ECOLOGICAL EXPERIENCES AND PERCEPTIONS OF SMALL-SCALE GILLNET AND PURSE SEINE FISHERS ON SEABIRDS AND OTHER NON-TARGET TAXA IN THE HUMBOLDT CURRENT SYSTEM, CHILE

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ABSTRACT

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Strategies to reduce the negative impacts of fisheries on ecosystems often come into conflict with fishers who have different experiences with, and perceptions of, biodiversity compared to policy makers and fisheries managers. We interviewed 800 fishers along 2400 kilometers of the Humboldt Current System (HCS) coast, assessing fishers' perceptions of the impacts of marine predators on fishing and their proposals to reduce conflicts with small-scale net fisheries. Vessel captains saw seabirds as positive indicators of fish presence along the HCS (mean probability 62.7%). In contrast, sea lions were perceived negatively, affecting catches for all fishers and causing fishing gear damage among gillnet fishers (97.1%). Among different measures suggested by fishers to reduce conflicts with non-target taxa, night fishing and marine protected areas (MPAs) were viewed as least likely to be implemented because these affect fishing performance (6% and 13.1%) through changes to at-sea safety and fishing effort displacement, respectively. In contrast, economic compensation and culling of currently protected sea lions were the most popular but also the most sensitive measures (31% and 33%, respectively). Different dimensions of experiences and perceptions of fishers are key to the bottom-up understanding of interactions in small-scale fisheries. This is especially true when measures to mitigate their impacts do not have any consolidated installation/monitoring, which is a continuing challenge for these types of fisheries globally. This study emphasizes the role of small-scale fishers as a source of diverse ecological experiences and perceptions to complement knowledge on sensitive conservation issues.

Key words: artisanal fisheries, ecological knowledge, management, mitigation, multispecies, fisheries

INTRODUCTION

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES) has proposed that consideration be made of nature's contributions to people (hereafter NCPs). Whether beneficial or detrimental, the notion of NCPs is grounded in human-ecological experiences and knowledge, leading to better understanding of how nature affects people's quality of life (Díaz *et al*. 2018).

NCPs are not limited to terrestrial ecosystems but are also relevant to marine ecosystems. Coastal communities, including small-scale fishers, can act as a great source of traditional ecological knowledge for studying, recognizing, and valuing NCPs (e.g., Liu *et al.* 2007, Pascual *et al*. 2017). Local knowledge, for example, is recognised as valuable for fisheries management and for understanding productive seascapes, particularly when funds are limited (Berkström *et al*. 2019).

Most nature-people relationships are generally considered to be positive. For example, small-scale fishers use seabird aggregations to find fishing grounds, which promotes positive perceptions towards seabirds (Cursach *et al.* 2016). However, species can also generate negative perceptions for some fishers (Díaz *et al*. 2018). Orcas *Orcinus orca* might damage Patagonian Toothfish *Dissostichus eleginoides*, one of the target fish in industrial longline fisheries (Söffker *et al*. 2015). This can facilitate negative perceptions from crew members towards this top predator.

One of the most productive marine ecosystems on Earth is the Humboldt Current System (HCS), which supports large and diverse fisheries and marine predators (Thiel *et al*. 2007). The HCS is home to predators that have a close relationship with artisanal fishers such as Marine Otters *Lontra felina* who demonstrate synanthropic behavior by feeding on fish by-products (Cursach *et al.* 2012). HCS is also home to sea lions. The damage that sea lions cause to fishing gear and their consumption of pelagic fish is well known, but the extent of this problem has not yet been systematically examined (Thiel *et al*. 2007).

In this paper, we determine fishers' perceptions towards seabirds and other groups of non-target taxa (reptiles, mammals) in the small-scale gillnet and purse seine fisheries across the HCS. In turn, we explore the potential of human ecological experiences as a means for identifying and reducing negative interactions of fisheries with non-target taxa. These insights are crucial, especially when evidence with a social-ecological basis is required for building decision-making policies. The incorporation of these insights, and resituation of reciprocal contributions between non-target marine species and fishers, can also improve the engagement of key stakeholders in ecosystem conservation actions and increase compliance in less-monitored small-scale fisheries (Ojeda *et al*. 2022).

METHODS

Study sites and fishers along the HCS

This study was carried out in eight small-scale fishing coves along *ca*. 2400 km of the coastal HCS, including north (~18°S–29°S), central (~33°S–37°S), and south (~ 39°S) areas in Chile (Fig. 1). We

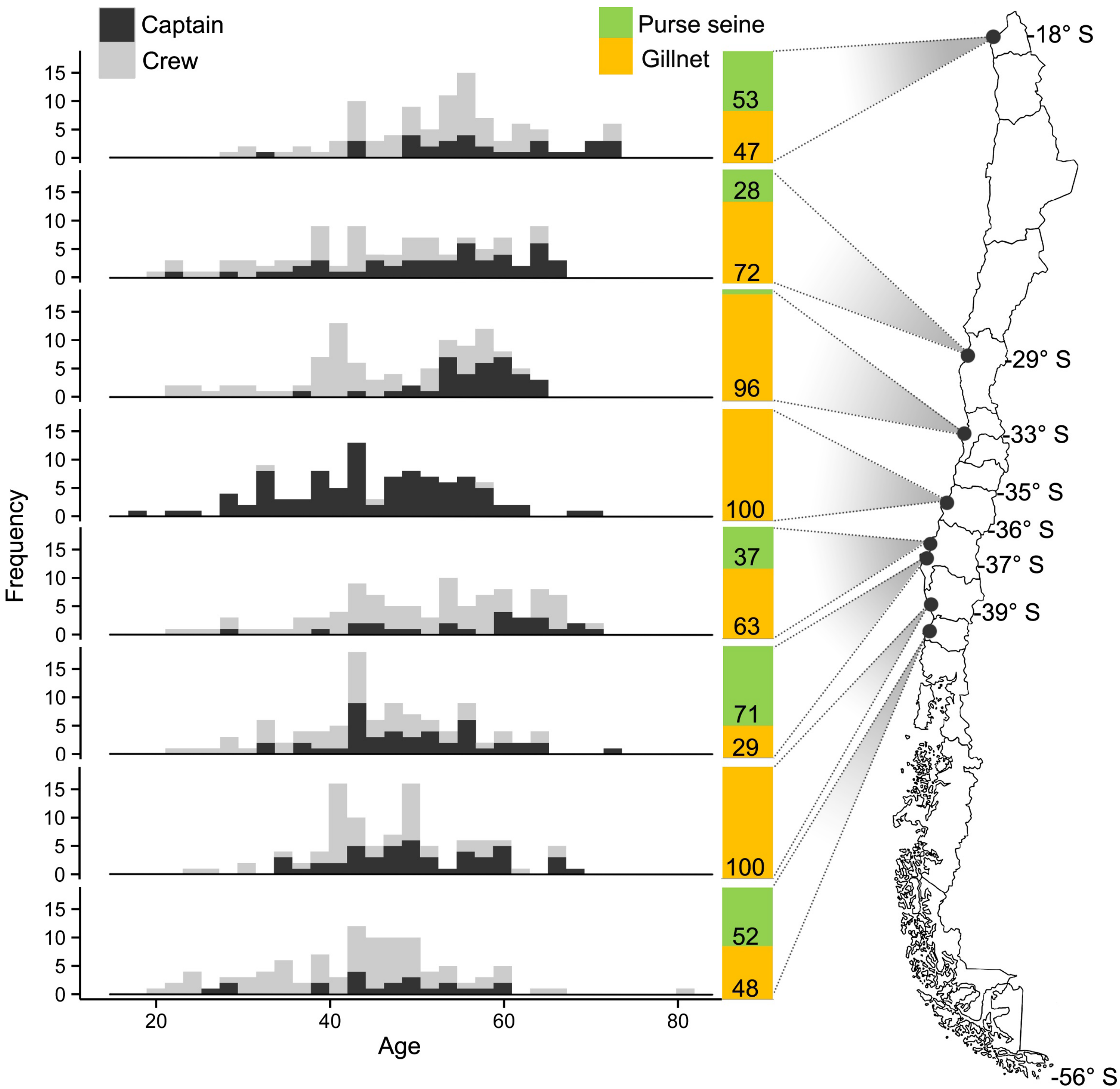

Fig. 1. Areas studied defined as north 18°S–29°S, central 33°S–37°S and south 39°S, along the Humboldt Current System in Chile. Frequencies of age groups of fishers in the role of captain and crew members are shown by the black and grey bars, respectively. The proportion of fishers surveyed who participate in purse seine and gillnet fishing for each area is also represented by green and orange bars, respectively.

conducted surveys with fishers to identify their perceptions of non-target taxa during the austral summer ($n = 400$) and winter ($n = 400$) in gillnet and purse seine fisheries during 2015–2016 (Fig. 1). Purse seine vessels target pelagic fish such as Anchovy *Engraulis ringens* and Sardine *Strangomera bentincki*. Gillnet boats target different pelagic and demersal fish species, including the Chilean Silverside *Odontesthes regia* in the north, South Pacific Hake *Merluccius gayi gayi* in central regions, and Corvina Drum *Cilus gilberti* in south-central Chile.

Perceptions by fishers and the reduction of negative interactions with non-target taxa

Surveys involved semi-structured questions applied through purposive sampling of small-scale netting fisheries to identify the at-sea role and experience of fishers in the HCS (e.g., questions 2–4, Appendix 1, available online). We included questions to identify traits of the fishers and their activity at sea, including: (i) age and years spent fishing, (ii) role deployed onboard (captain or crew member), and (iii) time spent fishing each year (seasonal or full-time).

We explored the relationship of these traits with negative or positive perceptions of non-target taxa. To do this, we applied neutral questions about fishers' perceptions of different non-target taxas' interactions with fisheries. Non-target taxa of interest included: (i) sea turtles, (ii) Marine Otters, (iii) dolphins, (iv) sea lions, and (v) seabirds. Fishers were also asked whether they perceived these interactions to be negative or positive (see question 5, Appendix 1). With fisher's arguments supporting their perceptions on non-target species, we built association networks to reconstruct the co-occurrence and frequency of terms through the Gephi platform (Bastian *et al*. 2009).

Where conflicts were identified from the overlap of non-target taxa and fisheries (e.g., through competition and bycatch), we asked fishers to select from a series of known management measures that aim to reduce negative interactions. These options were: (i) marine protected areas (MPAs), (ii) night fishing, (iii) change or modification of fishing gear, (iv) fishing gear compensation, and (v) monetary compensation. All of these options have been demonstrated to reduce negative interactions between fisheries and non-target taxa (e.g., Hall *et al*. 2000, Moreno *et al*. 2008, Løkkeborg 2011, Croxall *et al*. 2012). Finally, we asked fishers to suggest their own solutions for reducing conflicts in a series of open-ended questions.

Data analysis

To determine which variables were most influential in the frequency of positive and negative perceptions on non-target taxa among fishers, we used generalized linear models (GLM) with a binomial error structure. We applied two independent models to evaluate the probability of negative and positive perception. We used the following as predictor variables: (i) area (north, central, or south HCS), (ii) type of fishing gear (gillnet or purse seine), (iii) years spent fishing, (iv) amount of time spent fishing (part-time/seasonal or full-time as fisher), (v) fishers' age, (vi) role during fishing (captain or crew member), and (vii) fishing season (winter or summer). For model selection, we used stepwise selection using the Generalized Akaike Information Criterion (*stepGAIC*) function, showing the most parsimonious models. Final models also used a likelihood-ratio test. For each model, we presented the Cox Snell and Cragg Uhler generalized (Pseudo) R-squared values. For each model diagnostic, we used the *plot. gamlss()* function, which provides a series of plots for checking the normalized quantile residuals of the fitted models. This analysis was performed with "gamlss" package in R (Rigby *et al*. 2005).

To determine the relative importance of the options proposed to reduce conflicts, we performed a multivariate generalized linear model (*multi*GLM) with a binomial error structure. For this, the predictive variables that were used corresponded to the same seven variables of descriptive traits of the fishery and fishers, as previously described. The *multi*GLM was followed by a deviance analysis using PIT-trap resampling with 1000 iterations and the likelihood ratio test (Wang *et al*. 2014).

Finally, we performed univariate analyses for each proposal, with the same specifications described above for the multivariate approach. We performed this analysis using the "mvabund" package (Wang et al. 2012). All these analyses were performed in the software R (R Core Team 2013).

RESULTS

Purse seine and gillnet fishing conducted by small-scale fishers occured in varying concentrations along the HCS ($\chi^2 = 245.6$, $df = 7$, $P < 0.001$; Fig. 1). In the north and central HCS, fishers were most likely to use purse seiners targeting Anchovy and Sardine, respectively. In addition, gillnet use was seen in the coastal areas across the whole HCS (~39°S).

Significant positive and negative contributions were seen for seabirds, dolphins, and sea lions, but not for sea turtles and Marine Otters. We found that fishers (i.e., captains and crew on deck) who were primarily focused on fishing grounds around the central HCS (95% confidence interval [$CI_{95\%}$] = 0.824–0.945; Fig. 2) positively perceived seabirds (mean probability = 0.596). Among fishers,

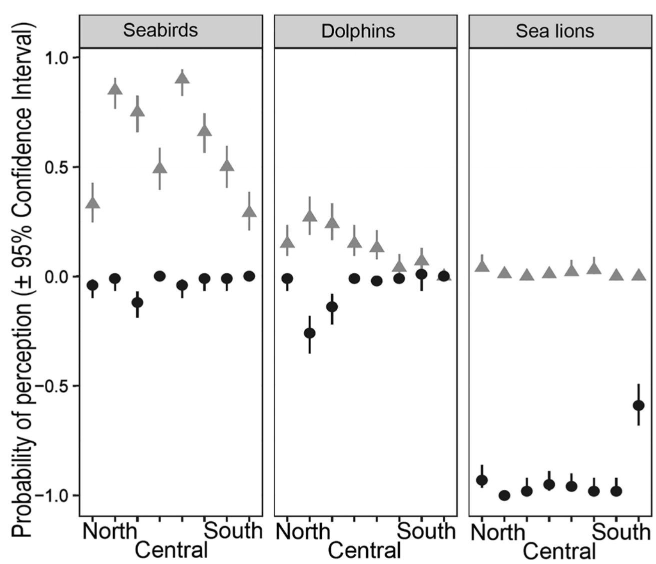

Fig. 2. Fishers' perception of seabirds, dolphins, and sea lions, with positive (grey triangles) and negative (black points) perceptions represented along the areas studied: north (~18°S–29°S), central (~33°S –37°S), and south (~39°S) in the Humboldt Current System.

TABLE 1
Predictive variables associated with fishers' positive perception (seabirds and dolphins) and negative perception (dolphins and sea lions) in the Humboldt Current System, Chile[a]

Predictive variables	*LR* χ^2	*df*	Pr (> χ^2)	R^{2a}	R^{2b}
Seabirds (positive)					
Area	163.355	7	**< 0.0001**		
Role during fishing	5.705	1	**0.0169**		
Time of year dedicated to fishing	2.707	1	0.0999	19.4	26.2
Dolphins (positive)					
Area	56.611	7	**< 0.0001**		
Fishing gear	3.216	1	0.0729	8.1	15.0
Dolphins (negative)					
Area	92.741	7	**< 0.0001**		
Fishers' age	3.627	1	0.0568	11.3	31.8
Sea lions (negative)					
Area	109.184	7	**< 0.0001**		
Fishing gear	44.821	1	**< 0.0001**		
Fishing season	7.725	1	**0.0054**	19.8	46.7

[a] We present the most parsimonious models obtained through stepwise model selection. Significant values for single variables are highlighted in bold. *LR* is the likelihood-ratio test for goodness of fit of models on fisher's perception. Predictive variables ordered from highest to lowest *LR* values. R^{2a} = generalised *R*-squared of "Cox Snell"; R^{2b} = generalised *R*-squared of "Cragg Uhler".

captains were the most likely to have positive perceptions towards seabirds when compared to crew members ($CI_{95\%}$ = 0.575–0.675; Table 1).

Perceptions towards dolphins were marginally positive throughout the HCS (0.131). Perceptions of fishers in the north and central HCS were more strongly positive ($CI_{95\%}$ = 0.190–0.365; Fig. 2), particularly in relation to gillnet fishing ($CI_{95\%}$ = 0.129–0.189; Table 1). However, the mean probability of negative perception of dolphins (0.060) was highest in the north and central HCS ($CI_{95\%}$ = 0.183–0.354; Fig. 2), a perception that marginally increased with fishers' age (slope ± standard error [SE] = 0.028 ± 0.02; Table 1).

Perceptions of the South American Sea Lion *Otaria flavescens* were negative throughout the HCS, with a high mean probability (0.920) along the whole of the HCS (Fig. 2). This view was mainly in relation to gillnet fisheries ($CI_{95\%}$ = 0.953–0.982; Table 1) coupled with the winter period ($CI_{95\%}$ = 0.914–0.961; Table 1).

Among arguments for positive perceptions of non-target taxa, fishers recognized seabirds as good indicators of target fish species (Fig. 3A). For dolphins, fishers highlighted several attributes, listed in order of importance: (i) fish indicators, (ii) facilitators of fishing, and (iii) component of the scenic beauty (Fig. 3A). Finally, some fishers recognized, though at lower frequency, that the presence of sea lions was a good indicator of target fish species (Fig. 3A).

Reasons for negative perceptions of non-target taxa included a minority of fishers associating seabirds with negative effects on catching success due to seabird disturbance of fish (Fig. 3B). Dolphins were also associated, in low frequency, with disturbing fish and damaging catch (Fig. 3B). Sea lions were strongly

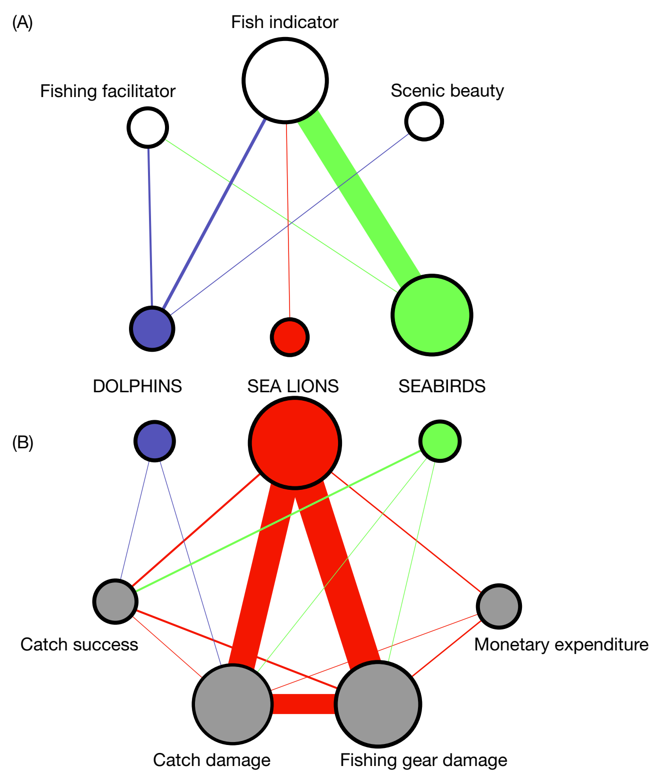

Fig. 3. Network of terms associated with positive (A) and negative (B) perceptions towards dolphins, sea lions, and seabirds. The sum of percentages is greater than 100% due to options that simultaneously included more than one term. Thickness of connectors is proportional to the occurrence and co-occurrence of terms (0.3%–0.9%). The size of each term corresponded to the sum of its edges.

TABLE 2
Multivariate approach on interaction among fishers' traits and available proposals to reduce conflicts with non-target species[a]

	Res. *df*	*df*. diff	Dev	Pr (> Dev)
(Intercept)	797			
Area	789	7	777.7	**0.001**
Fishing gear	784	1	20.3	**0.003**
Years as fisher	787	1	3.0	0.769
Time of year dedicated to fishing	785	1	14.1	**0.040**
Fishers' age	788	1	6.9	0.307
Role during fishing	786	1	20.9	**0.004**
Fishing season	796	1	12.1	0.073

[a] Significant values for traits are highlighted in bold. Res. *df* = Residual Degrees of Freedom; *df*. diff. = Degrees of Freedom Difference; Dev = Deviance; Pr (> Dev) = Probability of Deviance.

associated with negative perceptions related to fishing gear damage, catch damage, and economic expenses (Fig. 3B). The latter was due to a reduction in catching success and the costs of repair or replacement of fishing gear.

Fishers demonstrated a high probability of understanding solutions for reducing conflicts with non-target species which varied in relation to (i) their fishing area in the HCS, (ii) the fishing gear (purse seine *versus* gillnet) they used, (iii) whether they worked full-time or part-time as a fisher, and (iv) their position as captain or crew member. Fisher's traits, such as their age, years devoted to fishing, and seasonal fishing activity, did not vary in relation to geographical, gear type, or operative performance by fishers (Table 2).

In the univariate analysis of fisher's traits against potential management alternatives for the reduction of conflict with non-target taxa, fishers showed preference, from the lowest to highest mean probability, as follows: night fishing (0.060) < MPAs (0.131) < change or modification of fishing gear (0.140) < fishing gear compensation (0.170) < monetary compensation (0.310) < sea lion reduction derived from the open alternative proposed by fishers (0.330) (see Fig. 4). Night fishing, although reported with a low probability, had a high occurrence in gillnet fisheries, including in the central HCS ($CI_{95\%}$ = 0.120–0.270; Fig. 4). The univariate analysis of fishers' traits with management options showed interactions between night fishing, area of the HCS, and season when fishing is carried out (Table 3).

The preference for MPAs was strongest in the central HCS, where fishers argued that there is the need to implement exclusion areas for industrial fisheries ($CI_{95\%}$ = 0.551–0.730; Fig. 4). Change or modification of fishing gear was perceived favourably in the central HCS ($CI_{95\%}$ = 0.360–0.550; Fig. 4), where purse seine and gillnet fisheries overlap. The option of compensation with fishing gear was selected by fishers in some locations of the central HCS ($CI_{95\%}$ = 0.350–0.540; Fig. 4) and was linked to gillnet fisheries (Table 3).

Monetary compensation was suggested due to costs of damage to fishing gear and/or catches during interactions with non-target taxa. A relatively high proportion of fishers along the HCS preferred this option, particularly those based in the central HCS ($CI_{95\%}$ = 0.400–0.600; Fig. 4). Monetary subsidies were also linked to the summer fishing season, as well as to crew members in charge of gear maintenance on gillnet vessels (Table 3).

Finally, fishers suggested a systematic reduction of the sea lion populations through quotas. This option was very popular in the north HCS ($CI_{95\%}$ = 0.690–0.850; Table 3). Fishers explained that they felt that a direct reduction of sea lion numbers could reduce

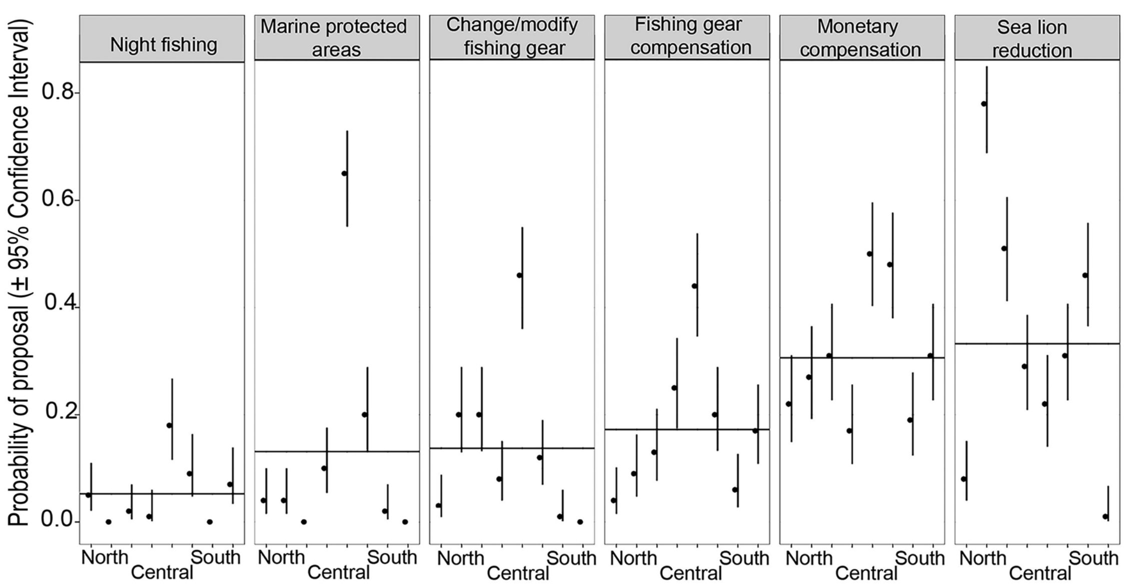

Fig. 4. Alternative proposals by fishers to reduce conflicts with non-target taxa along the areas studied in the Humboldt Current System. The proposals are sorted from lowest to highest mean latitudinal probability (horizontal line). The last proposal to reduce sea lion populations was freely suggested by the fishers. Probabilities are represented along the areas studied: north (~18°S–29°S), central (~33°S –37°S), and south (~39°S).

TABLE 3
Univariate approach evaluating interactions between fishers' traits and individual proposals to reduce conflicts with non-target species[a]

	Marine protected areas		Nocturnal fishing		Change/modify fishing gear		Fishing gear compensation		Monetary compensation		Sea lion reduction	
	Dev	Pr (> Dev)	Dev	Pr (> Dev)	Dev	Pr (> Dev)	Dev	Pr (> Dev)	Dev	Pr (> Dev)	Dev	Pr (> Dev)
(Intercept)												
Area	240.3	**0.001**	53.3	**0.001**	135.1	**0.001**	80.1	**0.001**	50.4	**0.001**	218.2	**0.001**
Fishing gear	5.2	**0.030**	3.5	0.073	1.3	0.257	6.5	**0.014**	2.0	0.154	1.5	0.215
Years as fisher	0.7	0.391	1.0	0.335	0.0	0.784	0.0	0.822	0.1	0.668	0.9	0.350
Time of year dedicated to fishing	6.6	**0.012**	2.8	0.084	4.2	0.056	0.0	0.973	0.3	0.592	0.0	0.854
Fishers' age	0.0	0.799	3.4	0.063	0.0	0.944	0.8	0.351	2.2	0.147	0.2	0.622
Role during fishing	0.8	0.361	1.4	0.231	1.8	0.164	0.0	0.770	15.5	**0.001**	1.1	0.291
Fishing season	0.3	0.574	5.0	**0.018**	0.3	0.548	0.2	0.621	4.7	**0.037**	1.3	0.247

[a] Significant values for traits are highlighted in bold. Dev = Deviance; Pr (> Dev) = Probability of Deviance.

overlap and conflict with fisheries. They also argued that sea lions could be an emergent economic resource due to the potential export of sea lion fat and skin to Asian markets.

DISCUSSION

In this study, we identified different perceptions of the relationships between small-scale fishers and non-target taxa. Whereas seabirds and dolphins were viewed as having positive value, sea lions were perceived negatively by those involved in fishing operations. Seabirds and dolphins were considered ecological indicators of productivity, and as a component scenic beauty. Albatrosses and shearwaters were perceived as indicators of fish. These seabird species were positively perceived by small-scale fishers for their role in helping to find fishing grounds in the fjords and HCS in southern and central Chile, as well as other highly productive areas in the northern hemisphere (Suazo *et al*. 2013, Lyday *et al*. 2015, Cursach *et al*. 2021).

This study also highlighted that dolphins have a cooperative interaction with the gillnet small-scale fishery in northern HCS. In Brazil, for example, the perceived benefits of cooperative fishing with dolphins were grouped into eight ecosystem services assigned into cultural and provisioning-related services (Machado *et al*. 2019). However, in the north and central HCS, elder fishers had a negative perception of dolphins. They argued that dolphins caused damage to fishing gear and that there was competition between fishers and dolphins who target the same fish species. This perception has also been reported in the Mediterranean Sea (Gonzalvo *et al*. 2015).

These findings remind us that perceptions of non-target taxa depend on ecological experiences and the intrinsic traits of fishers (Soga & Gaston 2016). Both seabirds and dolphins have positive instrumental and relational values for small-scale fishers in the HCS. This is important for conservation efforts, as relational values may have a positive impact on conservation planning when western scientific knowledge and local perspectives are combined (Chan *et al*. 2016, Ban *et al*. 2020).

In contrast, the South American Sea Lion represents one of the most important human-wildlife conflicts in the small-scale net fisheries of the HCS. For fishers, sea lions are negatively perceived for their role in damaging fishing gear and for their impacts on target fish species. This fisher-pinniped conflict increases when fishing operations overlap with feeding areas of these marine mammals (Wickens 1995). For instance, in the coastal gillnet fishery in Brazil, 24% of 484 fishing operations had interactions with sea lions (Machado *et al*. 2016).

Previous studies have highlighted that in several cases, fishers tend to overstate the impact of these interactions. In our study region, we know that negative interactions with sea lions in the HCS are reduced during the austral summer, when adult males remain in their colonies with only sporadic foraging trips during the breeding season (Acevedo *et al*. 2003, Sepúlveda *et al.* 2007). In contrast, during the non-breeding season, these mammals leave the colonies and increase their feeding on natural prey. In doing so, they also increase their consumption of fish species caught by fisheries, increasing the incidence of seasonal hotspots of negative interactions (Sepúlveda *et al.* 2001).

Recognition of the interactions with non-target taxa is a challenging task. It requires fishers' engagement, increasing their capacity and motivation to be an actor in local stewardship, and ensuring that their actions contribute to the long-term sustainability of fisheries (Bennett *et al*. 2018). Indeed, improvement in their fishing performance and success for their target species—through fishing gear or monetary subsidies, as identified in this study—might also increase the bycatch rates for non-target taxa, as previously identified for these purse seine and gillnet fisheries (Suazo *et al*. 2014).

Fishers' motivation to be actors in the local stewardship of their sea might also be affected by the perceived detrimental effect of MPAs on fishing effort displacement. This was one of the less popular options identified in this study for the reduction of conflicts with non-target taxa. However, fishers also react to customer demands and economic factors when making decisions. Considering the current absence of implementation and compliance with costeffective mitigation techniques to prevent bycatch of non-target species, this is an emerging field that can add value to small-scale catches (Mangel *et al.* 2018, Oliveira *et al*. 2021).

Therefore, the recognition of individual, group, and even network knowledge by fishers along the HCS (and further extended to fishers' feedback with fisheries managers) is essential, not only to provide information and guidelines for decision-makers, but also to increase fishers' engagement in tailored local environmental stewardship frameworks (Bennett *et al*. 2018).

Fishers and the reduction of negative interactions with seabirds and other non-target taxa

Conflicts between marine top predators and fishing operations have increased in recent decades. This includes detrimental impacts for both sensitive non-target taxa and economic issues for fishers (Lavigne 2003, Alexandre *et al*. 2022). Overfishing and increased fishing effort are pivotal factors in increasing the probability of interactions between sea lions and fishers (Machado *et al*. 2016).

In Chilean waters, most of the target species taken in netting fisheries are near their maximum biomass capacity or are overexploited, such as South Pacific Hake for gillnet fishing (SUBPESCA 2023). This fishery status reflects increased fishing efforts for small-scale fisheries and causes a high frequency of encounters between predators and fishers. The potential of MPAs to decrease overfishing by industrial vessels was proposed as one of the ways to reduce conflicts with non-target taxa. This was of particular interest in the central HCS for this study.

Fishers perceived that effective spatial and seasonal segregation between small-scale and industrial fisheries would result in a greater availability of target fish species for small-scale fisheries. This would be followed by increased predator benefits, leading to decreased conflicts caused by prey competition (Hooker & Gerber 2004).

The night fishing measure was also reported to reduce conflicts between fisheries and non-target taxa. However, while night setting in longline fisheries has been 100% effective in reducing negative impacts on albatrosses in industrial longliners, it is less effective for diving nocturnal petrels (Løkkeborg 2011). This measure is also less effective for sea lions, where bycatch events are higher at night and are more likely in coastal small-scale fisheries (Reyes *et al*. 2013). In addition, the recommendation of nocturnal fishing is also viewed as a constraining fishing activity and is emphasized at higher latitudes where daylight availability is more limited, as noted in this study for small-scale netting fisheries.

The change or modification of fishing gear has also been recognized as an alternative means to diversify fishing activity but also to reduce impacts on non-target taxa. For instance, the modification of longlines for faster sink rates, and devices for protection of target species, also reduced seabird bycatch and increased albatross populations in subantarctic waters (Robertson *et al*. 2017).

Buy-outs for loss of materials or changes in fishing habits, such as seasonal/spatial closures or bycatch thresholds, can act as quick reparative measures for fishers (Senko *et al*. 2014). Although monetary compensation may be an attractive alternative, throughout our studied areas and especially for gillnet fisheries, the externalization of costs from fisheries must be also addressed.

Across the HCS, fishers proposed the reduction of the population of the South American Sea Lion as one approach to reduce sea lion impacts on fisheries. Sea lion control through hunting quotas, and the commercial use of sea lions, were represented in high frequency in this study. However, a study carried out in Chile on marketing products derived from sea lions as oil and meal estimated that 12 000 sea lions per year would be required for this activity to be profitable (Urra *et al*. 2011). This constitutes about 8% of the total population of South American Sea Lions in Chile, a reduction that would seriously affect their conservation status. There is also a lack of evidence that culling sea lions is an effective measure for improving fish catch (Morissette *et al*. 2012).

Operational alternatives to reduce interactions between sea lions and small-scale fisheries are dependent on management measures that require the engagement of fishers. The most frequently used alternatives include increased attention given to the condition of fishing gear, fishing at night, and the dilution effect through community fishing in the same area (Sepúlveda *et al*. 2007).

Coupling fishers' experiences and perceptions in sensitive conservation issues

Fishers' experiences with non-target taxa form part of a diverse perceptive seascape, which depends on factors such as fisher's age and at-sea activity. Conservation initiatives must therefore recognise personal attributes of fishers, such as age and the role of crew members over time. This is central when considering how fisheries administration is aligned with fishers' perceptions.

The way in which fishers interact with seabirds and the South American Sea Lion along the HCS is of particular importance for this study. Fisheries can lead to the bycatch of seabird species in the Chilean section of the HCS (Suazo *et al.* 2014). A global crisis for the conservation of sensitive species like albatrosses and penguins is widely recognised, with fisheries bycatch identified as one of the main threats at sea (Dias *et al*. 2019). Seabird bycatch in small-scale purse seine and gillnet fisheries is an emerging arena because these important fisheries for the HCS are indicated among the main targets for the global conservation of sensitive seabird species like the Humboldt Penguin *Spheniscus humboldti* and the Pink-footed Shearwater *Ardenna creatopus*, respectively (Crawford *et al.* 2017, Melvin *et al.* 2023).

The diagnosis and mitigation of seabird bycatch on small-scale fisheries is limited (Pott & Wiedenfeld 2017). This is mainly due to reduced opportunities for studies and the need for coverage of huge fleets like in the HCS (e.g., > 400 vessels based in the port of Coronel, south-central Chile). However, is important to consider the potential positive economic impacts of seabird bycatch mitigation efforts on small-scale and artisanal fisheries, including reduced impacts of fishing performance and success (Melvin 2013, Suazo *et al*. 2017).

In the Northern Hemisphere, interactions with commercial fisheries may severely impact sea lion populations because many of the species targeted by fisheries are also consumed by sea lions (Baraff & Loughlin 2000). Fisheries, therefore, have the potential to reduce sea lion foraging efficiency by altering the abundance, composition, and distribution of available prey for sea lions. This can lead to long-term nutritional stress that may, in turn, disrupt the ecological interactions upon which sea lions depend for survival (Rosen & Trites 2000, Trites & Donnelly 2023).

In Chile, South American Sea Lions have shown drastic changes in their diet composition over the past 30 years (Muñoz *et al*. 2013). This shift has involved the consumption of lower trophic level prey, exchanging demersal South Pacific Hake and the Pink Cusk-eel *Genypterus blacodes* for small pelagic fish, such as sardines (George-Nascimento et al. 1985, Muñoz *et al*. 2013).

The generalist and opportunistic nature of the South American Sea Lion enables rapid changes in diet composition and food sources (Cappozzo & Perrin 2009). In addition to trophic interference, explicit interactions with gillnet fisheries have recently been recorded in central Chile (Sepúlveda *et al*. 2018). The abundance, distribution, and seasonal attributes of sea lions can, therefore, affect the fishing performance and success of artisanal fishers in this section of the HCS, where improvised deterrents have hitherto been ineffective.

To address negative interactions of non-target taxa with fisheries, Chile has allocated an annual budget of ~2 million US dollars since 2013 to develop national plans for the reduction of discards and bycatch of non-target taxa, including seabirds, marine turtles, and marine mammals, among others (Discard Reduction Plans, n.d.).

Despite not being explicitly incorporated into management practices, understanding these novel processes can improve governance on issues surrounding fishers' perceived conflicts with other non-target taxa by offering consensus incentives, such as trialed effective deterrents and/or mitigation measures. The knowledge gained from this study might also be used to explain why small-scale fishing operations in the southern regions of this study need MPAs and how marine predators that are being displaced by industrial fisheries' overfishing are affected (e.g., Gómez-Campos *et al*. 2011).

By including a wider perception of the marine environment covering target and non-target marine species defined by the fishers themselves, fisheries administration can draw on a novel source of information. This is particularly helpful when considering data-deficient small-scale fisheries where these conflicts may be further mitigated (Ruano-Chamorro *et al*. 2017). Otherwise, fishers whose fishing effort is displaced by not-so-popular measures, such as the creation of MPAs, may be provided with incentives to both secure fishing success and reduce interference with non-target taxa.

Approaches that consider the perceptions of small-scale fishers can enable the societal recognition of new ecological experiences. This includes the identification of key traits such as fishers' at-sea experience, geographical-seasonal distribution, and the operational role of the fisher onboard during their interaction with non-target taxa. This knowledge can also be used to help predict the reception and commitment to novel management measures in the administration of small-scale fisheries (Ward *et al.* 2015).

Monitoring interactions between marine species onboard a fishing vessel is, therefore, not the only way to form an integral view of fisheries and their management at the ecosystem level. By re-incorporating human dimensions into biological sciences, conservation efforts can achieve more plasticity and long-term scope (Bradshaw & Bekoff 2001).

Focusing on conflict reduction achieves a more realistic bottom-up approach to fisheries management. However, this is only feasible as a best practice, with the engagement and participation of fishers (Dolman *et al*. 2016). Marine conservation depends on human interactions and insights derived from fishers' experiences, and fishers' perceptions will provide more evidence for conservation issues at the ecosystem level.

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