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

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ABSTRACT

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 assigned 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.

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 stakeholder 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 stakeholder's 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 bourn 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