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Dichotomy of mangrove management: A review of research and policy in the Mesoamerican reef region

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ABSTRACT

Mangroves are declining globally at faster rates than tropical forests and coral reefs, with primary threats including, aquaculture, agriculture and climate change. Mangroves provide ecosystem services to coastal communities of Mexico, Belize, Guatemala and Honduras, which comprise the Mesoamerican Reef (MAR) ecoregion. Over the past two decades mangroves within the MAR have declined. Current estimates of mangrove cover in the region suggest that mangroves cover 239,176 ha of the MAR, equivalent to 1.7% of the world's mangroves. Concerted efforts to manage, conserve and protect mangrove forest are apparent in all four countries. Comprehensive laws that prohibit the cutting and clearing of mangroves have been implemented in Mexico, Guatemala and Honduras. Belize has a permitting system to regulate mangrove alterations. In addition, a total of seven international and regional agreements have been ratified. Across the ecoregion, forty-three protected areas have been designated that contain mangroves, providing protection to 111,396 ha of mangroves (47% of the total). However, our findings suggest a lack of transparency in the governance framework, a disconnect between management and research, and geopolitical differences have all played a role in reducing management efficacy. A key finding of our study reveals a distinct division in the perceived major threats to mangroves between Ramsar site managers and researchers. Ramsar site managers identify anthropogenic disturbances as key threats, while in contrast, the bulk of research focuses on natural disturbances. To promote the inclusion of evidence-based research within mangrove management plans, greater efforts to connect these important stakeholders are required.

1. Introduction

Mangroves are a diverse group of halophytic plant species, which form highly productive forests in the area between mean sea level and the highest spring tide mark along tropical and sub-tropical coastlines and estuaries (Tomlinson, 1994). Once perceived as mosquito infested wastelands, mangroves have now been recognized as highly productive and ecologically important ecosystems. Providing ecosystem services to marine and terrestrial environments, and human societies (Gilman et al., 2008; Nagelkerken et al., 2008), which are valued at US $9900–35,900 $ha^{-1}yr^{-1}$ (Costanza et al., 1997; Sathirithai and Barbier, 2001; Barbier, Hacker, Kennedy, Kock, Stier, 2011). Some of the most important mangrove ecosystem services include: coastline protection (in particular storm, hurricane and tsunami protection); waste water treatment; production of extractable materials; and provision of cultural sites (Rönnbäck et al., 2007; Warren-Rhodes et al., 2011). Despite the known value of these forests, mangroves are highly threatened. Deforestation estimates suggest mangrove cover has declined by 30–86% since the mid 1990's (Duke et al., 2007), and mangroves continue to decline globally at unprecedented rates (FAO, 2007). Globally the main threats to mangrove forests include: coastal development; logging for timber and fuel; aquaculture; salt extraction; and agriculture (Valiela et al., 2001; Alongi, 2002; Rönnbäck et al., 2007). The additional threats of climate change, e.g. sea-level rise, are also of concern (Schaeffer-Novelli et al., 2016; Short et al., 2016). Understanding if or how mangroves can adapt to such changes is of particular relevance to already threatened ecosystems, e.g. in the Caribbean (Godoy and De Lacerda, 2015; Sasmito et al., 2016).

The majority (over 70%) of mangroves are located within developing countries (Giri et al., 2011), where limited resources and capacity can inhibit effective management. At the international level, a number of treaties and conventions afford some protection to mangroves (Macintosh and Ashton, 2002), for example: the Ramsar Convention (1974); the Cartagena Convention (1983); and the International Tropical Timber Agreement (2011). However, few of these treaties provide any effective legal protection and none of them address the

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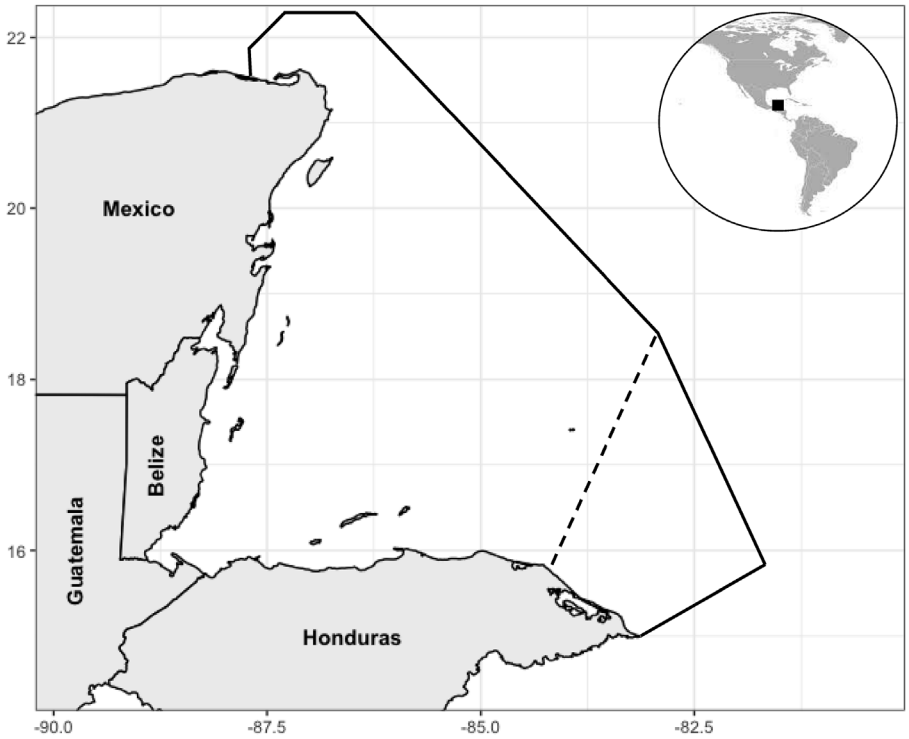

Fig. 1. Map of the Mesoamerican Reef Eco-region. Solid line highlights the area included within the study, the official boundary of the MAR (dotted line) does not include the eastern north shore of Honduras.

conservation, preservation, or management of a particular mangrove species (Polidoro et al., 2010). National legislation pertaining to mangrove management in the 1960's was primarily focused on mangrove exploitation (Carter et al., 2015). However, over the past five decades management has progressed which has led to the integration of mangroves into coastal zone management plans (Carter et al., 2015).

Common tools for the preservation and management of mangrove and other marine ecosystems include: marine protected areas (MPA's); nature reserves; wilderness areas; national monuments and national parks. Since 1974, increasing protection has been provided through Ramsar site designation. To date, 281 Ramsar sites (12.5% of all Ramsar sites) are intertidal forested wetlands, which includes mangrove forests (www.ramsar.org). Although increased recognition of mangroves in management plans is encouraging, the majority of plans associated with MPA's and Ramsar sites are based on generalized characteristics and threats, with limited reference to prior scientific research. In fact, there appears to be no effective mechanism for creating links between management activities for, and scientific research on, mangroves, thus research is rarely incorporated into management plans. Similar observations have been made in the management of coral reef ecosystems, where a mere 14% of information cited in management plans for the reefs of Australia, Kenya and Belize was primary research (Cvitanovic et al., 2014). In this case, research was deemed to be inaccessible to managers due to, long publication times, subscription only access to research and poor articulation of management implications of the research (Cvitanovic et al., 2014). Yet, for effective management to take place, evidence based decision-making is critical (Christensen et al., 1996; Ruckelshaus et al., 2008).

In this article we use the Mesoamerican reef (MAR) ecoregion as a case study, to examine the current status of mangroves, the legislation implemented to protect, manage and conserve mangroves, and review peer-reviewed scientific outputs from the region. The aim of this paper is to understand the current management paradigms within the MAR and identify threats to mangroves within the region. We compare the foci of management strategies and research programs in order to determine where overlap occurs and where there are gaps in the knowledge base.

2. Methods

2.1. Study area

We have chosen to focus on the Mesoamerican Reef (MAR) ecoregion because the majority of mangrove research is concentrated in South-East Asia, where larger and more diverse stands of mangroves are located (Saenger, 2002). Much less is known about these ecosystems in Latin America and the Caribbean (but see, Ellison and Farnsworth, 1997; Núñez-Farfán et al., 2002; Ellison, 2004). The MAR ecoregion extends over 1000 km from the Yucatan peninsula, Mexico (21.56°N; 087.09°W) to the east coast of Honduras (14.97°N; 083.16°W), encompassing the Caribbean coastlines, open-ocean, networks of cays, and offshore banks of Mexico, Belize, Guatemala and Honduras (Kramer and Kramer, 2002) (Fig. 1). It is home to the largest barrier reef in the western hemisphere and supports the livelihoods of approximately two million people (Kramer and Kramer, 2002), of particular importance are the fishing (Box and Canty, 2010) and tourism industries (Doiron and Weissenberger, 2014). Considerable attention has been given to coral reefs in the region, however seagrass and mangrove ecosystems have often been overlooked. In this review we consider the entire Honduran north shore as part of the MAR ecoregion, due to potentially high levels of connectivity between the Honduran east coast and the MAR (Butler et al., 2011; Truelove et al., 2015; Chollett et al., 2017). The boundaries of the ecoregion were originally defined by the presence of several physiogeographic boundaries, these include the Gulf of Mexico, strong oceanic currents between the Yucatan peninsular, Mexico and south west Cuba, the shallow waters of the Nicaraguan rise, Honduras, in addition to a number of terrestrial environmental variables, e.g. rainfall. The ecoregion was officially declared in 1997 as part of the Tulum agreement, where all four counties came together recognizing the importance of the region and the need to jointly manage a

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