Heterogeneous management and conservation perceptions within the gooseneck barnacle co-management system in Asturias (N. Spain)

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ABSTRACT

Stakeholders’ perceptions can influence the success of a fishery. It is important to take these perceptions into account when evaluating the development of a management system and its conservation policies. Structured questionnaires were used to determine fishers’ management and conservation perceptions of the Asturian gooseneck barnacle co-management system. Perceptions were analyzed for the entire fishery and for different socioeconomic factors, these were: location, age, years in the management system, way of access, alternative income sources and income. Fishers’ perceptions varied widely among socioeconomic factors. In fact, a trade-off between management and conservation perceptions was observed for the different categories within each socioeconomic factor, particularly for the years in the management system, location and income factors. Despite the heterogeneity in perceptions, the co-management system has successfully generated a strong conservation ethic in its resource users. Furthermore, as a group, gooseneck barnacle fishers hold positive perceptions on the performance of the management system. When generating management policies, fishers’ managers must take the heterogeneity of resource users present in the fishery into account. The gooseneck barnacle co-management system demonstrates that even within the same fishery there can be multiple paths to sustainability.

1. Introduction

The collapse of numerous fishing stocks in the past decades [1,2] has placed the topic of sustainable fisheries management as a global challenge. Despite the topic being in the forefront of policy discussions, many fisheries continue to decline [3]. The consequences of this decline are far-reaching and heterogeneous, ranging from ecosystem alterations [4] to the generation of poverty traps in fishing communities [5]. Therefore, it is crucial for global fisheries to achieve sustainability through management regimes adapted to their social, economic and ecologic objectives [6,7].

Co-management, the sharing of rights and responsibilities in the management of a resource between the government and stakeholders [8], is often proposed as a strategy to achieve sustainable fisheries [9,10]. In several case studies co-management systems have been know to enhance fishing stocks [11]. In other circumstances the implementation of co-management has stimulated the creation of social capital [12] and empowered the resource users [13]. However, researchers have warned that co-management is not a one-size-fits-all solution and might not adapt to the needs of all the stakeholders [14,15].

Fishers’ perceptions help tailor co-management arrangements. Perceptions towards management regimes and conservation policies can influence their success [16,17]. Perception research has emerged as a way to inform sustainable management strategies and to determine suitable conservation strategies [18]. Furthermore, researchers believe that the presence of conservation-oriented perceptions in socio-ecological systems signal improvements in management policies, which could lead towards better stewardship [19]. If fishers’ perceptions remain the same despite the implementation of new management policies they may revert to old practices that can hamper long-term conservation efforts [12]. Thus, to assess the long-term sustainability of a system it is important to analyze fishers’ perceptions on management strategies and ecosystem conservation.

The gooseneck barnacle fishery in Asturias has been co-managed since its inception in 1992 [15]. Recent studies observed high social capital and empowerment [20], sustainable trends in catch per unit effort and adaptive capacity in the fishery [21]. Despite these encouraging findings, fishers’ perceptions on the performance of the co-management system and on the conservation of the resource have not been assessed. Here we used perception research [18] to determine...
fishers’ level of agreement to two sets of statements. The first considers the social, economic and ecologic performance of the co-management system and therefore the fishery. The second evaluates fishers’ perceptions on the conservation of the resource. Finally, the relationship between conservation and management perceptions among distinct groups of users was analyzed.

2. Methods

2.1. The fishery

The gooseneck barnacle is a pedunculate cirripede that inhabits rocky shores between France and Senegal [22]. It is mainly harvested in the Iberian Peninsula where it can reach high market prices [23]. Fishers travel to the harvesting site either on foot or on a small-sized fishing vessel. Once they reach the harvesting site, gooseneck barnacles are removed from a rocky shore or island using a small metal shovel known as bistronza. Since the resource is generally located in wave-beaten areas [22] with harsh weather conditions [24] its harvest can be dangerous.

Before the 1990s, the gooseneck barnacle was not actively harvested in Asturias [20]. However, after the implementation of a pilot co-management system in 1992 the resource began to be commercialized in the area. Currently, the gooseneck barnacle co-management system is located between the Eo estuary (7.035831 W, 43.529291 N) and Cape Peñas (5.770935 W, 43.689880 N; Fig. 1). The system is divided into 7 management regions. From west to east the regions are: Tapia-Figueras, Viñavélez, Ortiguera, Puerto Vega, Luarca, Cudillero-Oviñana and Cabo Peñas. The local government agency Dirección General de Pesca Marítima del Principado de Asturias (DGPM) works with the fishers, through the associations, to generate management policies.

In the 2013–2014 fishing season, the system comprised 189 fishers with heterogeneous backgrounds [20]. Thus, data using 6 socioeconomic factors – location, age, years in the management system, way of access, alternative income sources and income- was analyzed. The location factor takes into account the seven possible regions where the fishers harvest the resource. Three different age groups – 20–35 years, 36–50 years and more than 50 years– and 4 categories for years in the management system - < 5, 5–10, 10–15 and > 15 years- were considered. Way of access refers to the way fishers travel to the fishing site –on foot, fishing vessel or both-. Alternative income sources can either be work on land or diversification to other fisheries. The income factor is divided into 3 classes - < 12,000, 12,000 – 18,000 and > 18,000 euros year−1 -. For a summary of the percentage of respondents per management region, age group, years in the management system, way of access, alternative income sources and income see Table 1.

2.2. Fishers’ perceptions

To quantify fishers’ perceptions on the performance of the management system and their current conservation perceptions open-ended interviews with different stakeholder groups and key informants in the 7 management regions were carried out. Based on this information a questionnaire was generated using closed Likert statements with anchor points strongly disagree and strongly agree. The questionnaires contained 8 statements regarding fishers’ perception on the performance of the co-management system and 11 statements on fishers’ perceptions on the conservation of the resource. A total of 76 questionnaires were administrated.

To test for different perceptions among socioeconomic groups a proportional odds logistic multiple regression was performed using the MASS [25] and RMS [26] packages in R. The proportional odds model can be written as

\[
\log \left( \frac{P_i}{1-P_i} \right) = \alpha + \beta X
\]

Where \( P_i \) is the probability of a fishers’ perception \( i \) being in rank category \( j \) or lower, \( \alpha \) is the intercept which determines the cut-off point between rank categories of \( j \) and \( \beta \) is the slope for all explanatory variables \( X \). Thus, intercepts depend on \( j \) but slopes are all equal. Multicollinearity among factors was assessed using Kendall’s tau. In the case of correlated variables, only the most representative factor was maintained in the model. The fit of the regression models was assessed using the estimated generalized \( R^2 \) [27]. To avoid over fitting the interactions among socioeconomic factors were not assessed [28]. Therefore, it was not possible to assess more complex models, which

![Fig. 1. Map of the Asturian coast showing the 7 management regions: Tapia-Figueras, Viñavélez, Ortiguera, Puerto Vega, Luarca, Cudillero-Oviñana and Cabo Peñas. The circles represent percentage of response per region. Figure adapted from Rivera et al. (2016) [20].](image-url)

Table 1

<table>
<thead>
<tr>
<th>Percentage per plan</th>
<th>Tapia-Figueras</th>
<th>Viñavélez</th>
<th>Ortiguera</th>
<th>Puerto Vega</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 12,000</td>
<td>37.50%</td>
<td>45.45%</td>
<td>23.08%</td>
<td>22.22%</td>
</tr>
<tr>
<td>12,000</td>
<td>51.28%</td>
<td>15.32%</td>
<td>45.24%</td>
<td></td>
</tr>
<tr>
<td>&gt; 12,000</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>20 to 35</th>
<th>35 to 50</th>
<th>&gt; 50</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 35</td>
<td>49.30%</td>
<td>15.49%</td>
<td>29.58%</td>
<td>5.63%</td>
</tr>
<tr>
<td>35 to 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&gt; 50</td>
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<table>
<thead>
<tr>
<th>Years in management system</th>
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<th>5–10</th>
<th>&gt; 15</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>19.72%</td>
<td>19.72%</td>
<td>32.39%</td>
<td>15.49%</td>
</tr>
<tr>
<td>5–10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 15</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Way of access</th>
<th>Fishing vessel</th>
<th>On foot</th>
<th>Both</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishing vessel</td>
<td>29.58%</td>
<td>21.13%</td>
<td>39.44%</td>
<td>9.86%</td>
</tr>
<tr>
<td>On foot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternative income sources</th>
<th>Fishing</th>
<th>Land</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishing</td>
<td>75.44%</td>
<td>15.79%</td>
<td>0.09%</td>
</tr>
<tr>
<td>Land</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>&lt; 12,000</th>
<th>12,000–18,000</th>
<th>&gt; 18,000</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 12,000</td>
<td>29.58%</td>
<td>38.03%</td>
<td>8.45%</td>
<td>23.94%</td>
</tr>
<tr>
<td>12,000–18,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 18,000</td>
<td></td>
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</table>
could account for part of the variability in perceptions present in the co-management system. Additionally, these differences were further corroborated using a Kruskal-Wallis one-way analysis of variance and Dunn’s test for post-hoc comparisons. Homogeneity of variances was assessed using Levene's test.

To understand what prompts the differences in perceptions the percentage of agreement to each statement (i.e. percentage of agree and strongly agree responses) was calculated. Some questions were reverse coded so all values of 4 or 5 (agree and strongly agree, respectively) indicate pro-conservation perceptions and high perceived performance of the management system. Additionally, the mean response and standard error for each group found within the six different socioeconomic factors: location (region), age group, years in the management system, way of access, alternative income sources and income was calculated.

3.2. Conservation of the resource

In general, fishers displayed elevated conservation perceptions. Almost 65% of the users are against the overexploitation of the resource. In fact, 57.58% are willing to change their harvesting habits in order to avoid overexploitation. Additionally, 89% of the interviewed fishers understand that some barnacles must remain on the fishing site once the season is over (Table 2). These perceptions highlight the fishers’ concern for the long-term sustainability of the resource. Despite the fact that the majority of the respondents tend to harvest their full daily allowable catch (56.34%), they make sure to select barnacles of high commercial quality (i.e. adults above commercial size) for their harvest. Furthermore, the respondents agree with the conservation methods employed in the management system such as the establishment of bans (80.28%; Table 2).

Most fishers place market demand above the commercial quality or size of the resource (77.78%). They also believe fishing sites should be protected once they have obtained the maximum economic benefit (85.71%), suggesting that revenue could be more important than conservation goals. Nevertheless, 70.42% of fishers consider that maintaining the barnacle population is more important than immediate economic gains (Table 2). Despite the positive perceptions of the respondents they do not believe their fellow fishers share in their concern, only 18% agree that other members of the management system are concerned with the protection of the resource.

3.3. Heterogeneity in fishers’ perceptions on the performance of the system

There was a strong correlation among socioeconomic factors. Age was correlated with years in the management system and with alternative income sources (Fig. S1). Also, way of access was correlated with alternative income sources and location (Fig. S1). Thus, age and way of access were removed from the proportional odds logistic regression.

According to the proportional odds multiple logistic regression for perceptions on the performance of the management system, there were significant differences among categories in the years in the management system and location factors ($R^2$: 0.17, $p < 0.0001$). The highest perceptions were held by the western most regions, fishers with over 15 years in the management system, fishers who have alternative incomes from sources on land and fishers with yearly earnings under 18,000 euros (Fig. 2).

It was observed through the proportional odds model that fishers who have been in the system for over 15 years and fishers who have been in the system for less than 5 years have similar positive perceptions of the system. Nevertheless, when the variable is analyzed independently it appears that fishers who have spent the least time in the management system on average have higher perceptions. This is also observable for the age factor (Table 3).

Table 2
Percentage of agreement with statements on fishers’ perception of the performance of the management system and on the conservation of the resource. To ensure the validity of the responses we used reverse wording in similar questions. Nevertheless, all responses are presented in positive voice. Statements have been summarized for clarity. For further details on fishers level of agreement per socioeconomic factor see Tables 1 and 2 in Supplementary Material.

<table>
<thead>
<tr>
<th>Performance of the management system</th>
<th>Level of agreement [%]</th>
<th>Conservation attitudes</th>
<th>Level of agreement [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-management is necessary for success</td>
<td>72.46</td>
<td>Fishing sites should not be overexploited</td>
<td>64.79</td>
</tr>
<tr>
<td>Pride in the co-management system</td>
<td>50.72</td>
<td>Change harvesting to prevent overexploitation</td>
<td>57.58</td>
</tr>
<tr>
<td>Contribution of all members</td>
<td>42.86</td>
<td>Fishing sites should not be left empty at the end of the season</td>
<td>89.39</td>
</tr>
<tr>
<td>Co-management system works better here</td>
<td>20.59</td>
<td>Protect high quality fishing sites</td>
<td>83.10</td>
</tr>
<tr>
<td>Resources overexploited before co-management</td>
<td>22.06</td>
<td>Do not harvest full total allowable catch</td>
<td>43.66</td>
</tr>
<tr>
<td>Co-management increased quality</td>
<td>44.29</td>
<td>Select barnacles</td>
<td>80.28</td>
</tr>
<tr>
<td>Co-management increased stock</td>
<td>36.23</td>
<td>Approve bans</td>
<td>80.28</td>
</tr>
<tr>
<td>Economic success</td>
<td>56.06</td>
<td>Resource quality above market demand</td>
<td>22.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protect sites after obtaining maximum economic gain</td>
<td>85.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protect sites before obtaining maximum economic gain</td>
<td>70.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other fishers also protect the resource</td>
<td>18.18</td>
</tr>
</tbody>
</table>
The Cabo Peñas and Luarca regions both hold the lowest perceptions of the management system mostly because they believe their particular TURFs are not up to par with the other regions (Table S1). Furthermore, the westernmost regions show greater concern in protecting fishing sites and preventing their overexploitation (Table S1).

Fishers who have alternative income sources on land have a higher perception of the management system. Nevertheless, no statistical significant differences were observed in the proportional odds model or through a Kruskal Wallis analysis (Fig. 2 and Table 3). However, the way of access factor, which was correlated with the alternative incomes factor, displayed significant differences in the Kruskal-Wallis analysis. Fishers in the on foot category had the highest perceptions on the performance of the management system, followed by those both on foot and in fishing vessels and finally those who reach fishing sites exclusively through fishing vessels (Table 3). These differences are mainly due to the fact that fishers in the on foot category and who diversify on land are more likely to perceive that the co-management system is essential for the success of the fishery and that all the members contribute to its functioning (Table S1).

Fishers' with the highest income (> 18,000 euros per year) had low
perceptions on the performance of the management system (Fig. 2 and Table 3). These differences are mostly caused because these fishers are not proud of the co-management system in their TURF and because they do not believe all members work toward the benefit of the system. Furthermore, fishers in this category do not perceive improvements in the amount or commercial quality of the gooseneck barnacles since the establishment of the system (Table S1).

3.4. Heterogeneity in fishers’ perceptions conservation perceptions

Significant differences were observed for income, location and years in the management system (Proportional odds multiple logistic regression $R^2$: 0.07, p: < 0.0001). On the contrary to the perceptions of the management system, fishers involved in the co-management system between 5–10 and 11–15 years and fishers with the highest incomes had the highest perceptions on the conservation of the resource (Fig. 2). These differences were also observed in years in the management system and income using a Kruskal-Wallis test ($\chi^2$: 10.37, d.f.: 3, p: 0.02 an $\chi^2$: 6.44, d.f.: 2, p: 0.04, respectively). However, no significant differences in conservation perceptions were observed for location using a Kruskal-Wallis test ($\chi^2$: 3.80, d.f.: 7, p: 0.7).

On average, the conservation perceptions of fishers who have been a part of the co-management system for the least amount of time (less than 5 years) were lower than those who have been part of the system for a longer time-period (Table 3). This was also observed in the age factor where the eldest fishers had higher conservation perceptions. These differences can be due to these groups willingness to leave some high commercial quality barnacles on the fishing site for the years to come (Table S2). Additionally, the fishers who have been in the management system for an intermediate amount of time have a high approval rate of the use of bans and catch restrictions to protect the resource (Table S2).

According to both statistical analyses employed, significant differences in conservation perceptions where observed among income categories, where the higher incomes displayed the highest conservation perceptions (Table 3). These categories strongly believe fishing sites should not be overexploited. Furthermore, fishers with higher incomes believe economic benefits should not be placed above the sustainability of the resource (Table S2).

No significant differences were observed for the alternative income sources factor in either the proportional odds logistic regression or the Kruskal-Wallis analysis. Nevertheless, the Kruskal-Wallis test displayed significant differences in the way of access factor, which was correlated with the alternative income sources factor. Respondents in the fishing vessel category had a higher regard for the conservation of the resource (Table 3). Fishers in this category were inclined to change their harvesting strategies to avoid overexploitation. Additionally, they perceived that other users were also involved in the protection of the resource. Although all groups were selective in their harvest, only the fishing vessel group harvested below their daily allowable catch (Table S2).

4. Discussion

Our results show that there is a high level of heterogeneity in perceptions depending on fishers’ socioeconomic characteristics. Additionally, socioeconomic categories with higher perceptions of the fishery have lower conservation perceptions and vice versa, suggesting a possible trade-off between management and conservation perceptions. Nevertheless, as a group, gooseneck barnacle fishers hold the management system in high regard and maintain conservation-oriented perceptions. However, even in a co-management system were resource users display high perceptions of the management system and concern for the conservation of the resource, social, economic and ecologic sustainability will not be equal for all users.

4.1. Performance of the management system

Co-management systems have been promoted as a solution for managing fisheries [32]. Many researchers believe collaborative systems have the potential to meet ecologic, economic and social goals [9,10,33,34]. Previous research on the gooseneck barnacle fishery in Asturias revealed increasing trends in catch per unit effort and stable market prices despite an economic crisis [21]. Additionally, open-ended interviews with the fishers suggested that co-management system had generated social capital and empowered the resource users [20]. Our results agree with these previous findings, where the majority of the fishers perceive a high performance of the co-management system to the point where it is a source of pride for them. They view it as an economic success and as an essential factor in the sustainability of the fishery (Table 2).

Nonetheless, several statements on the ecological performance of the co-management system did not receive high levels of agreement. Fishers do not perceive an increase in biomass or quality of the resource since the establishment of the co-management system (Table 2).

Considering the establishment of the co-management system was not driven by a crisis and that gooseneck barnacles were not actively harvested in the area before its implementation [15,20], it is likely that the stock in the area was at carrying capacity when the co-management system (and the harvesting) began. Thus, despite the sustainable management of the resource, the current biomass is bound to be lower than carrying capacity.

4.2. Conservation oriented ethic

As a group the gooseneck barnacle fishers in Asturias display high
conservation-ethics (Tables 2 and 3). When asked directly 65% are against the overexploitation of the resource however when questioned indirectly (i.e. some barnacles must remain in the fishing sites at the end of the season) the number rises to 89%. This suggests that fishers might not be aware of their behavior, high conservation ethics, since no one has interpreted it for them [35]. These perceptions might have arisen through their engagement in the co-management system [16] and their continuous collaboration with scientists [20]. This phenomenon also occurs with their perceptions of other fishers in the system. Only 18% of fishers agreed that other members of the co-management system are conservation-oriented (Table 2). However, the questionnaires demonstrate that the majority of the fishers hold strong conservation perceptions. Researchers have observed that trust among resource users is an important aspect for co-management systems to be effective [36]. Therefore, leaders in the community and government officials in the gooseneck barnacle fishery should work in reinforcing these values. Perhaps out-reach programs where the current results are presented to the community can help promote trust among resource users. Additionally, researchers must take these inconsistencies into account when generating questionnaires by ensuring the wording is comprehensible, re-stating questions in a different manner throughout the survey and adapting the statements to the idioms used by the respondents.

Over 70% of the respondents believe preserving the species is more important than short-term economic gains (Table 2). This is further exemplified in their perceptions towards the conservation strategies in the management system. Importantly, fishers agree with the policies established through the co-management system, such as bans, even if it means less revenue in the short-term. The co-management system in Asturias has enabled fishers to move beyond a Tragedy of the commons situation [37], where instead of aspiring for short-term economic gains they strive to achieve the long-term sustainability of the fishery.

4.3. Intergenerational trade-offs

The value fishers’ concede to the resource and the environment appears to increase through their engagement in the co-management system. As reports by Gelich et al. [16] for the Chilean co-management system, fishers in the eldest age groups and those who have been involved with the management system for a longer time period, have greater conservation concerns than the younger members of the management system. This might be driven by the learning-by-doing approach present in the gooseneck barnacle fishery in Asturias [21], which allows fishers to be more aware of their surroundings and the consequences of their actions. If this hypothesis is true, it is likely that the conservation perceptions of fishers new to the system will increase as they continue their engagement with the co-management system.

4.4. Heterogeneity based on economic diversification strategies

Fishers with higher incomes held the highest conservation perceptions (Fig. 2). This was due to the fact that they were willing to sacrifice economic gain for the long-term sustainability of the resource (Table S2). Perhaps due to their high incomes they can afford a reduction in their gooseneck barnacle harvest whereas fishers with lower incomes cannot. This suggests that gooseneck barnacles might not be the only source of income for the $> 18,000 euro year$−1 group.

Gooseneck barnacle fishers in Asturias are generally divided into 2 groups: professional fishers, who work on a fishing vessel and autonomous fishers, who mostly work on foot and are not part of a fishing vessel [20]. These differences are likely reflected in the way of access and alternative income sources factors, which were correlated (Fig. S1). Thus, we can assume that fishers who access by boat and diversify to other fisheries are part of an official fishing vessel (on boat) and those who access by foot and diversify to work on land are mostly autonomous with an individual fishing license. On average, fishers who work on land and those who access by foot had higher perceptions of the management system but lower conservation perceptions (Table 3). Fishers who work on fishing vessels dedicate themselves exclusively to fishing all year round [20]. Considering their livelihoods are intrinsically linked to the status of the fishing stock, it is not surprising that they place more value on the conservation of the resource than other users (Table 3). The community in a collaborative system can generate a sense of belonging and identity in the resource users [13]. However, the fishing vessel group harvests other species and only dedicates a few months to the gooseneck barnacle (usually October to December), hence their source of identity and attachment might not lie within the co-management community but with the artisanal fishing sector as a whole. Additionally, they are more invested in the resource being well preserved so they can obtain the most economic benefits (i.e. harvest of high commercial quality barnacles [38]) during their short harvest period. Autonomous fishers are generally exclusively devoted to the harvest of gooseneck barnacles during the fishing season and then supplement it with work on land or occasionally with other fisheries that can be done on foot, such as anemones, algae and sea urchins [20]. This group of fishers tends to invest more in collective activities (i.e. fishers’ association meetings and establishment of bans among others) where all members work toward the functioning of the management system (Table 2). This can generate social capital and improve the resilience of the system [39]. Even though they tend to display the lowest conservation perceptions, these are still positive (Table 2). Although the fishing vessel technique might be more economically and ecologically viable in the short-term the on foot fishers’ strategy could prove to be more sustainable in the long-term because they appear to be changing their social norms, making it less likely for them to revert to unsustainable practices [12].

5. Conclusion

Social and ecological heterogeneity is critical to inform natural resource management. Heterogeneity in fishers’ perceptions has been observed in the Asturian co-management system, mainly regarding a trade-off between performance and conservation perceptions in fishers with different incomes, years of engagement in the system and geographic location. Acknowledging this heterogeneity is critical to fine tune co-management practices regarding conservation of the resource, such as bans and daily allowable catch quotas. Despite heterogeneity among groups, fishers’ perceptions toward the gooseneck barnacle co-management system are generally positive regarding performance and conservation of the resource. Fisheries managers should consider the heterogeneity in resource users when generating management and conservation strategies. There is no single path to sustainable fisheries, management frameworks must adapt to the individual needs and socioeconomic backgrounds of the resource users. Perceptions research provides initial guidance in that direction.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2017.03.020.

References