



Submerged Coral Reefs in the Veracruz Reef System, Mexico, and its implications for marine protected area management

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ABSTRACT

Submerged coral reefs (SCRs) are found on the continental shelves of the tropical regions of the world. Unlike shallow reefs, such submerged structures have been little studied in the world despite their ecological importance. We present the results of several explorations carried out between 2015 and 2017 in the Sistema Arrecifal Veracruzano National Park (SAVNP) and surrounding areas, which account for the presence of 18 SCRs both inside and outside the National Park. The location of these reefs was based on user information, literature and official documents. Through the use of echo sounder, the dimensions and morphological conformation of the reefs were identified. The protection of submerged coral reefs in the SAVNP is limited. They are not fully considered in the MPA creation decrees, and most of them are located in areas assigned to artisanal fisheries. Connectivity, fisheries, port activities and the lack of scientific information are issues to be attended by environmental authorities to guarantee the protection of these ecosystems.

1. Introduction

A common theme of successful protected areas established to date is to include, wherever possible, appropriate and available science in the decision-making process (Lundquist and Granek, 2005). In Marine Protected Areas (MPA), effective management may depend, between other issues, in the substantial inclusion of representative habitats (Fox et al., 2012).

In the case of MPAs that integrate coral reefs, it is very common for protection and conservation initiatives to focus on those reefs that are near to the surface (Bridge et al., 2013). However, in many cases the spatial distribution and even the existence of deeper reefs are unknown (Harris et al., 2013). In fact, estimates of global impacts on coral ecosystems by anthropogenic activities underestimate the presence of those reefs that are submerged and are not easily detectable (Bridge et al., 2013; Harris et al., 2013).

In this paper we present the results of several explorations carried out between 2015 and 2017 in the Sistema Arrecifal Veracruzano National Park (SAVNP), México, and surrounding areas, which account for the presence of Submerged Coral Reefs (SCRs) both inside and outside the National Park. The geographical location and geomorphological configuration of the reefs are shown, and the implications of their presence for the management of the protected area are discussed.

With this work, it is intended that this type of ecosystem be known and considered in the conservation initiatives of the SAVNP, since there is no specific protection policy for its management.

1.1. Submerged Coral Reefs and Mesophotic Coral Ecosystems

The Submerged Coral Reefs (SCRs) are found on the continental shelves of the tropical regions of the world, at varying depths ranging from a few meters to more than 150. Due to this, such structures are generally not visible in aerial photographs or satellite images (Harris et al., 2013) nor are they perceptible when navigating the sea surface since they do not present zones of breakage of waves.

SCRs are reefs formed during periods of lower sea level, which currently have little or no modern upward coral framework accretion. They are thought to have drowned as a result of inimical environmental conditions associated with sea level rise during the last deglaciation (Abbey and Webster, 2011).

Although SCRs have lost their capacity for rapid growth, their ecological importance is notorious. At sites such as the Great Barrier Reef, Australia, these reefs have been reported to substantially increase the availability of suitable habitats for coral growth (Harris et al., 2013), and may contribute significantly to the production of coral larvae (Thomas et al., 2015). In addition, there is a hypothesis that

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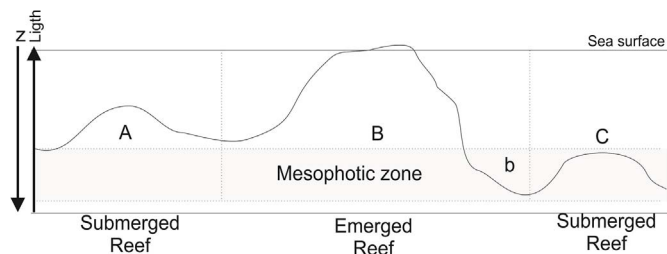


Fig. 1. Emerged and submerged reefs and their relationship with the mesophotic zones. A) Submerged reef outside the mesophotic zone; B) emerged reef with windward slope within the mesophotic zone (b); C) Submerged reef within the mesophotic zone.

these types of environments can serve as refuges for species affected by ocean warming (Bongaerts et al., 2010; Bridge et al., 2014; Harris et al., 2013; Riegl and Piller, 2003).

Several of these SCRs may represent or contain Mesophotic Coral Ecosystems (MCE). The MCE refer to coral communities that live in areas with low light intensity where photosynthesis is still possible in the zooxanthellae associated with corals (Hinderstein et al., 2010). These areas can have a wide range of depth depending on the particular oceanographic conditions that influence the penetration of solar radiation (Lesser et al., 2009). Not all submerged reefs are mesophotic ecosystems and not all mesophotic ecosystems can be classified as submerged reefs, since the presence of this type of ecosystem is determined primarily by the intensity of the light they receive from the surface. Therefore, many emerged reefs present these mesophotic conditions in their fore reef zone (Fig. 1).

1.2. SCRs in the Gulf of Mexico and Caribbean

In the northern portion of the Gulf of Mexico, several SCRs have been discovered, the most prominent and studied being the Flower Banks, which have depths between 36 and 52 m (Parker and Curry, 1956; Moore and Bullis, 1960; Brighth et al., 1984). It is also known the presence of this type of environments in shallow waters on the continental shelf of the Florida peninsula (Rohmann et al., 2005) where MCEs are also presented (Locker et al., 2010).

In the Caribbean Sea, the presence of SCRs in the Mesoamerican Reef System has been reported (Bongaerts et al., 2010). Recent studies have found SCR in the Yucatan peninsula (Blanchon et al., 2017), in Utila, Honduras (Andradi-Brown et al., 2016), Dominican Republic (Martínez Battle et al., 2003) and others.

1.3. The Sistema Arrecifal Veracruzano national park

The Sistema Arrecifal Veracruzano National Park is a coral reef area located in the central part of the Reef Corridor of the Southwest Gulf of Mexico (RCSGM) (Ortiz-Lozano et al., 2013), being the one that presents/displays a greater number of reef structures and coral species. This Marine Protected Area (MPA) was established by the Mexican Federal Government as National Park since 1992 (DOF, 1992), and acquired the name of Ramsar Site in 2004. Two years later it was registered as a reserve in the UNESCO Man and Biosphere program (Valadéz-Rocha and Ortiz-Lozano, 2013). This National Park underwent a major modification in its protection area in 2012 (DOF, 2012), when its boundaries were changed to facilitate the authorization of the project to expand the Port of Veracruz in Bahía Vergara. After 25 years of lacking a Management Program, in 2017 the Federal Government made official its publication.

Despite being a National Park that houses one of the largest Mexican ports, the presence of submerged reefs has been little documented within this protected area. The official charts do not clearly establish the presence of these structures, while fishermen and SCUBA diving service providers are more aware of their presence. The National Park

Management Program mentions only “drowned” reefs (common name assigned to submerged reefs) but it is not clear to show its location and does not establish particular policies for its protection.

2. Methods

The study area is defined as the area between Villa Rica, municipality of Actopan, and Antón Lizardo, Alvarado municipality, both in the state of Veracruz, Mexico (Fig. 2). Explorations were carried out between January 2015 and July 2017 in the study area. The sampling sites were selected from three sources of information.

Users. Reports were obtained of fishing sites in the towns of Villa Rica, Chachalacas, Veracruz, Boca del Río and Antón Lizardo. The fishermen provided data on the geographical location of these sites. A SCUBA dive shop in the Port of Veracruz provided us with the geographical coordinates of deep dive sites.

Literature. The geographic coordinates of places of interest for the sport diving established in the guide titled “Veracruz and its submarine tourism”, published by the Government of the State of Veracruz, were obtained.

Official cartography. Through the National Institute of Access to Information, a bathymetric chart was obtained from the Veracruz Reef System National Park generated in 2015 by the Integral Port Administration of Veracruz (IPA; request 0918200007217). This chart was used to verify the presence of reefs in sites reported by users (fishermen and divers), and to locate other potential reef sites. In addition, cartographic information generated by the National Commission of Protected Natural Areas (NCPNA) was obtained. This information served to locate the polygons of some submerged reefs, which were later modified through the samples made for this research.

From these data, visits were made to each site to make a reconnaissance of the place in order to verify the presence of coral structures, regardless of the live coral coverage. Bathymetric data were obtained using an echo sounder GARMIN echoMAP CHIRP 92sv. Since the objective of our research was to locate and demonstrate the presence of submerged reefs, the use of this measurement equipment represents a low cost tool that generates acceptable bathymetric charts. However, the use of higher definition equipment would be advisable for future investigations.

Transects were drawn 50 m apart on each submerged structures and depth data were taken every meter. The information collected with echo sounder (coordinates x, y, z) was transferred to a database to be used in the software SURFER 14 (Golden Software). The number of data obtained for each reef was different according to its dimensions (Table 1). Digital models were developed by interpolation (kriging) for each reef. The generated models were exported as isobaths to the ARCGIS software (ESRI) where the polygons of each reef were created. Surface, perimeter and morphological axe were calculated to dimension each reef building.

Each identified reef was assigned a name matching the sources of information. If they did not have a name, they were assigned an identification code (Table 2).

A review of official documents related to the management of this National Park was made to identify the role of submerged reefs within protection policies, including fishing and port activities. The documents consulted were the Decrees creating the protected area (1992 and 2012) and the Management Program (CONANP, 2017), as well as the Mexican laws related to the subject. In addition, the Environmental Impact Assessment of the Expansion Project of the Port of Veracruz in the North Zone was consulted to identify possible interactions between port activities and SCRs.

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