Networking Among Scientists and Managers Improves Benthic Habitat Knowledge at six remote Caribbean MPA's

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ABSTRACT

Improving benthic habitat information within remote Caribbean marine protected areas (MPA) requires diverse skills, including capability with remote sensing techniques and the use geographic information system (GIS) applications. A new network of scientists and managers within the region has formed to provide this capacity, with initial training funded by NOAA's International Coral Reef Conservation Program. After two years of cooperative work, the 16 collaborating scientists and managers from Mexico, Colombia, Venezuela, Dominican Republic, Puerto Rico and United States of America were able to increase the benthic habitat knowledge of MPAs in their countries. After two training sessions covering in-situ use of remote sensing gear and the manipulation of combined remotely-sensed imagery products, the group generated new habitat maps, verified habitat interpretations of existing benthic maps, and correctly layered old and recent field transects over maps having multiple datums. Habitat maps were based either on high resolution imagery in deep water environments (30 m) using side scan sonar, or more shallow water habitats (up to 10 m) using aerial photographs, satellite information or a combination of both. In addition, they received training in the use of Marxan as a conservation tool by learning from applications developed in Puerto Rico and Venezuela. Use of the internet and the creation of a virtual forum for further discussion have facilitated group communications and fostered further cohesion, thanks to the support of the CONANP (Mexican Commission of Protected Areas). Capacity building among trained participants explored alternatives on how to share limited available resources within developing countries while increasing skills in technologies and agencies or NGO's project developments. As a direct result, the group has obtained additional funds through the White Water to Blue Water initiative, and will continue this collaborative effort next year by working in Jaragua National Park in the Dominican Republic.

KEY WORDS: MPA capacity building, habitat mapping, functional networking

Trabajo Cooperativo entre Cientificos y Manejadores Mejoran el Conocimiento de Habitats Benticos en Seis AMP Remotas del Caribe

El mejoramiento de la información de hábitats bénticos en áreas marinas protegidas (AMP) remotas del Caribe requiere diversas habilidades, incluyendo la capacidad de usar técnicas de sensores remotos y la aplicación de sistemas de información geográfica (SIG). Una nueva red de trabajo de científicos y manejadores en la región se ha formado para proveer esta capacidad, con un entrenamiento inicial financiado por el Programa Internacional de Conservación de Arrecifes de la NOAA. Después de dos años de trabajo cooperativo, 16 científicos y manejadores de México, Colombia, Venezuela, República Dominicana, Puerto Rico y Estados Unidos de América ayudándose mutuamente fueron capaces de incrementar el conocimiento de los hábitats bénticos de AMPs en sus países. Con dos sesiones de entrenamiento incluyendo el uso in situ de equipos de sensores remotos y la manipulación de productos de imágenes de sensores remotos, el grupo generó nuevos mapas de hábitats, verificó la interpretación de mapas de hábitats existentes y supo utilizar correctamente capas de información de trabajos de campo antiguos y recientes en mapas que tenían múltiples datums. Los mapas de hábitats se basaron en imágenes de alta resolución en ambientes de aguas profundas (30 m) usando un sonar de barrido lateral o en fotos aéreas o

imágenes de satélite en ambientes más someros (hasta 10 m) o una combinación de los dos. Adicionalmente, ellos recibieron entrenamiento en el uso de Marxan como una herramienta de conservación, aprendiendo de aplicaciones desarrolladas en Puerto Rico y Venezuela. El uso del internet y la creación de un foro virtual ha facilitado la comunicación grupal y ha permitido una mayor cohesión, gracias al apoyo de la Comisión de Áreas Protegidas (CONANP) de México. El fortalecimiento entre los participantes entrenados busco alternativas para compartir los limitados recursos disponibles de los países en desarrollo a la vez que incremento la capacidad en el conocimiento de tecnologías y capacidades de desarrollo de proyectos de las agencias de gobierno o de ONG's. Como un resultado directo, el grupo ha obtenido fondos adicionales a través de la Iniciativa Agua Blanca hacia Agua Azul y continuara su esfuerzo colaborativo el próximo año trabajando en el Parque Nacional Jaragua en la Republica Dominicana.

PALABRAS CLAVES: Fortalecimiento de AMP, mapeo de hábitats, redes de cooperación.

INTRODUCTION

This paper presents results achieved with development of the project entitled "Increasing Training and Technique Exchange for Siting MPAs in Remote Coral Reef Environments in the Caribbean" funded by the Coral Reef International Program at NOAA/NOS. The project began in October 1, 2004 and ended in September 30, 2006.

The main objectives of project were to: a) Offer training in practical side scan sonar (SSS) methods to collect detailed habitat information. Training also covered analysis of existing aerial photographs/ satellite imagery; b) Increase exchange of experience in planning field work at distant oceanic areas looking at international/national cooperative alternatives by establishing working networks; c) Teach habitat concepts based on biological and ecological criteria, incorporating them into MPA management and designation; d) Increase capacity building by incorporating GIS tools to process and analyze multi-scale habitat information, as well as using various sources of imagery; e) Increase knowledge on application of habitat maps in Marine Reserve site and network design.

METHODS

The project consisted of two main training sessions of intense theoretical and practical courses dedicated to increase habitat knowledge in coral reefs from remote MPA's in the Caribbean. Participants were selected based on instructor experienced and by looking at existing databases such as GCFI (Gulf and Caribbean Fisheries Institute) and CAMPAM (Caribbean MPA management).

The first training session was conducted at Chinchorro Bank field station during April 11-26/05, were 16 people, including three instructors, from six countries worked on: a) Preparation of equipment and logistics, b) Conceptual basis on benthic habitats and generalities on marine acoustic, c) Develop a detailed work plan, including the preparation of the navigation files, selection of working area, equipment and software installation, d) collection and processing of side scan sonar imagery, including filtering, mosaic corrections and geotiff exports for future habitat digitizing, e) habitat classification and map generation, f) acquisition of extensive ground truthing information. The field work was done onboard of BIP VIII, the Chinchorro Bank Biosphere Reserve recently acquired research platform. Post-processing, regular classes and community meetings were held at the station conference room. Methods were adapted from Prada et al. 2004.

The second training session congregated 19 people in San Andres Island, Colombia which attended the course between April 31 and May 7, 2006. The course was held at SENA (Servicio Nacional de Aprendizaje) installations, which is a governmental agency dedicated to train people according to local industry requirements. The second session training focused in: a) Follow up and finishing participants project's by combining existing imagery from different technologies, b) Increase capacity building in GIS applications focused on habitat issues at remote coral reefs environments, c) Receive lectures on the use of Marxan, based on two Caribbean applications, d) Developed a special workshop, round tables and discussion forums looking at answers on MPA management and GIS necessities, e) Define future networking and training, including experience in field work at distant oceanic areas.

Additional capacity building obtained from this project was reflected by facilitating participation in international meetings, establishment of a web page and a web-discussion forum, formulation of a new proposal for extending collaborative mapping efforts, and by supporting local manager agencies with advise and sharing experiences implementing the mechanism of sister reserves.

RESULTS

As direct result from this project six Caribbean MPA maps were beneficiated with the increase in habitat knowledge of their coral reef environments. All maps generated have been posted on the project web page (http://pyucatan.conanp.gob.mx/sss.htm) and a short description of each mapping results is presented below.

Mexico Project 1: Benthic mapping of the Chinchorro bank Biosphere Reserve Diving Zone.

By, Bárbara Reveles, Jorge Carranza, Gerardo Ríos, Felipe Fonseca, Felipe Be, CONANP, Gildardo Alarcón, Secretaria de Marina and Antonio Iturbe, Universidad de Quintana Roo.

Georeferenced sonar habitats mosaics were used for

benthic habitat mapping, which produced a 1:3000 map with seven identified habitats accordingly with extensive ground truthing information collected immediately after the sonar acquisition. The new map identified benthic habitats for a total of 53.7 square kilometers, were two types of sand (with and without structure) accounting for up to 83% of the study area. In total 8.4 square kilometers of corals were identified within four different habitat types: continuous corals and large, medium and small coral patches. Submerged aquatic vegetation in this area represented less than 1% (Table 1, Appendix 1).

The new information was utilized to update the reserve management plan (SEMARNAT 2000), but resulted of significant resource when going through the process of Chinchorro's nomination as a UICN heritage site, presently under evaluation.

Mexico Project 2: Locating foraging areas of juvenile sea turtles within Arrecife Alacranes National Park

By, Felipe Be Estrella, CONANP

The objective of this project was to contribute with CONANP requirements in locating foraging areas for juvenile turtles within the Arrecife Alacranes National Park to define whether previously identified areas are inside of the conservation zones. Arrecife Alacranes is located 140 km North of Progreso on the Yucatan shelf (22° 34' 55" N, 89° 47' 53" W and 22° 21' 45'' N, 89° 36' 47''W) extending over 333.768 ha. The whole area is being recognized by its nesting beaches for *Chelonia mydas, Caretta caretta* and *Eretmochelys imbricata* among other biodiversity resources. The reef got its legal protection back in 1994. CONANP is interested in locate areas where juvenile turtles are abundant to continue with its mark and recapture programs.

Existing GPS positions were rescued from field work notes taken by local scientists 11 years ago and were given voluntarily to CONANP for this project. Points were located on top of existing benthic and zoning maps in order to classify them as in or out of conservation zones.

Results indicated that only four out of nine sites classified as areas with high turtle abundances were inside of the nuclei zone (protected zone). Same results were obtained when compared this sightings over previously identified areas as having high probability of turtle encounters.

Colombia Project: Benthic habitats of the south end of Quitasueño bank, Seaflower Biosphere Reserve.

By, Anthony Mitchell, Robert Hudgson and Giovanna Peñaloza, CORALINA.

The CORALINA team selected the south end of the remote Quitasueño bank as their study area. Quitasueño is the major coral reef bank in Colombia with an extension of 1,320 square kilometers, located between 14˚00' N, 81˚00' W and 14˚50'N, 81˚30' W, 70 km NNE of Providence island. This bank constitutes one of the three reef complexes within the northern section of the Seaflower MPA, established in 2005, and has been supported intense levels of industrial fishing. The project pretended to compare an existing benthic map generated from visual interpretation of aerial photographs with a new map generated by digital processing techniques using same aerial photographs (1:10.000) taken in 1960.

Initially the aerial photograph was georeferenced against a Landsat TM satellite image. A subset of 170 square kilometers at the south end of the bank was selected as the study area, mapping an area previously identified to be one of the most intensively area fished. Utilizing ILWIS (Integrated land and water information system) software Vs. 3.1 they run an unsupervised classification, obtaining a map with seven habitat classes. Habitat types were assigned to the habitat classes based on scientific information CORALINA collected during 2003 expedition to the bank and other existing biological information available.

The new map identified 58% of the area to be sand with dispersed algae, with additionally 30% conformed by other types of sand (having more structure). Corals represented only 10% of the area to be the most abundant habitat type followed by sand and dispersed corals and sand, corals and rubble (Table 1, 2). In comparison, in previous habitat map overestimated corals to be as high as 51% of the area and underestimated sand to account only for 49% of the study area.

The advantage of this project was to better illustrate reef complexity on the bank, not yet captured from the visual interpreters, with habitat polygons boundaries following more natural shapes and better definition of habitat types.

Dominican Republic Project 1: "Photo-interpretation of coastal and marine habitats of Laguna de Puerto Viejo, Azua".

By, Guilio Marin, Sub-secretariat of Coastal and Marine Resources, Office of Conservation and Management.

The study area is located at the south central section of the Dominican Republic shelf, in the Azua Peninsula (18° 18´ N, 70° 49' W and 18° 21' N, 70° 52' W), forming a 6.94 square kilometer typical coastal lagoon. The whole peninsula was declared as the wildlife reserve recognizing its value as nursery habitat (Luczkovich 1993). However, the lagoon supports intense levels of fishing and boating and receives discharges from the farming industry. Since 2002, the Sub-secretariat of Coastal and Marine Resources, Office of Conservation and Management is working on its management plan, thus the maps generated by this project will be an important contribution for management purposes.

Two aerial photographs (1:20.000) property of the Instituto Nacional de Recursos Hidráulicos (INDRHI) taken in 2000 were georeferenced based on a Landsat ETM+ image using ArcMap with 11 ground control points. A photo mosaic was generated using Erdas vs. 8.6. It was not possible to map the East section of the lagoon because

sediment load and sun glint interferences. 86 points were visually inspected for ground truthing purposes.

Results showed on the shallow area (up to 10 m depth) dominated by two types of vegetation, mangroves (*Rhizophora mangle, Conocarpus erectus*) on the coastal plain and seagrasses (*Thalassia testudinum, Halodule wrightii y Syringodium filiforme*) on the benthos, accounting for 70% of the total area (Tables 1, Appendix 1). Sandy beaches were also identified. Internal fringing reefs were found west of the channel entrance and along the reef crest. Isolated coral patches mostly of dead colonies (*Porites porites* and *P. furcata).*

Dominican Republic Project 2: A preliminary report on habitat mapping for marine underwater survey of queen conch, *Strombus gigas* in Parque Nacional del Este, Dominican Republic".

By, Jeannette Mateo, Sub-secretariat of Coastal and Marine Resources, Office of Conservation and Management.

This is an ongoing project funded by the government of the Dominican Republic and the Caribbean Regional Fisheries Mechanism (CRFM) and designed to rehabilitate and strengthen the management of queen conch in response to the CITES moratorium. The contribution of this project consisted in teaching how to correctly overlap habitat and biological information collected over time but having different georeference datums and be able to utilize this information into GIS framework, updating benthic habitat knowledge of the queen conch population in Dominican Republic.

Georeferenced for all biological information was based on a Landsat ETM+ image (http//:zulu.ssc.nasa.gov/mrsid). Corrections for image displacements due to variable datums used for map of conch transepts was created for 1998 and 2006 transepts, displaying starting point of each one combined with its orientation using the ARC-GIS software (Table 1). As a result an image exhibiting the topographic shape of Parque del Este, with superposed benthic map and conch transects for both 1998 and 2006 transepts was generated using Arc-Map.

Venezuela Project: "Characterization of submerged areas adjacent to Cayo Dos Mosquises Sur, Archipiélago Los Roques Nacional Park".

By: Juan Posada and Rodrigo Lazo from Universidad Simón Bolívar and Pablo Rodríguez from Dirección de Hidrografía y Navegación

This MPA was selected because it posses a research station, which has helped to collect background information and lack detailed habitat mapping at the interior of the passage between the two Cays. Fishing is not allowed and indeed few fishing activity is taking place, perhaps because its remoteness and shark abundance. Methods were similar to Schweizer et al. 2005.

The project improved detailed habitat knowledge of the study area (between 66° 54' W, 11° 49' N and 66° 52'W, 11° 47'N) using a Landsat TM image (Scene Id.: L70RWRS.002:2000152977) previously corrected by atmospheric and bathymetric interferences. Two new maps with three of three habitat types were produced: sand, sand and SAV and sand and coral.

Additional habitat maps were generated, this time by visually interpreting habitat types from 1949 (scale 1:30.000) from National Achieves and Records Administration, US and 1971 (scale 1:60.000) from Instituto Geográfico de Venezuela Simón Bolívar aerial photographs. Delineation of benthic habitats was done by using the habitat digitizer extension developed by NOAA/NOS Biogeography Team. This time five habitat types were identified: sand, SAV (submerged aquatic vegetation), reefs, sand and SAV, sand and reefs (Tables 1, Appendix 1).

Puerto Rico Project: Accuracy Assessment of Benthic Habitat Maps of Mona Island Natural Reserve, Puerto Rico

By, Michelle Shärer, Amigos de Amona

Mona Island Natural Reserve is located 73 km west of Puerto Rico, geographically located between 17.90 and 18.30 degrees North latitude, and 67.69 and 68.10 degrees West longitude. This MPA encompasses 157,000 hectares (ha) within the boundaries located 9 nautical miles surrounding two islands located in the Mona Passage between the Dominican Republic and Puerto Rico (Hernandez-Delgado 1996). A variety of endemic and endangered species are found on Mona and Monito, suggesting it is an important biogeographic stepping stone within the Caribbean region.

The National Ocean Service (NOS) Biogeography Team of the National Oceanic and Atmospheric Administration (NOAA) has produced benthic habitat maps for Puerto Rico and the U.S. Virgin Islands based on aerial photography of the region (NOAA 2001). This information has been available since 2001, although verification at scales less than 10km has only been performed within La Parguera Natural Reserve within the Puerto Rican archipelago. The goal of this project was to asses the accuracy by field surveys of a series of points within the area mapped by NOS for the Mona Island Natural Reserve.

545 of the 600 randomly selected points were visited for field verification in areas of depths less than 25 m. Points were uploaded directly from GIS to a handheld GPS (Garmin 76 Map) with DNR MN Garmin software. From July 2005 until March 2006 field work was conducted to collect data on the ecological parameters of the benthic habitats. Snorkeling in areas of depths less than 5 m and SCUBA diving in areas deeper than 5 m was conducted to verify the habitat characteristics of each point. Habitats were classified at each point following the definitions established by NOAA (2001). The frequency distribution of

comparable points was determined according to the description by NOAA from aerial photography and the in situ classification.

The greatest discrepancies in classification were observed for sand, scattered coral rock, colonized pavement with channels and colonized bedrock, difficult to map without field verification. Overall classification of points was dissimilar in 60% of the cases. The proportion of differences varied depending on habitat type. For instance, difference between colonized pavement with sand channels and spur and groove habitats is one of vertical relief, which is undetectable with aerial photography. Other dissimilari-

Table 1. Summary of habitat knowledge in coral reef environments generated by project participants in six remote Caribbean MPAs.

Country	MPA	Agency/ Authors	Project title	Source Data	Software	Results	Future work
Mexico	Chinchorro Bank Biosphere Reserve	CONANP[1], Secretaria de Marina[2], Universidad Quintana Roo[3]. Bárbara Reveles[1], Gerardo Rios[1], Jorge Carranza[1], Felipe Fonseca, José Castro[1], Daniela [1], Gildardo Alarcón[2], Antonio Iturbe[3].	Benthic habitat map of the diving zone within the Chinchorro Bank Biosphere Reserve.	SSS Marine Sonic 200 kHz. Landsat ETM. Spot.	Sea Scan PC PC Review Sonar web Arc View	-53.7 km2 of benthic mapping within the diving zone. -7 habitat types identified: sand with structure, sand with out structure, vegetation, continuous coral, small coral patch, medium coral patch and large coral patch. -Underwater video and pictures for map generation in 39 sites. -All results posted on the CONANP server.	Continue strengthen work in benthic habitat mapping within remote Caribbean MPAs.
	Arrecife Alacranes National Park	Felipe Be Estrella[1]	Location of Foraging areas of juvenile sea turtles	Existing Benthic maps GPS locations	Arc View	-Field observations taken in 1994 correctly located on existing benthic and zoning maps. -Most foraging areas were outside of no-take areas.	
San Andres archipelago, Colombia	Seaflower MPA	CORALINA Anthony Mitchell, Giovanna Peñaloza, Robert Hudgson.	Benthic habitats of the south end of Quitasueño bank, Seaflower Biosphere Reserve.	- Black and White 1960 aerial photograph. - Scale: 1:10.000. - 171 km^2	- ILWIS 3.2 - Non-supervised classification. - Accuracy verified with with 2003 field data.	- 6 habitat types identified: coarse sand with rubble, coral patch, fine sand with corals, sand and dispersed algae, sand with rubble and algae, reef barrier. - Sand and dispersed algae found to be the dominant habitat, important queen conch habitat. - Improvement of previous habitat knowledge.	- Compare results with traditional photo interpretation procedures. - Complete map accuracy with additional field data.

Table 1. Continued.

Dominican Republic	Laguna de Puerto Azua Wildlife Reserve	Sub-secretaria de Recursos Marinos y Pesqueros Guilio Marin	Photo-interpretation of the coastal and marine habitats of Laguna de Puerto Viejo, Azua.	Color aerial photographs. Scale 1:20.000. Landsat ETM 2000. Garmin Etrex Legend DGPS.	Arc View 3.2. Arc Map Erdas Imagine 8.6	- Photo-geo-reference with Landsat image. - 86 points visited. Habitat map. -identifying 15 coastal and marine habitats. - Shallow habitats dominated by seagrasses and algae, important lobster habitat.	
Dominican Republic	Parque Jaragua	Sub-secretaria de Recursos Marinos y Pesqueros Jeannette Mateo	A preliminary report on habitat mapping for marine underwater survey of queen conch, *Strombus gigas* in Parque Nacional del Este, Dominican Republic	Benthic and bathimetric maps. Landsat ETM 2000. Garmin Etrex Legend DGPS.	Arc GIS	- Available habitat maps corrected by use of different datums. - 27 transects in 1998 and 37 transects in 2006 transects correctly located on available habitat map.	Generate thematic maps on queen conch on current population status.
Puerto Rico	Mona Island Natural Reserve	Amigos de AMONA Michelle Shärer	Accuracy assessment of Benthic Habitat map of Mona Island natural Reserve, Puerto Rico.	NOAA/ NOS benthic habitat map. 1998 color aerial photographs. Scale: 1:50.000. Garmin 76 map DGPS.	Arc Map vs 8.2. DNR Garmin Software.	545 random pints within 1370 km2 of shallow habitats visited. Overall 60% misclassification. Higher similarities seen in seagrass and linear reef. Greater discrepancies for colonized pavement with sand channels, sand, scatter coral rock, and colonized bedrock.	
Venezuela	Archipiélago Los Roques National Park	[1] Universidad Simón Bolívar y [2] Dirección de Hidrografía y Navegación Juan M. Posada[1], Rodrigo Lazo[1] y Pablo Rodriguez[2]	Characterization of the submerged areas adjacent to Cayo Dos Mosquises sur, Los Roques National Park, Venezuela	Landsat TM 1998. 1944 and 1971 black and white aerial photographs. Nautical charts. DGPS Garmin 76.	Arc View 3.3.	Visual classification identifying 5 habitat types. Integration of various products for habitat mapping. Sand was found to be dominant habitat.	Habitat map using SSS. Begin map accuracy assessment procedures.

ties influenced by low numbers of comparisons were scattered coral rock and patch reef. The highest percentage of similarity between methods was observed in seagrass habitat followed by linear reef (Table 1).

DISCUSSION

The actions and results from this project demonstrated that sharing resources, experiences and knowledge was an effective strategy to achieve proposed objectives, while generating maps needed in MPA management across the region.

In addition to habitat related products, the project was also successful in helping local organizers by increasing its capacity building through community meetings, advice on management decisions, and analysis of alternative livelihoods among others.

Participants evaluated project results, benefits and limitations and graded the logistics and contents offered as one of high quality and evidenced the necessity to be concentrated during training sessions in order to accomplish all expected outputs. They also acknowledge the possibility to see and share experiences with local managers and have the opportunity to interact with the community, helping them by analyzing multiples points of view of similar situations faced by MPA managers in the Caribbean. Thanks to the CONANP support a discussion forum was created to allow for future cooperation and interaction (www.conanp.gob.mx/sig/foro_sig/)

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APPENDIX 1. Quantification of mapping areas generated for remote Caribbean MPAs on coral reef environments.

New habitat map for Laguna Puerto Viejo, Dominan Republic

Coastal / Marine habitats	Km^2	%
Subtropical dry forest	0.49	3.98
Sandy beach	0.11	0.88
Rocky inter-tidal	0.19	1.53
Mangrove	0.42	3.45
Wetland	2.83	23.02
Salt marsh	0.20	1.64
Artificial	0.05	0.45
Sandy bottom	2.32	18.84
Sand and algae	0.34	2.79
Rubble	0.03	0.21
Seagrass	3.77	30.64
Colonized hard bottom	0.24	1.97
Coral patch	0.03	0.20
Linear reef	0.47	3.80
Spur and groove	0.81	6.61
Undetermined	0.00	0.00
Total	12.30	

APPENDIX 1. Quantification of mapping areas generated for remote Caribbean MPAs on coral reef environments.

New habitat map for Diving zone of the Chinchorro Bank, Mexico		
Benthic habitats	Km^2	%
Sand with structure	29.0	58.0
San without structure	16.8	11.1
Submerge aquatic vegetation	0.5	10.0
Continuous corals	55.0	8.9
Large coral patches	10.0	
Medium coral Patches	8.0	9.7
Small coral patches	11.0	2.2
Total	54.7	

New habitat map for Quitasueño south end section, Colombia			Existing habitat map for Quitasueño south end section		
Benthic habitats	Km^2	%	Benthic habitats	Km^2	%
Sand and dispersed algae	101.0	58.0	Sand and rubble	43.8	25
Fine sand with scatter corals	19.3	11.1	Bioturbated sand and calcareous algae	41.6	24
Sand, rubble and algae	17.4	10.0			
Arena gruesa con escombros	15.4	8.9			
Coral Patches	16.8	9.7	Mixed corals	54.8	32
Reef crest	3.8	2.2	*Acropora palmata* - *Diploria strigosa*	2.6	1
			Montastraea spp	9.4	5
			Calcareous algae, *M. complanata* and Zoan-thids	21.7	12
unidentified	0.3	0.2			
Total	174.0		Total	173.8	

New habitat map for Dos Mosquises sur, Venezuela from satellite image			New habitat map for Dos Mosquises sur, Venezuela from 1949 aerial photographs			New habitat map for Dos Mosquises sur, Venezuela from 1971 aerial photographs		
Benthic habitats	Km^2	%	Benthic habitats	Km^2	%	Benthic habitats	Km^2	%
Sand	1.8	43.9	Sand	2.6	59.2	Sand	1.4	55.6
Sand and Rubble	0.6	14.0	Sand and Rubble	0.5	10.5	Sand and Rubble	0.2	6.5
Sand and Seagrass	0.5	11.3	Sand and Seagrass	0.5	10.8	Sand and Seagrass	0.3	10.7
Corals	0.8	19.5	Corals	0.6	12.8	Corals	0.2	7.7
Seagrass	0.5	11.3	Seagrass	0.3	6.6	Seagrass	0.5	19.5
Total	4.0		Total	4.3		Total	2.5	