Title: Why are fishers not enforcing their marine user rights?¹

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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 which 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 for fisheries (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

A 2014 report by the Food & Agriculture Organization stated that roughly one third of global marine fish stocks were overfished (FAO 2014). This report further estimated that rebuilding overfished stocks could increase global fisheries production by 16.5 million tonnes and annual rent by US\$32 billion (FAO 2014). As well as increasing rents for fishers and the

wider economy, better fisheries management could provide a range of additional benefits, including marine ecosystem conservation and the preservation of use and non-use values specific to marine and coastal zones (OECD 2013).

One way of managing fish stocks is to give fishers a stake in marine resources by establishing co-management systems, for example, by assigning territorial user rights for fisheries (TURFs) (FAO 2014; Wilen et al. 2012). Assigning user rights to fishers enables them to capture the benefits of sustainable management, which is expected to lead to more sustainable extraction behaviour and greater interest in the responsible use and management of the resource (FAO 2014; OECD 2013; Schlager and Ostrom 1992). Increasing fisher participation in management is also expected to lead to greater compliance with management restrictions (Hatcher et al. 2000).

Despite transitions to co-management strategies, problems with illegal, unreported and unregulated (IUU) fishing continue around the world. IUU fishing has been described by the FAO (2014) as a “major global threat” to the sustainable management of fisheries, maintenance of productive and healthy ecosystems, and the socio-economic conditions of small-scale and artisanal fishing communities. Higher levels of IUU fishing are expected when fisheries are not managed effectively or when management regimes are poorly enforced (Gallic and Cox 2006).

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 (Gibson et al. 2005; Guidetti et al. 2008).

Poaching of fisheries resources has been a problem in Chile (Gonzales et al. 2006) where overexploitation of benthic resources in the mid-1970s led to the adoption of a TURF co-management system in the early 1990s (Gelcich et al. 2008). Under the Chilean TURF system user rights are given to artisanal fisher organisations for the exploitation of benthic (bottom-dwelling) resources in geographically defined management areas (Castilla 2010). Involvement in the TURF 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 all monitoring in their management area. 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 450 TURFs currently in active operation (SERNAPESCA 2014).

Despite the introduction of co-management systems, poaching and illegal capture remain significant problems in Chile. Illegal catch of loco, *Concholepas concholepas*, the most economically important shellfish in Chile (Castilla 1997), is estimated to be as high as 50% of total catch (Gonzales et al. 2006). When fishers monitor TURF areas to prevent poaching

and illegal catch, these areas have higher species' abundance, biomass and richness than areas which are not monitored (Gelcich 2012). In addition to higher productivity, TURF areas which are monitored are also likely to generate higher revenues for fishers (Davis et al. 2015)². In Chile, we could therefore expect fishers to monitor their TURF management areas. However, of the 450 active TURFs in Chile, roughly a third are not monitored by the responsible fisher organization (González Poblete et al. 2013).

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). Enforcement is a major cost of fisheries management: in OECD countries, US\$ 752 million was spent on fisheries enforcement in 1997 - roughly 12% of total government financial transfers associated with fisheries policy (Wallis and Flaaten 2001). Despite this expenditure, analysis of global marine management capacity by Rife et al. (2013) concluded that funding for enforcement is probably deficient in many cases. In Chile, enforcement costs have been found to be a major cost of TURF management (Gelcich et al. 2009). Effective enforcement may also be prevented by environmental factors. Monitoring of marine management areas can occur from

²A reviewer raised the possibility of lower revenues creating a disincentive for monitoring rather than vice versa. However, anecdotal evidence in the region suggests that TURF areas were chosen because they were (at least initially) productive fishing grounds worthy of monitoring; productivity declined only after monitoring stopped.

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 be institutional or governance issues that prevent enforcement or reduce its effectiveness. Previous work on the management and monitoring of marine conservation projects concluded that government instability and insufficient government support may hamper enforcement efforts by fishers (Cudney-Bueno and Basurto 2009; Lundquist and Granek 2005). 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.

The objective of our study was to understand what factors have the greatest impacts on fishers' decisions when choosing not to monitor their co-management areas. To achieve this objective we interviewed fishers who were part of the co-management TURF program in the central marine region of Chile using a best-worst scaling (BWS) survey. A complementary analysis would be to investigate the effectiveness of government processes that support enforcement activities, but in this analysis we have focused on understanding fishers' perspectives. 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.

In the next section we briefly describe the study area; this is followed by a description of the BWS methodology and survey. In the fourth section, we present the results of our survey and

discrete choice models. A final section discusses the results and the implications of our work for future research and for policy making about marine co-management areas.

Study area

The study area for this analysis is the central marine region of Chile (Figure 1). Within this region there are over 30 fisher organisations, although not all organisations 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 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.

[Approximate location Figure 1]

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 2) (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).

[Approximate location Figure 2]

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 (representing 48% of the active artisanal fisher organisations with TURFs in that region). Surveys were conducted with members of the organisation's management group (the president, secretary and/or treasurer) and with other non-management members. The surveys were administered based on the availability of fishers' involved in the organisation, with five or six fishers in each organisation completing the survey.

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 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.

[Approximate location Table 1]

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:

$$U = \sum_i^7 \beta_i P_i + \sum_i^7 \sum_s \beta_{is} P_i X_s + \varepsilon, \quad i = 1, \dots, 7 \quad (1)$$

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:

$$\frac{\delta \pi_i}{\delta x_s} = \bar{\pi}_i \left(\beta_{is} - \sum_j^7 \bar{\pi}_j \beta_{js} \right), \quad i, j = 1, \dots, 7 \quad (2)$$

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, 9 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 2(a)). 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 9 respondents (17%) 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*. In a number of cases there was a discrepancy between the number of TURFs that respondents stated that their organisation had and the number of TURFs that the organisation had according to 2012 data from the Chilean fisheries department (SERNAPESCA 2015). Respondents to our survey identified only the 10 active TURFs in the study area. However, according to fisheries data, the fisher organisations surveyed in the study area collectively have 17 TURFs. This indicates that instead of 83% of the TURFs in the study area being enforced (Table 2(a)), only just over half of the TURFs in the study area are being enforced.

[Approximate location Table 2]

Respondents were asked how much of their organisation's income comes from fishing versus other activities. Data from this question is presented in Table 2(a), however, it was not always possible to determine whether fishers reported how much of their own income was from fishing – compared to their organisations' income, or whether they accounted for seasonal variability in income. Importantly, research has shown that income sources vary at different scales (individual vs. organizational; Gelcich et al. 2009) and through the different seasons (i.e. in summer tourism becomes important whereas in winter fishing is critical). The data suggests that organisations receive relatively low income from fishing, and supplement this income with income from other marine-related sources, for example tourism (including boat tours of the organisation's management area) or renting beach-side parking spaces, beach facilities, etc. Despite organisations gaining relatively low income from fishing, the importance of fishing to individual members of the organisation is large, which provides an incentive for organisations to monitor.

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 give more consistent 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 in our survey data 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 ($p < 0.05$). Although the combination of both best and worst choices can improve efficiency in identifying preferences, this is only the case if they are based on the same preference function. Given the results of our log likelihood testing, we could not combine best and worst choices and therefore used the best choices only. Further investigation into the causes of unstable preferences across best and worst decisions is warranted (Flynn and Marley 2014).

The next step in our analysis was to examine count data for each organisation's best choices (Table 3). 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.

[Approximate location Table 3]

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*. This group 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 model³ on the best choice data for each of the three groups (Table 4). 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 4, 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.

[Approximate location Table 4]

³ 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.

When estimating conditional logit models on the best choice data for each of the three groups (Table 4), ‘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 (terms reported in Table 2(b)), we found that several of these were significant ($p < 0.05$). A final conditional logit model estimated using these interactions is reported in Table 5. Note that the socio-economic variables are defined so that the baseline (upper panel) represents the majority of the sample (Table 2) and as a result these have similar preference rankings to the aggregated best choice conditional logit model (Table 4).

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 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 4, 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. Theoretically, combining the socio-economic interaction terms into the group models would have allowed for a finer disaggregation of heterogeneity into factors that are individual- and group-specific. However, it was not possible to combine the socio-economic interaction terms into the group models as the subsets of data were too small.

[Approximate location of Table 5]

What would help monitoring?

The BWS analysis identified reasons for not monitoring. In the survey 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 3). This factor was most frequently selected by respondents from Groups 1 and 3 (Table 6).

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.

When asked what would help their organisation monitor their TURF areas, only 12% of fishers identified that 'providing information about the benefits of monitoring' would help. Either fishers are mistrustful of outsiders' advice on this issue, or are aware of the benefits that monitoring can have, but consider that other constraints to monitoring capacity are more important. Respondents did not think that having more fishers in their organisation would help them monitor.

In the BWS questions, the option that received the highest score was ‘government punishments for poachers are not effective’ (Table 4). In these BWS questions, we asked respondents for their *personal* motivation for not monitoring. Interestingly, when we asked respondents what would help their organisation monitor TURF areas (Figure 3/Table 6), ‘stricter sanctions’ or ‘help detaining poachers’ were not identified by fishers as important factors. While this may appear inconsistent with the BWS results, the response reflects fishers’ views about what would help *their organisation* to monitor (rather than personal motivation). It may be the case that fishers deem the existing sanctions to be sufficient, and that therefore stricter sanctions would not help their organisation to monitor TURF areas. Rather, the problem appears to be related to the enforcement of those sanctions – which is a typical issue in many developing country contexts where the political will to enforce may be lacking, or budgets for protecting natural resources may be limited (Robinson et al. 2010).

[Approximate location of Figure 3]

[Approximate location of Table 6]

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. Lack of sufficient legal deterrent for poaching and/or effective apprehension and penalisation of poachers decreases the expected costs of illegal, unreported, and unregulated (IUU) fishing, which may lead to increased IUU activities (Gallic and Cox 2006). 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. This implies that if governments were to increase enforcement activities, then fishers would also be more likely to engage in enforcement – leading to a positive enforcement-feedback loop.

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).

Government support for enforcement activities is considered necessary to legitimise user rights in co-management systems (Kalikoski et al. 2002; McClanahan et al. 1997; Pomeroy and Berkes 1997; Ruddle 1998). In her eight principles for managing a commons, Ostrom (2005) highlights the need for the rule-making rights of community members to be respected by outside authorities. Where government institutions are weak, community-based enforcement may still be possible in management systems where traditional authority remains strong, which is the case in some fisheries in Palau or in American Samoa (Ruddle 1998). However, the success of community-based enforcement can also be influenced by strategic behaviour from enforcement agents. For example, in community-based forestry management in Tanzania, forest patrollers receive a share of fine revenue and therefore have an economic incentive to encourage some level of illegal behaviour (Robinson and Lokina 2012). We envision that research which links enforcement and corruption is an interesting area which should be explored further in TURF contexts.

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 (O'Ryan 2014). In this analysis, 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 (O'Ryan 2014). 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 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. Although direct subsidies for fishing may encourage unsustainable extraction (OECD 2006; Sumaila et al. 2010), in this analysis we are discussing subsidies for enforcement which are considered by some to be beneficial and even necessary (Milazzo 1998; OECD 2006; Sumaila and Delagran 2010; Sumaila et al. 2010).

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 willingness.

Therefore, even if organisation’s financial resources were to increase, perhaps through government subsidies, they still might choose not to monitor. Our results are consistent with the finding by Rife et al. (2013) that lack of enforcement is not caused by lack of funding.

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; Presidents of *El Quisco*, *Las Cruces Hombres*, *Navidad*, *Maitencillo* and *Algarrobo*, which have more than one TURF management area, reported that their organisations generally do not monitor the area which is furthest away. 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 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 1. Mean values for socio-economic interaction terms used in estimation of the conditional logit model reported in Table 5.

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

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Figure captions

Figure 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*.

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 <i>caleta</i>	✓

Figure 2. Example of a best-worst scaling question from the current study.

Note: This is an English translation of the Spanish original.

Figure 3. 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

Tables

Table 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 <i>caleta</i>

Table 2. (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 5.

(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

1 Table 3. 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	<i>Algarrobo</i>	20	29	17	0	23	9	3
	<i>El Quisco</i>	19	17	21	14	21	7	0
	<i>Horcon</i>	11	20	9	6	11	23	20
	<i>Navidad</i>	23	11	11	17	17	11	9
	<i>Las Cruces Hombres</i>	14	23	9	26	9	17	3
Group 1 mean		18	20	13	13	16	13	7
Group 2^a	<i>Los Molles</i>	31	9	20	17	11	11	0
	<i>Maitencillo</i>	37	17	17	9	6	14	0
	<i>Pichicuy</i>	29	9	17	29	3	11	3
	<i>Ventanas</i>	43	17	5	17	5	14	0
Group 2 mean		35	13	15	18	6	13	1
Group 3^a	<i>Las Cruces Mujeres</i>	14	31	29	6	17	3	0
Total		24	18	15	14	12	12	4

2 ^aGroup 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 3 of *Las Cruces Mujeres*.

Table 4. 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
<i>Algarrobo</i> 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	

^aReference case.

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

^bGroup 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*.

^cThese 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.

14 Table 5. 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	

15

16 **Table 6. 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

17 ^aGroup 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
18 3 of *Las Cruces Mujeres*.