. To measure the perception of damage, we asked for their evaluation of the damage caused by the sea lions.

**Table 1** Categories, questions and answer formats of the questionnaire applied to the fishing community of Torres/Passo de Torres, southern Brazilian coast

Categories	Questions	Answer categories
Socio-economic variables	(1) Age	<20, 21–30, 31–40, 41–50, >50
	(2) Education level	Elementary school incomplete, E.S. complete, High school incomplete, H.S. complete
	(3) Hierarchical level in the crew	Boat owner, captain, sailor
	(4) Amount of income sources	Fishing as the only source of income, fishing and other activity besides fishing
	(5) Fishing experience (=years of fishing)	<10, 11–20, 21–30, 31–40, >40
Knowledge about sea lions	(6) How many sea lions are on the island?	<50, about 100, about 200, about 300, do not know
	(7) During which season do you see more sea lions?	Spring, summer, autumn, winter, do not know
	(8) Are there female sea lions on the island?	Yes, No, Do not know
	(9) Are there sea lions pups on the island?	Yes, No, Do not know
	(10) Are there sea lions breeding on the island?	Yes, No, Do not know
Attitude towards sea lions	(11) Sea lions are:	Very interesting (+2), Interesting (+1), No opinion (0), Of little interest (–1), Of no interest (–2)
	(12) My interest to learn more about sea lions is:	Very big (+2), Big (+1), Medium (0), Small (–1), None (–2)
Behavioural intention	(13) I (...) thought about killing a sea lion:	Never (+2), Rarely (+1), Did not answer (0), Sometimes (–1), Always (–2)
Perception of the damage caused by sea lions	(14) How frequently do sea lions attack the fishing nets?	Never (+2), Rarely (+1), Do not know (0), Regularly (–1), Always (–2)
	(15) How many kilos of catch can a sea lion eat during each attack?	Up to 5 kg from (+2), Up to 20 kg (+1), No opinion(0), 20 kg to 50 kg (–1), More than 100 kg (–2)
	(16) How do you consider the damage caused by sea lions to the local fishing community?	Insignificant (+2), Small (+1), Medium (0), Substantial (–1), Highly substantial(–2)

## Data analysis

In order to evaluate socio-economic variables (for details see Table 1; Fig. 2), we used descriptive statistics to summarize the results and absolute frequency to present the behavioural intention of the fishermen towards sea lions (Fig. 2A–E) and perception of the damage (Fig. 2F–J). The number of the respondents was presented according to age, education level, hierarchical position within the crew, fishing as the only source of income and fishing experience (i.e. years of fishing). The correct and incorrect answers about knowledge of *O. flavescens* were evaluated based on information published on the natural history of the species as well as on the biodiversity of WRIL (Vaz-Ferreira, 1982a; Sanfelice et al., 1999; Crespo et al., 2012 and personal observations of the authors)

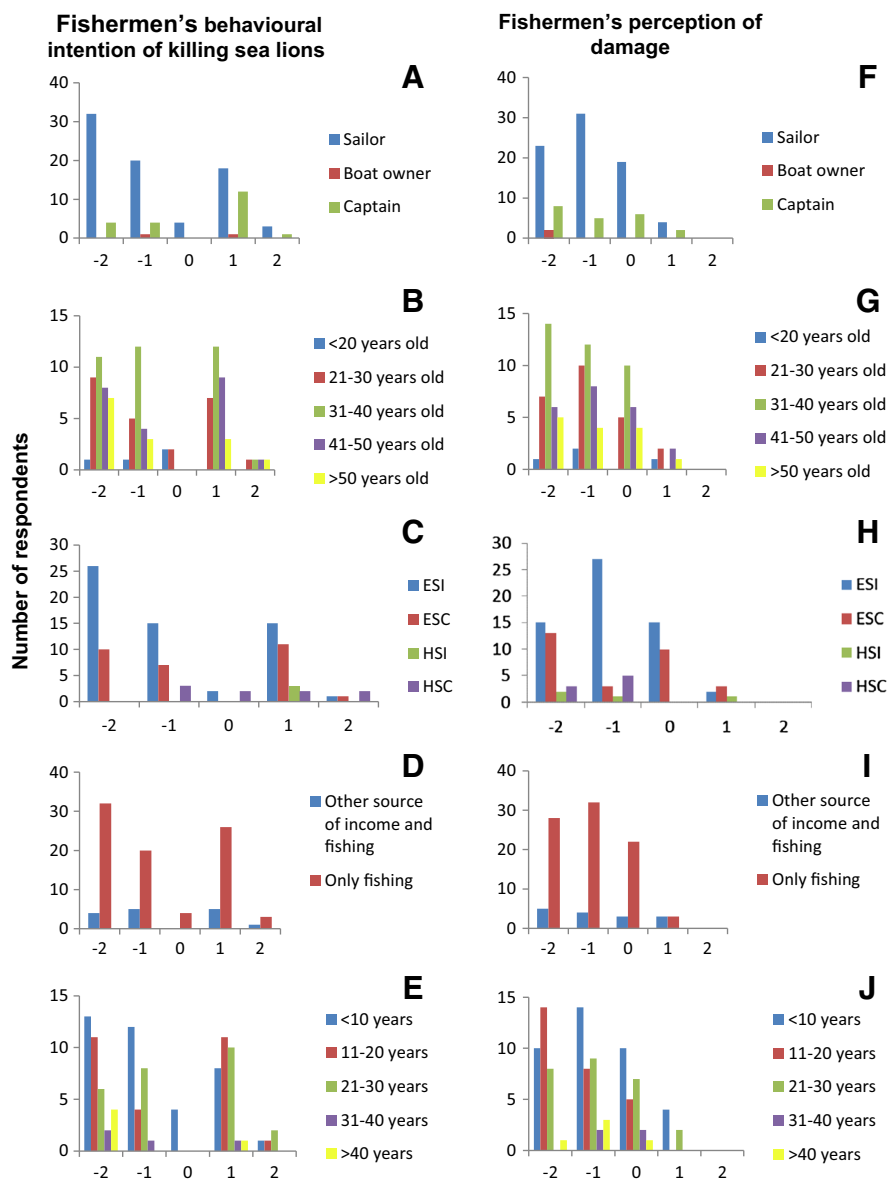
and classified according to the frequency of the responses.

The associations between perception of damage and knowledge about sea lions, and between perception of damage and attitude towards sea lions, were tested using the Pearson correlation coefficient. For this, the number of correct answers for the ecological questions was summed in each interview (i.e. out of 5). Then, the sum of correct answers on the ecological questions for all fishermen was independently correlated with their corresponding perception and attitudes values determined from the interviews, respectively. Moreover, the difference of the mean perception of the damage caused by sea lions among sailors, captains and boat owners was tested using ANOVA.

Additionally, the frequencies of the general perception damage caused by sea lions to the fisheries

**Fig. 2** Fishermen's perception of the damage (Table 1 question 16; Insignificant +2, Small +1, Medium 0, Substantial -1, Highly substantial -2) related to their:

**A** hierarchical level in the crew, **B** age, **C** education level (*ESI* elementary school incomplete, *ESC* elementary school complete, *HIS* high school incomplete, *HSC* high school complete), **D** amount of income sources and **E** fishing experience (years of fishing). Fishermen's behavioural intention of killing sea lions (Table 1, question 13; Never +2, Rarely +1, Did not answer 0, Sometimes -1, Always -2) related to their, **F** hierarchical level in the crew, **G** age, **H** education level, **I** amount of income sources and **J** fishing experience



(based again on Likert scale values) were calculated in order to represent the fishermen's stance (Fig. 2A–E). The same procedure was used to calculate the frequencies representing behavioural intention to attack a sea lion (Fig. 2A–E).

The overall attitude towards sea lions was calculated using the mean score of the values of the Likert scale attributed to two questions of attitude (see details above) answered by the 100 interviewees.

Standardized Cronbach's alphas were used to assess the reliability of the constructed scale (Vaske, 2008) for all categories of questions, with the

exception of question 13, because it is a single question of behavioural intention.

This question 13 (“I...never/rarely/did not answer/sometimes/or always...thought about killing a sea lion”) was treated as a behavioural intention to attack a sea lion instead of an attitude towards sea lions, which means it is an indication of an individual's readiness to perform a given behaviour (Ajzen, 2002).

To explain the relationship between the behavioural intention question and socio-economic variables we constructed a log linear model, using the GLM



function from R (R Core Team, 2013). We tested the hypothesis of whether (and which) socio-demographic variables influenced behavioural intention (i.e. to harm a sea lion). It is important to mention that the variable “fisherman’s age” was excluded from the model analysis, because it was collinear with work experience.

The full data set was analysed using a GLM framework, which extends the standard linear regression model by assuming a non-Normal error structure and using a “link” function (McCullagh & Nelder, 1989; Zuur et al., 2009). We used two different approaches to model the obtained responses, always using R language to fit the models (R Core Team, 2013). Firstly, we used logistic regression to model “perception of conflict” based on the answers obtained from questions in the perception section of the questionnaire (Table 1). Data were coded as “positive” and “negative” (i.e. 0 and 1) based on the sign (i.e.  $\leq 0$ ,  $> 0$ ) of the average of all three questions, rendering a dichotomic response variable. Additionally to the socio-economic categorical variables, we included as predictors the average of all the answers of the attitude section and the sum of the answers obtained from the knowledge section. Secondly, we tested the hypothesis that the knowledge of the fishermen on the biology of the sea lions increased with a higher formal education by fitting a Poisson regression (see results for further information on the hypothesis). Data were analysed using the GLM function of the package GLM2 and CLM form package Ordinal. The model selection was based on the  $\Delta AIC$ , and as a rule of thumb values that are less than two should be given consideration in addition to the selected model, while models with  $\Delta AICc$  values that are more than ten should receive little consideration (Burnham & Anderson, 2002).

In order to understand which variables influence fishermen’s perceptions, knowledge and attitude, non-metric multidimensional scaling (NMDS) were conducted through the analysis of the dissimilarity relationships among variables studied, with the exception of the variable fisherman’s age, due to its collinearity with fishing experience, as we mentioned before (for details see answer categories in Table 1). This analysis was performed with the Bray-Curtis dissimilarity index using two axes. Thus, the categories (perception, knowledge and attitude) were fitted to the ordination by the `envfit` function of the `vegan`

package (Oksanen et al., 2009) in the R statistical program version 3.12 (R Core Team, 2013).

Moreover, NMDS analyses were used to test the following six hypotheses, namely whether the groups of fishermen differed in perception of damage according to their (i) knowledge about the ecology of sea lions, (ii) attitude towards the species, and socio-economic aspects (Table 1) as (iii) education level, (iv) hierarchical position within the crew, (v) amount of income sources (e.g. fishing as the only source of income, or other activity besides fishing) and (vi) fishing experience (=years of fishing). All analyses were conducted in Past version 20, with a significance level of 0.05 and in the R statistical program version 3.12 (R Core Team, 2013).

## Results

### Socio-economic aspects of interviewed fishermen

One hundred fishermen were interviewed representing 30% of the community. The sample included two boat owners, 21 captains and 77 sailors, all of which fished with gillnets. For 85% of the respondents, fishing was the sole income source; the remaining 15% were mainly also construction workers. Ages ranged from 16 to 70 years (mean 35 years old) and fishing experience varied from 1 to 48 years (mean 24 years). Regarding education level, the sample comprised 59 fishermen with elementary school incomplete, 29 fishermen with elementary school complete, 4 fishermen with high school incomplete (i.e. less than nine years of schooling) and only 8 fishermen had completed high school (13 years of schooling). For a general view of the demographics of the sample, see Table 2.

### General knowledge, attitudes and perception of the fishermen towards South American sea lions

The presence of approximately 100 sea lions in the WRIL was answered correctly by 44% of the respondents, and 69% correctly answered that sea lions density was higher during the winter months. Eighty-eight percent of the interviewees correctly indicated the existence of female sea lions in the WRIL, but only 25% correctly answered that there is no breeding activity on the island while 19% answered “do not

**Table 2** Information on the general demographics of the fishermen interviewed in the study

Hierarchical level in the crew	Age range				
	<20	21–30	31–40	41–50	>50
Boat owner	0	0	1	1	0
Captain	0	2	12	6	1
Sailor	4	22	23	15	13
Total	4	24	36	22	14
Hierarchical level in the crew	Fishing experience (=years of fishing)				
	<10	11–20	21–30	31–40	>40
Boat owner	0	2	0	0	0
Captain	1	8	12	0	0
Sailor	37	17	14	4	5
Total	38	27	26	4	5
Hierarchical level in the crew	Education level				
	ESC	ESI	HSC	HSI	
Boat owner	0	1	0	1	
Captain	13	8	0	0	
Sailor	16	50	8	3	
Total	29	59	8	4	
Hierarchical level in the crew	Amount of income source				
	Only fishing	Fishing and other activity besides fishing			
Boat owner	2	0			
Captain	15	6			
Sailor	68	9			
Total	85	15			

*ESI* Elementary school incomplete, *ESC* elementary school complete, *HIS* high school incomplete, *HSC* high school complete

know” for this question. Eight percent believed that there are also pups on the island (correct answer, although they are rare).

Although the correlation between biological knowledge about the sea lions and perception of damage ( $r = -0.085$ ,  $P = 0.40$ ) was non-significant, the result suggests a tendency for fishermen with poorer ecological knowledge of sea lions to have a stronger sense that the species damages their livelihood.

The attitude of fishermen towards sea lions was slightly negative overall, with a mean of  $-0.72$ . Thirty-four percent of the fishermen thought that sea lions are very interesting creatures, 12% had a neutral opinion about them, and 28% thought them to be of

little or no interest. Overall, interest in sea lions was slightly negative ( $\bar{\chi} = -0.59$ ). In general, there was little interest in learning more about sea lions ( $\bar{\chi} = -0.85$ ), with 15% of the fishermen indicating no interest in learning more about sea lions, and only 15% showing willingness to learn more about the species. Ninety-two percent of respondents admitted having thought of killing sea lions ( $\bar{\chi} = -0.58$ ), rarely, sometimes or always. Thus, the answers to these questions indicated a general negative attitude and intent towards sea lions.

The overall perception of fishermen towards sea lions, in terms of damage that they cause, was very negative ( $\bar{\chi} = -1.47$ ). Eighty per cent of fishermen indicated that sea lions raid their fishing nets on every



occasion and 88% believe that sea lions remove more than 100 kg of fish from their net during each attack. In addition, 69% believe that the presence of sea lions cause substantial or highly substantial damage to the local fishing (see Table 1). However, we found no difference of the mean perception of the damage caused by sea lions among sailors, captains and boat owners, ( $\bar{x}$  sailor =  $-0.95$ ,  $\bar{x}$  captain =  $-0.90$  and  $\bar{x}$  boat owner =  $-2.0$ ,  $F = 1.36$ ,  $DF = 2$ ,  $P = 0.26$ ).

A significant positive correlation was found between attitude of fishermen towards sea lions, and their perception of damage by sea lions ( $r = 0.23$ ,  $P = 0.023$ ). This suggests that the less favourable the fishermen feel towards sea lions, the stronger their sense that the animals damage their livelihood. The scale had a Cronbach's alpha of 0.81, which indicates high level of reliability of the scale.

#### Influence of the knowledge, attitude and socio-economic variables on the perception of fishermen-sea lion conflict

The model selection process for which variables best predict the fishermen's perception of the conflict with sea lions is presented in Table 3. According to the  $\Delta AIC$  selection criteria, the model that took into account the effect of knowledge performed the best,

**Table 3** Model selection for Binomial Regression using as response variable the perception of the conflict and as predictors: *Knowledge* (the sum of the number of correct answers on the knowledge section of the questionnaire), *Attitude* (the average of the responses scores on the Attitude section of the questionnaire) and socio-economic variables (educational level, hierarchical level in the crew, amount of income sources and fishing experience)

Model	NP	AIC	$\Delta AIC$
Knowledge	2	30.131	
Education level	4	31.269	1.138
Full	13	32.925	2.794
Education level + knowledge	8	33.627	3.496
Hierarchical level in the crew	3	33.899	3.768
Null	1	35.589	5.458
Amount of income sources	2	37.515	7.384
Attitude	2	37.305	7.174
Fishing experience	5	37.845	7.714

The *Null* model accounts only for the intercept and the *Full model* includes every variable without interactions. *NP* Number of estimated parameters for the model

followed by the model with educational level as predictor which was within  $\Delta AIC$  of the best performing model. These two separate models performed better than a single model including both knowledge and educational level as predictors. Models with socio-economic predictors performed relatively poorly.

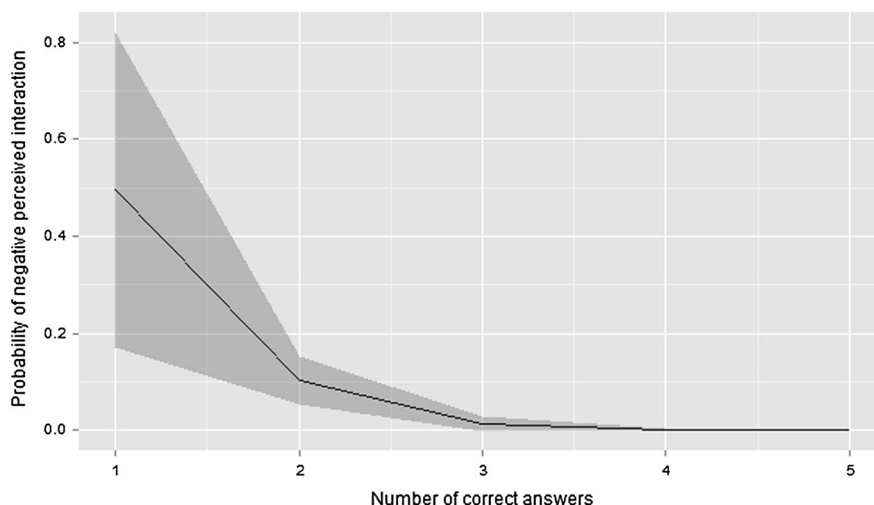
In terms of the best performing model (Fig. 3; Table 4), the number of correct answers on the biology of the sea lions (=knowledge) is a predictor of the probability that fishermen perceive interactions with sea lions as negative. If as little as one question was answered correctly, there was a 0.5 probability for the interaction to be considered negative, albeit with considerable variation. For fishermen that were capable to answer all questions correctly, the model predicted that the probability of considering the interactions with sea lions negatively was practically non-existent. We also modelled knowledge as a function of educational level (a categorical predictor) in order to test whether the information on the biology of the sea lions was acquired through formal education or by other means. The model performed poorly and had no predictive ability (result not shown). Knowledge levels of the different educational level categories of the fishermen are depicted in Fig. 4, showing no significant differences among the groups. Thus, fishermen's knowledge about sea lions affected more their perception of the conflict than the level of education.

#### Socio-economic aspects that should affect fishermen's knowledge, attitudes and perception of the fishermen towards South American sea lions

The results of NMDS analyses suggest that fishermen's knowledge is only influenced by the hierarchical position of the fisherman within the crew (Fig. 5A) and whether or not they have alternative sources of income besides fishing. In general, sailors correctly answering most of the biology questions about sea lions ( $P < 0.05$ ) and respondents whose only livelihood was fishing had more knowledge about the sea lions than those who had alternative jobs ( $P < 0.05$ ). Neither education level ( $P = 0.14$ ) nor years of fishing ( $P = 0.59$ ) affected fishermen's knowledge.

The hierarchical position of the interviewee within the fishing crew and amount of income sources influenced the attitudes toward sea lions (Fig. 5B). Boat owners and sailors had more negative attitudes toward sea lions ( $P < 0.05$ ) than captains. The first two

**Fig. 3** Response curve of the best performing model. The probability of perceiving sea lions negatively decays with increasing knowledge, i.e. the number of correct answers given on the biology of sea lions. Standard error (SE) is depicted in the shadowed area

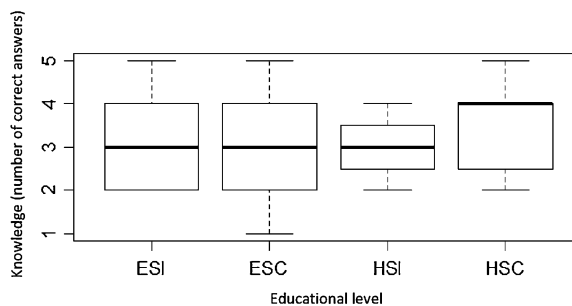


**Table 4** Estimates of the parameters for the best performing model

Parameter	Estimate	SE	P
Intercept	2.147	2.343	0.359
Knowledge	-2.162	1.101	0.0479

categories tended to think that sea lions are not interesting and were generally not interested in learning more about them. In fact, the results of questions regarding fishermen's behavioural intention towards sea lions (Fig. 2A–E) showed that 70 sailors of the 77 interviewed had considered killing sea lions (32 = always, 20 = sometimes and 18 = rarely) (Fig. 2A). Older fishermen had a more negative attitudes and behavioural intention towards sea lions ( $P < 0.05$ ) (Fig. 2B) while fishermen with a higher educational level presented more positive attitudes and behavioural intention towards sea lions ( $P < 0.05$ ) (Fig. 2C). The fishermen that live exclusively from fishing activity had more negative attitudes and behavioural intention towards sea lions than those with another work activity besides fishing ( $P < 0.05$ ) (Fig. 2D). However, fishing experience (years of fishing) did not affect fishermen's attitudes and behavioural intention towards sea lions ( $P < 0.98$ ) (Fig. 2E).

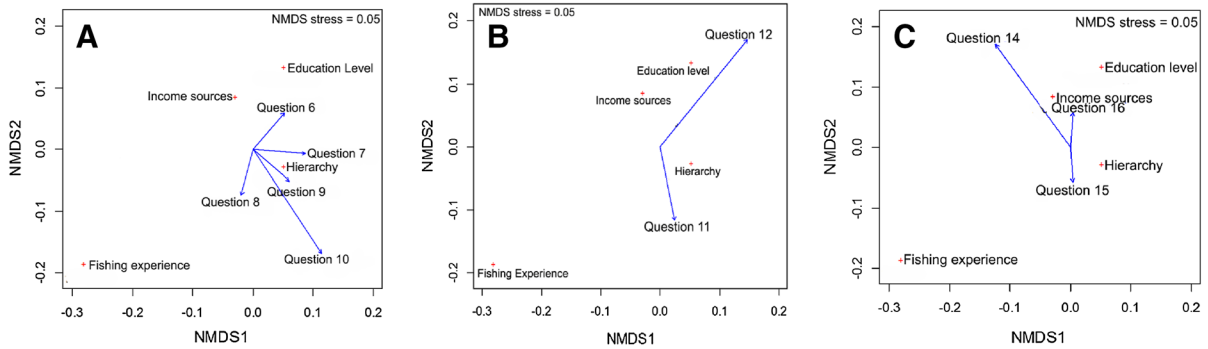
We also found that fishermen's perception of damage caused by sea lions (Fig. 2F–J) could be influenced by age (Fig. 2G) and educational level (Fig. 2H). Older fishermen had a stronger sense of the damage caused by sea lions ( $P < 0.05$ ) than young ones (Fig. 2G). Moreover, fishermen with a higher



**Fig. 4** Number of correct answers on the biology of the sea lions separated by educational level of respondents. Inside the *box* is represented the median, the *box* are the 1st and 3rd quartiles and the whiskers are the maximum and minimum observations. *ESI* Elementary school incomplete, *ESC* elementary school complete, *HSI* high school incomplete, *HSC* high school complete

educational level had a less severe perception of damage ( $P < 0.01$ ) (Fig. 2H). In contrast, the years dedicated to fishing (Fig. 2J) did not influence fishermen's perception of damage caused by sea lions ( $P = 0.78$ ). Regarding hierarchical position of the interviewee within the fishing crew (Fig. 2F), sailors and boat owners tended to believe that the sea lions raid the fishing nets more frequently and cause more damage, than did the captains ( $P = 0.06$ ). Another observed tendency was that fishermen with more than one source of income (fishing and other activity) (Fig. 2I) ( $P = 0.06$ ) also had less of a sense that sea lions cause loss and damage to their livelihood.

The selected log linear model for question 13 (Table 5) indicated that there is a conditional



**Fig. 5** NMDS plot of the relationship between socio-economic variables analysed in this study and **A** fishermen’s knowledge regarding the sea lions, **B** their attitude towards them and **C** their perception of the conflict

**Table 5** Log-linear models testing the influence of Educational level (Ed) and fishing experience (Ex) on the frequency of response (related to the answers of behavioural intention—Table 1 question 13)

Model	G <sup>2</sup>	Df	P value	AIC	Δ AIC
In Ed, Ex	66.97	76	0.761	205.7	
In Ed, Ex	91.55	88	0.377	206.3	0.6
In Ed Ex	75.98	76	0.479	214.7	8.4
In Ed Ex	0	0	—	290.8	76.1

dependence between behavioural intention of fishermen with regard to sea lions and their educational level, but no relation between behavioural intention and fishing experience. In other words, results suggested that the higher the level of education of the fishermen, the more positive their behavioural intention towards sea lions was. In this sense, fishermen that had either incomplete or completed high school education presented the lowest levels of intention to kill sea lions, when compared that had less education. This is independent on the years of work experience. Moreover, the number of older fishermen (>31 years) responding that they had considered killing a sea lion was roughly 20% higher than the number of young fishermen (20–30 years) (Fig. 2B) and this was not related to their education.

**Discussion**

The fishermen in southern Brazil are fairly knowledgeable about the sea lions, since 70% of the questions about sea lion biology were correctly answered. The most

problematic issue was the potential breeding activity that fishermen assumed to occur on the island, due to the presence of females and pups, which are essential members to consider a site as breeding area. Those pups are recently weaned and with only few months old (yearlings), according to recent aerial surveys conducted over the WRIL (Oliveira unpublished data). These yearling’s sea lions, as well as females, adult and subadult males probably come from Uruguayan rookeries helped by Malvinas Current (Pinedo, 1990; Oliveira, 2013) right after the end of their breeding season (Rosas et al., 1994). We believe that the assumption of the existence of breeding activity could lead to a perception that the local population of sea lions would be increasing, leading to increasing interactions with fishing activity. Simões-Lopes et al. (1995) were the first to mention female sea lions presence on the island, but no breeding activity observed. There are also South American fur seals on the WRIL (Vaz-Ferreira, 1982b; Sanfelice et al., 1999), which potentially could also give the impression of an increase in sea lion numbers. However, local fishermen were able to correctly identify *A. australis* as “little seal” (from Portuguese “foquinha”) and they seemed to believe that fur seals do not attack fishing nets (Pont pers. comm.). In fact, the interactions of *A. australis* with fisheries are rare along the coasts of South America (De María et al., 2013).

In terms of perception and attitude, the local fishermen were very negative towards the sea lions in the region, and with regard to the sea lion-fishing conflict. There have been a few other studies in the southern Brazilian coast that have analysed fishermen’s perception on the interactions with aquatic

mammals including: Neotropical otters (*Lontra longicaudis*) (Barbieri et al., 2012), common bottlenose dolphins (*Tursiops truncatus*) (Zappes et al., 2011) and southern right whales (*Eubalaena australis*) (Zappes et al., 2013). A positive perception of one of these aquatic mammal species by fishermen was only described in the case of the common bottlenose dolphins (Zappes et al., 2011), due to its cooperative fishing with local fishermen in the mouth of the Tramandaí Estuary (Simões-Lopes et al., 1998).

Barbieri et al. (2012) conducted 36 interviews with fishermen from Tramandaí Lagoon (RS), about 80 km south to the WRIL, concerning their interactions with Neotropical otters and the damage that they cause to the local fishing. All fishermen reported that otters interfered with fishing activities and about 86% described them as the most inconvenient animal for the local fisheries activities, although about 42% considered the damage attributed to the otters as “small”.

Zappes et al. (2013) interviewed 27 fishermen that work in the Southern Right Whale Environmental Preservation Area (EPA), in SC, about 180 km north to WRIL. Fifty-two percent of the fishermen described negative interactions related to whales ‘tearing and/or dragging the gillnets’, but in the fishermen’s eyes this type of interaction had minimal impact on the fishery.

Regarding the common bottlenose dolphins, Zappes et al. (2011) interviewed 22 artisanal fishermen from Tramandaí Estuary, where cooperative fishing between dolphins and fishermen has been occurring for decades (Simões-Lopes et al., 1998). All fishermen interviewed described that the presence of the animals in the region guarantees successful fishing because the fishing behaviour of the dolphins allows more efficient capture of fish, mainly mullets (*Mugil* spp.), with cast nets by fishermen. These dolphins have an apparent mutualistic interaction with artisanal fishermen, described as follows: through synchronized behaviour, a subset of these dolphins drive mullet schools towards the shoreline where fishermen are waiting with nets, and by ritualized signals, indicate when and where fishermen should cast the fishing nets (Simões-Lopes et al., 1998). The fishermen in the area affirm that their yields are thus greater than without dolphin cooperation. The dolphins also benefit from this fishing activity, because the fishes get cornered between fishermen and dolphins in the shoreline, which makes fish an easier catch for the dolphins. This fishing

community is apprehensive that the dolphins may eventually disappear, to the detriment of their yields, and have expressed concern that an apparent lack of environmental regulation of tourism of the region may be impacting the dolphins (Zappes et al., 2011).

In Scotland, Butler et al. (2011) studied the seal-salmon fishery conflict and reported that 81% of the fishermen believed that seals had a significant or moderate negative impact on stocks and catches, and therefore demanded control measures for the seal populations (*Phoca vitulina* and *Halichoerus grypus*). Currently, it is understood that the majority of these interactions are restricted to a few individuals termed “net specialist seals”, which were identified through photo-identification (Harris, 2012; Konigson et al., 2013; Harris et al., 2014). Despite a low number of identified net specialist seals (typically one or two seals per site—Harris, 2012), lethal control on specific seals at nets was employed in the local fisheries (salmon bag-nets).

In Greece, Glain et al. (2001) found that whereas fishermen perceive that Mediterranean monk seals (*Monachus monachus*) have a negative impact on their activity (61.5% reported the existence of interactions with seals), many held positive attitudes regarding the preservation of the species, probably due to the small seal population size (it is considered the world’s rarest pinniped species—Aguilar & Lowry, 2013). Moreover, while 52.5% of the Greek fishermen were concerned about the conflict, they also recognized that local fishing is affected by other major pressures that are unrelated to seals (e.g. overfishing and illegal fishing activities).

Hale et al. (2011) studying Mediterranean monk seals and their fisheries interactions in the Archipelago of Madeira found that only 1% of the fishermen considered the monk seal to be the principal reason for declining fish stocks, which underlines that the perception of fishermen is not always negative. However, it must be pointed out that in this case the local population of *M. monachus* is very small and interactions with fishing boats are very rare (Hale et al., 2011).

In the present study, factors such as the hierarchical position of fishermen within the crew and age did affect the fishermen’s perception of the damage caused by sea lions. As we expected, the perception and attitude of older fishermen, who witnessed several interactions with sea lions in the region were most negative. According to Moreno et al. (2009), in this

fishing community there is a financial hierarchy in the boat. Sailors (lower ranked fisherman) receive the lowest percentage of the profits from each fishing expedition (25% of profits are divided between all sailors, while the captain receives 25% and the remaining 50% goes to the owner of the boat). Our results indicated that the sailors, who were paid less, perceived the losses more keenly than the others did, although this result may be biased by the inequality in sample sizes considering that 77 sailors were interviewed in comparison with just 23 others (21 captains and 2 boat owners).

Two other important factors found to affect the fishermen's perceptions of the conflict with sea lions in the present study were the level of education and whether or not they also relied on alternative income sources. Fishermen with a lower educational level and for whom fishing was the only source of income had the most negative perception of sea lions and the sea lion-fishing conflict. According to them, they incurred a direct reduction in their percentage of profits per fishing day due to catch losses caused by sea lion depredation.

The knowledge on the biology of the sea lions was not related to the level of formal education that the respondent had obtained<sup>1</sup>, since is not acquired in school programs. In general, knowledge and the financial aspects can be considered the most influential factors on fishermen's perception of sea lions and their conflict with fishing in our study. However, Barbieri et al. (2012) found contrasting results in their study on the interactions between fishermen and the Neotropical otter in southern Brazil, where fishermen's perception of the damage cause by otters was not affected by whether or not they had another income source besides fishing. For the sake of comparison it must be pointed out that, although the geographical proximity, the fishing activity and gear type used by the fishermen that were the subject of that study, were different to this study, and the type and magnitude of damage caused by the otters was also different. In the Tramandaí Lagoon the fishermen use a system of buoys in the lagoon designating two areas of fishing according to the city where the fishermen live (Matos, 2001). This system helps to avoid conflicts between fishermen from two surrounding cities (Imbé and Tramandaí). Approximately 42% of the fishermen interviewed said the damage caused by the Neotropical otter was low.

The impression that *O. flavescens* eat great amounts of fish (eat ~ 100 kg in each interaction) was false,

taking into account that the species only eats 4% of their body mass with a maximum consumption of 12 kg per day (Kastelein et al., 1995). According to Machado (2013), the loss of catch caused by few sea lions that interacts with fisheries at the study area is around 36 t per year, representing about 3% of the annual catch of the local fishing community. In addition, the most commonly found fish in the sea lions stomach was the banded croaker (*Paralichthys brasiliensis*) which has a low economic value in the region (Machado, 2013), although a few twin beam trawlers ("tangoneros" in Portuguese) recently started to fish the species on an exploratory basis (Cardoso & Haimovici, 2011).

The sea lions occurring in RS, in southern Brazil, represent the northern limit of the distribution of *O. flavescens* in the Atlantic Ocean and are approximately 0.02% of the estimated global population (over 500,000 animals—Crespo et al., 2012). It is known that the sea lions that reach the Brazilian coast are mainly from Uruguay (Vaz-Ferreira, 1982a; Rosas et al., 1994; Oliveira, 2013), where the commercial sealing activity, mostly focused on the South American fur seals and sea lions ended in 1991 (Ximenez & Langguth, 2002). However, the births of sea lions in Uruguayan colonies are currently declining at a rate between 1 and 3% per year (Páez, 2005; Franco-Trecu, 2015) and interactions between sea lions and fisheries in Brazil may be contributing to this population decline (Machado et al., 2015a). Moreover, since 1997, records of interactions between fisheries and sea lions, including incidental bycatch, have been reported for Uruguay (Franco-Trecu et al., 2009; De María et al., 2013).

South American sea lion is the one of the pinniped species recorded on the southern Brazilian coast for which fishing activity is a significant threat to conservation status. There has been no mass killing of sea lions since 1985. However, records of carcasses of the species with bullet wounds and other signs of human violence have been reported in the last 16 years, based on which Machado et al. (2012) estimated that 21,4% of the sea lion mortality in this region (RS coast) could be attributed to the fishermen. Based on this information and applying the IUCN red list criteria, the species was recently listed as "Near Threatened" (NT) at the regional level (RS) by the local government.<sup>1</sup>

<sup>1</sup> Decree No. 51.797 of September 8, 2014 states the species of wild fauna threatened with extinction in the State of Rio Grande do Sul, southern Brazil.



Any decision on management action would be complex in this case, because sea lions also interact with fisheries outside of MPAs along the southern Brazilian coast. Acoustic deterrent devices that are sometimes used in attempts to mitigate marine mammal-fisheries interactions, are counterproductive in that they actually attract sea lions to the gillnets (Bordino et al., 2002). Changes to fishing practice, such as spatio-temporal restrictions, are also currently unrealistic, taking into account the power of the Brazilian fishery industry. Furthermore, the WRIL has no management plan at all, another fact that complicates efforts to protect the species in the area. Possibly the only management action that could mitigate these interactions is the presence of observers on board fishing vessels during the season of sea lion presence in the region.

Such observers would be tasked to document any and inform local and federal authorities. Thus, the presence of on board observers may avert aggressive behaviour by fishermen towards sea lion. The success of such a management action depends upon human resources, logistical and economical aspects (e.g. suitable accommodations for observers and financial support) and effective control of the local fishing fleet. However, considering the large size of the fleet and the long time that sea lions stay in the region, implementing this would not be straightforward and may not be a feasible management option even in the long term, for Brazil.

The problem between fishermen and sea lions is not only a function of economic loss caused by these animals, but also of the attitude of fishermen towards the sea lions that is influenced by their perception of the damage that sea lion cause, in which facts may be distorted. Therefore, we recommend the implementation of a comprehensive and long-term program of environmental education in this fishing community. This program should focus on the discussion of means to lessen the local conflict between fisheries and sea lions and to address the negative attitudes of the fishermen. In this sense, the program should include both ecological aspects, as the role of top predators in the marine system, and the possible negative impacts of their removal, as well as topics related to the sustainable use of the marine resources and their potential for wildlife tourism. It should be noted that WRIL is the only natural site along the entire Brazilian coast that pinnipeds can be observed on a regular

basis. The program should also address other factors that could cause a decrease in fishing days and lead to loss of productivity in the fisheries, which are not related to sea lions. The factors that must be discussed are effects of fishing pressure on fish stocks, bad weather conditions, silting up of the channel of the estuary, scarcity of trained crews and the high operational costs of the local fishing (Machado, 2013). Encouragement of an environmental education program involving the whole fishing community, could be the first step towards increasing fishermen's tolerance to the occasional losses caused by sea lions, to mitigate the conflict and to promote the coexistence of people and sea lions in southern Brazil. Ultimately, this could help to produce a new generation of fishermen that are more cognisant of their local marine environment and are able to perform sustainable fishing practices without compromising the conservation of the sea lions.

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