Synergies and tradeoffs in how managers, scientists, and fishers value coral reef ecosystem services

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\textbf{A B S T R A C T}

Managing ecosystems in a changing environment faces the challenge of balancing diverse competing perspectives on which ecosystem services – nature’s benefits – to prioritize. Consequently, we measured and compared how different stakeholders (managers, scientists and fishers) prioritize specific coral reef ecosystem services. Managers’ priorities were more aligned with scientists’ priorities but all stakeholder groups agreed that fishery, education, and habitat were high priorities. However, stakeholder groups differed in the extent to which they prioritized certain services. Fishers tended to assign greater estimates to fishery and education, managers to culture, and scientists to coastal protection. Furthermore, using network analysis to map the interactions between stakeholders’ priorities, we found distinct synergies and trade-offs in how ecosystem services were prioritized, representing areas of agreement and conflict. In the fishers’ network, trade-offs emerged between two services, both of a higher priority, such as fishery and habitat. Conversely, in the scientists’ network, trade-offs emerged between services of a higher and lower priority, such as habitat and culture. The trade-offs and synergies that emerged in the managers’ network overlap with both fishers’ and scientists’ suggesting a potential brokering role that managers can play in balancing both priorities and conflicts. We suggest that measuring ecosystem service priorities can highlight key areas of agreement and conflict, both within and across stakeholder groups, to be addressed when communicating and prioritizing decisions.

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1. Introduction

Societies are composed of individuals and groups that, because of diverse and often competing values and interests, often struggle to reach consensus-based decisions (Costanza, 2000; Verweij et al., 2006; Allison and Hobbs, 2010). Decision-makers are presented with hard choices; represent the values of a few – perhaps a dominant group – or face the task of balancing diverse values and priorities. Conservation and natural resource managers strive to maintain functioning landscapes, resisting or reversing environmental change. The task of managing these landscapes is exacerbated by the challenge of balancing priorities (McShane et al., 2011). This is in part because conservation is prioritized where threats to biodiversity are greatest (Pressey et al., 2007); in areas that are often inhabited by the poor, or that have significant economic potential (Adams et al., 2004; Adams and Hutton, 2007). Although diverse stakeholders are often engaged in decision-making processes, competing priorities are hard to resolve. A failure to account for the diverse priorities encountered undermines the progress made. For example, presenting only the values of a dominant economic interest potentially marginalizes the most vulnerable sectors of society (Hicks et al., 2009), increasing inequality, and exacerbating environmental decline (Cinner et al., 2011). To be successful, natural resource management should integrate conservation priorities with the goals of local resource users. Therefore, natural resource scientists and practitioners need to engage in complex decision-making processes that can deal with multiple objectives and balance competing priorities (Tetlock, 1986; Berkes, 2007; Ban et al., 2013).

Ecosystem services refer to the benefits humans gain from nature (MA, 2005). As a concept, ecosystem services incorporate diverse perspectives, balance ecological and human objectives, and have direct application and transferability to policy (Costanza et al., 1997; Turner et al., 2010; Atkinson et al., 2012). Furthermore, in accounting for the full range of benefits delivered by nature, ecosystem services research takes a holistic systems perspective capable of accounting for multiple benefits, and their interactions, simultaneously. Although human demand underpins ecosystem service concepts (Vira and Adams, 2009), stakeholder’s preferences for ecosystem services are often overlooked in decision-making and most

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evaluations focus on obtaining objectively measurable, biophysical (e.g. Chan et al., 2006) or economic estimates (e.g. Costanza et al., 1997; Boyd and Banzhaf, 2007; Martin-Lopez et al., 2012). Preferences are important because they reflect people's priorities and, together with the interpretation of the actions of others, help determine behaviour (Kaplan, 1985; Costanza, 2000). Slow progress in incorporating preferences, and understanding behaviour, has limited our ability to manage human–environment systems (Fulton et al., 2011).

Ecosystem services that tend to occur together are referred to as bundles, whereas services that occur at the expense of others create trade-offs (Bennett et al., 2009; Raudsepp-Hearne et al., 2010; Martin-Lopez et al., 2012). These differences will be reflected in the way people value ecosystem services and, because resources are finite (e.g. limited time or money), the way they prioritize ecosystem services (Costanza, 2000). For example, fisherman may value the fish they can catch off a coral reef and prioritize fishery services, a scientist may value the knowledge they can gain from studying a coral reef and prioritize educational services, and a tourist may value the diverse and colourful assemblages they can look at whilst snorkelling on a coral reef and prioritize recreational services. When stakeholders are in agreement and assign similar priorities to multiple ecosystem services, we would expect to see synergies (a similar concept to bundles, but based on stakeholders' priorities) between pairs of ecosystem services. Conversely, when stakeholders are in conflict and assign different priorities to multiple ecosystem services, we would expect to see trade-offs between pairs of ecosystem services. Synergies and trade-offs occur in space and time, and within and across stakeholder groups, creating opportunities and conflicts for natural resource management. Identifying synergies and trade-offs in stakeholders' preferences for ecosystem services should enable decision-makers to target opportunities where priorities align, and navigate or compensate for conflicts where priorities are in opposition.

Tradeoffs arise because people's interests vary and so they value different aspects of the same system (Hicks et al., 2009). Attempts to identify ecosystem service trade-offs have tended to ignore the distribution of benefits between groups and individuals within societies, thus failing to identify who benefits from the flow of ecosystem services and who loses out (Daw et al., 2011), and only a few studies have considered stakeholder's preferences for ecosystem services (Martin-Lopez et al., 2012). In order to fill this gap, we set out to determine stakeholders' ecosystem service priorities and identify areas of conflict (i.e. trade-offs: where stakeholders priorities diverge) and areas of agreement (i.e. synergies: where stakeholders priorities align). To do this we examine the prioritization of coral reef ecosystem services within, and across, three stakeholder groups who are likely to view the system at different scales (scientists, managers, and fishers) in three western Indian Ocean countries. Coral reefs in this region provide vital food and livelihood security to some of the world’s lowest income and most vulnerable people (Allison et al., 2009). In addition, this region has experienced some of the worst effects of climate change on live coral and associated fish assemblages (Graham et al., 2008). Therefore, the need for effective management, and the juxtaposition of competing values, provides an ideal lens through which to ask: (1) Do fishers, managers, and scientists prioritize ecosystem services differently? (2) What ecosystem service synergies, and trade-offs, exist within fisher, manager and scientist stakeholder groups?

2. Methods

2.1. Sampling

We used a combination of focus groups and individual semi-structured questionnaires to interview fishers, managers, and scientists from three countries (Kenya, Tanzania, and Madagascar) in the western Indian Ocean (WIO) region about their preferences for the benefits they identified from coral reef ecosystems. For the fishers, we conducted two preliminary qualitative focus groups, and 21 subsequent focus groups in each community – 6 communities in Madagascar, 6 in Tanzania, and 9 in Kenya. We obtained information from local fisher organizations on the age, primary gear used and place of residence for all registered fishers. We used this information to randomly select fishers across the age, gear and geographic range of all involved in the coral reef fishery. After piloting the surveys in each country, we conducted 497 individual fisher interviews from the 21 fishing communities representing between 20% and 40% of the fishers from each community.

We obtained information from the Western Indian Ocean Marine Sciences Association (WIOMSA) – the regions professional organization for marine research and management – on registered managers and scientists in the region. We used non-probability sampling techniques including convenience and snowball sampling (Henry, 1990) to approach scientists and managers who were delegates at the 2009 Western Indian Ocean Marine Sciences Association's (WIOMSA) biannual conference in Reunion, France. Delegates were asked where they worked and whether they worked as a scientist or manager. Only delegates working in Kenya, Tanzania, or Madagascar were included in this study. After piloting, our surveys with managers and scientists, we conducted individual interviews with 17 scientists and 8 managers representing 25%, 19%, and 19% of the managers and scientists from Kenya, Tanzania, and Madagascar attending the symposium. Many more fishers were interviewed than managers; however, this reflects the much larger number of fishers than managers or scientists working in the region. The distinction between managers and scientists can be fairly fluid (i.e. managers conduct science and some scientists manage). Our survey had to ask respondents whether they identified as managers or scientists rather than being able to stratify our sampling, this resulted in a smaller sample of managers than scientists and should be born in mind when interpreting the results.

2.2. Ecosystem service definitions

2.2.1. Expert elicitation

We used the Millennium Ecosystem Assessment (MA) classification system as a starting point to frame the key benefits stakeholders are likely to associate with the coral reef ecosystem. For each country we conducted individual “expert” interviews with managers and scientists, to establish which of the MA benefits were most relevant to our study. These interviews discussed the relevance of the services, how the services were experienced, wording to describe the services and suitable photographs to convey the services. We then conducted a focus group, bringing together seven expert managers and scientists, who had experience working in Kenya, Tanzania and Madagascar. The purpose of this was to ensure the services, wording, and photographs to be used in the three countries were as consistent as possible.

2.2.2. Stakeholder elicitation

We conducted two initial fisher focus groups in Kenya with all gears in the fishery represented; these contained six and seven fishers. The fishers were first asked to discuss the benefits they associated with the coral reef ecosystem. We then introduced the benefits elicited from the expert interviews, and the selected photographs, and established whether there was agreement between fishers and experts on the services identified and whether the photographs were appropriate. Once we had a more definite
Table 1
Ecosystem services, photographs, and descriptions used in the valuation exercises.

<table>
<thead>
<tr>
<th>Service</th>
<th>Picture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishery</td>
<td>![Fishery Picture]</td>
<td>This picture shows a fisher coming back from fishing with his catch which he may sell or use to feed his family. This illustrates the benefit we gain from the fish we catch and sell</td>
</tr>
<tr>
<td>Habitat</td>
<td>![Habitat Picture]</td>
<td>This picture shows a healthy coral reef with many fish and places for the small fish to hide. This illustrates the benefits we gain from having a healthy coral reef habitat</td>
</tr>
<tr>
<td>Coastal protection</td>
<td>![Coastal Protection Picture]</td>
<td>This picture shows a rough sea and some trees washed away by the waves. The coral reef provides a barrier against the force of these waves. This illustrates the benefit we gain from having the reef buffer the force of the waves</td>
</tr>
<tr>
<td>Sanitation</td>
<td>![Sanitation Picture]</td>
<td>This picture shows women gutting and washing their fish. The sea takes away a lot of waste for us. This illustrates the benefit we gain from using the sea to wash and clean, knowing that when we come back tomorrow the waters will be clear again</td>
</tr>
<tr>
<td>Tourism</td>
<td>![Tourism Picture]</td>
<td>This picture shows some tourists swimming and snorkelling, enjoying the marine environment. This illustrates the benefits we gain from being able to relax and enjoy the marine environment or having others come and enjoy it in this way</td>
</tr>
<tr>
<td>Education</td>
<td>![Education Picture]</td>
<td>This picture shows some children learning about the sea. There is a lot of knowledge in the coral reef environment that school children come and learn about or scientists come and study. This picture illustrates the benefits we gain from the knowledge we have from the time we and our elders have spent in the marine environment</td>
</tr>
<tr>
<td>Cultural</td>
<td>![Cultural Picture]</td>
<td>This picture shows a spiritual or cultural place related to the sea. Some people follow special traditions or norms involving the marine environment. This picture illustrates the benefits we gain from having cultural connections to the marine environment</td>
</tr>
</tbody>
</table>

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group of benefits associated with the coral reef ecosystem we conducted larger focus groups in each of the communities surveyed (21). These focus groups were to ensure the benefits we had identified through fisher and expert consultations were appropriate and comprehensive, and that the wording and photographs used captured locally appropriate meanings. The final selection included eight ecosystem services, with consistent definitions, but some different photographs were used across countries. The final eight ecosystem services included one provisioning service (identified as fishery), two regulating services (identified as coastal protection and sanitation), four cultural services (identified as culture, education, recreation, and bequest) (Krutilla, 1967; MA, 2005; Chan et al., 2011) and one supporting service (identified as habitat) (Kumar, 2010) (Table 1). Ecosystem service assessments often omit supporting services, partly to avoid double counting, or subsume them in regulating services (Kumar, 2010). However, we do not attempt to aggregate value across services, and therefore double counting should not pose a problem. Furthermore, we felt it important to include supporting services in our perception based assessment because the implications of whether people prioritize provisioning or supporting services affect management decisions.

2.3. Ecosystem service prioritization

We used individual semi-structured interviews to elicit stakeholder priorities for the eight identified ecosystem services. The interviews were piloted in each country to test the suitability of questions, structure, timing, and to ensure research assistants were comfortable in each setting. Respondents were provided with a photograph and brief description of each ecosystem service (developed in the focus groups; Table 1). The services were discussed with the respondents to establish a common understanding. We explained that we were interested in the respondents “personal preferences”. We then asked the respondents to (1) rank the services, according to how important the services were (1–8); and (2) to rate the services, by distributing counters according to “where they would most like to see improvements” (Montgomery, 2002; Hicks et al., 2009; Larson, 2009). Managers and scientists were provided with 100 points to distribute across the services. We had to adjust the exercise for fishers, who were provided with 20 points in four instalments to distribute across the services. The rating and ranking responses of the managers, scientists, and fishers were normalized to be on a common scale of 0–1. Data were tested for normality with Q–Q plots of the residuals and homogeneity of variances using Levene’s test prior to analysis (Field, 2009). We used Pearson’s correlation analysis to test for consistency between the manager, scientist, and fishers rating and ranking scores. The relative importance of services obtained by rating and ranking was consistent across stakeholder group (correlation r = 0.55, P = 0.001) so the rating responses were used for the remainder of the analyses.

2.4. Differences in ecosystem service prioritization, across stakeholder groups

2.4.1. Analysis

Broad variation in priority estimates assigned to ecosystem services was first assessed using a hierarchical cluster analysis, based on Euclidean distance, which found the greatest splits in the data were among the three stakeholder groups, with little effect of country. We therefore focus on patterns among and within stakeholders.

We used a principal components analysis (PCA), based on Euclidean distance, to examine the similarities and differences in the priorities managers, scientists, and fishers assign to the 8 ecosystem services (Legendre and Legendre, 1998, CANOCO 4.5). We then looked for differences, across stakeholder groups in the priorities assigned to individual ecosystem services using a MANOVA, followed by Tukey’s HSD post hoc analysis. To illustrate these differences, we calculated an effect size on all eight ecosystem services for each two way combination of the three stakeholder groups (Eq. [1]).

\[\text{Cohen’s } d = \frac{\bar{V}_{ij} - \bar{V}_{ij}}{\left(\text{SD}_{ij} + \text{SD}_{ij}\right)/2}\]  

where \(\bar{V}_{ij}\) = ecosystem service priority of the first stakeholder group; \(\bar{V}_{ij}\) = ecosystem service priority of the second stakeholder group, \(SD\) = standard deviation.

2.5. Differences in ecosystem service prioritization, within stakeholder groups

2.5.1. Analysis

We looked for differences in ecosystem service prioritization, within stakeholder groups, using a one way ANOVA for each stakeholder group (Field, 2009).

2.5.2. Synergies and trade-offs

A trade-off generally arises because two choices are incompatible with each other. For example, activities that maximize fishing yield (a provisioning service) tend to erode key processes necessary for maintaining functioning ecosystems, such as herbivory (a supporting service). Many approaches exist for quantifying trade-offs e.g. cost benefit analysis (CBA), social CBA, integrated CBA (de Groot et al., 2010) and multi-criteria decision analysis (MCDA) (Brown et al., 2002). These robust approaches, effective at engaging stakeholders in discussions over alternate options, that draw out trade-offs. However, people do not always consider the motivations or implications of their values and their resultant behaviour (Schwartz, 1996; Bardi and Goodwin, 2011). This can create trade-offs that are not obvious, are not realized until they occur, or affect a minority. Therefore, rather than focus on the services of a high priority, that are likely to be discussed, we were interested in drawing

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**Table 1** (Continued)

<table>
<thead>
<tr>
<th>Service</th>
<th>Picture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bequest</td>
<td><img src="image.png" alt="Bequest Picture" /></td>
<td>This picture of children represents the future of the reefs. This illustrates the benefits we gain from knowing we will have healthy reefs that we can pass on to our children so that they can benefit from all the benefits that we gain today.</td>
</tr>
</tbody>
</table>
out the important relationships that exist between all ecosystem services.

For each stakeholder group, we produced a correlation matrix based on a Pearson’s correlation analysis looking at similarities and dissimilarities in the way ecosystem services were prioritized. A positive correlation between service A and B, suggests that the estimates assigned are more similar to each other than by chance alone (Legendre and Legendre, 1998); individuals within a stakeholder group value these services in the same way representing a synergy between a pair of ecosystem services (Fig. 1a) (i.e. both services are high, or both services are low, relative to the range of values each service receives). A negative correlation between the values assigned to service A and B, suggests the estimates assigned are less similar to each other than by chance alone (Legendre and Legendre, 1998); individuals within a stakeholder group value these services differently and a trade-off exists (Fig. 1b) (i.e. when one service is high the other service is low, relative to the range of values each service receives).

2.5.3. Mapping synergies and trade-offs

We used network analysis (NA) to visualize the synergies and trade-offs in each stakeholder group and to determine key aspects of their interrelatedness. NA is the study of groups as networks of nodes connected by ties and provides methods to quantify the relations between nodes and the resultant network structure (Borgatti et al., 2009). Although network analysis is frequently used to study relationships between individuals, or groups of individuals (e.g. social network analysis see Ernost et al., 2009; Wasserman and Faust, 1994), in the 1990s NA radiated into a great number of fields including physics and biology (e.g. Bascompte, 2009), and continues to present new opportunities for interdisciplinary research (e.g. Bodin and Tengö, 2012). Consequently, the nodes of a network can represent organizations (Cohen et al., 2012), occupations (Cinner and Bodin, 2010), disciplines (Hicks et al., 2010), or species (Bascompte, 2009). In the same way, the ties between the nodes can represent similarities (e.g. attribute), relations (e.g. kinship), interactions, or flows; and each combination of ties and nodes creates different outcomes for the network (Borgatti et al., 2009). We use NA to examine the relationships between ecosystem service priorities within each stakeholder group. Therefore, for each stakeholder group, we have eight nodes, each representing a different ecosystem service. Our nodes are connected by ties that represent a synergy, or trade-off between a pair of ecosystem services, established from Pearson’s correlation analysis.

We dichotomized (converted to binary data) each stakeholder group’s Pearson’s correlation matrix in UCINET version 6.365 (Borgatti et al., 2002). The cutoff points were selected to include the coefficients representing 40% of the strongest negative, and 40% of the strongest positive correlations for each stakeholder group. Because the sample size of fishers, managers, and scientists differed, we decided to use a cut off point that represents a consistent proportion of correlations rather than a significance level which would be biased by sample size. The network analysis therefore gives an indication of the tendencies towards a trade-off or synergy within groups rather than an indication of the strength or number of connections across groups. It is worth noting that the manager network in particular is composed of a fairly small sample size, so although the positive and negative trends should be fairly robust, they will inherently have greater uncertainty associated with them. We produced two matrices for each stakeholder, one representing trade-offs (negative) and one representing synergies (positive). For each stakeholder group, we combined the positive and negative matrices in NetDraw (Borgatti, 2002) to create a network representing stakeholders’ synergies and tradeoffs in ecosystem service priorities. For each network, we calculated two types of centrality measures, degree and betweenness. Degree centrality is a measure of the number of connections between a service and all other services. Betweenness centrality is a measure of the number of shortest paths that run through a service, representing the importance of a service for connecting other services that would otherwise be unconnected (Wasserman and Faust, 1994).

3. Results

3.1. Differences in ecosystem service prioritization, across stakeholder groups

The first axis of the PCA (32.8% variation) distinguishes between fishers’ priorities and managers’ and scientists’ priorities, with fishers tending to prioritize fishery, education and habitat more than managers or scientists, who tended to prioritize coastal protection and culture more than fishers (Fig. 2). The second axis of the PCA (21.3% variation) revealed a weaker distinction between managers’ and scientists’ priorities (Fig. 2). These differences across stakeholders in the priorities assigned to specific ecosystem services were confirmed with a MANOVA test (Wilk’s value = 0.01, F8,39 = 10.2, P < 0.0001) (Table 2). Post hoc pairwise tests showed that fishers assigned significantly higher priorities to fishery than managers or scientists and significantly higher priorities to
education than scientists (Table 2 and Fig. 3a and b). Similarly, managers assigned significantly higher priorities to culture than scientists or fishers and significantly higher priorities to bequest and coastal protection than fishers (Table 2 and Fig. 3a and c). Finally, scientists assigned significantly higher priorities to coastal protection than fishers or scientists, and significantly higher priorities to bequest, recreation and culture than fishers (Table 2 and Fig. 3b and c).

3.1.1. Differences in ecosystem service prioritization, within stakeholder group

Fishers assigned their highest priorities to fishery, habitat, and education, and their lowest priorities to culture and recreation (Table 3). Fishers’ highest priorities were assigned significantly greater estimates than their lower priorities (F$_{1,7}$ = 51.8, P = 0.001). This is because fishers would assign almost all of their counters to one or two services, rather than distributing them more evenly. Scientists assigned their highest priorities to fishery, habitat and coastal protection and their lowest priorities to culture and sanitation (Table 3). Scientists’ highest priorities were assigned significantly greater estimates than their lower priorities, but to less of an extent than fishers (F$_{1,7}$ = 10.0, P = 0.001). Managers assigned their highest priorities to habitat, education, and bequest and their lowest priorities to sanitation (Table 3). However, there were no significant differences in the estimates managers assigned to their higher and lower priorities (F$_{1,7}$ = 0.7, P = 0.68). This is because managers tended to distribute their counters evenly across the range of ecosystem services.

3.1.2. Synergies and tradeoffs

The ecosystem service prioritization networks of all three stakeholder groups were associated with proportionally more trade-offs than synergies (Fig. 4). Habitat and recreation formed a synergy and coastal protection traded-off with culture for all stakeholder groups (fishers, managers and scientists) (Fig. 4). Fishers and scientists did not overlap on any other ties. Managers, overlapped with scientists on an additional three trade-offs (sanitation–recreation; sanitation–habitat; habitat–education) and with fishers on an additional two ties (a trade-off between recreation–education; a synergy between sanitation–coastal protection) (Fig. 4).

In the fishers’ network, three synergies were evident: recreation–habitat; sanitation–coastal protection; and fishery–bequest. A number of trade-offs were identified both between the synergy clusters and to other ecosystem services. For example, there were three trade-off ties between the fishery–bequest and the recreation–habitat synergy clusters, and both clusters had an additional trade-off tie with education. The sanitation–coastal protection synergy traded-off with culture and with fishery (Fig. 4a). In the

![Diagram](image)

**Fig. 3.** Differences in ecosystem service priorities between (a) managers and fishers; (b) scientists and fishers; and (c) scientists and managers. Asterisk shows where significant differences exist based on Tukey’s HSD post hoc analysis (α = 0.05).

managers’ network, two synergy clusters were evident: recreation–habitat; and sanitation–coastal protection–education, with five trade-off ties between these two synergy clusters. The sanitation–coastal protection–education cluster also traded-off with culture, and fishery traded-off with bequest (Fig. 4b). In the Scientists’ network, two synergy clusters were evident: recreation–habitat–coastal protection; and sanitation–culture. There were five trade-off ties between these two synergy clusters. In addition, culture traded-off with fishery, and habitat traded-off with education (Fig. 4c). Bequest was unconnected in this network.

3.2. Ecosystem service influence

In network analysis, degree and betweenness centrality measures give an indication of the influence a node has on the network. Degree measures the number of other nodes (in our case services) each individual node (service) connects to. Betweenness differs slightly by measuring the number of connections a node (service) makes between parts of the network that are otherwise unconnected.

Fishery was connected to the largest number of other services in the fishers’ network (habitat, sanitation, education, and bequest giving it a degree measure of 4). Fishery also connected the largest number of otherwise unconnected parts of the network (betweenness: 13) (Table 4). Coastal protection, education, recreation, and sanitation were connected to the largest number of other services in the managers’ network (all connected to 4 other services, giving them a degree measure of 4). Coastal protection also connected the largest number of otherwise unconnected parts of the network (betweenness 4) (Table 4). Culture and habitat were connected to the largest number of other services in the scientists’ network (culture was connected to recreation, habitat, coastal protection, fishery, and sanitation, giving it a degree measure of 5; and habitat was connected to culture, education, sanitation, coastal protection, and recreation also giving it a degree measure of 5). Culture and habitat were also connected the largest number of otherwise unconnected parts of the network (betweenness 5.3 and 5.3) (Table 4). These metrics suggest fishery is the most influential service in the fishers’ network, coastal protection the most influential service in the managers’ network, and culture the most influential services in the scientists’ network.

4. Discussion

Ecosystem service values depend on human preferences and demand, and not just the merits of the biological system, such as diversity and productivity (Vira and Adams, 2009). Therefore, using a multi-country case study of coral reef fisheries, we set out to: understand fishers’, managers’, and scientists’ ecosystem service preferences; measure their priorities; map the interactions associated with their priorities, and; explore how this information can be used when stakeholder groups come together to discuss the management of complex ecosystems. There were similarities and differences in fishers’, managers’, and scientists’ ecosystem service priorities. Fishers were more likely to prioritize fishery values, managers were more likely to prioritize cultural values and scientists were more likely to prioritize coastal protection values. Overall, fishers’ priorities were most distinct from managers and scientists. However, when we examined the interactions associated with each stakeholder groups’ priorities, areas of agreement and conflict emerged reflecting different trade-offs and synergies in stakeholders’ ecosystem service priorities. Interestingly, the synergies and trade-offs within the group of managers reflected...
aspects of the patterns seen in both groups of fishers and scientists. Because the interactions that emerge between peoples’ priorities reflect implicit rather than explicit preferences it can be challenging to incorporate these interactions into decision-making (McRae and Whittington, 1997). However, the synergies and trade-offs that emerge between stakeholders’ ecosystem service priorities may be the result of differences in their social characteristics, experiences, and conceptual understandings of the system; all attributes that if understood can be navigated.

Although different groups of people derive benefits from different ecosystem services (Daw et al., 2011), we found remarkable similarities in the ecosystem services that fishers, managers, and scientists considered a priority. All three groups assigned their highest priorities to fishery, education, and habitat. Differences emerged between stakeholder groups in the weights assigned to each service. Fishers were most distinct in their tendency to identify clear priorities, where managers and scientists tended to distribute their counters more evenly. Areas of agreement provide an opportunity for fishers, managers, and scientists to come together to discuss the management of these systems; a crucial component for successful resource management (Sutton and Tobin, 2009). Indeed, stakeholders are more easily engaged when data on their attitudes and preferences are collected early on in the management process (Day et al., 2007). Communication between stakeholders is important and serves to build an understanding of stakeholders’ different aspirations for management that can help in translating abstract issues such as goals for conservation, and ultimately create a space for solutions (Larson et al., 2013). For example, in 2004, the Great Barrier Reef Marine Park Authority in Australia implemented a new and ambitious conservation plan but faced a widespread belief that, before and up to 4 years after, the majority of stakeholders’ were in opposition to and dissatisfied by the plan. After an extensive consultative process the majority of recreational fishers were found to in fact support the plan and found it consistent with their values; stakeholders attributed this largely to their involvement in the consultation process (Sutton and Tobin, 2009). Despite the apparent similarities we found in stakeholders priorities, the differences that exist are likely to escalate unless explored. Thus, when stakeholders’ values appear to conflict, it is particularly constructive to engage the relevant stakeholders in a process that explores their priorities. This process can build a respect for alternative views, a trust between those involved, and highlight areas of agreement. For example, although the relative weights assigned to managers and scientists priorities differ, when they are put in the context of the weights assigned to fishers priorities they appeared very similar.

Although identifying and engaging stakeholders in a consultative process is important, the concept of ‘stakeholder’ is often controversial (Buchy and Race, 2001), and the identified groups are rarely homogenous (Leach et al., 1999). Furthermore, there are often power relationships within the stakeholder group that influences whose voice is heard and ultimately the outcome of resource management (Buchy and Race, 2001). We therefore examined the extent to which each stakeholder group’s priorities were in agreement, representing synergies between services, or in conflict, representing trade-offs between services. We found distinct synergies and trade-offs in fishers’, managers’, and scientists’ patterns of ecosystem service priorities that were not evident from the stakeholder groups’ priorities alone. For example, all stakeholder groups were in agreement that fishery, education, and habitat services represented their highest priorities, but this agreement across groups did not reflect agreement within groups. Instead, fishery traded off with habitat and education in the fishers network and habitat traded-off with education in the manager and scientist networks. The synergies and trade-offs associated with ecosystem services are a result of different priorities within a stakeholder group and identify potential conflicts or opportunities that may arise in a decision-making process. There is a danger that apparent similarities across groups may mask conflicts within stakeholder groups that if not addressed would ultimately impact how individuals behave (Kennedy et al., 2009). For example, because fishery was considered a priority across all stakeholder groups it would be reasonable to expect management focusing on yield maximization to receive support. This support may exist within the group of scientists, where fishery trades-off with culture – a service assigned a lower priority. However, there is likely to be conflicting support within the group of managers and fishers where fishery trades-off with services that are assigned high priorities – request for managers and habitat and education for fishers. Investing in a dominant service has the potential to create conflicts and even marginalize certain individuals. Yet, decision-makers looking for consensus tend to focus on the strongest values, neglecting potentially complex interactions that may lead to sub-optimal outcomes (Platt, 1973; Östrom, 1990).

Managers are likely to be better equipped to address conflicts or take advantage of opportunities that arise in environmental decision-making if they can understand what drives the differences in stakeholders’ priorities. It is generally accepted that people’s preferences are influenced by their characteristics, experiences, learning, and culture (Kaplan, 1985). Consequently, age, gender, and income, have been used to explain differences in environmental preferences (Nord et al., 1998; Howell and Laska, 1992). However, preferences result from conscious and subconscious motivations (Schwartz, 1996; Rardi and Schwartz, 2003), which presents a challenge for understanding how people come to have the preferences they do (Howell and Laska, 1992; Farber et al., 2002). It is likely that the ability to access and make use of the environment will influence people’s ecosystem services preferences (Leach et al., 1999). Ribot and Peluso (2003) developed a theory of access that identified nine categories that shape the processes and relations that enable people to benefit from their environment. These mechanisms include for example, people’s knowledge and skills, their social relations and identity, and the access they have to capital and markets. In doing so, Ribot and Peluso (2003) provide a useful framework through which managers can understand and explore differences in stakeholders’ preferences.

Subconcious influences on people’s preferences may be reflected in the way they perceive nature. For example, people perceive nature at different scales of time (Leopold and Schwartz, 1989), which influences the extent to which they prefer something today over something at a later time – or their time preferences. People who perceive the benefits of nature on shorter time scales are likely to prioritize immediate benefits over greater future benefits (Gollier, 2002). The trade-off between fishery and habitat in the fishers network suggests different fishers’ may have different time preferences. Some fishers prioritize an immediate return from increases in their fishery yield, whereas others see the benefit of investing in the habitat for an improvement in the fishery in the long term. Strong property rights are likely to lower this trade-off because people develop a confidence in the future benefits. Managers may therefore be wise to invest in suitable property rights along side existing management. Similarly, when people perceive two ecosystem services as mutually exclusive they are unlikely to prioritize both, which creates a trade-off relationship (Yee, 2011). For example, a synergy tie between recreation and habitat existed in all stakeholder networks, suggesting these services are not perceived as mutually exclusive. Indeed, reef based tourism is widespread in the region and closely associated with
healthy reefs for diving and snorkelling. However, in the fishers’ network, recreation traded-off with education and bequest, suggesting these services are likely to be perceived as mutually exclusive. This may be because tourism is seen to pose a threat to local cultures by presenting an appealing and lucrative alternative to learning about and maintaining local practices, knowledge, and traditions (Brown et al., 2006). This appeal may lead to the loss of local cultures, particularly in younger generations (Hill et al., 2011). When differences in stakeholders’ preferences are the result of differences in perceptions or experience rather than needs and traits, there is some potential for values to change (Bardi and Goodwin, 2011). Exploring the factors that influence peoples preferences, including access and perceptions, can help managers decide on cues to introduce that could build a common understanding, challenge existing values, and begin a process of value change.

Communication is important when trying to coordinate action (Ostmann, 1998; Ostrom, 1990), and is easier when people think in similar ways (Verweij et al., 2006). Fishers and scientists were most distinct from one another, suggesting that they would find it difficult to reach agreement on how to prioritize ecosystem services. Although the smaller sample size of managers creates greater uncertainty in the patterns for this group, managers’ priorities, trade-offs, and synergies overlapped the most with both fishers’ and scientists’. This suggests managers may be well placed to anticipate and understand some of the opportunities and conflicts that fishers and scientists associate with their ecosystem service priorities. Indeed, the nature of managers’ jobs means they have to mediate between fishers and scientists regularly. Although scientific research often informs management and conservation, it is managers who in the end must balance the research findings with local issues and priorities (Fazey et al., 2006). The ability of managers to balance the advice coming from scientists with their understanding of different stakeholders’ priorities is therefore likely to make them good negotiators around the issues of preference and associated decisions.

5. Conclusions

To enable effective and equitable resource management, policy makers should engage with the complexities associated with stakeholders’ preferences and priorities. We found that stakeholder’s priorities were often associated with implicit synergies and trade-offs, potentially creating elusive opportunities and unexpected conflicts (McShane et al., 2011). Effective and equitable resource management needs stewards that are capable of navigating these conflicts and capitalizing on opportunities to reach consensus. We show that managers may be capable of playing such a role. This role could be furthered by introducing cues, through discussions, that address and challenge the underlying motivations behind the observed synergies and trade-offs in ecosystem service priorities (Bardi and Goodwin, 2011). A greater understanding of these motivations will help build a common understanding of ecosystem service priorities and help reduce conflicts over management decisions.

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