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REPORT

The Links Between Resource Dependency and Attitude of Commercial Fishers to Coral Reef Conservation in the Red Sea

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Abstract The imperative to further constrain extractive uses of natural resources will strengthen as resources degrade through over-use or exposure to climate changes. Here, we explore an approach to increase the support for marine conservation among coral reef fishers. We explore the proposition that resource dependency in the Egyptian Red Sea can act as a barrier to conservation. We administered face-to-face surveys to 49% of the fishing industry to: (i) identify the level of compliance to the local marine protected area (MPA), (ii) assess the level of dependency on marine resources in the region and (iii) examine the relationship between resource dependency and conservation attitudes. Only 11.4% of fishers were aware of the MPA. Fishers were mostly limited in their social flexibility and livelihood options. Results suggest that resource dependency is highly and negatively correlated with conservation attitudes suggesting that management efforts need to seriously focus on reducing dependency if conservation goals are to be met.

Keywords Human dimensions · Social resilience · Attitudes · Resource dependency · Compliance · Marine protected areas

INTRODUCTION

Fisheries resources around the world are in crisis (Pauly et al. 2003). Targeted species and their habitats are under pressure from land-based sources of pollution (including runoff from agricultural land), unsustainable and destructive fishing, disease outbreaks and invasive species. Against this backdrop of conventional local stressors, has emerged the global threat of climate change (Cheung et al. 2009).

Coral reefs support a significant proportion of commercial fishing activities globally (Wilkinson 1999; Talbot and Wilkinson 2001). Perhaps even more importantly, coral reefs support artisanal and subsistence fishing activity that provides the basic needs for some 500 million people (Wilkinson 2008). Demands on fish and other resources provided by coral reefs continue to increase with human population and affluence, yet the ability of reefs to sustain provision of goods and services is declining. Approximately 19% of the world's coral reefs have been effectively destroyed (structurally and functionally), with another 35% under threat from local human pressures (Wilkinson 2008).

Recognising the looming crisis for coral reefs and the millions of people who depend on them (Jackson et al. 2001; Cinner et al. 2009), science and management communities have called for renewed action to conserve coral reefs through reducing greenhouse gas emissions, minimising local pressures on reefs and expanding coverage of marine protected areas (MPA) (www.coralreef.gov). Seemingly, effective conservation of coral reef ecosystems has never been more important. This means necessarily that additional constraints on human uses of coral reefs and on human activities in adjoining coastal zones and catchments will occur. However, these constraints will also impose significant, and often immediate, pressures on social systems. This creates a critical tension between conservation activities and short-term human interests, often leading to compromises in conservation outcomes as well as the long-term sustainability of goods and services upon which local communities depend.

The complexity of this interdependency between ecological and human systems means that reef-dependent industries and communities will continue to be under threat for the foreseeable future: partly because some level of ecosystem degradation is inevitable and also because many

conservation measures will in themselves impart substantial stress on social and economic systems (assuming that there is no non-consumptive alternative). Further, due to population growth and the accelerating impacts of climate change, communities and industries will place additional stress on marine resources which may lead to a further spiral of accelerating and mutual decline (Adger 2000; Cinner et al. 2009; Marshall 2010).

Marine protected areas are a central strategy of management approaches that aim to protect biodiversity, as well as support the social and economic wellbeing of human societies (Mascia 2003; IUCN-WCPA 2008). Increasing the proportion of marine areas under management or protection and maximising their effectiveness through informed design and implementation are priorities for international conservation efforts and organisations such as the Convention of Biological Diversity and the IUCN-the World Conservation Union (IUCN-WCPA 2008). Whilst MPAs are often justified on the grounds of delivering fishery benefits, in many instances these benefits take an extended period to be realised, if at all (Kareiva 2006; McClanahan et al. 2009). The lack of immediate and tangible outcomes from MPAs has often been used to criticise their use as a conservation tool. However, the vast majority of MPAs suffer from poor compliance, giving rise to the often-used term, 'paper parks' (Badalamenti et al. 2000) and a consequent failure to deliver expected benefits.

The solution to poor compliance most often presented is better enforcement. Compliance is largely a dilemma associated with a 'commons resource' where there are seldomly incentives for individuals to practice self-restraint in the harvesting of open-access natural resources (Hardin 1968). Apart from being expensive and subject to corruption, enforcement is not the only, or necessarily the most effective, strategy for compliance (Pollnac et al. 2010). Where dependency on marine resources is very strong, incentives to continue extractive activities (such as subsistence or poverty) readily outweigh disincentives (such as fines or jail). Strong resource dependency—the norm in many coral reef areas around the world—may be acting as a 'barrier' to accepting and complying with regulatory change (Marshall et al. 2007). Improved understanding of resource dependency, and knowing how to manage or reduce it, might be a much more cost-effective and sustainable approach to improving conservation effectiveness.

Resource dependency is a concept describing the nature and strength of the relationship that people have with the environment that they depend upon (Force et al. 1993; Bailey and Pomeroy 1996; Jacob et al. 2001). Previous work has identified a number of characteristics that define resource dependency (Humphrey 1995; Bailey 1997; Marshall et al. 2007). These factors can be measured and combined to evaluate the nature and strength of dependency on a resource. Here, we focus on a suite of factors that are readily measured and known in other systems or nations to be key drivers of dependency in fishers (Marshall 2008). Key social factors include the level of attachment to the occupation, employability, family characteristics and perceptions of change (where positive perceptions of the change event itself tend to be correlated with more resilient people). Economic factors include business characteristics, approach, debt and income. Environmental factors include nature of the interaction with the resource, level of specialisation, local skills and knowledge, and perceptions of environmental change and condition.

Resource dependency can be considered at multiple scales, ranging from individuals to fishing sectors or industries to communities and regions. Building on recent advances in approaches to assessing resource dependency (Fisher 2001; Jacob et al. 2001; Marshall 2008; Marshall et al. 2009a, b), we focus here on resource dependency of individuals as a basis for understanding attitudes and responses to implementation of conservation tools such as MPAs.

Implementing MPAs without sufficient knowledge of the likely socio-economic implications or challenges can impose levels of stress upon individuals, industries and communities that compromise their ability to adapt, tolerate or prosper under new regimes such as those imposed by an MPA (Wingard 2000; Cinner 2007; McClanahan et al. 2009). In Madagascar, Cinner et al. (2009) found that the capacity to adaptively manage resources may be offset by poor levels of trust between communities and resource managers. In Australia, Marshall (2007) found that perceptions of policies could significantly impact on the capacity of commercial fishers to cope and adapt to policy implementation. In general, MPAs that are implemented without due consideration of the likely social consequences can be associated with poor compliance (Sutinen and Kuperan 1999; Christie et al. 2003; McClanahan et al. 2008). This, in turn, compromises the ability of the MPA to deliver both conservation outcomes and long-term social and economic benefits.

We suggest that building knowledge of local dependency on marine resources into MPA planning and management can substantially improve the prospects for MPA success. Knowledge of resource dependency can also underpin efforts to minimise negative impacts of protected areas on resource users through strategies that reduce their dependency and increase their resilience to changes in resource access policy (Bailey and Pomeroy 1996; Ban et al. 2009). We study the commercial fishing industry in the marine component of Gemal Elba National Park to (i) identify conservation attitudes and level of compliance to

an MPA in the Egyptian Red Sea, (ii) assess the level of marine dependency in the region and (iii) assess whether there is any correlation between resource dependency and conservation attitudes. We then explore the significance of our findings for the planning and management of MPAs more generally and consider the implications for resilience of social–ecological systems to climate change.

METHODS

Case Study Context

The Red Sea

The Red Sea is rich in biodiversity (Sheppard et al. 1992) and in important marine habitats such as coral reefs, mangrove forests and seagrass beds, which act as nurseries for a range of commercially important fish species. Approximately 260 species of scleractinian hard coral (DeVantier et al. 2000) and over 1,200 species of fishes have been recorded from the Red Sea. Much of the biodiversity is concentrated in shallow-water coral reef habitat that fringes large sections of the Red Sea coastline and islands (Head 1987; Sheppard and Sheppard 1991; Turak et al. 2003). Coral reef communities within Egypt's waters have been affected by humans especially in localised areas near large cities, ports, coastal resorts and tourist sites (Kotb et al. 2008; Riegl and Piller 2000). Threats to the region's marine assets include rapid coastal development, pollution related to Egyptian and Saudi oil facilities and invasive species associated with the de-ballasting of ships (Hanafy et al. 2006).

Nine countries have coastlines bordering the Red Sea, but five make up the majority of the coastal strip: Egypt, Sudan, Eritrea, Saudi Arabia and Yemen. Approximately 5 million people live within the highly arid coastal zone, with 2 million concentrated in Jeddah, Saudi Arabia (Source: http://oils.gpa.unep.org/framework/region-12-next.htm). Fishing remains an important cultural and economic activity for many local residents, who have been joined more recently by an influx of migratory fishers from the Nile Delta and elsewhere around the Red Sea (Kotb et al. 2008). Fishing is mainly conducted by artisanal subsistence fishers, local commercial fishers and foreign industrial fishers (Tesfamicahel and Pitcher 2006). In 2005, there were 1,344 registered commercial fishing vessels in the Egyptian Red Sea. However, the industry has suffered a decline in fish production as a result of overfishing during the last decade. Fish production decreased from 82,400 tons per annum (TPA) in 1999 to 46,940 TPA in 2006. This decline has meant that many fishers are turning away from the sea towards inland aquaculture, or freshwater fish farming which is a sector of the fishing industry that has recently expanded (Kotb et al. 2008).

In some MPAs on the Sinai Peninsula, such as Ras Mohammed NP, negotiation with Bedouin fishers has lead to the creation of no-take fishing zones where all forms of harvesting are prohibited (Pearson and Shehata 1998; Benzoni et al. 2006). These have proved effective at protecting and enhancing finfish and invertebrate stock (Galal et al. 2002; Benzoni et al. 2006). Recently, there has been a declaration of a moratorium on net fishing within Egypt's Red Sea territorial waters and a proposal to establish no-take zones beyond the Sinai Peninsula (Amr Ali, HEPCA, personal communication). We focus our efforts towards an understanding of the links between resource dependency and conservation success in the Red Sea because of its long history of extractive uses of the marine environment, recent social dynamics in the fishing sector and the emergent prioritisation of ecosystem conservation within the region.

Gebel Elba National Park

The focus of this study was the Gebel Elba National Park in which both terrestrial and marine components are protected. Gebel Elba National Park is located approximately 820 km from Cairo in the southeast corner of the Eastern Desert of Egypt (Fig. 1). Established in 1985, the National Park covers 35,600 km^2 of land and sea (NCS 2006) and is managed as an IUCN category VI protected area. Sheppard et al. (1992) reported a fringing reef in the National Park that extends 70 km offshore, creating a mosaic of reef and other shallow marine habitats. A recent biodiversity survey of coastal waters in the northern sector of the National Park reported seagrass meadows, mangrove stands and coral reefs supporting commercially important species (IUCN 2007). There are three main groups of Indigenous people in the National Park; the Bishari, Ababda and the Rashayda (Abd El-Ghani and Abdel-Khalik 2006). The Local Land Council estimated the human population in Gebel Elba National Park to be 20,000 with 8,000 indigenous people living in Shalateen (Anon. 2002). Shalateen is the largest fishing village in the National Park, located 70 km south of the northern boundary of the National Park. According to Kemel (1998), there were 89 members of the fisheries cooperative and 25 outboard-powered fishing boats in Shalateen in 1998. He reported that fishermen are legally bound to participate in the cooperative to obtain fishing licenses (Kemel 1998). There are also 5,000 people from the Nile Valley living within Shalateen. Little is known about the impact of people on the Park's biological values, although impacts from herding and charcoal production suggest intense use of terrestrial habitats (Abd El-Ghani and Abdel-Khalik 2006).

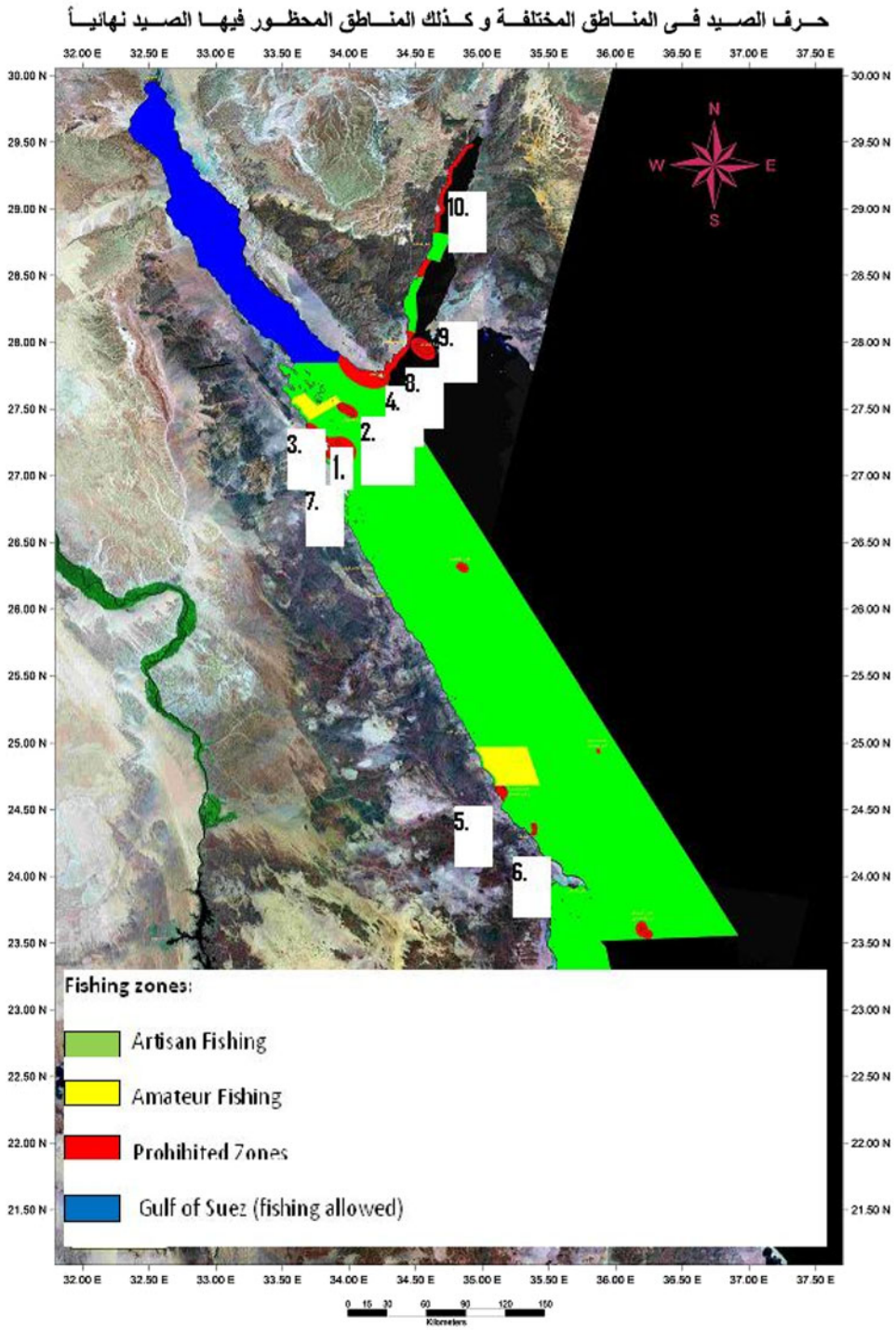

Fig. 1 Map of fishing zones in the Egyptian Red Sea. Fishing is prohibited at: 1. Shedwan Island & The coral reefs around the island, 2. Giftun Islands (Big & Small), Abu Monkar Island, Abu Ramad, 3. Magawish Islands (Big & Small), 4. Fanous Reefs & Abu Ramad, 5. The area between Wadi El Gemal Island & the land and the island & the coral reef adjacent to it. This area is the focus of this paper, 6. Hamata Island and surrounding reefs to 1 km from the edge of the coral reef adjacent to the islands, 7. The far Islands including (Brothers Islands, Abu Kizan, Zabargad, Roki, San Jons) and up to 1 km from the edge of the coral reef adjacent to the islands, 8. Ras Mohamed and the surrounding reefs, 9 Tiran Island & the surrounding reefs, 10. Gulf of Aqaba coast until 1 km from the edge of the coral reef areas, except the areas where fishing is allowed

Survey Development and Administration

A survey was designed to quantify and describe each fisher's level of dependency on the resource and their attitude to marine conservation. Forty-four fishers were invited to participate in the research and all fishers accepted (100% response rate). Interviewers were local people, and fishers were approached as they were leaving or returning from their fishing activities. Since 89 fishers are located within the region (Kemel 1998), the sample represents 49% of the local industry.

Fishers were located at the fishing village of Shalateen, the largest within Gebel Elba National Park. Forty-one percent of commercial fishers sampled in the study (18 fishers) lived in Gebel Elba National Park. Other fishers came from Quseir (25.3%), Shalateen (20.5%), Hemara

(11.4%), Suez (11.4), Safaga (9.1%), Fayoum (9.1%), Ismaelia (6.8%), Hamata (4.5%) and Manzala Dakahlya (2.3%).

Evaluating Resource Dependency

The level of resource dependency for individual fishers was examined using responses to survey statements reflecting the major dimensions of resource dependency. Survey questions were based on other studies of resource dependency in marine resource-dependant communities (Marshall et al. 2009a, b) but modified for the local context based on advice of local experts. We also included aspects of perceptions of change and perceptions of environmental change and condition, since we expected these to reflect the flexibility with which resource users undergo change. Some survey questions required a simple yes/no answer; others aimed to capture an attitude, opinion or stance. Respondents were asked to rate how strongly they agreed with these statements using a 4-point Likert rating scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). Results were analysed using frequency distributions (as percentages).

Evaluating Attitudes to Marine Conservation

Attitudes to marine conservation were captured as an indication of how likely commercial fishers were to support conservation measures such as MPAs. We asked fishers (1) what would be important to consider in protecting fisheries for future generations, (2) how valid are management approaches that protect adult fish that produce more young, (3) would you consider closing some areas of your fishing grounds to help protect fish stocks from overfishing and (4) are you aware that your village and coastal waters are in a protected area? We also asked fishers an open-ended question about why they would or would not consider closing some areas to help protect fish stocks from over fishing. These results were coded into two categories: positive or negative attitude towards marine conservation. This value was used as one of the correlates with resource dependency.

Method for Testing Correlations Between Resource Dependency and Conservation Attitudes

A major aim of the study was to assess whether there is any correlation between resource dependency and conservation attitudes for fishers in Gebel Elba National Park. We used respective responses to questions about whether fishers would consider fish protection and whether they had a positive or negative attitude as an indicator of their conservation attitude. Since conservation attitudes were recorded as 'positive/negative' or as a 'yes/no', a stepwise binary logistic regression analysis was conducted to assess the significance of the relationship between conservation attitude and each aspect of resource dependency. An alpha level of 0.05 was used as the minimum level to assess the significance of each relationship (Underwood 1997).

RESULTS

Level of Dependency on the Fisheries Resource

Social Attachment to Fishing

All but one fisher could not imagine a job they would rather do than fishing. Most had always been a fisher (85.7%). The mean age for fishers entering the industry was 12 years old (s.e. = 0.8). The range of ages at entering the industry was 5–35 years old and the mode was 10 years old.

Most fishers did not have a family member that had been in the industry (74.4%). Fishers did not spend a great deal of time with other fishers; most suggested that they spent just 'a little' time with them, and 22.5% of did not spend any time with other fishers.

Family Dependency

Most fishers in this study were married (86.4%). The mean number of their children was 2.97 (s.e. = 0.28) and the mode was 7. About half of the children were less than 16 years of age. At least one child over the age of 16 fished with their father (mean = 1.25, non-dependent children s.e. = 0.4). Most fishers owned their own home (94.1%) while 5.9% were paying rent.

Employability

Most fishers had never had another job (93.2%) and thought that they would not be able to easily obtain one outside of the industry (93.2%). The mean age of commercial fishers was 41 years old (s.e. = 1.8 years); the youngest was 21 and the oldest 74.

Perceptions of Change

Fishers believed that other fishers were more likely to adapt to change than they were (65.1%). Fishers did not see that they had other options available to them if they decided to no longer fish (93%). Most were confident that things would work out regardless of any change (90.7%). Most also thought that if asked to change where or how they fish, they would survive (95.3%). Fishers mostly thought that they were too young to retire and too old to find work

elsewhere (88.4%). They generally thought that they could cope with small changes in the industry (75%). However, 86% of fishers did not think that they were competitive enough to survive much longer in the industry. Many were not interested in learning new skills (90.7%). Some were nervous at the idea of trying something else (46.6%).

Business Situation

Most fishers sampled in this study were employed to fish (93%) and did not own their own fishing business (or boat). Many (55.8%) fished with 2–3 other fishers and 37.2% fished with 4–10 others. About 7% fished with only one other fisher. Fishers did not plan for their financial security (83%) but felt that they would be able to reorganise themselves in the event of change (90.7%).

Financial Situation

Nearly all fishers (95.3%) obtained all of their income from the commercial fishing industry. Of those that had additional sources of income, one was a driver, one was a painter and the other was a sheep trader. Fishers' income ranged between 225 and 1,100 Egyptian pounds each year (US $40–$200). Mean income for the fishery was 463 EP (s.e. = 29) (US $83). This is relatively low compared with the nation's mean of US $1580 (http://www.unicef.org/infobycountry/egypt_statistics.html).

Environmental Practices

At least 88% of those surveyed fished every month of the year. The average duration of a fishing trip was 7.7 days (s.e. = 0.6) but ranged between 4 and 30 days per trip. Fishers typically made 4.4 trips per month (s.e. = 0.6). They targeted different fish species depending on the season. Fishers mostly used handlines (47.7%) or nets (15.9%) or a combination of both (36.4%). Most fishers also always fish from a boat (75%). The mean length of boats was 8.3 m (s.e. = 0.2) and vessels ranged between 6 and 12 m.

Local Knowledge and Experience

The fishers surveyed have been fishing in local waters for a mean of 17.2 years (s.e. = 2.1 years; range 1–50 years). Most suggested that they knew their local waters 'very well' (97.6%). Most fishers fished in both coastal and offshore waters (64.3%) whilst 33.3% of fishers fished only local coastal waters. Twenty-one fishers (48.3%) did not know of any fish aggregation sites in the area. The remaining fishers described species that aggregated during spring, summer or winter months.

Perceptions of Environmental Change and Condition

Most fishers thought that the numbers of fish each year were stable (75%), and the remaining 25% of fishers thought fish stocks were decreasing. Overall 22.7% thought that there were too many fishers in the region, whilst 29.9% described the status of current fish stocks as 'god's willing'. Whilst one fisher suggested that fish stocks had reduced in the region because of bigger boats which come from the Port of Berenike which is situated ~85 km north of Shalateen, no other fishers attributed cause to the status of fish stocks in the region.

Marine Conservation Attitudes and Behaviours

Most fishers did not know what would be important to consider in protecting fisheries for future generations (86.2%). Four (9.2%) thought that fisheries resources needed to be conserved for the future, one (2.3%) thought that 'environmental control is the best solution that has ever happened to the village', and one (2.3%) stated that 'everything is in God's hands'.

Most fishers (90.9%) did not believe that it was a valid management approach to protect some adult fish even though it could result in more baby fish (because big fish produce proportionally more young). The remaining fishers were 'unsure'.

Fishers were divided on opinions about the benefits of closing some areas of their fishing grounds to help protect fish stocks from over-fishing. Some fishers were unsure (36.4%), some were positive (31.8%) and some were negative (31.8%). The reasons/responses that fishers gave ranged from 'being in Allah's/God's hands' (48.3%), 'give them a chance to grow' (13.7%), 'it would never work since fish move from one place to another' (6.9%), 'fishermen depend on fishing' (4.6%), close areas for outsiders only (4.6%) and 'please never close areas' (2.3%).

Most fishers were unaware that their village and surrounding coastal waters were in a protected area (79.5%). Some fishers were unsure (9.1%).

Correlations Between Resource Dependency and Conservation Attitudes

We found a significant correlation between fishers that would consider supporting fish protection measures and those that have had another job could easily get another job and those that agreed with the sentiment, 'Every time there is a change, I plan a way to make it work for me' (Table 1).

We also found a significant correlation between fishers' conservation attitude (positive or negative) and the age they entered the industry, their income and whether they agreed with the sentiments, 'Every time there is a change, I

Table 1 Results of a stepwise binary logistic regression analysis between aspects of resource dependency and conservation attitudes

Resource dependency	Would consider fish protection	Positive attitude toward MPA
Age entered the fishery	−0.147	0.314*
No. of dependent children <16 years old	−0.270	0.324
Age	0.126	0.255
Have you ever had another job?	0.313*	0.017
Could you easily get another job?	0.313*	0.204
Employee versus employer	0.088	0.200
Income	0.167	−0.339*
% Income from fishing industry	0.262	0.070
Use of nets, handlines or both (gear)	0.063	0.087
Fished in local waters versus further offshore	0.119	0.101
Perception of fish stocks being stable versus decreasing	0.094	0.184
'I could cope with small changes in the industry'	0.265	−0.232
'I am too young to retire and too old to find work elsewhere'	0.168	0.416**
'Every time there is a change, I plan a way to make it work for me'	0.368*	0.429**

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

plan a way to make it work for me' as well as 'I am too young to retire and too old to find work elsewhere' (Table 1).

DISCUSSION

We found that although the marine component of Gebel Elba National Park has been established for 23 years, only 11.4% of commercial fishers appeared to be clearly aware of it, suggesting that compliance to MPA requirements is minimal and/or that the local management agency has failed to raise awareness of the conservation status of the area among the local fishing community. However, our results also suggest that social factors are creating challenges or 'barriers' to marine conservation in the Red Sea (Marshall 2007; Marshall et al. 2009a, b). Specifically, we found a direct relationship between conservation attitudes and aspects of resource dependency. Fishers with a positive conservation attitude were more likely to have a comparatively higher income (Cinner and Pollnac 2004) and have entered the fishery at a later stage and were still young enough to find work elsewhere and plan for change. These results provide some strong support for our overarching hypothesis. However, many aspects of resource dependency were not highly correlated with conservation attitudes. For example, whether fishers had dependent children did not differentiate between fishers on the basis of conservation attitudes (Crean 1999; Capitani et al. 2004; Marshall 2008; Marshall et al. 2009a, b).

Our findings further support the notion that high levels of resource dependency are a barrier to fishers supporting conservation measures. This is due in part to the inflexibility of fishers to consider or obtain an alternative livelihood or earn additional income from elsewhere, and to absorb the costs of change. Such inflexibility is likely to reflect feelings of personal security. Without a positive outlook to the future, fishers in the Red Sea are unable to consider the longer-term sustainability of the marine environment.

Increasing the proportion of marine ecosystems under management or protection and maximising their effectiveness through better compliance while minimising social impacts are priorities for international conservation efforts. The imperative for more and larger MPAs is increasing, not only in the Red Sea but also in most marine ecosystems of the world (Lackey 1998). This is an important conservation goal, with expected long-term benefits to the broader society. However, resource-dependent people often are limited in their social flexibility and livelihood options, making them particularly vulnerable to change (Allison and Hobbs 2004). This explains why changes in resource access imposed by external forces (such as establishment of an MPA) can have particularly significant impacts on local resource users such as fishers (McClanahan et al. 2009).

The success of MPAs depends upon the adequacy and the breadth of the science behind it, the effects that it has on the resource and people, and how well the rules are communicated, followed and enforced. Understanding the human dimensions relating to an MPA is a critical step towards MPA success (Pomeroy et al. 2004). We hope that this investigation encourages MPA planners and managers to better communicate about local MPAs, test strategies for decreasing local dependency and increasing social resilience among resource-dependent peoples as a strategy to increase compliance with MPA rules and thus enhance marine conservation success.

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