What prevents fishers from enforcing their user rights?

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Abstract

Over-fishing is a global problem that damages the marine environment and compromises the long-term sustainability of fisheries. This damage can be mitigated by restricting catch or other activities that can occur in marine areas. However, such management is only effective when restrictions are enforced to ensure compliance. We expect fishers to help enforce restrictions when they have exclusive user rights and can capture the benefits of management. In a number of such cases, however, fisher participation in the enforcement of user rights is absent. In this analysis we used Chile as a case-study to investigate why fishers do not participate in enforcement even when they have exclusive territorial user rights (TURFs). We used a best-worst scaling survey to assess why fishers would choose not to participate in enforcement through monitoring their TURF management areas, and what would help to increase their participation. We found that the main reason fishers do not monitor is because they consider government policing of marine areas and punishment of poachers to be ineffective. Increased and timely responsiveness by government when poachers are detected and more stringent penalisation of poachers may lead to greater involvement in enforcement by fishers.

Key words: best-worst scaling; Chile; marine management; monitoring, small-scale fisheries; TURFs

Introduction

Management of a biological resource, such as a fishery, generally imposes restrictions on use of the resource to ensure its continued or increased productivity (Bulte et al. 1995; Guyader 2002). In the marine environment, management usually takes the form of catch restrictions (e.g. total allowable catch limits) or use restrictions (e.g. designation of a no-take area, declaration of closed seasons, or restrictions on which equipment may be used). These restrictions typically have to be enforced to yield any benefits. Enforcement occurs through monitoring to detect non-compliance with restrictions and through prosecution activities –

apprehending infringers and, if appropriate, penalising non-compliance (Anderson 1989). Different actors may perform each of these roles. For example, monitoring may be undertaken by a government agency or devolved to a non-government agency or to resource users themselves. Prosecution activities are typically performed by the government or a government agency. The benefits of enforcement include greater abundance, size, and diversity of the biological resource (Gelcich et al. 2012; Jennings et al. 1996; Samoilys et al. 2007). Under certain conditions these biological changes can translate into higher fisher revenue (Davis et al. 2015). With no enforcement, biological or economic benefits may be undermined by poaching (Byers and Noonburg 2007; Sethi and Hilborn 2008), or destroyed completely (Guidetti et al. 2008).

Management of coastal marine resources in Chile operates through a co-management system which is based on granting territorial user rights for fisheries (TURFs) (Castilla 2010). Under the Chilean TURF system, which has operated since the early 1990s, user rights are given to artisanal fisher organisations for the exploitation of benthic (bottom-dwelling) resources in geographically defined management areas. Involvement in the program requires fisher organisations to comply with negotiated total allowable catch limits, undertake annual surveys of key stocks, and bear all management costs. In particular, fisher organisations are responsible for monitoring their management area – and bear all monitoring costs. They notify the Chilean government of any observed breaches, i.e. poaching activity. The government is responsible for apprehending and penalising poachers. Note that although fishers' main role in enforcement is to monitor their management area, they may also assume responsibility for poacher apprehension and penalisation where these are directed at members of their own organisation. Since the introduction of the TURF program in Chile there has been widespread involvement by fisher organisations, with 809 TURFs currently approved (SERNAPESCA 2014).

Assigning user rights (likes TURFs) provides an incentive to invest in management because these rights allow resource managers to capture the benefits from that investment (Schlager and Ostrom 1992). In Chile, we could expect fishers to monitor their TURF management areas because it has been demonstrated that enforcement (of which monitoring is a key component) can lead to biological and economic benefits (Davis et al. 2015; Gelcich et al. 2012). However, of the 809 TURFs in Chile, roughly a third are not monitored by the responsible fisher (González Poblete et al. 2013; JC Castilla, personal communication). Non-

enforced TURF areas (areas that fishers are no longer monitoring) have lower productivity (Gelcich et al. 2012), and are likely to generate lower revenues for fishers (Davis et al. 2015).

Various potential explanations for poor enforcement have been identified in the literature. For example, although resource users have legal user rights in an area, they may face social costs from exercising those rights, such as alienation or ostracism by the local community. There is evidence that these social costs may be relevant in Chile, where fishers have commented that they do not want to denounce family members or neighbours for poaching (Bandin and Quiñones 2014). The decision not to participate in enforcement may relate to capacity issues, such as lack of time or financial resources (Jones 2001). Analysis of global marine management capacity by Rife et al. (2013) led to the conclusion that funding for enforcement is probably deficient in many cases. In Chile, enforcement costs have previously been found to be an important cost of TURF management (Bandin and Quiñones 2014; Gelcich et al. 2009). Effective enforcement may also be prevented by environmental factors. Monitoring of management areas can occur from the shore. However, not all coastal areas are accessible by vehicle, or have the infrastructure necessary to support shore-based enforcement activities (Lundquist and Granek 2005). In those cases, management areas may need to be enforced by boat, which is costly. Along the extensive coastline of Chile shore-based enforcement is very difficult (Castilla and Defeo 2001; Gelcich et al. 2009).

There can also be institutional or governance issues that prevent enforcement or reduce its effectiveness. Lundquist and Granek (2005) have commented that government instability hampers enforcement, particularly in developing nations. Lack of sufficient government support may also hamper enforcements efforts by fishers (Cudney-Bueno and Basurto 2009). For example, fishers in Chile may enforce catch restrictions within their own organisation and monitor TURF management areas to detect poaching – actions which allow stock levels to increase – but ultimately they may be unable, or lack the authority, to prevent poachers from outside the organisation from entering the area and stealing stock.

In this analysis we investigate why artisanal fisher organisations who are part of the co-management TURF program in Chile may choose not to monitor their TURF management areas. We interviewed fishers in the central marine region of Chile using a best-worst scaling (BWS) survey. The objective of our survey was to understand what has the greatest impact on fishers' decisions not to monitor their management areas. We also explored what could be

done to improve enforcement in the region. This understanding should help design policy incentives for increased monitoring for enforcement.

Study area

The study area for this analysis is the central marine region of Chile (Figure 0.1). Within this region there are over 30 fisher organisations, although not all are actively administered or currently fishing. Fisher organisations operate out of *caletas* ('fishing coves'); the coastal infrastructure where fishing activities occur. There can be more than one fisher organisation operating out of one *caleta.* For example, in the *Las Cruces caleta,* there is *Las Cruces Hombres* and *Las Cruces Mujeres*. We surveyed 10 organisations, from *Los Molles* in the north (32°24'S, 71°51'W) to *Navidad* in the south (33°94'S 71°85'W) (Figure 0.1). Each fisher organisation has between 12 and 60 members, and includes a management group composed of the president plus, for example, a treasurer, secretary, and/or a management area coordinator. The management group is elected periodically by the organisation members.

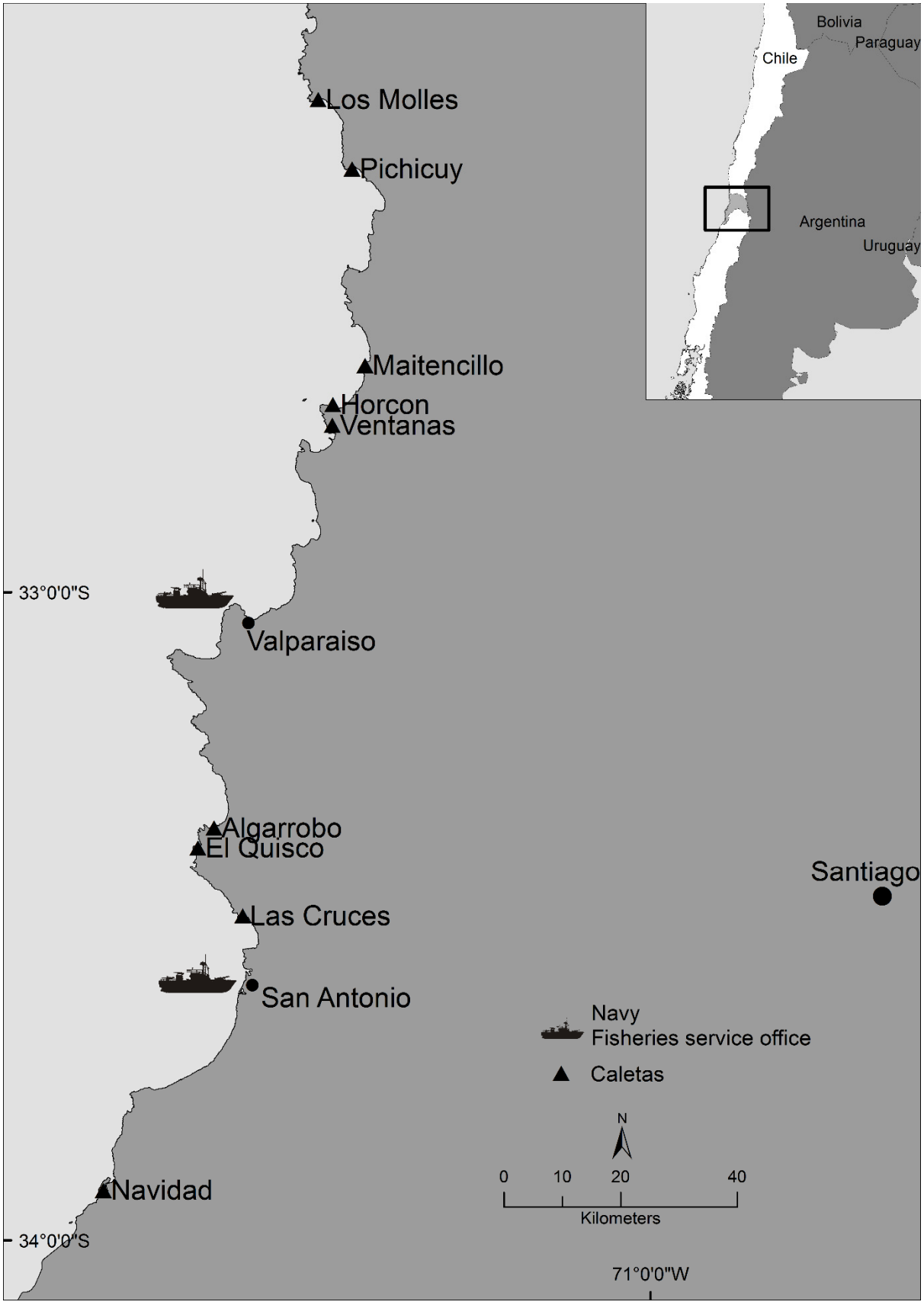

Figure 0.1. Locations of caletas, navy bases, and offices of the fisheries service (SERNAPESCA), within the study area.
Note: Two organisations operated out of caleta *Las Cruces*: *Las Cruces Hombres* and *Las Cruces Mujeres*.

Methods

Best-worst scaling

This study used a best-worst scaling (BWS) survey (Finn and Louviere 1992) directed at fishers in the case study region. BWS applications have principally been in the field of health economics (Flynn 2010; Lancsar et al. 2013). To date, there have been few BWS applications in an environmental economics context (Erdem et al. 2012; Rigby et al. 2014).

A BWS survey contains a number of choice sets which require the respondent to choose the "best" and "worst" options from varying sets of three or more options (for an example, see Figure 0.1) (Finn and Louviere 1992). Respondents are assumed to choose the two options which they feel exhibit the largest perceptual difference on an underlying continuum of interest (Finn and Louviere 1992). Analysis of the choice data allows each option to be rank-ordered on a common scale and assessed on the basis of its relative importance (Marti 2012). The current analysis used a 'case 1' BWS; this case is used to value simple concepts or objects which are not described by a set of attributes (Flynn 2010).

What **MOST** affects your decision	The decision not to monitor a management area	What **LEAST** affects your decision
✓	**1.** We feel too uncomfortable monitoring or denouncing poachers	
	2. Government punishments for poachers are not effective	
	3. Monitoring represents a high personal risk for guards	
	4. The management area is too far from the *caleta*	✓

Figure 0.1. Example of a best-worst scaling question from the current study.
Note: This is an English translation of the Spanish original.

BWS is well suited to investigate what artisanal fishers' in Chile perceive as the most important reason not to monitor their TURF management areas, and how much less important other reasons are. One of the main benefits of BWS is that individuals are forced to discriminate between options (Louviere and Flynn 2010). This gives BWS an advantage over rating scales (e.g. Likert) where each option can be rated as equally important. The BWS choice task is less cognitively demanding for respondents than a single ranking task (Marti 2012; Potoglou et al. 2011); this was a key factor in our choice of methodology because artisanal fishers in Chile typically have low education levels. Low education levels and lack of internet access in the study area make it necessary to conduct face-to-face interviews. This necessity, in combination with the fact that organisations are spread over a wide geographical area, increases survey expense and hence limits the population which can be sampled. Consequently, an important advantage for the present analysis is that BWS can deliver robust, policy-relevant information on preferences with a relatively small sample size (Flynn et al. 2008). In addition, non-parametric analysis of choice data can also be used as an approximate substitute for parametric analyses (where survey designs are orthogonal and balanced) (Finn and Louviere 1992; Flynn 2010) where there is a restricted sample size.

Survey development and administration

The purpose of this analysis was to investigate why artisanal fisher organisations, who are part of the co-management TURF program in Chile, may choose not to participate in the enforcement of their exclusive user rights. In particular, we wanted to identify the main reason fishers would choose not to monitor TURF management areas to detect poachers. Initial development of the survey was based on literature and expert knowledge, in particular identifying reasons fishers may choose not to monitor exclusive user rights. A pilot survey was conducted with six fishers from the *El Quisco* fisher organisation. The pilot tested whether survey wording was appropriate and understood by respondents, and whether we had included all the relevant reasons not to monitor in the BWS questions. The final survey was administered face-to-face with ten fisher organisations in central Chile. Five or six fishers in each organisation answered the survey questions, resulting in a total of 52 completed surveys. Surveys were conducted with members of the organisation's management group (the president, secretary and/or treasurer) and with other non-management members.

The final survey had three parts. Part 1 gathered information on the socio-economic characteristics of respondents including the role of the respondent within the organisation and

what the respondent perceived were the benefits (if any) of monitoring and enforcement more generally. We also collected details regarding their organisation, for example, whether the organisation had problems with poaching. Part 2 described the BWS questions and context; these questions asked the respondent to choose the most and least important reasons not to monitor their TURF management area. The BWS component was constructed using a balanced incomplete block design (BIBD) (Cochran and Cox 1950). A BIBD ensures that the occurrence and co-occurrence of options is constant; this minimizes the chance of respondents making assumptions about the importance of options based on aspects of the survey design (Flynn and Marley 2014). Although the literature suggests that BWS is less cognitively demanding than other choice experiment tasks (Potoglou et al. 2011), in the pilot we observed that respondents showed signs of "survey fatigue" half-way through the BWS questions. Because of this we limited the number of possible reasons not to monitor to seven (Table 0.1), as including more options would increase the number of BWS questions considerably. Each respondent was presented with seven BWS questions, which each showed four options – reasons not to monitor. Each of the seven possible reasons not to monitor was replicated four times within the survey. In Part 3 we asked respondents what would assist their organisation to monitor – or what would improve their capacity to monitor.

A feature of working with artisanal fisher organisations in Chile is the limited size of the data sets available for analysis. Use of BWS allows estimation of respondents' preferences even with small data sets, however, there are limits to what can be established econometrically when we seek to explain heterogeneity in preferences.

Table 0.1. The seven reasons not to monitor that were tested in the best-worst scaling survey.

Reasons not to monitor
Government punishments for poachers are not effective
We don't have the capacity to monitor (for example, economic resources or time)
Enforcement doesn't help to improve the productivity of our main resources
Monitoring represents a high personal risk for guards
The price of our main resources is too low to justify monitoring
We feel too uncomfortable monitoring or denouncing poachers
The management area is too far from the *caleta*

Analytical model

Parametric analysis of the BWS survey data draws on Random Utility Theory to create a model which can compare the importance of options and predict how often an option will be picked over another (Flynn and Marley 2014; McFadden 1974). Respondents' choice among options (in our study: reasons not to monitor), is modelled as a function of the characteristics

of those reasons using a conditional logit model (Hoffman and Duncan 1988). When modelling heterogeneity using observable characteristics, utility is given by:

$$U = \sum_{i}^{7} \beta_i P_i + \sum_{i}^{7} \sum_{s} \beta_{is} P_i X_s + \varepsilon, \qquad i = 1, \dots, 7$$

Where P_i are the reasons not to monitor, and β_i is the parameter estimate for each reason *i* not to monitor. *X* are socio-economic characteristics *s*, and β_{is} is the parameter estimate for each interaction term between reason not to monitor *i* with socio-economic characteristic *s*. The first two elements in equation 1 can be observed through respondents' choices, while stochastic component ε is unobserved.

To investigate whether observable characteristics could explain potential explanations for preference heterogeneity, we tested whether interactions between socio-economic characteristics and reasons not to monitor had significant marginal effects on choice probabilities. In the conditional logit model, the marginal effect of a change in a socio-economic characteristic is not constant, but varies depending on the reference probability level. This test is conducted by calculating the marginal effects of each interaction term:

$$\frac{\delta \pi_i}{\delta x_s} = \bar{\pi}_i \left(\beta_{is} - \sum_{j}^{7} \bar{\pi}_j \beta_{js} \right), \qquad i, j = 1, \dots, 7$$

Where π. is the reference probability level, which we set as the sample mean probability of selecting reasons not to monitor, *i* or *j,* and β_{js} is the parameter estimate for the interaction term for each reason not to monitor *j*, with each socio-economic characteristic *s*.

A model which included all interaction terms with significant marginal effects was our base model. To test whether interaction terms were 'needed' in the final model we removed one interaction term at a time – using a log likelihood ratio test to assess whether the reduced model was significantly better than the base model. Where the log likelihood of the new model was not significantly different ($p<0.05$), the relevant interaction term was removed from the model, otherwise it was retained.

Results

Socio-economic and organisation characteristics

Of the 52 respondents, nine presidents were interviewed, 17 were other members of the management group, and 26 were non-management members of their fisher organisations.

Ventanas was in the process of electing a new management group; as the new president had not yet been elected, the former president was interviewed and their position recorded as 'other management'. The majority of respondents were male (81%) and between 45 and 65 years of age (70%) (Table 0.1). Most respondents (87%) had been with their organisation for more than 10 years, and had not previously been a member of another organisation. Over two-thirds of respondents (69%) stated that their organisation was actively monitoring one management area, while 17 per cent (nine respondents) said that their organisation was not monitoring any area. Of these nine, four respondents were from *Horcon,* two were from *Las Cruces Hombres*, and one each from *Navidad*, *Maitencillo*, and *Pichicuy*.

Table 0.1. (a) Socio-economic characteristics of the sample (n=52); (b) Sample means for socio-economic interaction terms used in subsequent estimation of the conditional logit model reported in Table 0.4.

(a) Gender	%	Age	%
Male	81	<25	2
Female	19	25-34	0
		35-44	17
		45-54	33
		55-65	37
		>65	12
Years with current organisation	**%**	**Previously member of other organisation**	**%**
0-2	6	No	85
3-5	6	Yes, 0-3 yrs	8
6-10	2	Yes, 4-10 yrs	4
>10	87	Yes, >10 yrs	4
Number of management areas	**%**	**Number of management areas organisation is enforcing**	**%**
1	69	0	17
2	15	1	69
3	15	2	13
Position within organisation		**Percentage of organisations' income from fishing activities**	
President	17	<25%	51
Other mgmt.	33	25-50%	10
Member	50	50-75%	12
		>75%	27

(b) Socio economic characteristic/attitude (1=yes, 0=no)	Mean
Respondent has been with current organisation <10 years	0.13
President	0.17
Poaching within TURF management area by members of the organisation	0.42
Enforcement doesn't increase population of main resources	0.18
Organisation has managed TURF management area for <10 years	0.15

About half of the respondents (51%) stated that their organisation obtained less than 25 per cent of its income from fishing activities, while just over a quarter (27%) said that more than 75 per cent of their organisation's income came from fishing. Organisations supplement their fishing income with tourism (for example, boat tours of the organisation's management area) or renting parking spaces, beach facilities, etc.

Model results

The first step in our analysis was to estimate conditional logit models for both best and worst choices for each of the ten organisations. Several authors have suggested that there may be conditions under which the functional form of models of 'best' choices are different to models of 'worst' choices (Flynn and Marley 2014; Rigby et al. 2014). This inconsistency can be explained by a phenomenon known as positive-negative asymmetry; respondents agree more on negative evaluations than positive evaluations (Czapiński and Lewicka 1979; Peeters and Czapinski 1990). At the sample level this difference may manifest itself as differences in the utility function governing best and worst choices. At the individual level we anticipate this phenomenon to express itself as respondents being more systematic when choosing the greatest barrier to monitoring (their best choice), and less consistent when choosing the smallest barrier to monitoring (their worst choice). Consequently, we expected that best choices would be different to worst choices. We tested this hypothesis using a log likelihood ratio test to analyse whether models of best and worst choices could be combined. Results showed that best and worst choice data could not be combined for six of the ten organisations ($p<0.05$). Consequently we use the best choices only in our models. We expect these to give a more systematic indication of the preferences of respondents regarding reasons not to monitor.

The next step in our analysis was to examine count data for each organisation's best choices (Table 0.2). These counts show that, in aggregate, respondents considered 'government punishments for poachers are not effective' to be the most important reason not to monitor. 'The management area is too far from the *caleta'* was the least important reason. Another important reason not to monitor was a lack of capacity in the fisher organisation. However, at the organization level there was considerable heterogeneity in responses as indicated by differences in group means for each reason not to monitor.

Table 0.2. Count data (%) for best choices for each organisation, reported as percentages to control for different numbers of individuals in each group.

		Ineffective government penalties for poachers	Lack of capacity	Enforcement doesn't improve productivity	Personal risk	Price of resources too low	Not comfortable monitoring	Management area too far away
Group 1[a]	*Algarrobo*	20	29	17	0	23	9	3
	El Quisco	19	17	21	14	21	7	0
	Horcon	11	20	9	6	11	23	20
	La Boca	23	11	11	17	17	11	9
	Las Cruces Hombres	14	23	9	26	9	17	3
Group 1 mean		18	20	13	13	16	13	7
Group 2[a]	*Los Molles*	31	9	20	17	11	11	0
	Maitencillo	37	17	17	9	6	14	0
	Pichicuy	29	9	17	29	3	11	3
	Ventanas	43	17	5	17	5	14	0
Group 2 mean		35	13	15	18	6	13	1
Group 3[a]	*Las Cruces Mujeres*	14	31	29	6	17	3	0
	Total	24	18	15	14	12	12	4

[a]**Group 1 is composed of fisher organisations Algarrobo, El Quisco, Horcon, Navidad, and Las Cruces Hombres; Group 2 of Los Molles, Maitencillo, Pichicuy and Ventanas; and Group 3 of Las Cruces Mujeres.**

Initial evaluation of the best count data suggested that organisations could be aggregated into three groups based on their choices. Group 1 was composed of the organisations: *Algarrobo*, *El Quisco*, *Horcon*, *Navidad,* and *Las Cruces Hombres.* This group tended to place a low weight on 'the management area is too far from the *caleta*', and relatively uniform weights on the other reasons (although *Algarrobo* was notable in never selecting 'monitoring represents a high personal risk for guards'). Group 2 was composed of *Los Molles*, *Maitencillo*, *Pichicuy*, and *Ventanas.* They also placed a very low weight on 'the management area is too far from the *caleta*', but consistently weighted 'government punishments for poachers are not effective' above the other options. Group 3 had only one organisation: *Las Cruces Mujeres.* Although there were only five respondents in this final group, analysis of the best count data confirmed that their preferences were internally consistent; placing higher weights on 'enforcement doesn't help to improve the productivity our main resources' and lack of capacity as major reasons not to monitor.

We tested whether the choice data could be combined in these three groups by estimating a conditional logit model[1] on the best choice data for each of the three groups (Table 0.3). We then compared the log likelihood of these three models to the sum of the log likelihoods of the organisations when estimated individually. The results support the aggregation of organisations into Groups 1 and 2 ($p=0.45$ and $p=0.11$, respectively). A further log likelihood ratio test rejected a single aggregate model in which data from all three groups was combined ($p<0.001$). This aggregate model is reported in Table 0.3, and represents the mean preference across the whole sample. It shows similar preference ordering as the count method; ineffective government penalties for poaching was most important in fisher organisations' decision not to monitor and 'the management area is too far from the *caleta*' was the least important reason.

[1] Estimation of latent class models results in predicted membership of classes that is difficult to interpret on the basis of individuals' characteristics and are not reported here; the small sample size may limit the ability to estimate robust latent classes.

Table 0.3. Results from conditional logit models for the most important reason not to monitor TURF management areas (best choices). Preferences are relative to the option: ineffective government penalties for poachers. Aggregated model shows sample preferences (n=52). Groups 1, 2 & 3: show preference for each group (n=26, 21, and 5 respectively).

	Group 1[b]		Group 2[b]		Group 3[b]		Aggregated	
Reasons not to monitor	**coeff.**	**SE**	**coeff.**	**SE**	**coeff.**	**SE**	**coeff.**	**SE**
Ineffective government penalties for poachers[a]	0.00		0.00		0.00		0.00	
Lack of capacity	0.15	0.27	-1.45 ***	0.32	1.50 ***	0.75	-0.39 ***	0.18
Enforcement doesn't improve productivity	-0.28	0.29	-1.24 ***	0.30	1.36 ***	0.75	-0.58 ***	0.19
Personal risk	-0.10	0.30	-1.01 ***	0.29	-0.94	0.84	-0.69 ***	0.19
Not comfortable monitoring	-0.32	0.29	-1.45 ***	0.32	-1.64	1.10	-0.85 ***	0.20
Price of resources too low	-0.08	0.28	-2.29 ***	0.40	0.75	0.78	-0.85 ***	0.20
Management area too far away	-1.08 ***	0.35	-4.50 ***	1.02	-16.12 [c]	1385.16	-2.15 ***	0.31
Algarrobo x personal risk	-14.30 [c]	461.35						
Model statistics								
Number of observations	182		147		35		364	
Log likelihood	-238.02		-158.30		-32.51		-465.17	
Pseudo R^2	0.06		0.22		0.33		0.08	

[a]Reference case.

***p < .01; **p<0.05, ***p<0.01**

[b]Group 1 is composed of fisher organisations *Algarrobo*, *El Quisco*, *Horcon*, *Navidad*, and *Las Cruces Hombres*; Group 2 of *Los Molles*, *Maitencillo*, *Pichicuy* and *Ventanas*; and Group 3 of *Las Cruces Mujeres*.

[c]These are two occasions when a reason is *never* selected as best. In these cases the conditional logit model can exactly identify this behaviour by assigning any sufficiently large negative coefficient to that reason. The standard error of these coefficients consequently becomes large, as *any* large negative value will ensure that the predicted probability approximates zero – there is consequently very poor precision in the estimation of this value. This is equivalent to dropping this set of observations from the data, which would leave log likelihood and parameter values unchanged.

When estimating conditional logit models on the best choice data for each of the three groups (Table 0.3), 'government punishments for poachers are not effective' was set as the reference option against which the importance of all other options was assessed. A positive coefficient indicates that fishers considered an option more important in the decision not to monitor than this reference option; a negative coefficient indicates that the opposite was true. Group 1 has a simple preference structure: 'the management area is too far from the *caleta*' is the least preferred option, while there is no significant difference between the other alternatives ($p=0.55$). The only exception within Group 1 is the *Algarrobo* organisation, whose members are unique in never selecting 'monitoring represents a high personal risk for guards' as the most important reason not to monitor.

For Group 2, all options were less important than ineffective government penalties for poachers. The coefficients on reasons: lack of capacity, enforcement doesn't improve productivity, personal risk, and 'we feel too uncomfortable monitoring or denouncing poachers' are not significantly different ($p=0.56$). 'The price of our main resources is too low to justify monitoring' and 'the management area is too far from the *caleta*' are significantly less important than other reasons.

Group 3 (*Las Cruces Mujeres*) had a different preference structure compared to the other groups. Lack of capacity, followed by 'enforcement doesn't help to improve the productivity of our main resources,' were the most important reasons not to monitor. The other reasons not to monitor were ranked equally – with the exception of 'the management area is too far from the *caleta'* which was never selected by this group as the most important reason not to monitor.

We can explain heterogeneity in respondents' preferences by identifying differences between groups of organisations in the study region. An alternative approach to this grouping of organisations is to investigate whether there are significant interactions between individual's socio-economic characteristics and choice of reasons not to monitor. When we evaluated the marginal effects of interaction terms, we found that several of these were significant ($p<0.05$) (Table 0.1). A final conditional logit model estimated using these interactions is reported in Table 0.4. Note that the socio-economic variables are defined so that the baseline (upper panel) represents the majority of the sample (Table 0.1) and as a result these have similar preference rankings to the aggregated best choice conditional logit model (Table 0.3).

The coefficients on the interaction terms are interpreted as an increase or decrease in preference for a reason not to monitor specific to that group of respondents. For example, respondents who had been with their organisation for less than 10 years (13% of respondents) were more likely to think that feeling uncomfortable when monitoring or personal risk were good reasons not to monitor. Also, respondents who indicated that their organisation had managed a TURF management area for less than 10 years (respondents from *Las Cruces Mujeres*, see Appendix, Table 0.1) were more likely to think that 'enforcement doesn't help to improve the productivity of our main resources' and lack of capacity were good reasons not to monitor. This finding is consistent with the results of the conditional logit model for *Las Cruces Mujeres* (Table 0.3, Group 3). The findings of the two different models: those for groups, and the present model with significant interaction terms, provide similar explanations for heterogeneity in respondents' preferences. Note that it was not possible to combine the socio-economic interaction terms into the group models as the subsets of data were too small.

Table 0.4. Conditional logit model with interaction terms describing socio-economic characteristics and reasons not to monitor.

Reasons not to monitor		**Coeff.**		**SE**
Ineffective government penalties for poachers		0.00		
Lack of capacity		-0.60	***	0.20
Personal risk		-0.91	***	0.21
Enforcement doesn't improve productivity		-1.07	***	0.23
Not comfortable monitoring		-1.36	***	0.25
Management area too far away		-1.43	**	0.59
Price of resources too low		-1.59	***	0.31
Enforcement doesn't improve productivity	* Enforcement doesn't increase population of main resources	1.13	***	0.42
Enforcement doesn't improve productivity	* Managed a management area for <10 years	1.23	***	0.44
Lack of capacity	* Managed a management area for <10 years	1.24	***	0.43
Not comfortable monitoring	* Enforcement doesn't increase population of main resources	1.44	***	0.43
Not comfortable monitoring	* <10 years with current organisation	1.48	***	0.47
Price of resources too low	* Poaching by members of the organisation	1.40	***	0.37
Personal risk	* <10 years with current organisation	1.45	***	0.46
Management area too far away	* Enforcement doesn't increase population of main resources	1.69	**	0.67
Management area too far away	* President	1.83	***	0.66
Model statistics				
Number of observations		357		
Log likelihood		-420.07		
Pseudo R^2		0.15		

What would help monitoring?

The BWS analysis identified reasons for not monitoring. We also asked respondents what they thought would help their organisation monitor their TURF management areas. This question presented 10 possible factors that could assist with monitoring, from which respondents were asked to identify the three most important. Respondents said that financial assistance would most help their organisation to increase its monitoring capacity (Figure 0.1). This factor was most frequently selected by respondents from Groups 1 and 3 (Table 0.5). More support for monitoring by organisation members, and the development of monitoring technology were also identified as important factors that would help organisations to monitor. More support for monitoring from *within* the fisher organisation would mean more fishers within the organisation would participate in monitoring activities, i.e. take a turn on monitoring duty, or contribute financially to the cost of hiring guards. New monitoring technology might include security cameras with the range and resolution to pick up movement at sea, or buoys with cameras which could identify intrusions and send signals directly to the organisation's authorities.

Providing information about the benefits of monitoring was not identified as a factor that would help organisations to monitor. This could indicate that fishers are aware of the benefits that monitoring can have, but that other constraints to monitoring capacity are more important. Respondents did not think that having more fishers in their organisation would help them monitor.

Interestingly, while 'government punishments for poachers are not effective' received the highest score in the BWS questions, stricter sanctions or help detaining poachers were not the most important factors that would help organisations monitor their TURF areas. While this might appear inconsistent, the questions were qualitatively different. In the BWS questions, we asked what affected personal motivation to monitor or not. In this question we were asking what had the potential to assist organisations to monitor. The difference in responses therefore reflects fishers' views regarding what would help their organisation to monitor (related to assistance with monitoring) versus what most affects their personal motivation for monitoring (BWS questions).

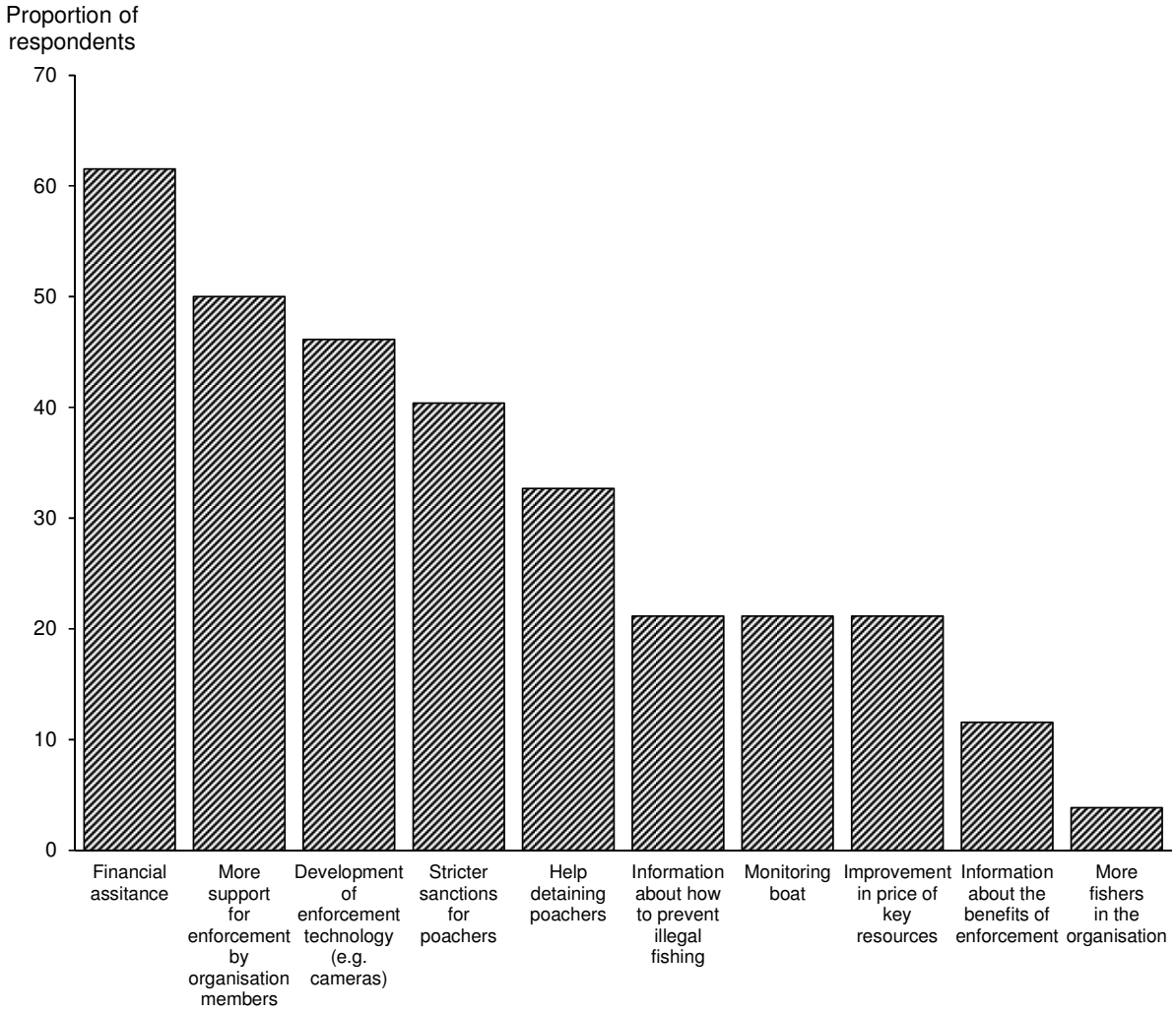

Figure 0.1. What fishers thought would help their organisation to monitor. Vertical axis describes the number of respondents (%) who indicated that a given factor would help their organisation to monitor.

Table 0.5. Factors that would help organisations enforce their TURF management area: mean values across sample (aggregated), and for each group.

	Means			
	Aggregated	**Group 1[a]**	**Group 2[a]**	**Group 3[a]**
Financial assistance	0.62	0.73	0.48	0.60
Help detaining poachers	0.33	0.35	0.29	0.40
Stricter sanctions for poachers	0.40	0.42	0.43	0.20
Information on how to prevent poaching	0.21	0.23	0.14	0.40
Information on the benefits of enforcement	0.12	0.12	0.14	0.00
An enforcement boat	0.21	0.19	0.24	0.20
More fishers in the organisation	0.04	0.08	0.00	0.00
More support for enforcement from within the organisation	0.50	0.46	0.52	0.60
Improvement in enforcement technology	0.46	0.35	0.57	0.60
Improvement in the price of main resources	0.21	0.31	0.14	0.00

[a]Group 1 is composed of fisher organisations Algarrobo, El Quisco, Horcon, Navidad, and Las Cruces Hombres; Group 2 of Los Molles, Maitencillo, Pichicuy and Ventanas; and Group 3 of Las Cruces Mujeres.

Discussion

We investigated why artisanal fisher organisations in Chile may choose not to monitor violations of their exclusive user rights, despite evidence that enforcement (of which monitoring is a key component) can provide fishers with net benefits (Davis et al. 2015). Various potential explanations for poor enforcement were identified in the literature, including institutional or governance issues (Lundquist and Granek 2005), social costs (Bandin and Quiñones 2014), capacity issues (Rife et al. 2013), and environmental factors (Gelcich et al. 2009). Our results identified ineffective government punishments for poaching as the most important reason why fishers choose not to monitor their TURF management areas. These findings are consistent with previous work investigating fishers' perceptions of the management of TURF areas in Chile (Bandin and Quiñones 2014; Gelcich et al. 2009).

Qualitative responses and informal discussion with fishers during the face-to-face surveys suggested that the judicial process in Chile does not sufficiently recognise the negative impacts of poaching, and that punishments are not sufficiently severe to deter poachers. Fishers also complained that government institutions, such as the navy or fisheries service, do not always respond to their distress calls when they detect poachers in their management areas. Although the co-management system in Chile requires fisher organisations to monitor their TURF management areas to detect poaching, it is the responsibility of government organisations (the navy and fisheries service) to apprehend and penalise poachers. These results suggest that the problem with enforcement in the central marine region of Chile is primarily one of governance: fishers may choose not to participate in enforcement activities because they think that the Chilean government does not provide sufficient legal deterrent for poaching and/or effectively apprehend and penalise poachers.

The need for government assistance to manage resources effectively has been observed in other parts of the world. Cudney-Bueno and Basurto (2009) studied the ability of a fishing community in Mexico to manage communal resources. They found that community-based management could be very successful in the short term, but that lack of government support or formal recognition of management structures compromised the long term viability of the system. This is similar to what is observed in Chile; organisations can enforce use restrictions within their own organisation, but may be unable to stop outsiders without government support. Further linkages between government instability (particularly in developing

countries) and shortcomings in management (particularly in enforcement activities) have been identified by Lundquist and Granek (2005).

There was heterogeneity in what organisations thought was the most important reason not to monitor their TURF management areas. Analysis of the BWS preference data revealed that groups of organisations shared similar preferences; this may be because organisations within each group share a world view, or adopt similar discourses – described as ways of interpreting or comprehending the world – to achieve help for enforcement (Gelcich et al. 2005). Groupings aligned very closely with a recent disaggregation of the *Federacion de Sindicatos de Trabajadores Pescadores Artesanales V Region* into separate northern and southern federations (D O'Ryan & S Gelcich, unpublished work). Group 1 is almost exclusively comprised of organisations from the Southern Federation, and Group 2 from the northern. Exceptions are *Horcon* and *Navidad*. The first of these abstained from membership of the Northern Federation, and recent work indicates they have no interactions with other northern organisations (D O'Ryan & S Gelcich, unpublished work). This may explain why their preferences differed to those of Group 2. *Navidad* is located in the south of the study area, but is not part of the Southern Federation. Results show that they share similar preferences with Group 1. The only organisation in Group 3 is *Las Cruces Mujeres* which, although part of the Southern Federation, is a unique organisation being entirely composed of women. All three groups were consistent in thinking that 'the management area is too far from the *caleta*' did not affect their decision not to monitor. However, each group had different preferences regarding the most important reason.

Ineffective government penalties for poaching significantly influenced Group 2 but not Group 1. This difference may be explained by the presence of Chilean navy bases and fisheries service offices in *Valparaiso* and *San Antonio* (Figure 0.1): locations which are close to Group 1 organisations, but further from Group 2. Organisations in Group 1 may thus enjoy a higher government agency presence than Group 2. Group 2 also indicated that the price of resources does not influence their decision not to monitor. The presence of high-end tourism in this northern region, and correspondingly higher prices for seafood than in the south, may explain this view.

Las Cruces Mujeres (Group 3) identified lack of capacity as the most important reason not to monitor. We expect this organisation to have a lower capacity to monitor than others because the majority of members do not own fishing boats and have alternative off-sector

employment; to monitor their management area *Las Cruces Mujeres* must contract guards from outside the organization. Respondents from this organisation also indicated that they would choose not to monitor because 'the price of our main resources is too low to justify monitoring' and 'enforcement doesn't help to improve the productivity of our main resources'. Two characteristics of the organisation might explain these attitudes. First, the organisation's principal reason for having a TURF management area is to provide seafood, or benthic resources, for community events which the organisation runs. This activity provides the organisation with a sporadic income from the TURF, and means they are less affected by market prices. Second, respondents indicated that their organisation had managed their TURF management area for less than ten years. Environmental awareness and sustainable behaviours (such as investing in enforcement) are expected to increase with time engaged in the TURF program (Gelcich et al. 2008).

Across the sample fishers identified financial assistance as an important factor that would help their organisation's capacity to monitor. Fisher organisations in Chile are not wealthy, and additional financial resources would undoubtedly remove some constraint to their productive capacity. However, in the BWS questions, respondents did not identify lack of capacity (financial resources or time) as a reason not to monitor TURF management areas. These results suggest that extra financial resources might affect organisations' capacity to monitor, but not their motivation. Therefore, even if organisation's financial resources were to increase, perhaps through government subsidies, they still might choose not to monitor. This result is consistent with the finding by Rife et al. (2013) that although funding for enforcement activities is probably deficient in many parts of the world, this is not the reason why enforcement is not occurring.

In this analysis we assessed how the distance between an area and a *caleta* may influence the decision of fisher organisations' not to monitor their management areas. In Chile one would expect that areas further from a *caleta* would be monitored less than closer areas. This is what we observe in the study area; fisher organisations that have more than one TURF management area generally do not monitor the area/s which are furthest away (M Santis 2014, unpublished work). However, amongst the seven reasons not to monitor that were presented in the BWS questions, fishers indicated that distance between a management area and their *caleta* had the least effect on their decision not to monitor. We can surmise that although distance is not what most affects this decision, more distant areas may be more

difficult to monitor. Hence when other factors present a barrier or reason not to monitor, then organisations stop monitoring more distant areas first. Additional research could more fully investigate this issue by ascertaining what affects the relative ease or cost of monitoring areas which are closer or further from *caletas*.

We found BWS worked well in our research context: identifying the most important reason not to monitor TURF management areas in the central marine region of Chile. Respondents were generally positive about the BWS choice task, although we observed that respondents from the organisation's management group appeared to understand the BWS questions more quickly than non-management respondents. We expect managers to have higher education levels, which may explain this difference. Based on our experience we suggest that BWS is likely to be a good methodology to use to investigate fisheries related issues; particularly in areas where sample sizes are likely to be constrained, and respondents have variable education levels. The BWS questions required less time, and presented a lower cognitive burden for respondents than tasks which would require all options to be ranked, or more complex choice experiments. We recommend that future researchers using this method in a study context where lower education levels are expected should conduct surveys face-to-face, as this interaction allows the BWS questions to be clarified if respondents have questions.

In our analysis we found that best choices were answered differently to worst choices, a phenomenon explained in the psychology literature as positive-negative asymmetry (Czapiński and Lewicka 1979; Peeters and Czapinski 1990). This difference in the way that best and worst questions are answered warrants consideration when conducting BWS surveys. In particular, it highlights the need for more research on the reasons why respondents may evaluate best and worst choices differently, and new ways of combining these choices where they are different. Additional analysis of BWS data could be conducted using scale-adjusted latent class models. These models may be able to identify further sources of heterogeneity amongst respondents; for example, groups of respondents who may be more or less systematic in identifying their best and/or worst choices. This has relevance given that we expect respondents to be less systematic when identifying their worst choices.

Conclusions

Our analysis found that the main reason artisanal fishers in Chile do not participate in enforcement through monitoring their TURF management areas, is because the government

does not effectively apprehend or penalise poachers. Increased and timely responsiveness by government agencies when poachers are detected, and more stringent penalisation of poachers, may lead to greater involvement in enforcement by fishers. This understanding should help design policy incentives for increased monitoring for enforcement – lack of which is a global problem. Increasing enforcement is expected to bring environmental benefits, and may also increase fishers' revenue. Increasing fishers' participation in enforcement may therefore increase the capacity of marine managers to manage marine resources sustainably, while improving the livelihoods of artisanal fishers and other industries reliant on these resources.

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Appendix

Table 0.1. Mean values for socio-economic interaction terms used in estimation of the conditional logit model reported in Table 0.4.

Socio economic characteristic/attitude (1=yes, 0=no)	Group 1[a]	Group 2[a]	Group 3[a]
Respondent has been with current organisation <10 years	0.19	0.05	0.20
President	0.19	0.14	0.20
Poaching within TURF management area by members of the organisation	0.65	0.19	0.20
Enforcement doesn't increase population of main resources	0.19	0.15	0.20
Organisation has managed TURF management area for <10 years	0.12	0.00	1.00

References

Anderson LG (1989) Enforcement issues in selecting fisheries management policy. Marine Resource Economics 6:261-277

Bandin RM, Quiñones RA (2014) Impacto de la captura ilegal en pesquerías artesanales bentónicas bajo el régimen de co-manejo: El caso de isla mocha, chile. Lat Am J Aquat Res 42:547-579

Bulte E, Folmer H, Heijman W (1995) Open access, common property and scarcity rent in fisheries. Environmental and Resource Economics 6:309-320

Byers J, Noonburg E (2007) Poaching, enforcement, and the efficacy of marine reserves. Ecological Applications 17:1851-1857

Castilla JC (2010) Fisheries in chile: Small pelagics, management, rights, and sea zoning. Bulletin of Marine Science 86:221-234

Castilla JC, Defeo O (2001) Latin american benthic shellfisheries: Emphasis on co-management and experimental practices. Reviews in Fish Biology and Fisheries 11:1-30

Cochran WG, Cox GM (1950) Experimental designs (Wiley Mathematical Statistics Series). Wiley, New York

Cudney-Bueno R, Basurto X (2009) Lack of cross-scale linkages reduces robustness of community-based fisheries management. PLoS ONE 4:e6253

Czapiński J, Lewicka M (1979) Dynamics of interpersonal attitudes: Positive–negative asymmetry. Polish Psychological Bulletin 10:31-40

Davis K, Kragt M, Gelcich S et al (2015) Accounting for enforcement costs in the spatial allocation of marine zones. Conservation Biology 29:226-237

Erdem S, Rigby D, Wossink A (2012) Using best–worst scaling to explore perceptions of relative responsibility for ensuring food safety. Food Policy 37:661-670

Finn A, Louviere JJ (1992) Determining the appropriate response to evidence of public concern: The case of food safety. Journal of Public Policy & Marketing 11:12-25

Flynn TN (2010) Valuing citizen and patient preferences in health: Recent developments in three types of best-worst scaling. Expert Review of Pharmacoeconomics & Outcomes Research 10:259-267

Flynn TN, Louviere JJ, Peters TJ et al (2008) Estimating preferences for a dermatology consultation using best-worst scaling: Comparison of various methods of analysis. BMC Medical Research Methodology C7 - 76 8:1-12

Flynn TN, Marley AAJ (2014) Best worst scaling: Theory and methods. In: Hess S, Daly A (eds) Handbook of choice modelling. Edward Elgar Publishing, UK

Gelcich S, Castilla JC, Kaiser MJ et al (2008) Engagement in co-management of marine benthic resources influences environmental perceptions of artisanal fishers. Environmental Conservation 35:36-45

Gelcich S, Edwards-Jones G, Kaiser MJ et al (2005) Using discourses for policy evaluation: The case of marine common property rights in chile. Society & Natural Resources 18:377-391

Gelcich S, Fernandez M, Godoy N et al (2012) Territorial user rights for fisheries as ancillary instruments for marine coastal conservation in chile. Conservation Biology 26:1005-1015

Gelcich S, Godoy N, Castilla JC (2009) Artisanal fishers' perceptions regarding coastal co-management policies in chile and their potentials to scale-up marine biodiversity conservation. Ocean & Coastal Management 52:424-432

González Poblete E, Cerda D'Amico R, Quezada Olivares J et al (2013) Diagnóstico del Estado y tendencias de la pesca artesanal en Chile. Dept: Subsecretaría de Pesca y Acuicultura de Chile, Valparaiso

Guidetti P, Milazzo M, Bussotti S et al (2008) Italian marine reserve effectiveness: Does enforcement matter? Biological Conservation 141:699-709

Guyader O (2002) Simulating the effect of regulatory systems in a fishery, an application to the french driftnet albacore fleet. Environmental and Resource Economics 23:1-28

Hoffman S, Duncan G (1988) Multinomial and conditional logit discrete-choice models in demography. Demography 25:415-427

Jennings S, Marshall SS, Polunin NVC (1996) Seychelles' marine protected areas: Comparative structure and status of reef fish communities. Biological Conservation 75:201-209

Jones PJS (2001) Marine protected area strategies: Issues, divergences and the search for middle ground. Reviews in Fish Biology and Fisheries 11:197-216

Lancsar E, Louviere J, Donaldson C et al (2013) Best worst discrete choice experiments in health: Methods and an application. Social Science & Medicine 76:74-82

Louviere JJ, Flynn TN (2010) Using best-worst scaling choice experiments to measure public perceptions and preferences for healthcare reform in australia. The Patient: Patient-Centered Outcomes Research 3:275-283

Lundquist CJ, Granek EF (2005) Strategies for successful marine conservation: Integrating socioeconomic, political, and scientific factors. Conservation Biology 19:1771-1778

Marti J (2012) A best–worst scaling survey of adolescents' level of concern for health and non-health consequences of smoking. Social Science & Medicine 75:87-97

McFadden D (1974) Conditional logit analysis of qualitative choice behavior. In: Zarembka P (ed) Frontiers in econometrics. Academic Press, New York

Peeters G, Czapinski J (1990) Positive-negative asymmetry in evaluations: The distinction between affective and informational negativity effects. European review of social psychology 1:33-60

Potoglou D, Burge P, Flynn T et al (2011) Best–worst scaling vs. Discrete choice experiments: An empirical comparison using social care data. Social Science & Medicine 72:1717-1727

Rife AN, Erisman B, Sanchez A et al (2013) When good intentions are not enough … insights on networks of "paper park" marine protected areas. Conservation Letters 6:200-212

Rigby D, Burton M, Lusk JL (2014) Journals, preferences, and publishing in agricultural and environmental economics. American Journal of Agricultural Economics

Samoilys MA, Martin-Smith KM, Giles BG et al (2007) Effectiveness of five small philippines' coral reef reserves for fish populations depends on site-specific factors, particularly enforcement history. Biological Conservation 136:584-601

Schlager E, Ostrom E (1992) Property-rights regimes and natural resources: A conceptual analysis. Land Economics 68:249-262

SERNAPESCA (Servicio Nacional de Pesca y Acuicultura) (2014) GTI Area de manejo. Dept: Servicio Nacional de Pesca y Acuicultura

Sethi SA, Hilborn R (2008) Interactions between poaching and management policy affect marine reserves as conservation tools. Biological Conservation 141:506-516