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Environmental and socioeconomic assessment of a poorly known coastal section in the southern Mexican Caribbean

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ABSTRACT

The Uvero-Punta Piedras section, a low-developed coastal strip located in the southern area of Quintana Roo, Mexico, is experiencing habitat degradation driven by unplanned population sprawl, unregulated tourism expansion and overfishing. The main objective of this study is to provide an environmental (coastal vegetation and coral reef condition) and socioeconomic (human population condition) baseline data of a poorly documented and weakly managed zone by the use of a set of rapid assessment methodologies, looking to assist the regional efforts to manage these coastal resources. To achieve this goal we used a series of surveying methods including remote sensing, geographic information systems and *in situ* land/underwater surveys, to allow a broad characterization of the resources' condition in the study zone. Results showed that reef habitat was dominated by macro-algae (61.2 ± 7.6%), followed by soft coral (gorgonians, 12.4 ± 4.1%), hard coral (8.2 ± 5.1%) and sponges (2.5 ± 1.3%). Zooanthids and tunicates represented less than 1% of the total; coral and macro algae estimates suggest a decline from records of 15 years ago. Highest fish densities were (144 ± 124 individuals/100 m^2), while lowest were (83 ± 25 individuals/100 m^2). The total average fish density recorded could also be reflecting a decrease trend in the reef community structure. The main economic activities in the area are fishing and land clearing. From December 2003, 22% (corresponding to 44 ha) of the total original vegetation cover in the studied area was deforested. By February 2007, the deforested area increased 4.4 ha more. Should this tendency continue, by 2025 it would only maintain 24% of its total coastal vegetation cover representing a huge habitat loss. The future of economic activities in these areas lie directly on the establishment of appropriate management strategies for the protection and conservation of the renowned biodiversity that this area comprises.

1. Introduction

The increase in human population density in coastal areas exerts enormous pressure on the integrity of coastal habitats (particularly over wetlands and coral reefs) affecting the processes on which the entire coastal ecosystem relies (Clark, 1992). This is despite the numerous environmental services they provide, ecologically and economically, to humans (Barbier, 1994; Moberg and Folke 1999, NOAA 2003).

In the State of Quintana Roo (Mexican Caribbean coast) mass tourism has been the main activity triggering development and hence the main source of ecological affectation. Cancun and its surrounding areas demonstrate striking examples of land conversion (Pérez-Villegas and Carrascal, 2000; Yáñez et al. 2004), causing

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extensive loss of the coastal vegetation cover to allow hotel and urban construction. In fact, more than 25% of Quintana Roo's mangrove coverage has been lost since 1985 (INE, 2005).

Such extensive vegetation removal results in a combination of negative effects that impose serious threats to underwater habitats. Water pollution, eutrophication and increased sedimentation flowing from disturbed terrestrial environments are some of the main causes of negative effects on coral and coral reefs functioning (Clark, 1992; Hoegh-Guldberg, 1999; Moberg and Folke 1999, D'Angelo and Wiedenmann, 2014). Throughout large parts of the Mesoamerican Barrier Reef, including the Quintana Roo region, intense fishing pressures coupled with poor land-use practises and unregulated coastal development pose major threats to reefs (Lang et al. 1998; Kramer et al. 2000; Almada-Villela et al. 2002; Murray, 2007).

Deficient coastal zone management can also cause socioeconomic and cultural conflicts. In Quintana Roo, the governmental policies for tourism development are affecting the state both ecologically and socially (Melbourne-Thomas et al. 2011). Mahahual town, a former small fishermen's village, has recently become a focal point for mass tourism development in the region (Olivera-Gómez and Campos-Cámara 2007). The potential land use program considers the construction of 30,000 hotel rooms on this region and a population up to 200,000 inhabitants by the year 2025 (Gobierno del Estado de Quintana Roo et al. 2005). The coastal and marine resources of this area will most likely be in jeopardy unless effective management strategies are to be established, bringing in the requirements of specific segments of the community (Cinner and Pollnac, 2004).

With regards to the already existing habitat loss, biodiversity reduction, and social conflicts brought about by coastal development trends, it is imperative that suitable environmental impact assessments are incorporated into the planning of any human activity (De Groot, 1992; Weber et al. 2006; Infante et al. 2009).

The utilization of a set of methods known as rapid assessments (RA) provides the opportunity for scientists to swiftly study the conditions around important ecosystems when time, funding and geography impose restrictions for more precise research (Maragos and Cook, 1995). RA techniques also provide a reference frame and base-line data for the study of ecosystem dynamics in order to rapidly generate and disseminate information, allowing for better design priorities, planning policies, as well as the establishment of conservation areasand sustainable management (Ojima et al. 1994; Allen and Werner, 2002). These techniques have been applied globally for data collection geared towards conservation, planning and development objectives (TNC, 1992; Maragos and Cook, 1995; DeVantier et al. 1998; Sedaghatkish and Roca, 1999; Sayre et al. 2000; Turak and Wakeford, 2002; Boles et al. 2004; Markham and Browne, 2007). Since time for the study is limited, RA does not intend to provide quantitative information on the dynamics of coastal ecological processes, however, it has its theoretical base in previous worldwide ecological research, it provides ecological indicators or actual status of natural systems.

The main objective of this study was to obtain environmental and socioeconomic base-line data and ecological indicators, using RA methodologies, to provide for a management-lacking zone within the tourism development region in southern Quintana Roo. To achieve this goal we used a series of surveying methods including remote sensing, Geographic Information Systems (GIS) and *in situ* surveys (on land and underwater), to allow a broad characterization of the resources' condition in the zone.

2. Materials and methods

Study area: The study was carried out in the Uvero - Punta Piedras (U-PP) section, located in southern Quintana Roo, Mexico (18° 56′47″-19° 04′ 12″ N, and 87° 37′ −87° 33′ W), bordered by the Sian Ka'an Biosphere Reserve on the north side, the Mesoamerican Barrier Reef System (MBRS) on the east, Uaymil Flora and Fauna Protection Area on the west and the town of Mahahual, which is without protection status but with traditional fishing activities and important fast-growing touristic activities, on the south (Gobierno del Estado de Quintana Roo et al. 2005, Fig. 1). The inland area is covered by wetlands such as mangrove, swamps, tropical low semi-evergreen forest and dune vegetation, and supported by a significant coastal lagoons system. The reef habitat, corresponding to Northern Central America, shelters more than 65 species of stony coral, 350 species of mollusc and more than 500 species of fish, together with a great diversity of marine invertebrates, birds, plants, marine turtles and mammals (Kramer and Kramer, 2002). The terrestrial and reef ecosystems of this area are supposed to be closely associated, as it is in all the Caribbean, through hydrodynamics, biological connectivity and buffering capacities of protection in both directions (Linton and Warner, 2003). However, in a summary of the available information about ecological, socioeconomic and shipping activities in the Mexican portion of the MBRS, specific information about our study area is lacking (Ardisson et al. 2011).

Assessment of the study zone: We used an assessment methodology that integrated different techniques, designed to collect a broad range of information about the ecological and anthropogenic conditions of the study zone. Each method used was selected according to its technical potential (standardized methods applied by similar studies on alike environments) and its suitability for implementation (cost-benefit potential).

Environmental diagnosis: The environmental diagnosis involved the characterization of: (1) the condition of the coral reef assemblages and, (2) the vegetation cover change associated with land use; we focused on the sand dune vegetation and adjacent mangrove lining the sea side of coastal lagoons within the immediate coastline strip. These two systems were selected as indicators because they best reflect the ecological impacts resulting from anthropogenic activities, such as vegetation clear off for timber, wood-fuel, agriculture, human settlement, fishing and tourism. The entire study zone was divided into four sectors ~6 km long each (Fig. 1). This approach allowed us to compare variables between these sectors and identify possible differences for each assessed variable.

Coral reef characterization: The reef characterization comprised a combination of techniques commonly used for coral and fish assessment (Maragos and Cook 1995, Page et al. 2001, Turak and Wakeford 2002, Almada-Villela et al. 2003, Núñez-Lara et al. 2003, Ruiz-Zárate et al. 2003, Steneck and Lang 1999, Kramer et al. 2005). A reef section was selected because it was neighbouring two protected areas (Fig. 1) and it was poorly known; some reefs in the northern and southern section have been characterized before from data taken in 1993 (Gutiérrez-Carbonell et al. 2005), 1999–2000 (Arias-González et al. 2011), and 2000–2010 (Acosta-González et al. 2013). This information provided an important baseline and reference for an overview of the change on the structure and diversity of the reef communities.

Data collection was conducted under a hierarchical survey design (English et al. 1997) based on three spatial scales: the local geographic area (zone = ~15 km of coastal line), reef sections (sectors I–IV; ~3–4 km of coastal line, every sector) and survey points (sites 1–14; ~1 km distant sites in every sector, except in sectors I and II) (Fig. 1). Fieldwork was carried out in two survey campaigns, late March and mid April 2007. Every survey site was selected based on satellite images, which aimed to concentrate the efforts on the inner (slope) fore-reef accretion structure because