Marine Policy 74 (2016) 153–157

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Missing the boat: Critical threats to coral reefs are neglected at global scale

Stephanie L. Wear[a,b,*]

[a] University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, NC 28557, United States
[b] The Nature Conservancy, Duke University Marine Lab, Beaufort, NC 28516, United States

ARTICLE INFO

Keywords:
Coastal development
Decision-making
Overfishing
Resource allocation
Ocean warming
Watershed pollution

ABSTRACT

Coral reefs have experienced a global decline due to overfishing, pollution, and warming oceans that are becoming increasingly acidic. To help halt and reverse this decline, interventions should be aimed at those threats reef experts and managers identify as most severe. The survey included responses from 170 managers, representing organizations from 50 countries and territories, and found that respondents generally agreed on the two major threats: overfishing and coastal development. However, resource allocation did not match this consensus on major threats. In particular, while overfishing receives much attention, coastal development and its attendant pollution are largely neglected and underfunded. These results call for a re-examination of how resources are allocated in coral reef conservation, with more attention given to aligning how money is spent with what are perceived to be the primary threats.

1. Introduction

Despite their well-documented importance to humans, coral reefs continue to decline at a steady pace [1–3]. *Reefs at Risk Revisited* (RRR), cited six primary stressors leading to the majority of decline in coral reefs: overfishing and destructive fishing, watershed-based pollution, marine-based pollution and damage, coastal development, thermal stress, and ocean acidification [3]. This report consolidated input from the world's leading experts on coral reefs and highlighted that these stressors are increasing in step with rising human population and activities (e.g., coastal development). Despite the collective efforts of many conservation organizations and governments to protect reefs, conservationists have been unable to keep pace with these anthropogenic threats. The authors of RRR conclude that the threat level increased by 30% between 1998 and 2011 [3] while coral coverage on reefs continued to decline [2].

It is clear that current reef conservation efforts are not sufficient. There are concurrent needs for both innovative approaches and a calibration of current reef conservation efforts with the magnitude of threats to these systems [4–7]. It is important to ask if resources are being put to best use [4,6,8]. To begin this process, reef conservationists must first assess if their resources (i.e., time and money) are being strategically allocated to address the major threats they face locally. This type of self-evaluation is critical to undertake, as threats change over time and conservationists and natural resource managers must continually track shifts in conservation priorities to determine whether their actions match those shifts [5]. While several studies have mapped the global distribution of threats [3,9,10] no studies have addressed the question of whether local coral reef conservation has adequately allocated resources to match the perceived local intensity of various threats to coral reefs.

An examination of the match between perceived threats and resource allocation is especially critical for coral reefs, because it is common for reef managers to cite a lack of resources as a limiting factor in their ability to achieve success (Author, personal observation). Using a survey of 170 reef managers from 110 different institutions around the world, an assessment was conducted to test whether perceived levels of the top six threats to coral reefs in their jurisdiction matched the relative amount of time and money allocated within their institutions. Specifically, the survey was designed to answer three main questions: (1) What is the perceived relative strength of threats to coral reef health? ; (2) Does the allocation of conservation and management resources match the degree of the perceived threat? ; and (3) If there are mismatches, why?

2. Material and methods

The experts surveyed for this study were comprised of practitioners with extensive experience (an average of 11.5 years) and knowledge of the coral reef conservation and management activities in their jurisdiction. Potential respondents were identified through The Nature Conservancy's Reef Resilience Network. This network was used because it is representative of the diversity of reef managers across the globe in that it includes reef managers from government, NGO,

* Correspondence address: The Nature Conservancy, Duke University Marine Lab, 135 Duke Marine Lab Road, Beaufort, NC 28516, United States.
E-mail address: swear@tnc.org.

http://dx.doi.org/10.1016/j.marpol.2016.09.009
Received 6 June 2016; Received in revised form 27 August 2016; Accepted 3 September 2016
Available online 21 September 2016

Table 1
List of geographies represented in the reef manager survey.

Geography name	
American Samoa[a]	Maldives
Australia	Marshall Islands
Bahamas	Mexico
Belize	Mozambique
Bermuda	Myanmar
Bonaire	New Zealand
Brazil	Palau
Cayman Islands	Philippines
Commonwealth of Northern Mariana Islands[a]	Pohnpei
Colombia	Puerto Rico[a]
Curacao	Saudi Arabia
Dominican Republic	Seychelles
Egypt	Solomon Islands
Fiji	Somalia
Germany	South Africa
Grenada	St. Eustatius
Guam[a]	St. Vincent and the Grenadines
Hawaii[a]	Tanzania
India	Thailand
Indonesia	Tonga
Jamaica	Trinidad and Tobago
Kenya	United Kingdom
Kosrae	Florida[a]
Lebanon	US Virgin Islands[a]
Madagascar	Venezuela
Malaysia	

[a] U.S. territories.

academic, and community organizations and managers working in more than 70 different countries and territories. From the larger pool of 750, 550 individuals were randomly chosen to receive a SurveyMonkey survey via email. The number selected to receive a survey (550) was chosen because returns on surveys in social science are often 20–30% and sample sizes of 100 are considered robust enough for evaluation and comparison [11]. The survey is available as Online Supplementary Material (OSM). The general goal of the study was provided in the introductory information and no incentive was provided to respondents to complete the survey. The survey data were collected between May and September of 2014. A total of 170 individuals responded to the survey. Of this group, 132 individuals completed the entire survey (47% NGOs, 11% academic, 33% government, and 8% private). These 132 respondents were representative of the geographic range of coral reefs as well as institutions involved in managing coral reef communities. Respondents were from 110 different institutions, 45 countries, and 5 territories (see Table 1 for geographies). Each of the respondents was asked to identify their job type (i.e., park manager, fisheries manager, natural/marine resource manager, research scientist, academic scientist, and program manager) and years of experience in coral reef conservation.

Six threat categories were used in the survey: (1) Overfishing and Destructive Fishing, (2) Watershed-based Pollution, (3) Marine-based Pollution and Damage, (4) Coastal Development, (5) Thermal Stress, and (6) Ocean Acidification. These categories were selected because they were identified as the top threats to coral reefs in RRR [3]. The same threat definitions provided by RRR were used (Table 2) to ensure consistency and clarity, and also allow the results to be placed in the context of RRR studies.

The perceived threat level of the six major threats was determined by asking respondents to rate the threats according to severity of threat to coral health in the respondent's jurisdiction. It is important to note the responses were not about global threats, but threats being experienced locally. To assess how time and money were being allocated to address each of the six major threats in those jurisdictions, the respondents were asked to estimate the amount of time and money their institution spent on each threat. Whether severity of threat aligned with the resources being directed to that threat was determined by comparing the ratings of threat severity and resource allocation.

All responses were pooled for each threat and the mean was calculated for each threat rating to estimate perceived threat ratings. In order to determine how much time was being spent to address each threat, all respondents combined were considered. All of the time estimates were pooled and a mean was calculated. In order to compare time or money spent to the perceived threat rating, only respondents that answered the questions about time and money were included in the threat ratings analyses.

Demographic and job description information about each respondent were reviewed to ensure the survey population was not biased towards a particular threat (i.e., overfishing) in terms of organizational or occupational mandate. Only three respondents identified themselves as a fisheries manager and only three institutions were identified as a fisheries agency or department. The vast majority of respondents represented organizations with broader natural resource or coral reef management purposes. The same steps were repeated in order to determine portion of budget dedicated to addressing each threat and how that compared to the perceived threat ratings.

To determine whether respondents currently perceived mismatches in threat severity and resource allocation to that threat, the respondents were asked whether resources allocated to addressing each particular threat were too little, too much, or just right for their jurisdiction. The responses were summed by threat category. To determine whether there was a strong opinion about a mismatch of allocations in general, all responses were combined in all threat categories. Respondents were given an opportunity to explain their responses if they had answered “too much” or “too little.”

To understand what factors respondents perceived to be major influences on decision-making about resource allocation, respondents were asked to select up to three options from eleven pre-selected choices, allowing them to also write in other responses. The eleven choices were intended to be comprehensive and selected based on past experience of working with coral reef managers at more than 25 international reef management workshops over 10 years in which over 600 managers attended (Author, personal observation). The responses were summed for each factor and the percentage was calculated across all responses. The six written responses that were provided were categorized into already existing factors.

2.1. Data analysis

Perceived threat level and resource allocation (time and money) data were analyzed using linear mixed-effects models with threat type as the fixed factor and respondent ID as the random effect factor. All analyses were conducted using R 3.1.2 (R Core Team 2015). The effect of threat type was tested by comparing the resulting deviance to F statistics (Type II sum of squares) using R car package. Tukey multiple comparisons were conducted using R multcomp package. Data from survey questions that assessed frequency of categorical responses, that is, whether there was too much or too little allocation to certain threats and factors that influence resource allocation decisions, were analyzed using chi-squared tests. Pairwise Fisher's test was used to test for differences between categories (P value adjustment method: holm).

3. Results

All threats were not viewed equally and a few threats emerged consistently as the most important. For respondents that answered time allocation questions, overfishing and coastal development were the most highly rated threats, and did not differ statistically from each other [Fig. 1a; n=95]. Watershed pollution and thermal stress did not differ statistically and were intermediate in rating and significantly lower than both overfishing and coastal development ($P < 0.03$ all contrasts). Marine pollution and ocean acidification did not differ from